CML Microcircuits

COMMUNICATION SEMICONDUCTORS

EV9710
Evaluation Kit
User Manual

Features

- **CMX971 Quadrature Modulator**

- **C-BUS Interface to Host Microcontroller**

- **Easy Interfacing to PE0601-xxxx**

- **Frequency Range 20 - 1000 MHz**

- **Direct Control Mode (host-less operation)**
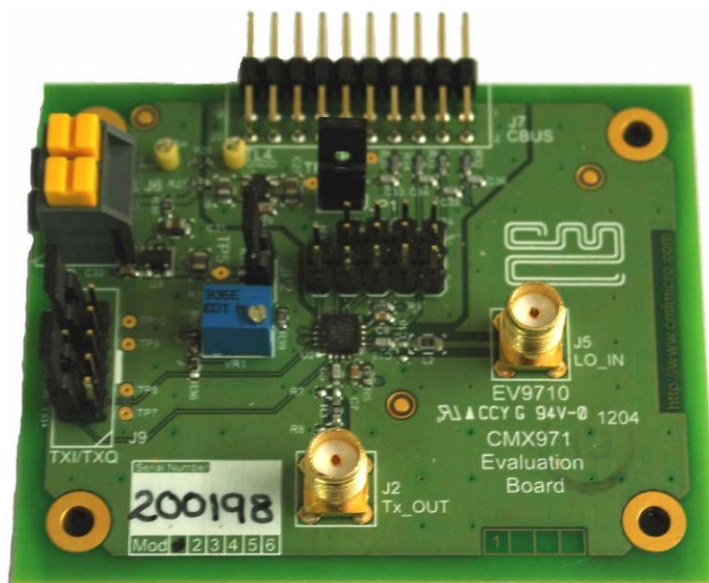
1   Brief Description

The EV9710 is an Evaluation Kit designed for evaluating and demonstrating the capabilities of the CMX971 integrated circuit. All the circuits necessary to demonstrate the facilities provided by the IC, such as matching circuits, power supply regulators, etc are provided on the EV9710 board.

A C-BUS interface connector is provided for control of the EV9710 by a host microcontroller or CML PE0002 interface card. The CMX971 can also be used in 'direct control' mode where a host or PE0002 is not required.
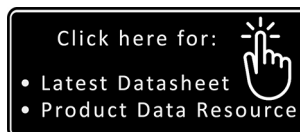
Click here for:
- Latest Datasheet
- Product Data Resource

CONTENTS

1.1   History

Version	Changes	Date
1	First Issue	April 2012

CML recommends that you check for the latest product datasheet version from the Datasheets page of the CML website: [www.cmlmicro.com].
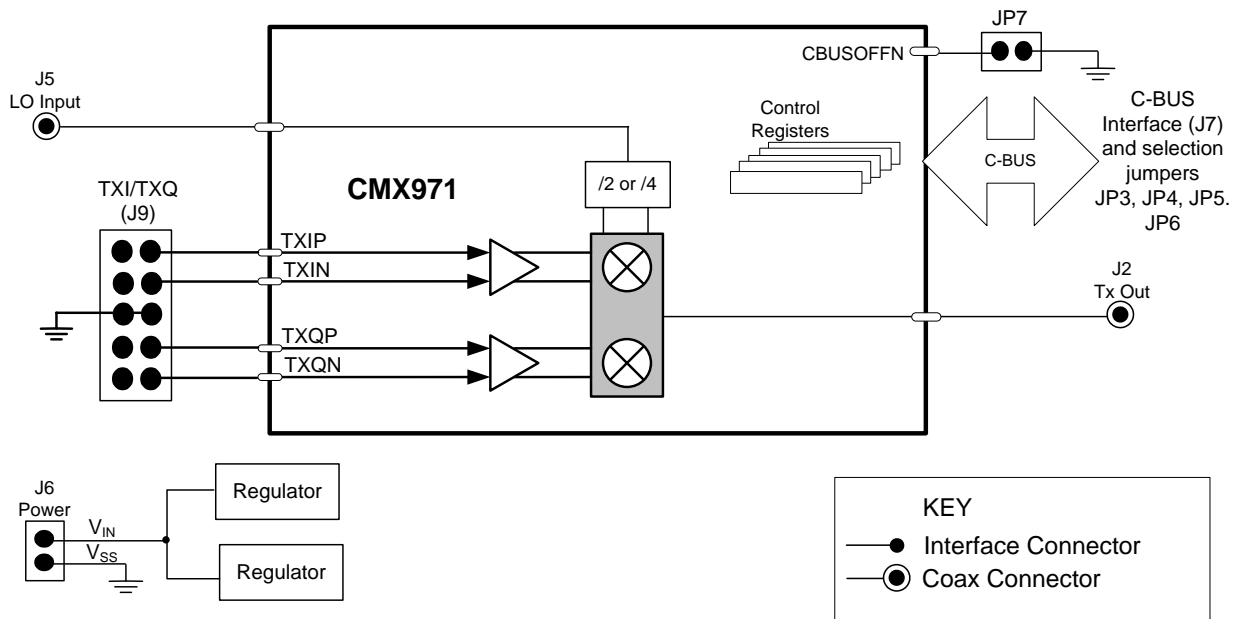
2   Block Diagram

Figure 1 EV9710 Block Diagram

3   Preliminary Information

3.1   Laboratory Equipment

The following laboratory equipment is recommended for use when testing this evaluation kit:

- Power Supply
- RF Signal Generator
- Spectrum Analyser
- Oscilloscope

For more detailed design or investigation work, additional RF test equipment may be required.

3.1.1   Power Supply

The supply input voltage to the PCB is nominally 7.2V (3.6V to 7.6V acceptable). On board regulators are provided to generate all voltage rails used on the PCB. The 7.2V supply should be rated at 100mA.

NOTE: Care should be exercised with the supplies as the circuitry is not protected for reverse polarity.

3.1.2   Control Interface

To use the EV9710, the user will need a mechanism to send and receive data and commands via the C-BUS host microcontroller interface on the CMX971, which is brought out on connector J7. The CMX971 Datasheet and User Manual give details of the registers and commands. Alternatively, the CMX971 Direct Control mode can be used by fitting JP7, see section 7.1.3 for further details.

A PE0002 Interface Card can be used to control the EV9710. A user interface program specifically for the EV9710 is available from the CML website (see www.cmlmicro.com for details).

3.2   Handling Precautions

In common with other evaluation kits, this product is designed for use in office and laboratory environments. The following practices will help ensure its proper operation.

3.2.1   Static Protection

This product uses low power CMOS circuits that can be damaged by electrostatic discharge. Partially damaged circuits can function erroneously, leading to misleading results. Observe ESD precautions at all times when handling this product.

3.2.2   Contents - Unpacking

Please ensure that you have received all of the items detailed on the separate information sheet (EK9710) and notify CML within 7 working days if the delivery is incomplete.

3.3   Approvals

This product is not approved to any EMC or other regulatory standard. Users are advised to observe local statutory requirements, which may apply to this product and the radio frequency signals that may emanate from it.

4   Quick Start

This section provides instructions for users who wish to experiment immediately with the EV9710 Evaluation Kit. A more complete description of the kit and its use appears later in this document. The user should read the appropriate CMX971 datasheet before using this kit.

4.1   First – Initial Setup

4.1.1   Make External Connections and Apply Power

An example of typical connections to the EV9710 is shown in Figure 2. Perform the following steps in sequence:

1. Connect test leads as shown in Figure 2, except the power to J6.
2. Connect a controller to C-BUS interface J7 (PE0002 can be used – see Figure 2. Note: J3 or J5 can be used on PE0002, but ensure the correct C-BUS port is selected when programming data).
3. Install PE0002 hardware/software and apply power to PE0002 – see section 4.1.2.
4. Power should be applied to the main supply input J6 (7.2V nominal). The CMX971 device will be reset on power-up.

The board is now ready for operation.
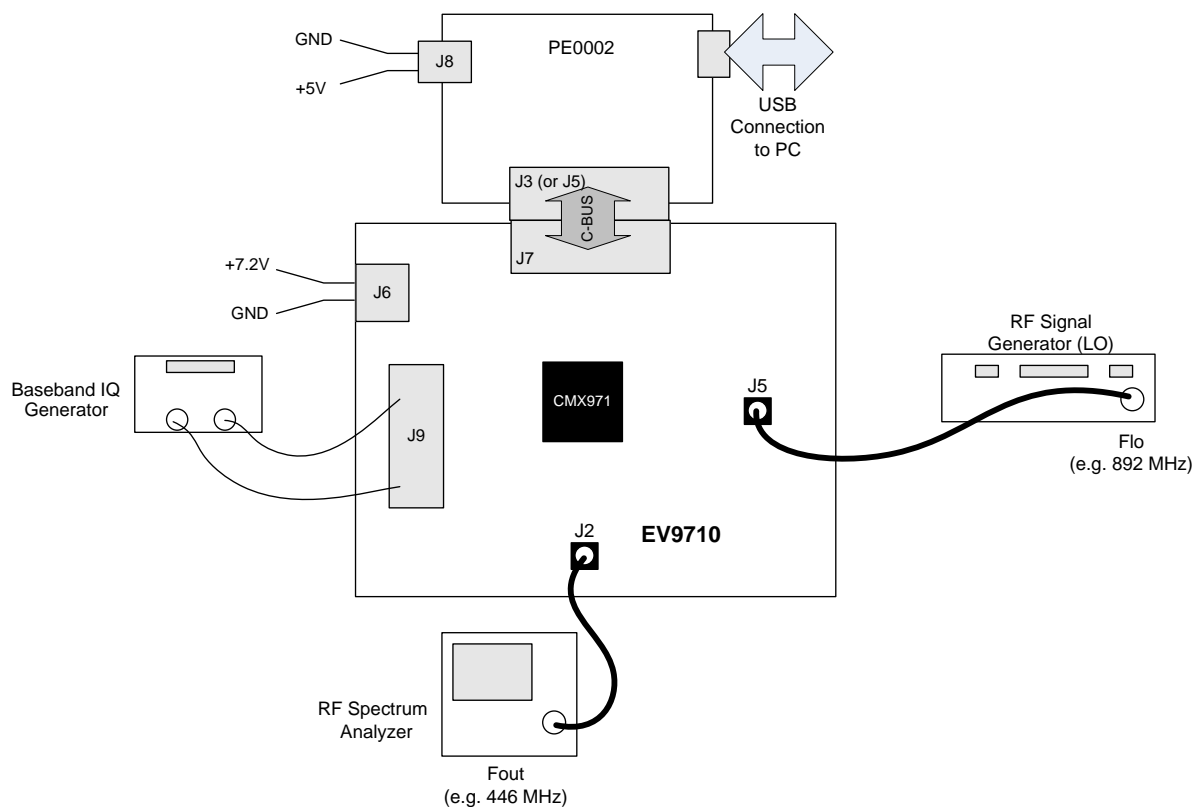
Figure 2   Typical Connections for EV9710

4.1.2   Hardware/Software Installation (for PE0002)

- Copy the file '`ES9700xx.zip`', which is downloaded from the CML website following registration, to the hard drive of your host PC.
- Extract the files to the hard drive of your host PC.
  - Connect a 5V dc supply to the PE0002 Interface.
  - Connect a 7.2V dc supply to the EV9710.
  - Attach a USB cable from connector J2 of the PE0002 Interface Card to the PC USB port.
- Turn on the power supply to the PE0002. The PE0002 power-on indicator D6 will light
- Install the USB driver when requested. The driver is in the same folder where the '`ES9700xx.zip`' files were extracted to, in directory '.\Driver'. Follow instructions on the screen to install the USB driver. Click the 'Continue Anyway' button when the Message Box in Figure 3 is shown.

Figure 3 USB Driver Installation Message Box

4.2   Second – Configure

In this second step the EV9710 is configured for Tx operation at 446MHz output frequency.

4.2.1   EV9710 Configuration

The following steps should be undertaken to configure the EV9710 to transmit at 446MHz with an I/Q input. Set the applied signals and register values as shown in the following table.

Note: Setting the CMX971 registers requires the use of the PE00002 host connected as above. The CMX971 datasheet give details of the registers and commands.

Signal or Register	Setting	Note
LO_IN (J5)	892MHz @-10dBm	This frequency is twice the RF output frequency that will be developed.
TXI/TXQ (J9)	1.6V dc	These inputs must be connected to 1.6V dc; do not leave them unconnected or open circuit.
General Reset register ($1A)	To ensure the device and hardware are in known states issue the General Reset command	See lower right of GUI tab "C-BUS Control".

Signal or Register	Setting	Note
General Control register ($1B)	The General Control register should be set to enable the following: • Bias generator • Tx Select Tx LO/2 mode.	Write $51 to register $1B.
Control register ($1E)	Select optimum operating frequency for the Modulator.	Write $00 to register $1E.
Tx_OUT (J2)	446MHz Output	Typically an output at 446MHz of approximately -40dBm should be seen on the spectrum analyser. This represents the nulled carrier condition.

4.3   Third – Operate

Following the configuration procedures given in sections 4.1 and 4.2, the EV9710 should be operating as a transmitter at 446MHz. Differential baseband I/Q signals (typically 1.0Vp-p[1]) can now be applied to develop a modulated RF output up to 0dBm PEP. Various evaluation tests can now be performed.

Notes:

a)   A single-ended input of 1Vp-p can be applied to TXI+ and TXQ+ (TXI- and TXQ- must be at 1.6V dc, this can be achieved by fitting R36 and R38 as 0R links and adjusting VR1 to get the desired dc level) to achieve approximately the same output power as with the differential input drive.

b)   The peak to average power ratio of the user-provided modulation will determine the mean RF output power delivered by the EV9710.

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[1] i.e. 500mVp-p on each pin TXIN/TXIP and TXQN/TXQP.

5   Signal Lists

Input power supply connections are via the two way snap socket J6. J2 and J5 are RF signal connections and use SMA 50 ohm sockets. J9 is a 10-pin header for modulator differential I/Q inputs which interface signals easily from the PE0601-xxx evaluation kit.

Signal	Signal Type	PCB Connector
Ground	DC	J6 Pin 1
+Vin (7.2V nominal)	DC	J6 Pin 2
Quadrature Modulator RF output	RF	J2
Local Oscillator RF input	RF	J5
Differential Quadrature Modulator inputs	Baseband	J9
C-BUS interface (e.g. to PE0002)	Logic	J7

Table 1 Signal List

Connections to the host C-BUS interface J7 are shown in Table 2. All are 3.3V logic levels unless otherwise stated.

CONNECTOR PINOUT for J7			
Connector Pin No.	**Signal Name**	**Signal Type**	**Description**
1	-	-	Spare pin. Leave unconnected.
2	CSN	I/P	C-BUS Chip Select.
3	-	-	Spare pin. Leave unconnected.
4	CDATA	I/P	C-BUS Data Input.
5	-	-	Spare pin. Leave unconnected.
6	SCLK	I/P	C-BUS Clock.
7	-	-	Spare pin. Leave unconnected.
8	RDATA	O/P	C-BUS Data Output
9	-	-	Spare pin. Leave unconnected.
10	IRQN	I/P	Interrupt request - if required. Not used, so remains unconnected on EV9710.
11	GNDD	Power	Connection to Digital Ground.
12	GNDD	Power	Connection to Digital Ground.
13	-	-	Spare pin. Leave unconnected.
14	-	-	Spare pin. Leave unconnected.
15	-	-	Spare pin. Leave unconnected.
16	-	-	Spare pin. Leave unconnected.
17	-	-	Spare pin. Leave unconnected.
18	-	-	Spare pin. Leave unconnected.
19	-	-	Spare pin. Leave unconnected.
20	-	-	Spare pin. Leave unconnected.

Table 2 C-BUS Interface

CONNECTOR PINOUT for J9			
Connector Pin No	**Signal Name**	**Signal Type**	**Description**
2	TXI+	Baseband	Positive Tx I input
4	TXI-	Baseband	Negative Tx I input
8	TXQ+	Baseband	Positive Tx Q input
10	TXQ-	Baseband	Negative Tx Q input
1, 3, 7, 9	N/C	-	-
5,6	GNDA	-	Ground (Analogue)

Table 3 Quadrature Modulator I/Q Input Connector

JUMPERS/LINKS			
Test Point Ref.	**Positions**	**Default**	**Description**
JP1	1-2	1-2	+3V3D
JP2	1-2	1-2	+3V3A
JP3	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = FREQ2 (CSN), pin 3 = GNDD
JP4	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = FREQ1 (S_DATA_IN), pin 3 = GNDD
JP5	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = RESETN (S_CLOCK), pin 3 = GNDD
JP6	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = DIVSET (S_DATA_OUT), pin 3 = GNDD
JP7	1-2	NF	When fitted, CBUSOFFN pin connected to GNDD and CMX971 in direct control mode.
Note: JP3, JP4, JP5 and JP6 are to be used in direct control mode with JP7 fitted, see section 7.1.3.			

Table 4 Jumpers/Links

TEST LOOPS/POINTS		
Test Point Ref.	**Typical Value**	**Description**
TL3	0V	GNDA
TL4	0V	GNDD
TP4	3.3V	+3V3 regulator output (+3V3D - digital supplies)
TP5	3.3V	+3V3 regulator output (+3V3A - analogue supplies)
TP6	-	C-BUS connector: IRQN
TP7, 8, 9, 10	-	Test points to spare pins of J9

Table 5 Test Loops and Points

Notes: I/P   = Input   BI   = Bidirectional   N/C   = No connection
                  O/P   = Output   TL   = Test Loop   TP   = Test Point
                  GND = Ground

Note that the voltages are typical for their active state.

6   Circuit Schematics and Board Details

For clarity, circuit schematics are available as a separate high-resolution file available from the CML web site as part of the support files package. The layout on each side is shown in Figure 4, below. The PCB is a 4-layer design fabricated with FR4 material and is 1.6mm thick. Full Gerber and drill files are available on request.
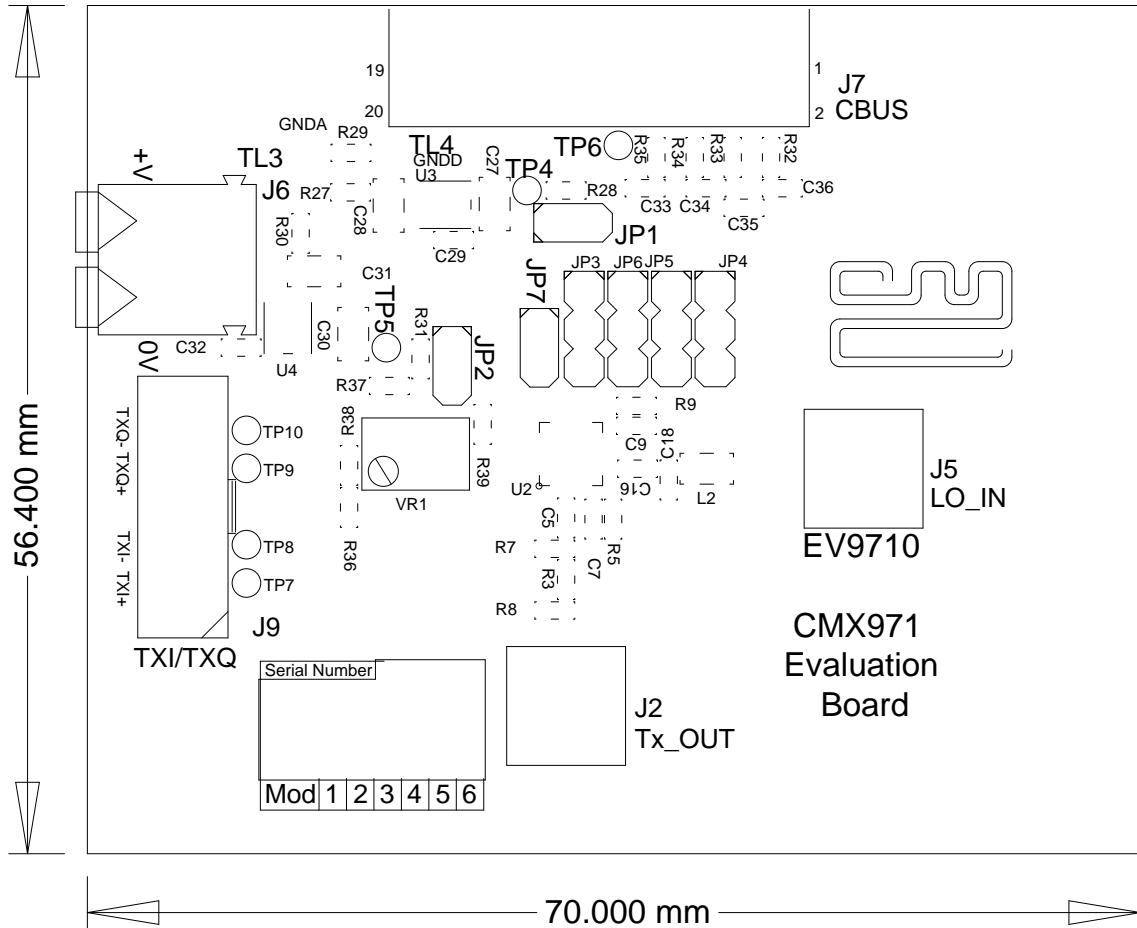

Figure 4 PCB Layout: top

7   Detailed Description

The CMX971 datasheet (available from www.cmlmicro.com) should be referred to for a detailed description of the CMX971 device.

The EV9710 functionality includes:

- Evaluation and demonstration of the CMX971 Quadrature Modulator.
- Interface to CMX7163 or CMX7164 evaluation boards (PE0601-7163 / PE0601-7164, not included) to allow demonstration/test of QAM, 2-FSK, 4-FSK and GMSK modulation.
- An interface that allows the card to be connected to a host microcontroller, to allow real-time control. A PC user interface can be provided using a PE0002 and ES9700 software.

If further design support is required, please contact your regional CML office or an approved CML distributor.

7.1   Hardware Description

7.1.1   Power Supply

Two 3.3V regulator supplies are generated on the PCB. U3 provides supply for digital circuits and U4 for analogue circuits. Current drawn from each supply rail may be measured by connecting an ammeter across JP1 (digital) or JP2 (analogue), after removing the corresponding jumper.

7.1.2   CMX971

This Evaluation Kit is configured to allow the CMX971 Quadrature Modulator to operate with single-ended or differential external inputs. The TXI/TXQ inputs can be accessed differentially for direct connection to a PE0601-xxxx kit, for example. For single-ended input operation it is necessary to bias the unused inputs (nominally +3V3A divided by 2), this can be done by fitting a 0R link at R36 and R38, then VR1 can be adjusted to achieve the desired dc level.

The modulator output is unmatched and can be operated from 20MHz to 1GHz.

The TxLO input circuit (L2, C16, C18) can be used with an external source; there is no matching on this input so a broad range of LO frequencies can be applied.

Power supply decoupling is provided by R5+C7 and R9+C9.

7.1.3   CMX971 Direct Control Mode

Connecting JP7 puts the device into Direct Control mode (PE0002 is not used, CBUSOFFN = 0V) and the selectors JP3, JP4, JP5 and JP6 can then be used to select the various modes. The functions enabled by the jumpers are shown in Table 6; they can be selected by fitting a link between pins 2 and 1 (high logic condition) or pins 2 and 3 (low logic condition) of the appropriate jumper.

Jumper	Function
JP5	**RESETN** - when low puts the device in low power mode. Note the pin does not have an internal pull-up resistor.
JP6	**DIVSET** - if low sets LO divider to /2, if high sets LO divider to /4 (equivalent to bit 6 of General Control Register, see CMX971 datasheet).
JP3/JP4	**FREQ1/FREQ2** – see CMX971 data sheet, section 7 for details.

Table 6 CMX971 Direct Control Mode Jumper/Pin Functions

7.2   PC Control Software Description

The EV9710 itself does not require any embedded firmware. However C-BUS control from an external microcontroller may be used. The CML product, PE0002, can be used with the EV9710 and PC software files (**ES9700xx.zip**). To use the software, connect the EV9710 as shown in Figure 2. First ensure the drivers supplied for the PE0002 are installed correctly. The executable must be in the same folder on the PC as the **EF0002xx.hex** file. Run the **ES9700xx.exe** and the main application window will open with a request for the Reset button to be pressed on the PE0002 board, see Figure 5. The window then displays a progress bar for the initialisation process. This software is common to a number of Evaluation Kits, so the appropriate kit must then be selected in a new dialog box, see Figure 6. Once the initialisation and kit selection process is complete, one of three tabs can be selected, as shown in Figure 7 to Figure 9.
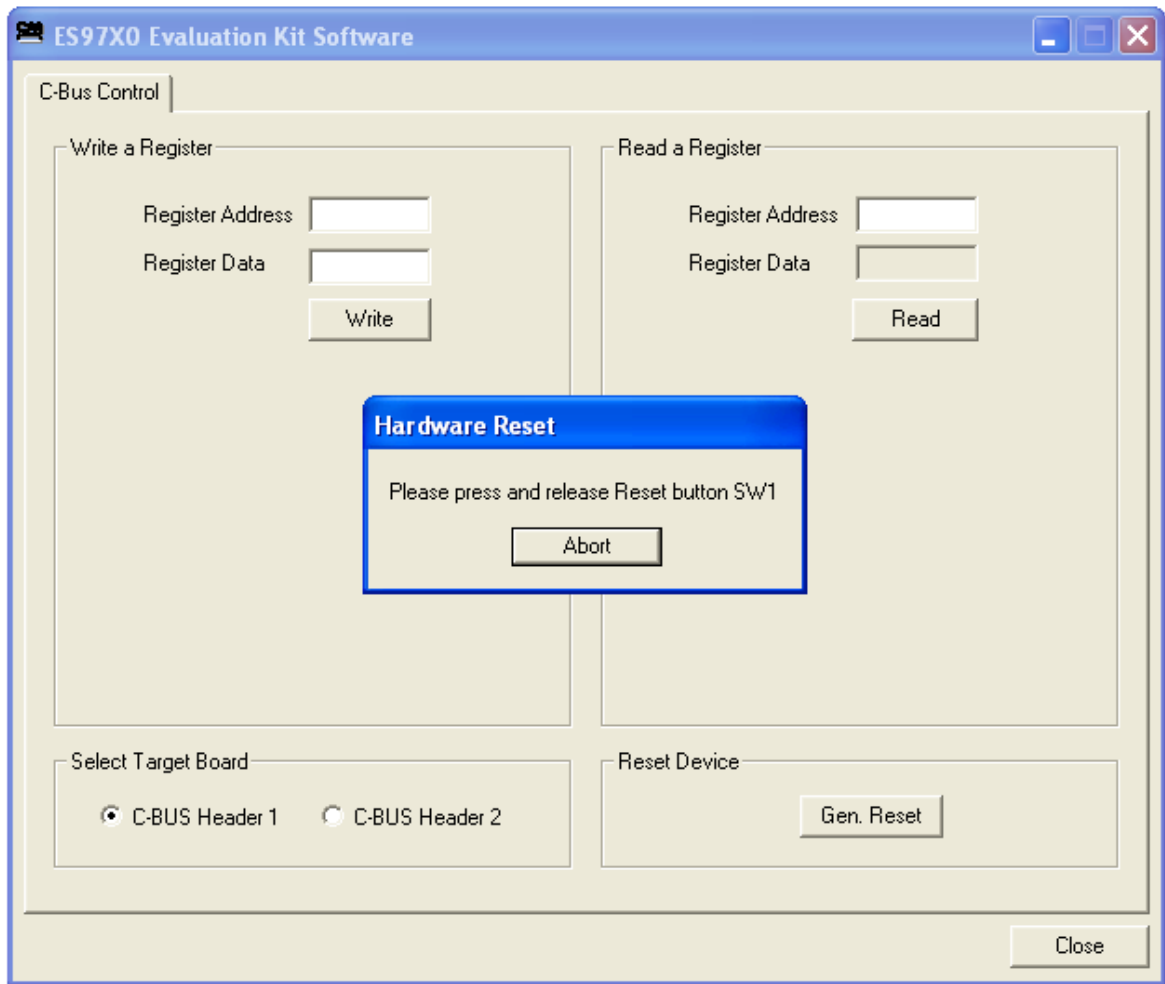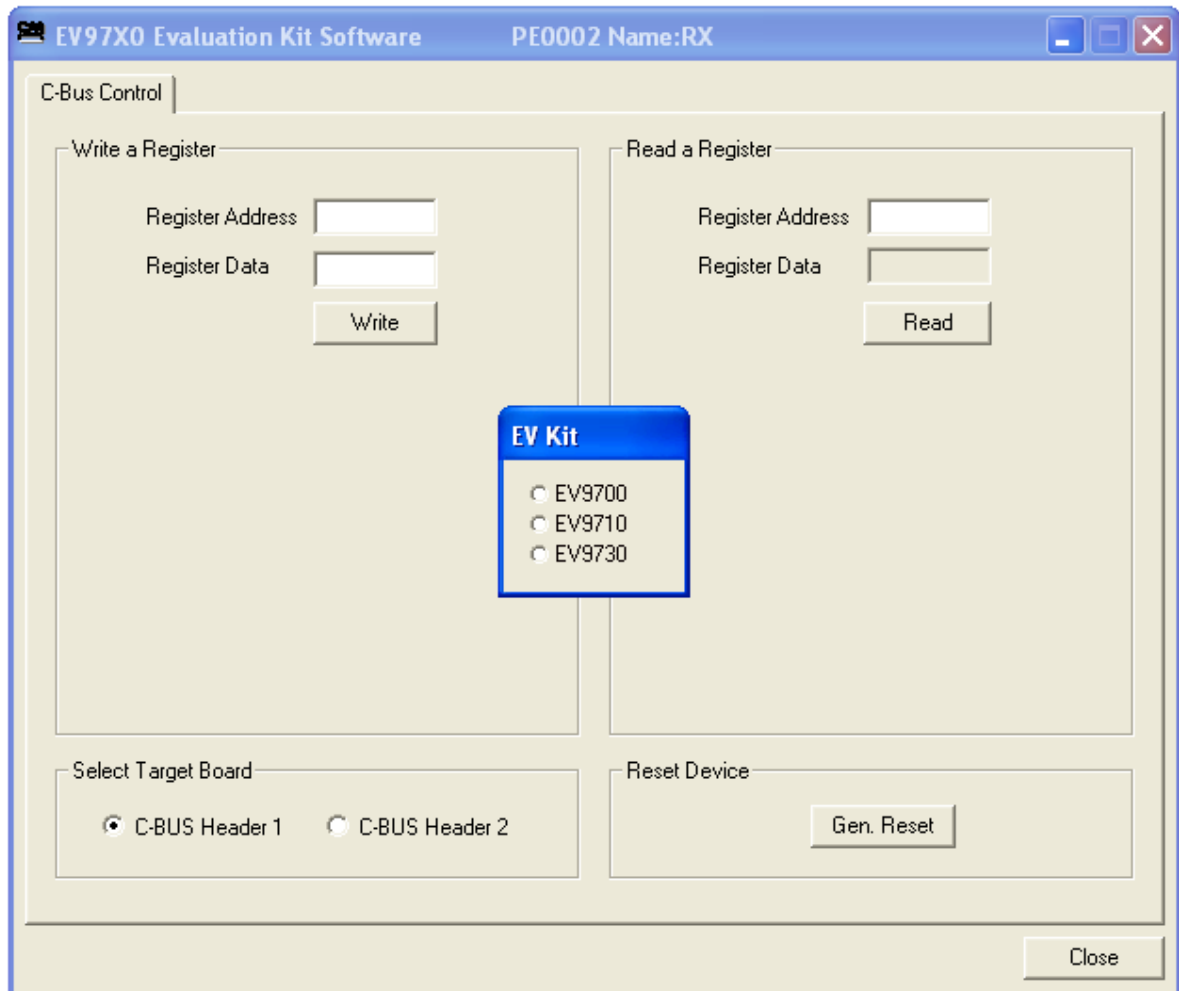
Figure 5 Reset Dialog Box

Figure 6 Product Selection Dialog Box

There are three tabs that represent a particular set of registers or a particular function of the CMX971. To select a tab simply click on the corresponding name in the row at the top of the program window. Setting or clearing the check box associated with a bit of a register will cause that bit to be set or cleared when the register is next written to. If the 'Auto Write' check box is set a register will be written whenever a check box, or list box associated with it, is modified. This removes the need to click the 'Write' button associated with that register. The program can be closed at any time by clicking the 'Close' button or by pressing 'Alt' and 'F4' keys simultaneously.

7.2.1   The C-BUS Control Tab
The C-BUS Control Tab allows the user to read from or write to any register or to issue a General Reset command, see Figure 7. The C-BUS header which is used can also be selected on this tab.
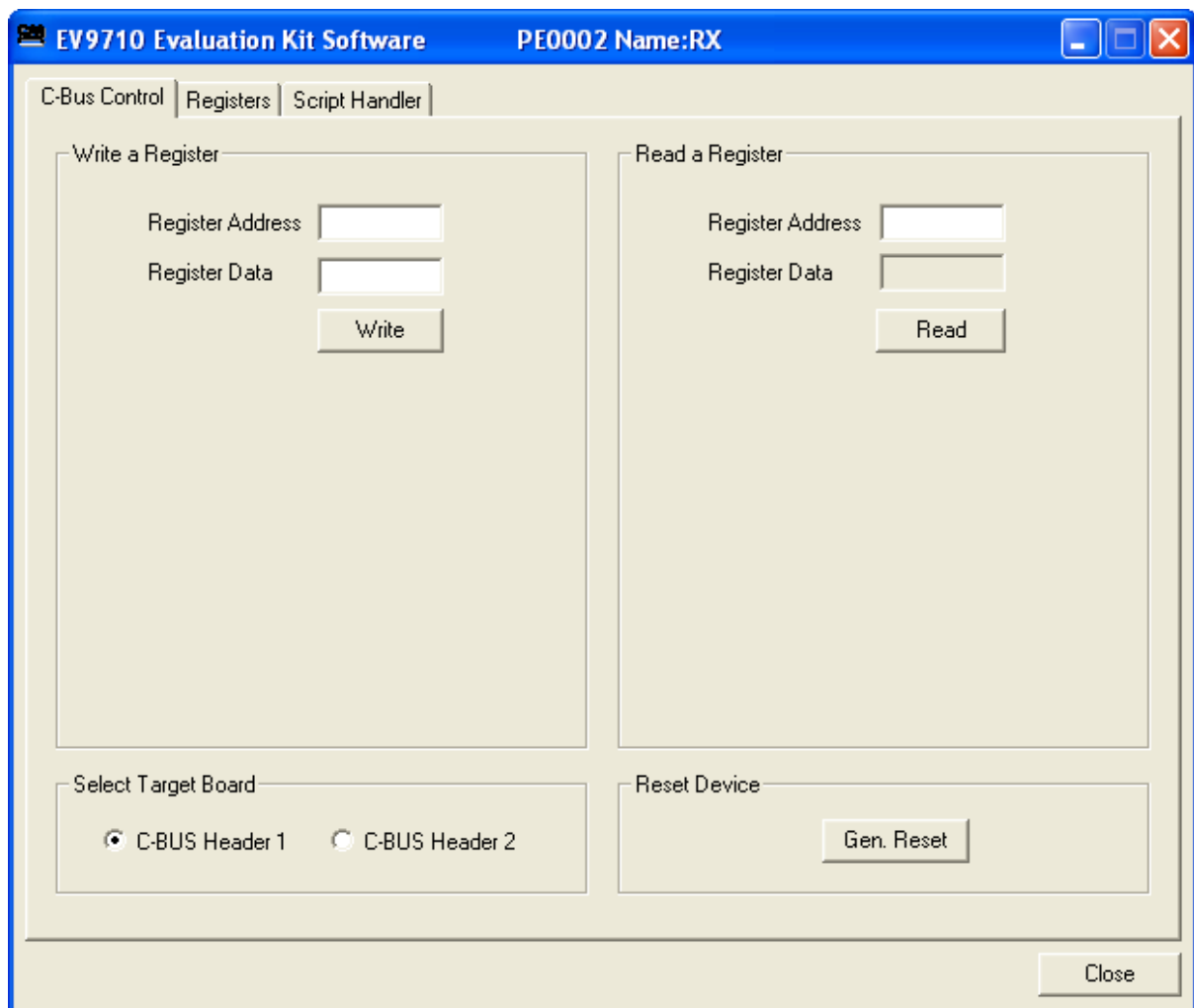
Figure 7 The C-BUS Control Tab

To perform a General Reset on the CMX971, either the Gen. Reset button can be clicked or a single write can be made to register $1A. The following script, which may be used with the **ES9700xx** software, is recommended.

```
;General Reset.pes
;This script will send a C-BUS General reset.
;Reset C-BUS (assigns register RESET a zero length parameter to get a single 8-bit write)
;format: register <device (1 or 2)> <C-BUS address> <# parameter bytes (0 to 2)>

RESET const $1A
        register 1 RESET 0
        copy 0 *RESET

;If using C-BUS port 2 then use the following lines
;       register 2 RESET 0
;       device 2
;       copy 0 *RESET
```
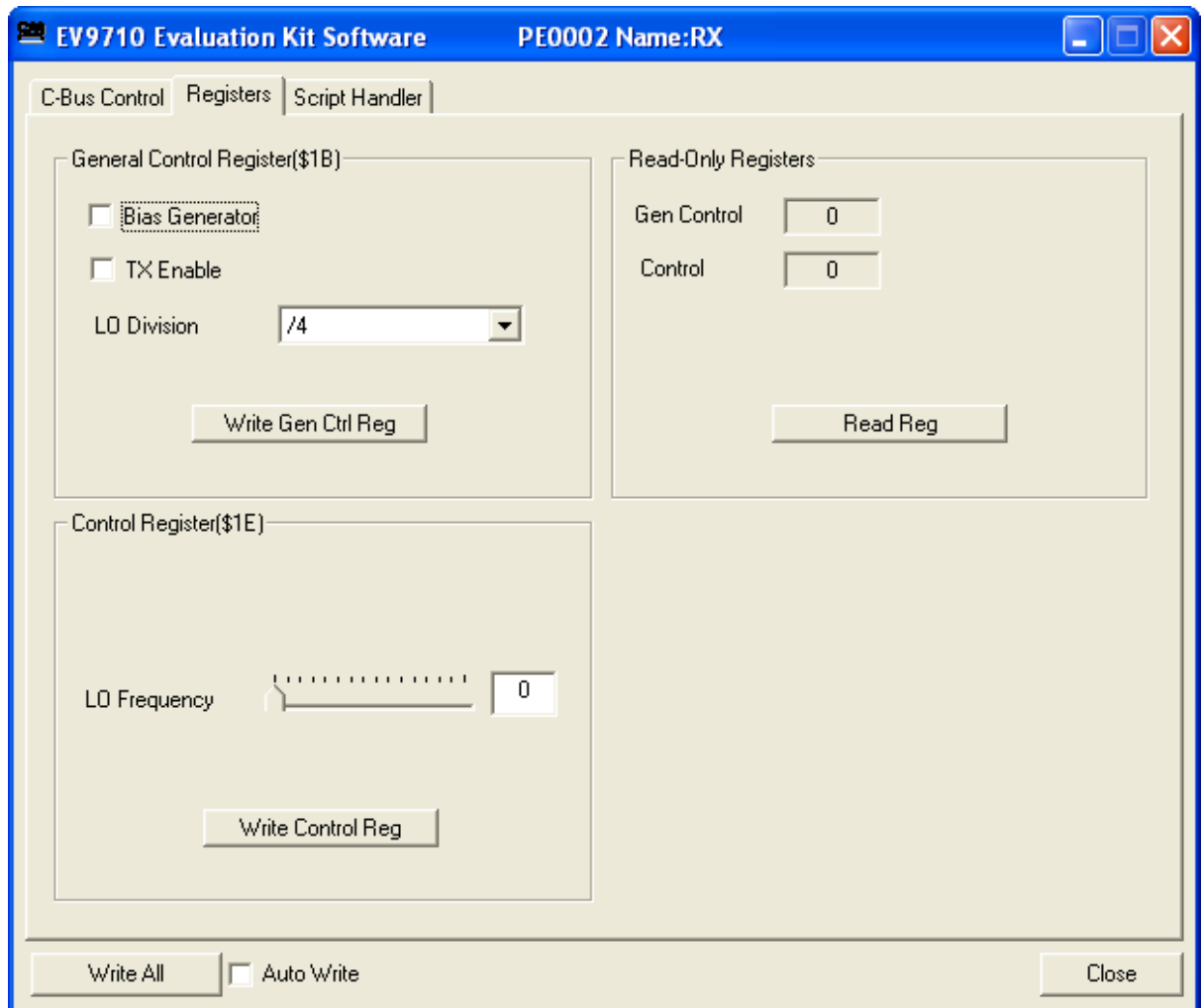
7.2.2   The Registers Tab
The Registers Tab gives the user access to all of the register controls on the CMX971, see Figure 8. Note all registers can be written to individually, as a whole mass register write ('Write All' bottom left hand corner of window). If Auto Write is checked, the register is changed as soon as the user makes changes to this window.

In the case of the Control register, a slide bar has been used to allow easy control during operation.

Figure 8 The Registers Tab

7.2.3   The Script Handler Tab

The Script Handler Tab (shown in Figure 9) allows the execution of script files consisting of register write, read, and delay commands. These are plain text files on the PC, which are compiled via the GUI but executed by the E2 Microprocessor on the PE0002 board. The script language is documented separately in the "Script Language Reference" document, which can be downloaded with the PE0002 support package from the CML website. Control of the EV9710 does not require the use of script files.
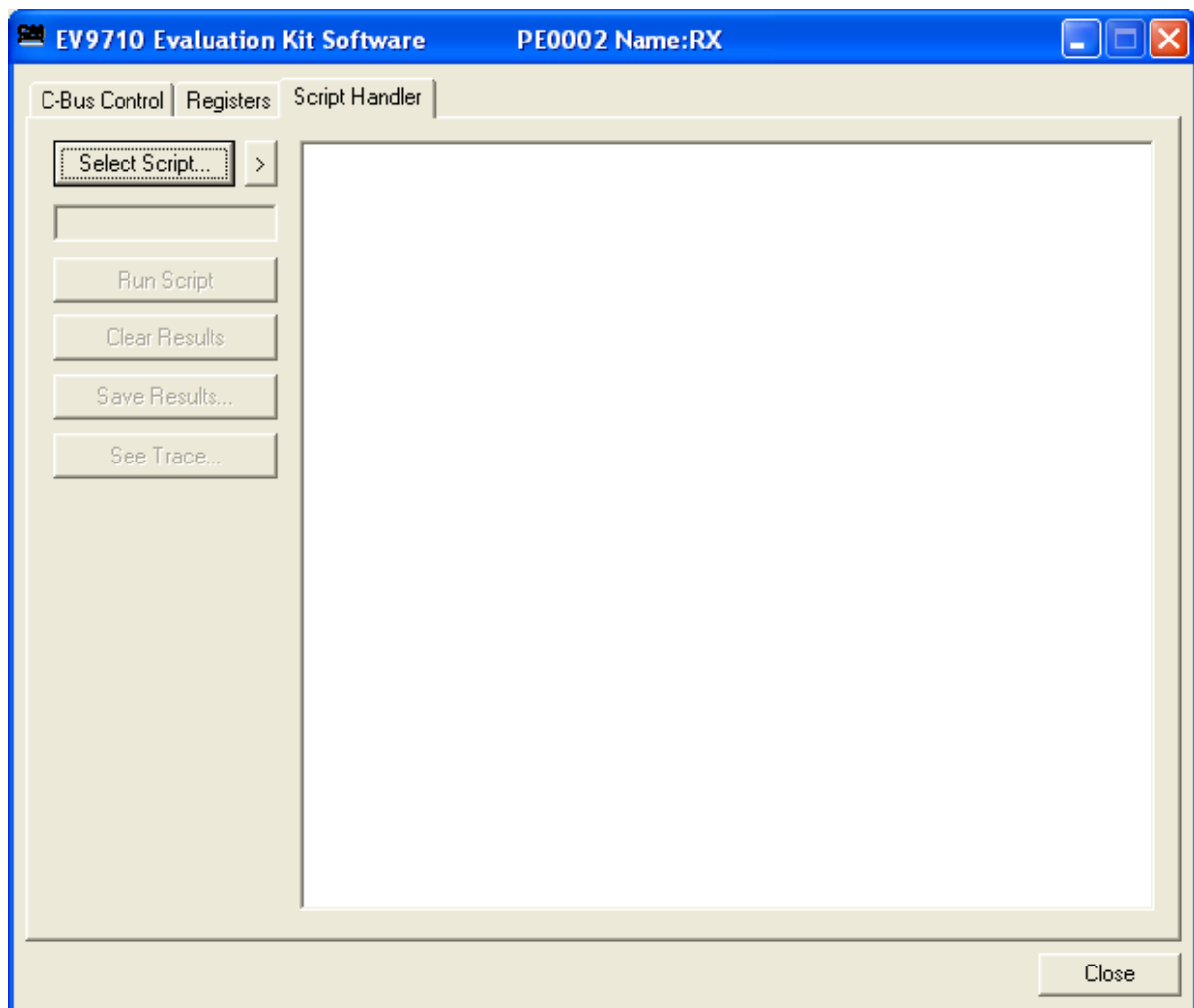
Figure 9 The Script Handler Tab

To select a script file, click on the 'Select Script' button. The Open File Dialog is displayed. Browse and select the script file. The folder that contains the script file will be the working folder of the script (i.e. all the files referenced in the script will be searched in this folder). Alternatively, select a script file from the recent files list. Click on the '>' button to display the list.

The results window displays the values returned by the script. These results can be saved to a text file or discarded by clicking on the 'Save Results' or 'Clear Results' buttons, respectively. When a script file is being executed the 'Run Script' button will change to be the 'Abort' button, the rest of the tab will be disabled and the other tabs cannot be selected.

After a script has finished running and when trace data is available, the 'See Trace…' button will be enabled. Up to 131072 C-BUS transactions can be logged in the PE0002 board. Click in the 'See Trace…' button to display the Trace dialog box. Note that the C-BUS transactions are only logged if the feature has been enabled in the script. See the "Script Language Reference" document for details.

7.3   Evaluation Tests

The EV9710 is intended to allow demonstration of CMX971 Quadrature Modulator. The following sections show some example tests (using LO/2 mode) along with typical results.

7.3.1   Single Tone Test

Apply a LO signal (J5) of 1GHz, -10dBm and a single tone I/Q input (J9) of 1Vp-p differential. Observing the results on a spectrum analyser the Tx output should look like the results in Figure 10. In Figure 10 the input signal on TXI/TXQ is a 7kHz tone in quadrature biased at 1.6Vdc.

From the plot it can be seen that at 500MHz the output level is ~ 0dBm, the image rejection is approximately 66dBc (delta marker 1) and the higher 3rd order product is ~ 46.4dBc (delta marker 2).
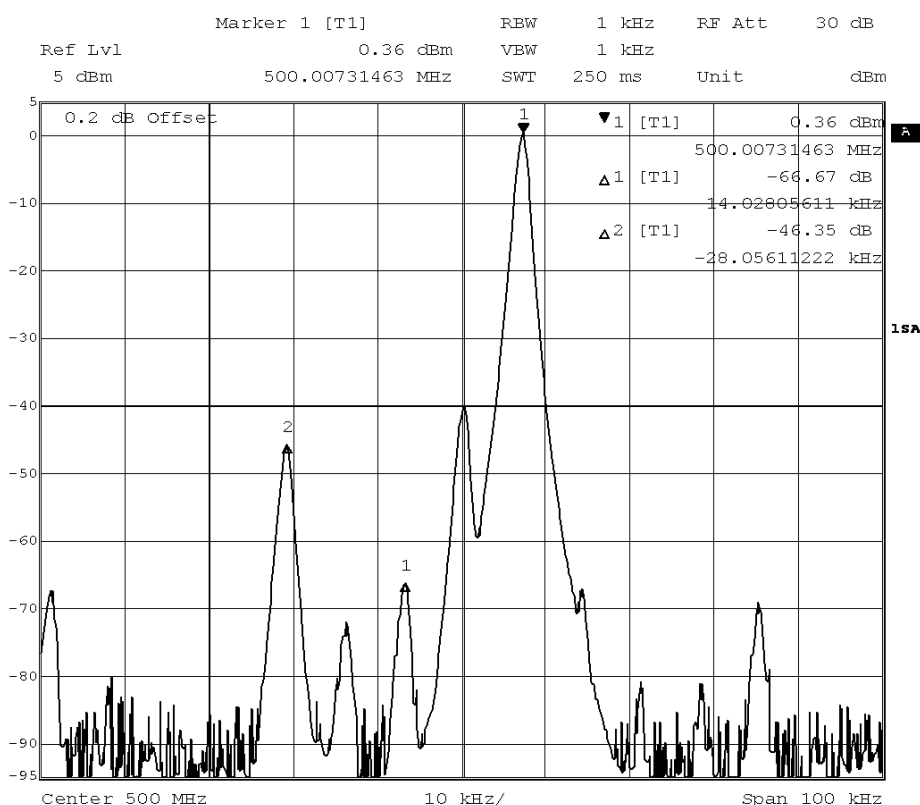
Figure 10 I/Q Modulator Output Spectrum with a Single Tone Input

7.3.2   Two Tone Test

Apply a LO signal (J5) of 1GHz, -10dBm and a two tone input to TXI and TXQ. The two tone test allows you to evaluate the linearity of the modulator. In Figure 11 is a plot of the I/Q modulator output with a two tone input, the input signal is a 7kHz and 9kHz tones applied differential at 1Vp-p in quadrature biased at 1.6Vdc.

From the plot it can be seen that at 500MHz the main output tone level is -6dBm, the highest IMD3 product (2f1 + f2) is 45.7dBc and the highest 3rd order product is ~ 57dBc.
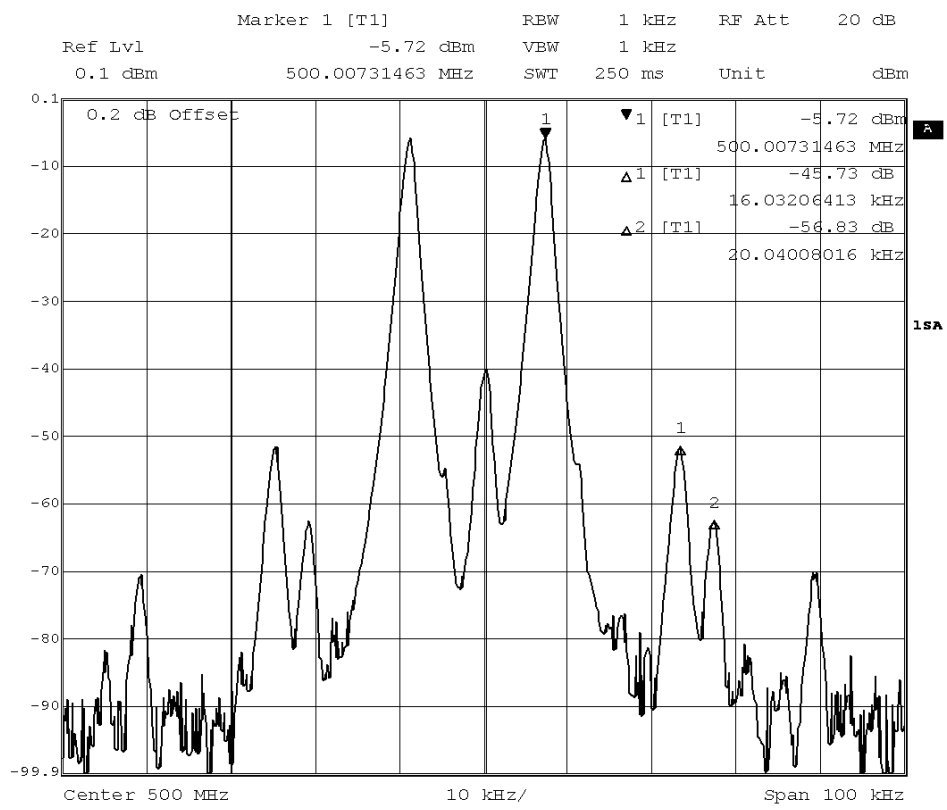
Figure 11 I/Q Modulator Output Spectrum with a Two Tone Input

7.4   Troubleshooting

The CMX971 is a complex RF system. If incorrectly programmed or modified, results will be at variance from datasheet performance. Please study the CMX971 datasheet, this manual and the associated schematics and layout drawings carefully when troubleshooting.

This section provides suggestions to help users resolve application issues they might encounter.

7.4.1   General

Error Observed	Possible Cause	Remedy
ES9700xx.exe software fails to run correctly and reports an error during start up.	Faulty USB port or cable.	Check USB cable to your PC.
	PE0002 or EV9710 is not powered up during start up.	Power up PE0002 (5.0V) and EV9710 (7.2V).
	Incorrect software for PE0002.	Contact: techsupport@cmlmicro.com
Programming data to EV9710 does not appear to work.	The data is being programmed to the wrong C-BUS port on PE0002.	Check whether EV9710 is connected to PE0002 Port 1 (J5) or Port 2 (J3) and ensure the correct window is used for programming data. (See PE0002 user manual for further information).

Table 7 Possible General Errors

7.4.2   Quadrature Modulator Operation

Error Observed	Possible Cause	Remedy
No output from the modulator.	The transmitter and/or the bias has not been enabled. C-BUS Tx enable ($1B, b0). C-BUS Bias enable ($1B, b4).	Set C-BUS Tx enable ($1B, b0='1') and set C-BUS Bias enable ($1B, b4='1').
	No LO signal applied.	Check LO signal is present at sufficient drive level.
	The wrong Tx divider ratio has been selected ($1B, b6)	Check CMX971 data sheet for details on register $1B to ensure correct divider ratio selected.
Carrier leakage high.	Each of the TXI/TXQ inputs are not at the same dc level (nominal is 1.6V dc).	Check the dc level on each of the four I/Q inputs is the same, nominally 1.6V dc.

Table 8 Possible Quadrature Modulator Errors

8   Performance Specification

8.1   Electrical Performance

8.1.1   Absolute Maximum Ratings
Exceeding these maximum ratings can result in damage to the Evaluation Kit.

	Min.	Max.	Units
Supply Voltage (V_{IN} - V_{SS})	0.0	8.4	V
Current into or out of V_{IN} and V_{SS} pins	0	+200	mA
Current into or out of any other connector pin	-20	+20	mA

8.1.2   Operating Limits
Correct operation of the EV9710 Evaluation Kit outside these limits is not implied.

	Notes	Min.	Max.	Units
Supply Voltage (V_{IN} - V_{SS})		3.6	7.6	V

8.1.3   Operating Characteristics

For the following conditions unless otherwise specified: $V_{IN} - V_{SS} = 7.2V$, $T_{AMB} = +25°C$.

	Notes	Min.	Typ.	Max.	Units
DC Parameters					
I_{IN} (CMX971 powersaved)	1	–	0.25	–	mA
I_{IN} (CMX971 Enabled)	1	–	63	–	mA
AC Parameters					
RF Output					
Impedance		–	50	–	Ω
Output Level		–	–	0	dBm
Frequency Range		20	–	1000	MHz
I/Q Input					
Differential Input Voltage	2	–	–	1	Vp-p
DC Level		–	1.6	–	Vdc
LO Input					
Input Impedance		–	200	–	Ω
Frequency Range	3	40	–	2000	MHz
Input Level		–	-10	–	dBm
C-BUS Interface					
See CMX971 datasheet					

Notes: 1. Total PCB current consumption.
2. Differential Input level required to achieve typical output level at 500MHz; 1Vp-p differential means 500mVp-p on each pin; if the modulator is driven single ended the input level should be 1Vp-p on TXIP and TXQP.
3. Local oscillator input frequency twice or four times the required operating frequency.