EVM User's Guide: TAS2783EVM

TAS2783 Evaluation Module

Description

The TAS2783EVM has been designed to demonstrate the performance of TAS2783 in a mono configuration. This evaluation module features an MCU to allow I^2S/TDM + I^2C to control the TAS2783 device over a USB connection. The evaulation module also features a boost converter IC to allow easy evaluation of the TAS2783 with a Class-H boost, as shown in the Class-H Boost Converter section. Up to eight devices can share a common bus through I^2S/TDM + I^2C, or through the SoundWire® Interface. Multiple TAS2783EVM can be interconnected for two to eight channel evaluation, as shown in the Multiple EVM Configuration section.

Get Started

1. Download TAS2783 data sheet
2. Order EVM and request access and download PPC3 from TAS2783 product folder
3. Visit and ask questions at e2e forum

Features

- USB Interface
- Software control via PurePath™ Console 3 (PPC3) GUI, USB-HID
- USB-class audio device, compatible with Microsoft® Windows® 7+
- External 100-mil headers
- SoundWire® 1.2 interface
- PSIA – I^2S/TDM interface
- I^2C interface
- Hardware Shutdown Control
- Interrupt Output
- Class-H Boost Converter

Applications

- Notebook PC, Chromebook, and tablets

Copyright © 2024 Texas Instruments Incorporated

1 EVM 3D View

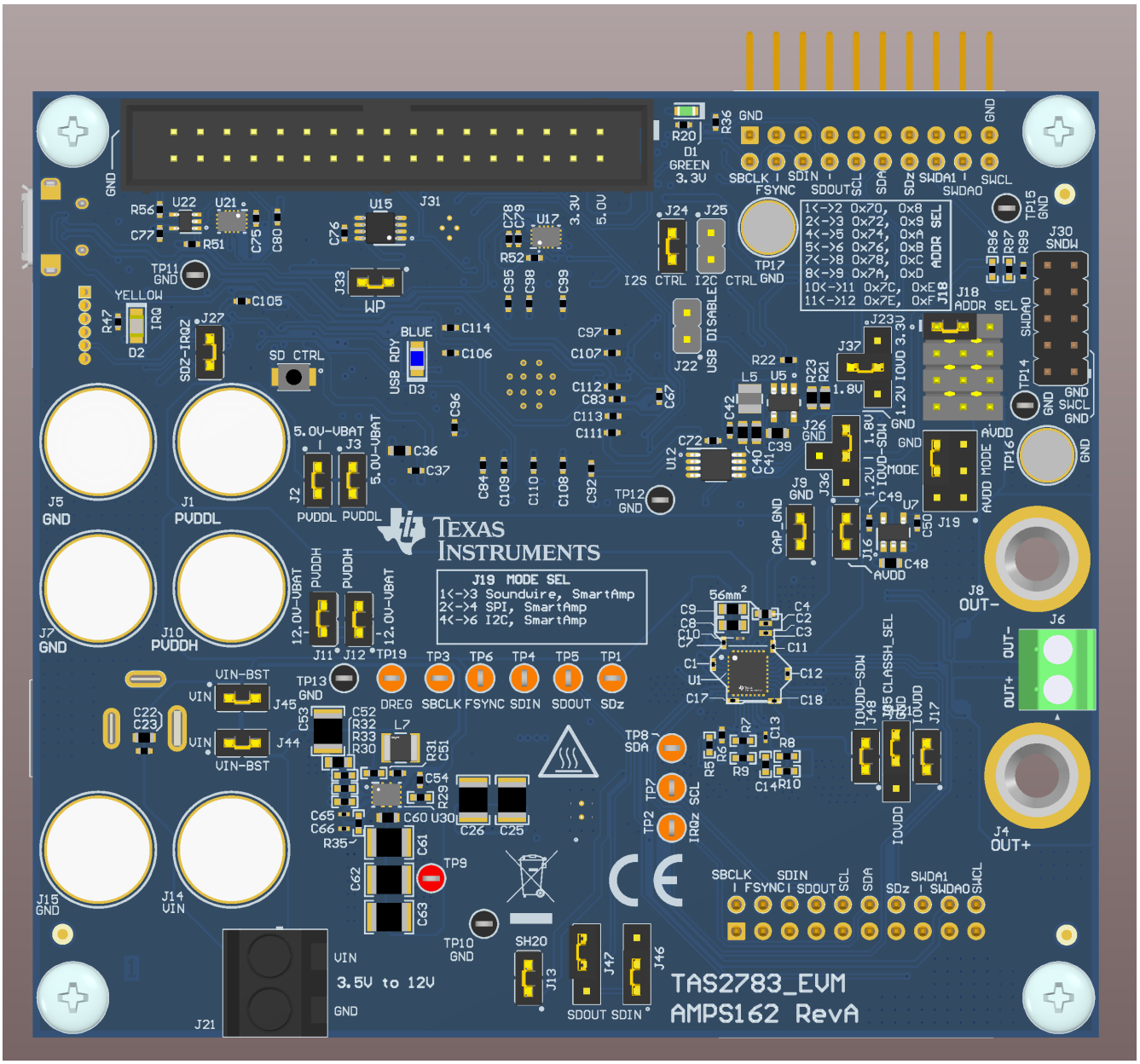


Figure 1-1. TAS2783EVM 3D View Top

Copyright © 2024 Texas Instruments Incorporated

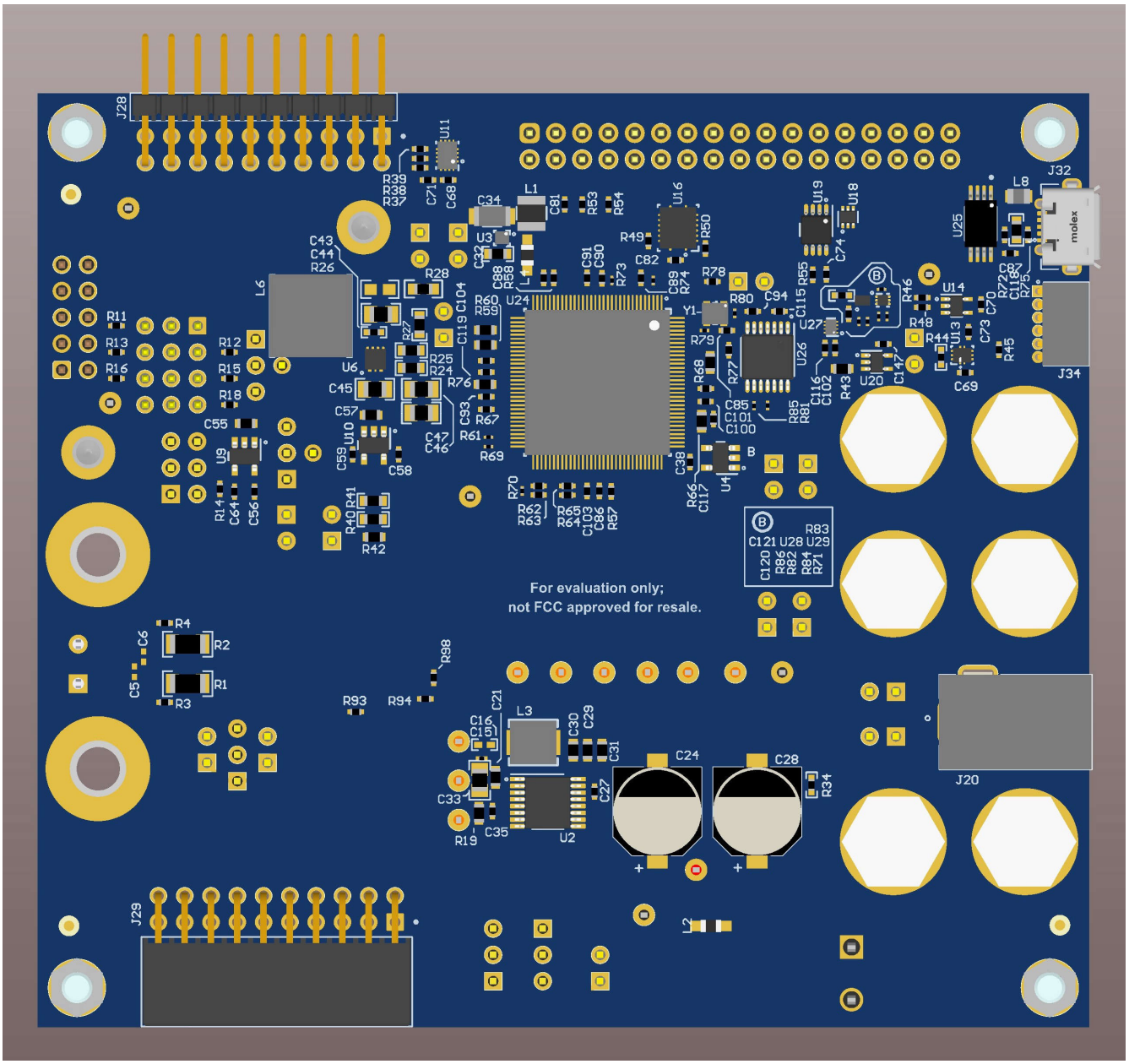


Figure 1-2. TAS2783EVM 3D View Bottom

Copyright © 2024 Texas Instruments Incorporated

2 Evaluation Module Overview

2.1 Introduction

This user's guide describes the function and use of the TAS2783EVM. This document includes the hardware configuration instructions, a quick-start guide, jumper and connector descriptions, software description, schematics, and printed circuit board (PCB) layout that demonstrate TI's recommended practices for these devices.

This section provides details on what is included inside the evaluation module box, what are TAS2783 capabilities and operation ranges, as well as what is the additional test equipment that can be required for a full audio evaluation.

2.2 Kit Contents

The evaluation kit consists of the following items:

- TAS2783EVM

A speaker is not included in the kit, however any speaker can be connected to each of the amplifiers outputs using the banana jacks, or screw terminals

Similarly, a power supply is not part of the kit, but a VIN supply of 3.5V to 12V can be connected to J14, J20 or J21.

2.3 Specifications

The TAS2783EVM is designed to demonstrate the performance of TAS2783 in a mono configuration. The TAS2783EVM can be connected to a PC through a USB connection. The evaluation kit works as any other soundcard. I^2S/TDM and I^2C can be interfaced externally with the TAS2783 device through the input header J28 as described in External I^2S/TDM and I^2C. The TAS2783 SoundWire® Interface is available for external connection at J30. The TAS2783EVM can be powered entirely from a single VIN supply provided from either J14,J20 or J21. Alternativly the supply rails can be provided externally. PVDDH at J10, PVDDL at J1, AVDD at J16, IOVDD at J17, and IOVDD_SDW at J48. This allows for easy evaluation of TAS2783 performance unders specific supply conditions. When supplying TAS2783 power externally be sure to reference Power Requirements.

2.4 Device Information

TAS2783 is a mono, digital-input, Class-D audio amplifier optimized for efficiently driving high peak power into a variety of loudspeakers for various audio applications. Y-Bridge technique is implemented at the output stage of the amplifier so that the device can change from two different voltage rails depending on the amount of power required at the output, improving efficiency significantly at lower power. The Class-D amplifier is capable of delivering 25W of output power into a 4Ω load at a source voltage of 16V. Integrated speaker voltage and current sense provides real time monitoring of speaker parameters like DC resistance and resonant frequency to protect the loudspeaker from mechanical or electrical damage. TAS2783 support SoundWire® and I^2S/TDM, I^2C interfaces.

Copyright © 2024 Texas Instruments Incorporated

3 Mono Setup Quick Start

Use the following instructions to complete a mono setup:

1. Install PPC3 with the TAS2783 plug-in.
2. Connect a speaker to J6.
3. Connect a 3.5V to 12V supply to connector J14, J20 or J21.
4. Connect a Micro USB Cable from PC to TAS2783EVM.
5. Verify that TI USB Audio UAC2.0 is the default playback device by opening the sound dialog from the Windows Control Panel.

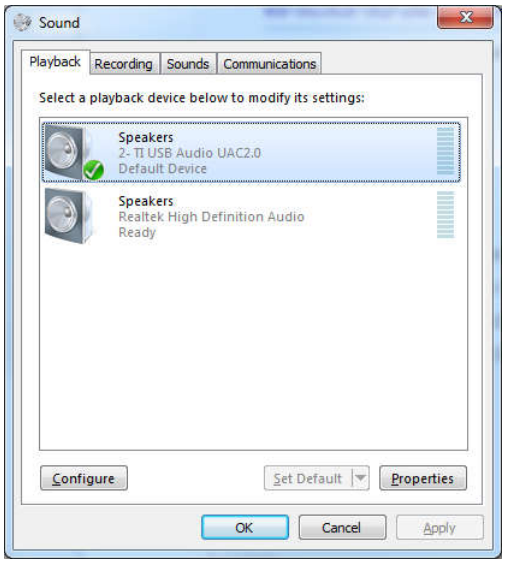


Figure 3-1. Windows Playback Devices

6. Set the maximum bit depth using the Texas Instruments USB Audio Device Control Panel found in the system tray.

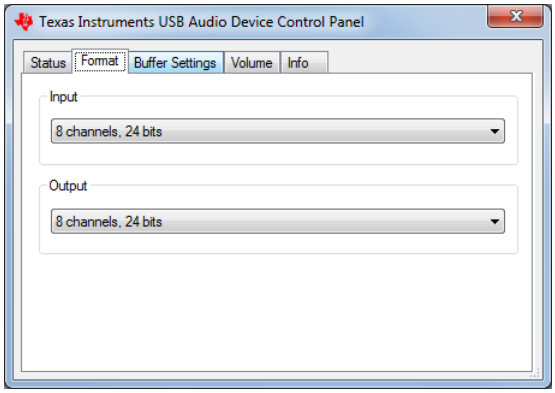


Figure 3-2. Texas Instruments USB Audio Device Control Panel

7. Set the sampling rate.
   - Right click TI USB Audio UAC2.0
   - Select Properties
   - Click Advanced tab
   - Select Rate

Copyright © 2024 Texas Instruments Incorporated

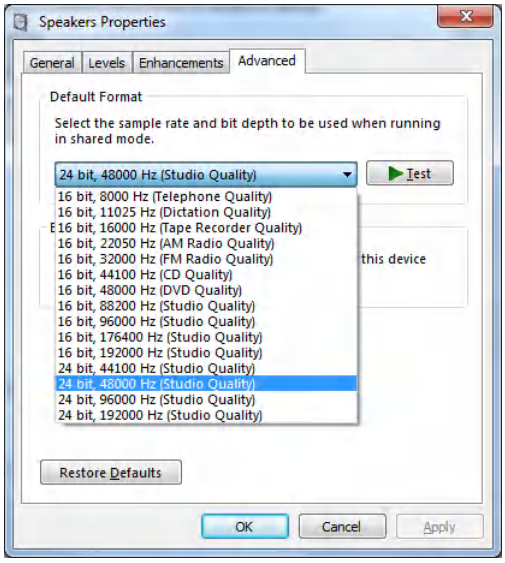


Figure 3-3. Windows Playback device Sample Rate

8. Open PPC3 and TAS2783 EVM plug-in.
9. Select the desired speaker configuration.
10. Connect the EVM to PPC3 by clicking on the connect button in the lower-left corner.
11. Open the Device Control panel from TAS2783 EVM Home.
12. Select ROM Mode from the drop-down menu.
13. Click the Apply button to initialize the device to default settings.
14. At this point the device is ready to play audio content through USB, for example, any sound card.
15. For initializing the Smart Amplifier features please refer to Software.

Copyright © 2024 Texas Instruments Incorporated

4 Hardware

4.1 Jumper Settings

Table 4-1. Default Jumper Settings

Jumper	Setting	Description
J2	Insert	PVDDL Current Sense
J3	Insert	PVDDL Current Sense
J9	Insert	Additional PVDDL Decoupling
J11	Insert	PVDDH Current Sense
J12	Insert	PVDDH Current Sense
J13	Insert	Bypass PWM Control, connect PWM_CTRL signal to boost converter
J16	Insert	AVDD Current Sense
J17	Insert	IOVDD Current Sense
J18	Insert (1-2)	I^2C Address 0x70 SDW Unique Id 0x8
J19	Insert (4-6)	I^2C, SmartAmp
J22	DNI	USB Disable
J23	Insert (1.8V)	1.8 V IOVDD Select
J24	Insert	I^2S USB Control. Insert for I^2S from USB, remove for I^2S from Input header J28
J25	DNI	I^2C USB Control. Insert for I^2C from USB, remove for I^2C from Input header J28
J27	Insert	SDz and IRQz USB Control
J33	Insert	EEPROM Write Protect
J35	Insert (2-3)	Class-H Select. 2-3 for boost always 12.5V, 1-2 for multilevel Class-H
J44	Insert	Boost Current Sense
J45	Insert	Boost Current Sense
J46	Insert (1-2)	SDIN Crossbar Select
J47	Insert (1-2)	SDOUT Crossbar Select
J48	Insert	IOVDD-SDW Current Sense
J49	Insert (1.8V)	1.8V IOVDD-SDW Select

4.2 Power Supply Configurations

TAS2783EVM provides flexible power supply configurations for different performance tests and use cases.

By default, the board is completely supplied by VIN which can be supplied by J14, J20 or J21 from 3.5V to 12V. This voltage is used to generate all the voltage rails: 5V for PVDDL, 12.5V for PVDDH, 3.3V, 1.8V, 1.2V, and 1V for different logic levels.

Alternatively, PVDDL and PVDDH can be supplied directly from an external supply using J1 and J10 connectors respectively. Remove J2 and J3 when using an external PVDDL voltage on J1. Remove J11 and J12 when using

Copyright © 2024 Texas Instruments Incorporated

an external PVDDH voltage on J10. Make sure VIN is still being supplied as this voltage is used to generate different lower voltage rails on the board. Consider the voltage range for each supply rail as described in Power Requirements.

4.3 Power Requirements

Recommended Operating Conditions lists the supply, input, and output requirements for TAS2783.

Table 4-2. Recommended Operating Conditions

Parameter	Value
Supply Voltage - PVDDL	2.7 to 5.5V
Supply Voltage - AVDD	1.65 to 1.95V
Supply Voltage - IOVDD	1.65 to 1.95V or 3 to 3.6V
Supply Voltage - IOVDD_SDW	1.65 to 1.95V
Supply Voltage - PVDDH	4.5V to 24V
Input Logic I2S/I2C	IOVDD
Input Logic SNDW	IOVDD_SDW
Output Power	25W
USB, USB class-audio	Micro-USB

4.4 Class-H Boost Converter

The TAS2783EVM has an on-board boost converter TPS61089. By default this boost converter supplies a constant 12.5V DC to the TAS2783 PVDDH supply. The EVM is configurable to support multi-level Class-H.

To configure the boost to provide a constant 12.5V configure the relevant jumper as shown in the table below.

Table 4-3. Jumper settings for fixed 12.5V boost

Jumper	Setting
J11	Insert
J12	Insert
J13	Insert
J35	Insert (2 - 3)
J44	Insert
J45	Insert

To configure the boost IC to be usable as a multi-level Class-H boost configure the relevant jumpers as shown in the table below.

Table 4-4. Jumper settings for Class-H operation

Jumper	Setting
J11	Insert
J12	Insert
J13	Insert
IOVDD Select (J23+J37)	Insert (1.8V)
J35	Insert (1 - 2)
J44	Insert
J45	Insert

Copyright © 2024 Texas Instruments Incorporated

To use the multi-level Class-H boost, select an Audio Mode in the Tuning and Audio Processing Panel that has the "External Class-H" feature. Once selected the controls for this feature are in the Device Control Panel. In Device Control find the Class-H window. Enter the following settings to enable the default Class-H configuration. Once the settings are entered press the Apply button in Device Control.

Table 4-5. EVM Default Class-H Setting for PPC3

Relevant Class H Setting	Value
IOVDD Voltage	1.8V
HPFB PWM Steps	8-steps or 16-steps
Open Drain	YES
Min Voltage	4.6V
Max Voltage	12.6V
FB Reference Voltage	1.212V
R1 resistance	330kOhm
Cut-off Frequency (Fc)	1kHz

4.5 Test Points

TAS2783EVM provides several test points for debugging and analysis purposes, Table 4-6 lists these test points along with a brief description of each signal.

Table 4-6. Test Points

Name	Signal Name	Description
TP1	SDz	Shutdown signal, pull-down externally to shutdown TAS2783
TP2	IRQz	Interrupt signal, pull-down by TAS2783 for signaling
TP3	SBCLK	Bit clock for TDM interface
TP4	SDIN	Data in for TDM interface
TP5	SDOUT	Data out for TDM interface
TP6	FSYNC	Frame sync for TDM interface
TP7	SCL	Clock for I^2C interface
TP8	SDA	Data for I^2C interface
TP10 - TP17	GND	GND reference

4.6 Multiple EVM Configuration

The TAS2783EVM is designed to be connectable with other EVMs to easily evaluate multi channel operation. The input header J28 can be mated to another EVMs output header J29. This header handles I^2S, I^2C, Shutdown, and SoundWire signals.

To enable two EVMs in a stereo setup:

1. Configure both EVMs jumpers as described in Jumper Settings
2. Connect the EVMs together as shown in the below image
3. On EVM 'B' remove J24 and populate J25
4. On EVM 'B' increment the I^2C address on J18. In the below example EVM 'A' is 0x70 and EVM B is 0x72
5. Either power both boards VIN seperatly through J14, J20 or J21. Alternatively a single supply can be used and J14 and J15 can be shorted between the boards using cables.
6. Insert micro USB in EVM 'A'
7. Connect to PPC3

Copyright © 2024 Texas Instruments Incorporated

For more than two channels the configuration is the same. Simply make sure that each EVM has a unique I²C address.

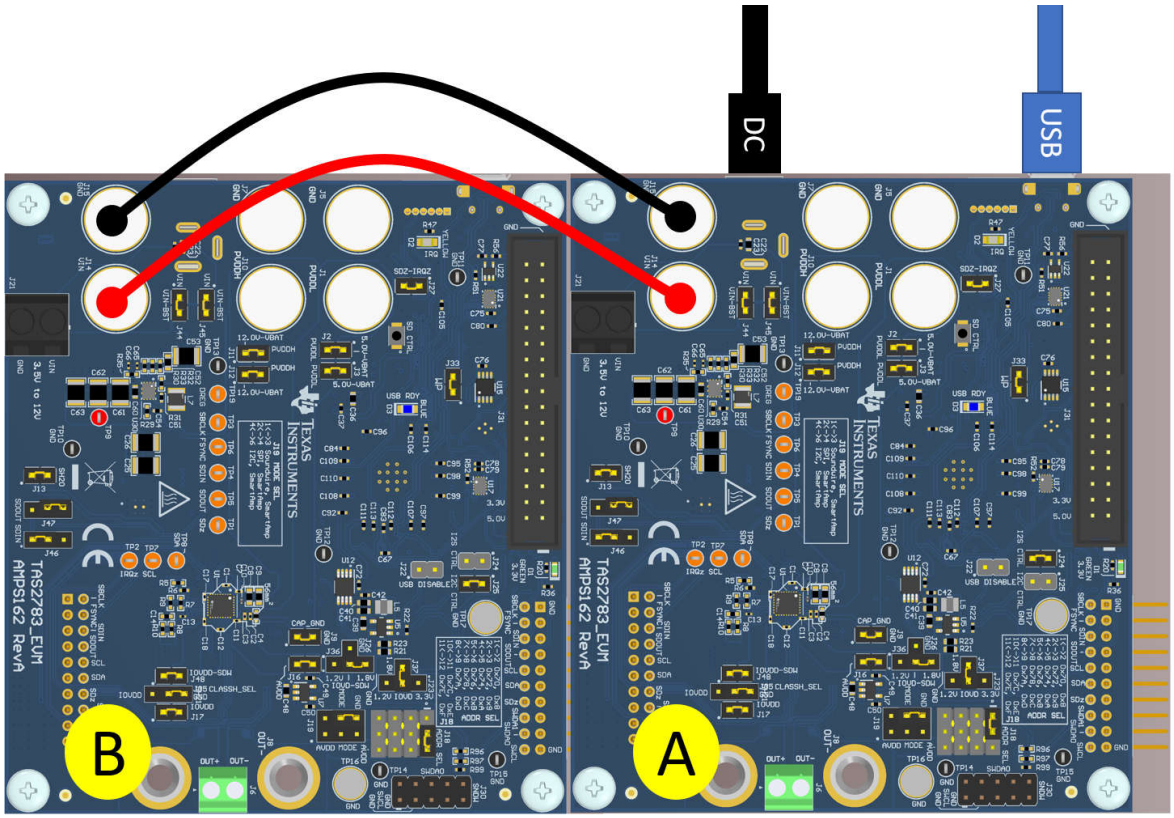


Figure 4-1. TAS2783EVM Stereo configuration

4.7 External I²S/TDM and I²C

The TAS2783EVM has an onboard MCU which handles the USB to I²S/I²C translation. The default EVM configuration is I²S/I²C from this MCU. If an external source such as Audio precision test equipment, or system prototype is desired to control the EVM, or if the EVM is being connected to another TAS2783EVM the Input header J28 can be used. The IO voltage of J28 is selectable using J23 in combination with J37. The IO voltage is selectable as 1.2 V, 1.8 V, or 3.3 V. Please note that TAS2783 does not support 1.2V signaling for I²S or I²C. 1.2 V IO voltage is only to be used in the case where 1.2 V SoundWire is being used along with a shutdown signal, SDZ, at the same 1.2 V IO voltage.

I²S control

J24	I2S Source
Insert	USB
Remove	Input header J28

I²C control

J25	I2C Source
Insert	Input header J28
Remove	USB

Copyright © 2024 Texas Instruments Incorporated

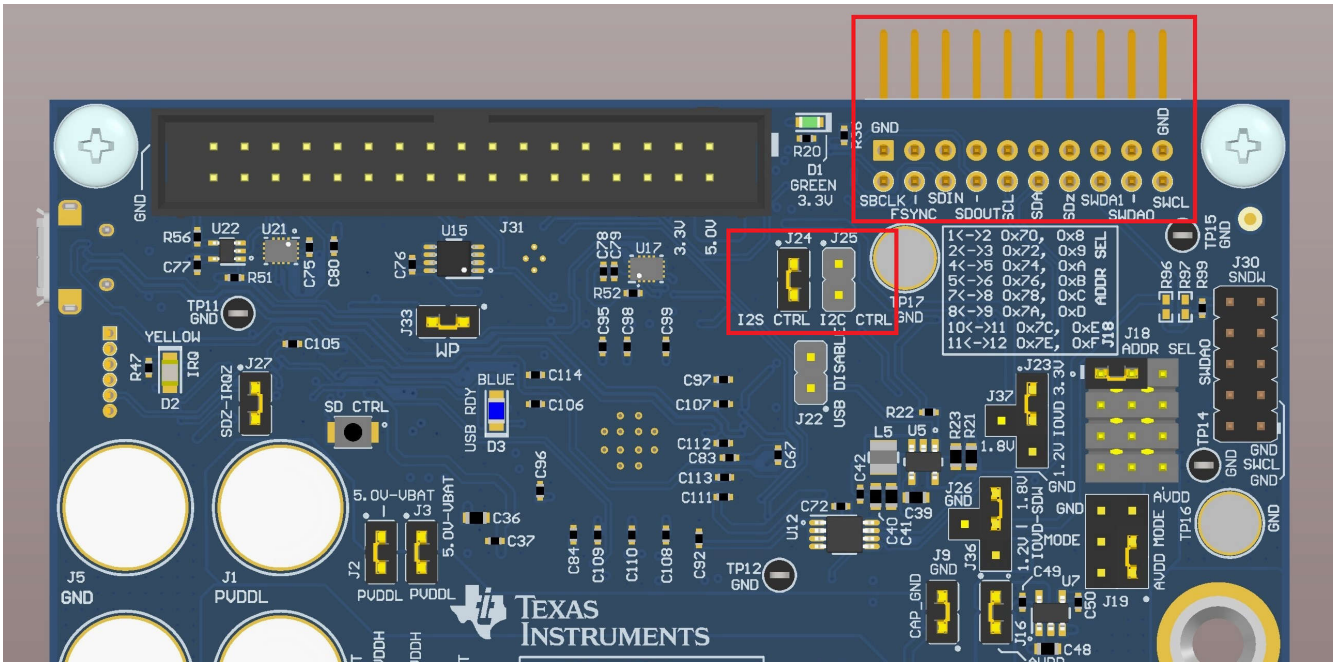


Figure 4-2. I²S/TDM and I²C Selector and Source

4.8 SoundWire Connector

The TAS2783EVM features a 100 mil header, J30, to allow direct connection to the SoundWire pins of the TAS2783 Device. This header features one SoundWire cock and two SoundWire data connections. The SoundWire signals are continuous with the pins of TAS2783. The IO voltage of the soundwire bus on the

Copyright © 2024 Texas Instruments Incorporated

TAS2783EVM should be selected to match the IO voltage of the host. This IO voltage can be selected using J36. IO voltages of 1.8 V and 1.2V are supported.

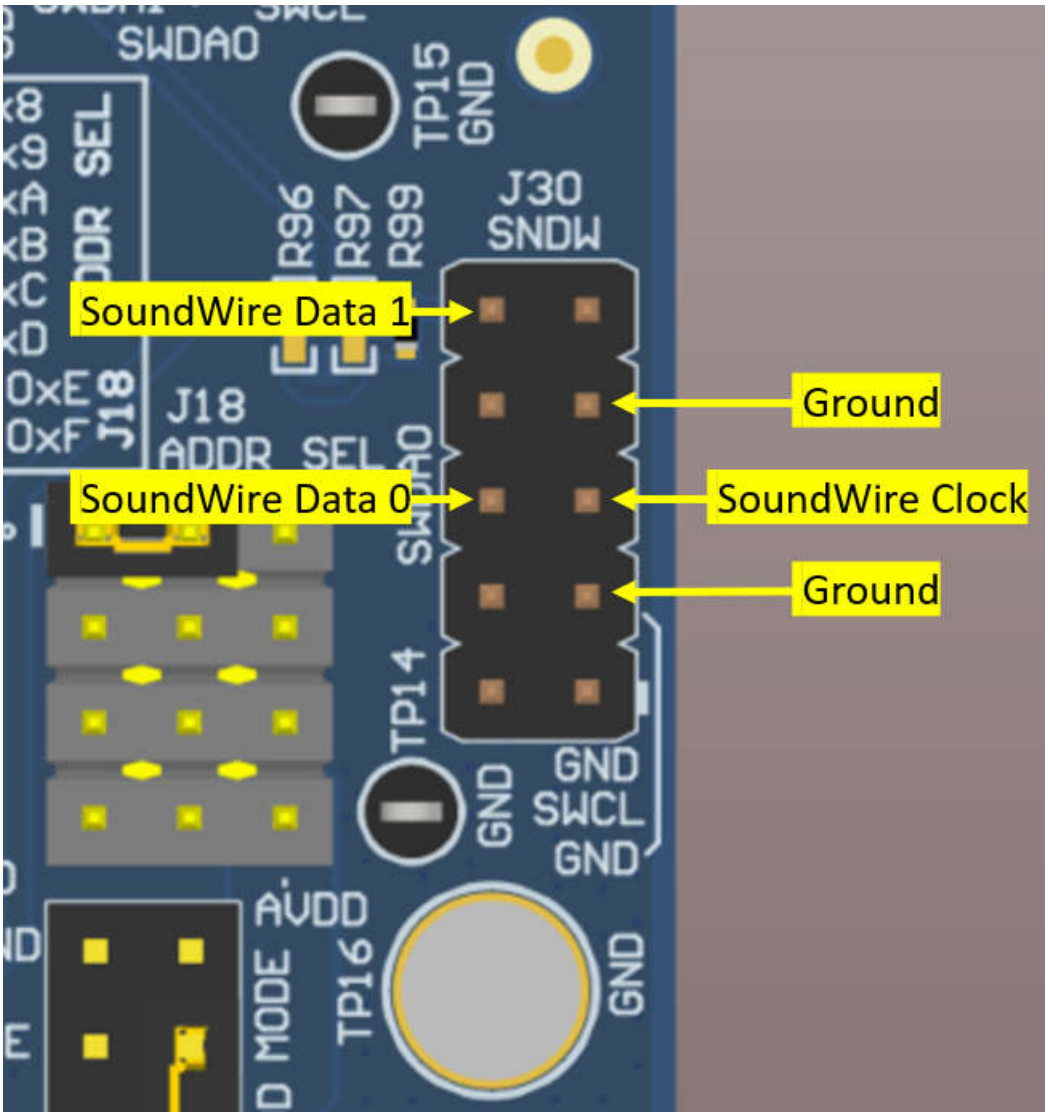


Figure 4-3. TAS2783EVM SoundWire Connector

5 Software

The TAS2783EVM can be easily configured with PPC3 GUI software.

5.1 PPC3 Overview

PurePath Console 3 (PPC3) is TI's GUI tool for configuring and tuning TI's Smart Amplifiers and Audio Converters. PPC3 allows for configuration of the devices datasheet features, Speaker characterization, Acoustic tuning, Direct I^2C configuraiton, and end-system integration.

Copyright © 2024 Texas Instruments Incorporated

In this section we will cover the basic functionalities of some of PPC3's key features.

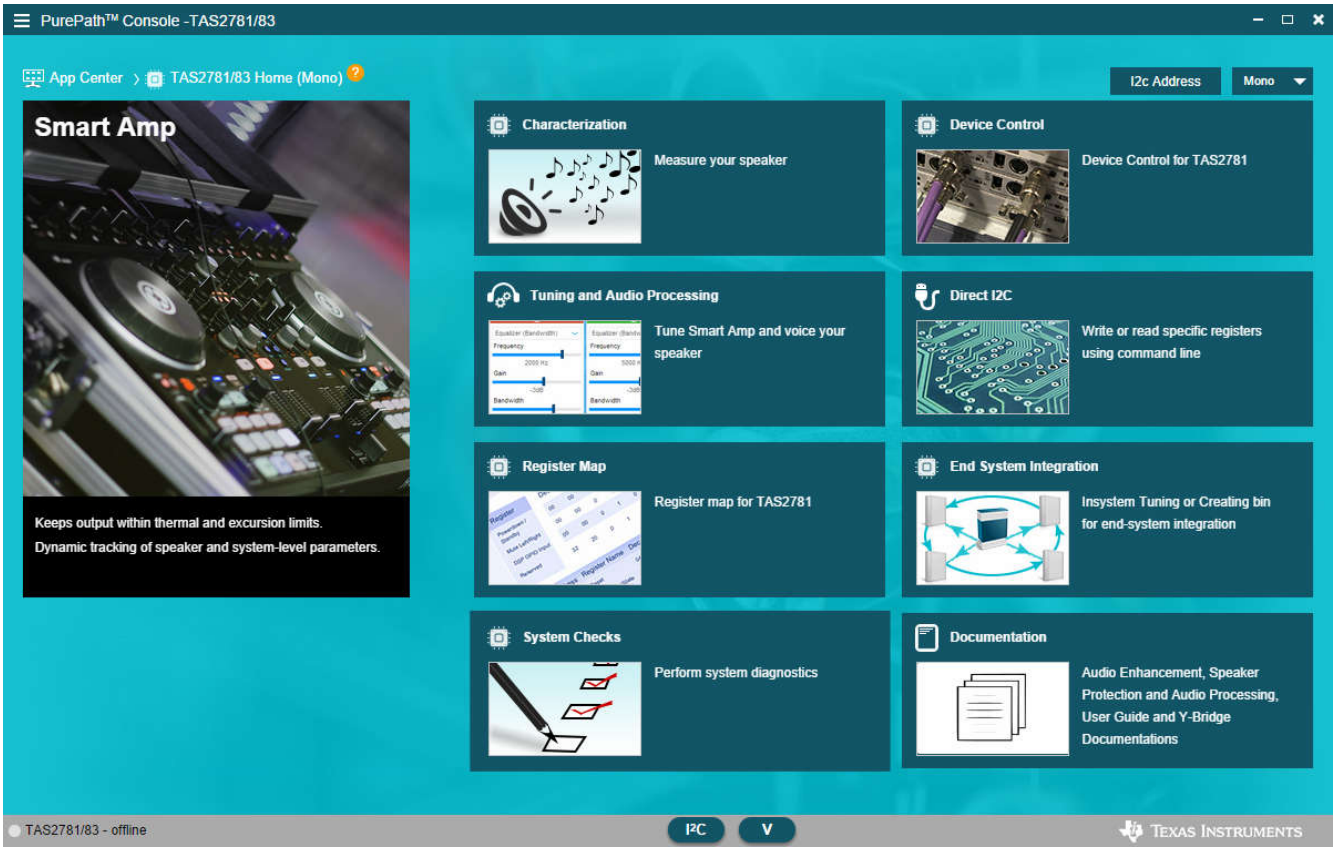


Figure 5-1. PPC3 Homepage

After launching the TAS2781/3 PPC3 application you will be prompted to select your speaker configuration, first select the number of amplifiers used in the dropdown menu, and then the specific configuration desired before beginning tuning your TAS2783 Smart Amplifier.

Copyright © 2024 Texas Instruments Incorporated

If you already have a tuning file it can be loaded by selecting the browse options and locating the existing .ppc3 file.

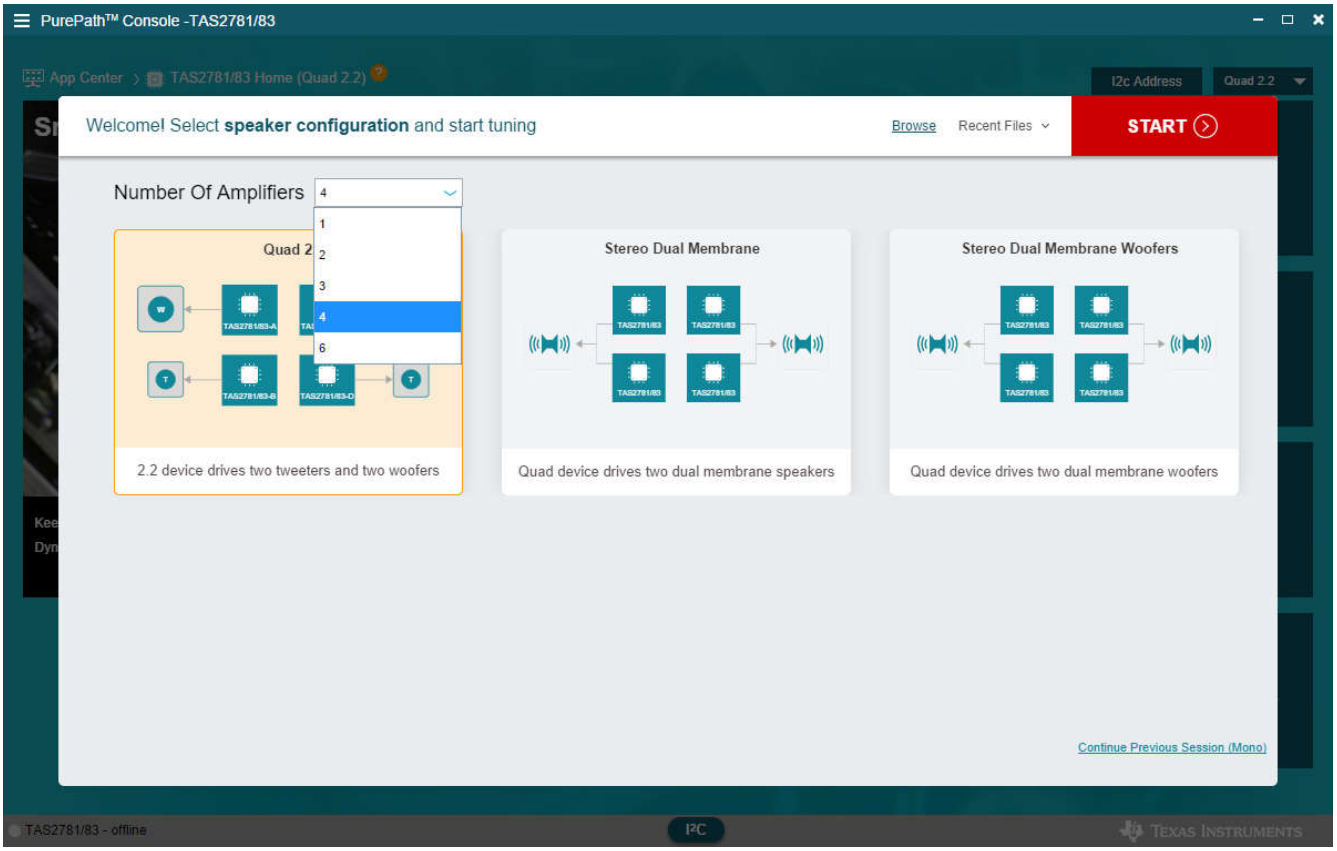


Figure 5-2. Speaker Configuration

5.2 Device Control Panel

Device control should be the first item configured when tuning TAS2783. This panel can be used to control all the datasheet features in TAS2783. For any details on each specific feature please refer to the TAS2783 data sheet. The controls are displayed in basic mode by default, for most users and use cases this is sufficient to configure the device. For advanced users and specific use cases, the advanced mode can be selected.

Key items to configure for any project in this panel are:

1. Power Mode - this is selecting which supply rails will be supplying the Class-D amplifier.
   a. PWR_MODE0 - The Class-D will only ever be switching to PVDDH.
   b. PWR_MODE1 - The Class-D will be in Y-bridge operation. The Class-D will switch to PVDDL when the output power is low. This is typically when the output power is below approximately 1W, depending on the specific settings. Conversely, the Class-D will switch to PVDDH when the output is higher than that 1W threshold. The transition will occur seamlessly without distortion due to TI's ultra-high PSRR.
   c. PWR_MODE2 - A 5V PVDDL will be generated internally from PVDDH. PVDDL does not need to be supplied externally and the Class-D will be switching to PVDDH. The Class-D will only switch to PVDDL when the audio level is lower than ~-100dBFS.
   d. PWR_MODE3 - this is a specialized power mode intended for lower power operation. This mode is intended to be used when the system may be idle. For example, when playing ultrasound for presence detection.
2. Amplifier Level - this is the amplifier's channel gain. The default value is 21dBV. Or 15.8Vpeak for a 0dBFS audio signal. The channel gain setting should be set such that a 0dBFS audio signal is *almost* clipping the PVDDH supply. Consider your system's PVDDH supply voltage and set the channel gain appropriately.
3. Other settings in the device control panel can be configured as needed, some settings and features may not apply to your end system. For additional clarity on these features please refer to the TAS2783 datasheet.

Copyright © 2024 Texas Instruments Incorporated

Some important controls are located on the navigation bar at the top right:

1. Tuning Mode/ROM Mode dropdown menu. Tuning Mode is the mode in which the DSP features are active (SmartAmp Protection, DRC, EQ, DEQ, Piano Noise Reducer, and so on). ROM Mode is bypassing all of these features and allowing TAS2783 to act as a simple Class-D amplifier. ROM Mode is useful when characterizing the system performance, such as efficiency and THD+N - All datasheet specifications are given in ROM Mode.
2. IRQ button is a useful tool during debugging, this pop-up window shows all the interrupt flags for both Live and Latched status. If you are facing any issues and are unable to get playback from the speaker, checking these flags can often give a clue to the issue.
3. The data Read button shows a pop-up window with the data obtained from internal SAR ADC conversion such as PVDDL, PVDDH, and Die Temperature, as well as the Sample Rate detected from the digital audio interface.
4. Apply button must be used to configure the device with configuration options that are selected. It is important to use the Apply button every time a change is made in the features shown in the device control panel.

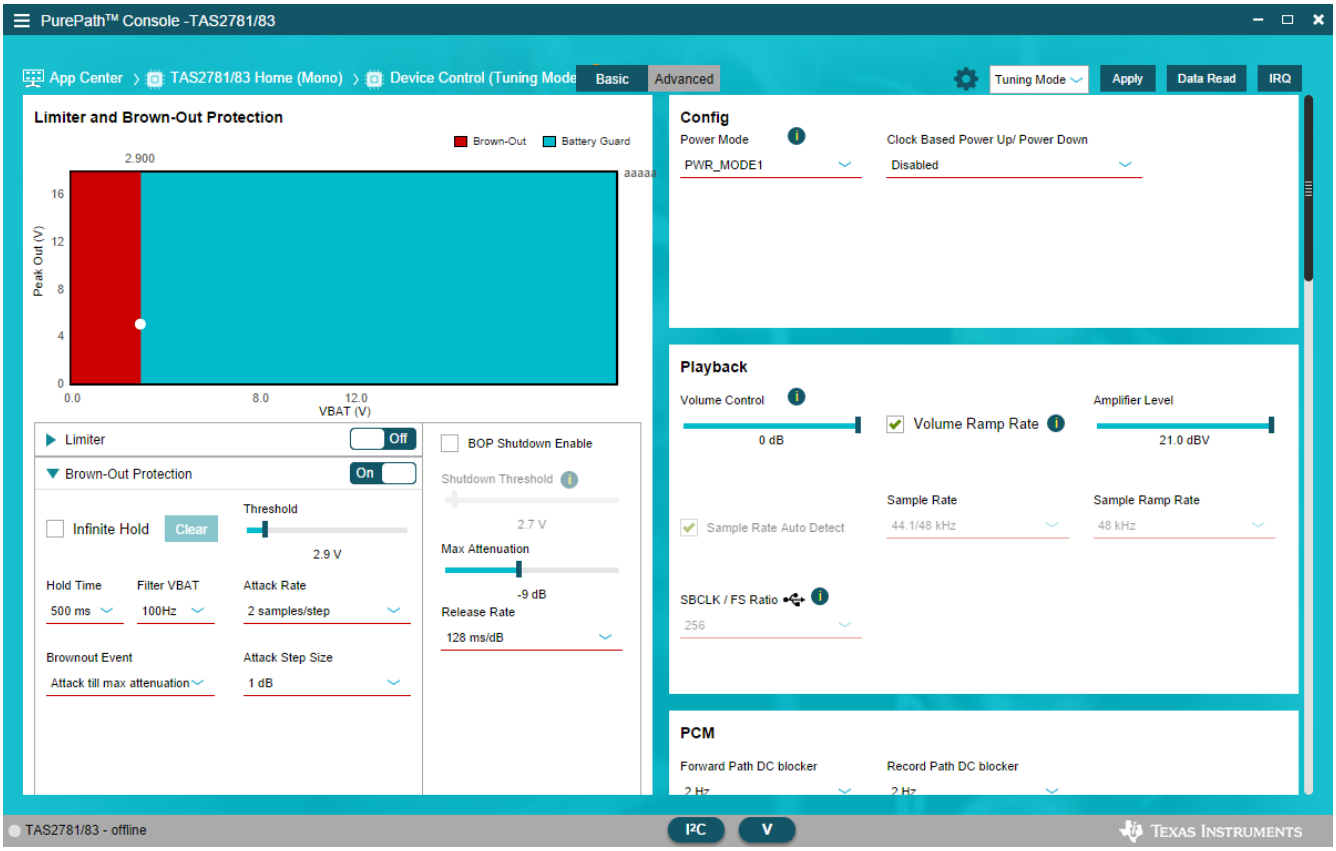


Figure 5-3. PPC3- Device Control Panel

5.3 Characterization

As its name implies, the Characterization panel holds the speaker's characterized data. It is critical to have this information accurately populated if you wish to use the SmartAmp Excursion or Thermal Protection. This section should be completed before continuing with the speaker tuning.

PPC3 supports speakers in both Thiele-Small or Lumped Physical models for excursion protection. Speaker models characterized on other test equipment or TI EVMs can be used. If your speaker vendor has provided these values to you they can be manually entered, otherwise, you can follow the PPC3 Characterization Wizard and characterize the speaker directly.

The thermal model (Proportional Gain, Integral Gain1, Integral Gain2, and Integral Cutoff) is unique to TIs algorithm and must be found through the characterization flow. Or the experienced user can tune them manually.

Copyright © 2024 Texas Instruments Incorporated

Previous generations of TI Smart amplifiers required additional hardware (PP-SALB2-EVM) to perform the PPC3 speaker characterization. In TAS2781/3 this requirement has been removed, and the speaker can be characterized using only the following.

1. TAS2783EVM
2. MicroUSB Cable
3. PC with PPC3
4. Optional (LK-G5001 Laser Controller and LK-H050 Laser Sensor
    a. The Laser sensor is only desired if the speaker's BL (force factor) is unknown. If it is known it can be entered manually, otherwise PPC3 will enter a conservative default value

This panel also holds the Safe Operating Area (SOA) limits of the speaker. These values should be provided by the speaker manufacture, found through advanced characterization such as Klippel test equipment, or the engineer can make an educated guess. Both the excursion limit and temperature limit have some margin included.

The excursion limit has some margin which should be entered by the engineer. Due to non-linearities in loudspeaker suspensions, the excursion will not be perfectly symmetrical in the positive and negative directions. For most speakers they will have a mechanical 'DC' offset at some frequencies. This DC offset should be found by playing tones across frequency and recording the excursion with a laser displacement sensor. Once quantified, this DC offset should be entered as a margin by clicking the 'i' icon.

The thermal limit margin should not be changed, this margin comes from the non-linearities of the IV-sense.

Other relevant items in this panel are the measured and modeled excursion and impedance plots. These can be referenced so the engineer can understand where the speaker may have the highest excursion, and how the Smart Amplifier may be limiting the output to prevent over-excursion.

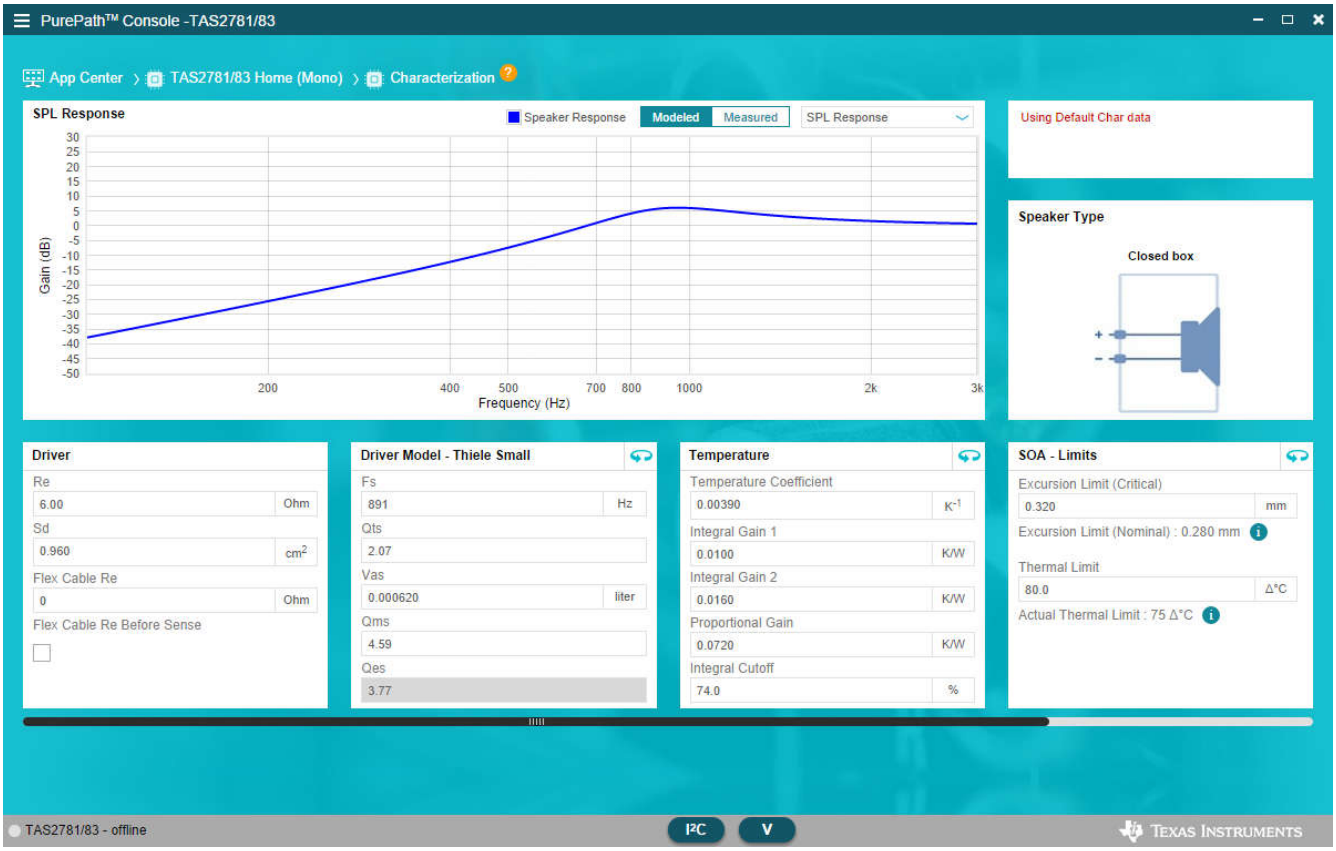


Figure 5-4. Characterization Panel

Copyright © 2024 Texas Instruments Incorporated

5.4 Tuning and Audio Processing

The Tuning and Audio Processing Panel is used for tuning the Smart Amplifier Protection and Audio Enhancement features. Tuning should only begin once the Device Control and Characterization Panels have been visited and adjusted appropriately.

When you first open this panel you will be prompted to select an audio mode. This is to select which Smart Amplifier features are to be enabled in the device. Choose the configuration based on the desired feature set in your end system.

Please note that if you select an audio mode that is using the External Class-H, those controls exist in the Device Control Panel.

Each DSP feature in the device is represented as its Panel.

1. Characterization Data - A quick access view of the current speaker's characterization data and SOA limits.
2. Smart Amp - Speaker protection, this panel allows for tuning of the Smart Amplifier protection time constants, and the amplifier's high pass filter.
3. Equalizer - multi-band parametric EQ.
4. DRC 3-Band - 3 Band RMS based Dynamic Range compressor,when tuned correctly, is useful for increasing perceived loudness and limiting distoriton.
5. VBAT Power Limiter - Dynamically limits output current to prevent brownout.
6. DEQ - Dynamic EQ - Narrow band EQ which only enables when audio is above a tuneable threshold. Used to limit distortion, rub, and buzz at problem frequencies like speaker resonance.
7. PBE - Psychoacoustic Bass Enhancer - generates harmonic bass content to give the perception of deeper bass. Most useful on small speakers.
8. Rattle Noise Suppressor - Single band DRC which will dynamically enable above a given threshold, useful to suppress narrow band signals which cause distortion or rattle, such as in the keyboards of notebook PCs.
9. TDM - Configure the ASI TX and RX from the TAS2783 Device.

Some other notable features:

- Tuning Snapshots - clicking the camera icon will save a 'snapshot' of the current tuning. Multiple snapshots can be saved at once so the tuning engineer can compare and contrast tuning flavors
- Import - this allows for tuning information from other ppc3 files to be imported.
- Block Diagram - to the right of the audio player, this icon will show the processing blocks in order of the signal flow.
- Volume Control - Digital volume
- Device slection - below the volume control, for multi-amplifier tuning files each channel can be selected and tuned independently

Copyright © 2024 Texas Instruments Incorporated

- Copy - allows for tuning and characterization to be copied from one channel to another.

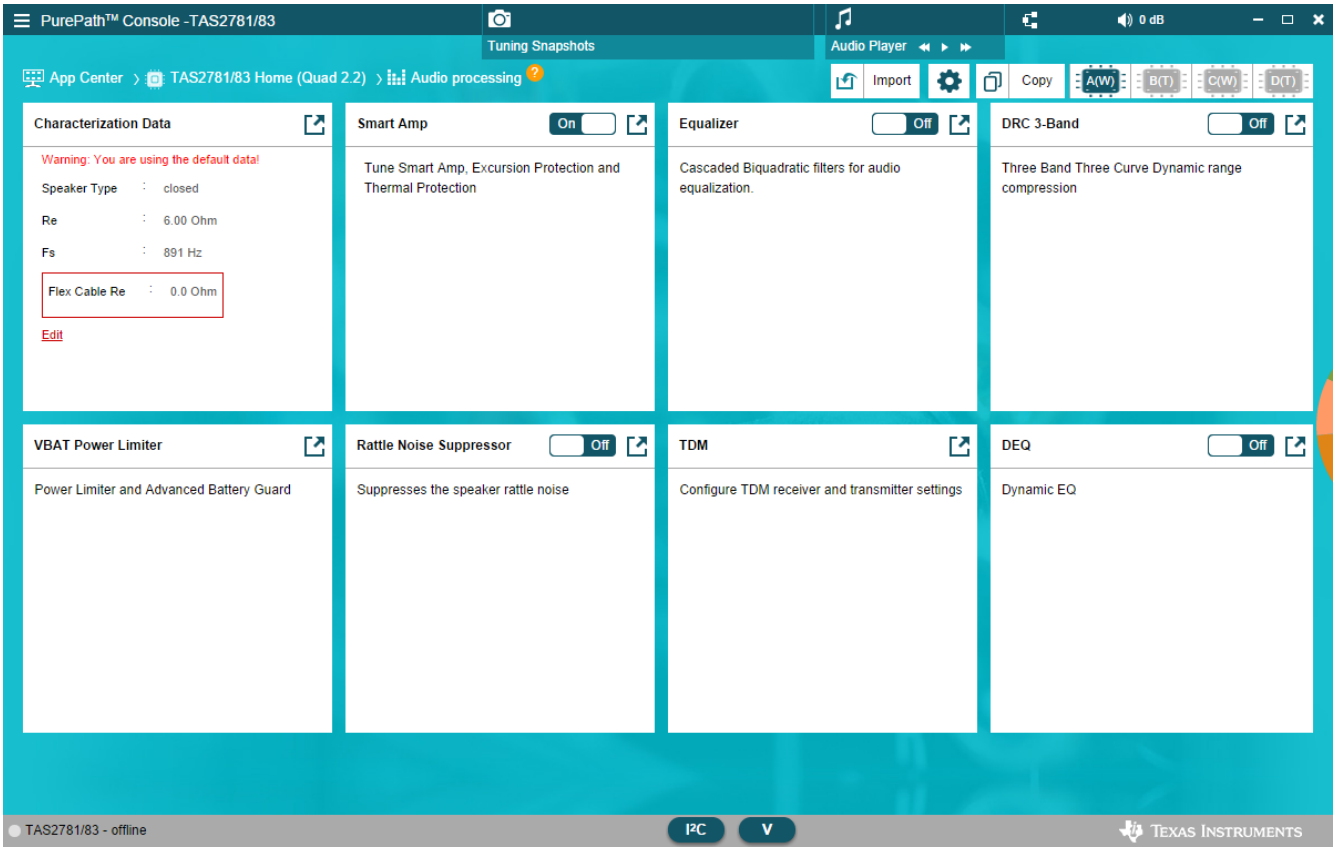


Figure 5-5. Tuning and Audio Processing Panel

5.5 Register Map

This panel shows the register values from TAS2783 device. It is similar information to what is included in the data sheet and it provides the ability to read the current values of all registers. The list can be sorted based on the register name or address.

Detailed description of each register is displayed on the right side when any specific register is selected on the left side.

Copyright © 2024 Texas Instruments Incorporated

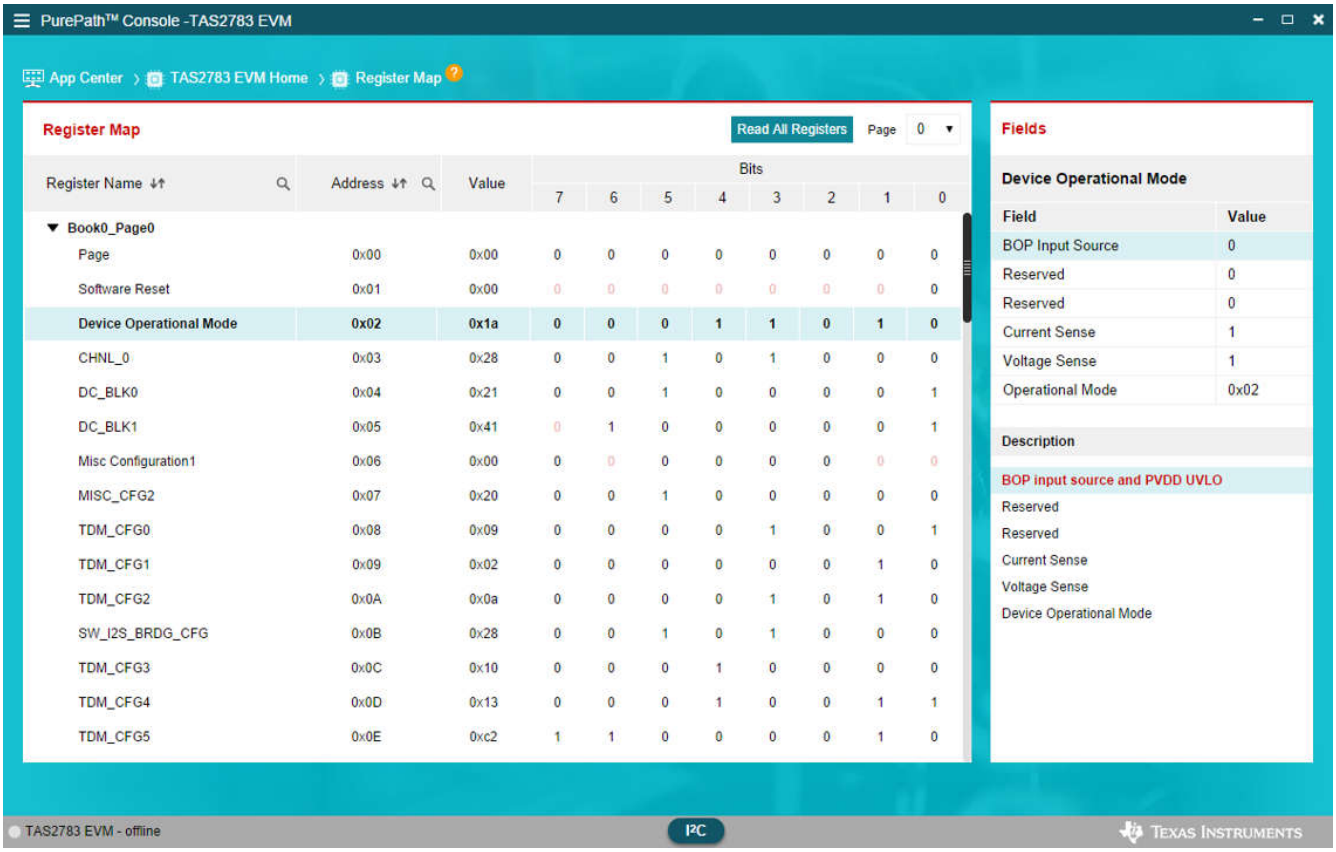


Figure 5-6. PPC3 - Register Map Panel

Copyright © 2024 Texas Instruments Incorporated

5.6 Direct I²C

The Direct I²C panel allows direct control of I²C read writes to the TAS2783 Device. The Direct I²C log feature also allows for the I²C transactions between PPC3 and the TAS2783EVM to be sniffed and recorded.

I²C .cfg files can be created, saved, and loaded into this window. Pressing execute will run the I²C commands and give an output log on the right side of the window. If PPC3 receives an ACK the log will state successful, and if PPC3 receives a NACK, or the syntax is incorrect the log will show an error.

Below is an example of the I2C syntax used in the DIrect I2C window. Single-byte and multi-byte reads and writes are supported, as well as delays in millisecond increments.

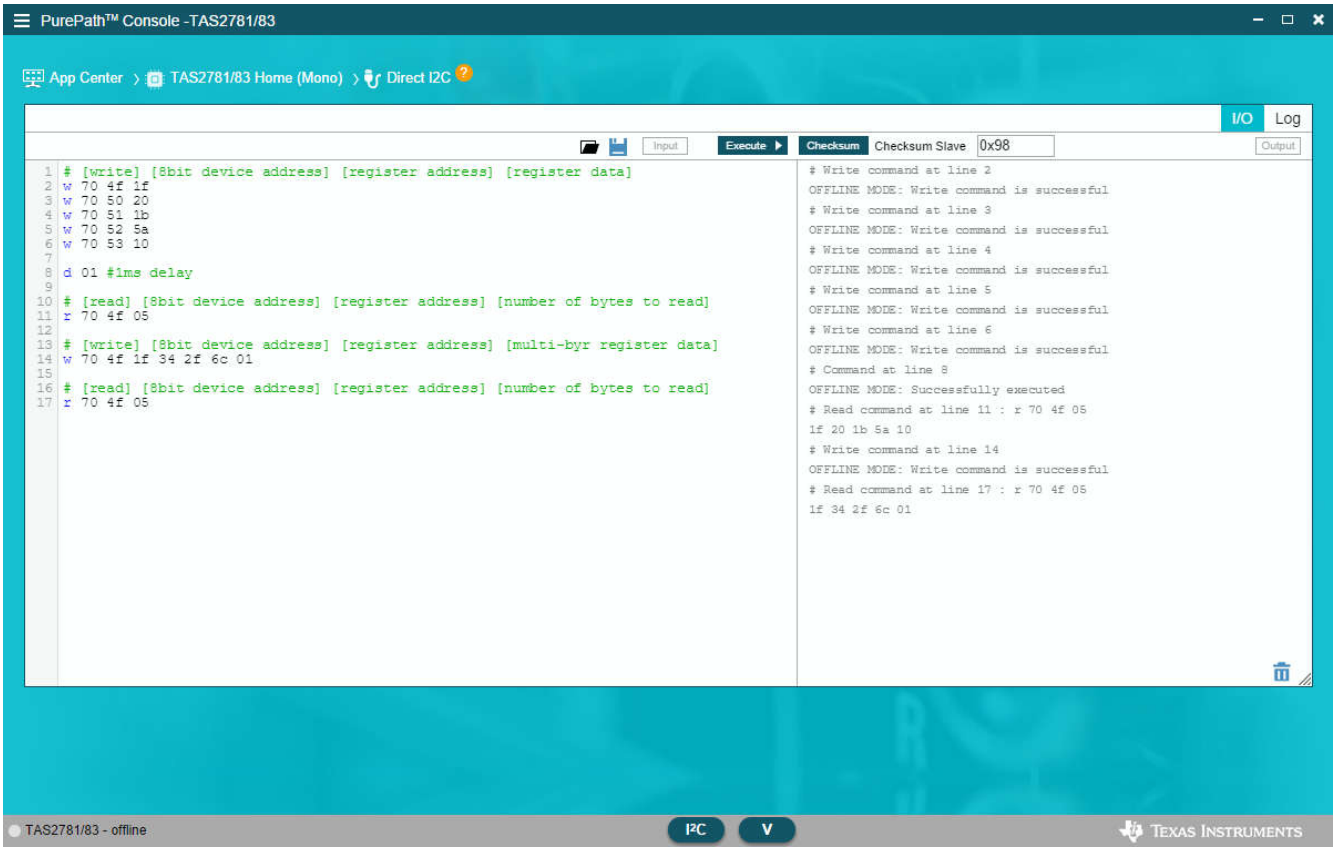


Figure 5-7. Direct I²C I/O

Copyright © 2024 Texas Instruments Incorporated

Below is a recorded log of the above script. PPC3 will begin recording once the green button in the upper right of the window is pressed.

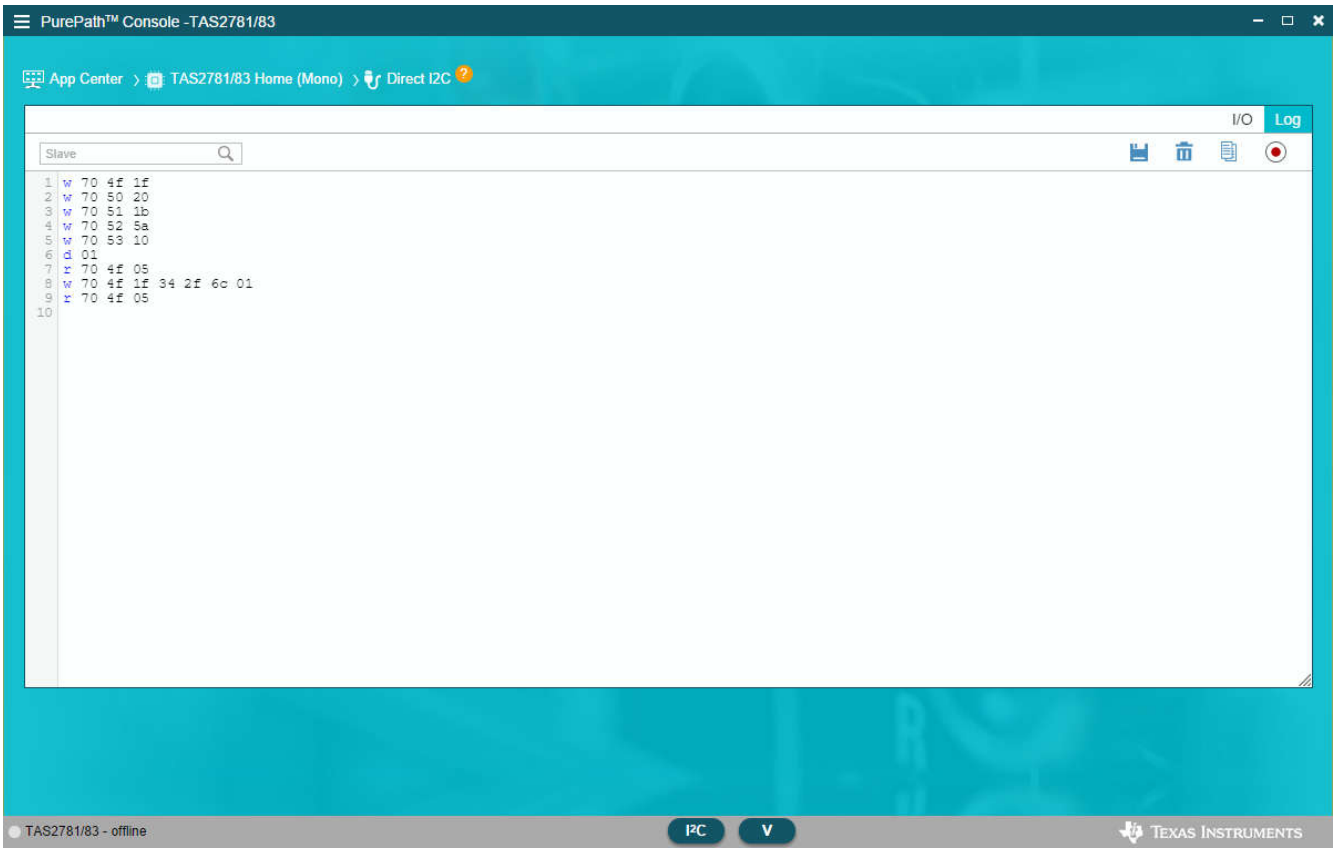


Figure 5-8. Direct I²C Logs

Copyright © 2024 Texas Instruments Incorporated

6 Reference

6.1 Schematics

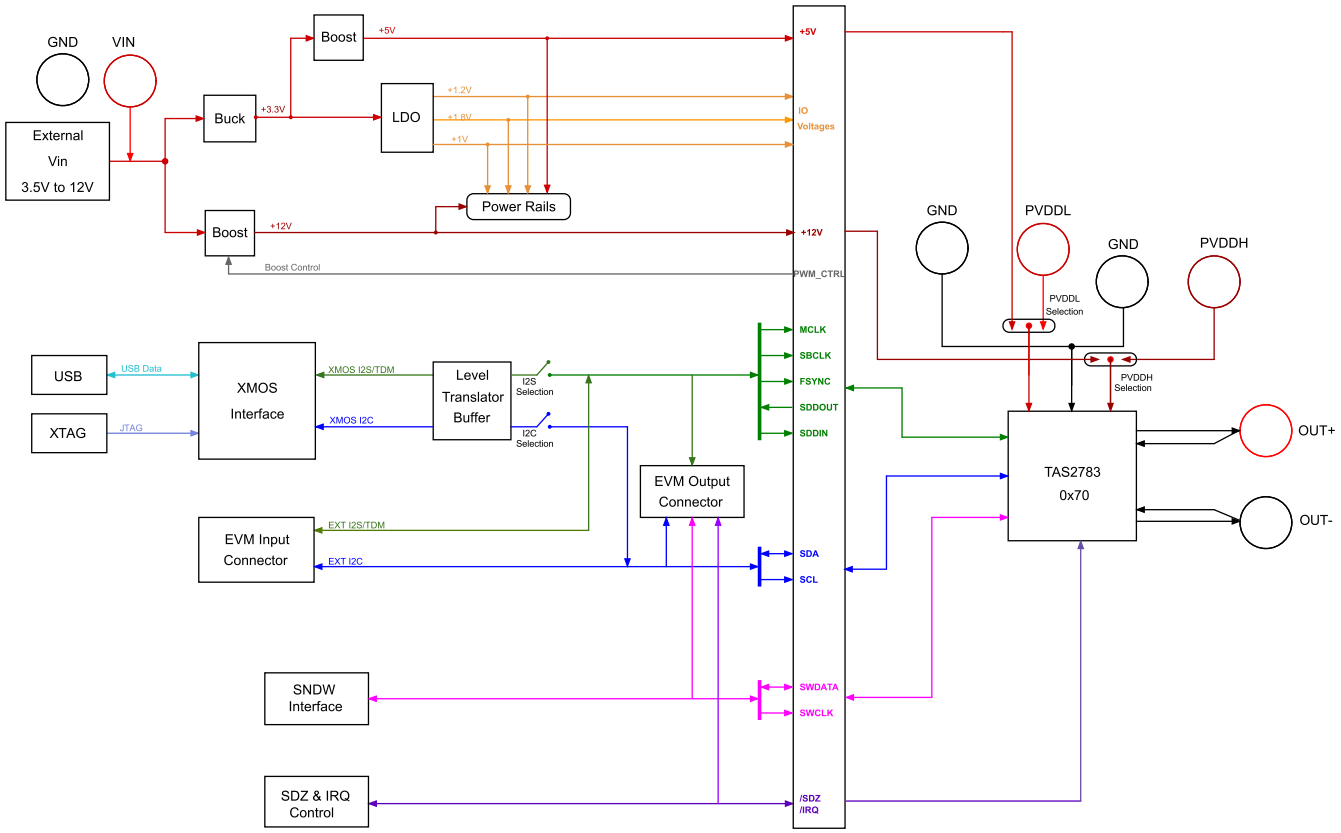


Figure 6-1. TAS2783EVM Schematic, Block Diagram

Copyright © 2024 Texas Instruments Incorporated

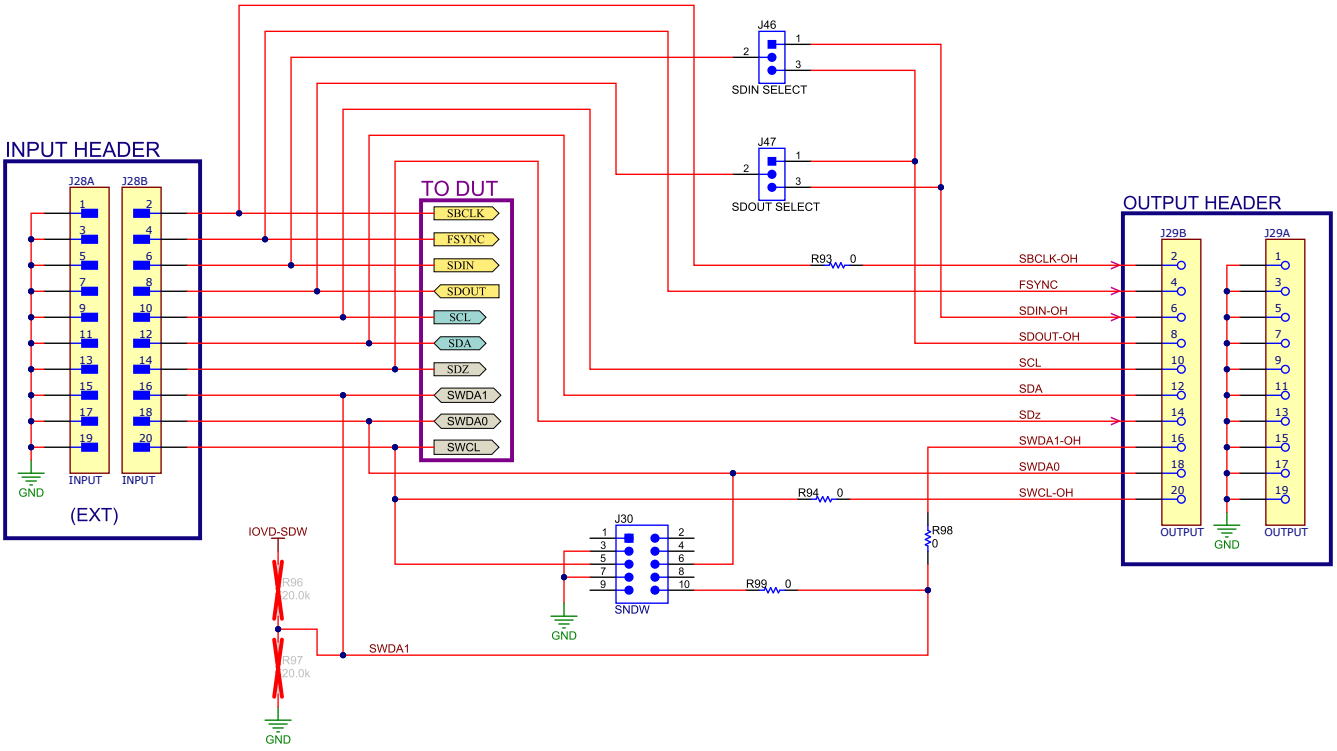


Figure 6-2. TAS2783EVM Schematic, Connectors

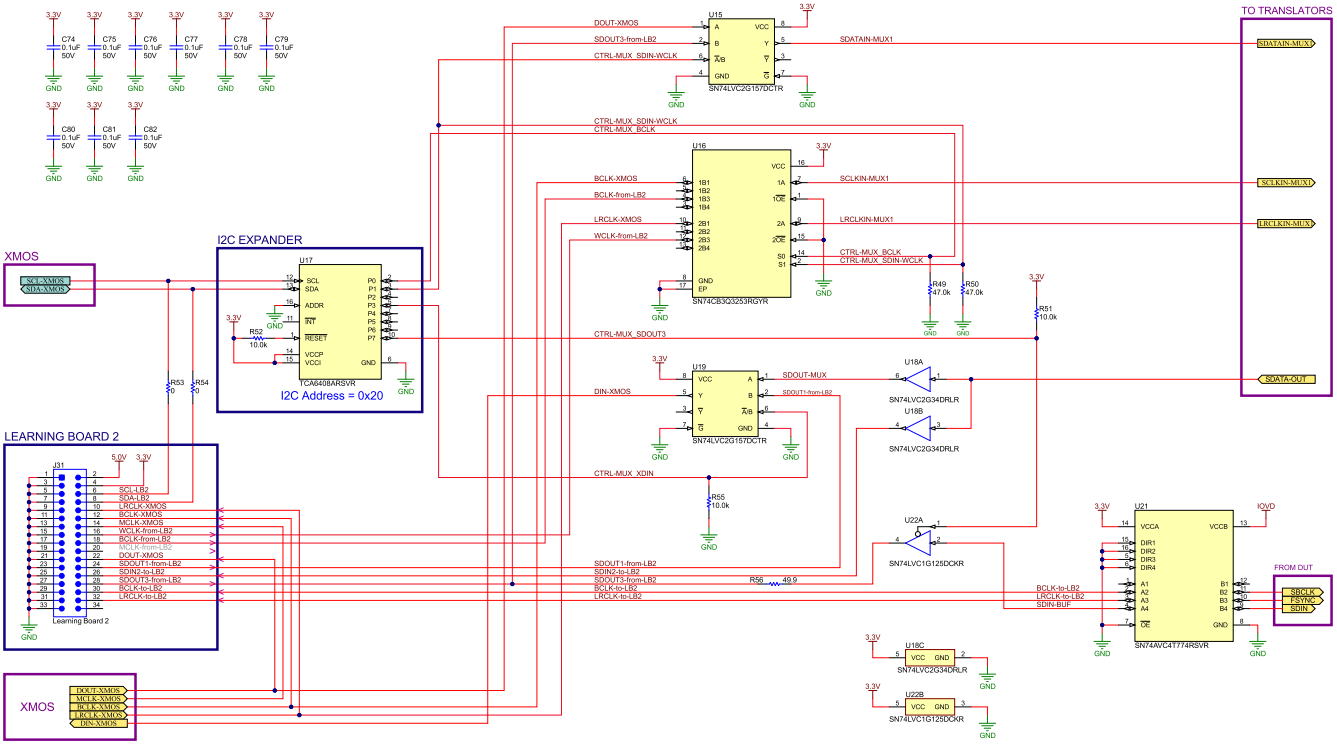


Figure 6-3. TAS2783EVM Schematic, Learning Board

Copyright © 2024 Texas Instruments Incorporated

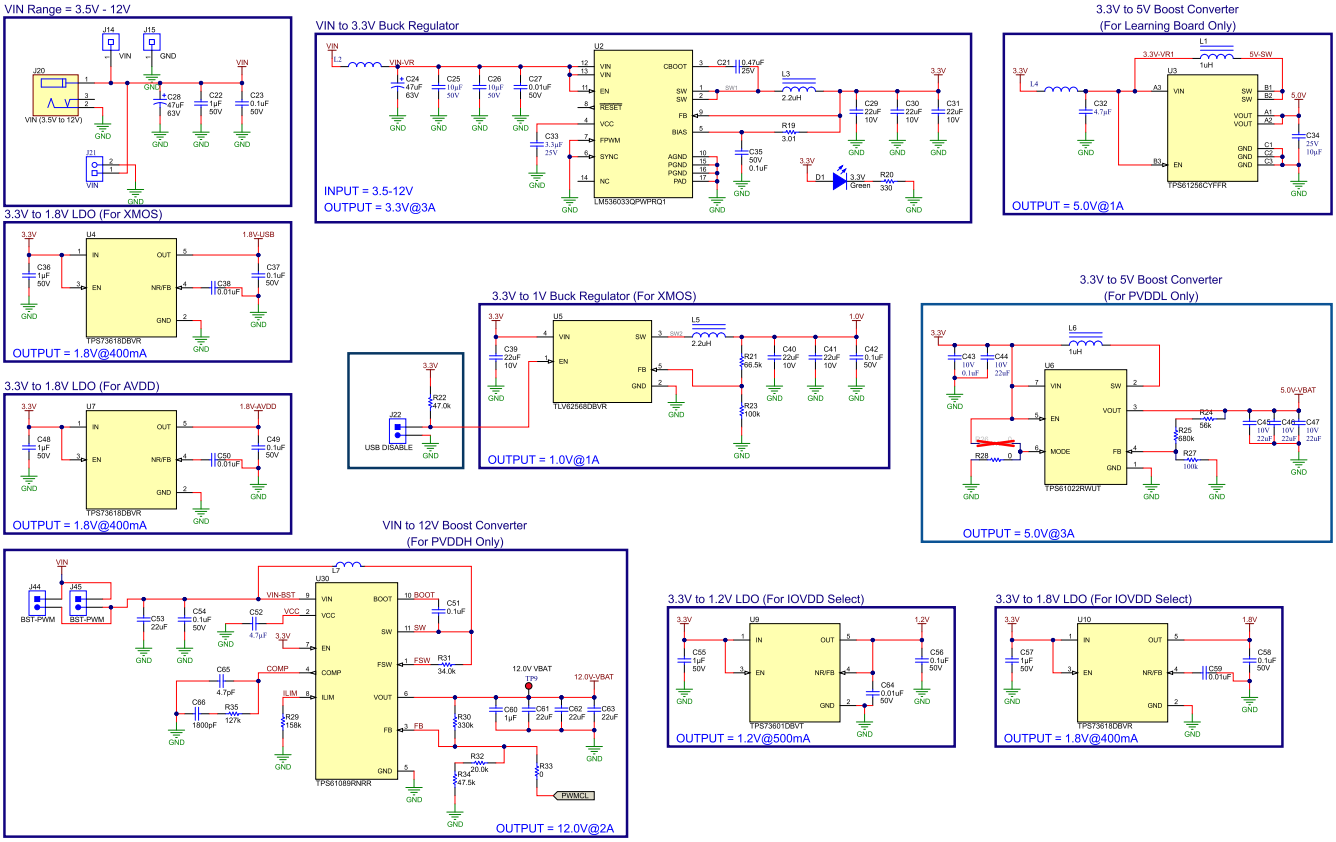


Figure 6-4. TAS2783EVM Schematic, Power Supplies

Copyright © 2024 Texas Instruments Incorporated

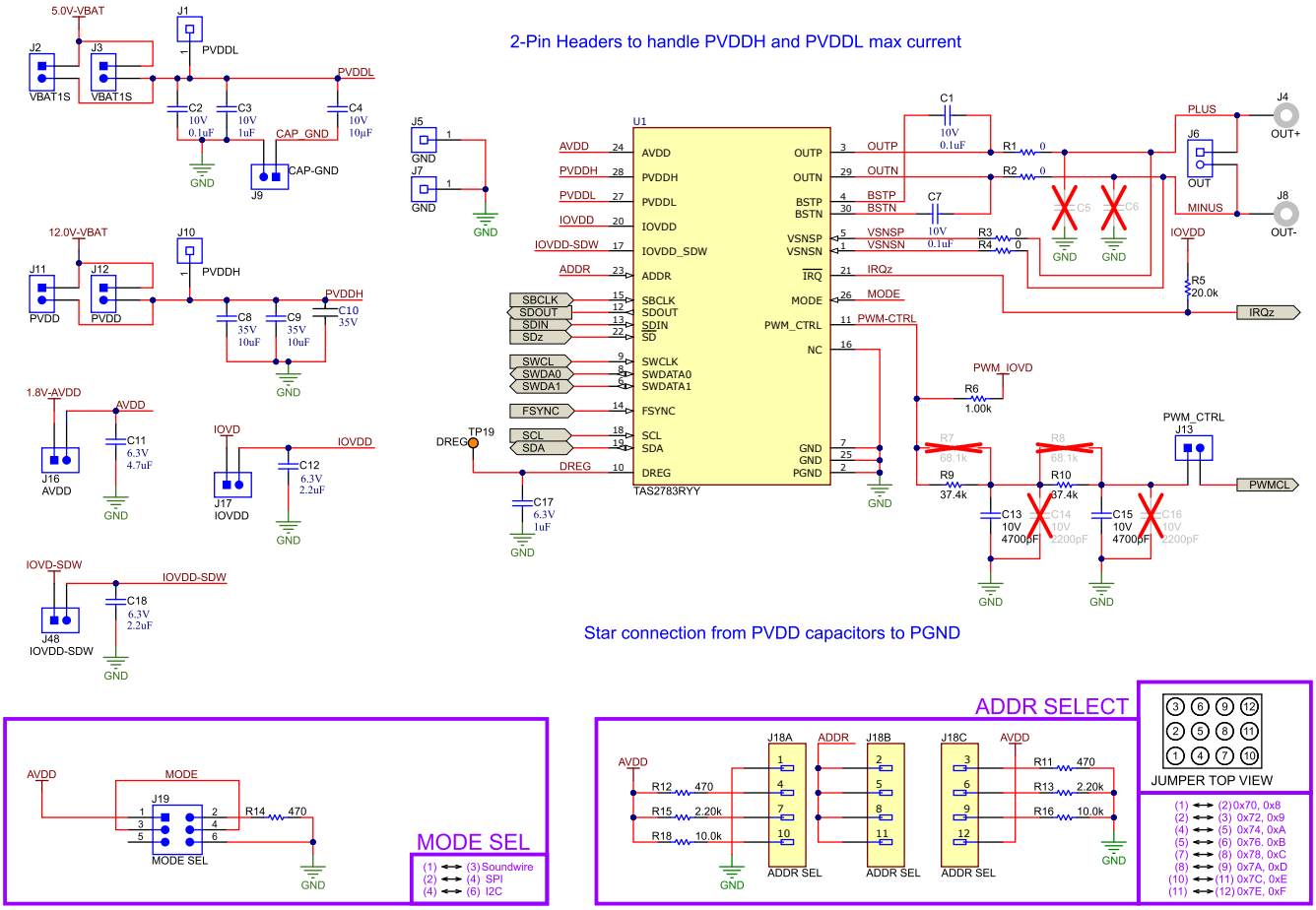


Figure 6-5. TAS2783EVM Schematic, DUT

Copyright © 2024 Texas Instruments Incorporated

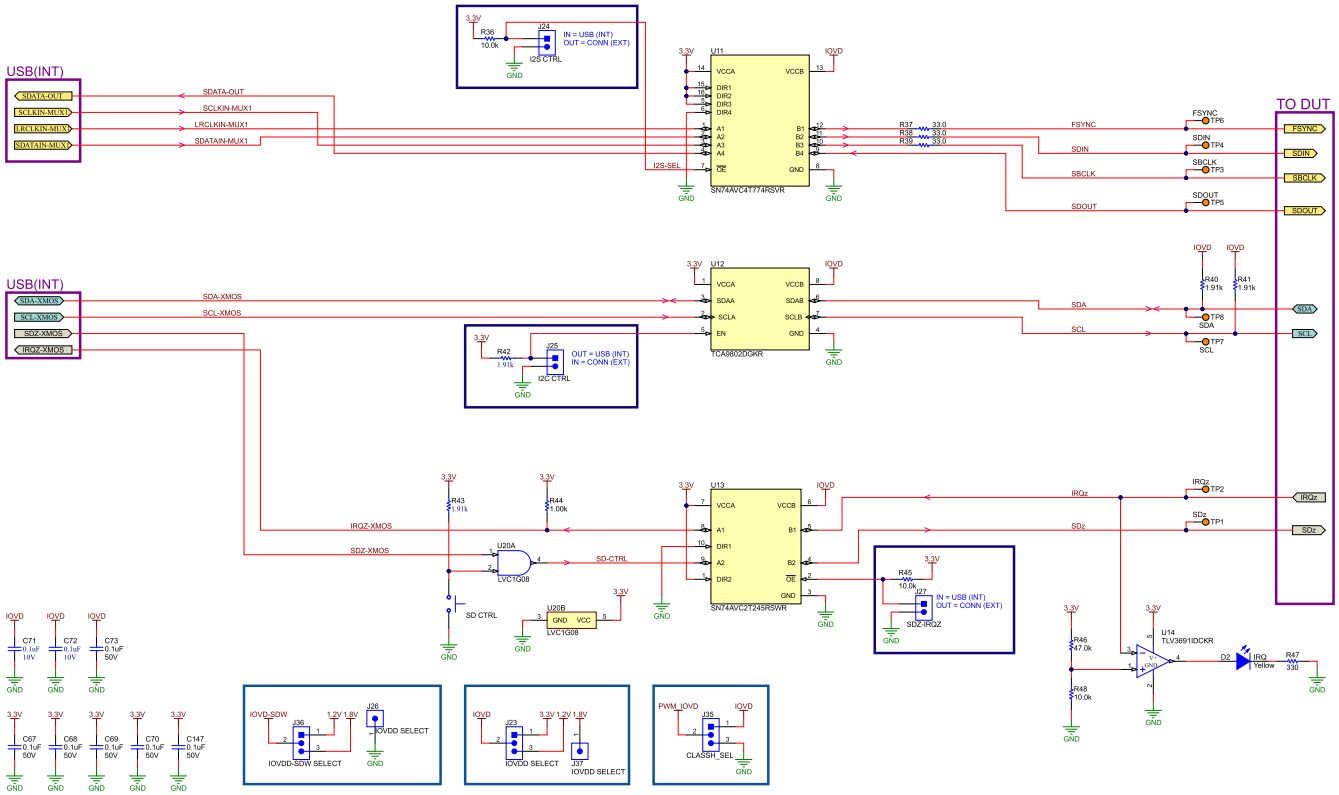


Figure 6-6. TAS2783EVM Schematic, Translators

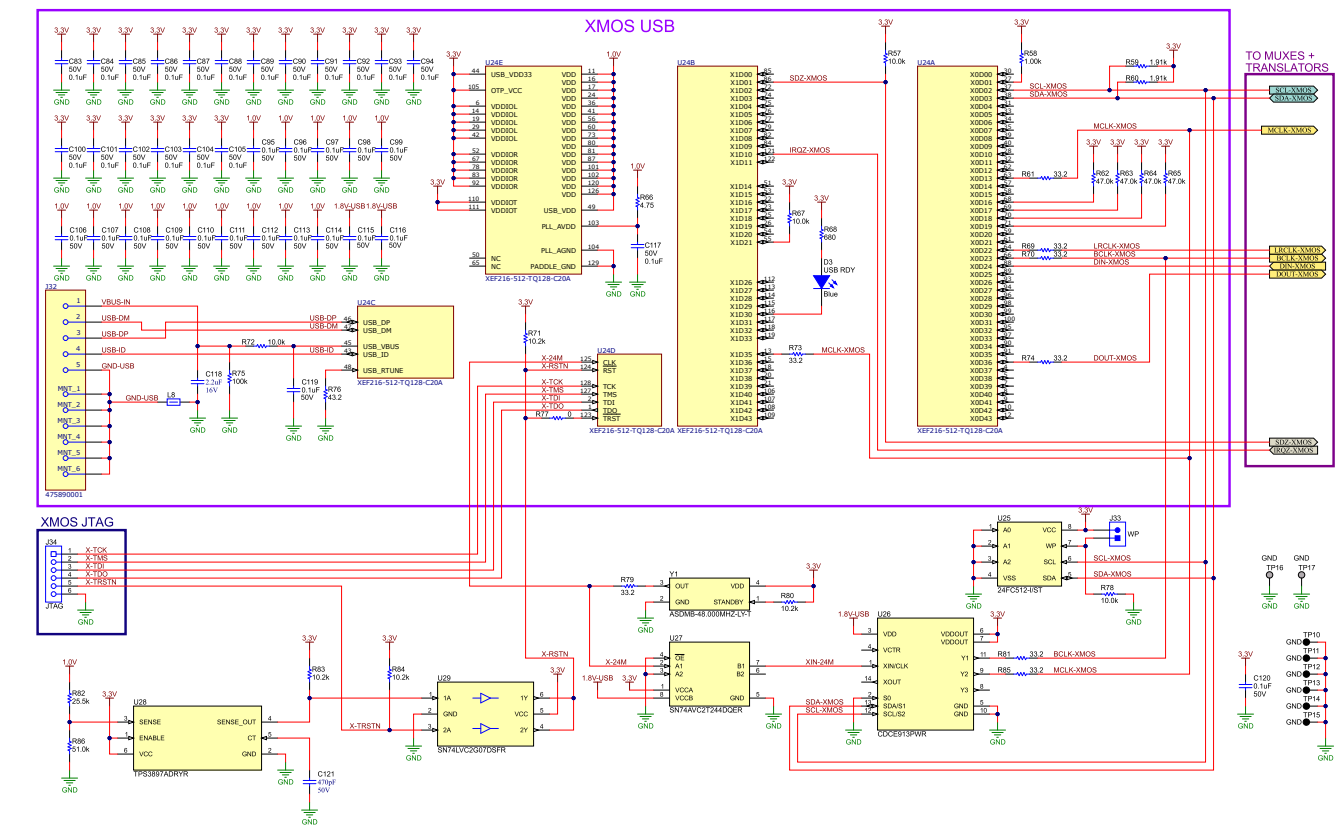


Figure 6-7. TAS2783EVM Schematic, XMOS USB

Copyright © 2024 Texas Instruments Incorporated

6.2 PCB Layouts

This section provides a list of important items to consider during component selection as well as layout. Following these guidelines help for proper device performance and operation.

1. All supply rails should be bypassed by low-ESR ceramic capacitors. Consider capacitance derating due to DC as this is considerably critical for higher power rails, a good rule of thumb is to select capacitors with rated voltage 2 or 3 times the supply rail voltage.

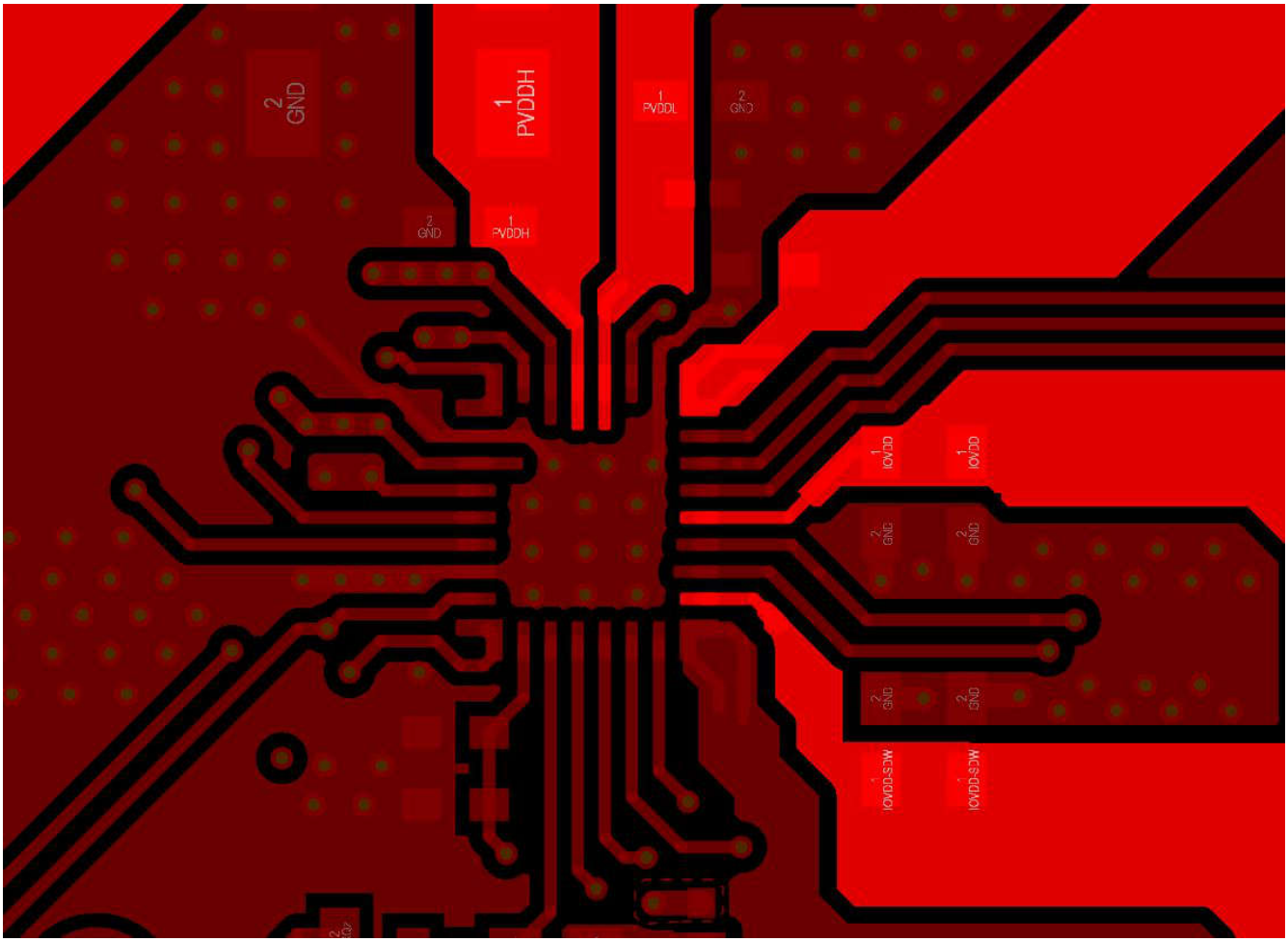


Figure 6-8. Supply Rails Layout

2. Use GND planes with multiple conductive epoxy filled vias to create a low impedance connection to PGND and GND, this also helps to minimize the GND noise. The layout design must target minimum parasitic loop inductance between PVDDH, PGND pins and decoupling capacitor.

Copyright © 2024 Texas Instruments Incorporated

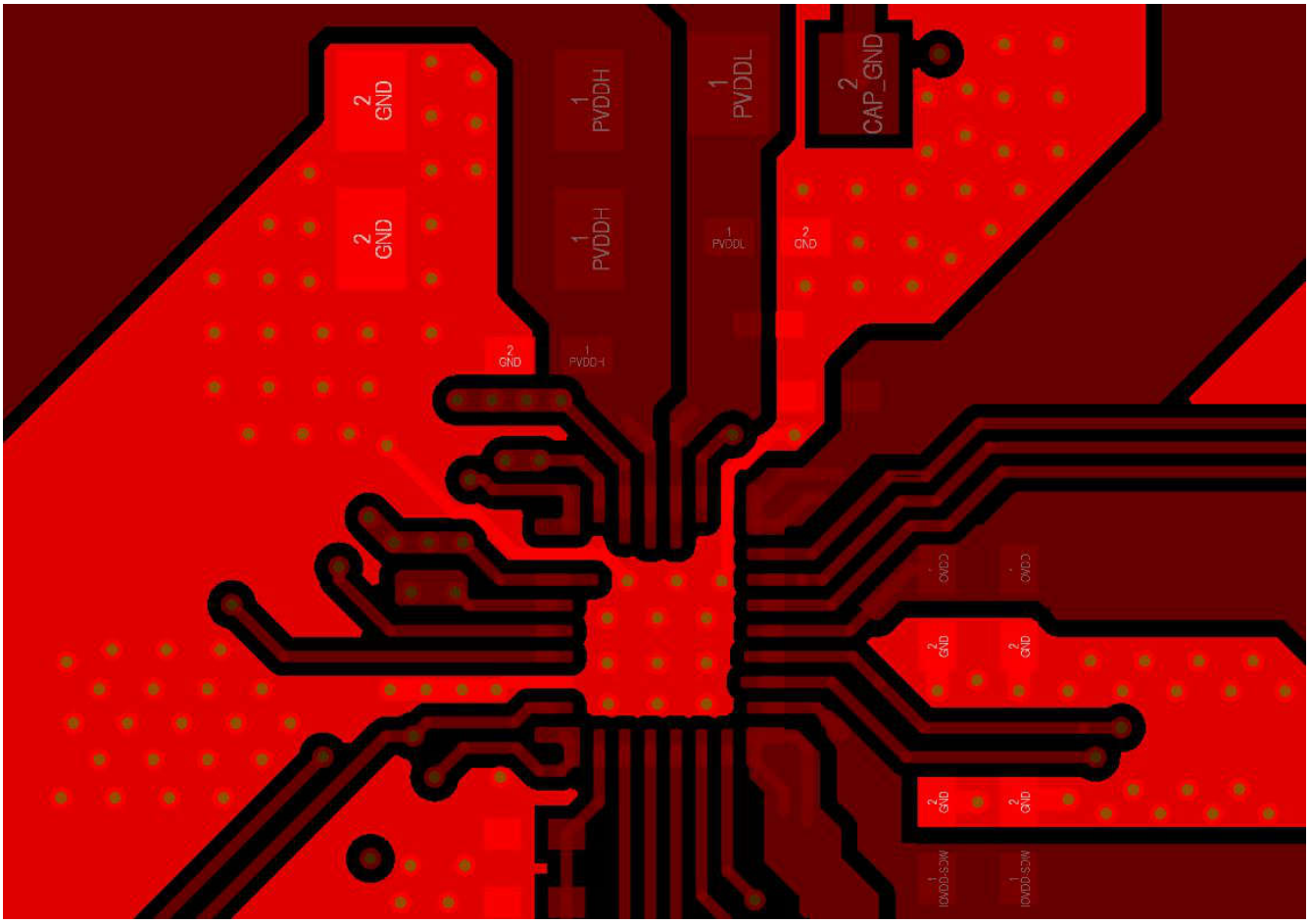


Figure 6-9. GND Layout

3. Use wider traces that carry high current such as PVDDH, PVDDL, OUT_P and OUT_N.
4. Connect VSNS_P and VSNS_N as close as possible to the speaker.
5. VSNS_P and VSNS_N should be connected between the EMI ferrite filter and the speaker if EMI ferrites are used at the outputs.
6. VSNS_P and VSNS_N routing should be separated and shielded from switching signals such as interface signals, speaker outputs and bootstrap pins.
7. Place bootstrap capacitors as close as possible to the BSTP/N pins.

Copyright © 2024 Texas Instruments Incorporated

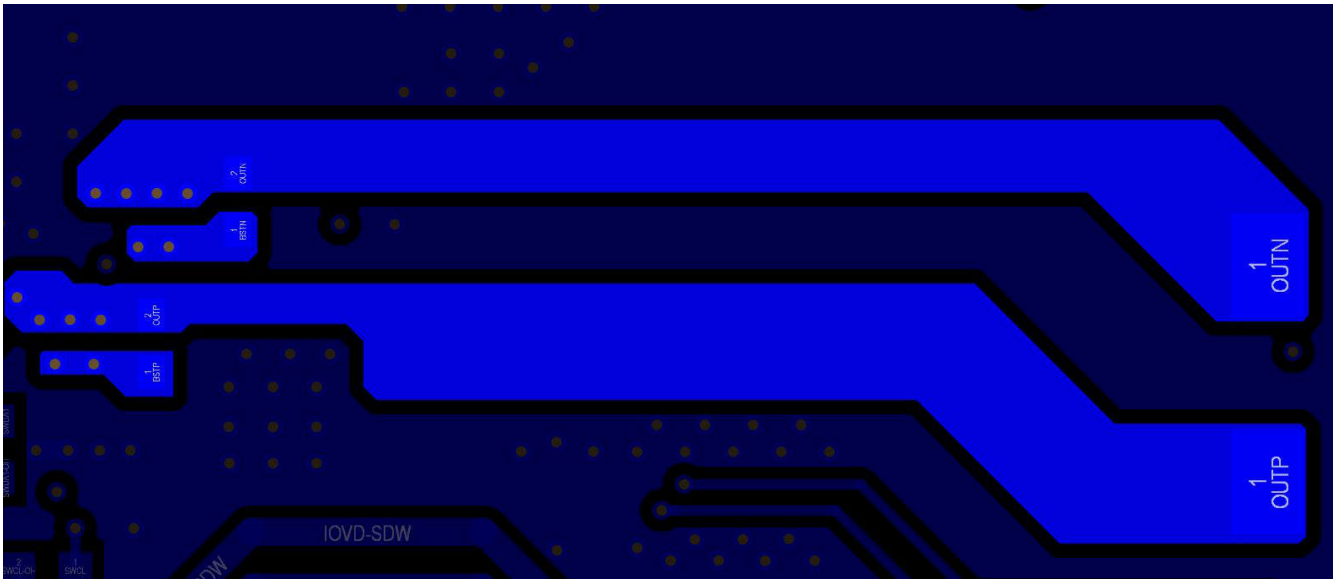


Figure 6-10. Bootstrap and Outputs Layout

6.3 Bill of Materials

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
!PCB1	1	Printed Circuit Board	Any	AMPS162		
C1, C2, C7	3	CAP, CERM, 0.1uF, 10V, +/- 10%, X5R, 0201	Samsung Electro-Mechanics	CL03A104KP3NNNC		
C3	1	CAP, CERM, 1uF, 10V, +/- 20%, X5R, 0201	Samsung Electro-Mechanics	CL03A105MP3NSNC		
C4	1	CAP, CERM, 10µF, 10V,+/- 20%, X5R, 0402	AVX	0402ZD106MAT2A		
C8, C9	2	CAP, CERM, 10uF, 35V, +/- 20%, X5R, 0603	Murata	GRM188R6YA106MA73D		
C10	1	Cap Ceramic 0.1uF 35V X5R 10% Pad SMD 0201 85C T/R	Murata Electronics North America	GRM033R6YA104KE14D		
C11	1	CAP, CERM, 4.7uF, 6.3V, +/- 20%, X5R, 0201	MuRata	GRM035R60J475ME15D		
C12, C18	2	CAP, CERM, 2.2uF, 6.3V,+/- 20%, X5R, 0201	MuRata	GRM033R60J225ME47D		
C13, C15	2	CAP, CERM, 4700pF, 10V, +/- 20%, X5R, 0201	MuRata	GRM033R61A472MA01D		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
C17	1	CAP, CERM, 1uF, 6.3V, +/- 20%, X5R, 0201	MuRata	GRM033R60J105MEA2D		
C21	1	CAP, CERM, 0.47uF, 25 , +/- 10%, X7R, 0603	MuRata	GRM188R71E474KA12D		
C22, C36, C48, C55, C57, C60	6	CAP, CERM, 1µF, 50V,+/- 20%, X5R, AEC-Q200 Grade 3, 0603	TDK	CGA3E3X5R1H105M080AB		
C23, C35, C37, C42, C49, C51, C54, C56, C58, C67, C68, C69, C70, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C87, C88, C89, C90, C91, C92, C93, C94, C95, C96, C97, C98, C99, C100, C101, C102, C103, C104, C105, C106, C107, C108, C109, C110, C111, C112, C113, C114, C115, C116, C117, C119, C120, C147	61	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, 0402	TDK	C1005X7R1H104K050BB		
C24, C28	2	CAP, AL, 47uF, 63V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	Panasonic	EEE-FK1J470P		
C25, C26	2	CAP, CERM, 10µF, 50V,+/- 10%, X5R, 1210	Samsung Electro-Mechanics	CL32A106KBJNNNE		
C27, C38, C50, C59, C64	5	CAP, CERM, 0.01uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	TDK	CGA2B3X7R1H103K050BB		
C29, C30, C31, C39, C40, C41	6	CAP, CERM, 22uF, 10V, +/- 20%, X5R, 0603	TDK	C1608X5R1A226M080AC		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
C32, C52	2	CAP, CERM, 4.7µF, 16V,+/- 10%, X5R, AEC-Q200 Grade 3, 0603	MuRata	GRT188R61C475KE13D		
C33	1	CAP, CERM, 3.3µF, 25V,+/- 10%, X7R, 0805	TDK	CGA4J1X7R1E335K125AC		
C34	1	CAP, CERM, 10µF, 25V,+/- 10%, X7R, 1206	TDK	C3216X7R1E106K160AB		
C43	1	CAP, CERM, 0.1uF, 10V, +/- 10%, X5R, 0402	MuRata	GRM155R61A104KA01D		
C44, C45, C46, C47	4	CAP, CERM, 22uF, 10V, +/- 20%, X5R, 0805	MuRata	GRM21BR61A226ME44L		
C53, C61, C62, C63	4	CAP, CERM, 22uF, 25V, +/- 10%, X7R, 1210	MuRata	GRM32ER71E226KE15L		
C65	1	CAP, CERM, 4.7pF, 50V, +/- 5%, C0G/NP0, 0201	MuRata	GRM0335C1H4R7CA01D		
C66	1	CAP, CERM, 1800pF, 10V, +/- 10%, X5R, 0201	MuRata	GRM033R61A182KA01D		
C71, C72	2	CAP, CERM, 0.1uF, 10V, +/- 10%, X7R, 0402	MuRata	GRM155R71A104KA01D		
C118	1	CAP, CERM, 2.2uF, 16V, +/- 10%, X7R, 0603	MuRata	GRM188Z71C225KE43		
C121	1	CAP, CERM, 470pF, 50V, +/- 10%, X7R, 0402	MuRata	GRM155R71H471KA01D		
D1	1	LED, Green, SMD	Lite-On	LTST-C191KGKT		
D2	1	LED, Yellow , SMD	Lite-On	LTST-C170KSKT		
D3	1	LED, Blue, SMD	Lite-On	LTST-C170TBKT		
H1, H2, H3, H4	4	MACHINE SCREW PAN PHILLIPS M3	APM HEXSEAL	RM3X8MM 2701		
H5, H6, H7, H8	4	Standoff, Hex,25mm Length, M3, Aluminum	Keystone	24438		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
J1, J5, J7, J10, J14, J15	6	Binding Post, Nickel, TH	Cinch Connectivity	111-2223-001		
J2, J3, J9, J11, J12, J13, J16, J17, J22, J24, J25, J27, J33, J44, J45, J48	16	Header, 100mil, 2x1, Gold, TH	Sullins Connector Solutions	PBC02SAAN		
J4, J8	2	Standard Banana Jack, Uninsulated, 5.5mm	Keystone	575-4		
J6	1	Conn Term Block, 2POS, 3.81mm, TH	Phoenix Contact	1727010		
J18	1		Samtec	TSW-104-07-G-T		
J19	1	Header, 100mil, 3x2, Gold, TH	Samtec	TSW-103-07-G-D		
J20	1	Power Jack, mini, 2.5mm OD, R/A, TH	Switchcraft	RAPC712X		
J21	1	Terminal Block, 5.08mm, 2x1, TH	Molex	395443002		
J23, J35, J36, J46, J47	5	Header, 100mil, 3x1, Gold, TH	Sullins Connector Solutions	PBC03SAAN		
J26, J37	2	Header, 100mil, 1x1, Gold, TH	Samtec	HTSW-101-09-G-S		
J28	1		Samtec	TSW-110-08-G-D-RA		
J29	1	20 Position Receptacle Connector Through Hole, Right Angle	SAMTEC	SSQ-110-02-G-D-RA		
J30	1	Header, 2.54mm, 5x2, Gold, TH	Wurth Elektronik	61301021121		
J31	1	Header(shrouded), 2.54mm, 17x2, Gold, TH	On-Shore Technology	302-S341		
J32	1	USB - micro AB Receptacle Connector 5 Position Surface Mount, Right Angle; Through Hole	Molex	475890001		
J34	1	Receptacle, 50mil, 6x1, Gold, R/A, TH	Sullins Connector Solutions	LPPB061NGCN-RC		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
L1	1	Inductor, Flat Wire, 1uH, 3.1A, 0.045ohm, SMD	MuRata Toko	1277AS-H-1R0M=P2		
L2, L4	2	WE-CBA SMT EMI Suppression Ferrite Bead, size 0805, 300Ohm, 3A	Wurth Elektronik			
L3	1	Inductor, Shielded, 2.2uH, 4A, 0.061ohm, AEC-Q200 Grade 0, SMD	Bourns	SRP4020TA-2R2M		
L5	1	Inductor, Multilayer, Ferrite, 2.2uH, 1.3A, 0.08ohm, SMD	MuRata	LQM2HPN2R2MG0L		
L6	1	Inductor, Shielded, Composite, 1uH, 21.8A, 0.00455ohm, SMD	Coilcraft	XAL7030-102MEB		
L7	1	1µH Shielded Wirewound Inductor 4.1A 22mOhm Max 1210 (3225 Metric)	Murata	DFE322520FD-1R0M=P2		
L8	1	Ferrite Bead, 30ohm @ 100MHz, 6A, 0805	TDK	MPZ2012S300AT000		
R1, R2	2	RES, 0, 5%, 0.25 W, 1206	Yageo America	RC1206JR-070RL		
R3, R4, R53, R54, R77, R93, R94, R98, R99	9	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GE0R00X		
R5, R32	2	RES, 20.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040220K0FKED		
R6, R44, R58	3	RES, 1.00 k, 1%, 0.1 W, 0402	Panasonic	ERJ-2RKF1001X		
R9, R10	2	RES, 37.4 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040237K4FKED		
R11, R12, R14	3	RES, 470, 1%, 0.063 W, 0402	Yageo America	RC0402FR-07470RL		
R13, R15	2	RES, 2.20 k, 1%, 0.1 W, 0402	Panasonic	ERJ-2RKF2201X		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
R16, R18, R36, R45, R48, R51, R52, R55, R57, R67, R72	11	RES, 10.0 k, 1%, 0.063 W, 0402	Yageo America	RC0402FR-0710KL		
R19	1	RES, 3.01, 1%, 0.1 W, 0603	Yageo	RC0603FR-073R01L		
R20, R47	2	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2RKF3300X		
R21	1	RES, 66.5 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-0766K5L		
R22, R46, R49, R50, R62, R63, R64, R65	8	RES, 47.0 k, 1%, 0.0625 W, 0402	Yageo America	RC0402FR-0747KL		
R23	1	RES, 100 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-07100KL		
R24	1	RES, 56 k, 5%, 0.1 W, 0603	Yageo	RC0603JR-0756KL		
R25	1	RES, 680 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-07680KL		
R27	1	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW0603100KFKEA		
R28	1	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V		
R29	1	RES, 158 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW0402158KFKED		
R30	1	RES, 330 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW0402330KFKED		
R31	1	RES, 34.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040234K0FKED		
R33	1	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GE0R00X		
R34	1	RES, 47.5 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040247K5FKED		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
R35	1	RES, 127 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW0402127KFKED		
R37, R38, R39	3	RES, 33.0, 1%, 0.1 W, 0402	Panasonic	ERJ-2RKF33R0X		
R40, R41, R42, R43, R59, R60	6	RES, 1.91 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-071K91L		
R56	1	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Stackpole Electronics Inc	RMCF0402FT49R9		
R61, R69, R70, R73, R74, R79, R81, R85	8	RES, 33.2, 1%, 0.05 W, 0201	Yageo America	RC0201FR-0733R2L		
R66	1	RES, 4.75, 1%, 0.1 W, 0603	Yageo	RC0603FR-074R75L		
R68	1	RES, 680, 1%, 0.1 W, 0603	Yageo	RC0603FR-07680RL		
R71, R80, R83, R84	4	RES, 10.2 k, 1%, 0.05 W, 0201	Yageo America	RC0201FR-0710K2L		
R75	1	RES, 100 k, 1%, 0.1 W, 0402	Panasonic	ERJ-2RKF1003X		
R76	1	RES, 43.2, 1%, 0.1 W, 0603	Yageo	RC0603FR-0743R2L		
R78	1	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Stackpole Electronics Inc	RMCF0402FT10K0		
R82	1	RES, 25.5 k, 1%, 0.05 W, 0201	Yageo America	RC0201FR-0725K5L		
R86	1	RES, 51.0 k, 1%, 0.05 W, 0201	Yageo America	RC0201FR-0751KL		
SD CTRL	1	SWITCH TACTILE SPST-NO 0.05A 12V	Omron Electronic Components	B3U-1000P	Omron Electronic Components	B3U-1000P-B
SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11, SH12, SH13, SH14, SH15, SH16, SH17, SH18, SH19, SH20, SH21	21	Shunt, 100mil, Gold plated, Black	Samtec	SNT-100-BK-G	3M	969102-0000-DA
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP19	9	Test Point, Miniature, Orange, TH	Keystone Electronics	5003		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
TP9	1	Test Point, Miniature, Red, TH	Keystone Electronics	5000		
TP10, TP11, TP12, TP13, TP14, TP15	6	Test Point, Miniature, Black, TH	Keystone Electronics	5001		
TP16, TP17	2	Terminal, Turret, TH, Double	Keystone	1503-2		
U1	1	SoundWireSM Class D Amplifier with Integrated DSP	Texas Instruments	TAS2783RYY		
U2	1	3.5 to 36Vin, 3 Ampere Synchronous DC-DC Converter for Automotive Applications, PWP0016D (TSSOP-16)	Texas Instruments	LM536033QPWPRQ1	Texas Instruments	LM536033QPWPTQ1
U3	1	3.5-MHz High Efficiency Step-Up Converter in Chip Scale Package, YFF0009ACAG (DSBGA-9)	Texas Instruments	TPS61256CYFFR	Texas Instruments	TPS61256CYFFT
U4, U7, U10	3	Single Output LDO, 400mA, Adj. (1.2 to 5.5V), Cap free, Low Noise, Reverse Current Protection, DBV0005A (SOT-23-5)	Texas Instruments	TPS73618DBVR		
U5	1	1A High Efficiency Step-Down Converter in SOT23-5 Package, DBV005A, DBV0005A (SOT-5)	Texas Instruments	TLV62568DBVR	Texas Instruments	TLV62568DBVT
U6	1	8A Boost Converter with 0.5V Ultra-Low Input Voltage, RWU0007A (VQFN-HR-7)	Texas Instruments	TPS61022RWUT	Texas Instruments	TPS61022RWUR

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
U9	1	Single Output LDO, 400mA, Adj. (1.2 to 5.5V), Cap free, Low Noise, Reverse Current Protection, DBV0005A (SOT-23-5)	Texas Instruments	TPS73601DBVT		
U11, U21	2	4-Bit Dual-Supply Bus Transceiver With Configurable Voltage-Level Shifting and 3-State Outputs, RSV0016A (UQFN-16)	Texas Instruments	SN74AVC4T774RSVR	Texas Instruments	
U12	1	Level-Translating I2C Bus Buffer/Repeater, DGK0008A (VSSOP-8)	Texas Instruments	TCA9802DGKR	Texas Instruments	TCA9802DGKT
U13	1	Dual-Bit, 2-DIR pin Dual-Supply Bus Transceiver w/ Configurable Voltage Translation, 3-State Output, UQFN-10, RSW0010A (UQFN-10)	Texas Instruments	SN74AVC2T245RSWR	Texas Instruments	
U14	1	0.9V to 6.5V, Nano-Power Comparator, DCK0005A (SOT-SC70-5)	Texas Instruments	TLV3691IDCKR	Texas Instruments	TLV3691IDCKT
U15, U19	2	Single 2-Line to 1-Line Data Selector/ Multiplexer, DCT0008A, LARGE T&R	Texas Instruments	SN74LVC2G157DCTR	Texas Instruments	SN74LVC2G157DCUT
U16	1	Dual 1-of-4 FET Multiplexer/ Demultiplexer 2.5V/3.3V Low-Voltage High-Bandwidth Bus Switch, RGY0016A (VQFN-16)	Texas Instruments	SN74CB3Q3253RGYR	Texas Instruments	

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
U17	1	Low-Voltage 8-Bit I2C and SMBus I/O Expander, 1.65 to 5.5V, -40 to 85 degC, 16-pin UQFN (RSV), Green (RoHS & no Sb/Br)	Texas Instruments	TCA6408ARSVR		
U18	1	Dual Buffer Gate, DRL0006A, LARGE T&R	Texas Instruments	SN74LVC2G34DRLR	Texas Instruments	
U20	1	Single 2-Input Positive-AND Gate, DCK0005A, LARGE T&R	Texas Instruments	SN74LVC1G08DCKR		
U22	1	Single Bus Buffer Gate With 3-State Outputs, DCK0005A, LARGE T&R	Texas Instruments	SN74LVC1G125DCKR		
U24	1	XCore XEF Microcontroller IC 32-Bit 16-Core 2000MIPs 2MB (2M x 8) FLASH 128-TQFP (14x14)	XMOS	XEF216-512-TQ128-C20A		
U25	1	512K I2C Serial EEPROM, TSSOP	Microchip	24FC512-I/ST		
U26	1	Programmable 1-PLL VCXO Clock Synthesizer with 2.5V or 3.3V LVCMOS Outputs, PW0014A (TSSOP-14)	Texas Instruments	CDCE913PWR	Texas Instruments	CDCE913PW
U27	1	Dual-Bit Dual-Supply Bus Transceiver, DQE0008A, LARGE T&R	Texas Instruments	SN74AVC2T244DQER		
U28	1	Single-Channel Ultra-Small Adjustable Supervisory Circuit With Active-High Open-Drain Output, DRY0006A (USON-6)	Texas Instruments	TPS3897ADRYR		

Copyright © 2024 Texas Instruments Incorporated

Designator	Quantity	Description	Manufacturer	PartNumber	Alternate Manufacturer	Alternate PartNumber
U29	1	Enhanced Product Dual Buffer/ Driver with Open-Drain Output, DCK0006A (SOT-SC70-6)	Texas Instruments	SN74LVC2G07DSFR		
U30	1	12.6V, 7A Fully-Integrated Synchronous Boost Converters in 2.0mm x 2.5mm VQFN Package, RNR0011A (VQFN-HR-11)	Texas Instruments	TPS61089RNRR	Texas Instruments	TPS61089RNRT
Y1	1	OSC, 48MHz, 1.8 to 3.3V, SMD	Abracon Corporation	ASDMB-48.000MHZ-LY-T		
C5, C6	0	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, 0402	TDK	C1005X7R1H104K050BB		
C14, C16	0	CAP, CERM, 2200pF, 10V, +/- 10%, X5R, 0402	MuRata	GRM155R61A222KA01D		
FID1, FID2, FID3, FID4, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A		
R7, R8	0	RES, 68.1 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040268K1FKED		
R26	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Panasonic	ERJ-3GEY0R00V		
R96, R97	0	RES, 20.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW040220K0FKED		

Copyright © 2024 Texas Instruments Incorporated

7 Additional Information

Trademarks

PurePath™ is a trademark of Texas Instruments.
Microsoft® and Windows® are registered trademarks of Microsoft Corporation.
All trademarks are the property of their respective owners.

8 Revision History

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

Changes from Revision * (August 2022) to Revision A (August 2024)	Page
• Updated link to TAS2780 product page	12

Copyright © 2024 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated