Getting started with STEVAL-CCA021V1,
STM32 performance line USB demonstration kit

1 Introduction

This user manual describes hardware and software of the STMicroelectronics™ STM32™ performance line USB demonstration kit based on the STM32F103 microcontroller and the I^2S TS4657 audio digital to analog converter (decoder). The audio output can be implemented either with the TS4962 driven onboard speaker which output is also available on the onboard mono jack connector, or through TS2012 stereo audio amplifier which can drive external speakers. Both audio amplifiers are Class-D. The audio input is available with an onboard microphone which is connected through TS472 microphone preamplifier to the ADC input of the microcontroller. To facilitate the reuse of the boards, the controller and the audio card can be disconnected, and used separately for other purposes.

This demonstration kit primarily offers a USB interface operating either under USB Audio Device Class for audio streaming, or Device Firmware Upgrade class (DFU) for application reprogramming through the USB. All design information are included in the kit and can be reused for a new development. The demonstration kit allows a quick evaluation of STMicroelectronics low-voltage audio components in Human machine interface (HMI) audio input/output, portable audio equipment, and simple PC USB demonstration kit applications.

Figure 1. STM32F103 USB demonstration kit - top view

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2 Description

The STM32 performance line USB demonstration kit is designed to demonstrate several STMicroelectronics products:

● The TS4657 is a stereo DAC that integrates a high-performance audio line driver capable of generating a 2.2 V_{RMS} output level from a single 3.0 to 5.5 V supply. One single supply is sufficient for the digital and analog parts of the circuit, thus eliminating the need for external regulators. The TS4657 is a low-power consumption device. It features only 22 mW power dissipation at a 3.0 V power supply in full operation. A 16-bit multi-bit sigma delta DAC is used, operating at 256 x Fs (where Fs is the sampling frequency) with oversampling digital interpolation filters. The digital audio data can be 16 to 24-bit long and sample rates from 32 to 48 kHz are supported. The TS4657 is packaged in a small 4 x 4 mm QFN20 package, ideal for portable applications.

● The STM32F103xx performance line family incorporates the high-performance ARM® Cortex™-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 128 KB and SRAM up to 20 KB), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, three general purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I2Cs and SPIs, three USARTs, a USB and a CAN. The STM32F103xx performance line family operates from a 2.0 to 3.6 V power supply. It is available in both the –40 to +85 °C temperature range and the –40 to +105 °C extended temperature range. A comprehensive set of power-saving mode allows designing low-power applications. The complete STM32F103xx performance line family includes devices in 5 different package types: from 36 pins to 100 pins.

● The TS2012 is a fully differential stereo Class-D power amplifier able to drive up to 1.15 W into a 8 Ω load at 5 V per channel. It achieves better efficiency compared to typical Class-AB audio amps. Pop and click reduction circuitry provides low on/off switch noise while allowing the device to start within 8 ms.

● The TS4962 is a differential Class-D BTL power amplifier. It is able to drive up to 2.3 W into a 4 Ω load and 1.4 W into a 8 Ω load at 5 V. It achieves outstanding efficiency (88 % typ.) compared to classical Class-AB audio amps. Pop and click reduction circuitry provides low on/off switch noise while allowing the device to start within 5 ms. A standby function (active low) allows to reduce the current consumption down to 10 nA typical.

● The TS472 is a differential-input microphone preamplifier optimized for high-performance, PDA and notebook audio systems. This device features an adjustable gain from 0dB to 40 dB with excellent power-supply and common-mode rejection ratios. In addition, the TS472 has a very low-noise microphone bias generator of 2 V. It also includes a complete shutdown function, with active low standby mode.

3 Boards key features

STM32 performance line controller board

- STM32F103 performance line microcontroller
- 16 MHz crystal unit
- USB connector and ESD protection
- Two LEDs driven by the microcontroller
- Push button to control the firmware mode
- Connectors summary
    - 20-pin dual line header for connection to the TS4657 audio card
    - Full JTAG connector

TS4657 audio card

- TS4657 - single supply stereo digital audio line driver with 2.2 V_{RMS} capless outputs
    - 16- to 24-bit audio data format stereo DAC, 32 to 48 kHz sample rate
    - I²S, right- or left-justified compatible digital audio interface
- TS2012 - filter-free stereo 2 x 2.8 W Class-D audio power amplifier
    - Output available either on the mono jack connector or fed to the onboard speaker
- TS4962 - 2.8 W filter-free mono Class-D audio power amplifier
    - Output available either through mono jack connector or to onboard speaker
- TS472 - very low noise microphone preamplifier with 2.0 V bias output and active low standby mode
    - Single ended output available for connection to ADC of a microcontroller
- Onboard microphone and small speaker
- Connectors summary
    - 20-pin dual line header for connection to the STM32 performance line controller board
    - Two RCA connectors available as TS4657 line outputs
    - Mono jack connector available as TS4962 amplifier output
    - Two terminal connectors available as TS2012 outputs

4 General system description

The STM32F103 USB demonstration kit consists of two boards. The STM32F103 controller board receives the audio data through USB from PC and transfers them into the I^2S data stream in the PCM16 format suitable for the TS4657 audio DAC. In addition, the STM32F103 can act as an interface with a microphone line connected to the microcontroller ADC pin.

The second board performs the audio function, using the TS4657 digital to analog converter (DAC). Its output is passed to TS4962 Class-D mono amplifier that either feeds the onboard speaker or drives the external mono speaker through the onboard mono jack connector. The DAC output is also connected to TS2012 stereo Class-D amplifier which output is available outside the board for external stereo speakers through terminal connectors. The audio input is available through the onboard microphone which output is amplified by TS472 microphone preamplifier. This microphone line is considered to be connected to the ADC input of the microcontroller on the STM32F103 controller board.

Figure 2.   STM32F103 USB demonstration kit - block diagram
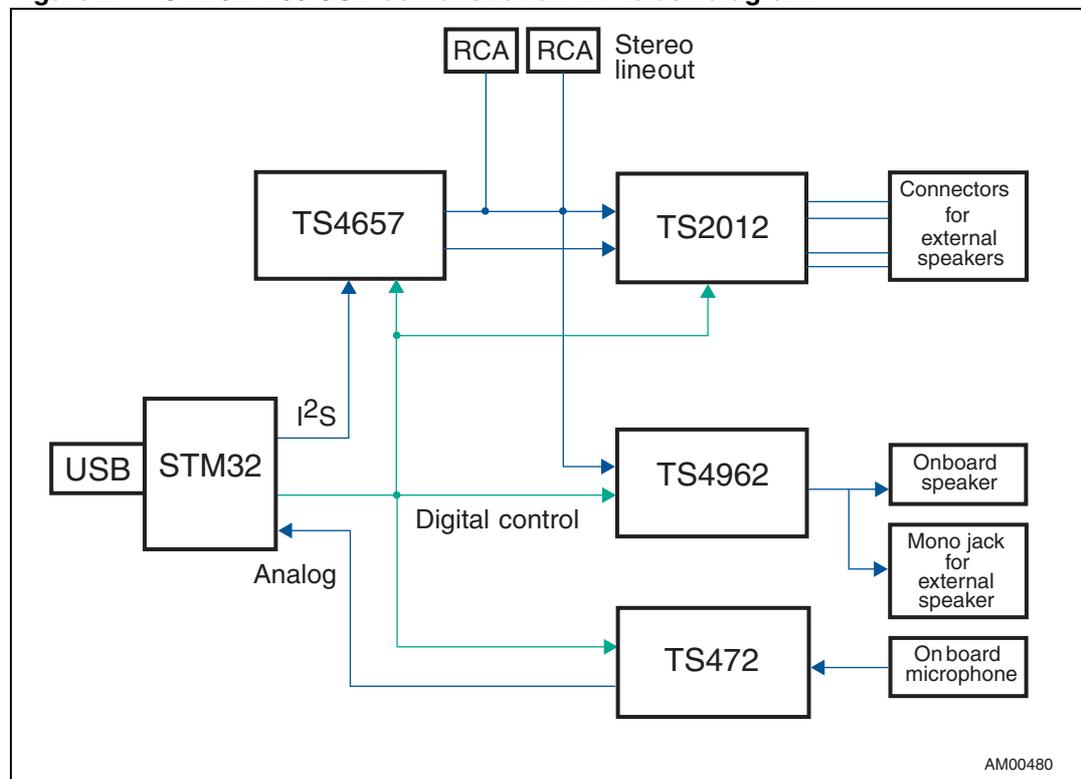
5 Getting started

5.1 System requirements

In order to use the STM32 performance line USB demonstration kit with the Microsoft®
Windows® operating system, a recent version of Windows, such as Windows XP, Windows
98, Windows Millennium or Windows 2000 must be installed on your PC.

The version of the Windows OS installed on your PC may be checked by clicking the
"System" icon in the Control Panel.

5.2 Package contents

The STM32 performance line USB demonstration kit includes the following items:

Hardware content

● One STM32 controller board with USB and I²S audio connector + one TS4657 audio
card board.

● One soldered STM32F103RET6 ARM-based 32-bit microcontroller device (LQFP64
package). It embeds Flash memory allowing 10 thousands reprogramming cycles. (The
min. value of the endurance = 10 Kcycles). The STM32F103RET6 is delivered already
programmed with the demonstration firmware.

Software content

● STM32 Design Firmware Update (DFU) firmware

● STM32 DFU application that offers PC USB demonstration kit functionality

Documentation

● STM32F103, TS4657IQT, TS2012IQT, TS4962IQT, TS472IQT datasheets

● PCB production data

● STM32F103 and audio devices flyers

● This user manual UM0722

5.3 Software driver installation

The following steps are required to install the software driver of the USB Audio Device Class
device:

1. Connect the STM32 performance line USB demonstration kit to your PC/laptop USB
port and let the Windows recognize the Audio Device Class device

2. There is no need for any particular user action, just follow installation process and
acknowledge default Audio Device Class device driver to operating system once
requested. At the end of the installation a new Sound controller appears in the Device
Manager window as shown in *Figure 3*.

This new USB audio device becomes the main audio output for time being.

Warning: Do not place the STM32 performance line USB demonstration kit speaker close to your ears. It might harm your hearing if the card is set to deliver the maximum output power.

Figure 3.   Device manager window - new USB audio device
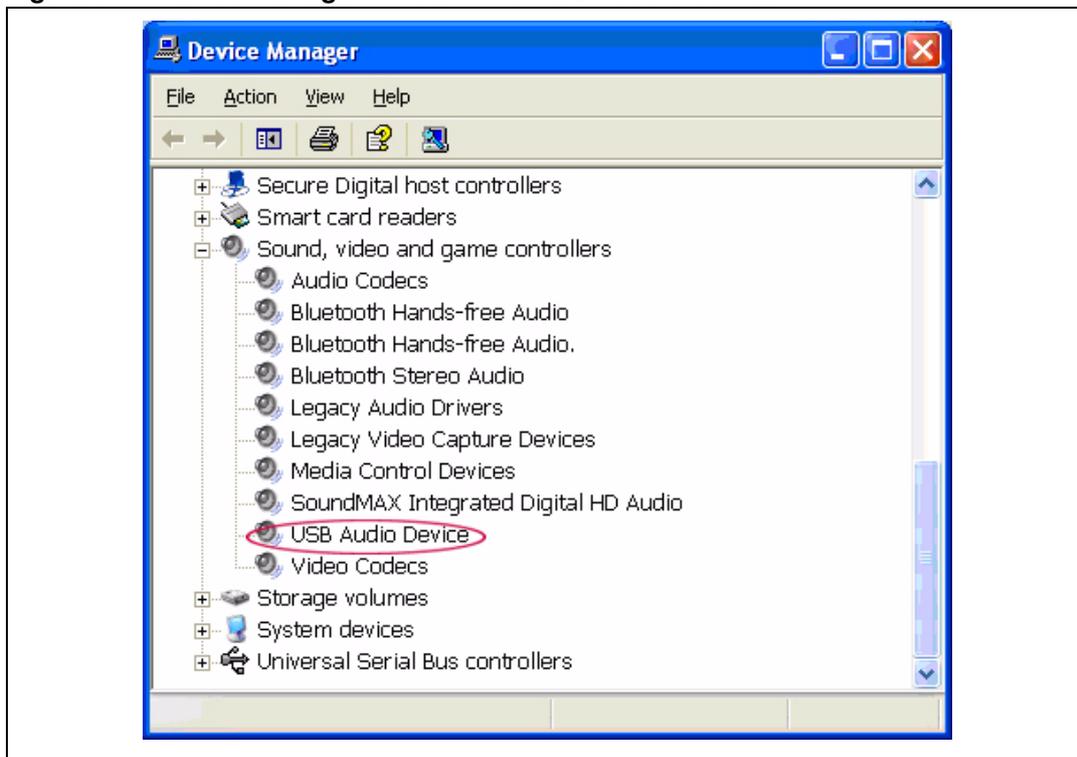
6   Boards layout

6.1   STM32 controller board layout

Figure 4.   STM32 controller board layout
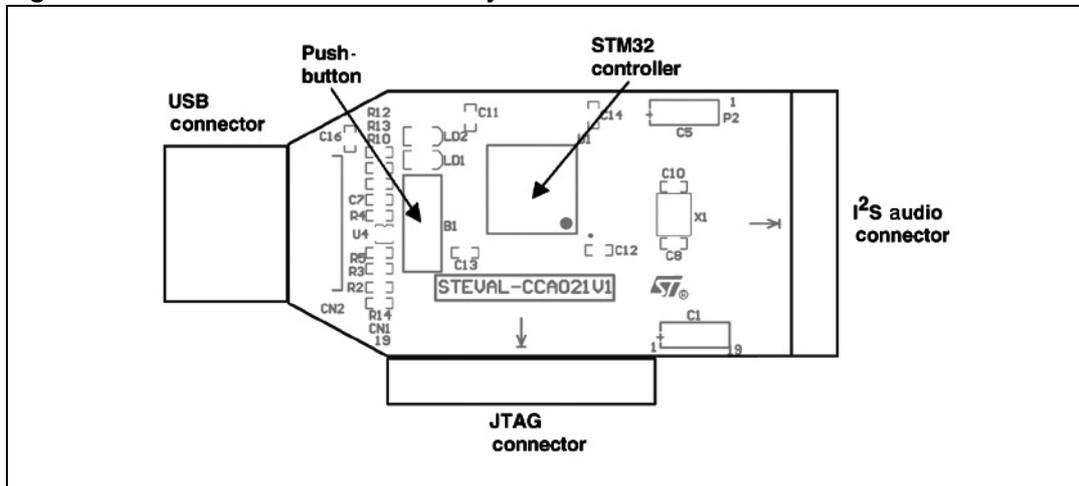
6.2   TS4657 audio card layout

Figure 5.   TS4657 audio card board layout
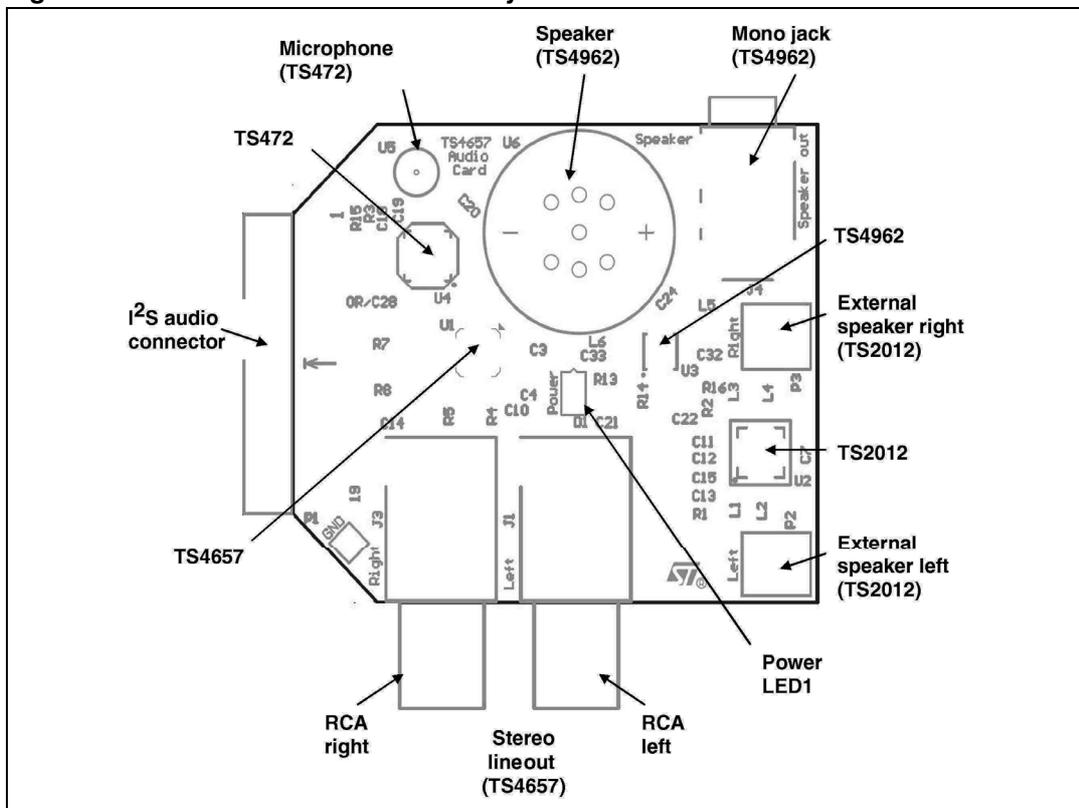
7 System setup

STM32 performance line USB demonstration kit can be used in two application software modes together with at least five audio input / output connection schemes. This chapter gives a brief description of all possible audio hardware settings. The present demonstration kit is designed to be operated always with a personal computer and powered via USB peripheral bus.

Warning: **Do not attach the external speakers when the STM32 performance line USB demonstration kit is powered on, that is when the card is connected via USB with PC. It is recommended to always unplug the card from your PC before connecting or disconnecting the external speakers. Short-circuiting the power audio amplifier output pins may damage the power audio amplifier output stages.**

7.1 Demonstration kit output mode

7.1.1 Onboard speaker configuration

This is the default configuration after the STM32 performance line USB demonstration kit is plugged into the available PC USB port. The green LED LD2 switches on when the demonstration kit is in operating mode. The PC automatically detects the new demonstration kit and all audio outputs are automatically redirected to the new sound device by Windows. For example, play any multimedia content on a media player, and listen to the audio output from the onboard speaker.

Figure 6.   Onboard speaker system setup
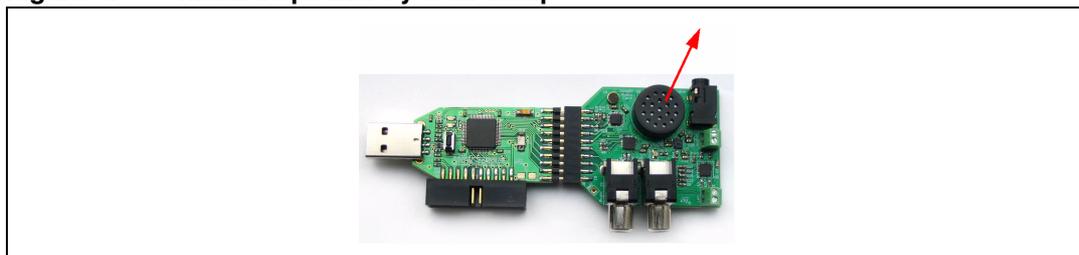
7.1.2 External mono speaker or headphone configuration

The system setup is the same as for the default onboard speaker mode. Just connect properly the selected external speaker, and follow the instructions given in *Section 9.7* LD2 is switched on when the demonstration kit operates in this mode.

Figure 7.   External mono speaker or headphone system setup
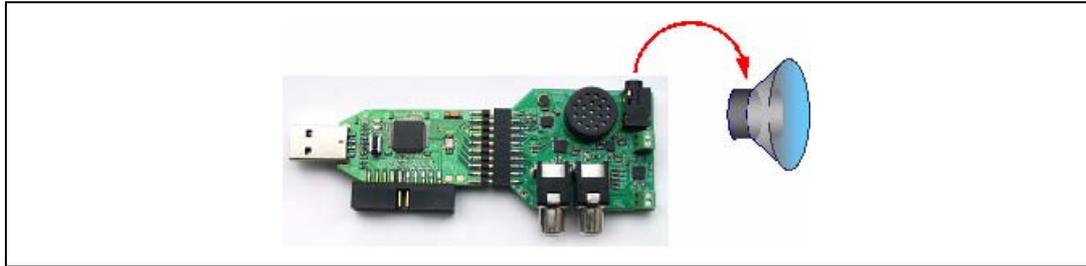
7.1.3   External amplified stereo output configuration

To change the audio output from the default onboard speaker to the TS2012 power output, briefly press the B1 button on the controller board. In this mode the red LD1 and the green LD2 are both on. By pressing again the B1 button you can get back to the default onboard speaker mode. Please read *Section 9.8* for further information about the best external speaker configuration and limitations of the demonstration kit.

Figure 8.   External amplified stereo output system setup
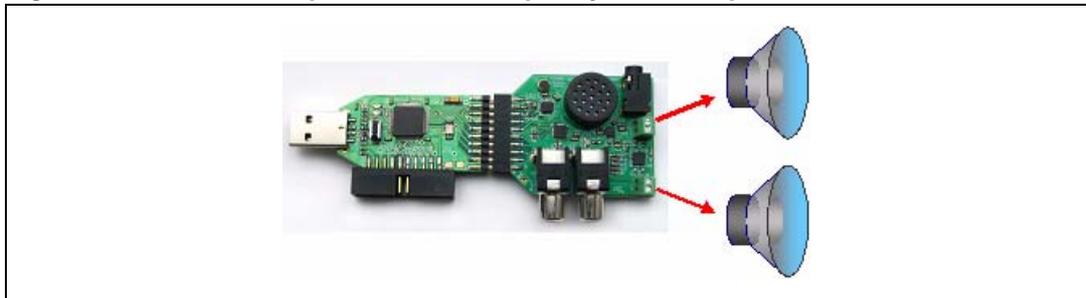
7.1.4   Lineout output configuration

Whatever the firmware application mode, the user can always use lineout RCA stereo interface to obtain standardized audio signal that can be further processed by an external audio equipment.

Figure 9.   Lineout output system setup
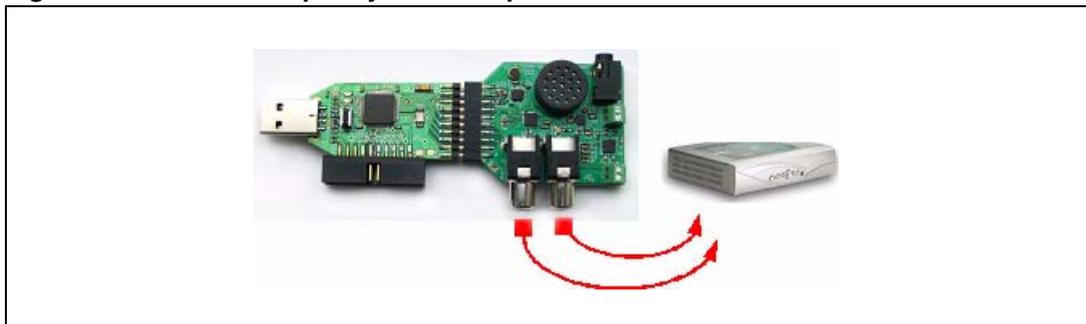
7.2   Microphone record-replay mode

The onboard microphone can be used only in record-replay mode. To change the operating mode from PC USB demonstration kit to record-replay mode, press B1 for approximately 1 s.

In this mode the STM32 performance line USB demonstration kit records 5 s long audio sample and than plays it back through any mean (speaker) presented in the above chapter. In this mode, LD2 blinks at a fast rate when the demonstration kit is recording, and at a slower rate when the acquired record is being played back. The red LED LD1 functionality does not change. When LD1 is off the onboard speaker is used for playback, when LD1 is on the external stereo speakers are used.

Figure 10.   Microphone record-replay mode system setup
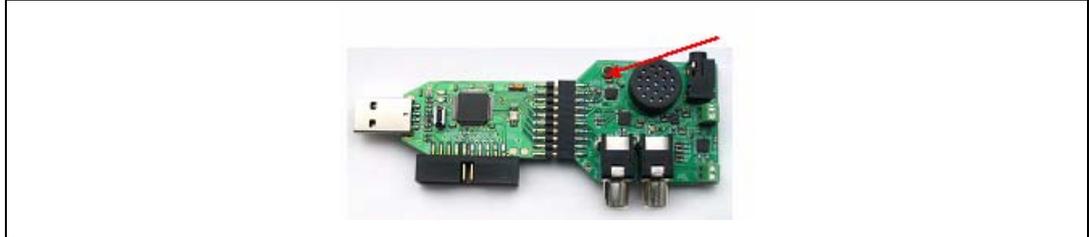
8 Connectors of the STM32 performance line controller board

8.1 I²S audio connector P2

The P2 connector is used to interconnect the STM32F103 controller board and the TS4657 audio card. This connector is functionally compatible with the P1 connector described in *Section 9.1*.

Table 1. I²S audio connector pins description of the STM32 controller board

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	GND	6	PA0 pin of the MCU	11	PC3 pin of the MCU	16	PB7 pin of the MCU (I2C1_SDA funct. not used)
2	+5V0 from USB	7	A3V3 - +3V3 supply voltage for analog domain	12	I2S2_SD, PB15 pin of the MCU	17	Standby for TS4962 (onboard speaker and mono jack)
3	PA3 pin of the MCU	8	I2S2_WS, PB12 pin of the MCU	13	PC2 pin of the MCU	18	PB6 pin of the MCU (I2C1_SCL funct. not used)
4	PA2 pin of the MCU	9	VSSA ground for analog domain	14	I2S2_MCK, PC6 pin of the MCU	19	GND
5	PA1 pin of the MCU (ADC)	10	I2S2_CK, PB13 pin of the MCU	15	PC1 pin of the MCU	20	+3V3

Figure 11. I²S audio connector of the STM32 controller board - schematic
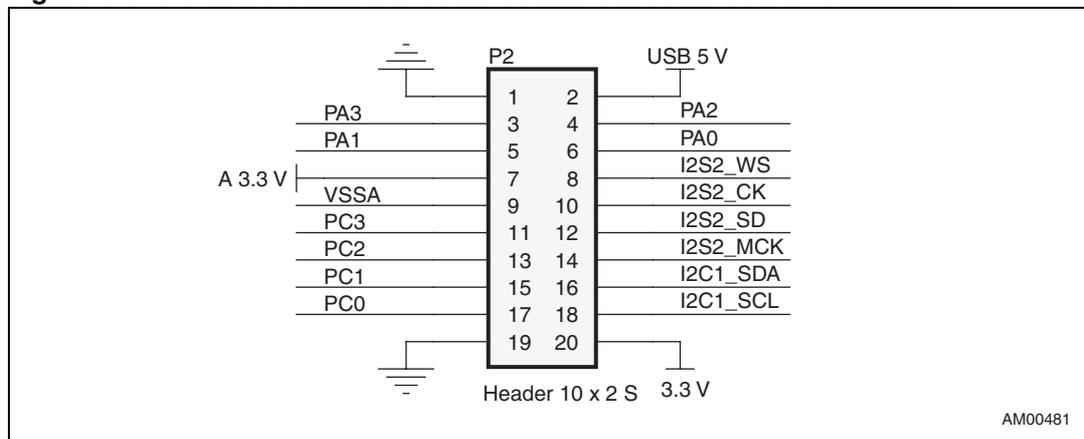
8.2 JTAG connector CN1

The 20-pin connector (CN1) provides the JTAG interface as shown in *Figure 12*. This interface is primarily used to communicate with a PC using suitable USB/JTAG converter box such as J-Link from IAR Systems™ or RLink from Raisonance, etc. There exists a wide

choice of development tools on the market supporting microcontroller Flash memory programming and application debugging.

Figure 12. JTAG connector
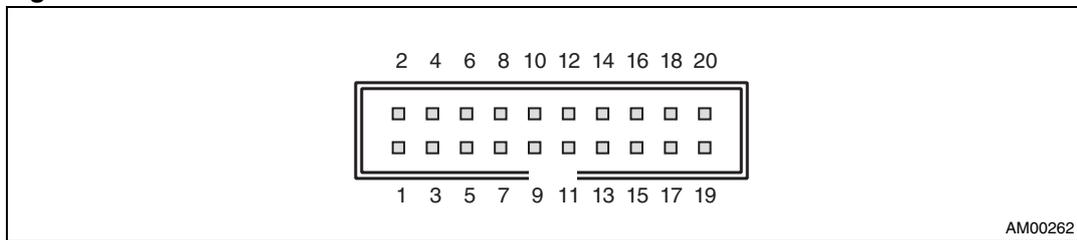
Table 2. JTAG connector pins description

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	3V3 DC	6	GND	11	RTCK Connected to GND by R1 (10 kΩ)	16	GND
2	3V3 DC	7	JTMS	12	GND	17	DBGRQ Connected to GND by R2 (10 kΩ)
3	JTRST	8	GND	13	JTDO	18	GND
4	GND	9	JTCK	14	GND	19	DBGACK Connected to GND by R14 (10 kΩ)
5	JTDI	10	GND	15	NRST	20	GND

Figure 13. JTAG connector CN1 - schematic
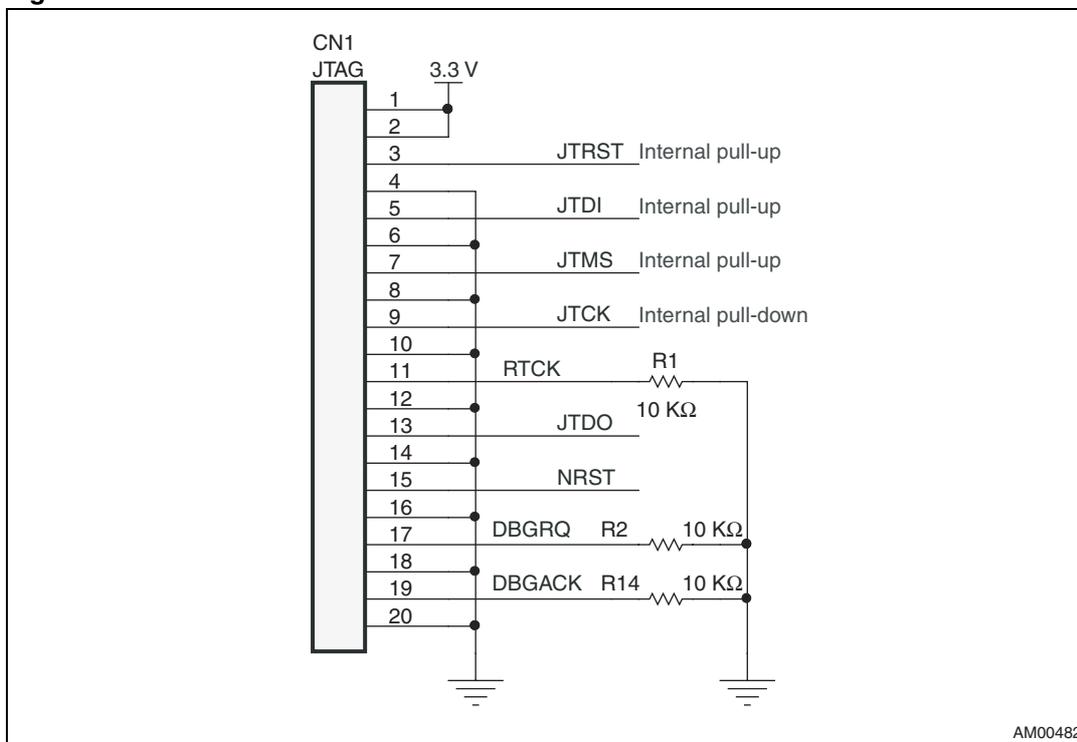
# 9 Connectors and functionality of the TS4657 audio card

9.1 I²S audio connector P1

The P1 connector is used to interconnect the STM32F103 controller board and the TS4657 audio card. This connector is functionally compatible with the P2 connector described in *Section 8.1*.

Table 3.   I²S audio connector pins description of the TS4657 audio card

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	GND	6	G1 Gain select for TS2012	11	Right channel mute for TS2012	16	Data format selection FMT2 for TS4657
2	+5V0	7	V_{CCA} +3.3 V supply voltage for microphone domain	12	TS4657 SDAT I²S signal	17	Standby for TS4962 (onboard speaker and mono jack)
3	Microphone shutdown	8	TS4657 LRCLK I²S signal	13	Left channel mute for TS2012	18	Data format selection FMT1 for TS4657
4	G0 gain select for TS2012	9	GNDA ground for microphone domain	14	TS4657 MCLK I²S signal (master clock)	19	GND
5	Analog output from microphone preamplifier	10	TS4657 BCLK I²S signal	15	Standby for TS4657	20	NC

Figure 14.   I²S audio connector of the TS4657 audio card - schematic
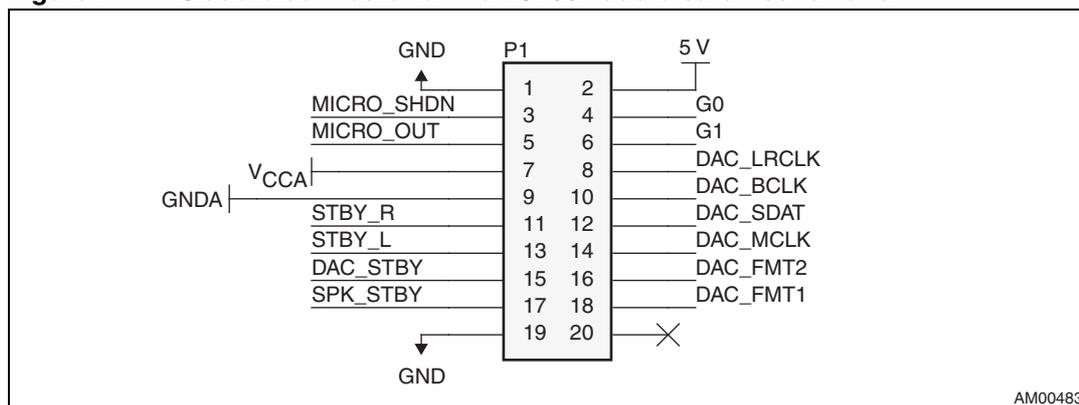
9.2 Mono jack connector J4 and the onboard speaker U6

The mono jack audio connector J4 is connected to the output of the TS4962 Class-D mono audio amplifier U3. The amplifier drives either the onboard speaker or the J4 mono jack

connector if an external speaker is connected. The output is never available to J4 and U6 at the same time because the mono jack connector J4 has the pin disconnection capability.

Table 4. Mono jack connector J4 pins description of the TS4657 audio card

Pin	Signal
1	OUT− line of the TS4962 mono amplifier
2	OUT+ line of the TS4962 mono amplifier (present if the external speaker is connected)
3	OUT+ line of the TS4962 amplifier connected to the pin 2 of the onboard speaker U6 when the external speaker is not connected.

Figure 15. Mono jack audio connector J4 and the onboard speaker U6
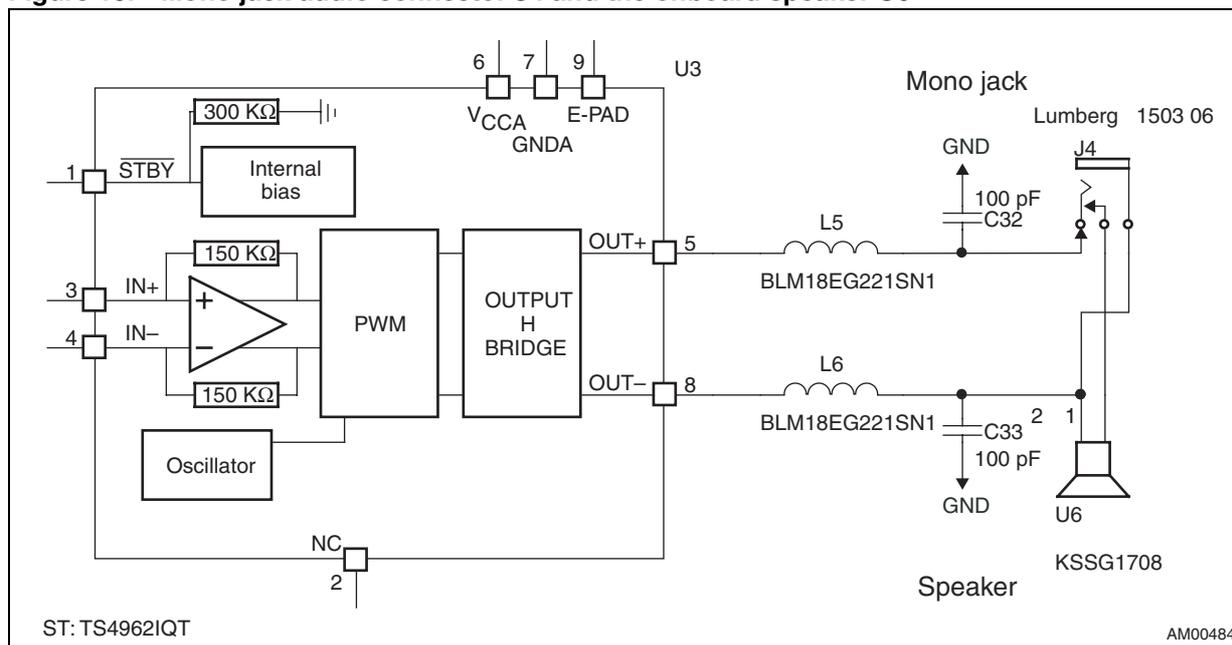
9.3 TS2012 stereo output terminal connectors P2, P3

The TS2012 stereo Class-D amplifier output is available outside the board through the onboard terminal connectors P2 and P3.

Table 5. TS2012 stereo output terminal connectors P2, P3

Connector P2		Connector P3	
Pin	Signal	Pin	Signal
1	L_{OUT+}	1	R_{OUT-}
2	L_{OUT-}	2	R_{OUT+}

Figure 16. TS2012 stereo output terminal connectors P2, P3
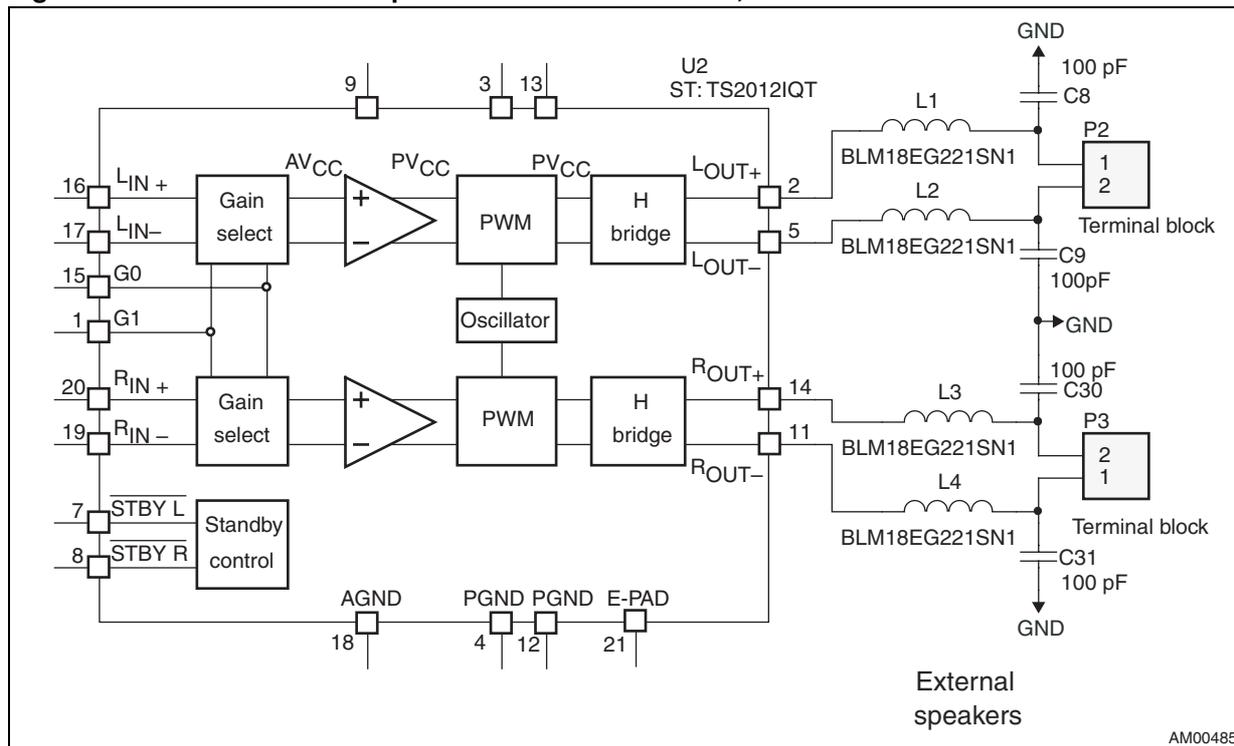
9.4 TS4657 stereo DAC output audio RCA connectors J1, J3

The TS4657 stereo DAC audio output is available as lineout signal through the onboard RCA connectors J1, J3.

Table 6. TS4657 stereo DAC output audio RCA connectors J1, J3

Connector J1		Connector J3	
Pin	Signal	Pin	Signal
1	L_{OUT}	1	R_{OUT}
2	GND	2	GND

Figure 17. TS4657 stereo DAC output audio RCA connectors J1, J3
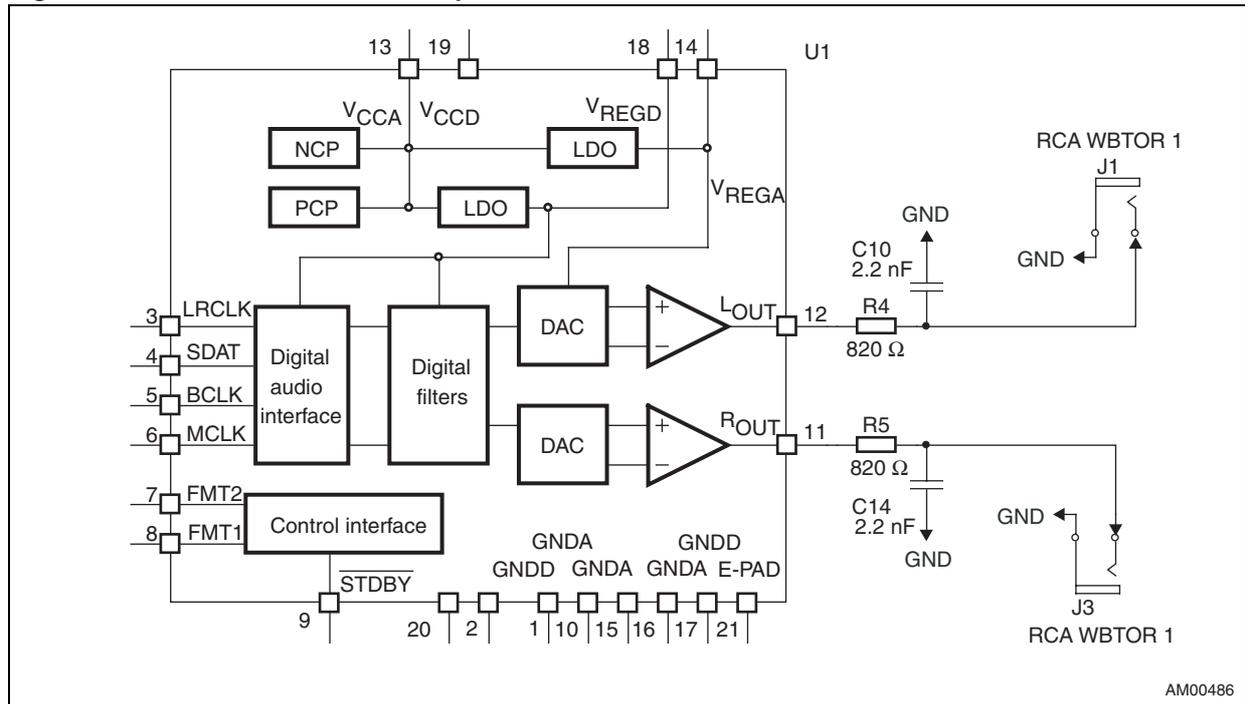
9.5 Microphone functionality

An onboard microphone is available on the TS4657 audio card. The microphone is connected to the microphone preamplifier TS472, which operates in single-ended output configuration. The preamplifier output is available on the I²S audio connector P1 and is connected also to the ADC input pin of the STM32 MCU on the controller board.

The microphone unit U5 is supplied from the TS472 preamplifier 2.0 V bias pin. R11, R12 (1 KΩ) resistors are polarizing resistors for biasing of the microphone. C19 and C20 are input coupling capacitors that block the DC voltage at the amplifier input pins and their value determines also the cut-off of the low input frequencies. C18 and C23 are low pass filter capacitors which allow to cut-off the high frequencies (100 pF ~ 20 kHz). C28 is assembled with 0Ω resistor in order to have DC coupling between the preamplifier and the STM32 microcontroller. For AC coupling the C28 value determines also the cut-off of the low output frequencies. The preamplifier gain can be changed by different values of the R17 resistor (see TS472 datasheet on www.st.com). In this configuration the gain is fixed to 40 dB. R3 represents the input impedance of the following stage and is also used to charge the output capacitor C28. R3 is assembled in the default configuration but can be safely removed. R15 is not necessary in case the standby pin connection is correctly handled on the side of the microcontroller. TS472 has a weak pull-down resistor already embedded. If there is no connection on the standby pin to the microcontroller, the preamplifier is in the standby mode. The amplifier is powered from +3.3 V coming from the controller board.

Figure 18.   Microphone functionality

Microphone preamplifier
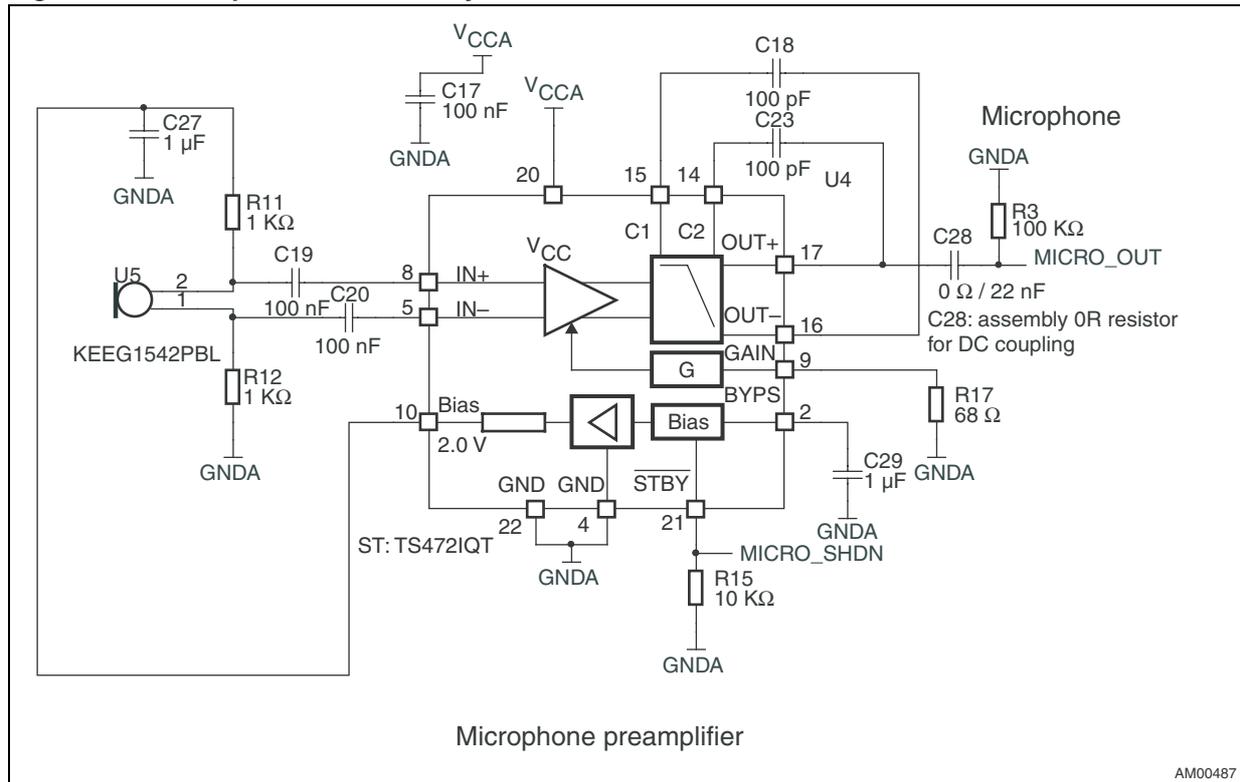
9.6   TS4657 stereo audio DAC functionality

The TS4657 is a stereo digital to analog converter. It is a 16-bit multi-bit sigma delta DAC operating at 256 x audio sample rate with over sampling digital interpolation filters. The digital audio data can be 16 to 24 bit long and sample rates from 32 to 48 kHz are supported.

The digital I^{2}S interface has four lines: LRCLK (left - right channel selection), SDAT (audio data), BCLK (bit clock) and MCLK (master clock - over sampling clock). The selection of the data format can be performed through two pins (FMT1, FMT2). The supported data formats are:

● Right-justified, 16-bit data, Data valid on rising edge of BCLK

● Right-justified, 24-bit data, Data valid on rising edge of BCLK

● Left-justified, 16-bit up to 24-bit data, Data valid on rising edge of BCLK

● I²S, 16-bit up to 24-bit data, Data valid on rising edge of BCLK

The standby mode can be entered by driving the standby pin low. The pin features internal weak pull down resistor. For practical reason there is also an external pull-down resistor R20 which is helpful when utilizing the amplifier with a microcontroller. The same is valid for the format pins (FMT1, FMT2) and pull down resistors R7 and R8. The RC passives R4, R5, C10 and C14 are low pass filter network. The output is referenced to ground. The lineout RCA connectors J1, J3 are available on the board for both audio channels. The DAC is powered from +5 V coming from the controller board. One single supply is sufficient for the digital and analog parts of the circuit, thus eliminating the need for external regulators.

Figure 19. TS4657 stereo audio DAC functionality
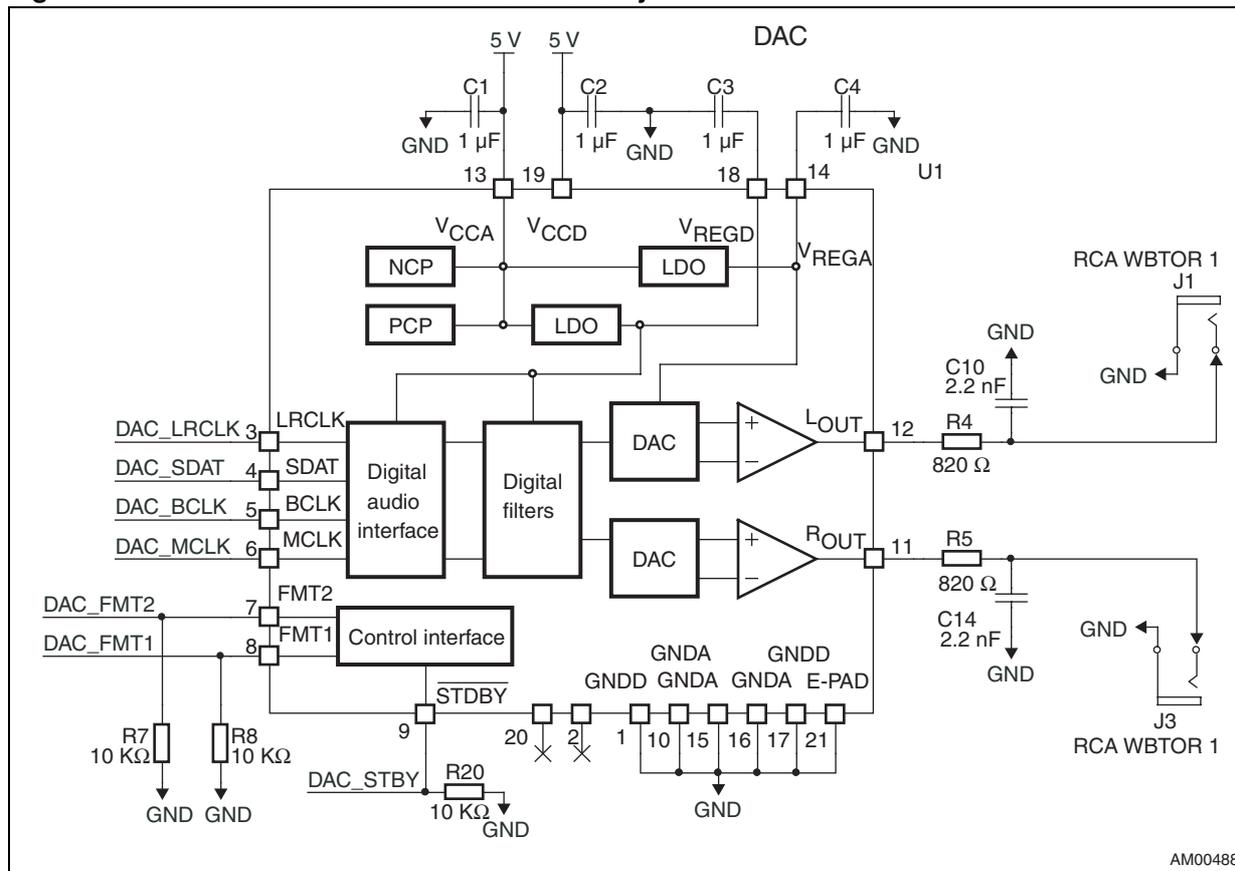
9.7 TS4962 mono Class-D power amplifier functionality

The TS4962 is a differential Class-D power amplifier. It is able to drive up to 1.4 W into a 8 Ω load at 5 V. The gain of the device can be controlled via two external gain-setting resistors R14 and R16. The amplifier is configured in single ended input configuration and signaled from the left channel of the TS4657 audio DAC. A standby function (active low) allows switching the amplifier off. As in previous cases there is an internal weak pull down resistor on this standby pin and an external 10 KΩ (R13) resistor connected to the GND which is useful when utilizing the amplifier with a microcontroller. L5, L6, C32, C33 filters increase the EMI when an external speaker is connected through long cables. The amplifier is powered from +5 V coming from the controller board.

Figure 20.   TS4962 mono Class-D amplifier functionality
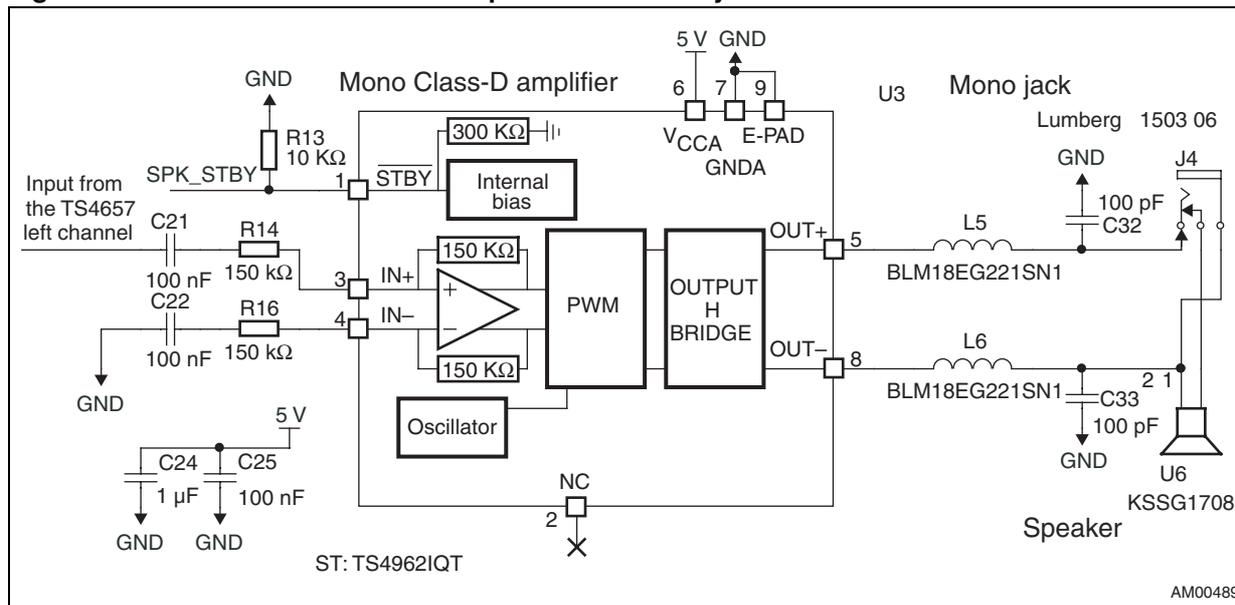
> **Warning:**   **The maximum output power of the TS4962 mono amplifier is 2.2 W at 5 V into 4 Ω speaker and 1.4 W at 5 V into 8 Ω speaker. Please take into consideration the maximum current of the USB port which is typically 500 mA (2.5 W). When the demonstration kit sinks more current from the USB port, it is automatically disconnected from the PC. If this happens just unplug and plug again your demonstration kit.**

9.8   TS2012 stereo Class-D power amplifier functionality

The TS2012 stereo audio Class-D amplifier is connected to the output of the TS4657 audio DAC. The TS2012 input is configured in the single-ended configuration. The amplifier is able to drive up to 1.35 W into a 8 Ω load at 5 V per channel. The device has four different gain settings utilizing two discrete pins: G0 and G1. These pins are controlled by STM32 MCU in the firmware. The gain is set to the minimal value by default thanks to the internal weak pull down resistors. There are also two external pull down resistors R1, R2 which are useful when utilizing the amplifier with a microcontroller. Two standby pins (active low) allow each channel to be switched off independently (internal weak pull down resistors together with external R9 and R10 are present). L1, L2, L3, L4, C8, C9, C30, C31 increase the EMI when the external speakers are connected through long cables. The amplifier is powered from +5 V supplied by from the controller board.

Figure 21. TS2012 stereo Class-D amplifier functionality
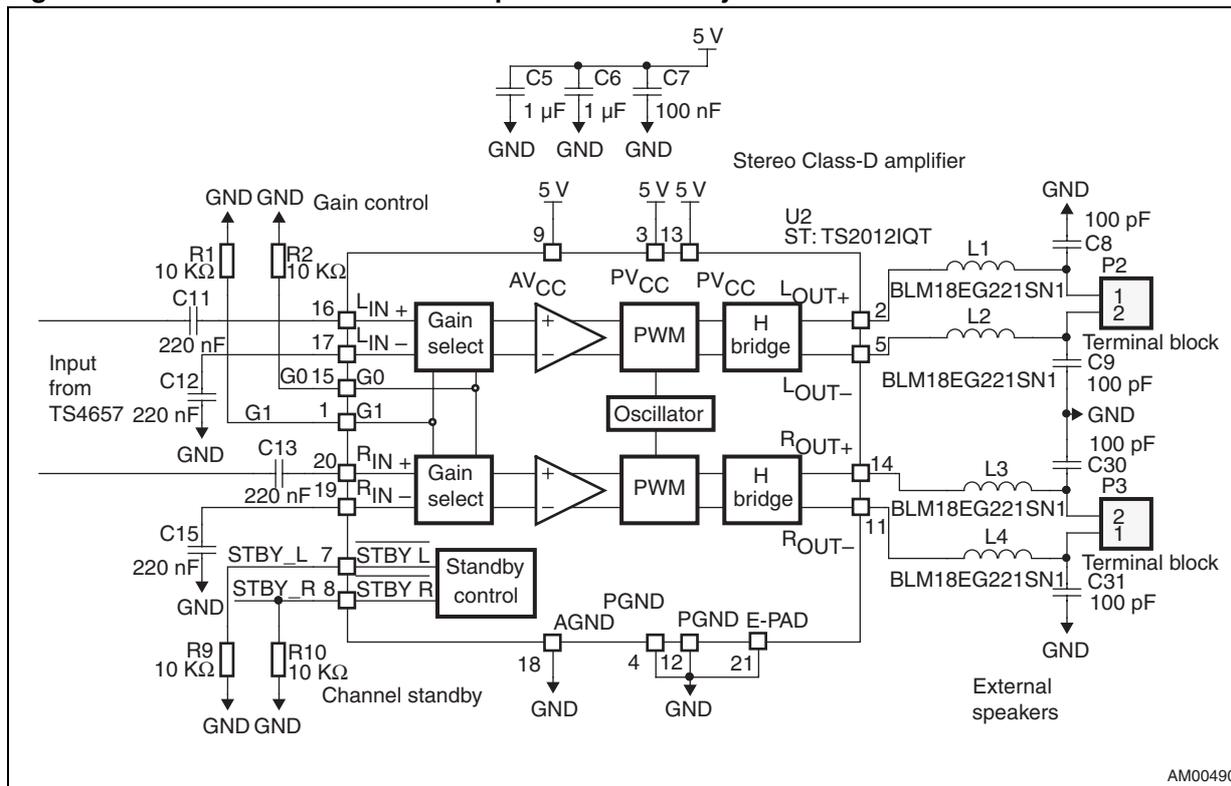
Warning: The maximum output power per channel of the TS2012 stereo amplifier is 1.35 W at 5 V into 8 Ω speaker and 2.2 W at 5 V per channel into 4 Ω speaker. Please take into consideration the maximum current of the USB port which is typically 500 mA (2.5 W). When the demonstration kit sinks more current from the USB port, it is automatically disconnected from the PC. If this happens just unplug and plug again your demonstration kit.

10 LEDs and buttons

10.1 LED indicators on the STM32 controller board

The green LED (LD2) indicates that the demonstration kit is in operating mode. When it is switched on continuously, the PC USB demonstration kit is active; when it flashes, the card operates in the record-replay. The red LED (LD1) indicates the selected audio output. LD1 switched on continuously indicates that the TS2012 power output is used. By default, LD1 is switched off and the onboard speaker is selected.

10.2 LED indicators on the TS4657 audio card

The TS4657 audio card board features one green LED (LED1). It indicates that the +5 V supply voltage is present on pin 2 of the I^2S audio connector P1.

10.3 B1 button on the STM32 controller board

B1 button is used to switch between audio outputs and also between demonstration kit operating modes. To switch from onboard speaker to TS2012 power output, briefly press B1. To change the operating mode from PC USB demonstration kit to record-replay, press B1 for approximately 1s.

11 Demonstration kit software

This section presents the main ready-to-use software techniques that are implemented on the STM32 performance line USB demonstration kit.

11.1 Design firmware upgrade

This paragraph describes the implementation of a device firmware upgrade (DFU) capability in the STM32F103xx microcontroller. It follows the DFU class specification defined by the USB Implementers Forum for reprogramming an application through USB. The DFU principle is particularly well suited for the USB applications that need to be reprogrammed in the field: The same USB connector can be used for both the standard operating mode and the reprogramming process.

This operation is made possible by the IAP capability featured by most of the STMicroelectronics USB Flash microcontrollers, which allows a Flash MCU to be reprogrammed by any communication channel.

The DFU process, like any other IAP process, is based on the execution of firmware located in one small part of the Flash memory. This firmware manages the erase and program of the others Flash memory areas, depending on the device features:

Main program/Code Flash, data Flash/EEPROM, or any other memory connected to the microcontroller including serial I^{2}C or SPI Flash memories).

The STM32 performance line USB demonstration kit features DFU capability used to program the internal Flash memory.

Refer to the UM0412, Getting started with DfuSe USB device firmware upgrade STMicroelectronics extension (available online from: www.st.com/mcu), for more details on the driver installation and PC user interface.

11.2 USB Audio Device Class

An audio device, as defined by the Universal Serial Bus Class Definition for audio devices specification, is a device or a function embedded in composite devices that are used to manipulate audio, voice, and sound-related functionality. This includes both audio data (analog and digital) and the functionality that is used to directly control the audio environment, such as volume and tone control.

All audio devices are grouped, from the USB-FS-device point of view, in the audio interface class. This class is divided into several subclasses. The Universal Serial Bus Class Definition for audio devices specification details the three following subclasses:

● **AudioControl Interface subclass (AC):** each audio function has a single AudioControl interface. The AC interface is used to control the functional behavior of a particular audio function. To achieve this functionality, this interface can use the following endpoints:

– A control endpoint (endpoint 0) for manipulating unit and terminal settings and retrieving the state of the audio function using class-specific requests.

– An interrupt endpoint for status returns. This endpoint is optional. The AudioControl interface is the single entry point to access the internals of the audio

function. All requests that are concerned with the manipulation of certain audio controls within the audio function's units or terminals must be directed to the AudioControl interface of the audio function. Likewise, all descriptors related to the internals of the audio function are part of the class-specific AudioControl interface descriptor.

● **AudioStreaming Interface Subclass (AS)**: AudioStreaming interfaces are used to interchange digital audio data streams between the host and the audio function. They are optional. An audio function can have zero or more AudioStreaming interfaces associated with it, each possibly carrying data of a different nature and format. Each AudioStreaming interface can have at most one isochronous data endpoint.

● **MIDIStreaming Interface Subclass (MIDIS):** MIDIStreaming interfaces are used to transport MIDI data streams into and out of the audio function. To be able to manipulate the physical properties of an audio function, its functionality must be divided into addressable entities. Two types of such generic entities are identified and are called units and terminals. The Universal Serial Bus Class Definition for audio devices specification defines seven types of standard units and terminals that are considered adequate to represent most audio functions. These are:

– Input terminal
– Output terminal
– Mixer unit
– Selector unit
– Feature unit
– Processing unit
– Extension unit

For more information about the audio class characteristics and requirements please refer to the Universal Serial Bus Device Class Definition for audio devices specification provided by the usb.org website.

11.3 PC USB demonstration kit and record-replay applications

In order to demonstrate all capabilities of the TS4657 audio card is the delivered user application structured into two operation modes: PC USB demonstration kit and record-replay.

11.3.1 PC USB demonstration kit application

This part of the demonstration firmware gives examples of how to use the STM32F10xxx USB-FS-device peripheral to communicate with the PC host in the isochronous transfer mode. The code provides a demonstration of the correct method for configuring an isochronous endpoint, receiving or transmitting data from/to the host and also shows how to use the data in a real-time application.

General characteristics

● USB-FS-device characteristics:

  – Endpoint 0: used to enumerate the device and to respond to class-specific requests. The maximum packet size of this endpoint is 64 bytes.

  – Endpoint 1 (OUT): used to receive the audio stream from the PC host with a maximum packet size up to 192 bytes.

● Audio characteristics:

  – Audio data format: type I / PCM format / stereo.

  – Audio data resolution: 16 bits.

  – Sample frequency: 48 kHz.

● I^2S characteristics:

  – Channel frequency (also called LEFT/RIGHT clock) is 48 kHz

  – MCLK, the external master clock is 12.288 MHz

  – Packet frame is fixed to 16-bit

  – Data format is LSB-justified standard (Right-Justified)

The aim of the PC demonstration kit application mode is to store the data (audio Stream) received from the host PC in a specific buffer called Stream_Buffer and to use the I^2S peripheral to play it through external DAC afterwards.

As detailed before, the STM32F10xxx manages the isochronous data transfer using the double buffer mode. So to copy the received data from the PMA to the Stream_Buff (using DMA transfer), the swapping between the two PMA buffers (ENDP1_BUF0Addr and ENDP1_BUF1Addr) has to be managed. Swapping access to the PMA is managed according to the buffer usage between the USB-FS-device IP and the firmware. This operation is provided by the EP1_OUT_Callback () function (usb_endp.c file). After the end of the copy process, global variables called B0_Ready or B1_Ready are set.

To play back the audio samples received from the host is the I^2S audio peripheral used. The Samples variable controls the streaming flow to synchronize the data from the USB-FS-device with the Stream buffer used by the I^2S peripheral.

For further details on usage of USB-FS-device firmware library for Audio Device Class purposes, please refer to UM0424, STM32F10xxx USB-FS-device development kit available online from www.st.com.

11.3.2 Record-replay application

In the second mode of operation has the demonstration application task to capture vicinity sound from embedded microphone, process simple normalization of the signal, store acquired waveform into buffer in RAM (Record_Buff[]) in PCM16 format and finally play this sample back through the same I^2S mechanism like in previous application mode. This procedure is performed in a infinite loop till another mode is set by button press.

11.4 Updating demonstration application in the demonstration kit

For the STM32 the DFU mode is entered after an MCU reset if:

● The DFU mode is forced by the user: the user presses the key push-button during a reset (while he is attaching the evaluation dongle to the USB).

● There is no correct code available in the applicative area: before jumping to the applicative code, the DFU code tests if there is a correct top-of-stack address in the first address in the applicative area of the internal Flash memory (for the STM32F10xxx the first applicative address is 0x0800 3000). This is done by reading the value of the first applicative address and verifying if the MSB half-word is equal to 0x2000 (base address of the RAM area in the STM32F10xxx).

Once the device is in the DFU mode, you can simply update main application with support of tools coming from STM in DfuSe package. For further information, please refer to UM0412 "Getting started with DfuSe USB device firmware upgrade STMicroelectronics extension" user manual, available online from: www.st.com/mcu.

12 Test measurement of the audio signal

Figure 22. Typical I^{2}S waveform
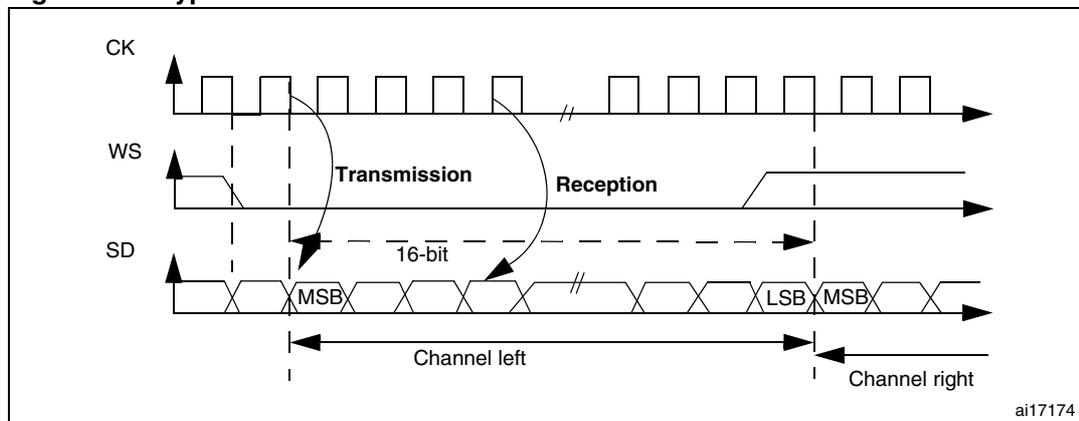
Figure 23. TS4657 output versus the I^{2}S input (10 kHz signal reconstruction)
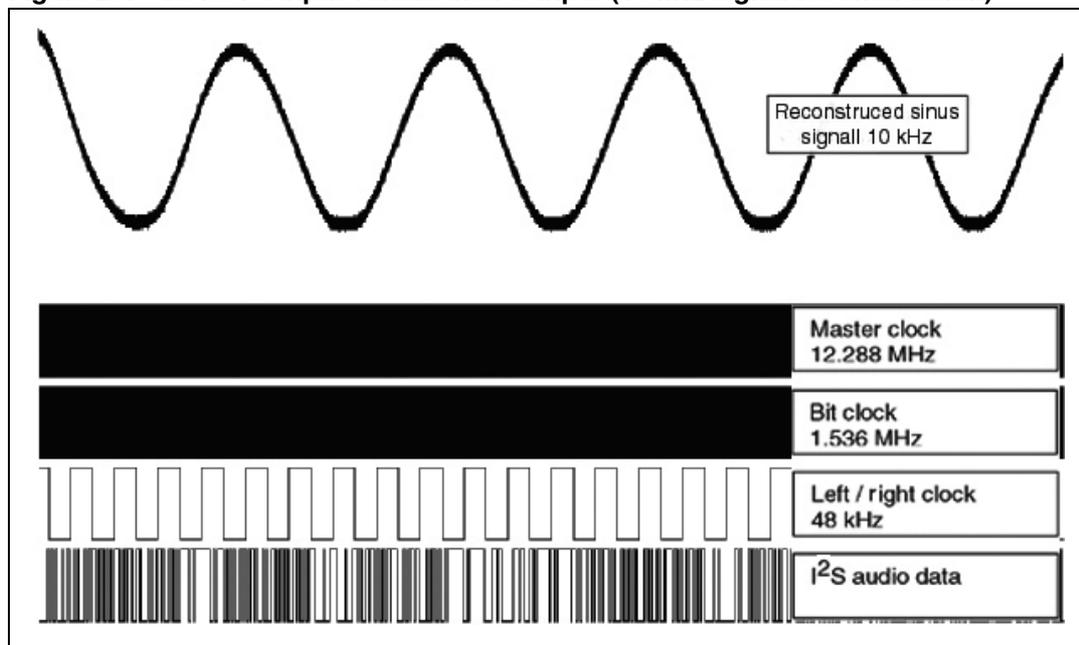
Figure 24.   TS4657 output versus the I²S input (10 kHz signal reconstruction) - detail
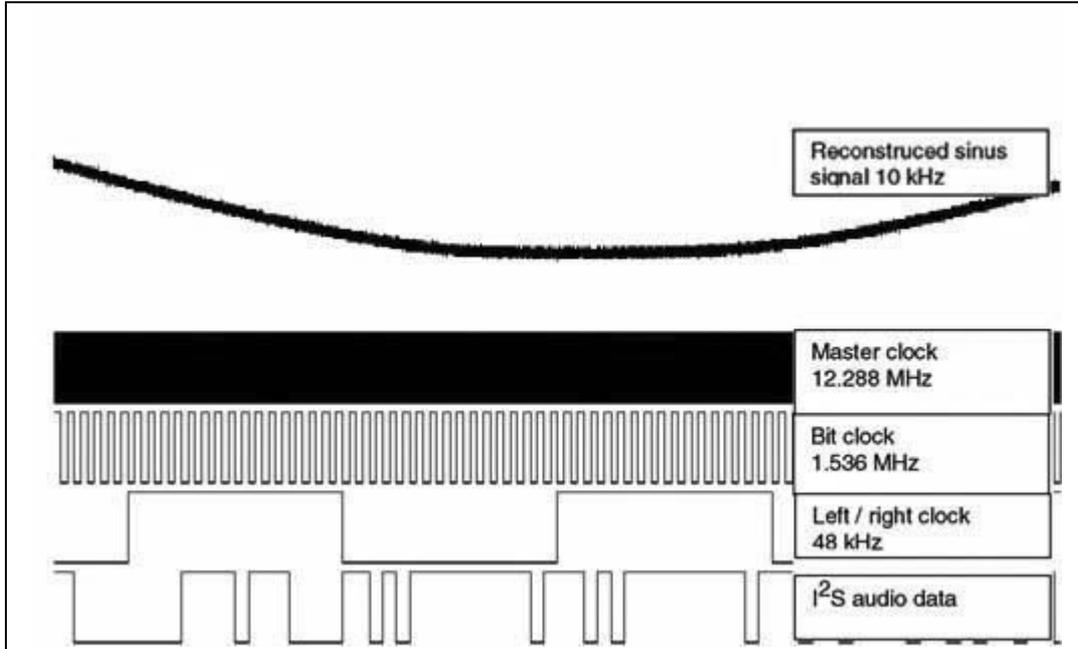
Figure 25.   Typical output from the Class-D amplifiers
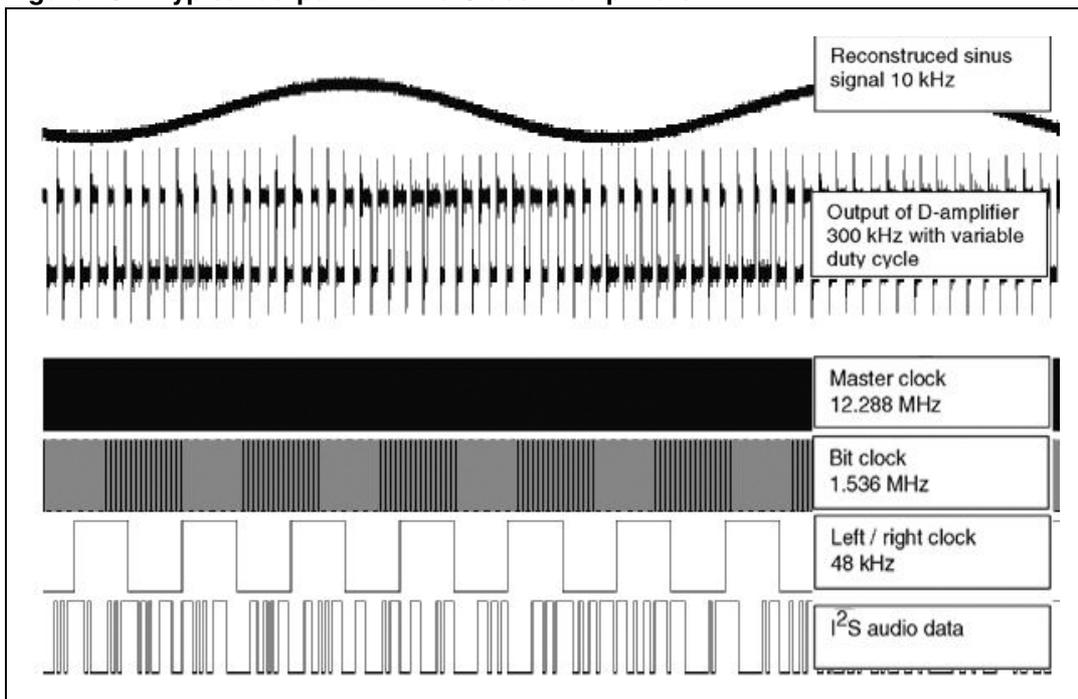
13 Addendum

Appendix A STM32F103 controller board - BOM

Table 7. Bill of material

Description	Comment	Designator	Footprint	Qty	Supplier name	Supplier order code	Note
Button	DT2112C	B1	Button_DT2112C	1	GM Electronic®	630-121	
Polarized capacitor	4.7 μF	C1	3528_AB	1	GM Electronic	907-125	Do not populate
Polarized capacitor	4.7 μF	C5	3528_AB	1	GM Electronic	907-125	
Capacitor	1 μF	C2, C3	C1206	2	GM Electronic	905-152	
Capacitor	10 nF	C4	0603	1	GM Electronic	972-014	
Capacitor	4.7 nF	C6	0603	1	GM Electronic	972-067	
Capacitor	100 nF	C7, C9, C11, C12, C13, C14, C15	0603	7	GM Electronic	972-012	
Capacitor	100 nF	C16	0603	1	GM Electronic	972-012	Do not populate
Capacitor	33 pF	C8, C10	0603	2	GM Electronic	972-019	
JTAG header, side mounting	MLW20G	CN1	HDR2X10 S	1	GM Electronic	800-036	
USB Connector	USB1X90A PCB	CN2	USB_1X90A_PCB4_MV	1	GM Electronic	832-139	
BLM18EG221SN1	Inductor	L1	0603	1	Farnell (Murata Manufacturing Co.,Ltd.)	1515716	
LED 0805 RED 45/130°	GME 960-024	LD1	D0805B	1	GM Electronic	960-024	
LED 0805 GREEN 35/130°	GME 960-023	LD2	D0805B	1	GM Electronic	960-023	
Header, 10-pin, dual row, side mounting	BL220G	P2	HDR2X10 S	1	GM Electronic	832-070	
Resistor	10 KΩ	R1, R2, R6, R9, R10, R14	0603	6	GM Electronic	901-399	

Table 7.   Bill of material (continued)

Description	Comment	Designator	Footprint	Qty	Supplier name	Supplier order code	Note
Resistor	1.5 kΩ	R3	0603	1	GM Electronic	901-504	
Resistor	4.7 Ω	R4, R5	0603	2	GM Electronic	901-648	
Resistor	1 MΩ	R7	0603	1	GM Electronic	901-445	
Resistor	0 Ω	R8	0603	1	GM Electronic	901-396	
Resistor	470 Ω	R12	0603	1	GM Electronic	901-495	
Resistor	220 Ω	R13	0603	1	GM Electronic	901-491	
STM32 ARM-based 32-bit MCU with 512 KB Flash, 64-pin LQFP	STM32F103RET6	U1	LQFP64_N	1	STMicroelectronics	STM32F103RET6	
Stabilizator	LD3985XX33	U2	SOT23-5L	1	STMicroelectronics	LD3985M33	
64 Mbit, low voltage, Serial Flash memory	M25P64-VME6G	U3	VDFPN8(8*6)	1	STMicroelectronics	M25P64-VME6G	Do not populate
Very low capacitance ESD protection	USBLC6-2P6	U4	SOT-666	1	STMicroelectronics	USBLC6-2P6	
Crystal	TSX-3225 / 16MHz	X1	TSX-3225_FA-238	1	EPSON	TSX-3225 / X1E000021011401	
Capacitor	1 µF	C1, C2, C3, C4, C5, C6, C24, C27, C29	[0603]	9	Farnell (Kemet)	9227776	
Capacitor	100 nF	C7, C16, C17, C19, C20, C21, C22, C25, C34	[0603]	9	GM Electronic	972-012	
Capacitor	100 pF	C8, C9, C18, C23, C30, C31, C32, C33	[0603]	8	GM Electronic	972-013	
Capacitor	2.2 nF	C10, C14	[0603]	2	GM Electronic	972-060	
Capacitor	220 nF	C11, C12, C13, C15	[0603]	4	GM Electronic	972-034	
Polarized capacitor (surface mount)	10 µF/16V	C26, C35, C36	C3225[1210]	3	GM Electronic	907-112	

Table 7. **Bill of material (continued)**

Description	Comment	Designator	Footprint	Qty	Supplier name	Supplier order code	Note
Capacitor	0 Ω /22 nF	C28	[0603]	1	GM Electronic	901-396	
Typical red, green, yellow, amber GaAs LED	LED_GREEN_ 0805	LED1	2012[0805]_TO_ DIODE_wave	1	GM Electronic	960-023	
RCA phono jack, right angle, thru-hole, snap-in	RCA WBTOR 1	J1, J3	RCA/4.5-H2	2	Farnell (Lumberg)	1200146	
Socket, 3.5 mm jack, mono	Lumberg 1503 06	J4	JACK/6-V3A	1	Farnell (Lumberg)	1243243	
Inductor	BLM18EG221S N1	L1, L2, L3, L4, L5, L6	1608[0603]	6	Farnell (Murata)	1515716	
Header, 10-pin, dual row, side mounting	Header 2 x 10 pin, S2G20	P1	HDR2X10 S	1	GM Electronic	832-023	
Header, 2-pin, terminal block, PCB, 2.54 mm, 2-way	Terminal block	P2, P3	MPT 0,5/ 2-2,54	2	Farnell (PHOENIX CONTACT)	3041359	
Resistor	10 KΩ	R1, R2, R7, R8, R9, R10, R13, R15, R20	[0603]	9	GM Electronic	901-399	
Resistor	100 KΩ	R3	[0603]	1	GM Electronic	901-529	
Resistor	820 Ω	R4, R5	[0603]	2	GM Electronic	901-500	
Resistor	680 Ω	R6	[0603]	1	GM Electronic	901-498	
Resistor	1 KΩ	R11, R12	[0603]	2	GM Electronic	901-502	
Resistor	150 kΩ	R14, R16	[0603]	2	GM Electronic	901-633	
Resistor	68 Ω	R17	[0603]	1	GM Electronic	901-408	
Single supply stereo digital audio line driver	ST: TS4657IQT	U1	QFN20_TS4657	1	STMicroelectronics	TS4657IQT	

Table 7. **Bill of material (continued)**

Description	Comment	Designator	Footprint	Qty	Supplier name	Supplier order code	Note
Filter-free stereo 2 x 2.8 W Class-D audio power amplifier	ST: TS2012IQT	U2	QFN20 - TS2012	1	STMicroelectronics	TS2012IQT	
2.8 W filter-free mono Class-D audio power amplifier	ST: TS4962IQT	U3	DFN8 - TS4962	1	STMicroelectronics	TS4962IQT	
Low noise microphone preamplifier	ST: TS472IQT	U4	QFN24_TS472	1	STMicroelectronics	TS472IQT	
Microphone	KEEG1542PBL	U5	KEC2740	1	Farnell (KINGSTATE)	1502746	
Transducer, speaker	KSSG1708	U6	KSS1708	1	Farnell (KINGSTATE)	1502738	

Appendix B STM32F103 controller board

Figure 26. STM32F103 controller board - top overlay
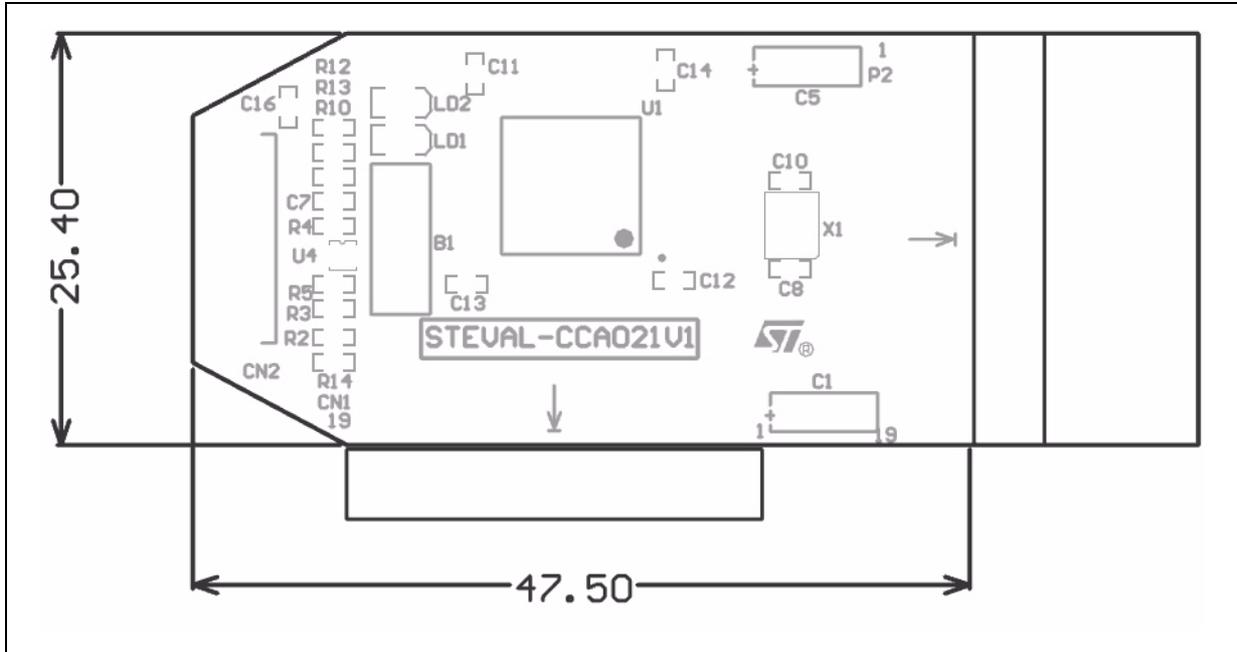
Figure 27. STM32F103 controller board - bottom overlay
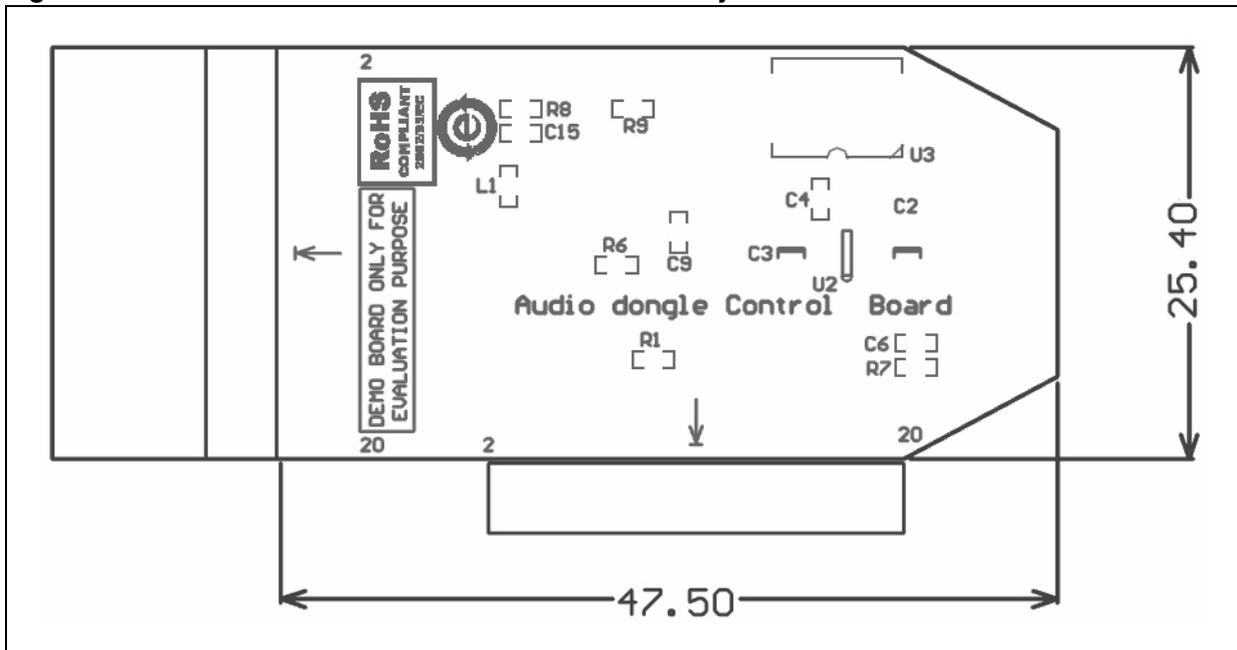
Figure 28. TS4657 audio card - top layer
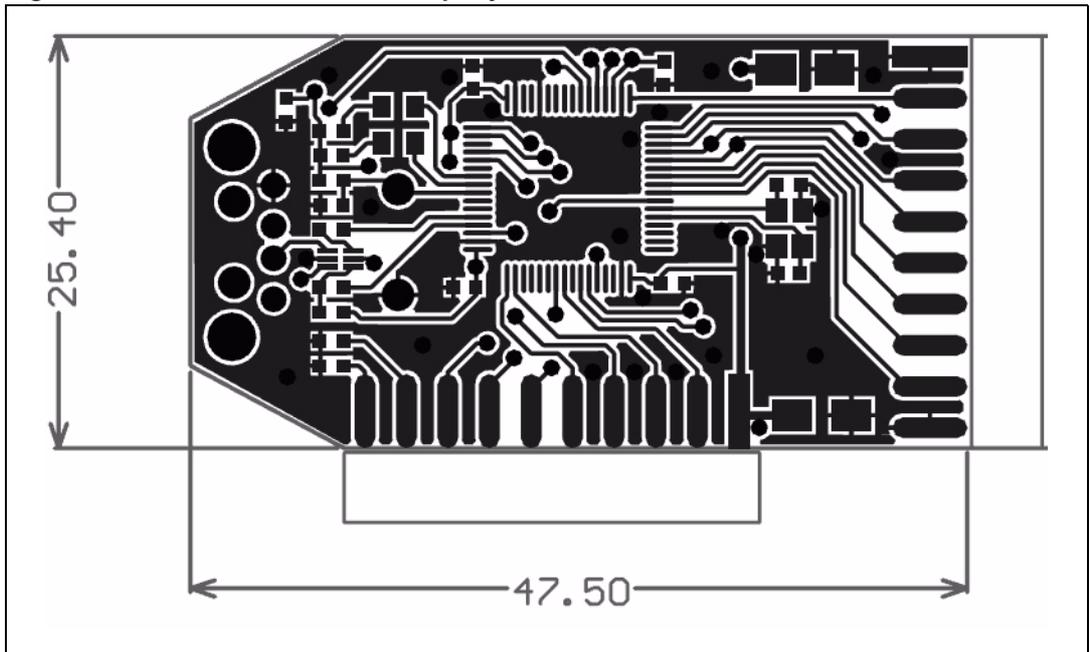
Figure 29. TS4657 audio card - bottom layer
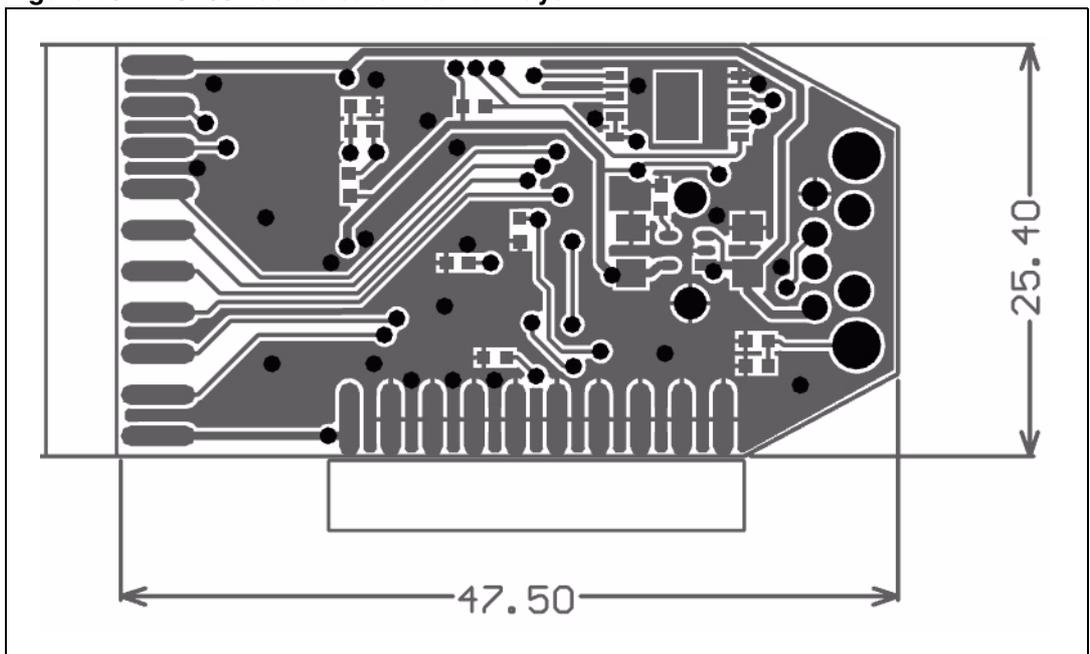
# Appendix C TS4657 audio card - artwork prints

Figure 30. TS4657 audio card - top overlay
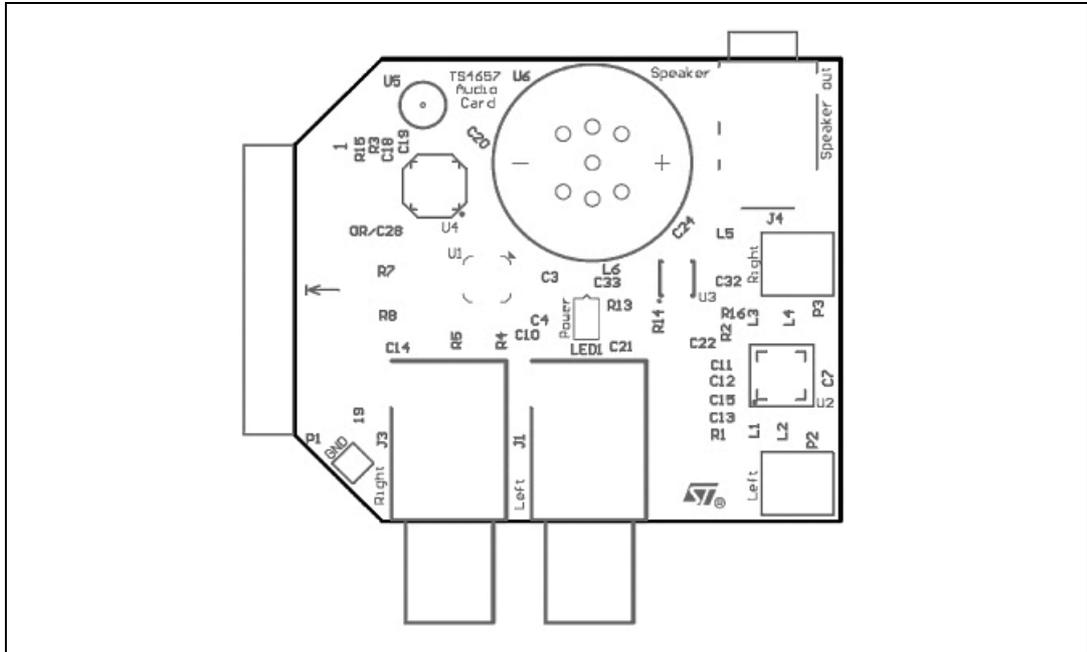
**Figure 31. TS4657 audio card - bottom overlay**
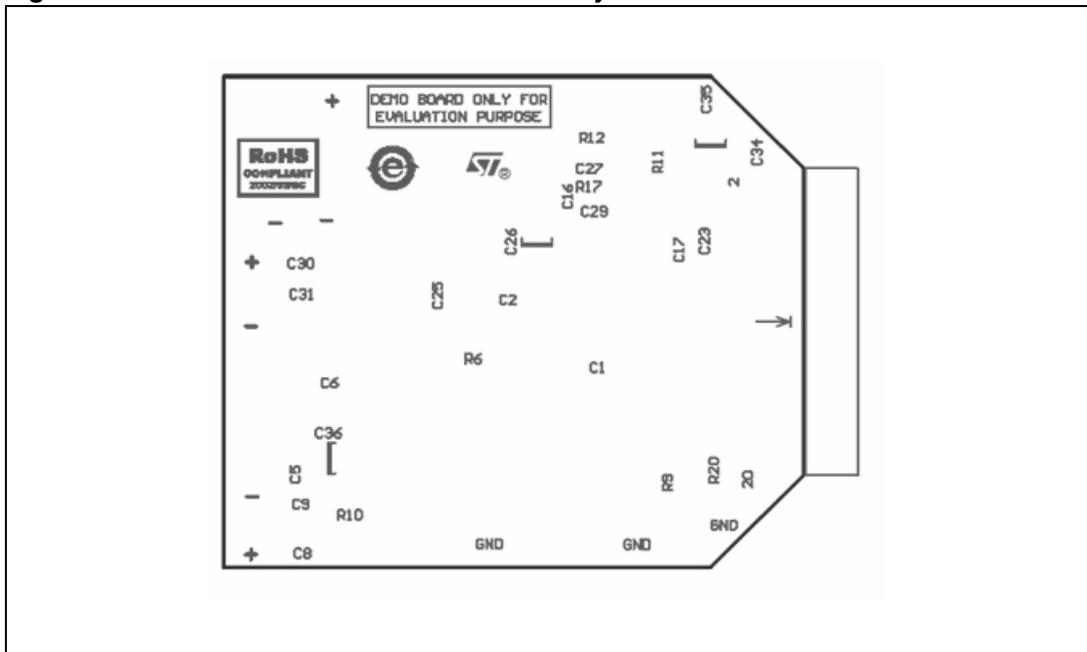
Figure 32.   TS4657 audio card - top layer
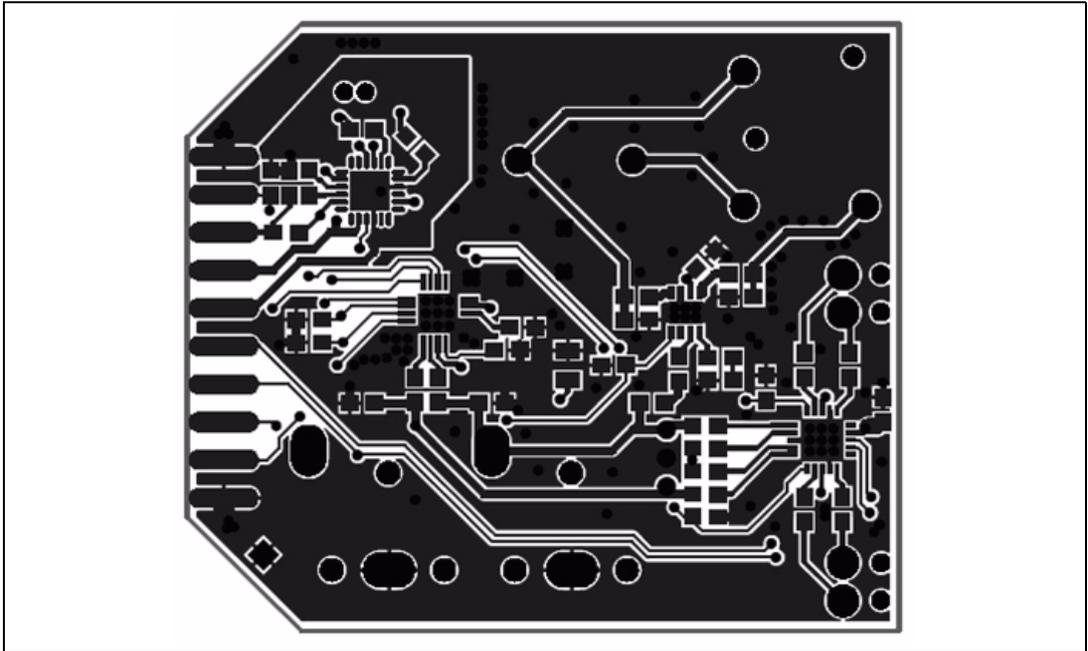
Figure 33.   TS4657 audio card - bottom layer

# Appendix D   STM32F103 controller board - schematic

Figure 34.   STM32F103 controller board - schematic - part 1
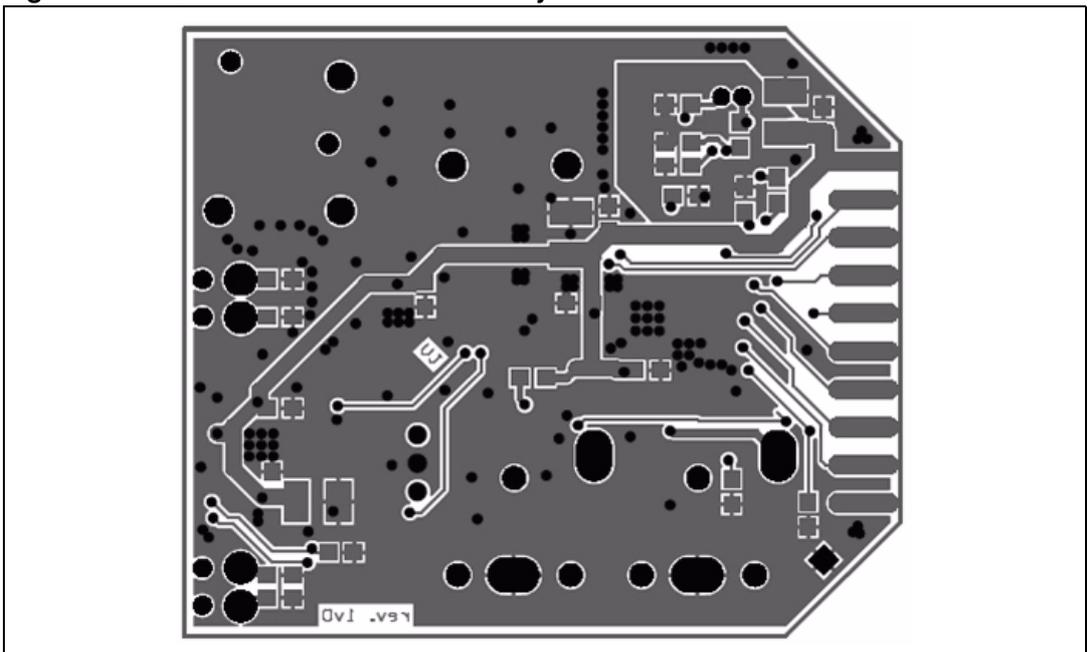
Figure 35. STM32F103 controller board - schematic - part 2
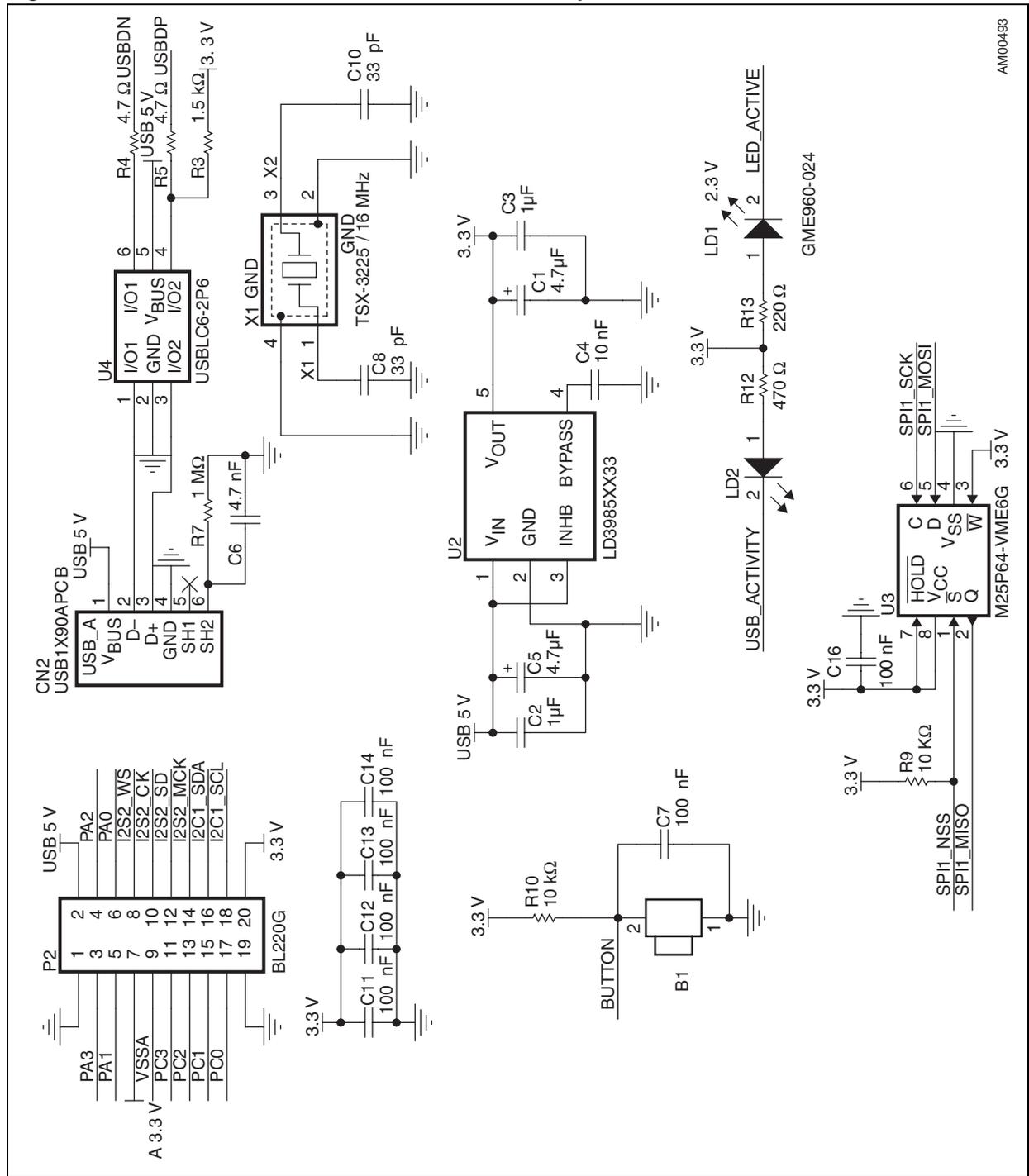
Appendix E   TS4657 audio card - schematic

Figure 36.   TS4657 audio card - schematic - part 1
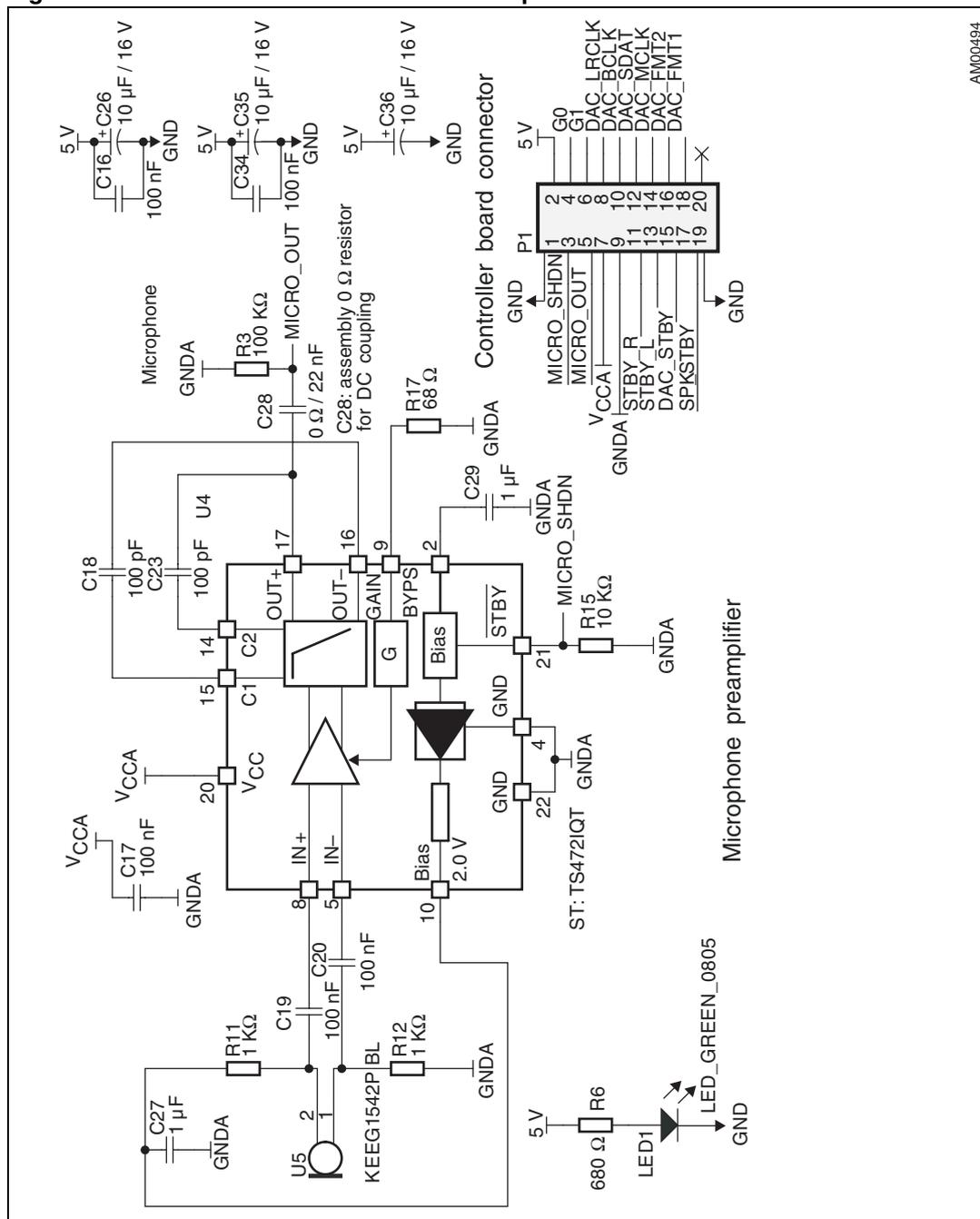
Figure 37.   TS4657 audio card - schematic - part 2
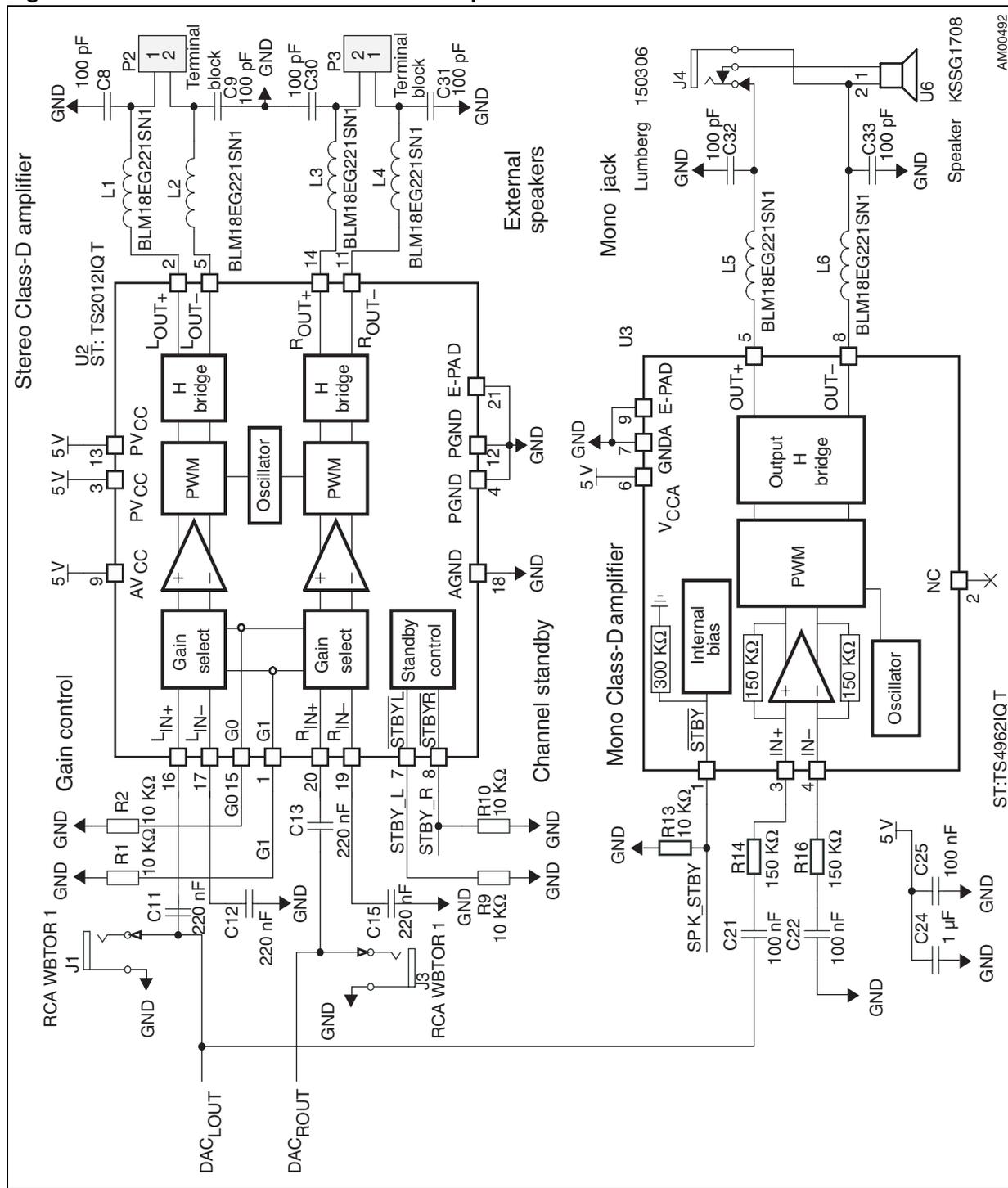
Figure 38. TS4657 audio card - schematic - part 3
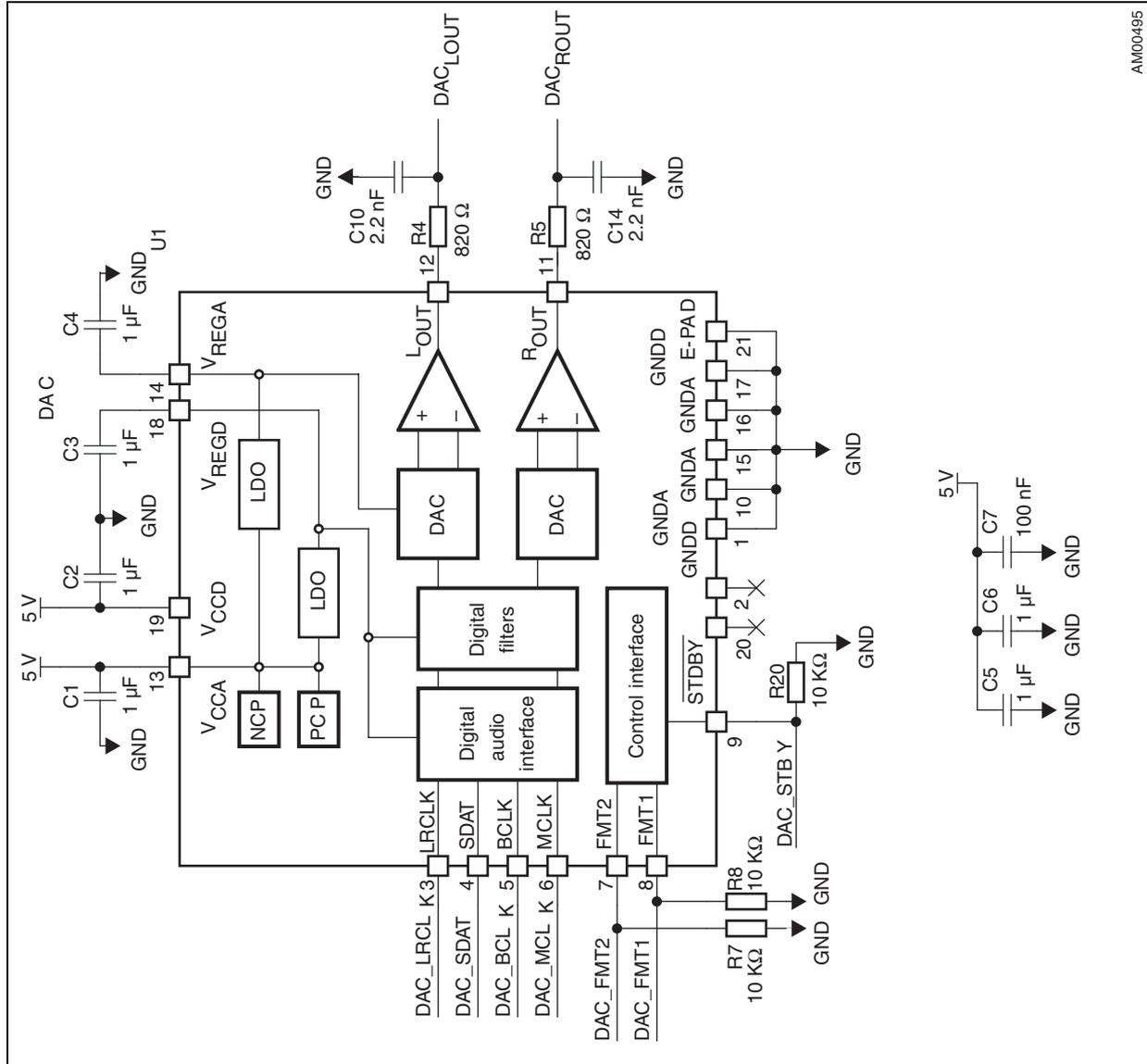
Revision history

Table 8.   Docsument revision history

Date	Revision	Changes
27-Aug-2009	1	Initial release.

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