TAS5780M Evaluation Module

This user's guide describes the operation of the TAS57780M Evaluation Modules (EVM). The EVM is connected to the PurePath™ Console Motherboard (PPCMB). The main contents of this document are:

- Hardware descriptions and implementation
- Start-up procedure using PurePath Console3 (PPC3) software with TAS5780M plug-in

Related documents:

- TAS5780M Data Sheet (SLASEG7)
- PurePath Console Motherboard User's Guide (SLOU366)
- PurePath Graphic Development Suite (PurePath Console)
- PurePath Console 3 User Manual (SLOU408)

Required equipment and accessories:

1. TAS5780MEVM
2. PurePath Console Motherboard
3. A USB micro type-B cable
4. Power Supply Unit (PSU) 8 – 26.4 VDC
5. Speakers and cables
6. Desktop or laptop running Windows 7, Windows 8 or Windows 8.1
7. Audio source: This can be a DVD player with appropriate SPDIF cable or Playback Media from Windows 7, Windows 8 or Windows 8.1

1 Hardware Overview

The TAS5780MEVM showcases the latest TI digital input Class-D closed loop amplifier. The TAS5780M is an I^2S or TDM input class D amplifier with 96-kHz processing. The EVM is used in conjunction with the PurePath Console Motherboard (PPCMB). The PVDD supply is provided via the TAS5780EVM and is regulated to 5 VDC and 3.3 VDC on the PPCMB. The PPCMB provides the I^2S, I^2C, and 3.3 VDC to the TAS5780MEVM.

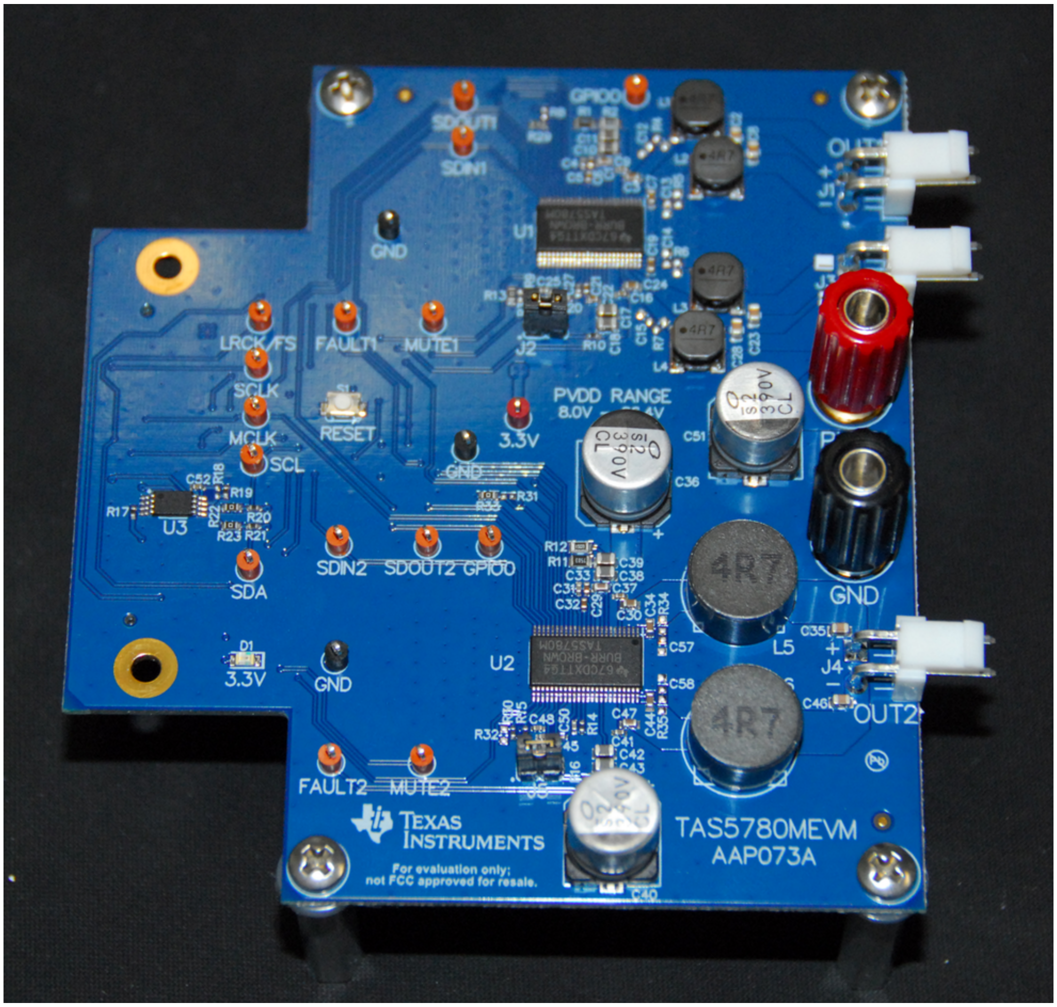

Figure 1. TAS5780MEVM

1.1 Features

- GUI control via USB port
- Stereo and mono channels with I^2S input
- Processed and non-processed mono channel I^2S input
- Operates in BTL or PBTL

1.2 Functions

The TAS5780MEVM is controlled by the PPCMB. The PPCMB sends I^2C commands from PPC3 to the TAS5780M. Upon PPC3 execution and connection, the TAS5780M is put in software mode.

The digital audio data input to the TAS5780EVM is sent from PPCMB and is selectable from USB audio, optical SPDIF, coaxial SPDIF, PSIA (external I2S), and analog ADC sources. When a digital audio data input is selected, the PPC3 automatically sends appropriate scripts to the device in use.

1.3 Detailed Operations

Upon power-on, the PPCMB uses USB audio input (default). The I²S signals LRCLK, SCLK, SDIN and MCLK come from the TAS1020B. foobar2000 or similar non-processing media source can be used to stream audio. The TAS1020B enumerates as the following device on a Microsoft® Windows® operating system (OS): USB audio (USB-AudioEVM), Human Interface Devices, and USB Composite Device, see Figure 2.

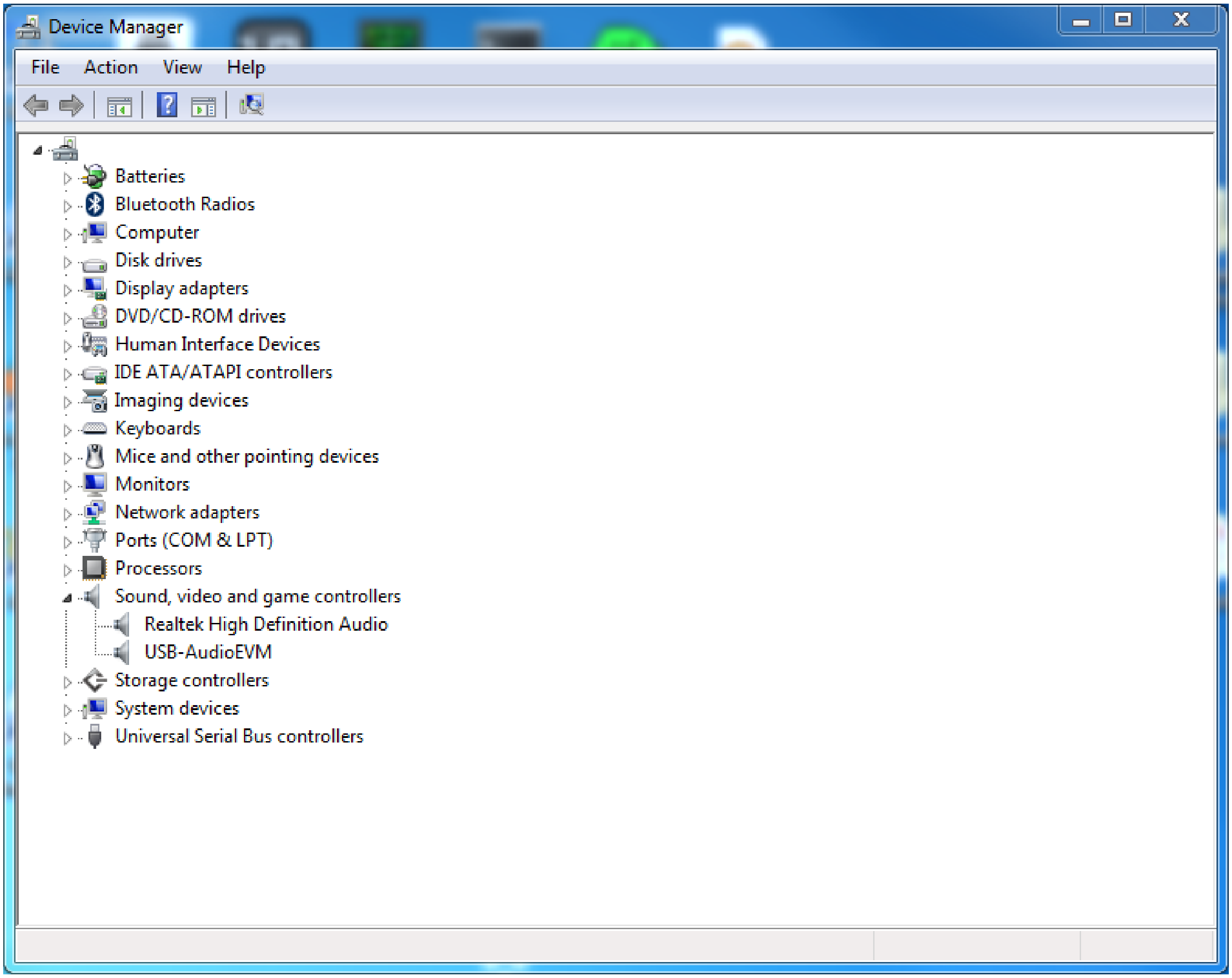

Figure 2. Device Manager

2 Hardware Setup

Step 1: Connect the PPCMB to the TAS5780MEVM.

Step 2: Connect speakers to TAS5780MEVM.

Step 3: Connect a PSU to the TAS5780MEVM and turn on the power. 5-V and 3.3-V LEDs (Yellow) are illuminated. The USB Lock LED (Blue) is also illuminated.

Step 4: Plug in a USB cable from the PC to the PPCMB.

Step 5: If an optical SPDIF source is used, the blue SPDIF clock-locked LED is illuminated.

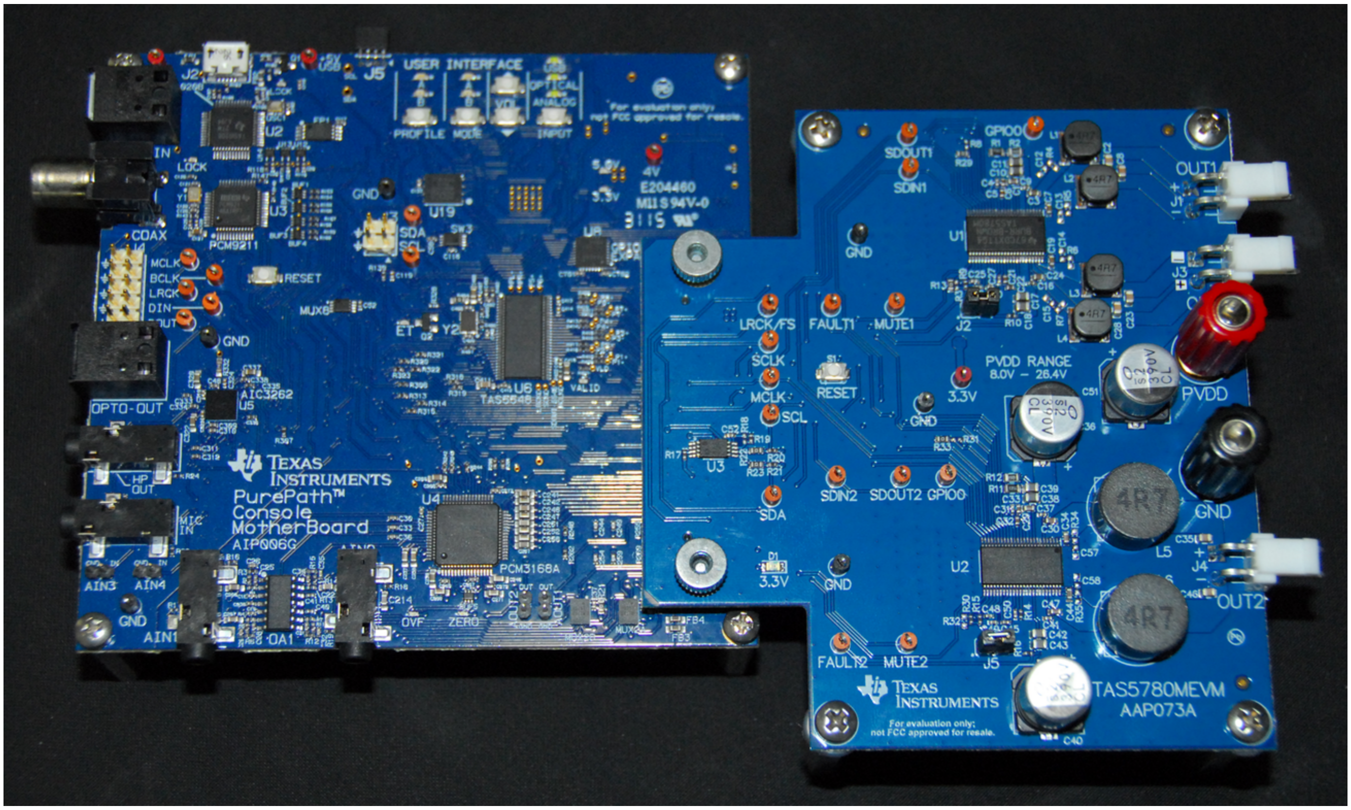

Figure 3. PPCMB and TAS5780MEVM Connection

3 Software Overview

3.1 PurePath Console 3 (PPC3)

PurePath™ Console 3 (PPC3) is a software platform for Texas Instruments' audio devices. Many of these audio devices can be configured, tuned and validated. This platform has the ability to support a number of TI's audio devices with features that make the audio tuning experience more intuitive and exciting. Access can be requested on http://www.ti.com/tool/PUREPATHCONSOLE.

Once approval is given, go to www.ti.com/mysecuresoftware to download the software. After login, users will see this webpage with a similar list of software products available for download.

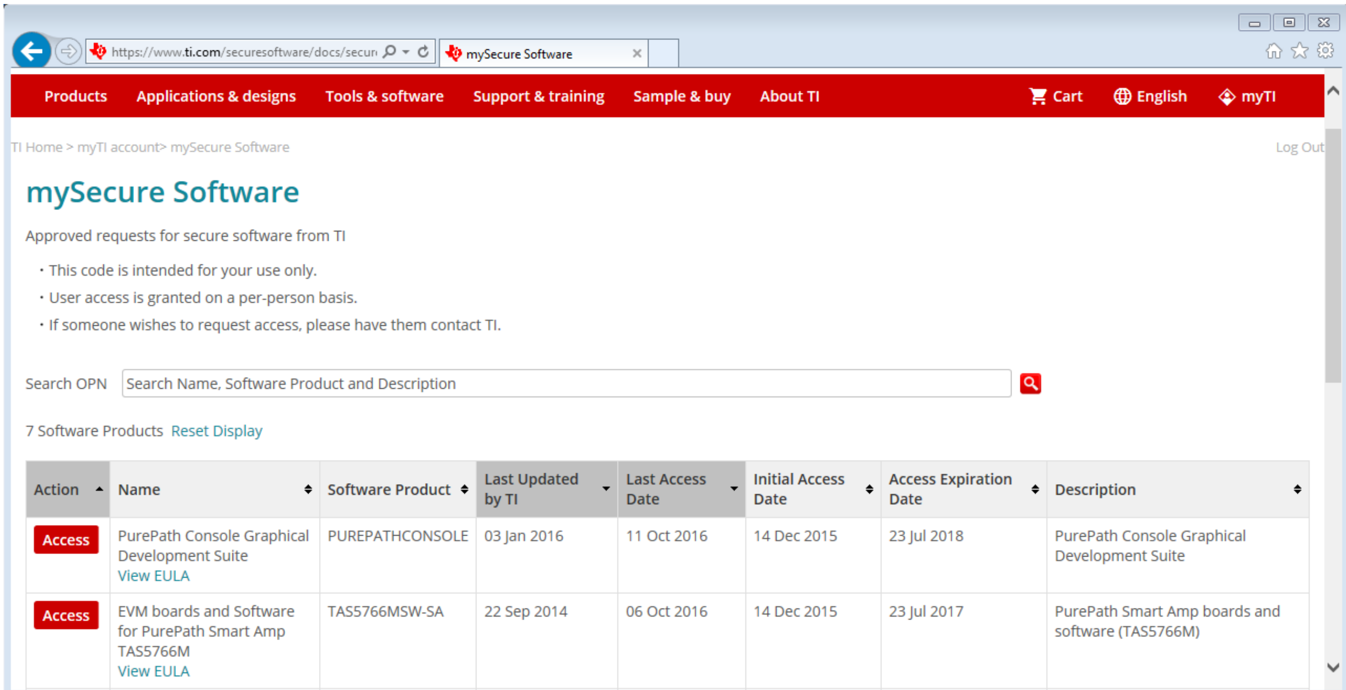

Figure 4. PPC3 Download Window

Run the installation program. Also download the PPC3 User Manual (SLOU408) for further instructions. The following window is displayed when PPC3 is launched for the first time.

When the window in Figure 5 is displayed, click on "sign in" to see TAS5780 EVM application. Click on TAS5780M box to download TAS5780M EVM App. Installation window will pop up, then click "Install".

Figure 5. PPC3 Window

After installation, TAS5780 EVM box will appear in “Installed EVM Apps” section, see Figure 6. Click on TAS5780 box to launch TAS5780 App.

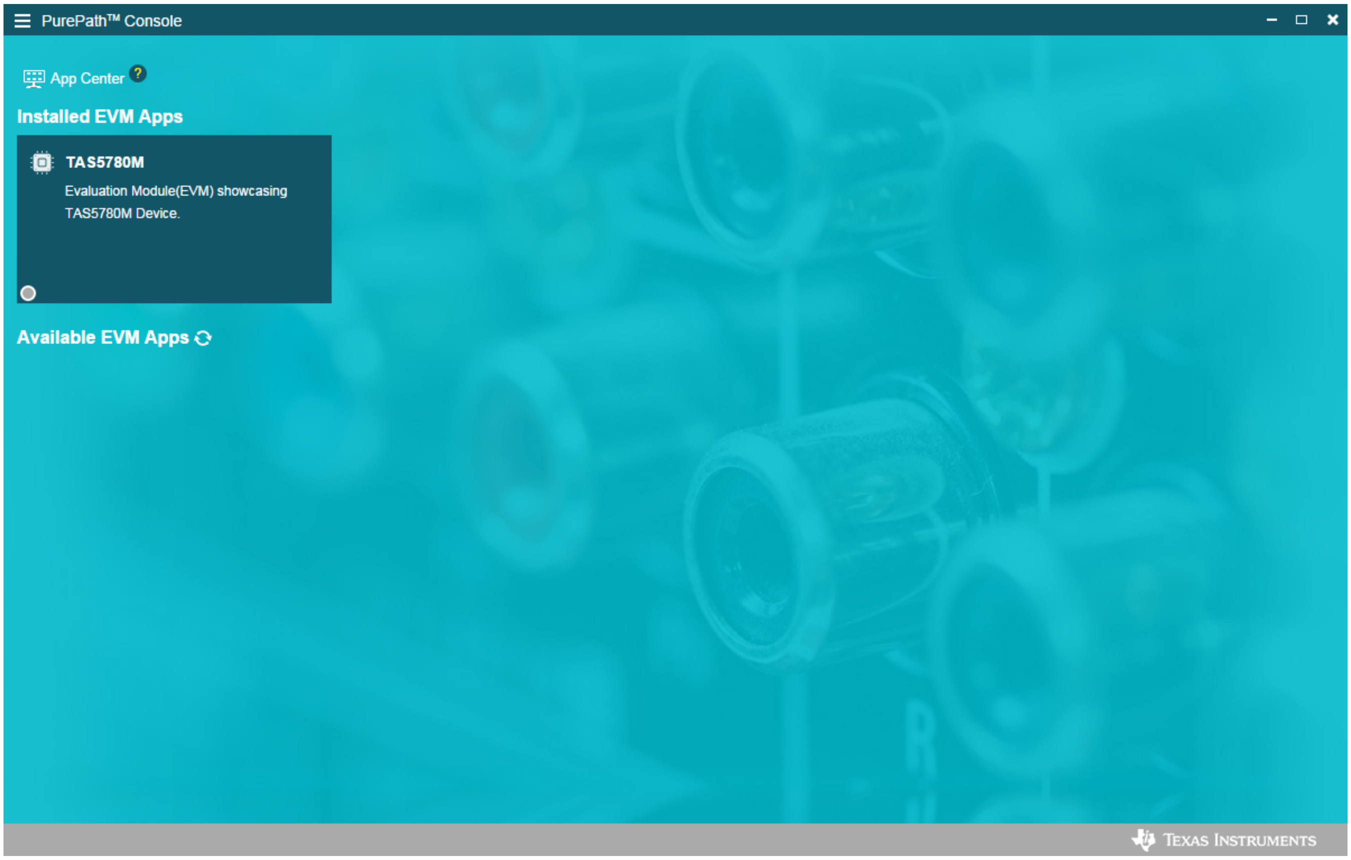

Figure 6. Installed EVM Apps

3.2 TAS5780M Home Page

When the TAS5780M EVM App is launched, the TAS5780M Home Page is shown, see Figure 7. It displays features that are available for that EVM. When a feature is selected, then the respective page is loaded.

If the EVM is powered on and the USB is connected to the PC, the Home Page will display “Connect” button in the bottom left corner. If the USB is not connected, only “TAS5780M – offline” is shown.

There are six pages available in the TAS5780 EVM App: System Checks, Direct I2C, Audio I/O, Register Map, End System Integration and Tuning and Audio Processing.

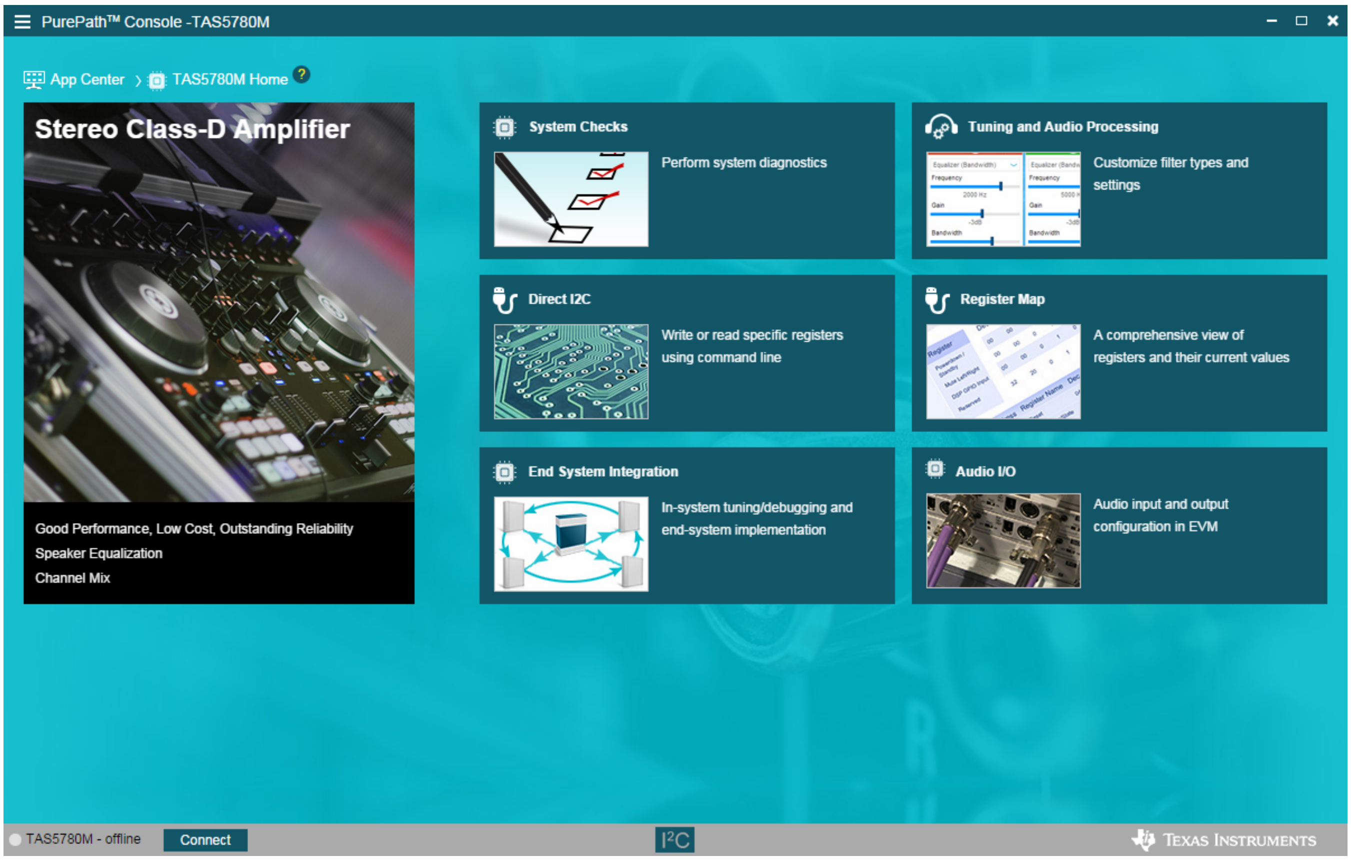

Figure 7. TAS5780M Home Page

3.3 System Checks

The System Checks Page (See Figure 8) is used to determine whether the EVM can be configured correctly and receive audio stream from PC via USB. These checks will complete in a few minutes if no problem is detected. It is recommended to run the system checks before proceeding to the *Turning and Audio Processing* section.

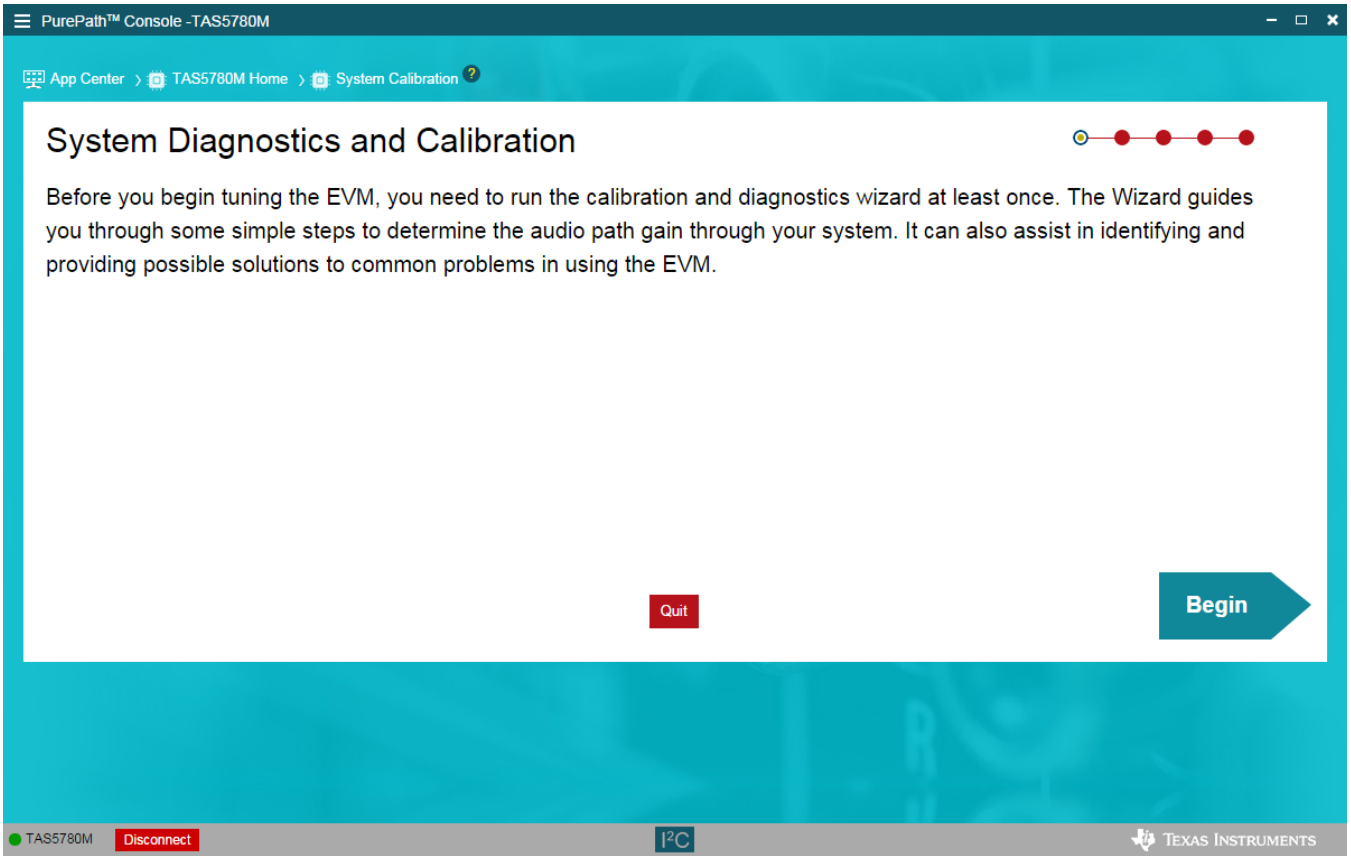

Figure 8. System Checks Page

3.4 Direct I²C

The I/O tab in the Direct I²C has two sub sections. The Input section has the provision to enter the read or write commands scripts. Clicking the Execute button will execute the commands written in the Input section. The status of the execution is displayed in the *Output* section as shown in Figure 9.

The Checksum button on the right is used to compute the checksum value of a cfg file. Load a cfg file by clicking the *Checksum* button and then the computed XOR and CRC checksum will show on the *Output* section

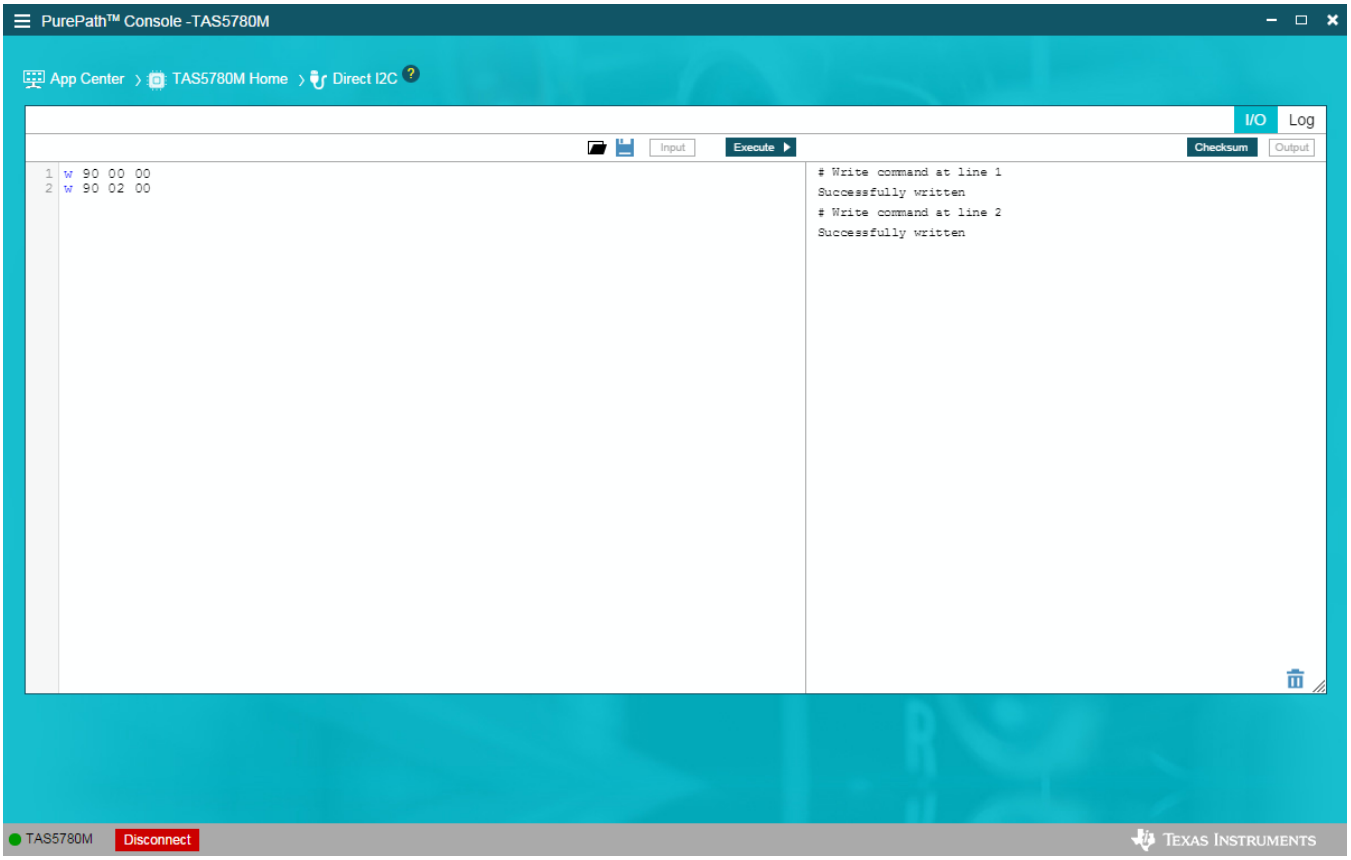

Figure 9. Direct I²C Page, I/O Tab

The Log tab in the Direct I^2C displays the I^2C command history, if the record option is enabled. The log tab has a search option to search for a particular command. The search key can be found at the top left of the window with the search icon. ‘Save to a file’ can be used to save the log as a .cfg file. ‘Delete Output’ clears the log history. ‘Copy to a Clipboard’ copies the log text to the clipboard. Clicking the ‘Start Recording’ button starts recording the I^2C transactions and displays them in the log window. ‘Stop Recording’ stops recording I^2C transactions.

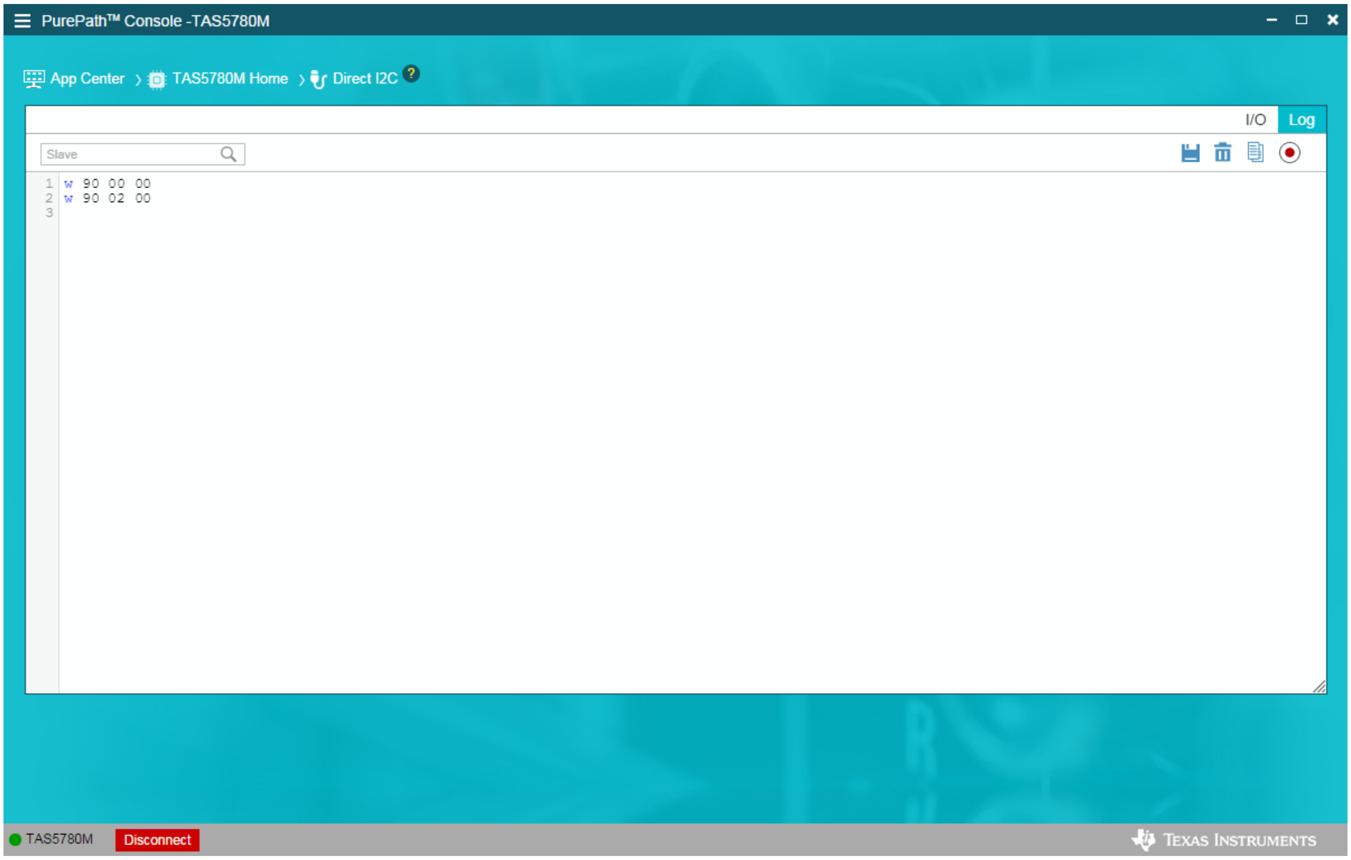

Figure 10. Direct I^2C Page, Log Tab

3.5 Audio I/O

This tool selects the desired audio input to the EVM. USB, coax, analog ,optical and PSIA (external I^2S) are supported by the motherboard. USB audio source is selected as default.

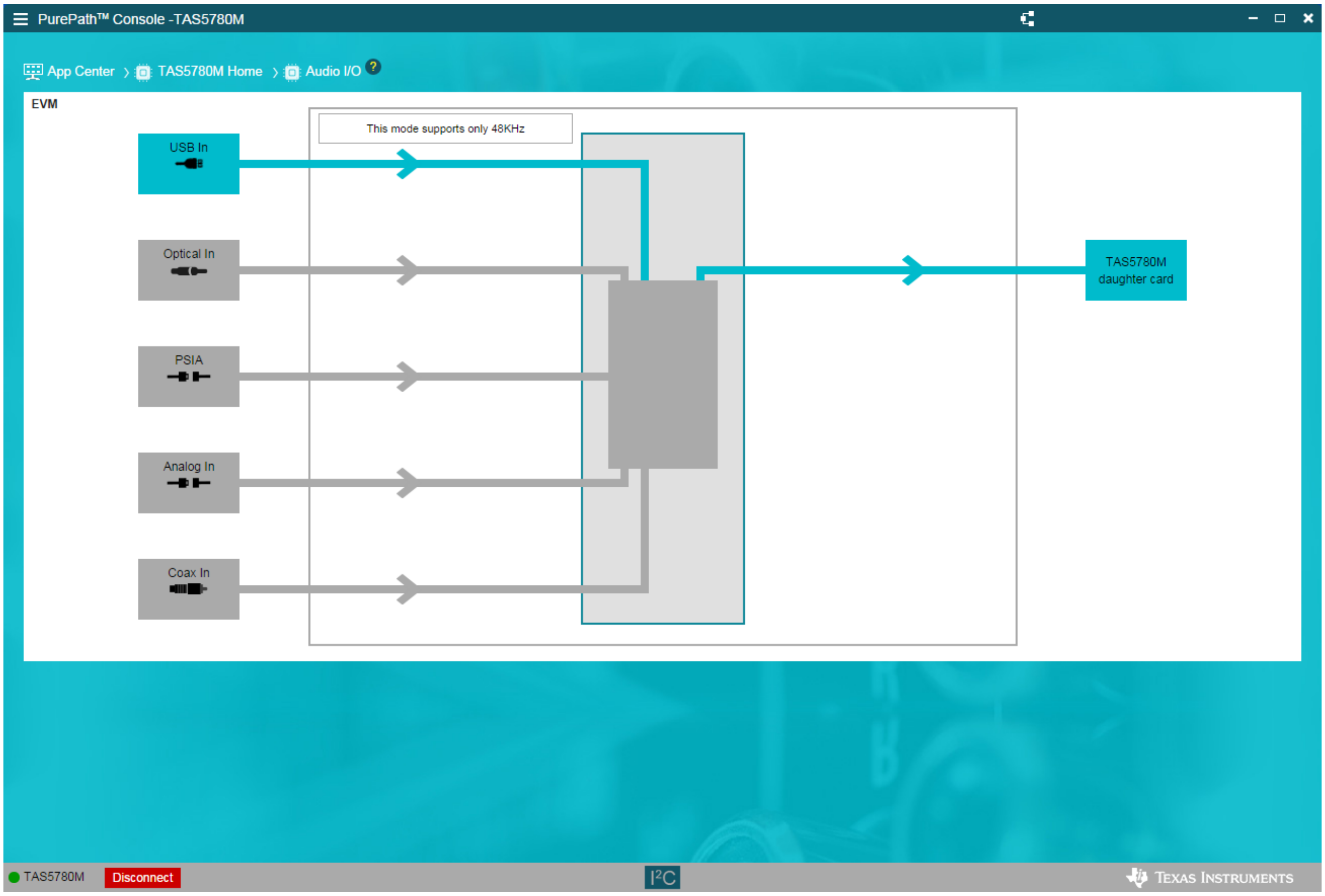

Figure 11. Audio I/O Page

3.6 Register Map

The Register Map Page shows the current I²C register values (hexadecimal) in the TAS5780M and it can be also used to change the register values. Manually changing register values is accomplished by double-clicking in the desired bit to change. Clicking on Read All Registers allows monitoring of the register status of the amplifier. The Fields section shows the register name and a brief description of each bit that affects the selected register.

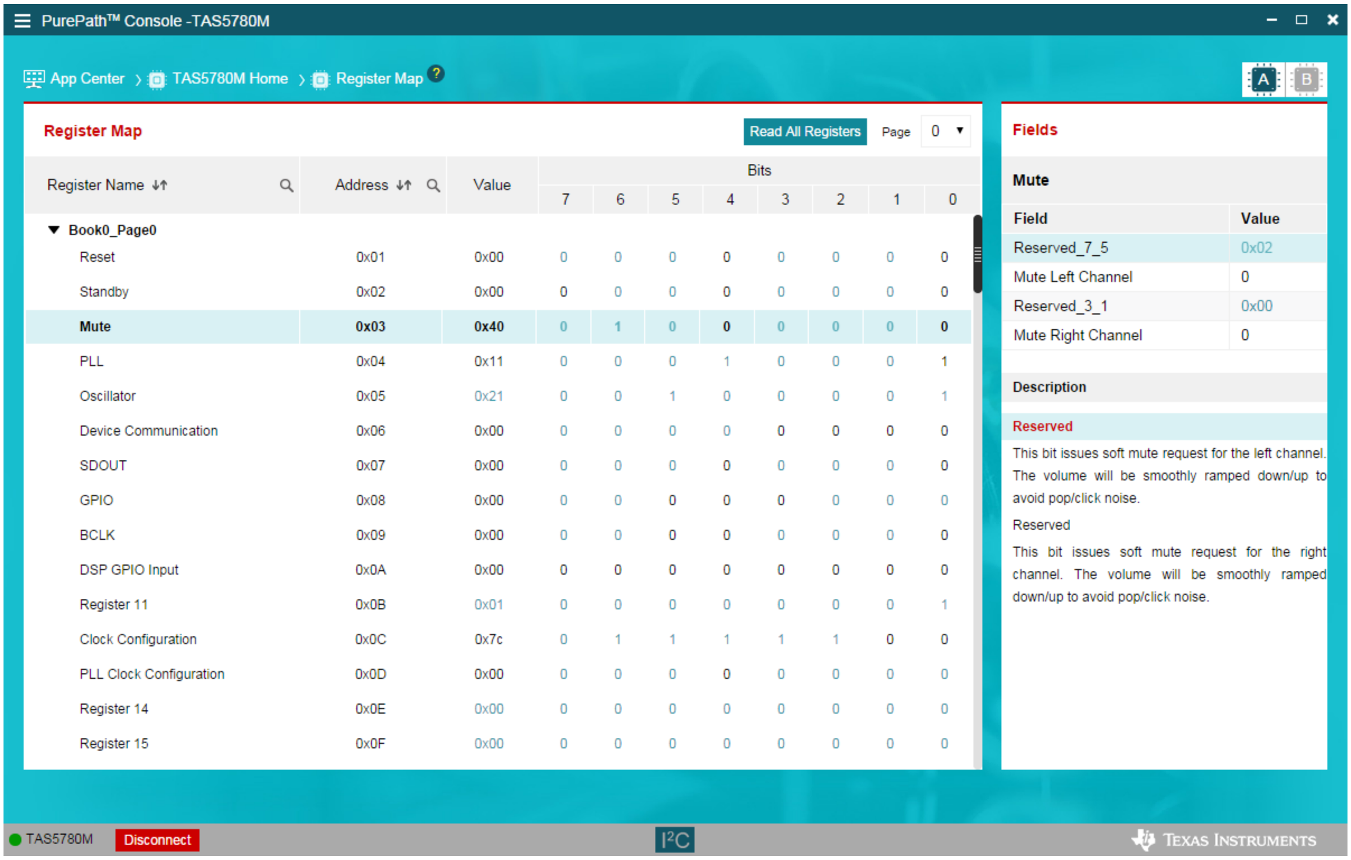

Figure 12. Register Map Page

3.7 End System Integration

The End System Integration Page offers a powerful tool to generate a configuration file to use with processors and a method to debug the device in the end system. Three options are available: (1) Dump Current State into a Header file, (2) In-System Debugging and (3) In-System Tuning.

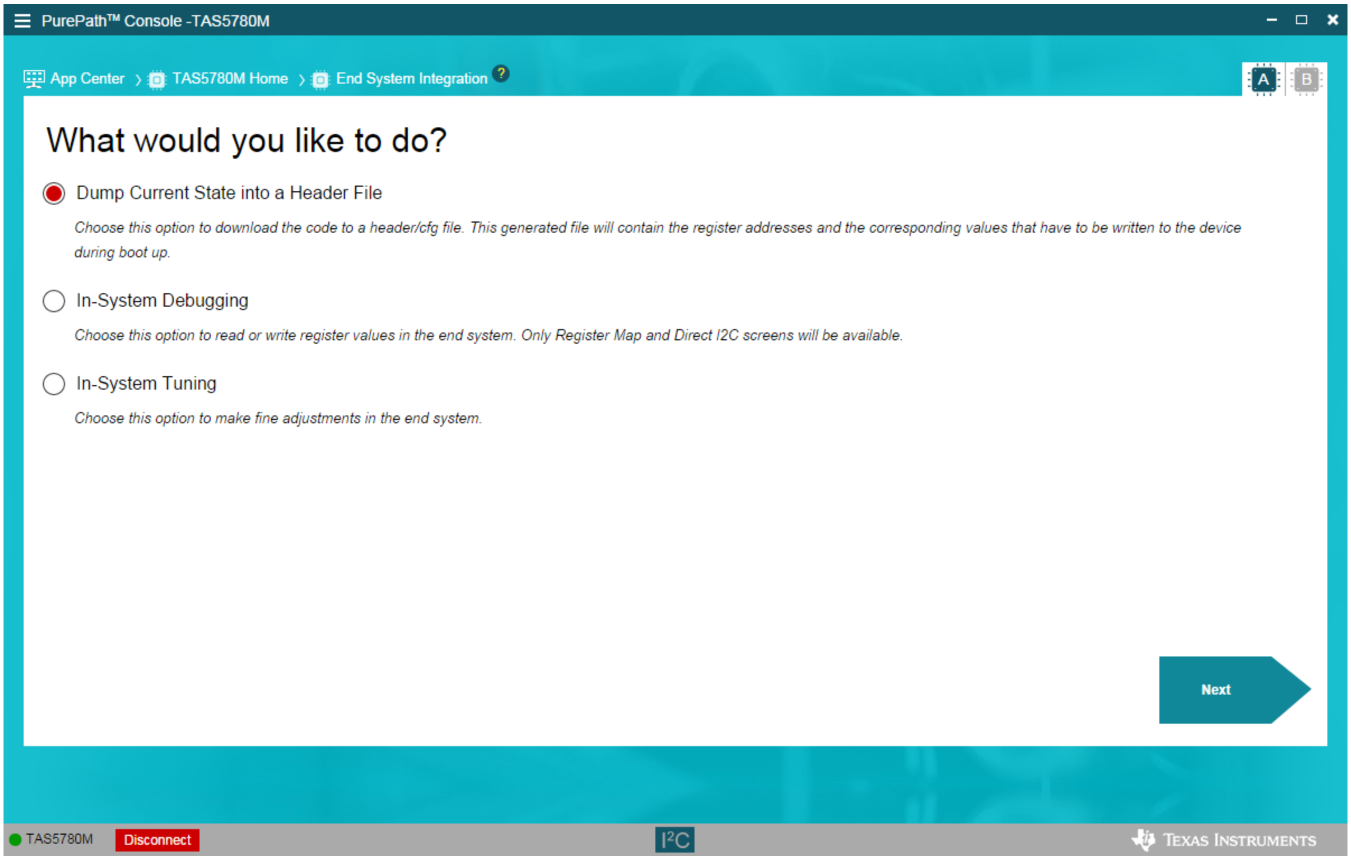

Figure 13. End System Integration Page

3.7.1 Dump Current State into a Header File

This tool is used to generate a header or configuration file for the evaluated device according to the features evaluated and configured with PPC3. A few settings are available for file generation, including the format, end system I^2C address, burst length and so forth. The generated file can be saved in the PC or shown in the output window on the right.

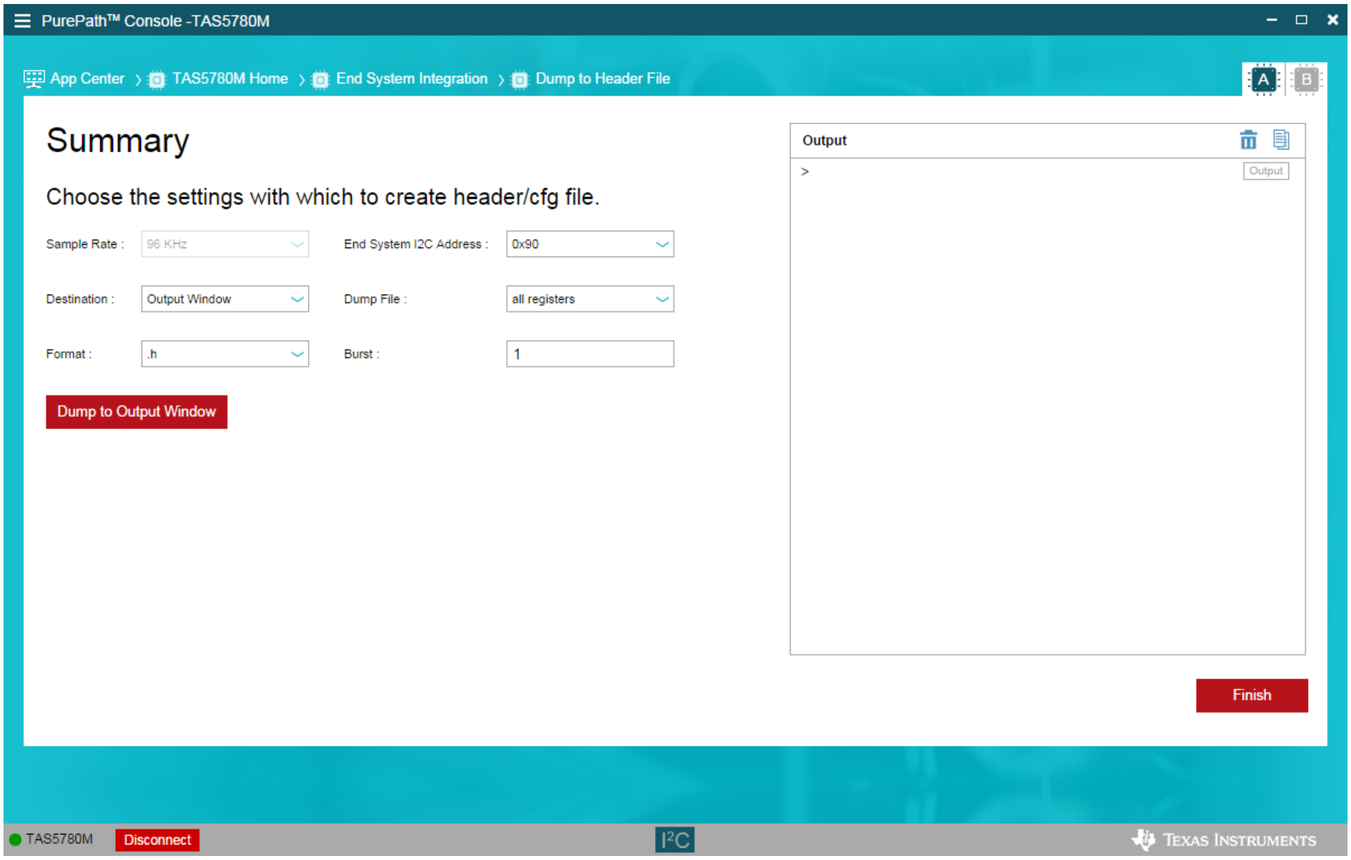

Figure 14. Header File Generation

3.7.2 In-System Debugging

This tool helps debug the device which is already integrated in the end-system. This is possible by connecting the I^2C signals of the end-system device to the SCL, SDA, and GND test points of PPCMB. Only Register Map and Direct I^2C will be available in this mode. Leave the In-System Debugging Mode by clicking on the Disconnect button on the bottom left corner of the window.

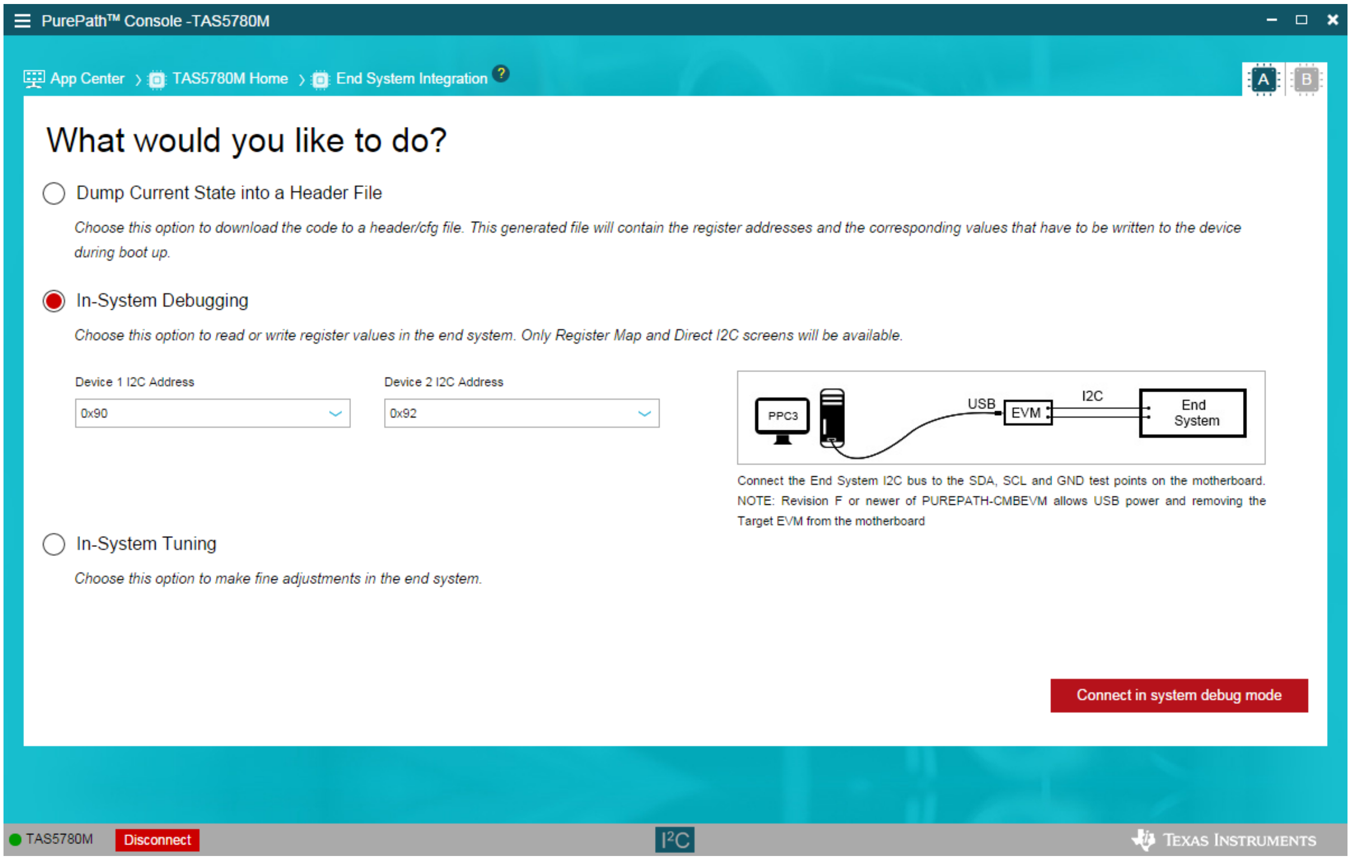

Figure 15. In-System Debugging

3.7.3 In-System Tuning

Even if the device is integrated in the end application, it is still possible to make fine adjustments with the help of In-System Tuning. Like the In-System Debugging above, this is done by connecting I^2C signals from PPCMB to the TAS5780M device in the end-system.

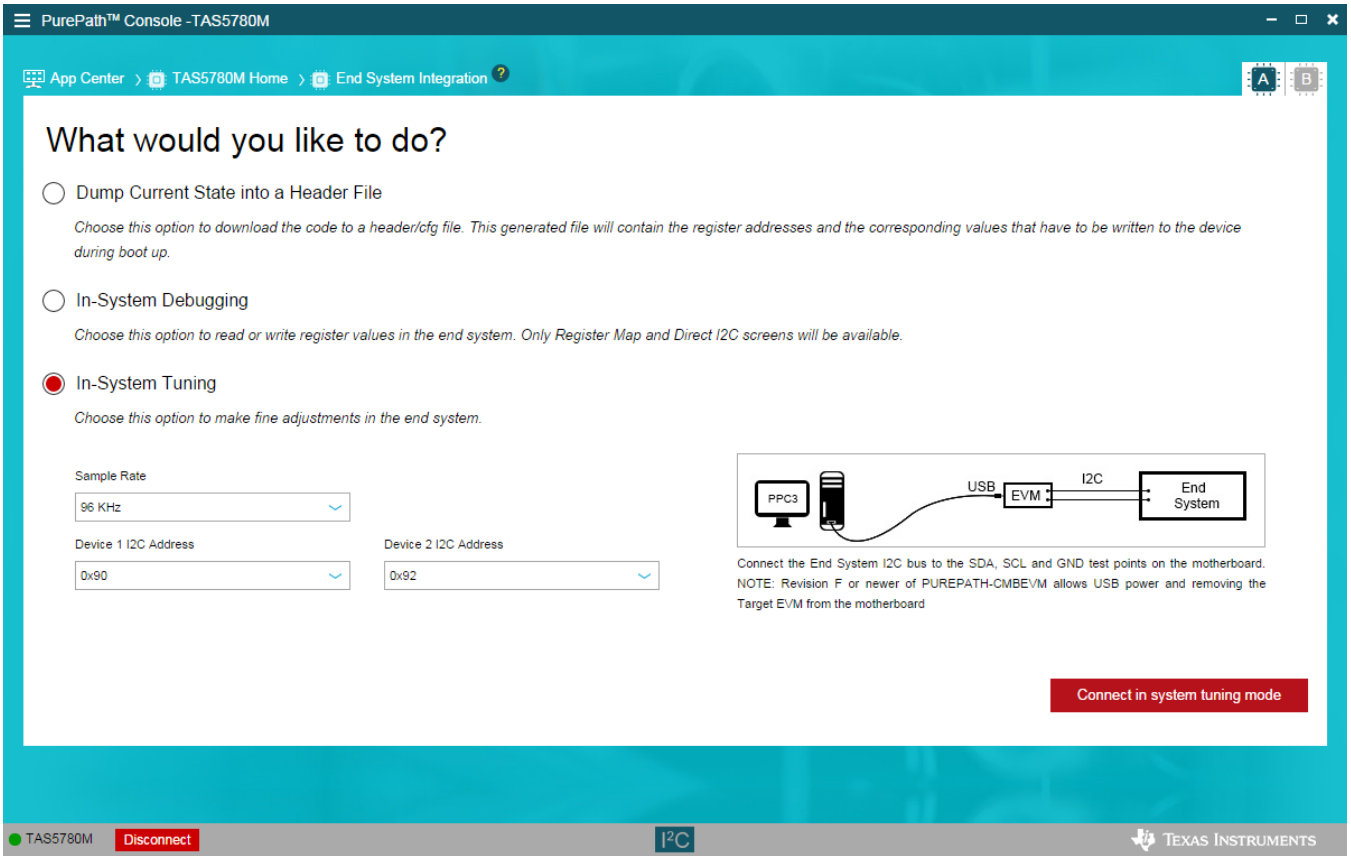

Figure 16. In-System Tuning

3.8 Tuning and Audio Processing

3.8.1 Input Mixer

The input mixer can be used to mix the left and right channel input signals as shown in Figure 17. The input mixer has four coefficients, which control the mixing and gains of the input signals.

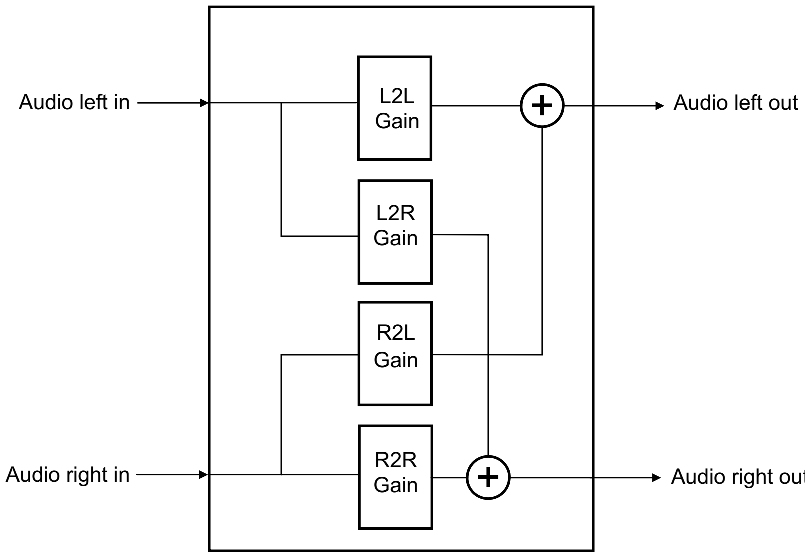

Figure 17. Input Mixer

Table 1 shows the default values of the four coefficients in the Basic Tab (see Figure 18). If the Invert Phase boxes are selected, the L2L / R2R Gain will simply be -1.

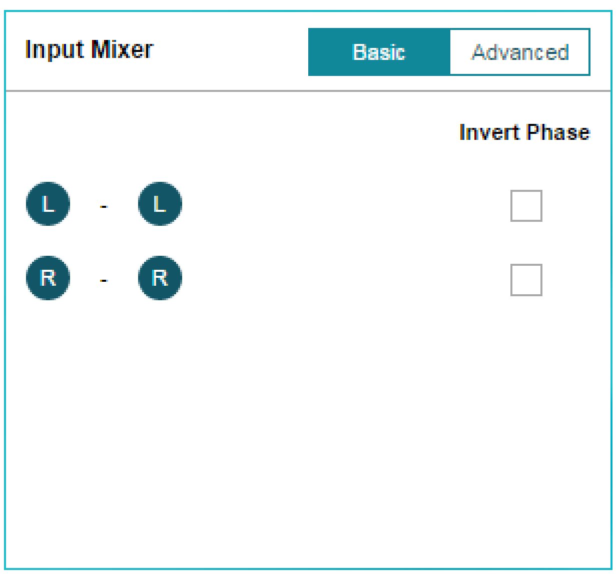

Figure 18. Basic Tab

Table 1. Coefficient Values in Basic Tab

Coefficient	Value
L2L Gain	1
L2L Gain	0
R2L Gain	0
R2R Gain	1

Switch to the Advanced tab (see Figure 19) if all the four coefficients need to be adjusted. Note that the four parameters need to be specified in decibels (dB). Like the Invert Phase boxes in the Basic tab, the Inv Phase options will reverse the sign of the gain values.

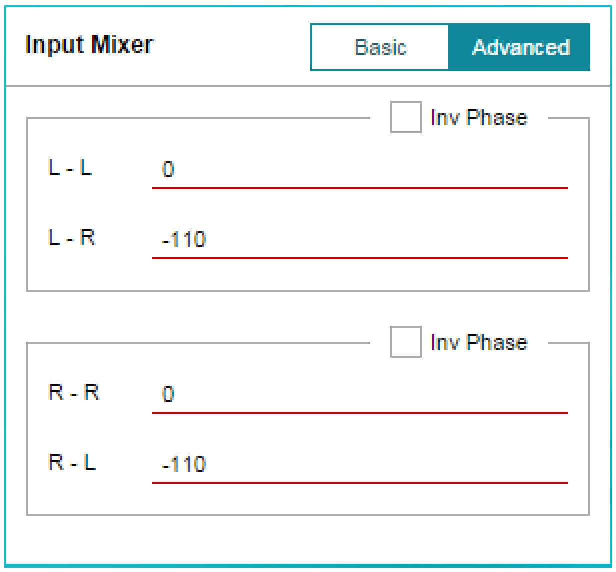

Figure 19. Advanced Tab

3.8.2 Sample Rate Configuration

The process flow in the TAS5780M is based on 96 kHz audio signals, but can support multiple sample rates: 96 kHz, 88.2 kHz, 48 kHz, 44.1 kHz and 32 kHz. To achieve the rates, It uses its interpolator and two Equalizer banks.

The interpolator can be configured to work with 1x, 2x or 3x. While playing 96 kHz, 88.2 kHz, 48 kHz and 44.1 kHz, TAS5780M is configured in auto mode to detect sample rates and interpolate. When 32 kHz audio is played, a 3x interpolator should be activated by writing an additional script. PPC3 automatically does this when the 32kHz sample rate is chosen.

The EQ Bank 1 will have equalizer coefficients computed for the 96 kHz. When second EQ bank is enabled, EQ Bank 2 will have equalizer coefficients computed for 88.2 kHz. When playing 88.2 kHz or 44.1 kHz audio, TAS5780M needs to be configured to use the EQ Bank 2. PPC3 automatically does this when the 88.2 kHz or 44.1 kHz sample rate is chosen

Table 2. Sample Rates and Corresponding EQ Banks

Sample Rate	Auto Detected	Interpolation	EQ Bank
96 kHz	Yes	1x	Bank 1
88.2 kHz	Yes	1x	Bank 2
48 kHz	Yes	2x	Bank 1
44.1 kHz	Yes	2x	Bank 2
32 kHz	No	3x	Bank 1

Figure 20 shows the Sample Rate Configuration Tab. Choose your preferred audio source in the Audio I/O page and then select a proper sampling rate of audio in the dropdown box. Either Bank 1 or Bank 2 will be active after the sampling rate is entered.

The Sync Bank 1 and 2 box is used to make sure the equalizer coefficients on Bank 1 and Bank 2 are synchronized when either of them is changed.

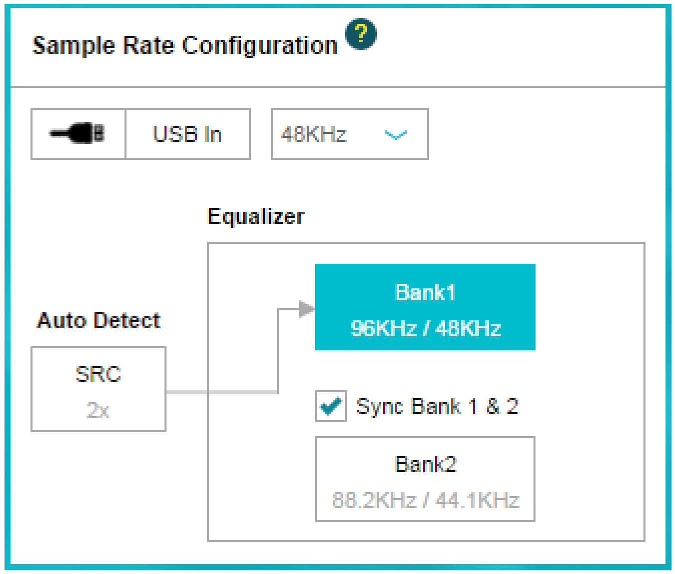

Figure 20. Sample Rate Configuration

3.8.3 Equalize

The Equalizer window contains 12 independent filters designed for tuning the frequency response of the overall system. This is where the bulk of the frequency compensation occurs. Complex tuning shapes can be made to compensate for deficiencies in speaker response.

Figure 21. Equalizer Tuning Window

Figure 20 shows the Equalizer audio processing window. Both left and right channels have 12 filters individually, which appear under the frequency graph. Each filter has quite a few different filter types and can be turned on or off independently. All the changes to these filters are reflected in Figure 21. The composite plot (red) shows the overall frequency response alteration applied to the incoming digital audio data. The equalizers for left and right channels are configured independently by default, but they can be ganged by selecting *Ganged* option. *Phase, Group Delay, Impulse Response* and Pole zero charts are also available on the right side.

3.8.4 DEQ

The dynamic equalizer mixes the audio signals routed through two paths containing one BQ each based upon the signal level detected by the sense path, as shown in Figure 22.

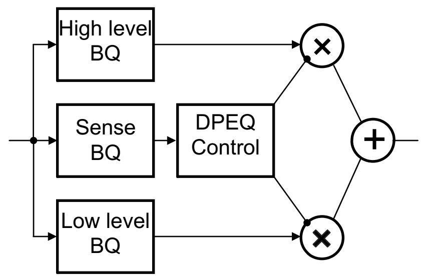

Figure 22. DEQ

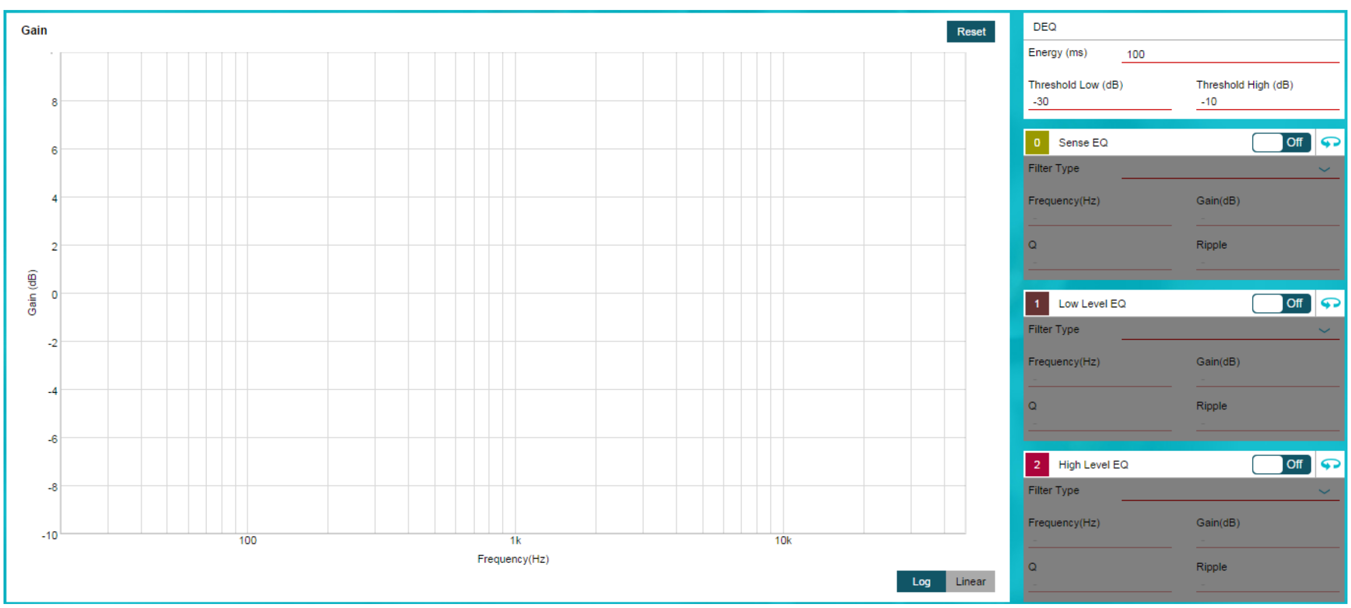

Figure 23. DEQ Tuning Window

3.8.4.1 DEQ

The Energy simply tells the algorithm for how long to average the samples of audio before it determines how it compares to the mixing thresholds. The shorter the time, the faster the mixer reacts to changes in the input signal level. The longer the time, the slower the mixer reacts to changes in level.

The mixing of the two paths (low level and high level) is controlled by setting the Threshold Low and Threshold High. When the averaged signal (as set by the Energy) is below the Threshold Low, the dynamic mixer sends all of the audio through the low-level path. When the signal is above the Threshold High, it is sent through the upper-level path. When the signal is between the two, it is mixed together by the dynamic mixer.

3.8.4.2 Sense EQ

The sense path contains 1 configurable Biquad, which can be used to focus the DEQ sensing on a specific frequency bandwidth.

3.8.4.3 Low Level EQ

The low-level path also has 1 configurable Biquad to establish the EQ curve which the audio is sent through when the time averaged signal is at a low-level. This fully-functional Biquad can be assigned to several filter types. This determines frequency response when low-level is active based on the Energy configuration and the mixing thresholds.

3.8.4.4 High Level EQ

The high-level path, similar to the low-level path, has 1 Biquad that can set the EQ curve used when the time averaged input signal is above the upper mixing threshold.

3.8.5 DRC

The Dynamic Range Control (DRC) is a feed-forward mechanism that can be used to automatically control the audio signal amplitude or the dynamic range within specified limits. The dynamic range control is done by sensing the audio signal level using an estimate of the alpha filter energy then adjusting the gain based on the region and slope parameters that are defined.

The two-band dynamic range control is comprised of two DRCs that can be spilt into two bands using the BQ at the input of each band. The frequency where the two bands are spilt is referred to as the crossover frequency. The crossover frequency is the cut off frequency for the low pass filter used to create the low band and the cut off frequency for the high pass filter used to create the high band.

The DRC in each band is equipped with individual energy, attack, and decay time constants. The DRC time constants control the transition time of changes and decisions in the DRC gain during compression or expansion. The energy, attack, and decay time constants affect the sensitivity level of the DRC. The shorter the time constant, the more aggressive the DRC response and vice versa.

This DRC can be used for power limiting and signal compression; therefore, it must be tested with maximum signal levels for the desired application. Use a resistive load for initial testing. However, the speaker used in the end application must be used for final testing and tweaking.

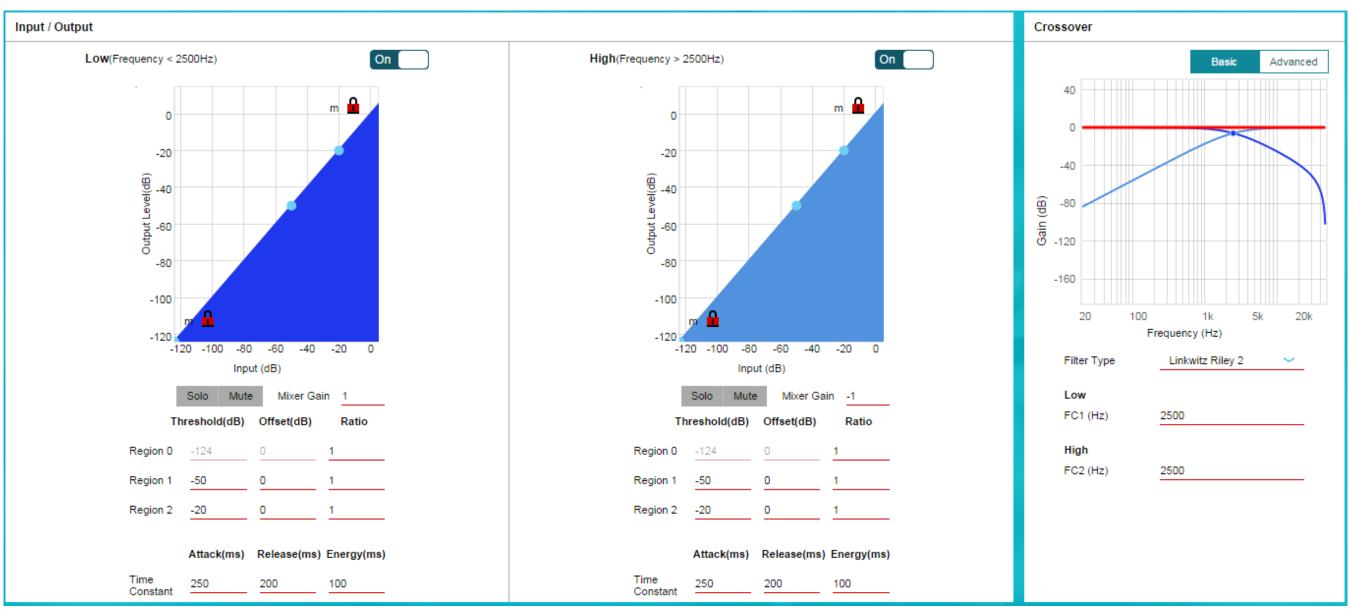

Figure 24. DRC Tuning Window

The Input / Output region has consists of two identical windows for low and high bands. Each has a DRC curve that offers 3 regions of compression. The points on the DRC curve can be dragged and dropped.

Below the DRC plot, parameters such as threshold, offset and ratio can be manually typed in for each of the 3 regions. By typing a value and pressing *Enter* on the keyboard, the DRC curve automatically adjusts to the entered parameter.

3.8.5.1 DRC Time Constant

Change time constants by entering new values for each band.

Attack(ms) determines the attack time of the DRC and Release(ms) determines the release time once the windowed energy band passes. Energy(ms) controls the time averaging windowing uses to determine the average signal energy; therefore, where the incoming signal compares to the set DRC curve. It is beneficial to have control over the DRC time constant for a given frequency band to avoid beating tones caused by the DRC attack and the incoming signal frequency

The mixer gain controls the relative gain of each of the 2 frequency bands when they are mixed together. This is used to attenuate one of the frequency bands relative to the others, if needed. **Make note of the sign of the gain coefficients**. Since filters effect phase, a phase reversal or a 180 degree phase shift may be necessary. Use a negative sign on the coefficient to reverse the phase

3.8.5.2 Crossover

By default, the two-band crossover frequencies are set to 2500 Hz, using second-order Linkwitz-Riley filters. This filter type is chosen because the total sum of the two-band signals has a flat response without having to calculate individual cross-over frequencies for unity summation. The crossover frequencies need to be separated far enough in the frequency range from each other to avoid any dip caused by the filter sum response.

The crossover configuration has two tabs. In the Basic Tab, only the filter type and two cut-off frequencies need to be determined. Go to the Advanced Tab if more parameters need to be adjusted.

3.8.6 Full Band AGL

The Full Band AGL is a feedback mechanism that can be used to automatically control the audio signal amplitude or dynamic range within specified limits. The automatic gain limiting is done by sensing the audio signal level using an alpha filter energy structure at the output of the AGL then adjusting the gain based on the whether the signal level is above or below the defined threshold. Three decisions made by the AGL are engage, disengage, or do nothing. The rate at which the AGL engages or disengages depends on the attack and release settings respectively.

Figure 25 shows the AGL Tuning Window. By default, the AGL is disabled and it can be enabled by clicking the ON/OFF switch on the top right corner.

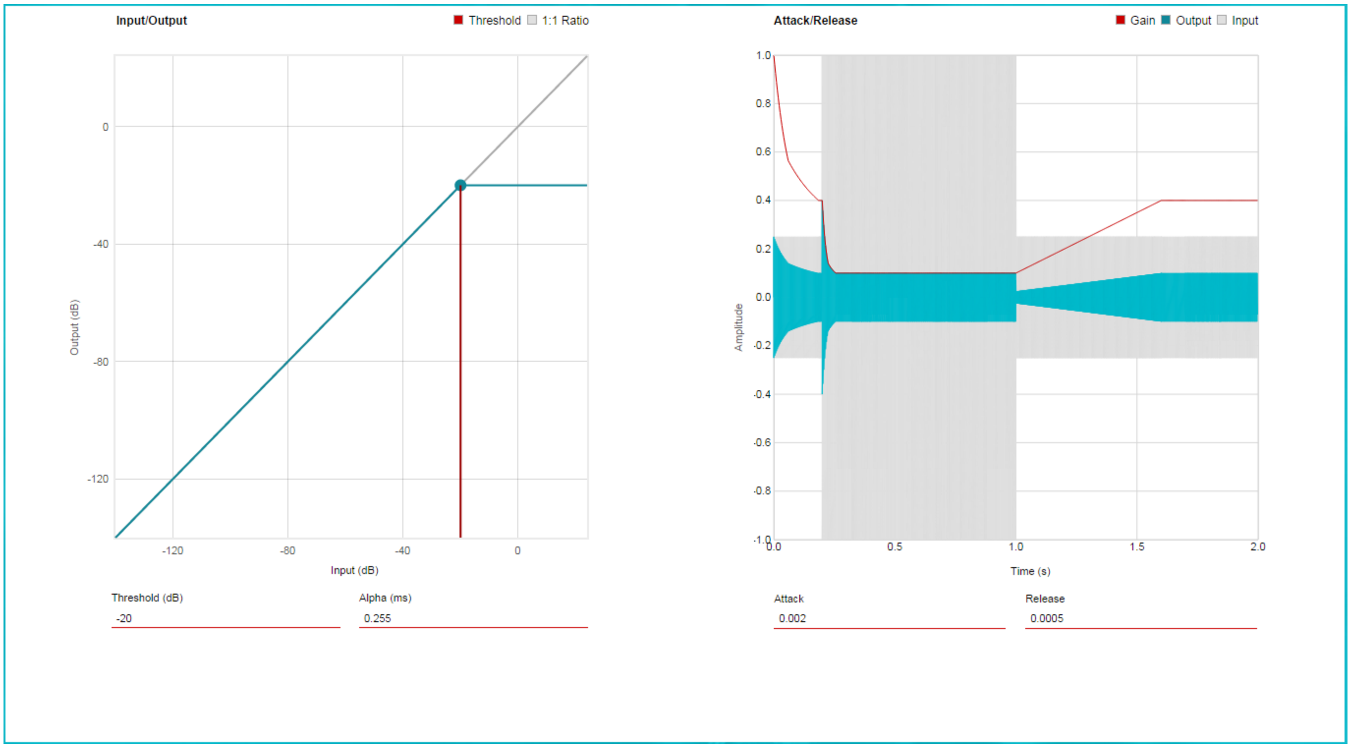

Figure 25. AGL Tuning Window

3.8.6.1 Threshold(dB)

This parameter sets the threshold at which the compressor will be activated. Lowering the threshold will cause the compression to be activated at lower volume levels. Once the signal exceeds this threshold, compression will be applied.

3.8.6.2 Alpha(ms)

This parameter configures the sharpness of the compression knee of the AGL.

3.8.6.3 Attack

This parameter controls how quickly compression will be applied to the signal. Higher values will cause the compressor to respond to signals slowly, while lower values will give faster response times.

3.8.6.4 Release

This parameter controls how quickly compression will be removed from the signal as the signal gets quieter. Higher values will cause the compressor to release from signals slowly, while lower values will give faster response times.

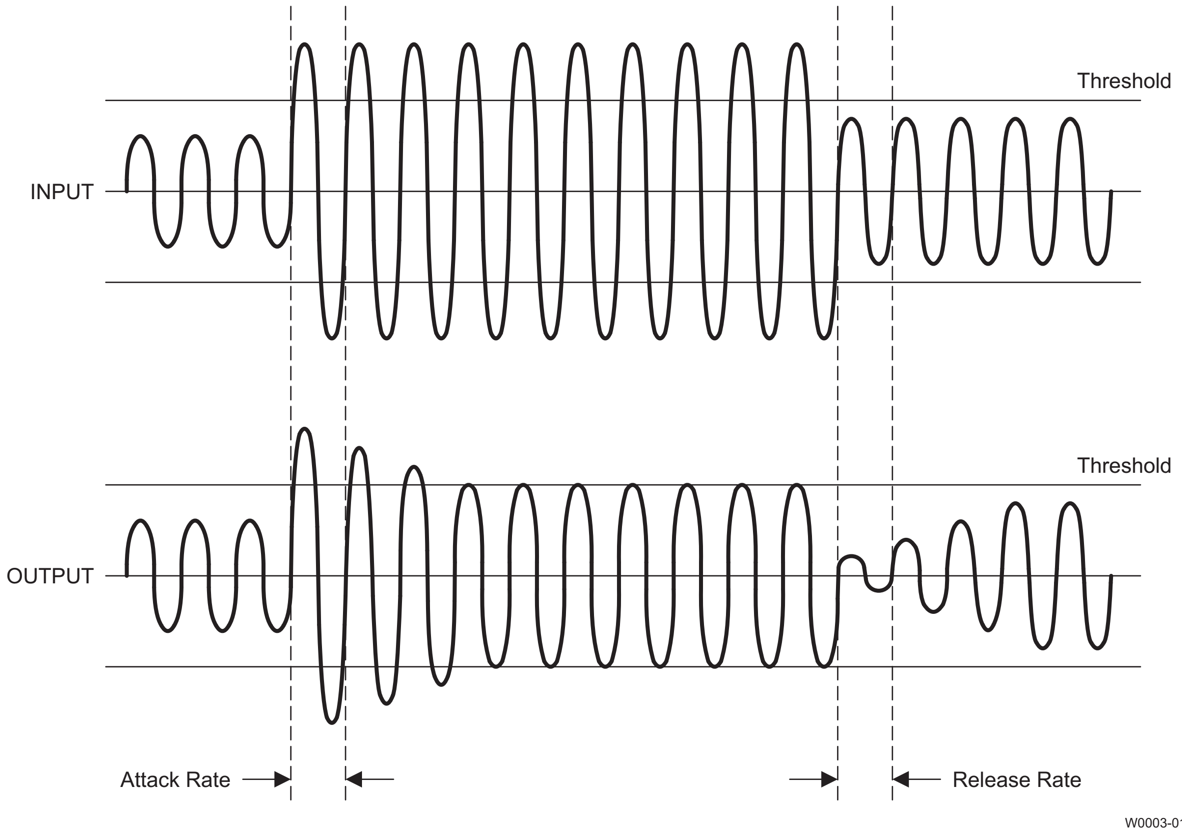

Figure 26. AGL Attack and Release

3.8.7 THD Boost / Fine Volume

A THD boost and fine volume together can be used to achieve digitally the specified THD levels without voltage clipping. It allows users to achieve the same THD (for example, 10% THD) for different power levels (15 W/10W/5W) with same PVCC level.

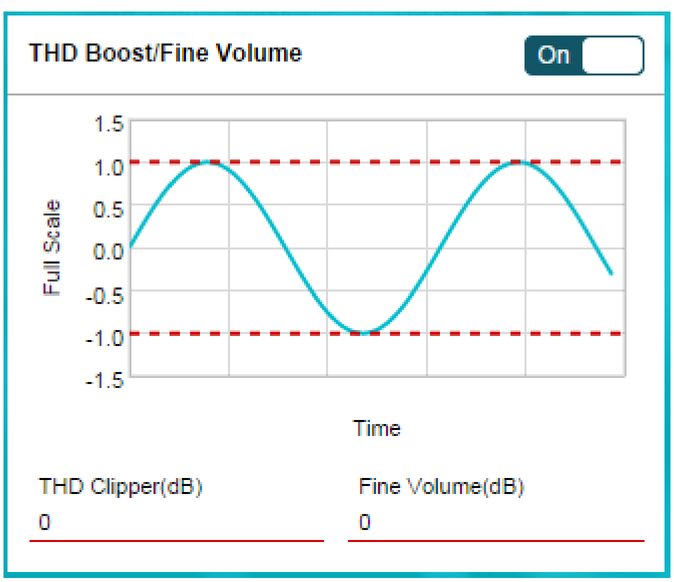

Figure 27. THD Boost / Fine Volume

3.8.7.1 THD Clipper (dB)

The THD clipper controls the signal level at which clipping occurs.

3.8.7.2 Fine Volume (dB)

The fine volume sets additional fine volume steps from –110 dB to 6 dB.

3.8.8 Simple Register Tuning

The SDOUT Origin dropdown list selects what is being output as SDOUT via GPIO pins.

The Mute check box can be used to mute / unmute the TAS580M device. The Standby and Powerdown check boxes will put the TAS5780M device into standby mode or powerdown mode if they are checked.

The DAC Gain spinner controls the digital volume of DAC. The digital volume is 24 dB to -103 dB in -0.5 dB step. The Analog DAC Gain dropdown list selects the analog gain. Two options are available: 2 Vrms FS (0 dB) or 1 Vrms FS (-6 dB).

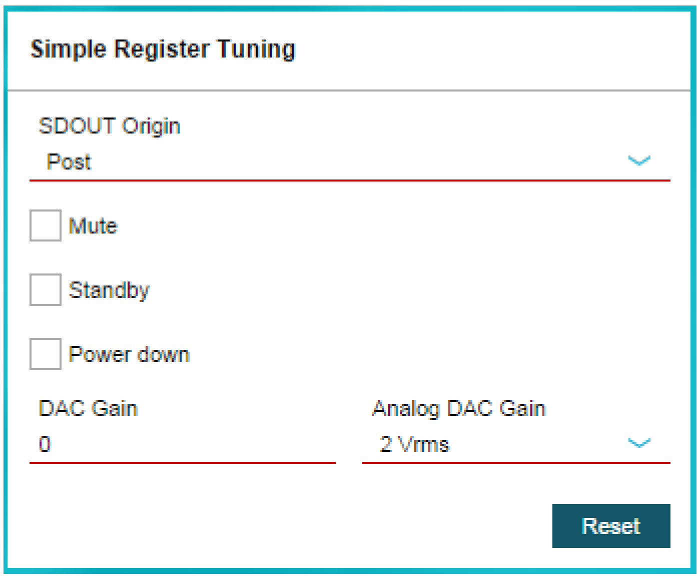

Figure 28. Simple Register Tuning

3.8.9 Level Meter

Figure 29 shows the level meter, which uses an energy estimator with a programmable time constant to adjust the sensitivity level based on signal frequency and desired accuracy level. The level meter will appear if the LM icon on the bottom is clicked.

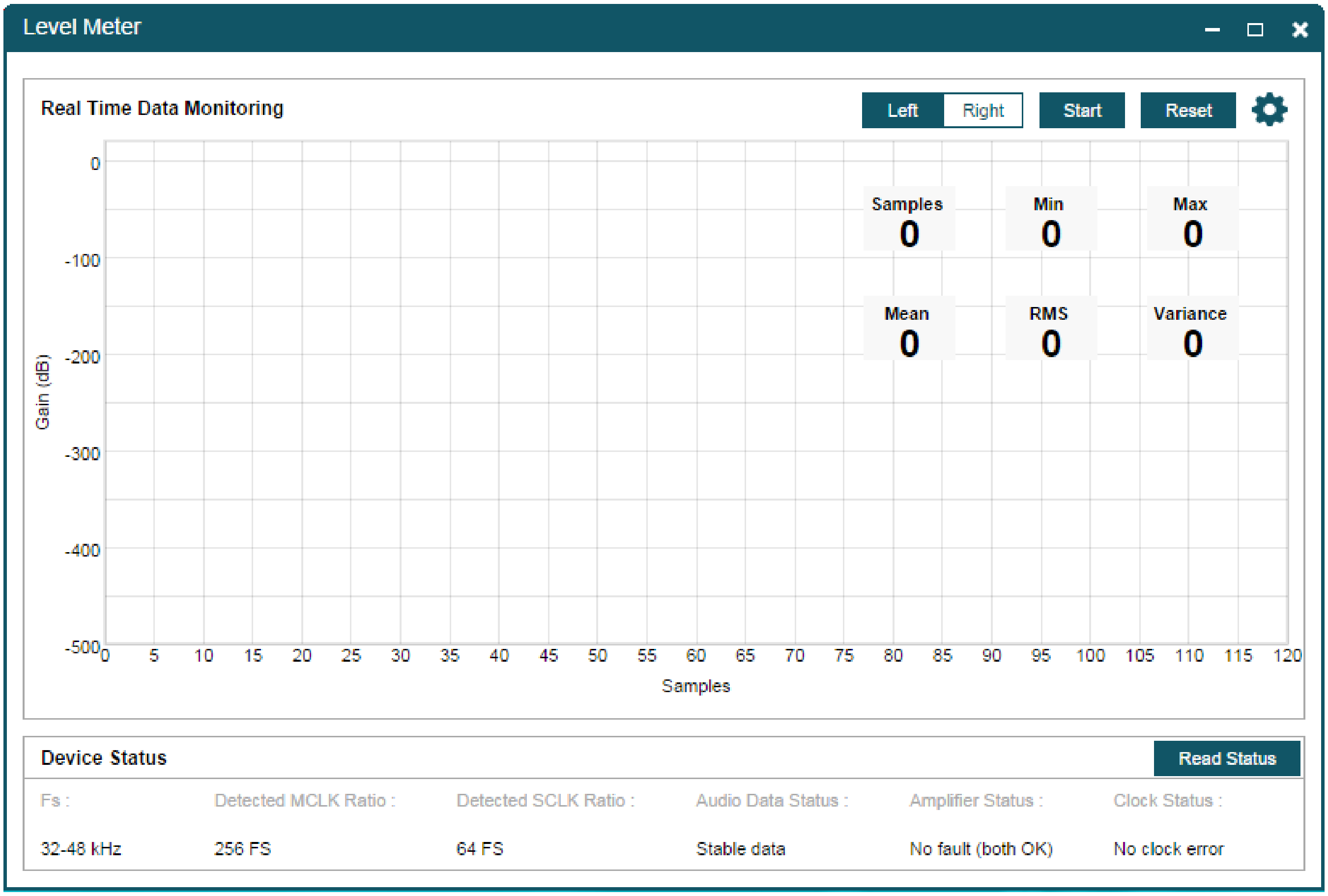

Figure 29. Level Meter

4 Board Layouts, Bill of Materials, and Schematic

This section includes the EVM schematics, board layouts and bill of materials.

4.1 Schematics

Figure 30 through Figure 32 illustrate the schematic for this EVM.

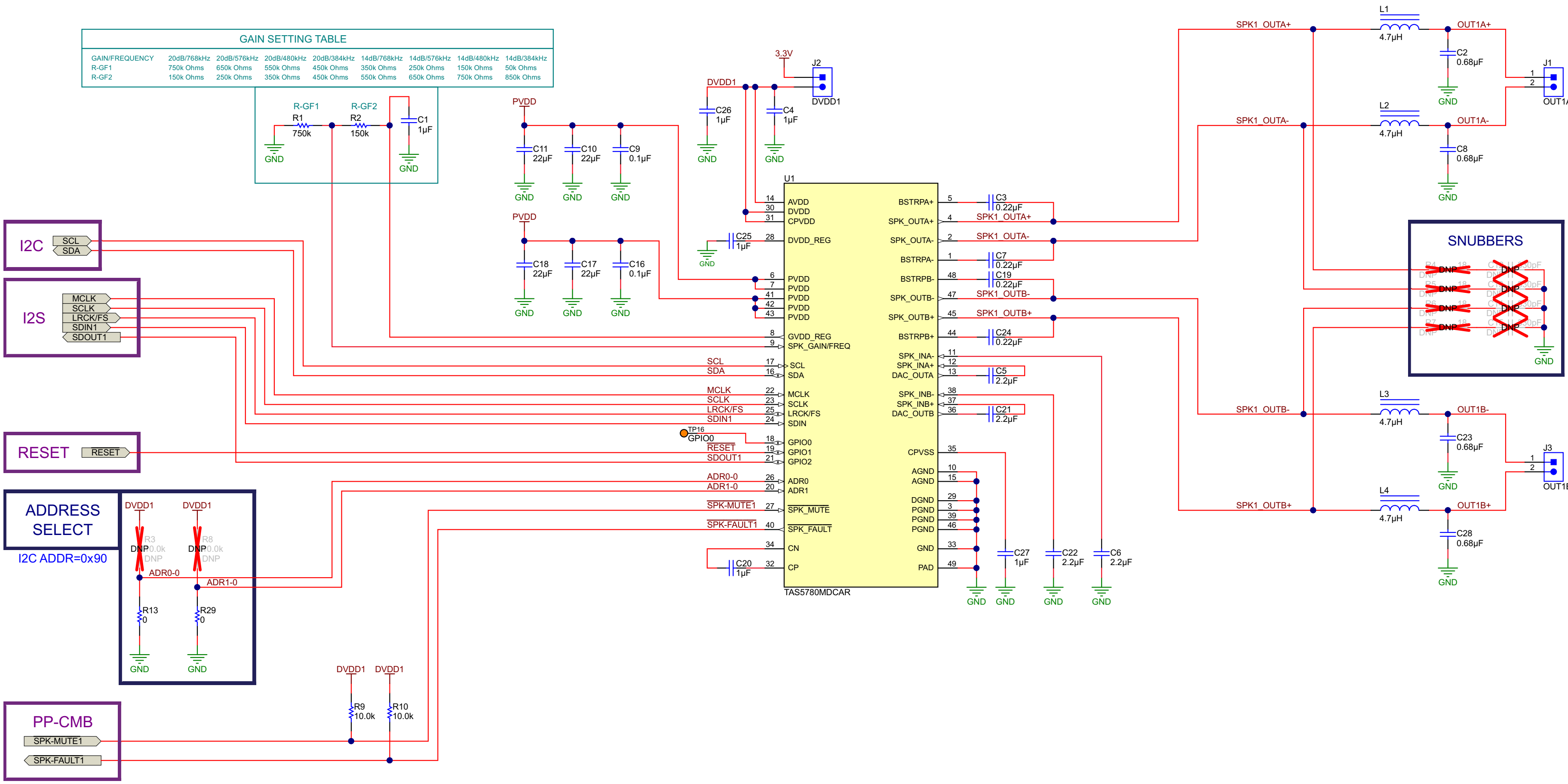

Figure 30. Schematic (1 of 3)

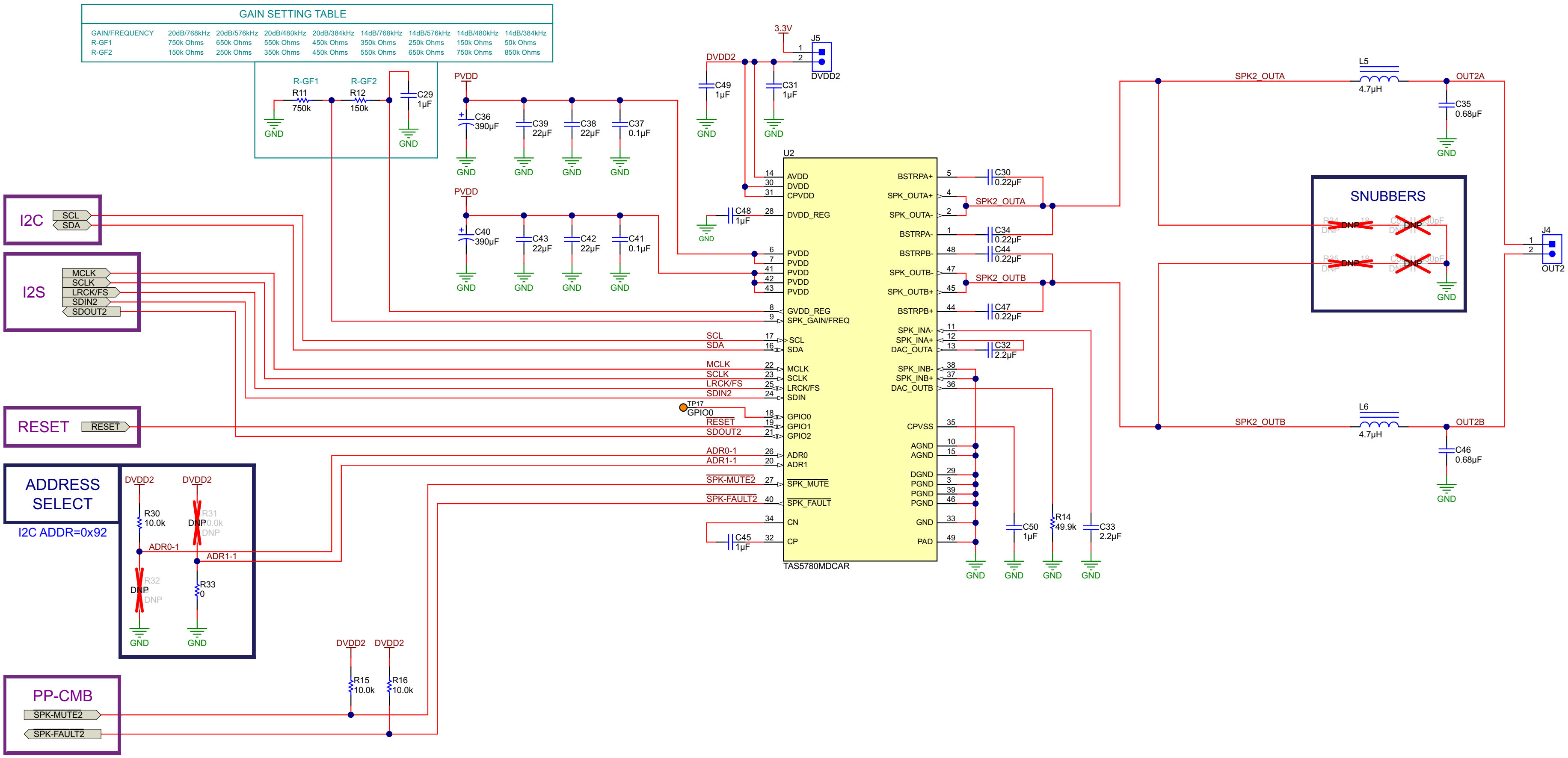

Figure 31. Schematic (2 of 3)

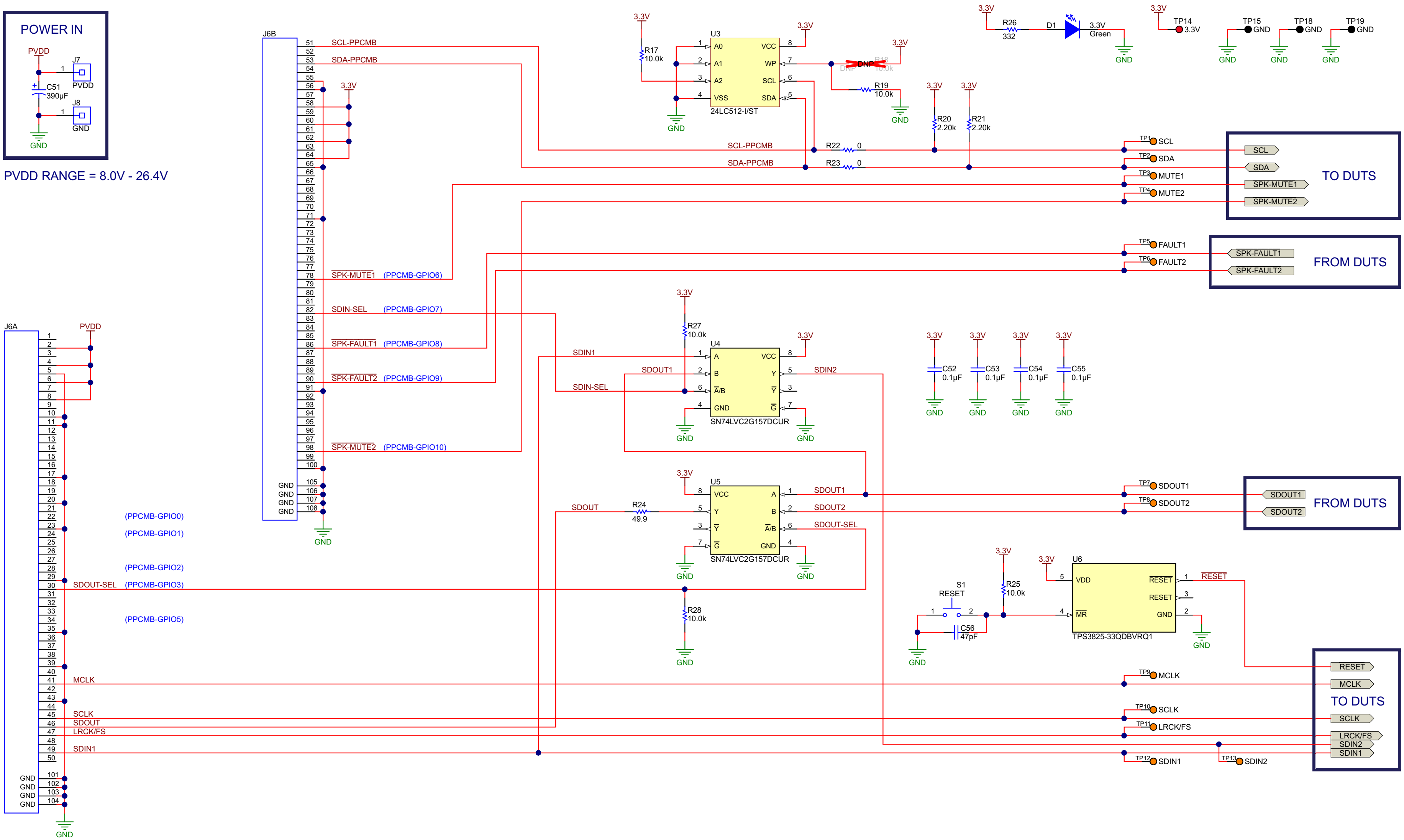

Figure 32. Schematic (3 of 3)

4.2 Board Layouts

Figure 33 and Figure 34 illustrate the board layouts for the EVM.

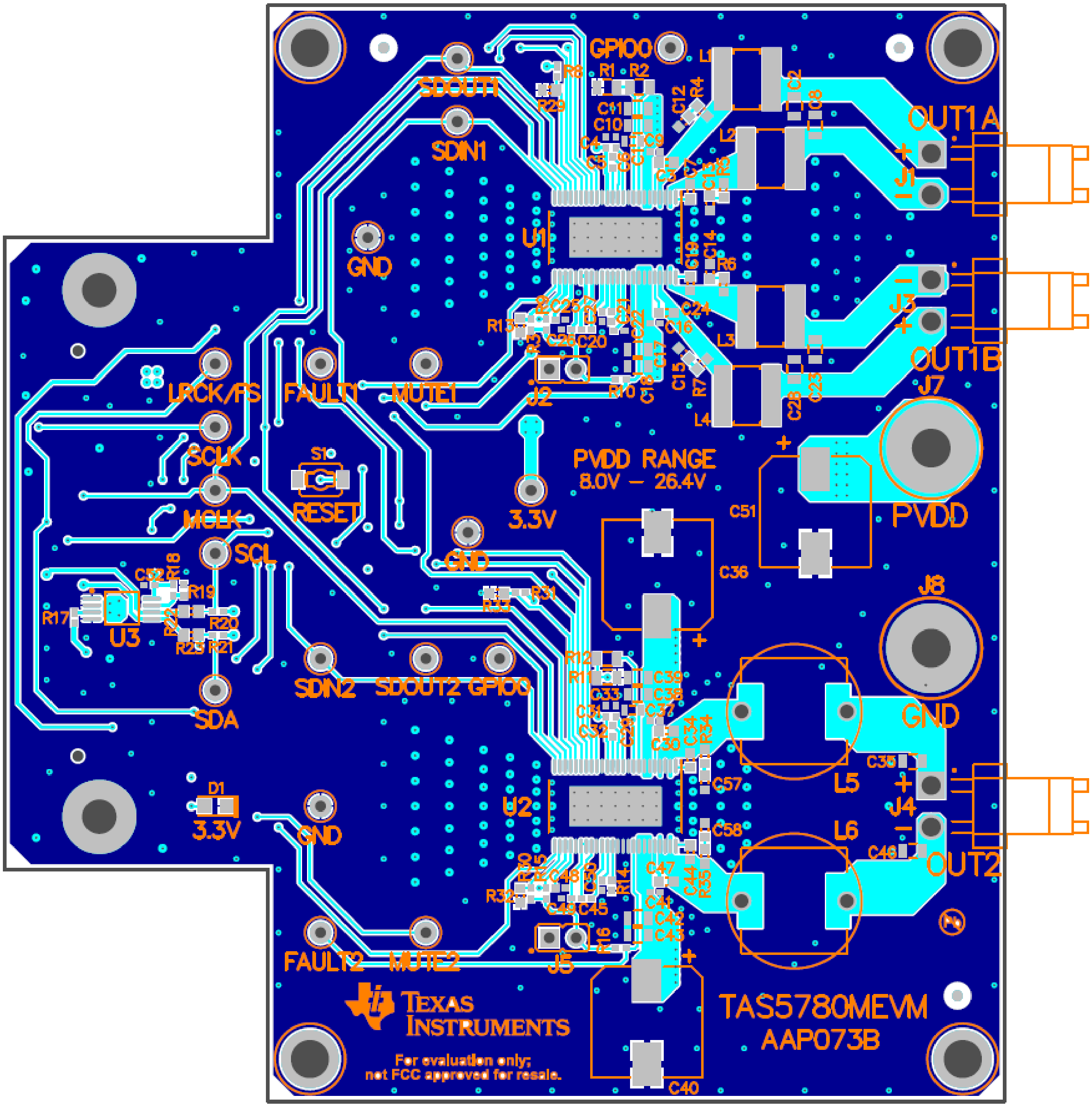

Figure 33. Top Composite Assembly

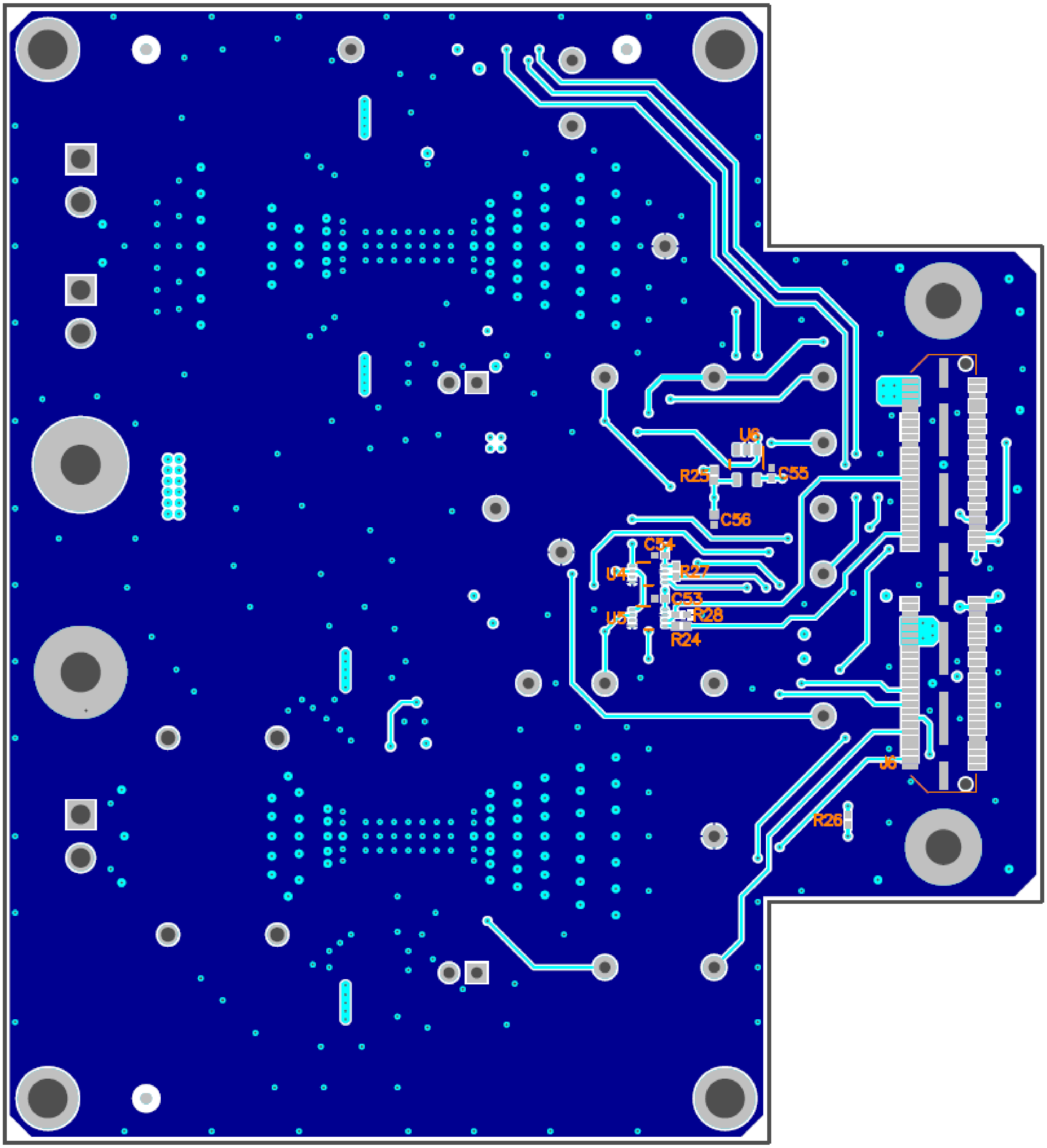

Figure 34. Bottom Composite Assembly

4.3 Bill of Materials

Table 3. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C1, C29	2	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0603	0603	GRM185R61C105KE44D	MuRata		
C2, C8, C23, C28, C35, C46	6	0.68uF	CAP, CERM, 0.68 µF, 50 V, +/- 20%, X7R, 0805	0805	C2012X7R1H684M125AB	TDK		
C3, C7, C19, C24, C30, C34, C44, C47	8	0.22uF	CAP, CERM, 0.22 µF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H224K080AB	TDK		
C4, C20, C25, C26, C27, C31, C45, C48, C49, C50	10	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0402	0402	C1005X5R1C105K050BC	TDK		
C5, C6, C21, C22, C32, C33	6	2.2uF	CAP, CERM, 2.2 µF, 16 V, +/- 10%, X5R, 0402	0402	C1005X5R1C225K050BC	TDK		
C9, C16, C37, C41, C52, C53, C54, C55	8	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK		
C10, C11, C17, C18, C38, C39, C42, C43	8	22uF	CAP, CERM, 22 µF, 35 V, +/- 20%, JB, 0805	0805	C2012JB1V226M125AC	TDK		
C36, C40, C51	3	390uF	CAP, AL, 390 µF, 35 V, +/- 20%, 0.08 ohm, SMD	10x10	UCL1V391MNL1GS	Nichicon		
C56	1	47pF	CAP, CERM, 47pF, 25V, +/-5%, C0G/NP0, 0402	0402	GRM1555C1E470JA01D	MuRata		
D1	1	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On		
H1, H2, H3, H4	4		MACHINE SCREW PAN PHILLIPS M3	M3 Screw	RM3X8MM 2701	APM HEXSEAL		
H5, H6, H7, H8	4		Washer, Flat, #4 Nylon		3200	Keystone		
H9, H10, H11, H12	4		Standoff, HexBrass M3, 30 mm	Spacer M3, 30mm	R30-1003002	Harwin		
J1, J3, J4	3		Header (friction lock), 3.96mm, 2x1, Tin, R/A, TH	Header, 2x1, 3.96mm, R/A	B2PS-VH(LF)(SN)	JST Manufacturing		
J2, J5	2		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
J6	1		Connector, 100 Pos. 0.635mm, SMT	Connector, 1575x235x280 mil	QTS-050-01-F-D-A	Samtec		
J7	1		Binding Post, RED, TH	11.4x27.2mm	7006	Keystone		
J8	1		Binding Post, BLACK, TH	11.4x27.2mm	7007	Keystone		
L1, L2, L3, L4	4	4.7uH	Inductor, Shielded, 4.7 µH, 4 A, 0.023 ohm, SMD	6.3x4.5x6.3mm	1255AY-4R7M=P3	MuRata Toko		
L5, L6	2	4.7uH	Inductor, Wirewound, Ferrite, 4.7 µH, 8.7 A, 0.0085 ohm, TH	D12.8xH9mm	744750420047	Wurth Elektronik		
R1, R11	2	750k	RES, 750 k, 1%, 0.125 W, 0805	0805	ERJ-6ENF7503V	Panasonic		
R2, R12	2	150k	RES, 150 k, 1%, 0.125 W, 0805	0805	ERJ-6ENF1503V	Panasonic		
R9, R10, R15, R16, R17, R19	6	10.0k	RES, 10.0 k, 1%, 0.063 W, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R13, R22, R23, R29, R33	5	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R14	1	49.9k	RES, 49.9 k, 1%, 0.063 W, 0402	0402	CRCW040249K9FKED	Vishay-Dale		
R20, R21	2	2.20k	RES, 2.20 k, 1%, 0.063 W, 0402	0402	CRCW04022K20FKED	Vishay-Dale		
R24	1	49.9	RES, 49.9, 1%, 0.063 W, 0402	0402	CRCW040249R9FKED	Vishay-Dale		

Table 3. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R25, R27, R28, R30	4	10.0k	RES, 10.0k ohm, 1%, 0.063W, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R26	1	332	RES, 332, 1%, 0.063 W, 0402	0402	CRCW0402332RFKED	Vishay-Dale		
S1	1		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	Switch, 4.4x2x2.9 mm	TL1015AF160QG	E-Switch		
SH1, SH2	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP16, TP17	15		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone		
TP14	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP15, TP18, TP19	3		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
U1, U2	2		Digital Input, Closed-Loop Class-D Amplifier with 96-kHz Processing, DCA0048G (TSSOP-48)	DCA0048G	TAS5780MDCAR	Texas Instruments	TAS5780MDCA	Texas Instruments
U3	1		EEPROM, 512KBIT, 400KHZ, 8TSSOP	TSSOP-8	24LC512-I/ST	Microchip		
U4, U5	2		Single 2-Line to 1-Line Data Selector Multiplexer, DCU0008A	DCU0008A	SN74LVC2G157DCUR	Texas Instruments	SN74LVC2G157DCUT	Texas Instruments
U6	1		Processor Supervisory Circuit, DBV0005A	DBV0005A	TPS3825-33QDBVRQ1	Texas Instruments		Texas Instruments
C12, C13, C14, C15, C57, C58	0	330pF	CAP, CERM, 330 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H331JA01D	MuRata		
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
R3, R8, R31	0	10.0k	RES, 10.0k ohm, 1%, 0.063W, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R4, R5, R6, R7, R34, R35	0	18	RES, 18, 5%, 0.1 W, 0603	0603	CRCW060318R0JNEA	Vishay-Dale		
R18	0	10.0k	RES, 10.0 k, 1%, 0.063 W, 0402	0402	CRCW040210K0FKED	Vishay-Dale		
R32	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including 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 and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

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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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

   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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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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8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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