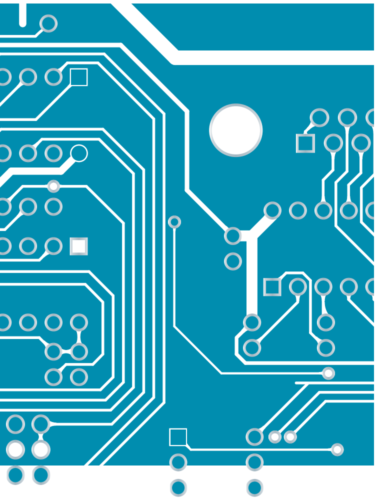
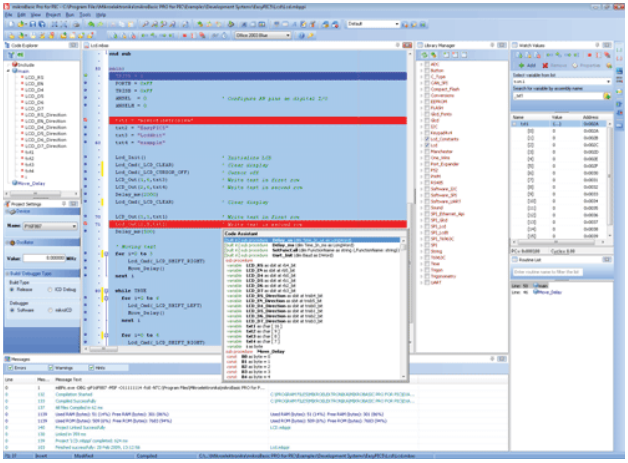
MikroElektronika

SOFTWARE AND HARDWARE SOLUTIONS FOR EMBEDDED WORLD . . . making it simple

mikroBASIC PRO for PIC





USER MANUAL

Develop your applications quickly and easily with the world's most intuitive mikroBasic PRO for PIC Microcontrollers.

Highly sophisticated IDE provides the power you need with the simplicity of a Windows based point-and-click environment.

With useful implemented tools, many practical code examples, broad set of built-in routines, and a comprehensive Help, mikroBasic PRO for PIC makes a fast and reliable tool, which can satisfy needs of experienced engineers and beginners alike.

April 2009.

Reader's note

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This manual covers *mikroBASIC PRO for PIC* version 1.0 and the related topics. Newer versions may contain changes without prior notice.

COMPILER BUG REPORTS:
The compiler has been carefully tested and debugged. It is, however, not possible to guarantee a 100 % error free product. If you would like to report a bug, please contact us at the address office@mikroe.com. Please include next information in your bug report:

- Your operating system
- Version of *mikroBASIC PRO for PIC*
- Code sample
- Description of a bug

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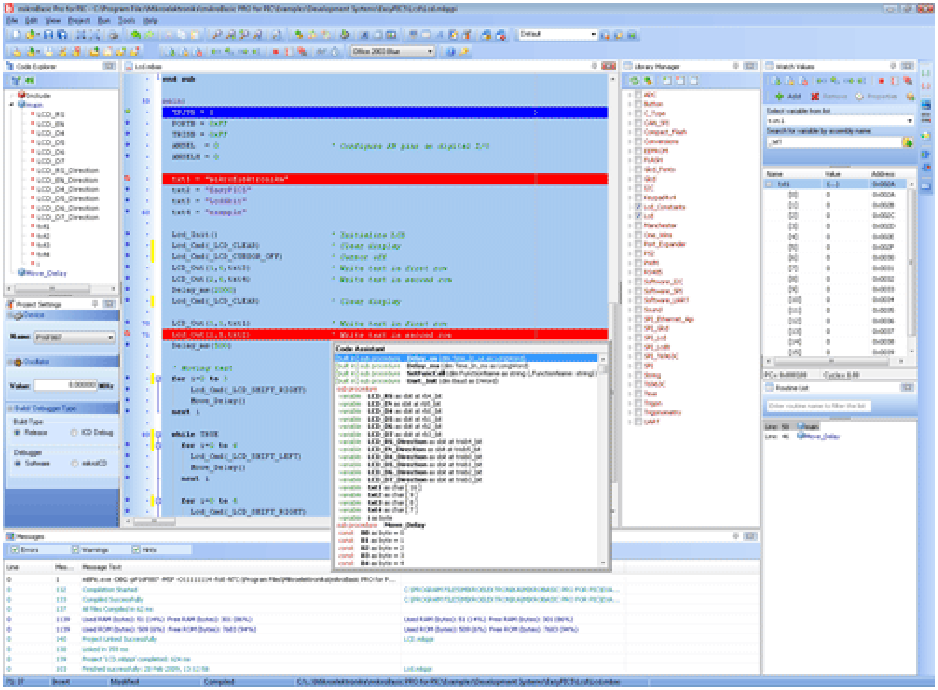
CHAPTER 1

Introduction to *mikroBasic PRO for PIC*

The *mikroBasic PRO for PIC* is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control.



mikroBasic PRO for PIC IDE

Features

mikroBasic PRO for PIC allows you to quickly develop and deploy complex applications:

- Write your Basic source code using the built-in Code Editor (Code and Parameter Assistants, Code Folding, Syntax Highlighting, Spell Checker, Auto Correct, Code Templates, and more.)
- Use included mikroBasic PRO libraries to dramatically speed up the development: data acquisition, memory, displays, conversions, communication etc.
- Monitor your program structure, variables, and functions in the Code Explorer.
- Generate commented, human-readable assembly, and standard HEX compatible with all programmers.
- Use the integrated mikroICD (In-Circuit Debugger) Real-Time debugging tool to monitor program execution on the hardware level.
- Inspect program flow and debug executable logic with the integrated Software Simulator.
- Get detailed reports and graphs: RAM and ROM map, code statistics, assembly isting, calling tree, and more.
- *mikroBasic PRO for PIC* provides plenty of examples to expand, develop, and use as building bricks in your projects. Copy them entirely if you deem fit – that's why we included them with the compiler.

Where to Start

- In case that you're a beginner in programming PIC microcontrollers, read carefully th PIC Specifics chapter. It might give you some useful pointers on PIC constraints, code portability, and good programming practices.

- If you are experienced in Basic programming, you will probably want to con sult *mikroBasic PRO for PIC* Specifics first. For language issues, you can always refer to the comprehensive Language Reference. A complete list of included libraries is available at *mikroBasic PRO for PIC* Libraries.

- If you are not very experienced in Basic programming, don't panic! *mikroBa sic PRO for PIC* provides plenty of examples making it easy for you to go quickly. We suggest that you first consult Projects and Source Files, and then start browsing the examples that you're the most interested in.

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TECHNICAL SUPPORT

In case you encounter any problem, you are welcome to our support forums at www.mikroe.com/forum/. Here, you may also find helpful information, hardware tips, and practical code snippets. Your comments and suggestions on future development of the *mikroBasic PRO for PIC* are always appreciated — feel free to drop a note or two on our Wishlist.

In our Knowledge Base www.mikroe.com/en/kb/ you can find the answers to Frequently Asked Questions and solutions to known problems. If you can not find the solution to your problem in Knowledge Base then report it to Support Desk www.mikroe.com/en/support/. In this way, we can record and track down bugs more efficiently, which is in our mutual interest. We respond to every bug report and question in a suitable manner, ever improving our technical support

How to Register

The latest version of the *mikroBasic PRO for PIC* is always available for downloading from our website. It is a fully functional software libraries, examples, and comprehensive help included.

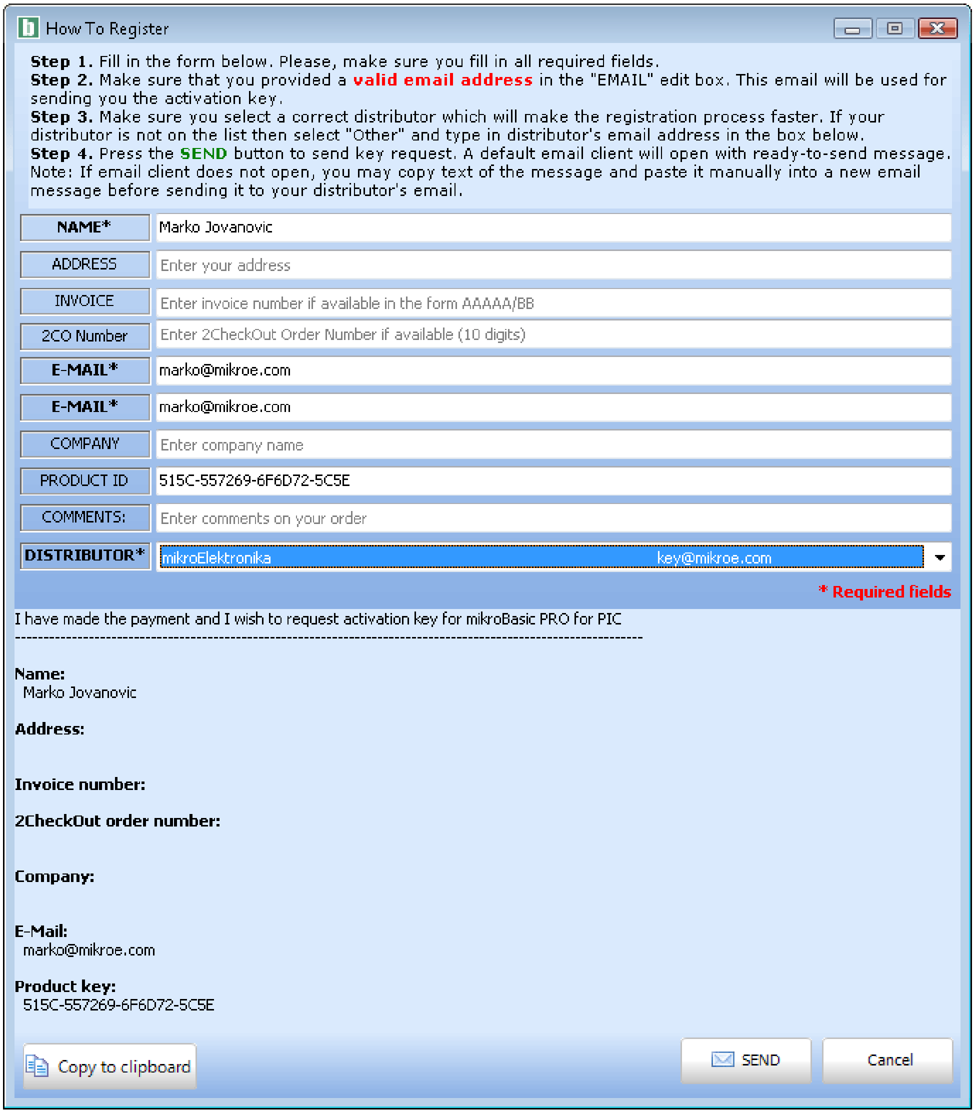
The only limitation of the free version is that it cannot generate hex output over 2 KB. Although it might sound restrictive, this margin allows you to develop practical, working applications with no thinking of demo limit. If you intend to develop really complex projects in the *mikroBasic PRO for PIC*, then you should consider the possibility of purchasing the license key.

Who Gets the License Key

Buyers of the *mikroBasic PRO for PIC* are entitled to the license key. After you have completed the payment procedure, you have an option of registering your *mikroBasic PRO*. In this way you can generate hex output without any limitations.

How to Get License Key

After you have completed the payment procedure, start the program. Select **Help › How to Register** from the drop-down menu or click the How To Register Icon 🔑 Fill out the registration form (figure below), select your distributor, and click the Send button.



Step 1. Fill in the form below. Please, make sure you fill in all required fields.
Step 2. Make sure that you provided a **valid email address** in the "EMAIL" edit box. This email will be used for sending you the activation key.
Step 3. Make sure you select a correct distributor which will make the registration process faster. If your distributor is not on the list then select "Other" and type in distributor's email address in the box below.
Step 4. Press the **SEND** button to send key request. A default email client will open with ready-to-send message.
Note: If email client does not open, you may copy text of the message and paste it manually into a new email message before sending it to your distributor's email.

NAME*	Marko Jovanovic
ADDRESS	Enter your address
INVOICE	Enter invoice number if available in the form AAAAA/BB
2CO Number	Enter 2CheckOut Order Number if available (10 digits)
E-MAIL*	marko@mikroe.com
E-MAIL*	marko@mikroe.com
COMPANY	Enter company name
PRODUCT ID	515C-557269-6F6D72-5C5E
COMMENTS:	Enter comments on your order
DISTRIBUTOR*	mikroElektronika key@mikroe.com

*** Required fields**

I have made the payment and I wish to request activation key for mikroBasic PRO for PIC

Name:
Marko Jovanovic

Address:

Invoice number:

2CheckOut order number:

Company:

E-Mail:
marko@mikroe.com

Product key:
515C-557269-6F6D72-5C5E

This will start your e-mail client with message ready for sending. Review the information you have entered, and add the comment if you deem it necessary. Please, do not modify the subject line.

Upon receiving and verifying your request, we will send the license key to the e-mail address you specified in the form.

After Receving the License Key

The license key comes as a small autoextracting file – just start it anywhere on your computer in order to activate your copy of compiler and remove the demo limit. You do not need to restart your computer or install any additional components. Also, there is no need to run the mikroBasic PRO for PIC at the time of activation.

Notes:

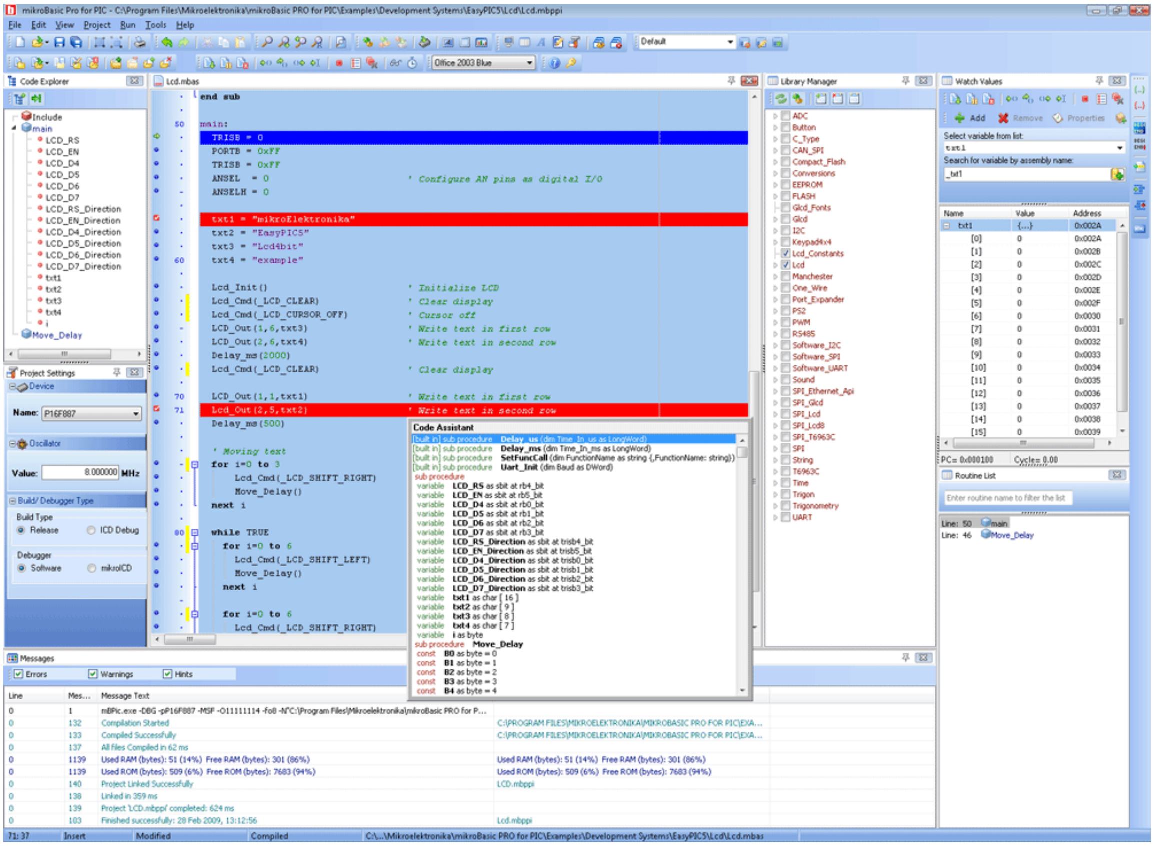
- The license key is valid until you format your hard disk. In case you need to format the hard disk, you should request a new activation key.
- Please keep the activation program in a safe place. Every time you upgrade the compiler you should start this program again in order to reactivate the license.

CHAPTER 2

mikroBasic PRO for PIC Environment

The *mikroBasic PRO for PIC* is an user-friendly and intuitive environment:

IDE OVERVIEW



mikroBasic Pro for PIC - C:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Examples\Development Systems\EasyPIC5\Lcd\Lcd.mbppi

Name: P16F887

Value: 8.000000 MHz

Build Type
● Release ○ ICD Debug

Debugger
● Software ○ mikroICD

```
end sub

main:
  TRISB = 0
  PORTB = 0xFF
  TRISB = 0xFF
  ANSEL  = 0                        ' Configure AN pins as digital I/O
  ANSELH = 0

  txt1 = "mikroElektronika"
  txt2 = "EasyPIC5"
  txt3 = "Lcd4bit"
  txt4 = "example"

  Lcd_Init()                        ' Initialize LCD
  Lcd_Cmd(_LCD_CLEAR)               ' Clear display
  Lcd_Cmd(_LCD_CURSOR_OFF)          ' Cursor off
  LCD_Out(1,6,txt3)                 ' Write text in first row
  LCD_Out(2,6,txt4)                 ' Write text in second row
  Delay_ms(2000)
  Lcd_Cmd(_LCD_CLEAR)               ' Clear display

  LCD_Out(1,1,txt1)                 ' Write text in first row
  Lcd_Out(2,5,txt2)                 ' Write text in second row
  Delay_ms(500)

  ' Moving text
  for i=0 to 3
      Lcd_Cmd(_LCD_SHIFT_RIGHT)
      Move_Delay()
  next i

  while TRUE
    for i=0 to 6
      Lcd_Cmd(_LCD_SHIFT_LEFT)
      Move_Delay()
    next i

    for i=0 to 6
      Lcd_Cmd(_LCD_SHIFT_RIGHT)
```

Code Assistant

```
[built in] sub procedure   Delay_us (dim Time_In_us as LongWord)
[built in] sub procedure   Delay_ms (dim Time_In_ms as LongWord)
[built in] sub procedure   SetFuncCall (dim FunctionName as string {,FunctionName: string})
[built in] sub procedure   Uart_Init (dim Baud as DWord)
sub procedure
 variable   LCD_RS as sbit at rb4_bit
 variable   LCD_EN as sbit at rb5_bit
 variable   LCD_D4 as sbit at rb0_bit
 variable   LCD_D5 as sbit at rb1_bit
 variable   LCD_D6 as sbit at rb2_bit
 variable   LCD_D7 as sbit at rb3_bit
 variable   LCD_RS_Direction as sbit at trisb4_bit
 variable   LCD_EN_Direction as sbit at trisb5_bit
 variable   LCD_D4_Direction as sbit at trisb0_bit
 variable   LCD_D5_Direction as sbit at trisb1_bit
 variable   LCD_D6_Direction as sbit at trisb2_bit
 variable   LCD_D7_Direction as sbit at trisb3_bit
 variable   txt1 as char [ 16 ]
 variable   txt2 as char [ 9 ]
 variable   txt3 as char [ 8 ]
 variable   txt4 as char [ 7 ]
 variable   i as byte
sub procedure   Move_Delay
 const   B0 as byte = 0
 const   B1 as byte = 1
 const   B2 as byte = 2
 const   B3 as byte = 3
 const   B4 as byte = 4
```

Select variable from list: txt1

Search for variable by assembly name: _txt1

Name	Value	Address
txt1	{...}	0x002A
[0]	0	0x002A
[1]	0	0x002B
[2]	0	0x002C
[3]	0	0x002D
[4]	0	0x002E
[5]	0	0x002F
[6]	0	0x0030
[7]	0	0x0031
[8]	0	0x0032
[9]	0	0x0033
[10]	0	0x0034
[11]	0	0x0035
[12]	0	0x0036
[13]	0	0x0037
[14]	0	0x0038
[15]	0	0x0039

PC= 0x000100 Cycle= 0.00

Line: 50 main
Line: 46 Move_Delay

Line	Mes...	Message Text	
0	1	mBPic.exe -DBG -pP16F887 -MSF -O11111114 -fo8 -N"C:\Program Files\Mikroelektronika\mikroBasic PRO for P...	
0	132	Compilation Started	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	133	Compiled Successfully	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	137	All files Compiled in 62 ms	
0	1139	Used RAM (bytes): 51 (14%) Free RAM (bytes): 301 (86%)	Used RAM (bytes): 51 (14%) Free RAM (bytes): 301 (86%)
0	1139	Used ROM (bytes): 509 (6%) Free ROM (bytes): 7683 (94%)	Used ROM (bytes): 509 (6%) Free ROM (bytes): 7683 (94%)
0	140	Project Linked Successfully	LCD.mbppi
0	138	Linked in 359 ms	
0	139	Project 'LCD.mbppi' completed: 624 ms	
0	103	Finished successfully: 28 Feb 2009, 13:12:56	Lcd.mbppi

71: 37 Insert Modified Compiled C:\...\Mikroelektronika\mikroBasic PRO for PIC\Examples\Development Systems\EasyPIC5\Lcd\Lcd.mbas

- The Code Editor features adjustable Syntax Highlighting, Code Folding, Code Assistant, Parameters Assistant, Spell Checker, Auto Correct for com mon typos and Code Templates (Auto Complete).
- The Code Explorer is at your disposal for easier project management.
- The Project Manager alows multiple project management
- General project settings can be made in the Project Settings window
- Library manager enables simple handling libraries being used in a project
- The Error Window displays all errors detected during compiling and linking.
- The source-level Software Simulator lets you debug executable logic step-by-step by watching the program flow.
- The New Project Wizard is a fast, reliable, and easy way to create a project
- Help files are syntax and context sensitive.
- Like in any modern Windows application, you may customize the layout of *mikroBasic PRO for PIC* to suit your needs best.

- Spell checker underlines identifiers which are unknown to the project. In this way it helps the programmer to spot potential problems early, much before the project is compiled.
  Spell checker can be disabled by choosing the option in the Preferences dialog (F12).

MAIN MENU OPTIONS

Available Main Menu options are:

- 

- 

- 

- 

- 

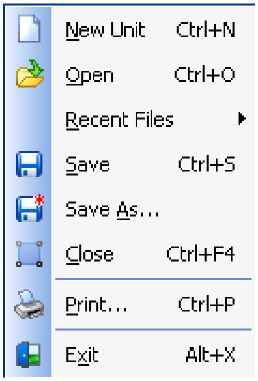
- 

- 

Related topics: Keyboard shortcuts

FILE MENU OPTIONS

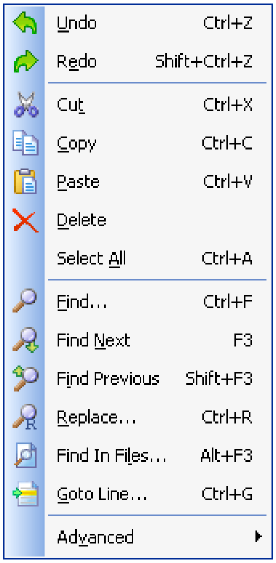
The File menu is the main entry point for manipulation with the source files.



File	Description
New Unit Ctrl+N	Open a new editor window.
Open Ctrl+O	Open source file for editing or image file for viewing.
Recent Files	Reopen recently used file.
Save Ctrl+S	Save changes for active editor.
Save As...	Save the active source file with the different name or change the file type.
Close Alt+F4	Close active source file.
Print... Ctrl+P	Print Preview.
Exit Alt+X	Exit IDE.

Related topics: Keyboard shortcuts, File Toolbar, Managing Source Files

EDIT MENU OPTIONS

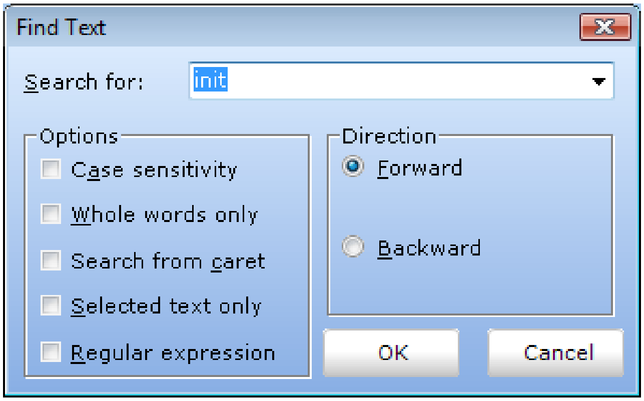


Edit	Description
Undo Ctrl+Z	Undo last change.
Redo Shift+Ctrl+Z	Redo last change.
Cut Ctrl+X	Cut selected text to clipboard.
Copy Ctrl+C	Copy selected text to clipboard.
Paste Ctrl+V	Paste text from clipboard.
Delete	Delete selected text.
Select All Ctrl+A	Select all text in active editor.
Find... Ctrl+F	Find text in active editor.
Find Next F3	Find next occurence of text in active editor.
Find Previous Shift+F3	Find previous occurence of text in active editor.
Replace... Ctrl+R	Replace text in active editor.
Find In Files... Alt+F3	Find text in current file, in all opened files, or in files from desired folder.
Goto Line... Ctrl+G	Goto to the desired line in active editor.
Advanced ▸	Advanced Code Editor options

Advanced »		Description
Comment	Shift+Ctrl+.	Comment selected code or put single line comment if there is no selection.
Uncomment	Shift+Ctrl+,	Uncomment selected code or remove single line comment if there is no selection.
Indent	Shift+Ctrl+I	Indent selected code.
Outdent	Shift+Ctrl+U	Outdent selected code.
Lowercase	Ctrl+Alt+L	Changes selected text case to lowercase.
Uppercase	Ctrl+Alt+U	Changes selected text case to uppercase.
Titlecase	Ctrl+Alt+T	Changes selected text case to titlercase.

Find Text

Dialog box for searching the document for the specified text. The search is performed in the direction specified. If the string is not found a message is displayed.



Find Text

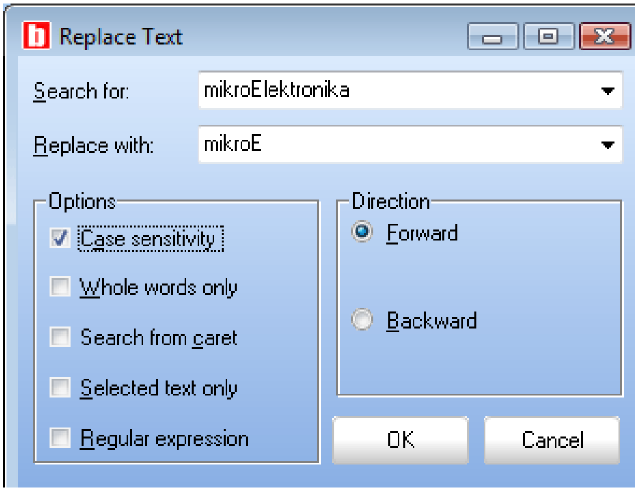
Search for: init

Options
☐ Case sensitivity
☐ Whole words only
☐ Search from caret
☐ Selected text only
☐ Regular expression

Direction
● Forward
○ Backward

Replace Text

Dialog box for searching for a text string in file and replacing it with another text string.



Search for: mikroElektronika

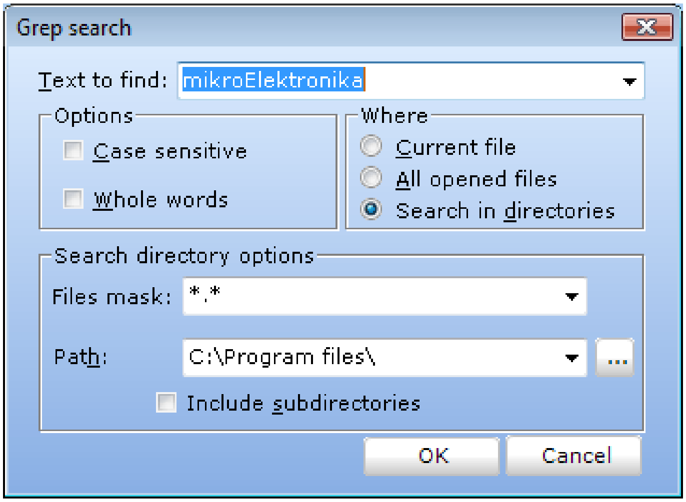
Replace with: mikroE

Options
- ☑ Case sensitivity
- ☐ Whole words only
- ☐ Search from caret
- ☐ Selected text only
- ☐ Regular expression

Direction
- ● Forward
- ○ Backward

Find In Files

Dialog box for searching for a text string in current file, all opened files, or in files on a disk.
The string to search for is specified in the Text to find field. If Search in directories option is selected, The files to search are specified in the Files mask and Path fields.



Text to find: mikroElektronika

Options
- ☐ Case sensitive
- ☐ Whole words

Where
- ○ Current file
- ○ All opened files
- ● Search in directories

Search directory options

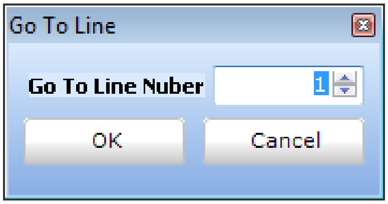
Files mask: *.*

Path: C:\Program files\

☐ Include subdirectories

Go To Line

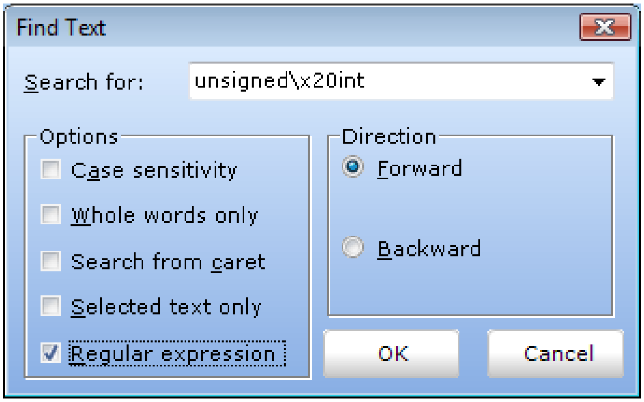
Dialog box that allows the user to specify the line number at which the cursor should be positioned.



Go To Line Nuber: 1

Regular expressions option

By checking this box, you will be able to advance your search, through Regular expressions.



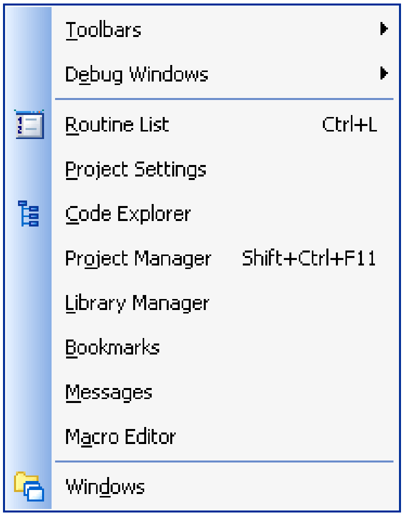
Search for: unsigned\x20int

- ☐ Case sensitivity
- ☐ Whole words only
- ☐ Search from caret
- ☐ Selected text only
- ☑ Regular expression

- ● Forward
- ○ Backward

Related topics: Keyboard shortcuts, Edit Toolbar, Advanced Edit Toolbar

VIEW MENU OPTIONS



File	Description
Toolbars	Show/Hide toolbars.
Debug Windows	Show/Hide Software Simulator/mikroICD (In-Circuit Debugger) debug windows.
Routines List	Show/Hide Routine List in active editor.
Project Settings	Show/Hide Project Settings window.
Code Explorer	Show/Hide Code Explorer window.
Project Manager Shift+Ctrl+F11	Show/Hide Project Manager window.
Library Manager	Show/Hide Library Manager window.
Bookmarks	Show/Hide Bookmarks window.
Messages	Show/Hide Error Messages window.
Macro Editor	Show/Hide Macro Editor window.
Windows	Show Window List window.

TOOLBARS

File Toolbar

File Toolbar is a standard toolbar with following options:

Icon	Description
	Opens a new editor window.
	Open source file for editing or image file for viewing.
	Save changes for active window.
	Save changes in all opened windows.
	Close current editor.
	Close all editors.
	Print Preview.

Edit Toolbar

Edit Toolbar is a standard toolbar with following options:

Icon	Description
	Undo last change.
	Redo last change.
	Cut selected text to clipboard.
	Copy selected text to clipboard.
	Paste text from clipboard.

Advanced Edit Toolbar

Advanced Edit Toolbar comes with following options:

Icon	Description
{..}	Comment selected code or put single line comment if there is no selection
{..}	Uncomment selected code or remove single line comment if there is no selection.
BEGI END	Select text from starting delimiter to ending delimiter.
BEGI END	Go to ending delimiter.
	Go to line.
	Indent selected code lines.
	Outdent selected code lines.
HTML	Generate HTML code suitable for publishing current source code on the web.

Find/Replace Toolbar

Find/Replace Toolbar is a standard toolbar with following options:

Icon	Description
🔍	Find text in current editor.
🔍	Find next occurence.
🔍	Find previous occurence.
🔍 R	Replace text.
🔍	Find text in files.

Project Toolbar

Project Toolbar comes with following options:

Icon	Description
	New project
	Open Project
	Save Project
	Close current project
	Edit project settings.
	Add existing project to project group.
	Remove existing project from project group
	Add File To Project
	Remove File From Project

Build Toolbar

Build Toolbar comes with following options:

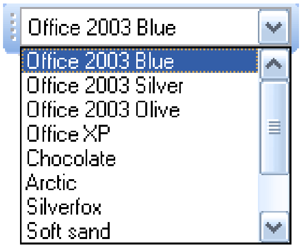
Icon	Description
	Build current project.
	Build all opened projects.
	Build and program active project.
	Start programmer and load current HEX file.
	Open assembly code in editor.
	Open listing file in editor.
	View statistics for current project.

Debugger

Debugger Toolbar comes with following options:

Icon	Description
⇩	Start Software Simulator or mikro ICD (In-Circuit Debugger).
⏸	Run/Pause debugger.
✖	Stop debugger.
➡()	Step into.
↷()	Step over.
()➡	Step out.
➡I	Run to cursor.
■	Toggle breakpoint.
☰	Toggle breakpoints.
✖	Clear breakpoints.
👓	View watch window
⏱	View stopwatch window

Styles Toolbar



Styles toolbar allows you to easily customize your workspace.

Tools Toolbar

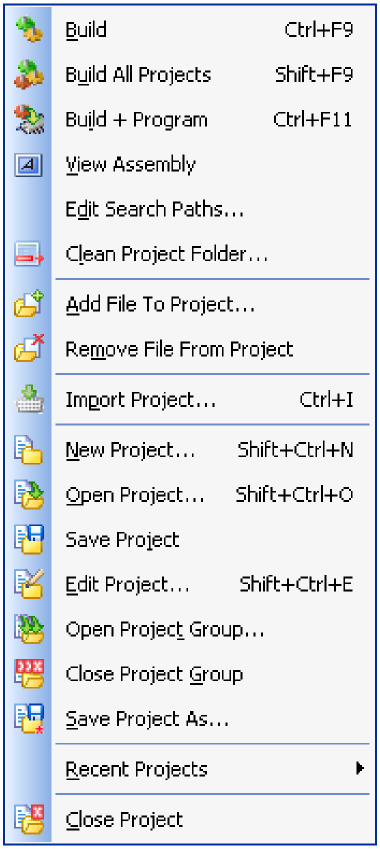
Tools Toolbar comes with following default options:

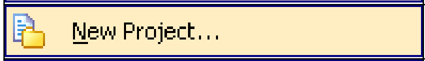
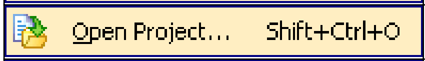
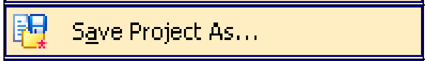
Icon	Description
🖥	Run USART Terminal
▦	EEPROM
A	ASCII Chart
📝	Seven segment decoder tool.
🔨	Optiions menu

The Tools toolbar can easily be customized by adding new tools in Options(F12) window.

Related topics: Keyboard shortcuts, Integrated Tools, Debugger Windows

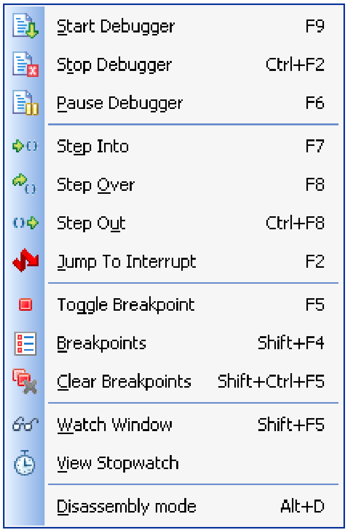
PROJECT MENU OPTIONS



Project	Description
 Build Ctrl+F9	Build active project.
 Build All Projects Shift+F9	Build all projects.
 Build + Program Ctrl+F11	Build and program active project.
 View Assembly	View Assembly.
 Edit Search Paths...	Edit search paths.
 Clean Project Folder...	Clean Project Folder
 Add File To Project...	Add file to project.
 Remove File From Project	Remove file from project.
 New Project...	Open New Project Wizard
 Open Project... Shift+Ctrl+O	Open existing project.
 Save Project	Save current project.
 Edit Project... Shift+Ctrl+E	Edit project settings
 Open Project Group...	Open project group.
 Close Project Group	Close project group.
 Save Project As...	Save active project file with the different name.
 Recent Projects ▸	Open recently used project.
 Close Project	Close active project.

Related topics: Keyboard shortcuts, Project Toolbar, Creating New Project, Project Manager, Project Settings

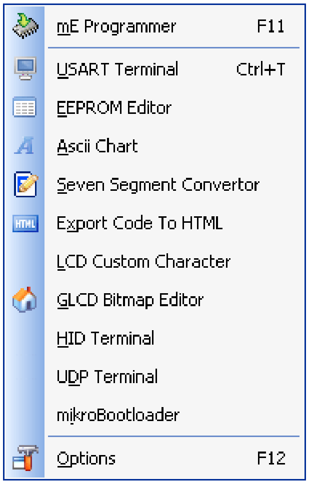
RUN MENU OPTIONS



Run	Description
Start Debugger F9	Start Software Simulator.
Stop Debugger Ctrl+F2	Stop debugger.
Pause Debugger F6	Pause Debugger.
Step Into F7	Step Into.
Step Over F8	Step Over.
Step Out Ctrl+F8	Step Out.
Jump To Interrupt F2	Jump to interrupt in current project.
Toggle Breakpoint F5	Toggle Breakpoint.
Show/Hide Breakpoints Shift+F4	Breakpoints.
Clear Breakpoints Shift+Ctrl+F5	Clear Breakpoints.
Watch Window Shift+F5	Show/Hide Watch Window
View Stopwatch	Show/Hide Stopwatch Window
Disassembly mode Ctrl+D	Toggle between Basic source and disassembly.

Related topics: Keyboard shortcuts, Debug Toolbar

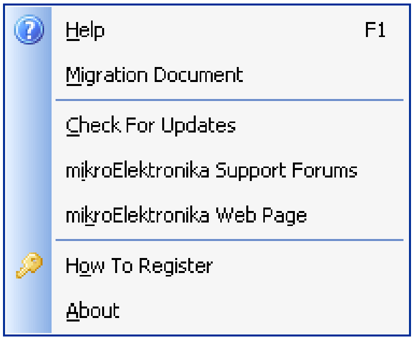
TOOLS MENU OPTIONS



Tools	Description
mE Programmer F11	Run mikroElektronika Programmer
USART Terminal Ctrl+T	Run USART Terminal
EEPROM Editor	Run EEPROM Editor
Ascii Chart	Run ASCII Chart
Seven Segment Convertor	Run 7 Segment Display Decoder
Export Code To HTML	Generate HTML code suitable for publishing source code on the web.
LCD Custom Character	Run Lcd custom character
GLCD Bitmap Editor	Run Glcd bitmap editor
HID Terminal	Run HID Terminal
UDP Terminal	Run UDP communication terminal
mikroBootloader	Run mikroBootloader
Options F12	Open Options window

Related topics: Keyboard shortcuts, Tools Toolbar

HELP MENU OPTIONS



Help	Description
Help F1	Open Help File.
Migration Document	Open Code Migration Document.
Check For Updates	Check if new compiler version is available.
mikroElektronika Support Forums	Open mikroElektronika Support Forums in a default browser.
mikroElektronika Web Page	Open mikroElektronika Web Page in a default browser.
How To Register	Information on how to register
About	Open About window.

Related topics: Keyboard shortcuts

KEYBOARD SHORTCUTS

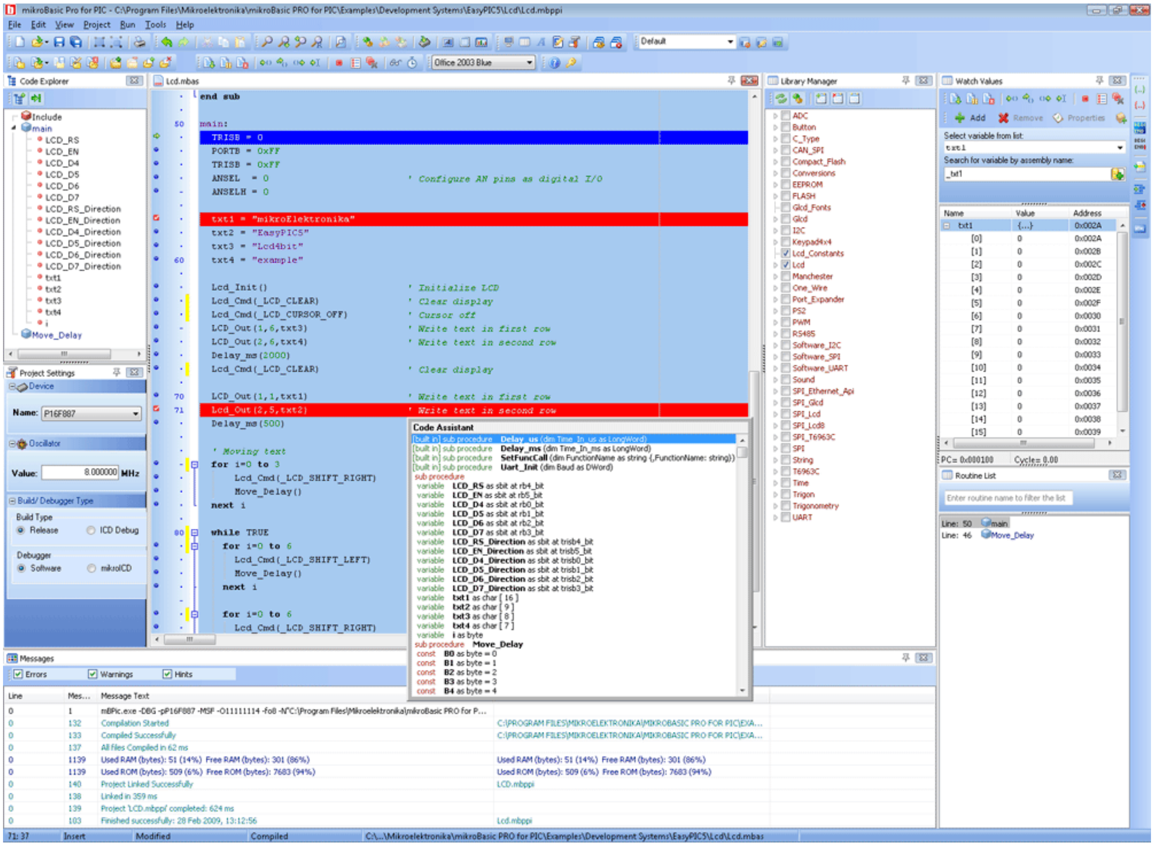
Below is a complete list of keyboard shortcuts available in *mikroBasic PRO for PIC* IDE. You can also view keyboard shortcuts in the Code Explorer window, tab Keyboard.

IDE Shortcuts	
F1	Help
Ctrl+N	New Unit
Ctrl+O	Open
Ctrl+Shift+O	Open Project
Ctrl+Shift+N	Open New Project
Ctrl+K	Close Project
Ctrl+Shift+E	Edit Project
Ctrl+F9	Compile
Shift+F9	Compile All
Ctrl+F11	Compile and Program
Shift+F4	View breakpoints
Ctrl+Shift+F5	Clear breakpoints
F11	Start PICFlash Programmer
F12	Preferences
Basic Editor Shortcuts	
F3	Find, Find Next
Shift+F3	Find Previous
Alt+F3	Grep Search, Find in Files
Ctrl+A	Select All
Ctrl+C	Copy
Ctrl+F	Find
Ctrl+R	Replace
Ctrl+P	Print
Ctrl+S	Save unit
Ctrl+Shift+S	Save All
Ctrl+V	Paste
Ctrl+X	Cut
Ctrl+Y	Delete entire line
Ctrl+Z	Undo
Ctrl+Shift+Z	Redo
Advanced Editor Shortcuts	
Ctrl+Space	Code Assistant
Ctrl+Shift+Space	Parameters Assistant
Ctrl+D	Find declaration
Ctrl+E	Incremental Search
Ctrl+L	Routine List
Ctrl+G	Goto line
Ctrl+J	Insert Code Template
Ctrl+Shift+.	Comment Code
Ctrl+Shift+,	Uncomment Code
Ctrl+*number*	Goto bookmark
Ctrl+Shift+*number*	Set bookmark
Ctrl+Shift+I	Indent selection
Ctrl+Shift+U	Unindent selection
TAB	Indent selection
Shift+TAB	Unindent selection
Alt+Select	Select columns
Ctrl+Alt+Select	Select columns
Ctrl+Alt+L	Convert selection to lowercase
Ctrl+Alt+U	Convert selection to uppercase
Ctrl+Alt+T	Convert to Titlecase

mikroICD Debugger and Software Simulator Shortcuts	
F2	Jump To Interrupt
F4	Run to Cursor
F5	Toggle Breakpoint
F6	Run/Pause Debugger
F7	Step into
F8	Step over
F9	Debug
Ctrl+F2	Reset
Ctrl+F5	Add to Watch List
Ctrl+F8	Step out
Alt+D	Dissasembly view
Shift+F5	Open Watch Window
Ctrl+Shift+A	Show Advanced Breakpoints

IDE OVERVIEW

The *mikroBasic PRO for PIC* is an user-friendly and intuitive environment:



Name: P16F887

Value: 8.000000 MHz

Build Type: ● Release ○ ICD Debug

Debugger: ● Software ○ mikroICD

```
end sub

main:
  TRISB = 0
  PORTB = 0xFF
  TRISB = 0xFF
  ANSEL  = 0                        ' Configure AN pins as digital I/O
  ANSELH = 0

  txt1 = "mikroElektronika"
  txt2 = "EasyPIC5"
  txt3 = "Lcd4bit"
  txt4 = "example"

  Lcd_Init()                        ' Initialize LCD
  Lcd_Cmd(_LCD_CLEAR)               ' Clear display
  Lcd_Cmd(_LCD_CURSOR_OFF)          ' Cursor off
  LCD_Out(1,6,txt3)                 ' Write text in first row
  LCD_Out(2,6,txt4)                 ' Write text in second row
  Delay_ms(2000)
  Lcd_Cmd(_LCD_CLEAR)               ' Clear display

  LCD_Out(1,1,txt1)                 ' Write text in first row
  Lcd_Out(2,5,txt2)                 ' Write text in second row
  Delay_ms(500)

  ' Moving text
  for i=0 to 3
      Lcd_Cmd(_LCD_SHIFT_RIGHT)
      Move_Delay()
  next i

  while TRUE
    for i=0 to 6
      Lcd_Cmd(_LCD_SHIFT_LEFT)
      Move_Delay()
    next i

    for i=0 to 6
      Lcd_Cmd(_LCD_SHIFT_RIGHT)
```

Code Assistant

```
[built in] sub procedure   Delay_us (dim Time_In_us as LongWord)
[built in] sub procedure   Delay_ms (dim Time_In_ms as LongWord)
[built in] sub procedure   SetFuncCall (dim FunctionName as string {,FunctionName: string})
[built in] sub procedure   Uart_Init (dim Baud as DWord)
sub procedure
  variable   LCD_RS as sbit at rb4_bit
  variable   LCD_EN as sbit at rb5_bit
  variable   LCD_D4 as sbit at rb0_bit
  variable   LCD_D5 as sbit at rb1_bit
  variable   LCD_D6 as sbit at rb2_bit
  variable   LCD_D7 as sbit at rb3_bit
  variable   LCD_RS_Direction as sbit at trisb4_bit
  variable   LCD_EN_Direction as sbit at trisb5_bit
  variable   LCD_D4_Direction as sbit at trisb0_bit
  variable   LCD_D5_Direction as sbit at trisb1_bit
  variable   LCD_D6_Direction as sbit at trisb2_bit
  variable   LCD_D7_Direction as sbit at trisb3_bit
  variable   txt1 as char [ 16 ]
  variable   txt2 as char [ 9 ]
  variable   txt3 as char [ 8 ]
  variable   txt4 as char [ 7 ]
  variable   i as byte
sub procedure   Move_Delay
  const   B0 as byte = 0
  const   B1 as byte = 1
  const   B2 as byte = 2
  const   B3 as byte = 3
  const   B4 as byte = 4
```

Select variable from list: txt1

Search for variable by assembly name: _txt1

Name	Value	Address
txt1	{...}	0x002A
[0]	0	0x002A
[1]	0	0x002B
[2]	0	0x002C
[3]	0	0x002D
[4]	0	0x002E
[5]	0	0x002F
[6]	0	0x0030
[7]	0	0x0031
[8]	0	0x0032
[9]	0	0x0033
[10]	0	0x0034
[11]	0	0x0035
[12]	0	0x0036
[13]	0	0x0037
[14]	0	0x0038
[15]	0	0x0039

PC= 0x000100 Cycle= 0.00

Line: 50 main
Line: 46 Move_Delay

☑ Errors ☑ Warnings ☑ Hints

Line	Mes...	Message Text	
0	1	mBPic.exe -DBG -pP16F887 -MSF -O11111114 -fo8 -N"C:\Program Files\Mikroelektronika\mikroBasic PRO for P...	
0	132	Compilation Started	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	133	Compiled Successfully	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	137	All files Compiled in 62 ms	
0	1139	Used RAM (bytes): 51 (14%) Free RAM (bytes): 301 (86%)	Used RAM (bytes): 51 (14%) Free RAM (bytes): 301 (86%)
0	1139	Used ROM (bytes): 509 (6%) Free ROM (bytes): 7683 (94%)	Used ROM (bytes): 509 (6%) Free ROM (bytes): 7683 (94%)
0	140	Project Linked Successfully	LCD.mbppi
0	138	Linked in 359 ms	
0	139	Project 'LCD.mbppi' completed: 624 ms	
0	103	Finished successfully: 28 Feb 2009, 13:12:56	Lcd.mbppi

71: 37 Insert Modified Compiled C:\...\Mikroelektronika\mikroBasic PRO for PIC\Examples\Development Systems\EasyPIC5\Lcd\Lcd.mbas

- The Code Editor features adjustable Syntax Highlighting, Code Folding, Code Assistant, Parameters Assistant, Spell Checker, Auto Correct for com mon typos and Code Templates (Auto Complete).
- The Code Explorer is at your disposal for easier project management.
- The Project Manager alows multiple project management
- General project settings can be made in the Project Settings window
- Library manager enables simple handling libraries being used in a project
- The Error Window displays all errors detected during compiling and linking.
- The source-level Software Simulator lets you debug executable logic step-by-step by watching the program flow.
- The New Project Wizard is a fast, reliable, and easy way to create a project
- Help files are syntax and context sensitive.

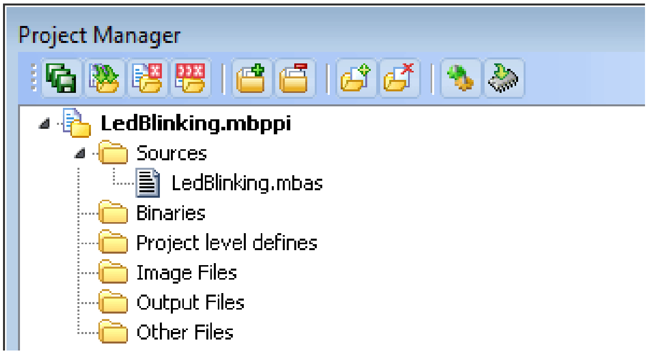
- Like in any modern Windows application, you may customize the layout of *mikroBacic for PIC* to suit your needs best.
- Spell checker underlines identifiers which are unknown to the project. In this way it helps the programmer to spot potential problems early, much before the project is compiled.
  Spell checker can be disabled by choosing the option in the Preferences dialog (F12).

CUSTOMIZING IDE LAYOUT

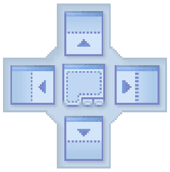
Docking Windows

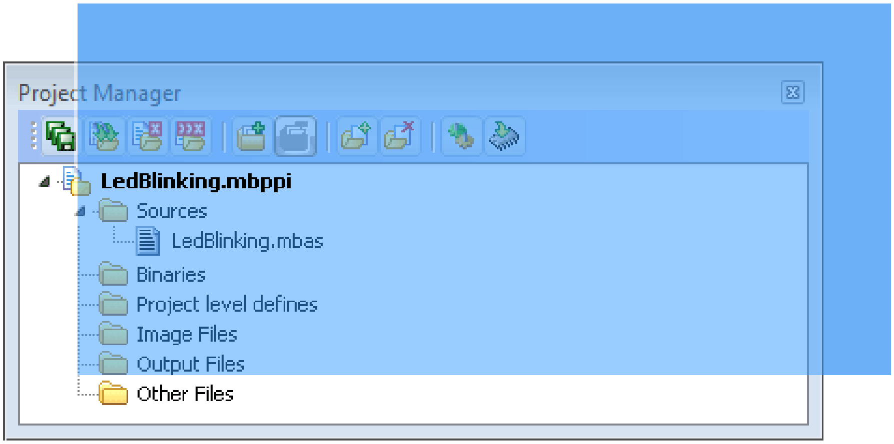
You can increase the viewing and editing space for code, depending on how you arrange the windows in the IDE.

Step 1: Click the window you want to dock, to give it focus.

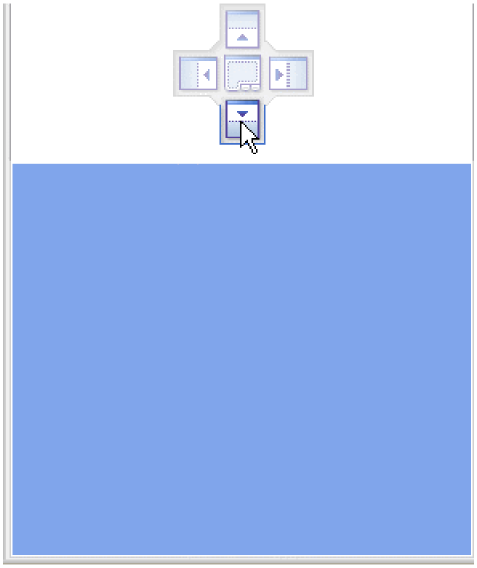


Step 2: Drag the tool window from its current location. A guide diamond appears. The four arrows of the diamond point towards the four edges of the IDE.





Step 3: Move the pointer over the corresponding portion of the guide diamond. An outline of the window appears in the designated area.



Step 4: To dock the window in the position indicated, release the mouse button.

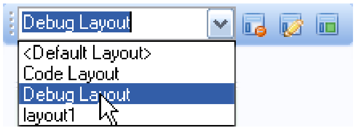
Tip: To move a dockable window without snapping it into place, press CTRL while dragging it.

Saving Layout

Once you have a window layout that you like, you can save the layout by typing the name for the layout and pressing the Save Layout Icon .

To set the layout select the desired layout from the layout drop-down list and click the Set Layout Icon .

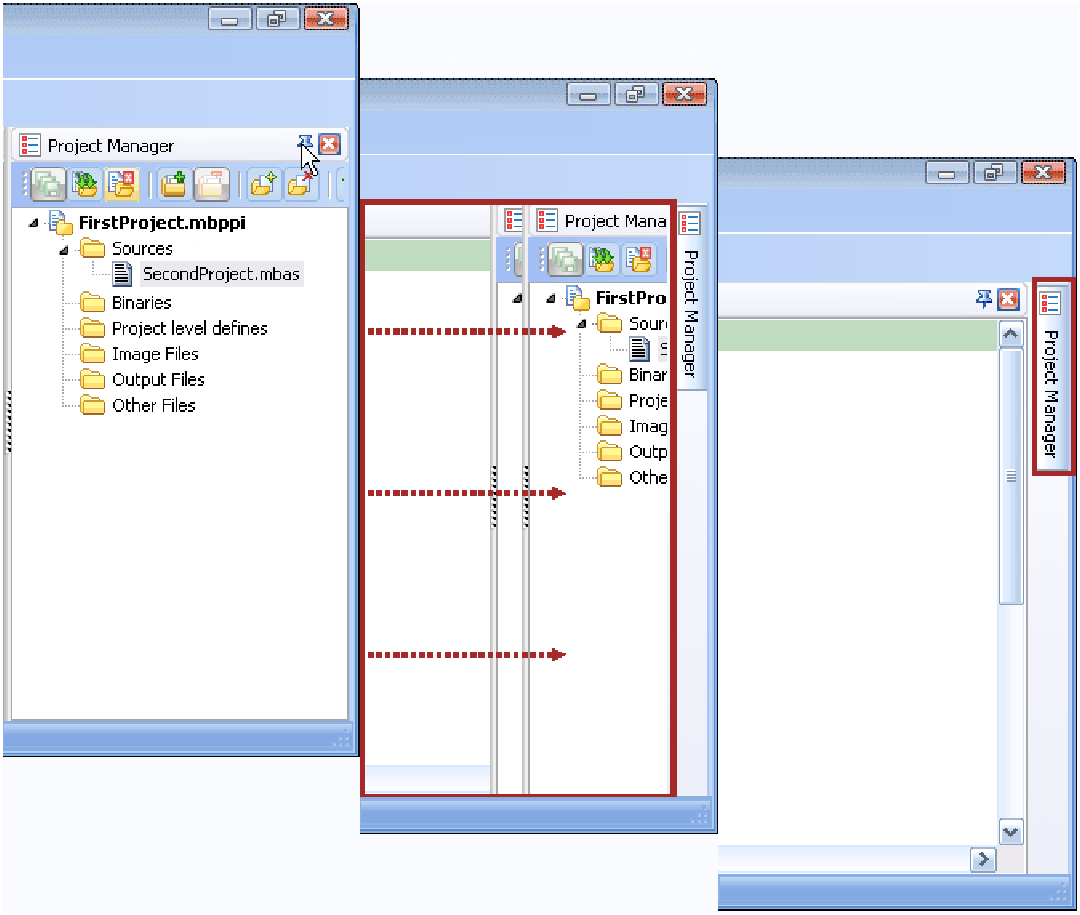
To remove the layout from the drop-down list, select the desired layout from the list and click the Delete Layout Icon .



Auto Hide

Auto Hide enables you to see more of your code at one time by minimizing tool windows along the edges of the IDE when not in use.

- Click the window you want to keep visible to give it focus.
- Click the Pushpin Icon on the title bar of the window.



When an auto-hidden window loses focus, it automatically slides back to its tab on the edge of the IDE. While a window is auto-hidden, its name and icon are visible on a tab at the edge of the IDE. To display an auto-hidden window, move your pointer over the tab. The window slides back into view and is ready for use.

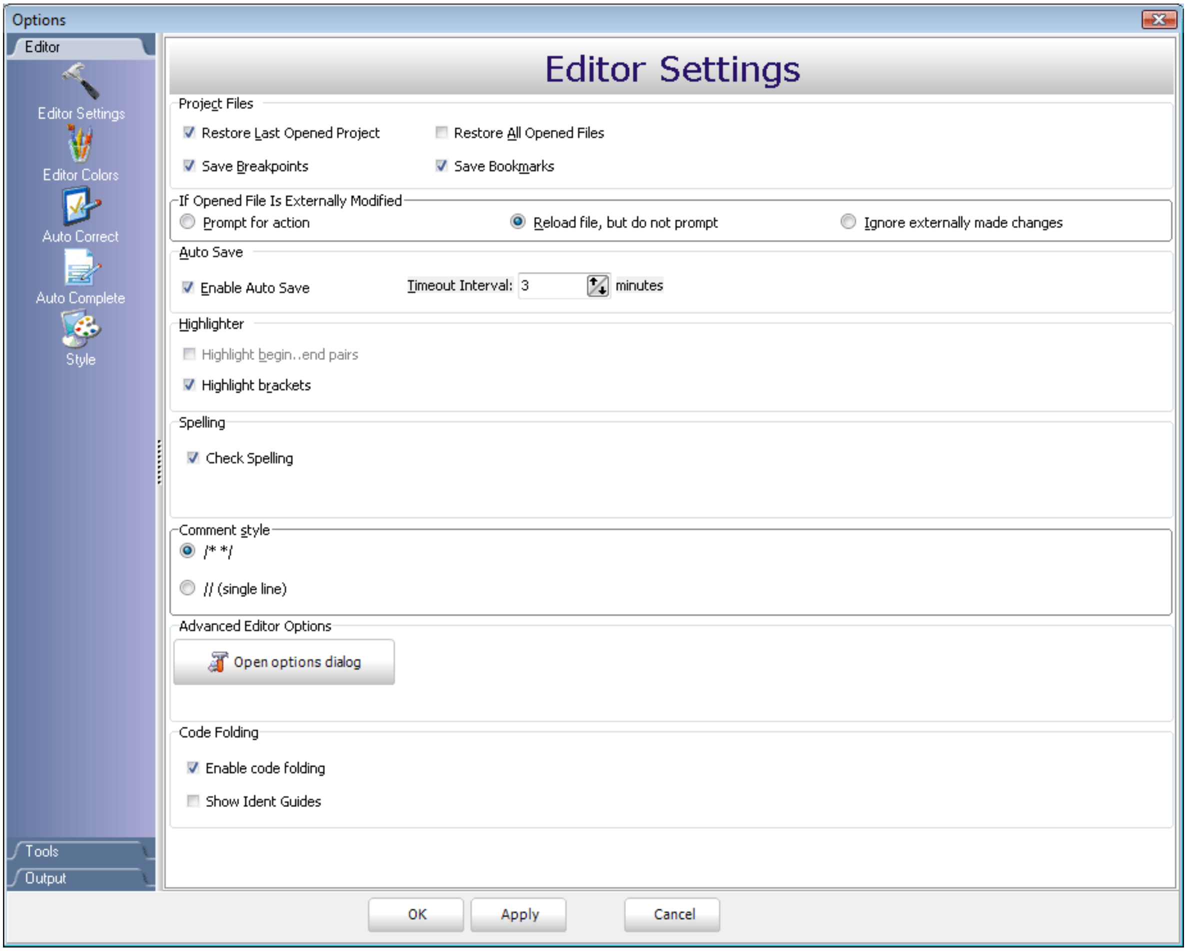
ADVANCED CODE EDITOR

The Code Editor is advanced text editor fashioned to satisfy needs of professionals. General code editing is the same as working with any standard text-editor, including familiar Copy, Paste and Undo actions, common for Windows environment.

Advanced Editor Features

- Adjustable Syntax Highlighting
- Code Assistant
- Code Folding
- Parameter Assistant
- Code Templates (Auto Complete)
- Auto Correct for common typos
- Spell Checker
- Bookmarks and Goto Line
- Comment / Uncomment

You can configure the Syntax Highlighting, Code Templates and Auto Correct from the Editor Settings dialog. To access the Settings, click **Tools › Options** from the drop-down menu, click the Show Options Icon or press F12 key.



Project Files

☑ Restore Last Opened Project ☐ Restore All Opened Files

☑ Save Breakpoints ☑ Save Bookmarks

If Opened File Is Externally Modified

○ Prompt for action ● Reload file, but do not prompt ○ Ignore externally made changes

Auto Save

☑ Enable Auto Save Timeout Interval: 3 minutes

Highlighter

☐ Highlight begin..end pairs

☑ Highlight brackets

Spelling

☑ Check Spelling

Comment style

● /* */

○ // (single line)

Advanced Editor Options

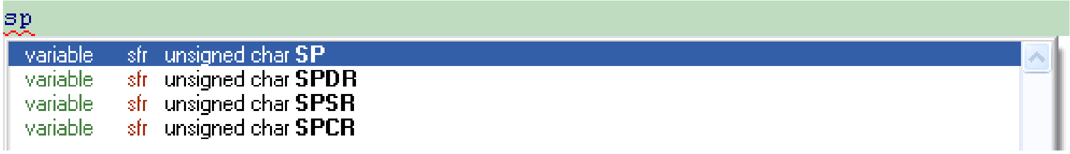
Code Folding

☑ Enable code folding

☐ Show Ident Guides

Code Assistant

If you type the first few letters of a word and then press **Ctrl**+**Space**, all valid identifiers matching the letters you have typed will be prompted in a floating panel (see the image below). Now you can keep typing to narrow the choice, or you can select one from the list using the keyboard arrows and **Enter**.

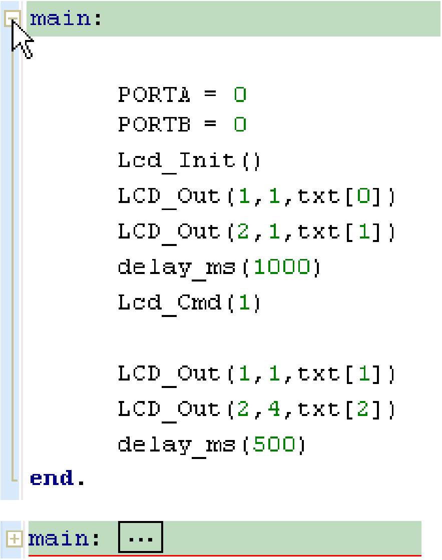


```
sp
variable   sfr  unsigned char SP
variable   sfr  unsigned char SPDR
variable   sfr  unsigned char SPSR
variable   sfr  unsigned char SPCR
```

Code Folding

Code folding is IDE feature which allows users to selectively hide and display sections of a source file. In this way it is easier to manage large regions of code within one window, while still viewing only those subsections of the code that are relevant during a particular editing session.

While typing, the code folding symbols (**-** and **+**) appear automatically. Use the folding symbols to hide/unhide the code subsections.



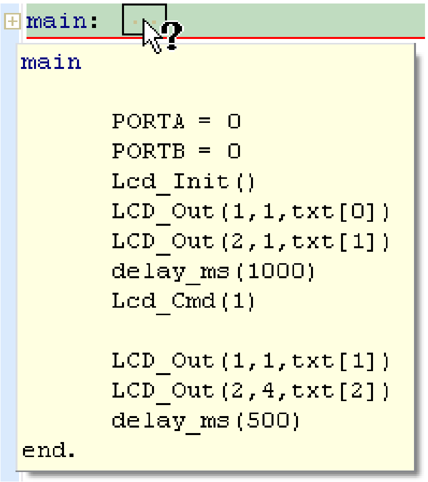
```
main:

      PORTA = 0
      PORTB = 0
      Lcd_Init()
      LCD_Out(1,1,txt[0])
      LCD_Out(2,1,txt[1])
      delay_ms(1000)
      Lcd_Cmd(1)

      LCD_Out(1,1,txt[1])
      LCD_Out(2,4,txt[2])
      delay_ms(500)
end.

main: ...
```

If you place a mouse cursor over the tooltip box, the collapsed text will be shown in a tooltip style box.



```
main:
main

       PORTA = 0
       PORTB = 0
       Lcd_Init()
       LCD_Out(1,1,txt[0])
       LCD_Out(2,1,txt[1])
       delay_ms(1000)
       Lcd_Cmd(1)

       LCD_Out(1,1,txt[1])
       LCD_Out(2,4,txt[2])
       delay_ms(500)
end.
```

Parameter Assistant

The Parameter Assistant will be automatically invoked when you open parenthesis "(" or press **Shift+Ctrl+Space**. If the name of a valid function precedes the parenthesis, then the expected parameters will be displayed in a floating panel. As you type the actual parameter, the next expected parameter will become bold.

```
channel : byte
ADC_Read(
```

Code Templates (Auto Complete)

You can insert the Code Template by typing the name of the template (for instance, `whiles`), then press **Ctrl+J** and the Code Editor will automatically generate a code.

You can add your own templates to the list. Select **Tools › Options** from the drop-down menu, or click the Show Options Icon and then select the Auto Complete Tab. Here you can enter the appropriate keyword, description and code of your template.

Autocomplete macros can retreive system and project information:

- `%DATE%` - current system date
- `%TIME%` - current system time
- `%DEVICE%` - device(MCU) name as specified in project settings
- `%DEVICE_CLOCK%` - clock as specified in project settings
- `%COMPILER%` - current compiler version

These macros can be used in template code, see template `ptemplate` provided with *mikroBasic PRO for PIC* installation.

Auto Correct

The Auto Correct feature corrects common typing mistakes. To access the list of recognized typos, select **Tools › Options** from the drop-down menu, or click the Show Options Icon and then select the Auto Correct Tab. You can also add your own preferences to the list.

Also, the Code Editor has a feature to comment or uncomment the selected code by simple click of a mouse, using the Comment Icon {..} and Uncomment Icon {..} from the Code Toolbar.

Spell Checker

The Spell Checker underlines unknown objects in the code, so they can be easily noticed and corrected before compiling your project.

Select **Tools › Options** from the drop-down menu, or click the Show Options Icon and then select the Spell Checker Tab.

Bookmarks

Bookmarks make navigation through a large code easier. To set a bookmark, use **Ctrl+Shift+*number*.** To jump to a bookmark, use **Ctrl+*number***.

Goto Line

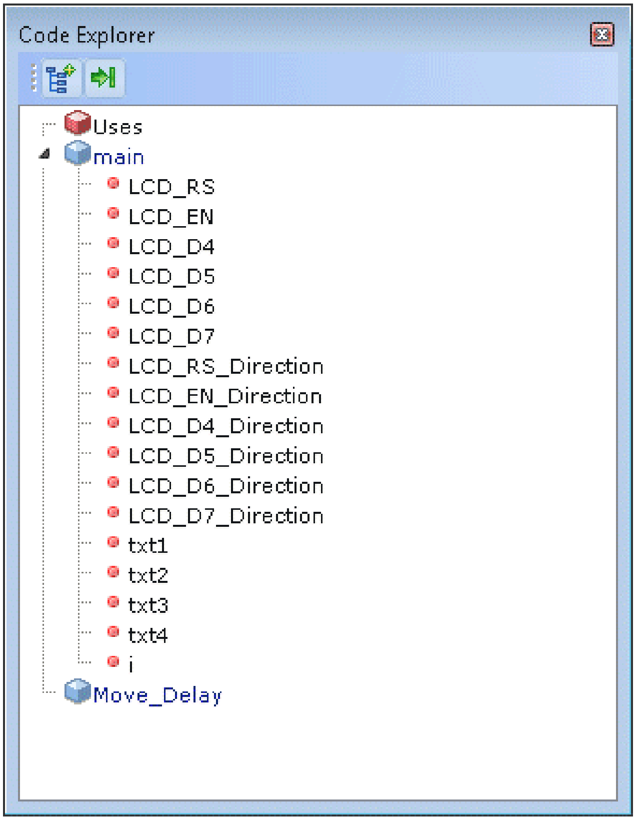
The Goto Line option makes navigation through a large code easier. Use the shortcut **Ctrl+G** to activate this option.

Comment / Uncomment

Also, the Code Editor has a feature to comment or uncomment the selected code by simple click of a mouse, using the Comment Icon {..} and Uncomment Icon {..} from the Code Toolbar.

CODE EXPLORER

The Code Explorer gives clear view of each item declared inside the source code. You can jump to a declaration of any item by right clicking it. Also, besides the list of defined and declared objects, code explorer displays message about first error and it's location in code.



Code Explorer

- Uses
- main
  - LCD_RS
  - LCD_EN
  - LCD_D4
  - LCD_D5
  - LCD_D6
  - LCD_D7
  - LCD_RS_Direction
  - LCD_EN_Direction
  - LCD_D4_Direction
  - LCD_D5_Direction
  - LCD_D6_Direction
  - LCD_D7_Direction
  - txt1
  - txt2
  - txt3
  - txt4
  - i
- Move_Delay

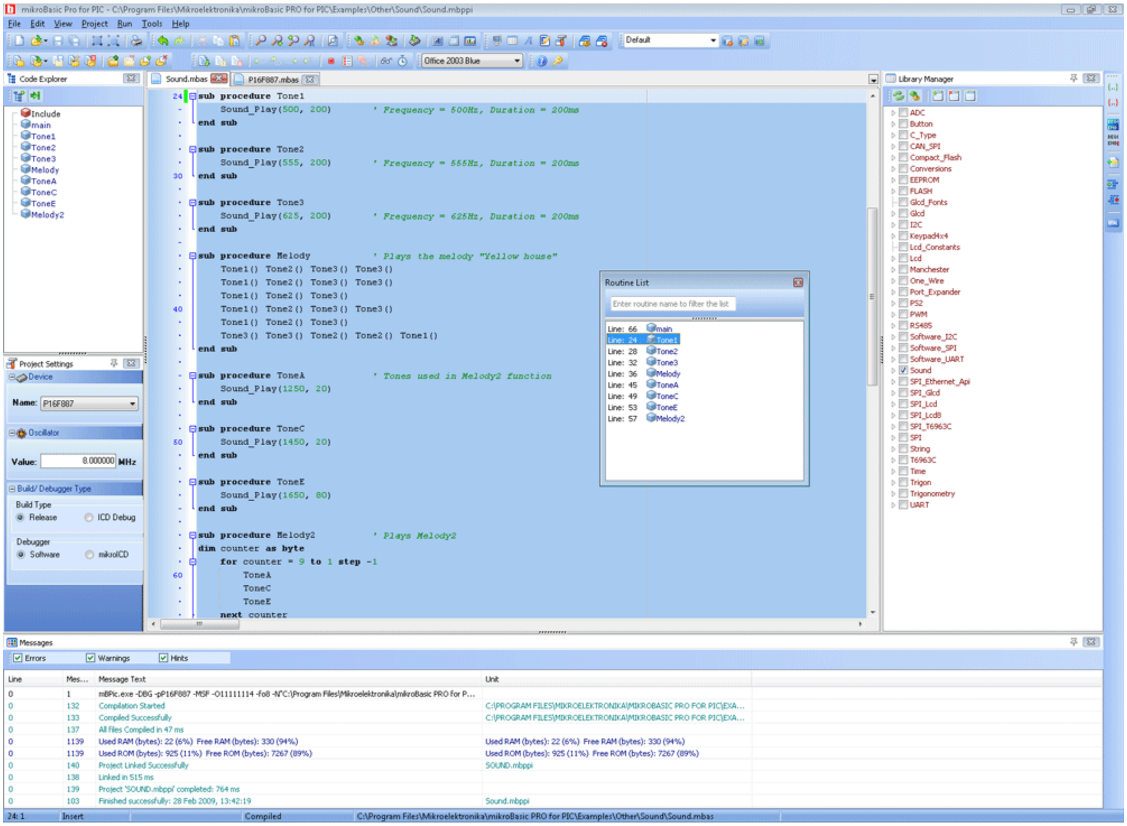
Following options are available in the Code Explorer:

Icon	Description
⊞	Expand/Collapse all nodes in tree.
➜	Locate declaration in code.

ROUTINE LIST

Routine list diplays list of routines, and enables filtering routines by name. Routine list window can be accessed by pressing **Ctrl+L**.

You can jump to a desired routine by double clicking on it.



```
sub procedure Tone1
    Sound_Play(500, 200)        ' Frequency = 500Hz, Duration = 200ms
end sub

sub procedure Tone2
    Sound_Play(555, 200)        ' Frequency = 555Hz, Duration = 200ms
end sub

sub procedure Tone3
    Sound_Play(625, 200)        ' Frequency = 625Hz, Duration = 200ms
end sub

sub procedure Melody            ' Plays the melody "Yellow house"
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3()
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3()
    Tone3() Tone3() Tone2() Tone2() Tone1()
end sub

sub procedure ToneA             ' Tones used in Melody2 function
    Sound_Play(1250, 20)
end sub

sub procedure ToneC
    Sound_Play(1450, 20)
end sub

sub procedure ToneE
    Sound_Play(1650, 80)
end sub

sub procedure Melody2           ' Plays Melody2
dim counter as byte
    for counter = 9 to 1 step -1
        ToneA
        ToneC
        ToneE
    next counter
```

Routine List

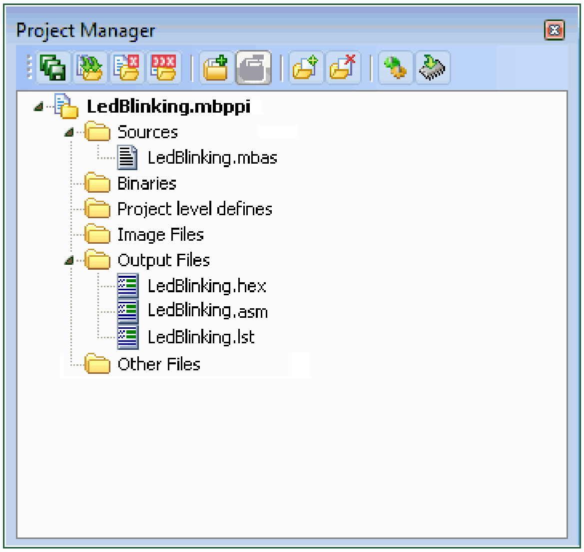
Enter routine name to filter the list

```
Line:  66   main
Line:  24   Tone1
Line:  28   Tone2
Line:  32   Tone3
Line:  36   Melody
Line:  45   ToneA
Line:  49   ToneC
Line:  53   ToneE
Line:  57   Melody2
```

Line	Mes...	Message Text	Unit
0	1	mBPic.exe -DBG -pP16F887 -MSF -O11111114 -fo8 -N"C:\Program Files\Mikroelektronika\mikroBasic PRO for P...	
0	132	Compilation Started	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	133	Compiled Successfully	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXA...
0	137	All files Compiled in 47 ms	
0	1139	Used RAM (bytes): 22 (6%) Free RAM (bytes): 330 (94%)	Used RAM (bytes): 22 (6%) Free RAM (bytes): 330 (94%)
0	1139	Used ROM (bytes): 925 (11%) Free ROM (bytes): 7267 (89%)	Used ROM (bytes): 925 (11%) Free ROM (bytes): 7267 (89%)
0	140	Project Linked Successfully	SOUND.mbppi
0	138	Linked in 515 ms	
0	139	Project 'SOUND.mbppi' completed: 764 ms	
0	103	Finished successfully: 28 Feb 2009, 13:42:19	Sound.mbppi

PROJECT MANAGER

Project Manager is IDE feature which allows users to manage multiple projects. Several projects which together make project group may be open at the same time. Only one of them may be active at the moment.
Setting project in **active** mode is performed by **double click** on the desired project in the Project Manager.



Following options are available in the Project Manager:

Icon	Description
	Save project Group.
	Open project group.
	Close the active project.
	Close project group.
	Add project to the project group.
	Remove project from the project group.
	Add file to the active project.
	Remove selected file from the project.
	Build the active project.
	Run mikroElektronika's Flash programmer.

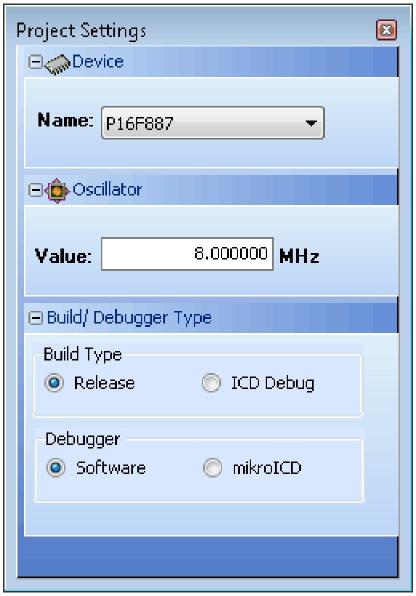
For details about adding and removing files from project see Add/Remove Files from Project.

Related topics: Project Settings, Project Menu Options, File Menu Options, Project Toolbar, Build Toolbar, Add/Remove Files from Project

PROJECT SETTINGS WINDOW

Following options are available in the Project Settings Window:

- Device - select the appropriate device from the device drop-down list.
- Oscillator - enter the oscillator frequency value.
- Build/Debugger Type - choose debugger type.



Name: P16F887

Value: 8.000000 **MHz**

● Release ○ ICD Debug

● Software ○ mikroICD

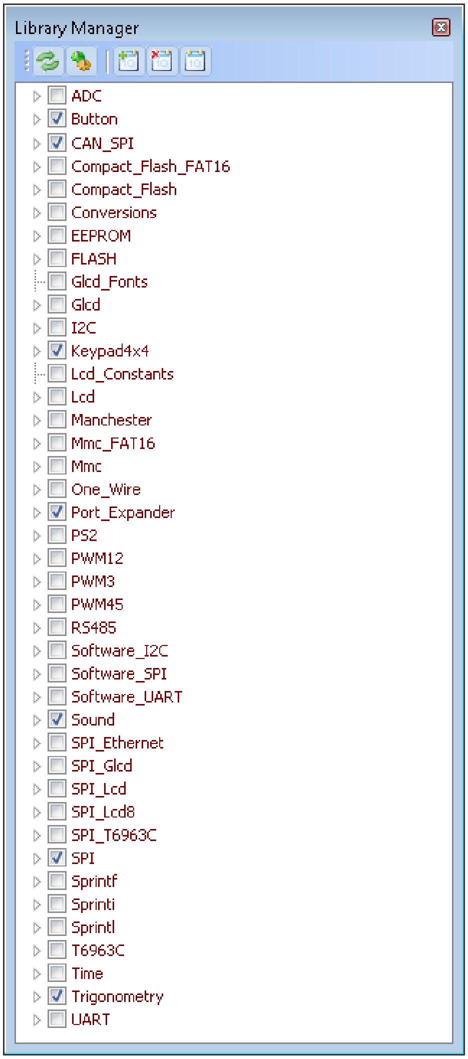
Related topics: Memory Model, Project Manager

LIBRARY MANAGER

Library Manager enables simple handling libraries being used in a project. Library Manager window lists all libraries (extencion `.mcl`) which are instantly stored in the compiler *Uses* folder. The desirable library is added to the project by selecting check box next to the library name.

In order to have all library functions accessible, simply press the button **Check All** and all libraries will be selected. In case none library is needed in a project, press the button **Clear All** and all libraries will be cleared from the project.

Only the selected libraries will be linked.



- ☐ ADC
- ☑ Button
- ☑ CAN_SPI
- ☐ Compact_Flash_FAT16
- ☐ Compact_Flash
- ☐ Conversions
- ☐ EEPROM
- ☐ FLASH
- ☐ Glcd_Fonts
- ☐ Glcd
- ☐ I2C
- ☑ Keypad4x4
- ☐ Lcd_Constants
- ☐ Lcd
- ☐ Manchester
- ☐ Mmc_FAT16
- ☐ Mmc
- ☐ One_Wire
- ☑ Port_Expander
- ☐ PS2
- ☐ PWM12
- ☐ PWM3
- ☐ PWM45
- ☐ RS485
- ☐ Software_I2C
- ☐ Software_SPI
- ☐ Software_UART
- ☑ Sound
- ☐ SPI_Ethernet
- ☐ SPI_Glcd
- ☐ SPI_Lcd
- ☐ SPI_Lcd8
- ☐ SPI_T6963C
- ☑ SPI
- ☐ Sprintf
- ☐ Sprinti
- ☐ Sprintl
- ☐ T6963C
- ☐ Time
- ☑ Trigonometry
- ☐ UART

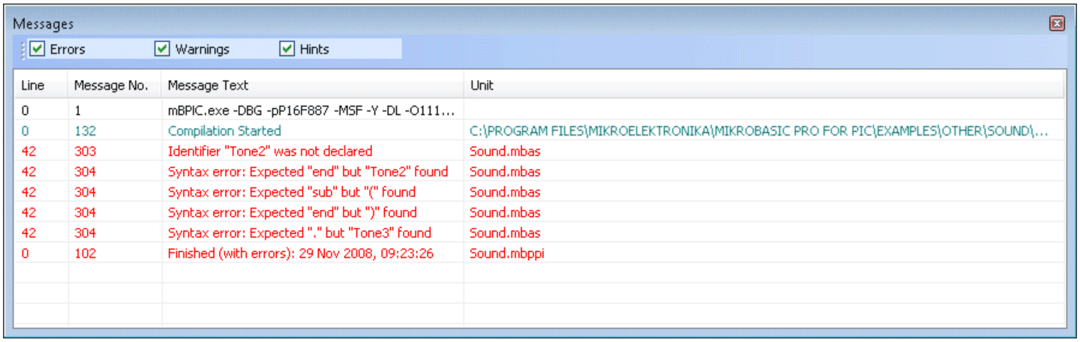
Icon	Description
	Refresh Library by scanning files in "Uses" folder.Useful when new libraries are added by copying files to "Uses" folder.
	Rebuild all available libraries. Useful when library sources are available and need refreshing.
	Include all available libraries in current project.
	No libraries from the list will be included in current project.
	Restore library to the state just before last project saving.

Related topics: *mikroBasic PRO for PIC* Libraries, Creating New Library

ERROR WINDOW

In case that errors were encountered during compiling, the compiler will report them and won't generate a hex file. The Error Window will be prompted at the bottom of the main window by default.

The Error Window is located under message tab, and displays location and type of errors the compiler has encountered. The compiler also reports warnings, but these do not affect the output; only errors can interefere with the generation of hex.



Line	Message No.	Message Text	Unit
0	1	mBPIC.exe -DBG -pP16F887 -MSF -Y -DL -O111...	
0	132	Compilation Started	C:\PROGRAM FILES\MIKROELEKTRONIKA\MIKROBASIC PRO FOR PIC\EXAMPLES\OTHER\SOUND\...
42	303	Identifier "Tone2" was not declared	Sound.mbas
42	304	Syntax error: Expected "end" but "Tone2" found	Sound.mbas
42	304	Syntax error: Expected "sub" but "(" found	Sound.mbas
42	304	Syntax error: Expected "end" but ")" found	Sound.mbas
42	304	Syntax error: Expected "." but "Tone3" found	Sound.mbas
0	102	Finished (with errors): 29 Nov 2008, 09:23:26	Sound.mbppi

Double click the message line in the Error Window to highlight the line where the error was encountered.

Related topics: Error Messages

STATISTICS

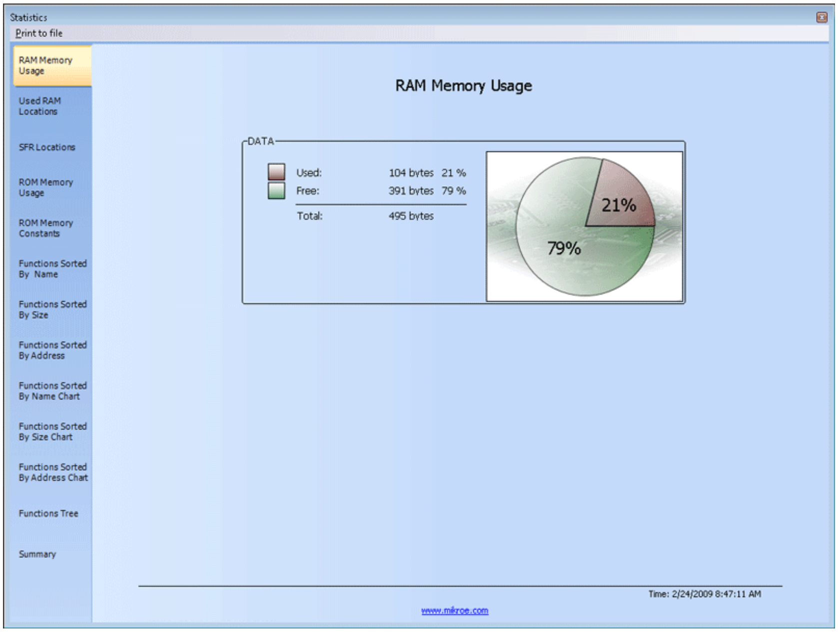
After successful compilation, you can review statistics of your code. Click the Statistics Icon .

Memory Usage Windows

Provides overview of RAM and ROM usage in the form of histogram.

RAM Memory Usage

Displays RAM memory usage in a pie-like form.



RAM Memory Usage

DATA

🟥	Used:	104 bytes	21 %
🟩	Free:	391 bytes	79 %
	Total:	495 bytes	

Time: 2/24/2009 8:47:11 AM

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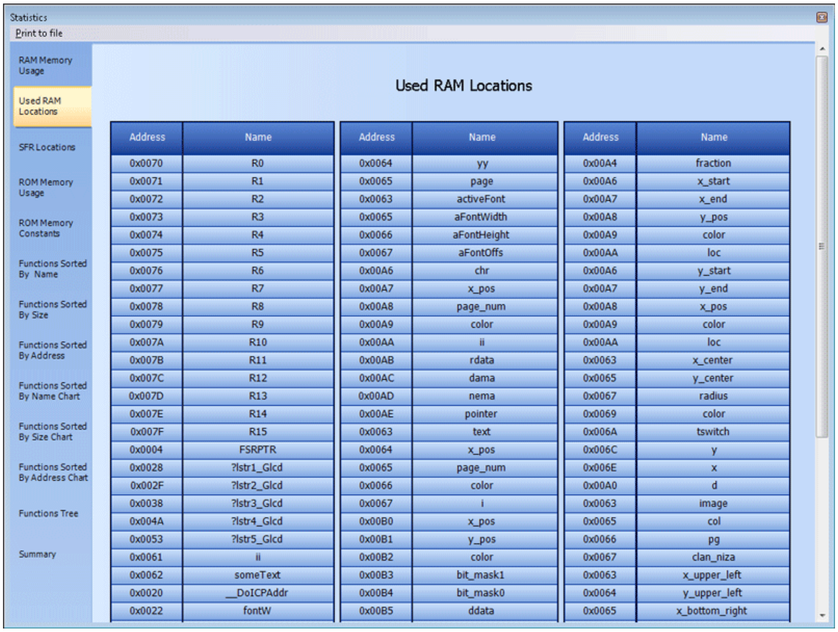
Used RAM Locations

Displays used RAM memory locations and their names.

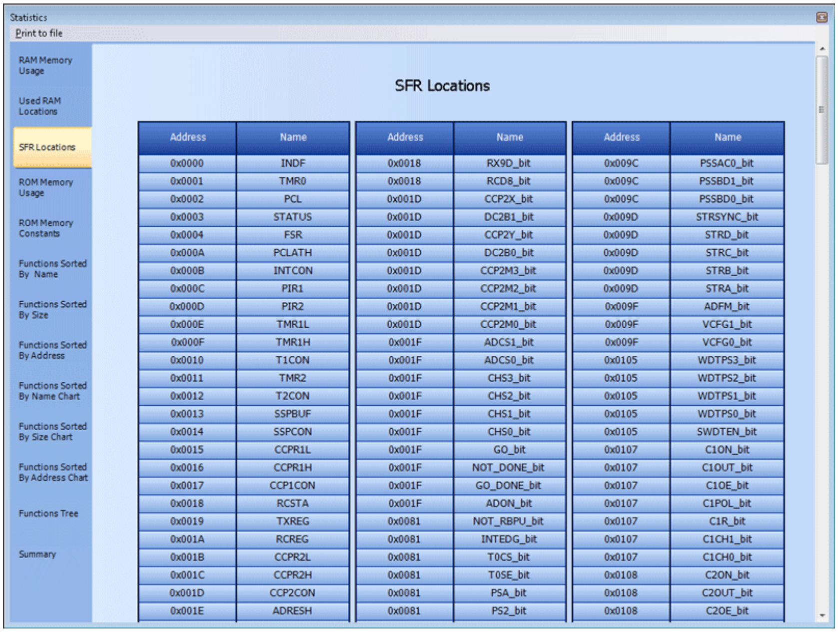


Used RAM Locations

Address	Name	Address	Name	Address	Name
0x0070	R0	0x0064	yy	0x00A4	fraction
0x0071	R1	0x0065	page	0x00A6	x_start
0x0072	R2	0x0063	activeFont	0x00A7	x_end
0x0073	R3	0x0065	aFontWidth	0x00A8	y_pos
0x0074	R4	0x0066	aFontHeight	0x00A9	color
0x0075	R5	0x0067	aFontOffs	0x00AA	loc
0x0076	R6	0x00A6	chr	0x00A6	y_start
0x0077	R7	0x00A7	x_pos	0x00A7	y_end
0x0078	R8	0x00A8	page_num	0x00A8	x_pos
0x0079	R9	0x00A9	color	0x00A9	color
0x007A	R10	0x00AA	ii	0x00AA	loc
0x007B	R11	0x00AB	rdata	0x0063	x_center
0x007C	R12	0x00AC	dama	0x0065	y_center
0x007D	R13	0x00AD	nema	0x0067	radius
0x007E	R14	0x00AE	pointer	0x0069	color
0x007F	R15	0x0063	text	0x006A	tswitch
0x0004	FSRPTR	0x0064	x_pos	0x006C	y
0x0028	?lstr1_Glcd	0x0065	page_num	0x006E	x
0x002F	?lstr2_Glcd	0x0066	color	0x00A0	d
0x0038	?lstr3_Glcd	0x0067	i	0x0063	image
0x004A	?lstr4_Glcd	0x00B0	x_pos	0x0065	col
0x0053	?lstr5_Glcd	0x00B1	y_pos	0x0066	pg
0x0061	ii	0x00B2	color	0x0067	clan_niza
0x0062	someText	0x00B3	bit_mask1	0x0063	x_upper_left
0x0020	__DoICPAddr	0x00B4	bit_mask0	0x0064	y_upper_left
0x0022	fontW	0x00B5	ddata	0x0065	x_bottom_right

SFR Locations

Displays list of used SFR locations.

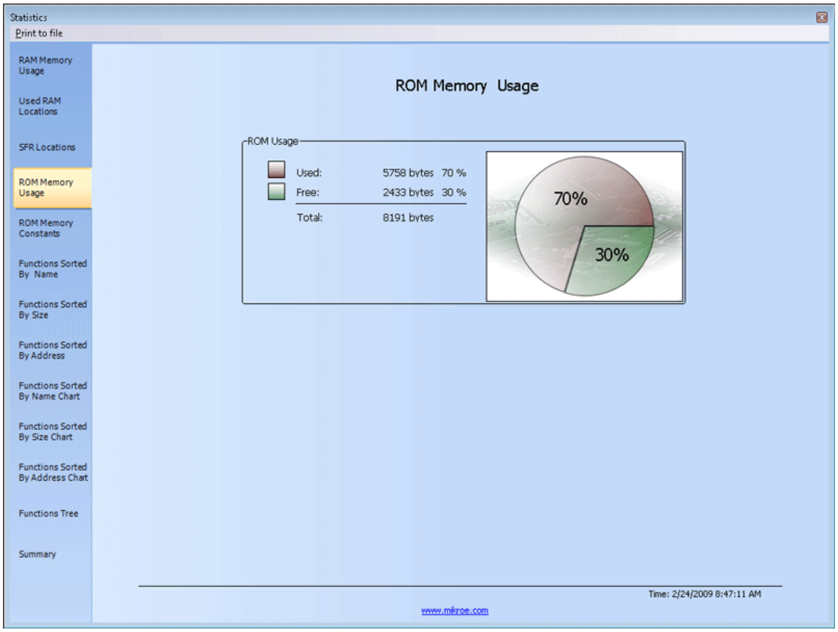


SFR Locations

Address	Name	Address	Name	Address	Name
0x0000	INDF	0x0018	RX9D_bit	0x009C	PSSAC0_bit
0x0001	TMR0	0x0018	RCD8_bit	0x009C	PSSBD1_bit
0x0002	PCL	0x001D	CCP2X_bit	0x009C	PSSBD0_bit
0x0003	STATUS	0x001D	DC2B1_bit	0x009D	STRSYNC_bit
0x0004	FSR	0x001D	CCP2Y_bit	0x009D	STRD_bit
0x000A	PCLATH	0x001D	DC2B0_bit	0x009D	STRC_bit
0x000B	INTCON	0x001D	CCP2M3_bit	0x009D	STRB_bit
0x000C	PIR1	0x001D	CCP2M2_bit	0x009D	STRA_bit
0x000D	PIR2	0x001D	CCP2M1_bit	0x009F	ADFM_bit
0x000E	TMR1L	0x001D	CCP2M0_bit	0x009F	VCFG1_bit
0x000F	TMR1H	0x001F	ADCS1_bit	0x009F	VCFG0_bit
0x0010	T1CON	0x001F	ADCS0_bit	0x0105	WDTPS3_bit
0x0011	TMR2	0x001F	CHS3_bit	0x0105	WDTPS2_bit
0x0012	T2CON	0x001F	CHS2_bit	0x0105	WDTPS1_bit
0x0013	SSPBUF	0x001F	CHS1_bit	0x0105	WDTPS0_bit
0x0014	SSPCON	0x001F	CHS0_bit	0x0105	SWDTEN_bit
0x0015	CCPR1L	0x001F	GO_bit	0x0107	C1ON_bit
0x0016	CCPR1H	0x001F	NOT_DONE_bit	0x0107	C1OUT_bit
0x0017	CCP1CON	0x001F	GO_DONE_bit	0x0107	C1OE_bit
0x0018	RCSTA	0x001F	ADON_bit	0x0107	C1POL_bit
0x0019	TXREG	0x0081	NOT_RBPU_bit	0x0107	C1R_bit
0x001A	RCREG	0x0081	INTEDG_bit	0x0107	C1CH1_bit
0x001B	CCPR2L	0x0081	T0CS_bit	0x0107	C1CH0_bit
0x001C	CCPR2H	0x0081	T0SE_bit	0x0108	C2ON_bit
0x001D	CCP2CON	0x0081	PSA_bit	0x0108	C2OUT_bit
0x001E	ADRESH	0x0081	PS2_bit	0x0108	C2OE_bit

ROM Memory Usage

Displays ROM memory space usage in a pie-like form.



ROM Memory Usage

ROM Usage

Used:	5758 bytes	70 %
Free:	2433 bytes	30 %
Total:	8191 bytes	

Time: 2/24/2009 8:47:11 AM

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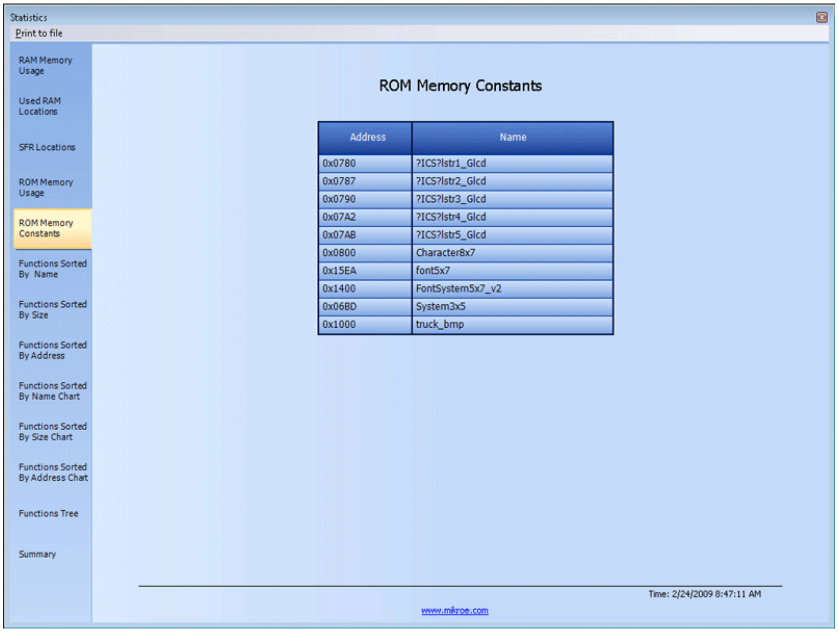
ROM Memory Constants

Displays ROM memory constants and their addresses.



ROM Memory Constants

Address	Name
0x0780	?ICS?lstr1_Glcd
0x0787	?ICS?lstr2_Glcd
0x0790	?ICS?lstr3_Glcd
0x07A2	?ICS?lstr4_Glcd
0x07AB	?ICS?lstr5_Glcd
0x0800	Character8x7
0x15EA	font5x7
0x1400	FontSystem5x7_v2
0x06BD	System3x5
0x1000	truck_bmp

Time: 2/24/2009 8:47:11 AM

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Functions Sorted By Name

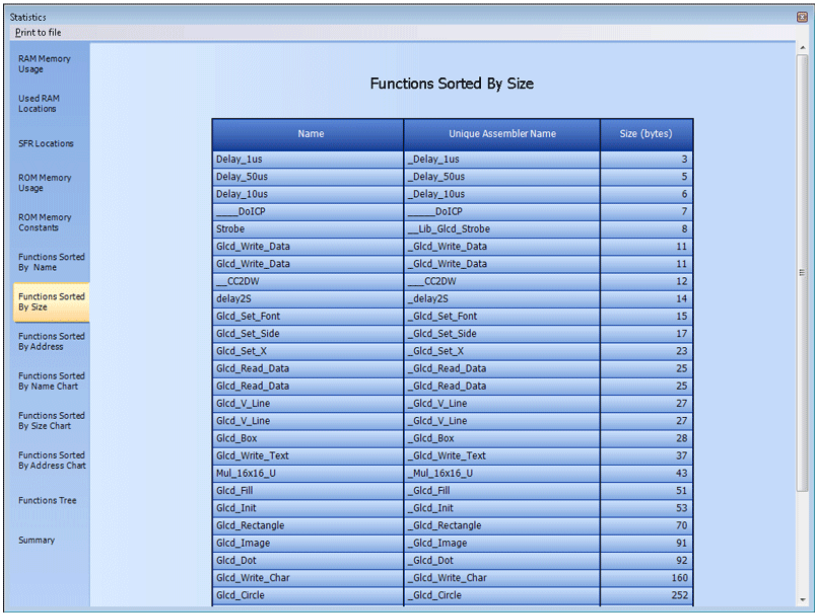
Sorts and displays functions by their addresses, symbolic names, and unique assembler names.

Functions Sorted By Name

Address	Name	Unique Assembler Name
0x006F	____DoICP	_____DoICP
0x01D6	__CC2DW	___CC2DW
0x0005	Delay_10us	_Delay_10us
0x0118	Delay_1us	_Delay_1us
0x0013	Delay_50us	_Delay_50us
0x0540	delay2S	_delay2S
0x0524	Glcd_Box	_Glcd_Box
0x0283	Glcd_Circle	_Glcd_Circle
0x00A1	Glcd_Dot	_Glcd_Dot
0x055D	Glcd_Fill	_Glcd_Fill
0x01BB	Glcd_H_Line	_Glcd_H_Line
0x0228	Glcd_Image	_Glcd_Image
0x04B1	Glcd_Init	_Glcd_Init
0x037F	Glcd_Line	_Glcd_Line
0x0034	Glcd_Read_Data	_Glcd_Read_Data
0x01E2	Glcd_Rectangle	_Glcd_Rectangle
0x054E	Glcd_Set_Font	_Glcd_Set_Font
0x0018	Glcd_Set_Page	_Glcd_Set_Page
0x0023	Glcd_Set_Side	_Glcd_Set_Side
0x004D	Glcd_Set_X	_Glcd_Set_X
0x00FD	Glcd_V_Line	_Glcd_V_Line
0x011B	Glcd_Write_Char	_Glcd_Write_Char
0x0064	Glcd_Write_Data	_Glcd_Write_Data
0x04E6	Glcd_Write_Text	_Glcd_Write_Text
0x0590	main	_main
0x0076	Mul_16x16_U	_Mul_16x16_U

Functions Sorted By Size

Sorts and displays functions by their size, in the ascending order.



Functions Sorted By Size

Name	Unique Assembler Name	Size (bytes)
Delay_1us	_Delay_1us	3
Delay_50us	_Delay_50us	5
Delay_10us	_Delay_10us	6
____DoICP	_____DoICP	7
Strobe	__Lib_Glcd_Strobe	8
Glcd_Write_Data	_Glcd_Write_Data	11
Glcd_Write_Data	_Glcd_Write_Data	11
__CC2DW	___CC2DW	12
delay2S	_delay2S	14
Glcd_Set_Font	_Glcd_Set_Font	15
Glcd_Set_Side	_Glcd_Set_Side	17
Glcd_Set_X	_Glcd_Set_X	23
Glcd_Read_Data	_Glcd_Read_Data	25
Glcd_Read_Data	_Glcd_Read_Data	25
Glcd_V_Line	_Glcd_V_Line	27
Glcd_V_Line	_Glcd_V_Line	27
Glcd_Box	_Glcd_Box	28
Glcd_Write_Text	_Glcd_Write_Text	37
Mul_16x16_U	_Mul_16x16_U	43
Glcd_Fill	_Glcd_Fill	51
Glcd_Init	_Glcd_Init	53
Glcd_Rectangle	_Glcd_Rectangle	70
Glcd_Image	_Glcd_Image	91
Glcd_Dot	_Glcd_Dot	92
Glcd_Write_Char	_Glcd_Write_Char	160
Glcd_Circle	_Glcd_Circle	252

Functions Sorted By Addresses

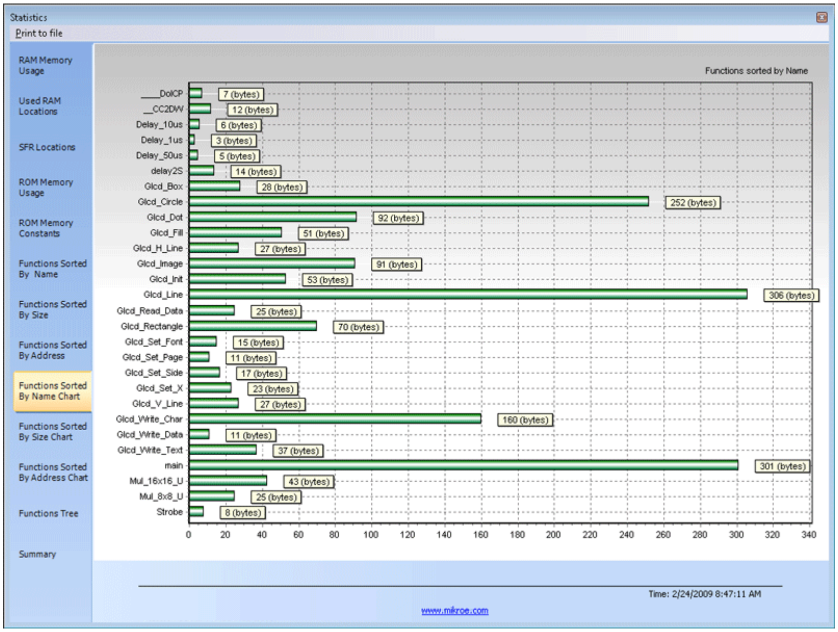
Sorts and displays functions by their size, in the ascending order.

Functions Sorted By Address

Address	Name	Unique Assembler Name
0x0005	Delay_10us	_Delay_10us
0x000B	Strobe	__Lib_Glcd_Strobe
0x0013	Delay_50us	_Delay_50us
0x0018	Glcd_Set_Page	_Glcd_Set_Page
0x0023	Glcd_Set_Side	_Glcd_Set_Side
0x0034	Glcd_Read_Data	_Glcd_Read_Data
0x004D	Glcd_Set_X	_Glcd_Set_X
0x0064	Glcd_Write_Data	_Glcd_Write_Data
0x006F	____DoICP	____DoICP
0x0076	Mul_16x16_U	_Mul_16x16_U
0x00A1	Glcd_Dot	_Glcd_Dot
0x00FD	Glcd_V_Line	_Glcd_V_Line
0x0118	Delay_1us	_Delay_1us
0x011B	Glcd_Write_Char	_Glcd_Write_Char
0x01BB	Glcd_H_Line	_Glcd_H_Line
0x01D6	__CC2DW	__CC2DW
0x01E2	Glcd_Rectangle	_Glcd_Rectangle
0x0228	Glcd_Image	_Glcd_Image
0x0283	Glcd_Circle	_Glcd_Circle
0x037F	Glcd_Line	_Glcd_Line
0x04B1	Glcd_Init	_Glcd_Init
0x04E6	Glcd_Write_Text	_Glcd_Write_Text
0x050B	Mul_8x8_U	_Mul_8x8_U
0x0524	Glcd_Box	_Glcd_Box
0x0540	delay2S	_delay2S
0x054E	Glcd_Set_Font	_Glcd_Set_Font

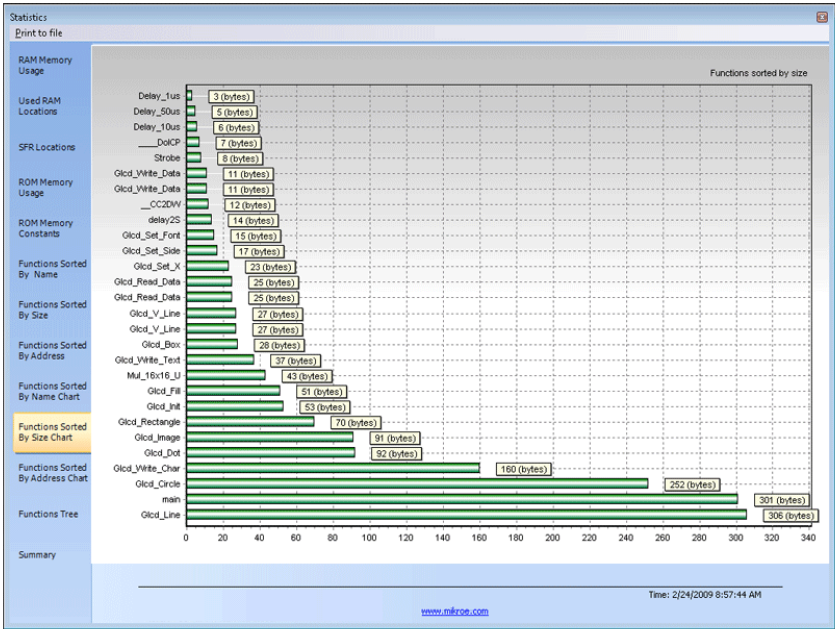
Functions Sorted By Name Chart

Sorts and displays functions by their names in a chart-like form.



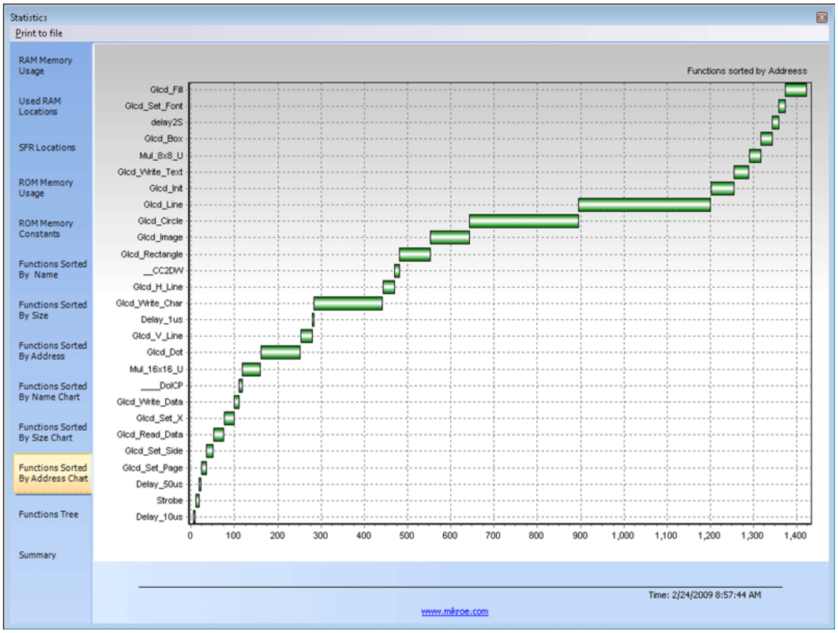
Functions Sorted By Size Chart

Sorts and displays functions by their sizes in a chart-like form



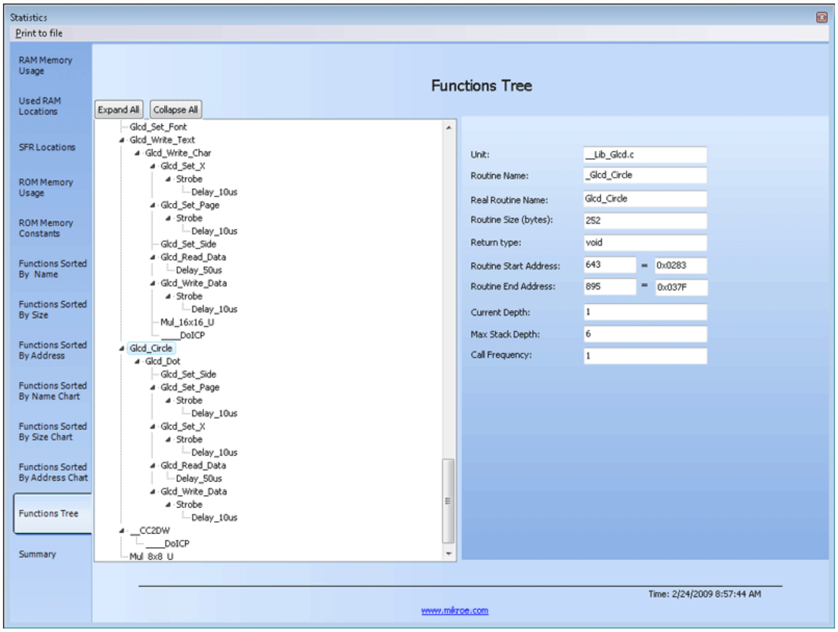
Functions Sorted By Addresses Chart

Sorts and displays functions by their addresses in a chart-like form.



Function Tree

Displays Function Tree with the relevant data for each function.



```
Glcd_Set_Font
Glcd_Write_Text
    Glcd_Write_Char
        Glcd_Set_X
            Strobe
                Delay_10us
        Glcd_Set_Page
            Strobe
                Delay_10us
        Glcd_Set_Side
        Glcd_Read_Data
            Delay_50us
        Glcd_Write_Data
            Strobe
                Delay_10us
        Mul_16x16_U
        ____DoICP
Glcd_Circle
    Glcd_Dot
        Glcd_Set_Side
        Glcd_Set_Page
            Strobe
                Delay_10us
        Glcd_Set_X
            Strobe
                Delay_10us
        Glcd_Read_Data
            Delay_50us
        Glcd_Write_Data
            Strobe
                Delay_10us
__CC2DW
    ____DoICP
Mul_8x8_U
```

Unit: __Lib_Glcd.c
Routine Name: _Glcd_Circle
Real Routine Name: Glcd_Circle
Routine Size (bytes): 252
Return type: void
Routine Start Address: 643 = 0x0283
Routine End Address: 895 = 0x037F
Current Depth: 1
Max Stack Depth: 6
Call Frequency: 1

Time: 2/24/2009 8:57:44 AM

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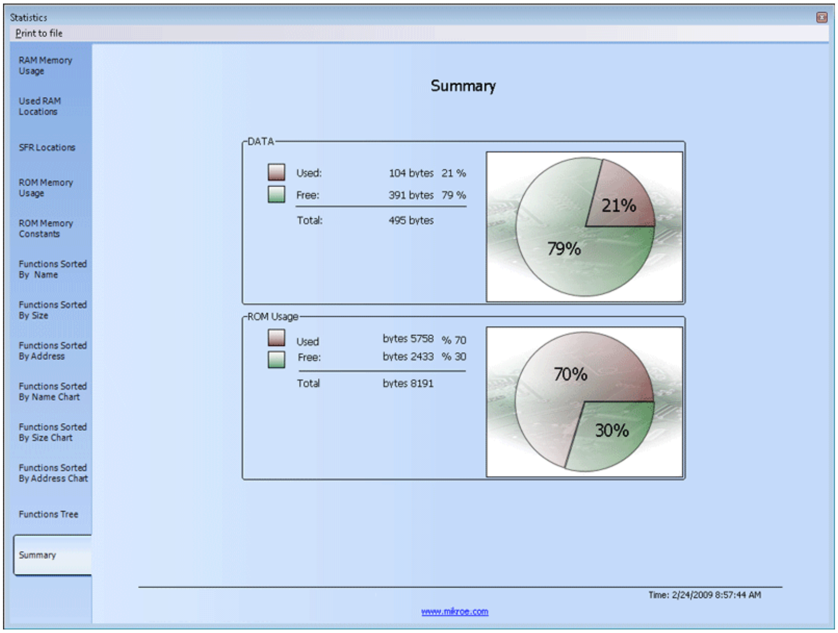
Memory Summary

Displays summary of RAM and ROM memory in a pie-like form.



DATA

🟥	Used:	104 bytes	21 %
🟩	Free:	391 bytes	79 %
	Total:	495 bytes	

ROM Usage

🟥	Used	bytes 5758	% 70
🟩	Free:	bytes 2433	% 30
	Total	bytes 8191	

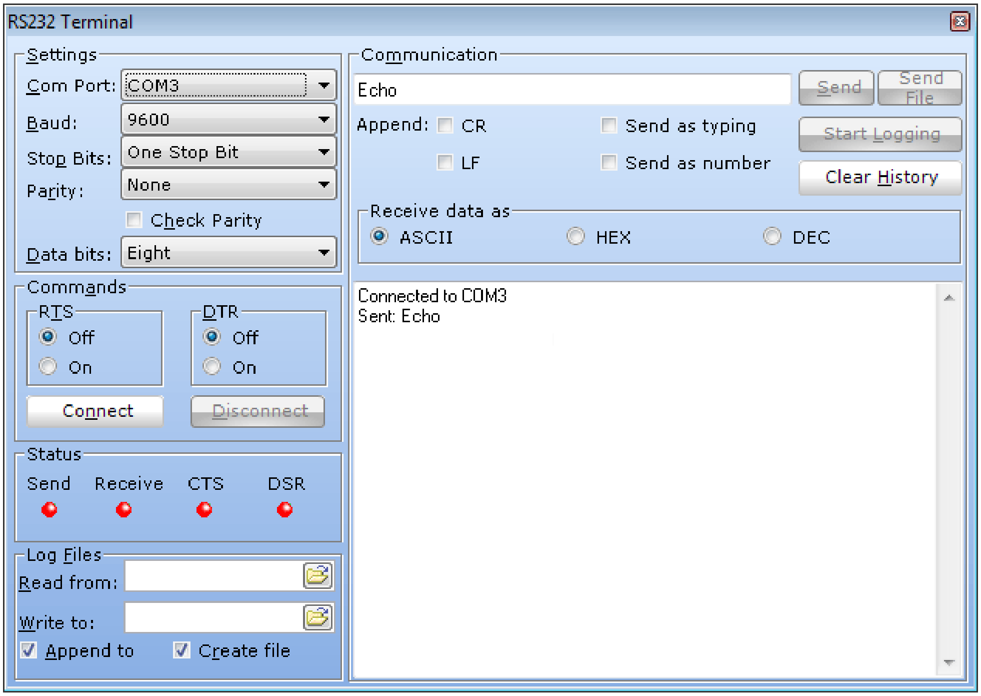
Time: 2/24/2009 8:57:44 AM

www.mikroe.com

INTEGRATED TOOLS

USART Terminal

The *mikroBasic PRO for PIC* includes the USART communication terminal for RS232 communication. You can launch it from the drop-down menu **Tools › USART Terminal** or by clicking the USART Terminal Icon from Tools toolbar.



RS232 Terminal

Settings
Com Port: COM3
Baud: 9600
Stop Bits: One Stop Bit
Parity: None
☐ Check Parity
Data bits: Eight

Commands
RTS: ● Off ○ On
DTR: ● Off ○ On

Communication
Echo
Append: ☐ CR ☐ LF
☐ Send as typing
☐ Send as number
Receive data as: ● ASCII ○ HEX ○ DEC

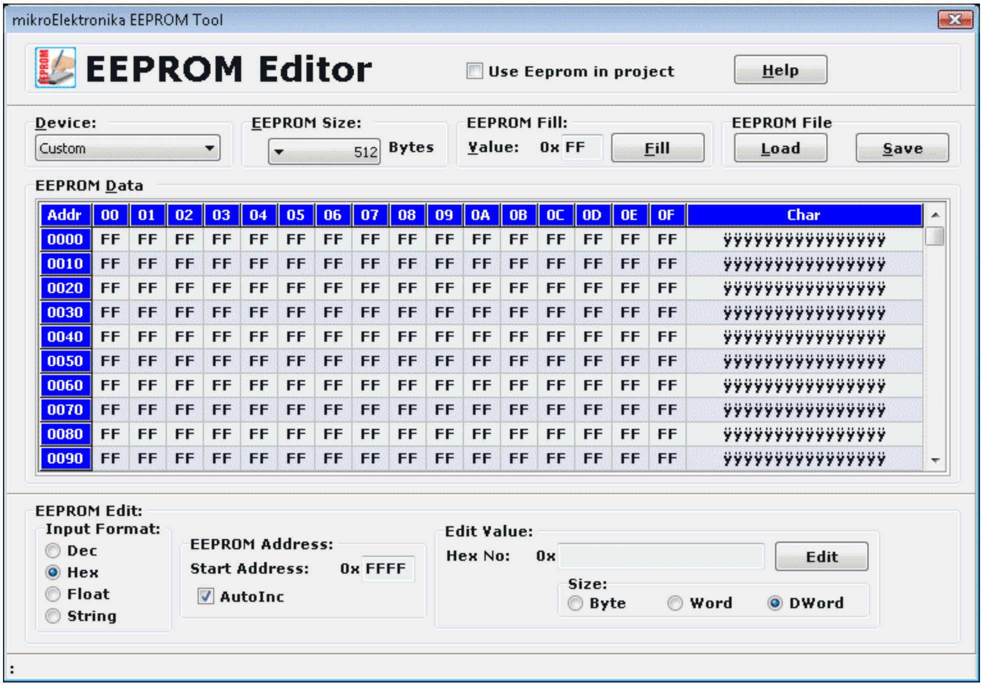
Log Files
Read from:
Write to:
☑ Append to ☑ Create file

```
Connected to COM3
Sent: Echo
```

EEPROM Editor

The EEPROM Editor is used for manipulating MCU's EEPROM memory. You can launch it from the drop-down menu **Tools › EEPROM Editor**. When *Use this EEPROM definition* is checked compiler will generate Intel hex file `project_name.ihex` that contains data from EEPROM editor.

When you run mikroElektronika programmer software from mikroBasic PRO for PIC IDE - `project_name.hex` file will be loaded automatically while `ihex` file must be loaded manually.



☐ Use Eeprom in project

Device: Custom

EEPROM Size: 512 Bytes

EEPROM Fill: Value: 0x FF

Addr	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	Char
0000	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0010	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0020	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0030	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0040	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0050	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0060	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0070	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0080	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
0090	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ

Input Format:
○ Dec
● Hex
○ Float
○ String

Start Address: 0x FFFF

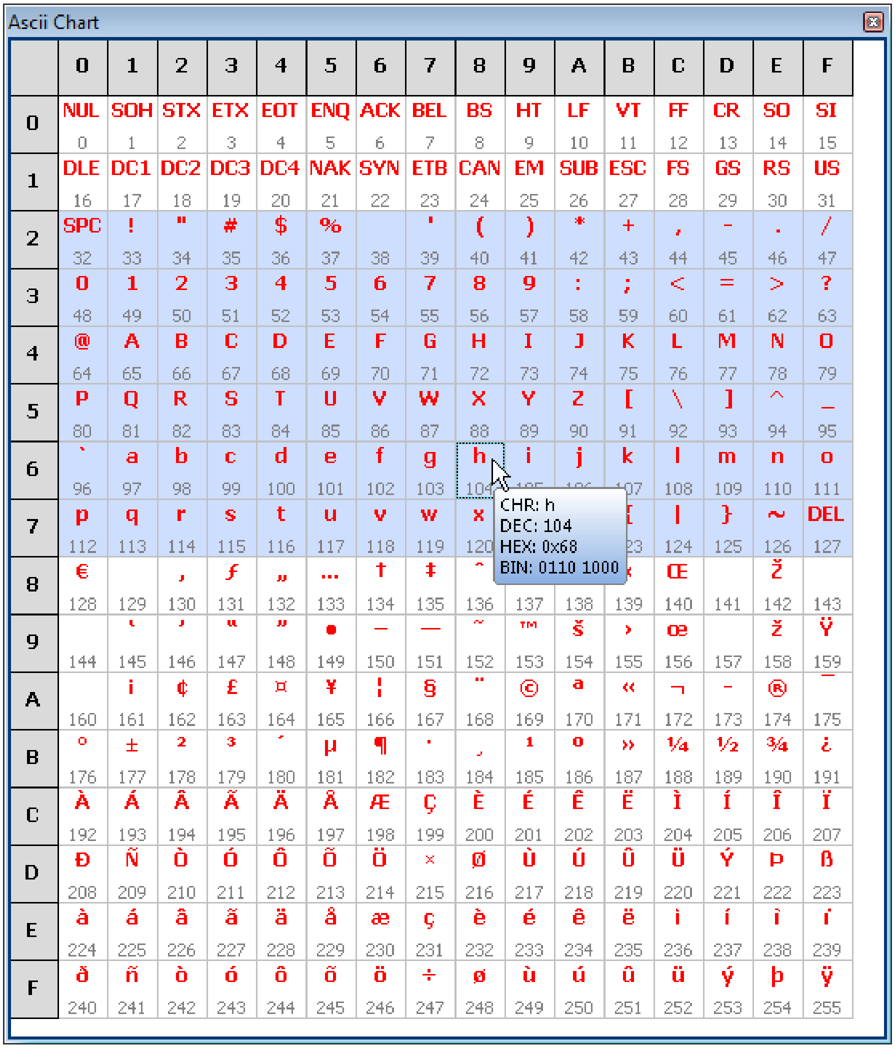
☑ AutoInc

Hex No: 0x

Size: ○ Byte ○ Word ● DWord

ASCII Chart

The ASCII Chart is a handy tool, particularly useful when working with Lcd display. You can launch it from the drop-down menu **Tools › ASCII chart** or by clicking the View ASCII Chart Icon from Tools toolbar.



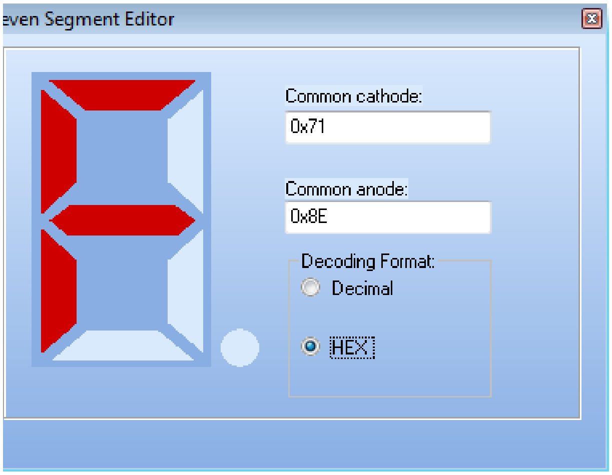
Ascii Chart

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL 0	SOH 1	STX 2	ETX 3	EOT 4	ENQ 5	ACK 6	BEL 7	BS 8	HT 9	LF 10	VT 11	FF 12	CR 13	SO 14	SI 15
1	DLE 16	DC1 17	DC2 18	DC3 19	DC4 20	NAK 21	SYN 22	ETB 23	CAN 24	EM 25	SUB 26	ESC 27	FS 28	GS 29	RS 30	US 31
2	SPC 32	! 33	" 34	# 35	$ 36	% 37	38	' 39	(40	) 41	* 42	+ 43	, 44	- 45	. 46	/ 47
3	0 48	1 49	2 50	3 51	4 52	5 53	6 54	7 55	8 56	9 57	: 58	; 59	< 60	= 61	> 62	? 63
4	@ 64	A 65	B 66	C 67	D 68	E 69	F 70	G 71	H 72	I 73	J 74	K 75	L 76	M 77	N 78	O 79
5	P 80	Q 81	R 82	S 83	T 84	U 85	V 86	W 87	X 88	Y 89	Z 90	[91	\ 92	] 93	^ 94	_ 95
6	` 96	a 97	b 98	c 99	d 100	e 101	f 102	g 103	h 104	i 105	j 106	k 107	l 108	m 109	n 110	o 111
7	p 112	q 113	r 114	s 115	t 116	u 117	v 118	w 119	x 120	[illegible]	[illegible]	[illegible]	| 124	} 125	~ 126	DEL 127
8	€ 128	129	‚ 130	ƒ 131	„ 132	… 133	† 134	‡ 135	ˆ 136	137	138	139	Œ 140	141	Ž 142	143
9	144	‘ 145	’ 146	“ 147	” 148	• 149	– 150	— 151	˜ 152	™ 153	š 154	› 155	œ 156	157	ž 158	Ÿ 159
A	160	¡ 161	¢ 162	£ 163	¤ 164	¥ 165	¦ 166	§ 167	¨ 168	© 169	ª 170	« 171	¬ 172	- 173	® 174	¯ 175
B	° 176	± 177	² 178	³ 179	´ 180	µ 181	¶ 182	· 183	¸ 184	¹ 185	º 186	» 187	¼ 188	½ 189	¾ 190	¿ 191
C	À 192	Á 193	Â 194	Ã 195	Ä 196	Å 197	Æ 198	Ç 199	È 200	É 201	Ê 202	Ë 203	Ì 204	Í 205	Î 206	Ï 207
D	Ð 208	Ñ 209	Ò 210	Ó 211	Ô 212	Õ 213	Ö 214	× 215	Ø 216	Ù 217	Ú 218	Û 219	Ü 220	Ý 221	Þ 222	ß 223
E	à 224	á 225	â 226	ã 227	ä 228	å 229	æ 230	ç 231	è 232	é 233	ê 234	ë 235	ì 236	í 237	î 238	ï 239
F	ð 240	ñ 241	ò 242	ó 243	ô 244	õ 245	ö 246	÷ 247	ø 248	ù 249	ú 250	û 251	ü 252	ý 253	þ 254	ÿ 255

CHR: h
DEC: 104
HEX: 0x68
BIN: 0110 1000

Seven Segment Decoder

The Seven Segment Display Decoder is a convenient visual panel which returns decimal/hex value for any viable combination you would like to display on 7seg. Click on the parts of 7 segment image to get the requested value in the edit boxes. You can launch it from the drop-down menu **Tools › Seven Segment Convertor** or by clicking the Seven Segment Icon from Tools toolbar.



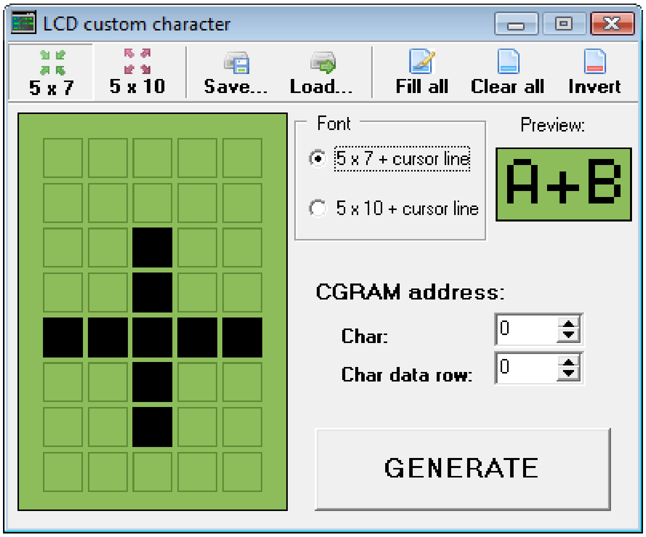
Common cathode: 0x71

Common anode: 0x8E

Decoding Format:
○ Decimal
● HEX

Lcd Custom Character

mikroBasic PRO for PIC includes the Lcd Custom Character. Output is *mikroBasic PRO for PIC* compatible code. You can launch it from the drop-down menu **Tools › Lcd Custom Character**.



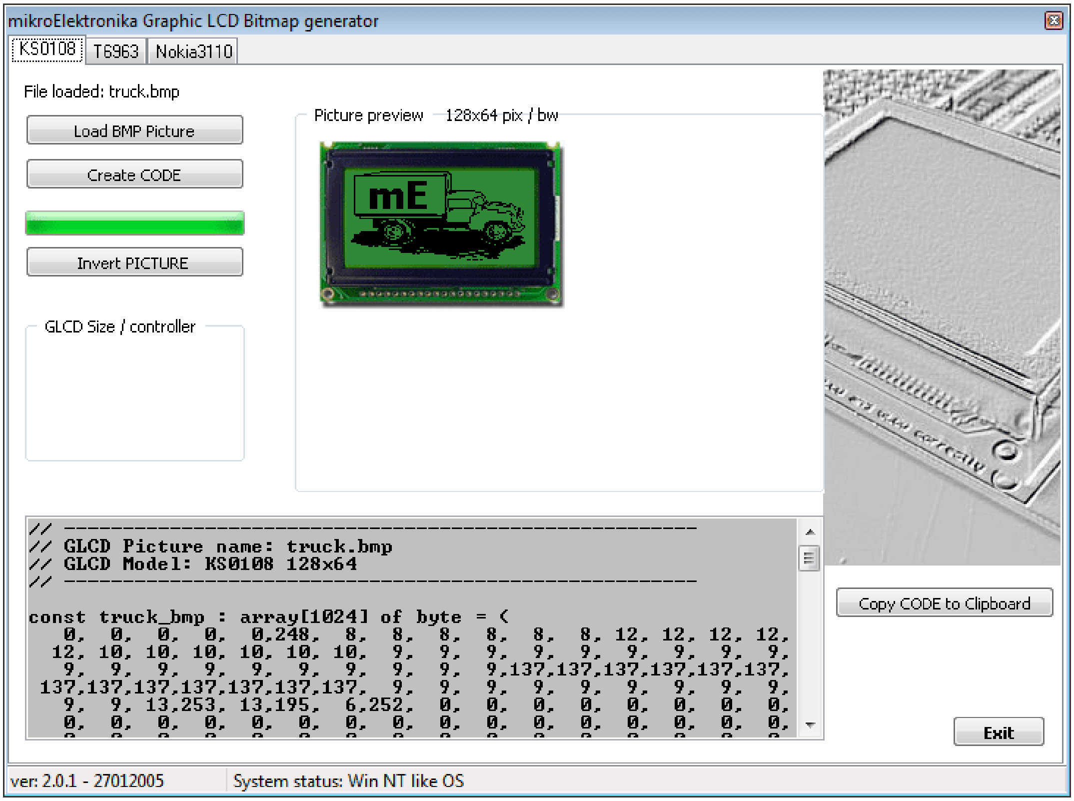
Font
● 5 x 7 + cursor line
○ 5 x 10 + cursor line

Preview: A+B

CGRAM address:
Char: 0
Char data row: 0

Graphic LCD Bitmap Editor

The *mikroBasic PRO for PIC* includes the Graphic Lcd Bitmap Editor. Output is the mikroBasic PRO for PIC compatible code. You can launch it from the drop-down menu **Tools › Glcd Bitmap Editor.**



File loaded: truck.bmp

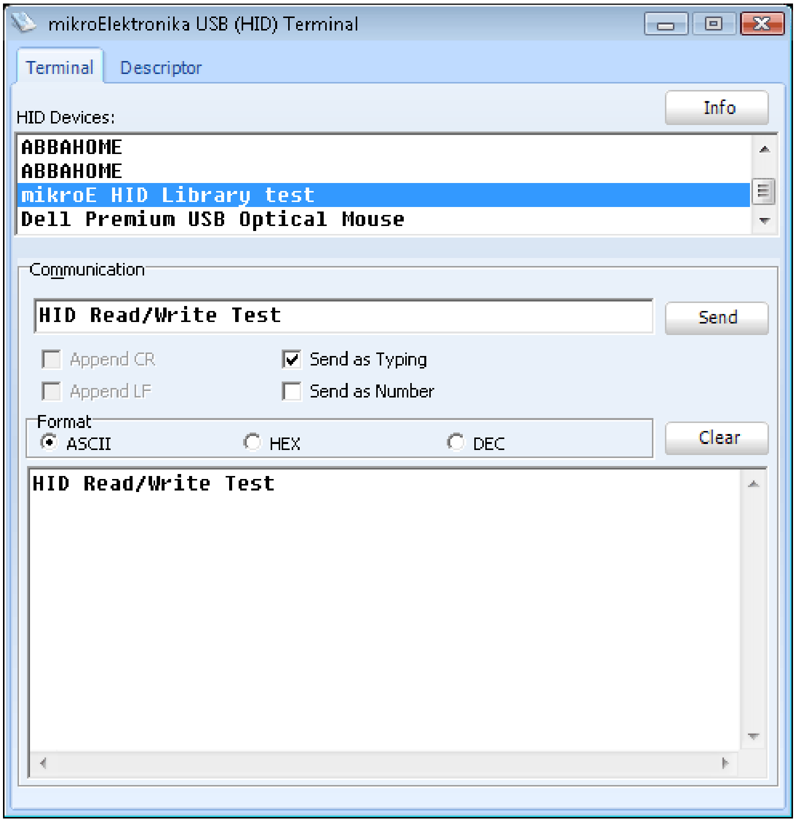
```
// --------------------------------------------------------
// GLCD Picture name: truck.bmp
// GLCD Model: KS0108 128x64
// --------------------------------------------------------

const truck_bmp : array[1024] of byte = (
   0,   0,   0,   0,   0,248,   8,   8,   8,   8,   8,   8, 12, 12, 12, 12,
  12, 10, 10, 10, 10, 10, 10,   9,   9,   9,   9,   9,   9,   9,   9,   9,
   9,   9,   9,   9,   9,   9,   9,   9,   9,   9,137,137,137,137,137,137,
 137,137,137,137,137,137,137,   9,   9,   9,   9,   9,   9,   9,   9,   9,
   9,   9, 13,253, 13,195,   6,252,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
```

ver: 2.0.1 - 27012005

System status: Win NT like OS

HID Terminal

The *mikroBasic PRO for PIC* includes the HID communication terminal for USB communication. You can launch it from the drop-down menu **Tools › HID Terminal**.



```
ABBAHOME
ABBAHOME
mikroE HID Library test
Dell Premium USB Optical Mouse
```

HID Read/Write Test

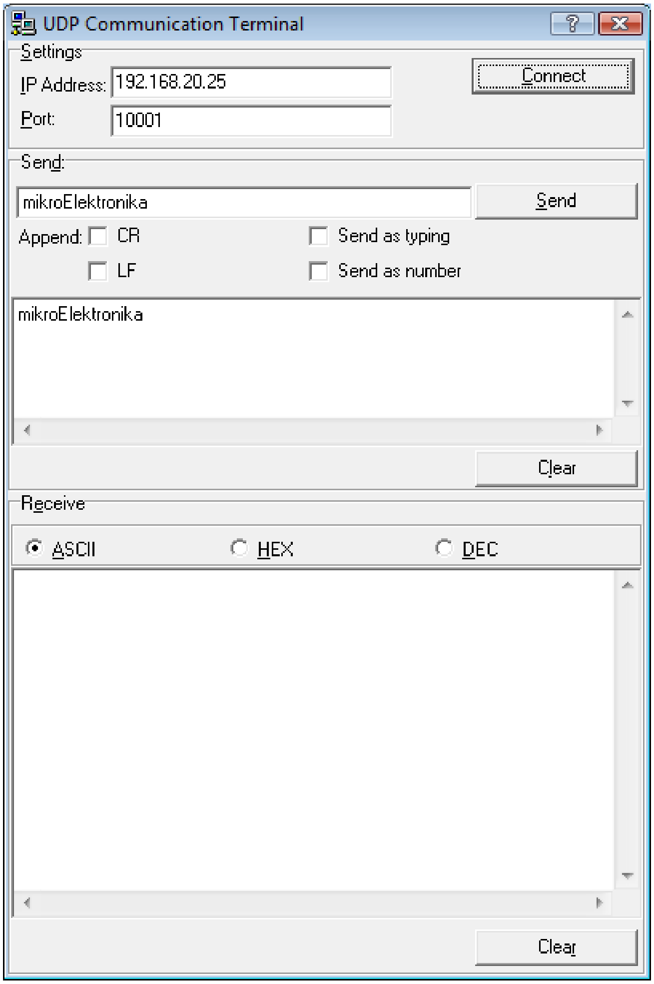
☐ Append CR ☑ Send as Typing
☐ Append LF ☐ Send as Number

● ASCII ○ HEX ○ DEC

```
HID Read/Write Test
```

Udp Terminal

The *mikroBasic PRO for PIC* includes the UDP Terminal. You can launch it from the drop-down menu **Tools › UDP Terminal.**



IP Address: 192.168.20.25

Port: 10001

mikroElektronika

☐ CR

☐ LF

☐ Send as typing

☐ Send as number

mikroElektronika

● ASCII ○ HEX ○ DEC

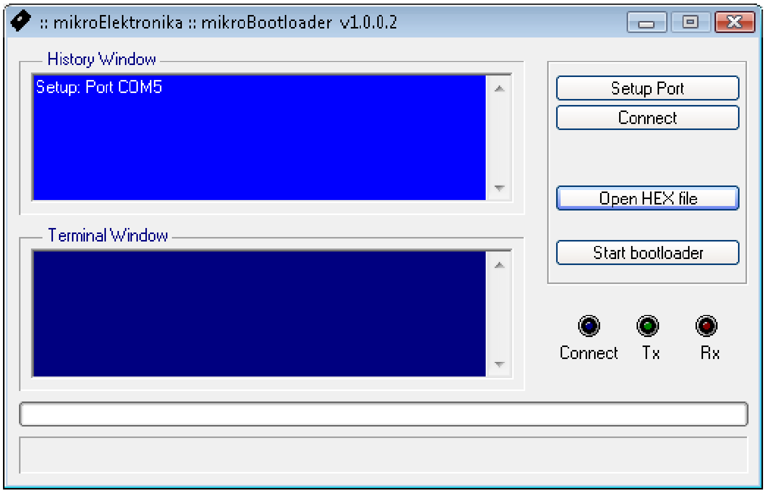
MIKROBOOTLOADER

What is a Bootloader

(From Microchip's document AN732) The PIC16F87X family of microcontrollers has the ability to write to their own program memory. This feature allows a small bootloader program to receive and write new firmware into memory. In its most simple form, the bootloader starts the user code running, unless it finds that new firmware should be downloaded. If there is new firmware to be downloaded, it gets the data and writes it into program memory. There are many variations and additional features that can be added to improve reliability and simplify the use of the bootloader.
Note: mikroBootloader can be used only with PIC MCUs that support flash write.

How to use mikroBootloader

1. Load the PIC with the appropriate hex file using the conventional programming techniques (e.g. for PIC16F877A use `p16f877a.hex`).
2. Start mikroBootloader from the drop-down menu **Tools › Bootoader.**
3. Click on **Setup Port** and select the COM port that will be used. Make sure that BAUD is set to 9600 Kpbs.
4. Click on **Open File** and select the HEX file you would like to upload.
5. Since the bootcode in the PIC only gives the computer 4-5 sec to connect, you should reset the PIC and then click on the **Connect** button within 4-5 seconds.
6. The last line in then history window should now read "Connected".
7. To start the upload, just click on the **Start Bootloader** button.
8. Your program will written to the PIC flash. Bootloader will report an errors that may occur.
9. Reset your PIC and start to execute.



Setup: Port COM5

Features

The boot code gives the computer 5 seconds to get connected to it. If not, it starts running the existing user code. If there is a new user code to be downloaded, the boot code receives and writes the data into program memory.

The more common features a bootloader may have are listed below:

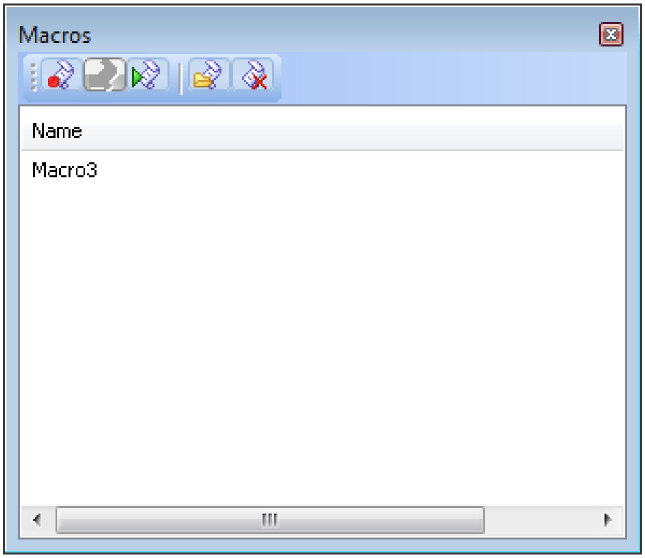
- Code at the Reset location.
- Code elsewhere in a small area of memory.
- Checks to see if the user wants new user code to be loaded.
- Starts execution of the user code if no new user code is to be loaded.
- Receives new user code via a communication channel if code is to be loaded.
- Programs the new user code into memory.

Integrating User Code and Boot Code

The boot code almost always uses the Reset location and some additional program memory. It is a simple piece of code that does not need to use interrupts; therefore, the user code can use the normal interrupt vector at 0x0004. The boot code must avoid using the interrupt vector, so it should have a program branch in the address range 0x0000 to 0x0003. The boot code must be programmed into memory using conventional programming techniques, and the configuration bits must be programmed at this time. The boot code is unable to access the configuration bits, since they are not mapped into the program memory space.

Macro Editor

A macro is a series of keystrokes that have been 'recorded' in the order performed. A macro allows you to 'record' a series of keystrokes and then 'playback', or repeat, the recorded keystrokes.



Name
Macro3

The Macro offers the following commands:

Icon	Description
●	Starts 'recording' keystrokes for later playback.
■	Stops capturing keystrokesthat was started when the Start Recordig command was selected.
▶	Allows a macro that has been recorded to be replayed.
📂	New macro.
✗	Delete macro.

Related topics: Advanced Code Editor, Code Templates

Options

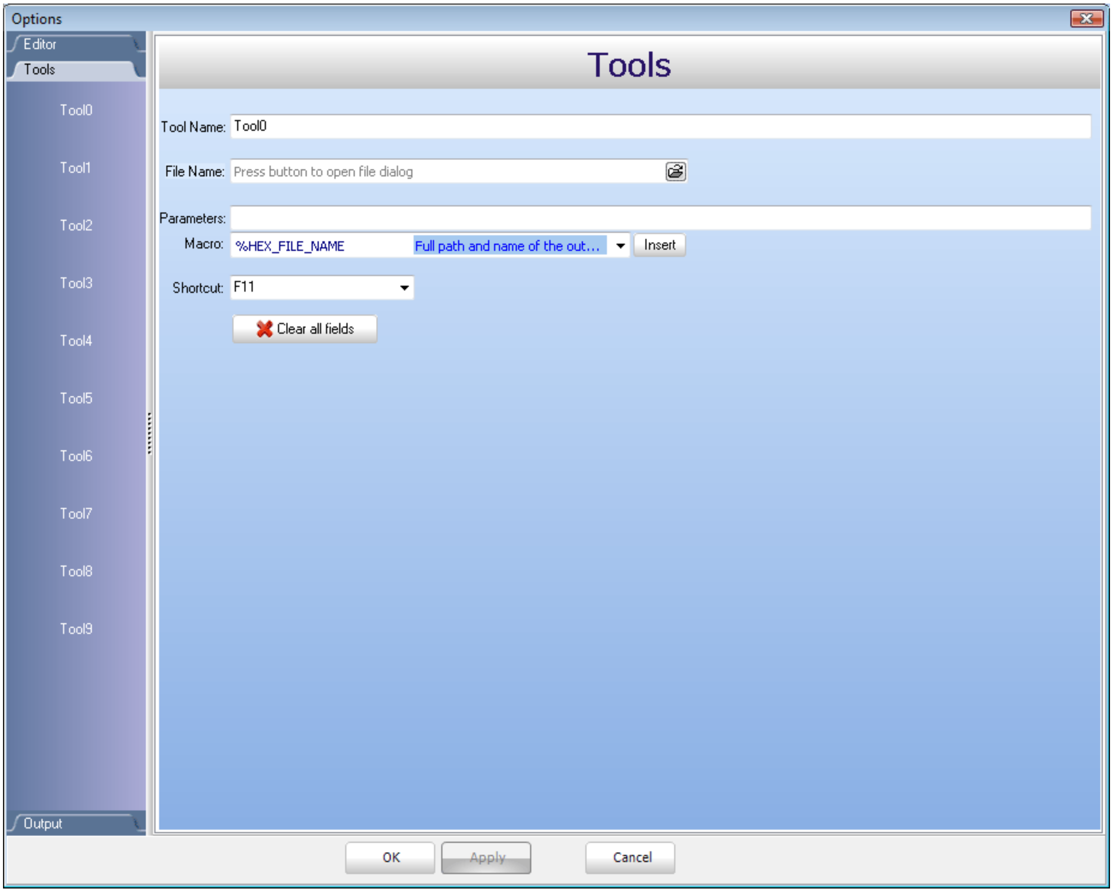
Options menu consists of three tabs: Code Editor, Tools and Output settings

Code editor

The Code Editor is advanced text editor fashioned to satisfy needs of professionals.

Tools

The *mikroBasic PRO for PIC* includes the Tools tab, which enables the use of shortcuts to external programs, like Calculator or Notepad.
You can set up to 10 different shortcuts, by editing Tool0 - Tool9.



Tool Name: Tool0

File Name: Press button to open file dialog

Parameters:

Macro: %HEX_FILE_NAME Full path and name of the out... Insert

Shortcut: F11

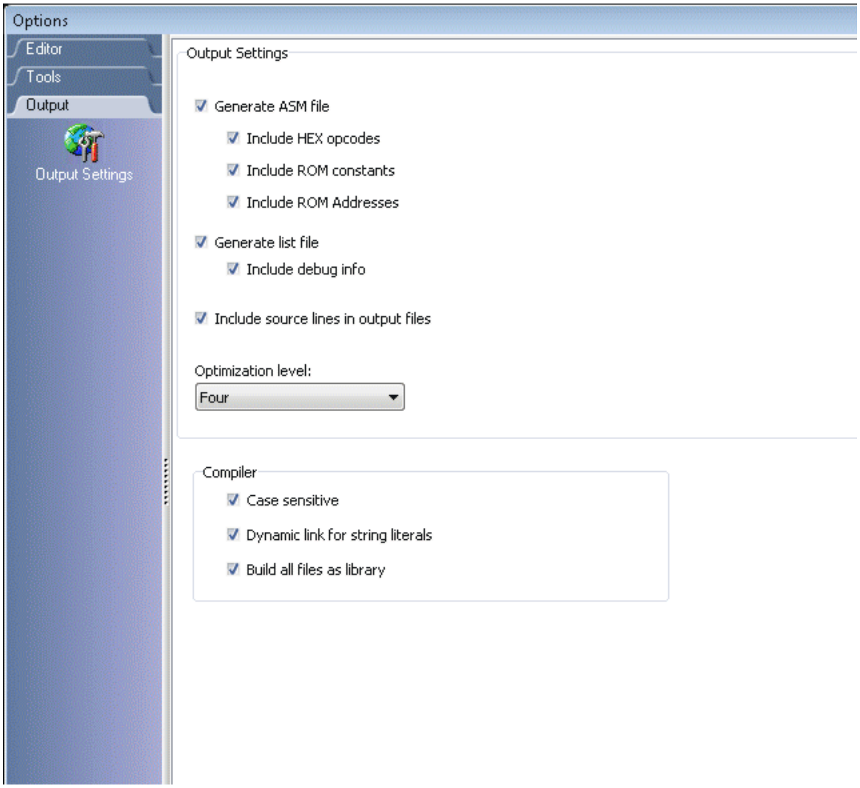
Output settings

By modifying Output Settings, user can configure the content of the output files. You can enable or disable, for example, generation of ASM and List file.

Also, user can choose optimization level, and compiler specific settings, which include case sensitivity, dynamic link for string literals setting (described in mikroBasic PRO for PIC specifics).

Build all files as library enables user to use compiled library (`*.mcl`) on any PIC MCU (when this box is checked), or for a selected PIC MCU (when this box is left unchecked).

For more information on creating new libraries, see Creating New Library.



Output Settings

☑ Generate ASM file
  ☑ Include HEX opcodes
  ☑ Include ROM constants
  ☑ Include ROM Addresses

☑ Generate list file
  ☑ Include debug info

☑ Include source lines in output files

Optimization level: Four

Compiler
  ☑ Case sensitive
  ☑ Dynamic link for string literals
  ☑ Build all files as library

REGULAR EXPRESSIONS

Introduction

Regular Expressions are a widely-used method of specifying patterns of text to search for. Special metacharacters allow you to specify, for instance, that a particular string you are looking for, occurs at the beginning, or end of a line, or contains `n` recurrences of a certain character.

Simple matches

Any single character matches itself, unless it is a metacharacter with a special meaning described below. A series of characters matches that series of characters in the target string, so the pattern "`short`" would match "`short`" in the target string. You can cause characters that normally function as metacharacters or escape sequences to be interpreted by preceding them with a backslash "`\`".
For instance, metacharacter "`^`" matches beginning of string, but "`\^`" matches character "`^`", and "`\\`" matches "`\`", etc.

Examples :

`unsigned` matches string `'unsigned'`
`\^unsigned` matches string `'^unsigned'`

Escape sequences

Characters may be specified using a escape sequences: "`\n`" matches a newline, "`\t`" a tab, etc. More generally, `\xnn`, where `nn` is a string of hexadecimal digits, matches the character whose ASCII value is `nn`.
If you need wide(Unicode)character code, you can use '`\x{nnnn}`', where '`nnnn`' - one or more hexadecimal digits.

`\xnn` - char with hex code `nn`
`\x{nnnn}`- char with hex code `nnnn` (one byte for plain text and two bytes for Unicode)
`\t` - tab (HT/TAB), same as `\x09`
`\n` - newline (NL), same as `\x0a`
`\r` - car.return (CR), same as `\x0d`
`\f` - form feed (FF), same as `\x0c`
`\a` - alarm (bell) (BEL), same as `\x07`
`\e` - escape (ESC) , same as `\x1b`

Examples:

```
unsigned\x20int matches 'unsigned int' (note space in the middle)
\tunsigned matches 'unsigned' (predecessed by tab)
```

Character classes

You can specify a character class, by enclosing a list of characters in `[]`, which will match any of the characters from the list. If the first character after the "`[`" is "`^`", the class matches any character not in the list.

Examples:

`count[aeiou]r` finds strings `'countar', 'counter',` etc. but not `'countbr', 'countcr'`, etc.
`count[^aeiou]r` finds strings `'countbr', 'countcr',` etc. but not `'countar', 'counter'`, etc.

Within a list, the "`-`" character is used to specify a range, so that `a-z` represents all characters between "`a`" and "`z`", inclusive.

If you want "`-`" itself to be a member of a class, put it at the start or end of the list, or escape it with a backslash.
If you want '`]`', you may place it at the start of list or escape it with a backslash.

Examples:

`[-az]` matches '`a`', '`z`' and '`-`'
`[az-]` matches '`a`', '`z`' and '`-`'
`[a\-z]` matches '`a`', '`z`' and '`-`'
`[a-z]` matches all twenty six small characters from '`a`' to '`z`'
`[\n-\x0D]` matches any of `#10,#11,#12,#13.`
`[\d-t]` matches any digit, '`-`' or '`t`'.
`[]-a]` matches any char from '`]`'..'`a`'.

Metacharacters

Metacharacters are special characters which are the essence of regular expressions.There are different types of metacharacters, described below.

Metacharacters - Line separators

`^` - start of line
`$` - end of line
`\A` - start of text
`\Z` - end of text
`.` - any character in line

Examples:

`^PORTA` - matches string `' PORTA '` only if it's at the beginning of line
`PORTA$` - matches string `' PORTA '` only if it's at the end of line
`^PORTA$` - matches string `' PORTA '` only if it's the only string in line
`PORT.r` - matches strings like `'PORTA', 'PORTB', 'PORT1'` and so on

The "`^`" metacharacter by default is only guaranteed to match beginning of the input string/text, and the "`$`" metacharacter only at the end. Embedded line separators will not be matched by `^`" or "`$`".
You may, however, wish to treat a string as a multi-line buffer, such that the "`^`" will match after any line separator within the string, and "`$`" will match before any line separator.
Regular expressons works with line separators as recommended at www.unicode.org (http://www.unicode.org/unicode/reports/tr18/):

Metacharacters - Predefined classes

`\w` - an alphanumeric character (including "_")
`\W` - a nonalphanumeric
`\d` - a numeric character
`\D` - a non-numeric
`\s` - any space (same as `[ \t\n\r\f`])
`\S` - a non space

You may use `\w, \d` and `\s` within custom character classes.

Example:

`routi\de` - matches strings like '`routi1e`', '`routi6e`' and so on, but not '`routine`', '`routime`' and so on.

Metacharacters - Word boundaries

A word boundary (`"\b"`) is a spot between two characters that has a `"\w"` on one side of it and a `"\W"` on the other side of it (in either order), counting the imaginary characters off the beginning and end of the string as matching a `"\W"`.

`\b` - match a word boundary)
`\B` - match a non-(word boundary)

Metacharacters - Iterators

Any item of a regular expression may be followed by another type of metacharacters - iterators. Using this metacharacters,you can specify number of occurences of previous character, metacharacter or subexpression.

`*` - zero or more ("greedy"), similar to {0,}
`+` - one or more ("greedy"), similar to {1,}
`?` - zero or one ("greedy"), similar to {0,1}
`{n}` - exactly n times ("greedy")
`{n,}` - at least n times ("greedy")
`{n,m}` - at least n but not more than m times ("greedy")
`*?` - zero or more ("non-greedy"), similar to {0,}?
`+?` - one or more ("non-greedy"), similar to {1,}?
`??` - zero or one ("non-greedy"), similar to {0,1}?
`{n}?` - exactly n times ("non-greedy")
`{n,}?` - at least n times ("non-greedy")
`{n,m}?` - at least n but not more than m times ("non-greedy")

So, digits in curly brackets of the form, `{n,m}`, specify the minimum number of times to match the item n and the maximum `m`. The form `{n}` is equivalent to `{n,n}` and matches exactly `n` times. The form `{n,}` matches n or more times. There is no limit to the size of `n` or `m`, but large numbers will chew up more memory and slow down execution.

If a curly bracket occurs in any other context, it is treated as a regular character.

Examples:

`count.*r ß`- matches strings like '`counter`', '`countelkjdflkj9r`' and '`countr`'
`count.+r` - matches strings like '`counter`', '`countelkjdflkj9r`' but not '`countr`'
`count.?r` - matches strings like '`counter`', '`countar`' and '`countr`' but not '`countelkj9r`'
`counte{2}r` - matches string '`counteer`'
`counte{2,}r` - matches strings like '`counteer`', '`counteeer`', '`counteeer`' etc.
`counte{2,3}r` - matches strings like '`counteer`', or '`counteeer`' but not '`counteeeer`'

A little explanation about "greediness". "Greedy" takes as many as possible, "non-greedy" takes as few as possible.
For example, '`b+`' and '`b*`' applied to string '`abbbbc`' return '`bbbb`', '`b+?`' returns '`b`', '`b*?`' returns empty string, '`b{2,3}?`' returns '`bb`', '`b{2,3}`' returns '`bbb`'.

Metacharacters - Alternatives

You can specify a series of alternatives for a pattern using "`|`" to separate them, so that `bit|bat|bot` will match any of "`bit`", "`bat`", or "`bot`" in the target string (as would `b(i|a|o)t)`. The first alternative includes everything from the last pattern delimiter `("(", "["`, or the beginning of the pattern) up to the first "`|`", and the last alternative contains everything from the last "`|`" to the next pattern delimiter. For this reason, it's common practice to include alternatives in parentheses, to minimize confusion about where they start and end.

Alternatives are tried from left to right, so the first alternative found for which the entire expression matches, is the one that is chosen. This means that alternatives are not necessarily greedy. For example: when matching `rou|rout` against "`routine`", only the "`rou`" part will match, as that is the first alternative tried, and it successfully matches the target string (this might not seem important, but it is important when you are capturing matched text using parentheses.) Also remember that "`|`" is interpreted as a literal within square brackets, so if you write `[bit|bat|bot]`, you're really only matching `[biao|]`.

Examples:

`rou(tine|te)` - matches strings '`routine`' or '`route`'.

Metacharacters - Subexpressions

The bracketing construct (`...`) may also be used for define regular subexpressions. Subexpressions are numbered based on the left to right order of their opening parenthesis. First subexpression has number '`1`'

Examples:

`(int){8,10}` matches strings which contain 8, 9 or 10 instances of the '`int`'
`routi([0-9]|a+)e` matches '`routi0e`', '`routi1e`' , '`routine`', '`routinne`', '`routinnne`' etc.

Metacharacters - Backreferences

Metacharacters `\1` through `\9` are interpreted as backreferences. \ matches previously matched subexpression `#`.

Examples:

`(.)\1+` matches '`aaaa`' and '`cc`'.
`(.+)\1+` matches '`abab`' and '`123123`'
`(['"]?)(\d+)\1` matches "`13`" (in double quotes), or '`4`' (in single quotes) or `77` (without quotes) etc

mikroBasic PRO for PIC COMMAND LINE OPTIONS

Usage: `mBPIC.exe  [-<opts> [-<opts>]] [<infile> [-<opts>]] [-<opts>]]`
Infile can be of `*.mpas` and `*.mcl` type.

The following parameters and some more (see manual) are valid:

- `-P` : MCU for which compilation will be done.
- `-FO` : Set oscillator.
- `-SP` : Add directory to the search path list.
- `-N` : Output files generated to file path specified by filename.
- `-B` : Save compiled binary files (`*.mcl`) to 'directory'.
- `-O` : Miscellaneous output options.
- `-DBG` : Generate debug info.
- `-E` : Set memory model opts (`S | C | L (small, compact, large)`).
- `-L` : Check and rebuild new libraries.
- `-C` : Turn on case sensitivity.

Example:

```
 mBPIC.exe -MSF -DBG -pPIC16F887 -C -O11111114 -fo8 -N"C:\Lcd\Lcd.mcpav"
-SP"C:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Defs\"
         -SP"C:\Program    Files\Mikroelektronika\mikroBasic    PRO    for
PIC\Uses\LTE64KW\" - SP"C:\Lcd\"      "Lcd.mbas"      "__Lib_Math.mcl"
"__Lib_MathDouble.mcl"
        "__Lib_System.mcl"  "__Lib_Delays.mcl"  "__Lib_LcdConsts.mcl"
"__Lib_Lcd.mcl"
```

Parameters used in the example:

- `-MSF` : Short Message Format; used for internal purposes by IDE.
- `-DBG` : Generate debug info.
- `-pPIC16F887` : MCU PIC16F887 selected.
- `-C` : Turn on case sensitivity.
- `-O11111114` : Miscellaneous output options.
- `-fo8` : Set oscillator frequency [in MHz].
- `-N"C:\Lcd\Lcd.mcpav" -SP"C:\Program Files\Mikroelektronika\mikroBasic  PRO for PIC\defs\"` : Output files generated to file path specified by file name.
- `-SP"C:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\defs\"` : Add directory to the search path list.
- `-SP"C:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\uses\"` : Add directory to the search path list.
- `-SP"C:\Lcd\" : Add directory to the search path list.`
- `"Lcd.mbas" "__Lib_Math.mcl" "__Lib_MathDouble.mcl" "__Lib_System.mcl"  "__Lib_Delays.mcl"  "__Lib_LcdConsts.mcl" "__Lib_Lcd.mcl"` : Specify input files.

PROJECTS

The mikroBasic PRO for PIC organizes applications into projects, consisting of a single project file (extension .mcpav) and one or more source files (extension). mikroBasic PRO for PIC IDE allows you to manage multiple projects (see Project Manager). Source files can be compiled only if they are part of a project.

The project file contains the following information:

- project name and optional description,
- target device,
- device flags (config word),
- device clock,
- list of the project source files with paths,
- image files,
- other files.

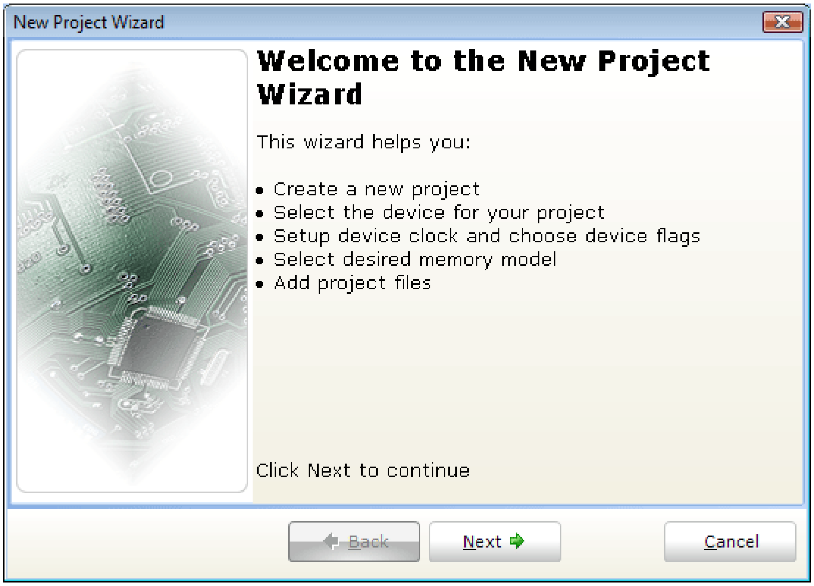
Note that the project does *not* include files in the same way as preprocessor does, see Add/Remove Files from Project.

New Project

The easiest way to create a project is by means of the New Project Wizard, drop-down menu **Project > New Project** or by clicking the New Project Icon from Project Toolbar.

New Project Wizard Steps

Start creating your New project, by clicking Next button:



New Project Wizard

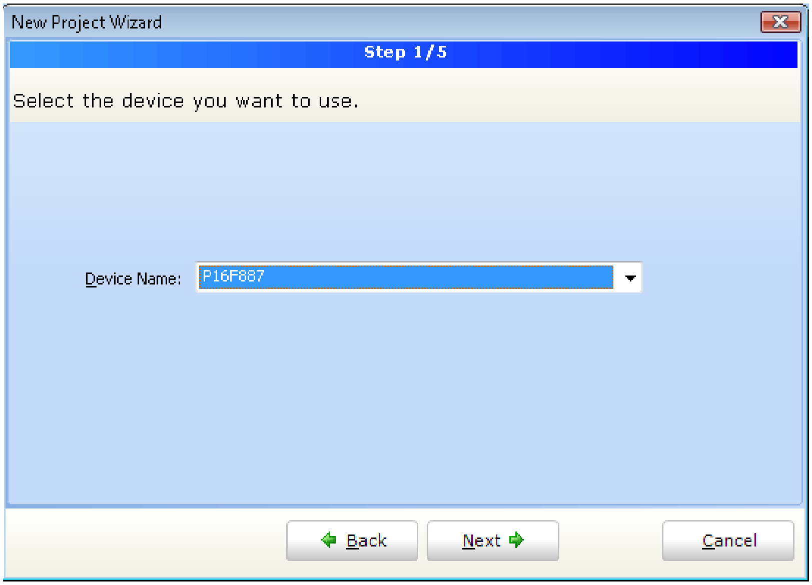
Welcome to the New Project Wizard

This wizard helps you:

- Create a new project
- Select the device for your project
- Setup device clock and choose device flags
- Select desired memory model
- Add project files

Click Next to continue

Step One - Select the device from the device drop-down list.



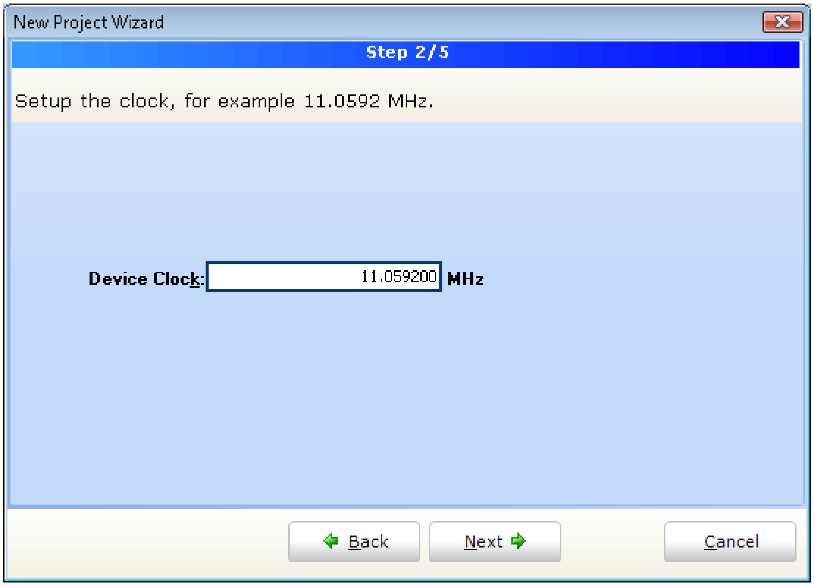
New Project Wizard

Step 1/5

Select the device you want to use.

Device Name: P16F887

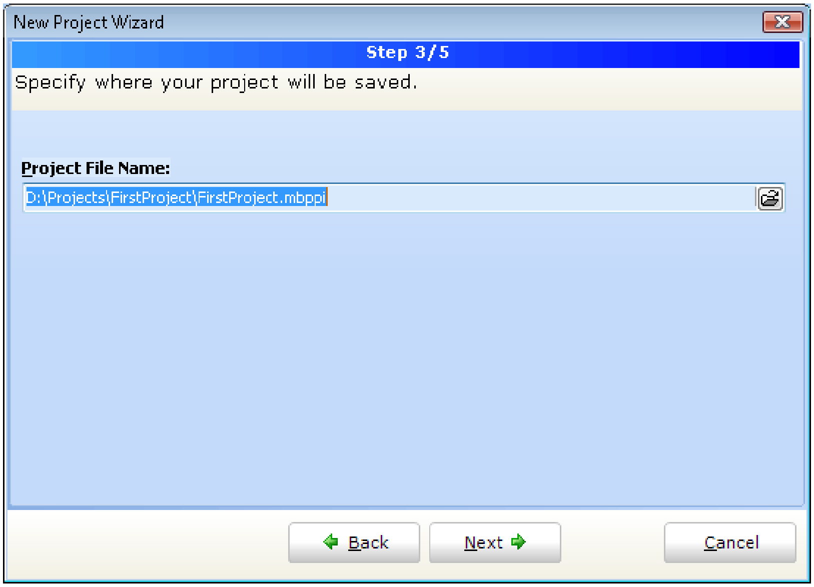
Step Two- enter the oscillator frequency value.



Setup the clock, for example 11.0592 MHz.

Device Clock: 11.059200 MHz

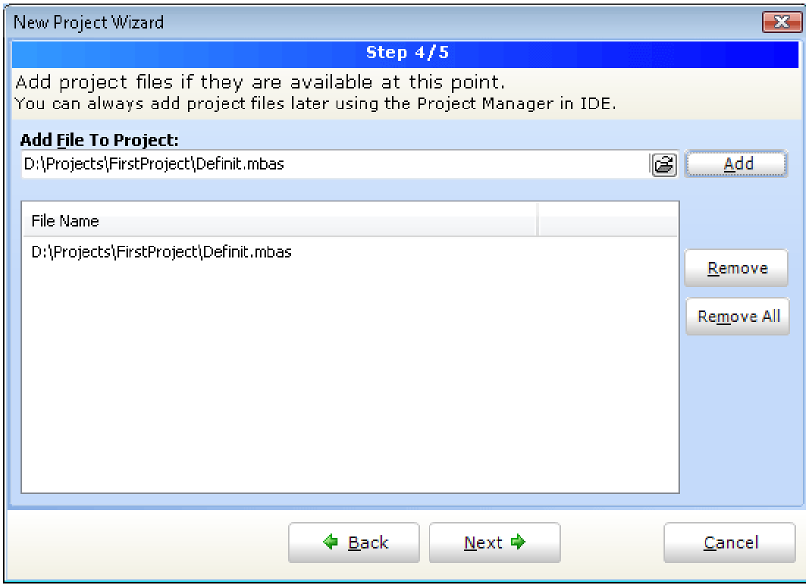
Step Three - Specify the location where your project will be saved.



Specify where your project will be saved.

Project File Name: D:\Projects\FirstProject\FirstProject.mbppi

Step Four - Add project file to the project if they are avaiable at this point. You can always add project files later using Project Manager.

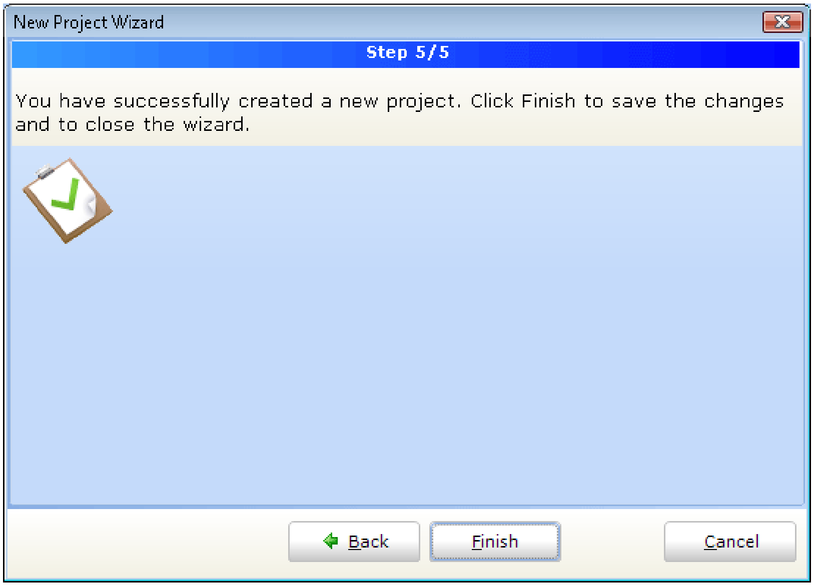


Add project files if they are available at this point.
You can always add project files later using the Project Manager in IDE.

Add File To Project: D:\Projects\FirstProject\Definit.mbas

File Name
D:\Projects\FirstProject\Definit.mbas

Step Five - Click Finish button to create your New Project:



You have successfully created a new project. Click Finish to save the changes and to close the wizard.

Related topics: Project Manager, Project Settings

CUSTOMIZING PROJECTS

You can change basic project settings in the Project Settings window. You can change chip, oscillator frequency, and memory model. Any change in the Project Setting Window affects currently active project only, so in case more than one project is open, you have to ensure that exactly the desired project is set as active one in the Project Manager. Also, you can change configuration bits of the selected chip in the Edit Project window.

Managing Project Group

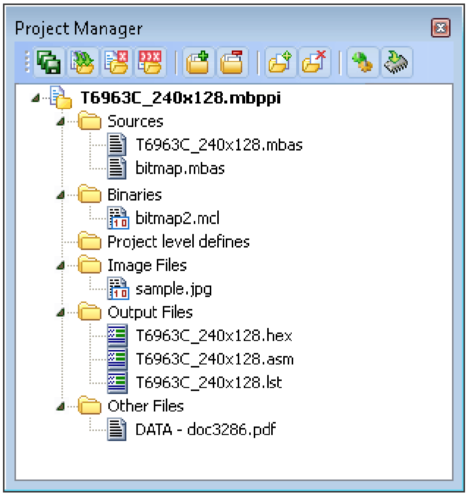
mikroBasic PRO for PIC IDE provides covenient option which enables several projects to be open simultaneously. If you have several projects being connected in some way, you can create a project group.

The project group may be saved by clicking the Save Project Group Icon from the Project Manager window. The project group may be reopend by clicking the Open Project Group Icon . All relevant data about the project group is stored in the project group file (extension `.mpg`)

Add/Remove Files from Project

The project can contain the following file types:

- `.mpas` source files
- `.mcl` binary files
- `.pld` project level defines files (future upgrade)
- image files
- `.hex`, `.asm` and `.lst` files, see output files. These files can not be added or removed from project.
- other files



Project Manager

- T6963C_240x128.mbppi
  - Sources
    - T6963C_240x128.mbas
    - bitmap.mbas
  - Binaries
    - bitmap2.mcl
  - Project level defines
  - Image Files
    - sample.jpg
  - Output Files
    - T6963C_240x128.hex
    - T6963C_240x128.asm
    - T6963C_240x128.lst
  - Other Files
    - DATA - doc3286.pdf

The list of relevant source files is stored in the project file (extension `.mbpav`).

To add source file to the project, click the Add File to Project Icon Each added source file must be self-contained, i.e. it must have all necessary definitions after preprocessing.

To remove file(s) from the project, click the Remove File from Project Icon

Note: For inclusion of the module files, use the include clause. See File Inclusion for more information.

Project Level Defines

Project Level Defines (.pld) files can also be added to project. Project level define files enable you to have defines that are visible in all source files in the project. One project may contain several pld files. A file must contain one definition per line, for example:

```
ANALOG
DEBUG
TEST
```

There are some predefined project level defines. See predefined project level defines

Related topics: Project Manager, Project Settings

SOURCE FILES

Source files containing Basic code should have the extension `.mbas`. The list of source files relevant to the application is stored in project file with extension `.mbpav`, along with other project information. You can compile source files only if they are part of the project.

Managing Source Files

Creating new source file

To create a new source file, do the following:

1. Select **File › New Unit** from the drop-down menu, or press **Ctrl+N**, or click the New File Icon from the File Toolbar.
2. A new tab will be opened. This is a new source file. Select **File › Save** from the drop-down menu, or press **Ctrl+S**, or click the Save File Icon from the File Toolbar and name it as you want.

If you use the New Project Wizard, an empty source file, named after the project with extension `.mbas,` will be created automatically. The mikroBasic PRO for PIC does not require you to have a source file named the same as the project, it's just a matter of convenience.

Opening an existing file

1. Select **File › Open** from the drop-down menu, or press **Ctrl+O**, or click the Open File Icon from the File Toolbar. In Open Dialog browse to the location of the file that you want to open, select it and click the Open button.
2. The selected file is displayed in its own tab. If the selected file is already open, its current Editor tab will become active.

Printing an open file

1. Make sure that the window containing the file that you want to print is the active window.
2. Select **File › Print** from the drop-down menu, or press **Ctrl+P**.
3. In the Print Preview Window, set a desired layout of the document and click the OK button. The file will be printed on the selected printer.

Saving file

1. Make sure that the window containing the file that you want to save is the active window.
2. Select **File › Save** from the drop-down menu, or press **Ctrl+S**, or click the Save File Icon 💾 from the File Toolbar.

Saving file under a different name

1. Make sure that the window containing the file that you want to save is the active window.
2. Select **File** › **Save As** from the drop-down menu. The New File Name dialog will be displayed.
3. In the dialog, browse to the folder where you want to save the file.
4. In the File Name field, modify the name of the file you want to save.
5. Click the Save button.

Closing file

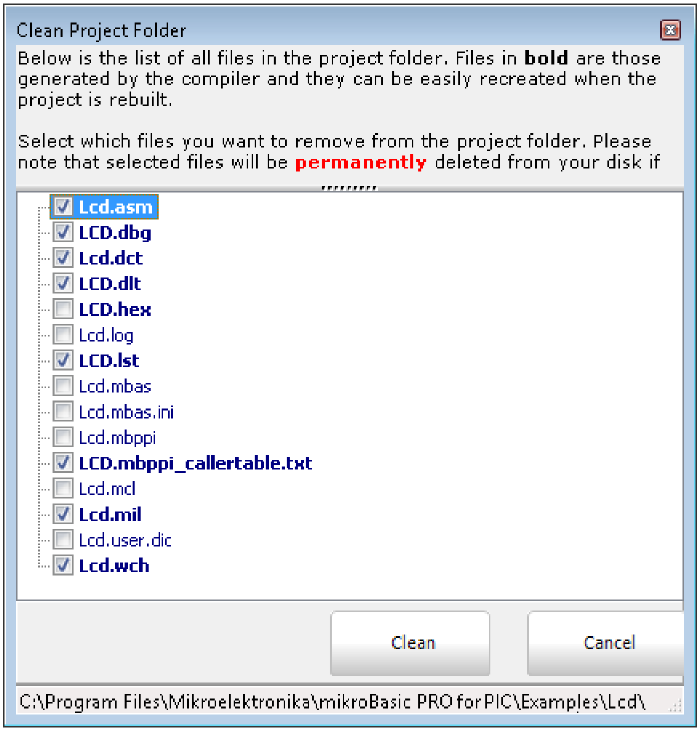
1. Make sure that the tab containing the file that you want to close is the active tab.
2. Select **File › Close** from the drop-down menu, or right click the tab of the file that you want to close and select **Close** option from the context menu.
3. If the file has been changed since it was last saved, you will be prompted to save your changes.

Related topics:File Menu, File Toolbar, Project Manager, Project Settings,

CLEAN PROJECT FOLDER

This menu gives you option to choose which files from your current project you want to delete.

Files marked in bold can be easily recreated by building a project. Other files should be marked for deletion only with a great care, because IDE cannot recover them.



Clean Project Folder

Below is the list of all files in the project folder. Files in **bold** are those generated by the compiler and they can be easily recreated when the project is rebuilt.

Select which files you want to remove from the project folder. Please note that selected files will be **permanently** deleted from your disk if

- ☑ **Lcd.asm**
- ☑ **LCD.dbg**
- ☑ **Lcd.dct**
- ☑ **LCD.dlt**
- ☐ **LCD.hex**
- ☐ Lcd.log
- ☑ **LCD.lst**
- ☐ Lcd.mbas
- ☐ Lcd.mbas.ini
- ☐ Lcd.mbppi
- ☑ **LCD.mbppi_callertable.txt**
- ☐ Lcd.mcl
- ☑ **Lcd.mil**
- ☐ Lcd.user.dic
- ☑ **Lcd.wch**

C:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Examples\Lcd\

Related topics: Customizing Projects

COMPILATION

When you have created the project and written the source code, it's time to compile it. Select **Project › Build** from the drop-down menu, or click the Build Icon from the Project Toolbar. If more more than one project is open you can compile all open projects by selecting **Project › Build All** from the drop-down menu, or click the Build All Icon from the Project Toolbar.

Progress bar will appear to inform you about the status of compiling. If there are some errors, you will be notified in the Error Window. If no errors are encountered, the *mikroBasic PRO for PIC* will generate output files.

Output Files

Upon successful compilation, the *mikroBasic PRO for PIC* will generate output files in the project folder (folder which contains the project file `.mbpav`). Output files are summarized in the table below:

Format	Description	File Type
Intel HEX	Intel style hex records. Use this file to program PIC MCU	`.hex`
Binary	mikro Compiled Library. Binary distribution of application that can be included in other projects.	`.mcl`
List File	Overview of PIC memory allotment: instruction addresses, registers, routines and labels.	`.lst`
Assembler File	Human readable assembly with symbolic names, extracted from the List File.	`.asm`

Assembly View

After compiling the program in the *mikroBasic PRO for PIC*, you can click the View Assembly icon or select **Project › View Assembly** from the drop-down menu to review the generated assembly code (`.asm` file) in a new tab window. Assembly is human-readable with symbolic names.

Related topics:Project Menu, Project Toolbar, Error Window, Project Manager, Project Settings

ERROR MESSAGES

Compiler Error Messages:

- `"%s"` is not valid identifier.
- Unknown type `"%s"`.
- IIdentifier `"%s"` was not declared.
- Syntax error: Expected `"%s"` but `"%s"` found.
- Argument is out of range `"%s"`.
- Syntax error in additive expression.
- File `"%s"` not found.
- Invalid command `"%s"`.
- Not enough parameters.
- Too many parameters.
- Too many characters.
- Actual and formal parameters must be identical.
- Invalid ASM instruction: `"%s"`.
- Identifier `"%s"` has been already declared in `"%s"`.
- Syntax error in multiplicative expression.
- Definition file for `"%s"` is corrupted.
- ORG directive is currently supported for interrupts only.
- Not enough ROM.
- Not enough RAM.
- External procedure `"%s"` used in `"%s"` was not found.
- Internal error: `"%s"`.
- Unit cannot recursively use itself.
- `"%s"` cannot be used out of loop.
- Actual and formal parameters do not match (`"%s"` to `"%s"`).
- Constant cannot be assigned to.
- Constant array must be declared as global.
- Incompatible types (`"%s"` to `"%s"`).
- Too many characters (`"%s"`).
- Soft_Uart cannot be initialized with selected baud rate/device clock.
- Main label cannot be used in modules.
- Break/Continue cannot be used out of loop.
- Preprocessor Error: `"%s"`.
- Expression is too complicated.
- Duplicated label `"%s"`.
- Complex type cannot be declared here.
- Record is empty.
- Unknown type `"%s"`.
- File not found `"%s"`.
- Constant argument cannot be passed by reference.
- Pointer argument cannot be passed by reference.

- Operator `"%s"` not applicable to these operands `"%s"`.
- Exit cannot be called from the main block.
- Complex type parameter must be passed by reference.
- Error occured while compiling `"%s"`.
- Recursive types are not allowed.
- Adding strings is not allowed, use "strcat" procedure instead.
- Cannot declare pointer to array, use pointer to structure which has array field.
- Return value of the function `"%s"` is not defined.
- Assignment to for loop variable is not allowed.
- `"%s"` is allowed only in the main program.
- Start address of `"%s"` has already been defined.
- Simple constant cannot have a fixed address.
- Invalid date/time format.
- Invalid operator `"%s"`.
- File `"%s"` is not accessible.
- Forward routine `"%s"` is missing implementation.
- ";" is not allowed before "else".
- Not enough elements: expected `"%s"`, but `"%s"` elements found.
- Too many elements: expected `"%s"` elements.
- "external" is allowed for global declarations only.
- Destination size `("%s")` does not match source size `("%s")` .
- Routine prototype is different from previous declaration.
- Division by zero.
- Uart module cannot be initialized with selected baud rate/device clock.
- `"%s"` cannot be of `"%s"` type.
- Array of `"%s"` can not be declared.
- Incomplete variable declaration: `"%s".`
- Recursive build of units is not allowed (`""%s""`).
- Object must be smaller than 64kb in size: `""%s"".`
- Index out of bounds.
- With statment cannot be used with this argument `""%s""` .
- Reset directive is available only on P18 family.

Warning Messages:

- Variable `"%s"` is not initialized.
- Return value of the function `"%s"` is not defined.
- Identifier `"%s"` overrides declaration in unit `"%s".`
- Generated baud rate is `%s` bps (error = %s percent).
- Result size may exceed destination array size.
- Infinite loop.
- Implicit typecast performed from `"%s"` to `"%s".`
- Implicit typecast of integral value to pointer.
- Library `"%s"` was not found in search path.
- Interrupt context saving has been turned off.
- Source size `(%s)` does not match destination size `(%s)`.
- Aggregate padded with zeros `(%s)` in order to match declared size `(%s)`.
- Suspicious pointer conversion.
- Source size may exceed destination size.

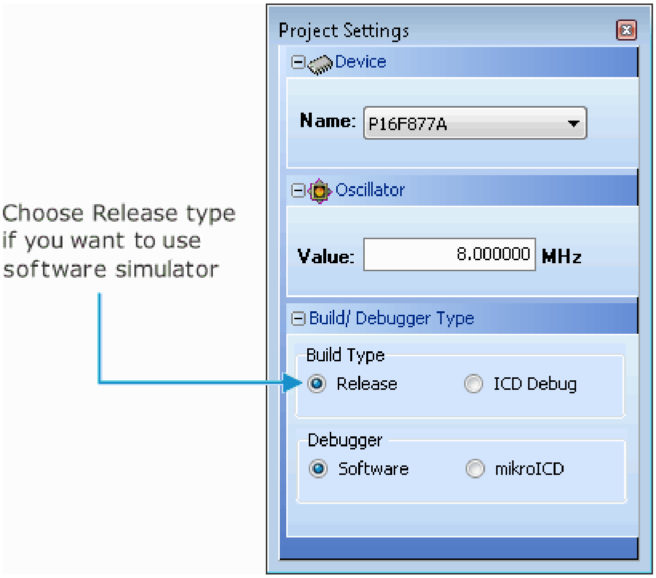
Hint Messages:

- Constant `"%s"` has been declared, but not used.
- Variable `"%s"` has been declared, but not used.
- Unit `"%s"` has been recompiled.
- Variable `"%s"` has been eliminated by optimizer.
- Compiling unit `"%s"`.

SOFTWARE SIMULATOR OVERVIEW

The Source-level Software Simulator is an integral component of the *mikroBasic PRO for PIC* environment. It is designed to simulate operations of the PIC MCUs and assist the users in debugging Basic code written for these devices.

Upon completion of writing your program, choose **Release** build Type in the Project Settings window:



Choose Release type if you want to use software simulator

Project Settings

Device

Name: P16F877A

Oscillator

Value: 8.000000 MHz

Build/ Debugger Type

Build Type

● Release ○ ICD Debug

Debugger

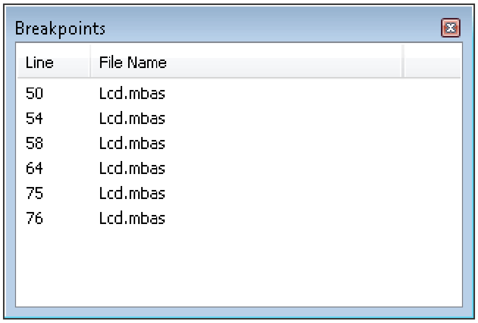
● Software ○ mikroICD

After you have successfully compiled your project, you can run the Software Simulator by selecting **Run › Start Debugger** from the drop-down menu, or by clicking the Start Debugger Icon from the Debugger Toolbar. Starting the Software Simulator makes more options available: Step Into, Step Over, Step Out, Run to Cursor, etc. Line that is to be executed is color highlighted (blue by default).

Note: The Software Simulator simulates the program flow and execution of instruction lines, but it cannot fully emulate 8051 device behavior, i.e. it doesn't update timers, interrupt flags, etc.

Breakpoints Window

The Breakpoints window manages the list of currently set breakpoints in the project. Doubleclicking the desired breakpoint will cause cursor to navigate to the corresponding location in source code.


Breakpoints

Line	File Name
50	Lcd.mbas
54	Lcd.mbas
58	Lcd.mbas
64	Lcd.mbas
75	Lcd.mbas
76	Lcd.mbas

Watch Window

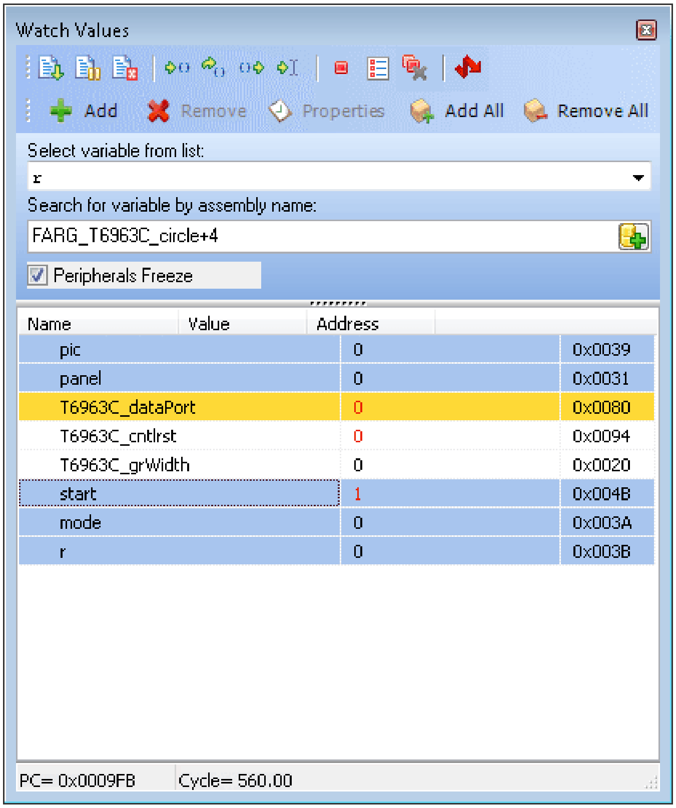
The Software Simulator Watch Window is the main Software Simulator window which allows you to monitor program items while simulating your program. To show the Watch Window, select **View › Debug Windows** › Watch from the drop-down menu.

The Watch Window displays variables and registers of the MCU, along with their addresses and values.

There are two ways of adding variable/register to the watch list:

- by its real name (variable's name in "Basic" code). Just select desired variable/register from ***Select variable from list*** drop-down menu and click the Add Butto Add.
- by its name ID (assembly variable name). Simply type name ID of the variable/register you want to display into **Search the variable by assemby name** box and click the Add Button Add .
- Viables can also be removed from the Watch window, just select the vari able that you want to remove and then click the Remove Button Remove .
- Add All Button Add All adds all variables.
- Remove All Button Remove All removes all variables.

You can also expand/collapse complex variables, i.e. struct type variables, strings... Values are updated as you go through the simulation. Recently changed items are colored red.



Select variable from list: r

Search for variable by assembly name: FARG_T6963C_circle+4

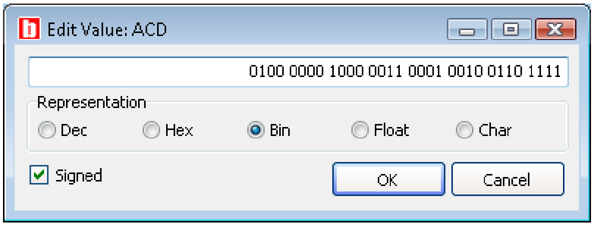
☑ Peripherals Freeze

Name	Value	Address
pic	0	0x0039
panel	0	0x0031
T6963C_dataPort	0	0x0080
T6963C_cntlrst	0	0x0094
T6963C_grWidth	0	0x0020
start	1	0x004B
mode	0	0x003A
r	0	0x003B

PC= 0x0009FB Cycle= 560.00

Double clicking a variable or clicking the Properties Button Properties opens the Edit Value window in which you can assign a new value to the selected variable/register. Also, you can choose the format of variable/register representation between decimal, hexadecimal, binary, float or character. All representations except float are unsigned by default. For signed representation click the check box next to the ***Signed*** label.

An item's value can be also changed by double clicking item's value field and typing the new value directly.



0100 0000 1000 0011 0001 0010 0110 1111

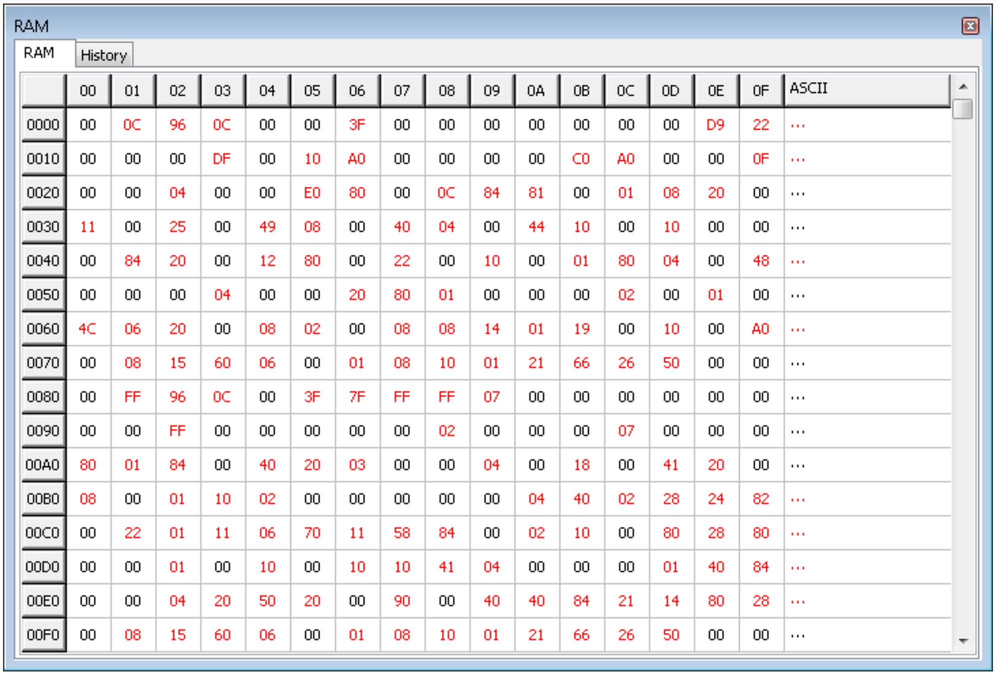
Representation: ○ Dec ○ Hex ● Bin ○ Float ○ Char

☑ Signed

View RAM Window

The Software Simulator RAM Window is available from the drop-down menu, **View › Debug Windows › View RAM.**

The View RAM Window displays the map of PIC's RAM, with recently changed items colored red.



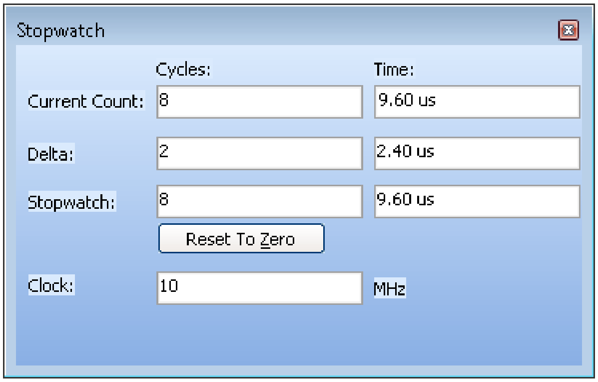
	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	ASCII
0000	00	0C	96	0C	00	00	3F	00	00	00	00	00	00	00	D9	22	...
0010	00	00	00	DF	00	10	A0	00	00	00	00	C0	A0	00	00	0F	...
0020	00	00	04	00	00	E0	80	00	0C	84	81	00	01	08	20	00	...
0030	11	00	25	00	49	08	00	40	04	00	44	10	00	10	00	00	...
0040	00	84	20	00	12	80	00	22	00	10	00	01	80	04	00	48	...
0050	00	00	00	04	00	00	20	80	01	00	00	00	02	00	01	00	...
0060	4C	06	20	00	08	02	00	08	08	14	01	19	00	10	00	A0	...
0070	00	08	15	60	06	00	01	08	10	01	21	66	26	50	00	00	...
0080	00	FF	96	0C	00	3F	7F	FF	FF	07	00	00	00	00	00	00	...
0090	00	00	FF	00	00	00	00	00	02	00	00	00	07	00	00	00	...
00A0	80	01	84	00	40	20	03	00	00	04	00	18	00	41	20	00	...
00B0	08	00	01	10	02	00	00	00	00	00	04	40	02	28	24	82	...
00C0	00	22	01	11	06	70	11	58	84	00	02	10	00	80	28	80	...
00D0	00	00	01	00	10	00	10	10	41	04	00	00	00	01	40	84	...
00E0	00	00	04	20	50	20	00	90	00	40	40	84	21	14	80	28	...
00F0	00	08	15	60	06	00	01	08	10	01	21	66	26	50	00	00	...

Stopwatch Window

The Software Simulator Stopwatch Window is available from the drop-down menu, **View › Debug Windows › Stopwatch.**

The Stopwatch Window displays *a current count* of cycles/time since the last Software Simulator action. Stopwatch measures the execution time (number of cycles) from the moment Software Simulator has started and can be reset at any time. *Delta* represents the number of cycles between the lines where Software Simulator action has started and ended.

Note: The user can change the clock in the Stopwatch Window, which will recalculate values for the latest specified frequency. Changing the clock in the Stopwatch Window does not affect actual project settings – it only provides a simulation.



	Cycles:	Time:
Current Count:	8	9.60 us
Delta:	2	2.40 us
Stopwatch:	8	9.60 us

Clock: 10 MHz

SOFTWARE SIMULATOR OPTIONS

Name	Description	Function Key	Toolbar Icon
Start Debugger	Start Software Simulator.	[F9]	
Run/Pause Debugger	Run or pause Software Simulator.	[F6]	
Stop Debugger	Stop Software Simulator.	[Ctrl+F2]	
Toggle Breakpoints	Toggle breakpoint at the current cursor position. To view all breakpoints, select Run > View Breakpoints from the drop–down menu. Double clicking an item in the Breakpoints Window List locates the breakpoint.	[F5]	
Run to cursor	Execute all instructions between the current instruction and cursor position.	[F4]	
Step Into	Execute the current Basic (single or multi–cycle) instruction, then halt. If the instruction is a routine call, enter the routine and halt at the first instruction following the call.	[F7]	
Step Over	Execute the current Basic (single or multi–cycle) instruction, then halt.	[F8]	
Step Out	Execute all remaining instructions in the current routine, return and then halt.	[Ctrl+F8]	

Related topics: Run Menu, Debug Toolbar

CREATING NEW LIBRARY

mikroBasic PRO for PIC allows you to create your own libraries. In order to create a library in *mikroBasic PRO for PIC* follow the steps bellow:

1. Create a new Basic source file, see Managing Source Files
2. Save the file in the compiler's Uses folder:
   `DriveName:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Uses\P16\`
   `DriveName:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Uses\P18\`
   If you are creating library for PIC16 MCU family the file should be saved in P16 folder.
   If you are creating library for PIC18 MCU family the file should be saved in P18 folder.
   If you are creating library for PIC16 and PIC18 MCU families the file should be saved in both folders.
3. Write a code for your library and save it.
4. Add `__Lib_Example` file in some project, see Project Manager. Recompile the project.
   If you wish to use this library for all MCUs, then you should go to **Tools › Options › Output settings**, and check **Build all files as library** box.
   This will build libraries in a common form which will work with all MCUs. If this box is not checked, then the library will be built for selected MCU.
   Bear in mind that compiler will report an error if a library built for specific MCU is used for another one.
5. Compiled file `__Lib_Example.mcl` should appear in `...\mikroBasic PRO for PIC\Uses\P16\` folder.
6. Open the definition file for the MCU that you want to use. This file is placed in the compiler's Defs folder:
   `DriveName:\Program Files\Mikroelektronika\mikroBasic PRO for PIC\Defs\`
   and it is named `MCU_NAME.mlk`, for example `P16F887.mlk`
7. Add the the following segment of code to `<LIBRARIES>` node of the definition file (definition file is in XML format):

```
<LIB>
   <ALIAS>Example_Library</ALIAS>
   <FILE>__Lib_Example</FILE>
   <TYPE>REGULAR</TYPE>
</LIB>
```

8. Add Library to mlk file for each MCU that you want to use with your library.
9. Click Refresh button in Library Manager
10. `Example_Library` should appear in the Library manager window.

Multiple Library Versions

Library Alias represents unique name that is linked to corresponding Library `.mcl` file. For example UART library for 16F887 is different from UART library for 18F4520 MCU. Therefore, two different UART Library versions were made, see `mlk` files for these two MCUs. Note that these two libraries have the same Library Alias (UART) in both `mlk` files. This approach enables you to have identical representation of UART library for both MCUs in Library Manager.

Related topics: Library Manager, Project Manager, Managing Source Files

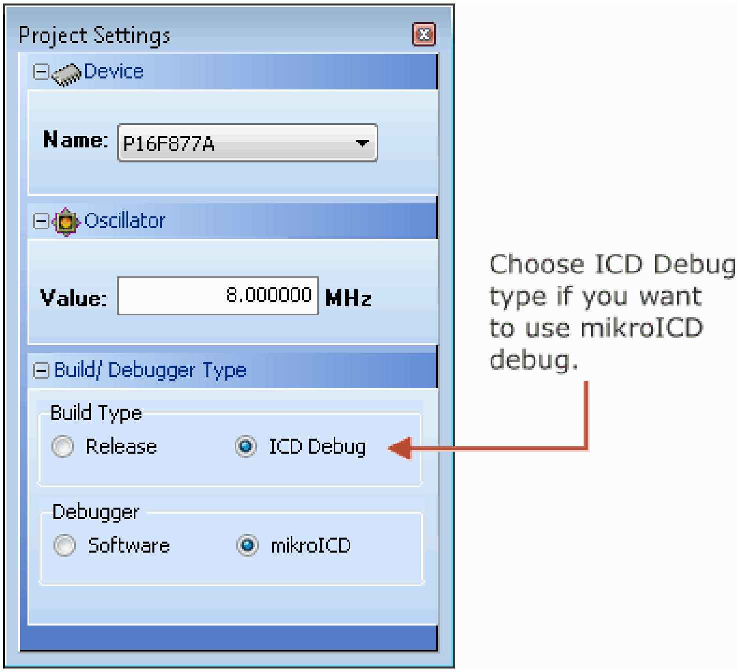
CHAPTER 3

MIKROICD (IN-CIRCUIT DEBUGGER)

mikroICD is highly effective tool for **Real-Time debugging** on hardware level. ICD debugger enables you to execute a *mikroBasic PRO for PIC* program on a host PIC microcontroller and view variable values, Special Function Registers (SFR), memory and EEPROM as the program is running.

Step No. 1

If you have appropriate hardware and software for using mikroICD then you have to upon completion of writing your program to choose between **Release** build Type or **ICD Debug** build type.



Project Settings

Device

Name: P16F877A

Oscillator

Value: 8.000000 MHz

Build/ Debugger Type

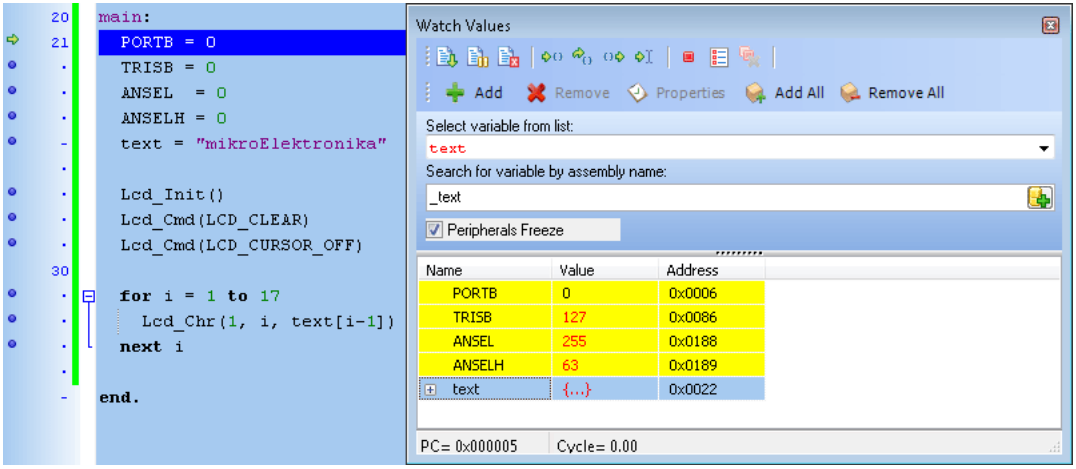
Build Type
○ Release ● ICD Debug

Debugger
○ Software ● mikroICD

Choose ICD Debug type if you want to use mikroICD debug.

Step No. 2

You can run the mikroICD by selecting **Run › Debug** from the drop-down menu, or by clicking Debug Icon . Starting the Debugger makes more options available: Step Into, Step Over, Run to Cursor, etc. Line that is to be executed is color highlighted (blue by default). There is also notification about program execution and it can be found on Watch Window (yellow status bar). Note that some functions take time to execute, so running of program is indicated on Watch Window.



```
main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(LCD_CLEAR)
  Lcd_Cmd(LCD_CURSOR_OFF)

  for i = 1 to 17
    Lcd_Chr(1, i, text[i-1])
  next i

end.
```

Select variable from list: text

Search for variable by assembly name: _text

☑ Peripherals Freeze

Name	Value	Address
PORTB	0	0x0006
TRISB	127	0x0086
ANSEL	255	0x0188
ANSELH	63	0x0189
text	{...}	0x0022

PC= 0x000005 Cycle= 0.00

mikroICD Debugger Optional

Name	Description	Function Key
`+Debug`	Start Software Simulator.	[F9]
`Run/Pause Debugger`	Run or pause Software Simulator.	[F6]
`Toggle Breakpoints`	Toggle breakpoint at the current cursor position. To view all breakpoints, select Run > View Breakpoints from the drop–down menu. Double clicking an item in the window list locates the breakpoint.	[F5]
`Run to cursor`	Execute all instructions between the current instruction and cursor position.	[F4]
`Step Into`	Execute the current C (single– or multi–cycle) instruction, then halt. If the instruction is a routine call, enter the routine and halt at the first instruction following the call.	[F7]
`Step Over`	Execute the current C (single– or multi–cycle) instruction, then halt. If the instruction is a routine call, skip it and halt at the first instruction following the call.	[F8]
`Flush RAM`	Flushes current PIC RAM. All variable values will be changed according to values from watch window.	N/A
`Disassembly View`	Toggle between disassembly and Basic source view.	[Alt+D]

MIKROICD DEBUGGER EXAMPLE

Here is a step by step mikroICD Debugger Example.

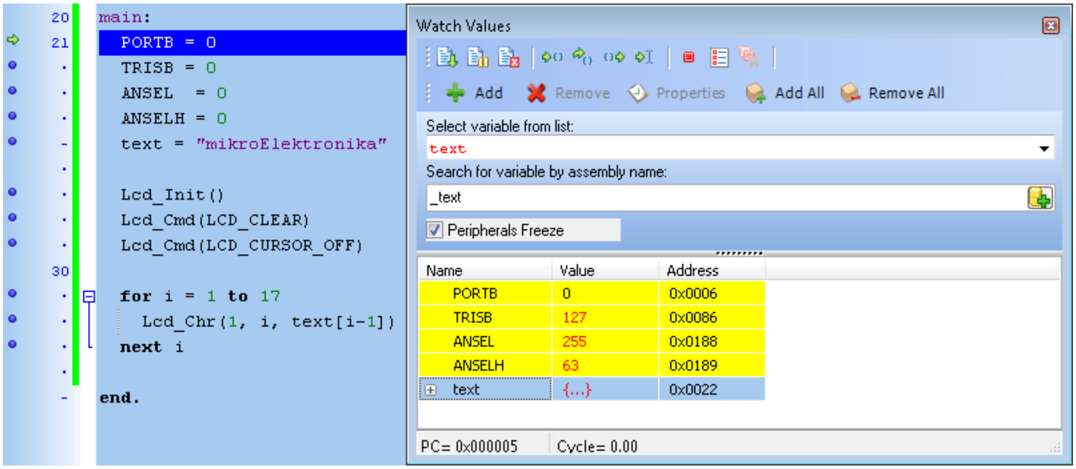
Step No. 1

First you have to write a program. We will show how mikroICD works using this example:

```
program Lcd_Test

dim LCD_RS as sbit at RB4_bit
dim LCD_EN as sbit at RB5_bit
dim LCD_D4 as sbit at RB0_bit
dim LCD_D5 as sbit at RB1_bit
dim LCD_D6 as sbit at RB2_bit
dim LCD_D7 as sbit at RB3_bit

dim LCD_RS_Direction as sbit at TRISB4_bit
dim LCD_EN_Direction as sbit at TRISB5_bit
dim LCD_D4_Direction as sbit at TRISB0_bit
dim LCD_D5_Direction as sbit at TRISB1_bit
dim LCD_D6_Direction as sbit at TRISB2_bit
dim LCD_D7_Direction as sbit at TRISB3_bit

dim text as char[17]
    i     as byte

main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(_LCD_CLEAR)
  Lcd_Cmd(_LCD_CURSOR_OFF)

  for i=1 to 17
    Lcd_Chr(1,i,text[i-1])
  next i

end.
```

Step No. 2

After successful compilation and PIC programming press **F9** for starting mikroICD. After mikroICD initialization blue active line should appear.



```
main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(LCD_CLEAR)
  Lcd_Cmd(LCD_CURSOR_OFF)

  for i = 1 to 17
    Lcd_Chr(1, i, text[i-1])
  next i

end.
```

Select variable from list: text

Search for variable by assembly name: _text

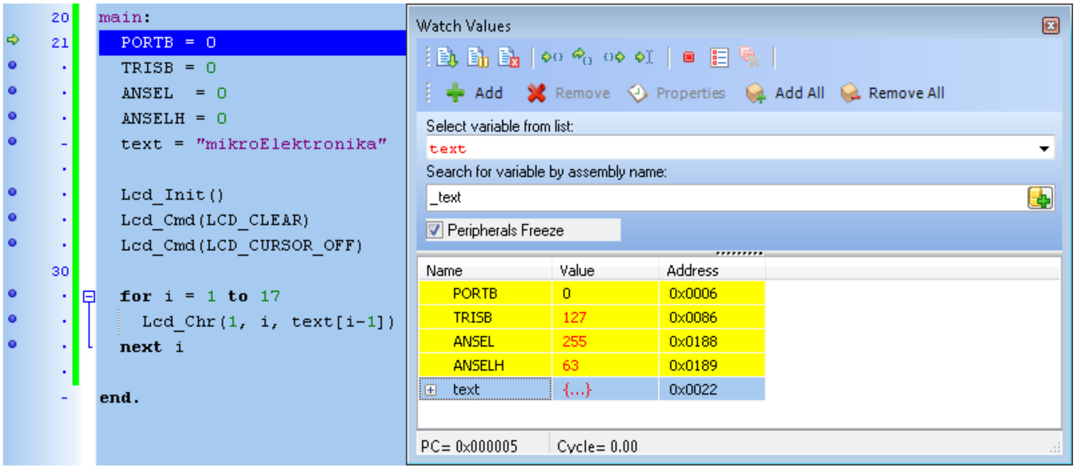
☑ Peripherals Freeze

Name	Value	Address
PORTB	0	0x0006
TRISB	127	0x0086
ANSEL	255	0x0188
ANSELH	63	0x0189
⊞ text	{...}	0x0022

PC= 0x000005 Cycle= 0.00

Step No. 3

We will debug program line by line. Pressing **F8** we are executing code line by line. It is recommended that user does not use Step Into **[F7]** and Step Over **[F8]** over Delays routines and routines containing delays. Instead use Run to cursor **[F4]** and Breakpoints functions. All changes are read from PIC and loaded into Watch Window. Note that **PORTB, TRISB, ANSEL** and **ANSELH** changed its value.



```
main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(LCD_CLEAR)
  Lcd_Cmd(LCD_CURSOR_OFF)

  for i = 1 to 17
    Lcd_Chr(1, i, text[i-1])
  next i

end.
```

Select variable from list: text

Search for variable by assembly name: _text

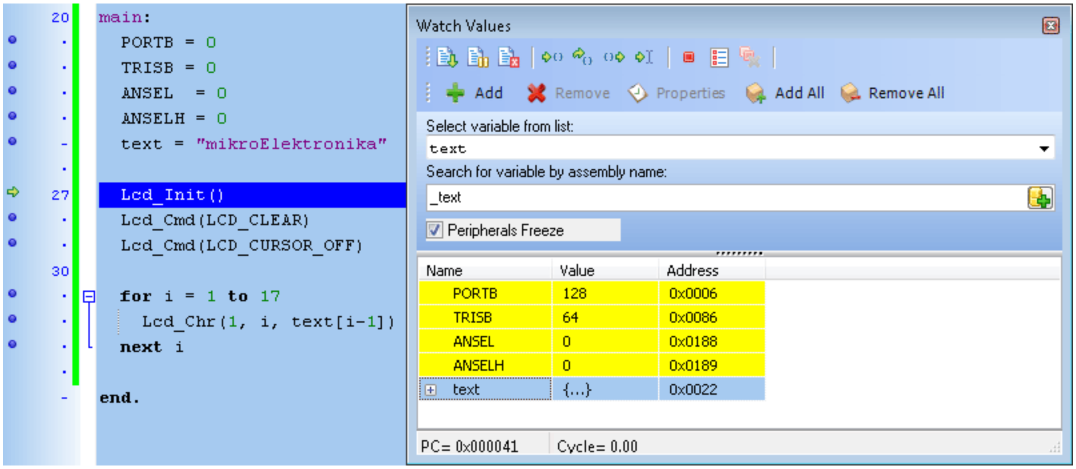
☑ Peripherals Freeze

Name	Value	Address
PORTB	0	0x0006
TRISB	127	0x0086
ANSEL	255	0x0188
ANSELH	63	0x0189
⊞ text	{...}	0x0022

PC= 0x000005 Cycle= 0.00

Step No. 4

Step Into **[F7]** and Step Over **[F8]** are mikroICD debugger functions that are used in stepping mode. There is also Real-Time mode supported by mikroICD. Functions that are used in Real-Time mode are Run/ Pause Debugger **[F6]** and Run to cursor **[F4]**. Pressing **F4** goes to line selected by user. User just have to select line with cursor and press **F4**, and code will be executed until selected line is reached.



```
main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(LCD_CLEAR)
  Lcd_Cmd(LCD_CURSOR_OFF)

  for i = 1 to 17
    Lcd_Chr(1, i, text[i-1])
  next i

end.
```

Select variable from list: text

Search for variable by assembly name: _text

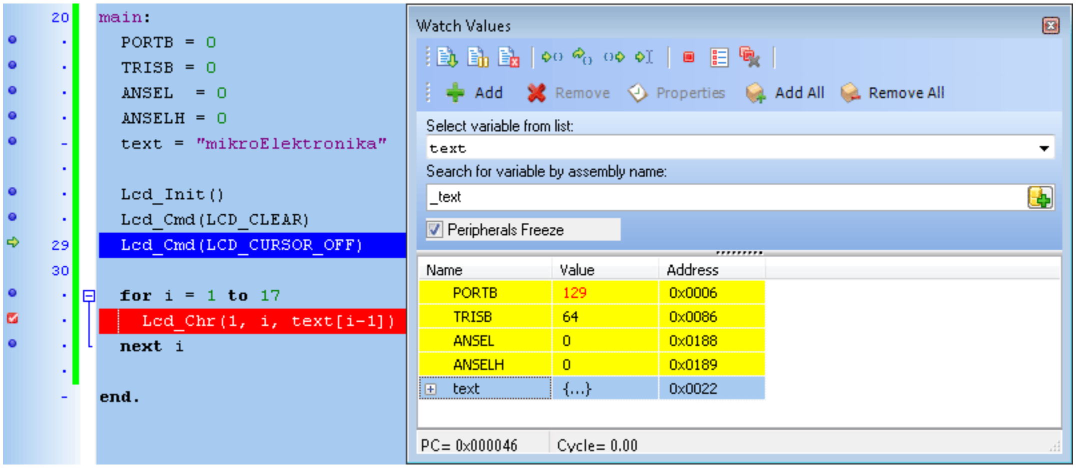
☑ Peripherals Freeze

Name	Value	Address
PORTB	128	0x0006
TRISB	64	0x0086
ANSEL	0	0x0188
ANSELH	0	0x0189
⊞ text	{...}	0x0022

PC= 0x000041 Cycle= 0.00

Step No. 5

Run(Pause) Debugger **[F6]** and Toggle Breakpoints **[F5]** are mikroICD debugger functions that are used in Real-Time mode. Pressing **F5** marks line selected by user for breakpoint. **F6** executes code until breakpoint is reached. After reaching breakpoint Debugger halts. Here at our example we will use breakpoints for writing "mikroElektronika" on Lcd char by char. Breakpoint is set on Lcd_Chr and program will stop everytime this function is reached. After reaching breakpoint we must press **F6** again for continuing program execution.



```
main:
  PORTB = 0
  TRISB = 0
  ANSEL  = 0
  ANSELH = 0
  text = "mikroElektronika"

  Lcd_Init()
  Lcd_Cmd(LCD_CLEAR)
  Lcd_Cmd(LCD_CURSOR_OFF)

  for i = 1 to 17
    Lcd_Chr(1, i, text[i-1])
  next i

end.
```

Select variable from list: text

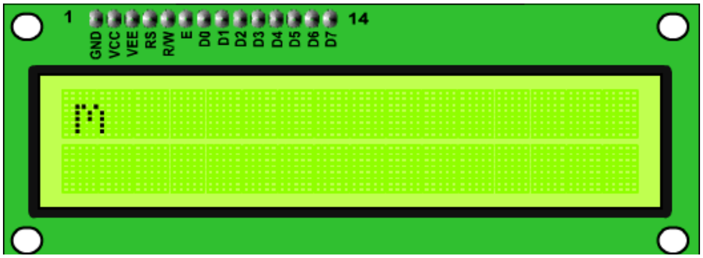
Search for variable by assembly name: _text

☑ Peripherals Freeze

Name	Value	Address
PORTB	129	0x0006
TRISB	64	0x0086
ANSEL	0	0x0188
ANSELH	0	0x0189
⊞ text	{...}	0x0022

PC= 0x000046 Cycle= 0.00

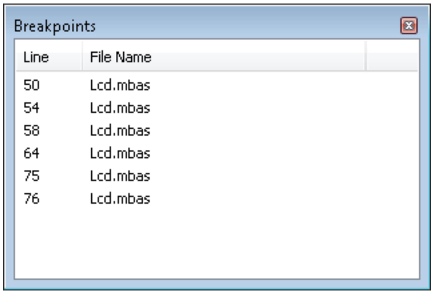
Breakpoints has been separated into two groups. There are hardware and software break points. Hardware breakpoints are placed in PIC and they provide fastest debug. Number of hardware breakpoints is limited (1 for P16 and 1 or 3 or 5 for P18). If all hardware brekpoints are used, next breakpoints that will be used are software breakpoint. Those breakpoints are placed inside mikroICD, and they simulate hardware breakpoints. Software breakpoints are much slower than hardware breakpoints. This differences between hardware and software differences are not visible in mikroICD software but their different timings are quite notable, so it is important to know that there is two types of breakpoints.



MIKROICD (IN-CIRCUIT DEBUGGER) OVERVIEW

Breakpoints Window

The Breakpoints window manages the list of currently set breakpoints in the project. Doubleclicking the desired breakpoint will cause cursor to navigate to the corresponding location in source code.

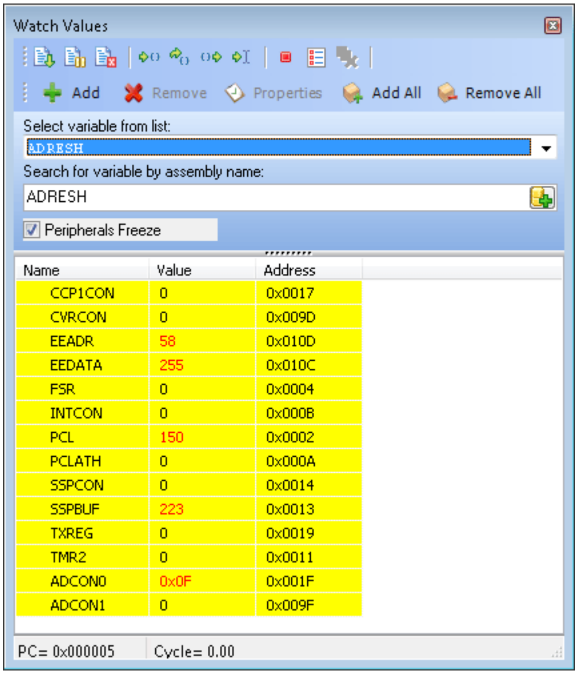


Line	File Name
50	Lcd.mbas
54	Lcd.mbas
58	Lcd.mbas
64	Lcd.mbas
75	Lcd.mbas
76	Lcd.mbas

Watch Window

Debugger Watch Window is the main Debugger window which allows you to monitor program items while running your program. To show the Watch Window, select **View › Debug Windows › Watch Window** from the drop-down menu.

The Watch Window displays variables and registers of PIC, with their addresses and values. Values are updated as you go through the simulation. Use the drop-down menu to add and remove the items that you want to monitor. Recently changed items are colored red.



Select variable from list: ADRESH

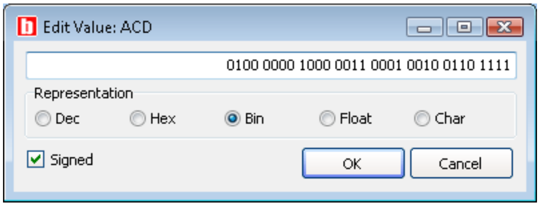
Search for variable by assembly name: ADRESH

☑ Peripherals Freeze

Name	Value	Address
CCP1CON	0	0x0017
CVRCON	0	0x009D
EEADR	58	0x010D
EEDATA	255	0x010C
FSR	0	0x0004
INTCON	0	0x000B
PCL	150	0x0002
PCLATH	0	0x000A
SSPCON	0	0x0014
SSPBUF	223	0x0013
TXREG	0	0x0019
TMR2	0	0x0011
ADCON0	0x0F	0x001F
ADCON1	0	0x009F

PC= 0x000005 Cycle= 0.00

Double clicking an item opens the Edit Value window in which you can assign a new value to the selected variable/register. Also, you can change view to binary, hex, char, or decimal for the selected item.



Edit Value: ACD

0100 0000 1000 0011 0001 0010 0110 1111

Representation

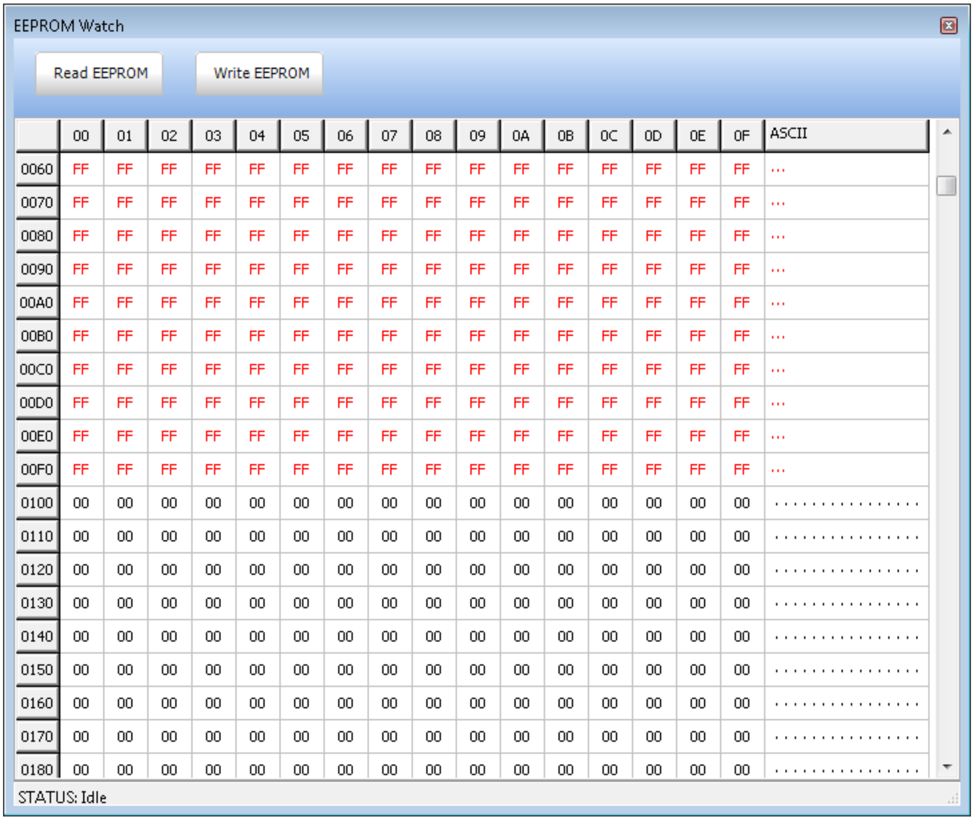
○ Dec ○ Hex ● Bin ○ Float ○ Char

☑ Signed

EEPROM Watch Window

mikroICD EEPROM Watch Window is available from the drop-down menu, View › **Debug Windows › View EEPROM.**

The EEPROM Watch window shows current values written into PIC internal EEPROM memory. There are two action buttons concerning EEPROM Watch window - **Write EEPROM** and **Read EEPROM. Write EEPROM** writes data from EEPROM Watch window into PIC internal EEPROM memory. **Read EEPROM** reads data from PIC internal EEPROM memory and loads it up in EEPROM window.



EEPROM Watch

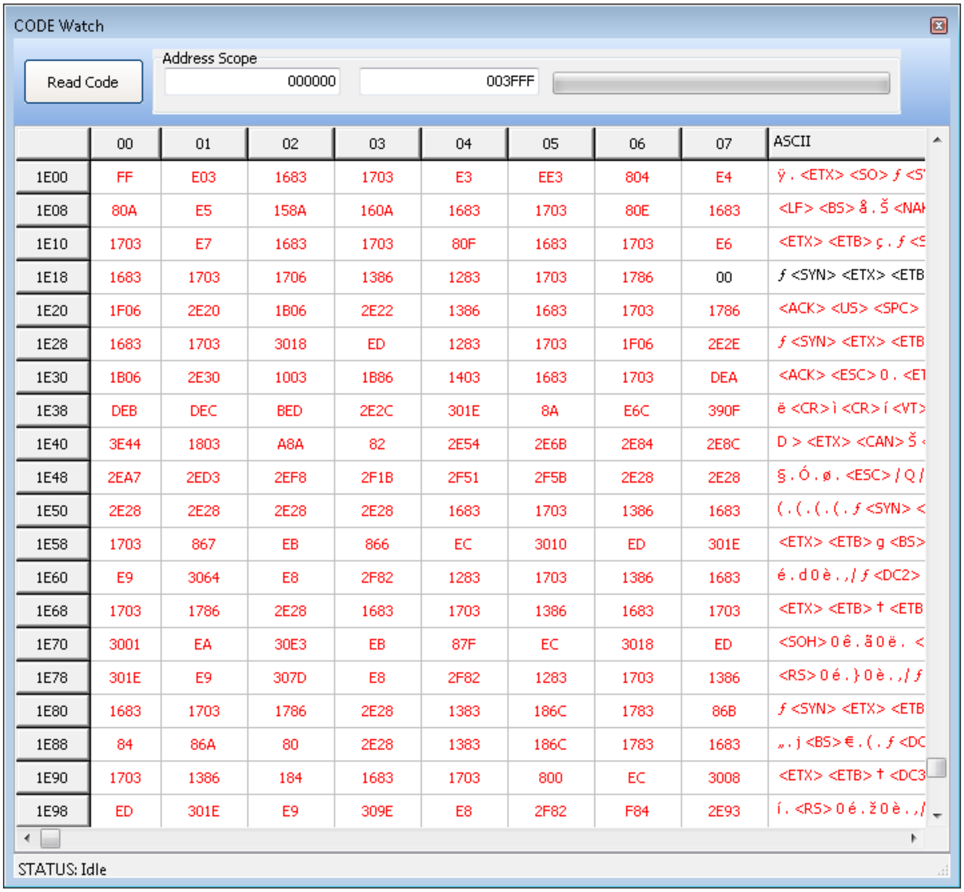
	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	ASCII
0060	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
0070	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
0080	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
0090	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00A0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00B0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00C0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00D0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00E0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
00F0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	...
0100	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0110	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0120	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0130	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0150	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0160	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0170	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
0180	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....

STATUS: Idle

Code Watch Window

mikroICD Code Watch Window is available from the drop-down menu, **View › Debug Windows › View Code.**

The Code Watch window shows code (hex code) written into PIC. There is action button concerning Code Watch window - **Read Code. Read Code** reads code from PIC and loads it up in View Code Window.
Also, you can set an address scope in which hex code will be read.



Address Scope: 000000 003FFF

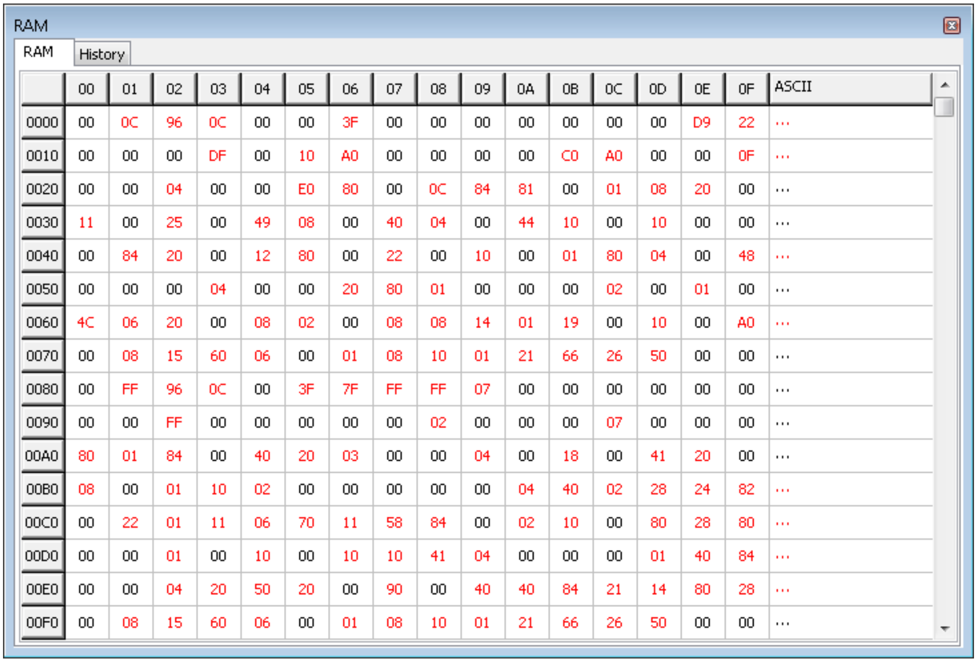
	00	01	02	03	04	05	06	07	ASCII
1E00	FF	E03	1683	1703	E3	EE3	804	E4	ÿ . <ETX> <SO> ƒ <S
1E08	80A	E5	158A	160A	1683	1703	80E	1683	<LF> <BS> å . Š <NA
1E10	1703	E7	1683	1703	80F	1683	1703	E6	<ETX> <ETB> ç . ƒ <
1E18	1683	1703	1706	1386	1283	1703	1786	00	ƒ <SYN> <ETX> <ETB
1E20	1F06	2E20	1B06	2E22	1386	1683	1703	1786	<ACK> <US> <SPC>
1E28	1683	1703	3018	ED	1283	1703	1F06	2E2E	ƒ <SYN> <ETX> <ETB
1E30	1B06	2E30	1003	1B86	1403	1683	1703	DEA	<ACK> <ESC> 0 . <E
1E38	DEB	DEC	BED	2E2C	301E	8A	E6C	390F	ë <CR> ì <CR> í <VT>
1E40	3E44	1803	A8A	82	2E54	2E6B	2E84	2E8C	D > <ETX> <CAN> Š
1E48	2EA7	2ED3	2EF8	2F1B	2F51	2F5B	2E28	2E28	§ . Ó . ø . <ESC> / Q /
1E50	2E28	2E28	2E28	2E28	1683	1703	1386	1683	(. (. (. (. ƒ <SYN> <
1E58	1703	867	EB	866	EC	3010	ED	301E	<ETX> <ETB> g <BS>
1E60	E9	3064	E8	2F82	1283	1703	1386	1683	é . d 0 è . , / ƒ <DC2>
1E68	1703	1786	2E28	1683	1703	1386	1683	1703	<ETX> <ETB> † <ETB
1E70	3001	EA	30E3	EB	87F	EC	3018	ED	<SOH> 0 ê . ă 0 ë . <
1E78	301E	E9	307D	E8	2F82	1283	1703	1386	<RS> 0 é . } 0 è . , / ƒ
1E80	1683	1703	1786	2E28	1383	186C	1783	86B	ƒ <SYN> <ETX> <ETB
1E88	84	86A	80	2E28	1383	186C	1783	1683	„ . j <BS> € . (. ƒ <DC
1E90	1703	1386	184	1683	1703	800	EC	3008	<ETX> <ETB> † <DC3
1E98	ED	301E	E9	309E	E8	2F82	F84	2E93	í . <RS> 0 é . ž 0 è . , /

STATUS: Idle

View RAM Window

Debugger View RAM Window is available from the drop-down menu, **View › Debug Windows › View RAM.**

The View RAM Window displays the map of PIC's RAM, with recently changed items colored red.



	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	ASCII
0000	00	0C	96	0C	00	00	3F	00	00	00	00	00	00	00	D9	22	···
0010	00	00	00	DF	00	10	A0	00	00	00	00	C0	A0	00	00	0F	···
0020	00	00	04	00	00	E0	80	00	0C	84	81	00	01	08	20	00	···
0030	11	00	25	00	49	08	00	40	04	00	44	10	00	10	00	00	···
0040	00	84	20	00	12	80	00	22	00	10	00	01	80	04	00	48	···
0050	00	00	00	04	00	00	20	80	01	00	00	00	02	00	01	00	···
0060	4C	06	20	00	08	02	00	08	08	14	01	19	00	10	00	A0	···
0070	00	08	15	60	06	00	01	08	10	01	21	66	26	50	00	00	···
0080	00	FF	96	0C	00	3F	7F	FF	FF	07	00	00	00	00	00	00	···
0090	00	00	FF	00	00	00	00	00	02	00	00	00	07	00	00	00	···
00A0	80	01	84	00	40	20	03	00	00	04	00	18	00	41	20	00	···
00B0	08	00	01	10	02	00	00	00	00	00	04	40	02	28	24	82	···
00C0	00	22	01	11	06	70	11	58	84	00	02	10	00	80	28	80	···
00D0	00	00	01	00	10	00	10	10	41	04	00	00	00	01	40	84	···
00E0	00	00	04	20	50	20	00	90	00	40	40	84	21	14	80	28	···
00F0	00	08	15	60	06	00	01	08	10	01	21	66	26	50	00	00	···

Common Errors

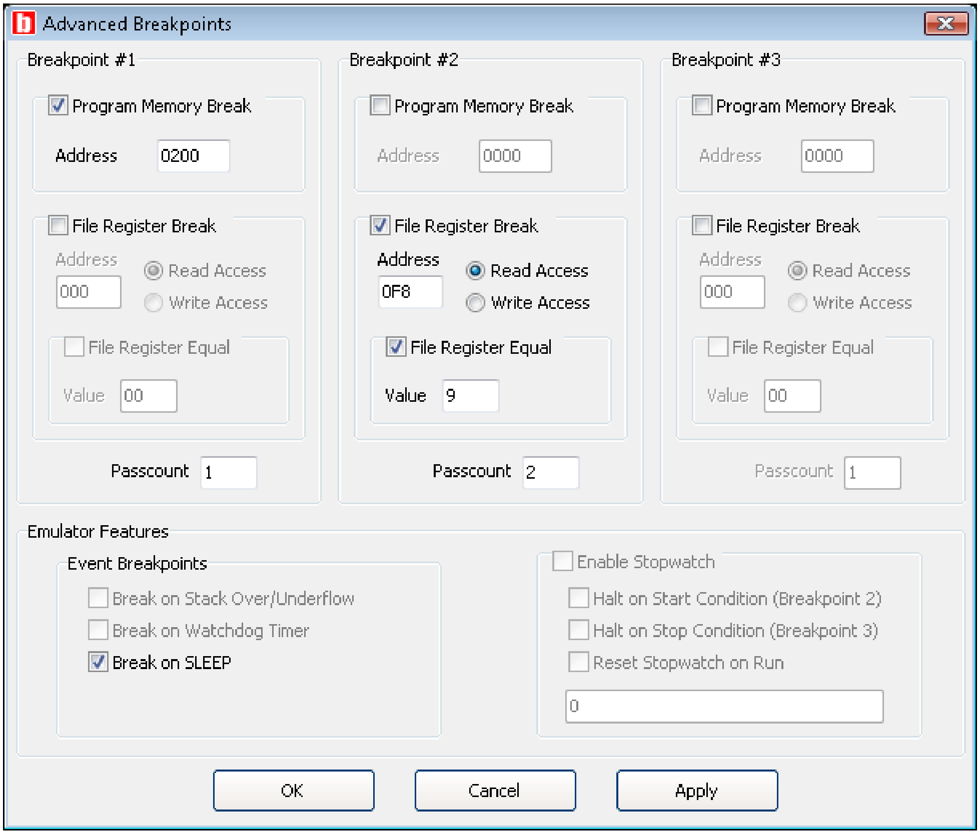
- Trying to program PIC while mikroICD is active.
- Trying to debug **Release** build Type version of program.
- Trying to debug changed program code which hasn't been compiled and programmed into PIC.
- Trying to select line that is empty for Run to cursor **[F4]** and Toggle Break points **[F5]** functions.
- Trying to debug PIC with mikroICD while Watch Dog Timer is enabled.
- Trying to debug PIC with mikroICD while Power Up Timer is enabled.
- It is not possible to force Code Protect while trying to debug PIC with mikroICD.
- Trying to debug PIC with mikroICD with pull-up resistors set to ON on RB6 and RB7.
- For correct mikroICD debugging do not use pull-ups.

MIKRO ICD ADVANCED BREAKPOINTS

mikro ICD provides the possibility to use the Advanced Breakpoints. Advanced Breakpoints can be used with PIC18 and PIC18FJ MCUs. To enable Advanced Breakpoints set the *Advanced Breakpoints* checkbox inside Watch window :

☑ Advanced Breakpoints

To configure Advanced Breakpoints, start mikroICD **[F9]** and select **View › Debug Windows › Advanced Breakpoints** option from the drop-down menu or use **[Ctrl+Shift+A]** shortcut



Advanced Breakpoints

Breakpoint #1
☑ Program Memory Break
Address 0200
☐ File Register Break
Address 000
● Read Access
○ Write Access
☐ File Register Equal
Value 00
Passcount 1

Breakpoint #2
☐ Program Memory Break
Address 0000
☑ File Register Break
Address 0F8
● Read Access
○ Write Access
☑ File Register Equal
Value 9
Passcount 2

Breakpoint #3
☐ Program Memory Break
Address 0000
☐ File Register Break
Address 000
● Read Access
○ Write Access
☐ File Register Equal
Value 00
Passcount 1

Emulator Features
Event Breakpoints
☐ Break on Stack Over/Underflow
☐ Break on Watchdog Timer
☑ Break on SLEEP

☐ Enable Stopwatch
☐ Halt on Start Condition (Breakpoint 2)
☐ Halt on Stop Condition (Breakpoint 3)
☐ Reset Stopwatch on Run
0

Note: When Advanced Breakpoints are enabled mikroICD operates in Real-Time mode, so it will support only the following set of commands: `Start Debugger` **[F9]**, `Run/Pause Debugger` **[F6]** and `Stop Debugger` **[Ctrl+F2]**. Once the Advanced Breakpoint is reached, the Advanced Breakpoints feature can be disabled and mikroICD debugging can be continued with full set of commands. If needed, Advanced Breakepoints can be re-enabled without restarting mikroICD.

Note: Number of Advanced Breakpoints is equal to number of Hardware breakpoints and it depends on used MCU.

Program Memory Break

Program Memory Break is used to set the Advanced Breakpoint to the specific address in program memory. Because of PIC pipelining mechanism program execution may stop one or two instructions after the address entered in the `Address` field. Value entered in the `Address` field must be in hex format.

Note: Program Memory Break can use the Passcount option. The program execution will stop when the specified program address is reached for the N-th time, where N is the number entered in the `Passcount` field. When some Advanced Breakpoint stops the program execution, passcount counters for all Advanced Breakpoints will be cleared.

File Register Break

File Register Break can be used to stop the code execution when read/write access to the specific data memory location occurs. If `Read Access` is selected, the *File Register Equal* option can be used to set the matching value. The program execution will be stopped when the value read from the specified data memory location is equal to the number written in the `Value` field. Values entered in the `Address` and `Value` fields must be in hex format.

Note: File Register Break can also use the Passcount option in the same way as Program Memory Break.

Emulator Features

Event Breakpoints

- **Break on Stack Overflow/Underflow** : not implemented.
- **Break on Watchdog Timer** : not implemented.
- **Break on SLEEP** : break on SLEEP instruction. SLEEP instruction will not be executed. If you choose to continue the mikroICD debugging **[F6]** then the program execution will start from the first instruction following the SLEEP instruction.

Stopwatch

Stopwatch uses Breakpoint#2 and Breakpoint#3 as a Start and Stop conditions. To use the Stopwatch define these two Breakpoints and check the Enable Stopwatch checkbox.

Stopwatch options:

- **Halt on Start Condition (Breakpoint#2)**: when checked, the program exe cution will stop on `Breakpoint#2`. Otherwise, `Breakpoint#2` will be used only to start the Stopwatch.
- **Halt on Stop Condition (Breakpoint#3):** when checked, the program exe cution will stop on `Breakpoint#3`. Otherwise, `Breakpoint#3` will be used only to stop the Stopwatch.
- **Reset Stopwatch on Run** : when checked, the Stopwatch will be cleared before continuing program execution and the next counting will start from zero. Otherwise, the next counting will start from the previous Stopwatch value.

CHAPTER 4

mikroBasic PRO for PIC Specifics

The following topics cover the specifics of mikroBasic PRO for PICcompiler:

- Basic Standard Issues
- Predefined Globals and Constants
- Accessing Individual Bits
- Interrupts
- PIC Pointers
- Linker Directives
- Built-in Routines
- Code Optimization

BASIC STANDARD ISSUES

Divergence from the Basic Standard

- Function recursion is not supported because of no easily-usable stack and limited memory PIC Specific

Basic Language Extensions

mikroBasic PRO for PIC has additional set of keywords that do not belong to the standard Basic language keywords:

- `code`
- `data`
- `rx`
- `sfr`
- `at`
- `sbit`
- `bit`

Related topics: Keywords, PIC Specific

PREDEFINED GLOBALS AND CONSTANTS

In order to facilitate PIC programming, *mikroBasic PRO for PIC* implements a number of predefined globals and constants.

SFRs and related constants

All PIC SFRs are implicitly declared as global variables of `volatile word` type. These identifiers have an external linkage, and are visible in the entire project. When creating a project, the mikroBasic PRO for PIC will include an appropriate (`*.mbas`) file from defs folder, containing declarations of available SFRs and constants (such as PORTB, ADPCFG, etc). All identifiers are in upper case, identical to nomenclature in the Microchip datasheets.

For a complete set of predefined globals and constants, look for “Defs” in the mikroBasic PRO for PIC installation folder, or probe the Code Assistant for specific letters (**Ctrl+Space** in the Code Editor).

Math constants

In addition, several commonly used math constants are predefined in *mikroBasic PRO for PIC:*

```
PI         =  3.1415926
PI_HALF   =  1.5707963
TWO_PI    =  6.2831853
E          =  2.7182818
```

Predefined project level defines

These defines are based on a value that you have entered/edited in the current project, and it is equal to the name of selected device for the project.
If PIC16F887 is selected device, then PIC16F887 token will be defined as 1, so it can be used for conditional compilation:

```
#IFDEF P16F887
...
#ENDIF
```

Related topics: Project level defines

ACCESSING INDIVIDUAL BITS

The *mikroBasic PRO for PIC* allows you to access individual bits of 8-bit variables. It also supports `sbit` and `bit` data types

Accessing Individual Bits Of Variables

If you are familiar with a particular MCU, you can access bits by name:

```
' Clear bit 0 on PORTA
RA0_bit = 0
```

Also, you can simply use the direct member selector (.) with a variable, followed by one of identifiers B0, B1, … , B7, or 0, 1, … 7, with 7 being the most significant bit

```
' Clear bit 0 on PORTA
PORTA.B0 = 0

' Clear bit 5 on PORTB
PORTB.5 = 0
```

There is no need of any special declarations. This kind of selective access is an intrinsic feature of mikroBasic PRO for PIC and can be used anywhere in the code. Identifiers B0–B7 are not case sensitive and have a specific namespace. You may override them with your own members `B0-B7` within any given structure.

See Predefined Globals and Constants for more information on register/bit names.

sbit type

The *mikroBasic PRO for PIC* compiler has `sbit` data type which provides access to bit-addressable SFRs. You can access them in several ways:

```
dim LEDA as sbit at PORTA.B0
dim Name as sbit at sfr-name.B<bit-position>

dim LEDB as sbit at PORTB.0
dim Name as sbit at sfr-name.<bit-position>

dim LEDC as sbit at RC0_bit
dim Name as sbit at bit-name_bit;
```

bit type

The mikroBasic PRO for PIC compiler provides a bit data type that may be used for variable declarations. It can not be used for argument lists, and function-return values.

```
dim bf as bit   ' bit variable
```

There are no pointers to bit variables:

~~`dim ptr as ^bit`~~ `' invalid`

An array of type bit is not valid:

~~`dim arr as array[5] of bit`~~ `' invalid`

Note :

- Bit variables can not be initialized.
- Bit variables can not be members of structures.
- Bit variables do not have addresses, therefore unary operator @ (address of) is not applicable to these variables.

`Related topics: Predefined globals and constants`

INTERRUPTS

Interrupts can be easily handled by means of reserved word `interrupt`. mikroBasic PRO for PIC implictly declares procedure `interrupt` which cannot be redeclared.

Write your own procedure body to handle interrupts in your application. Note that you cannot call routines from within interrupt due to stack limitations.

mikroBasic PRO for PIC saves the following SFR on stack when entering interrupt and pops them back upon return:

- PIC12 family: `W, STATUS, FSR, PCLATH`
- PIC16 family: `W, STATUS, FSR, PCLATH`
- PIC18 family: `FSR` (fast context is used to save `WREG, STATUS, BSR`)

P18 priority interrupts

Note: For the P18 family both low and high interrupts are supported.

For P18 low priority interrupts reserved word is `interrupt_low:`

1. function with name `interrupt` will be linked as ISR (interrupt service rou tine) for high level interrupt
2. function with name `interrupt_low` will be linked as ISR for low level inter rupt_low

If interrupt priority feature is to be used then the user should set the appropriate SFR bits to enable it. For more information refer to datasheet for specific device.

Routine Calls from Interrupt

Calling functions and procedures from within the interrupt routine is now possible. The compiler takes care about the registers being used, both in "interrupt" and in "main" thread, and performs "smart" context-switching between the two, saving only the registers that have been used in both threads.

The functions and procedures that don't have their own frame (no arguments and local variables) can be called both from the interrupt and the "main" thread.

Interrupt Examples

Here is a simple example of handling the interrupts from TMR0 (if no other interrupts are allowed):

```
sub procedure interrupt
  counter = counter + 1
  TMR0 = 96
  INTCON = $20
end sub
```

In case of multiple interrupts enabled, you need to test which of the interrupts occurred and then proceed with the appropriate code (interrupt handling):

```
sub procedure interrupt
  if TestBit(INTCON, TMR0IF) = 1 then
    counter = counter + 1
    TMR0 = 96
    ClearBit(INTCON, TMR0F)
   ' ClearBit is realised as an inline function,
   ' and may be called from within an interrupt
  else
    if TestBit(INTCON, RBIF) = 1 then
      counter = counter + 1
      TMR0 = 96
      ClearBit(INTCON,RBIF)
    end if
  end if
end sub
```

LINKER DIRECTIVES

mikroBasic PRO for PIC uses internal algorithm to distribute objects within memory. If you need to have a variable or routine at the specific predefined address, use the linker directives `absolute` and `org`.

Note: You must specify an even address when using the linker directives.

Directive absolute

Directive `absolute` specifies the starting address in RAM for a variable. If the variable spans more than 1 word (16-bit), the higher words will be stored at the consecutive locations.
The `absolute` directive is appended to the declaration of a variable:

```
dim x as word absolute 0x32
' Variable x will occupy 1 word (16 bits) at address 0x32

dim y as longint absolute 0x34
' Variable y will occupy 2 words at addresses 0x34 and 0x36
```

Be careful when using the absolute directive because you may overlap two variables by accident. For example:

```
dim  i as word absolute 0x42
' Variable i will occupy 1 word at address 0x42;

dim jj as longint absolute 0x40
' Variable will occupy 2 words at 0x40 and 0x42; thus,
' changing i changes jj at the same time and vice versa
```

Note: You must specify an even address when using the directive `absolute`.

Directive org

The directive `org` specifies the starting address of a routine in ROM. It is appended to the declaration of routine. For example:

```
sub procedure proc(dim par as word) org 0x200
' Procedure will start at the address 0x200;
...
end sub
```

Note: You must specify an even address when using the directive `org`.

Directive orgal

Use the `orgall` directive to specify the address above which all routines, constants will be placed. Example:

```
main:
  orgall(0x200)  ' All the routines, constants in main program will
be above the address 0x200

  ...

end.
```

BUILT-IN ROUTINES

The *mikroBasic PRO for PIC* compiler provides a set of useful built-in utility functions.

The `Lo, Hi, Higher, Highest` routines are implemented as macros. If you want to use these functions you must include `built_in.h` header file (located in the `inlclude` folder of the compiler) into your project.

The `Delay_us` and `Delay_ms` routines are implemented as “inline”; i.e. code is generated in the place of a call, so the call doesn’t count against the nested call limit.

The `Vdelay_ms`, `Delay_Cyc` and `Get_Fosc_kHz` are actual Basic routines. Their sources can be found in `Delays.mbas` file located in the `uses` folder of the compiler.

- Lo
- Hi
- Higher
- Highest

- Inc
- Dec

- SetBit
- ClearBit
- TestBit

- Delay_us
- Delay_ms

- Clock_KHz
- Clock_MHz

- Reset
- ClrWdt

- DisableContextSaving

- SetFuncCall

- GetDateTime
- GetVersion

Lo

Prototype	`sub function Lo(number as longint) as byte`
Returns	Lowest 8 bits (byte)of `number`, bits 7..0.
Description	Function returns the lowest byte of `number`. Function does not interpret bit patterns of `number` – it merely returns 8 bits as found in register. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Arguments must be variable of scalar type (i.e. Arithmetic Types and Pointers).
Example	`d = 0x1AC30F4` `tmp = Lo(d)   ' Equals 0xF4`

Hi

Prototype	`sub function Hi(number as longint) as byte`
Returns	Returns next to the lowest byte of number, bits 8..15.
Description	Function returns next to the lowest byte of `number`. Function does not interpret bit patterns of `number` – it merely returns 8 bits as found in register. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Arguments must be variable of scalar type (i.e. Arithmetic Types and Pointers).
Example	`d = 0x1AC30F4` `tmp = Hi(d)   ' Equals 0x30`

Higher

Prototype	`sub function Higher(number as longint) as byte`
Returns	Returns next to the highest byte of `number`, bits 16..23.
Description	Function returns next to the highest byte of `number`. Function does not interpret bit patterns of `number` – it merely returns 8 bits as found in register. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Arguments must be variable of scalar type (i.e. Arithmetic Types and Pointers).
Example	`d = 0x1AC30F4` `tmp = Higher(d)   ' Equals 0xAC`

Highest

Prototype	`sub function Highest(number as longint) as byte`
Returns	Returns the highest byte of `number`, bits 24..31.
Description	Function returns the highest byte of `number`. Function does not interpret bit patterns of `number` – it merely returns 8 bits as found in register. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Arguments must be variable of scalar type (i.e. Arithmetic Types and Pointers).
Example	`d = 0x1AC30F4` `tmp = Highest(d)    ' Equals 0x01`

Inc

Prototype	`sub procedure Inc(dim byref par as longint)`
Returns	Nothing.
Description	Increases parameter `par` by 1.
Requires	Nothing.
Example	`p = 4` `Inc(p)    ' p is now 5`

Dec

Prototype	`sub procedure Dec(dim byref par as longint)`
Returns	Nothing.
Description	Decreases parameter `par` by 1.
Requires	Nothing.
Example	`p = 4` `Dec(p)    ' p is now 3`

Delay_us

Prototype	`sub procedure Delay_us(const time_in_us as longword)`
Returns	Nothing.
Description	Creates a software delay in duration of `time_in_us` microseconds (a constant). Range of applicable constants depends on the oscillator frequency. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Nothing.
Example	`Delay_us(1000)   ' One millisecond pause`

Delay_ms

Prototype	`sub procedure Delay_ms(const time_in_ms as longword)`
Returns	Nothing.
Description	Creates a software delay in duration of `time_in_ms` milliseconds (a constant). Range of applicable constants depends on the oscillator frequency. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Nothing.
Example	`Delay_ms(1000)   ' One second pause`

Clock_KHz

Prototype	`sub function Clock_Khz() as word`
Returns	Device clock in KHz, rounded to the nearest integer.
Description	Function returns device clock in KHz, rounded to the nearest integer. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Nothing.
Example	`clk = Clock_kHz()`

Clock_MHz

Prototype	`sub function Clock_MHz()as byte`
Returns	Device clock in MHz, rounded to the nearest integer.
Description	Function returns device clock in MHz, rounded to the nearest integer. This is an “inline” routine; code is generated in the place of the call, so the call doesn’t count against the nested call limit.
Requires	Nothing.
Example	`clk = Clock_MHz()`

Reset

Prototype	`sub procedure Reset`
Returns	Nothing.
Description	This procedure is equal to assembler instruction reset. This procedure works only for P18.
Requires	Nothing.
Example	`Reset 'Resets the PIC MCU`

ClrWdt

Prototype	`sub procedure ClrWdt`
Returns	Nothing.
Description	This procedure is equal to assembler instruction **clrwdt.**
Requires	Nothing.
Example	`ClrWdt 'Clears PIC's WDT`

DisableContextSaving

Prototype	`sub procedure DisableContextSaving()`
Returns	Nothing.
Description	Use the DisableContextSaving() to instruct the compiler not to automatically perform context-switching. This means that no regiser will be saved/restored by the compiler on entrance/exit from interrupt service routine. This enables the user to manually write code for saving registers upon entrance and to restore them before exit from interrupt.
Requires	Nothing.
Example	`DisableContextSaving() 'instruct the compiler not to automatically perform context-switching`

SetFuncCall

Prototype	`sub procedure SetFuncCall(FuncName as string)`
Returns	Nothing.
Description	Function informs the linker about a specific routine being called. SetFuncCall has to be called in a routine which accesses another routine via a pointer. Function prepares the caller tree, and informs linker about the procedure usage, making it possible to link the called routine.
Requires	Nothing.

Example

```
sub procedure first(p, q as byte)
...
  SetFuncCall(second)  ' let linker know that we will call the routine 'second'
...
end sub
```

GetDateTime

Prototype	`sub function GetDateTime() as string`
Returns	String with date and time when this routine is compiled.
Description	Use the GetDateTime() to get date and time of compilation as string in your code.
Requires	Nothing.
Example	`str : GetDateTime()`

GetVersion

Prototype	`sub function GetVersion() as string`
Returns	String with current compiler version.
Description	Use the GetVersion() to get the current version of compiler.
Requires	Nothing.
Example	`str = GetVersion() ' for example, str will take the value of '8.2.1.6'`

CODE OPTIMIZATION

Optimizer has been added to extend the compiler usability, cut down the amount of code generated and speed-up its execution. The main features are:

Constant folding

All expressions that can be evaluated in the compile time (i.e. are constant) are being replaced by their results. (3 + 5 -> 8);

Constant propagation

When a constant value is being assigned to a certain variable, the compiler recognizes this and replaces the use of the variable by constant in the code that follows, as long as the value of a variable remains unchanged.

Copy propagation

The compiler recognizes that two variables have the same value and eliminates one of them further in the code.

Value numbering

The compiler "recognizes" if two expressions yield the same result and can therefore eliminate the entire computation for one of them.

"Dead code" ellimination

The code snippets that are not being used elsewhere in the programme do not affect the final result of the application. They are automatically removed.

Stack allocation

Temporary registers ("Stacks") are being used more rationally, allowing VERY complex expressions to be evaluated with a minimum stack consumption.

Local vars optimization

No local variables are being used if their result does not affect some of the global or volatile variables.

Better code generation and local optimization

Code generation is more consistent and more attention is payed to implement specific solutions for the code "building bricks" that further reduce output code size.

CHAPTER 5

PIC Specifics

In order to get the most from your m*ikroBasic PRO for PIC* compiler, you should be familiar with certain aspects of PIC MCU. This knowledge is not essential, but it can provide you a better understanding of PICs' capabilities and limitations, and their impact on the code writing.

Types Efficiency

First of all, you should know that PIC's ALU, which performs arithmetic operations, is optimized for working with bytes. Although mikroBasic PRO for PIC is capable of handling very complex data types, PIC may choke on them, especially if you are working on some of the older models. This can dramatically increase the time needed for performing even simple operations. Universal advice is to use the smallest possible type in every situation. It applies to all programming in general, and doubly so with microcontrollers.

Get to know your tool. When it comes down to calculus, not all PIC MCUs are of equal performance. For example, PIC16 family lacks hardware resources to multiply two bytes, so it is compensated by a software algorithm. On the other hand, PIC18 family has HW multiplier, and multiplication works considerably faster.

Nested Calls Limitations

Nested call represents a function call within function body, either to itself (recursive calls) or to another function. Recursive calls, as form of cross-calling, are unsupported by mikroBasic PRO for PIC due to the PIC's stack and memory limitations.

mikroBasic PRO for PIC limits the number of non-recursive nested calls to:

- 8 calls for PIC12 family,
- 8 calls for PIC16 family,
- 31 calls for PIC18 family

Note that some of the built-in routines do not count against this limit, due to their "inline" implementation.

Number of the allowed nested calls decreases by one if you use any of the following operators in the code: * / %. It further decreases if you use interrupts in the program. Number of decreases is specified by number of functions called from interrupt. Check functions reentrancy.

If the allowed number of nested calls is exceeded, the compiler will report a stack overflow error.

PIC18FxxJxx Specifics

Shared Address SFRs

mikroBasic PRO for PIC does not provide auto setting of bit for acessing alternate register. This is new feature added to pic18fxxjxx family and will be supported in future. In several locations in the SFR bank, a single address is used to access two different hardware registers. In these cases, a “legacy” register of the standard PIC18 SFR set (such as OSCCON, T1CON, etc.) shares its address with an alternate register. These alternate registers are associated with enhanced configuration options for peripherals, or with new device features not included in the standard PIC18 SFR map. A complete list of shared register addresses and the registers associated with them is provided in datasheet.

PIC16 Specifics

Breaking Through Pages

In applications targeted at PIC16, no single routine should exceed one page (2,000 instructions). If routine does not fit within one page, linker will report an error. When confront with this problem, maybe you should rethink the design of your application – try breaking the particular routine into several chunks, etc.

Limits of Indirect Approach Through FSR

Pointers with PIC16 are “near”: they carry only the lower 8 bits of the address. Compiler will automatically clear the 9th bit upon startup, so that pointers will refer to banks 0 and 1. To access the objects in banks 2 or 3 via pointer, user should manually set the IRP, and restore it to zero after the operation.

Note: It is very important to take care of the IRP properly, if you plan to follow this approach. If you find this method to be inappropriate with too many variables, you might consider upgrading to PIC18.

Note: If you have many variables in the code, try rearranging them with linker directive absolute. Variables that are approached only directly should be moved to banks 3 and 4 for increased efficiency.

Related topics: mikroBasic PRO for PIC specifics

MEMORY TYPE SPECIFIERS

The mikroBasic PRO for PIC supports usage of all memory areas. Each variable may be explicitly assigned to a specific memory space by including a memory type specifier in the declaration, or implicitly assigned.

The following memory type specifiers can be used:

- `code`
- `data`
- `rx`
- `sfr`

Memory type specifiers can be included in svariable declaration.
For example:

```
dim data_buffer as byte data          ' puts data_buffer in data ram
const txt = "Enter parameter" code   ' puts text in program memory
```

code

Description	The `code` memory type may be used for allocating constants in program memory.
Example	`'puts txt in program memory` `const txt = "Enter parameter" code;`

data

Description	This memory specifier is used when storing variable to the internal data SRAM.
Example	`' puts data_buffer in data ram` `dim data_buffer as byte data`

rx

Description	This memory specifier allows variable to be stored in the Rx space (Register file). **Note:** In most of the cases, there will be enough space left for the user variables in the Rx space. However, since compiler uses Rx space for storing temporary variables, it might happen that user variables will be stored in the internal data SRAM, when writing complex programs.
Example	`' puts y in Rx space` `dim y as char rx`

sfr

Description	This memory specifier in combination with (rx, io, data) allows user to access special function registers. It also instructs compiler to maintain same identifier in Basic and assembly.

Example	`dim io_buff as byte io sfr      ' put io_buff in I/O memory space`
	`dim y as char rx sfr            ' puts y in Rx space`
	`dim temp as byte data sfr and dim temp as byte sfr are equivalent, and put temp in Extended I/O Space.`

Note: If none of the memory specifiers are used when declaring a variable, `data` specifier will be set as default by the compiler.

Related topics: Accessing individual bits, SFRs, Constants, Functions

CHAPTER 6

mikroBasic PRO for PIC Language Reference

The mikroBasic PRO for PIC Language Reference describes the syntax, semantics and implementation of the mikroBasic PRO for PIC language.

The aim of this reference guide is to provide a more understandable description of the mikroBasic PRO for PIC language to the user.

- **Lexical Elements**

    - Whitespace
    - Comments
    - Tokens

        - Literals
        - Keywords
        - Identifiers
        - Punctuators

- **Program Organization**
    - Program Organization
    - Scope and Visibility
    - Modules

- **Variables**
- **Constants**
- **Labels**
- **Symbols**
- **Functions and Procedures**

    - Functions
    - Procedures

- **Types**

    - Simple Types
    - Arrays
    - Strings
    - Pointers
    - Structures
    - Types Conversions

        - Implicit Conversion
        - Explicit Conversion

- **Operators**

    - Introduction to Operators
    - Operators Precedence and Associativity
    - Relational Operators
    - Bitwise Operators
    - Boolean Operators

LEXICAL ELEMENTS OVERVIEW

The following topics provide a formal definition of the *mikroBasic PRO for PIC* lexical elements. They describe different categories of word-like units (tokens) recognized by language.
In the tokenizing phase of compilation, the source code file is parsed (i.e. broken down) into tokens and whitespace. The tokens in *mikroBasic PRO for PIC* are derived from a series of operations performed on your programs by the compiler.

A *mikroBasic PRO for PIC* program starts as a sequence of ASCII characters representing the source code, created by keystrokes using a suitable text editor (such as the mikroBasic PRO for PIC Code Editor). The basic program unit in *mikroBasic PRO for PIC* is a file. This usually corresponds to a named file located in RAM or on disk, having the extension `.mbas.`

WHITESPACE

Whitespace is a collective name given to spaces (blanks), horizontal and vertical tabs, newline characters and comments. Whitespace can serve to indicate where tokens start and end, but beyond this function, any surplus whitespace is discarded. For example, two sequences

```
dim tmp as byte
dim j as wordand
```

and

```
dim  tmp  as  byte
dim    j  as  word
```

are lexically equivalent and parse identically.

Newline Character

Newline character (CR/LF) is not a whitespace in BASIC, and serves as a statement terminator/separator. In *mikroBasic PRO for PIC*, however, you may use newline to break long statements into several lines. Parser will first try to get the longest possible expression (across lines if necessary), and then check for statement terminators.

Whitespace in Strings

The ASCII characters representing whitespace can occur within string literals, in which case they are protected from the normal parsing process (they remain a part of the string). For example,

```
some_string = “mikro foo”
```

parses to four tokens, including a single string literal token:

```
some_string
=
“mikro foo”
newline character
```

COMMENTS

Comments are pieces of a text used to annotate a program, and are technically another form of whitespace. Comments are for the programmer’s use only. They are stripped from the source text before parsing.

Use the apostrophe to create a comment:

```
' Any text between an apostrophe and the end of the
' line constitutes a comment. May span one line only.
```

There are no multi-line comments in *mikroBasic PRO for PIC*.

TOKENS

Token is the smallest element of a *mikroBasic PRO for PIC* program, meaningful to the compiler. The parser separates tokens from the input stream by creating the longest token possible using the input characters in a left–to–right scan.

mikroBasic PRO for PIC recognizes the following kinds of tokens:

- keywords
- identifiers
- constants
- operators
- punctuators (also known as separators)

Token Extraction Example

Here is an example of token extraction. See the following code sequence:

```
end_flag = 0
```

The compiler would parse it into four tokens:

```
 end_flag      ' variable identifier
=              ' assignment operator
0              ' literal
newline        ' statement terminator
```

Note that `end_flag` would be parsed as a single identifier, rather than the keyword end followed by the identifier `_flag`.

LITERALS

Literals are tokens representing fixed numeric or character values.

The data type of a constant is deduced by the compiler using such clues as numeric value and format used in the source code.

Integer Literals

Integral values can be represented in decimal, hexadecimal, or binary notation.

In decimal notation, numerals are represented as a sequence of digits (without commas, spaces, or dots), with optional prefix `+` or `-` operator to indicate the sign. Values default to positive (`6258` is equivalent to `+6258`).

The dollar-sign prefix (`$`) or the prefix 0x indicates a hexadecimal numeral (for example, `$8F` or `0x8F`).

The percent-sign prefix (`%`) indicates a binary numeral (for example, `%0101`).

Here are some examples:

```
11       ' decimal literal
$11      ' hex literal, equals decimal 17
0x11     ' hex literal, equals decimal 17
%11      ' binary literal, equals decimal 3
```

The allowed range of values is imposed by the largest data type in mikroBasic PRO for PIC – `longword`. The compiler will report an error if the literal exceeds `4294967295 ($FFFFFFFF)`.

Floating Point Literals

A floating-point value consists of:

- Decimal integer
- Decimal point
- Decimal fraction
- `e` or `E` and a signed integer exponent (optional)

You can omit either the decimal integer or decimal fraction (but not both).

Negative floating constants are taken as positive constants with the unary operator minus (-) prefixed.

mikroBasic PRO for PIC limits floating-point constants to the range of ±1.17549435082 * 10^{-38} .. ±6.80564774407 * 10^{38}.

Here are some examples:

```
0.          ' = 0.0
-1.23       ' = -1.23
23.45e6     ' = 23.45 * 10^6
2e-5        ' = 2.0 * 10^-5
3E+10       ' = 3.0 * 10^10
.09E34      ' = 0.09 * 10^34
```

Character Literals

Character literal is one character from the extended ASCII character set, enclosed with quotes (for example, "`A`"). Character literal can be assigned to variables of `byte` and `char` type (variable of byte will be assigned the ASCII value of the character). Also, you can assign character literal to a string variable.

String Literals

String literal is a sequence of characters from the extended ASCII character set, enclosed with quotes. Whitespace is preserved in string literals, i.e. parser does not "go into" strings but treats them as single tokens.

Length of string literal is a number of characters it consists of. String is stored internally as the given sequence of characters plus a final `null` character. This `null` character is introduced to terminate the string, it does not count against the string's total length.

String literal with nothing in between the quotes (*`null string`*) is stored as a single null character.

You can assign string literal to a string variable or to an array of char.

Here are several string literals:

```
“Hello world!”             ' message, 12 chars long
“Temperature is stable”    ' message, 21 chars long'
“                          ' two spaces, 2 chars long
“C”                        ' letter, 1 char long
“ “                        ' null string, 0 chars long
```

The quote itself cannot be a part of the string literal, i.e. there is no escape sequence. You could use the built-in function Chr to print a quote: Chr(34). Also, see String Splicing.

KEYWORDS

Keywords are the words reserved for special purposes and must not be used as normal identifier names.

Beside standard BASIC keywords, all relevant SFR are defined as global variables and represent reserved words that cannot be redefined (for example: `P0, TMR1, T1CON`, etc). Probe Code Assistant for specific letters (**Ctrl**+**Space** in Editor) or refer to Predefined Globals and Constants.

Here is the alphabetical listing of keywords in *mikroBasic PRO for PIC*:

- `Abstract`
- `And`
- `Array`
- `As`
- `at`
- `Asm`
- `Assembler`
- `Automated`
- `bdata`
- `Begin`
- `bit`
- `Case`
- `Cdecl`
- `Class`
- `Code`
- `compact`
- `Const`
- `Constructor`
- `Contains`
- `Data`
- `Default`
- `deprecated`
- `Destructor`
- `Dispid`
- `Dispinterface`
- `Div`
- `Do`
- `Downto`
- `Dynamic`
- `Else`
- `End`
- `Except`
- `Export`
- `Exports`
- `External`
- `Far`

- File
- Finalization
- Finally
- For
- Forward
- Function
- Goto
- idata
- If
- ilevel
- Implementation
- In
- Index
- Inherited
- Initialization
- Inline
- Interface
- Is
- Label
- large
- Library
- Message
- Mod
- name
- Near
- Nil
- Not
- Object
- Of
- on
- Or
- org
- Out
- overload
- Override
- package
- Packed
- Pascal
- pdata
- platform
- Private
- Procedure
- Program
- Property
- Protected
- Public
- Published
- Raise
- Read
- Readonly

- `Record`
- `Register`
- `Reintroduce`
- `Repeat`
- `requires`
- `Reset`
- `Resourcestring`
- `Resume`
- `Safecall`
- `sbit`
- `Set`
- `sfr`
- `Shl`
- `Shr`
- `small`
- `Stdcall`
- `Stored`
- `String`
- `Stringresource`
- `Then`
- `Threadvar`
- `To`
- `Try`
- `Type`
- `Unit`
- `Until`
- `Uses`
- `Var`
- `Virtual`
- `Volatile`
- `While`
- `With`
- `Write`
- `Writeonly`
- `xdata`
- `Xor`

Also, *mikroBasic PRO for PIC* includes a number of predefined identifiers used in libraries. You could replace them by your own definitions, if you plan to develop your own libraries. For more information, see mikroBasic PRO for PIC Libraries.

IDENTIFIERS

Identifiers are arbitrary names of any length given to functions, variables, symbolic constants, user-defined data types and labels. All these program elements will be referred to as *objects* throughout the help (don't get confused about the meaning of *object* in object-oriented programming).

Identifiers can contain the letters `a` to `z` and `A` to `Z`, underscore character "`_`", and digits from `0` to `9`. First character must be a letter or an underscore, i.e. identifier cannot begin with a numeral.

Case Sensitivity

mikroBasic PRO for PIC is not case sensitive, so `Sum,` `sum,` and `suM` are equivalent identifiers.

Uniqueness and Scope

Although identifier names are arbitrary (within the rules stated), errors result if the same name is used for more than one identifier within the same scope. Simply, duplicate names are *illegal* within the same scope. For more information, refer to Scope and Visibility.

Identifier Examples

Here are some valid identifiers:

```
temperature_V1
Pressure
no_hit
dat2string
SUM3
_vtext
```

… and here are some invalid identifiers:

```
7temp          ' NO -- cannot begin with a numeral
%higher        ' NO -- cannot contain special characters
xor            ' NO -- cannot match reserved word
j23.07.04      ' NO -- cannot contain special characters (dot)
```

PUNCTUATORS

The mikroBasic punctuators (also known as separators) are:

- [ ] – Brackets
- ( ) – Parentheses
- , – Comma
- : – Colon
- . – Dot

Brackets

Brackets `[ ]` indicate single and multidimensional array subscripts:

```
dim alphabet as byte[ 30]
' ...
alphabet[ 2]  = "c"
```

For more information, refer to Arrays.

Parentheses

Parentheses `( )` are used to group expressions, isolate conditional expressions and indicate function calls and function declarations:

```
d = c *  (a  + b)                   ' Override normal precedence
if  (d = z)  then ...               ' Useful with conditional statements
func()                               ' Function call, no arguments
sub function func2(dim n as word 'Function declaration w/ parameters
```

For more information, refer to Operators Precedence and Associativity, Expressions or Functions and Procedures.

Comma

Comma (`,`) separates the arguments in function calls:

```
LCD_Out(1, 1, txt);
```

Furthermore, the comma separates identifiers in declarations:

```
dim i, j, k as word
```

The comma also separates elements of array in initialization lists:

```
const MONTHS as byte[ 12]  = (31,28,31,30,31,30,31,31,30,31,30,31)
```

Colon

Colon (`:`) is used to indicate a labeled statement:

```
start:  nop
  '...
goto start
```

For more information, refer to Labels.

Dot

Dot (`.`) indicates access to a structure member. For example:

```
person.surname = "Smith"
```

For more information, refer to Structures.

Dot is a necessary part of floating point literals. Also, dot can be used for accessing individual bits of registers in mikroBasic PRO.

PROGRAM ORGANIZATION

mikroBasic PRO for PIC imposes strict program organization. Below you can find models for writing legible and organized source files. For more information on file inclusion and scope, refer to Modules and to Scope and Visibility.

Organization of Main Unit

Basically, the main source file has two sections: declaration and program body. Declarations should be in their proper place in the code, organized in an orderly manner. Otherwise, the compiler may not be able to comprehend the program correctly.

When writing code, follow the model presented below. The main unit should look like this:

```
program <program name>
include <include other modules>

'********************************************************
'* Declarations (globals):
'********************************************************

' symbols declarations
symbol ...

' constants declarations
const ...

' structures declarations
structure ...

' variables declarations
dim  Name[,  Name2...]  as  [^]type  [ absolute  0x123]  [ external]
[ volatile] [ register] [ sfr]

' procedures declarations
sub procedure procedure_name(...)
  <local declarations>
  ...
end sub

' functions declarations
sub function function_name(...) as return_type
  <local declarations>
  ...
end sub

'********************************************************
```

```
'* Program body:
'*******************************************************

main:
   ' write your code here
end.
```

Organization of Other Modules

Modules other than main start with the keyword `module`. Implementation section starts with the keyword `implements`. Follow the model presented below:

```
module  <module name>
include <include other modules>

'*******************************************************
'* Interface (globals):
'*******************************************************

' symbols declarations
symbol ...

' constants declarations
const ...

' structures declarations
structure ...

' variables declarations
dim Name[, Name2...] as [^]type [absolute 0x123] [external]
[volatile] [register] [sfr]

' procedures prototypes
sub procedure sub_procedure_name([dim byref] [const] ParamName as
[^]type, [dim byref] [const] ParamName2, ParamName3 as [^]type)

' functions prototypes
sub function sub_function_name([dim byref] [const] ParamName as
[^]type, [dim byref] [const] ParamName2, ParamName3 as [^]type) as
[^]type

'*******************************************************
'* Implementation:
'*******************************************************
implements

' constants declarations
```

```
const ...

' variables declarations
dim ...

' procedures declarations
sub procedure sub_procedure_name([dim byref] [const] ParamName as
[^]type, [dim byref] [const] ParamName2, ParamName3 as [^]type)
[ilevel 0x123] [overload] [forward]
  <local declarations>
  ...
end sub

' functions declarations
sub function sub_function_name([dim byref] [const] ParamName as
[^]type, [dim byref] [const] ParamName2, ParamName3 as [^]type) as
[^]type [ilevel 0x123] [overload] [forward]
  <local declarations>
  ...
end sub

end.
```

Note: Sub functions and sub procedures must have the same declarations in the interface and implementation section. Otherwise, compiler will report an error.

SCOPE AND VISIBILITY

Scope

The scope of an identifier is a part of the program in which the identifier can be used to access its object. There are different categories of scope, which depends on how and where identifiers are declared:

Place of declaration	Scope
Identifier is declared in the declaration section of the main module, out of any function or procedure	Scope extends from the point where it is declared to the end of the current file, including all routines enclosed within that scope. These identifiers have a *file scope* and are referred to as *globals.*
Identifier is declared in the function or procedure	Scope extends from the point where it is declared to the end of the current routine. These identifiers are referred to as *locals*.
Identifier is declared in the interface section of the module	Scope extends the interface section of a module from the point where it is declared to the end of the module, and to any other module or program that uses that module. The only exception are symbols which have a scope limited to the file in which they are declared.
Identifier is declared in the implementation section of the module, but not within any function or procedure	Scope extends from the point where it is declared to the end of the module. The identifier is available to any function or procedure in the module.

Visibility

The visibility of an identifier is that region of the program source code from which legal access to the identifier's associated object can be made.

Scope and visibility usually coincide, though there are circumstances under which an object becomes temporarily hidden by the appearance of a duplicate identifier, i.e. the object still exists but the original identifier cannot be used to access it until the scope of the duplicate identifier is ended.

Technically, visibility cannot exceed scope, but scope *can* exceed visibility.

MODULES

In *mikroBasic PRO for PIC*, each project consists of a single project file and one or more module files. The project file, with extension .mbpav contains information on the project, while modules, with extension .mbas, contain the actual source code. See Program Organization for a detailed look at module arrangement.

Modules allow you to:

- break large programs into encapsulated modules that can be edited sepa rately,
- create libraries that can be used in different projects,
- distribute libraries to other developers without disclosing the source code.

Each module is stored in its own file and compiled separately; compiled modules are linked to create an application. To build a project, the compiler needs either a source file or a compiled module file for each module.

Include Clause

mikroBasic PRO for PIC includes modules by means of the `include` clause. It consists of the reserved word `include`, followed by a quoted module name. Extension of the file should not be included.

You can include one file per `include` clause. There can be any number of the `include` clauses in each source file, but they all must be stated immediately after the program (or module) name.

Here's an example:

```
program MyProgram

include "utils"
include "strings"
include "MyUnit"

...
```

For the given module name, the compiler will check for the presence of `.mcl` and `.mbas` files, in order specified by search paths.

- If both `.mbas` and `.mcl` files are found, the compiler will check their dates and include the newer one in the project. If the `.mbas` file is newer than the `.mcl`, then `.mbas` file will be recompiled and new `.mcl` will be created, overwriting the old `.mcl`.
- If only the `.mbas` file is found, the compiler will create the `.mcl` file and

include it in the project;
- If only the `.mcl` file is present, i.e. no source code is available, the compiler will include it as found;
- If none of the files found, the compiler will issue a “File not found” warning.

Main Module

Every project in *mikroBasic PRO for PIC* requires a single main module file. The main module is identified by the keyword `program` at the beginning. It instructs the compiler where to “start”.

After you have successfully created an empty project with Project Wizard, Code Editor will display a new main module. It contains the bare-bones of the program:

```
program MyProject

' main procedure
main:
  ' Place program code here
end.
```

Other than comments, nothing should precede the keyword `program`. After the program name, you can optionally place the `include` clauses.

Place all global declarations (constants, variables, labels, routines, structures) before the label `main`.

Other Modules

Modules other than main start with the keyword `module`. Newly created blank module contains the bare-bones:

```
module MyModule

implements

end.
```

Other than comments, nothing should precede the keyword `module`. After the module name, you can optionally place the `include` clauses.

Interface Section

Part of the module above the keyword `implements` is referred to as *interface* section. Here, you can place global declarations (constants, variables, labels, routines, structures) for the project.

Do *not* define routines in the interface section. Instead, state the prototypes of routines (from implementation section) that you want to be visible outside the module. Prototypes must exactly match the declarations.

Implementation Section

Implementation section hides all irrelevant innards from other units, allowing encapsulation of code.

Everything declared below the keyword `implements` is *private,* i.e. has its scope limited to the file. When you declare an identifier in the implementation section of a module, you cannot use it outside the module, but you can use it in any block or routine defined within the module.

By placing the prototype in the interface section of the module(above the `implements`) you can make the routine *public*, i.e. visible outside of module. Prototypes must exactly match the declarations.

VARIABLES

Variable is an object whose value can be changed during the runtime. Every variable is declared under unique name which must be a valid identifier. This name is used for accessing the memory location occupied by the variable.

Variables are declared in the declaration part of the file or routine — each variable needs to be declared before it is used. Global variables (those that do not belong to any enclosing block) are declared below the `include` statements, above the label `main.`

Specifying a data type for each variable is mandatory. *mikroBasic PRO for PIC* syntax for variable declaration is:

```
dim identifier_list as type
```

Here, *`identifier_list`* is a comma-delimited list of valid identifiers, and type can be any data type.

For more details refer to Types and Types Conversions. For more information on variables' scope refer to the chapter Scope and Visibility.

Here are a few examples:

```
dim i, j, k as byte
dim counter, temp as word
dim samples as longint[ 100]
```

External Modifier

Use the `external` modifier to indicate that the actual place and initial value of the variable, or body of the function, is defined in a separate source code module.

Variables and PIC

Every declared variable consumes part of RAM memory. Data type of variable determines not only the allowed range of values, but also the space a variable occupies in RAM memory. Bear in mind that operations using different types of variables take different time to be completed. *mikroBasic PRO for PIC* recycles local variable memory space – local variables declared in different functions and procedures share the same memory space, if possible.

There is no need to declare SFR explicitly, as *mikroBasic PRO for PIC* automatically declares relevant registers as global variables of word. For example: `W0`, `TMR1`, etc.

CONSTANTS

Constant is a data whose value cannot be changed during the runtime. Using a constant in a program consumes no RAM memory. Constants can be used in any expression, but cannot be assigned a new value.

Constants are declared in the declaration part of the program or routine, with the following syntax:

```
const constant_name [ as type] = value
```

Every constant is declared under unique `constant_name` which must be a valid identifier. It is a tradition to write constant names in uppercase. Constant requires you to specify `value`, which is a literal appropriate for the given type. `type` is optional and in the absence of it , the compiler assumes the “smallest” type that can accommodate `value`.

Note: You cannot omit `type` if declaring a constant array.

Here are a few examples:

```
const MAX as longint = 10000
const MIN = 1000        ' compiler will assume word type
const SWITCH = "n"      ' compiler will assume char type
const MSG = "Hello"     ' compiler will assume string type
const MONTHS as byte[ 12] = (31,28,31,30,31,30,31,31,30,31,30,31)
```

LABELS

Labels serve as targets for the goto and gosub statements. Mark the desired statement with label and colon like this:

```
label_identifier : statement
```

No special declaration of label is necessary in *mikroBasic PRO for PIC*.

Name of the label needs to be a valid identifier. The labeled statement and `goto/gosub` statement must belong to the same block. Hence it is not possible to jump into or out of routine. Do not mark more than one statement in a block with the same label.

Note: The label `main` marks the entry point of a program and must be present in the main module of every project. See Program Organization for more information.

Here is an example of an infinite loop that calls the procedure `Beep` repeatedly:

```
loop:
  Beep
goto loop
```

SYMBOLS

mikroBasic PRO for PIC symbols allow you to create simple macros without parameters. You can replace any line of code with a single identifier alias. Symbols, when properly used, can increase code legibility and reusability.

Symbols need to be declared at the very beginning of the module, right after the module name and (optional) `include` clauses. Check Program Organization for more details. Scope of a symbol is always limited to the file in which it has been declared.

Symbol is declared as:

```
symbol alias = code
```

Here, `alias` must be a valid identifier which you will use throughout the code. This identifier has a file scope. The `code` can be any line of code (literals, assignments, function calls, etc).

Using a symbol in the program consumes no RAM – the compiler will simply replace each instance of a symbol with the appropriate line of code from the declaration.

Here is an example:

```
symbol MAXALLOWED = 216          ' Symbol as alias for numeric value
symbol PORT = P0                 ' Symbol as alias for SFR
symbol MYDELAY = Delay_ms(1000)  ' Symbol as alias for procedure call

dim cnt as byte   ' Some variable

'...
main:

if cnt > MAXALLOWED then
  cnt = 0
  PORT.1 = 0
  MYDELAY
end if
```

Note: Symbols do not support macro expansion in a way the C preprocessor does.

FUNCTIONS AND PROCEDURES

Functions and procedures, collectively referred to as *routines*, are subprograms (self-contained statement blocks) which perform a certain task based on a number of input parameters. When executed, a function returns value while procedure does not.

Functions

A function is declared like this:

```
sub function function_name(parameter_list) as return_type
  [  local declarations ]
  function body
end sub
```

`function_name` represents a function's name and can be any valid identifier. `return_type` is a type of return value and can be any simple type. Within parentheses, `parameter_list` is a formal parameter list very similar to variable declaration.In *mikroBasic PRO for PIC*, parameters are always passed to a function by value. To pass an argument by address, add the keyword `byref` ahead of identifier.

`Local declarations` are optional declarations of variables and/or constants, local for the given function. `Function body` is a sequence of statements to be executed upon calling the function.

Calling a function

A function is called by its name, with actual arguments placed in the same sequence as their matching formal parameters. The compiler is able to coerce mismatching arguments to the proper type according to implicit conversion rules. Upon a function call, all formal parameters are created as local objects initialized by values of actual arguments. Upon return from a function, a temporary object is created in the place of the call and it is initialized by the value of the function result. This means that function call as an operand in complex expression is treated as the function result.

In standard Basic, a `function_name` is automatically created local variable that can be used for returning a value of a function. mikroBasic PRO for PIC also allows you to use the automatically created local variable `result` to assign the return value of a function if you find function name to be too ponderous. If the return value of a function is not defined the compiler will report an error.

Function calls are considered to be *primary expressions* and can be used in situations where expression is expected. A function call can also be a self-contained statement and in that case the return value is discarded.

Example

Here's a simple function which calculates x^n based on input parameters `x` and `n (n > 0)`:

```
sub function power(dim x, n as byte) as longint
dim i as byte
  result = 1
  if n > 0 then
    for i = 1 to n
      result = result*x
    next i
  end if
end sub
```

Now we could call it to calculate 3^{12}:

```
tmp = power(3, 12)
```

PROCEDURES

Procedure is declared like this:

```
sub procedure procedure_name(parameter_list)
  [ local declarations ]
  procedure body
end sub
```

`procedure_name` represents a procedure's name and can be any valid identifier. Within parentheses, *`parameter_list`* is a formal parameter list very similar to variable declaration. In mikroBasic PRO for PIC, parameters are always passed to procedure by value; to pass argument by address, add the keyword `byref` ahead of identifier.

`Local declarations` are optional declaration of variables and/or constants, local for the given procedure. *`Procedure body`* is a sequence of statements to be executed upon calling the procedure.

Calling a procedure

A procedure is called by its name, with actual arguments placed in the same sequence as their matching formal parameters. The compiler is able to coerce mismatching arguments to the proper type according to implicit conversion rules. Upon procedure call, all formal parameters are created as local objects initialized by values of actual arguments.

Procedure call is a self-contained statement.

Example

Here's an example procedure which transforms its input time parameters, preparing them for output on LCD:

```
sub procedure time_prep(dim byref sec, min, hr as byte)
  sec  = ((sec and $F0) >> 4)*10 + (sec and $0F)
  min  = ((min and $F0) >> 4)*10 + (min and $0F)
  hr   = ((hr  and $F0) >> 4)*10 + (hr  and $0F)
end sub
```

Function Pointers

Function pointers are allowed in *mikroBasic PRO for PIC*. The example shows how to define and use a function pointer:

Example:

Example demonstrates the usage of function pointers. It is shown how to declare a procedural type, a pointer to function and finally how to call a function via pointer.

```
program Example;

typedef TMyFunctionType = function (dim param1, param2 as byte, dim
param3 as word) as word ' First, define the procedural type

dim MyPtr as ^TMyFunctionType   ' This is a pointer to previously
defined type
dim sample as word

sub function Func1(dim p1, p2 as byte, dim p3 as word) as word ' Now,
define few functions which will be pointed to. Make sure that param-
eters match the type definition
  result = p1 and p2 or p3
end sub
```

```
sub function Func2(dim abc, def as byte, dim ghi as word) as word
'Another function of the same kind. Make sure that parameters match
the type definition
  result =  abc * def + ghi
end sub

sub function Func3(dim first, yellow as byte, dim monday as word) as
word   ' Yet another function. Make sure that parameters match the
type definition
  result =  monday - yellow - first
end sub

' main program:
main:
  MyPtr = @Func1              ' MyPtr now points to Func1
  Sample = MyPtr^(1, 2, 3)   ' Perform function call via pointer, call
Func1, the return value is 3
  MyPtr = @Func2              ' MyPtr now points to Func2
  Sample = MyPtr^(1, 2, 3)   ' Perform function call via pointer, call
Func2, the return value is 5
  MyPtr = @Func3              ' MyPtr now points to Func3
  Sample = MyPtr^(1, 2, 3)   ' Perform function call via pointer, call
Func3, the return value is 0
end.
```

A function can return a complex type. Follow the example bellow to learn how to declare and use a function which returns a complex type.

Example:

This example shows how to declare a function which returns a complex type.

```
program Example

structure TCircle          ' Structure
  dim CenterX, CenterY as word
  dim Radius as byte
end structure

dim MyCircle as TCircle ' Global variable

sub function DefineCircle(dim x, y as word, dim r as byte) as TCircle
' DefineCircle function returns a Structure
  result.CenterX = x
  result.CenterY = y
  result.Radius = r
end sub
```

```
main:
 MyCircle = DefineCircle(100, 200, 30) 'Get a Structure via function
call
 MyCircle.CenterX = DefineCircle(100, 200, 30). CenterX + 20
'Access a Structure field via function call
  '                    |------------------------| |-----|
  '                       |                            |
  '                    Function returns TCircle    Access to one
                                                  field of TCircle
end.
```

Forward declaration

A function can be declared without having it followed by it's implementation, by having it followed by the forward procedure. The effective implementation of that function must follow later in the module. The function can be used after a forward declaration as if it had been implemented already. The following is an example of a forward declaration:

```
program Volume

dim Volume as word

sub function First(a as word, b as word) as word forward

sub function Second(c as word) as word
dim tmp as word
  tmp = First(2, 3)
  result = tmp * c
end sub

sub function First(a, b as word) as word
  result = a * b
end sub

main:
  Volume = Second(4)
end.
```

Functions reentrancy

Functions reentrancy is allowed if the function has no parameters and local variables, or if the local variables are placed in the Rx space. Remember that the PIC has stack and memory limitations which can varies greatly between MCUs.

TYPES

Basic is strictly typed language, which means that every variable and constant need to have a strictly defined type, known at the time of compilation.

The type serves:

- to determine correct memory allocation required,
- to interpret the bit patterns found in the object during subsequent accesses,
- in many type-checking situations, to ensure that illegal assignments are trapped.

mikroBasic PRO for PIC supports many standard (predefined) and user-defined data types, including signed and unsigned integers of various sizes, arrays, strings, pointers and structures.

Type Categories

Types can be divided into:

- simple types
- arrays
- strings
- pointers
- structures

SIMPLE TYPES

Simple types represent types that cannot be divided into more basic elements and are the model for representing elementary data on machine level. Basic memory unit in *mikroBasic PRO for PIC* has 8 bits.

Here is an overview of simple types in *mikroBasic PRO for PIC*:

Type	Size	Range
`byte, char`	8–bit	0 .. 255
`short`	8–bit	-127 .. 128
`word`	16–bit	0 .. 65535
`integer`	16–bit	-32768 .. 32767
`longword`	32–bit	0 .. 4294967295
`longint`	32–bit	-2147483648 .. 2147483647
`float`	32–bit	$\pm 1.17549435082 * 10^{-38}$ .. $\pm 6.80564774407 * 10^{38}$
`bit`	1–bit	0 or 1
`sbit`	1–bit	0 or 1

You can assign signed to unsigned or vice versa only using the explicit conversion. Refer to Types Conversions for more information.

ARRAYS

An array represents an indexed collection of elements of the same type (called the base type). Since each element has a unique index, arrays, unlike sets, can meaningfully contain the same value more than once.

Array Declaration

Array types are denoted by constructions in the following form:

```
type[array_length]
```

Each of elements of an array is numbered from 0 through `array_length - 1`. Every element of an array is of *type* and can be accessed by specifying array name followed by element's index within brackets.

Here are a few examples of array declaration:

```
dim weekdays as byte[7]
dim samples  as word[50]

main:
  ' Now we can access elements of array variables, for example:
  samples[0] = 1
  if samples[37] = 0 then
    ' ...
```

Constant Arrays

Constant array is initialized by assigning it a comma-delimited sequence of values within parentheses. For example:

```
' Declare a constant array which holds number of days in each month:
const MONTHS as byte[12] = (31,28,31,30,31,30,31,31,30,31,30,31)
```

Note that indexing is zero based; in the previous example, number of days in January is `MONTHS[0]` and number of days in December is `MONTHS[11]`.

The number of assigned values must not exceed the specified length. Vice versa is possible, when the trailing “excess” elements will be assigned zeroes.

For more information on arrays of char, refer to Strings.

STRINGS

A string represents a sequence of characters equivalent to an array of `char`. It is declared like this:

```
string[string_length]
```

The specifier *`string_length`* is a number of characters a string consists of. The string is stored internally as the given sequence of characters plus a final null character (zero). This appended “stamp” does not count against string’s total length.

A null string ("") is stored as a single `null` character.

You can assign string literals or other strings to string variables. The string on the right side of an assignment operator has to be shorter than another one, or of equal length. For example:

```
dim msg1 as string[ 20]
dim msg2 as string[ 19]

main:
  msg1 = "This is some message"
  msg2 = "Yet another message"

  msg1 = msg2   ' this is ok, but vice versa would be illegal
```

Alternately, you can handle strings element–by–element. For example:

```
dim s as string[ 5]
' ...
s = "mik"
' s[0] is char literal "m"
' s[1] is char literal "i"
' s[2] is char literal "k"
' s[3] is zero
' s[4] is undefined
' s[5] is undefined
```

Be careful when handling strings in this way, since overwriting the end of a string will cause an unpredictable behavior.

Note

mikroBasic PRO for PIC includes String Library which automatizes string related tasks.

POINTERS

A pointer is a data type which holds a memory address. While a variable accesses that memory address directly, a pointer can be thought of as a reference to that memory address.

To declare a pointer data type, add a carat prefix (^) before type. For example, if you are creating a pointer to an integer, you would write:

```
^integer
```

To access the data at the pointer's memory location, you add a carat after the variable name. For example, let's declare variable `p` which points to `word`, and then assign the pointed memory location value `5`:

```
dim p as ^word
'...
p^ = 5
```

A pointer can be assigned to another pointer. However, note that only the address, not the value, is copied. Once you modify the data located at one pointer, the other pointer, when dereferenced, also yields modified data.

@ Operator

The @ operator constructs a pointer to its operand. The following rules are applied to @:

- If X is a variable, @X returns a pointer to X.

  Note: If variable X is of array type, the @ operator will return pointer to it's first basic element, except when the left side of the statement in which X is used is an array pointer. In this case, the @ operator will return pointer to array, not to it's first basic element.

```
program example

dim w   as word
    ptr_b    as ^byte
    ptr_arr as ^byte[ 10]
    arr      as  byte[ 10]
main:
  ptr_b    = @arr ' @ operator will return ^byte
  w         = @arr ' @ operator will return ^byte
  ptr_arr = @arr ' @ operator will return ^byte[10]
end.
```

- If F is a routine (a function or procedure), @F returns a pointer to F.

Related topics: Pointer Arithmetic

STRUCTURES

A structure represents a heterogeneous set of elements. Each element is called a *member*; the declaration of a structure type specifies a name and type for each member. The syntax of a structure type declaration is

```
structure structname
  dim member1 as type1
  '...
  dim membern as typen
end structure
```

where `structname` is a valid identifier, each `type` denotes a type, and each `member` is a valid identifier. The scope of a member identifier is limited to the structure in which it occurs, so you don't have to worry about naming conflicts between member identifiers and other variables.

For example, the following declaration creates a structure type called `Dot`:

```
structure Dot
  dim x as float
  dim y as float
end structures
```

Each `Dot` contains two members: x and y coordinates; memory is allocated when you instantiate the structure, like this:

```
dim m, n as Dot
```

This variable declaration creates two instances of `Dot,` called `m` and `n`.

A member can be of the previously defined structure type. For example:

```
' Structure defining a circle:
structure Circle
  dim radius as float
  dim center as Dot
end structure
```

Structure Member Access

You can access the members of a structure by means of dot (`.`) as a direct member selector. If we had declared the variables `circle1` and `circle2` of the previously defined type `Circle`:

```
dim circle1, circle2 as Circle
```

we could access their individual members like this:

```
circle1.radius = 3.7
circle1.center.x = 0
circle1.center.y = 0
```

You can also commit assignments between complex variables, if they are of the same type:

```
circle2 = circle1   ' This will copy values of all members
```

TYPES CONVERSIONS

Conversion of variable of one type to variable of another type is typecasting. *mikroBasic PRO for PIC* supports both implicit and explicit conversions for built-in types.

Implicit Conversion

Compiler will provide an automatic implicit conversion in the following situations:

- statement requires an expression of particular type (according to language definition), and we use an expression of different type,
- operator requires an operand of particular type, and we use an operand of different type,
- function requires a formal parameter of particular type, and we pass it an object of different type,
- `result` does not match the declared function return type.

Promotion

When operands are of different types, implicit conversion promotes the less complex type to more complex type taking the following steps:

```
byte/char  →  word
short      →  integer
short      →  longint
integer    →  longint
integral   →  float
```

Higher bytes of extended unsigned operand are filled with zeroes. Higher bytes of extended signed operand are filled with bit sign (if number is negative, fill higher bytes with one, otherwise with zeroes). For example:

```
dim a as byte
dim b as word
'...
a = $FF
b = a   ' a is promoted to word, b becomes $00FF
```

Clipping

In assignments and statements that require an expression of particular type, destination will store the correct value only if it can properly represent the result of expression, i.e. if the result fits in destination range.

If expression evaluates to a more complex type than expected, excess of data will be simply clipped (higher bytes are lost).

```
dim i as byte
dim j as word
'...
j = $FF0F
i = j   ' i becomes $0F, higher byte $FF is lost
```

Explicit Conversion

Explicit conversion can be executed at any point by inserting type keyword (`byte`, `word`, `short`, `integer`, `longint` or `float`) ahead of an expression to be converted. The expression must be enclosed in parentheses. Explicit conversion can be performed only on the operand left of the assignment operator

Special case is the conversion between signed and unsigned types. Explicit conversion between signed and unsigned data does not change binary representation of data — it merely allows copying of source to destination.

For example:

```
dim a as byte
dim b as short
'...
b = -1
a = byte(b)   ' a is 255, not 1

' This is because binary representation remains
' 11111111;  it's just interpreted differently now
```

You cannot execute explicit conversion on the operand left of the assignment operator:

```
word(b) = a   ' Compiler will report an error
```

OPERATORS

Operators are tokens that trigger some computation when being applied to variables and other objects in an expression.

There are four types of operators in in *mikroBasic PRO for PIC*:

- Arithmetic Operators
- Bitwise Operators
- Boolean Operators
- Relational Operators

OPERATORS PRECEDENCE AND ASSOCIATIVITY

There are 4 precedence categories in *mikroBasic PRO for PIC*. Operators in the same category have equal precedence with each other.

Each category has an associativity rule: left-to-right (→) or right-to-left (←). In the absence of parentheses, these rules resolve the grouping of expressions with operators of equal precedence.

Precedence	Operands	Operators	Associativity
4	1	`@` `not` `+` `-`	←
3	2	`*` `/` `div` `mod` `and` `<<` `>>`	→
2	2	`+` `-` `or` `xor`	→
1	2	`=` `<>` `<` `>` `<=` `>=`	→

ARITHMETIC OPERATORS

Arithmetic operators are used to perform mathematical computations. They have numerical operands and return numerical results. Since the `char` operators are technically `bytes`, they can be also used as unsigned operands in arithmetic operations.

All arithmetic operators associate from left to right.

Operator	Operation	Operands	Result
`+`	addition	`byte, short, word, integer, longint, longword, float`	`byte, short, word, integer, longint, longword, float`
`-`	subtraction	`byte, short, word, integer, longint, longword, float`	`byte, short, word, integer, longint, longword, float`
`*`	multiplication	`byte, short, word, integer, longint, longword, float`	`byte, short, word, integer, longint, longword, float`
`/`	division, floating-point	`byte, short, word, integer, longint, longword, float`	`float`
`div`	division, rounds down to nearest integer	`byte, short, word, integer, longint, longword`	`byte, short, word, integer, longint, longword`
`mod`	modulus, returns the remainder of integer division (cannot be used with floating points)	`byte, short, word, integer, longint, longword`	`byte, short, word, integer, longint, longword`

Division by Zero

If 0 (zero) is used explicitly as the second operand (i.e. `x div 0`), the compiler will report an error and will not generate code.
But in case of implicit division by zero: `x div y`, where `y` is 0 (zero), the result will be the maximum integer (i.e `255`, if the result is byte type; `65536`, if the result is `word` type, etc.).

Unary Arithmetic Operators

Operator `-` can be used as a prefix unary operator to change sign of a signed value. Unary prefix operator `+` can be used, but it doesn't affect data.

For example:

```
b = -a;
```

RELATIONAL OPERATORS

Use relational operators to test equality or inequality of expressions. All relational operators return `TRUE` or `FALSE`.

Operator	Operation
=	equal
<>	not equal
>	greater than
<	less than
>=	greater than or equal
<=	less than or equal

All relational operators associate from left to right.

Relational Operators in Expressions

The equal sign (=) can also be an assignment operator, depending on context.

Precedence of arithmetic and relational operators was designated in such a way to allow complex expressions without parentheses to have expected meaning:

```
if aa + 5 >= bb - 1.0 / cc then    ' same as: if (aa + 5) >= (bb -
(1.0 / cc)) then
   dd = My_Function()
end if
```

BITWISE OPERATORS

Use bitwise operators to modify individual bits of numerical operands.

Bitwise operators associate from left to right. The only exception is the bitwise complement operator `not` which associates from right to left.

Bitwise Operators Overview

Operator	Operation
`and`	bitwise AND; compares pairs of bits and generates a 1 result if both bits are 1, otherwise it returns 0
`or`	bitwise (inclusive) OR; compares pairs of bits and generates a 1 result if either or both bits are 1, otherwise it returns 0
`xor`	bitwise exclusive OR (XOR); compares pairs of bits and generates a 1 result if the bits are complementary, otherwise it returns 0
`not`	bitwise complement (unary); inverts each bit
`shl`	bitwise shift left; moves the bits to the left, discards the far left bit and assigns 0 to the right most bit.
`shr`	bitwise shift right; moves the bits to the right, discards the far right bit and if unsigned assigns 0 to the left most bit, otherwise sign extends

Logical Operations on Bit Level

and	**0**	**1**
0	0	0
1	0	1

or	**0**	**1**
0	0	1
1	1	1

xor	**0**	**1**
0	0	1
1	1	0

not	**0**	**1**
	1	0

The Bitwise operators `and`, `or`, and `xor` perform logical operations on the appropriate pairs of bits of their operands. The operator `not` complements each bit of its operand. For example:

```
$1234 and $5678          'equals $1230

' because ..

'$1234 : 0001 0010 0011 0100
'$5678 : 0101 0110 0111 1000
'----------------------------
```

```
'and   : 0001 0010 0011 0000

'.. that is, $1230


' Similarly:
$1234 or  $5678          'equals $567C
$1234 xor $5678          'equals $444C
not $1234                 'equals $EDCB
```

Unsigned and Conversions

If a number is converted from less complex to more complex data type, the upper bytes are filled with zeroes. If a number is converted from more complex to less complex data type, the data is simply truncated (the upper bytes are lost).
For example:

```
dim a as byte
dim b as word
' ...
  a = $AA
  b = $F0F0
  b = b and a
  ' a is extended with zeroes; b becomes $00A0
```

Signed and Conversions

If number is converted from less complex to more complex data type, the upper bytes are filled with ones if sign bit is 1 (number is negative); the upper bytes are filled with zeroes if sign bit is 0 (number is positive). If number is converted from more complex to less complex data type, the data is simply truncated (the upper bytes are lost).
For example:

```
dim a as byte
dim b as word
'  ...
  a = -12
  b = $70FF
  b = b and a

  ' a is sign extended, upper byte is $FF;
  ' b becomes $70F4
```

Bitwise Shift Operators

The binary operators << and >> move the bits of the left operand by a number of positions specified by the right operand, to the left or right, respectively. Right operand has to be positive and less than 255.

With shift left (<<), left most bits are discarded, and "new" bits on the right are assigned zeroes. Thus, shifting unsigned operand to the left by *n* positions is equivalent to multiplying it by 2^n if all discarded bits are zero. This is also true for signed operands if all discarded bits are equal to the sign bit.

With shift right (>>), right most bits are discarded, and the "freed" bits on the left are assigned zeroes (in case of unsigned operand) or the value of the sign bit (in case of signed operand). Shifting operand to the right by n positions is equivalent to dividing it by 2^n.

BOOLEAN OPERATORS

Although *mikroBasic PRO for PIC* does not support `boolean` type, you have Boolean operators at your disposal for building complex conditional expressions. These operators conform to standard Boolean logic and return either `TRUE` (all ones) or `FALSE` (zero):

Operator	Operation
`and`	logical AND
`or`	logical OR
`xor`	logical exclusive OR (XOR)
`not`	logical negation

Boolean operators associate from left to right. Negation operator `not` associates from right to left.

EXPRESSIONS

An expression is a sequence of operators, operands and punctuators that returns a value.

The *primary expressions* include: literals, constants, variables and function calls. More complex expressions can be created from primary expressions by using operators. Formally, expressions are defined recursively: subexpressions can be nested up to the limits of memory.

Expressions are evaluated according to certain conversion, grouping, associativity and precedence rules that depend on the operators used, presence of parentheses, and data types of the operands. The precedence and associativity of the operators are summarized in Operator Precedence and Associativity. The way operands and subexpressions are grouped does not necessarily specify the actual order in which they are evaluated by *mikroBasic PRO for PIC*.

STATEMENTS

Statements define algorithmic actions within a program. Each statement needs to be terminated with a semicolon (;). In the absence of specific jump and selection statements, statements are executed sequentially in the order of appearance in the source code.

The most simple statements are assignments, procedure calls and jump statements. These can be combined to form loops, branches and other structured statements.

Refer to:

- Assignment Statements
- Conditional Statements
- Iteration Statements (Loops)
- Jump Statements

- asm Statement

ASSIGNMENT STATEMENTS

Assignment statements have the form:

```
variable = expression
```

The statement evaluates `expression` and assigns its value to `variable`. All the rules of implicit conversion are applied. `Variable` can be any declared variable or array element, and `expression` can be any expression.

Do not confuse the assignment with relational operator = which tests for equality. *mikroBasic PRO for PIC* will interpret the meaning of the character = from the context

CONDITIONAL STATEMENTS

Conditional or selection statements select one of alternative courses of action by testing certain values. There are two types of selection statements:

- if
- select case

If Statement

Use the keyword `if` to implement a conditional statement. The syntax of the `if` statement has the following form:

```
if expression then
  statements
[else
  other statements]
end if
```

When `expression` evaluates to true, `statements` execute. If `expression` is false, `other statements` execute. The `expression` must convert to a boolean type; otherwise, the condition is ill-formed. The `else` keyword with an alternate block of statements (`other statements`) is optional.

Nested if statements

Nested if statements require additional attention. A general rule is that the nested conditionals are parsed starting from the innermost conditional, with each `else` bound to the nearest available `if` on its left:

```
if expression1 then
if expression2 then
statement1
else
statement2
end if
end if
```

The compiler treats the construction in this way:

```
if expression1 then
  if expression2 then
     statement1
  else
     statement2
  end if
end if
```

In order to force the compiler to interpret our example the other way around, we have to write it explicitly:

```
if expression1 then
  if expression2 then
    statement1
  end if
else
  statement2
end if
```

SELECT CASE STATEMENT

Use the `select case` statement to pass control to a specific program branch, based on a certain condition. The select case statement consists of selector expression (condition) and list of possible values. The syntax of the select case statement is:

```
select case selector
  case value_1
    statements_1
  ...
  case value_n
    statements_n
  [case else
    default_statements]
end select
```

`selector` is an expression which should evaluate as integral value. `values` can be literals, constants, or expressions, and `statements` can be any statements. The `case else` clause is optional.

First, the `selector` expression (condition) is evaluated. The `select case` statement then compares it against all available `values`. If the match is found, the `statements` following the match evaluate, and the `select case` statement terminates. In case there are multiple matches, the first matching statement will be executed. If none of the `values` matches the `selector`, then `default_statements` in the `case else` clause (if there is one) are executed.

Here is a simple example of the `select case` statement:

```
select case operator
  case "*"
    res = n1 * n2
  case "/"
    res = n1 / n2
  case "+"
    res = n1 + n2
  case "-"
    res = n1 - n2
  case else
    res = 0
    cnt = cnt + 1
end select
```

Also, you can group values together for a match. Simply separate the items by commas:

```
select case reg
   case 0
     opmode = 0
   case 1,2,3,4
     opmode = 1
   case 5,6,7
     opmode = 2
end select
```

Nested Case Statements

Note that the `select case` statements can be nested – *values* are then assigned to the innermost enclosing `select case` statement.

ITERATION STATEMENTS

Iteration statements let you loop a set of statements. There are three forms of iteration statements in *mikroBasic PRO for PIC:*

- for
- while
- do

You can use the statements break and continue to control the flow of a loop statement. `break` terminates the statement in which it occurs, while `continue` begins executing the next iteration of the sequence.

FOR STATEMENT

The `for` statement implements an iterative loop and requires you to specify the number of iterations. The syntax of the `for` statement is:

```
for counter = initial_value to final_value [ step step_value]
  statements
next counter
```

`counter` is a variable being increased by `step_value` with each iteration of the loop. The parameter `step_value` is an optional integral value, and defaults to 1 if omitted. Before the first iteration, `counter` is set to `initial_value` and will be incremented until it reaches (or exceeds) the `final_value`. With each iteration, `statements` will be executed.

`initial_value` and `final_value` should be expressions compatible with `counter;` `statements` can be any statements that do not change the value of `counter`.

Note that the parameter `step_value` may be negative, allowing you to create a countdown.

Here is an example of calculating scalar product of two vectors, `a` and `b`, of length `n`, using the `for` statement:

```
s = 0
for i = 0 to n-1
  s = s + a[ i] * b[ i]
next i
```

Endless Loop

The `for` statement results in an endless loop if `final_value` equals or exceeds the range of the `counter`'s type.

WHILE STATEMENT

Use the `while` keyword to conditionally iterate a statement. The syntax of the `while` statement is:

```
while expression
  statements
wend
```

statements executed repeatedly as long as *expression* evaluates true. The test takes place before *statement* are executed. Thus, if *expression* evaluates false on the first pass, the loop does not execute.

Here is an example of calculating scalar product of two vectors, using the `while` statement:

```
s = 0
i = 0;
while i < n
  s = s + a[i] * b[i]
  i = i + 1
wend
```

Probably the easiest way to create an endless loop is to use the statement:

```
while TRUE
 ' ...
wend
```

DO STATEMENT

The `do` statement executes until the condition becomes true. The syntax of the `do` statement is:

```
do
  statements
loop until expression
```

`statements` are executed repeatedly until `expression` evaluates true. `expression` is evaluated *after* each iteration, so the loop will execute `statements` at least once.

Here is an example of calculating scalar product of two vectors, using the `do` statement:

```
s = 0
i = 0
do
  s = s + a[i] * b[i]
  i = i + 1
loop until i = n
```

JUMP STATEMENTS

A jump statement, when executed, transfers control unconditionally. There are five such statements in in *mikroBasic PRO for PIC:*

- break
- continue
- exit
- goto
- gosub

BREAK AND CONTINUE STATEMENTS

Break Statement

Sometimes, you might need to stop the loop from within its body. Use the `break` statement within loops to pass control to the first statement following the innermost loop (`for,` `while,` or `do`).

For example:

```
Lcd_Out(1, 1, "No card inserted")

' Wait for CF card to be plugged; refresh every second
while true
  if Cf_Detect() = 1 then
    break
  end if
  Delay_ms(1000)
wend

' Now we can work with CF card ...
Lcd_Out(1, 1, "Card detected   ")
```

Continue Statement

You can use the `continue` statement within loops to “skip the cycle”:

- `continue` statement in `for` loop moves program counter to the line with key word `for`
- `continue` statement in `while` loop moves program counter to the line with loop condition (top of the loop,
- `continue` statement in `do` loop moves program counter to the line with loop condition (top of the loop).

```
` continue jumps here
for i := ...
  ...
  continue;
    ...
  next i
```

```
' continue jumps here
while condition
    ...
    continue;
    ...
  wend
```

```
 do
   ...
    continu
    ...
 `continue jumps here
loop until condition
```

EXIT STATEMENT

The `exit` statement allows you to break out of a routine (function or procedure). It passes the control to the first statement following the routine call.

Here is a simple example:

```
sub procedure Proc1()
dim error as byte
      ... ' we're doing something here
  if error = TRUE then
      exit
   end if
  ... ' some code, which won't be executed if error is true
end sub
```

Note: If breaking out of a function, return value will be the value of the local variable `result` at the moment of exit.

GOTO STATEMENT

Use the `goto` statement to unconditionally jump to a local label — for more information, refer to Labels. Syntax of `goto` statement is:

```
goto label_name
```

This will transfer control to the location of a local label specified by *`label_name`*. The `goto` line can come before or after the label.

Label and `goto` statement must belong to the same block. Hence it is not possible to jump into or out of a procedure or function.

You can use `goto` to break out from any level of nested control structures. Never jump *into* a loop or other structured statement, since this can have unpredictable effects.

The use of `goto` statement is generally discouraged as practically every algorithm can be realized without it, resulting in legible structured programs. One possible application of the `goto` statement is breaking out from deeply nested control structures:

```
for i = 0 to n
  for j = 0 to m
    ...
    if disaster
      goto Error
    end if
    ...
  next j
next i
 .
 .
 .
Error: ' error handling code
```

GOSUB STATEMENT

Use the `gosub` statement to unconditionally jump to a local label — for more information, refer to Labels. The syntax of the gosub statement is:

```
gosub label_name
...
label_name:
...
return
```

This will transfer control to the location of a local label specified by `label_name`. Also, the calling point is remembered. Upon encountering the `return` statement, program execution will continue with the next statement (line) after `gosub`. The `gosub` line can come before or after the label.

It is not possible to jump into or out of routine by means of `gosub`. Never jump *into* a loop or other structured statement, since this can have unpredictable effects.

Note: Like with `goto`, the use of `gosub` statement is generally discouraged. *mikroBasic PRO for PIC* supports `gosub` only for the sake of backward compatibility. It is better to rely on functions and procedures, creating legible structured programs.

asm STATEMENT

mikroBasic PRO for PIC allows embedding assembly in the source code by means of the `asm` statement. Note that you cannot use numerals as absolute addresses for register variables in assembly instructions. You may use symbolic names instead (listing will display these names as well as addresses).

You can group assembly instructions with the `asm` keyword:

```
asm
   block of assembly instructions
end asm
```

mikroBasic PRO for PIC comments are not allowed in embedded assembly code. Instead, you may use one-line assembly comments starting with semicolon.

Note: Compiler doesn't expect memory banks to be changed inside the assembly code. If the user wants to do this, then he must restore the previous bank selection.

DIRECTIVES

Directives are words of special significance which provide additional functionality regarding compilation and output.

The following directives are available for use:

- Compiler directives for conditional compilation,
- Linker directives for object distribution in memory.

COMPILER DIRECTIVES

Any line in source code with leading # is taken as a compiler directive. The initial # can be preceded or followed by whitespace (excluding new lines). The compiler directives are not case sensitive.

You can use conditional compilation to select particular sections of code to compile while excluding other sections. All compiler directives must be completed in the source file in which they begun.

Directives #DEFINE and #UNDEFINE

Use directive `#DEFINE` to define a conditional compiler constant (“flag”). You can use any identifier for a flag, with no limitations. No conflicts with program identifiers are possible because the flags have a separate name space. Only one flag can be set per directive.

For example:

```
#DEFINE extended_format
```

Use `#UNDEFINE` to undefine (“clear”) previously defined flag.

Directives #IFDEF, $IFNDEF, #ELSEIF and #ELSE

Conditional compilation is carried out by the `#IFDEF` and `$IFNDEF` directives. `#IFDEF` tests whether a flag is currently defined, and `$IFNDEF` if the flag is not defined; i.e. whether a previous `#DEFINE` directive has been processed for that flag and is still in force.

Directives `#IFDEF` and `$IFNDEF` are terminated by the `#ENDIF` directive and can have any number of the `#ELSEIF` clauses and an optional `#ELSE` clause:

```
#IFDEF flag THEN
  block of code
[ #ELSEIF flag_1 THEN
  block of code 1
...
#ELSEIF flag_n THEN
  block of code n ]
[ #ELSE
  alternate block of code ]
#ENDIF
```

First, `$IFDEF` checks if `flag` is defined by means of `$DEFINE`. If so, only *block of code* will be compiled. Otherwise, the compiler will check flags `flag_1 .. flag_n` and execute the appropriate *block of code i*. Eventually, if none of the flags is set, alternate *block of code* in `#ELSE` (if any) will be compiled.

`#ENDIF` ends the conditional sequence. The result of the preceding scenario is that only one section of code (possibly empty) is passed on for further processing. The processed section can contain further conditional clauses, nested to any depth; each `#IFDEF` must be matched with a closing `#ENDIF`.

Unlike `$IFDEF`, `$IFNDEF` checks if `flag` is *not* defined by means of `$DEFINE`, thus producing the opposite results.

Here is an example:

```
' Uncomment the appropriate flag for your application:
'#DEFINE resolution8
'#DEFINE resolution10
'#DEFINE resolution12

#IFDEF resolution8 THEN
  ... ' code specific to 8-bit resolution
#ELSEIF resolution10 THEN
  ... ' code specific to 10-bit resolution
#ELSEIF resolution12 THEN
  ... ' code specific to 12-bit resolution
```

```
#ELSE
  ... ' default code
#ENDIF
```

Predefined Flags

The compiler sets directives upon completion of project settings, so the user doesn't need to define certain flags.
Here is an example:

```
#IFDEF 16F887 ' If 16F887 MCU is selected
#IFNDEF 18F4550 ' If 18F4550 MCU is selected
```

See also predefined project level defines.

Linker Directives

mikroBasic PRO for PIC uses internal algorithm to distribute objects within memory. If you need to have a variable or routine at the specific predefined address, use the linker directives `absolute` and `org`.

Note: You must specify an even address when using the linker directives.

Directive absolute

The directive `absolute` specifies the starting address in RAM for a variable. If the variable spans more than 1 word (16-bit), higher words will be stored at the consecutive locations.

The `absolute` directive is appended to the declaration of a variable:

```
dim x as word absolute 0x32
' Variable x will occupy 1 word (16 bits) at address 0x32

dim y as longint absolute 0x34
' Variable y will occupy 2 words at addresses 0x34 and 0x36
```

Be careful when using `absolute` directive, as you may overlap two variables by accident. For example:

```
dim  i as word absolute 0x42
' Variable i will occupy 1 word at address 0x42;

dim jj as longint absolute 0x40
' Variable will occupy 2 words at 0x40 and 0x42; thus,
' changing i changes jj at the same time and vice versa
```

Note: You must specify an even address when using the directive `absolute`.

Directive org

The directive `org` specifies the starting address of a routine in ROM. It is appended to the declaration of routine. For example:

```
sub procedure proc(dim par as word) org 0x200
' Procedure will start at the address 0x200;
...
end sub
```

Note: You must specify an even address when using the directive `org`.

Directive orgall

Use the `orgall` directive to specify the address above which all routines, constants will be placed. Example:

```
main:
  orgall(0x200)  ' All the routines, constants in main program will
be above the address 0x200

  ...

end.
```

CHAPTER 7

mikroBasic PRO for PIC Libraries

mikroBasic PRO for PIC provides a set of libraries which simplify the initialization and use of PIC compliant MCUs and their modules:

Use Library manager to include *mikroBasic PRO for PIC* Libraries in you project.

Hardware PIC-specific Libraries

- ADC Library
- CAN Library
- CANSPI Library
- Compact Flash Library
- EEPROM Library
- Ethernet PIC18FxxJ60 Library
- Flash Memory Library
- Graphic Lcd Library
- I^{2}C Library
- Keypad Library
- Lcd Library
- Manchester Code Library
- Multi Media Card library
- OneWire Library
- Port Expander Library
- PS/2 Library
- PWM Library
- RS-485 Library
- Software I^{2}C Library
- Software SPI Library
- Software UART Library
- Sound Library
- SPI Library
- SPI Ethernet Library
- SPI Graphic Lcd Library
- SPI Lcd Library
- SPI Lcd8 Library
- SPI T6963C Graphic Lcd Library
- T6963C Graphic Lcd Library
- UART Library
- USB HID Library

Miscellaneous Libraries

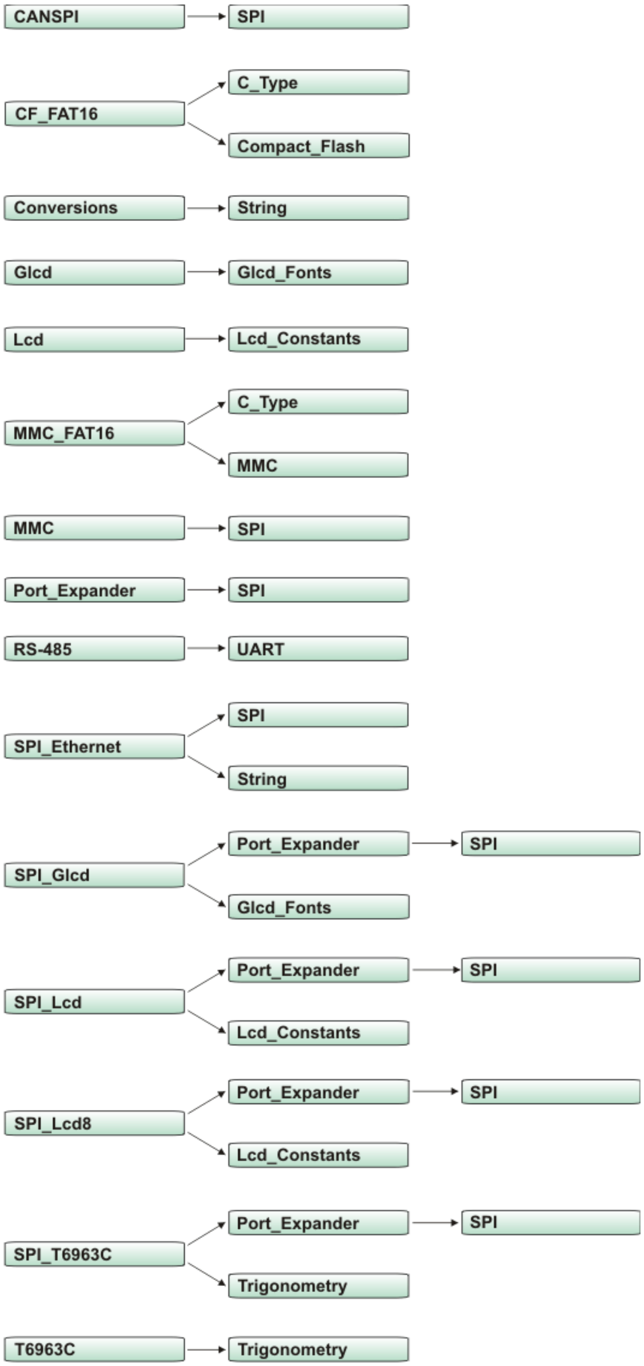
- Button Library
- Conversions Library
- Math Library
- String Library
- Time Library
- Trigonometry Library

See also Built-in Routines.

LIBRARY DEPENDENCIES

Certain libraries use (depend on) function and/or variables, constants defined in other libraries.
Image below shows clear representation about these dependencies.

For example, SPI_Glcd uses Glcd_Fonts and Port_Expander library which uses SPI library.
This means that if you check SPI_Glcd library in Library manager, all libraries on which it depends will be checked too.



Related topics: Library manager, 8051 Libraries

Hardware Libraries

- ADC Library
- CAN Library
- CANSPI Library
- Compact Flash Library
- EEPROM Library
- Ethernet PIC18FxxJ60 Library
- Flash Memory Library
- Graphic Lcd Library
- I^{2}C Library
- Keypad Library
- Lcd Library
- Manchester Code Library
- Multi Media Card library
- OneWire Library
- Port Expander Library
- PS/2 Library
- PWM Library
- RS-485 Library
- Software I^{2}C Library
- Software SPI Library
- Software UART Library
- Sound Library
- SPI Library
- SPI Ethernet Library
- SPI Graphic Lcd Library
- SPI Lcd Library
- SPI Lcd8 Library
- SPI T6963C Graphic Lcd Library
- T6963C Graphic Lcd Library
- UART Library
- USB HID Library

ADC LIBRARY

ADC (Analog to Digital Converter) module is available with a number of PIC MCUs. Library function `Adc_Read` is included to provide you comfortable work with the module.

Library Routines

- ADC_Read

ADC_Read

Prototype	`sub function ADC_Read(dim channel as byte) as word`
Returns	10-bit unsigned value read from the specified channel
Description	Initializes PIC's internal ADC module to work with RC clock. Clock determines the time period necessary for performing AD conversion (min 12TAD). Parameter channel represents the channel from which the analog value is to be acquired. Refer to the appropriate datasheet for channel-to-pin mapping
Requires	Nothing.
Example	

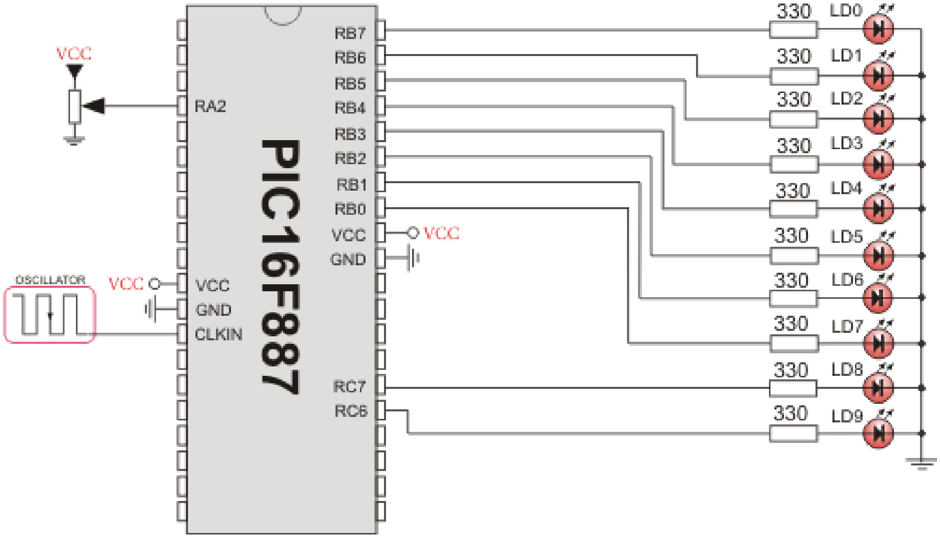
```
dim tmp as word
...
tmp = ADC_Read(2)   ' Read analog value from channel 2
```

Library Example

This example code reads analog value from channel 2 and displays it on PORTB and PORTC.

```
program ADC_on_LEDs
dim adc_rd as word

main:
  EBDIS_bit = 1                ' set External Bus Disable bit
  CMCON   = CMCON or 0x07     ' turn off comparators
  ADCON1  = ADCON1 or 0x0C    ' Set AN2 channel pin as analog
  TRISA2_bit = 1              '   input

  TRISB = 0x00                ' Set PORTB as output
  TRISC = 0x00                ' Set PORTC as output

  while (TRUE)
    adc_rd = ADC_Read(2)      ' get ADC value from 2nd channel
    PORTB = adc_rd            ' display adc_rd[7..0]
    PORTC = Hi(adc_rd)        ' display adc_rd[9..8]
  wend
end.
```

HW Connection



ADC HW connection

CAN LIBRARY

mikroBasic provides a library (driver) for working with the CAN module.

CAN is a very robust protocol that has error detection and signalling, self–checking and fault confinement. Faulty CAN data and remote frames are re-transmitted automatically, similar to the Ethernet.

Data transfer rates vary from up to 1 Mbit/s at network lengths below 40m to 250 Kbit/s at 250m cables, and can go even lower at greater network distances, down to 200Kbit/s, which is the minimum bitrate defined by the standard. Cables used are shielded twisted pairs, and maximum cable length is 1000m.

CAN supports two message formats:

- Standard format, with 11 identifier bits, and
- Extended format, with 29 identifier bits

Note: Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.

Library Routines

- CANSetOperationMode
- CANGetOperationMode
- CANInitialize
- CANSetBaudRate
- CANSetMask
- CANSetFilter
- CANRead
- CANWrite

Following routines are for the internal use by compiler only:

- RegsToCANID
- CANIDToRegs

Be sure to check CAN constants necessary for using some of the functions

CANSetOperationMode

Prototype	`sub procedure CANSetOperationMode(dim mode, wait_flag as byte)`
Returns	Nothing.
Description	Sets CAN to requested mode, i.e. copies mode to CANSTAT. Parameter mode needs to be one of CAN_OP_MODE constants (see CAN constants). Parameter `wait_flag` needs to be either 0 or $FF: ■ If set to $FF, this is a blocking call – the function won't "return" until the requested mode is set. ■ If 0, this is a non-blocking call. It does not verify if CAN module is switched to requested mode or not. Caller must use `CANGetOperationMo`de to verify correct operation mode before performing mode specific operation.
Requires	Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.
Example	`CANSetOperationMode(_CAN_MODE_CONFIG, $FF)`

CANGetOperationMode

Prototype	`sub function CANGetOperationMode as byte`
Returns	Current opmode.
Description	Function returns current operational mode of CAN module.
Requires	Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.
Example	`if CANGetOperationMode = _CAN_MODE_NORMAL then` `...`

CANInitialize

Prototype

```
sub procedure CANInitialize(dim SJW, BRP, PHSEG1, PHSEG2,
PROPSEG, CAN_CONFIG_FLAGS as byte)
```

Returns

Nothing.

Description

Initializes CAN. All pending transmissions are aborted. Sets all mask registers to 0 to allow all messages.

Filter registers are set according to flag value:

```
if (CAN_CONFIG_FLAGS and _CAN_CONFIG_VALID_XTD_ MSG)<> 0
   ' Set all filters to XTD_MSG
else if (config and _CAN_CONFIG_VALID_STD_MSG) <> 0
   ' Set all filters to STD_MSG
else
   ' Set half of the filters to STD, and the rest to XTD_MSG.
```

Parameters:

- `SJW` as defined in 18XXX8 datasheet (1–4)
- `BRP` as defined in 18XXX8 datasheet (1–64)
- `PHSEG1` as defined in 18XXX8 datasheet (1–8)
- `PHSEG2` as defined in 18XXX8 datasheet (1–8)
- `PROPSEG` as defined in 18XXX8 datasheet (1–8)
- `CAN_CONFIG_FLAGS` is formed from predefined constants (see CAN constants)

Requires

CAN must be in Config mode; otherwise the function will be ignored.

Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.

Example

```
init =  _CAN_CONFIG_SAMPLE_THRICE   and
         _CAN_CONFIG_PHSEG2_PRG_ON   and
         _CAN_CONFIG_STD_MSG         and
         _CAN_CONFIG_DBL_BUFFER_ON   and
         _CAN_CONFIG_VALID_XTD_MSG   and
         _CAN_CONFIG_LINE_FILTER_OFF
...
CANInitialize(1,1,3,3,1,init)   'Initialize CAN
```

CANSetBaudRate

Prototype	`sub procedure CANSetBaudRate(dim SJW, BRP, PHSEG1, PHSEG2, PROPSEG, CAN_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Sets CAN baud rate. Due to complexity of CAN protocol, you cannot simply force a bps value. Instead, use this function when CAN is in Config mode. Refer to datasheet for details. Parameters: ■ `SJW` as defined in 18XXX8 datasheet (1–4) ■ `BRP` as defined in 18XXX8 datasheet (1–64) ■ `PHSEG1` as defined in 18XXX8 datasheet (1–8) ■ `PHSEG2` as defined in 18XXX8 datasheet (1–8) ■ `PROPSEG` as defined in 18XXX8 datasheet (1–8) ■ `CAN_CONFIG_FLAGS` is formed from predefined constants (see CAN constants)
Requires	CAN must be in Config mode; otherwise the function will be ignored. Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.

Example

```
init = _CAN_CONFIG_SAMPLE_THRICE and
         _CAN_CONFIG_PHSEG2_PRG_ON      and
         _CAN_CONFIG_STD_MSG            and
         _CAN_CONFIG_DBL_BUFFER_ON      and
         _CAN_CONFIG_VALID_XTD_MSG      and
         _CAN_CONFIG_LINE_FILTER_OFF
...
CANSetBaudRate (1, 1, 3, 3, 1, init)
```

CANSetMask

Prototype	`sub procedure CANSetMask(dim CAN_MASK as byte, dim value as longint, dim CAN_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Function sets mask for advanced filtering of messages. Given `value` is bit adjusted to appropriate buffer mask registers. Parameters: ■ `CAN_MASK` is one of predefined constant values (see CAN constants) ■ `value` is the mask register value ■ `CAN_CONFIG_FLAGS` selects type of message to filter, either `_CAN_CONFIG_XTD_MSG` or `_CAN_CONFIG_STD_MSG`
Requires	CAN must be in Config mode; otherwise the function will be ignored. Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.
Example	see below

Example

```
' Set all mask bits to 1, i.e. all filtered bits are relevant:
CANSetMask(_CAN_MASK_B1, -1,_CAN_CONFIG_XTD_MSG)

' Note that -1 is just a cheaper way to write $FFFFFFFF.
' Complement will do the trick and fill it up with ones.
```

CANSetFilter

Prototype	`sub procedure CANSetFilter(dim CAN_FILTER as byte, dim value as longint, dim CAN_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Function sets message filter. Given value is bit adjusted to appropriate buffer mask registers. Parameters: ■ `CAN_FILTER` is one of predefined constant values (see CAN constants) ■ `value` is the filter register value ■ `CAN_CONFIG_FLAGS` selects type of message to filter, either `_CAN_CONFIG_XTD_MSG` or `_CAN_CONFIG_STD_MSG`
Requires	CAN must be in Config mode; otherwise the function will be ignored. Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.
Example	`' Set id of filter B1_F1 to 3:` `CANSetFilter(_CAN_FILTER_B1_F1, 3, _CAN_CONFIG_XTD_MSG)`

CANRead

Prototype	`sub function CANRead(dim byref id as longint, dim byref data as byte[8] , dim byref datalen, CAN_RX_MSG_FLAGS as byte) as byte`
Returns	Message from receive buffer or zero if no message found.
Description	Function reads message from receive buffer. If at least one full receive buffer is found, it is extracted and returned. If none found, function returns zero. Parameters: ■ `id` is message identifier ■ `data` is an array of bytes up to 8 bytes in length ■ `datalen` is data length, from 1–8. ■ `CAN_RX_MSG_FLAGS` is value formed from constants (see CAN constants)
Requires	CAN must be in mode in which receiving is possible. Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.
Example	

```
dim len, rcv, rx as byte
dim id  as longint
dim data as byte[8]

' ...
rx = 0
' ...
rcv = CANRead(id, data, len, rx)
```

CANWrite

Prototype	`sub function CANWrite(dim id as longint, dim byref data as byte[ 8] , dim datalen, CAN_TX_MSG_FLAGS as byte) as byte`
Returns	Returns zero if message cannot be queued (buffer full).
Description	If at least one empty transmit buffer is found, function sends message on queue for transmission. If buffer is full, function returns 0. Parameters: ■ `id` CAN message identifier. Only 11 or 29 bits may be used depending on message type (standard or extended) ■ `data` is an array of bytes up to 8 bytes in length ■ `datalen` is data length, from 1–8. ■ `CAN_RX_MSG_FLAGS` is value formed from constants (see CAN constants)
Requires	CAN must be in Normal mode. Microcontroller must be connected to CAN transceiver (MCP2551 or similar) which is connected to CAN bus.

Example

```
dim id as longint
dim tx, data as byte

' ...
tx = _CAN_TX_PRIORITY_0 and
      _CAN_TX_XTD_FRAME
' ...
CANWrite(id, data, 2, tx)
```

CAN Constants

There is a number of constants predefined in CAN library. To be able to use the library effectively, you need to be familiar with these. You might want to check the example at the end of the chapter.

CAN_OP_MODE

`CAN_OP_MODE` constants define CAN operation mode. Function `CANSetOperationMode` expects one of these as its argument:

```
const  _CAN_MODE_BITS     = $E0   ' Use it to access mode bits
const  _CAN_MODE_NORMAL   = 0
const  _CAN_MODE_SLEEP    = $20
const  _CAN_MODE_LOOP     = $40
const  _CAN_MODE_LISTEN   = $60
const  _CAN_MODE_CONFIG   = $80
```

CAN_CONFIG_FLAGS

`CAN_CONFIG_FLAGS` constants define flags related to CAN module configuration. Functions `CANInitialize` and `CANSetBaudRate` expect one of these (or a bitwise combination) as their argument:

```
const  _CAN_CONFIG_DEFAULT               = $FF   ' 11111111

const  _CAN_CONFIG_PHSEG2_PRG_BIT        = $01
const  _CAN_CONFIG_PHSEG2_PRG_ON         = $FF   ' XXXXXXX1
const  _CAN_CONFIG_PHSEG2_PRG_OFF        = $FE   ' XXXXXXX0

const  _CAN_CONFIG_LINE_FILTER_BIT       = $02
const  _CAN_CONFIG_LINE_FILTER_ON        = $FF   ' XXXXXX1X
const  _CAN_CONFIG_LINE_FILTER_OFF       = $FD   ' XXXXXX0X

const  _CAN_CONFIG_SAMPLE_BIT            = $04
const  _CAN_CONFIG_SAMPLE_ONCE           = $FF   ' XXXXX1XX
const  _CAN_CONFIG_SAMPLE_THRICE         = $FB   ' XXXXX0XX

const  _CAN_CONFIG_MSG_TYPE_BIT          = $08
const  _CAN_CONFIG_STD_MSG               = $FF   ' XXXX1XXX
const  _CAN_CONFIG_XTD_MSG               = $F7   ' XXXX0XXX

const  _CAN_CONFIG_DBL_BUFFER_BIT       = $10
const  _CAN_CONFIG_DBL_BUFFER_ON         = $FF   ' XXX1XXXX
const  _CAN_CONFIG_DBL_BUFFER_OFF        = $EF   ' XXX0XXXX
const  _CAN_CONFIG_MSG_BITS              = $60

const  _CAN_CONFIG_ALL_MSG               = $FF   ' X11XXXXX
const  _CAN_CONFIG_VALID_XTD_MSG         = $DF   ' X10XXXXX
const  _CAN_CONFIG_VALID_STD_MSG         = $BF   ' X01XXXXX
const  _CAN_CONFIG_ALL_VALID_MSG         = $9F   ' X00XXXXX
```

You may use bitwise and to form config byte out of these values. For example:

```
init =   _CAN_CONFIG_SAMPLE_THRICE and
          _CAN_CONFIG_PHSEG2_PRG_ON  and
          _CAN_CONFIG_STD_MSG        and
          _CAN_CONFIG_DBL_BUFFER_ON  and
          _CAN_CONFIG_VALID_XTD_MSG  and
          _CAN_CONFIG_LINE_FILTER_OFF
...
CANInitialize(1, 1, 3, 3, 1, init)    ' Initialize CAN
```

CAN_TX_MSG_FLAGS

CAN_TX_MSG_FLAGS are flags related to transmission of a CAN message:

```
const _CAN_TX_PRIORITY_BITS   = $03
const _CAN_TX_PRIORITY_0      = $FC   ' XXXXXX00
const _CAN_TX_PRIORITY_1      = $FD   ' XXXXXX01
const _CAN_TX_PRIORITY_2      = $FE   ' XXXXXX10
const _CAN_TX_PRIORITY_3      = $FF   ' XXXXXX11

const _CAN_TX_FRAME_BIT       = $08
const _CAN_TX_STD_FRAME       = $FF   ' XXXXX1XX
const _CAN_TX_XTD_FRAME       = $F7   ' XXXXX0XX

const _CAN_TX_RTR_BIT         = $40
const _CAN_TX_NO_RTR_FRAME   = $FF   ' X1XXXXXX
const _CAN_TX_RTR_FRAME       = $BF   ' X0XXXXXX
```

You may use bitwise and to adjust the appropriate flags. For example:

```
' form value to be used with CANSendMessage:
send_config =   _CAN_TX_PRIORITY_0   and
                _CAN_TX_XTD_FRAME    and
                _CAN_TX_NO_RTR_FRAME;
...
CANSendMessage(id, data, 1, send_config)
```

CAN_RX_MSG_FLAGS

`CAN_RX_MSG_FLAGS` are flags related to reception of CAN message. If a particular bit is set; corresponding meaning is TRUE or else it will be FALSE.

```
const _CAN_RX_FILTER_BITS  = $07 'Use it to access filter   bits
const _CAN_RX_FILTER_1      = $00
const _CAN_RX_FILTER_2      = $01
const _CAN_RX_FILTER_3      = $02
const _CAN_RX_FILTER_4      = $03
const _CAN_RX_FILTER_5      = $04
const _CAN_RX_FILTER_6      = $05
const _CAN_RX_OVERFLOW      = $08 ' Set if Overflowed; else clear
const _CAN_RX_INVALID_MSG  = $10 ' Set if invalid; else clear
const _CAN_RX_XTD_FRAME     = $20 ' Set if XTD message; else clear
const _CAN_RX_RTR_FRAME     = $40 ' Set if RTR message; else clear
const _CAN_RX_DBL_BUFFERED = $80 ' Set if message was
                                 ' hardware double-buffered
```

You may use bitwise and to adjust the appropriate flags. For example:

```
if (MsgFlag and CAN_RX_OVERFLOW) = 0 then
  ...
  ' Receiver overflow has occurred.
  ' We have lost our previous message.
```

CAN_MASK

`CAN_MASK` constants define mask codes. Function `CANSetMask` expects one of these as its argument:

```
const CAN_MASK_B1   = 0
const CAN_MASK_B2   = 1
```

CAN_FILTER

`CAN_FILTER` constants define filter codes. Function CANSetFilter expects one of these as its argument:

```
const _CAN_FILTER_B1_F1   = 0
const _CAN_FILTER_B1_F2   = 1
const _CAN_FILTER_B2_F1   = 2
const _CAN_FILTER_B2_F2   = 3
const _CAN_FILTER_B2_F3   = 4
const _CAN_FILTER_B2_F4   = 5
```

Library Example

This is a simple demonstration of CAN Library routines usage. First node initiates the communication with the second node by sending some data to its address. The second node responds by sending back the data incremented by 1. First node then does the same and sends incremented data back to second node, etc.

Code for the first CANSPI node:

```
program CAN_1st

dim Can_Init_Flags, Can_Send_Flags, Can_Rcv_Flags as byte ' can flags
    Rx_Data_Len as byte                  ' received data length in bytes
    RxTx_Data as byte[ 8]                ' can rx/tx data buffer
    Msg_Rcvd as byte                     ' reception flag
    ID_1st, ID_2nd as longint            ' node IDs
    Rx_ID as longint

main:
  PORTC = 0                              ' clear PORTC
  TRISC = 0                              ' set PORTC as output

  Can_Init_Flags = 0                     '
  Can_Send_Flags = 0                     ' clear flags
  Can_Rcv_Flags  = 0                     '

  Can_Send_Flags = _CAN_TX_PRIORITY_0 and     ' form value to be used
                   _CAN_TX_XTD_FRAME and      '   with CANWrite
                   _CAN_TX_NO_RTR_FRAME

 Can_Init_Flags  =  _CAN_CONFIG_SAMPLE_THRICE  and  'form  value  to  be
used
                   _CAN_CONFIG_PHSEG2_PRG_ON and 'with CANInit
                   _CAN_CONFIG_XTD_MSG and
                   _CAN_CONFIG_DBL_BUFFER_ON and
                   _CAN_CONFIG_VALID_XTD_MSG
ID_1st = 12111
ID_2nd = 3
RxTx_Data[ 0]  = 9                       ' set initial data to be sent

CANInitialize(1,3,3,3,1,Can_Init_Flags)     ' Initialize CAN module
CANSetOperationMode(_CAN_MODE_CONFIG,0xFF)  ' set CONFIGURATION mode
CANSetMask(_CAN_MASK_B1,-1,_CAN_CONFIG_XTD_MSG) ' set all mask1 bits
to ones
CANSetMask(_CAN_MASK_B2,-1,_CAN_CONFIG_XTD_MSG) ' set all mask2 bits
to ones
CANSetFilter(_CAN_FILTER_B2_F4,ID_2nd,_CAN_CONFIG_XTD_MSG)   'set  id
of filter B2_F4 to 2nd node ID

CANSetOperationMode(_CAN_MODE_NORMAL,0xFF)   'set NORMAL mode
```

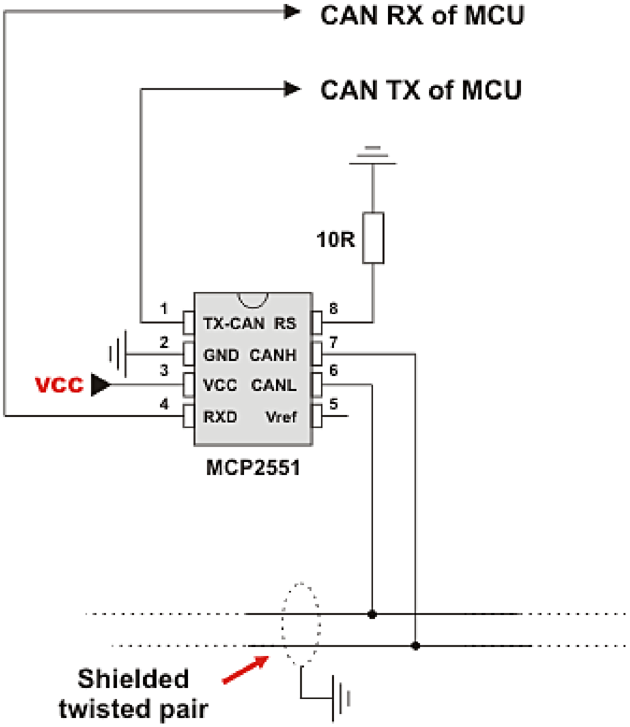
```
CANWrite(ID_1st, RxTx_Data, 1, Can_Send_Flags 'send initial message

while TRUE
  Msg_Rcvd = CANRead(Rx_ID , RxTx_Data , Rx_Data_Len, Can_Rcv_Flags)
   if ((Rx_ID = ID_2nd) and (Msg_Rcvd <> 0)) <> 0 then
      PORTC = RxTx_Data[ 0]       ' output data at PORTC
      RxTx_Data[ 0] = RxTx_Data[ 0] + 1
      Delay_ms(10)
      CANWrite(ID_1st, RxTx_Data, 1, Can_Send_Flags)   ' send incre-
mented data back
    end if
  wend
end.
```

Code for the second CANSPI node:

```
program CAN_2nd

dim Can_Init_Flags, Can_Send_Flags, Can_Rcv_Flags as byte  'CAN flags
    Rx_Data_Len as byte        ' received data length in bytes
    RxTx_Data as byte[ 8]      ' can rx/tx data buffer
    Msg_Rcvd as byte           ' reception flag
    ID_1st, ID_2nd as longin ' node IDs
    Rx_ID as longint

main:
  PORTC = 0                  ' clear PORTC
  TRISC = 0                  ' set PORTC as output

  Can_Init_Flags = 0         '
  Can_Send_Flags = 0         ' clear flags
  Can_Rcv_Flags  = 0         '

  Can_Send_Flags = _CAN_TX_PRIORITY_0 and ' form value to be used
                    _CAN_TX_XTD_FRAME and ' with CANWrite
                    _CAN_TX_NO_RTR_FRAME

  Can_Init_Flags = _CAN_CONFIG_SAMPLE_THRICE and ' form value to be
used
                   _CAN_CONFIG_PHSEG2_PRG_ON and  'with CANInit
                   _CAN_CONFIG_XTD_MSG and
                   _CAN_CONFIG_DBL_BUFFER_ON and
                   _CAN_CONFIG_VALID_XTD_MSG and
                   _CAN_CONFIG_LINE_FILTER_OFF
  ID_1st = 12111
  ID_2nd = 3
  RxTx_Data[ 0] = 9                    ' set initial data to be sent
```

```
   CANInitialize(1,3,3,3,1,Can_Init_Flags ' initialize external CAN
module
   CANSetOperationMode(_CAN_MODE_CONFIG,0xFF)   '  set  CONFIGURATION
mode
   CANSetMask(_CAN_MASK_B1,-1,_CAN_CONFIG_XTD_MSG)  ' set  all  mask1
bits to ones
   CANSetMask(_CAN_MASK_B2,-1,_CAN_CONFIG_XTD_MSG)   ' set all mask2
bits to ones
   CANSetFilter(_CAN_FILTER_B2_F3,ID_1st,_CAN_CONFIG_XTD_MSG)  '  set
id of filter B2_F3 to 1st node ID

  CANSetOperationMode(_CAN_MODE_NORMAL,0xFF)        ' set NORMAL mode

  while true                                      ' endless loop
     Msg_Rcvd  =  CANRead(Rx_ID  ,  RxTx_Data  ,  Rx_Data_Len,  Can_Rcv_
Flags)                                             ' receive message
  if ((Rx_ID = ID_1st) and (Msg_Rcvd <> 0)) <> 0 then   ' if message
received check id
      PORTC = RxTx_Data[ 0]       ' id correct, output data at PORTC
      Inc(RxTx_Data[ 0])          ' increment received data
      CANWrite(ID_2nd, RxTx_Data, 1, Can_Send_Flags)' send increment-
ed data back
     end if
  wend
end.
```

HW Connection



Example of interfacing CAN transceiver with MCU and bus.

CANSPI LIBRARY

The SPI module is available with a number of the PIC compliant MCUs. The mikroBasic PRO for PIC provides a library (driver) for working with mikroElektronika's CANSPI Add-on boards (with MCP2515 or MCP2510) via SPI interface.

The CAN is a very robust protocol that has error detection and signalization, self–checking and fault confinement. Faulty CAN data and remote frames are re-transmitted automatically, similar to the Ethernet.

Data transfer rates depend on distance. For example, 1 Mbit/s can be achieved at network lengths below 40m while 250 Kbit/s can be achieved at network lengths below 250m. The greater distance the lower maximum bitrate that can be achieved. The lowest bitrate defined by the standard is 200Kbit/s. Cables used are shielded twisted pairs.

CAN supports two message formats:

- Standard format, with 11 identifier bits and
- Extended format, with 29 identifier bits

Note:

- Consult the CAN standard about CAN bus termination resistance.
- An effective CANSPI communication speed depends on SPI and certainly is slower than “real” CAN.
- The library uses the SPI module for communication. User must initialize SPI module before using the SPI Graphic Lcd Library.
  For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the SPI_Set_Active routine.
- CANSPI module refers to mikroElektronika's CANSPI Add-on board connect ed to SPI module of MCU.

External dependecies of CANSPI Library

The following variables must be defined in all projects using CANSPI Library:	Description:	Example :
`dim CanSpi_CS as sbit sfr external`	Chip Select line.	`dim CanSpi_CS as sbit at RC0_bit`
`dim CanSpi_Rst as sbit sfr external`	Reset line.	`dim CanSpi_Rst as sbit at RC2_bit`
`dim CanSpi_CS_Direction as sbit sfr external`	Direction of the Chip Select pin.	`dim CanSpi_CS_Direction as sbit at TRISC0_bit`
`dim CanSpi_Rst_Bit_Direction as sbit sfr external`	Direction of the Reset pin.	`dim CanSpi_Rst_Bit_Direction as sbit at TRISC2_bit`

Library Routines

- CANSPISetOperationMode
- CANSPIGetOperationMode
- CANSPIInitialize
- CANSPISetBaudRate
- CANSPISetMask
- CANSPISetFilter
- CANSPIread
- CANSPIWrite

The following routines are for an internal use by the library only:

- RegsToCANSPIID
- CANSPIIDToRegs

Be sure to check CANSPI constants necessary for using some of the sub functions.

CANSPISetOperationMode

Prototype	`sub procedure CANSPISetOperationMode(dim mode as byte, dim WAIT as byte)`
Returns	Nothing.
Description	Sets the CANSPI module to requested mode. Parameters : ■ `mode`: CANSPI module operation mode. Valid values: `CANSPI_OP_MODE` constants (see CANSPI constants). ■ `WAIT`: CANSPI mode switching verification request. If `WAIT = 0`, the call is non-blocking. The sub function does not verify if the CANSPI module is switched to requested mode or not. Caller must use `CANSPIGetOperationMode` to verify correct operation mode before performing mode specific operation. If `WAIT != 0`, the call is blocking – the sub function won't "return" until the requested mode is set.
Requires	The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' set the CANSPI module into configuration mode (wait inside
CANSPISetOperationMode until this mode is set)
CANSPISetOperationMode(_CANSPI_MODE_CONFIG, 0xFF)
```

CANSPIGetOperationMode

Prototype	`sub function CANSPIGetOperationMode() as byte`
Returns	Current operation mode.
Description	The sub function returns current operation mode of the CANSPI module. Check `CANSPI_OP_MODE` constants (see CANSPI constants) or device datasheet for operation mode codes.
Requires	The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' check whether the CANSPI module is in Normal mode and if it is
do something.
if (CANSPIGetOperationMode() = _CANSPI_MODE_NORMAL) then
  ...
end if
```

CANSPIInitialize

Prototype	`sub procedure CANSPIInitialize(dim SJW as byte, dim BRP as byte, dim PHSEG1 as byte, dim PHSEG2 as byte, dim PROPSEG as byte, dim CANSPI_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Initializes the CANSPI module. Stand-Alone CAN controller in the CANSPI module is set to: ■ Disable CAN capture ■ Continue CAN operation in Idle mode ■ Do not abort pending transmissions ■ Fcan clock: 4*Tcy (Fosc) ■ Baud rate is set according to given parameters ■ CAN mode: Normal ■ Filter and mask registers IDs are set to zero ■ Filter and mask message frame type is set according to `CAN_CONFIG_FLAGS` value `SAM,SEG2PHTS,WAKFIL` and `DBEN` bits are set according to `CAN_CONFIG_FLAGS` value. Parameters: ■ `SJW` as defined in CAN controller's datasheet ■ `BRP` as defined in CAN controller's datasheet ■ `PHSEG1` as defined in CAN controller's datasheet ■ `PHSEG2` as defined in CAN controller's datasheet ■ `PROPSEG` as defined in CAN controller's datasheet ■ `CAN_CONFIG_FLAGS` is formed from predefined constants (see CANSPI con stants)
Requires	Global variables : ■ `CanSpi_CS`: Chip Select line ■ `CanSpi_Rst:` Reset line ■ `CanSpi_CS_Bit_Direction`: Direction of the Chip Select pin ■ `CanSpi_Rst_Bit_Direction`: Direction of the Reset pin must be defined before using this function. The CANSPI routines are supported only by MCUs with the SPI module. The SPI module needs to be initialized. See the SPI1_Init and SPI1_Init_Advanced routines. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' CANSPI module connections
dim CanSpi_CS      as sbit at   RC0_bit
    CanSpi_CS_Direction  as sbit at TRISC0_bit
    CanSpi_Rst  as sbit at RC2_bit
    CanSpi_Rst_Direction  as sbit at TRISC2_bit
' End CANSPI module connections

...

dim Can_Init_Flags as byte
  ...
  Can_Init_Flags = _CANSPI_CONFIG_SAMPLE_THRICE and   ' form value
to be used
                    _CANSPI_CONFIG_PHSEG2_PRG_ON and   ' with
CANSPIInitialize
                     _CANSPI_CONFIG_XTD_MSG        and
                     _CANSPI_CONFIG_DBL_BUFFER_ON and
                     _CANSPI_CONFIG_VALID_XTD_MSG
  ...
  SPI1_Init()                             ' initialize SPI module
  CANSPIInitialize(1,3,3,3,1,Can_Init_Flags)   ' initialize exter-
nal CANSPI module
```

CANSPISetBaudRate

Prototype	`sub procedure CANSPISetBaudRate(dim SJW as byte, dim BRP as byte, dim PHSEG1 as byte, dim PHSEG2 as byte, dim PROPSEG as byte, dim CANSPI_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Sets the CANSPI module baud rate. Due to complexity of the CAN protocol, you can not simply force a bps value. Instead, use this sub function when the CANSPI module is in Config mode. `SAM`, `SEG2PHTS` and `WAKFIL` bits are set according to `CANSPI_CONFIG_FLAGS` value. Refer to datasheet for details. Parameters: ■ `SJW` as defined in CAN controller's datasheet ■ `BRP` as defined in CAN controller's datasheet ■ `PHSEG1` as defined in CAN controller's datasheet ■ `PHSEG2` as defined in CAN controller's datasheet ■ `PROPSEG` as defined in CAN controller's datasheet ■ `CAN_CONFIG_FLAGS` is formed from predefined constants (see CANSPI constants)
Requires	The CANSPI module must be in Config mode, otherwise the sub function will be ignored. See CANSPISetOperationMode. The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.
Example	

```
' set required baud rate and sampling rules
dim can_config_flags as byte
...
CANSPISetOperationMode(_CANSPI_MODE_CONFIG, 0xFF)    ' set CONFIG-
URATION mode (CANSPI module mast be in config mode for baud rate
settings)
can_config_flags = _CANSPI_CONFIG_SAMPLE_THRICE and
                    _CANSPI_CONFIG_PHSEG2_PRG_ON and
                    _CANSPI_CONFIG_STD_MSG        and
                    _CANSPI_CONFIG_DBL_BUFFER_ON and
                    _CANSPI_CONFIG_VALID_XTD_MSG and
                    _CANSPI_CONFIG_LINE_FILTER_OFF
CANSPISetBaudRate(1, 1, 3, 3, 1, can_config_flags)
```

CANSPISetMask

Prototype	`sub procedure CANSPISetMask(dim CANSPI_MASK as byte, dim val as longint, dim CANSPI_CONFIG_FLAGS as byte)`
Returns	Nothing.
Description	Configures mask for advanced filtering of messages. The parameter value is bit-adjusted to the appropriate mask registers. Parameters: ■ `CAN_MASK`: CANSPI module mask number. Valid values: `CANSPI_MASK` costants (see CANSPI constants) ■ `val`: mask register value ■ `CAN_CONFIG_FLAGS`: selects type of message to filter. Valid values: `_CANSPI_CONFIG_ALL_VALID_MSG`, `_CANSPI_CONFIG_MATCH_MSG_TYPE and CANSPI_CONFIG_STD_MSG`, `_CANSPI_CONFIG_MATCH_MSG_TYPE and CANSPI_CONFIG_XTD_MSG`. (see CANSPI constants)
Requires	The CANSPI module must be in Config mode, otherwise the sub function will be ignored. See CANSPISetOperationMode. The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' set the appropriate filter mask and message type value
CANSPISetOperationMode(_CANSPI_MODE_CONFIG,0xFF)  ' set CONFIGURATION mode (CANSPI module must be in config mode for mask settings)

' Set all B1 mask bits to 1 (all filtered bits are relevant):
' Note that -1 is just a cheaper way to write 0xFFFFFFFF.
' Complement will do the trick and fill it up with ones.
CANSPISetMask(_CANSPI_MASK_B1, -1, _CANSPI_CONFIG_MATCH_MSG_TYPE and _CANSPI_CONFIG_XTD_MSG)
```

CANSPISetFilter

Prototype	`sub procedure CANSPISetFilter(dim CANSPI_FILTER as byte, dim val as longint, dim CANSPI_CONFIG_FLAGS as byte)`
Returns	Nothing.

Description	Configures message filter. The parameter `value` is bit-adjusted to the appropriate filter registers.
	Parameters:
	■ `CAN_FILTER`: CANSPI module filter number. Valid values: `CANSPI_FILTER` constants (see CANSPI constants)
	■ `val`: filter register value
	■ `CAN_CONFIG_FLAGS`: selects type of message to filter. Valid values:
	`_CANSPI_CONFIG_ALL_VALID_MSG,`
	`_CANSPI_CONFIG_MATCH_MSG_TYPE and CANSPI_CONFIG_STD_MSG,`
	`_CANSPI_CONFIG_MATCH_MSG_TYPE and CANSPI_CONFIG_XTD_MSG.`
	(see CANSPI constants)

Requires	The CANSPI module must be in Config mode, otherwise the function will be ignored. See CANSPISetOperationMode. The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example	`' set the appropriate filter value and message type`
	`CANSPISetOperationMode(_CANSPI_MODE_CONFIG,0xFF)`
	`' set CONFIGURATION mode (CANSPI module must be in config mode for filter settings)`
	`' Set id of filter B1_F1 to 3:`
	`CANSPISetFilter(_CANSPI_FILTER_B1_F1, 3, _CANSPI_CONFIG_XTD_MSG)`

CANSPIRead

Prototype	`sub function CANSPIRead(dim byref id as longint, dim byref rd_data as byte[ 8] , dim data_len as byte, dim CANSPI_RX_MSG_FLAGS as byte) as byte`
Returns	- `0` if nothing is received - `0xFF` if one of the Receive Buffers is full (message received)
Description	If at least one full Receive Buffer is found, it will be processed in the following way: ■ Message ID is retrieved and stored to location provided by the `id` parameter ■ Message data is retrieved and stored to a buffer provided by the `rd_data` parameter ■ Message length is retrieved and stored to location provided by the `data_len` parameter ■ Message flags are retrieved and stored to location provided by the `CAN_RX_MSG_FLAGS` parameter Parameters: ■ `id:` message identifier storage address ■ `rd_data:` data buffer (an array of bytes up to 8 bytes in length) ■ `data_len:` data length storage address. ■ `CAN_RX_MSG_FLAGS:` message flags storage address
Requires	The CANSPI module must be in a mode in which receiving is possible. See CANSPISetOperationMode. The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' check the CANSPI module for received messages. If any was
received do something.
dim msg_rcvd, rx_flags, data_len as byte
 rd_data as byte[ 8]
 msg_id as longint
...
CANSPISetOperationMode(_CANSPI_MODE_NORMAL,0xFF)    ' set NORMAL
mode (CANSPI module must be in mode in which receive is possible)
...
rx_flags = 0                                      ' clear message flags
if (msg_rcvd = CANSPIRead(msg_id, rd_data, data_len, rx_flags)
   ...
end if
```

CANSPIWrite

Prototype	`sub function CANSPIWrite(dim id as longint, dim byref wr_data as byte[8], dim data_len as byte, dim CANSPI_TX_MSG_FLAGS as byte) as byte`
Returns	■ `0` if all Transmit Buffers are busy ■ `0xFF` if at least one Transmit Buffer is available
Description	If at least one empty Transmit Buffer is found, the function sends message in the queue for transmission. Parameters: ■ `id:`CAN message identifier. Valid values: 11 or 29 bit values, depending on message type (standard or extended) ■ `wr_data:` data to be sent (an array of bytes up to 8 bytes in length) ■ `data_len:` data length. Valid values: 1 to 8 ■ `CAN_RX_MSG_FLAGS`: message flags
Requires	The CANSPI module must be in mode in which transmission is possible. See CANSPISetOperationMode. The CANSPI routines are supported only by MCUs with the SPI module. MCU has to be properly connected to mikroElektronika's CANSPI Extra Board or similar hardware. See connection example at the bottom of this page.

Example

```
' send message extended CAN message with the appropriate ID and
data
dim tx_flags as byte
 rd_data as byte[ 8]
 msg_id as longint
...
CANSPISetOperationMode(_CANSPI_MODE_NORMAL, 0xFF)
' set NORMAL mode (CANSPI must be in mode in which transmission
is possible)

tx_flags = _CANSPI_TX_PRIORITY_0 ands _CANSPI_TX_XTD_FRAME
' set message flags
CANSPIWrite(msg_id, rd_data, 2, tx_flags)
```

CANSPI Constants

There is a number of constants predefined in the CANSPI library. You need to be familiar with them in order to be able to use the library effectively. Check the example at the end of the chapter.

CANSPI_OP_MODE

The `CANSPI_OP_MODE` constants define CANSPI operation mode. Function CANSPISetOperationMode expects one of these as it's argument:

```
const
     _CANSPI_MODE_BITS as byte = 0xE0 Use this to access opmode  bits
     _CANSPI_MODE_NORMAL as byte = 0x00
     _CANSPI_MODE_SLEEP  as byte = 0x20
     _CANSPI_MODE_LOOP   as byte = 0x40
     _CANSPI_MODE_LISTEN as byte = 0x60
     _CANSPI_MODE_CONFIG as byte = 0x80
```

CANSPI_CONFIG_FLAGS

The `CANSPI_CONFIG_FLAGS` constants define flags related to the CANSPI module configuration. The functions CANSPIInitialize, CANSPISetBaudRate, CANSPISetMask and CANSPISetFilter expect one of these (or a bitwise combination) as their argument:

```
const
       _CANSPI_CONFIG_DEFAULT         as byte   = $FF    ' 11111111

    _CANSPI_CONFIG_PHSEG2_PRG_BIT     as byte   = $01
    _CANSPI_CONFIG_PHSEG2_PRG_ON      as byte   = $FF    ' XXXXXXX1
    _CANSPI_CONFIG_PHSEG2_PRG_OFF     as byte   = $FE    ' XXXXXXX0

    _CANSPI_CONFIG_LINE_FILTER_BIT    as byte = $02
    _CANSPI_CONFIG_LINE_FILTER_ON     as byte = $FF    ' XXXXXX1X
    _CANSPI_CONFIG_LINE_FILTER_OFF    as byte = $FD    ' XXXXXX0X

    _CANSPI_CONFIG_SAMPLE_BIT          as byte = $04
    _CANSPI_CONFIG_SAMPLE_ONCE         as byte = $FF    ' XXXXX1XX
    _CANSPI_CONFIG_SAMPLE_THRICE      as byte = $FB    ' XXXXX0XX

    _CANSPI_CONFIG_MSG_TYPE_BIT       as byte = $08
    _CANSPI_CONFIG_STD_MSG             as byte = $FF    ' XXXX1XXX
    _CANSPI_CONFIG_XTD_MSG             as byte = $F7    ' XXXX0XXX

    _CANSPI_CONFIG_DBL_BUFFER_BIT   as byte = $10
     _CANSPI_CONFIG_DBL_BUFFER_ON    as byte = $FF ' XXX1XXXX
```

```
     _CANSPI_CONFIG_DBL_BUFFER_OFF as byte = $EF    ' XXX0XXXX

     _CANSPI_CONFIG_MSG_BITS        as byte = $60
     _CANSPI_CONFIG_ALL_MSG         as byte = $FF    ' X11XXXXX
     _CANSPI_CONFIG_VALID_XTD_MSG   as byte = $DF    ' X10XXXXX
     _CANSPI_CONFIG_VALID_STD_MSG   as byte = $BF    ' X01XXXXX
     _CANSPI_CONFIG_ALL_VALID_MSG   as byte = $9F    ' X00XXXXX
```

You may use bitwise and to form config byte out of these values. For example:

```
init   = _CANSPI_CONFIG_SAMPLE_THRICE   and
          _CANSPI_CONFIG_PHSEG2_PRG_ON  and
          _CANSPI_CONFIG_STD_MSG        and
          _CANSPI_CONFIG_DBL_BUFFER_ON   and
          _CANSPI_CONFIG_VALID_XTD_MSG   and
          _CANSPI_CONFIG_LINE_FILTER_OFF
...
CANSPIInit(1, 1, 3, 3, 1, init)    ' initialize CANSPI
```

CANSPI_TX_MSG_FLAGS

`CANSPI_TX_MSG_FLAGS` are flags related to transmission of a CAN message:

```
const
     _CANSPI_TX_PRIORITY_BITS as byte = $03
     _CANSPI_TX_PRIORITY_0     as byte = $FC    ' XXXXXX00
     _CANSPI_TX_PRIORITY_1     as byte = $FD    ' XXXXXX01
     _CANSPI_TX_PRIORITY_2     as byte = $FE    ' XXXXXX10
     _CANSPI_TX_PRIORITY_3     as byte = $FF    ' XXXXXX11

     _CANSPI_TX_FRAME_BIT      as byte  = $08
     _CANSPI_TX_STD_FRAME      as byte  = $FF   ' XXXXX1XX
     _CANSPI_TX_XTD_FRAME      as byte  = $F7   ' XXXXX0XX

     _CANSPI_TX_RTR_BIT         as byte  = $40
     _CANSPI_TX_NO_RTR_FRAME   as byte   = $FF   ' X1XXXXXX
     _CANSPI_TX_RTR_FRAME      as byte  = $BF    ' X0XXXXXX
```

You may use bitwise and to adjust the appropriate flags. For example:

```
 ' form value to be used with CANSendMessage:
send_config  = _CANSPI_TX_PRIORITY_0      and
                _CANSPI_TX_XTD_FRAME      and
                _CANSPI_TX_NO_RTR_FRAME
...
CANSPI1Write(id, data, 1, send_config)
```

CANSPI_RX_MSG_FLAGS

`CANSPI_RX_MSG_FLAGS` are flags related to reception of CAN message. If a particular bit is set then corresponding meaning is TRUE or else it will be FALSE.

```
const
    _CANSPI_RX_FILTER_BITS  as byte = $07  ' Use this to access fil-
ter bits
    _CANSPI_RX_FILTER_1     as byte = $00
    _CANSPI_RX_FILTER_2     as byte = $01
    _CANSPI_RX_FILTER_3     as byte = $02
    _CANSPI_RX_FILTER_4     as byte = $03
    _CANSPI_RX_FILTER_5     as byte = $04
    _CANSPI_RX_FILTER_6     as byte = $05

    _CANSPI_RX_OVERFLOW     as byte = $08  ' Set if Overflowed else
cleared
    _CANSPI_RX_INVALID_MSG  as byte = $10  ' Set if invalid else
cleared
    _CANSPI_RX_XTD_FRAME    as byte = $20  ' Set if XTD message else
cleared
    _CANSPI_RX_RTR_FRAME    as byte = $40  ' Set if RTR message else
cleare
    _CANSPI_RX_DBL_BUFFERED as byte = $80  ' Set if this message was
hardware double-buffered
```

You may use bitwise and to adjust the appropriate flags. For example:

```
if (MsgFlag and _CANSPI_RX_OVERFLOW) <> 0 then
  ...
  ' Receiver overflow has occurred.
  ' We have lost our previous message.
end if
```

CANSPI_MASK

The `CANSPI_MASK` constants define mask codes. Function CANSPISetMask expects one of these as it's argument:

```
const
     _CANSPI_MASK_B1 as byte = 0
     _CANSPI_MASK_B2 as byte = 1
```

CANSPI_FILTER

The `CANSPI_FILTER` constants define filter codes. Functions CANSPISetFilter expects one of these as it's argument:

```
const
    _CANSPI_FILTER_B1_F1 as byte = 0
    _CANSPI_FILTER_B1_F2 as byte = 1
    _CANSPI_FILTER_B2_F1 as byte = 2
    _CANSPI_FILTER_B2_F2 as byte = 3
    _CANSPI_FILTER_B2_F3 as byte = 4
    _CANSPI_FILTER_B2_F4 as byte = 5
```

Library Example

This is a simple demonstration of CANSPI Library routines usage. First node initiates the communication with the second node by sending some data to its address. The second node responds by sending back the data incremented by 1. First node then does the same and sends incremented data back to second node, etc.

Code for the first CANSPI node:

```
program Can_Spi_1st

dim Can_Init_Flags, Can_Send_Flags, Can_Rcv_Flags as byte     ' can
flags
    Rx_Data_Len as byte                  ' received data length in bytes
    RxTx_Data    as byte[ 8]             ' can rx/tx data buffer
    Msg_Rcvd as byte                     ' reception flag
    Tx_ID, Rx_ID as longint              ' can rx and tx ID

' CANSPI module connections
dim CanSpi_CS as sbit at RC0_bit
    CanSpi_CS_Direction as sbit at TRISC0_bit
    CanSpi_Rst as sbit at RC2_bit
    CanSpi_Rst_Direction as sbit at TRISC2_bit
' End CANSPI module connections

main:
  ANSEL   = 0                    ' Configure AN pins as digital I/O
  ANSELH = 0
  PORTB  = 0
  TRISB  = 0

  Can_Init_Flags = 0                           '
  Can_Send_Flags = 0                           ' clear flags
  Can_Rcv_Flags   = 0                          '

  Can_Send_Flags = _CANSPI_TX_PRIORITY_0 and   ' form value to be used
                  _CANSPI_TX_XTD_FRAME and    '      with CANSPIWrite
                  _CANSPI_TX_NO_RTR_FRAME

  Can_Init_Flags = _CANSPI_CONFIG_SAMPLE_THRICE and ' form value to
be used
                _CANSPI_CONFIG_PHSEG2_PRG_ON and    ' with CANSPIInit
                _CANSPI_CONFIG_XTD_MSG and
                _CANSPI_CONFIG_DBL_BUFFER_ON and
                _CANSPI_CONFIG_VALID_XTD_MSG
```

```
SPI1_Init()                              ' initialize SPI1 module
CANSPIInitialize(1,3,3,3,1,Can_Init_Flags) 'Initialize external CAN-
SPI module
CANSPISetOperationMode(_CANSPI_MODE_CONFIG,0xFF)   'set CONFIGURATION
mode
CANSPISetMask(_CANSPI_MASK_B1,-1,_CANSPI_CONFIG_XTD_MSG)    'set  all
mask1 bits to ones
CANSPISetMask(_CANSPI_MASK_B2,-1,_CANSPI_CONFIG_XTD_MSG)     'set all
mask2 bits to ones
CANSPISetFilter(_CANSPI_FILTER_B2_F4,3,_CANSPI_CONFIG_XTD_MSG)   'set
id of filter B1_F1 to 3

CANSPISetOperationMode(_CANSPI_MODE_NORMAL,0xFF)   'set NORMAL mode

   RxTx_Data[ 0]  = 9                      ' set initial data to be sent

   Tx_ID = 12111                                                        '
set transmit ID

   CANSPIWrite(Tx_ID, RxTx_Data, 1, Can_Send_Flags)   ' send initial
message
   while TRUE                                         ' endless loop
          Msg_Rcvd  =  CANSPIRead(Rx_ID  ,  RxTx_Data  ,  Rx_Data_Len,
Can_Rcv_Flags)    ' receive message
          if  ((Rx_ID  = 3)  and Msg_Rcvd)  then   ' if message received
check id
          PORTB  = RxTx_Data[ 0]       ' id correct, output data at PORTC
          Inc(RxTx_Data[ 0])          ' increment received data
          Delay_ms(10)
          CANSPIWrite(Tx_ID, RxTx_Data, 1, Can_Send_Flags)     ' send
incremented data back
      end if
   wend
end.
```

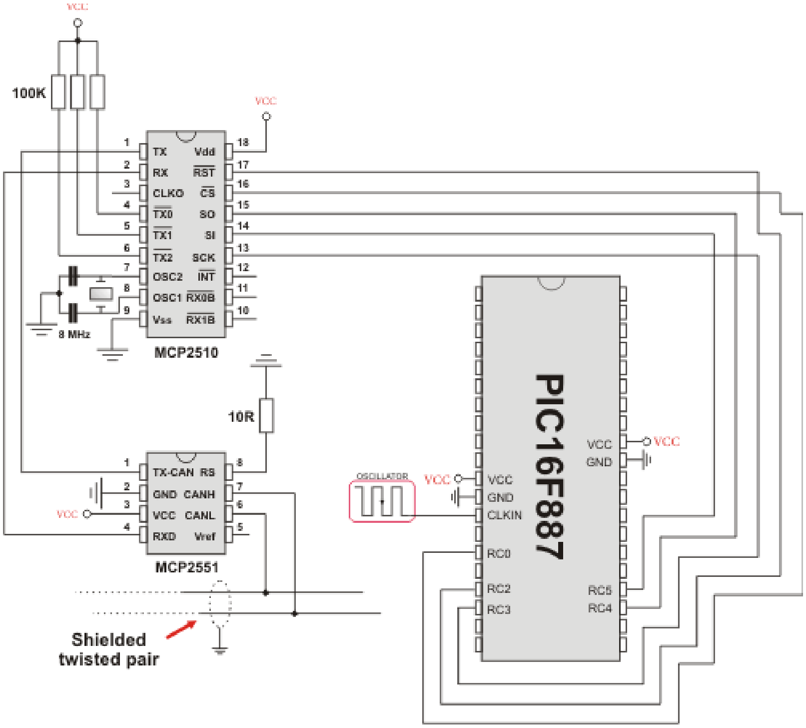
Code for the second CANSPI node:

```
program Can_Spi_2nd

dim Can_Init_Flags, Can_Send_Flags, Can_Rcv_Flags as byte      ' can
flags
      Rx_Data_Len as byte              ' received data length in bytes
      RxTx_Data     as byte[ 8]        ' CAN rx/tx data buffer
      Msg_Rcvd as byte                 ' reception flag
      Tx_ID, Rx_ID as longint          ' can rx and tx ID

' CANSPI module connections
dim CanSpi_CS as sbit at RC0_bit
      CanSpi_CS_Direction as sbit at TRISC0_bit
```

```
      CanSpi_Rst as sbit at PORTC.B2
      CanSpi_Rst_Direction as sbit at TRISC2_bit
' End CANSPI module connections

main:
  ANSEL  = 0                     ' Configure AN pins as digital I/O
  ANSELH = 0
  PORTB = 0                      ' clear PORTB
  TRISB = 0                      ' set PORTB as output

  Can_Init_Flags = 0             '
  Can_Send_Flags = 0             ' clear flags
  Can_Rcv_Flags  = 0             '

  Can_Send_Flags = _CANSPI_TX_PRIORITY_0 and  ' form value to be used
                   _CANSPI_TX_XTD_FRAME and   '  with CANSPIWrite
                   _CANSPI_TX_NO_RTR_FRAME

  Can_Init_Flags = _CANSPI_CONFIG_SAMPLE_THRICE and ' Form value to
be used
                   _CANSPI_CONFIG_PHSEG2_PRG_ON and   '  with
CANSPIInit
                    _CANSPI_CONFIG_XTD_MSG and
                    _CANSPI_CONFIG_DBL_BUFFER_ON and
                    _CANSPI_CONFIG_VALID_XTD_MSG and
                    _CANSPI_CONFIG_LINE_FILTER_OFF
SPI1_Init()                                                      '
initialize SPI1 module
CANSPIInitialize(1,3,3,3,1,Can_Init_Flags)
' initialize external CANSPI module
CANSPISetOperationMode(_CANSPI_MODE_CONFIG,0xFF)
' set CONFIGURATION mode
CANSPISetMask(_CANSPI_MASK_B1,-1,_CANSPI_CONFIG_XTD_MSG)
' set all mask1 bits to ones
CANSPISetMask(_CANSPI_MASK_B2,-1,_CANSPI_CONFIG_XTD_MSG)
' set all mask2 bits to ones
CANSPISetFilter(_CANSPI_FILTER_B2_F3,12111,_CANSPI_CONFIG_XTD_MSG)
' set id of filter B1_F1 to 3
CANSPISetOperationMode(_CANSPI_MODE_NORMAL,0xFF)
' set NORMAL mode
  Tx_ID = 3   ' set tx ID

 while TRUE                       ' endless loop
 Msg_Rcvd = CANSPIRead(Rx_ID, RxTx_Data, Rx_Data_Len, Can_Rcv_Flags)
'receive message
     if ((Rx_ID = 12111) and Msg_Rcvd) then
       PORTB =
        RxTx_Data[ 0]            ' id correct, output data at PORTC
       Inc(RxTx_Data[ 0] )       ' increment received data
```

```
CANSPIWrite(Tx_ID, RxTx_Data,1, Can_Send_Flags    ' send incremented
data back
    end if
  wend
end.
```

HW Connection



Example of interfacing CAN transceiver MCP2510 with MCU via SPI interface

COMPACT FLASH LIBRARY

The Compact Flash Library provides routines for accessing data on Compact Flash card (abbr. CF further in text). CF cards are widely used memory elements, commonly used with digital cameras. Great capacity and excellent access time of only a few microseconds make them very attractive for the microcontroller applications.

In CF card, data is divided into sectors. One sector usually comprises 512 bytes. Routines for file handling, the Cf_Fat routines, are not performed directly but successively through 512B buffer.

Note: Routines for file handling can be used only with FAT16 file system.

Note: Library functions create and read files from the root directory only.

Note: Library functions populate both FAT1 and FAT2 tables when writing to files, but the file data is being read from the FAT1 table only; i.e. there is no recovery if the FAT1 table gets corrupted.

Note: If MMC/SD card has Master Boot Record (MBR), the library will work with the first available primary (logical) partition that has non-zero size. If MMC/SD card has Volume Boot Record (i.e. there is only one logical partition and no MBRs), the library works with entire card as a single partition. For more information on MBR, physical and logical drives, primary/secondary partitions and partition tables, please consult other resources, e.g. Wikipedia and similar.

Note: Before writing operation, make sure not to overwrite boot or FAT sector as it could make your card on PC or digital camera unreadable. Drive mapping tools, such as Winhex, can be of great assistance.

External dependencies of Compact Flash Library

The following variables must be defined in all projects using Compact Flash Library:	**Description :**	**Example :**
`dim CF_Data_Port as byte sfr external`	Compact Flash Data Port.	`dim CF_Data_Port as byte at PORTD`
`dim CF_RDY as sbit sfr external`	Ready signal line.	`dim CF_RDY as sbit at RB7_bit`
`dim CF_WE as sbit sfr external`	Write Enable signal line.	`dim CF_WE as sbit at RB6_bit`

dim CF_OE as sbit sfr external	Output Enable signal line.	dim CF_OE as sbit at RB5_bit
dim CF_CD1 as sbit r external	Chip Detect signal line.	dim CF_CD1 as sbit at RB4_bit
dim CF_CE1 as sbit sfr external	Chip Enable signal line.	dim CF_CE1 as sbit at RB3_bit
dim CF_A2 as sbit sfr external	Address pin 2.	dim CF_A2 as sbit at RB2_bit
dim CF_A1 as sbit sfr external	Address pin 1.	dim CF_A1 as sbit at RB1_bit
dim CF_A0 as sbit sfr external	Address pin 0.	dim CF_A0 as sbit at RB0_bit
dim CF_RDY_direction as sbit sfr external	Direction of the Ready pin.	dim CF_RDY_direction as sbit at TRISB7_bit
dim CF_WE_direction as sbit sfr external	Direction of the Write Enable pin.	dim CF_WE_direction as sbit at TRISB6_bit
dim CF_OE_direction as sbit sfr external	Direction of the Output Enable pin	dim CF_OE_direction as sbit at TRISB5_bit
dim CF_CD1_direction as sbit sfr external	Direction of the Chip Detect pin.	dim CF_CD1_direction as sbit at TRISB4_bit
dim CF_CE1_direction as sbit sfr external	Direction of the Chip Enable pin.	dim CF_CE1_direction as sbit at TRISB3_bit
dim CF_A2_direction as sbit sfr external	Direction of the Address 2 pin.	dim CF_A2_direction as sbit at TRISB2_bit
dim CF_A1_direction as sbit sfr external	Direction of the Address 1 pin.	dim CF_A1_direction as sbit at TRISB1_bit
dim CF_A0_direction as sbit sfr external	Direction of the Address 0 pin.	dim CF_A0_direction as sbit at TRISB0_bit

Library Routines

- Cf_Init
- Cf_Detect
- Cf_Enable
- Cf_Disable
- Cf_Read_Init
- Cf_Read_Byte
- Cf_Write_Init
- Cf_Write_Byte
- Cf_Read_Sector
- Cf_Write_Sector

Routines for file handling:

- Cf_Fat_Init
- Cf_Fat_QuickFormat
- Cf_Fat_Assign
- Cf_Fat_Reset
- Cf_Fat_Read
- Cf_Fat_Rewrite
- Cf_Fat_Append
- Cf_Fat_Delete
- Cf_Fat_Write
- Cf_Fat_Set_File_Date
- Cf_Fat_Get_File_Date
- Cf_Fat_Get_File_Size
- Cf_Fat_Get_Swap_File

Cf_Init

Prototype	`sub procedure Cf_Init()`
Returns	Nothing.
Description	Initializes ports appropriately for communication with CF card.
Requires	Global variables : ■ `CF_Data_Port` : Compact Flash data port ■ `CF_RDY` : Ready signal line ■ `CF_WE` : Write enable signal line ■ `CF_OE` : Output enable signal line ■ `CF_CD1` : Chip detect signal line ■ `CF_CE1` : Enable signal line ■ `CF_A2` : Address pin 2 ■ `CF_A1` : Address pin 1 ■ `CF_A0` : Address pin 0 ■ `CF_Data_Port_direction` : Direction of the Compact Flash data direction port ■ `CF_RDY_direction` : Direction of the Ready pin ■ `CF_WE_direction` : Direction of the Write enable pin ■ `CF_OE_direction` : Direction of the Output enable pin ■ `CF_CD1_direction` : Direction of the Chip detect pin ■ `CF_CE1_direction` : Direction of the Chip enable pin ■ `CF_A2_direction` : Direction of the Address 2 pin ■ `CF_A1_direction` : Direction of the Address 1 pin ■ `CF_A0_direction` : Direction of the Address 0 pin must be defined before using this function.

Example

```
 set compact flash pinout
dim CF_Data_Port as byte at PORTD

dim CF_RDY as sbit at RB7_bit
dim CF_WE  as sbit at RB6_bit
dim CF_OE  as sbit at RB5_bit
dim CF_CD1 as sbit at RB4_bit
dim CF_CE1 as sbit at RB3_bit
dim CF_A2  as sbit at RB2_bit
dim CF_A1  as sbit at RB1_bit
dim CF_A0  as sbit at RB0_bit
dim CF_RDY_direction as sbit at TRISB7_bit
dim CF_WE_direction  as sbit at TRISB6_bit
dim CF_OE_direction  as sbit at TRISB5_bit
dim CF_CD1_direction as sbit at TRISB4_bit
dim CF_CE1_direction as sbit at TRISB3_bit
dim CF_A2_direction  as sbit at TRISB2_bit
dim CF_A1_direction  as sbit at TRISB1_bit
dim CF_A0_direction  as sbit at TRISB0_bit
' end of cf pinout

'Init CF
Cf_Init()
```

Cf_Detect

Prototype	`sub function CF_Detect() as byte`
Returns	- 1 - if CF card was detected - 0 - otherwise
Description	Checks for presence of CF card by reading the chip detect pin.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	see below

```
' Wait until CF card is inserted:
while (Cf_Detect() = 0)
  nop
wend
```

Cf_Enable

Prototype	`sub procedure Cf_Enable()`
Returns	Nothing.
Description	Enables the device. Routine needs to be called only if you have disabled the device by means of the Cf_Disable routine. These two routines in conjunction allow you to free/occupy data line when working with multiple devices.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	`' enable compact flash` `Cf_Enable()`

Cf_Disable

Prototype	`sub procedure Cf_Disable()`
Returns	Nothing.
Description	Routine disables the device and frees the data lines for other devices. To enable the device again, call Cf_Enable. These two routines in conjunction allow you to free/occupy data line when working with multiple devices.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	`' disable compact flash` `Cf_Disable()`

Cf_Read_Init

Prototype	`sub procedure Cf_Read_Init(dim address as longword, dim sector_count as byte)`
Returns	Nothing.
Description	Initializes CF card for reading. Parameters : - `address:` the first sector to be prepared for reading opera tion. - `sector_count:` number of sectors to be prepared for read ing operation.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	`' initialize compact flash for reading from sector 590` `Cf_Read_Init(590, 1)`

Cf_Read_Byte

Prototype	`sub function CF_Read_Byte() as byte`
Returns	Returns a byte read from Compact Flash sector buffer. **Note**: Higher byte of the `unsigned` return value is cleared.
Description	Reads one byte from Compact Flash sector buffer location currently pointed to by internal read pointers. These pointers will be autoicremented upon reading.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init. CF card must be initialized for reading operation. See Cf_Read_Init.

Example	`' Read a byte from compact flash:`
	`dim data as byte`
	`...`
	`data = Cf_Read_Byte()`

Cf_Write_Init

Prototype	`sub procedure Cf_Write_Init(dim address as longword, dim sectcnt as byte)`
Returns	Nothing.
Description	Initializes CF card for writing. Parameters : - `address:` the first sector to be prepared for writing operation - `sectcnt:` number of sectors to be prepared for writing operation.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	`' initialize compact flash for writing to sector 590` `Cf_Write_Init(590, 1)`

Cf_Write_Byte

Prototype	`sub procedure Cf_Write_Byte(dim data_ as byte)`
Returns	Nothing.
Description	Writes a byte to Compact Flash sector buffer location currently pointed to by writing pointers. These pointers will be autoicremented upon reading. When sector buffer is full, its content will be transfered to appropriate flash memory sector. Parameters : - `data_`: byte to be written.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. CF card must be initialized for writing operation. See Cf_Write_Init.

Example	`dim data_ as byte`
	`...`
	`data = 0xAA`
	`Cf_Write_Byte(data)`

Cf_Read_Sector

Prototype	`sub procedure Cf_Read_Sector(dim sector_number as longword, dim byref buffer as byte[512])`
Returns	Nothing.
Description	Reads one sector (512 bytes). Read data is stored into buffer provided by the buffer parameter. Parameters : ■ `sector_number`: sector to be read. ■ `buffer:` data buffer of at least 512 bytes in length.
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	see below

Example

```
' read sector 22
dim data as array[ 512]  of byte
...
Cf_Read_Sector(22, data)
```

Cf_Write_Sector

Prototype	`sub procedure Cf_Write_Sector(dim sector_number as longword, dim byref buffer as byte[ 512] )`
Returns	Nothing.
Description	Writes 512 bytes of data provided by the buffer parameter to one CF sector. Parameters : ■ `sector_number:` sector to be written to. ■ `buffer:` data buffer of 512 bytes in length
Requires	The corresponding MCU ports must be appropriately initialized for CF card. See Cf_Init.
Example	see below

Example

```
' write to sector 22
dim data as array[ 512]  of byte
...
Cf_Write_Sector(22, data)
```

Cf_Fat_Init

Prototype	`sub function Cf_Fat_Init() as byte`
Returns	■ `0` - if CF card was detected and successfully initialized ■ `1` - if FAT16 boot sector was not found ■ `255` - if card was not detected
Description	Initializes CF card, reads CF FAT16 boot sector and extracts data needed by the library.
Requires	Nothing.

Example

```
init the FAT library
if (Cf_Fat_Init() = 0) then
  ...
end if
```

Cf_Fat_QuickFormat

Prototype	`sub function Cf_Fat_QuickFormat(dim byref cf_fat_label as string[11]) as byte`
Returns	■ `0` - if CF card was detected and formated and initialized ■ `1` - if FAT16 format was unseccessful ■ `255` - if card was not detected
Description	Formats to FAT16 and initializes CF card. Parameters : ■ `cf_fat_label:` volume label (11 characters in length). If less than 11 characters are provided, the label will be padded with spaces. If an empty string is passed, the volume will not be labeled. **Note:** This routine can be used instead or in conjunction with the Cf_Fat_Init routine. **Note:** If CF card already contains a valid boot sector, it will remain unchanged (except volume label field) and only FAT and ROOT tables will be erased. Also, the new volume label will be set.
Requires	Nothing.

Example

```
'--- format and initialize the FAT library
if ( Cf_Fat_QuickFormat('mikroE') = 0) then
  ...
end if
```

Cf_Fat_Assign

<table>
<tr><td>Prototype</td><td><code>sub function Cf_Fat_Assign(dim byref filename as char[12] , dim file_cre_attr as byte) as byte</code></td></tr>
<tr><td>Returns</td><td>

0 if file does not exist and no new file is created.
1 if file already exists or file does not exist but a new file is created.

</td></tr>
<tr><td>Description</td><td>
Assigns file for file operations (read, write, delete...). All subsequent file operations will be applied to the assigned file.
Parameters :

<code>filename:</code> name of the file that should be assigned for file operations.

The file name should be in DOS 8.3 (file_name.extension) format. The file name and extension will be automatically padded with spaces by the library if they have less than length required (i.e. "mikro.tx" -> "mikro .tx "), so the user does not have to take care of that. The file name and extension are case insensitive. The library will convert them to the proper case automatically, so the user does not have to take care of that.
Also, in order to keep backward compatibility with the first version of this library, file names can be entered as UPPERCASE string of 11 bytes in length with no dot character between the file name and extension (i.e. "MIKROELETXT" -> MIKROELE.TXT). In this case the last 3 characters of the string are considered to be file extension.

<code>file_cre_attr:</code> file creation and attributs flags. Each bit corresponds to the appropriate file attribut:

<table>
<tr><th>Bit</th><th>Mask</th><th>Description</th></tr>
<tr><td>0</td><td>0x01</td><td>Read Only</td></tr>
<tr><td>1</td><td>0x02</td><td>Hidden</td></tr>
<tr><td>2</td><td>0x04</td><td>System</td></tr>
<tr><td>3</td><td>0x08</td><td>Volume Label</td></tr>
<tr><td>4</td><td>0x10</td><td>Subdirectory</td></tr>
<tr><td>5</td><td>0x20</td><td>Archive</td></tr>
<tr><td>6</td><td>0x40</td><td>Device (internal use only, never found on disk)</td></tr>
<tr><td>7</td><td>0x80</td><td>File creation flag. If the file does not exist and this flag is set, a new file with specified name will be created.</td></tr>
</table>
Note: Long File Names (LFN) are not supported.
</td></tr>
<tr><td>Requires</td><td>CF card and CF library must be initialized for file operations. See Cf_Fat_Init</td></tr>
<tr><td>Example</td><td><code>' create file with archive attribut if it does not already exist</code>
<code>Cf_Fat_Assign('MIKRO007.TXT',0xA0)</code></td></tr>
</table>

Cf_Fat_Reset

Prototype	`sub procedure Cf_Fat_Reset(dim byref size as longword)`
Returns	Nothing.
Description	Opens currently assigned file for reading. Parameters : ■ `size`: buffer to store file size to. After file has been open for reading its size is returned through this parameter.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign

Example	`dim size as longword`
	`...`
	`Cf_Fat_Reset(size)`

Cf_Fat_Read

Prototype	`sub procedure Cf_Fat_Read(dim byref bdata as byte)`
Returns	Nothing.
Description	Reads a byte from currently assigned file opened for reading. Upon function execution file pointers will be set to the next character in the file. Parameters : ■ bdata: buffer to store read byte to. Upon this function execution read byte is returned through this parameter
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign. File must be open for reading. See Cf_Fat_Reset.

Example	`dim character as byte`
	`...`
	`Cf_Fat_Read(character)`

Cf_Fat_Rewrite

Prototype	`sub procedure Cf_Fat_Read()`
Returns	Nothing.
Description	Opens currently assigned file for writing. If the file is not empty its content will be erased.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. The file must be previously assigned. See Cf_Fat_Assign.
Example	`' open file for writing` `Cf_Fat_Rewrite()`

Cf_Fat_Append

Prototype	`sub procedure Cf_Fat_Append()`
Returns	Nothing.
Description	Opens currently assigned file for appending. Upon this function execution file pointers will be positioned after the last byte in the file, so any subsequent file writing operation will start from there.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign.
Example	`'open file for appending` `Cf_Fat_Append()`

Cf_Fat_Delete

Prototype	`sub procedure Cf_Fat_Delete()`
Returns	Nothing.
Description	Deletes currently assigned file from CF card.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign.
Example	

```
'delete current file
Cf_Fat_Delete()
```

Cf_Fat_Write

Prototype	`sub procedure Cf_Fat_Write(dim byref fdata as byte[512], dim data_len as word)`
Returns	Nothing.
Description	Writes requested number of bytes to currently assigned file opened for writing. Parameters : ■ `fdata:` data to be written. ■ `data_len`: number of bytes to be written.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign. File must be open for writing. See Cf_Fat_Rewrite or Cf_Fat_Append
Example	

```
dim file_contents as array[42] of byte
...
Cf_Fat_Write(file_contents, 42) ' write data to the assigned file
```

Cf_Fat_Set_File_Date

Prototype	`sub procedure Cf_Fat_Set_File_Date(dim year as word, dim month as byte, dim day as byte, dim hours as byte, dim mins as byte, dim seconds as byte)`
Returns	Nothing.
Description	Sets the date/time stamp. Any subsequent file writing operation will write this stamp to currently assigned file's time/date attributs. Parameters : ■ `year:` year attribute. Valid values: 1980-2107 ■ `month`: month attribute. Valid values: 1-12 ■ `day:` day attribute. Valid values: 1-31 ■ `hours:` hours attribute. Valid values: 0-23 ■ `mins:` minutes attribute. Valid values: 0-59 ■ `seconds`: seconds attribute. Valid values: 0-59
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign. File must be open for writing. See Cf_Fat_Rewrite or Cf_Fat_Append.
Example	`Cf_Fat_Set_File_Date(2005,9,30,17,41,0)`

Cf_Fat_Get_File_Date

Prototype	`sub procedure Cf_Fat_Get_File_Date(dim byref year as word, dim byref month as byte, dim byref day as byte, dim byref hours as byte, dim byref mins as byte)`
Returns	Nothing.
Description	Reads time/date attributes of currently assigned file. Parameters : - `year:`buffer to store year attribute to. Upon function execution year attribute is returned through this parameter. - `month`: buffer to store month attribute to. Upon function execution month attribute is returned through this parameter. - `day:` buffer to store day attribute to. Upon function execution day attribute is returned through this parameter. - `hours:` buffer to store hours attribute to. Upon function execution hours attribute is returned through this parameter. - `mins:` buffer to store minutes attribute to. Upon function execution minutes attribute is returned through this parameter.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign.
Example	

```
dim year as word
    month, day, hours, mins as byte
...
Cf_Fat_Get_File_Date(year, month, day, hours, mins)
```

Cf_Fat_Get_File_Size

Prototype	`sub function Cf_Fat_Get_File_Size() as longword`
Returns	Size of the currently assigned file in bytes.
Description	This function reads size of currently assigned file in bytes.
Requires	CF card and CF library must be initialized for file operations. See Cf_Fat_Init. File must be previously assigned. See Cf_Fat_Assign.
Example	

```
dim my_file_size as longword
...
my_file_size = Cf_Fat_Get_File_Size()
```

Cf_Fat_Get_Swap_File

Prototype	`sub function Cf_Fat_Get_Swap_File(dim sectors_cnt as longint, dim byref filename as string[ 11] , dim file_attr as byte) as longword`
Returns	■ Number of the start sector for the newly created swap file, if there was enough free space on CF card to create file of required size. ■ 0 - otherwise.
Description	This function is used to create a swap file of predefined name and size on the CF media. If a file with specified name already exists on the media, search for consecutive sectors will ignore sectors occupied by this file. Therefore, it is recommended to erase such file if it exists before calling this function. If it is not erased and there is still enough space for a new swap file, this function will delete it after allocating new memory space for a new swap file. The purpose of the swap file is to make reading and writing to CF media as fast as possible, by using the Cf_Read_Sector() and Cf_Write_Sector() functions directly, without potentially damaging the FAT system. The swap file can be considered as a "window" on the media where the user can freely write/read data. Its main purpose in the mikroBasic's library is to be used for fast data acquisition; when the time-critical acquisition has finished, the data can be re-written into a "normal" file, and formatted in the most suitable way. Parameters: ■ `sectors_cnt`: number of consecutive sectors that user wants the swap file to have. ■ `filename:` name of the file that should be assigned for file operations. The file name should be in DOS 8.3 (file_name.extension) format. The file name and extension will be automatically padded with spaces by the library if they have less than length required (i.e. "mikro.tx" -> "mikro .tx "), so the user does not have to take care of that. The file name and extension are case insensitive. The library will convert them to the proper case automatically, so the user does not have to take care of that. Also, in order to keep backward compatibility with the first version of this library, file names can be entered as UPPERCASE string of 11 bytes in length with no dot character between the file name and extension (i.e. "MIKROELETXT" -> MIKROELE.TXT). In this case the last 3 characters of the string are considered to be file extension. ■ file_attr: file creation and attributs flags. Each bit corresponds to the appropriate file attribut:

Description

Bit	Mask	Description
0	0x01	Read Only
1	0x02	Hidden
2	0x04	System
3	0x08	Volume Label
4	0x10	Subdirectory
5	0x20	Archive
6	0x40	Device (internal use only, never found on disk)
7	0x80	Not used

Note: Long File Names (LFN) are not supported.

Requires

CF card and CF library must be initialized for file operations. See Cf_Fat_Init.

Example

```
program
'--------------- Try to create a swap file with archive atribute,
whose size will be at least 1000 sectors.
'                 If it succeeds, it sends the No. of start sec-
tor  over USART
dim size as longword
...
main:
  ...
  size = Cf_Fat_Get_Swap_File(1000, "mikroE.txt", 0x20)
  if size then
    UART1_Write(0xAA)
    UART1_Write(Lo(size))
    UART1_Write(Hi(size))
    UART1_Write(Higher(size))
      UART1_Write(Highest(size))
    UART1_Write(0xAA)
  end if
end.
```

Library Example

The following example demonstrates various aspects of the Cf_Fat16 library: Creation of new file and writing down to it; Opening existing file and re-writing it (writing from start-of-file); Opening existing file and appending data to it (writing from end-of-file); Opening a file and reading data from it (sending it to USART terminal); Creating and modifying several files at once;

```
program CF_Fat16_Test

  ' set compact flash pinout
dim
   Cf_Data_Port as byte at PORTD

   CF_RDY  as sbit at RB7_bit
   CF_WE   as sbit at RB6_bit
   CF_OE   as sbit at RB5_bit
   CF_CD1  as sbit at RB4_bit
   CF_CE1  as sbit at RB3_bit
   CF_A2   as sbit at RB2_bit
   CF_A1   as sbit at RB1_bit
   CF_A0   as sbit at RB0_bit

   CF_RDY_direction as sbit at TRISB7_bit
   CF_WE_direction  as sbit at TRISB6_bit
   CF_OE_direction  as sbit at TRISB5_bit
   CF_CD1_direction as sbit at TRISB4_bit
   CF_CE1_direction as sbit at TRISB3_bit
   CF_A2_direction  as sbit at TRISB2_bit
   CF_A1_direction  as sbit at TRISB1_bit
   CF_A0_direction  as sbit at TRISB0_bit
  ' end of cf pinout

  FAT_TXT as string[ 20]
  file_contents as string[ 50]

  filename as string[ 14]     ' File names

  character as byte
  loop_, loop2 as byte
  size as longint

  Buffer as byte[ 512]

'-------------- Writes string to USART
sub procedure Write_Str(dim byref ostr as byte[ 2] )
```

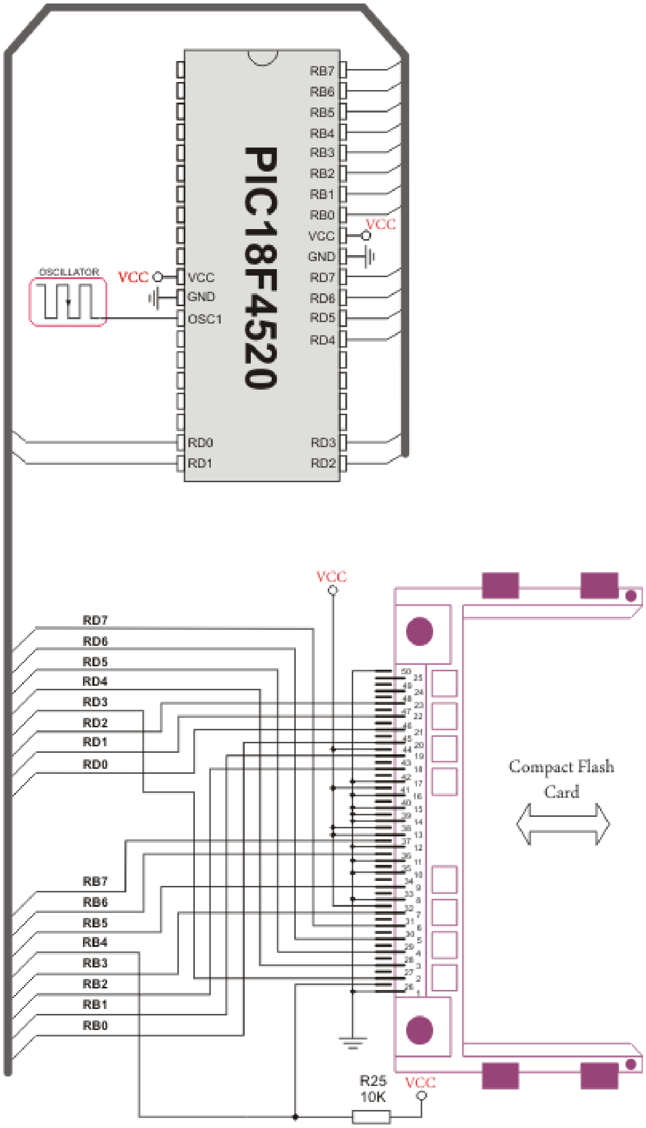
```
dim
  i as byte

  i = 0
  while ostr[ i]  <>  0
    UART1_Write(ostr[ i] )
    Inc(i)
  wend
  UART1_Write($0A)
end sub

'-------------- Creates new file and writes some data to it
sub procedure Create_New_File

 filename[ 7]  = "A"
  Cf_Fat_Assign(filename,  0xA0)        ' Will not find file and then
create file
  Cf_Fat_Rewrite()                      ' To clear file and start with
new data
   for loop_=1  to  90                   ' We want 5 files on the MMC
card

PORTC = loop_
    file_contents[ 0]  = loop_ div 10 + 48
    file_contents[ 1]  = loop_ mod 10 + 48
   Cf_Fat_Write(file_contents, 38) ' write data to the assigned file
    UART1_Write(".")
  next loop_
end sub

'-------------- Creates many new files and writes data to them
sub procedure Create_Multiple_Files

  for loop2 = "B" to "Z"
    UART1_Write(loop2) ' this line can slow down the performance
    filename[ 7]  = loop2                   ' set filename
    Cf_Fat_Assign(filename,  0xA0)      ' find existing file or cre-
ate a new one
     Cf_Fat_Rewrite                         ' To clear file and start
with new data
    for loop_  = 1 to 44
      file_contents[ 0]  = loop_ div 10 + 48
      file_contents[ 1]  = loop_ mod 10 + 48
       Cf_Fat_Write(file_contents, 38)  ' write data to the assigned
file
    next loop_
  next loop2
end sub

'-------------- Opens an existing file and rewrites it
```

```
sub procedure Open_File_Rewrite

  filename[ 7] = "C"                    ' Set filename for single-file
tests
  Cf_Fat_Assign(filename, 0)
  Cf_Fat_Rewrite
  for loop_ = 1 to 55
    file_contents[ 0] = byte(loop_ div 10 + 48)
    file_contents[ 1] = byte(loop_ mod 10 + 48)
   Cf_Fat_Write(file_contents, 38) ' write data to the assigned file
  next loop_
end sub
'-------------- Opens an existing file and appends data to it
'                (and alters the date/time stamp)
sub procedure Open_File_Append
   filename[ 7] = "B"
   Cf_Fat_Assign(filename, 0)
   Cf_Fat_Set_File_Date(2005,6,21,10,35,0)
   Cf_Fat_Append
   file_contents = " for mikroElektronika 2005"      ' Prepare file
for append

file_contents[ 26] = 10                       ' LF
  Cf_Fat_Write(file_contents, 27)            ' Write data to assigned
file
end sub

'-------------- Opens an existing file, reads data from it and puts
it to USART
sub procedure Open_File_Read
  filename[ 7] = "B"
  Cf_Fat_Assign(filename, 0)
  Cf_Fat_Reset(size)                    ' To read file, sub procedure
returns size of file
  while size > 0
    Cf_Fat_Read(character)
    UART1_Write(character)           ' Write data to USART
    Dec(size)
  wend
end sub

'-------------- Deletes a file. If file doesn"t exist, it will first
be created
'                and then deleted.

sub procedure Delete_File
  filename[ 7] = "F"
  Cf_Fat_Assign(filename, 0)
  Cf_Fat_Delete
end sub
```

```
'-------------- Tests whether file exists, and if so sends its cre-
ation date
'                  and file size via USART
sub procedure Test_File_Exist(dim fname as byte)
dim
  fsize as longint
  year as word
  month_, day, hour_, minute_ as byte
  outstr as byte[ 12]
 filename[ 7]  = "B"          ' uncomment this line to search for file
that DOES exists
'  filename[ 7]  = "F"         ' uncomment this line to search for file
that DOES NOT exist
  if Cf_Fat_Assign(filename, 0) <> 0 then
    '--- file has been found - get its date
    Cf_Fat_Get_File_Date(year,month_,day,hour_,minute_)
    WordToStr(year, outstr)
    Write_Str(outstr)
    ByteToStr(month_, outstr)
    Write_Str(outstr)
    WordToStr(day, outstr)
    Write_Str(outstr)
    WordToStr(hour_, outstr)
    Write_Str(outstr)
    WordToStr(minute_, outstr)
    Write_Str(outstr)
    '--- get file size
    fsize = Cf_Fat_Get_File_Size
    LongIntToStr(fsize, outstr)
    Write_Str(outstr)
  else
    '--- file was not found - signal it
    UART1_Write(0x55)
    Delay_ms(1000)
    UART1_Write(0x55)
  end if
end sub

'-------------- Tries to create a swap file, whose size will be at
least 100
'                  sectors (see Help for details)
sub procedure M_Create_Swap_File
  dim i as word

    for i=0 to 511
      Buffer[ i]  = i
    next i
     size = Cf_Fat_Get_Swap_File(5000, "mikroE.txt", 0x20)     ' see
help on this sub function for details
```

```
    if (size <> 0) then

        LongIntToStr(size, fat_txt)
        Write_Str(fat_txt)

        for i=0 to 4999
            Cf_Write_Sector(size, Buffer)
            size = size+1
            UART1_Write(".")
        next i
    end if
end sub

'-------------- Main. Uncomment the sub function(s) to test the
desired operation(s)
main:
     FAT_TXT = "FAT16 not found"
     file_contents = "XX CF FAT16 library by Anton Rieckert"
     file_contents[37] = 10            ' newline
     filename = "MIKRO00xTXT"

ADCON1 = ADCON1 or 0x0F      '  Configure pins as digital I/O

     TRISC = 0               '  we will use PORTC to signal test end
     PORTC = 0

     UART1_Init(19200)       ' Set up USART for file reading
     delay_ms(100)
     UART1_Write_Text(":Start:")

     ' --- Init the FAT library
     ' --- use Cf_Fat_QuickFormat instead of init routine if a for-
mat is needed
     if Cf_Fat_Init() = 0 then
         '--- test sub functions
         '----- test group #1
         Create_New_File()
         Create_Multiple_Files()
         '----- test group #2
         Open_File_Rewrite()
         Open_File_Append()
         Delete_File
         '----- test group #3
         Open_File_Read()
         Test_File_Exist("F")
         M_Create_Swap_File()
         '--- Test termination
         UART1_Write(0xAA)
     else
         UART1_Write_Text(FAT_TXT)
     end if
     '--- signal end-of-test
     UART1_Write_Text(":End:")
end.
```

HW Connection



Pin diagram of CF memory card

EEPROM LIBRARY

EEPROM data memory is available with a number of PIC MCUs. mikroBasic PRO for PIC includes library for comfortable work with EEPROM.

Library Routines

- EEPROM_Read
- EEPROM_Write

EEPROM_Read

Prototype	`sub function EEPROM_Read(dim Address as word) as byte`
Returns	Returns byte from specified address.
Description	Reads data from specified address. Parameter address is of byte type, which means it can address only 256 locations. For PIC18 micros with more EEPROM data locations, it is programmer's responsibility to set SFR EEADRH register appropriately.
Requires	Requires EEPROM module. Ensure minimum 20ms delay between successive use of routines EEPROM_Write and EEPROM_Read. Although PIC will write the correct value, EEPROM_Read might return an undefined result.
Example	`tmp = EEPROM_Read($3F)`

EEPROM_Write

Prototype	`sub procedure EEPROM_Write(dim Address as word, dim Data as byte)`
Returns	Nothing.
Description	Writes data to specified address. Parameter address is of byte type, which means it can address only 256 locations. For PIC18 micros with more EEPROM data locations, it is programmer's responsibility to set SFR EEADRH register appropriately. Be aware that all interrupts will be disabled during execution of EEPROM_Write routine (GIE bit of INTCON register will be cleared). Routine will set this bit on exit.
Requires	Requires EEPROM module. Ensure minimum 20ms delay between successive use of routines `EEPROM_Write` and `EEPROM_Read`. Although PIC will write the correct value, `EEPROM_Read` might return an undefined result.
Example	`EEPROM_Write($32)`

Library Example

The example writes values at 20 successive locations of EEPROM. Then, it reads the written data and prints on PORTB for a visual check.

```
program Eeprom

dim counter as byte        ' loop variable

main:
ANSEL =  0                 ' Configure AN pins as digital I/O
ANSELH = 0
C1ON_bit = 0               ' Disable comparators
C2ON_bit = 0

PORTB = 0
PORTC = 0
PORTD = 0
TRISB = 0
TRISC = 0
TRISD = 0
for counter = 0 to 31                 ' Fill data buffer
EEPROM_Write(0x80+counter, counter) 'Write data to address 0x80+ii
next counter

EEPROM_Write(0x02,0xAA)           ' Write some data at address 2
EEPROM_Write(0x50,0x55)            ' Write some data at address 0150
```

```
    Delay_ms(1000)                   ' Blink PORTB and PORTC diodes
    PORTB = 0xFF                    ' to indicate reading start
    PORTC = 0xFF
    Delay_ms(1000)
    PORTB = 0x00
    PORTC = 0x00
    Delay_ms(1000)

    PORTB = EEPROM_Read(0x02)     ' Read data from address 2 and dis
    play
    it on PORTB
    PORTC = EEPROM_Read(0x50)     ' Read data from address 0x50 and dis
    play it on PORTC

    Delay_ms(1000)

    for counter = 0 to 31           ' Read 32 bytes block from address
    0x100
    PORTD = EEPROM_Read(0x80+counter) ' and display data on PORTC
    Delay_ms(100)
   next counter
end.
```

Ethernet PIC18FxxJ60 Library

`PIC18FxxJ60` family of microcontrollers feature an embedded Ethernet controller module. This is a complete connectivity solution, including full implementations of both Media Access Control (MAC) and Physical Layer transceiver (PHY) modules. Two pulse transformers and a few passive components are all that are required to connect the microcontroller directly to an Ethernet network.

The Ethernet module meets all of the IEEE 802.3 specifications for 10-BaseT connectivity to a twisted-pair network. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted IP checksum calculations. Provisions are also made for two LED outputs to indicate link and network activity

This library provides the posibility to easily utilize ethernet feature of the above mentioned MCUs.

Ethernet PIC18FxxJ60 library supports:

- IPv4 protocol.
- ARP requests.
- ICMP echo requests.
- UDP requests.
- TCP requests (no stack, no packet reconstruction).
- ARP client with cache.
- DNS client.
- UDP client.
- DHCP client.
- packet fragmentation is **NOT** supported.

Note: Global library variable `Ethernet_userTimerSec` is used to keep track of time for all client implementations (ARP, DNS, UDP and DHCP). It is user responsibility to increment this variable each second in it's code if any of the clients is used.

Note: For advanced users there are header files `("eth_j60LibDef.h"` and `"eth_j60LibPrivate.h"`) in Uses\P18 folder of the compiler with description of all routines and global variables, relevant to the user, implemented in the Ethernet PIC18FxxJ60 Library.

Library Routines

- Ethernet_Init
- Ethernet_Enable
- Ethernet_Disable
- Ethernet_doPacket
- Ethernet_putByte
- Ethernet_putBytes
- Ethernet_putString
- Ethernet_putConstString
- Ethernet_putConstBytes
- Ethernet_getByte
- Ethernet_getBytes
- Ethernet_UserTCP
- Ethernet_UserUDP
- Ethernet_getIpAddress
- Ethernet_getGwIpAddress
- Ethernet_getDnsIpAddress
- Ethernet_getIpMask
- Ethernet_confNetwork
- Ethernet_arpResolve
- Ethernet_sendUDP
- Ethernet_dnsResolve
- Ethernet_initDHCP
- Ethernet_doDHCPLeaseTime
- Ethernet_renewDHCP

Ethernet_Init

Prototype	`sub procedure Ethernet_Init(dim byref mac as byte, dim byref ip as byte, dim fullDuplex as byte)`
Returns	Nothing.
Description	This is MAC module routine. It initializes Ethernet controller. This function is internaly splited into 2 parts to help linker when coming short of memory. Ethernet controller settings (parameters not mentioned here are set to default): ■ receive buffer start address : `0x0000`. ■ receive buffer end address : `0x19AD`. ■ transmit buffer start address: `0x19AE`. ■ transmit buffer end address : `0x1FFF`. ■ RAM buffer read/write pointers in auto-increment mode. ■ receive filters set to default: CRC + MAC Unicast + MAC Broad cast in OR mode. ■ flow control with TX and RX pause frames in full duplex mode. ■ frames are padded to `60` bytes + CRC. ■ maximum packet size is set to `1518`. ■ Back-to-Back Inter-Packet Gap: 0x15 in full duplex mode;`0x12` in half duplex mode. ■ Non-Back-to-Back Inter-Packet Gap: `0x0012` in full duplex mode; `0x0C12` in half duplex mode. ■ half duplex loopback disabled. ■ LED configuration: default (LEDA-link status, LEDB-link activity). Parameters: ■ `mac:` RAM buffer containing valid MAC address. ■ ip: RAM buffer containing valid IP address. ■ `fullDuplex`: ethernet duplex mode switch. Valid values: `0` (half duplex mode, predefined library const `Ethernet_HALFDUPLEX`) and `1` (full duplex mode, predefined library const `Ethernet_FULLDUPLEX`). **Note:** If a DHCP server is to be used, IP address should be set to `0.0.0.0`.
Requires	Nothing.

Example

```
dim
   myMacAddr as byte[ 6]   ' my MAC address
   myIpAddr   as byte[ 4]  ' my IP addr
   ...
   myMacAddr[ 0]  = 0x00
   myMacAddr[ 1]  = 0x14
   myMacAddr[ 2]  = 0xA5
   myMacAddr[ 3]  = 0x76
   myMacAddr[ 4]  = 0x19
   myMacAddr[ 5]  = 0x3F

   myIpAddr[ 0]   = 192
   myIpAddr[ 1]   = 168
   myIpAddr[ 2]   = 20
   myIpAddr[ 3]   = 60

Ethernet_Init(myMacAddr, myIpAddr, Ethernet_FULLDUPLEX)
```

Ethernet_Enable

<table>
<tr><td>Prototype</td><td><code>sub procedure Ethernet_Enable(dim enFlt as byte)</code></td></tr>
<tr><td>Returns</td><td>Nothing.</td></tr>
<tr><td>Description</td><td>This is MAC module routine. This routine enables appropriate network traffic on the MCU's internal Ethernet module by the means of it's receive filters (unicast, multicast, broadcast, crc). Specific type of network traffic will be enabled if a corresponding bit of this routine's input parameter is set. Therefore, more than one type of network traffic can be enabled at the same time. For this purpose, predefined library constants (see the table below) can be ORed to form appropriate input value.

Parameters:

- <code>enFlt:</code> network traffic/receive filter flags. Each bit corresponds to the appropriate network traffic/receive filter:
<table>
<tr><th>Bit</th><th>Mask</th><th>Description</th><th>Predefined library const</th></tr>
<tr><td>0</td><td>0x01</td><td>MAC Broadcast traffic/receive filter flag. When set, MAC broadcast traffic will be enabled.</td><td><code>_Ethernet_BROADCAST</code></td></tr>
<tr><td>1</td><td>0x02</td><td>MAC Multicast traffic/receive filter flag. When set, MAC multicast traffic will be enabled.</td><td><code>_Ethernet_MULTICAST</code></td></tr>
<tr><td>2</td><td>0x04</td><td>not used</td><td>none</td></tr>
<tr><td>3</td><td>0x08</td><td>not used</td><td>none</td></tr>
<tr><td>4</td><td>0x10</td><td>not used</td><td>none</td></tr>
<tr><td>5</td><td>0x20</td><td>CRC check flag. When set, packets with invalid CRC field will be discarded.</td><td><code>_Ethernet_CRC</code></td></tr>
<tr><td>6</td><td>0x40</td><td>not used</td><td>none</td></tr>
<tr><td>7</td><td>0x80</td><td>MAC Unicast traffic/receive filter flag. When set, MAC unicast traffic will be enabled.</td><td><code>_Ethernet_UNICAST</code></td></tr>
</table>
Note: Advance filtering available in the MCU's internal Ethernet module such as <code>Pattern Match</code>, <code>Magic Packet</code> and <code>Hash Table</code> can not be enabled by this routine. Additionaly, all filters, except CRC, enabled with this routine will work in OR mode, which means that packet will be received if any of the enabled filters accepts it.
Note: This routine will change receive filter configuration on-the-fly. It will not, in any way, mess with enabling/disabling receive/transmit logic or any other part of the MCU's internal Ethernet module. The MCU's internal Ethernet module should be properly cofigured by the means of Ethernet_Init routine.</td></tr>
<tr><td>Requires</td><td>Ethernet module has to be initialized. See Ethernet_Init.</td></tr>
<tr><td>Example</td><td><code>Ethernet_Enable(_Ethernet_CRC or _Ethernet_UNICAST) ' enable CRC checking and Unicast traffic</code></td></tr>
</table>

Ethernet_Disable

<table>
<tr><td>Prototype</td><td><code>sub procedure Ethernet_Disable(dim disFlt as byte)</code></td></tr>
<tr><td>Returns</td><td>Nothing.</td></tr>
<tr><td>Description</td><td>This is MAC module routine. This routine disables appropriate network traffic on the MCU's internal Ethernet module by the means of it's receive filters (unicast, multicast, broadcast, crc). Specific type of network traffic will be disabled if a corresponding bit of this routine's input parameter is set. Therefore, more than one type of network traffic can be disabled at the same time. For this purpose, predefined library constants (see the table below) can be ORed to form appropriate input value.

Parameters:

■ <code>disFlt:</code> network traffic/receive filter flags. Each bit corresponds to the appropriate network traffic/receive filter:
<table>
<tr><th>Bit</th><th>Mask</th><th>Description</th><th>Predefined library const</th></tr>
<tr><td>0</td><td>0x01</td><td>MAC Broadcast traffic/receive filter flag. When set, MAC broadcast traffic will be disabled.</td><td><code>_Ethernet_BROADCAST</code></td></tr>
<tr><td>1</td><td>0x02</td><td>MAC Multicast traffic/receive filter flag. When set, MAC multicast traffic will be disabled.</td><td><code>_Ethernet_MULTICAST</code></td></tr>
<tr><td>2</td><td>0x04</td><td>not used</td><td>none</td></tr>
<tr><td>3</td><td>0x08</td><td>not used</td><td>none</td></tr>
<tr><td>4</td><td>0x10</td><td>not used</td><td>none</td></tr>
<tr><td>5</td><td>0x20</td><td>CRC check flag. When set, CRC check will be disabled and packets with invalid CRC field will be accepted.</td><td><code>_Ethernet_CRC</code></td></tr>
<tr><td>6</td><td>0x40</td><td>not used</td><td>none</td></tr>
<tr><td>7</td><td>0x80</td><td>MAC Unicast traffic/receive filter flag. When set, MAC unicast traffic will be disabled.</td><td><code>_Ethernet_UNICAST</code></td></tr>
</table>
Note: Advance filtering available in the MCU's internal Ethernet module such as <code>Pattern Match</code>, <code>Magic Packet</code> and <code>Hash Table</code> can not be disabled by this routine.
Note: This routine will change receive filter configuration on-the-fly. It will not, in any way, mess with enabling/disabling receive/transmit logic or any other part of the MCU's internal Ethernet module. The MCU's internal Ethernet module should be properly cofigured by the means of Ethernet_Init routine.</td></tr>
<tr><td>Requires</td><td>Ethernet module has to be initialized. See Ethernet_Init.</td></tr>
<tr><td>Example</td><td><code>Ethernet_Enable(_Ethernet_CRC or _Ethernet_UNICAST) ' enable CRC checking and Unicast traffic</code></td></tr>
</table>

Ethernet_doPacket

Prototype	`sub procedure EEPROM_Write(dim Address as word, dim Data as byte)`
Returns	■ 0 - upon successful packet processing (zero packets received or received packet processed successfully). ■ 1 - upon reception error or receive buffer corruption. Ethernet controller needs to be restarted. ■ 2 - received packet was not sent to us (not our IP, nor IP broadcast address). ■ 3 - received IP packet was not IPv4. ■ 4 - received packet was of type unknown to the library.
Description	This is MAC module routine. It processes next received packet if such exists. Packets are processed in the following manner: ■ ARP & ICMP requests are replied automatically. ■ upon TCP request the Ethernet_UserTCP function is called for further processing. ■ upon UDP request the Ethernet_UserUDP function is called for further processing. **Note**: `Ethernet_doPacket` must be called as often as possible in user's code.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	see below

```
while true
  ...
  Ethernet_doPacket()   ' process received packets
  ...
wend
```

Ethernet_putByte

Prototype	`sub procedure Ethernet_putByte(dim v as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores one byte to address pointed by the current Ethernet controller's write pointer (EWRPT). Parameters: ■ `v:` value to store
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  data as byte
  ...
  Ethernet_putByte(data)    ' put an byte into ethernet buffer
```

Ethernet_putBytes

Prototype	`sub procedure Ethernet_putBytes(dim ptr as ^byte, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores requested number of bytes into Ethernet controller's RAM starting from current Ethernet controller's write pointer (EWRPT) location. Parameters: ■ `ptr:` RAM buffer containing bytes to be written into Ethernet controller's RAM. ■ `n:` number of bytes to be written
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  buffer as byte[17]
  ...
  buffer = "mikroElektronika"
  ...
Ethernet_putBytes(buffer, 16)   ' put an RAM array into ethernet
buffer
```

Ethernet_putConstBytes

Prototype	`sub procedure Ethernet_putConstBytes(const ptr as ^byte, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores requested number of const bytes into Ethernet controller's RAM starting from current Ethernet controller's write pointer (EWRPT) location. Parameters: ■ `ptr:` const buffer containing bytes to be written into Ethernet controller's RAM. ■ `n:` number of bytes to be written.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	see below

```
const
  buffer as byte[17]
  ...
  buffer = "mikroElektronika"
  ...
  Ethernet_putConstBytes(buffer, 16) ' put a const array into
ethernet buffer
```

Ethernet_putString

Prototype	`sub function Ethernet_putString(dim ptr as ^byte) as word`
Returns	Number of bytes written into Ethernet controller's RAM.
Description	This is MAC module routine. It stores whole string (excluding null termination) into Ethernet controller's RAM starting from current Ethernet controller's write pointer (`EWRPT`) location. Parameters: ■ `ptr:` string to be written into Ethernet controller's RAM.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	see below

```
dim
  buffer as string[16]
  ...
  buffer = "mikroElektronika"
  ...
  Ethernet_putString(buffer) ' put a RAM string into ethernet
buffer
```

Ethernet_putConstString

Prototype	`sub function Ethernet_putConstString(const ptr as ^byte) as word`
Returns	Number of bytes written into Ethernet controller's RAM.
Description	This is MAC module routine. It stores whole const string (excluding null termination) into Ethernet controller's RAM starting from current Ethernet controller's write pointer (EWRPT) location. Parameters: ■ `ptr:` const string to be written into Ethernet controller's RAM.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
const
  buffer as string[ 16]
  ...
  buffer = "mikroElektronika"
  ...
  Ethernet_putConstString(buffer)  ' put a const string into eth-
ernet buffer
```

Ethernet_getByte

Prototype	`sub function Ethernet_getByte() as byte`
Returns	Byte read from Ethernet controller's RAM.
Description	This is MAC module routine. It fetches a byte from address pointed to by current Ethernet controller's read pointer (`ERDPT`).
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  buffer as byte
  ...
  buffer = Ethernet_getByte()   ' read a byte from ethernet
buffer
```

Ethernet_getBytes

Prototype	`sub procedure Ethernet_getBytes(dim ptr as ^byte, dim addr as word, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It fetches equested number of bytes from Ethernet controller's RAM starting from given address. If value of `0xFFFF` is passed as the address parameter, the reading will start from current Ethernet controller's read pointer (`ERDPT`) location. Parameters: ■ `ptr:` buffer for storing bytes read from Ethernet controller's RAM. ■ `addr`: Ethernet controller's RAM start address. Valid values: `0..8192`. ■ `n`: number of bytes to be read.
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  buffer as byte[ 16]
  ...
  Ethernet_getBytes(buffer, 0x100, 16) ' read 16 bytes, starting
from address 0x100
```

Ethernet_UserTCP

Prototype	`sub function Ethernet_UserTCP(dim byref remoteHost as byte[ 4] , dim remotePort, localPort, reqLength as word) as word`
Returns	■ 0 - there should not be a reply to the request. ■ Length of TCP/HTTP reply data field - otherwise.
Description	This is TCP module routine. It is internally called by the library. The user accesses to the TCP/HTTP request by using some of the Ethernet_get routines. The user puts data in the transmit buffer by using some of the Ethernet_put routines. The function must return the length in bytes of the TCP/HTTP reply, or 0 if there is nothing to transmit. If there is no need to reply to the TCP/HTTP requests, just define this function with return(0) as a single statement. Parameters: ■ `remoteHost:` client's IP address. ■ `remotePort:` client's TCP port. ■ `localPort:` port to which the request is sent. ■ `reqLength:` TCP/HTTP request data field length. **Note**: The function source code is provided with appropriate example projects. The code should be adjusted by the user to achieve desired reply.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	This function is internally called by the library and should not be called by the user's code.

Ethernet_UserUDP

Prototype	`sub function Ethernet_UserUDP(dim byref remoteHost as byte[ 4] , dim remotePort, destPort, reqLength as word) as word`
Returns	■ 0 - there should not be a reply to the request. ■ Length of UDP reply data field - otherwise.
Description	This is UDP module routine. It is internally called by the library. The user accesses to the UDP request by using some of the Ethernet_get routines. The user puts data in the transmit buffer by using some of the Ethernet_put routines. The function must return the length in bytes of the UDP reply, or 0 if nothing to transmit. If you don't need to reply to the UDP requests, just define this function with a return(0) as single statement. Parameters: Parameters: ■ `remoteHost:` client's IP address. ■ `remotePort:` client's port. ■ `destPort:` port to which the request is sent. ■ `reqLength:` UDP request data field length. **Note**: The function source code is provided with appropriate example projects. The code should be adjusted by the user to achieve desired reply.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	This function is internally called by the library and should not be called by the user's code.

Ethernet_getIpAddress

Prototype	`sub function Ethernet_getIpAddress() as word`
Returns	Ponter to the global variable holding IP address.
Description	This routine should be used when DHCP server is present on the network to fetch assigned IP address. **Note**: User should always copy the IP address from the RAM location returned by this routine into it's own IP address buffer. These locations should not be altered by the user in any case!
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  ipAddr as byte[ 4]   ' user IP address buffer
  ...
  memcpy(ipAddr, Ethernet_getIpAddress(), 4)   ' fetch IP address
```

Ethernet_getGwIpAddress

Prototype	`sub function Ethernet_getGwIpAddress() as word`
Returns	Ponter to the global variable holding gateway IP address.
Description	This routine should be used when DHCP server is present on the network to fetch assigned gateway IP address. **Note:** User should always copy the IP address from the RAM location returned by this routine into it's own gateway IP address buffer. These locations should not be altered by the user in any case!
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  gwIpAddr as byte[ 4]   ' user gateway IP address buffer
  ...
  memcpy(gwIpAddr, Ethernet_getGwIpAddress(), 4)   ' fetch gateway IP address
```

Ethernet_getDnsIpAddress

Prototype	`sub function Ethernet_getDnsIpAddress() as word`
Returns	Ponter to the global variable holding DNS IP address.
Description	This routine should be used when DHCP server is present on the network to fetch assigned DNS IP address. **Note:** User should always copy the IP address from the RAM location returned by this routine into it's own DNS IP address buffer. These locations should not be altered by the user in any case!
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  dnsIpAddr as byte[4]   ' user DNS IP address buffer
  ...
  memcpy(dnsIpAddr, Ethernet_getDnsIpAddress(), 4)   ' fetch DNS server address
```

Ethernet_getIpMask

Prototype	`sub function Ethernet_getIpMask() as word`
Returns	Ponter to the global variable holding IP subnet mask.
Description	This routine should be used when DHCP server is present on the network to fetch assigned IP subnet mask. **Note:** User should always copy the IP address from the RAM location returned by this routine into it's own IP subnet mask buffer. These locations should not be altered by the user in any case!
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  IpMask as byte[4]   ' user IP subnet mask buffer
  ...
  memcpy(IpMask, Ethernet_getIpMask(), 4)   ' fetch IP subnet mask
```

Ethernet_confNetwork

Prototype	`sub procedure Ethernet_confNetwork(dim byref ipMask, gwIpAddr, dnsIpAddr as byte[ 4] )`
Returns	Nothing.
Description	Configures network parameters (IP subnet mask, gateway IP address, DNS IP address) when DHCP is not used. Parameters: ■ `ipMask:` IP subnet mask. ■ `gwIpAddr` gateway IP address. ■ `dnsIpAddr:` DNS IP address. **Note:** The above mentioned network parameters should be set by this routine only if DHCP module is not used. Otherwise DHCP will override these settings.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  ipMask     as byte[ 4]   ' network mask (for example :
255.255.255.0)
  gwIpAddr   as byte[ 4]   ' gateway (router) IP address
  dnsIpAddr  as byte[ 4]   ' DNS server IP address
  ...
  gwIpAddr[ 0]   = 192
  gwIpAddr[ 1]   = 168
  gwIpAddr[ 2]   = 20
  gwIpAddr[ 3]   = 6

  dnsIpAddr[ 0]  = 192
  dnsIpAddr[ 1]  = 168
  dnsIpAddr[ 2]  = 20
  dnsIpAddr[ 3]  = 100

  ipMask[ 0]     = 255
  ipMask[ 1]     = 255
  ipMask[ 2]     = 255
  ipMask[ 3]     = 0
  ...
  Ethernet_confNetwork(ipMask, gwIpAddr, dnsIpAddr)  ' set network
configuration parameters
```

Ethernet_arpResolve

Prototype	`sub function Ethernet_arpResolve(dim byref ip as byte[ 4] , dim tmax as byte) as word`
Returns	■ MAC address behind the IP address - the requested IP address was resolved. ■ 0 - otherwise.
Description	This is ARP module routine. It sends an ARP request for given IP address and waits for ARP reply. If the requested IP address was resolved, an ARP cash entry is used for storing the configuration. ARP cash can store up to 3 entries. For ARP cash structure refer to `"eth_j60LibDef.h"` header file in the compiler's Uses/P18 folder. Parameters: ■ `ip:` IP address to be resolved. ■ `tmax:` time in seconds to wait for an reply. **Note:** The Ethernet services are not stopped while this routine waits for ARP reply. The incoming packets will be processed normaly during this time.
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  IpAddr as byte[ 4]   ' IP address
  ...
  IpAddr[ 0] = 192
  IpAddr[ 0] = 168
  IpAddr[ 0] = 1
  IpAddr[ 0] = 1
  ...
  Ethernet_arpResolve(IpAddr, 5) ' get MAC address behind the
above IP address, wait 5 secs for the response
```

Ethernet_sendUDP

Prototype

```
sub function Ethernet_sendUDP(dim byref destIP as byte[ 4] , dim
sourcePort, destPort as word, dim pkt as ^byte, dim pktLen as
word) as byte
```

Returns	■ 1 - UDP packet was sent successfully. ■ 0 - otherwise.
Description	This is UDP module routine. It sends an UDP packet on the network. Parameters: ■ `destIP`: remote host IP address. ■ `sourcePort:` local UDP source port number. ■ `destPort:` destination UDP port number. ■ `pkt:` packet to transmit. ■ `pktLen:` length in bytes of packet to transmit.
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
dim
  IpAddr as byte[ 4]   ' remote IP address
  ...
  IpAddr[ 0]  = 192
  IpAddr[ 0]  = 168
  IpAddr[ 0]  = 1
  IpAddr[ 0]  = 1
  ...
  Ethernet_sendUDP(IpAddr, 10001, 10001, "Hello", 5)  ' send Hello
message to the above IP address, from UDP port 10001 to UDP port
10001
```

Ethernet_dnsResolve

Prototype	`sub function Ethernet_dnsResolve(dim byref host as byte[ 4] , dim tmax as byte) as word`
Returns	■ pointer to the location holding the IP address - the requested host name was resolved. ■ 0 - otherwise.
Description	This is DNS module routine. It sends an DNS request for given host name and waits for DNS reply. If the requested host name was resolved, it's IP address is stored in library global variable and a pointer containing this address is returned by the routine. UDP port 53 is used as DNS port. Parameters: ■ `host:` host name to be resolved. ■ `tmax:` time in seconds to wait for an reply. **Note:** The Ethernet services are not stopped while this routine waits for DNS reply. The incoming packets will be processed normaly during this time. **Note:** User should always copy the IP address from the RAM location returned by this routine into it's own resolved host IP address buffer. These locations should not be altered by the user in any case!
Requires	Ethernet module has to be initialized. See Ethernet_Init.
Example	

```
dim
  remoteHostIpAddr as byte[ 4]     ' user host IP address buffer
  ...
  ' SNTP server:
  ' Zurich, Switzerland: Integrated Systems Lab, Swiss Fed. Inst.
of Technology
  ' 129.132.2.21: swisstime.ethz.ch
  ' Service Area: Switzerland and Europe
  memcpy(remoteHostIpAddr,
Ethernet_dnsResolve("swisstime.ethz.ch", 5), 4)
```

Ethernet_initDHCP

Prototype	`sub function Ethernet_initDHCP(dim tmax as byte) as byte`
Returns	■ 1 - network parameters were obtained successfully. ■ 0 - otherwise.
Description	This is DHCP module routine. It sends an DHCP request for network parameters (IP, gateway, DNS addresses and IP subnet mask) and waits for DHCP reply. If the requested parameters were obtained successfully, their values are stored into the library global variables. These parameters can be fetched by using appropriate library IP get routines: ■ Ethernet_getIpAddress - fetch IP address. ■ Ethernet_getGwIpAddress - fetch gateway IP address. ■ Ethernet_getDnsIpAddress - fetch DNS IP address. ■ Ethernet_getIpMask - fetch IP subnet mask. UDP port 68 is used as DHCP client port and UDP port 67 is used as DHCP server port. Parameters: ■ `tmax`: time in seconds to wait for an reply. Note: The Ethernet services are not stopped while this routine waits for DNS reply. The incoming packets will be processed normaly during this time. Note: When DHCP module is used, global library variable `Ethernet_userTimerSec` is used to keep track of time. It is user responsibility to increment this variable each second in it's code.
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
...
  Ethernet_initDHCP(5)  ' get network configuration from DHCP
server, wait 5 sec for the response
  ...
```

Ethernet_doDHCPLeaseTime

Prototype	`sub function Ethernet_doDHCPLeaseTime() as byte`
Returns	■ 0 - lease time has not expired yet. ■ 1 - lease time has expired, it's time to renew it.
Description	This is DHCP module routine. It takes care of IP address lease time by decrementing the global lease time library counter. When this time expires, it's time to contact DHCP server and renew the lease.
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
while true
  ...
  if(Ethernet_doDHCPLeaseTime() <> 0) then
    ... ' it's time to renew the IP address lease
  end if
wend
```

Ethernet_renewDHCP

Prototype	`sub function Ethernet_renewDHCP(dim tmax as byte) as byte`
Returns	■ 1 - upon success (lease time was renewed). ■ 0 - otherwise (renewal request timed out).
Description	This is DHCP module routine. It sends IP address lease time renewal request to DHCP server. Parameters: ■ `tmax`: time in seconds to wait for an reply.
Requires	Ethernet module has to be initialized. See Ethernet_Init.

Example

```
while true
  ...
  if(Ethernet_doDHCPLeaseTime() <> 0) then
    Ethernet_renewDHCP(5)   ' it's time to renew the IP address
lease, with 5 secs for a reply
  end if
  ...
wend
```

Library Example

This code shows how to use the PIC18FxxJ60 Ethernet library :

- the board will reply to ARP & ICMP echo requests
- the board will reply to UDP requests on any port :
  returns the request in upper char with a header made of remote host IP & port number
- the board will reply to HTTP requests on port 80, GET method with path names :
  / will return the HTML main page
  /s will return board status as text string
  /t0 ... /t7 will toggle RD0 to RD7 bit and return HTML main page
  all other requests return also HTML main page.

```
program enc_ethernet

' ***********************************
' * RAM variables
' *

dim myMacAddr    as byte[ 6]     ' my MAC address
     myIpAddr     as byte[ 4]     ' my IP address
     gwIpAddr     as byte[ 4]     ' gateway (router) IP address
     ipMask       as byte[ 4]     ' network mask (for example:
255.255.255.0)
     dnsIpAddr    as byte[ 4]      ' DNS server IP address

const httpHeader as string[ 31]   = "HTTP/1.1 200 OK"+chr(10)+"Content-
type: "   ' HTTP header
const httpMimeTypeHTML as string[ 13]    = "text/html"+chr(10)+chr(10)
' HTML MIME type
const       httpMimeTypeScript        as        string[ 14]         =
"text/plain"+chr(10)+chr(10)                  ' TEXT MIME type
const httpMethod as string[ 5]          = "GET /"

' *
' * web page, splited into 2 parts :
' * when coming short of ROM, fragmented data is handled more effi-
ciently by linker
' *
' * this HTML page calls the boards to get its status, and builds
itself with javascript
' *

const indexPage as string[ 763]  =
```

```
               "<meta http-equiv=" + Chr(34) + "refresh"  + Chr(34) + " con
               tent="  + Chr(34) + "3;url=http://192.168.20.60"  + Chr(34) +
               ">" +
               "<HTML><HEAD></HEAD><BODY>"+
               "<h1>PIC18FxxJ60 Mini Web Server</h1>"+
               "<a href=/>Reload</a>"+
               "<script src=/s></script>"+
               "<table><tr><td valign=top><table border=1
               style="+chr(34)+"font-size:20px ;font-family: terminal
               ;"+chr(34)+"> "+
               "<tr><th colspan=2>ADC</th></tr>"+
               "<tr><td>AN2</td><td><script>document.write(AN2)</script>
               </td></tr>"+
               "<tr><td>AN3</td><td><script>document.write(AN3)
               </script></td></tr>"+
               "</table></td><td><table border=1 style="+chr(34)+"font-
               size:20px ;font-family: terminal ;"+chr(34)+"> "+
               "<tr><th colspan=2>PORTB</th></tr>"+
               "<script>"+
               "var str,i;"+
               "str="+chr(34)+chr(34)+"; "+
               "for(i=0;i<8;i++)"+
               "{ str+="+chr(34)+"<tr><tb gcolor=pink>BUTTON #"+chr(34)+"+i+"
               +chr(34)+"</td>"+chr(34)+"; "+
               "if(PORTB&(1<<i)){ str+="+chr(34)+"<td   bgcolor=red>ON"
               +chr(34)+";} "+
               "else { str+="+chr(34)+"<td bgcolor=#cccccc>OFF"+chr(34)+";} "+
               "str+="+chr(34)+"</td></tr>"+chr(34)+";} "+
               "document.write(str) ;"+
               "</script>"

        const indexPage2 as string[470]  =
                "</table></td><td>"+
                "<table border=1 style="+chr(34)+"font-size:20px ;font-fami
                ly: terminal ;"+chr(34)+"> "+
                "<tr><th colspan=3>PORTD</th></tr>"+
                "<script>"+
                "var str,i;"+
                "str="+chr(34)+chr(34)+"; "+
                "for(i=0;i<3;i++)"+
                "{ str+="+chr(34)+"<tr><td bgcolor=yellow>LED
                #"+chr(34)+"+i+"+chr(34)+"</td>"+chr(34)+"; "+
                "if(PORTD&(1<<i)){ str+="+chr(34)+"<td bgcolor=red>ON"+chr
                (34)+";} "+
                "else { str+="+chr(34)+"<td bgcolor=#cccccc>OFF"+chr(34)+";} "+
                "str+="+chr(34)+"</td><td><a href=/t"+chr(34)+"+i+"+chr(34)+
                ">Toggle</a></td></tr>"+chr(34)+";} "+
                 "document.write(str) ;"+
                 "</script>"
```

```
       "</table></td></tr></table>"+
       "This is HTTP request #<script>document.write(REQ)</script>
       </BODY></HTML>"

dim    getRequest    as byte[ 15]    ' HTTP request buffer
       dyna          as byte[ 30]    ' buffer for dynamic response
       httpCounter   as word         ' counter of HTTP requests
       txt           as string[ 11]

' ******************************************
' * user defined functions
' *

' *
 * this function is called by the library
' * the user accesses to the HTTP request by successive calls to
Ethernet_getByte()
' * the user puts data in the transmit buffer by successive calls to
Ethernet_putByte()
' * the function must return the length in bytes of the HTTP reply,
or 0 if nothing to transmit
' *
' * if you don't need to reply to HTTP requests,
' * just define this function with a return(0) as single statement
' *
' *
sub function Ethernet_UserTCP(dim byref remoteHost as byte[ 4] ,
    dim remotePort, localPort, reqLength as word) as word
    dim  i as word        ' my reply length
      bitMask as byte   ' for bit mask
      txt             as string[ 11]
    result = 0
    if(localPort <> 80) then ' I listen only to web request on port
80
      result = 0
      exit
     end if

     'get 10 first bytes only of the request, the rest does not mat
ter here
    for i = 0 to 10
    getRequest[ i]  = Ethernet_getByte()
    next i

    getRequest[ i]  = 0
    ' copy httpMethod to ram for use in memcmp routine
    for i = 0 to 4
      txt[ i]  = httpMethod[ i]
    next i
```

```
        if(memcmp(@getRequest, @txt, 5) <> 0) then   ' only GET method
is supported here
          result = 0
          exit
      end if

      Inc(httpCounter)                             ' one more request done

       if(getRequest[ 5]  = "s") then              ' if request path name
starts with s, store dynamic data in transmit buffer
          ' the text string replied by this request can be interpreted
as javascript statements
          ' by browsers

         result = Ethernet_putConstString(@httpHeader)    ' HTTP header
         result = result + Ethernet_putConstString(@httpMimeTypeScript)
' with text MIME type

         ' add AN2 value to reply
         WordToStr(ADC_Read(2), dyna)
         txt   = "var AN2="
         result = result + Ethernet_putString(@txt)
         result = result + Ethernet_putString(@dyna)
         txt   = ";"
         result = result + Ethernet_putString(@txt)

         ' add AN3 value to reply
         WordToStr(ADC_Read(3), dyna)
         txt   = "var AN3="
         result = result + Ethernet_putString(@txt)
         result = result + Ethernet_putString(@dyna)
         txt   = ";"
         result = result + Ethernet_putString(@txt)

         ' add PORTB value (buttons) to reply
         txt   = "var PORTB="
         result = result + Ethernet_putString(@txt)
         WordToStr(PORTB, dyna)
         result = result + Ethernet_putString(@dyna)
         txt   = ";"
         result = result + Ethernet_putString(@txt)

         ' add PORTD value (LEDs) to reply
         txt   = "var PORTD="
         result = result + Ethernet_putString(@txt)
         WordToStr(PORTD, dyna)
         result = result + Ethernet_putString(@dyna)
         txt   = ";"
         result = result + Ethernet_putString(@txt)
```

```
          ' add HTTP requests counter to reply
          WordToStr(httpCounter, dyna)
          txt   = "var REQ="
          result = result + Ethernet_putString(@txt)
          result = result + Ethernet_putString(@dyna)
          txt   = ";"
          result = result + Ethernet_putString(@txt)
        else
           if(getRequest[ 5]  = "t")  then    ' if request path name starts
      with t, toggle PORTD (LED) bit number that comes after
            bitMask = 0
            if(isdigit(getRequest[ 6] )  <>  0)  then   ' if 0 <= bit number
      <= 9, bits 8 & 9 does not exist but does not matter
              bitMask = getRequest[ 6]  - "0"   ' convert ASCII to integer
              bitMask = 1 << bitMask          ' create bit mask
              PORTD    = PORTD xor bitMask     ' toggle PORTD with xor oper
      ator
              end if
            end if
        end if

      if(result = 0) then ' what do to by default
        result = Ethernet_putConstString(@httpHeader)   ' HTTP header
        result = result + Ethernet_putConstString(@httpMimeTypeHTML)
    ' with HTML MIME type
        result = result + Ethernet_putConstString(@indexPage)
    ' HTML page first part
       result = result + Ethernet_putConstString(@indexPage2)
    ' HTML page second part
      end if

      ' return to the library with the number of bytes to transmit
    end sub

    '*
    ' *  this function is called by the library
    ' * the user accesses to the UDP request by successive calls to
      Ethernet_getByte()
    ' * the user puts data in the transmit buffer by successive calls to
      Ethernet_putByte()
    ' * the function must return the length in bytes of the UDP reply,
      or 0 if nothing to transmit
    ' *
    ' * if you don't need to reply to UDP requests,
    ' * just define this function with a return(0) as single statement
    ' *
    ' *
    sub function Ethernet_UserUDP(dim byref remoteHost as byte[ 4] ,
                                  dim remotePort, destPort, reqLength
    as word) as word
```

```
       dim txt as string[ 5]
       result = 0
     ' reply is made of the remote host IP address in human readable
       format
       byteToStr(remoteHost[ 0] , dyna)         ' first IP address byte
       dyna[ 3]  = "."
       byteToStr(remoteHost[ 1] , txt)              ' second
       dyna[ 4]  = txt[ 0]
       dyna[ 5]  = txt[ 1]
       dyna[ 6]  = txt[ 2]
       dyna[ 7]  = "."
       byteToStr(remoteHost[ 2] , txt)              ' second
       dyna[ 8]   = txt[ 0]
       dyna[ 9]   = txt[ 1]
       dyna[ 10]  = txt[ 2]

       dyna[ 11]  = "."
       byteToStr(remoteHost[ 3] , txt)              ' second
       dyna[ 12]  = txt[ 0]
       dyna[ 13]  = txt[ 1]
       dyna[ 14]  = txt[ 2]

       dyna[ 15]  = ":"                              ' add separator

       ' then remote host port number
       WordToStr(remotePort, txt)
       dyna[ 16]  = txt[ 0]
       dyna[ 17]  = txt[ 1]
       dyna[ 18]  = txt[ 2]
       dyna[ 19]  = txt[ 3]
       dyna[ 20]  = txt[ 4]
       dyna[ 21]  = "[ "
       WordToStr(destPort, txt)
       dyna[ 22]  = txt[ 0]
       dyna[ 23]  = txt[ 1]
       dyna[ 24]  = txt[ 2]
       dyna[ 25]  = txt[ 3]
       dyna[ 26]  = txt[ 4]
       dyna[ 27]  = "] "
       dyna[ 28]  = 0

       ' the total length of the request is the length of the dynam
ic string plus the text of the request
       result = 28 + reqLength

       ' puts the dynamic string into the transmit buffer
       Ethernet_putBytes(@dyna, 28)
       'then puts the request string converted into upper char into
the transmit buffer
```

```
        while(reqLength <> 0)
          Ethernet_putByte(Ethernet_getByte())
          reqLength = reqLength - 1
        wend

        ' back to the library with the length of the UDP reply
end sub

main:
  ADCON1 = 0x0B       ' ADC convertors will be used with AN2 and AN3
  CMCON  = 0x07       ' turn off comparators

  PORTA  = 0
  TRISA  = 0x0C       ' RA2:RA3 - analog inputs
                      ' RA1:RA0 - ethernet LEDA:LEDB

  PORTB  = 0
  TRISB  = 0xFF       ' set PORTB as input for buttons

  PORTD  = 0
  TRISD  = 0           ' set PORTD as output

  httpCounter = 0

  ' set mac address
  myMacAddr[ 0]  = 0x00
  myMacAddr[ 1]  = 0x14
  myMacAddr[ 2]  = 0xA5
  myMacAddr[ 3]  = 0x76
  myMacAddr[ 4]  = 0x19
  myMacAddr[ 5]  = 0x3F

  ' set IP address
  myIpAddr[ 0]  = 192
  myIpAddr[ 1]  = 168
  myIpAddr[ 2]  = 20
  myIpAddr[ 3]  = 60

  ' set gateway address
  gwIpAddr[ 0]   = 192
  gwIpAddr[ 1]   = 168
  gwIpAddr[ 2]   = 20
  gwIpAddr[ 3]   = 6

  ' set dns address
  dnsIpAddr[ 0]  = 192
  dnsIpAddr[ 1]  = 168
  dnsIpAddr[ 2]  = 20
  dnsIpAddr[ 3]  = 1
```

```
' `set subnet mask
  ipMask[ 0]     = 255
  ipMask[ 1]     = 255
  ipMask[ 2]     = 255
  ipMask[ 3]     = 0

'  *
'  * starts ENC28J60 with :
'  * reset bit on PORTC.B0
'  * CS bit on PORTC.B1
'  * my MAC & IP address
'  * full duplex
'  *
  Ethernet_Init(myMacAddr, myIpAddr, _Ethernet_FULLDUPLEX)    ' init
   ethernet module
  Ethernet_setUserHandlers(@Ethernet_UserTCP, @Ethernet_UserUDP)  '
   set user handlers

  ' dhcp will not be used here, so use preconfigured addresses
  Ethernet_confNetwork(ipMask, gwIpAddr, dnsIpAddr)

  while TRUE                     ' do forever
    Ethernet_doPacket()          ' process incoming Ethernet packets

'  *
'  * add your stuff here if needed
'  * Ethernet_doPacket() must be called as often as possible
'  * otherwise packets could be lost
'  *
  wend
end.
```

FLASH MEMORY LIBRARY

This library provides routines for accessing microcontroller Flash memory. Note that prototypes differ for PIC16 and PIC18 families.

Note: Due to the P16/P18 family flash specifics, flash library is MCU dependent. Since the P18 family differ significantlly in number of bytes that can be erased and/or written to specific MCUs, the appropirate suffix is added to the names of functions in order to make it easier to use them. Flash memory operations are MCU dependent :

1. **Read** operation supported. For this group of MCU's only read function is implemented.
2. **Read** and **Write** operations supported (write is executed as erase-and-write). For this group of MCU's read and write functions are implemented. Note that write operation which is executed as erase-and-write, may write less bytes than it erases.
3. **Read**, **Write** and **Erase** operations supported. For this group of MCU's read, write and erase functions are implemented. Further more, flash memory block has to be erased prior to writting (write operation is not executed as erase-and-write).
Please refer to MCU datasheet before using flash library.

Please refer to MCU datasheet before using flash library.

Library Routines

- FLASH_Read
- FLASH_Read_N_Bytes
- FLASH_Write
- FLASH_Write_8
- FLASH_Write_16
- FLASH_Write_32
- FLASH_Write_64
- FLASH_Erase
- FLASH_Erase_64
- FLASH_Erase_1024
- FLASH_Erase_Write
- FLASH_Erase_Write_64
- FLASH_Erase_Write_1024

FLASH_Read

Prototype	`' for PIC16`
	`sub function FLASH_Read(dim Address as word) as word`
	
	`' forPIC18`
	`sub function FLASH_Read(dim address as dword)as byte`

Returns	Returns data byte from Flash memory.
Description	Reads data from the specified address in Flash memory.
Requires	Nothing.

Example

```
' for PIC18
dim tmp as byte
...
main:
   ...
   tmp = FLASH_Read(0x0D00)
   ...
end.
```

FLASH_Read_N_Bytes

Prototype	`' for PIC18` `sub procedure FLASH_Read_N_Bytes(dim address as longint, dim byref data as byte, dim N as word)`
Returns	Nothing.
Description	Reads N data from the specified `address` in Flash memory to varibale pointed by `data`
Requires	Nothing.
Example	`FLASH_Read_N(0x0D00,data_buffer,sizeof(data_buffer))`

FLASH_Write

Prototype

```
' for PIC16
sub procedure FLASH_Write(dim Address as word, dim byref Data as
word[ 4] )
' forPIC18
sub procedure FLASH_Write_8(dim address as dword, dim byref data
as byte[ 8] )

sub procedure FLASH_Write_16(dim address as dword, dim byref data
as byte[ 16] )

sub procedure FLASH_Write_32(dim address as dword, dim byref data
as byte[ 32] )

sub procedure FLASH_Write_64(dim address as dword, dim byref data
as byte[ 64] )
```

Returns

Nothing.

Description

Writes block of data to Flash memory. Block size is MCU dependent.
P16: This function may erase memory segment before writing block of data to it (MCU dependent). Furthermore, memory segment which will be erased may be greater than the size of the data block that will be written (MCU dependent). Therefore it is recommended to write as many bytes as you erase. FLASH_Write writes 4 flash memory locations in a row, so it needs to be called as many times as it is necessary to meet the size of the data block that will be written.
P18: This function does not perform erase prior to write.

Requires

Flash memory that will be written may have to be erased before this function is called (MCU dependent). Refer to MCU datasheet for details.

Example

Write consecutive values in 64 consecutive locations, starting from 0x0D00:

```
dim toWrite as byte[ 64]
...
main:
...
' initialize array:
for i = 0 to 63
    toWrite[ i]  = i
   next i
...
' write contents of the array to the address 0x0D00:
FLASH_Write_64(0x0D00, toWrite)
...
end.
```

FLASH_Erase

Prototype	`' for PIC16`
	`sub procedure FLASH_Erase(dim address as word)`
	`'forPIC18`
	`sub procedure FLASH_Erase_64(dim address as dword)`
	`sub procedure FLASH_Erase_1024(dim address as dword)`

Returns	Nothing.
Description	Erases memory block starting from a given address. For P16 familly is implemented only for those MCU's whose flash memory does not support erase-and-write operations (refer to datasheet for details).
Requires	Nothing.
Example	Erase 64 byte memory memory block, starting from address $0D00: `FLASH_Erase_64($0D00)`

FLASH_Erase_Write

Prototype	`' for PIC18`
	`sub procedure FLASH_Erase_Write_64(dim address as dword, dim byref data as byte[ 64] )`
	`sub procedure FLASH_Erase_Write_1024(dim address as dword, dim byref data as byte[ 1024] )`

Returns	None.
Description	Erase then write memory block starting from a given address.
Requires	Nothing.
Example	

```
dim toWrite as byte[ 64]
...
main:
...
' initialize array:
for i = 0 to 63
   toWrite[ i] = i
next i ...
' erase block of memory at address 0x0D00 then write contents of
the array to the address 0x0D00:
FLASH_Erase_Write_64(0x0D00, toWrite)
...
end.
```

Library Example

This is a simple demonstration how to use to PIC16 internal flash memory to store data. The data is being written starting from the given location; then, the same locations are read and the data is displayed on PORTB and PORTC.

```
program Flash_Write

dim counter as byte
    addr, data_ as word
    dataAR as word[ 4][ 4]

  ANSEL  = 0                               ' Configure AN pins as digital
  ANSELH = 0
  C1ON_bit = 0                             ' Disable comparators
  C2ON_bit = 0
  PORTB = 0                                ' Initial PORTB value
  TRISB = 0                                ' Set PORTB as output
  PORTC = 0                                ' Initial PORTC value
  TRISC = 0                                ' Set PORTC as output
  Delay_ms(500)

  ' All block writes
  ' to program memory are done as 16-word erase by
  ' eight-word write operations. The write operation is
  ' edge-aligned and cannot occur across boundaries.
  ' Therefore it is recommended to perform flash writes in 16-word
     chunks.
  ' That is why lower 4 bits of start address [3:0] must be zero.
  ' Since FLASH_Write routine performs writes in 4-word chunks,
  ' we need to call it 4 times in a row.

  dataAR[ 0][ 0] = 0x3FAA+0
  dataAR[ 0][ 1] = 0x3FAA+1
  dataAR[ 0][ 2] = 0x3FAA+2
  dataAR[ 0][ 3] = 0x3FAA+3
  dataAR[ 1][ 0] = 0x3FAA+4
  dataAR[ 1][ 1] = 0x3FAA+5
  dataAR[ 1][ 2] = 0x3FAA+6
  dataAR[ 1][ 3] = 0x3FAA+7
  dataAR[ 2][ 0] = 0x3FAA+8
  dataAR[ 2][ 1] = 0x3FAA+9
  dataAR[ 2][ 2] = 0x3FAA+10
  dataAR[ 2][ 3] = 0x3FAA+11
  dataAR[ 3][ 0] = 0x3FAA+12
  dataAR[ 3][ 1] = 0x3FAA+13
  dataAR[ 3][ 2] = 0x3FAA+14
  dataAR[ 3][ 3] = 0x3FAA+15
```

```
    addr = 0x0430           ' starting Flash address, valid for P16F88
    for counter = 0 to 3     ' write some data to Flash
        Delay_ms(100)
        FLASH_Write(addr+counter*4, dataAR[counter])
    next counter
    Delay_ms(500)

    addr = 0x0430
    for counter = 0 to 15
      data_ = FLASH_Read(addr)          ' P16's FLASH is 14-bit wide, so
      Inc(addr)
      Delay_us(10)                      ' two MSB's will always be '00'
      PORTB = data_                     ' display data on PORTB LS Byte
      PORTC = word(data_ >> 8)          ' and PORTC MS Byte
      Delay_ms(500)
    next counter
end.
```

GRAPHIC LCD LIBRARY

The *mikroBasic PRO for PIC* provides a library for operating Graphic LCD 128x64 (with commonly used Samsung KS108/KS107 controller).

For creating a custom set of Glcd images use Glcd Bitmap Editor Tool.

External dependencies of Graphic LCD Library

The following variables must be defined in all projects using Graphic LCD Library:	Description:	Example :
`dim GLCD_DataPort as byte sfr external`	Glcd Data Port	`dim GLCD_DataPort as byte at PORTD_bit`
`dim GLCD_CS1 as sbit sfr external`	Chip Select 1 line.	`dim GLCD_CS1 as sbit at RB0_bit`
`dim GLCD_CS2 as sbit sfr external`	Chip Select 2 line.	`dim GLCD_CS2 as sbit at RB1_bit`
`dim GLCD_RS as sbit sfr external`	Register select line.	`dim GLCD_RS as sbit at RB2_bit`
`dim GLCD_RW as sbit sfr external`	Read/Write line.	`dim GLCD_RW as sbit at RB3_bit`
`dim GLCD_RST as sbit sfr external`	Reset line.	`dim GLCD_RST as sbit at RB4_bit`
`dim GLCD_EN as sbit sfr external`	Enable line.	`dim GLCD_EN as sbit at RB5_bit`
`dim GLCD_CS1_Direction as sbit sfr external`	Direction of the Chip Select 1 pin.	`dim GLCD_CS1_Direction as sbit at TRISB0_bit`
`dim GLCD_CS2_Direction as sbit sfr external`	Direction of the Chip Select 2 pin.	`dim GLCD_CS2_Direction as sbit at TRISB1_bit`
`dim GLCD_RS_Direction as sbit sfr external`	Direction of the Register select pin.	`dim GLCD_RS_Direction as sbit at TRISB2_bit`
`dim GLCD_RW_Direction as sbit sfr external`	Direction of the Read/Write pin.	`dim GLCD_RW_Direction as sbit at TRISB3_bit`
`dim GLCD_EN_Direction as sbit sfr external`	Direction of the Enable pin.	`dim GLCD_EN_Direction as sbit at TRISB4_bit`
`dim GLCD_RST_Direction as sbit sfr external`	Direction of the Reset pin.	`dim GLCD_RST_Direction as sbit at TRISB5_bit`

Library Routines

Basic routines:

- Glcd_Init
- Glcd_Set_Side
- Glcd_Set_X
- Glcd_Set_Page
- Glcd_Read_Data
- Glcd_Write_Data

Advanced routines:

- Glcd_Fill
- Glcd_Dot
- Glcd_Line
- Glcd_V_Line
- Glcd_H_Line
- Glcd_Rectangle
- Glcd_Box
- Glcd_Circle
- Glcd_Set_Font
- Glcd_Write_Char
- Glcd_Write_Text
- Glcd_Image

Glcd_Init

Prototype	`sub procedure Glcd_Init()`
Returns	Nothing.
Description	Initializes the Glcd module. Each of the control lines is both port and pin configurable, while data lines must be on a single port (pins <0:7>).
Requires	Global variables : ■ `GLCD_CS1` : Chip select 1 signal pin ■ `GLCD_CS2` : Chip select 2 signal pin ■ `GLCD_RS` : Register select signal pin ■ `GLCD_RW` : Read/Write Signal pin ■ `GLCD_EN` : Enable signal pin ■ `GLCD_RST` : Reset signal pin ■ `GLCD_DataPort` : Data port ■ `GLCD_CS1_Direction` : Direction of the Chip select 1 pin ■ `GLCD_CS2_Direction` : Direction of the Chip select 2 pin ■ `GLCD_RS_Direction` : Direction of the Register select signal pin ■ `GLCD_RW_Direction` : Direction of the Read/Write signal pin ■ `GLCD_EN_Direction` : Direction of the Enable signal pin ■ `GLCD_RST_Direction` : Direction of the Reset signal pin must be defined before using this function.
Example	

```
' Glcd module connections
dim GLCD_DataPort as byte at PORTD

dim GLCD_CS1 as sbit at RB0_bit
    GLCD_CS2 as sbit at RB1_bit
    GLCD_RS  as sbit at RB2_bit
    GLCD_RW  as sbit at RB3_bit
    GLCD_EN  as sbit at RB4_bit
    GLCD_RST as sbit at RB5_bit

dim GLCD_CS1_Direction as sbit at TRISB0_bit
    GLCD_CS2_Direction as sbit at TRISB1_bit
    GLCD_RS_Direction  as sbit at TRISB2_bit
    GLCD_RW_Direction  as sbit at TRISB3_bit
    GLCD_EN_Direction  as sbit at TRISB4_bit
    GLCD_RST_Direction as sbit at TRISB5_bit
' End Glcd module connections

...
Glcd_Init()
```

Glcd_Set_Side

Prototype	`sub procedure Glcd_Set_Side(dim x_pos as byte)`
Returns	Nothing.
Description	Selects Glcd side. Refer to the Glcd datasheet for detailed explaination. Parameters : ■ `x_pos`: position on x-axis. Valid values: 0..127 The parameter `x_pos` specifies the Glcd side: values from 0 to 63 specify the left side, values from 64 to 127 specify the right side. Note: For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine.

Example	The following two lines are equivalent, and both of them select the left side of Glcd:
	`Glcd_Select_Side(0)`
	`Glcd_Select_Side(10)`

Glcd_Set_X

Prototype	`sub procedure Glcd_Set_X(dim x_pos as byte)`
Returns	Nothing.
Description	Sets x-axis position to `x_pos` dots from the left border of Glcd within the selected side. Parameters : ■ `x_pos:` position on x-axis. Valid values: 0..63 **Note:** For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`Glcd_Set_X(25)`

Glcd_Set_Page

Prototype	`sub procedure Glcd_Set_Page(dim page as byte)`
Returns	Nothing.
Description	Selects page of the Glcd. Parameters : ■ `page`: page number. Valid values: 0..7 **Note:** For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`Glcd_Set_Page(5)`

Glcd_Read_Data

Prototype	`sub function Glcd_Read_Data() as byte`
Returns	One byte from Glcd memory.
Description	Reads data from from the current location of Glcd memory and moves to the next location.
Requires	Glcd needs to be initialized, see Glcd_Init routine. Glcd side, x-axis position and page should be set first. See functions Glcd_Set_Side, Glcd_Set_X, and Glcd_Set_Page.
Example	

```
dim data as byte
...
data = Glcd_Read_Data()
```

Glcd_Write_Data

Prototype	`sub procedure Glcd_Write_Data(dim ddata as byte)`
Returns	Nothing.
Description	Writes one byte to the current location in Glcd memory and moves to the next location. Parameters : ■ `ddata:` data to be written
Requires	Glcd needs to be initialized, see Glcd_Init routine. Glcd side, x-axis position and page should be set first. See functions Glcd_Set_Side, Glcd_Set_X, and Glcd_Set_Page.

Example	`dim data as byte`
	`...`
	`Glcd_Write_Data(data)`

Glcd_Fill

Prototype	`sub procedure Glcd_Fill(dim pattern as byte)`
Returns	Nothing.
Description	Fills Glcd memory with the byte `pattern`. Parameters : ■ `pattern:` byte to fill Glcd memory with To clear the Glcd screen, use `Glcd_Fill(0)`. To fill the screen completely, use `Glcd_Fill(0xFF)`.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Clear screen` `Glcd_Fill(0)`

Glcd_Dot

Prototype	`sub procedure Glcd_Dot(dim x_pos as byte, dim y_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a dot on Glcd at coordinates (`x_pos, y_pos`). Parameters : ■ `x_pos:` x position. Valid values: 0..127 ■ `y_pos:` y position. Valid values: 0..63 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines a dot state: 0 clears dot, 1 puts a dot, and 2 inverts dot state. **Note:** For x and y axis layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Invert the dot in the upper left corner` `Glcd_Dot(0, 0, 2)`

Glcd_Line

Prototype	`sub procedure Glcd_Line(dim x_start as integer, dim y_start as integer, dim x_end as integer, dim y_end as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a line on Glcd. Parameters : ■ `x_start`: x coordinate of the line start. Valid values: 0..127 ■ `y_start`: y coordinate of the line start. Valid values: 0..63 ■ `x_end`: x coordinate of the line end. Valid values: 0..127 ■ `y_end`: y coordinate of the line end. Valid values: 0..63 ■ `color`: color parameter. Valid values: 0..2 The parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a line between dots (0,0) and (20,30)` `Glcd_Line(0, 0, 20, 30, 1)`

Glcd_V_Line

Prototype	`sub procedure Glcd_V_Line(dim y_start as byte, dim y_end as byte, dim x_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a vertical line on lcd. Parameters : - `y_start`: y coordinate of the line start. Valid values: 0..63 - `y_end`: y coordinate of the line end. Valid values: 0..63 - `x_pos`: x coordinate of vertical line. Valid values: 0..127 - `color`: color parameter. Valid values: 0..2 The parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a vertical line between dots (10,5) and (10,25)` `Glcd_V_Line(5, 25, 10, 1)`

Glcd_H_Line

Prototype	`sub procedure Glcd_V_Line(dim x_start as byte, dim x_end as byte, dim y_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a horizontal line on Glcd. Parameters : - `x_start:` x coordinate of the line start. Valid values: 0..127 - `x_end:` x coordinate of the line end. Valid values: 0..127 - `y_pos:` y coordinate of horizontal line. Valid values: 0..63 - `color:` color parameter. Valid values: 0..2 The parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a horizontal line between dots (10,20) and (50,20)` `Glcd_H_Line(10, 50, 20, 1)`

Glcd_Rectangl

Prototype	`sub procedure Glcd_Rectangle(dim x_upper_left as byte, dim y_upper_left as byte, dim x_bottom_right as byte, dim y_bottom_right as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a rectangle on Glcd. Parameters : ■ `x_upper_left`: x coordinate of the upper left rectangle corner. Valid values: 0..127 ■ `y_upper_left`: y coordinate of the upper left rectangle corner. Valid values: 0..63 ■ `x_bottom_right`: x coordinate of the lower right rectangle corner. Valid values: 0..127 ■ `y_bottom_right`: y coordinate of the lower right rectangle corner. Valid values: 0..63 ■ `color`: color parameter. Valid values: 0..2 The parameter `color` determines the color of the rectangle border: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a rectangle between dots (5,5) and (40,40)` `Glcd_Rectangle(5, 5, 40, 40, 1)`

Glcd_Box

Prototype	`sub procedure Glcd_Box(dim x_upper_left as byte, dim y_upper_left as byte, dim x_bottom_right as byte, dim y_bottom_right as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a box on Glcd. Parameters : ■ `x_upper_left`: x coordinate of the upper left box corner. Valid values: 0..127 ■ `y_upper_left`: y coordinate of the upper left box corner. Valid values: 0..63 ■ `x_bottom_right`: x coordinate of the lower right box corner. Valid values: 0..127 ■ `y_bottom_right`: y coordinate of the lower right box corner. Valid values:0..63 ■ `color`: color parameter. Valid values: 0..2 The parameter `color` determines the color of the box fill: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a box between dots (5,15) and (20,40)` `Glcd_Box(5, 15, 20, 40, 1)`

Glcd_Circle

Prototype	`sub procedure Glcd_Circle(dim x_center as integer, dim y_center as integer, dim radius as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a circle on Glcd. Parameters : ■ `x_center`: x coordinate of the circle center. Valid values: 0..127 ■ `y_center`: y coordinate of the circle center. Valid values: 0..63 ■ `radius`: radius size ■ c`olor`: color parameter. Valid values: 0..2 The parameter `color` determines the color of the circle line: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw a circle with center in (50,50) and radius=10` `Glcd_Circle(50, 50, 10, 1)`

Glcd_Set_Font

Prototype	`sub procedure Glcd_Set_Font(dim byref const ActiveFont as ^byte, dim FontWidth as byte, dim FontHeight as byte, dim FontOffs as word)`
Returns	Nothing.
Description	Sets font that will be used with Glcd_Write_Char and Glcd_Write_Text routines. Parameters : ■ `activeFont`: font to be set. Needs to be formatted as an array of char ■ `aFontWidth`: width of the font characters in dots. ■ `aFontHeight`: height of the font characters in dots. ■ `aFontOffs`: number that represents difference between the *mikroBasic PRO for PIC* character set and regular ASCII set (eg. if 'A' is 65 in ASCII character, and 'A' is 45 in the *mikroBasic PRO for PIC* character set, aFontOffs is 20). Demo fonts supplied with the library have an offset of 32, which means that they start with space. The user can use fonts given in the file "`__Lib_GLCDFonts.mpas`" file located in the Uses folder or create his own fonts.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Use the custom 5x7 font "myfont" which starts with space (32):` `Glcd_Set_Font(myfont, 5, 7, 32)`

Glcd_Write_Char

Prototype	`sub procedure Glcd_Write_Char(dim chr as byte, dim x_pos as byte, dim page_num as byte, dim color as byte)`
Returns	Nothing.
Description	Prints character on the Glcd. Parameters : ■ `chr:` character to be written ■ `x_pos:` character starting position on x-axis. Valid values: 0..(127-Font Width) ■ `page_num:` the number of the page on which character will be written. Valid values: 0..7 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the color of the character: 0 white, 1 black, and 2 inverts each dot. **Note:** For x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine. Use Glcd_Set_Font to specify the font for display; if no font is specified, then default 5x8 font supplied with the library will be used.
Example	`' Write character 'C' on the position 10 inside the page 2:` `Glcd_Write_Char('C', 10, 2, 1)`

Glcd_Write_Text

Prototype	`sub procedure Glcd_Write_Text(dim byref text as string[20], dim x_pos as byte, dim page_num as byte, dim color as byte)`
Returns	Nothing.
Description	Prints text on Glcd. Parameters : ■ `text`: text to be written ■ `x_pos`: text starting position on x-axis. ■ `page_num`: the number of the page on which text will be written. Valid values: 0..7 ■ `color`: color parameter. Valid values: 0..2 The parameter `color` determines the color of the text: 0 white, 1 black, and 2 inverts each dot. **Note:** For x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized, see Glcd_Init routine. Use Glcd_Set_Font to specify the font for display; if no font is specified, then default 5x8 font supplied with the library will be used.
Example	`' Write text "Hello world!" on the position 10 inside the page 2:` `Glcd_Write_Text("Hello world!", 10, 2, 1);`

Glcd_Image

Prototype	`sub procedure Glcd_Image(dim byref const image as ^byte)`
Returns	Nothing.
Description	Displays bitmap on Glcd. Parameters : ■ `image`: image to be displayed. Bitmap array must be located in code memory. Use the *mikroBasic PRO for PIC* integrated Glcd Bitmap Editor to convert image to a constant array suitable for displaying on Glcd.
Requires	Glcd needs to be initialized, see Glcd_Init routine.
Example	`' Draw image my_image on Glcd` `Glcd_Image(my_image)`

Library Example

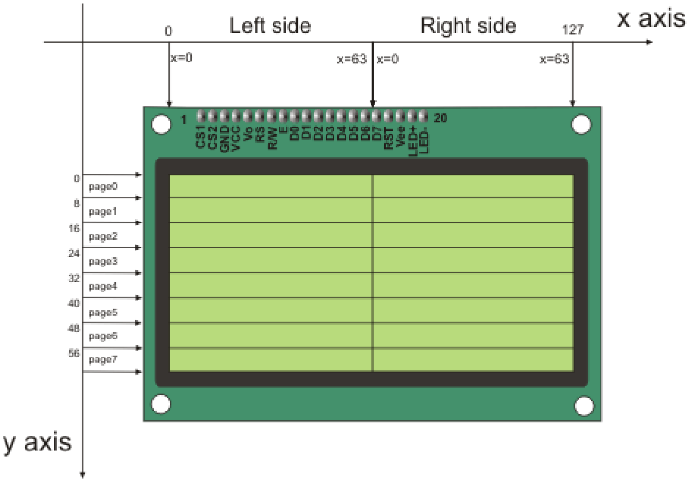
The following example demonstrates routines of the Glcd library: initialization, clear(pattern fill), image displaying, drawing lines, circles, boxes and rectangles, text displaying and handling.

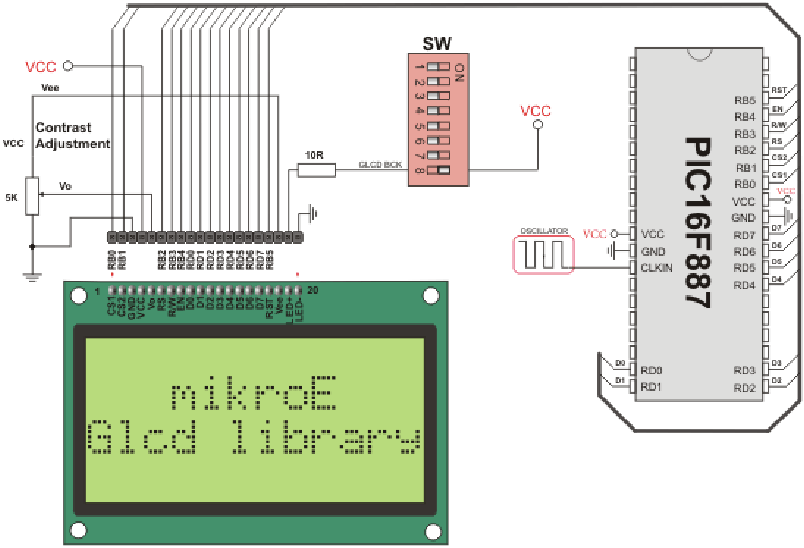
```
program Glcd_Test;

include bitmap

   ' Glcd module connections
  dim GLCD_DataPort as byte at PORTD

  dim GLCD_CS1 as sbit at RB0_bit
      GLCD_CS2 as sbit at RB1_bit
      GLCD_RS  as sbit at RB2_bit
      GLCD_RW  as sbit at RB3_bit
      GLCD_EN  as sbit at RB4_bit
      GLCD_RST as sbit at RB5_bit

dim GLCD_CS1_Direction as sbit at TRISB0_bit
    GLCD_CS2_Direction as sbit at TRISB1_bit
    GLCD_RS_Direction  as sbit at TRISB2_bit
    GLCD_RW_Direction  as sbit at TRISB3_bit
    GLCD_EN_Direction  as sbit at TRISB4_bit
    GLCD_RST_Direction as sbit at TRISB5_bit
' End Glcd module connections

dim counter as byte
    someText as char[ 18]

sub procedure Delay2S()          ' 2 seconds delay sub function
  Delay_ms(2000)
end sub

main:
  ANSEL   = 0                    ' Configure AN pins as digital I/O
  ANSELH  = 0

  Glcd_Init()                                ' Initialize Glcd
  Glcd_Fill(0x00)                            ' Clear Glcd

while TRUE
    Glcd_Image(@truck_bmp)                   ' Draw image
    Delay2S() delay2S()

     Glcd_Fill(0x00)                         ' Clear Glcd

    Glcd_Box(62,40,124,63,1)                 ' Draw box
```

```
 Glcd_Rectangle(5,5,84,35,1)             ' Draw rectangle
 Glcd_Line(0, 0, 127, 63, 1)             ' Draw line
 Delay2S()
 counter = 5

while (counter <= 59)      ' Draw horizontal and vertical lines
 Delay_ms(250)
 Glcd_V_Line(2, 54, counter, 1)
 Glcd_H_Line(2, 120, counter, 1)
 Counter = counter + 5
wend

Delay2S()

Glcd_Fill(0x00)                              ' Clear Glcd

Glcd_Set_Font(@Character8x7, 8, 7, 32)   ' Choose font
 "Character8x7"
Glcd_Write_Text("mikroE", 1, 7, 2)        ' Write string

for counter = 1 to 10                        ' Draw circles
  Glcd_Circle(63,32, 3*counter, 1)
next counter
Delay2S()

Glcd_Box(10,20, 70,63, 2)                   ' Draw box}
Delay2S()

Glcd_Fill(0xFF)                              ' Fill Glcd
Glcd_Set_Font(@Character8x7, 8, 7, 32)   ' Change font
someText = "8x7 Font"
Glcd_Write_Text(someText, 5, 0, 2)        ' Write string
delay2S()

Glcd_Set_Font(@System3x6, 3, 5, 32)       ' Change font
someText = "3X5 CAPITALS ONLY"
Glcd_Write_Text(someText, 60, 2, 2)       ' Write string
delay2S()

Glcd_Set_Font(@font5x7, 5, 7, 32)         ' Change font
someText = "5x7 Font"
Glcd_Write_Text(someText, 5, 4, 2)        ' Write string
delay2S()

Glcd_Set_Font(@FontSystem5x7_v2, 5, 7, 32)  ' Change font
someText = "5x7 Font (v2)"
Glcd_Write_Text(someText, 5, 6, 2)        ' Write string
delay2S()
```

```
    Glcd_Set_Font(@FontSystem5x7_v2, 5, 7, 32) ' Change font
    someText = "5x7 Font (v2)"
    Glcd_Write_Text(someText, 5, 6, 2)       ' Write string
    delay2S()
  wend
end.
```

HW Connection





Glcd HW connection

I²C LIBRARY

I²C full master MSSP module is available with a number of PIC MCU models. *mikroBasic PRO for PIC* provides library which supports the master I²C mode.

Note: Some MCUs have multiple I²C modules. In order to use the desired I²C library routine, simply change the number `1` in the prototype with the appropriate module number, i.e. `I2C1_Init(100000)`

Library Routines

- I2C1_Init
- I2C1_Start
- I2C1_Repeated_Start
- I2C1_Is_Idle
- I2C1_Rd
- I2C1_Wr
- I2C1_Stop

I2C1_Init

Prototype	`sub procedure I2C1_Init(const clock as longint)`
Returns	Nothing.
Description	Initializes I²C with desired clock (refer to device data sheet for correct values in respect with *Fosc*). Needs to be called before using other functions of I²C Library. You don’t need to configure ports manually for using the module; library will take care of the initialization.
Requires	Library requires MSSP module on PORTB or PORTC. **Note**: Calculation of the I²C clock value is carried out by the compiler, as it would produce a relatively large code if performed on the libary level. Therefore, compiler needs to know the value of the parameter in the compile time. That is why this parameter needs to be a constant, and not a variable.
Example	`I2C1_Init(100000)`

I2C1_Start

Prototype	`sub function I2C1_Start as byte`
Returns	I^2 there is no error, function returns 0.
Description	Determines if I^{2}C bus is free and issues START signal.
Requires	I^{2}C must be configured before using this function. See I2C1_Init.
Example	`if I2C1_Start = 0 then` `...`

I2C1_Repeated_Start

Prototype	`sub procedure I2C1_Repeated_Start`
Returns	Nothing.
Description	Issues repeated START signal.
Requires	I^{2}C must be configured before using this function. See I2C1_Init.
Example	`I2C1_Repeated_Start`

I2C1_Is_Idle

Prototype	`sub function I2C1_Is_Idle as byte`
Returns	Returns `TRUE` if I^{2}C bus is free, otherwise returns `FALSE`.
Description	Tests if I^{2}C bus is free.
Requires	I^{2}C must be configured before using this function. See I2C1_Init.
Example	`if I2C1_Is_Idle then` `...`

I2C1_Rd

Prototype	`sub function I2C1_Rd(dim ack as byte) as byte`
Returns	Returns one byte from the slave.
Description	Reads one byte from the slave, and sends *not acknowledge* signal if parameter `ack` is 0, otherwise it sends *acknowledge.*
Requires	I²C must be configured before using this function. See I2C1_Init. Also, START signal needs to be issued in order to use this function. See I2C1_Start.
Example	Read data and send *not acknowledge* signal: `tmp = I2C1_Rd(0)`

I2C1_Wr

Prototype	`sub function I2C1_Wr(dim data as byte) as byte`
Returns	Returns 0 if there were no errors.
Description	Sends data byte (parameter `data`) via I²C bus.
Requires	I²C must be configured before using this function. See I2C1_Init. Also, START signal needs to be issued in order to use this function. See I2C1_Start.
Example	`I2C1_Write($A3)`

I2C1_Stop

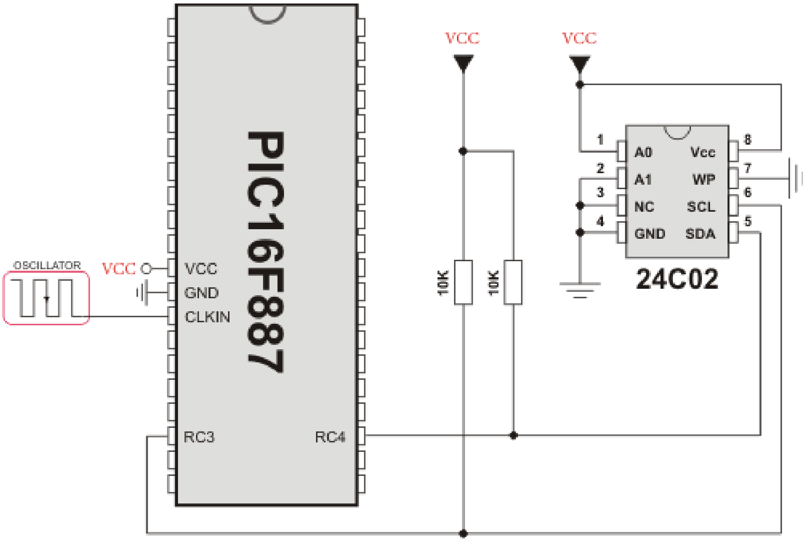
Prototype	`sub procedure I2C1_Stop`
Returns	Nothing.
Description	Issues STOP signal.
Requires	I²C must be configured before using this function. See I2C1_Init.
Example	`I2C1_Stop`

Library Example

This code demonstrates use of I2C Library procedures and functions. PIC MCU is connected (pins SCL and SDA) to 24c02 EEPROM. Program sends data to EEPROM (data is written at address 2). Then, we read data via I^{2}C from EEPROM and send its value to PORTD, to check if the cycle was successful. The figure below shows how to interface 24c02 to PIC.

```
program I2C_Simple

main:
    ANSEL  = 0              ' Configure AN pins as digital I/O
    ANSELH = 0
    PORTB = 0
    TRISB = 0               ' Configure PORTB as output

    I2C1_Init(100000)       ' initialize I2C communication
    I2C1_Start()            ' issue I2C start signal
    I2C1_Wr(0xA2)           ' send byte via I2C (device address + W)
    I2C1_Wr(2)              ' send byte (address of EEPROM location)
    I2C1_Wr(0xAA)           ' send data (data to be written)
    I2C1_Stop()             ' issue I2C stop signal

    Delay_100ms()

    I2C1_Start()            ' issue I2C start signal
    I2C1_Wr(0xA2)           ' send byte via I2C  (device address + W)
    I2C1_Wr(2)              ' send byte (data address)
    I2C1_Repeated_Start()   ' issue I2C signal repeated start
    I2C1_Wr(0xA3)           ' send byte (device address + R)
    PORTB = I2C1_Rd(0)      ' Read the data (NO acknowledge)
    I2C1_Stop()             ' issue I2C stop signal
end.
```

HW Connection



Interfacing 24c02 to PIC via I²C

KEYPAD LIBRARY

The *mikroBasic PRO for PIC* provides a library for working with 4x4 keypad. The library routines can also be used with 4x1, 4x2, or 4x3 keypad. For connections explanation see schematic at the bottom of this page.

External dependencies of Keypad Library

The following variables must be defined in all projects using Keypad Library:	Description:	Example :
`dim keypadPort as byte sfr external`	Keypad Port	`dim keypadPort as byte at PORTD`

Library Routines

- Keypad_Init
- Keypad_Key_Press
- Keypad_Key_Click

Keypad_Init

Prototype	`sub procedure Keypad_Init()`
Returns	Nothing.
Description	Initializes port for working with keypad.
Requires	Global variables : ■ `keypadPort` - Keypad port must be defined before using this function.
Example	see below

Example

```
' Keypad module connections
dim keypadPort as byte at PORTD
' End of keypad module connections
...
Keypad_Init()
```

Keypad_Key_Press

Prototype	`sub function Keypad_Key_Press() as byte`
Returns	The code of a pressed key (1..16). If no key is pressed, returns 0.
Description	Reads the key from keypad when key gets pressed.
Requires	Port needs to be initialized for working with the Keypad library, see Keypad_Init.

Example	`dim kp as byte`
	`...`
	`kp = Keypad_Key_Press()`

Keypad_Key_Click

Prototype	`sub function Keypad_Key_Click() as byte`
Returns	The code of a clicked key (1..16). If no key is clicked, returns 0.
Description	Call to `Keypad_Key_Click` is a blocking call: the function waits until some key is pressed and released. When released, the function returns 1 to 16, depending on the key. If more than one key is pressed simultaneously the function will wait until all pressed keys are released. After that the function will return the code of the first pressed key.
Requires	Port needs to be initialized for working with the Keypad library, see Keypad_Init.

Example	`dim kp as byte`
	`...`
	`kp = Keypad_Key_Click()`

Library Example

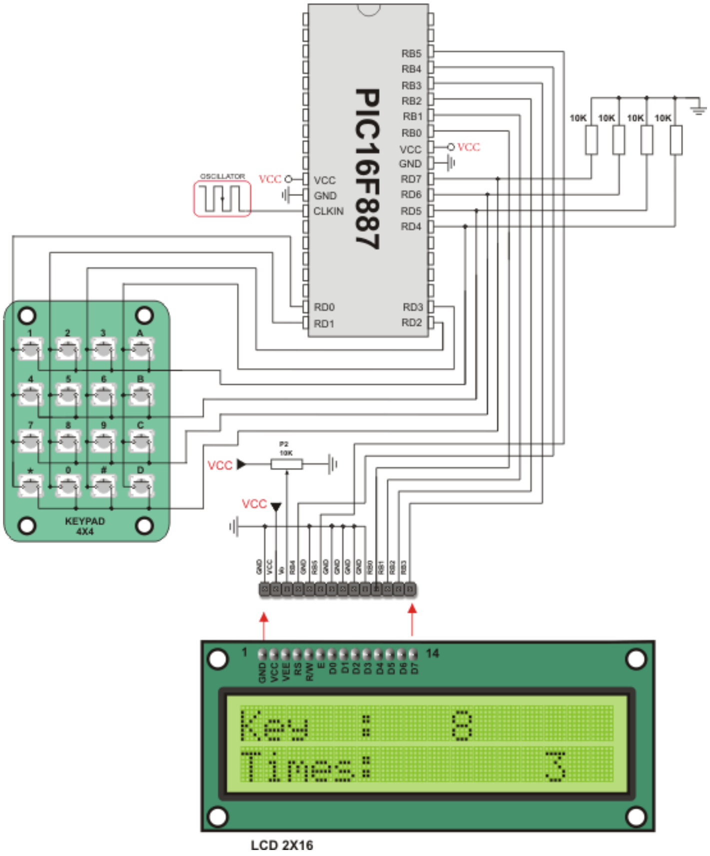
This is a simple example of using the Keypad Library. It supports keypads with 1..4 rows and 1..4 columns. The code being returned by Keypad_Key_Click() function is in range from 1..16. In this example, the code returned is transformed into ASCII codes [0..9,A..F] and displayed on Lcd. In addition, a small single-byte counter displays in the second Lcd row number of key presses.

```
program Keypad_Test
dim kp, cnt, oldstate as byte
    txt as byte[ 7]

' Keypad module connections
dim keypadPort as byte at PORTC
' End Keypad module connections

' Lcd module connections
dim LCD_RS as sbit at RB4_bit
    LCD_EN as sbit at RB5_bit
    LCD_D4 as sbit at RB0_bit
    LCD_D5 as sbit at RB1_bit
    LCD_D6 as sbit at RB2_bit
    LCD_D7 as sbit at RB3_bit

    LCD_RS_Direction as sbit at TRISB4_bit
    LCD_EN_Direction as sbit at TRISB5_bit
    LCD_D4_Direction as sbit at TRISB0_bit
    LCD_D5_Direction as sbit at TRISB1_bit
    LCD_D6_Direction as sbit at TRISB2_bit
    LCD_D7_Direction as sbit at TRISB3_bit
' End Lcd module connections
main:
  oldstate = 0
  cnt = 0                         ' Reset counter
  Keypad_Init()                   ' Initialize Keypad
  ANSEL  = 0                      ' Configure AN pins as digital I/O
  ANSELH =
  Lcd_Init()                      ' Initialize Lcd
  Lcd_Cmd(_LCD_CLEAR)             ' Clear display
  Lcd_Cmd(_LCD_CURSOR_OFF)        ' Cursor off
  Lcd_Out(1, 1, "Key  :")         ' Write message text on Lcd
  Lcd_Out(2, 1, "Times:")

while TRUE

    kp = 0                        ' Reset key code variable

    ' Wait for key to be pressed and released
    while ( kp = 0 )
```

```
        kp = Keypad_Key_Click()           ' Store key code in kp vari-
able
      wend
      ' Prepare value for output, transform key to it"s ASCII value
      select case kp
        'case 10: kp = 42    ' "*"         ' Uncomment this block for
keypad4x3
        'case 11: kp = 48    ' "0"
        'case 12: kp = 35    ' "#"
        'default: kp += 48

      case 1
        kp = 49   ' 1                      ' Uncomment this block for
keypad4x4
      case 2
        kp = 50   ' 2
      case 3
        kp = 51   ' 3
      case 4
        kp = 65   ' A
      case 5
        kp = 52   ' 4
      case 6
        kp = 53   ' 5
      case 7
        kp = 54   ' 6
      case 8
        kp = 66   ' B
      case 9
        kp = 55   ' 7
      case 10
        kp = 56   ' 8
      case 11
        kp = 57   ' 9
      case 12
        kp = 67   ' C
      case 13
        kp = 42   ' *
      case 14
        kp = 48   ' 0
      case 15
        kp = 35   ' #
      case 16
        kp = 68   ' D

    end select

      if (kp <> oldstate) then      'Pressed key differs from previous
        cnt = 1
```

```
      oldstate = kp
      else                            ' Pressed key is same as previous
      Inc(cnt)
      end if
      Lcd_Chr(1, 10, kp)              ' Print key ASCII value on Lcd

      if (cnt = 255) then             ' If counter varialble overflow
         cnt = 0
         Lcd_Out(2, 10, "      ")
      end if

      WordToStr(cnt, txt)             ' Transform counter value to string
      Lcd_Out(2, 10, txt)             ' Display counter value on Lcd
  wend
end.
```

HW Connection



4x4 Keypad connection scheme

LCD LIBRARY

The mikroBasic PRO for PIC provides a library for communication with Lcds (with HD44780 compliant controllers) through the 4-bit interface. An example of Lcd connections is given on the schematic at the bottom of this page.

For creating a set of custom Lcd characters use Lcd Custom Character Tool.

External dependencies of LCD Library

The following variables must be defined in all projects using LCD Library:	Description:	Example :
`dim LCD_RS as sbit sfr external`	Register Select line.	`dim LCD_RS as sbit at RB4_bit`
`dim LCD_EN as sbit sfr external`	Enable line.	`dim LCD_EN as sbit at RB5_bit`
`dim LCD_D7 as sbit sfr external`	Data 7 line.	`dim LCD_D7 as sbit at RB3_bit`
`dim LCD_D6 as sbit sfr external`	Data 6 line.	`dim LCD_D6 as sbit at RB2_bit`
`dim LCD_D5 as sbit sfr external`	Data 5 line.	`dim LCD_D5 as sbit at RB1_bit`
`dim LCD_D4 as sbit sfr external`	Data 4 line.	`dim LCD_D4 as sbit at RB0_bit`
`dim LCD_RS_Direction as sbit sfr external`	Register Select direction pin.	`dim LCD_RS_Direction as sbit at TRISB4_bit`
`dim LCD_EN_Direction as sbit sfr external`	Enable direction pin.	`dim LCD_EN_Direction as sbit at TRISB5_bit`
`dim LCD_D7_Direction as sbit sfr external`	Data 7 direction pin.	`dim LCD_D7_Direction as sbit at TRISB3_bit`
`dim LCD_D6_Direction as sbit sfr external`	Data 6 direction pin.	`dim LCD_D6_Direction as sbit at TRISB2_bit`
`dim LCD_D5_Direction as sbit sfr externald`	Data 5 direction pin.	`dim LCD_D5_Direction as sbit at TRISB1_bit`
`dim LCD_D4_Direction as sbit sfr external`	Data 4 direction pin.	`dim LCD_D4_Direction as sbit at TRISB0_bit`

Library Routines

- Lcd_Init
- Lcd_Out
- Lcd_Out_Cp
- Lcd_Chr
- Lcd_Chr_Cp
- Lcd_Cmd

Lcd_Init

Prototype	`sub procedure Lcd_Init()`
Returns	Nothing.
Description	Initializes Lcd module.
Requires	■ `LCD_D7:` Data bit 7 ■ `LCD_D6`: Data bit 6 ■ `LCD_D5`: Data bit 5 ■ `LCD_D4`: Data bit 4 ■ `LCD_RS:` Register Select (data/instruction) signal pin ■ `LCD_EN`: Enable signal pin ■ `LCD_D7_Direction:` Direction of the Data 7 pin ■ `LCD_D6_Direction`: Direction of the Data 6 pin ■ `LCD_D5_Direction:` Direction of the Data 5 pin ■ `LCD_D4_Direction:` Direction of the Data 4 pin ■ `LCD_RS_Direction:` Direction of the Register Select pin ■ `LCD_EN_Direction:` Direction of the Enable signal pin must be defined before using this function.
Example	

```
 'Lcd module connections
dim
   LCD_RS as sbit at RB4_bit
   LCD_EN as sbit at RB5_bit
   LCD_D7 as sbit at RB3_bit
   LCD_D6 as sbit at RB2_bit
   LCD_D5 as sbit at RB1_bit
   LCD_D4 as sbit at RB0_bit

dim
   LCD_RS as sbit at TRISB4_bit
   LCD_EN as sbit at TRISB5_bit
   LCD_D7 as sbit at TRISB3_bit
   LCD_D6 as sbit at TRISB2_bit
   LCD_D5 as sbit at TRISB1_bit
   LCD_D4 as sbit at TRISB0_bit
' End Lcd module connections
...
Lcd_Init()
```

Lcd_Out

Prototype	`sub procedure Lcd_Out(dim row as byte, dim column as byte, dim byref text as string[20])`
Returns	Nothing.
Description	Prints text on LCD starting from specified position. Both string variables and literals can be passed as a text. Parameters : ■ `row:` starting position row number ■ `column:` starting position column number ■ `text`: text to be written
Requires	The LCD module needs to be initialized. See Lcd_Init routine.
Example	`' Write text "Hello!" on Lcd starting from row 1, column 3:` `Lcd_Out(1, 3, "Hello!")`

Lcd_Out_Cp

Prototype	`sub procedure Lcd_Out_Cp(dim byref text as string[19])`
Returns	Nothing.
Description	Prints text on LCD at current cursor position. Both string variables and literals can be passed as a text. Parameters : ■ `text:` text to be written
Requires	The LCD module needs to be initialized. See Lcd_Init routine.
Example	`' Write text "Here!" at current cursor position:` `Lcd_Out_Cp("Here!")`

Lcd_Chr

Prototype	`sub procedure Lcd_Chr(dim row as byte, dim column as byte, dim out_char as byte)`
Returns	Nothing.
Description	Prints character on LCD at specified position. Both variables and literals can be passed as a character. Parameters : ■ `row:` writing position row number ■ `column:` writing position column number ■ `out_char:` character to be written
Requires	The LCD module needs to be initialized. See Lcd_Init routine.
Example	`' Write character "i" at row 2, column 3:` `Lcd_Chr(2, 3, 'i')`

Lcd_Chr_Cp

Prototype	`sub procedure Lcd_Chr_Cp(dim out_char as byte)`
Returns	Nothing.
Description	Prints character on LCD at current cursor position. Both variables and literals can be passed as a character. Parameters : ■ `out_char:` character to be written
Requires	The LCD module needs to be initialized. See Lcd_Init routine.
Example	`' Write character "e" at current cursor position:` `Lcd_Chr_Cp('e')`

Lcd_Cmd

Prototype	`sub procedure Lcd_Cmd(dim out_char as byte)`
Returns	Nothing.
Description	Sends command to LCD. Parameters : ■ `out_char:` command to be sent **Note:** Predefined constants can be passed to the function, see Available LCD Commands.
Requires	The LCD module needs to be initialized. See Lcd_Init table.
Example	`' Clear Lcd display:` `Lcd_Cmd(_LCD_CLEAR)`

Available LCD Commands

Lcd Command	Purpose
`LCD_FIRST_ROW`	Move cursor to the 1st row
`LCD_SECOND_ROW`	Move cursor to the 2nd row
`LCD_THIRD_ROW`	Move cursor to the 3rd row
`LCD_FOURTH_ROW`	Move cursor to the 4th row
`LCD_CLEAR`	Clear display
`LCD_RETURN_HOME`	Return cursor to home position, returns a shifted display to its original position. Display data RAM is unaffected.
`LCD_CURSOR_OFF`	Turn off cursor
`LCD_UNDERLINE_ON`	Underline cursor on
`LCD_BLINK_CURSOR_ON`	Blink cursor on
`LCD_MOVE_CURSOR_LEFT`	Move cursor left without changing display data RAM
`LCD_MOVE_CURSOR_RIGHT`	Move cursor right without changing display data RAM
`LCD_TURN_ON`	Turn LCD display on
`LCD_TURN_OFF`	Turn LCD display off
`LCD_SHIFT_LEFT`	Shift display left without changing display data RAM
`LCD_SHIFT_RIGHT`	Shift display right without changing display data RAM

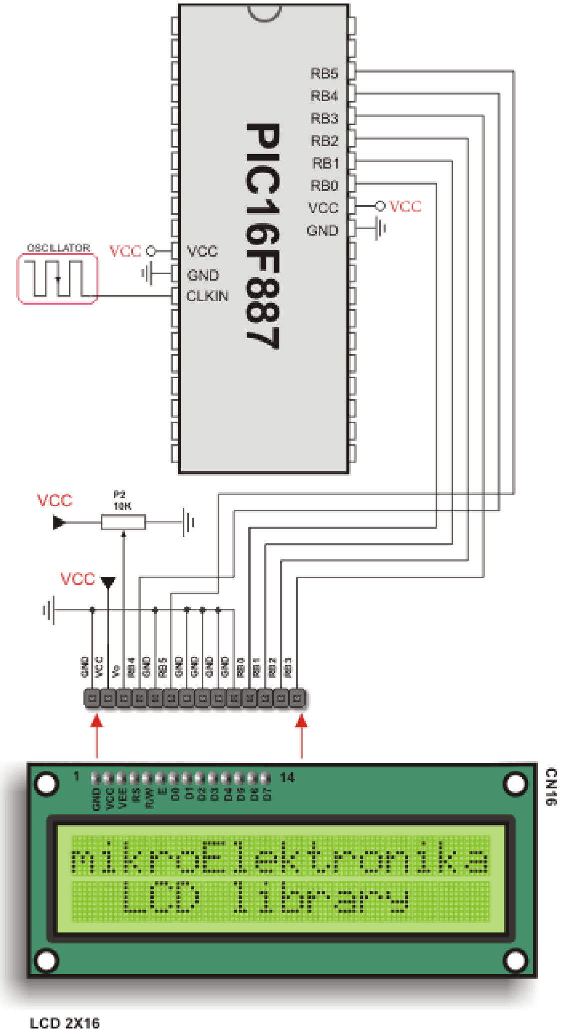
Library Example

The following code demonstrates usage of the LCD Library routines:

```
program Lcd

' Lcd module connections
dim LCD_RS as sbit at RB4_bit
    LCD_EN as sbit at RB5_bit
    LCD_D4 as sbit at RB0_bit
    LCD_D5 as sbit at RB1_bit
    LCD_D6 as sbit at RB2_bit
    LCD_D7 as sbit at RB3_bit

    LCD_RS_Direction as sbit at TRISB4_bit
    LCD_EN_Direction as sbit at TRISB5_bit
    LCD_D4_Direction as sbit at TRISB0_bit
    LCD_D5_Direction as sbit at TRISB1_bit
    LCD_D6_Direction as sbit at TRISB2_bit
    LCD_D7_Direction as sbit at TRISB3_bit
' End Lcd module connections

dim txt1 as char[ 16]
    txt2 as char[ 9]
    txt3 as char[ 8]
    txt4 as char[ 7]
    i    as byte                     ' Loop variable

sub procedure Move_Delay()      ' Function used for text moving
  Delay_ms(500)                 ' You can change the moving speed here
end sub

main:
  TRISB = 0
  PORTB = 0xFF
  TRISB = 0xFF
  ANSEL  = 0                     ' Configure AN pins as digital I/O
  ANSELH = 0

  txt1 = "mikroElektronika"
  txt2 = "EasyPIC5"
  txt3 = "Lcd4bit"
  txt4 = "example"

  Lcd_Init()                         ' Initialize Lcd
  Lcd_Cmd(_LCD_CLEAR)                ' Clear display
  Lcd_Cmd(_LCD_CURSOR_OFF)           ' Cursor off
  Lcd_Out(1,6,txt3)                  ' Write text in first row
  Lcd_Out(2,6,txt4)                  ' Write text in second row
```

```
    Delay_ms(2000)
    Lcd_Cmd(_LCD_CLEAR)                ' Clear display

    Lcd_Out(1,1,txt1)                  ' Write text in first row
    Lcd_Out(2,5,txt2)                  ' Write text in second row
    Delay_ms(500)

    ' Moving text
    for i=0 to 3                       ' Move text to the right 4 times
        Lcd_Cmd(_LCD_SHIFT_RIGHT)
        Move_Delay()
    next i

    while TRUE                          ' Endless loop
      for i=0 to 7                      ' Move text to the left 8 times
        Lcd_Cmd(_LCD_SHIFT_LEFT)
        Move_Delay()
      next i

      for i=0 to 7                     ' Move text to the right 8 times
        Lcd_Cmd(_LCD_SHIFT_RIGHT)
        Move_Delay()
      next i
    wend
end.
```

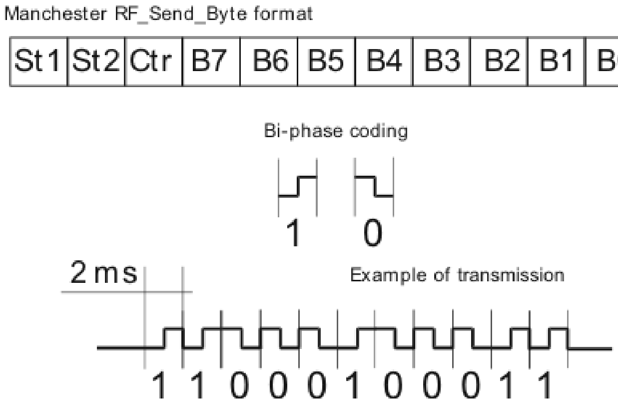
HW Connection



LCD HW connection

MANCHESTER CODE LIBRARY

The *mikroBasic PRO for PIC* provides a library for handling Manchester coded signals. The Manchester code is a code in which data and clock signals are combined to form a single self-synchronizing data stream; each encoded bit contains a transition at the midpoint of a bit period, the direction of transition determines whether the bit is 0 or 1; the second half is the true bit value and the first half is the complement of the true bit value (as shown in the figure below).



Notes: The Manchester receive routines are blocking calls (`Man_Receive_Init` and `Man_Synchro`). This means that MCU will wait until the task has been performed (e.g. byte is received, synchronization achieved, etc).
Note: Manchester code library implements time-based activities, so interrupts need to be disabled when using it.

External dependencies of Manchester Code Library

The following variables must be defined in all projects using Manchester Code Library:	Description:	Example :
`dim MANRXPIN as sbit sfr external`	Receive line.	`dim MANRXPIN as sbit at RC0_bit`
`dim MANTXPIN as sbit sfr external`	Transmit line.	`dim MANTXPIN as sbit at RC1_bit`
`dim MANRXPIN_Direction as sbit sfr external`	Direction of the Receive pin.	`dim MANRXPIN_Direction as sbit at TRISC0_bit`
`dim MANTXPIN_Direction as sbit sfr external`	Direction of the Transmit pin.	`dim MANTXPIN_Direction as sbit at TRISC1_bit`

Library Routines

- Man_Receive_Init
- Man_Receive
- Man_Send_Init
- Man_Send
- Man_Synchro
- Man_Out

The following routines are for the internal use by compiler only:

- Manchester_0
- Manchester_1
- Manchester_Out

Man_Receive_Init

Prototype	`sub function Man_Receive_Init()as word`
Returns	- `0` - if initialization and synchronization were successful. - `1` - upon unsuccessful synchronization. - `255` - upon user abort.
Description	The function configures Receiver pin and performs synchronization procedure in order to retrieve baud rate out of the incoming signal. **Note:** In case of multiple persistent errors on reception, the user should call this routine once again or Man_Synchro routine to enable synchronization.
Requires	Global variables : - `MANRXPIN :` Receive line - `MANRXPIN_Direction :` Direction of the receive pin must be defined before using this function.
Example	see below

```
' Initialize Receiver
dim MANRXPIN as sbit at RC0_bit
dim MANRXPIN_Direction as sbit at TRISC0_bit
...
Man_Receive_Init()
```

Man_Receive

Prototype	`sub function Man_Receive(dim byreferror as byte) as byte`
Returns	A byte read from the incoming signal.
Description	The function extracts one byte from incoming signal. Parameters : ■ `error`: error flag. If signal format does not match the expected, the `error` flag will be set to non-zero.
Requires	To use this function, the user must prepare the MCU for receiving. See Man_Receive_Init.
Example	

```
dim data, error as byte
...
data = 0
error = 0
data = Man_Receive(&error)

if (error <> 0) then
' error handling
end if
```

Man_Send_Init

Prototype	`sub procedure Man_Send_Init()`
Returns	Nothing.
Description	The function configures Transmitter pin.
Requires	Global variables : ■ `MANRXPIN :` Receive line ■ `MANRXPIN_Direction :` Direction of the receive pin must be defined before using this function
Example	

```
' Initialize Transmitter:
dim MANTXPIN as sbit at PORTC1_bit
dim MANTXPIN_Direction as sbit at TRISC1_bit
...
Man_Send_Init()
```

Man_Send

Prototype	`sub procedure Man_Send(tr_data as byte)`
Returns	Nothing.
Description	Sends one byte. Parameters : ■ `tr_data:` data to be sent **Note:** Baud rate used is 500 bps.
Requires	To use this function, the user must prepare the MCU for sending. See Man_Send_Init.

Example	`dim msg as byte`
	`...`
	`Man_Send(msg)`

Man_Synchro

Prototype	`sub function Man_Synchro() as word`
Returns	■ `0` - if synchronization was not successful. ■ Half of the manchester bit length, given in multiples of 10us - upon successful synchronization.
Description	Measures half of the manchester bit length with 10us resolution.
Requires	To use this function, you must first prepare the MCU for receiving. See Man_Receive_Init.

Example	`dim man__half_bit_len as word`
	`...`
	`man__half_bit_len = Man_Synchro()`

Man_Break

Prototype	`sub procedure Man_Break()`
Returns	Nothing.
Description	Man_Receive is blocking routine and it can block the program flow. Call this routine from interrupt to unblock the program execution. This mechanism is similar to WDT. **Note:** Interrupts should be disabled before using Manchester routines again (see note at the top of this page).
Requires	Nothing.

Example

```
dim data1, error_, counter as byte

sub procedure interrupt()
  if (INTCON.T0IF <> 0) then
    if (counter >= 20) then
      Man_Break()
      counter = 0              ' reset counter
    end if
    else
      Inc(counter)             ' increment counter
    INTCON.T0IF = 0            ' Clear Timer0 overflow interrupt flag
  end if
end sub

main:
  counter = 0
  OPTION_REG = 0x04            ' TMR0 prescaler set to 1:32

  ...

  Man_Receive_Init()

  ...

  ' try Man_Receive with blocking prevention mechanism
  INTCON.GIE = 1               ' Global interrupt enable
  INTCON.T0IE = 1              ' Enable Timer0 overflow interrupt
  data1 = Man_Receive(error_)
  INTCON.GIE = 0               ' Global interrupt disable
end.
```

Library Example

The following code is code for the Manchester receiver, it shows how to use the Manchester Library for receiving data:

```
program Manchester_Receiver

' LCD module connections
dim LCD_RS as sbit at RB4_bit
    LCD_EN as sbit at RB5_bit
    LCD_D4 as sbit at RB0_bit
    LCD_D5 as sbit at RB1_bit
    LCD_D6 as sbit at RB2_bit
    LCD_D7 as sbit at RB3_bit

    LCD_RS_Direction as sbit at TRISB4_bit
    LCD_EN_Direction as sbit at TRISB5_bit
    LCD_D4_Direction as sbit at TRISB0_bit
    LCD_D5_Direction as sbit at TRISB1_bit
    LCD_D6_Direction as sbit at TRISB2_bit
    LCD_D7_Direction as sbit at TRISB3_bit
' End LCD module connections

' Manchester module connections
dim MANRXPIN as sbit at RC0_bit
    MANRXPIN_Direction as sbit at TRISC0_bit
    MANTXPIN as sbit at RC1_bit
    MANTXPIN_Direction as sbit at TRISC1_bit
' End Manchester module connections

dim error_flag, ErrorCount, temp as byte

main:
    ErrorCount = 0
    ANSEL  = 0                    ' Configure AN pins as digital I/O
    ANSELH = 0
    C1ON_bit = 0                   ' Disable comparators
    C2ON_bit = 0
    TRISC5_bit = 0
    Lcd_Init()                      ' Initialize LCD
    Lcd_Cmd(_LCD_CLEAR)             ' Clear LCD display

    Man_Receive_Init()              ' Initialize Receiver

  while TRUE                         ' Endless loop
      Lcd_Cmd(_LCD_FIRST_ROW)        ' Move cursor to the 1st row
      while TRUE                     ' Wait for the "start" byte
         temp = Man_Receive(error_flag) ' Attempt byte receive
```

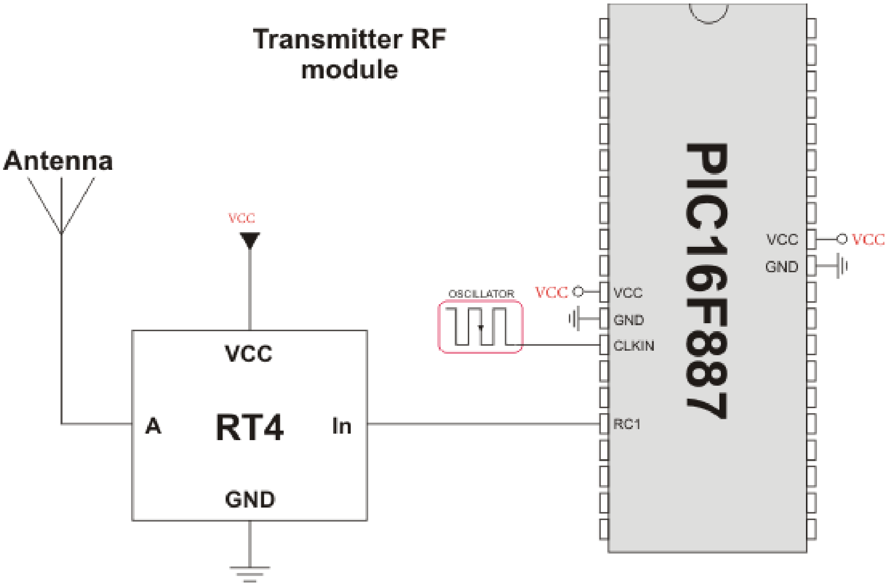
```
 if (temp = 0x0B) then     ' "Start" byte, see Transmitter example
               break       ' We got the starting sequence
            end if
            if (error_flag <> 0) then ' Exit so we do not loop for-
ever
               break
            end if
           wend

         do
            temp = Man_Receive(error_flag)    ' Attempt byte receive
             if (error_flag <> 0) then        ' If error occured
                Lcd_Chr_CP("?")         ' Write question mark on LCD
                 Inc(ErrorCount)        ' Update error counter
                 if (ErrorCount > 20) then     ' In case of multiple
errors
                temp = Man_Synchro()      ' Try to synchronize again
                'Man_Receive_Init() ' Alternative, try to Initialize
Receiver again
                 ErrorCount = 0              ' Reset error counter
              end if
           else                             ' No error occured
               if (temp <> 0x0E) then           ' If "End" byte was
received(see Transmitter example)
                Lcd_Chr_CP(temp)            '  do not write received
byte on LCD
             end if
           Delay_ms(25)
         end if
     loop until ( temp = 0x0E )
   wend                    ' If "End" byte was received exit do loop
end.
```

The following code is code for the Manchester transmitter, it shows how to use the Manchester Library for transmitting data:

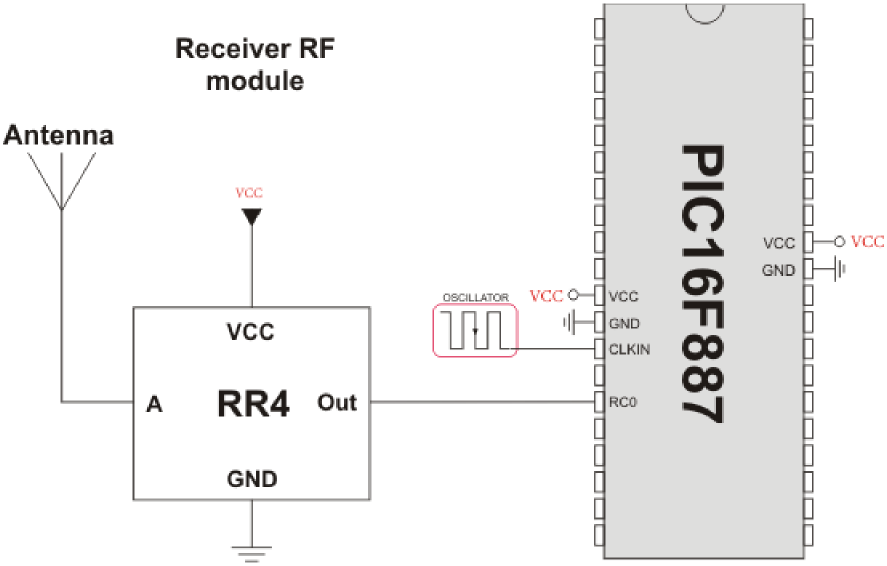
```
program Manchester_Transmitter

' Manchester module connections
dim MANRXPIN as sbit at RC0_bit
    MANRXPIN_Direction as sbit at TRISC0_bit
    MANTXPIN as sbit at RC1_bit
    MANTXPIN_Direction as sbit at TRISC1_bit
' End Manchester module connections

dim index, character as byte
    s1 as char[17]
main:
    s1 = "mikroElektronika"
```

```
    ANSEL  = 0                    ' Configure AN pins as digital I/O
    ANSELH = 0
    C1ON_bit = 0                      ' Disable comparators
    C2ON_bit = 0

    Man_Send_Init()                   ' Initialize transmitter

  while TRUE                          ' Endless loop
      Man_Send(0x0B)                  ' Send "start" byte
      Delay_ms(100)                   ' Wait for a while

      character = s1[0]               ' Take first char from string
      index = 0                       ' Initialize index variable
      while (character <> 0)          ' String ends with zero
          Man_Send(character)         ' Send character
          Delay_ms(90)                ' Wait for a while
          Inc(index)                  ' Increment index variable
          character = s1[index]       ' Take next char from string
      wend
      Man_Send(0x0E)                  ' Send "end" byte
      Delay_ms(1000)
    wend
end.
```

Connection Example



Simple Transmitter connection



Simple Receiver connection

MULTI MEDIA CARD LIBRARY

The Multi Media Card (MMC) is a flash memory card standard. MMC cards are currently available in sizes up to and including 1 GB, and are used in cell phones, mp3 players, digital cameras, and PDA's.
mikroBasic PRO for PIC provides a library for accessing data on Multi Media Card via SPI communication.This library also supports SD(Secure Digital) memory cards.

Secure Digital Card

Secure Digital (SD) is a flash memory card standard, based on the older Multi Media Card (MMC) format.
SD cards are currently available in sizes of up to and including 2 GB, and are used in cell phones, mp3 players, digital cameras, and PDAs.

Notes:

- Library works with PIC18 family only;
- The library uses the SPI module for communication. User must initialize SPI module before using the SPI Graphic Lcd Library.
  For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.
- Routines for file handling can be used only with FAT16 file system.
- Library functions create and read files from the root directory only;
- Library functions populate both FAT1 and FAT2 tables when writing to files, but the file data is being read from the FAT1 table only; i.e. there is no recovery if FAT1 table is corrupted.

Note: The SPI module has to be initialized through `SPI1_Init_Advanced` routine with the following parameters:

- SPI Master
- 8bit mode
- primary prescaler 16
- Slave Select disabled
- data sampled in the middle of data output time
- clock idle low
- Serial output data changes on transition from idle clock state to active clock state

```
SPI1_Init_Advanced(_SPI_MASTER_OSC_DIV16,  _SPI_DATA_SAMPLE_MIDDLE,
_SPI_CLK_IDLE_LOW, _SPI_LOW_2_HIGH)
```

must be called before initializing Mmc_Init.
Note: Once the MMC/SD card is initialized, the user can reinitialize SPI at higher speed. See the Mmc_Init and Mmc_Fat_Init routines.

External dependencies of MMC Library

The following variables must be defined in all projects using MMC Library:	Description:	Example :
`dim Mmc_Chip_Select as sbit sfr external`	Chip select pin.	`dim Mmc_Chip_Select as sbit at RC2_bit`
`dim Mmc_Chip_Select_Direction as sbit sfr external`	Direction of the chip select pin.	`dim Mmc_Chip_Select_Direction as sbit at TRISC2_bit`

Library Routines

- Mmc_Init
- Mmc_Read_Sector
- Mmc_Write_Sector
- Mmc_Read_Cid
- Mmc_Read_Csd

Routines for file handling:

- Mmc_Fat_Init
- Mmc_Fat_QuickFormat
- Mmc_Fat_Assign
- Mmc_Fat_Reset
- Mmc_Fat_Read
- Mmc_Fat_Rewrite
- Mmc_Fat_Append
- Mmc_Fat_Delete
- Mmc_Fat_Write
- Mmc_Fat_Set_File_Date
- Mmc_Fat_Get_File_Date
- Mmc_Fat_Get_File_Size
- Mmc_Fat_Get_Swap_File

Mmc_Init

Prototype	`sub function Mmc_Init() as byte`
Returns	- 0 - if MMC/SD card was detected and successfully initialized - 1 - otherwise
Description	Initializes MMC through hardware SPI interface. Mmc_Init needs to be called before using other functions of this library.
Requires	Global variables : - `Mmc_Chip_Select`: Chip Select line - `Mmc_Chip_Select_Direction`: Direction of the Chip Select pin must be defined before using this function. The appropriate hardware SPI module must be previously initialized. See the SPI1_Init, SPI1_Init_Advanced routines.
Example	

```
' MMC module connections
dim Mmc_Chip_Select as sbit sfr at RC2_bit
dim Mmc_Chip_Select_Direction as sbit sfr at TRISC2_bit
' MMC module connections

dim error as byte
...
SPI1_Init()

error = Mmc_Init()            ' Init with CS line at RB2
```

Mmc_Read_Sector

Prototype	`sub function Mmc_Read_Sector(dim sector as longint, dim byref data as byte[ 512] ) as byte`
Returns	■ 0 - i if reading was successful ■ 1 - otherwise
Description	The function reads one sector (512 bytes) from MMC card. Parameters: ■ `sector:` MMC/SD card sector to be read. ■ `dbuff:` buffer of minimum 512 bytes in length for data storage.
Requires	MMC/SD card must be initialized. See Mmc_Init.

Example

```
' read sector 510 of the MMC/SD card
dim error as word
    sectorNo as longword
    dataBuffer as char[ 512]
...

main:
  ...
  sectorNo = 510
  error = Mmc_Read_Sector(sectorNo, dataBuffer)
  ...
end.
```

Mmc_Write_Sector

Prototype	`sub function Mmc_Write_Sector(dim sector as longint, dim byref data_ as byte[ 512] ) as byte`
Returns	■ `0` - if writing was successful ■ `1` -if there was an error in sending write command ■ `2` - if there was an error in writing (data rejected)
Description	The function writes 512 bytes of data to one MMC card sector. Parameters: ■ `sector`: MMC/SD card sector to be written to. ■ `dbuff:` data to be written (buffer of minimum 512 bytes in length).
Requires	MMC/SD card must be initialized. See Mmc_Init

Example

```
' write to sector 510 of the MMC/SD card
dim error as word
    sectorNo as longword
    dataBuffer as char[ 512]
...

main:
  ...
  sectorNo = 510
  error = Mmc_Write_Sector(sectorNo, dataBuffer)
  ...
end.
```

Mmc_Read_Cid

Prototype	`sub function Mmc_Read_Cid(dim byref data_cid as byte[16]) as byte`
Returns	■ `0` - if CID register was read successfully ■ `1` -if there was an error while reading
Description	The function reads 16-byte CID register. Parameters: ■ `data_cid:` buffer of minimum 16 bytes in length for storing CID register content.
Requires	MMC/SD card must be initialized. See Mmc_Init

Example

```
dim error as word
    dataBuffer as byte[16]
...
main:
  ...
  error = Mmc_Read_Cid(dataBuffer)
  ...
end.
```

Mmc_Read_Csd

Prototype	`sub function Mmc_Read_Csd(dim byref data_for_registers as byte[16]) as byte`
Returns	■ `0` - if CSD register was read successfully ■ `1`- if there was an error while reading
Description	The function reads 16-byte CSD register. Parameters: ■ `data_csd:`buffer of minimum 16 bytes in length for storing CSD register content.
Requires	MMC/SD card must be initialized. See Mmc_Init

Example

```
dim error as word
    dataBuffer  as char[16]
...
main:
  ...
  error = Mmc_Read_Csd(dataBuffer)
  ...
end.
```

Mmc_Fat_Init

Prototype	`sub function Mmc_Fat_Init() as byte`
Returns	■ `0` - if MMC/SD card was detected and successfully initialized ■ `1` - if FAT16 boot sector was not found ■ `255` - if MMC/SD card was not detected
Description	Initializes MMC/SD card, reads MMC/SD FAT16 boot sector and extracts necessary data needed by the library. **Note**: MMC/SD card has to be formatted to FAT16 file system.
Requires	Global variables : ■ `Mmc_Chip_Select:` Chip Select line ■ `Mmc_Chip_Select_Direction:` Direction of the Chip Select pin must be defined before using this function. The appropriate hardware SPI module must be previously initialized. See the SPI1_Init, SPI1_Init_Advanced routines.

Example

```
' MMC module connections
dim Mmc_Chip_Select as sbit sfr at RC2_bit
dim Mmc_Chip_Select_Direction as sbit sfr at TRISC2_bit
' MMC module connections

' Initialize SPI1 module and set pointer(s) to SPI1 functions
SPI1_Init_Advanced(MASTER_OSC_DIV64, DATA_SAMPLE_MIDDLE,
CLK_IDLE_LOW, LOW_2_HIGH)

'use fat16 quick format instead of init routine if a formatting
is needed
if (Mmc_Fat_Init() = 0) then
...
end if

' reinitialize SPI1 at higher speed
SPI1_Init_Advanced(MASTER_OSC_DIV4, DATA_SAMPLE_MIDDLE,
CLK_IDLE_LOW, LOW_2_HIGH)
```

Mmc_Fat_QuickFormat

Prototype	`sub function Mmc_Fat_QuickFormat(dim mmc_fat_label as string[11]) as byte`
Returns	- `0` - if MMC/SD card was detected, successfully formated and initialized - `1` - if FAT16 format was unseccessful - `255` - if MMC/SD card was not detected
Description	Formats to FAT16 and initializes MMC/SD card. Parameters: - `mmc_fat_label:` volume label (11 characters in length). If less than 11 characters are provided, the label will be padded with spaces. If null string is passed volume will not be labeled **Note:** This routine can be used instead or in conjunction with Mmc_Fat_Init routine. **Note:** If MMC/SD card already contains a valid boot sector, it will remain unchanged (except volume label field) and only FAT and ROOT tables will be erased. Also, the new volume label will be set.
Requires	The appropriate hardware SPI module must be previously initialized.
Example	

Example

```
Initialize SPI1 module and set pointer(s) to SPI1 functions
SPI1_Init_Advanced(MASTER_OSC_DIV64, DATA_SAMPLE_MIDDLE,
CLK_IDLE_LOW, LOW_2_HIGH)

' Format and initialize MMC/SD card and MMC_FAT16 library globals
if (Mmc_Fat_QuickFormat('mikroE') = 0) then
  ...
end if

' Reinitialize the SPI module at higher speed (change primary
prescaler).
SPI1_Init_Advanced(MASTER_OSC_DIV4, DATA_SAMPLE_MIDDLE,
CLK_IDLE_LOW, LOW_2_HIGH)
```

Mmc_Fat_Assign

<table>
<tr><td>Prototype</td><td><code>sub function Mmc_Fat_Assign(dim byref filename as char[12] , dim file_cre_attr as byte) as byt</code></td></tr>
<tr><td>Returns</td><td>■ 1 - if file already exists or file does not exist but a new file is created.
■ 0 - if file does not exist and no new file is created.</td></tr>
<tr><td>Description</td><td>Assigns file for file operations (read, write, delete...). All subsequent file operations will be applied on an assigned file.
Parameters:
■ <code>filename:</code> name of the file that should be assigned for file operations. File name should be in DOS 8.3 (file_name.extension) format. The file name and extension will be automatically padded with spaces by the library if they have less than length required (i.e. "mikro.tx" -> "mikro .tx "), so the user does no have to take care of that. The file name and extension are case insensitive. The library will convert them to proper case automatically, so the user does not have to take care of that. Also, in order to keep backward compatibility with the first version of this library, file names can be entered as UPPERCASE string of 11 bytes in length with no dot character between file name and extension (i.e. "MIKROELETXT" -> MIKROELE.TXT). In this case last 3 charac ters of the string are considered to be file extension.
■ <code>file_cre_attr:</code> file creation and attributs flags. Each bit corresponds to the appropriate file attribut:
<table>
<tr><th>Bit</th><th>Mask</th><th>Description</th></tr>
<tr><td>0</td><td>0x01</td><td>Read Only</td></tr>
<tr><td>1</td><td>0x02</td><td>Hidden</td></tr>
<tr><td>2</td><td>0x04</td><td>System</td></tr>
<tr><td>3</td><td>0x08</td><td>Volume Label</td></tr>
<tr><td>4</td><td>0x10</td><td>Subdirectory</td></tr>
<tr><td>5</td><td>0x20</td><td>Archive</td></tr>
<tr><td>6</td><td>0x40</td><td>Device (internal use only, never found on disk)</td></tr>
<tr><td>7</td><td>0x80</td><td>File creation flag. If file does not exist and this flag is set, a new file with specified name will be created.</td></tr>
</table>
Note: Long File Names (LFN) are not supported.</td></tr>
<tr><td>Requires</td><td>MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init</td></tr>
<tr><td>Example</td><td><code>' create file with archive attribut if it does not already exist</code>
<code>Mmc_Fat_Assign("MIKRO007.TXT",0xA0)</code></td></tr>
</table>

Mmc_Fat_Reset

Prototype	`sub procedure Mmc_Fat_Reset(dim byref size as longword)`
Returns	Nothing.
Description	Opens currently assigned file for reading. Parameters: ■ `size:` buffer to store file size to. After file has been open for reading its size is returned through this parameter.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign.

Example

```
dim size as longword
...
main:
  ...
  Mmc_Fat_Reset(size)
  ...
end.
```

Mmc_Fat_Read

Prototype	`sub procedure Mmc_Fat_Read(dim byref bdata as byte)`
Returns	Nothing.
Description	Reads a byte from the currently assigned file opened for reading. Upon function execution file pointers will be set to the next character in the file. Parameters: ■ `bdata`: buffer to store read byte to. Upon this function execution read byte is returned through this parameter.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign. The file must be opened for reading. See Mmc_Fat_Reset.

Example

```
dim character as byte
...
main:
  ...
  Mmc_Fat_Read(character)
  ...
end.
```

Mmc_Fat_Rewrite

Prototype	`sub procedure Mmc_Fat_Rewrite()`
Returns	Nothing.
Description	Opens the currently assigned file for writing. If the file is not empty its content will be erased.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign.
Example	`' open file for writing` `Mmc_Fat_Rewrite()`

Mmc_Fat_Append

Prototype	`sub procedure Mmc_Fat_Append()`
Returns	Nothing.
Description	Opens the currently assigned file for appending. Upon this function execution file pointers will be positioned after the last byte in the file, so any subsequent file write operation will start from there.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign.
Example	`' open file for appending` `Mmc_Fat_Append()`

Mmc_Fat_Delete

Prototype	`sub procedure Mmc_Fat_Delete()`
Returns	Nothing.
Description	Deletes currently assigned file from MMC/SD card.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign
Example	

```
' delete current file
Mmc_Fat_Delete()
```

Mmc_Fat_Write

Prototype	`sub procedure Mmc_Fat_Write(dim byref fdata as byte[ 512] , dim data_len as word)`
Returns	Nothing.
Description	Writes requested number of bytes to the currently assigned file opened for writing. Parameters: ■ `fdata:` data to be written. ■ `data_len:` number of bytes to be written.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign. The file must be opened for writing. See Mmc_Fat_Rewrite or Mmc_Fat_Append.
Example	

```
'dim file_contents as char[ 42]
...
main:
  ...
 Mmc_Fat_Write(file_contents, 42) 'write data to the assigned
file
   ...
end.
```

Mmc_Fat_Set_File_Date

Prototype	`sub procedure Mmc_Fat_Set_File_Date(dim year as word, dim month, day, hours, mins, seconds as byte)`
Returns	Nothing.
Description	Sets the date/time stamp. Any subsequent file write operation will write this stamp to the currently assigned file's time/date attributs. Parameters: ■ `year`: year attribute. Valid values: 1980-2107 ■ `month:` month attribute. Valid values: 1-12 ■ `day:` day attribute. Valid values: 1-31 ■ `hours:` hours attribute. Valid values: 0-23 ■ `mins`: minutes attribute. Valid values: 0-59 ■ `seconds:` seconds attribute. Valid values: 0-59
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign. The file must be opened for writing. See Mmc_Fat_Rewrite or Mmc_Fat_Append.
Example	`Mmc_Fat_Set_File_Date(2005,9,30,17,41,0)`

Mmc_Fat_Get_File_Date

Prototype	`sub procedure Mmc_Fat_Get_File_Date(dim byref year as word, dim byref month, day, hours, mins as byte)`
Returns	Nothing.
Description	Reads time/date attributes of the currently assigned file. Parameters: ■ `year`: buffer to store year attribute to. Upon function execution year attribute is returned through this parameter. ■ `month`: buffer to store month attribute to. Upon function execution month attribute is returned through this parameter. ■ `day:` buffer to store day attribute to. Upon function execution day attribute is returned through this parameter. ■ `hours:` buffer to store hours attribute to. Upon function execution hours attribute is returned through this parameter. ■ `mins:` buffer to store minutes attribute to. Upon function execution minutes attribute is returned through this parameter.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign.

Example

```
dim year as word
    month, day, hours, mins as byte
...
main:
  ...
  Mmc_Fat_Get_File_Date(year, month, day, hours, mins)
  ...
end.
```

Mmc_Fat_Get_File_Size

Prototype	`sub function Mmc_Fat_Get_File_Size() as longword`
Returns	Size of the currently assigned file in bytes.
Description	This function reads size of the currently assigned file in bytes.
Requires	MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init. The file must be previously assigned. See Mmc_Fat_Assign.
Example	

```
dim my_file_size as longword
...
main:
  ...
  my_file_size = Mmc_Fat_Get_File_Size
  ...
end.
```

Mmc_Fat_Get_Swap_File

Prototype	`sub function Mmc_Fat_Get_Swap_File(dim sectors_cnt as longint, dim byref filename as string[11], dim file_attr as byte) as dword`
Returns	■ Number of the start sector for the newly created swap file, if there was enough free space on the MMC/SD card to create file of required size. ■ 0 - otherwise.
Description	This function is used to create a swap file of predefined name and size on the MMC/SD media. If a file with specified name already exists on the media, search for consecutive sectors will ignore sectors occupied by this file. Therefore, it is recommended to erase such file if it already exists before calling this function. If it is not erased and there is still enough space for a new swap file, this function will delete it after allocating new memory space for a new swap file. The purpose of the swap file is to make reading and writing to MMC/SD media as fast as possible, by using the Mmc_Read_Sector() and Mmc_Write_Sector() functions directly, without potentially damaging the FAT system. The swap file can be considered as a "window" on the media where the user can freely write/read data. It's main purpose in the mikroBasic PRO for PIC's library is to be used for fast data acquisition; when the time-critical acquisition has finished, the data can be re-written into a "normal" file, and formatted in the most suitable way. Parameters: ■ `sectors_cnt:` number of consecutive sectors that user wants the swap file to have.

Description

- `filename:` name of the file that should be assigned for file operations. File name should be in DOS 8.3 (file_name.extension) format. The file name and extension will be automatically padded with spaces by the library if they have less than length required (i.e. "mikro.tx" -> "mikro .tx "), so the user does no have to take care of that. The file name and extension are case insensitive. The library will convert them to proper case automatically, so the user does not have to take care of that.
Also, in order to keep backward compatibility with the first version of this library, file names can be entered as UPPERCASE string of 11 bytes in length with no dot character between file name and extension (i.e. "MIKROELETXT" -> MIKROELE.TXT). In this case last 3 characters of the string are considered to be file extension.

- `file_attr:` file creation and attributs flags. Each bit corresponds to the appropriate file attribut:

Bit	**Mask**	**Description**
0	0x01	Read Only
1	0x02	Hidden
2	0x04	System
3	0x08	Volume Label
4	0x10	Subdirectory
5	0x20	Archive
6	0x40	Device (internal use only, never found on disk)
7	0x80	Not used

Note: Long File Names (LFN) are not supported.

Requires

MMC/SD card and MMC library must be initialized for file operations. See Mmc_Fat_Init

Example

```
'-------------- Try to create a swap file with archive atribute,
whose size will be at least 1000 sectors.
'                 If it succeeds, it sends No. of start sector
over UART
dim size as longword
...
main:
  ...
  size = Mmc_Fat_Get_Swap_File(1000, "mikroE.txt", 0x20)
  if size then
    UART1_Write(0xAA)
    UART1_Write(Lo(size))
    UART1_Write(Hi(size))
    UART1_Write(Higher(size))
    UART1_Write(Highest(size))
    UART1_Write(0xAA
    end if
  ...
end.
```

Library Example

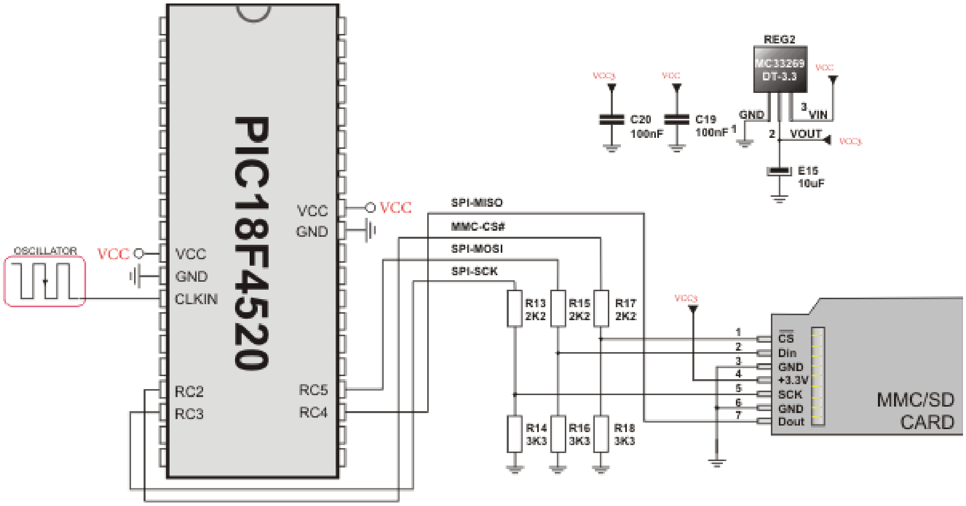
The following example demonstrates MMC library test. Upon flashing, insert a MMC/SD card into the module, when you should receive the "Init-OK" message. Then, you can experiment with MMC read and write functions, and observe the results through the Usart Terminal.

```
program MMC_Test

dim MMC_chip_select as sbit at RC2_bit
dim MMC_chip_select_direction as sbit at TRISC2_bit

const FILL_CHAR = "m"
dim   i, SectorNo as word
dim   mmc_error as byte
dim   data_ok as bit

' Variables for MMC routines
  SectorData as byte[ 512]  ' Buffer for MMC sector reading/writing
  data_for_registers as byte[ 16]  ' buffer for CID and CSD registers

' UART write text and new line (carriage return + line feed)
sub procedure UART_Write_Line(dim byref uart_text as byte)
  UART1_Write_Text(uart_text)
  UART1_Write(13)
  UART1_Write(10)

end sub

' Display byte in hex
sub procedure printhex(dim i as byte)
dim high, low as byte

  high = i and 0xF0                    ' High nibble
  high = high >> 4
  high = high + "0"
  if ( high > "9" ) then
    high = high + 7
    low = (i and 0x0F) + "0"           ' Low nibble
    if ( low > "9" ) then
      low = low + 7
    end if

    UART1_Write(high)
    UART1_Write(low)
  end if
end sub
```

```
main:
  ADCON1 = ADCON1 or 0x0F            ' Configure AN pins as digital
  CMCON  = CMCON or 7               ' Turn off comparators

  ' Initialize UART1 module
  UART1_Init(19200)
  Delay_ms(10)

  UART_Write_Line("PIC-Started")  ' PIC present report

  ' Initialize SPI1 module
  SPI1_Init_Advanced(_SPI_MASTER_OSC_DIV64, _SPI_DATA_SAMPLE_MIDDLE,
   _SPI_CLK_IDLE_LOW, _SPI_LOW_2_HIGH)

  ' initialise a MMC card
    mmc_error = Mmc_Init()
    if ( mmc_error = 0 ) then
      UART_Write_Line("MMC Init-OK")      ' If MMC present report
    else
        UART_Write_Line("MMC Init-error")   ' If error report
    end if
    ' Fill MMC buffer with same characters
    for i = 0 to 511
      SectorData[ i]  = FILL_CHAR
    next i
   Write sector
    mmc_error = Mmc_Write_Sector(SectorNo, SectorData)
      if ( mmc_error = 0 ) then
      UART_Write_Line("Write-OK")
      else   ' if there are errors.....
        UART_Write_Line("Write-Error")
    end if

    ' Reading of CID register
    mmc_error = Mmc_Read_Cid(data_for_registers)
    if ( mmc_error = 0 ) then
      UART1_Write_Text("CID : ")
      for i = 0 to 15
        printhex(data_for_registers[ i] )
      next i
        UART_Write_Line("  ")
      else
        UART_Write_Line("CID-error")
    end if
```

```
    ' Reading of CSD register
    mmc_error = Mmc_Read_Csd(data_for_registers)
    if ( mmc_error = 0 ) then
      UART1_Write_Text("CSD : ")
      for i = 0 to 15
        printhex(data_for_registers[ i] )
      next i
        UART_Write_Line("   ")
      else
      UART_Write_Line("CSD-error")
    end if

    ' Read sector
    mmc_error = Mmc_Read_Sector(SectorNo, SectorData)
    if ( mmc_error = 0 ) then
      UART_Write_Line("Read-OK")
      else   ' if there are errors.....
        UART_Write_Line("Read-Error")
    end if

    ' Chech data match
    data_ok = 1
    for i = 0 to 511
      UART1_Write(SectorData[ i] )
       if (SectorData[ i] <> FILL_CHAR) then
         data_ok = 0
         break
       end if
next i

    if ( data_ok <> 0 ) then
      UART_Write_Line("Content-OK")
else
        UART_Write_Line("Content-Error")
    end if

    ' Signal test end
    UART_Write_Line("Test End.")
end.
```

HW Connection



Pin diagram of MMC memory card

ONEWIRE LIBRARY

The OneWire library provides routines for communication via the Dallas OneWire protocol, for example with DS18x20 digital thermometer. OneWire is a Master/Slave protocol, and all communication cabling required is a single wire. OneWire enabled devices should have open collector drivers (with single pull-up resistor) on the shared data line.

Slave devices on the OneWire bus can even get their power supply from data line. For detailed schematic see device datasheet.

Some basic characteristics of this protocol are:

- single master system,
- low cost
- low transfer rates (up to 16 kbps),
- fairly long distances (up to 300 meters),
- small data transfer packages.

Each OneWire device has also a unique 64-bit registration number (8-bit device type, 48-bit serial number and 8-bit CRC), so multiple slaves can co-exist on the same bus.

Note that oscillator frequency Fosc needs to be at least 4MHz in order to use the routines with Dallas digital thermometers.

Note: This library implements time-based activities, so interrupts need to be disabled when using OneWire library.

Library Routines

- Ow_Reset
- Ow_Read
- Ow_Write

Ow_Reset

Prototype	`sub function Ow_Reset(dim byref port as byte, pin as byte) as byte`
Returns	0 if DS1820 is present, and 1 if not present.
Description	Issues OneWire reset signal for DS1820. Parameters port and `pin` specify the location of DS1820.
Requires	Works with Dallas DS1820 temperature sensor only.
Example	To reset the DS1820 that is connected to the RA5 pin: `Ow_Reset(PORTA, 5)`

Ow_Read

Prototype	`sub function Ow_Read(dim byref port as byte, dim pin as byte) as byte`
Returns	Data read from an external device over the OneWire bus.
Description	Reads one byte of data via the OneWire bus.
Requires	Works with Dallas DS1820 temperature sensor only.
Example	`tmp = Ow_Read(PORTA, 5)`

Ow_Write

Prototype	`sub procedure Ow_Write(dim byref port as byte, dim pin, par as byte)`
Returns	Nothing.
Description	Writes one byte of data (argument par) via OneWire bus.
Requires	Works with Dallas DS1820 temperature sensor only.
Example	`Ow_Write(PORTA, 5, $CC)`

Library Example

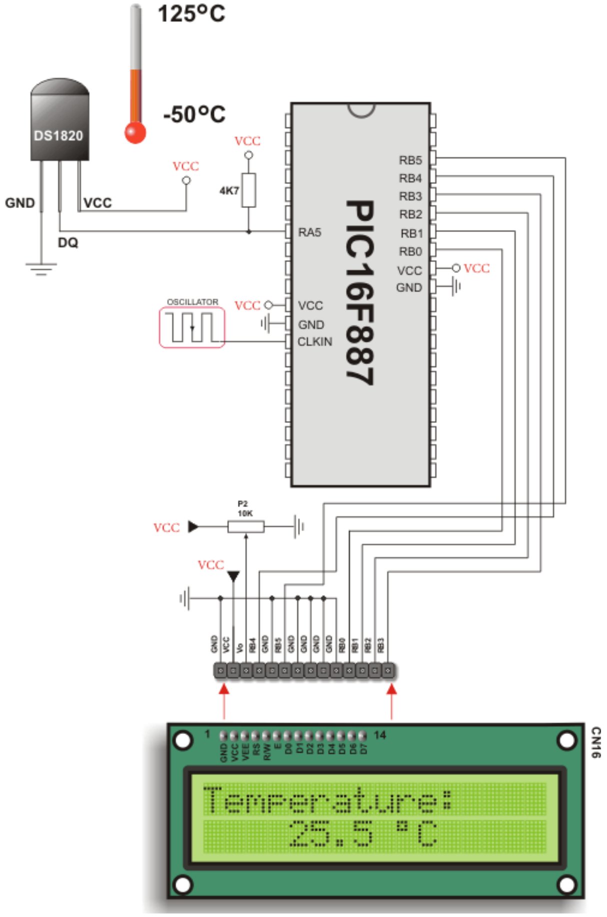
This example reads the temperature using DS18x20 connected to pin PORTA.B5. After reset, MCU obtains temperature from the sensor and prints it on the Lcd. Make sure to pull-up PORTA.B5 line and to turn off the PORTA LEDs.

```
program OneWire

' Lcd module connections
dim LCD_RS as sbit at RB4_bit
    LCD_EN as sbit at RB5_bit
    LCD_D4 as sbit at RB0_bit
    LCD_D5 as sbit at RB1_bit
    LCD_D6 as sbit at RB2_bit
    LCD_D7 as sbit at RB3_bit
    LCD_RS_Direction as sbit at TRISB4_bit
    LCD_EN_Direction as sbit at TRISB5_bit
    LCD_D4_Direction as sbit at TRISB0_bit
    LCD_D5_Direction as sbit at TRISB1_bit
    LCD_D6_Direction as sbit at TRISB2_bit
    LCD_D7_Direction as sbit at TRISB3_bit
' End Lcd module connections

'   Set  TEMP_RESOLUTION  to  the  corresponding  resolution  of  used
DS18x20 sensor:
'  18S20: 9  (default setting can be 9,10,11,or 12)
'  18B20: 12
const TEMP_RESOLUTION as byte = 9

dim text as byte[ 9]
    temp as word

sub procedure Display_Temperature( dim temp2write as word )
const RES_SHIFT = TEMP_RESOLUTION - 8

dim temp_whole as byte
    temp_fraction as word

    text = "000.0000"
    ' check if temperature is negative
    if (temp2write and 0x8000) then
        text[ 0] = "-"
        temp2write = not temp2write + 1
    end if

   ' extract temp_whole
    temp_whole = word(temp2write >> RES_SHIFT)

   ' convert temp_whole to characters
    if ( temp_whole div 100 ) then
```

```
      text[ 0]  = temp_whole div 100  + 48
    else
      text[ 0]  = "0"
    end if

    text[ 1]  = (temp_whole div 10)mod 10 + 48      ' Extract tens digit
    text[ 2]  =  temp_whole mod 10 + 48            ' Extract ones digit

    ' extract temp_fraction and convert it to unsigned int
    temp_fraction  =  word(temp2write << (4-RES_SHIFT))
    temp_fraction  = temp_fraction and 0x000F
    temp_fraction  = temp_fraction * 625

    ' convert temp_fraction to characters
     text[ 4]  = word(temp_fraction div 1000)        + 48   ' Extract
thousands digit
    text[ 5]  = word((temp_fraction div 100)mod 10 + 48)  ' Extract hun-
dreds digit
    text[ 6]  = word((temp_fraction div 10)mod 10  + 48)  ' Extract tens
digit
    text[ 7]  = word(temp_fraction mod 10)   + 48       ' Extract ones
digit

    ' print temperature on Lcd
    Lcd_Out(2, 5, text)
end sub

main:
  ANSEL  = 0                      ' Configure AN pins as digital I/O
  ANSELH = 0

  text = "000.0000"
  Lcd_Init()                                     ' Initialize Lcd
  Lcd_Cmd(_LCD_CLEAR)                            ' Clear Lcd
  Lcd_Cmd(_LCD_CURSOR_OFF)                       ' Turn cursor off
  Lcd_Out(1, 1, " Temperature:   ")

  Lcd_Chr(2,13,178)     ' Print degree character, "C" for Centigrades
                         ' different Lcd displays have different char
code for degree
  Lcd_Chr(2,14,"C")      ' if you see greek alpha letter try typing
178 instead of 223

  '--- main loop
  while (TRUE)
    '--- perform temperature reading
    Ow_Reset(PORTE, 2)          ' Onewire reset signal
    Ow_Write(PORTE, 2, 0xCC)     ' Issue command SKIP_ROM
    Ow_Write(PORTE, 2, 0x44)     ' Issue command CONVERT_T
    Delay_us(120)
```

```
    Ow_Reset(PORTE, 2)
    Ow_Write(PORTE, 2, 0xCC)          ' Issue command SKIP_ROM
    Ow_Write(PORTE, 2, 0xBE)          ' Issue command READ_SCRATCHPAD

    temp =  Ow_Read(PORTE, 2)
    temp = (Ow_Read(PORTE, 2) << 8) + temp

    '--- Format and display result on Lcd

    Display_Temperature(temp)

    Delay_ms(520)
  wend
end.
```

HW Connection



Example of DS1820 connection

PORT EXPANDER LIBRARY

The *mikroBasic PRO for PIC* provides a library for communication with the Microchip's Port Expander MCP23S17 via SPI interface. Connections of the PIC compliant MCU and MCP23S17 is given on the schematic at the bottom of this page.

Note: Library uses the SPI module for communication. The user must initialize SPI module before using the Port Expander Library.

Note: Library does not use Port Expander interrupts.

External dependencies of Port Expander Library

The following variables must be defined in all projects using Port Expander Library:	Description:	Example :
`dim SPExpanderRST as sbit sfr external;`	Reset line.	`dim SPExpanderRST as sbit at RC0_bit`
`dim SPExpanderCS as sbit sfr external`	Chip Select line.	`dim SPExpanderCS as sbit at RC1_bit`
`dim SPExpanderRST_Direction as sbit sfr external`	Direction of the Reset pin.	`dim SPExpanderRST_Direction as sbit at TRISC0_bit`
`dim SPExpanderCS_Direction as sbit sfr external`	Direction of the Chip Select pin.	`dim SPExpanderCS_Directions as sbit at TRISC1_bit`

Library Routine

- Expander_Init
- Expander_Read_Byte
- Expander_Write_Byte
- Expander_Read_PortA
- Expander_Read_PortB
- Expander_Read_PortAB
- Expander_Write_PortA
- Expander_Write_PortB
- Expander_Write_PortAB
- Expander_Set_DirectionPortA
- Expander_Set_DirectionPortB
- Expander_Set_DirectionPortAB
- Expander_Set_PullUpsPortA
- Expander_Set_PullUpsPortB
- Expander_Set_PullUpsPortAB

Expander_Init

Prototype	`sub procedure Expander_Init(dim ModuleAddress as byte)`
Returns	Nothing.
Description	Initializes Port Expander using SPI communication. Port Expander module settings : ■ hardware addressing enabled ■ automatic address pointer incrementing disabled (byte mode) ■ BANK_0 register adressing ■ slew rate enabled Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page
Requires	Global variables : ■ `SPExpanderCS:` Chip Select line ■ `SPExpanderRST:` Reset line ■ `SPExpanderCS_Direction:` Direction of the Chip Select pin ■ `SPExpanderRST_Direction:` Direction of the Reset pin must be defined before using this function. SPI module needs to be initialized. See SPI1_Init and SPI1_Init_Advanced routines.
Example	

```
' port expander pinout definition
dim SPExpanderCS as sbit at RC1_bit
    SPExpanderRST as sbit at RC0_bit
    SPExpanderCS_Direction as sbit at TRISC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit

...
SPI1_Init()                       ' initialize SPI module
Expander_Init(0)                 ' initialize port expander
```

Expander_Read_Byte

Prototype	`sub function Expander_Read_Byte(dim ModuleAddress as byte, dim RegAddress as byte) as byte`
Returns	Byte read.
Description	The function reads byte from Port Expander. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `RegAddress:` Port Expander's internal register address
Requires	Port Expander must be initialized. See Expander_Init.

Example	`' Read a byte from Port Expander's register`
	`dim read_data as byte`
	`...`
	`read_data = Expander_Read_Byte(0,1)`

Expander_Write_Byte

Prototype	`sub procedure Expander_Write_Byte(dim ModuleAddress as byte, dim RegAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	Routine writes a byte to Port Expander. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `RegAddress:` Port Expander's internal register address ■ `Data_:` data to be written
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Write a byte to the Port Expander's register` `Expander_Write_Byte(0,1,0xFF)`

Expander_Read_PortA

Prototype	`sub function Expander_Read_PortA(dim ModuleAddress as byte) as byte`
Returns	Byte read.
Description	The function reads byte from Port Expander's PortA. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortA should be configured as input. See Expander_Set_DirectionPortA and Expander_Set_DirectionPortAB routines.

Example	`' Read a byte from Port Expander's PORTA`
	`dim read_data as byte`
	`...`
	`Expander_Set_DirectionPortA(0,0xFF)  'set expander's porta to be input`
	`...`
	`read_data = Expander_Read_PortA(0)`

Expander_Read_PortB

Prototype	`sub function Expander_Read_PortB(dim ModuleAddress as byte) as byte`
Returns	Byte read.
Description	The function reads byte from Port Expander's PortB. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortB should be configured as input. See Expander_Set_DirectionPortB and Expander_Set_DirectionPortAB routines.

Example	`' Read a byte from Port Expander's PORTB`
	`dim read_data as byte`
	`...`
	`Expander_Set_DirectionPortB(0,0xFF)          ' set expander's portb to be input`
	`...`
	`read_data = Expander_Read_PortB(0)`

Expander_Read_PortAB

Prototype	`sub function Expander_Read_PortAB(dim ModuleAddress as byte) as word`
Returns	Word read.
Description	The function reads word from Port Expander's ports. PortA readings are in the higher byte of the result. PortB readings are in the lower byte of the result. Parameters : ■ `ModuleAddress`: Port Expander hardware address, see schematic at the bottom of this page
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortA and PortB should be configured as inputs. See Expander_Set_DirectionPortA, Expander_Set_DirectionPortB and Expander_Set_DirectionPortAB routines.

Example

```
' Read a byte from Port Expander's PORTA and PORTB
dim read_data as word
...
Expander_Set_DirectionPortAB(0,0xFFFF)   ' set expander's porta and portb to be input
...
read_data = Expander_Read_PortAB(0)
```

Expander_Write_PortA

Prototype	`sub procedure Expander_Write_PortA(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function writes byte to Port Expander's PortA. Parameters : ■ `ModuleAddress`: Port Expander hardware address, see schematic at the bottom of this page ■ `Data_`: data to be written
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortA should be configured as output. See Expander_Set_DirectionPortA and Expander_Set_DirectionPortAB routines.

Example

```
' Write a byte to Port Expander's PORTA

...
Expander_Set_DirectionPortA(0,0x00)   ' set expander's porta to be output
...
Expander_Write_PortA(0, 0xAA)
```

Expander_Write_PortB

Prototype	`sub procedure Expander_Write_PortB(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function writes byte to Port Expander's PortB. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data to be written
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortB should be configured as output. See Expander_Set_DirectionPortB and Expander_Set_DirectionPortAB routines.

Example

```
' Write a byte to Port Expander's PORT

...
Expander_Set_DirectionPortB(0,0x00)   ' set expander's portb to be
output
...
Expander_Write_PortB(0, 0x55)
```

Expander_Write_PortAB

Prototype	`sub procedure Expander_Write_PortAB(dim ModuleAddress as byte, dim Data_ as word)`
Returns	Nothing.
Description	The function writes word to Port Expander's ports. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data to be written. Data to be written to PortA are passed in `Data`'s higher byte. Data to be written to PortB are passed in `Data`'s lower byte
Requires	Port Expander must be initialized. See Expander_Init. Port Expander's PortA and PortB should be configured as outputs. See Expander_Set_DirectionPortA, Expander_Set_DirectionPortB and Expander_Set_DirectionPortAB routines.

Example

```
' Write a byte to Port Expander's PORTA and PORTB

...
Expander_Set_DirectionPortAB(0,0x0000)   ' set expander's porta
and portb to be output
...
Expander_Write_PortAB(0, 0xAA55)
```

Expander_Set_DirectionPortA

Prototype	`sub procedure Expander_Set_DirectionPortA(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function sets Port Expander's PortA direction. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data to be written to the PortA direction register. Each bit corresponds to the appropriate pin of the PortA register. Set bit designates corresponding pin as input. Cleared bit designates corresponding pin as output.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Set Port Expander's PORTA to be output` `Expander_Set_DirectionPortA(0,0x00)`

Expander_Set_DirectionPortB

Prototype	`sub procedure Expander_Set_DirectionPortB(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function sets Port Expander's PortB direction. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data to be written to the PortB direction register. Each bit corresponds to the appropriate pin of the PortB register. Set bit designates corresponding pin as input. Cleared bit designates corresponding pin as output.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Set Port Expander's PORTB to be input` `Expander_Set_DirectionPortB(0,0xFF)`

Expander_Set_DirectionPortAB

Prototype	`sub procedure Expander_Set_DirectionPortAB(dim ModuleAddress as byte, dim Direction as word)`
Returns	Nothing.
Description	The function sets Port Expander's PortA and PortB direction. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Direction:` data to be written to direction registers. Data to be written to the PortA direction register are passed in `Direction`'s higher byte. Data to be written to the PortB direction register are passed in `Direction`'s lower byte. Each bit corresponds to the appropriate pin of the PortA/PortB register. Set bit designates corresponding pin as input. Cleared bit designates corresponding pin as output.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Set Port Expander's PORTA to be output and PORTB to be input` `Expander_Set_DirectionPortAB(0,0x00FF)`

Expander_Set_PullUpsPortA

Prototype	`sub procedure Expander_Set_PullUpsPortA(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function sets Port Expander's PortA pull up/down resistors. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data for choosing pull up/down resistors configuration. Each bit corresponds to the appropriate pin of the PortA register. Set bit enables pull-up for corresponding pin.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Set Port Expander's PORTA pull-up resistors` `Expander_Set_PullUpsPortA(0, 0xFF)`

Expander_Set_PullUpsPortB

Prototype	`sub procedure Expander_Set_PullUpsPortB(dim ModuleAddress as byte, dim Data_ as byte)`
Returns	Nothing.
Description	The function sets Port Expander's PortB pull up/down resistors. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `Data_:` data for choosing pull up/down resistors configuration. Each bit corresponds to the appropriate pin of the PortB register. Set bit enables pull-up for corresponding pin.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`'Set Port Expander's PORTB pull-up resistors` `Expander_Set_PullUpsPortB(0, 0xFF)`

Expander_Set_PullUpsPortAB

Prototype	`sub procedure Expander_Set_PullUpsPortAB(dim ModuleAddress as byte, dim PullUps as word)`
Returns	Nothing.
Description	The function sets Port Expander's PortA and PortB pull up/down resistors. Parameters : ■ `ModuleAddress:` Port Expander hardware address, see schematic at the bottom of this page ■ `PullUps:` data for choosing pull up/down resistors configuration. PortA pull up/down resistors configuration is passed in `PullUps`'s higher byte. PortB pull up/down resistors configuration is passed in `PullUps`'s lower byte. Each bit corresponds to the appropriate pin of the PortA/PortB register. Set bit enables pull-up for corresponding pin.
Requires	Port Expander must be initialized. See Expander_Init.
Example	`' Set Port Expander's PORTA and PORTB pull-up resistors` `Expander_Set_PullUpsPortAB(0, 0xFFFF)`

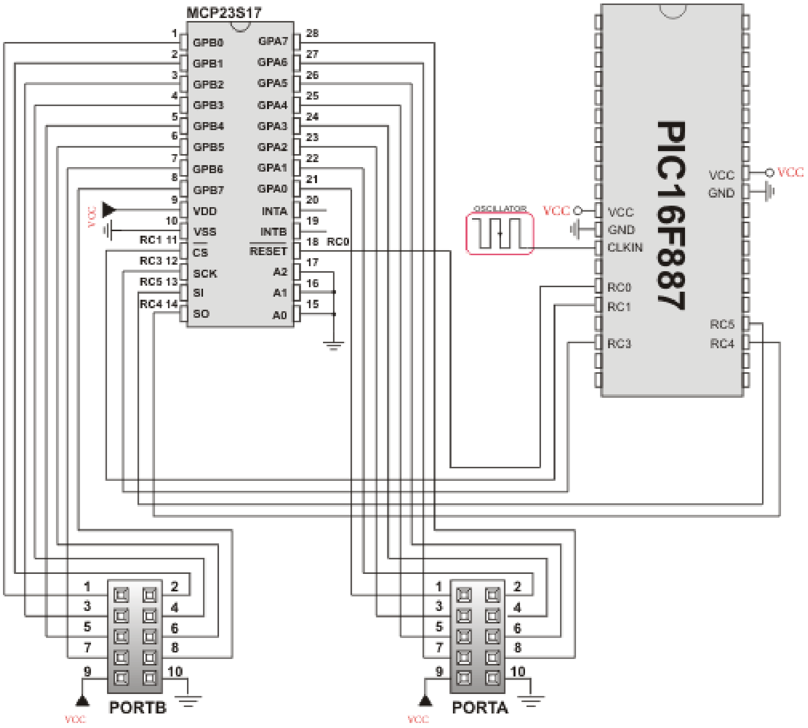
Library Example

The example demonstrates how to communicate with Port Expander MCP23S17.

Note that Port Expander pins A2 A1 A0 are connected to GND so Port Expander Hardware Address is 0.

```
program PortExpander

' Port Expander module connections
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS  as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction  as sbit at TRISC1_bit
' End Port Expander module connections

dim counter as byte' = 0

main:
  counter = 0
  ANSEL  = 0                      ' Configure AN pins as digital I/O
  ANSELH = 0
  TRISB  = 0                      ' Set PORTB as output
  PORTB  = 0

   SPI1_Init_Advanced(_SPI_MASTER_OSC_DIV4, _SPI_DATA_SAMPLE_MIDDLE,
   _SPI_CLK_IDLE_LOW, _SPI_LOW_2_HIGH)
  Expander_Init(0)                     ' Initialize Port Expander
  Expander_Set_DirectionPortA(0, 0x00) ' Set Expander's PORTA to be
output
  Expander_Set_DirectionPortB(0,0xFF)  ' Set Expander's PORTB to be
input
  Expander_Set_PullUpsPortB(0,0xFF)    ' Set pull-ups to all of the
Expander's PORTB pins

  while TRUE                           ' Endless loop
    Expander_Write_PortA(0, counter)   ' Write i to expander's PORTA
    Inc(counter)
    PORTB = Expander_Read_PortB(0)      ' Read expander's PORTB and
write it to LEDs
    Delay_ms(100)
  wend

end.
```

HW Connection



Port Expander HW connection

PS/2 LIBRARY

The *mikroBasic PRO for PIC* provides a library for communication with the common PS/2 keyboard.

Note: The library does not utilize interrupts for data retrieval, and requires the oscillator clock to be at least 6MHz.

Note: The pins to which a PS/2 keyboard is attached should be connected to the pull-up resistors.

Note: Although PS/2 is a two-way communication bus, this library does not provide MCU-to-keyboard communication; e.g. pressing the **Caps Lock** key will not turn on the Caps Lock LED.

External dependencies of PS/2 Library

The following variables must be defined in all projects using PS/2 Library:	Description:	Example :
`dim PS2_Data as sbit sfr external`	PS/2 Data line.	`dim PS2_Data as sbit at RC0_bit`
`dim PS2_Clock as sbit sfr external`	PS/2 Clock line.	`dim PS2_Clock as sbit at RC1_bit`
`dim PS2_Data_Direction as sbit sfr external`	Direction of the PS/2 Data pin.	`dim PS2_Data_Direction as sbit at TRISC0_bit`
`dim PS2_Clock_Direction as sbit sfr external`	Direction of the PS/2 Clock pin.	`dim PS2_Clock_Direction as sbit at TRISC1_bit`

Library Routines

- Ps2_Config
- Ps2_Key_Read

Ps2_Config

Prototype	`sub procedure Ps2_Config()`
Returns	Nothing.
Description	Initializes the MCU for work with the PS/2 keyboard.
Requires	Global variables : ■ `PS2_Data:` Data signal line ■ `PS2_Clock:` Clock signal line in ■ `PS2_Data_Direction:` Direction of the Data pin ■ `PS2_Clock_Direction:` Direction of the Clock pin must be defined before using this function.

Example

```
' PS2 pinout definition
dim PS2_Data as sbit at RC0_bit
dim PS2_Clock as sbit at RC1_bit
dim PS2_Data_Direction as sbit at TRISC0_bit
dim PS2_Clock_Direction as sbit at TRISC1_bit
' End of PS2 pinout definition
...
Ps2_Config()          ' Init PS/2 Keyboard
```

Ps2_Key_Read

Prototype	`sub function Ps2_Key_Read(dim byref value as byte, dim byref special as byte, dim byref pressed as byte) as byte`
Returns	- `1` if reading of a key from the keyboard was successful - `0` if no key was pressed
Description	The function retrieves information on key pressed. Parameters : - `value:` holds the value of the key pressed. For characters, numerals, punctuation marks, and space `value` will store the appropriate ASCII code. Routine “recognizes” the function of **Shift** and **Caps Lock**, and behaves appropriately. For special function keys see Special Function Keys Table. - `special:` is a flag for special function keys (**F1, Enter, Esc**, etc). If key pressed is one of these, `special` will be set to 1, otherwise 0. - `pressed:` is set to 1 if the key is pressed, and 0 if it is released.
Requires	PS/2 keyboard needs to be initialized. See Ps2_Config routine.
Example	

```
dim value, special, pressed as byte
...
do {
  if (Ps2_Key_Read(value, special, pressed)) then
    if ((value = 13) and (special = 1)) then
      break
    end if
  end if
loop until (0=1)
```

Special Function Keys

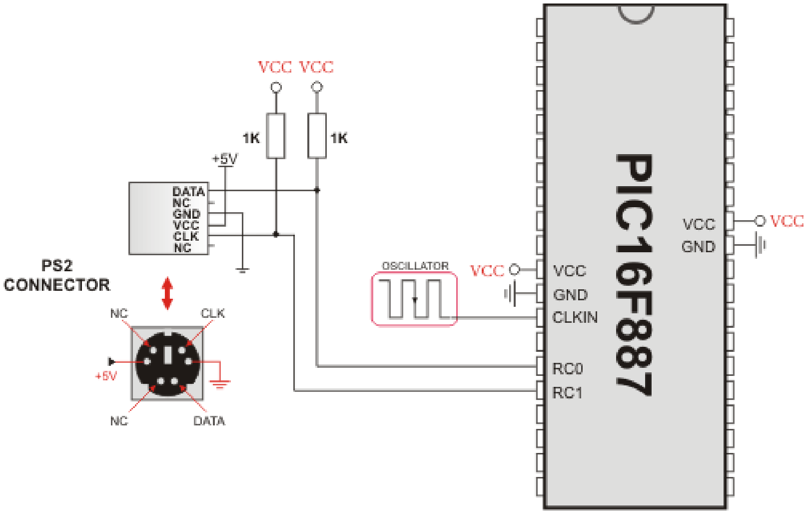
Key	Value returned
F1	1
F2	2
F3	3
F4	4
F5	5
F6	6
F7	7
F8	8
F9	9
F10	10
F11	11
F12	12
Enter	13
Page Up	14
Page Down	15
Backspace	16
Insert	17
Delete	18
Windows	19
Ctrl	20
Shift	21
Alt	22
Print Screen	23
Pause	24
Caps Lock	25
End	26
Home	27
Scroll Lock	28
Num Lock	29
Left Arrow	30
Right Arrow	31
Up Arrow	32
Down Arrow	33
Escape	34
Tab	35

Library Example

This simple example reads values of the pressed keys on the PS/2 keyboard and sends them via UART.

```
program PS2_Example

dim keydata, special, down as byte

dim PS2_Data            as sbit at PORTC.0
    PS2_Clock           as sbit at PORTC.1

    PS2_Data_Direction  as sbit at TRISC.0
    PS2_Clock_Direction as sbit at TRISC.1


main:
  ANSEL   = 0                ' Configure AN pins as digital I/O
  ANSELH  = 0

  UART1_Init(19200)              ' Initialize UART module at 9600 bps
  Ps2_Config()                   ' Init PS/2 Keyboard
  Delay_ms(100)                  ' Wait for keyboard to finish
  UART1_Write_Text("Ready")      ' Ready

  while TRUE                                  ' Endless loop
    if Ps2_Key_Read(keydata, special, down) then ' If data was read
from PS/2
      if (down <> 0) and (keydata = 16) then    ' Backspace read
        UART1_Write(0x08)                        ' Send Backspace to
usart terminal
      else
        if (down <> 0) and (keydata = 13) then   ' Enter read
          UART1_Write(10)                      ' Send carriage return to
usart terminal
          UART1_Write(13)                     ' Uncomment this line if
usart terminal also expects line feed
                                              ' for new line transition
        else
          if (down <> 0) and (special = 0) and (keydata <> 0) then
' Common key read
            UART1_Write(keydata)        ' Send key to usart terminal
          end if
        end if
      end if
    end if
    Delay_ms(10)                            ' Debounce period
  wend
end.
```

HW Connection



Example of PS2 keyboard connection

PWM LIBRARY

CCP module is available with a number of PIC MCUs. *mikroBasic PRO for PIC* provides library which simplifies using PWM HW Module.

Note: Some MCUs have multiple CCP modules. In order to use the desired CCP library routine, simply change the number 1 in the prototype with the appropriate module number, i.e. `PWM2_Start()`

Library Routines

- PWM1_Init
- PWM1_Set_Duty
- PWM1_Start
- PWM1_Stop

PWM1_Init

Prototype	`sub procedure PWM1_Init(dim freq as longint)`
Returns	Nothing.
Description	Initializes the PWM module with duty ratio 0. Parameter freq is a desired PWM frequency in Hz (refer to device data sheet for correct values in respect with Fosc). This routine needs to be called before using other functions from PWM Library.
Requires	MCU must have CCP module. **Note:** Calculation of the PWM frequency value is carried out by the compiler, as it would produce a relatively large code if performed on the libary level. Therefore, compiler needs to know the value of the parameter in the compile time. That is why this parameter needs to be a constant, and not a variable.
Example	Initialize PWM module at 5KHz: `PWM1_Init(5000)`

PWM1_Set_Duty

Prototype	`sub procedure PWM1_Set_Duty(dim duty_ratio as byte)`
Returns	Nothing.
Description	Sets PWM duty ratio. Parameter duty takes values from 0 to 255, where 0 is 0%, 127 is 50%, and 255 is 100% duty ratio. Other specific values for duty ratio can be calculated as `(Percent*255)/100`.
Requires	MCU must have CCP module. PWM1_Init must be called before using this routine.
Example	Set duty ratio to 75%: `PWM1_Set_Duty(192)`

PWM1_Start

Prototype	`sub procedure PWM1_Star`
Returns	Nothing.
Description	Starts PWM.
Requires	MCU must have CCP module. PWM1_Init must be called before using this routine.
Example	`PWM1_Start`

PWM1_Stop

Prototype	`sub procedure PWM1_Stop`
Returns	Nothing.
Description	Stops PWM.
Requires	MCU must have CCP module. PWM1_Init must be called before using this routine. PWM1_Start should be called before using this routine, otherwise it will have no effect as the PWM module is not running.
Example	`PWM1_Stop`

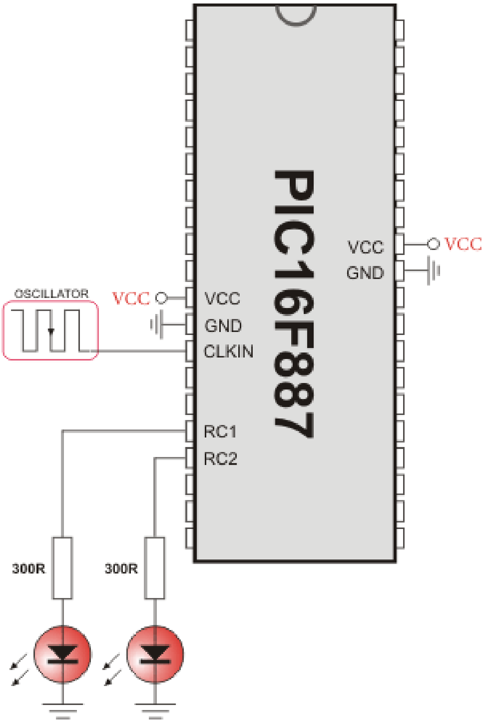
Library Example

The example changes PWM duty ratio on pin PB3 continually. If LED is connected to PB3, you can observe the gradual change of emitted light.

```
program PWM_Test

dim current_duty, current_duty1, old_duty, old_duty1 as byte

sub procedure InitMain()
  ANSEL  = 0                              ' Configure AN pins as digital I/O
  ANSELH = 0

  PORTA = 255
  TRISA = 255                             ' configure PORTA pins as input
  PORTB = 0                               ' set PORTB to 0
  TRISB = 0                               ' designate PORTB pins as output
  PORTC = 0                               ' set PORTC to 0
  TRISC = 0                               ' designate PORTC pins as output
  PWM1_Init(5000)                         ' Initialize PWM1 module at 5KHz
  PWM2_Init(5000)                         ' Initialize PWM2 module at 5KHz
end sub

main:
  InitMain()
  current_duty  = 16                      ' initial value for current_duty
  current_duty1 = 16                      ' initial value for current_duty1

  PWM1_Start()                            ' start PWM1
  PWM2_Start()                            ' start PWM2
  PWM1_Set_Duty(current_duty)             ' Set current duty for PWM1
  PWM2_Set_Duty(current_duty1)            ' Set current duty for PWM2

  while (TRUE)                            ' endless loop
    if (RA0_bit <> 0) then                ' button on RA0 pressed
      Delay_ms(40)
      Inc(current_duty)                   ' increment current_duty
      PWM1_Set_Duty(current_duty)
    end if

    if (RA1_bit <> 0) then                ' button on RA1 pressed
      Delay_ms(40)
      Dec(current_duty)                   ' decrement current_duty
      PWM1_Set_Duty(current_duty)
    end if
    if (RA2_bit <> 0) then                ' button on RA2 pressed
      Delay_ms(40)
      Inc(current_duty1)                  ' increment current_duty1
      PWM2_Set_Duty(current_duty1)
```

```
    end if

        if (RA3_bit <> 0) then                   ' button on RA3 pressed
           Delay_ms(40)
           Dec(current_duty1)                     ' decrement current_duty1
           PWM2_Set_Duty(current_duty1)
         end if

         Delay_ms(5)                    ' slow down change pace a little
    wend
end.
```

HW Connection



PWM demonstration

RS-485 LIBRARY

RS-485 is a multipoint communication which allows multiple devices to be connected to a single bus. The mikroBasic PRO for PIC provides a set of library routines for comfortable work with RS485 system using Master/Slave architecture. Master and Slave devices interchange packets of information. Each of these packets contains synchronization bytes, CRC byte, address byte and the data. Each Slave has unique address and receives only packets addressed to it. The Slave can never initiate communication.

It is the user's responsibility to ensure that only one device transmits via 485 bus at a time.

The RS-485 routines require the UART module. Pins of UART need to be attached to RS-485 interface transceiver, such as LTC485 or similar (see schematic at the bottom of this page).

Note: The library uses the UART module for communication. The user must initialize the appropriate UART module before using the RS-485 Library. For MCUs with two UART modules it is possible to initialize both of them and then switch by using the `UART_Set_Active` function. See the UART Library functions.

Library constants:

- START byte value = `150`
- STOP byte value = `169`
- Address `50` is the broadcast address for all Slaves (packets containing address `50` will be received by all Slaves except the Slaves with addresses `150` and `169`).

External dependencies of RS-485 Library

The following variable must be defined in all projects using RS-485 Library:	Description:	Example :
`dim RS485_rxtx_pin as sbit sfr external`	Control RS-485 Transmit/Receive operation mode	`dim RS485_rxtx_pin as sbit at RC2_bit`
`dim RS485_rxtx_pin_direction as sbit sfr ternal`	Direction of the RS-485 Transmit/Receive pin	`dim RS485_rxtx_pin_direction as sbit at TRISC2_bit`

Library Routines

- RS485Master_Init
- RS485Master_Receive
- RS485Master_Send
- RS485Slave_Init
- RS485Slave_Receive
- RS485Slave_Send

RS485master_Init

Prototype	`sub procedure RS485Master_Init()`
Returns	Nothing.
Description	Initializes MCU as a Master for RS-485 communication.
Requires	Global variables : ■ `RS485_rxtx_pin` - this pin is connected to RE/DE input of RS-485 transceiver(see schematic at the bottom of this page). RE/DE signal controls RS-485 transceiver operation mode. ■ `RS485_rxtx_pin_direction` - direction of the RS-485 Transmit/Receive pin must be defined before using this function. UART HW module needs to be initialized. See UARTx_Init

Example

```
' RS485 module pinout
dim RS485_rxtx_pin as sbit at RC2_bit
dim RS485_rxtx_pin_direction as sbit at TRISC2_bit
' End of RS485 module pinout
...
UART1_Init(9600)                      ' initialize UART module
RS485Master_Init()                    ' intialize MCU as a Master
for RS-485 communication
```

RS485master_Receive

Prototype	`sub procedure RS485Master_Receive(dim byref data_buffer as byte[20])`
Returns	Nothing.
Description	Receives messages from Slaves. Messages are multi-byte, so this routine must be called for each byte received. Parameters : ■ `data_buffer:` 7 byte buffer for storing received data, in the following manner: ■ `data[ 0..2] :` message content ■ `data[ 3] :` number of message bytes received, 1–3 ■ `data[ 4] :` is set to 255 when message is received ■ `data[ 5] :` is set to 255 if error has occurred ■ `data[ 6] :` address of the Slave which sent the message The function automatically adjusts `data[ 4]` and `data[ 5]` upon every received message. These flags need to be cleared by software.
Requires	MCU must be initialized as a Master for RS-485 communication. See RS485master_Init.

Example	`dim msg as byte[ 20]`
	`...`
	`RS485Master_Receive(msg)`

RS485master_Send

Prototype	`sub procedure Rs485Master_Send(dim byref data_buffer as byte[ 20] , dim datalen as byte, dim slave_address as byte)`
Returns	Nothing.
Description	Sends message to Slave(s). Message format can be found at the bottom of this page. Parameters : ■ `data_buffer:` data to be sent ■ `datalen:` number of bytes for transmition. Valid values: 0...3. ■ `slave_address:` Slave(s) address
Requires	MCU must be initialized as a Master for RS-485 communication. See RS485Master_Init. It is the user's responsibility to ensure (by protocol) that only one device sends data via 485 bus at a time.

Example	`dim msg as byte[ 20]`
	`...`
	`' send 3 bytes of data to slave with address 0x12`
	`RS485Master_Send(msg, 3, 0x12)`

RS485slave_Init

Prototype	`sub procedure RS485Slave_Init(dim slave_address as byte)`
Returns	Nothing.
Description	Initializes MCU as a Slave for RS-485 communication. Parameters : ■ `slave_address:` Slave address
Requires	Global variables : ■ `RS485_rxtx_pin` - this pin is connected to RE/DE input of RS-485 transceiver(see schematic at the bottom of this page). RE/DE signal controls RS-485 transceiver operation mode. Valid values: `1` (for transmitting) and `0` (for receiving) ■ `RS485_rxtx_pin_direction` - direction of the RS-485 Transmit/Receive pin must be defined before using this function. UART HW module needs to be initialized. See UARTx_Init.

Example

```
' RS485 module pinout
dim RS485_rxtx_pin as sbit  at RC2_bit
dim RS485_rxtx_pin_direction as sbit  at TRISC2_bit
' End of RS485 module pinout
...
UART1_Init(9600)                       ' initialize UART module
RS485Slave_Init(160)                   ' intialize MCU as a Slave
for RS-485 communication with address 160
```

RS485slave_Receive

Prototype	`sub procedure RS485Slave_Receive(dim byref data_buffer as byte[ 20] )`
Returns	Nothing.
Description	Receives messages from Master. If Slave address and Message address field don't match then the message will be discarded. Messages are multi-byte, so this routine must be called for each byte received. Parameters : ■ `data_buffer:` 6 byte buffer for storing received data, in the following manner: ■ `data[ 0..2] :` message content ■ `data[ 3] :` number of message bytes received, 1–3 ■ `data[ 4] :` is set to 255 when message is received ■ `data[ 5] :` is set to 255 if error has occurred The function automatically adjusts `data[ 4]` and `data[ 5]` upon every received message. These flags need to be cleared by software.
Requires	MCU must be initialized as a Slave for RS-485 communication. See RS485slave_Init.

Example	`dim msg as byte[ 5]`
	`...`
	`RS485Slave_Read(msg)`

RS485slave_Send

Prototype	`sub procedure RS485Slave_Send(dim byref data_buffer as byte[ 20] , dim datalen as byte)`
Returns	Nothing.
Description	Sends message to Master. Message format can be found at the bottom of this page. Parameters : ■ `data_buffer:` data to be sent ■ `datalen:` number of bytes for transmition. Valid values: 0...3.
Requires	MCU must be initialized as a Slave for RS-485 communication. See RS485Slave_Init. It is the user's responsibility to ensure (by protocol) that only one device sends data via 485 bus at a time.

Example	`dim msg as byte[ 8]`
	`...`
	`' send 2 bytes of data to the master`
	`RS485Slave_Send(msg, 2)`

Library Example

This is a simple demonstration of RS485 Library routines usage.

Master sends message to Slave with address 160 and waits for a response. The Slave accepts data, increments it and sends it back to the Master. Master then does the same and sends incremented data back to Slave, etc.

Master displays received data on PORTB, while error on receive (0xAA) and number of consecutive unsuccessful retries are displayed on PORTD. Slave displays received data on PORTB, while error on receive (0xAA) is displayed on PORTD. Hardware configurations in this example are made for the EasyPIC5 board and 16F887.

RS485 Master code:

```
program RS485_Master_Example

dim dat as byte[ 10]             ' buffer for receving/sending messages
    i, j as byte
    cnt as longint

dim rs485_rxtx_pin  as sbit at RC2_bit          ' set transcieve pin
    rs485_rxtx_pin_direction as sbit at TRISC2_bit     ' set tran
   scieve pin direction

' Interrupt routine
sub procedure interrupt()
  RS485Master_Receive(dat)
end sub

main:
  cnt = 0
  ANSEL  = 0                         ' Configure AN pins as digital I/O
  ANSELH = 0

  C1ON_bit = 0                       ' Disable comparators
  C2ON_bit = 0

  PORTB  = 0
  PORTD  = 0
  TRISB  = 0
  TRISD  = 0

  UART1_Init(9600)                     ' initialize UART1 module
  Delay_ms(100)
```

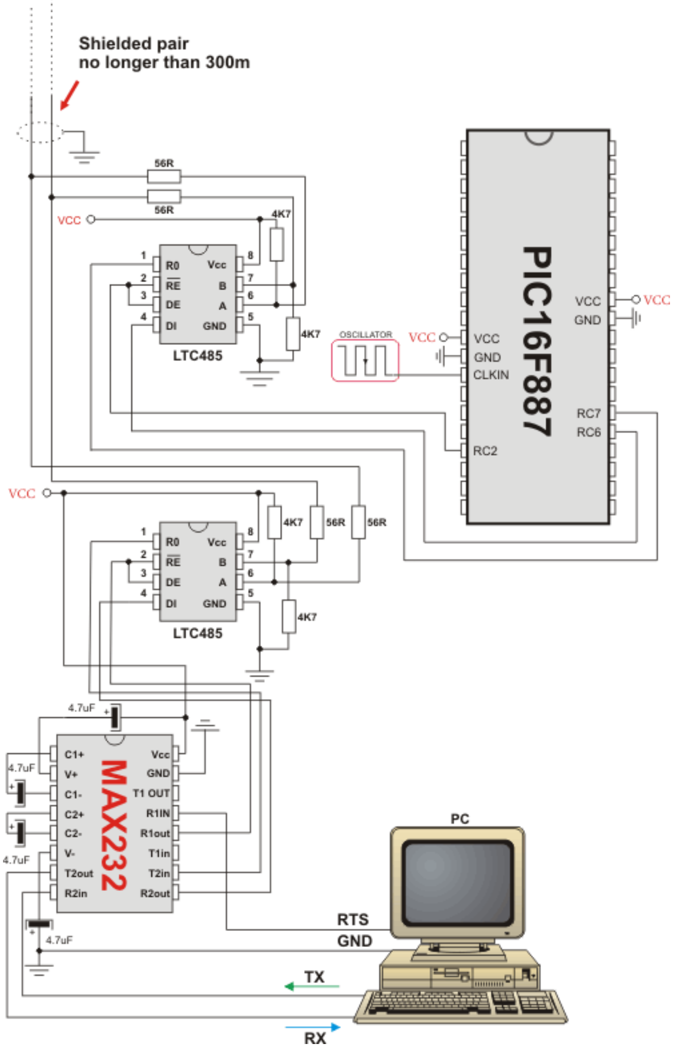
```
 RS485Master_Init()       ' initialize MCU as Master
dat[0] = 0xAA
dat[1] = 0xF0
dat[2] = 0x0F
dat[4] = 0                ' ensure that message received flag is 0
dat[5] = 0                ' ensure that error flag is 0
dat[6] = 0

RS485Master_Send(dat,1,160)

PIE1.RCIE = 1                ' enable interrupt on UART1 receive
PIE2.TXIE = 0                ' disable interrupt on UART1 transmit
INTCON.PEIE = 1              ' enable peripheral interrupts
INTCON.GIE = 1               ' enable all interrupts

while TRUE                ' upon completed valid message receiving
                          ' data[4] is set to 255
  Inc(cnt)
  if (dat[5] <> 0) then        ' if an error detected, signal it
    PORTD = 0xAA                ' by setting portd to 0xAA
  end if

  if (dat[4] <> 0) then         ' if message received successfully
    cnt = 0
    dat[4] = 0                  ' clear message received flag
    j = dat[3]
    for i = 1 to dat[3]         ' show data on PORTB
      PORTB = dat[i-1]
    next i
    dat[0] = dat[0]+1                 ' increment received dat[0]
    Delay_ms(1)                       ' send back to slave
    RS485Master_Send(dat,1,160)
  end if

    if (cnt > 100000) then    ' if in 100000 poll-cycles the answer
    Inc(PORTD)                        '   was not detected, signal
    cnt = 0                           '   failure of send-message
    RS485Master_Send(dat,1,160)
    if (PORTD > 10) then              ' if sending failed 10 times
   RS485Master_Send(dat,1,50)   '  send message on broadcast address
    end if
  end if
wend
end.
```

RS485 Slave code:

```
program RS485_Slave_Example

dim dat as byte[ 20]          ' buffer for receving/sending messages
    i, j as byte

dim rs485_rxtx_pin as sbit at RC2_bit           ' set transcieve pin
    rs485_rxtx_pin_direction as sbit at TRISC2_bit ' set transcieve
   pin direction

' Interrupt routine
sub procedure interrupt()
  RS485Slave_Receive(dat)
end sub

main:
  ANSEL  = 0                        ' Configure AN pins as digital I/O
  ANSELH = 0
  C1ON_bit = 0                      ' Disable comparators
  C2ON_bit = 0

  PORTB = 0
  PORTD = 0
  TRISB = 0
  TRISD = 0

  UART1_Init(9600)           ' initialize UART1 module
  Delay_ms(100)
  RS485Slave_Init(160)       ' Initialize MCU as slave, address 160

  dat[ 4]  = 0               ' ensure that message received flag is 0
  dat[ 5]  = 0               ' ensure that message received flag is 0
  dat[ 6]  = 0               ' ensure that error flag is 0

  PIE1.RCIE = 1               ' enable interrupt on UART1 receive
  PIE2.TXIE = 0               ' disable interrupt on UART1 transmit
  INTCON.PEIE = 1             ' enable peripheral interrupts
  INTCON.GIE = 1              ' enable all interrupts

while TRUE
    if (dat[ 5] <> 0) then     ' if an error detected, signal it by
       PORTD = 0xAA            '   setting PORTD to 0xAA
       dat[ 5]  = 0
    end if
    if (dat[ 4] <> 0) then      ' upon completed valid message receive
        dat[ 4]  = 0            '  data[4] is set to 0xFF
   j = dat[ 3]
         for i = 1 to dat[ 3]   ' show data on PORTB
```

```
          PORTB = dat[i-1]
        next i
        dat[0] = dat[0]+1           ' increment received dat[0]
        Delay_ms(1)
        RS485Slave_Send(dat,1)       '  and send it back to master
    end if
  wend
end.
```

HW Connection



Example of interfacing PC to PIC16F887 MCU via RS485 bus with LTC485 as RS-485 transceiver

Message format and CRC calculations

Q: How is CRC checksum calculated on RS485 master side?

```
_START_BYTE = 0x96; ' 10010110
_STOP_BYTE  = 0xA9; ' 10101001

PACKAGE:
--------
_START_BYTE 0x96
ADDRESS
DATALEN
[ DATA1]             ' if exists
[ DATA2]             ' if exists
[ DATA3]             ' if exists
CRC
_STOP_BYTE  0xA9


DATALEN bits
------------
bit7 = 1  MASTER SENDS
       0   SLAVE  SENDS
bit6 = 1  ADDRESS WAS XORed with 1, IT WAS EQUAL TO _START_BYTE or
   _STOP_BYTE
       0  ADDRESS UNCHANGED
bit5 = 0  FIXED
bit4 = 1  DATA3 (if exists) WAS XORed with 1, IT WAS EQUAL TO
   _START_BYTE or _STOP_BYTE
      0  DATA3 (if exists) UNCHANGED
bit3 = 1  DATA2 (if exists) WAS XORed with 1, IT WAS EQUAL TO
   _START_BYTE or _STOP_BYTE
      0  DATA2 (if exists) UNCHANGED
bit2 = 1  DATA1 (if exists) WAS XORed with 1, IT WAS EQUAL TO
   _START_BYTE or _STOP_BYTE
       0  DATA1 (if exists) UNCHANGED
bit1bit0 = 0 to 3 NUMBER OF DATA BYTES SEND


CRC generation :
----------------
crc_send  = datalen ^ address;
crc_send ^= data[ 0] ;     ' if exists
crc_send ^= data[ 1] ;     ' if exists
crc_send ^= data[ 2] ;     ' if exists
crc_send = ~crc_send;
if ((crc_send == _START_BYTE) || (crc_send == _STOP_BYTE))
   crc_send++;
NOTE: DATALEN<4..0> can not take the _START_BYTE<4..0> or
   _STOP_BYTE<4..0> values.
```

SOFTWARE I^{2}C LIBRARY

The *mikroBasic PRO for PIC* provides routines for implementing Software I^{2}C communication. These routines are hardware independent and can be used with any MCU. The Software I^{2}C library enables you to use MCU as Master in I^{2}C communication. Multi-master mode is not supported.

Note: This library implements time-based activities, so interrupts need to be disabled when using Software I^{2}C.

Note: All Software I^{2}C Library functions are blocking-call functions (they are waiting for I^{2}C clock line to become logical one).

Note: The pins used for the Software I^{2}C communication should be connected to the pull-up resistors. Turning off the LEDs connected to these pins may also be required.

External dependecies of Soft_I2C Library

The following variables must be defined in all projects using Soft_I2C Library:	Description:	Example :
`dim Soft_I2C_Scl as sbit sfr external`	Soft I^{2}C Clock line.	`dim Soft_I2C_Scl as sbit at RC3_bit`
`dim Soft_I2C_Sda as sbit sfr external`	Soft I^{2}C Data line.	`dim Soft_I2C_Sda as sbit at RC4_bit`
`dim Soft_I2C_Scl_Direction as sbit sfr external`	Direction of the Soft I^{2}C Clock pin.	`dim Soft_I2C_Scl_Direction as sbit at TRISC3_bit`
`dim Soft_I2C_Sda_Direction as sbit sfr external`	Direction of the Soft I^{2}C Data pin.	`dim Soft_I2C_Sda_Direction as sbit at TRISC4_bit`

Library Routines

- Soft_I2C_Init
- Soft_I2C_Start
- Soft_I2C_Read
- Soft_I2C_Write
- Soft_I2C_Stop
- Soft_I2C_Break

Soft_I2C_Init

Prototype	`sub procedure Soft_I2C_Init()`
Returns	Nothing.
Description	Configures the software I^{2}C module.
Requires	Global variables : ■ `Soft_I2C_Scl:` Soft I^{2}C clockline ■ `Soft_I2C_Sda:` Soft I^{2}C data line ■ `Soft_I2C_Scl_Direction:` Direction of the Soft I^{2}C clock pin ■ `Soft_I2C_Sda_Direction:` Direction of the Soft I^{2}C data pin must be defined before using this function.

Example

```
'Soft_I2C pinout definition
dim Soft_I2C_Scl                 as sbit at RC3_bit
dim Soft_I2C_Sda                 as sbit at RC4_bit
dim Soft_I2C_Scl_Direction as sbit at TRISC3_bit
dim Soft_I2C_Sda_Direction as sbit at TRISC4_bit
'End of Soft_I2C pinout definition
...
Soft_I2C_Init()
```

Soft_I2C_Start

Prototype	`sub procedure Soft_I2C_Start()`
Returns	Nothing.
Description	Determines if the I^{2}C bus is free and issues START signal.
Requires	Software I^{2}C must be configured before using this function. See Soft_I2C_Init routine.

Example

```
' Issue START signal
Soft_I2C_Start()
```

Soft_I2C_Read

Prototype	`sub function Soft_I2C_Read(dim ack as word) as byte`
Returns	One byte from the Slave.
Description	Reads one byte from the slave. Parameters : ■ `ack:` acknowledge signal parameter. If the `ack==0` *not acknowledge* signal will be sent after reading, otherwise the *acknowledge* signal will be sent.
Requires	Soft I^{2}C must be configured before using this function. See Soft_I2C_Init routine. Also, START signal needs to be issued in order to use this function. See Soft_I2C_Start routine.

Example	`dim take as word`
	`...`
	`' Read data and send the not_acknowledge signal`
	`take = Soft_I2C_Read(0)`

Soft_I2C_Write

Prototype	`sub function Soft_I2C_Write(dim _Data as byte) as byte`
Returns	■ `0` if there were no errors. ■ `1` if write collision was detected on the I^{2}C bus.
Description	Sends data byte via the I^{2}C bus. Parameters : ■ `_Data:` data to be sent
Requires	Soft I^{2}C must be configured before using this function. See Soft_I^{2}C_Init routine. Also, START signal needs to be issued in order to use this function. See Soft_I2C_Start routine.

Example	`dim _data, error as byte`
	`...`
	`error = Soft_I2C_Write(data)`
	`error = Soft_I2C_Write(0xA3)`

Soft_I2C_Stop

Prototype	`sub procedure Soft_I2C_Stop()`
Returns	Nothing.
Description	Issues STOP signal.
Requires	Soft I^{2}C must be configured before using this function. See Soft_I^{2}C_Init routine.

Example

```
' Issue STOP signal
Soft_I2C_Stop()
```

Soft_I2C_Break

Prototype	`sub procedure Soft_I2C_Break()`
Returns	Nothing.
Description	All Software I$_2$C Library functions can block the program flow (see note at the top of this page). Calling this routine from interrupt will unblock the program execution. This mechanism is similar to WDT. Note: Interrupts should be disabled before using Software I^{2}C routines again (see note at the top of this page).
Requires	Nothing.

Example

```
dim data1, error_, counter as byte

sub procedure interrupt()
  if (INTCON.T0IF <> 0) then
    if (counter >= 20) then
      Soft_I2C_Break()
      counter = 0              ' reset counter
    end if
    else
      Inc(counter)          ' increment counter
    INTCON.T0IF = 0         ' Clear Timer0 overflow interrupt flag
  end if
end sub

main:
  counter = 0
  OPTION_REG = 0x04          ' TMR0 prescaler set to 1:32

  ...

  ' try Soft_I2C_Init with blocking prevention mechanism
  INTCON.GIE = 1              ' Global interrupt enable
  INTCON.T0IE = 1             ' Enable Timer0 overflow interrupt
  data1 = Soft_I2C_Init(error_)
  INTCON.GIE = 0              ' Global interrupt disable
end.
```

LLibrary Example

The example demonstrates Software I¸C Library routines usage. The PIC MCU is connected (SCL, SDA pins) to PCF8583 RTC (real-time clock). Program reads date and time are read from the RTC and prints it on Lcd.

```
program RTC_Read

dim seconds, minutes, hours, _day, _month, year as byte     ' Global
date/time variables

' Software I2C connections
dim Soft_I2C_Scl   as sbit at RC3_bit
    Soft_I2C_Sda   as sbit at RC4_bit
    Soft_I2C_Scl_Direction as sbit at TRISC3_bit
    Soft_I2C_Sda_Direction as sbit at TRISC4_bit
' End Software I2C connections

' Lcd module connections
dim LCD_RS as sbit at RB4_bit
    LCD_EN as sbit at RB5_bit
    LCD_D4 as sbit at RB0_bit
    LCD_D5 as sbit at RB1_bit
    LCD_D6 as sbit at RB2_bit
    LCD_D7 as sbit at RB3_bit
    LCD_RS_Direction as sbit at TRISB4_bit
    LCD_EN_Direction as sbit at TRISB5_bit
    LCD_D4_Direction as sbit at TRISB0_bit
    LCD_D5_Direction as sbit at TRISB1_bit
    LCD_D6_Direction as sbit at TRISB2_bit
    LCD_D7_Direction as sbit at TRISB3_bit
' End Lcd module connections

'----------------------  Reads  time  and  date  information  from  RTC
(PCF8583)
sub procedure Read_Time()
   Soft_I2C_Start()             ' Issue start signal
  Soft_I2C_Write(0xA0)         ' Address PCF8583, see PCF8583 datasheet
   Soft_I2C_Write(2)            ' Start from address 2
   Soft_I2C_Start()             ' Issue repeated start signal
   Soft_I2C_Write(0xA1)          ' Address PCF8583 for reading R/W=1
   seconds = Soft_I2C_Read(1)  ' Read seconds byte
   minutes = Soft_I2C_Read(1)  ' Read minutes byte
   hours = Soft_I2C_Read(1)    ' Read hours byte
   _day = Soft_I2C_Read(1)     ' Read year/day byte
   _month = Soft_I2C_Read(0)   ' Read weekday/month byte}
   Soft_I2C_Stop()              ' Issue stop signal}
end sub
```

```
'-------------------- Formats date and time
sub procedure Transform_Time()
  seconds  =  ((seconds and 0xF0) >> 4)*10 + (seconds and 0x0F)  '
Transform seconds
  minutes  =  ((minutes and 0xF0) >> 4)*10 + (minutes and 0x0F)   '
Transform months
  hours    =  ((hours and 0xF0)  >> 4)*10  + (hours and 0x0F)     '
Transform hours
  year     =   (_day and 0xC0) >> 6               ' Transform year
  _day      =  ((_day and 0x30) >> 4)*10    + (_day and 0x0F)     '
Transform day
  _month    =  ((_month and 0x10)  >> 4)*10 + (_month and 0x0F)   '
Transform month
end sub

'-------------------- Output values to Lcd
sub procedure Display_Time()
   Lcd_Chr(1, 7, (_day / 10)   + 48)    ' Print tens digit of day
variable
   Lcd_Chr(1, 8, (_day mod 10)   + 48)   ' Print oness digit of day
variable
   Lcd_Chr(1,10, (_month / 10) + 48)
   Lcd_Chr(1,11, (_month mod 10) + 48)
   Lcd_Chr(1,16,  year         + 56)      ' Print year vaiable + 8
(start from year 2008)

   Lcd_Chr(2, 7, (hours / 10)   + 48)
   Lcd_Chr(2, 8, (hours mod 10)   + 48)
   Lcd_Chr(2,10, (minutes / 10) + 48)
   Lcd_Chr(2,11, (minutes mod 10) + 48)
   Lcd_Chr(2,13, (seconds / 10) + 48)
   Lcd_Chr(2,14, (seconds mod 10) + 48)
end sub

'------------------ Performs project-wide init
sub procedure Init_Main()
  TRISB = 0
  PORTB = 0xFF
  TRISB = 0xFF
  ANSEL  = 0                  ' Configure AN pins as digital I/O
  ANSELH = 0
  Soft_I2C_Init()              ' Initialize Soft I2C communication
  Lcd_Init()                  ' Initialize Lcd
  Lcd_Cmd(_LCD_CLEAR)         ' Clear Lcd display
  Lcd_Cmd(_LCD_CURSOR_OFF)    ' Turn cursor off
  Lcd_Out(1,1,"Date:")        ' Prepare and output static text on Lcd
  Lcd_Chr(1,9,":")
  Lcd_Chr(1,12,":")
  Lcd_Out(2,1,"Time:")
  Lcd_Chr(2,9,":")
```

```
    Lcd_Chr(2,12,":")
    Lcd_Out(1,13,"200")
end sub

'------------------ Main sub procedure
main:
  Init_Main()                ' Perform initialization

  while TRUE                 ' Endless loop
    Read_Time()              ' Read time from RTC(PCF8583)
    Transform_Time()         ' Format date and time
    Display_Time()           ' Prepare and display on Lcd
  wend
end.
```

SOFTWARE SPI LIBRARY

The *mikroBasic PRO for PIC* provides routines for implementing Software SPI communication. These routines are hardware independent and can be used with any MCU. The Software SPI Library provides easy communication with other devices via SPI: A/D converters, D/A converters, MAX7219, LTC1290, etc.

Library configuration:

- SPI to Master mode
- Clock value = 20 kHz.
- Data sampled at the middle of interval.
- Clock idle state low.
- Data sampled at the middle of interval.
- Data transmitted at low to high edge.

Note: The Software SPI library implements time-based activities, so interrupts need to be disabled when using it.

External dependencies of Software SPI Library

The following variables must be defined in all projects using Software SPI Library:	Description:	Example :
`dim SoftSpi_SDI as sbit sfr external`	Data In line.	`dim SoftSpi_SDI as sbit at RC4_bit`
`dim SoftSpi_SDO as sbit sfr external`	Data Out line.	`dim SoftSpi_SDO as sbit at RC5_bit`
`dim SoftSpi_CLK as sbit sfr external`	Clock line.	`dim SoftSpi_CLK as sbit at RC3_bit`
`dim SoftSpi_SDI_Direction as sbit sfr external`	Direction of the Data In pin.	`dim SoftSpi_SDI_Direction as sbit at TRISC4_bit`
`dim SoftSpi_SDO_Direction as sbit sfr external`	Direction of the Data Out pin	`dim SoftSpi_SDO_Direction as sbit at TRISC5_bit`
`dim SoftSpi_CLK_Direction as sbit sfr external`	Direction of the Clock pin	`dim SoftSpi_CLK_Direction as sbit at TRISC3_bit`

Library Routines

- Soft_Spi_Init
- Soft_Spi_Read
- Soft_Spi_Write

Soft_Spi_Init

Prototype	`sub procedure Soft_SPI_Init()`
Returns	Nothing.
Description	Configures and initializes the software SPI module.
Requires	Global variables: ■ `Chip_Select`: Chip select line ■ `SoftSpi_SDI:` Data in line ■ `SoftSpi_SDO:` Data out line ■ `SoftSpi_CLK:` Data clock line ■ `Chip_Select_Direction:` Direction of the Chip select pin ■ `SoftSpi_SDI_Direction:` Direction of the Data in pin ■ `SoftSpi_SDO_Direction:` Direction of the Data out pin ■ `SoftSpi_CLK_Direction:` Direction of the Data clock pin must be defined before using this function.

Example

```
' soft_spi pinout definition
dim Chip_Select as sbit at RC1_bit
dim SoftSpi_SDI as sbit at RC4_bit
dim SoftSpi_SDO as sbit at RC5_bit
dim SoftSpi_CLK as sbit at RC3_bit

dim Chip_Select_Direction as sbit at TRISC1_bit
dim SoftSpi_SDI_Direction as sbit at TRISC4_bit
dim SoftSpi_SDO_Direction as sbit at TRISC5_bit
dim SoftSpi_CLK_Direction as sbit at TRISC3_bit
' end of soft_spi pinout definition
...
Soft_SPI_Init()  ' Init Soft_SPI
```

Soft_Spi_Read

Prototype	`sub function Soft_SPI_Read(dim sdata as byte) as word`
Returns	Byte received via the SPI bus.
Description	This routine performs 3 operations simultaneously. It provides clock for the Software SPI bus, reads a byte and sends a byte. Parameters : ■ `sdata:` data to be sent.
Requires	Soft SPI must be initialized before using this function. See Soft_SPI_Init routine.

Example

```
dim data_read as byte
    data_send as byte
...
' Read a byte and assign it to data_read variable
' (data_send byte will be sent via SPI during the Read operation)
data_read = Soft_SPI_Read(data_send)
```

Soft_Spi_Write

Prototype	`sub procedure Soft_SPI_Write(dim sdata as byte)`
Returns	Nothing.
Description	This routine sends one byte via the Software SPI bus. Parameters : ■ `sdata:` data to be sent
Requires	Soft SPI must be initialized before using this function. See Soft_SPI_Init routine.

Example

```
' Write a byte to the Soft SPI bus
Soft_SPI_Write(0xAA)
```

Library Example

This code demonstrates using library routines for Soft_SPI communication. Also, this example demonstrates working with Microchip's MCP4921 12-bit D/A con verter.

```
program Soft_SPI

' DAC module connections
dim Chip_Select as sbit at RC1_bit
    SoftSpi_CLK as sbit at RC3_bit
    SoftSpi_SDI as sbit at RC4_bit
    SoftSpi_SDO as sbit at RC5_bit

dim Chip_Select_Direction as sbit at TRISC1_bit
    SoftSpi_CLK_Direction as sbit at TRISC3_bit
    SoftSpi_SDI_Direction as sbit at TRISC4_bit
    SoftSpi_SDO_Direction as sbit at TRISC5_bit
' End DAC module connections

dim value as word

sub procedure InitMain()
  TRISA0_bit = 1                         ' Set RA0 pin as input
  TRISA1_bit = 1                         ' Set RA1 pin as input
  Chip_Select = 1                        ' Deselect DAC
  Chip_Select_Direction = 0              ' Set CS# pin as Output
  Soft_Spi_Init()                        ' Initialize Soft_SPI
end sub

' DAC increments (0..4095) --> output voltage (0..Vref)
sub procedure DAC_Output(dim valueDAC as word)
dim temp as byte
  Chip_Select = 0                        ' Select DAC chip
   ' Send High Byte
  temp = word(valueDAC >> 8) and 0x0F    ' Store valueDAC[11..8] to
temp[3..0]

  temp = temp or 0x30       ' Define DAC setting, see MCP4921 datasheet
  Soft_SPI_Write(temp)      ' Send high byte via Soft SPI

   ' Send Low Byte
  temp = valueDAC            ' Store valueDAC[7..0] to temp[7..0]
  Soft_SPI_Write(temp)       ' Send low byte via Soft SPI

  Chip_Select = 1            ' Deselect DAC chip
end sub
```

```
main:
  ANSEL = 0
  ANSELH = 0
  InitMain()                       ' Perform main initialization
  value = 2048                     ' When program starts, DAC gives
                                   '  the output in the mid-range
  while (TRUE)                     ' Endless loop
    if ((RA0_bit) and (value < 4095)) then    ' If PA0 button is
pressed
      Inc(value)                               '   increment value
    else
      if ((RA1_bit) and (value > 0)) then   'If PA1 button is pressed
        Dec(value)                            ' decrement value
      end if
    end if

    DAC_Output(value)                      ' Send value to DAC chip
    Delay_ms(1)                            ' Slow down key repeat pace
  wend
end.
```

SOFTWARE UART LIBRARY

mikroBasic provides library which implements software UART. These routines are hardware independent and can be used with any MCU. You can easily communicate with other devices via RS232 protocol – simply use the functions listed below.

Note: This library implements time-based activities, so interrupts need to be disabled when using Soft UART.

Library Routines

- Soft_Uart_Init
- Soft_Uart_Read
- Soft_Uart_Write
- Soft_UART_Break

Soft_UART_Init

Prototype	`sub procedure Soft_UART_Init(dim byref port as byte, dim rx_pin, tx_pin, baud_rate, inverted as byte) as byte`
Returns	■ `2` - error, requested baud rate is too low ■ `1` - error, requested baud rate is too high ■ `0` - successfull initialization
Description	Configures and initializes the software UART module. Parameters : ■ `port:` port to be used. ■ `rx_pin:` sets rx_pin to be used. ■ `tx_pin:` sets tx_pin to be used. ■ `baud_rate:` baud rate to be set. Maximum baud rate depends on the MCU's clock and working conditions. ■ `inverted:` inverted output flag. When set to a non-zero value, inverted logic on output is used. Software UART routines use Delay_Cyc routine. If requested baud rate is too low then calculated parameter for calling `Delay_Cyc` exceeeds `Delay_Cyc` argument range. If requested baud rate is too high then rounding error of `Delay_Cyc` argument corrupts Software UART timings.
Requires	Nothing.

Example	This will initialize software UART and establish the communication at 9600 bps:
	`dim error as byte`
	`...`
	`error = Soft_UART_Init(PORTB, 1, 2, 9600, 0)`

Soft_UART_Read

Prototype	`sub function Soft_UART_Read(dim byref error as byte) as byte`
Returns	Returns a received byte.
Description	Function receives a byte via software UART. Parameter error will be zero if the transfer was successful. This is a non-blocking function call, so you should test the `error` manually (check the example below).
Requires	Soft UART must be initialized and communication established before using this function. See Soft_UART_Init.
Example	Here's a loop which holds until data is received:

```
error = 1
do
  data = Soft_UART_Read(error)
loop until error = 0
```

Soft_Uart_Write

Prototype	`sub procedure Soft_UART_Write(dim data as byte)`
Returns	Nothing.
Description	Function transmits a byte (`data`) via UART.
Requires	Soft UART must be initialized and communication established before using this function. See Soft_UART_Init. Be aware that during transmission, software UART is incapable of receiving data – data transfer protocol must be set in such a way to prevent loss of information.
Example	`Soft_UART_Write($0A)`

Soft_UART_Break

Prototype `sub procedure Soft_UART_Break()`

Returns Nothing.

Description Soft_UART_Read is blocking routine and it can block the program flow. Call this routine from interrupt to unblock the program execution. This mechanism is similar to WDT.

Note: Interrupts should be disabled before using Software UART routines again (see note at the top of this page).

Requires Nothing.

Example

```
dim data1, error_, counter as byte

sub procedure interrupt()
  if (INTCON.T0IF <> 0) then
    if (counter >= 20) then
      Soft_UART_Break()
      counter = 0              ' reset counter
    end if
    else
      Inc(counter)             ' increment counter
    INTCON.T0IF = 0            ' Clear Timer0 overflow interrupt flag
  end if
end sub

main:
  counter = 0
  OPTION_REG = 0x04            ' TMR0 prescaler set to 1:32

  ...

  if (Soft_UART_Init(PORTC, 7, 6, 9600, 0) = 0) then
    Soft_UART_Write(0x55)
  end if

  ...

  ' try Soft_UART_Read with blocking prevention mechanism
  INTCON.GIE = 1               ' Global interrupt enable
  INTCON.T0IE = 1              ' Enable Timer0 overflow interrupt
  data1 = Soft_UART_Read(error_)
 INTCON.GIE = 0                ' Global interrupt disable
end.
```

Library Example

The example demonstrates simple data exchange via software UART. When PIC MCU receives data, it immediately sends the same data back. If PIC is connected to the PC (see the figure below), you can test the example from *mikroBasic PRO for PIC* terminal for RS232 communication, menu choice **Tools › Terminal.**

```
program Soft_UART

dim error_flag as byte
    counter, byte_read as byte    ' Auxiliary variables
main:

  ANSEL  = 0                      ' Configure AN pins as digital I/O
  ANSELH = 0

  TRISB = 0x00                    ' Set PORTB as output (error sig
  nalization)
  PORTB = 0                       ' No error
  VDelay_ms(370)
  error_flag = Soft_UART_Init(PORTC, 7, 6, 14400, 0)  ' Initialize
  Soft UART at 14400 bps
  if (error_flag > 0) then
      PORTB = error_flag           ' Signalize Init error
      while (TRUE)
        nop                        ' Stop program
      wend
    end if
  Delay_ms(100)


  for counter = "z" to "A" step -1   ' Send bytes from 'z' downto 'A'
    Soft_UART_Write(counter)
    Delay_ms(100)
  next counter

  while TRUE                                    ' Endless loop
       byte_read = Soft_UART_Read(error_flag)' Read byte, then test
  error flag
      if (error_flag <> 0) then                ' If error was detected
      PORTB = error_flag                      ' signal it on PORTB
      else
        Soft_UART_Write(byte_read)       ' If error was not detected,
  return byte read
      end if
    wend
end.
```

SOUND LIBRARY

The *mikroBasic PRO for PIC* provides a Sound Library to supply users with routines necessary for sound signalization in their applications. Sound generation needs additional hardware, such as piezo-speaker (example of piezo-speaker interface is given on the schematic at the bottom of this page).

Library Routines

- Sound_Init
- Sound_Play

Sound_Init

Prototype	`sub procedure Sound_Init(dim byref snd_port as byte, dim snd_pin as byte)`
Returns	Nothing.
Description	Configures the appropriate MCU pin for sound generation. Parameters : ■ `snd_port`: sound output port address ■ `snd_pin`: sound output pin
Requires	Nothing.
Example	`Sound_Init(PORTD, 3)   ' Initialize sound at RD3`

Sound_Play

Prototype	`sub procedure Sound_Play(dim freq_in_Hz as word, dim duration_ms as word)`
Returns	Nothing.
Description	Generates the square wave signal on the appropriate pin. Parameters : - `freq_in_Hz:` signal frequency in Hertz (Hz) - `duration_ms:` signal duration in miliseconds (ms)
Requires	In order to hear the sound, you need a piezo speaker (or other hardware) on designated port. Also, you must call Sound_Init to prepare hardware for output before using this function.
Example	`' Play sound of 1KHz in duration of 100ms` `Sound_Play(1000, 100)`

Library Example

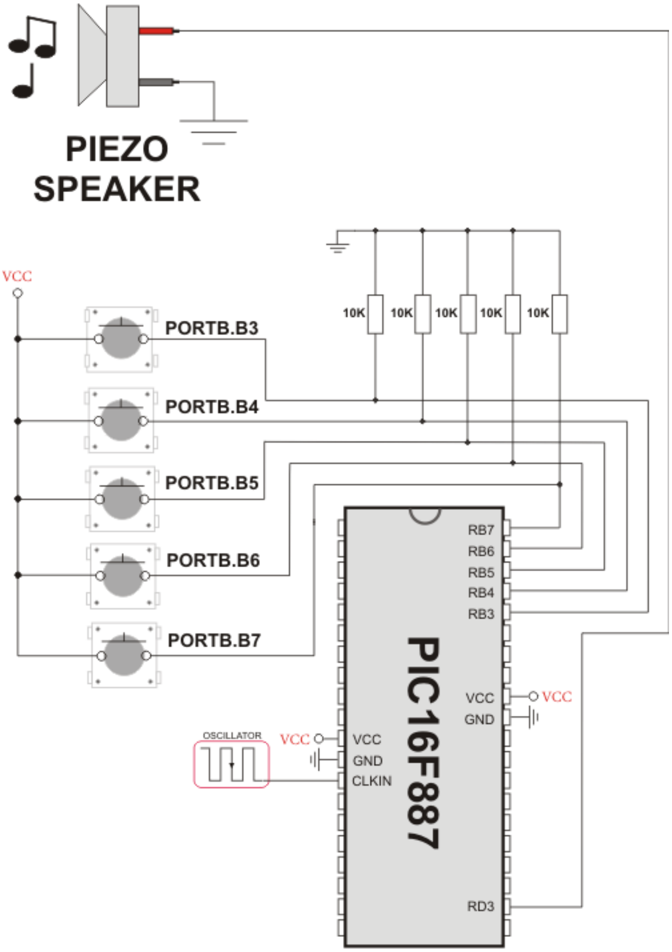
The example is a simple demonstration of how to use the Sound Library for playing tones on a piezo speaker.

```
program Sound

sub procedure Tone1()
    Sound_Play(659, 250)         ' Frequency = 659Hz, duration = 250ms
end sub

sub procedure Tone2()
    Sound_Play(698, 250)          ' Frequency = 698Hz, duration = 250ms
end sub

sub procedure Tone3()
    Sound_Play(784, 250)         ' Frequency = 784Hz, duration = 250ms
end sub

sub procedure Melody()           ' Plays the melody "Yellow house"
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3()
    Tone1() Tone2() Tone3() Tone3()
    Tone1() Tone2() Tone3()
    Tone3() Tone3() Tone2() Tone2() Tone1()
end sub

sub procedure ToneA()              ' Tones used in Melody2 function
```

```
 Sound_Play( 880, 50)
end sub

sub procedure ToneC()
    Sound_Play(1046, 50)
end sub

sub procedure ToneE()
    Sound_Play(1318, 50)
end sub

sub procedure Melody2()                     ' Plays Melody2
dim counter as byte
    for counter = 9 to 1 step -1
        ToneA()
        ToneC()
        ToneE()
    next counter
end sub

main:

  ANSEL  = 0                         ' Configure AN pins as digital I/O
  ANSELH = 0

  C1ON_bit = 0                       ' Disable comparators
  C2ON_bit = 0

  TRISB  = 0xF0                      ' Configure RB7..RB4 as input, RB3
   as output

  Sound_Init(PORTD, 3)
  Sound_Play(880, 5000)

   while TRUE                           ' endless loop
     if (Button(PORTB,7,1,1)) then ' If PORTB.7 is pressed play Tone1
           Tone1()
           while (RB7_bit <> 0)
             nop                     ' Wait for button to be released
           wend
       end if

       if (Button(PORTB,6,1,1)) then ' If PORTB.6 is pressed play
   Tone1
           Tone2()
           while (RB6_bit <> 0)
       nop                             ' Wait for button to be released
           wend
       end if
```

```
      if (Button(PORTB,4,1,1)) then   ' If PORTB.4 is pressed play
  Tone1
          Melody()
          while (RB4_bit <> 0)
           nop                          ' Wait for button to be released
          wend
      end if
    wend
end.
```

HW Connection



Example of Sound Library sonnection

SPI LIBRARY

SPI module is available with a number of PIC MCU models. mikroBasic PRO for PIC provides a library for initializing Slave mode and comfortable work with Master mode. PIC can easily communicate with other devices via SPI: A/D converters, D/A converters, MAX7219, LTC1290, etc. You need PIC MCU with hardware integrated SPI (for example, PIC16F877).

Note: Some PIC18 MCUs have multiple SPI modules. Switching between the SPI modules in the SPI library is done by the SPI_Set_Active function (SPI module has to be previously initialized).

Note: In order to use the desired SPI library routine, simply change the number 1 in the prototype with the appropriate module number, i.e. SPI2_Init()

Library Routines

- Spi_Init
- Spi_Init_Advanced
- Spi_Read
- Spi_Write
- SPI_Set_Active

SPI1_Init

Prototype	`sub procedure SPI1_Init()`
Returns	Nothing.
Description	This routine configures and enables SPI module with the following settings: - master mode - 8 bit data transfer - most significant bit sent first - serial clock low when idle - data sampled on leading edge - serial clock = fosc/4
Requires	MCU must have SPI module.
Example	`' Initialize the SPI module with default settings` `SPI1_Init()`

Spi1_Init_Advanced

<table>
<tr><td>Prototype</td><td><code>sub procedure SPI1_Init_Advanced(dim master_slav, data_sample, clock_idle, transmit_edge as byte)</code></td></tr>
<tr><td>Returns</td><td>Nothing.</td></tr>
<tr><td>Description</td><td>Configures and initializes SPI. <code>SPI1_Init_Advanced</code> or <code>SPI1_Init</code> needs to be called before using other functions of SPI Library.
Parameters <code>mode, data_sample</code> and <code>clock_idle</code> configure the SPI module, and can have the following values:
<table>
<tr><th>Description</th><th>Predefined library const</th></tr>
<tr><td colspan="2">SPI work mode:</td></tr>
<tr><td><code>Master clock = Fosc/4</code></td><td><code>_MASTER_OSC_DIV4</code></td></tr>
<tr><td><code>Master clock = Fosc/16</code></td><td><code>_MASTER_OSC_DIV16</code></td></tr>
<tr><td><code>Master clock = Fosc/64</code></td><td><code>_MASTER_OSC_DIV64</code></td></tr>
<tr><td><code>Master clock source TMR2</code></td><td><code>_MASTER_TMR2</code></td></tr>
<tr><td><code>Slave select enabled</code></td><td><code>_SLAVE_SS_ENABLE</code></td></tr>
<tr><td><code>Slave select disabled</code></td><td><code>_SLAVE_SS_DIS</code></td></tr>
<tr><td colspan="2">Data sampling interval:</td></tr>
<tr><td><code>Input data sampled in middle of interval</code></td><td><code>_DATA_SAMPLE_MIDDLE</code></td></tr>
<tr><td><code>Input data sampled at the end of interval</code></td><td><code>_DATA_SAMPLE_END</code></td></tr>
<tr><td colspan="2">SPI clock idle state:</td></tr>
<tr><td><code>Clock idle HIGH</code></td><td><code>_CLK_IDLE_HIGH</code></td></tr>
<tr><td><code>Clock idle LOW</code></td><td><code>_CLK_IDLE_LOW</code></td></tr>
<tr><td colspan="2">Transmit edge:</td></tr>
<tr><td><code>Data transmit on low to high edgefirst</code></td><td><code>_LOW_2_HIGH</code></td></tr>
<tr><td><code>Data transmit on high to low edge _HIGH_2_LOW</code></td><td><code>_HIGH_2_LOW</code></td></tr>
</table></td></tr>
<tr><td>Requires</td><td>MCU must have SPI module.</td></tr>
<tr><td>Example</td><td><code>' Set SPI to master mode, clock = Fosc/4, data sampled at the middle of interval, clock idle state low and data transmitted at low to high edge:</code>
<code>SPI1_Init_Advanced(_MASTER_OSC_DIV4, _DATA_SAMPLE_MIDDLE, _CLK_IDLE_LOW, _LOW_2_HIGH)</code></td></tr>
</table>

Spi1_Read

Prototype	`sub function SPI1_Read(dim buffer as byte) as byte`
Returns	Received data.
Description	Reads one byte from the SPI bus. Parameters : ■ `buffer:` dummy data for clock generation (see device Datasheet for SPI modules implementation details)
Requires	SPI module must be initialized before using this function. See SPI1_Init and SPI1_Init_Advanced routines.

Example	`' read a byte from the SPI bus`
	`dim take, dummy1 as byte`
	`...`
	`take = SPI1_Read(dummy1)`

Spi1_Write

Prototype	`sub procedure SPI1_Write(dim wrdata as byte)`
Returns	Nothing.
Description	Writes byte via the SPI bus. Parameters : ■ `wrdata:` data to be sent
Requires	SPI module must be initialized before using this function. See SPI1_Init and SPI1_Init_Advanced routines.

Example	`' write a byte to the SPI bus`
	`dim buffer as byte`
	`...`
	`SPI1_Write(buffer)`

SPI_Set_Active

Prototype	`void SPI_Set_Active(char (*read_ptr)(char))`
Returns	Nothing.
Description	Sets the active SPI module which will be used by the SPI routines. Parameters : ■ `read_ptr:` SPI1_Read handler
Requires	Routine is available only for MCUs with two SPI modules. Used SPI module must be initialized before using this function. See the SPI1_Init, SPI1_Init_Advanced
Example	`SPI_Set_Active(SPI2_Read) ' Sets the SPI2 module active`

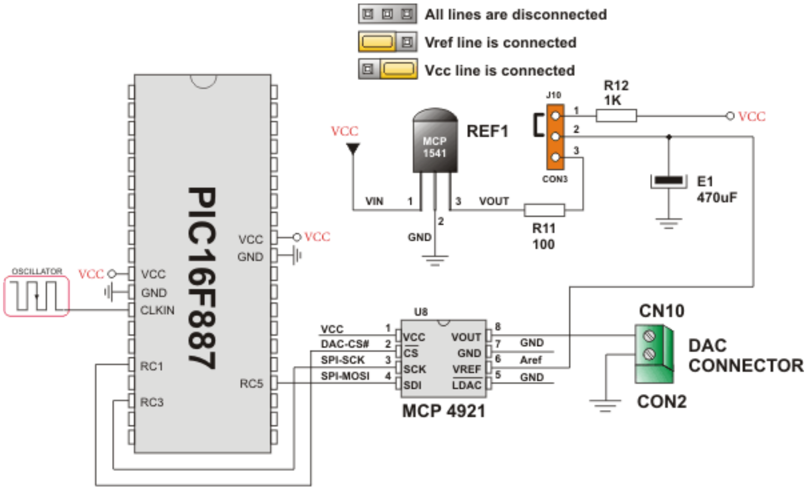
Library Example

The code demonstrates how to use SPI library functions for communication between SPI module of the MCU and Microchip's MCP4921 12-bit D/A converter

```
program SPI

' DAC module connections
dim Chip_Select as sbit at RC1_bit
    Chip_Select_Direction as sbit at TRISC1_bit
' End DAC module connections

dim value as word

sub procedure InitMain()
  TRISA0_bit = 1                           ' Set RA0 pin as input
  TRISA1_bit = 1                           ' Set RA1 pin as input
  Chip_Select = 1                          ' Deselect DAC
  Chip_Select_Direction = 0                ' Set CS# pin as Output
  SPI1_Init()                              ' Initialize SPI1 module
end sub

' DAC increments (0..4095) --> output voltage (0..Vref)
sub procedure DAC_Output(dim valueDAC as word)
dim temp as byte
  Chip_Select = 0                        ' Select DAC chip

' Send High Byte
  temp = word(valueDAC >> 8) and 0x0F   ' Store valueDAC[11..8] to
temp[3..0]
  temp = temp or 0x30   ' Define DAC setting, see MCP4921 datasheet
```

```
    SPI1_Write(temp)      ' Send high byte via SPI

  ' Send Low Byte
  temp = valueDAC       ' Store valueDAC[7..0] to temp[7..0]
  SPI1_Write(temp)      ' Send low byte via SPI

  Chip_Select = 1       ' Deselect DAC chip
end sub

main:
  ANSEL = 0
  ANSELH = 0
  InitMain()             ' Perform main initialization
  value = 2048           ' When program starts, DAC gives
                         ' the output in the mid-range
  while TRUE             ' Endless loop
   if ((RA0_bit) and (value < 4095)) then  ' If RA0 button is pressed
      Inc(value)                           ' increment value
    else
     if ((RA1_bit) and (value > 0)) then   ' If RA1 button is pressed
        Dec(value)                         ' decrement value
      end if
    end if

    DAC_Output(value)               ' Send value to DAC chip
    Delay_ms(1)                    ' Slow down key repeat pace
  wend
end.
```

HW Connection



SPI HW connection

SPI ETHERNET LIBRARY

The `ENC28J60` is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI™). It is designed to serve as an Ethernet network interface for any controller equipped with SPI.

The `ENC28J6`0 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted IP checksum calculations. Communication with the host controller is implemented via two interrupt pins and the SPI, with data rates of up to 10 Mb/s. Two dedicated pins are used for LED link and network activity indication.

This library is designed to simplify handling of the underlying hardware (`ENC28J60`). It works with any PIC with integrated SPI and more than 4 Kb ROM memory. 38 to 40 MHz clock is recommended to get from 8 to 10 Mhz SPI clock, otherwise PIC should be clocked by `ENC28J60` clock output due to its silicon bug in SPI hardware. If you try lower PIC clock speed, there might be board hang or miss some requests.

SPI Ethernet library supports:

- IPv4 protocol.
- ARP requests.
- ICMP echo requests.
- UDP requests.
- TCP requests (no stack, no packet reconstruction).
- ARP client with cache.
- DNS client.
- UDP client.
- DHCP client.
- packet fragmentation is **NOT** supported.

Note: Due to PIC16 RAM/Flash limitations pic16 library does **NOT** have ARP, DNS, UDP and DHCP client support implemented.

Note: Global library variable `SPI_Ethernet_userTimerSec` is used to keep track of time for all client implementations (ARP, DNS, UDP and DHCP). It is user responsibility to increment this variable each second in it's code if any of the clients is used.

Note: For advanced users there are header files (`"eth_enc28j60LibDef.h"` and `"eth_enc28j60LibPrivate.h"`) in Uses\P16 and Uses\P18 folders of the compiler with description of all routines and global variables, relevant to the user, implemented in the SPI Ethernet Library.

Note: The appropriate hardware SPI module must be initialized before using any of the SPI Ethernet library routines. Refer to SPI Library.
For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.

External dependencies of SPI Ethernet Library

The following variables must be defined in all projects using SPI Ethernet Library:	Description:	Example :
`dim SPI_Ethernet_CS as sbit sfr external`	ENC28J60 chip select pin.	`dim SPI_Ethernet_CS as sbit at RC1_bit`
`dim SPI_Ethernet_RST as sbit sfr external`	ENC28J60 reset pin.	`dim SPI_Ethernet_RST as sbit at RC0_bit`
`dim SPI_Ethernet_CS_Direction as sbit sfr external`	Direction of the ENC28J60 chip select pin.	`dim SPI_Ethernet_CS_Direction as sbit at TRISC1_bit`
`dim SPI_Ethernet_RST_Direction as sbit sfr external`	Direction of the ENC28J60 reset pin.	`dim SPI_Ethernet_RST_Direction as sbit at TRISC0_bit`

The following routines must be defined in all project using SPI Ethernet Library:	Description:	Example :
`sub function SPI_Ethernet_UserTCP (dim remoteHost as ^byte, dim remotePort as word, dim localPort as word, dim reqLength as word) as word`	TCP request handler.	Refer to the library example at the bottom of this page for code implementation.
`sub function SPI_Ethernet_UserUDP(dim remoteHost as ^byte, dim remotePort as word, dim destPort as word, dim reqLength as word) as word`	UDP request handler.	Refer to the library example at the bottom of this page for code implementation.

Library Routines

- SPI_Ethernet_Init
- SPI_Ethernet_Enable
- SPI_Ethernet_Disable
- SPI_Ethernet_doPacket
- SPI_Ethernet_putByte
- SPI_Ethernet_putBytes
- SPI_Ethernet_putString
- SPI_Ethernet_putConstString
- SPI_Ethernet_putConstBytes
- SPI_Ethernet_getByte
- SPI_Ethernet_getBytes
- SPI_Ethernet_UserTCP
- SPI_Ethernet_UserUDP

SPI_Ethernet_Init

Prototype	`sub procedure SPI_Ethernet_Init(dim mac as ^byte, dim ip as ^byte, dim fullDuplex as byte)`
Returns	Nothing.
Description	This is MAC module routine. It initializes ENC28J60 controller. This function is internaly splited into 2 parts to help linker when coming short of memory. `ENC28J60` controller settings (parameters not mentioned here are set to default): ■ receive buffer start address : 0x0000. ■ receive buffer end address : 0x19AD. ■ transmit buffer start address: 0x19AE. ■ transmit buffer end address : 0x1FFF. ■ RAM buffer read/write pointers in auto-increment mode. ■ receive filters set to default: CRC + MAC Unicast + MAC Broadcast in OR mode. ■ flow control with TX and RX pause frames in full duplex mode. ■ frames are padded to 60 bytes + CRC. ■ maximum packet size is set to `1518.` ■ Back-to-Back Inter-Packet Gap: 0x15 in full duplex mode; 0x12 in half duplex mode. ■ Non-Back-to-Back Inter-Packet Gap: `0x0012` in full duplex mode; `0x0C12` in half duplex mode. ■ Collision window is set to 63 in half duplex mode to accomodate some `ENC28J60` revisions silicon bugs. ■ CLKOUT output is disabled to reduce EMI generation.

Description	■ half duplex loopback disabled. ■ LED configuration: default (LEDA-link status, LEDB-link activity). Parameters: ■ `mac:` RAM buffer containing valid MAC address. ■ `ip:` RAM buffer containing valid IP address. ■ `fullDuplex:` ethernet duplex mode switch. Valid values: `0` (half duplex mode) and `1` (full duplex mode).
Requires	Global variables : ■ `SPI_Ethernet_CS:` Chip Select line ■ `SPI_Ethernet_CS_Direction`: Direction of the Chip Select pin ■ `SPI_Ethernet_RST: Reset line` ■ `SPI_Ethernet_RST_Direction:` Direction of the Reset pin must be defined before using this function. The SPI module needs to be initialized. See the SPI1_Init and SPI1_Init_Advanced routines.

Example

```
' mE ehternet NIC pinout
dim SPI_Ethernet_RST as sbit at RC0_bit
dim SPI_Ethernet_CS as sbit at RC1_bit
dim SPI_Ethernet_RST_Direction as sbit at TRISC0_bit
dim SPI_Ethernet_CS_Direction as sbit at TRISC1_bit
' end mE ehternet NIC pinout

const SPI_Ethernet_HALFDUPLEX = 0
const SPI_Ethernet_FULLDUPLEX = 1

  myMacAddr as byte[ 6]  ' my MAC address
  myIpAddr  as byte[ 4]  ' my IP addr
  ...
  myMacAddr[ 0]  = 0x00
  myMacAddr[ 1]  = 0x14
  myMacAddr[ 2]  = 0xA5
  myMacAddr[ 3]  = 0x76
  myMacAddr[ 4]  = 0x19
  myMacAddr[ 5]  = 0x3F

  myIpAddr[ 0]   = 192
  myIpAddr[ 1]   = 168
  myIpAddr[ 2]   = 20
  myIpAddr[ 3]   = 60

 SPI1_Init()
 SPI_Ethernet_Init(myMacAddr, myIpAddr, SPI_Ethernet_FULLDUPLEX)
```

SPI_Ethernet_Enable

<table>
<tr><td>Prototype</td><td><code>sub procedure SPI_Ethernet_Enable(dim enFlt as byte)</code></td></tr>
<tr><td>Returns</td><td>Nothing.</td></tr>
<tr><td>Description</td><td>
<p>This is MAC module routine. This routine enables appropriate network traffic on the <code>ENC28J60</code> module by the means of it's receive filters (unicast, multicast, broadcast, crc). Specific type of network traffic will be enabled if a corresponding bit of this routine's input parameter is set. Therefore, more than one type of network traffic can be enabled at the same time. For this purpose, predefined library constants (see the table below) can be ORed to form appropriate input value.</p>
<p>Parameters:</p>
<code>enFlt:</code> network traffic/receive filter flags. Each bit corresponds to the appropriate network traffic/receive filter:
<table>
<tr><th>Bit</th><th>Mask</th><th>Description</th><th>Predefined library const</th></tr>
<tr><td>0</td><td>0x01</td><td>MAC Broadcast traffic/receive filter flag. When set, MAC broadcast traffic will be enabled.</td><td>_SPI_Ethernet_BROADCAST</td></tr>
<tr><td>1</td><td>0x02</td><td>MAC Multicast traffic/receive filter flag. When set, MAC multicast traffic will be enabled.</td><td>_SPI_Ethernet_MULTICAST</td></tr>
<tr><td>2</td><td>0x04</td><td>not used</td><td>none</td></tr>
<tr><td>3</td><td>0x08</td><td>not used</td><td>none</td></tr>
<tr><td>4</td><td>0x10</td><td>not used</td><td>none</td></tr>
<tr><td>5</td><td>0x20</td><td>CRC check flag. When set, packets with invalid CRC field will be discarded.</td><td>_SPI_Ethernet_CRC</td></tr>
<tr><td>6</td><td>0x40</td><td>not used</td><td>none</td></tr>
<tr><td>7</td><td>0x80</td><td>MAC Unicast traffic/receive filter flag. When set, MAC unicast traffic will be enabled.</td><td>_SPI_Ethernet_UNICAST</td></tr>
</table>
<p>Note: Advance filtering available in the <code>ENC28J60</code> module such as <code>Pattern Match</code>, <code>Magic Packet</code> and <code>Hash Table</code> can not be enabled by this routine. Additionaly, all filters, except CRC, enabled with this routine will work in OR mode, which means that packet will be received if any of the enabled filters accepts it.</p>
</td></tr>
</table>

Description	**Note:** This routine will change receive filter configuration on-the-fly. It will not, in any way, mess with enabling/disabling receive/transmit logic or any other part of the `ENC28J60` module. The `ENC28J60` module should be properly cofigured by the means of SPI_Ethernet_Init routine.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	`SPI_Ethernet_Enable(_SPI_Ethernet_CRC or _SPI_Ethernet_UNICAST) ' enable CRC checking and Unicast traffic`

SPI_Ethernet_Disable

Prototype	`sub procedure SPI_Ethernet_Disable(dim disFlt as byte)`
Returns	Nothing.

Description

This is MAC module routine. This routine disables appropriate network traffic on the ENC28J60 module by the means of it's receive filters (unicast, multicast, broadcast, crc). Specific type of network traffic will be disabled if a corresponding bit of this routine's input parameter is set. Therefore, more than one type of network traffic can be disabled at the same time. For this purpose, predefined library constants (see the table below) can be ORed to form appropriate input value.

Parameters:

- `disFlt:` network traffic/receive filter flags. Each bit corresponds to the appropriate network traffic/receive filter:

Bit	Mask	Description	Predefined library const
0	0x01	MAC Broadcast traffic/receive filter flag. When set, MAC broadcast traffic will be disabled.	`_SPI_Ethernet_BROADCAST`
1	0x02	MAC Multicast traffic/receive filter flag. When set, MAC multicast traffic will be disabled.	`_SPI_Ethernet_MULTICAST`
2	0x04	not used	none
3	0x08	not used	none
4	0x10	not used	none
5	0x20	CRC check flag. When set, CRC check will be disabled and packets with invalid CRC field will be accepted.	`_SPI_Ethernet_CRC`
6	0x40	not used	none
7	0x80	MAC Unicast traffic/receive filter flag. When set, MAC unicast traffic will be disabled.	`_SPI_Ethernet_UNICAST`

Description	**Note:** Advance filtering available in the `ENC28J60` module such as `Pattern Match`, `Magic Packet` and `Hash Table` can not be disabled by this routine. **Note:** This routine will change receive filter configuration on-the-fly. It will not, in any way, mess with enabling/disabling receive/transmit logic or any other part of the `ENC28J60` module. The `ENC28J60` module should be properly cofigured by the means of SPI_Ethernet_Init routine.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	`SPI_Ethernet_Disable(_SPI_Ethernet_CRC or _SPI_Ethernet_UNICAST) ' disable CRC checking and Unicast traffic`

SPI_Ethernet_doPacket

Prototype	`sub function SPI_Ethernet_doPacket() as byte`
Returns	■ `0` - upon successful packet processing (zero packets received or received packet processed successfully). ■ `1` - upon reception error or receive buffer corruption. ENC28J60 controller needs to be restarted. ■ `2` - received packet was not sent to us (not our IP, nor IP broadcast address). ■ `3` - received IP packet was not IPv4 ■ `4` - received packet was of type unknown to the library.
Description	This is MAC module routine. It processes next received packet if such exists. Packets are processed in the following manner: ■ ARP & ICMP requests are replied automatically. ■ upon TCP request the SPI_Ethernet_UserTCP function is called for further processing. ■ upon UDP request the SPI_Ethernet_UserUDP function is called for further processing. **Note:** `SPI_Ethernet_doPacket` must be called as often as possible in user's code.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	

```
while TRUE
  ...
  SPI_Ethernet_doPacket() ' process received packets
  ...
wend
```

SPI_Ethernet_putByte

Prototype	`sub procedure SPI_Ethernet_putByte(dim v as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores one byte to address pointed by the current `ENC28J60` write pointer (`EWRPT`). Parameters: - `v:` value to store
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	See below.

Example

```
dim data as byte
...
SPI_Ethernet_putByte(data)  ' put an byte into ENC28J60 buffer
```

SPI_Ethernet_putBytes

Prototype	`sub procedure SPI_Ethernet_putBytes(dim ptr as ^byte, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores requested number of bytes into ENC28J60 RAM starting from current ENC28J60 write pointer (EWRPT) location. Parameters: - `ptr:` RAM buffer containing bytes to be written into `ENC28J60` RAM. - `n:` number of bytes to be written.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	See below.

Example

```
dim
  buffer as byte[ 17]
  ...
  buffer = "mikroElektronika"
  ...
  SPI_Ethernet_putBytes(buffer, 16)  ' put an RAM array into
ENC28J60 buffer
```

SPI_Ethernet_putConstBytes

Prototype	`sub procedure SPI_Ethernet_putConstBytes(const ptr as ^byte, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It stores requested number of const bytes into `ENC28J60` RAM starting from current `ENC28J60` write pointer (`EWRPT`) location. Parameters: ■ `ptr:` const buffer containing bytes to be written into `ENC28J60` RAM. ■ `n:` number of bytes to be written.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	

```
const
  buffer as byte[17]
  ...
  buffer = "mikroElektronika"
  ...
  SPI_Ethernet_putConstBytes(buffer, 16)  ' put a const array into ENC28J60 buffer
```

SPI_Ethernet_putString

Prototype	`sub function SPI_Ethernet_putString(dim ptr as ^byte) as word`
Returns	Number of bytes written into `ENC28J60` RAM.
Description	This is MAC module routine. It stores whole string (excluding null termination) into `ENC28J60` RAM starting from current `ENC28J60` write pointer (`EWRPT`) location. Parameters: ■ `ptr:` string to be written into `ENC28J60` RAM.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	

```
dim
  buffer as string[16]
  ...
  buffer = "mikroElektronika"
  ...
  SPI_Ethernet_putString(buffer)  ' put a RAM string into ENC28J60 buffer
```

SPI_Ethernet_putConstString

Prototype	`sub function SPI_Ethernet_putConstString(const ptr as ^byte) as word`
Returns	Number of bytes written into `ENC28J60` RAM.
Description	This is MAC module routine. It stores whole const string (excluding null termination) into `ENC28J60` RAM starting from current `ENC28J60` write pointer (`EWRPT`) location. Parameters: ■ `ptr:` const string to be written into `ENC28J60` RAM.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	

```
const
  buffer as string[ 16]
  ...
  buffer = "mikroElektronika"
  ...
  SPI_Ethernet_putConstString(buffer)  ' put a const string into
ENC28J60 buffer
```

SPI_Ethernet_getByte

Prototype	`sub function SPI_Ethernet_getByte() as byte`
Returns	Byte read from `ENC28J60` RAM.
Description	This is MAC module routine. It fetches a byte from address pointed to by current `ENC28J60` read pointer (`ERDPT`).
Requires	Ethernet module has to be initialized. See Spi_Ethernet_Init.
Example	

```
dim buffer as byte<>
...
buffer = SPI_Ethernet_getByte()  ' read a byte from ENC28J60
buffer
```

SPI_Ethernet_getBytes

Prototype	`sub procedure SPI_Ethernet_getBytes(dim ptr as ^byte, dim addr as word, dim n as byte)`
Returns	Nothing.
Description	This is MAC module routine. It fetches equested number of bytes from `ENC28J60` RAM starting from given address. If value of `0xFFFF` is passed as the address parameter, the reading will start from current `ENC28J60` read pointer (`ERDPT`) location. Parameters: ■ `ptr:` buffer for storing bytes read from `ENC28J60` RAM. ■ `addr:` `ENC28J60` RAM start address. Valid values: `0..8192`. ■ `n:` number of bytes to be read.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	

```
dim
  buffer as byte[ 16]
  ...
  SPI_Ethernet_getBytes(buffer, 0x100, 16) ' read 16 bytes,
starting from address 0x100
```

SPI_Ethernet_UserTCP

Prototype	`sub function SPI_Ethernet_UserTCP(dim remoteHost as ^byte, dim remotePort as word, dim localPort as word, dim reqLength as word) as word`
Returns	■ `0` - there should not be a reply to the request. ■ Length of TCP/HTTP reply data field - otherwise.
Description	This is TCP module routine. It is internally called by the library. The user accesses to the TCP/HTTP request by using some of the SPI_Ethernet_get routines. The user puts data in the transmit buffer by using some of the SPI_Ethernet_put routines. The function must return the length in bytes of the TCP/HTTP reply, or 0 if there is nothing to transmit. If there is no need to reply to the TCP/HTTP requests, just define this function with return(0) as a single statement. Parameters: ■ `remoteHost` : client's IP address. ■ `remotePort` : client's TCP port. ■ `localPort` : port to which the request is sent. ■ `reqLength` : TCP/HTTP request data field length. **Note:** The function source code is provided with appropriate example projects. The code should be adjusted by the user to achieve desired reply.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	This function is internally called by the library and should not be called by the user's code.

SPI_Ethernet_UserUDP

Prototype	`sub function SPI_Ethernet_UserUDP(dim remoteHost as ^byte, dim remotePort as word, dim destPort as word, dim reqLength as word) as word`
Returns	■ `0` - there should not be a reply to the request. ■ Length of UDP reply data field - otherwise.
Description	This is UDP module routine. It is internally called by the library. The user accesses to the UDP request by using some of the SPI_Ethernet_get routines. The user puts data in the transmit buffer by using some of the SPI_Ethernet_put routines. The function must return the length in bytes of the UDP reply, or 0 if nothing to transmit. If you don't need to reply to the UDP requests, just define this function with a return(0) as single statement. Parameters: ■ `remoteHost` : client's IP address. ■ `remotePort` : client's port. ■ `destPort` : port to which the request is sent. ■ `reqLength` : UDP request data field length. **Note:** The function source code is provided with appropriate example projects. The code should be adjusted by the user to achieve desired reply.
Requires	Ethernet module has to be initialized. See SPI_Ethernet_Init.
Example	This function is internally called by the library and should not be called by the user's code.

Library Example

This code shows how to use the PIC mini Ethernet library :

- the board will reply to ARP & ICMP echo requests
- the board will reply to UDP requests on any port : returns the request in upper char with a header made of remote host IP & port number
- the board will reply to HTTP requests on port 80, GET method with path names
  / will return the HTML main page
  /s will return board status as text string
  /t0 ... /t7 will toggle P3.b0 to P3.b7 bit and return HTML main page
  all other requests return also HTML main page.

Main program code:

```
program enc_ethernet

' ***********************************
' * RAM variables
' *
dim myMacAddr as byte[6]    ' my MAC address
    myIpAddr  as byte[4]    ' my IP address

' mE ehternet NIC pinout
  SPI_Ethernet_Rst as sbit at RC0_bit
  SPI_Ethernet_CS  as sbit at RC1_bit
  SPI_Ethernet_Rst_Direction as sbit at TRISC0_bit
  SPI_Ethernet_CS_Direction  as sbit at TRISC1_bit
' end ethernet NIC definitions

' ************************************************************
' * ROM constant strings
' *
const httpHeader as string[31]  = "HTTP/1.1 200 OK"+chr(10)+"Content-
type: "   ' HTTP header
const  httpMimeTypeHTML  as  string[13]  =  "text/html"+chr(10)+chr(10)
' HTML MIME type
const httpMimeTypeScript as string[14]  = "text/plain"+chr(10)+chr(10)
' TEXT MIME type
const httpMethod as string[5]           = "GET /"

' *
' * web page, splited into 2 parts :
' * when coming short of ROM, fragmented data is handled more effi-
ciently by linker
' *
' * this HTML page calls the boards to get its status, and builds
itself with javascript
' *
const indexPage as string[763]  =
                "<meta http-equiv=" + Chr(34) + "refresh"  + Chr(34)
+ " content="  + Chr(34) + "3;url=http://192.168.20.60"  + Chr(34)
+ ">" +
                 "<HTML><HEAD></HEAD><BODY>"+
                 "<h1>PIC + ENC28J60 Mini Web Server</h1>"+
                 "<a href=/>Reload</a>"+
                 "<script src=/s></script>"+
                 "<table><tr><td valign=top><table border=1
style="+chr(34)+"font-size:20px ;font-family: terminal
;"+chr(34)+"> "+
                  "<tr><th colspan=2>ADC</th></tr>"+
                  "<script>"+
                   "var str,i;"+
                   "str="+chr(34)+chr(34)+"; "+
```

```
                 "for(i=0;i<8;i++)"+
                 "{str+="+chr(34)+"<tr><td bgcolor=pink>BUTTON#"+chr(34)
+"+i+"+chr(34)+"</td>"+chr(34)+"; "+
                 "if(PORTB&(1<<i)){str+="+chr(34)+"<td  bgcolor=red>ON"+
   chr(34)+";}"
                 "else {str+="+chr(34)+"<td bgcolor=#cccccc>OFF"+chr(34)
+";}"+
                 "str+="+chr(34)+"</td></tr>"+chr(34)+";}"+
                 "document.write(str) ;"+
                 "</script>"

const indexPage2 as string[470] =
                 "</table></td><td>"+
                 "<table border=1 style="+chr(34)+"font-size:20px ;font-
family: terminal ;"+chr(34)+"> "+
                  "<tr><th colspan=3>PORTD</th></tr>"+
                  "<script>"+
                   "var str,i;"+
                   "str="+chr(34)+chr(34)+"; "+
                   "for(i=0;i<8;i++)"+
                   "{str+="+chr(34)+"<tr><td        bgcolor=yellow>LED
#"+chr(34)+"+i+"+chr(34)+"</td>"+chr(34)+"; "+
                    "if(PORTD&(1<<i)){str+="+chr(34)+"<td     bgcolor=
red>ON"+chr(34)+";}"+
                    "else  {str+="+chr(34)+"<td  bgcolor=#cccccc>  OFF"+
chr(34)+";}"+
                     "str+="+chr(34)+"</td><td><a  href=/t"+chr(34)+"+i+
"+chr(34)+">Toggle</a></td></tr>"+chr(34)+";}"+
                    "document.write(str) ;"+
                    "</script>"+
                    "</table></td></tr></table>"+
                    "This is HTTP request #<script>document.write(REQ)
</script></BODY></HTML>"

dim   getRequest  as byte[15]     ' HTTP request buffer
      dyna        as byte[30]     ' buffer for dynamic response
      httpCounter as word         ' counter of HTTP requests
      tmp         as string[11]

' *******************************************
' * user defined sub functions
' *

' *
' * this sub function is called by the library
' * the user accesses to the HTTP request by successive calls to
SPI_Ethernet_getByte()
' * the user puts data in the transmit buffer by successive calls to
SPI_Ethernet_putByte()
```

```
' * the sub function must return the length in bytes of the HTTP
reply, or 0 if nothing to transmit
' *
' * if you don"t need to reply to HTTP requests,
' * just define this sub function with a return(0) as single state-
ment
' *
' *


sub function Spi_Ethernet_UserTCP(dim byref remoteHost as byte[4],
                                  dim remotePort, localPort, reqLength
as word) as word
  dim
       i    as word                         ' general purpose integer
       bitMask as byte                      ' for bit mask

  result = 0

  if(localPort <> 80) then ' I listen only to web request on port 80
    result = 0
    exit
  end if

  ' get 10 first bytes only of the request, the rest does not mat-
ter here
  for i = 0 to 10
    getRequest[i] = Spi_Ethernet_getByte()
  next i
  getRequest[i] = 0

  ' copy httpMethod to ram for use in memcmp routine
  for i = 0 to 4
    tmp[i] = httpMethod[i]
  next i

  if(memcmp(@getRequest, @tmp, 5) <> 0) then  ' only GET method is
supported here
      result = 0
      exit
  end if

Inc(httpCounter)                              ' one more request done

  if(getRequest[5] = "s") then          ' if request path name starts
with s, store dynamic data in transmit buffer
      ' the text string replied by this request can be interpreted
as javascript statements
      ' by browsers
```

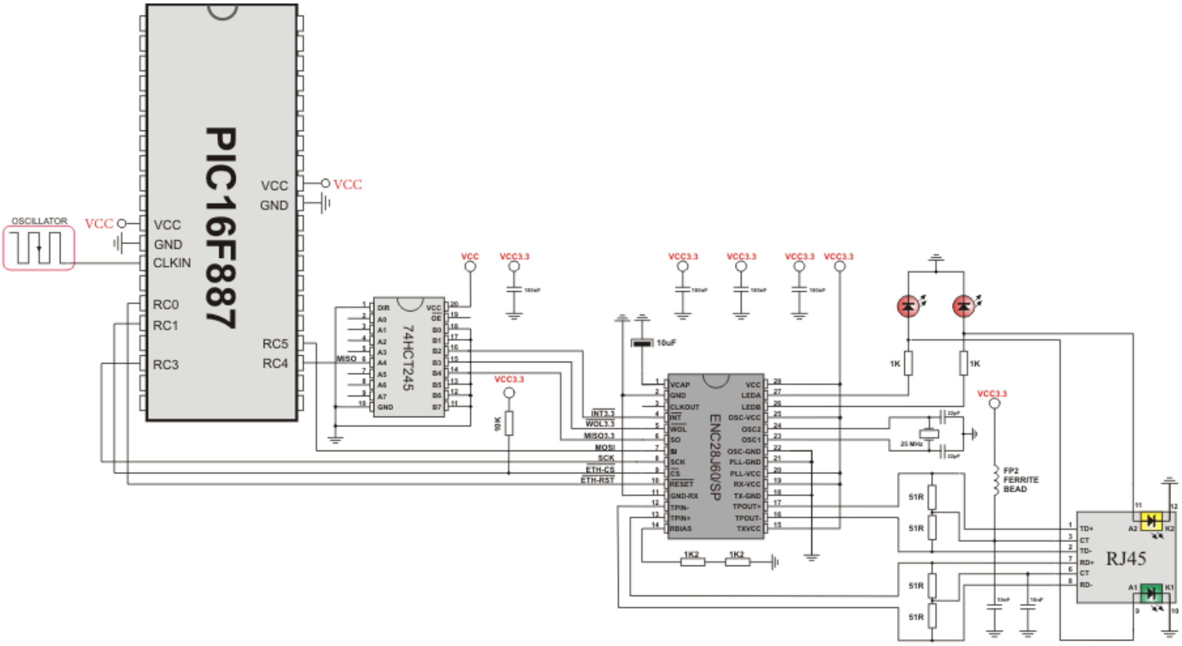
```
      result      =      SPI_Ethernet_putConstString(@httpHeader)
' HTTP header
      result=result  +  SPI_Ethernet_putConstString(@httpMimeType
Script)  ' with text MIME type

      ' add AN2 value to reply
      WordToStr(ADC_Read(2), dyna)
      tmp = "var AN2="
      result = result + SPI_Ethernet_putString(@tmp)
      result = result + SPI_Ethernet_putString(@dyna)
      tmp = ";"
      result = result + SPI_Ethernet_putString(@tmp)

      ' add AN3 value to reply
      WordToStr(ADC_Read(3), dyna)
      tmp = "var AN3="
      result = result + SPI_Ethernet_putString(@tmp)
      result = result + SPI_Ethernet_putString(@dyna)
      tmp = ";"
      result = result + SPI_Ethernet_putString(@tmp)

      ' add PORTB value (buttons) to reply
      tmp = "var PORTB= "
      result = result + SPI_Ethernet_putString(@tmp)
      WordToStr(PORTB, dyna)
      result = result + SPI_Ethernet_putString(@dyna)
      tmp = ";"
      result = result + SPI_Ethernet_putString(@tmp)

      ' add PORTD value (LEDs) to reply
      tmp = "var PORTD= "
      result = result + SPI_Ethernet_putString(@tmp)
      WordToStr(PORTD, dyna)
      result = result + SPI_Ethernet_putString(@dyna)
      tmp = ";"
      result = result + SPI_Ethernet_putString(@tmp)

      ' add HTTP requests counter to reply
      WordToStr(httpCounter, dyna)
      tmp = "var REQ=   "
      result = result + SPI_Ethernet_putString(@tmp)
      result = result + SPI_Ethernet_putString(@dyna)
      tmp = ";"
      result = result + SPI_Ethernet_putString(@tmp)
else
    if(getRequest[5]  = "t") then   ' if request path name starts with
t, toggle PORTD (LED) bit number that comes after
      bitMask = 0
     if(isdigit(getRequest[6]) <> 0) then   ' if 0 <= bit number <=
```

```
9, bits 8 & 9 does not exist but does not matter
        bitMask = getRequest[ 6] - "0"     ' convert ASCII to integer
        bitMask = 1 << bitMask             ' create bit mask
        PORTD   = PORTD xor bitMask        ' toggle PORTD with xor
operator
      end if
    end if
  end if

  if(result = 0) then ' what do to by default
    result = SPI_Ethernet_putConstString(@httpHeader) ' HTTP header
    result = result + SPI_Ethernet_putConstString(@httpMimeTypeHTML)
' with HTML MIME type
    result = result + SPI_Ethernet_putConstString(@indexPage)
' HTML page first part
    result = result + SPI_Ethernet_putConstString(@indexPage2)
' HTML page second part
  end if
  ' return to the library with the number of bytes to transmit
end sub

' *
' *      this code shows how to use the Spi_Ethernet mini library :
' *          the board will reply to ARP & ICMP echo requests
' *          the board will reply to UDP requests on any port :
' *                returns the request in upper char with a header
made of remote host IP & port number
' *           the board will reply to HTTP requests on port 80, GET
method with pathnames :
' *                      /        will return the HTML main page
' *                     /s        will return board status as text
string
' *                     /t0 ... /t7     will toggle RD0 to RD7 bit
and return HTML main page
' *                      all other requests return also HTML main
page
' *
sub function Spi_Ethernet_UserUDP(dim byref remoteHost as byte[ 4],
                               dim remotePort, destPort, reqLength
as word) as word
  result = 0
  ' reply is made of the remote host IP address in human readable
format
  byteToStr(remoteHost[ 0], dyna)   ' first IP address byte
  dyna[ 3] = "."
  byteToStr(remoteHost[ 1], tmp)    ' second
  dyna[ 4] = tmp[ 0]
  dyna[ 5] = tmp[ 1]
  dyna[ 6] = tmp[ 2]
  dyna[ 7] = ". "
```

```
  byteToStr(remoteHost[ 2] , tmp)    ' second
  dyna[ 8]  = tmp[ 0]
  dyna[ 9]  = tmp[ 1]
  dyna[ 10]  = tmp[ 2]
  dyna[ 11]  = "."
  byteToStr(remoteHost[ 3] , tmp)    ' second
  dyna[ 12]  = tmp[ 0]
  dyna[ 13]  = tmp[ 1]
  dyna[ 14]  = tmp[ 2]

  dyna[ 15]  = ":"                    ' add separator

   ' then remote host port number
  WordToStr(remotePort, tmp)
  dyna[ 16]  = tmp[ 0]
  dyna[ 17]  = tmp[ 1]
  dyna[ 18]  = tmp[ 2]
  dyna[ 19]  = tmp[ 3]
  dyna[ 20]  = tmp[ 4]
  dyna[ 21]  = "[ "
  WordToStr(destPort, tmp)
  dyna[ 22]  = tmp[ 0]
  dyna[ 23]  = tmp[ 1]
  dyna[ 24]  = tmp[ 2]
  dyna[ 25]  = tmp[ 3]
  dyna[ 26]  = tmp[ 4]
  dyna[ 27]  = "] "
  dyna[ 28]  = 0

   ' the total length of the request is the length of the dynamic
string plus the text of the request
  result = 28 + reqLength

   ' puts the dynamic string into the transmit buffer
  SPI_Ethernet_putBytes(@dyna, 28)

   ' then puts the request string converted into upper char into the
transmit buffer
  while(reqLength <> 0)
    SPI_Ethernet_putByte(SPI_Ethernet_getByte())
    reqLength = reqLength - 1
  wend
   ' back to the library with the length of the UDP reply
end sub
main:
  ANSEL = 0x0C              ' AN2 and AN3 convertors will be used
  PORTA = 0
  TRISA = 0xff              ' set PORTA as input for ADC

  ANSELH = 0                ' Configure other AN pins as digital I/O
```

```
  PORTB   = 0
  TRISB   = 0xff           ' set PORTB as input for buttons

  PORTD = 0
  TRISD = 0                ' set PORTD as output

  httpCounter = 0

  ' set mac address
  myMacAddr[ 0]  = 0x00
  myMacAddr[ 1]  = 0x14
  myMacAddr[ 2]  = 0xA5
  myMacAddr[ 3]  = 0x76
  myMacAddr[ 4]  = 0x19
  myMacAddr[ 5]  = 0x3F

  ' set IP address
  myIpAddr[ 0]  = 192
  myIpAddr[ 1]  = 168
  myIpAddr[ 2]  = 20
  myIpAddr[ 3]  = 60

'   *
'   * starts ENC28J60 with :
'   * reset bit on PORTC.B0
'   * CS bit on PORTC.B1
'   * my MAC & IP address
'   * full duplex
'   *

SPI1_Init()   ' init spi module
SPI_Ethernet_Init(myMacAddr,  myIpAddr,  _SPI_Ethernet_FULLDUPLEX)
' init ethernet module
SPI_Ethernet_setUserHandlers(@SPI_Ethernet_UserTCP,
@SPI_Ethernet_UserUDP) ' set user handlers

  while TRUE                   ' endless loop
    SPI_Ethernet_doPacket()     ' process incoming Ethernet packets

'     *
'     * add your stuff here if needed
'     * SPI_Ethernet_doPacket() must be called as often as possible
'     * otherwise packets could be lost
'     *
  wend
end.
```

HW Connection



SPI GRAPHIC LCD LIBRARY

The *mikroBasic PRO for PIC* provides a library for operating Graphic Lcd 128x64 (with commonly used Samsung KS108/KS107 controller) via SPI interface.

For creating a custom set of Glcd images use Glcd Bitmap Editor Tool.

Note: The library uses the SPI module for communication. User must initialize SPI module before using the SPI Graphic Lcd Library.
For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.

Note: This Library is designed to work with the mikroElektronika's Serial Lcd/Glcd Adapter Board pinout, see schematic at the bottom of this page for details.

External dependencies of SPI Graphic LCD Library

The implementation of SPI Graphic LCD Library routines is based on Port Expander Library routines.
External dependencies are the same as Port Expander Library external dependencies.

Library Routines

Basic routines:

- SPI_Glcd_Init
- SPI_Glcd_Set_Side
- SPI_Glcd_Set_Page
- SPI_Glcd_Set_X
- SPI_Glcd_Read_Data
- SPI_Glcd_Write_Data

Advanced routines:

- SPI_Glcd_Fill
- SPI_Glcd_Dot
- SPI_Glcd_Line
- SPI_Glcd_V_Line
- SPI_Glcd_H_Line
- SPI_Glcd_Rectangle
- SPI_Glcd_Box
- SPI_Glcd_Circle
- SPI_Glcd_Set_Font
- SPI_Glcd_Write_Char
- SPI_Glcd_Write_Text
- SPI_Glcd_Image

SPI_Glcd_Init

Prototype	`sub procedure SPI_Glcd_Init(dim DeviceAddress as byte)`
Returns	Nothing.
Description	Initializes the Glcd module via SPI interface. Parameters : ■ `DeviceAddress:` SPI expander hardware address, see schematic at the bottom of this page
Requires	Global variables : ■ `SPExpanderCS:` Chip Select line ■ `SPExpanderRST`: Reset line ■ `SPExpanderCS_Direction:` Direction of the Chip Select pin ■ `SPExpanderRST_Direction:` Direction of the Reset pin must be defined before using this function. SPI module needs to be initialized. See SPI1_Init and SPI1_Init_Advanced routines.
Example	

```
' port expander pinout definition
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction as sbit at TRISC1_bit
' end of port expander pinout definition
...
' If Port Expander Library uses SPI1 module :
SPI1_Init()   ' Initialize SPI module used with PortExpander
SPI_Glcd_Init(0)
```

SPI_Glcd_Set_Side

Prototype	`sub procedure SPI_Glcd_Set_Side(dim x_pos as byte)`
Returns	Nothing.
Description	Selects Glcd side. Refer to the Glcd datasheet for detail explanation. Parameters : - `x_pos`: position on x-axis. Valid values: 0..127 The parameter `x_pos` specifies the Glcd side: values from 0 to 63 specify the left side, values from 64 to 127 specify the right side. **Note**: For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see Spi_Glcd_Init routines.

Example	The following two lines are equivalent, and both of them select the left side of Glcd:
	`SPI_Glcd_Set_Side(0);`
	`SPI_Glcd_Set_Side(10);`

SPI_Glcd_Set_Page

Prototype	`procedure Spi_Glcd_Set_Page(page : byte);`
Returns	Nothing.
Description	Selects page of Glcd. Parameters : - `page:` page number. Valid values: 0..7 **Note:** For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`SPI_Glcd_Set_Page(5)`

SPI_Glcd_Set_X

Prototype	`sub procedure SPI_Glcd_Set_X(dim x_pos as byte)`
Returns	Nothing.
Description	Sets x-axis position to `x_pos` dots from the left border of Glcd within the selected side. Parameters : - `x_pos:` position on x-axis. Valid values: 0..63 **Note:** For side, x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`SPI_Glcd_Set_X(25)`

SPI_Glcd_Read_Data

Prototype	`sub function SPI_Glcd_Read_Data() as byte`
Returns	One byte from Glcd memory.
Description	Reads data from the current location of Glcd memory and moves to the next location.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines. Glcd side, x-axis position and page should be set first. See the functions SPI_Glcd_Set_Side, SPI_Glcd_Set_X, and SPI_Glcd_Set_Page.

Example	`dim data as byte`
	`...`
	`data = SPI_Glcd_Read_Data()`

SPI_Glcd_Write_Data

Prototype	`sub procedure SPI_Glcd_Write_Data(dim Ddata as byte)`
Returns	Nothing.
Description	Writes one byte to the current location in Glcd memory and moves to the next location. Parameters : ■ `Ddata:` data to be written
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines. Glcd side, x-axis position and page should be set first. See the functions SPI_Glcd_Set_Side, SPI_Glcd_Set_X, and SPI_Glcd_Set_Page.

Example	`dim ddata as byte`
	`...`
	`SPI_Glcd_Write_Data(ddata)`

SPI_Glcd_Fill

Prototype	`sub procedure SPI_Glcd_Fill(dim pattern as byte)`
Returns	Nothing.
Description	Fills Glcd memory with byte pattern. Parameters : ■ `pattern:` byte to fill Glcd memory with To clear the Glcd screen, use `SPI_Glcd_Fill(0).` To fill the screen completely, use `SPI_Glcd_Fill(0xFF).`
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Clear screen` `SPI_Glcd_Fill(0)`

SPI_Glcd_Dot

Prototype	`sub procedure SPI_Glcd_Dot(dim x_pos as byte, dim y_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a dot on Glcd at coordinates (`x_pos, y_pos`). Parameters : ■ `x_pos:` x position. Valid values: 0..127 ■ `y_pos:` y position. Valid values: 0..63 ■ `color`: color parameter. Valid values: 0..2 The parameter `color` determines the dot state: 0 clears dot, 1 puts a dot, and 2 inverts dot state. **Note:** For x and y axis layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`'Invert the dot in the upper left corner` `SPI_Glcd_Dot(0, 0, 2)`

SPI_Glcd_Line

Prototype	`sub procedure SPI_Glcd_Line(dim x_start as integer, dim y_start as integer, dim x_end as integer, dim y_end as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a line on Glcd. Parameters : ■ `x_start:` x coordinate of the line start. Valid values: 0..127 ■ `y_start:` y coordinate of the line start. Valid values: 0..63 ■ `x_end:` x coordinate of the line end. Valid values: 0..127 ■ `y_end:` y coordinate of the line end. Valid values: 0..63 ■ `color:` color parameter. Valid values: 0..2 Parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Draw a line between dots (0,0) and (20,30)` `SPI_Glcd_Line(0, 0, 20, 30, 1)`

SPI_Glcd_V_Line

Prototype	`sub procedure SPI_Glcd_V_Line(dim y_start as byte, dim y_end as byte, dim x_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a vertical line on Glcd. Parameters : ■ `y_start:` y coordinate of the line start. Valid values: 0..63 ■ `y_end:` y coordinate of the line end. Valid values: 0..63 ■ `x_pos:` x coordinate of vertical line. Valid values: 0..127 ■ `color:` color parameter. Valid values: 0..2 Parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Draw a vertical line between dots (10,5) and (10,25)` `SPI_Glcd_V_Line(5, 25, 10, 1)`

SPI_Glcd_H_Line

Prototype	`sub procedure SPI_Glcd_V_Line(dim x_start as byte, dim x_end as byte, dim y_pos as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a horizontal line on Glcd. Parameters : ■ `x_start:` x coordinate of the line start. Valid values: 0..127 ■ `x_end:` x coordinate of the line end. Valid values: 0..127 ■ `y_pos:` y coordinate of horizontal line. Valid values: 0..63 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the line color: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`'Draw a horizontal line between dots (10,20) and (50,20)` `SPI_Glcd_H_Line(10, 50, 20, 1)`

SPI_Glcd_Rectangle

Prototype	`sub procedure SPI_Glcd_Rectangle(dim x_upper_left as byte, dim y_upper_left as byte, dim x_bottom_right as byte, dim y_bottom_right as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a rectangle on Glcd. Parameters : ■ `x_upper_left:` x coordinate of the upper left rectangle corner. Valid values: 0..127 ■ `y_upper_left:` y coordinate of the upper left rectangle corner. Valid values: 0..63 ■ `x_bottom_right:` x coordinate of the lower right rectangle corner. Valid values: 0..127 ■ `y_bottom_right:` y coordinate of the lower right rectangle corner. Valid values: 0..63 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the color of the rectangle border: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see S_Glcd_Init routines.
Example	`' Draw a rectangle between dots (5,5) and (40,40)` `SPI_Glcd_Rectangle(5, 5, 40, 40, 1)`

SPI_Glcd_Box

Prototype	`sub procedure SPI_Glcd_Box(dim x_upper_left as byte, dim y_upper_left as byte, dim x_bottom_right as byte, dim y_bottom_right as byte, dim color as byte)`
Returns	Nothing.
Description	Draws a box on Glcd. Parameters : ■ `x_upper_left:` x coordinate of the upper left box corner. Valid values: 0..127 ■ `y_upper_left:` y coordinate of the upper left box corner. Valid values: 0..63 ■ `x_bottom_right:` x coordinate of the lower right box corner. Valid values: 0..127 ■ `y_bottom_right:` y coordinate of the lower right box corner. Valid values: 0..63 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the color of the box fill: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Draw a box between dots (5,15) and (20,40)` `SPI_Glcd_Box(5, 15, 20, 40, 1)`

SPI_Glcd_Circle

Prototype	`sub procedure SPI_Glcd_Circle(dim x_center as integer, dim y_center as integer, dim radius as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a circle on Glcd. Parameters : ■ `x_center:` x coordinate of the circle center. Valid values: 0..127 ■ `y_center:` y coordinate of the circle center. Valid values: 0..63 ■ `radius:` radius size ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the color of the circle line: 0 white, 1 black, and 2 inverts each dot.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routine.
Example	`' Draw a circle with center in (50,50) and radius=10` `SPI_Glcd_Circle(50, 50, 10, 1)`

SPI_Glcd_Set_Font

Prototype	`sub procedure SPI_Glcd_Set_Font(dim activeFont as longint, dim aFontWidth as byte, dim aFontHeight as byte, dim aFontOffs as word)`
Returns	Nothing.
Description	Sets font that will be used with SPI_Glcd_Write_Char and SPI_Glcd_Write_Text routines. Parameters : ■ `activeFont:` font to be set. Needs to be formatted as an array of char ■ `aFontWidth:` width of the font characters in dots. ■ `aFontHeight:` height of the font characters in dots. ■ `aFontOffs:` number that represents difference between the *mikroBasic PRO for PIC* character set and regular ASCII set (eg. if 'A' is 65 in ASCII character, and 'A' is 45 in the *mikroBasic PRO for PIC* character set, aFontOffs is 20). Demo fonts supplied with the library have an offset of 32, which means that they start with space. The user can use fonts given in the file “__Lib_Glcd_fonts.mbas” file located in the Uses folder or create his own fonts.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Use the custom 5x7 font "myfont" which starts with space (32):` `SPI_Glcd_Set_Font(@myfont, 5, 7, 32)`

SPI_Glcd_Write_Char

Prototype	`sub procedure SPI_Glcd_Write_Char(dim chr1 as byte, dim x_pos as byte, dim page_num as byte, dim color as byte)`
Returns	Nothing.
Description	Prints character on Glcd. Parameters : ■ `chr1:` character to be written ■ `x_pos:` character starting position on x-axis. Valid values: 0..(127-FontWidth) ■ `page_num:` the number of the page on which character will be written. Valid values: 0..7 ■ `color:` color parameter. Valid values: 0..2 The parameter color determines the color of the character: 0 white, 1 black, and 2 inverts each dot. **Note:** For x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines. Use the SPI_Glcd_Set_Font to specify the font for display; if no font is specified, then the default 5x8 font supplied with the library will be used.
Example	`' Write character 'C' on the position 10 inside the page 2:` `SPI_Glcd_Write_Char("C", 10, 2, 1)`

SPI_Glcd_Write_Text

Prototype	`sub procedure SPI_Glcd_Write_Text(dim byref text as string[ 40] , dim x_pos as byte, dim page_numb as byte, dim color as byte)`
Returns	Nothing.
Description	Prints text on Glcd. Parameters : ■ `text:` text to be written ■ `x_pos:` text starting position on x-axis. ■ `page_num:` the number of the page on which text will be written. Valid values: 0..7 ■ `color:` color parameter. Valid values: 0..2 The parameter `color` determines the color of the text: 0 white, 1 black, and 2 inverts each dot. **Note:** For x axis and page layout explanation see schematic at the bottom of this page.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines. Use the SPI_Glcd_Set_Font to specify the font for display; if no font is specified, then the default 5x8 font supplied with the library will be used.
Example	`' Write text "Hello world!" on the position 10 inside the page 2:` `SPI_Glcd_Write_Text("Hello world!", 10, 2, 1)`

SPI_Glcd_Image

Prototype	`sub procedure SPI_Glcd_Image(dim const image as ^byte)`
Returns	Nothing.
Description	Displays bitmap on Glcd. Parameters : - `image:` image to be displayed. Bitmap array can be located in both code and RAM memory (due to the mikroBasic PRO for PIC pointer to const and pointer to RAM equivalency). Use the mikroBasic PRO's integrated Glcd Bitmap Editor (menu option **Tools › Glcd Bitmap Editor**) to convert image to a constant array suitable for displaying on Glcd.
Requires	Glcd needs to be initialized for SPI communication, see SPI_Glcd_Init routines.
Example	`' Draw image my_image on Glcd` `SPI_Glcd_Image(my_image)`

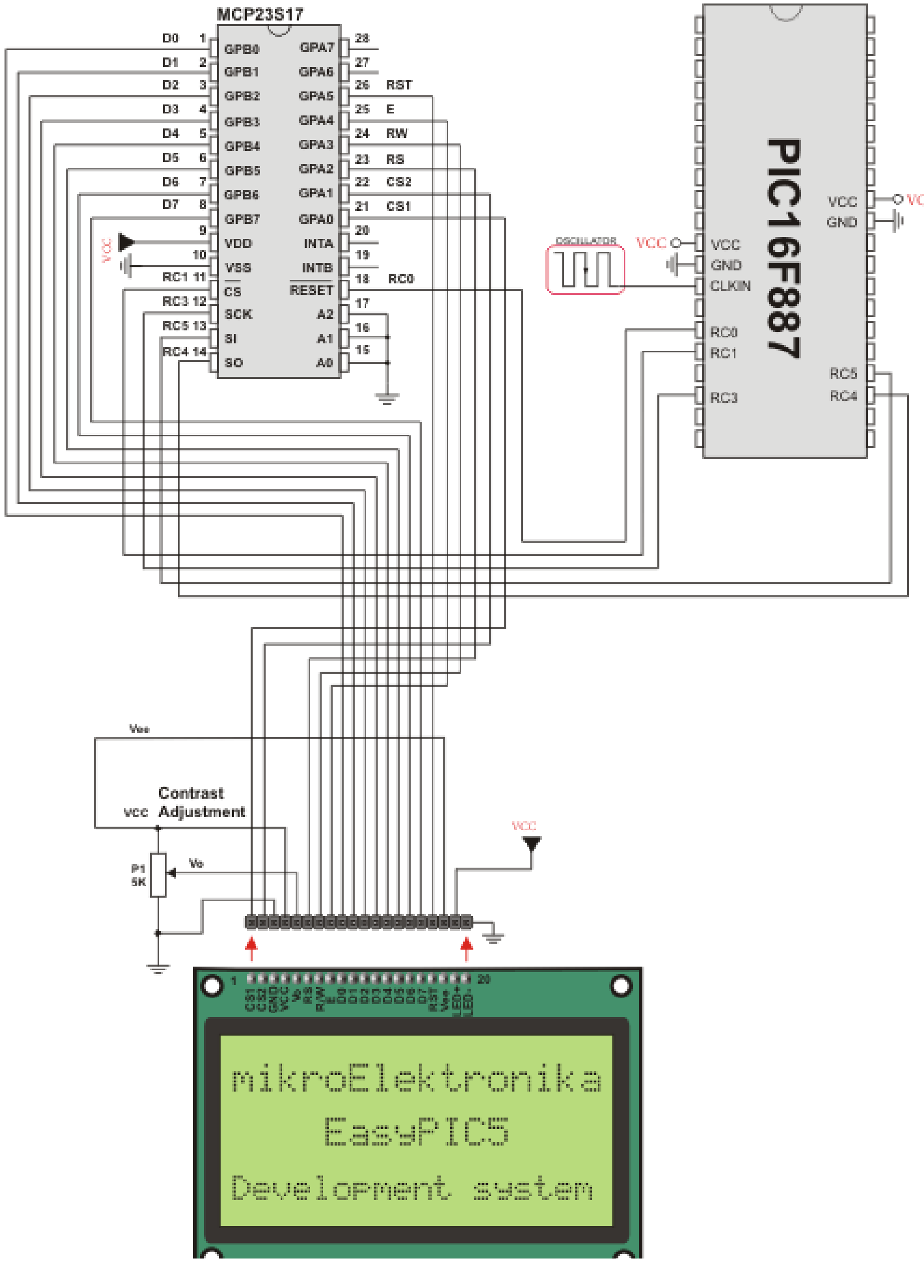
Library Example

The example demonstrates how to communicate to KS0108 Glcd via the SPI module, using serial to parallel convertor MCP23S17.

```
program SPI_Glcd

include bitmap

' Port Expander module connections
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS  as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction  as sbit at TRISC1_bit
' End Port Expander module connections

dim someText as char[20]
    counter as byte

sub procedure Delay2S
  delay_ms(2000)
end sub

main:
      SPI1_Init_Advanced(_SPI_MASTER_OSC_DIV4,_SPI_DATA_SAMPLE_MIDDLE,
_SPI_CLK_IDLE_LOW, _SPI_LOW_2_HIGH)  ' Initialize SPI module
```

```
used with PortExpander
      SPI_Glcd_Init(0)                      ' Initialize Glcd via SPI
      SPI_Glcd_Fill(0x00)                    ' Clear Glcd

  while TRUE
    SPI_Glcd_Image(@truck_bmp)              ' Draw image
    Delay2s() Delay2s()

    SPI_Glcd_Fill(0x00)                      ' Clear Glcd
    Delay2s

    SPI_Glcd_Box(62,40,124,56,1)                      ' Draw box
    SPI_Glcd_Rectangle(5,5,84,35,1)                   ' Draw rectangle
    SPI_Glcd_Line(0, 63, 127, 0,1)                    ' Draw line
    Delay2s()
    counter = 5
    while (counter < 60)           ' Draw horizontal and vertical line
      Delay_ms(250)
      SPI_Glcd_V_Line(2, 54, counter, 1)
      SPI_Glcd_H_Line(2, 120, counter, 1)
      counter = counter + 5
    wend
    Delay2s()

    SPI_Glcd_Fill(0x00)                              ' Clear Glcd
    SPI_Glcd_Set_Font(@Character8x7, 8, 8, 32)   ' Choose font
    SPI_Glcd_Write_Text("mikroE", 5, 7, 2)        ' Write string

    for counter = 1 to 10 ' Draw circles
      SPI_Glcd_Circle(63,32, 3*counter, 1)
    next counter
    Delay2s()

    SPI_Glcd_Box(12,20, 70,63, 2)                     ' Draw box
    Delay2s()

    SPI_Glcd_Fill(0xFF)                               ' Fill Glcd

    SPI_Glcd_Set_Font(@Character8x7, 8, 7, 32)   ' Change font
    someText = "8x7 Font"
    SPI_Glcd_Write_Text(someText, 5, 1, 2)        ' Write string
    Delay2s()

    SPI_Glcd_Set_Font(@System3x6, 3, 5, 32)       ' Change font
    someText = "3X5 CAPITALS ONLY"
    SPI_Glcd_Write_Text(someText, 5, 3, 2)        ' Write string
    Delay2s()

    SPI_Glcd_Set_Font(@font5x7, 5, 7, 32)         ' Change font
    someText = "5x7 Font"
    SPI_Glcd_Write_Text(someText, 5, 5, 2)        ' Write string
    Delay2s()
  wend
end.
```

HW Connection



SPI GLCD HW connection

SPI LCD LIBRARY

The *mikroBasic PRO for PIC* provides a library for communication with Lcd (with HD44780 compliant controllers) in 4-bit mode via SPI interface.

For creating a custom set of Lcd characters use Lcd Custom Character Tool.

Note: The library uses the SPI module for communication. The user must initialize the SPI module before using the SPI Lcd Library.
For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.

Note: This Library is designed to work with the mikroElektronika's Serial Lcd Adapter Board pinout. See schematic at the bottom of this page for details.

External dependencies of SPI LCD Library

The implementation of SPI LCD Library routines is based on Port Expander Library routines.

External dependencies are the same as Port Expander Library external dependencies.

Library Routines

- Spi_Lcd_Config
- Spi_Lcd_Out
- Spi_Lcd_Out_Cp
- Spi_Lcd_Chr
- Spi_Lcd_Chr_Cp
- Spi_Lcd_Cmd

SPI_Lcd_Config

Prototype	`sub procedure SPI_Lcd_Config(dim DeviceAddress as byte)`
Returns	Nothing.
Description	Initializes the Lcd module via SPI interface. Parameters : ■ `DeviceAddress:` SPI expander hardware address, see schematic at the bottom of this page
Requires	Global variables : ■ `SPExpanderCS:` Chip Select line ■ `SPExpanderRST:` Reset line ■ `SPExpanderCS_Direction:` Direction of the Chip Select pin ■ `SPExpanderRST_Direction:` Direction of the Reset pin

Example

```
' port expander pinout definition
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction as sbit at TRISC1_bit
' end of port expander pinout definition
...
' If Port Expander Library uses SPI1 module
SPI1_Init()        ' Initialize SPI module used with POrtExpander
SPI_Lcd_Config(0)  ' initialize lcd over spi interface
```

SPI_Lcd_Out

Prototype	`sub procedure SPI_Lcd_Out(dim row as byte, dim column as byte, dim byref text as string[ 20] )`
Returns	Nothing.
Description	Prints text on the Lcd starting from specified position. Both string variables and literals can be passed as a text. Parameters: ■ `row:` starting position row number ■ `column:` starting position column number ■ `text:` text to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd_Config routines.

Example

```
' Write text "Hello!" on Lcd starting from row 1, column 3:
SPI_Lcd_Out(1, 3, "Hello!")
```

SPI_Lcd_Out_Cp

Prototype	`sub procedure SPI_Lcd_Out_CP(dim text as string[ 19] )`
Returns	Nothing.
Description	Prints text on the Lcd at current cursor position. Both string variables and literals can be passed as a text. Parameters : ■ `text:` text to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd_Config routines.
Example	`'Write text "Here!" at current cursor position:` `SPI_Lcd_Out_CP("Here!")`

SPI_Lcd_Chr

Prototype	`sub procedure SPI_Lcd_Chr(dim Row as byte, dim Column as byte, dim Out_Char as byte)`
Returns	Nothing.
Description	Prints character on Lcd at specified position. Both variables and literals can be passed as character. Parameters : ■ `Row:` writing position row number ■ `Column:` writing position column number ■ `Out_Char:` character to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd_Config routines.
Example	`' Write character "i" at row 2, column 3:` `SPI_Lcd_Chr(2, 3, 'i')`

SPI_Lcd_Chr_Cp

Prototype	`sub procedure SPI_Lcd_Chr_CP(dim Out_Char as byte)`
Returns	Nothing.
Description	Prints character on Lcd at current cursor position. Both variables and literals can be passed as character. Parameters : ■ `Out_Char:` character to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd_Config routines.
Example	`' Write character "e" at current cursor position:` `SPI_Lcd_Chr_Cp('e')`

SPI_Lcd_Cmd

Prototype	`sub procedure SPI_Lcd_Cmd(dim out_char as byte)`
Returns	Nothing.
Description	Sends command to Lcd. Parameters : ■ `out_char:` command to be sent **Note:** Predefined constants can be passed to the function, see Available SPI Lcd Commands.
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd_Config routines.
Example	`' Clear Lcd display:` `SPI_Lcd_Cmd(_LCD_CLEAR)`

Available LCD Commands

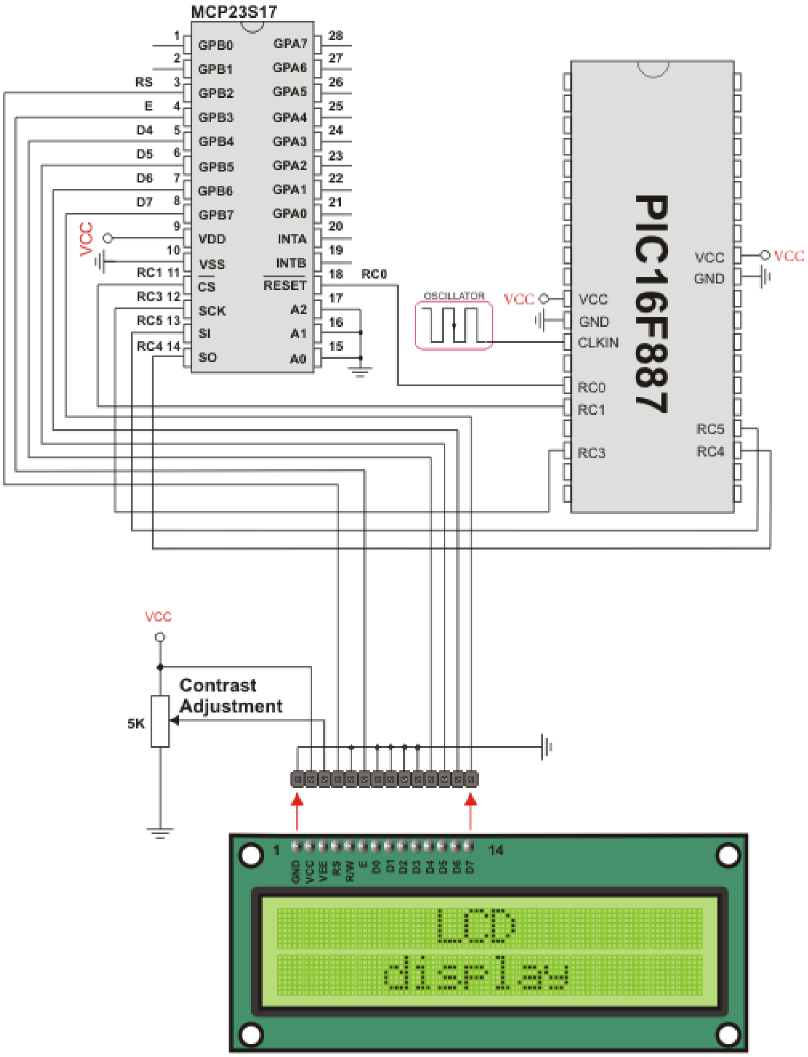
Lcd Command	Purpose
`_LCD_FIRST_ROW`	Move cursor to the 1st row
`_LCD_SECOND_ROW`	Move cursor to the 2nd row
`_LCD_THIRD_ROW`	Move cursor to the 3rd row
`_LCD_FOURTH_ROW`	Move cursor to the 4th row
`_LCD_CLEAR`	Clear display
`_LCD_RETURN_HOME`	Return cursor to home position, returns a shifted display to its original position. Display data RAM is unaffected.
`_LCD_CURSOR_OFF`	Turn off cursor
`_LCD_UNDERLINE_ON`	Underline cursor on
`_LCD_BLINK_CURSOR_ON`	Blink cursor on
`_LCD_MOVE_CURSOR_LEFT`	Move cursor left without changing display data RAM
`_LCD_MOVE_CURSOR_RIGHT`	Move cursor right without changing display data RAM
`_LCD_TURN_ON`	Turn Lcd display on
`_LCD_TURN_OFF`	Turn Lcd display off
`_LCD_SHIFT_LEFT`	Shift display left without changing display data RAM
`_LCD_SHIFT_RIGHT`	Shift display right without changing display data RAM

Library Example

This example demonstrates how to communicate Lcd via the SPI module, using serial to parallel convertor MCP23S17.

```
program SPI_Lcd

dim text as char[ 17]

' Port Expander module connections
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS   as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction   as sbit at TRISC1_bit
' End Port Expander module connections

main:
  text = "mikroElektronika"
  SPI1_Init()                         ' Initialize SPI module used with
PortExpander
  SPI_Lcd_Config(0)                   ' Initialize Lcd over SPI inter-
face
  SPI_Lcd_Cmd(_LCD_CLEAR)              ' Clear display
  SPI_Lcd_Cmd(_LCD_CURSOR_OFF)        ' Turn cursor off
  SPI_Lcd_Out(1,6, "mikroE")          ' Print text to Lcd, 1st row,
6th column
  SPI_Lcd_Chr_CP("!")                 ' Append "!"
  SPI_Lcd_Out(2,1, text)              ' Print text to Lcd, 2nd row, 1st
column
end.
```

HW Connection



SPI LCD HW connection

SPI LCD8 (8-BIT INTERFACE) LIBRARY

The *mikroBasic PRO for PIC* provides a library for communication with Lcd (with HD44780 compliant controllers) in 8-bit mode via SPI interface.

For creating a custom set of Lcd characters use Lcd Custom Character Tool.

Note: Library uses the SPI module for communication. The user must initialize the SPI module before using the SPI Lcd Library.
For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.

Note: This Library is designed to work with mikroElektronika's Serial Lcd/GLcd Adapter Board pinout, see schematic at the bottom of this page for details.

External dependencies of SPI LCD Library

The implementation of SPI Lcd Library routines is based on Port Expander Library routines.

External dependencies are the same as Port Expander Library external dependencies.

Library Routines

- SPI_Lcd8_Config
- SPI_Lcd8_Out
- SPI_Lcd8_Out_Cp
- SPI_Lcd8_Chr
- SPI_Lcd8_Chr_Cp
- SPI_Lcd8_Cmd

SPI_Lcd8_Config

Prototype	`sub procedure SPI_Lcd8_Config(dim DeviceAddress as byte)`
Returns	Nothing.
Description	Initializes the Lcd module via SPI interface. Parameters : ■ `DeviceAddress:` spi expander hardware address, see schematic at the bottom of this page
Requires	Global variables : ■ `SPExpanderCS`: Chip Select line ■ `SPExpanderRST:` Reset line ■ `SPExpanderCS_Direction:` Direction of the Chip Select pin ■ `SPExpanderRST_Direction:` Direction of the Reset pin must be defined before using this function. SPI module needs to be initialized. See SPI1_Init and SPI1_Init_Advanced routines.
Example	

```
' port expander pinout definition
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction as sbit at TRISC1_bit
' end of port expander pinout definition
...
SPI1_Init()                 ' Initialize SPI interface
SPI_Lcd8_Config(0)          ' Intialize Lcd in 8bit mode via spi
```

SPI_Lcd8_Out

Prototype	`sub procedure SPI_Lcd8_Out(dim row as byte, dim column as byte, dim byref text as string[19])`
Returns	Nothing.
Description	Prints text on Lcd starting from specified position. Both string variables and literals can be passed as a text. Parameters : ■ `row:` starting position row number ■ `column:` starting position column number ■ `text:` text to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd8_Config routines
Example	

```
' Write text "Hello!" on Lcd starting from row 1, column 3:
SPI_Lcd8_Out(1, 3, "Hello!")
```

SPI_Lcd8_Out_Cp

Prototype	`sub procedure SPI_Lcd8_Out_CP(dim text as string[19])`
Returns	Nothing.
Description	Prints text on Lcd at current cursor position. Both string variables and literals can be passed as a text. Parameters : ■ `text:` text to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd8_Config routines.
Example	`' Write text "Here!" at current cursor position:` `SPI_Lcd8_Out_CP("Here!")`

SPI_Lcd8_Chr

Prototype	`sub procedure SPI_Lcd8_Chr(dim Row as byte, dim Column as byte, dim Out_Char as byte)`
Returns	Nothing.
Description	Prints character on LCD at specified position. Both variables and literals can be passed as character. Parameters : ■ `row:` writing position row number ■ `column:` writing position column number ■ `out_char:` character to be written
Requires	LCD needs to be initialized for SPI communication, see SPI_Lcd8_Config routines.
Example	`' Write character "i" at row 2, column 3:` `SPI_Lcd8_Chr(2, 3, 'i')`

SPI_Lcd8_Chr_Cp

Prototype	`sub procedure SPI_Lcd8_Chr_CP(dim Out_Char as byte)`
Returns	Nothing.
Description	Prints character on Lcd at current cursor position. Both variables and literals can be passed as character. Parameters : ■ `out_char:` character to be written
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd8_Config routines.

Example	Print “e” at current cursor position:
	`' Write character "e" at current cursor position:`
	`SPI_Lcd8_Chr_Cp('e')`

SPI_Lcd8_Cmd

Prototype	`sub procedure SPI_Lcd8_Cmd(dim out_char as byte)`
Returns	Nothing.
Description	Sends command to Lcd. Parameters : ■ `out_char`: command to be sent Note: Predefined constants can be passed to the function, see Available SPI Lcd8 Commands.
Requires	Lcd needs to be initialized for SPI communication, see SPI_Lcd8_Config routines.
Example	`' Clear Lcd display:` `SPI_Lcd8_Cmd(_LCD_CLEAR)`

Available LCD Commands

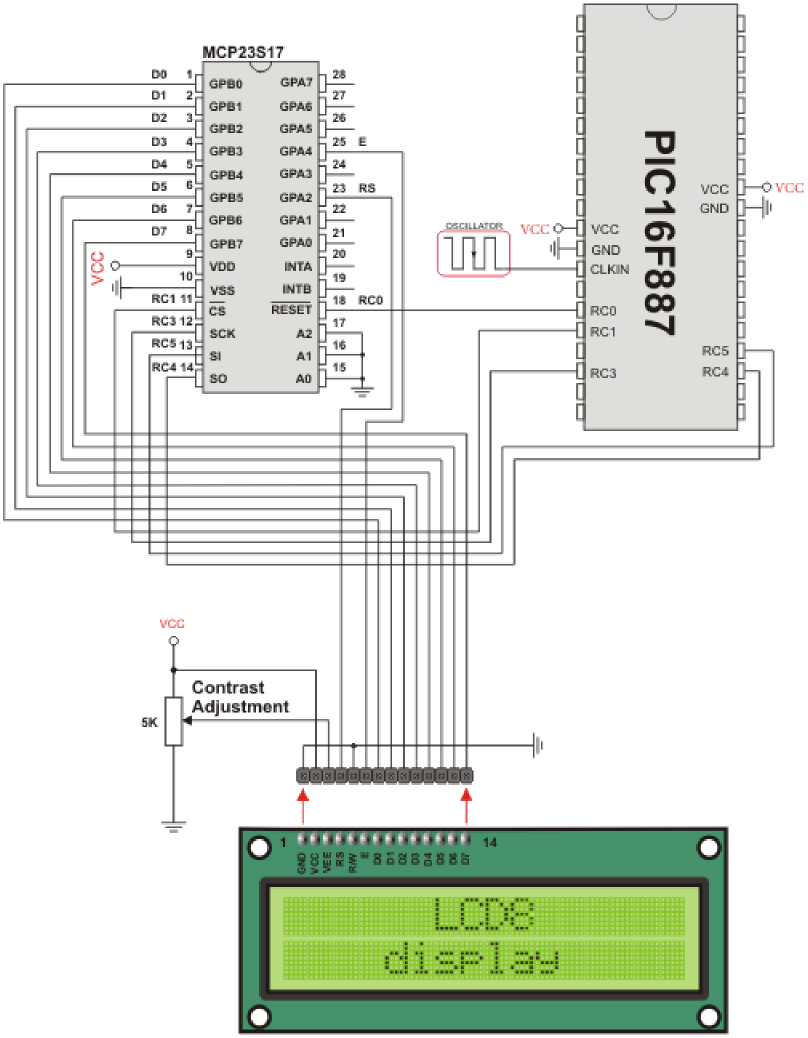
Lcd Command	Purpose
`_LCD_FIRST_ROW`	Move cursor to the 1st row
`_LCD_SECOND_ROW`	Move cursor to the 2nd row
`_LCD_THIRD_ROW`	Move cursor to the 3rd row
`_LCD_FOURTH_ROW`	Move cursor to the 4th row
`_LCD_CLEAR`	Clear display
`_LCD_RETURN_HOME`	Return cursor to home position, returns a shifted display to its original position. Display data RAM is unaffected.
`_LCD_CURSOR_OFF`	Turn off cursor
`_LCD_UNDERLINE_ON`	Underline cursor on
`_LCD_BLINK_CURSOR_ON`	Blink cursor on
`_LCD_MOVE_CURSOR_LEFT`	Move cursor left without changing display data RAM
`_LCD_MOVE_CURSOR_RIGHT`	Move cursor right without changing display data RAM
`_LCD_TURN_ON`	Turn Lcd display on
`_LCD_TURN_OFF`	Turn Lcd display off
`_LCD_SHIFT_LEFT`	Shift display left without changing display data RAM
`_LCD_SHIFT_RIGHT`	Shift display right without changing display data RAM

Library Example

This example demonstrates how to communicate Lcd in 8-bit mode via the SPI module, using serial to parallel convertor MCP23S17.

```
program Spi_Lcd8_Test

dim text as char[ 16]

' Port Expander module connections
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS   as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction  as sbit at TRISC1_bit
' End Port Expander module connections

main:
  text = "mikroE"
  SPI1_Init()                         ' Initialize SPI module used
with PortExpander
  SPI_Lcd8_Config(0)                  ' Intialize Lcd in 8bit mode
via SPI
  SPI_Lcd8_Cmd(_LCD_CLEAR)            ' Clear display
  SPI_Lcd8_Cmd(_LCD_CURSOR_OFF)       ' Turn cursor off
  SPI_Lcd8_Out(1,6, text)             ' Print text to Lcd, 1st row,
6th column...
  SPI_Lcd8_Chr_CP("!")                 ' Append "!"
  SPI_Lcd8_Out(2,1, "mikroElektronika") ' Print text to Lcd, 2nd row,
1st column...
  SPI_Lcd8_Out(3,1, text)              ' For Lcd modules with more
than two rows
  SPI_Lcd8_Out(4,15, text)             ' For Lcd modules with more
than two rows
end.
```

HW Connection



SPI LCD8 HW connection

SPI T6963C GRAPHIC LCD LIBRARY

The *mikroBasic PRO for PIC* provides a library for working with Glcds based on TOSHIBA T6963C controller via SPI interface. The Toshiba T6963C is a very popular Lcd controller for the use in small graphics modules. It is capable of controlling displays with a resolution up to 240x128. Because of its low power and small outline it is most suitable for mobile applications such as PDAs, MP3 players or mobile measurement equipment. Although this controller is small, it has a capability of displaying and merging text and graphics and it manages all interfacing signals to the displays Row and Column drivers.

For creating a custom set of Glcd images use Glcd Bitmap Editor Tool.

Note: The library uses the SPI module for communication. The user must initialize SPI module before using the SPI T6963C Glcd Library.
For MCUs with two SPI modules it is possible to initialize both of them and then switch by using the `SPI_Set_Active()` routine.

Note: This Library is designed to work with mikroElektronika's Serial Glcd 240x128 and 240x64 Adapter Boards pinout, see schematic at the bottom of this page for details.

Note: Some mikroElektronika's adapter boards have pinout different from T6369C datasheets. Appropriate relations between these labels are given in the table below:

Adapter Board	T6369C datasheet
RS	C/D
R/W	/RD
E	/WR

External dependencies of SPI T6963C Graphic Lcd Library

The implementation of SPI T6963C Graphic Lcd Library routines is based on Port Expander Library routines.

External dependencies are the same as Port Expander Library external dependencies.

Library Routines

- SPI_T6963C_Config
- SPI_T6963C_WriteData
- SPI_T6963C_WriteCommand
- SPI_T6963C_SetPtr
- SPI_T6963C_WaitReady
- SPI_T6963C_Fill
- SPI_T6963C_Dot
- SPI_T6963C_Write_Char
- SPI_T6963C_Write_Text
- SPI_T6963C_Line
- SPI_T6963C_Rectangle
- SPI_T6963C_Box
- SPI_T6963C_Circle
- SPI_T6963C_Image
- SPI_T6963C_Sprite
- SPI_T6963C_Set_Cursor
- SPI_T6963C_ClearBit
- SPI_T6963C_SetBit
- SPI_T6963C_NegBit
- SPI_T6963C_DisplayGrPanel
- SPI_T6963C_DisplayTxtPanel
- SPI_T6963C_SetGrPanel
- SPI_T6963C_SetTxtPanel
- SPI_T6963C_PanelFill
- SPI_T6963C_GrFill
- SPI_T6963C_TxtFill
- SPI_T6963C_Cursor_Height
- SPI_T6963C_Graphics
- SPI_T6963C_Text
- SPI_T6963C_Cursor
- SPI_T6963C_Cursor_Blink

SPI_T6963C_Config

Prototype

```
sub procedure SPI_T6963C_Config(dim width as word, dim height as
word, dim fntW as word, dim DeviceAddress as byte, dim wr as
byte, dim rd as byte, dim cd as byte, dim rst as byte)
```

Returns

Nothing.

Description

Initalizes the Graphic Lcd controller.

Parameters :

- `width:` width of the GLCD panel
- `height:` height of the GLCD panel
- `fntW:` font width
- `DeviceAddress:` SPI expander hardware address, see schematic at the bottom of this page
- `wr:` write signal pin on GLCD control port
- `rd:` read signal pin on GLCD control port
- `cd:` command/data signal pin on GLCD control port
- `rst:` reset signal pin on GLCD control port

Display RAM organization:
The library cuts RAM into panels : a complete panel is one graphics panel followed by a text panel (see schematic below).

```
schematic:
+---------------------- + /\
+ GRAPHICS PANEL #0     +  |
+                       +  |
+                       +  |
+                       +  |
+---------------------- +  | PANEL 0
+ TEXT PANEL #0         +  |
+                       + \/
+---------------------- + /\
+ GRAPHICS PANEL #1     +  |
+                       +  |
+                       +  |
+                       +  |
+---------------------- +  | PANEL 1
+ TEXT PANEL #2         +  |
+                       +  |
+---------------------- + \/
```

Requires

Global variables :

- `SPExpanderCS:` Chip Select line
- `SPExpanderRST:` Reset line
- `SPExpanderCS_Direction:` Direction of the Chip Select pin

Requires	■ `SPExpanderRST_Direction`: Direction of the Reset pin must be defined before using this function. SPI module needs to be initialized. See SPI1_Init and SPI1_Init_Advanced routines.
Example	see code below

```
' port expander pinout definition
dim SPExpanderRST as sbit at RC0_bit
    SPExpanderCS  as sbit at RC1_bit
    SPExpanderRST_Direction as sbit at TRISC0_bit
    SPExpanderCS_Direction  as sbit at TRISC1_bit
' end of port expander pinout definition
...
' Initialize SPI module
SPI1_Init()
SPI_T6963C_Config(240, 64, 8, 0, 0, 1, 3, 4)
```

SPI_T6963C_WriteData

Prototype	`sub procedure SPI_T6963C_WriteData(dim Ddata as byte)`
Returns	Nothing.
Description	Writes data to T6963C controller via SPI interface. Parameters : ■ `Ddata`: data to be written
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_WriteData(AddrL)`

SPI_T6963C_WriteCommand

Prototype	`sub procedure SPI_T6963C_WriteCommand(dim Ddata as byte)`
Returns	Nothing.
Description	Writes command to T6963C controller via SPI interface. Parameters : ■ `Ddata`: command to be written
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_WriteCommand(SPI_T6963C_CURSOR_POINTER_SET)`

SPI_T6963C_SetPtr

Prototype	`sub procedure SPI_T6963C_SetPtr(dim p as word, dim c as byte)`
Returns	Nothing.
Description	Sets the memory pointer p for command c. Parameters : ■ `p:` address where command should be written ■ `c:` command to be written
Requires	SToshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_SetPtr(T6963C_grHomeAddr + start,T6963C_ADDRESS_POINTER_SET)`

SPI_T6963C_WaitReady

Prototype	`sub procedure SPI_T6963C_WaitReady()`
Returns	Nothing.
Description	Pools the status byte, and loops until Toshiba Glcd module is ready.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_WaitReady()`

SPI_T6963C_Fill

Prototype	`sub procedure SPI_T6963C_Fill(dim v as byte, dim start as word, dim len as word)`
Returns	Nothing.
Description	Fills controller memory block with given byte. Parameters : ■ `v:` byte to be written ■ `start:` starting address of the memory block ■ `len:` length of the memory block in bytes
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Fill(0x33, 0x00FF, 0x000F)`

SPI_T6963C_Dot

Prototype	`sub procedure SPI_T6963C_Dot(dim x as integer, dim y as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a dot in the current graphic panel of Glcd at coordinates (x, y). Parameters : ■ `x:` dot position on x-axis ■ `y:` dot position on y-axis ■ `color:` color parameter. Valid values: SPI_T6963C_BLACK and SPI_T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Dot(x0, y0, pcolor)`

SPI_T6963C_Write_Char

Prototype	`sub procedure SPI_T6963C_Write_Char(dim c as byte, dim x as byte, dim y as byte, dim mode as byte)`
Returns	Nothing.
Description	Writes a char in the current text panel of Glcd at coordinates (x, y). Parameters : ■ `c:` char to be written ■ `x:` char position on x-axis ■ `y:` char position on y-axis ■ `mode:` mode parameter. Valid values: SPI_T6963C_ROM_MODE_OR, SPI_T6963C_ROM_MODE_XOR, SPI_T6963C_ROM_MODE_AND and SPI_T6963C_ROM_MODE_TEXT Mode parameter explanation: ■ `OR Mode`: In the OR-Mode, text and graphics can be displayed and the data is logically “OR-ed”. This is the most common way of combining text and graphics for example labels on buttons. ■ `XOR-Mode:` In this mode, the text and graphics data are combined via the logical “exclusive OR”. This can be useful to display text in negative mode, i.e. white text on black background. ■ `AND-Mode:` The text and graphic data shown on display are combined via the logical “AND function”. ■ `TEXT-Mode:` This option is only available when displaying just a text. The Text Attribute values are stored in the graphic area of display memory. For more details see the T6963C datasheet.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Write_Char("A",22,23,AND)`

SPI_T6963C_Write_Text

Prototype	`sub procedure SPI_T6963C_Write_Text(dim byref str as byte[ 10] , dim x as byte, dim y as byte, dim mode as byte)`
Returns	Nothing.
Description	Writes text in the current text panel of Glcd at coordinates (x, y). Parameters : ■ `str:` text to be written ■ `x:` text position on x-axis ■ `y:` text position on y-axis ■ `mode:` mode parameter. Valid values: SPI_T6963C_ROM_MODE_OR, SPI_T6963C_ROM_MODE_XOR, SPI_T6963C_ROM_MODE_AND and SPI_T6963C_ROM_MODE_TEXT Mode parameter explanation: ■ `OR Mode`: In the OR-Mode, text and graphics can be displayed and the data is logically "OR-ed". This is the most common way of combining text and graphics for example labels on buttons. ■ `XOR-Mode:` In this mode, the text and graphics data are combined via the logical "exclusive OR". This can be useful to display text in negative mode, i.e. white text on black background. ■ `AND-Mode:` The text and graphic data shown on the display are com bined via the logical "AND function". ■ `TEXT-Mode:` This option is only available when displaying just a text. The Text Attribute values are stored in the graphic area of display memory. For more details see the T6963C datasheet.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Write_Text("GLCD LIBRARY DEMO, WELCOME !", 0, 0, T6963C_ROM_MODE_EXOR)`

SPI_T6963C_Line

Prototype	`sub procedure SPI_T6963C_Line(dim x0 as integer, dim y0 as integer, dim x1 as integer, dim y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a line from (x0, y0) to (x1, y1). Parameters : ■ `x0:` x coordinate of the line start ■ `y0:` y coordinate of the line end ■ `x1:` x coordinate of the line start ■ `y1:` y coordinate of the line end ■ `pcolor:` color parameter. Valid values: SPI_T6963C_BLACK and SPI_T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Line(0, 0, 239, 127, T6963C_WHITE)`

SPI_T6963C_Rectangle

Prototype	`sub procedure SPI_T6963C_Rectangle(dim x0 as integer, dim y0 as integer, dim x1 as integer, dim y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a rectangle on Glcd. Parameters : ■ `x0:` x coordinate of the upper left rectangle corner ■ `y0:` y coordinate of the upper left rectangle corner ■ `x1:` x coordinate of the lower right rectangle corner ■ `y1:` y coordinate of the lower right rectangle corner ■ `pcolor:` color parameter. Valid values: SPI_T6963C_BLACK and SPI_T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Rectangle(20, 20, 219, 107, T6963C_WHITE)`

SPI_T6963C_Box

Prototype	`sub procedure SPI_T6963C_Box(dim x0 as integer, dim y0 as integer, dim x1 as integer, dim y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a box on the Glcd Parameters : ■ `x0:` x coordinate of the upper left box corner ■ `y0:` y coordinate of the upper left box corner ■ `x1:` x coordinate of the lower right box corner ■ `y1:` y coordinate of the lower right box corner ■ `pcolor:` color parameter. Valid values: SPI_T6963C_BLACK and SPI_T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Box(0, 119, 239, 127, T6963C_WHITE)`

SPI_T6963C_Circle

Prototype	`sub procedure SPI_T6963C_Circle(dim x as integer, dim y as integer, dim r as longint, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a circle on the Glcd. Parameters : ■ `x:` x coordinate of the circle center ■ `y:` y coordinate of the circle center ■ `r:` radius size ■ `pcolor:` color parameter. Valid values: SPI_T6963C_BLACK and SPI_T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Circle(120, 64, 110, T6963C_WHITE)`

SPI_T6963C_Image

Prototype	`sub procedure SPI_T6963C_image(const pic as ^byte)`
Returns	Nothing.
Description	Displays bitmap on Glcd. Parameters : - `pic:` image to be displayed. Bitmap array can be located in both code and RAM memory (due to the mikroBasic PRO for PIC pointer to const and pointer to RAM equivalency). Use the mikroBasic PRO's integrated Glcd Bitmap Editor (menu option **Tools › Glcd Bitmap Editor**) to convert image to a constant array suitable for displaying on Glcd. **Note:** Image dimension must match the display dimension.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Image(my_image)`

SPI_T6963C_Sprite

Prototype	`sub procedure SPI_T6963C_sprite(dim px, py as byte, const pic as ^byte, dim sx, sy as byte)`
Returns	Nothing.
Description	Fills graphic rectangle area (px, py) to (px+sx, py+sy) with custom size picture. Parameters : - `px:` x coordinate of the upper left picture corner. Valid values: multiples of the font width - `py:` y coordinate of the upper left picture corner - `pic:` picture to be displayed - `sx:` picture width. Valid values: multiples of the font width - `sy:` picture height Note: If `px` and `sx` parameters are not multiples of the font width they will be scaled to the nearest lower number that is a multiple of the font width.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Sprite(76, 4, einstein, 88, 119)  ' draw a sprite`

SPI_T6963C_Set_Cursor

Prototype	`sub procedure SPI_T6963C_set_cursor(dim x, y as byte)`
Returns	Nothing.
Description	Sets cursor to row x and column y. Parameters : ■ `x:` cursor position row number ■ `y:` cursor position column number
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Set_Cursor(cposx, cposy)`

SPI_T6963C_ClearBit

Prototype	`sub procedure SPI_T6963C_clearBit(dim b as byte)`
Returns	Nothing.
Description	Clears control port bit(s). Parameters : ■ `b:` bit mask. The function will clear bit x on control port if bit x in bit mask is set to 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' clear bits 0 and 1 on control port` `SPI_T6963C_ClearBit(0x03)`

SPI_T6963C_SetBit

Prototype	`sub procedure SPI_T6963C_setBit(dim b as byte)`
Returns	Nothing.
Description	Sets control port bit(s). Parameters : ■ `b:` bit mask. The function will set bit x on control port if bit x in bit mask is set to 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' set bits 0 and 1 on control port` `SPI_T6963C_SetBit(0x03)`

SPI_T6963C_NegBit

Prototype	`sub procedure SPI_T6963C_negBit(dim b as byte)`
Returns	Nothing.
Description	Negates control port bit(s). Parameters : - `b:` bit mask. The function will negate bit x on control port if bit x in bit mask is set to 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' negate bits 0 and 1 on control port` `SPI_T6963C_NegBit(0x03)`

SPI_T6963C_DisplayGrPanel

Prototype	`sub procedure SPI_T6963C_DisplayGrPanel(dim n as byte)`
Returns	Nothing.
Description	Display selected graphic panel. Parameters : - `n`: graphic panel number. Valid values: `0` and `1.`
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' display graphic panel 1` `SPI_T6963C_DisplayGrPanel(1)`

SPI_T6963C_DisplayTxtPanel

Prototype	`sub procedure SPI_T6963C_DisplayTxtPanel(dim n as byte)`
Returns	Nothing.
Description	Display selected text panel. Parameters : - `n:` text panel number. Valid values: 0 and 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' display text panel 1` `SPI_T6963C_DisplayTxtPanel(1)`

SPI_T6963C_SetGrPanel

Prototype	`sub procedure SPI_T6963C_SetGrPanel(dim n as byte)`
Returns	Nothing.
Description	Compute start address for selected graphic panel and set appropriate internal pointers. All subsequent graphic operations will be preformed at this graphic panel. Parameters : ■ `n:` graphic panel number. Valid values: 0 and 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' set graphic panel 1 as current graphic panel.` `SPI_T6963C_SetGrPanel(1)`

SPI_T6963C_SetTxtPanel

Prototype	`sub procedure SPI_T6963C_SetTxtPanel(dim n as byte)`
Returns	Nothing.
Description	Compute start address for selected text panel and set appropriate internal pointers. All subsequent text operations will be preformed at this text panel. Parameters : ■ `n:` text panel number. Valid values: 0 and 1.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' set text panel 1 as current text panel.` `SPI_T6963C_SetTxtPanel(1)`

SPI_T6963C_PanelFill

Prototype	`sub procedure SPI_T6963C_PanelFill(dim v as byte)`
Returns	Nothing.
Description	Fill current panel in full (graphic+text) with appropriate value (0 to clear). Parameters : ■ `v:` value to fill panel with.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`clear current panel` `SPI_T6963C_PanelFill(0)`

SPI_T6963C_GrFill

Prototype	`sub procedure SPI_T6963C_GrFill(dim v as byte)`
Returns	Nothing.
Description	Fill current graphic panel with appropriate value (0 to clear). Parameters : ■ `v:` value to fill graphic panel with.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' clear current graphic panel` `SPI_T6963C_GrFill(0)`

SPI_T6963C_TxtFill

Prototype	`sub procedure SPI_T6963C_TxtFill(dim v as byte)`
Returns	Nothing.
Description	Fill current text panel with appropriate value (0 to clear). Parameters : ■ `v:` this value increased by 32 will be used to fill text panel.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' clear current text panel` `SPI_T6963C_TxtFill(0)`

SPI_T6963C_Cursor_Height

Prototype	`sub procedure SPI_T6963C_Cursor_Height(dim n as byte)`
Returns	Nothing.
Description	Set cursor size. Parameters : ■ `n:` cursor height. Valid values: 0..7.
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`SPI_T6963C_Cursor_Height(7)`

SPI_T6963C_Graphics

Prototype	`sub procedure SPI_T6963C_Graphics(dim n as byte)`
Returns	Nothing.
Description	Enable/disable graphic displaying. Parameters : ■ `n:` graphic enable/disable parameter. Valid values: `0` (disable graphic dispaying) and `1` (enable graphic displaying).
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`'enable graphic displaying` `SPI_T6963C_Graphics(1)`

SPI_T6963C_Text

Prototype	`sub procedure SPI_T6963C_Text(dim n as byte)`
Returns	Nothing.
Description	Enable/disable text displaying. Parameters : ■ `n:` text enable/disable parameter. Valid values: `0` (disable text dispaying) and `1` (enable text displaying).
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' enable text displaying` `SPI_T6963C_Text(1)`

SPI_T6963C_Cursor

Prototype	`sub procedure SPI_T6963C_Cursor(dim n as byte)`
Returns	Nothing.
Description	Set cursor on/off. Parameters : ■ `n:` on/off parameter.Valid values: `0` (set cursor off) and `1` (set cursor on).
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' set cursor on` `SPI_T6963C_Cursor(1)`

SPI_T6963C_Cursor_Blink

Prototype	`sub procedure SPI_T6963C_Cursor_Blink(dim n as byte)`
Returns	Nothing.
Description	Enable/disable cursor blinking. Parameters : ■ `n:` cursor blinking enable/disable parameter. Valid values: `0` (disable cursor blinking) and `1` (enable cursor blinking).
Requires	Toshiba Glcd module needs to be initialized. See SPI_T6963C_Config routine.
Example	`' enable cursor blinking` `SPI_T6963C_Cursor_Blink(1)`

Library Example

The following drawing demo tests advanced routines of the SPI T6963C Glcd library. Hardware configurations in this example are made for the T6963C 240x128 display, EasyPIC5 board and PIC16F887.

```
program SPI_T6963C_240x128

include __Lib_SPIT6963C_Const
include bitmap
include bitmap2

dim
' Port Expander module connections
```

```
  SPExpanderRST as sbit at RC0_bit
  SPExpanderCS  as sbit at RC1_bit
  SPExpanderRST_Direction as sbit at TRISC0_bit
  SPExpanderCS_Direction  as sbit at TRISC1_bit
' End Port Expander module connections

dim   panel  as byte             ' current panel
          i  as word            ' general purpose register
       curs as byte             ' cursor visibility
      cposx,
      cposy as word             ' cursor x-y position
      txt, txt1 as string[29]


main:
  txt1 = " EINSTEIN WOULD HAVE LIKED mE"
  txt  = " GLCD LIBRARY DEMO, WELCOME !"

  ANSEL  = 0                        ' Configure AN pins as digital I/O
  ANSELH = 0
  C1ON_bit = 0                      ' Disable comparators
  C2ON_bit = 0

  TRISB0_bit = 1                    ' Set RB0 as input
  TRISB1_bit = 1                    ' Set RB1 as input
  TRISB2_bit = 1                    ' Set RB2 as input
  TRISB3_bit = 1                    ' Set RB3 as input
  TRISB4_bit = 1                    ' Set RB4 as input

  ' Initialize SPI module
  SPI1_Init()

' ' If Port Expander Library uses SPI2 module
  ' Pass pointer to SPI Read sub function of used SPI module

  ' Initialize SPI module used with PortExpander
  '  SPI2_Init_Advanced(_SPI_MASTER, _SPI_FCY_DIV32, _SPI_CLK_HI_
TRAILING)

'  *
'  * init display for 240 pixel width and 128 pixel height
'  * 8 bits character width
'  * data bus on MCP23S17 portB
'  * control bus on MCP23S17 PORTA
'  * bit 2 is !WR
'  * bit 1 is !RD
'  * bit 0 is !CD
'  * bit 4 is RST
'  * chip enable, reverse on, 8x8 font internaly set in library
```

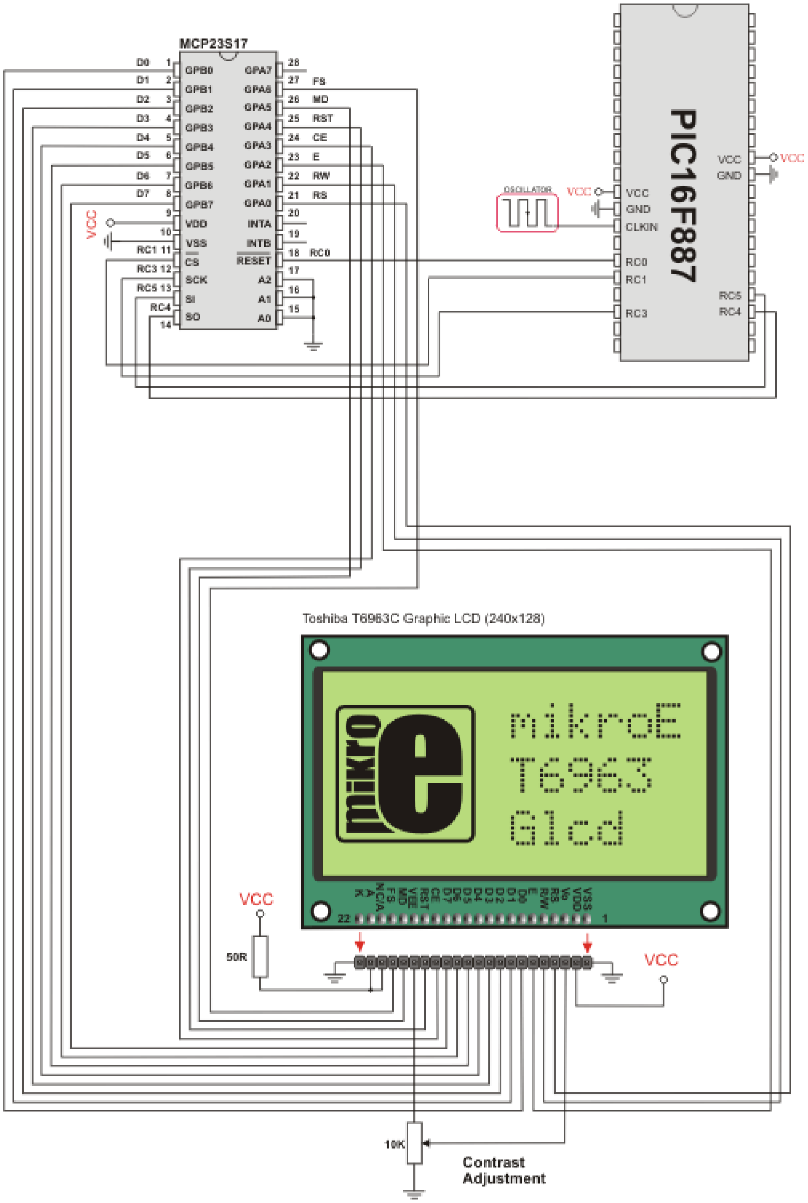
```
'  *

  ' Initialize SPI Toshiba 240x128
  SPI_T6963C_Config(240, 128, 8, 0, 2, 1, 0, 4)
  'Delay_ms(1000)

'   *
'   * Enable both graphics and text display at the same time
'   *

  SPI_T6963C_graphics(1)

  SPI_T6963C_text(1)

  panel = 0
  i = 0
  curs = 0
  cposx = 0
  cposy = 0

'   *
'   * Text messages
'   *
  SPI_T6963C_write_text(txt, 0, 0, SPI_T6963C_ROM_MODE_XOR)
  SPI_T6963C_write_text(txt1, 0, 15, SPI_T6963C_ROM_MODE_XOR)

'   *
'   * Cursor
'   *
  SPI_T6963C_cursor_height(8)         ' 8 pixel height
  SPI_T6963C_set_cursor(0, 0)         ' move cursor to top left
  SPI_T6963C_cursor(0)                 ' cursor off

'   *
'   * Draw rectangles
'   *
  SPI_T6963C_rectangle(0, 0, 239, 127, SPI_T6963C_WHITE)
  SPI_T6963C_rectangle(20, 20, 219, 107, SPI_T6963C_WHITE)
  SPI_T6963C_rectangle(40, 40, 199, 87, SPI_T6963C_WHITE)
  SPI_T6963C_rectangle(60, 60, 179, 67, SPI_T6963C_WHITE)


'   *
'   * Draw a cross
'   *
  SPI_T6963C_line(0, 0, 239, 127, SPI_T6963C_WHITE)
  SPI_T6963C_line(0, 127, 239, 0, SPI_T6963C_WHITE)

'   *
```

```
'   * Draw solid boxes
'   *
  SPI_T6963C_box(0, 0, 239, 8, SPI_T6963C_WHITE)
  SPI_T6963C_box(0, 119, 239, 127, SPI_T6963C_WHITE)

'   *
'   * Draw circles
'   *
  SPI_T6963C_circle(120, 64, 10,  SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 30,  SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 50,  SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 70,  SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 90,  SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 110, SPI_T6963C_WHITE)
  SPI_T6963C_circle(120, 64, 130, SPI_T6963C_WHITE)

  SPI_T6963C_sprite(76, 4, @einstein, 88, 119)    ' Draw a sprite

  SPI_T6963C_setGrPanel(1)               ' Select other graphic panel

  SPI_T6963C_sprite(0, 0,  @mikroe, 240, 64)    ' 240x128 can"t be
stored in most of PIC16 MCUs
  SPI_T6963C_sprite(0, 64, @mikroe, 240, 64)      ' it is replaced
with smaller picture 240x64
                                ' Smaller picture is drawn two times

  while TRUE                                          ' Endless loop

       '*
       '* If PORTB_0 is pressed, toggle the display between graphic
panel 0 and graphic 1
       '*

    if (RB0_bit <> 0) then
        Inc(panel)
        panel = panel and 1
        SPI_T6963C_displayGrPanel(panel)
        Delay_ms(300)

    '*
    '* If PORTB_2 is pressed, display only text panel
    '*
      else
        if (RB2_bit <> 0) then
            SPI_T6963C_graphics(0)
            SPI_T6963C_text(1)
            Delay_ms(300)
    '*
    '* If PORTB_3 is pressed, display text and graphic panels
    '*
```

```
       else
          if  (RB3_bit <> 0)  then
              SPI_T6963C_graphics(1)
              SPI_T6963C_text(1)
              Delay_ms(300)

    '*
    '*  If PORTB_4 is pressed, change cursor
    '*
          else
            if(RB4_bit <> 0)  then
              Inc(curs)
              if  (curs = 3)  then
                curs = 0
              end if
              select case curs
                case 0
                     ' no cursor
                     SPI_T6963C_cursor(0)
                case 1
                       ' blinking cursor
                       SPI_T6963C_cursor(1)
                       SPI_T6963C_cursor_blink(1)
                case 2
                       ' non blinking cursor
                       SPI_T6963C_cursor(1)
                       SPI_T6963C_cursor_blink(0)
              end select  'case
                Delay_ms(300)

            end if
          end if
        end if
      end if
    end if

      '*
      '* Move cursor, even if not visible
      '*
      Inc(cposx)
      if  (cposx = SPI_T6963C_txtCols)  then
        cposx = 0
        Inc(cposy)
        if  (cposy = SPI_T6963C_grHeight / SPI_T6963C_CHARACTER_
HEIGHT)  then
          cposy = 0
        end if
      end if
      SPI_T6963C_set_cursor(cposx, cposy)
```

```
        Delay_ms(100)
    wend
  end.
```

HW Connection



SPI T6963C Glcd HW connection

T6963C GRAPHIC LCD LIBRARY

The *mikroBasic PRO for PIC* provides a library for working with Glcds based on TOSHIBA T6963C controller. The Toshiba T6963C is a very popular Lcd controller for the use in small graphics modules. It is capable of controlling displays with a resolution up to 240x128. Because of its low power and small outline it is most suitable for mobile applications such as PDAs, MP3 players or mobile measurement equipment. Although small, this contoller has a capability of displaying and merging text and graphics and it manages all the interfacing signals to the displays Row and Column drivers.

For creating a custom set of Glcd images use Glcd Bitmap Editor Tool.

Note: ChipEnable(CE), FontSelect(FS) and Reverse(MD) have to be set to appropriate levels by the user outside of the `T6963C_Init` function. See the Library Example code at the bottom of this page.
Note: Some mikroElektronika's adapter boards have pinout different from T6369C datasheets. Appropriate relations between these labels are given in the table below:

Adapter Board	T6369C datasheet
RS	C/D
R/W	/RD
E	/WR

External dependencies of T6963C Graphic LCD Library

The following variables must be defined in all projects using T6963C Graphic LCD library:	Description:	Example :
`dim T6963C_dataPort as byte sfr external`	T6963C Data Port.	`dim T6963C_dataPort as byte at PORTD`
`dim T6963C_ctrlwr as sbit sfr external`	Write signal.	`dim T6963C_ctrlwr as sbit at RC2_bit`
`dim T6963C_ctrlrd as sbit sfr external`	Read signal.	`dim T6963C_ctrlrd as sbit at RC1_bit`
`dim T6963C_ctrlcd as sbit sfr external`	Command/Data signal.	`dim T6963C_ctrlcd as sbit at RC0_bit`
`dim T6963C_ctrlrst as sbit sfr external`	Reset signal.	`dim T6963C_ctrlrst as sbit at RC4_bit`
`dim T6963C_ctrlwr_Direction as sbit sfr external`	Direction of the Write pin.	`dim T6963C_ctrlwr_Direction as sbit at TRISC2_bit`

The following variables must be defined in all projects using T6963C Graphic LCD library:	Description:	Example :
`dim T6963C_ctrlrd_Direction as sbit sfr external`	Direction of the Read pin.	`dim T6963C_ctrlrd_Direction as sbit at TRISC1_bit`
`dim T6963C_ctrlcd_Direction as sbit sfr external`	Direction of the Command/Data pin.	`dim T6963C_ctrlcd_Direction as sbit at TRISC0_bit`
`dim T6963C_ctrlrst_Direction as sbit sfr external`	Direction of the Reset pin.	`dim T6963C_ctrlrst_Direction as sbit at TRISC4_bit`

Library Routines

- T6963C_Init
- T6963C_WriteData
- T6963C_WriteCommand
- T6963C_SetPtr
- T6963C_WaitReady
- T6963C_Fill
- T6963C_Dot
- T6963C_Write_Char
- T6963C_Write_Text
- T6963C_Line
- T6963C_Rectangle
- T6963C_Box
- T6963C_Circle
- T6963C_Image
- T6963C_Sprite
- T6963C_Set_Cursor
- T6963C_DisplayGrPanel
- T6963C_DisplayTxtPanel
- T6963C_SetGrPanel
- T6963C_SetTxtPanel
- T6963C_PanelFill
- T6963C_GrFill
- T6963C_TxtFill
- T6963C_Cursor_Height
- T6963C_Graphics
- T6963C_Text
- T6963C_Cursor
- T6963C_Cursor_Blink

T6963C_Init

Prototype

```
sub procedure T6963C_init(dim width, height, fntW as byte)
```

Returns

Nothing.

Description

Initializes T6963C Graphic Lcd controller.

Parameters :

- `width:` width of the Glcd panel
- `height:` height of the Glcd panel
- `fntW:` font width

Display RAM organization:
The library cuts the RAM into panels : a complete panel is one graphics panel followed by a text panel (see schematic below).

```
schematic:
+--------------------- +  /\
+ GRAPHICS PANEL #0    +   |
+                      +   |
+                      +   |
+                      +   |
+--------------------- +   | PANEL 0
+ TEXT PANEL #0        +   |
+                      +  \/
+--------------------- +  /\
+ GRAPHICS PANEL #1    +   |
+                      +   |
+                      +   |
+                      +   |
+--------------------- +   | PANEL 1
+ TEXT PANEL #1        +   |
+                      +   |
+--------------------- +  \/
```

Requires

Global variables :

- `T6963C_dataPort`: Data Port
- `T6963C_ctrlwr`: Write signal pin
- `T6963C_ctrlrd:` Read signal pin
- `T6963C_ctrlcd:` Command/Data signal pin
- `T6963C_ctrlrst:` Reset signal pin
- `T6963C_ctrlwr_Direction:` Direction of Write signal pin
- `T6963C_ctrlrd_Direction:` Direction of Read signal pin
- `T6963C_ctrlcd_Direction:` Direction of Command/Data signal pin
- `T6963C_ctrlrst_Direction:` Direction of Reset signal pin

must be defined before using this function.

Example

```
  'T6963C module connections
dim T6963C_dataPort as byte at PORTD
dim T6963C_ctrlwr as sbit at RC2_bit
dim T6963C_ctrlrd as sbit at RC1_bit
dim T6963C_ctrlcd as sbit at RC0_bit
dim T6963C_ctrlrst as sbit at RC4_bit
dim T6963C_ctrlwr_Direction as sbit at TRISC2_bit
dim T6963C_ctrlrd_Direction as sbit at TRISC1_bit
dim T6963C_ctrlcd_Direction as sbit at TRISC0_bit
dim T6963C_ctrlrst_Direction as sbit at TRISC4_bit
' End of T6963C module connections

...
' init display for 240 pixel width, 128 pixel height and 8 bits
character width
T6963C_init(240, 128, 8)
```

T6963C_WriteData

Prototype	`sub procedure T6963C_WriteData(dim mydata as byte)`
Returns	Nothing.
Description	Writes data to T6963C controller. Parameters : ■ `mydata:` data to be written
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_WriteData(AddrL)`

T6963C_WriteCommand

Prototype	`sub procedure T6963C_WriteCommand(dim mydata as byte)`
Returns	Nothing.
Description	Writes command to T6963C controller. Parameters : ■ `mydata:` command to be written
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_WriteCommand(T6963C_CURSOR_POINTER_SET)`

T6963C_SetPtr

Prototype	`sub procedure T6963C_SetPtr(dim p as word, dim c as byte)`
Returns	Nothing.
Description	Sets the memory pointer p for command c. Parameters : ■ `p:` address where command should be written ■ `c:` command to be written
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_SetPtr(T6963C_grHomeAddr + start, T6963C_ADDRESS_POINTER_SET)`

T6963C_WaitReady

Prototype	`sub procedure T6963C_WaitReady()`
Returns	Nothing.
Description	Pools the status byte, and loops until Toshiba Glcd module is ready.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_WaitReady()`

T6963C_Fill

Prototype	`sub procedure T6963C_Fill(dim v as byte, dim start, len as word)`
Returns	Nothing.
Description	Fills controller memory block with given byte. Parameters : ■ `v:` byte to be written ■ `start:` starting address of the memory block ■ `len:` length of the memory block in bytes
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Fill(0x33,0x00FF,0x000F)`

T6963C_Dot

Prototype	`sub procedure T6963C_Dot(dim x, y as integer, dim color as byte)`
Returns	Nothing.
Description	Draws a dot in the current graphic panel of Glcd at coordinates (x, y). Parameters : - `x:` dot position on x-axis - `y:` dot position on y-axis - `color:` color parameter. Valid values: T6963C_BLACK and T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Dot(x0, y0, pcolor)`

T6963C_Write_Char

Prototype	`sub procedure T6963C_Write_Char(dim c, x, y, mode as byte)`
Returns	Nothing.
Description	Writes a char in the current text panel of Glcd at coordinates (x, y). Parameters : - `c:` char to be written - `x:` char position on x-axis - `y:` char position on y-axis - `mode:` mode parameter. Valid values: T6963C_ROM_MODE_OR, T6963C_ROM_MODE_XOR, T6963C_ROM_MODE_AND and T6963C_ROM_MODE_TEXT Mode parameter explanation: - `OR Mode`: In the OR-Mode, text and graphics can be displayed and the data is logically “OR-ed”. This is the most common way of combining text and graphics for example labels on buttons. - `XOR-Mode:` In this mode, the text and graphics data are combined via the logical “exclusive OR”. This can be useful to display text in the negative mode, i.e. white text on black background. - `AND-Mode:` The text and graphic data shown on display are combined via the logical “AND function”. - `TEXT-Mode:`This option is only available when displaying just a text. The Text Attribute values are stored in the graphic area of display memory. For more details see the T6963C datasheet.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Write_Char('A',22,23,AND)`

T6963C_Write_Text

Prototype	`sub procedure T6963C_Write_Text(dim byref str as byte[ 10] , dim x, y, mode as byte)`
Returns	Nothing.
Description	Writes text in the current text panel of Glcd at coordinates (x, y). Parameters : ■ `str:` text to be written ■ `x:` text position on x-axis ■ `y:` text position on y-axis ■ `mode:` mode parameter. Valid values: T6963C_ROM_MODE_OR, T6963C_ROM_MODE_XOR, T6963C_ROM_MODE_AND and T6963C_ROM_MODE_TEXT Mode parameter explanation: ■ `OR Mode:` In the OR-Mode, text and graphics can be displayed and the data is logically “OR-ed”. This is the most common way of combining text and graphics for example labels on buttons. ■ `XOR-Mode:` In this mode, the text and graphics data are combined via the logical “exclusive OR”. This can be useful to display text in the negatiive mode, i.e. white text on black background. ■ `AND-Mode:` The text and graphic data shown on display are combined via the logical “AND function”. ■ `TEXT-Mode:` This option is only available when displaying just a text. The Text Attribute values are stored in the graphic area of display memory. For more details see the T6963C datasheet.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Write_Text(" GLCD LIBRARY DEMO, WELCOME !", 0, 0, T6963C_ROM_MODE_XOR)`

T6963C_Line

Prototype	`sub procedure T6963C_Line(dim x0, y0, x1, y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a line from (x0, y0) to (x1, y1). Parameters : ■ `x0:` x coordinate of the line start ■ `y0:` y coordinate of the line end ■ `x1:` x coordinate of the line start ■ `y1:` y coordinate of the line end ■ `pcolor:` color parameter. Valid values: T6963C_BLACK and T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Line(0, 0, 239, 127, T6963C_WHITE)`

T6963C_Rectangle

Prototype	`sub procedure T6963C_Rectangle(dim x0, y0, x1, y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a rectangle on Glcd. Parameters : ■ `x0:` x coordinate of the upper left rectangle corner ■ `y0:` y coordinate of the upper left rectangle corner ■ `x1:` x coordinate of the lower right rectangle corner ■ `y1:` y coordinate of the lower right rectangle corner ■ `pcolor:` color parameter. Valid values: T6963C_BLACK and T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Rectangle(20, 20, 219, 107, T6963C_WHITE)`

T6963C_Box

Prototype	`psub procedure T6963C_Box(dim x0, y0, x1, y1 as integer, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a box on Glcd. Parameters : ■ `x0:` x coordinate of the upper left box corner ■ `y0:` y coordinate of the upper left box corner ■ `x1:` x coordinate of the lower right box corner ■ `y1:` y coordinate of the lower right box corner ■ `pcolor:` color parameter. Valid values: T6963C_BLACK and T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Box(0, 119, 239, 127, T6963C_WHITE)`

T6963C_Circle

Prototype	`sub procedure T6963C_Circle(dim x, y as integer, dim r as longint, dim pcolor as byte)`
Returns	Nothing.
Description	Draws a circle on Glcd. Parameters : ■ `x:` x coordinate of the circle center ■ `y:` y coordinate of the circle center ■ `r:` radius size ■ `pcolor:` color parameter. Valid values: T6963C_BLACK and T6963C_WHITE
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Circle(120, 64, 110, T6963C_WHITE)`

T6963C_Image

Prototype	`sub procedure T6963C_Image(const pic as ^byte)`
Returns	Nothing.
Description	Displays bitmap on Glcd. Parameters : ■ `pic:` image to be displayed. Bitmap array can be located in both code and RAM memory (due to the mikroBasic PRO for PIC pointer to const and pointer to RAM equivalency). Use the mikroBasic PRO's integrated Glcd Bitmap Editor (menu option **Tools › Glcd Bitmap Editor**) to convert image to a constant array suitable for displaying on Glcd. **Note:** Image dimension must match the display dimension.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`TT6963C_Image(mc)`

T6963C_Sprite

Prototype	`sub procedure T6963C_Sprite(dim px, py, sx, sy as byte, const pic as ^byte)`
Returns	Nothing.
Description	Fills graphic rectangle area (px, py) to (px+sx, py+sy) with custom size picture. Parameters : ■ `px:` x coordinate of the upper left picture corner. Valid values: multiples of the font width ■ `py:` y coordinate of the upper left picture corner ■ `pic:` picture to be displayed ■ `sx:` picture width. Valid values: multiples of the font width ■ `sy:` picture height **Note**: If `px` and `sx` parameters are not multiples of the font width they will be scaled to the nearest lower number that is a multiple of the font width.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Sprite(76, 4, einstein, 88, 119) ' draw a sprite`

T6963C_Set_Cursor

Prototype	`sub procedure T6963C_Set_Cursor(dim x, y as byte)`
Returns	Nothing.
Description	Sets cursor to row x and column y. Parameters : ■ `x:` cursor position row number ■ `y:` cursor position column number
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Set_Cursor(cposx, cposy)`

T6963C_DisplayGrPanel

Prototype	`sub procedure T6963C_DisplayGrPanel(dim n as byte)`
Returns	Nothing.
Description	Display selected graphic panel. Parameters : ■ `n:` graphic panel number. Valid values: `0` and `1`.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' display text panel 1` `T6963C_DisplayTxtPanel(1)`

T6963C_DisplayTxtPanel

Prototype	`sub procedure T6963C_DisplayTxtPanel(dim n as byte)`
Returns	Nothing.
Description	Display selected text panel. Parameters : ■ `n`: text panel number. Valid values: `0` and `1.`
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' display text panel 1` `T6963C_DisplayTxtPanel(1)`

T6963C_SetGrPanel

Prototype	`sub procedure T6963C_SetGrPanel(dim n as byte)`
Returns	Nothing.
Description	Compute start address for selected graphic panel and set appropriate internal pointers. All subsequent graphic operations will be preformed at this graphic panel. Parameters : ■ `n:` graphic panel number. Valid values: `0` and `1`.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' set graphic panel 1 as current graphic panel.` `T6963C_SetGrPanel(1)`

T6963C_SetTxtPanel

Prototype	`sub procedure T6963C_SetTxtPanel(dim n as byte)`
Returns	Nothing.
Description	Compute start address for selected text panel and set appropriate internal pointers. All subsequent text operations will be preformed at this text panel. Parameters ■ `n:` text panel number. Valid values: `0` and `1`.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' set text panel 1 as current text panel.` `T6963C_SetTxtPanel(1)`

T6963C_PanelFill

Prototype	`sub procedure T6963C_PanelFill(dim v as byte)`
Returns	Nothing.
Description	Fill current panel in full (graphic+text) with appropriate value (0 to clear). Parameters : ■ `v`: value to fill panel with.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`clear current panel` `T6963C_PanelFill(0)`

T6963C_GrFill

Prototype	`procedure T6963C_GrFill(v : byte);`
Returns	Nothing.
Description	Fill current graphic panel with appropriate value (0 to clear). Parameters : ■ `v:` value to fill graphic panel with.
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`‘clear current graphic panel` `T6963C_GrFill(0)`

T6963C_TxtFill

Prototype	`sub procedure T6963C_TxtFill(dim v as byte)`
Returns	Nothing.
Description	Fill current text panel with appropriate value (0 to clear). Parameters : ■ `v:` this value increased by 32 will be used to fill text panel.
Requires	Toshiba GLCD module needs to be initialized. See the T6963C_Init routine.
Example	`' clear current text panel` `T6963C_TxtFill(0)`

T6963C_Cursor_Height

Prototype	`sub procedure T6963C_Cursor_Height(dim n as byte)`
Returns	Nothing.
Description	Set cursor size. Parameters : - `n` cursor height. Valid values: `0..7.`
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`T6963C_Cursor_Height(7)`

T6963C_Graphics

Prototype	`sub procedure T6963C_Graphics(dim n as byte)`
Returns	Nothing.
Description	Enable/disable graphic displaying. Parameters : - `n:` on/off parameter. Valid values: `0` (disable graphic dispaying) and `1` (enable graphic displaying).
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' enable graphic displaying` `T6963C_Graphics(1)`

T6963C_Text

Prototype	`sub procedure T6963C_Text(dim n as byte)`
Returns	Nothing.
Description	Enable/disable text displaying. Parameters : - `n:` on/off parameter. Valid values: 0 (disable text dispaying) and 1 (enable text displaying).
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' enable text displaying` `T6963C_Text(1)`

T6963C_Cursor

Prototype	`sub procedure T6963C_Cursor(dim n as byte)`
Returns	Nothing.
Description	Set cursor on/off. Parameters : ■ `n:` on/off parameter. Valid values: `0` (set cursor off) and `1` (set cursor on).
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' set cursor on` `T6963C_Cursor(1)`

T6963C_Cursor_Blink

Prototype	`sub procedure T6963C_Cursor_Blink(dim n as byte)`
Returns	Nothing.
Description	Enable/disable cursor blinking. Parameters : ■ `n:` on/off parameter. Valid values: `0` (disable cursor blinking) and `1` (enable cursor blinking).
Requires	Toshiba Glcd module needs to be initialized. See the T6963C_Init routine.
Example	`' enable cursor blinking` `T6963C_Cursor_Blink(1)`

Library Example

The following drawing demo tests advanced routines of the T6963C Glcd library. Hardware configurations in this example are made for the T6963C 240x128 display, EasyPIC5 board and PIC16F887.

```
program T6963C_240x128

include __Lib_T6963C_Consts
include einstein_bmp
include mikroe_bmp

' T6963C module connections
dim T6963C_dataPort as byte at PORTD         ' DATA port

dim T6963C_ctrlwr as sbit at RC2_bit         ' WR write signal
dim T6963C_ctrlrd as sbit at RC1_bit         ' RD read signal
dim T6963C_ctrlcd as sbit at RC0_bit         ' CD command/data signal
dim T6963C_ctrlrst as sbit at RC4_bit        ' RST reset signal
dim T6963C_ctrlwr_Direction as sbit at TRISC2_bit  ' WR write signal
direction
dim T6963C_ctrlrd_Direction as sbit at TRISC1_bit  ' RD read signal
direction
dim T6963C_ctrlcd_Direction as sbit at TRISC0_bit  ' CD command/data
signal direction
dim T6963C_ctrlrst_Direction as sbit at TRISC4_bit  ' RST reset sig-
nal direction

' Signals not used by library, they are set in main sub function
dim T6963C_ctrlce as sbit at RC3_bit          ' CE signal
dim T6963C_ctrlfs as sbit at RC6_bit          ' FS signal
dim T6963C_ctrlmd as sbit at RC5_bit          ' MD signal
dim  T6963C_ctrlce_Direction  as  sbit  at  TRISC3_bit     '  CE  signal
direction
dim T6963C_ctrlfs_Direction as sbit at TRISC6_bit        ' FS signal
direction
dim T6963C_ctrlmd_Direction as sbit at TRISC5_bit          ' MD sig-
nal direction
' End T6963C module connections

dim   panel as byte           ' current panel
          i as word           ' general purpose register
       curs as byte           ' cursor visibility
      cposx,
      cposy as word           ' cursor x-y position
      txtcols as byte         ' number of text coloms
      txt, txt1 as string[ 29]

main:
  txt1 = " EINSTEIN WOULD HAVE LIKED mE"
  txt  = " GLCD LIBRARY DEMO, WELCOME !"

  ANSEL  = 0                          ' Configure AN pins as digital I/O
  ANSELH = 0
  C1ON_bit = 0                        ' Disable comparators
  C2ON_bit = 0
```

```
  TRISB0_bit = 1                   ' Set RB0 as input
  TRISB1_bit = 1                   ' Set RB1 as input
  TRISB2_bit = 1                   ' Set RB2 as input
  TRISB3_bit = 1                   ' Set RB3 as input
  TRISB4_bit = 1                   ' Set RB4 as input

  T6963C_ctrlce_Direction = 0
  T6963C_ctrlce = 0               ' Enable T6963C
  T6963C_ctrlfs_Direction = 0
  T6963C_ctrlfs = 0               ' Font Select 8x8
  T6963C_ctrlmd_Direction = 0
  T6963C_ctrlmd = 0               ' Column number select

  panel = 0
  i = 0
  curs = 0
  cposx = 0
  cposy = 0

  ' Initialize T6369C
  T6963C_init(240, 128, 8)

'   *
'   * Enable both graphics and text display at the same time
'   *
  T6963C_graphics(1)
  T6963C_text(1)

'   *
'   * Text messages
'   *
  T6963C_write_text(txt, 0, 0, T6963C_ROM_MODE_XOR)
  T6963C_write_text(txt1, 0, 15, T6963C_ROM_MODE_XOR)


'   *
'   * Cursor
'   *
  T6963C_cursor_height(8)         ' 8 pixel height
  T6963C_set_cursor(0, 0)         ' Move cursor to top left
  T6963C_cursor(0)               ' Cursor off

'   *
'   * Draw rectangles
'   *
  T6963C_rectangle(0, 0, 239, 127, T6963C_WHITE)
  T6963C_rectangle(20, 20, 219, 107, T6963C_WHITE)
  T6963C_rectangle(40, 40, 199, 87, T6963C_WHITE)
  T6963C_rectangle(60, 60, 179, 67, T6963C_WHITE)
```

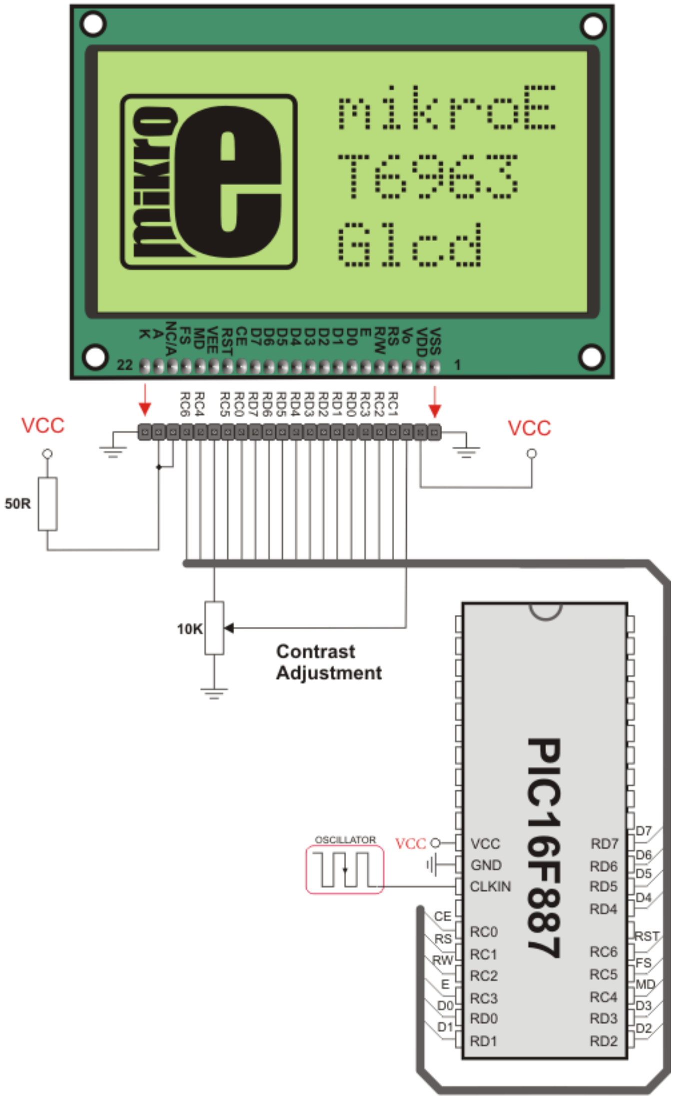
```
'    *
'    * Draw a cross
'    *
  T6963C_line(0, 0, 239, 127, T6963C_WHITE)
  T6963C_line(0, 127, 239, 0, T6963C_WHITE)

'    *
'    * Draw solid boxes
'    *
  T6963C_box(0, 0, 239, 8, T6963C_WHITE)
  T6963C_box(0, 119, 239, 127, T6963C_WHITE)

'    *
'    * Draw circles
'    *
  T6963C_circle(120, 64, 10, T6963C_WHITE)
  T6963C_circle(120, 64, 30, T6963C_WHITE)
  T6963C_circle(120, 64, 50, T6963C_WHITE)
  T6963C_circle(120, 64, 70, T6963C_WHITE)
  T6963C_circle(120, 64, 90, T6963C_WHITE)
  T6963C_circle(120, 64, 110, T6963C_WHITE)
  T6963C_circle(120, 64, 130, T6963C_WHITE)

  T6963C_sprite(76, 4, @einstein, 88, 119)       ' Draw a sprite

  T6963C_setGrPanel(1)                         ' Select other graphic panel

   T6963C_sprite(0, 0,  @mikroe_bmp, 240, 64)   ' 240x128 can"t be
stored in most of PIC16 MCUs
  T6963C_sprite(0, 64, @mikroe_bmp, 240, 64)    ' it is replaced with
smaller picture 240x64
                                                 '   Smaller picture
is drawn two times

  while TRUE                                     ' Endless loop

     '*
     '* If PORTB_0 is pressed, toggle the display between graphic
panel 0 and graphic 1
    '*

    if (RB0_bit <> 0) then
          T6963C_graphics(1)
          T6963C_text(0)
          Delay_ms(300)

     '*
     '* If PORTB_1 is pressed, display only graphic panel
     '*
```

```
              else
              if   (RB1_bit <>  0)  then
                  Inc(panel)
                  panel = panel and 1
                  T6963C_setPtr((T6963C_grMemSize   +  T6963C_txtMemSize)   *
panel, T6963C_GRAPHIC_HOME_ADDRESS_SET)
                 Delay_ms(300)

            '*
            '* If PORTB_2 is pressed, display only text panel
            '*
              else
                if (RB2_bit <>  0)  then
                  T6963C_graphics(0)
                  T6963C_text(1)
                  Delay_ms(300)

            '*
            '* If PORTB_3 is pressed, display text and graphic panels
            '*
                else
                  if (RB3_bit <>  0)  then
                    T6963C_graphics(1)
                    T6963C_text(1)
                    Delay_ms(300)

            '*
            '*  If PORTB_4 is pressed, change cursor
            '*
                  else
                    if(RB4_bit <>  0)  then
                      Inc(curs)
                      if (curs = 3)  then
                        curs = 0
                      end if
                      select case curs
                        case 0
                               ' no cursor
                               T6963C_cursor(0)
                        case 1
                               ' blinking cursor
                               T6963C_cursor(1)
                               T6963C_cursor_blink(1)
                        case 2
                               ' non blinking cursor
                               T6963C_cursor(1)
                               T6963C_cursor_blink(0)
                      end select  'case
                        Delay_ms(300)
```

```
               end if
                  end if
                end if
              end if
            end if

              '*
              '* Move cursor, even if not visible
              '*
              Inc(cposx)
              if (cposx = T6963C_txtCols) then
                cposx = 0
                Inc(cposy)
                if (cposy = T6963C_grHeight / T6963C_CHARACTER_HEIGHT) then
                  cposy = 0
                end if
              end if
              T6963C_set_cursor(cposx, cposy)

              Delay_ms(100)
          wend
        end.
```

HW Connection

Toshiba T6963C Graphic LCD (240x128)



T6963C Glcd HW connection

UART LIBRARY

UART hardware module is available with a number of PIC MCUs. mikroBasic PRO for PIC UART Library provides comfortable work with the Asynchronous (full duplex) mode.

You can easily communicate with other devices via RS-232 protocol (for example with PC, see the figure at the end of the topic – RS-232 HW connection). You need a PIC MCU with hardware integrated UART, for example 16F887. Then, simply use the functions listed below.

Note: Some PIC18 MCUs have multiple UART modules. Switching between the UART modules in the UART library is done by the UART_Set_Active function (UART module has to be previously initialized).
Note: In order to use the desired UART library routine, simply change the number 1 in the prototype with the appropriate module number, i.e. UART2_Init(2400)

Library Routines

- UART1_Init
- UART1_Data_Ready
- UART1_Tx_Idle
- UART1_Read
- UART1_Read_Text
- UART1_Write
- UART1_Write_Text
- UART_Set_Active

UART1_Init

Prototype	`sub procedure UART1_Init(dim baud_rate as longint)`
Returns	Nothing.
Description	Configures and initializes the UART module. The internal UART module module is set to: ■ receiver enabled ■ transmitter enabled ■ frame size 8 bits ■ 1 STOP bit ■ parity mode disabled ■ asynchronous operation Parameters : ■ `baud_rate:` requested baud rate Refer to the device data sheet for baud rates allowed for specific Fosc.
Requires	You'll need PIC MCU with hardware UART. `UART1_Init` needs to be called before using other functions from UART Library. **Note:** Calculation of the UART baud rate value is carried out by the compiler, as it would produce a relatively large code if performed on the libary level. Therefore, compiler needs to know the value of the parameter in the compile time. That is why this parameter needs to be a constant, and not a variable.

Example

```
'This will initialize hardware UART1 module and establish the
communication at 2400 bps
  UART1_Init(2400)
```

UART1_Data_Read

Prototype	`sub function UART1_Data_Ready() as byte`
Returns	Function returns 1 if data is ready or 0 if there is no data.
Description	The function tests if data in receive buffer is ready for reading.
Requires	MCU with the UART module. The UART module must be initialized before using this routine. See the UART1_Init routine.

Example

```
dim receive as byte
...
' read data if ready
if (UART1_Data_Ready() = 1) then
  receive = UART1_Read()
end if
```

UART1_Tx_Idle

Prototype	`char UART1_Tx_Idle()`
	■ `1` if the data has been transmitted ■ `0` otherwise
Description	Use the function to test if the transmit shift register is empty or not.
Requires	UART HW module must be initialized and communication established before using this function. See UART1_Init.
Example	

```
' If the previous data has been shifted out, send next data:
if (UART1_Tx_Idle = 1) then
  UART1_Write(_data)
end if
```

UART1_Read

Prototype	`sub function UART1_Read() as byte`
Returns	Received byte.
Description	The function receives a byte via UART. Use the UART1_Data_Ready function to test if data is ready first.
Requires	MCU with the UART module. The UART module must be initialized before using this routine. See UART1_Init routine.
Example	

```
dim receive as byte
...
' read data if ready
if (UART1_Data_Ready() = 1) then
  receive = UART1_Read()
```

UART1_Read_Text

Prototype	`sub procedure UART1_Read_Text(dim byref Output as string[ 255] , dim byref Delimiter as string[ 10] , dim Attempts as byte)`
Returns	Nothing.
Description	Reads characters received via UART until the delimiter sequence is detected. The read sequence is stored in the parameter output; delimiter sequence is stored in the parameter `delimiter`. This is a blocking call: the delimiter sequence is expected, otherwise the procedure exits(if the delimiter is not found). Attempts defines number of received characters in which Delimiter sequence is expected. If Attempts is set to 255, this routine will continously try to detect the Delimiter sequence.
Requires	UART HW module must be initialized and communication established before using this function. See UART1_Init.

Example

Read text until the sequence “OK” is received, and send back what’s been received:

```
UART1_Init(4800)                            ' initialize UART module
Delay_ms(100)

 while TRUE
   if (UART1_Data_Ready() = 1)          ' if data is received
     UART1_Read_Text(output, 'delim', 10)  ' reads text until
'delim' is found
     UART1_Write_Text(output)              ' sends back text
   end if
 wend.
```

UART1_Write

Prototype	`sub procedure UART1_Write(dim TxData as byte)`
Returns	Nothing.
Description	The function transmits a byte via the UART module. Parameters : ■ `TxData:` data to be sent
Requires	MCU with the UART module. The UART module must be initialized before using this routine. See UART1_Init routine.

Example

```
dim data_ as byte
...
data_ = 0x1E
UART1_Write(data_)
```

UART1_Write_Text

Prototype	`sub procedure UART1_Write_Text(dim byref uart_text as string[ 255]`
Returns	Nothing.
Description	Sends text (parameter `uart_text`) via UART. Text should be zero terminated.
Requires	UART HW module must be initialized and communication established before using this function. See UART1_Init.

Example

Read text until the sequence “OK” is received, and send back what’s been received:

```
UART1_Init(4800)                          ' initialize UART module
Delay_ms(100)

 while TRUE
   if (UART1_Data_Ready() = 1)              ' if data is received
       UART1_Read_Text(output, 'delim', 10)  ' reads text until
'delim' is found
     UART1_Write_Text(output)               ' sends back text
   end if
 wend.
```

UART_Set_Active

Prototype	`sub procedure UART_Set_Active (dim read_ptr as ^Tread_ptr, dim write_ptr as ^Twrite_ptr, dim ready_ptr as ^Tready_ptr, dim tx_idle_ptr as ^Ttx_idle_ptr)`
Returns	Nothing.
Description	Sets active UART module which will be used by the UART library routines. Parameters : ■ `read_ptr:` UART1_Read handler ■ `write_ptr:` UART1_Write handler ■ `ready_ptr:` UART1_Data_Ready handler ■ `tx_idle_ptr:` UART1_Tx_Idle handler
Requires	Routine is available only for MCUs with two UART modules. Used UART module must be initialized before using this routine. See UART1_Init routine.

Example

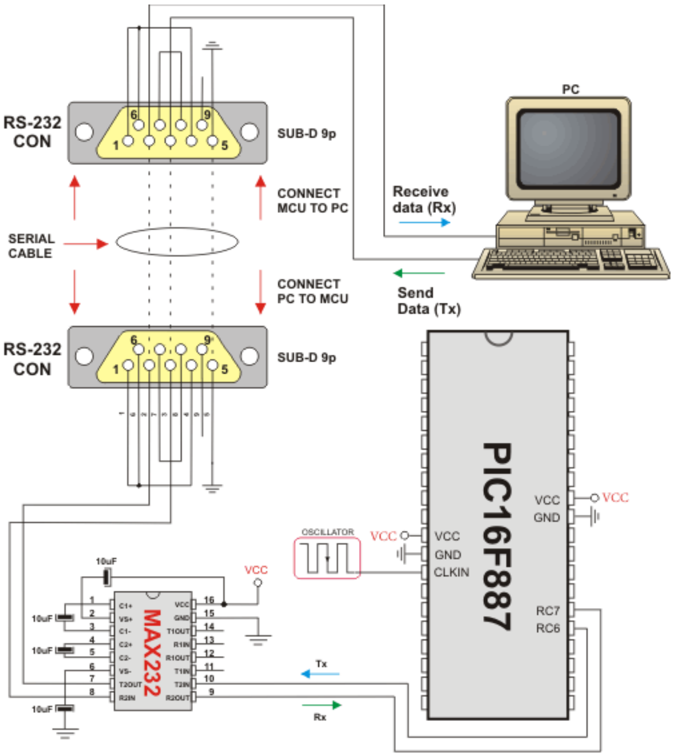
```
'Activate UART2 module
UART_Set_Active(UART1_Read, UART1_Write, UART1_Data_Ready,
UART1_Tx_Idle)
```

Library Example

This example demonstrates simple data exchange via UART. If MCU is connected to the PC, you can test the example from the *mikroBasic PRO for PIC* USART Terminal.

```
program UART
dim uart_rd as byte

main:
  UART1_Init(9600)                ' Initialize UART module at 9600 bps
  Delay_ms(100)                   ' Wait for UART module to stabilize

  while (TRUE)                    ' Endless loop
    if (UART1_Data_Ready() <> 0) then   ' If data is received,
      uart_rd = UART1_Read()      '   read the received data,
      UART1_Write(uart_rd)        '   and send data via UART
    end if
  wend
end.
```

HW Connection



UART HW connection

USB HID Library

Universal Serial Bus (USB) provides a serial bus standard for connecting a wide variety of devices, including computers, cell phones, game consoles, PDA’s, etc.

mikroBasic PRO for PIC includes a library for working with human interface devices via Universal Serial Bus. A human interface device or HID is a type of computer device that interacts directly with and takes input from humans, such as the keyboard, mouse, graphics tablet, and the like.

Descriptor File

Each project based on the USB HID library should include a descriptor source file which contains vendor id and name, product id and name, report length, and other relevant information. To create a descriptor file, use the integrated USB HID terminal of mikroBasic (**Tools › USB HID Terminal**). The default name for descriptor file is USBdsc.pbas, but you may rename it.

The provided code in the “Examples” folder works at 48MHz, and the flags should not be modified without consulting the appropriate datasheet first.

Library Routines

- Hid_Enable
- Hid_Read
- Hid_Write
- Hid_Disable

Hid_Enable

Prototype	`sub procedure Hid_Enable(dim readbuff, writebuff as word)`
Returns	Nothing.
Description	Enables USB HID communication. Parameters readbuff and writebuff are the addresses of Read Buffer and the Write Buffer, respectively, which are used for HID communication. You can pass buffer names with the @ operator. This function needs to be called before using other routines of USB HID Library.
Requires	Nothing.
Example	`Hid_Enable(@rd, @wr)`

Hid_Read

Prototype	`sub function Hid_Read as byte`
Returns	Number of characters in the Read Buffer received from the host.
Description	Receives message from host and stores it in the Read Buffer. Function returns the number of characters received in the Read Buffer.
Requires	USB HID needs to be enabled before using this function. See Hid_Enable.
Example	`length = Hid_Read`

Hid_Write

Prototype	`sub procedure Hid_Write(dim writebuff as word, dim len as byte)`
Returns	Nothing.
Description	Function sends data from Write Buffer writebuff to host. Write Buffer is the address of the parameter used in initialization; see Hid_Enable. You can pass a buffer name with the @ operator. Parameter len should specify a length of the data to be transmitted.
Requires	USB HID needs to be enabled before using this function. See Hid_Enable.
Example	`Hid_Write(@wr, len)`

Hid_Disable

Prototype	`sub procedure Hid_Disable`
Returns	Nothing.
Description	Disables USB HID communication.
Requires	USB HID needs to be enabled before using this function. See Hid_Enable.
Example	`Hid_Disable()`

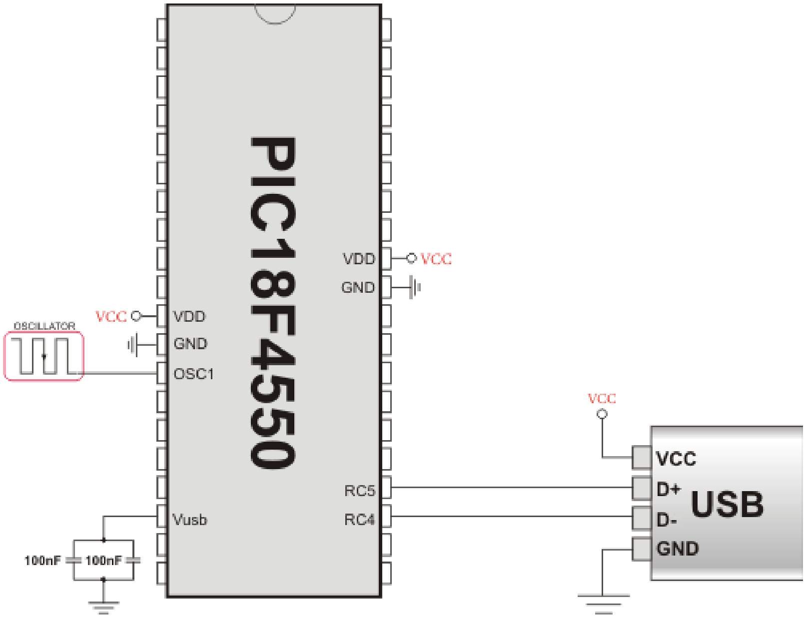
Library Example

The following example continually sends sequence of numbers 0..255 to the PC via Universal Serial Bus.

```
program hid_test

dim k as byte
dim userRD_buffer as byte[ 64]
dim userWR_buffer as byte[ 64]

sub procedure interrupt
  asm
    CALL _Hid_InterruptProc
    nop
  end asm
end sub

sub procedure Init_Main
  ' Disable all interrupts
  ' Disable GIE, PEIE, TMR0IE, INT0IE,RBIE
  INTCON   = 0
  INTCON2 = $F5
  INTCON3 = $C0
  ' Disable Priority Levels on interrupts
  RCON.IPEN = 0
  PIE1 = 0
  PIE2 = 0
  PIR1 = 0
  PIR2 = 0

  ' Configure all ports with analog function as digital
  ADCON1 = ADCON1 or $0F

  ' Ports Configuration
  TRISA = 0
  TRISB = 0
  TRISC = $FF
  TRISD = $FF
  TRISE = $07

  LATA = 0
  LATB = 0
  LATC = 0
  LATD = 0
  LATE = 0

  ' Clear user RAM
  ' Banks [00 .. 07] ( 8 x 256 = 2048 Bytes )
```

```
  asm
    LFSR     FSR0, $000
    MOVLW    $08
    CLRF     POSTINC0, 0
    CPFSEQ   FSR0H, 0
    BRA      $ - 2
  end asm

  ' Timer 0
  T0CON = $07;
  TMR0H = (65536 - 156) >> 8
  TMR0L = (65536 - 156) and $FF
  INTCON.T0IE  = 1                ' Enable T0IE
  T0CON.TMR0ON = 1
end sub


'** Main Program **

main:
  Init_Main()
  Hid_Enable(@userRD_buffer, @userWR_buffer)

  do
    for k = 0 to 255
      ' Prepare send buffer
      userWR_buffer[0] = k

      ' Send the number via USB
      Hid_Write(@userWR_buffer, 1)
    next k
  loop until FALSE

  Hid_Disable
end.
```

HW Connection



USB connection scheme

MISCELLANEOUS LIBRARIES

- Button Library
- Conversions Library
- Math Library
- String Library
- Time Library
- Trigonometry Library

BUTTON LIBRARY

The Button library contains miscellaneous routines useful for a project development.

- Button

Button

Prototype	`sub function Button(dim byref port as byte, dim pin, time, active_state as byte) as byte`
Returns	Returns 0 or 255.
Description	Function eliminates the influence of contact flickering upon pressing a button (debouncing). Parameter port specifies the location of the button; parameter pin is the pin number on designated port and goes from 0..7; parameter `time` is a debounce period in milliseconds; parameter `active_state` can be either 0 or 1, and it determines if the button is active upon logical zero or logical one.
Requires	Button pin must be configured as input.
Example	Example reads RB0, to which the button is connected; on transition from 1 to 0 (release of button), PORTD is inverted:

```
while true
  if Button(PORTB, 0, 1, 1) then
    oldstate = 255
  end if
  if oldstate and Button(PORTB, 0, 1, 0) then
    PORTD = not(PORTD)
    oldstate = 0
  end if
wend
```

CONVERSIONS LIBRARY

mikroBasic PRO for PIC Conversions Library provides routines for numerals to strings and BCD/decimal conversions.

Library Routines

You can get text representation of numerical value by passing it to one of the following routines:

- ByteToStr
- ShortToStr
- WordToStr
- IntToStr
- LongintToStr
- LongWordToStr
- FloatToStr
- StrToInt
- StrToWord

The following sub functions convert decimal values to BCD and vice versa:

- Dec2Bcd
- Bcd2Dec16
- Dec2Bcd16

ByteToStr

Prototype	`sub procedure ByteToStr(dim input as word, dim byref output as string[2])`
Returns	Nothing.
Description	Converts input byte to a string. The output string is right justified and remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input:` byte to be converted ■ `output:` destination string
Requires	Nothing.

Example

```
dim t as word
    txt as string[2]
...
t = 24
ByteToStr(t, txt)   ' txt is " 24" (one blank here)
```

ShortToStr

Prototype	`sub procedure ShortToStr(dim input as short, dim byref output as string[3])`
Returns	Nothing.
Description	Converts input short (signed byte) number to a string. The output string is right justified and remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input:` short number to be converted ■ `output:` destination string
Requires	Nothing.

Example

```
dim t as short
    txt as string[3]
...
t = -24
ByteToStr(t, txt)   ' txt is " -24" (one blank here)
```

WordToStr

Prototype	`sub procedure WordToStr(dim input as word, dim byref output as string[ 4] )`
Returns	Nothing.
Description	Converts input word to a string. The output string is right justified and the remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input:` word to be converted ■ `output:` destination string
Requires	Nothing.

Example

```
dim t as word
    txt as string[4]
...
t = 437
WordToStr(t, txt)   ' txt is "  437" (two blanks here)
```

IntToStr

Prototype	`sub procedure IntToStr(dim input as integer, dim byref output as string[ 5]`
Returns	Nothing.
Description	Converts input integer number to a string. The output string is right justified and the remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input:` integer number to be converted ■ `output:` destination string
Requires	Nothing.

Example

```
dim input as integer
    txt as string[ 5]
'...

input = -4220
IntToStr(input, txt)    ' txt is ' -4220'
```

LongintToStr

Prototype	`sub procedure LongintToStr(dim input as longint, dim byref output as string[10])`
Returns	Nothing.
Description	Converts input longint number to a string. The output string is right justified and the remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input:` longint number to be converted ■ `output:` destination string
Requires	Nothing.
Example	

```
dim input as longint
    txt as string[10]
'...

input = -12345678
IntToStr(input, txt)      ' txt is '   -12345678'
```

LongWordToStr

Prototype	`sub procedure LongWordToStr(dim input as longword, dim byref output as string[9])`
Returns	Nothing.
Description	Converts input double word number to a string. The output string is right justified and the remaining positions on the left (if any) are filled with blanks. Parameters : ■ `input`: double word number to be converted ■ `output:` destination string
Requires	Nothing.
Example	

```
dim input as longint
    txt as string[9]
'...

input = 12345678
IntToStr(input, txt)      ' txt is '   12345678'
```

FloatToStr

Prototype	`sub function FloatToStr(dim input as real, dim byref output as string[22])`
Returns	■ 3 if input number is NaN ■ 2 if input number is -INF ■ 1 if input number is +INF ■ 0 if conversion was successful
Description	Converts a floating point number to a string. Parameters : ■ `input:` floating point number to be converted ■ `output:` destination string The output string is left justified and null terminated after the last digit. **Note:** Given floating point number will be truncated to 7 most significant digits before conversion.
Requires	Nothing.

Example

```
dim ff1, ff2, ff3 as real
    txt as string[22]
  ...
  ff1 = -374.2
  ff2 = 123.456789
  ff3 = 0.000001234

  FloatToStr(ff1, txt)  ' txt is "-374.2"
  FloatToStr(ff2, txt)  ' txt is "123.4567"
  FloatToStr(ff3, txt)  ' txt is "1.234e-6"
```

StrToInt

Prototype	`sub function StrToInt(dim byref input as string[6]) as integer`
Returns	Integer variable.
Description	Converts a string to integer
Requires	The string is assumed to be a correct representation of a number.

Example

```
dim ii as integer

main:
  ii = StrToInt('-1234')
end.
```

StrToWord

Prototype	`sub function StrToWord(dim byref input as string[5]) as word`
Returns	Word variable.
Description	Converts a string to word.
Requires	`input` string with length of max 5 chars. The string is assumed to be a correct representation of a number.

Example

```
dim ww as word

main:

  ww = StrToword('65432')

end.
```

Dec2Bcd

Prototype	`function Dec2Bcd (dim decnum as byte) as byte`
Returns	Converted BCD value.
Description	Converts input number to its appropriate BCD representation. Parameters : ■ `decnum:` number to be converted
Requires	Nothing.

Example

```
dim a, b as byte
...
a = 22
b = Dec2Bcd(a)  ' b equals 34
```

Bcd2Dec16

Prototype	`sub function Bcd2Dec16(dim bcdnum as word) as word`
Returns	Converted decimal value.
Description	Converts 16-bit BCD numeral to its decimal equivalent. Parameters : ■ `bcdnum:` 16-bit BCD numeral to be converted
Requires	Nothing.
Example	

```
dim a, b as word
...
a = 0x1234          ' a equals 4660
b = Bcd2Dec16(a)   ' b equals 1234
```

Dec2Bcd16

Prototype	`sub function Dec2Bcd16(dim decnum as word) as word`
Returns	Converted BCD value.
Description	Converts decimal value to its BCD equivalent. Parameters : ■ `decnum` decimal number to be converted
Requires	Nothing.
Example	

```
dim a, b as word
...
a = 2345
b = Dec2Bcd16(a)   ' b equals 9029
```

MATH LIBRARY

The mikroBasic PRO for PIC provides a set of library functions for floating point math handling. See also Predefined Globals and Constants for the list of predefined math constants.

Library Functions

- acos
- asin
- atan
- atan2
- ceil
- cos
- cosh
- eval_poly
- exp
- fabs
- floor
- frexp
- dexp
- log
- log10
- modf
- pow
- sin
- sinh
- sqrt
- tan
- tanh

acos

Prototype	`sub function acos(dim x as real) as real`
Description	The function returns the arc cosine of parameter x; that is, the value whose cosine is `x`. The input parameter `x` must be between -1 and 1 (inclusive). The return value is in radians, between 0 and Π (inclusive).

asin

Prototype	`sub function asin(dim x as real) as real`
Description	The function returns the arc sine of parameter `x`; that is, the value whose sine is `x.` The input parameter `x` must be between -1 and 1 (inclusive). The return value is in radians, between - Π/2 and Π/2 (inclusive).

atan

Prototype	`sub function atan(dim arg as real) as real`
Description	The function computes the arc tangent of parameter `arg`; that is, the value whose tangent is `arg`. The return value is in radians, between -Π/2 and Π/2 (inclusive).

atan2

Prototype	`sub function atan2(dim y as real, dim x as real) as real`
Description	This is the two-argument arc tangent function. It is similar to computing the arc tangent of `y/x`, except that the signs of both arguments are used to determine the quadrant of the result and `x` is permitted to be zero. The return value is in radians, between -Π and Π (inclusive).

ceil

Prototype	`sub function ceil(dim x as real) as real`
Description	The function returns value of parameter `x` rounded up to the next whole number.

cos

Prototype	`sub function cos(dim arg as real) as real`
Description	The function returns the cosine of `arg` in radians. The return value is from -1 to 1.

cosh

Prototype	`sub function cosh(dim x as real) as real`
Description	The function returns the hyperbolic cosine of `x`, defined mathematically as $(e^{x}+e^{-x})/2$. If the value of `x` is too large (if overflow occurs), the function fails.

eval_poly

Prototype	`sub function eval_poly(dim x as real, dim byref d as array[10] of real, dim n as integer) as real`
Description	Function Calculates polynom for number `x`, with coefficients stored in `d[]`, for degree `n`.

exp

Prototype	`sub function exp(dim x as real) as real`
Description	The function returns the value of e — the base of natural logarithms — raised to the power `x` (i.e. e^x).

fabs

Prototype	`sub function fabs(dim d as real) as real`
Description	The function returns the absolute (i.e. positive) value of `d`.

floor

Prototype	`sub function floor(dim x as real) as real`
Description	The function returns the value of parameter `x` rounded down to the nearest integer.

frexp

Prototype	`sub function frexp(dim value as real, dim byref eptr as integer) as real`
Description	The function splits a floating-point value `value` into a normalized fraction and an integral power of 2. The return value is a normalized fraction and the integer exponent is stored in the object pointed to by `eptr`.

ldexp

Prototype	`sub function ldexp(dim value as real, dim newexp as integer) as real`
Description	The function returns the result of multiplying the floating-point number `value` by 2 raised to the power `newexp` (i.e. returns value $* \ 2^{newexp}$).

log

Prototype	`sub function log(dim x as real) as real`
Description	The function returns the natural logarithm of `x` (i.e. $\log_e(x)$).

log10

Prototype	`sub function log10(dim x as real) as real`
Description	The function returns the base-10 logarithm of `x` (i.e. $\log_{10}(x)$).

modf

Prototype	`sub function modf(dim val as real, dim byref iptr as real) as real`
Description	The function returns the signed fractional component of val, placing its whole number component into the variable pointed to by `iptr`.

pow

Prototype	`sub function pow(dim x as real, dim y as real) as real`
Description	The function returns the value of `x` raised to the power `y` (i.e. x^y). If `x` is negative, the function will automatically cast y into `longint`.

sin

Prototype	`sub function sin(dim arg as real) as real`
Description	The function returns the sine of `arg` in radians. The return value is from -1 to 1.

sinh

Prototype	`sub function sinh(dim x as real) as real`
Description	The function returns the hyperbolic sine of `x`, defined mathematically as $(e^x-e^{-x})/2$. If the value of `x` is too large (if overflow occurs), the function fails.

sqrt

Prototype	`sub function sqrt(dim x as real) as real`
Description	The function returns the non negative square root of `x`.

tan

Prototype	`sub function tan(dim x as real) as real`
Description	The function returns the tangent of `x` in radians. The return value spans the allowed range of floating point in *mikroBasic PRO for PIC.*

tanh

Prototype	`sub function tanh(dim x as real) as real)`
Description	The function returns the hyperbolic tangent of `x`, defined mathematically as `sinh(x)/cosh(x)`.

STRING LIBRARY

The *mikroBasic PRO for PIC* includes a library which automatizes string related tasks

Library Functions

- memchr
- memcmp
- memcpy
- memmove
- memset
- strcat
- strchr
- strcmp
- strcpy
- strlen
- strncat
- strncpy
- strspn
- strcspn
- strncmp
- strpbrk
- strrchr
- strstr

memchr

Prototype	`sub function memchr(dim p as ^byte, dim ch as byte, dim n as word) as word`
Description	The function locates the first occurrence of the word `ch` in the initial `n` words of memory area starting at the address `p`. The function returns the offset of this occurrence from the memory address `p` or `0xFF` if `ch` was not found. For the parameter p you can use either a numerical value (literal/variable/constant) indicating memory address or a dereferenced value of an object, for example `@mystring` or `@PORTB`.

memcmp

<table>
<tr><td>Prototype</td><td><code>sub function memcmp(dim p1, p2 as ^byte, dim n as word) as integer</code></td></tr>
<tr><td>Description</td><td>
<p>The function returns a positive, negative, or zero value indicating the relationship of first n words of memory areas starting at addresses <code>p1</code> and <code>p2</code>.</p>
<p>This function compares two memory areas starting at addresses <code>p1</code> and <code>p2</code> for n words and returns a value indicating their relationship as follows:</p>
<pre>
Value   Meaning
< 0   p1 "less than" p2
= 0   p1 "equal to" p2
> 0   p1 "greater than" p2
</pre>
<p>The value returned by the function is determined by the difference between the values of the first pair of words that differ in the strings being compared.</p>
<p>For parameters <code>p1</code> and <code>p2</code> you can use either a numerical value (literal/variable/constant) indicating memory address or a dereferenced value of an object, for example <code>@mystring</code> or <code>@PORTB</code>.</p>
</td></tr>
</table>

memcpy

Prototype	`sub procedure memcpy(dim p1, p2 as ^byte, dim nn as word)`
Description	The function copies `nn` words from the memory area starting at the address `p2` to the memory area starting at `p1`. If these memory buffers overlap, the `memcpy` function cannot guarantee that words are copied before being overwritten. If these buffers do overlap, use the `memmove` function. For parameters `p1` and `p2` you can use either a numerical value (literal/variable/constant) indicating memory address or a dereferenced value of an object, for example `@mystring` or `@PORTB`.

memmove

Prototype	`sub procedure memmove(dim p1, p2, as ^byte, dim nn as word)`
Description	The function copies `nn` words from the memory area starting at the address `p2` to the memory area starting at `p1`. If these memory buffers overlap, the `Memmove` function ensures that the words in `p2` are copied to `p1` before being overwritten. For parameters `p1` and `p2` you can use either a numerical value (literal/variable/constant) indicating memory address or a dereferenced value of an object, for example `@mystring` or `@PORTB`.

memset

Prototype	`sub procedure memset(dim p as ^byte, dim character as byte, dim n as word)`
Description	The function fills the first `n` words in the memory area starting at the address `p` with the value of word `character`. For parameter `p` you can use either a numerical value (literal/variable/constant) indicating memory address or a dereferenced value of an object, for example `@mystring` or `@PORTB`.

strcat

Prototype	`sub procedure strcat(dim byref s1, s2 as string[100])`
Description	The function appends the value of string `s2` to string `s1` and terminates `s1` with a null character.

strchr

Prototype	`sub function strchr(dim byref s as string[100], dim ch as byte) as word`
Description	The function searches the string `s` for the first occurrence of the character `ch`. The null character terminating `s` is not included in the search. The function returns the position (index) of the first character `ch` found in `s`; if no matching character was found, the function returns `0xFF`.

strcmp

Prototype

```
sub function strcmp(dim byref s1, s2 as string[100]) as short
```

Description

The function lexicographically compares the contents of the strings `s1` and `s2` and returns a value indicating their relationship:

```
Value    Meaning
< 0       s1 "less than" s2
= 0       s1 "equal to" s2
> 0       s1 "greater than" s2
```

The value returned by the function is determined by the difference between the values of the first pair of words that differ in the strings being compared.

strcpy

Prototype	`sub procedure strcpy(dim byref s1, s2 as string[100])`
Description	The function copies the value of the string `s2` to the string `s1` and appends a null character to the end of `s1`.

strcspn

Prototype	`sub function strcspn(dim byref s1, s2 as string[100]) as word`
Description	The function searches the string `s1` for any of the characters in the string `s2`. The function returns the index of the first character located in `s1` that matches any character in `s2`. If the first character in `s1` matches a character in `s2`, a value of 0 is returned. If there are no matching characters in `s1`, the length of the string is returned (not including the terminating null character).

strlen

Prototype	`sub function strlen(dim byref s as string[100]) as word`
Description	The function returns the length, in words, of the string `s`. The length does not include the null terminating character.

strncat

Prototype	`sub procedure strncat(dim byref s1, s2 as string[100], dim size byte)`
Description	The function appends at most `size` characters from the string `s2` to the string `s1` and terminates `s1` with a null character. If `s2` is shorter than the `size` characters, `s2` is copied up to and including the null terminating character.

strncmp

Prototype	`sub function strncmp(dim byref s1, s2 as string[100], dim len as byte) as short`

Description	The function lexicographically compares the first `len` words of the strings `s1` and `s2` and returns a value indicating their relationship:
	`Value      Meaning`
	`< 0        s1 "less than" s2`
	`= 0        s1 "equal to" s2`
	`> 0        s1 "greater than" s2`
	The value returned by the function is determined by the difference between the values of the first pair of words that differ in the strings being compared (within first `len` words).

strncpy

Prototype	`sub procedure strncpy(dim byref s1, s2 as string[100], dim size as word)`
Description	The function copies at most `size` characters from the string `s2` to the string `s1`. If `s2` contains fewer characters than `size`, `s1` is padded out with null characters up to the total length of the `size` characters.

strpbrk

Prototype	`sub function strpbrk(dim byref s1, s2 as string[100]) as word`
Description	The function searches `s1` for the first occurrence of any character from the string `s2`. The null terminator is not included in the search. The function returns an index of the matching character in `s1`. If `s1` contains no characters from `s2`, the function returns `0xFF`.

strrchr

Prototype	`sub function strrchr(dim byref s as string[100], dim ch as byte) as word`
Description	The function searches the string s for the last occurrence of the character `ch`. The null character terminating `s` is not included in the search. The function returns an index of the last `ch` found in `s;` if no matching character was found, the function returns `0xFF`.

strspn

Prototype	`sub function strspn(dim byref s1, s2 as string[100]) as byte`
Description	The function searches the string `s1` for characters not found in the `s2` string. The function returns the index of first character located in `s1` that does not match a character in `s2`. If the first character in `s1` does not match a character in `s2`, a value of 0 is returned. If all characters in `s1` are found in `s2`, the length of `s1` is returned (not including the terminating null character).

strstr

Prototype	`sub function strstr(dim byref s1, s2 as string[100]) as word`
Description	The function locates the first occurrence of the string `s2` in the string `s1` (excluding the terminating null character). The function returns a number indicating the position of the first occurrence of `s2` in `s1`; if no string was found, the function returns `0xFF`. If `s2` is a null string, the function returns `0`.

TIME LIBRARY

The Time Library contains functions and type definitions for time calculations in the UNIX time format which counts the number of seconds since the "epoch". This is very convenient for programs that work with time intervals: the difference between two UNIX time values is a real-time difference measured in seconds.

What is the epoch?
Originally it was defined as the beginning of 1970 GMT. (January 1, 1970 Julian day) GMT, Greenwich Mean Time, is a traditional term for the time zone in England.

The TimeStruct type is a structure type suitable for time and date storage.

Library Routines

- Time_dateToEpoch
- Time_epochToDate
- Time_datediff

Time_dateToEpoch

Prototype	`sub function Time_dateToEpoch(dim byref ts as TimeStruct) as longint`
Returns	Number of seconds since January 1, 1970 0h00mn00s.
Description	This function returns the UNIX time : number of seconds since January 1, 1970 0h00mn00s. Parameters : - `ts:` time and date value for calculating UNIX time.
Requires	Nothing.
Example	

```
dim ts1 as TimeStruct
    Epoch as longint
...
' what is the epoch of the date in ts ?
epoch = Time_dateToEpoch(ts1)
```

Time_epochToDate

Prototype	`sub procedure Time_epochToDate(dim e as longint, dim byref ts as TimeStruct)`
Returns	Nothing.
Description	Converts the UNIX time to time and date. Parameters : ■ `e:` UNIX time (seconds since UNIX epoch) ■ `ts:` time and date structure for storing conversion output
Requires	Nothing.

Example

```
dim ts2 as TimeStruct
    epoch as longint
...
' what date is epoch 1234567890 ?
epoch = 1234567890
Time_epochToDate(epoch,ts2)
```

Time_dateDiff

Prototype	`sub function Time_dateDiff(dim t1 as ^TimeStruct, dim t2 as ^TimeStruct) as longint`
Returns	Time difference in seconds as a signed long.
Description	This function compares two dates and returns time difference in seconds as a signed long. The result is positive if `t1` is before `t2`, null if `t1` is the same as `t2` and negative if `t1` is after `t2`. Parameters : ■ `t1:` time and date structure (the first comparison parameter) ■ `t2:` time and date structure (the second comparison parameter)
Requires	Nothing.

Example

```
dim ts1, ts2 as TimeStruct
    diff as longint
...
' how many seconds between these two dates contained in ts1 and
ts2 buffers?
 diff = Time_dateDiff(ts1, ts2)
```

Library Example

Demonstration of Time library routines usage for time calculations in UNIX time format.

```
program Time_Demo

dim epoch, diff as longint

'***********************************
   ts1, ts2 as TimeStruct
'***********************************
main:

  ts1.ss = 0
  ts1.mn = 7
  ts1.hh = 17
  ts1.md = 23
  ts1.mo = 5
  ts1.yy = 2006

  ' *
  ' * What is the epoch of the date in ts ?
  ' *
  epoch = Time_dateToEpoch(@ts1)     ' 1148404020

  ' *
  ' * What date is epoch 1234567890 ?
  ' *
  epoch = 1234567890
  Time_epochToDate(epoch, @ts2)      ' {0x1E, 0x1F, 0x17, 0x0D, 0x04,
0x02, 0x07D9)

  ' *
  ' * How much seconds between this two dates ?
  ' *
  diff = Time_dateDiff(@ts1, @ts2)          ' 86163870

end.
```

TimeStruct type definition

```
structure TimeStruct
  dim ss as byte      ' seconds
  dim mn as byte      ' minutes
  dim hh as byte      ' hours
  dim md as byte      ' day in month, from 1 to 31
  dim wd as byte      ' day in week, monday=0, tuesday=1, .... sun-
day=6
  dim mo as byte      ' month number, from 1 to 12 (and not from 0
to 11 as with unix C time !)
  dim yy as word      ' year Y2K compliant, from 1892 to 2038
end structure
```

TRIGONOMETRY LIBRARY

The *mikroBasic PRO for PIC* implements fundamental trigonometry functions. These functions are implemented as look-up tables. Trigonometry functions are implemented in integer format in order to save memory.

Library Routines

- sinE3
- cosE3

sinE3

Prototype	`sub function sinE3(dim angle_deg as word) as integer`
Returns	The function returns the sine of input parameter.
Description	The function calculates sine multiplied by 1000 and rounded to the nearest integer: `result = round(sin(angle_deg)*1000)` Parameters: - `angle_deg:` input angle in degrees **Note:** Return value range: `-1000..1000.`
Requires	Nothing.

Example	`dim res as integer`
	`...`
	`res = sinE3(45)   ' result is 707`

cosE3

Prototype	`sub function cosE3(dim angle_deg as word) as integer`
Returns	The function returns the cosine of input parameter.
Description	The function calculates cosine multiplied by 1000 and rounded to the nearest integer: `result = round(cos(angle_deg)*1000)` Parameters: ■ `angle_deg:` input angle in degrees **Note:** Return value range: `-1000..1000.`
Requires	Nothing.

Example	`dim res as integer`
	`...`
	`res = cosE3(196)   ' result is -193`

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