TAS5755MEVM Evaluation Module

This manual describes the operation of the TAS5755MEVM to evaluate the performance of the TAS5755M integrated digital audio power amplifier. The main contents of this document are:

- Details on properly connecting a TAS5755M evaluation module (EVM) and the details of the EVM
- Details on installing and using the GUI to program the TAS5755MEVM
- Quick-start guide for the common modes in which the TAS5755MEVM can be used
- Details on using the audio processing features like EQ and DRC

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1 Overview

The TAS5755M evaluation module demonstrates the TAS5755M device from Texas Instruments. The TAS5755M combines a high-performance PWM processor with a class-D audio power amplifier. This EVM can be configured with two single-ended (SE) speakers with a BTL subwoofers (2.1) or two bridge-tied speakers (BTL) (2.0). Review the TAS5755M data sheet (SLOS982) for detailed information about the device. The TAS5755M has additional audio processing features such as surround sound (3D).

The EVM software with its graphic user interface (GUI) facilitates evaluation by providing access to the TAS5755M registers through a USB port.

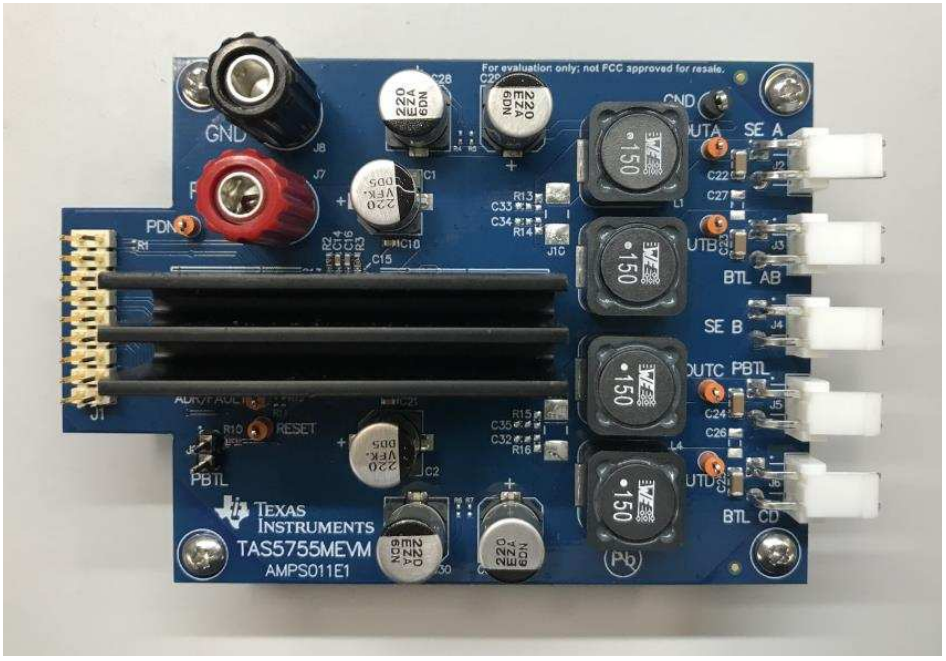

Figure 1. TAS5755MEVM Printed-Circuit Board

The EVM, together with other TI components on this board, is a complete 2.1-channel digital audio amplifier system. The MC57xxPSIA Controller board includes a USB interface, a digital input (SPDIF), analog inputs via the ADC, power inputs, and other features like a mute function and power down.

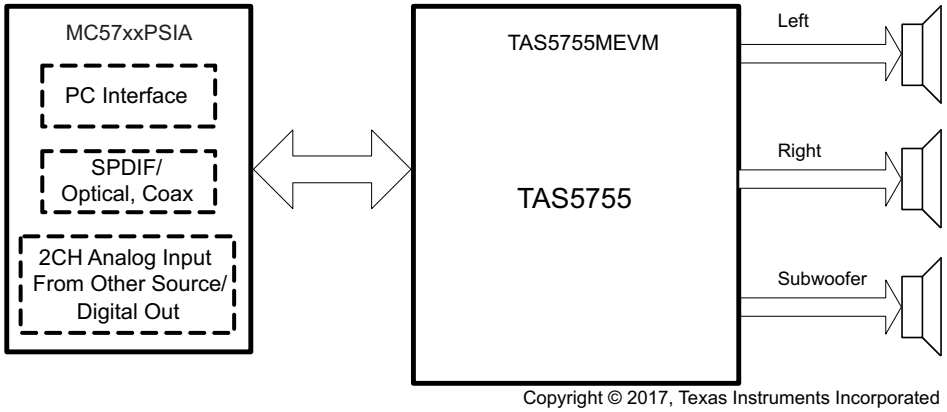

Figure 2. Complete System and EVM Signal Path Overview

1.1 TAS5755MEVM and MC57xxPSIA Features

The EVM and MC57xxPSIA have the following features:

- Channel evaluation module design
- Self-contained protection systems and control pins
- USB interface
- Standard I^2S data input using optical or coaxial inputs
- Analog input through analog-to-digital converter
- Subwoofer connection—the PWM terminal provides the PWM signal and power to an external subwoofer board
- Access to control signal gain and data format through EVM-software GUI

2 Installation

This section describes the EVM and software installation.

2.1 EVM Installation

Figure 3 shows the EVM connected to the MC57xxPSIA, including cables, connectors. Figure 4 illustrates and highlights different parts of the EVM board.

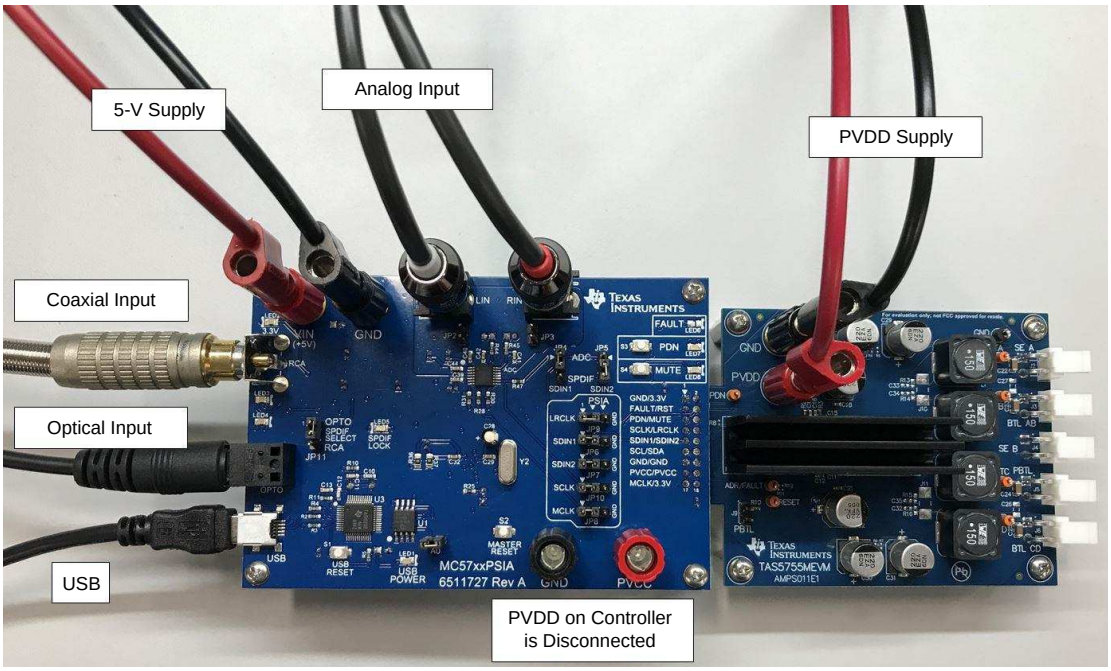

Figure 3. General Connection Picture

The following are the basic tools for the initial EVM power up.

- Power supply for digital supply (5-V)
- Power supply (PVDD)
- Banana-plug test leads for power supplies and speakers
- Optical or coaxial cable for SPDIF interface based on signal source
- USB cable
- EVM software
- Speakers or loads for outputs

Figure 4. EVM Board Speaker Outputs

The following sections describe the TAS5755MEVM board in regards to power supply (PSU) and system interfaces.

2.1.1 Connecting the TAS5755MEVM to MC57xxPSIA

On the right side of the MC57xxPSIA is a terminal block and another is located on the left of the TAS5755MEVM (labeled J1). Carefully place the MC57xxPSIA block above the TAS5755MEVM block and gently push down.

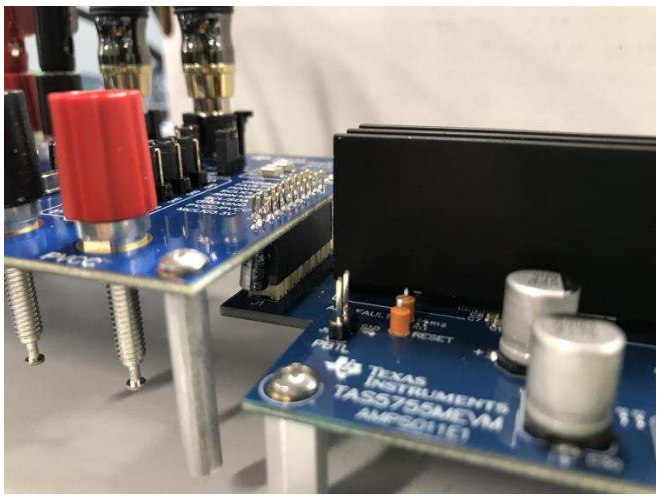

Figure 5. Connecting TAS5755MEVM to MC57xxPSIA

2.1.2 PSU Interface

The TAS5755MEVM is powered by two power supplies: a 5-V power supply (V_{IN}) connected to the MC57xx controller board, and the PVDD power supply connected directly to the EVM board. The 3.3-V level is generated on the controller board by a voltage regulator from the 5-V supply.

NOTE: The power-supply cable length must be minimized. Increasing the length of the PSU cable increases the distortion of the amplifier at high output levels and low frequencies.

The maximum output-stage supply voltage depends on the speaker load resistance. Check the recommended maximum supply voltage in the TAS5755 data sheet (SLOS982).

2.1.3 Loudspeaker Connectors

CAUTION

All speaker outputs are biased at V_{CC} / 2 and must not be connected to ground (for example, through an oscilloscope ground).

Loudspeaker connections vary by device setup and the evaluation module features a dedicated connector for each configuration. When using SE or BTL mode, ensure that the jumper J9 is populated indicating that BTL rather than PBTL mode is enabled. When connecting a speaker in SE mode, connect the TAS5755MEVM speaker to one of the two SE connectors labeled SE A (J2) and SE B (J4). When connecting a speaker in BTL mode, connect the speaker to one of the two BLT connectors labeled BTL AB (J3) and BTL CD (J6). Note that the EVM is set up to use only channels A and B in the SE mode, for a production application; however, any of the four channels (A, B, C, D) can be setup for SE mode operation. To use PBTL mode, depopulate the jumper on the header labeled J9 and populate jumpers J10 and J11 with a high-current wire or jumper. The speaker can then be connected to the connector labeled PBTL (J5).

Speakers or loads can be connected to the outputs A-D with clip leads, or cables can be made with female connectors (JST VHR-2N) that can mate to male connectors on the EVM board.

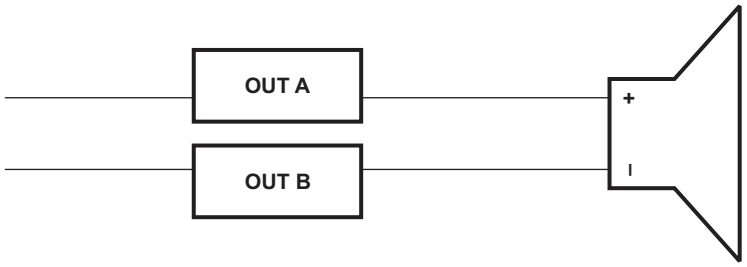

Figure 6. BTL Connection

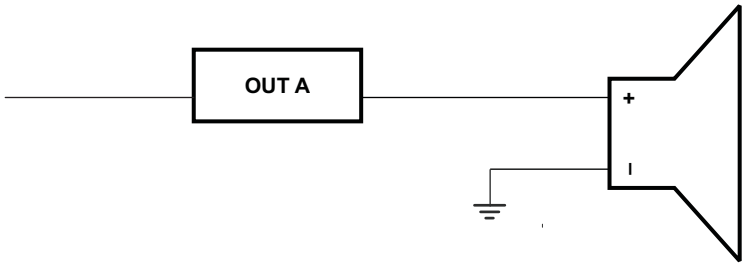

Figure 7. SE Connection

2.1.4 USB Interface

The TAS5755M registers are accessed through I^2C bus lines SDA and SCL. The USB circuit and USB connector on the MC57xxPSIA board facilitates the connection between a host computer and the device. The EVM USB circuit is powered by the 5-V USB line of the host PC and is independent of the power supplies available on the board. The USB device that is used is a TAS1020B from Texas Instruments.

2.1.5 Digital Audio Interface SPDIF

The Digital Audio Interface SPDIF (RCA, OPTO) accepts digital audio data using the I^2S protocol. See the TAS5755M data sheet for more information.

The RCA connector and the OPTO connector are the two SPDIF interfaces on the MC57xxPSIA board. The jumper JP11 toggles between the OPTO and RCA connector to accommodate the signal source. When the RCA cable or optical cable is connected and the signal source is powered up, verify that the SPDIF lock indicator (blue LED5) illuminates, confirming that a viable signal is available to the device. Install a jumper on JP4 across the middle pin and the pin marked SPDIF to connect the digital source to SDIN1. Install a jumper on JP5 to connect the digital source to SDIN2.

For detailed information on how the data and clocks are provided to the TAS5755M, see Figure 24 and the DIR9001 device data sheet (SLES198).

2.1.6 ADC Interface

In the absence of a digital signal source, the PCM1808 ADC can be used to convert an analog audio signal to a digital signal to the TAS5755M. The DIR9001 still provides clock signals to the ADC in this process. A 12-MHz crystal is installed on the MC57xxPSIA board. The ADC is an additional feature of this board to provide flexibility in sourcing an audio signal to the TAS5755M. Review the PCM1808 data sheet (SLES177) for a detailed description of the ADC on this EVM. Install the jumper on JP4 and J5 across the middle pin and the pin marked ADC to select ADC as the source for SDIN1 and SDIN2, and finally, install JP2 and JP3.

2.1.7 Board Power-Up General Guidelines

Connect the MC57xxPSIA and the TAS5755MEVM boards by locating pin 1 on each board, indicated by a small white triangle. The MC57xxPSIA plugs down onto the TAS5755MEVM board (that is, the TAS5755MEVM board fits underneath the MC57xxPSIA board). Pin 1 on each board must be connected to each other.

Install the EVM software on the PC before powering up the board. After connecting the loudspeakers or other loads, power supplies, and the data line, power up the 5-V power supply first; then power up the PVDD power supply.

2.2 Software Installation

Download the *TAS57X1 Graphical Design Environment* (GDE) from the TI Web site, located on the TAS5755MEVM product page. The TI Web site always has the latest release and any updates to versions of the GUI.

NOTE: The TAS5755MEVM is recognized as a TAS5731 device by the GDE software. The TAS5731 device must be selected in the software when using this EVM.

Execute the GUI install program, Setup.exe. Once the program is installed, the program group and shortcut icon is created in Start → Program → Texas Instruments Inc → TAS57X1 GDE.

The TAS5731 tab opens when the GUI starts. The TAS5731 tab has two subwindows. One shows the *Process Flow* window. This window also shows *Input* select, *Mode* select, *Channel*, and *Master Volume*. All functions are shown in the same order as in the device.

The other subwindow, the *Properties* window, has the properties that a user can update by selecting from the available options. The properties available depend on the device selected.

3 Using the GUI Software

This section describes the details of using the *TAS57xx Graphical User Interface* (GUI) software tool to interface with the TAS5755M device. The software is available for download at the TAS5755M product page on www.ti.com. The main function of the GUI is to provide the user an easy way to manipulate the device register space for attaining the required signal processing flow. The block diagram of the *Digital Audio Processing* (DAP) flow of the TAS5755M, taken from the TAS5755M data sheet is shown in Figure 8.

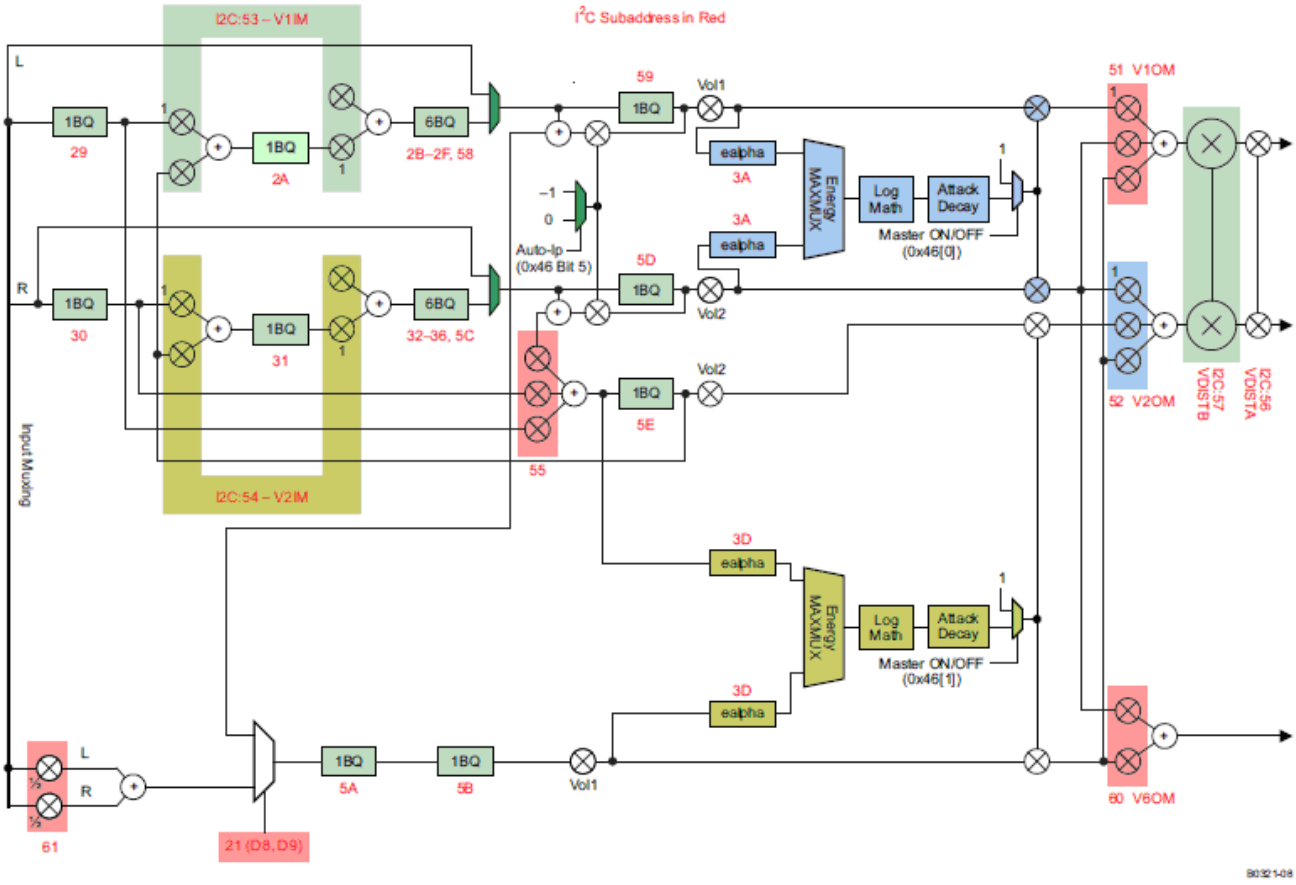

Figure 8. TAS5755M DAP Block Diagram

3.1 *Launching the GUI interface*

The GUI interface can be opened by clicking on the *TAS57X1 GDE* icon under the Texas Instruments Inc title in the start program menu.

NOTE: The PPSI2C variable should be set before the GUI interface (or the *Memory Tool*) is opened. If the GUI was opened prior to setting the environment variable (Step 1), close and then reopen the GUI interface.

3.2 Setting the I²C Device Address

The I²C slave address of the TAS5755 can either be 0x34 or 0x36 depending on the state of Pin 21 (Addr/Fault) at device power on. The slave address is 0x34 when Addr/Fault is low and 0x36 when it is high. By default, the EVM address is configured to 0x34 with Addr/Fault pulled low by R12. The slave address can be set through the GUI by navigating to the *Tools* menu and opening the *I2C Memory Tool*. Clicking the **Change Device Address** button opens a dialog to specify the device address as shown in Figure 9. By default the EVM device address is 34 so the address should be changed by entering 34 and clicking *change*.

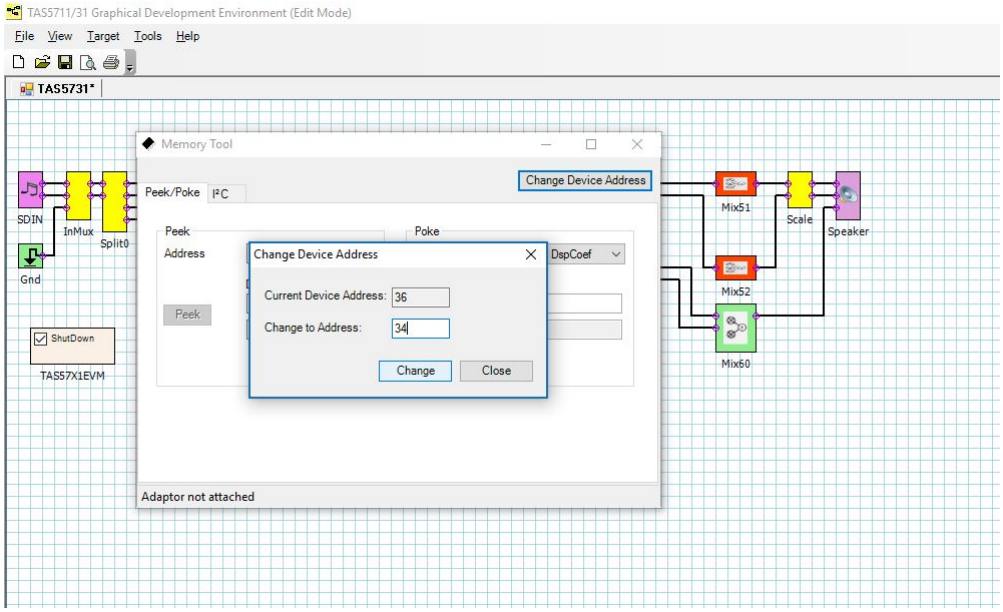

Figure 9. Changing the Device Address

3.3 Initializing the Device

Figure 10 shows a snap-shot of the GUI when it is first launched. The different blocks seen on the GUI window are defined functions that can each be used to set the register space to a desired value. (For example, the volume block shown in Green, can be used to set the desired master-volume level. Changes made to this block, update the master-volume register with the corresponding hex value).

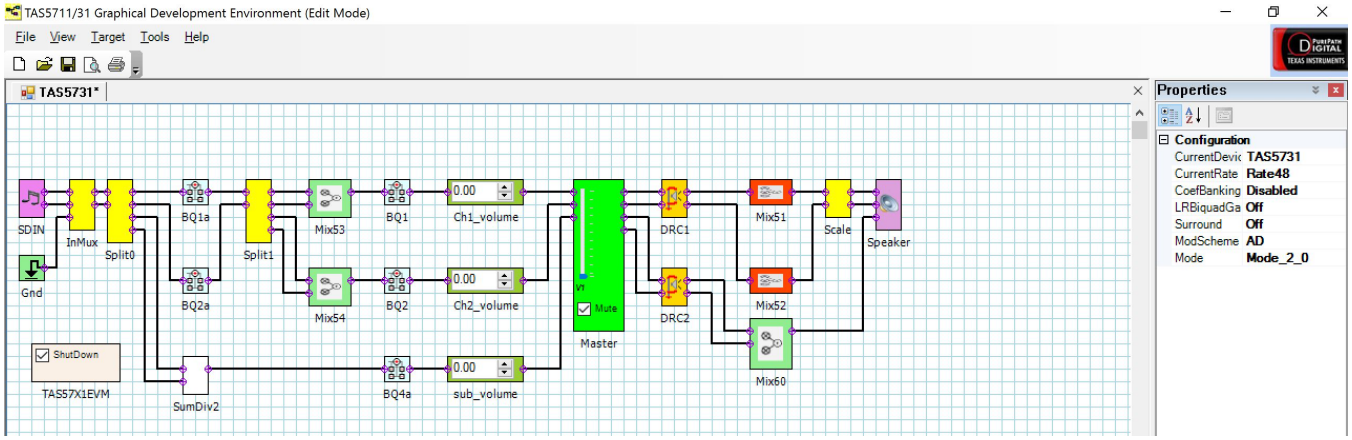

Figure 10. Default GUI Interface on Start-up

The drop-down properties menu seen on the right-hand side of the GUI window (Figure 10) is used to specify the device to be used. A zoomed snap-shot of the properties menu is shown in Figure 11. Select TAS5731 from the *CurrentDevice* option menu. Other settings like modulation scheme (AD or BD), operation mode (2.0 or 2.1), and so forth, can also be specified using this menu.

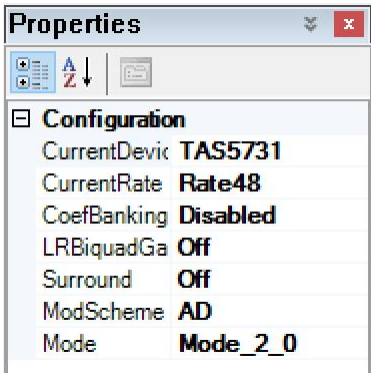

Figure 11. Zoomed-In Snapshot of the Configuration Drop-Down Menu

To initiate the GUI control, the first step is to 'Connect' the GUI. To do this, scroll to the *Target* section of the menu and click on *Connect* (as shown in Figure 12)

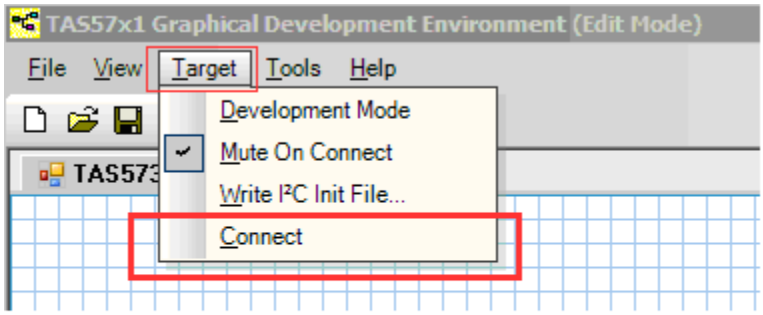

Figure 12. Initiating Connect from the Target Menu

After the *Target-Connect* operation, the GUI window background changes from white (with grid) to a solid light-green. All the blocks seen in the GUI window are now active and any updates made on these blocks updates the corresponding register space. Also, note that the configuration menu options on the right-hand side (highlighted with blue-box in Figure 13) are now grayed out and cannot be updated. The *Target-Connect* operation automatically updates the trim register (0x1B) to factory-trim mode, now the device can be set to stream audio output with only two additional operations: exit-shutdown and un-mute

The device shut-down mode can be toggled through the *Shutdown* checkbox (highlighted with a red-box in Figure 13). Uncheck this box to bring the device out of shutdown. Similarly, the mute state of master volume can be toggled using the *Mute* checkbox (highlighted with a red-box in Figure 13). After un-muting the master volume, use the volume slider to set the volume to the desired level. The current volume level is displayed in the menu area on the right-hand side of the GUI window. After completing these basic operations, the device can now stream audio.

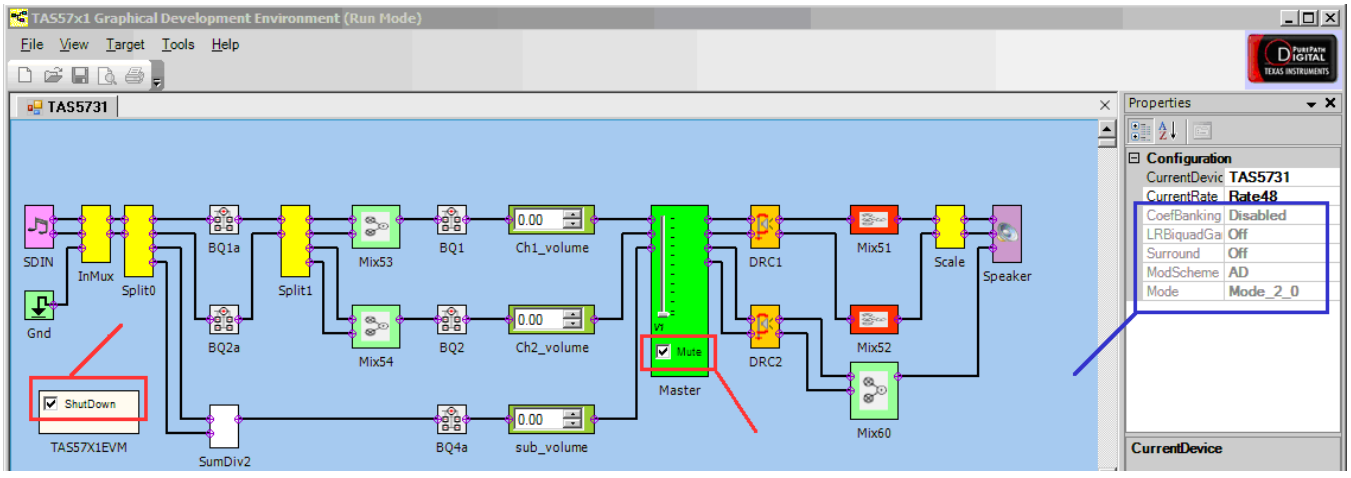

Figure 13. Toggling Shut-Down and Mute States

3.4 Using EQ Function

The Bi-Quad registers in the TAS5755M can be programmed for EQ and other signal processing applications using the BQ blocks on the GUI. Commonly used signal processing functions are EQ, Treble-Shelf, Bass-Shelf, Low-pass, and high-pass filters. In particular, the EQ function can be used to equalize (hence the name EQ) the non-ideal frequency response of the speaker. The BQ blocks on the GUI are highlighted in Figure 14.

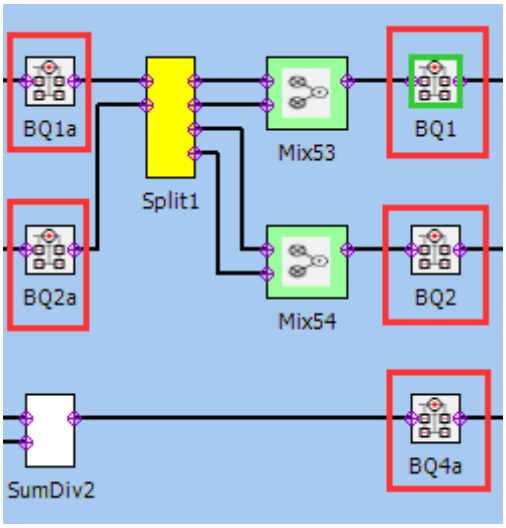

Figure 14. TAS57xx GUI EQ Blocks

When a BQ-block is selected on the GUI by using a single mouse click, the device registers associated with that particular BQ block are displayed in the properties window. Double-Clicking on the BQ-block, opens the *Filter Creation Tool for TAS570x* window. The Figure 15 shows the filter-creation window corresponding to block BQ1, where eight bi-quad registers are available for programming. Each of these can be independently programmed by using the corresponding entry fields. The default setting for all bi-quads is *AllPass* mode. The different filter options available are seen in the drop-down menu in Figure 15. The frequency and phase response of the filters can be viewed using the frequency and phase response tabs of the filter tool. Finally, when the *Apply* button is clicked, the bi-quad registers of the device are updated with the programmed settings.

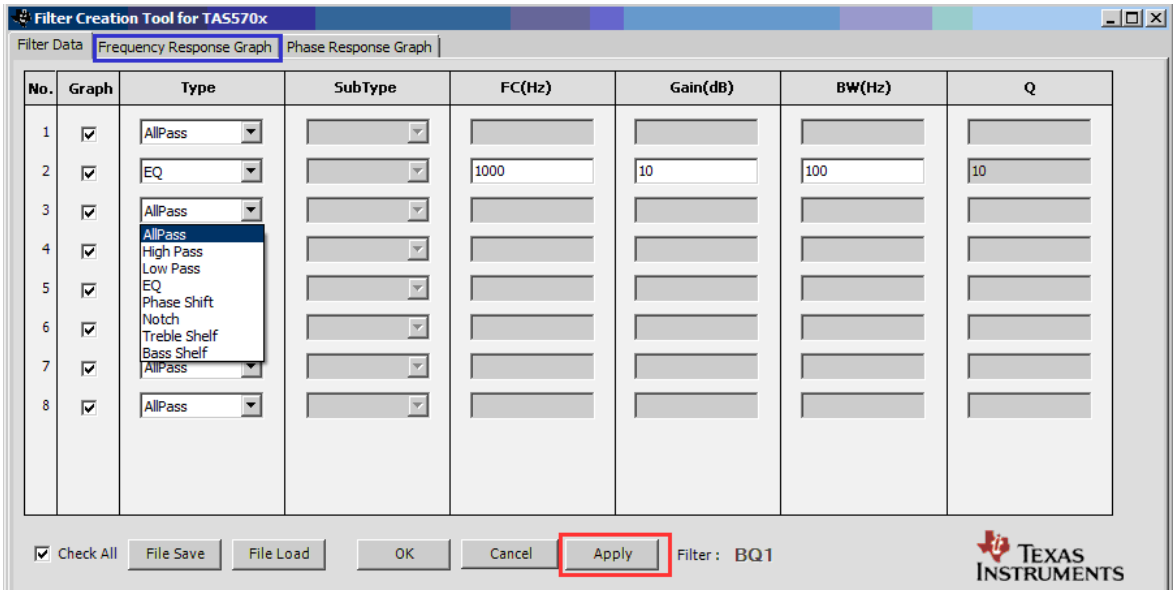

Figure 15. EQ-Tool Filter Creation Window

3.4.1 Woofer Channel Defaults to Low Pass Configuration

The GUI defaults to a 2.1 configuration where the BTL CD channel receives a low pass filter. However, due to a bug in the GUI, this low pass filter is not shown. To fix this problem the BQ4a block should be opened and the current settings applied to the channel by clicking the *Apply* button as shown in Figure 16. This will ensure the GUI and the EVM filters are in sync.

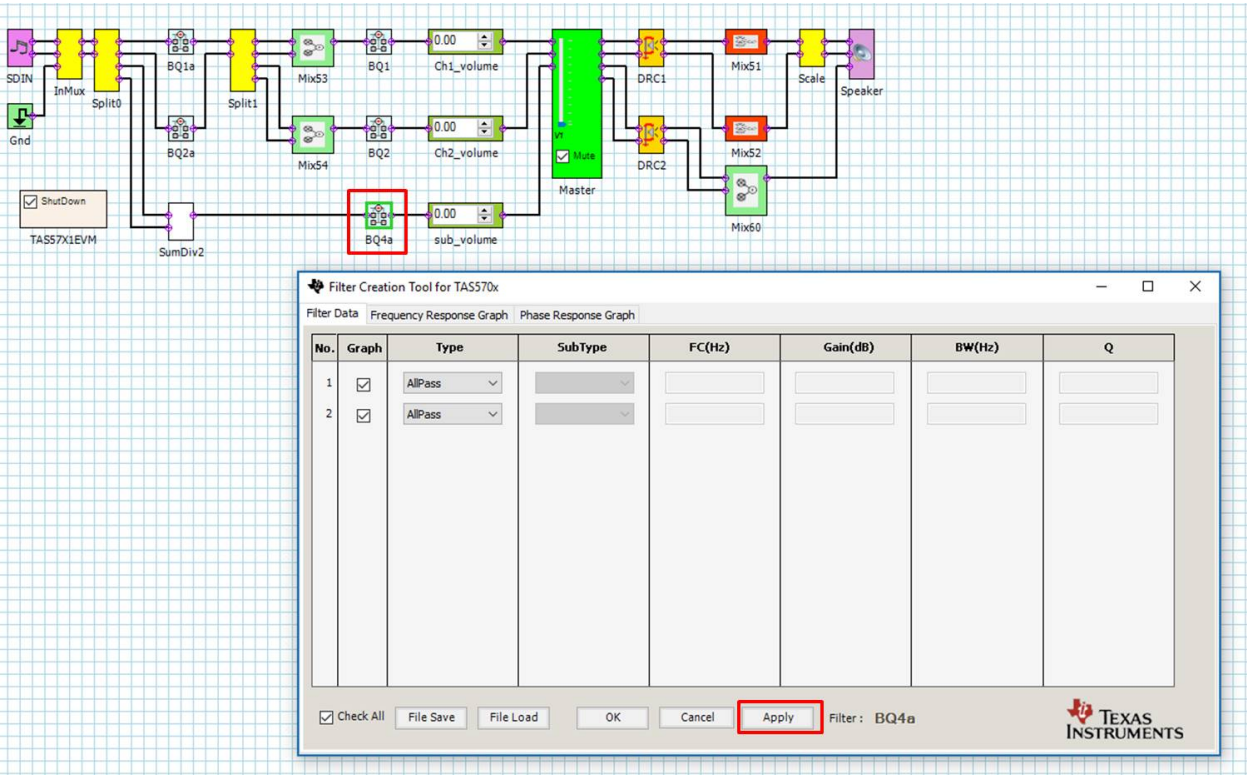

Figure 16. Fixing Low Pass Filter Bug on Woofer Channel

3.5 *Using the DRC Function:*

The TAS5755M has two DRC blocks; DRC-1 and DRC-2. Left and right channels are processed using DRC-1, and the sub-channel is processed via DRC-2. The DRC blocks on the TAS57X1 GUI are highlighted in Figure 17. A single click on the DRC block brings up the I^2C register information in the properties window as seen in Figure 17. The default state of the DRC control is in disabled state, as seen in the *Runtime Properties* section of Figure 17. To use the DRC function in the GUI, update the DRC control to the *Enabled* state. Note that the DRC-1 and DRC-2 have independent enable and disable controls.

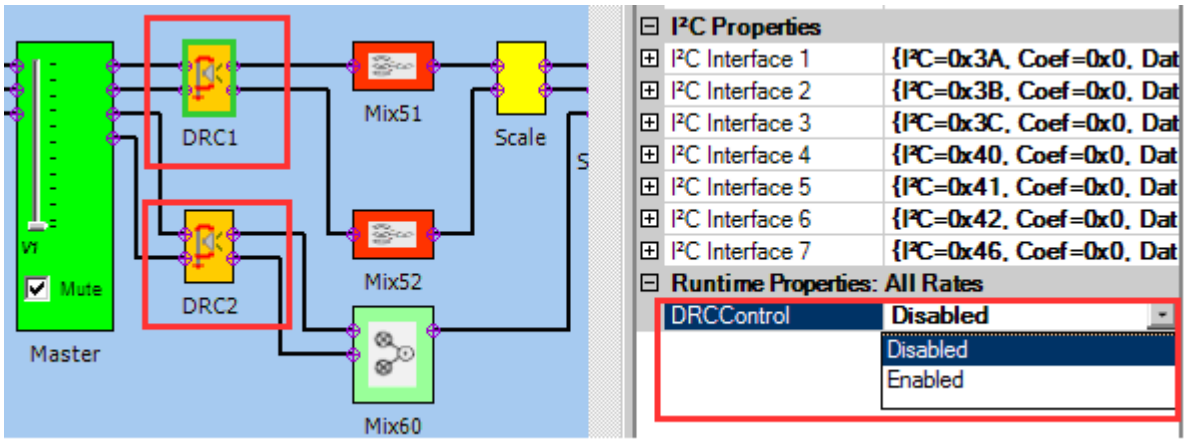

Figure 17. TAS57X1 GUI DRC Blocks

The different parameters of the DRC such as Threshold, Compression, Offset and attack, decay time constants can be programmed using the DRC customization tool, which is opened by double clicking the DRC block on the GUI window. Figure 18 shows the controls for DRC-1, with the user programmable inputs highlighted. The plot on the right estimates the output versus input level corresponding to the user inputs.

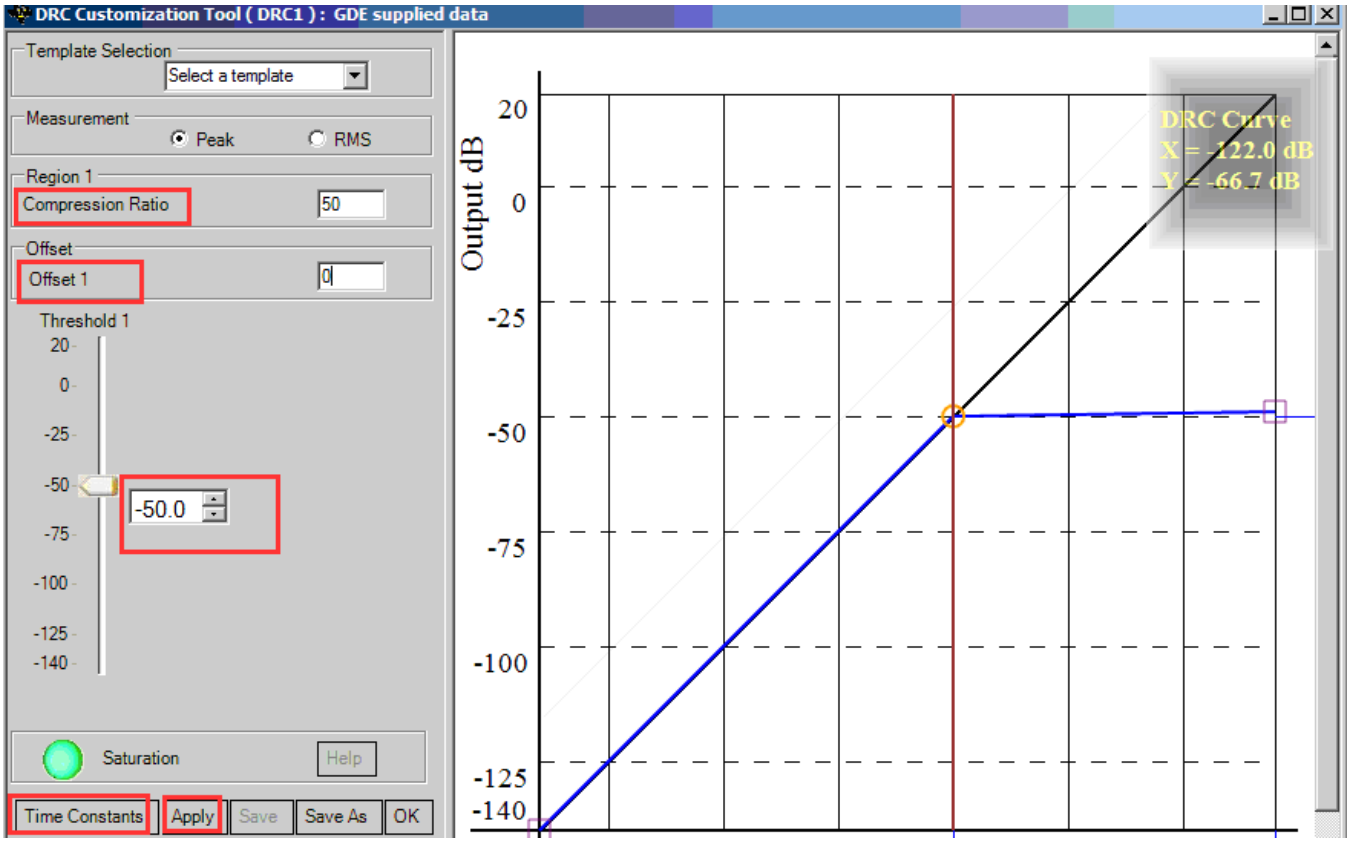

Figure 18. TAS57xx GUI DRC Customization Tool

The DRC time-constants can be programmed via the *Time Constants* window that can be opened by clicking on the *Time Constants* in the DRC customization tool. The *Time Constants* window snap shot is shown in Figure 19.

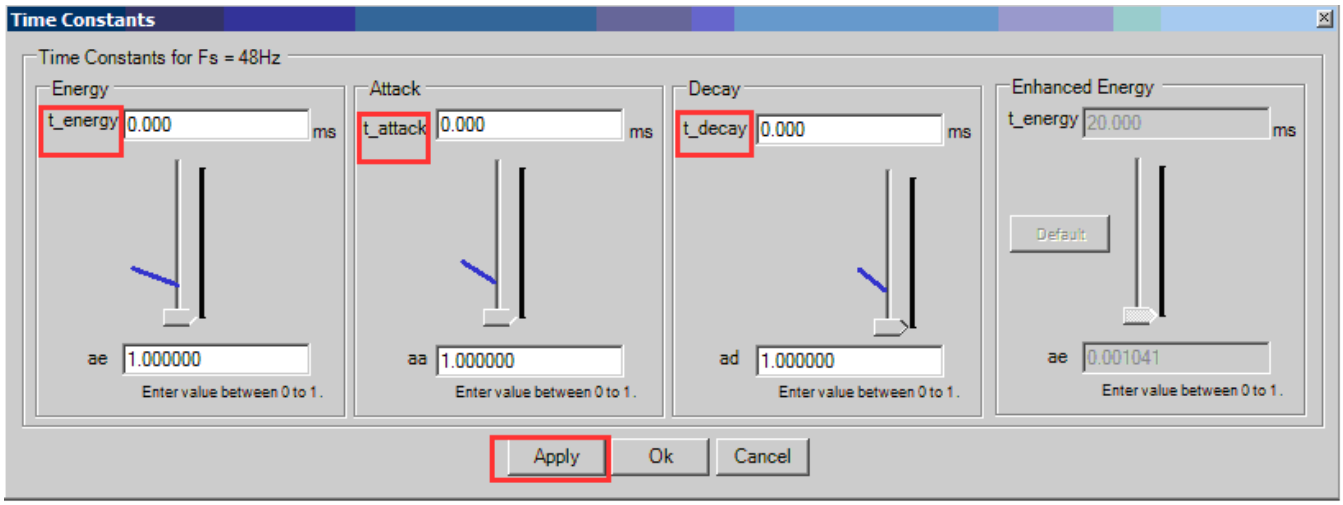

Figure 19. DRC Time Constants Window

3.6 Using the Mixer and Scaler Nodes

Figure 20 shows a snap shot of the different mixer and scaler blocks from the GUI. The mixer nodes can be used to mix the contents of the different channels. The input mixer can be used to mix the channels before they are processed by the bi-quads and DRC, while the output mixer nodes are used to mix the channels after they are processed through these blocks. The scaler blocks at the output can be used to scale the outputs.

Clicking on any of these blocks displays their configuration options in the properties window. Figure 20 shows an example where the output-mixer 0x51 is selected. Update the mixer configuration by changing the values in the properties window.

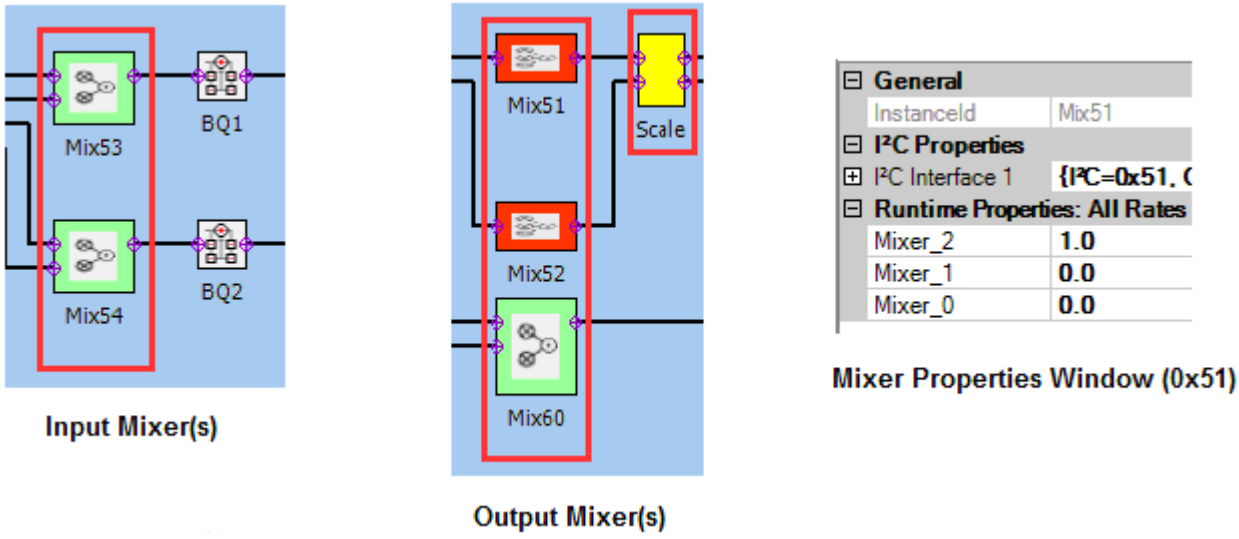

Figure 20. Input, Output Mixer and Scaler Nodes

3.7 Using the I²C Memory Tool

The GUI installation includes an I²C read-write interface, called the *Memory Tool*. Using the *Memory Tool*, the device registers can manually be read or written to. The tool can either be opened using the GUI menu (as shown in Figure 21), or can also be launched stand-alone even when the GUI window is not opened, through the Windows → All-Programs → Texas Instruments Inc → I2C Memory tool option. The stand-alone capability is especially convenient when an existing I²C file needs to be loaded to update device registers or when performing I²C debug.

Figure 21 shows a snap-shot of the *Memory Tool* window. Click the *I²C* tab at the top to view the *Read/Write* and *Execute I2C Command File* options. For Read operation, provide register sub-address and register size (length) in bytes. Clicking on the *Read* button displays the contents of the register in the *Data* window. For a *Write* operation, provide the data to be written in the *Data* field, and then click the *Write* button.

The *Memory Tool* can also be used to load a pre-defined I²C register file. Clicking the browse button on the bottom-right allows the user to browse to the location of the I²C script file, after selecting the desired file, clicking the Execute button, implements the register write operations specified in the file.

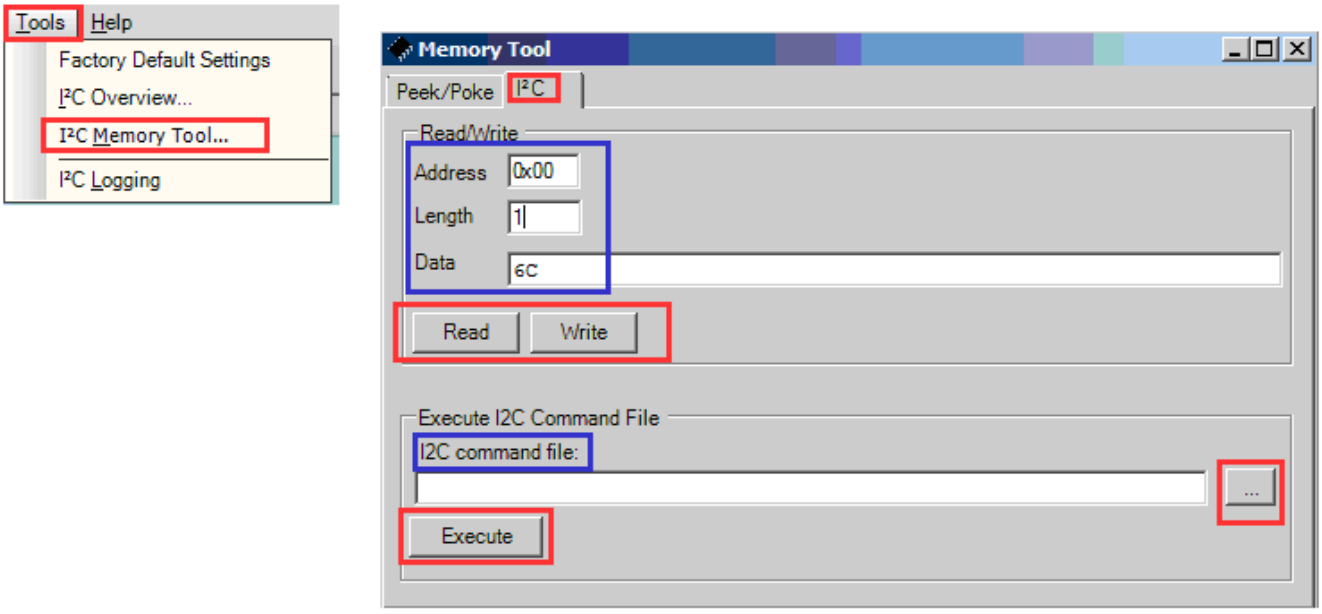

Figure 21. I²C Memory Tool

4 Jumpers and Control Utilities on the MC57xxPSIA Board

4.1 RCA and OPTICAL Jumpers

Select the jumper to reflect whether the source is RCA or Optical.

4.2 Switches

Reset is an active-low function. Pressing the master reset switch (S2) resets the TAS5755M device; USB RESET (S1) resets the USB bus. Pressing PDN (S4) powers down the TAS5755M.

4.3 LED Indicators

LED descriptions follow:

- LED1: USB power connector installed at J1
- LED2: 3.3-V power is valid
- LED3: RCA connection made
- LED4: Optical connection made
- LED5: SPDIF signal locked
- LED6: Not Populated
- LED7: PDN switch (S4) is asserted

5 Board Layouts, Schematic, and Bill of Materials

This section contains the TAS5755MEVM board layouts, schematic, and the bill of materials (BOM).

5.1 TAS5755MEVM Board Layout

Figure 22 shows the TAS5755MEVM top copper layer and Figure 23 shows the TAS5755MEVM bottom copper layer.

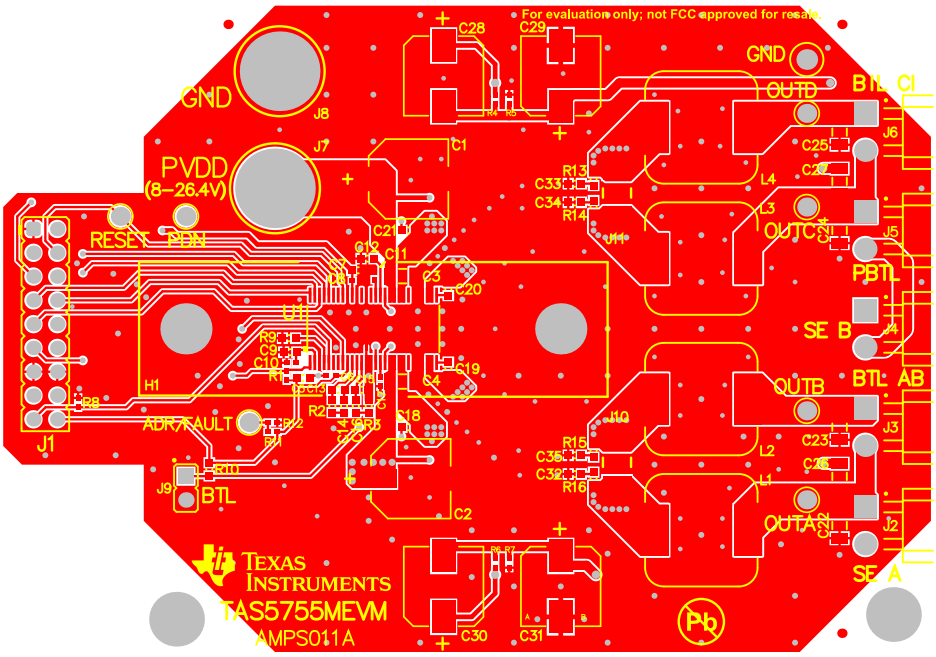

Figure 22. TAS5755MEVM Top Copper Layer

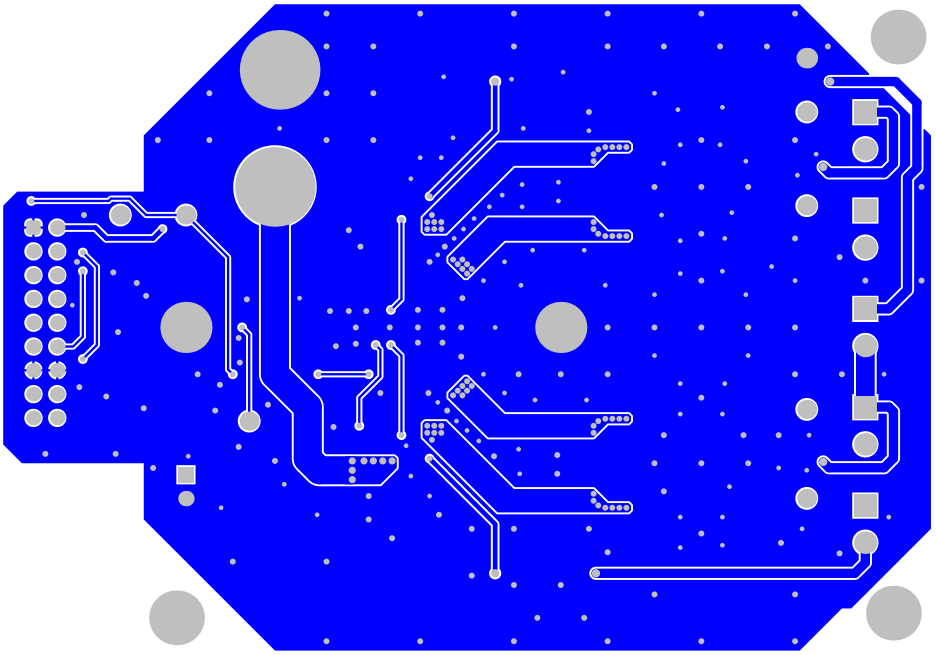

Figure 23. TAS5755MEVM Bottom Copper Layer

5.2 TAS5755MEVM Schematic

Figure 24 illustrates the TAS5755MEVM schematic.

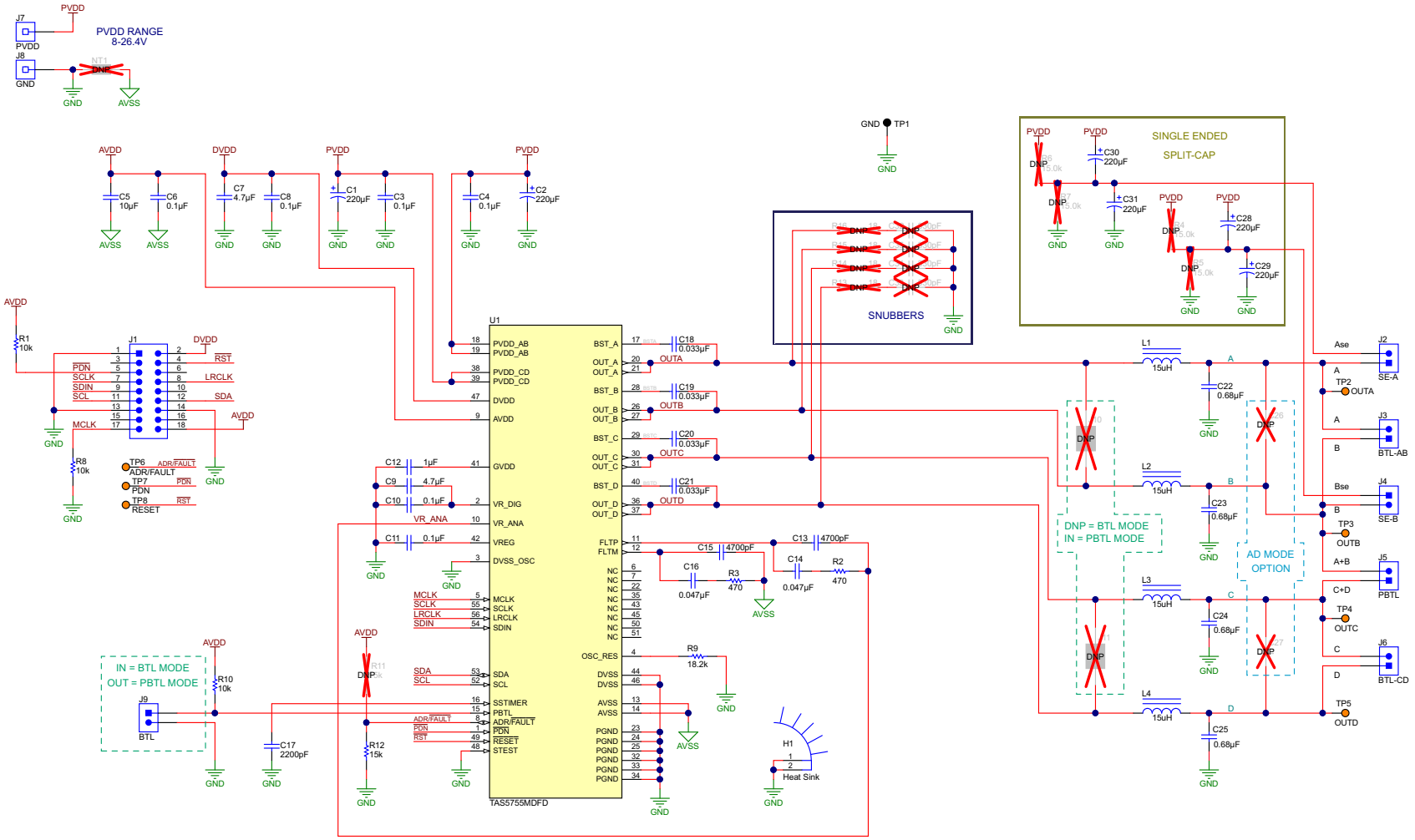

Figure 24. TAS5755MEVM Schematic

5.3 Bill of Materials

Table 1 lists the BOM for this EVM.

Table 1. TAS5755MEVM Bill Of Materials(1)

QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
2	220uF	CAP, AL, 220 µF, 35 V, ±20%, 0.16 ohm, SMD	SMT Radial F	EEE-FK1V221P	Panasonic		
2	0.1uF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 1206	1206	GRM319R71H104KA01D	Murata		
1	10uF	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0603	0603	C1608X5R1A106M080AC	TDK		
4	0.1uF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK		
2	4.7uF	CAP, CERM, 4.7 µF, 10 V, ±10%, X5R, 0603	0603	CGB3B1X5R1A475K055AC	TDK		
1	1uF	CAP, CERM, 1 µF, 25 V, ±10%, X7R, 0603	0603	GRM188R71E105KA12D	Murata		
2	4700pF	CAP, CERM, 4700 pF, 50 V, ±10%, X7R, 0603	0603	GRM188R71H472KA01D	Murata		
2	0.047uF	CAP, CERM, 0.047 µF, 16 V, ±10%, X7R, 0603	0603	GRM188R71C473KA01D	Murata		
1	2200pF	CAP, CERM, 2200 pF, 25 V, ±10%, X7R, 0402	0402	GRM155R71E222KA01D	Murata		
4	0.033uF	CAP, CERM, 0.033 µF, 50 V, ±10%, X7R, 0603	0603	GRM188R71H333KA61D	Murata		
4	0.68uF	CAP, CERM, 0.68 µF, 50 V, ±10%, X7R, 1206	1206	GRM31MR71H684KA88L	Murata		
4	220uF	CAP, Polymer Hybrid, 220 µF, 25 V, ±20%, 27 ohm, 8x10 SMD	8x10	EEHZA1E221P	Panasonic		
1		HEAT SINK FOR TI MOD, 50x13.9mm	HEAT SINK, 50x13.9mm	ATS-TI10P-521-C1-R1	Advanced Thermal Solutions		
2		MACHINE SCREW PAN PHILLIPS M3 5mm	Screw M3 Phillips head	MPMS 003 0005 PH	B&F Fastener Supply		
4		MACHINE SCREW PAN PHILLIPS 4-40	Machine Screw, 4-40, 1/4 inch	PMSSS 440 0025 PH	B&F Fastener Supply		
4		HEX STANDOFF 4-40 ALUMINUM 1/2"	HEX STANDOFF 4-40 ALUMINUM 1/2 inch	2203	Keystone		
1		Header, 2.54mm, 9x2, Tin, TH	Header, 2.54mm, 9x2, TH	PEC09DAAN	Sullins Connector Solutions		
5		Header (friction lock), 3.96mm, 2x1, Tin, R/A, TH	Header, 2x1, 3.96mm, R/A	B2PS-VH(LF)(SN)	JST Manufacturing		
1		Binding Post, RED, TH	11.4x27.2mm	7006	Keystone		
1		Binding Post, BLACK, TH	11.4x27.2mm	7007	Keystone		
1		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
4	15uH	Inductor, Shielded Drum Core, Ferrite, 15 µH, 6.5 A, 0.02075 ohm, SMD	WE-PD-XXL	7447709150	Wurth Elektronik		
2	10k	RES, 10 k, 5%, 0.063 W, 0402	0402	CRCW040210K0JNED	Vishay-Dale		
2	470	RES, 470, 1%, 0.1 W, 0603	0603	RC0603FR-07470RL	Yageo America		
1	18.2k	RES, 18.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0718K2L	Yageo America		
1	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	CRCW060310K0JNEA	Vishay-Dale		
1	15k	RES, 15 k, 5%, 0.063 W, 0402	0402	CRCW040215K0JNED	Vishay-Dale		
1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
1	Black	Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone		
7		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone		
1		2x45 W or 2 x 18W + 1 x 45W Digital Input Audio Amplifier with Equalizer, 2-Band DRC, and License-free 3D Effect, DFD0056A (HTSSOP-56)	DFD0056A	TAS5755MDFD	Texas Instruments		Texas Instruments

(1) Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

Table 1. TAS5755MEVM Bill Of Materials[(1)] (continued)

QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
0	0.33uF	CAP, CERM, 0.33 µF, 50 V, ±10%, X7R, 1206	1206	GRM319R71H334KA01D	Murata		
0	330pF	CAP, CERM, 330 pF, 50 V, ±5%, C0G/NP0, 0603	0603	GRM1885C1H331JA01D	Murata		
0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
0		JUMPER TIN SMD	6.85x0.97x2.51 mm	S1911-46R	Harwin		
0	15.0k	RES, 15.0 k, 1%, 0.063 W, 0402	0402	CRCW040215K0FKED	Vishay-Dale		
0	15k	RES, 15 k, 5%, 0.063 W, 0402	0402	CRCW040215K0JNED	Vishay-Dale		
0	18	RES, 18, 5%, 0.1 W, 0603	0603	CRCW060318R0JNEA	Vishay-Dale		

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (August 2017) to A Revision	Page
• Changed images in the *TAS5755MEVM Board Layout* section.	18
• Changed schematic.	19
• Changed BOM.	20

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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