TAS2020 Evaluation Module

TEXAS INSTRUMENTS

Description

The TAS2020EVM has been designed to demonstrate the performance of TAS2020 in a mono configuration. The EVM utilizes the AC-MB to provide a USB to Audio interface to the EVM. Up to four devices can share a common bus through I^{2}S/TDM and I^{2}C interfaces. The TAS2020EVM also supports a dual-mono configuration by combining two TAS2020EVMs.

Get Started

1. Order the TAS2020EVM and request access to download PPC3 from TAS2020 product folder.
2. Read the TAS2020 data sheet.
3. Request and download PurePath Console 3.
4. Request access to the TAS2020-SW page.
5. Visit E2E forum for any questions.

Features

- Mono speaker evaluation
- Plug-n-play hardware mode
- Advanced software mode interface using PurePath™ Console 3 Windows® software
- EVM interconnection for stereo testing
- USB input
- External I^{2}C and I^{2}S/TDM host controller connection available

Applications

- Mobile phone, tablets and wearables
- Smart speakers with voice assistance
- Bluetooth and wireless speakers

TAS2020 Mono Evaluation Module
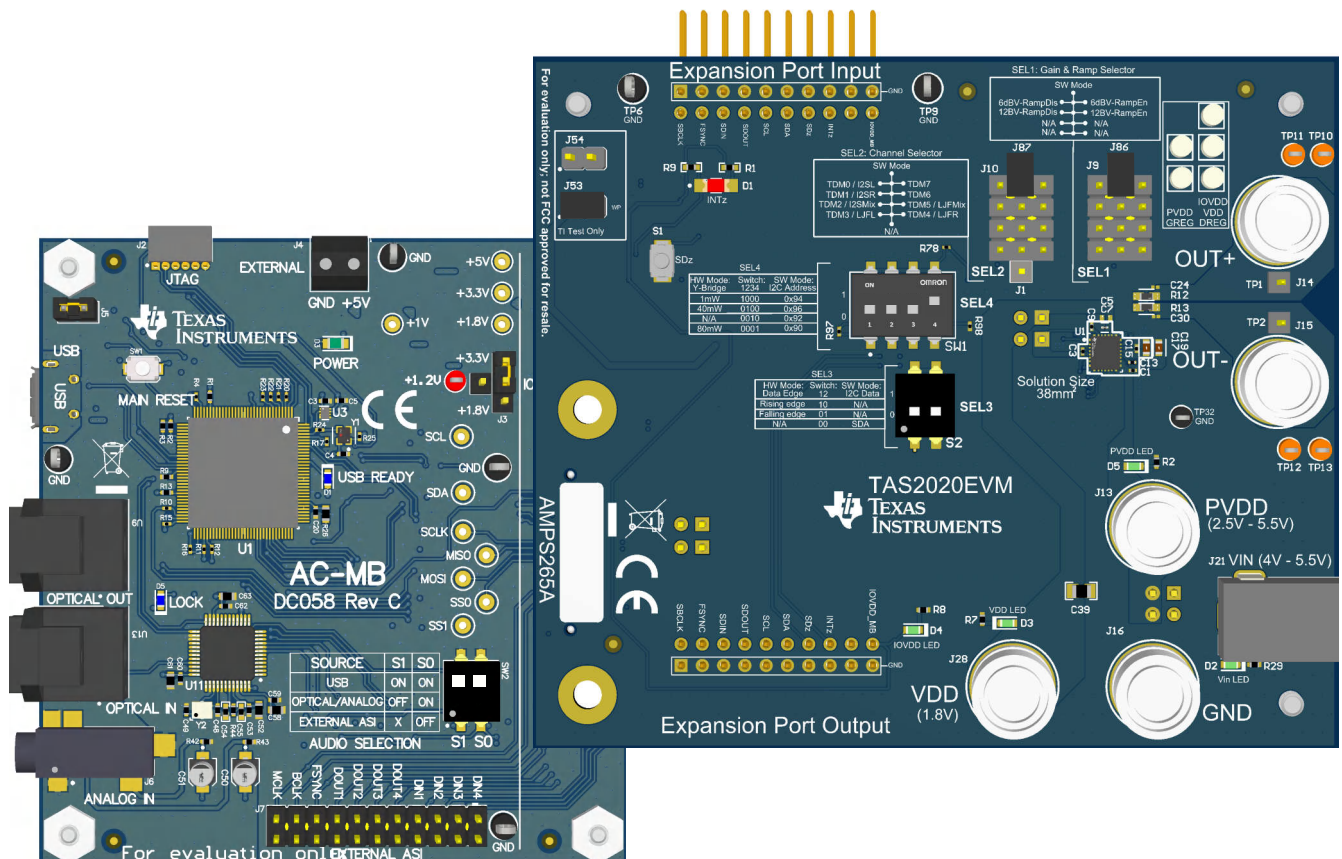
1 Evaluation Module Overview

1.1 Introduction

This user's guide describes the function and use of the TAS2020EVM. 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. In addition, this document includes a Troubleshooting section that can help with common usage errors and problems occuring during TAS2020EVM evaluation.

This section provides details on what is included inside the evaluation module box, what are TAS2020 capabilities and operation ranges, as well as what is the additional test equipment that can be required for a full audio evaluation.

1.2 Kit Contents

The evaluation kit consists of the following items:

- TAS2020EVM
- AC-MB controller board

A speaker is not included in the kit however, any speaker or dummy load rated for the expected output power can be connected to the output connectors using the banana jacks.

Similarly, a power supply is not part of the kit, but the barrel jack connector can be connected to any power supply in a range of 4V to 5.5V. A micro-USB cable is also needed if software mode is used.

1.3 Specification

The TAS2020 is a digital input Class-D audio amplifier optimized for delivering best battery life for music playback and voice calls.

The simple supply configuration allows TAS2020 to be easily implemented in 1S battery applications. TAS2020EVM showcases the 1S battery configuration broadly used in mobile and industrial applications. Two EVMs can be interconnected for a stereo demonstration, as shown in Section 3.8.
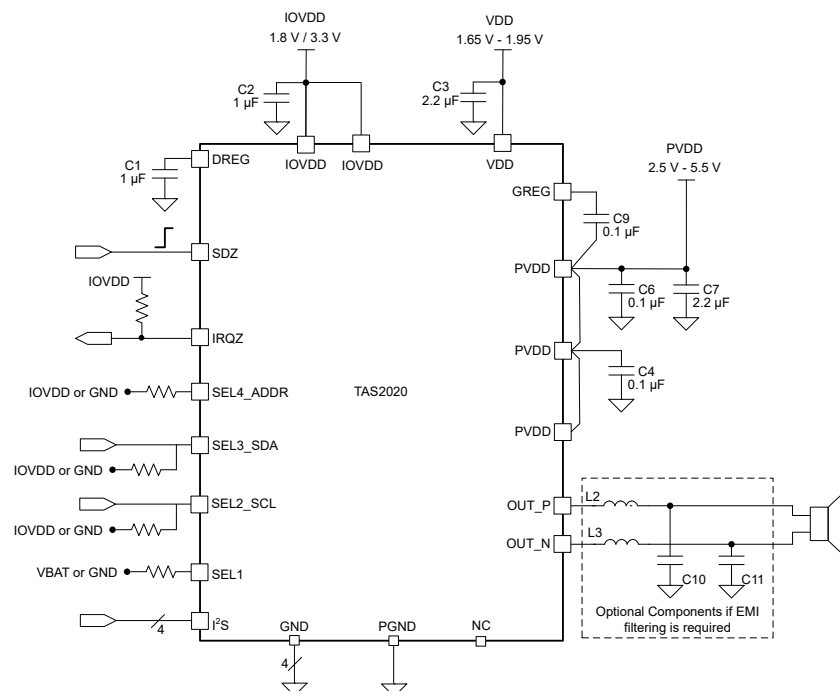

Figure 1-1. Application Diagram for 1S Battery System

1.4 Device Information

TAS2020 is a mono, digital-input, Class-D audio amplifier optimized for efficiently driving high peak power into small loudspeaker applications. The Class-D amplifier is capable of delivering 3.3W into an 4Ω load at a battery voltage of 3.6V. Up to four devices can share a common bus via I^{2}S/TDM and I^{2}C interfaces. TAS2020 also supports a simple hardware-controlled mode in which the I^{2}C is disabled and replaced with basic option selection re-purposing some of the digital control pins.

2 Quick Start Guide

2.1 TAS2020EVM Setup for Hardware Mode

Follow the information presented in this section to properly set the EVM for Hardware Pin-Controlled Mode. Place the jumpers as instructed in Table 2-1.

Table 2-1. Hardware Pin-Control Mode Jumper Settings

| Location	Jumper	Setting	Description
Front	SEL1 (J9/J86)	12dBV-RampEn	Short 2nd to top-right corner to select 12dBV gain and volume ramp enabled.
	SEL2 (J10/J87/J1)	TDM0 / I2SL	Short top left corner for TDM0 channel selection.
	SEL3 (S2)	10	Select BCLK Rising Edge.
	SEL4 (SW1)	0001	Select the Y-Bridge threshold as 80mW.
	EEPROM address (J53)	Short	TI Test jumper.
	EEPROM (J54)	Open	TI Test jumper.
Back	VIN to PVDD (J22)	Short	VIN (J21) = PVDD for TAS2020.
	VDD (J7)	Short	Connect LDO to TAS2020 VDD.
	IOVDD (J3)	Short	Connect AC-MB IOVDD to TAS2020 IOVDD.
	SCL (J18)	Open	Disconnect SCL from AC-MB.
	SDA (J19)	Open	Disconnect SDA from AC-MB.
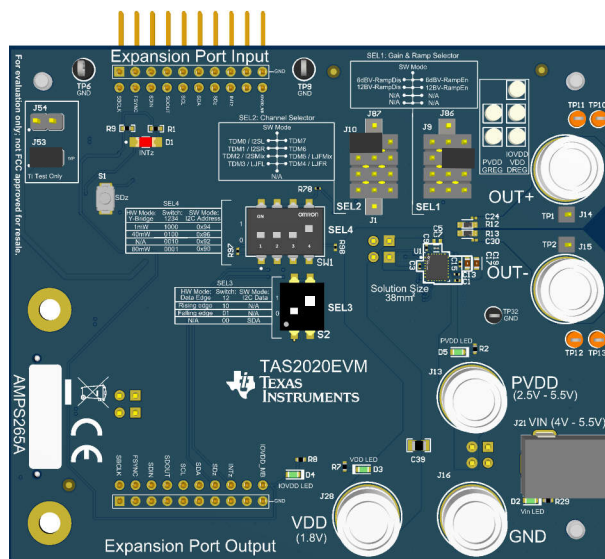
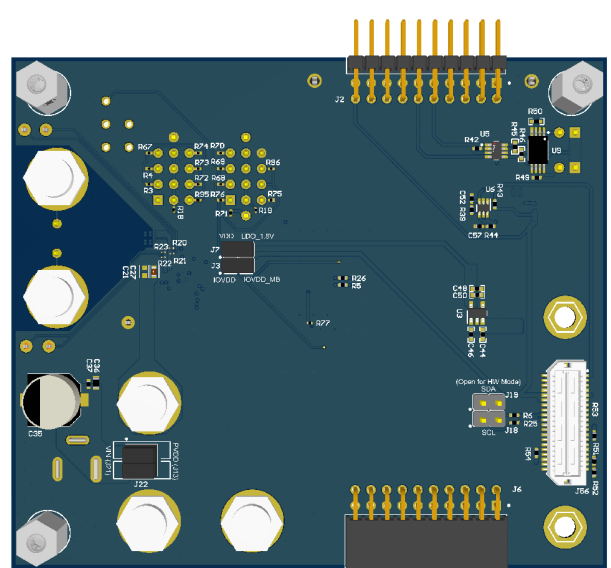**Figure 2-1. Hardware Pin-Control Mode Jumper Settings (Front Side)**

Figure 2-2. Hardware Mode Jumper Settings (Back Side)

Once all the jumpers on the EVM are properly configured, follow the steps below:

- Connect AC-MB to EVM by placing the EVM on top of the edge of the AC-MB.
- Set the IOVDD jumper on AC-MB to either 3.3V or 1.8V.
- Connect 5V power adapter to barrel jack J21 on TAS2020EVM
- Connect USB cable from PC to AC-MB.

At this moment, the device is powered up and running, ready to play audio. The evaluation kit works as any other sound card, select the EVM as system playback device and use any software like web browser, media player, and so forth.

2.2 TAS2020EVM Setup for Software Mode

Follow the information presented in this section to properly set the EVM for Software Mode. Place the jumpers as instructed in Table 2-2. The EVM comes in this Software Mode configuration by default.

Table 2-2. Software Mode Jumper Settings

| Location	Jumper	Setting	Description
Front	SEL1 (J9/J86)	SW Mode	Short from the middle row to the top pin to select SW mode.
	SEL2 (J10/J87/J1)	SW Mode	Short from the middle row to the top pin. This pin is re-purposed as SCL.
	SEL3 (S2)	00	This pin is re-purposed as SDA.
	SEL4 (SW1)	0001	Select the I^{2}C address option as 0x90.
	EEPROM address (J53)	Short	TI Test jumper.
	EEPROM (J54)	Open	TI Test jumper.
Back	VIN to PVDD (J22)	Short	VIN (J21) = PVDD for TAS2020.
	VDD (J7)	Short	Connect LDO to TAS2020 VDD.
	IOVDD (J3)	Short	Connect AC-MB IOVDD to TAS2020 IOVDD.
	SCL (J18)	Short	Connect SCL from AC-MB.
	SDA (J19)	Short	Connect SDA from AC-MB.
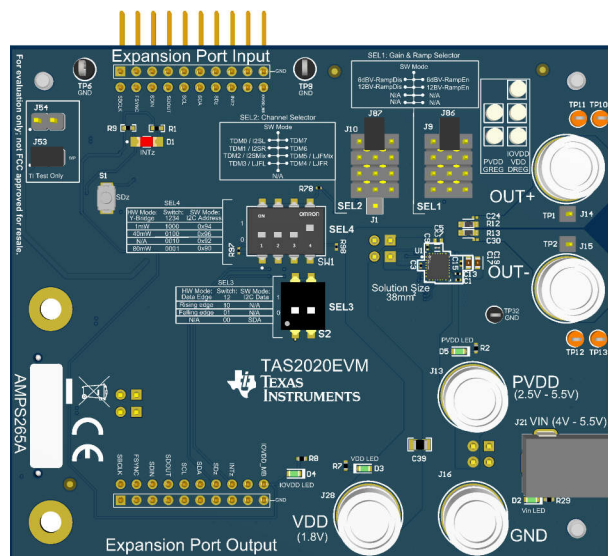
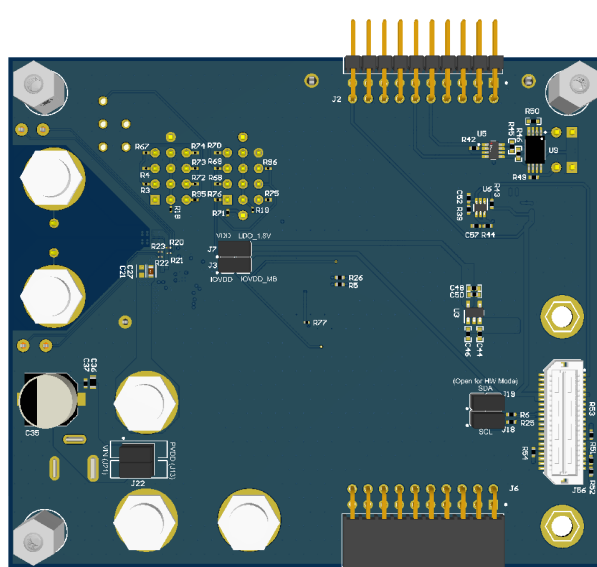**Figure 2-3. Software Mode Jumper Settings (Front Side)**

Figure 2-4. Software Mode Jumper Settings (Back Side)

Once all the jumpers on the EVM are properly configured, follow the steps below:

- Connect AC-MB to EVM by placing the EVM on top of the edge of the AC-MB.
- Set the IOVDD jumper on AC-MB to either 3.3V or 1.8V.
- Connect USB cable from PC to AC-MB.
- Connect 5V power adapter to barrel jack J21 on TAS2020EVM.
- Configure TAS2020 registers with PurePath Console (PPC3).

At this moment, the device is powered up and running, ready to play audio. The evaluation kit works as any other sound card, select the EVM as system playback device and use any software like web browser, media player, and so forth.

3 Hardware

3.1 I^{2}C Target Address Selection

TAS2020 supports 4 different I^{2}C selectable addresses. When SEL1 is set to Software Mode by shorting the middle row to the top pin (J86), the device checks the configuration of SEL4 to select the device address. Use SEL4 jumper to select the required I^{2}C address.

<table>
<tr><td>CAUTION</td></tr>
<tr><td>By default, the amplifier is configured to play the audio slot according to the I^{2}C address, that is, in a TDM system, device with address 0x90 plays slot 0, address 0x92 plays slot 1, and so on.</td></tr>
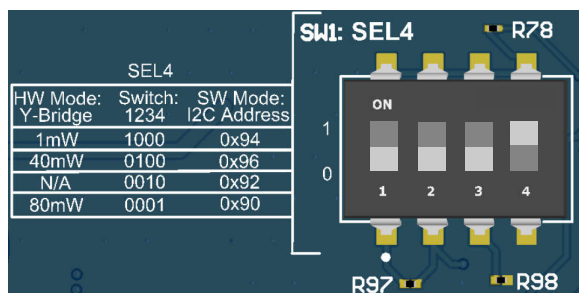</table>

Figure 3-1. SEL4 (SW1) Address Selection

3.2 PVDD Power Supply Options

PVDD pin on U1 is directly connected to J13 which can be used to measure current consumption on TAS2020. Banana jack J13 can be connected to barrel-jack J21 by shorting the 2 jumpers on J22. This allows flexible supply options for PVDD to use either banana or barrel-jack supply.

3.3 VDD Power Supply Options

VDD supply to TAS2020 is powered by an on-board 1.8V LDO. This LDO is powered from 5V connected to barrel jack J21.

J7 on the bottom side of the EVM can be used to open this power supply connection for current measurement purposes. If J7 is open, an external VDD must be connected to the J28 banana jack.

3.4 IOVDD Power Supply Options

IOVDD supply to TAS2020 is powered by AC-MB. For simplicity, the same IOVDD voltage selected on AC-MB is used for TAS2020.

J3 on the bottom side of the EVM can be used to open this power supply connection for current measurement purposes. If J3 is open, then an external IOVDD must be connected to the IOVDD test point close to TAS2020 - U1.

3.5 Speaker Outputs

OUT+ (J14) and OUT- (J15) are the outputs from the amplifier. Banana cables can be connected directly to these jacks. Alternatively the banana jack can be unscrewed to use bare wires, similar to a screw terminal.

3.6 AC-MB Settings

3.6.1 Audio Serial Interface Settings

The AC-MB provides the digital audio signals to the evaluation module from the USB, optical connector, stereo jack, and external audio serial interface (ASI) header. A block diagram of the ASI routing on the AC-MB is shown in Figure 3-1.
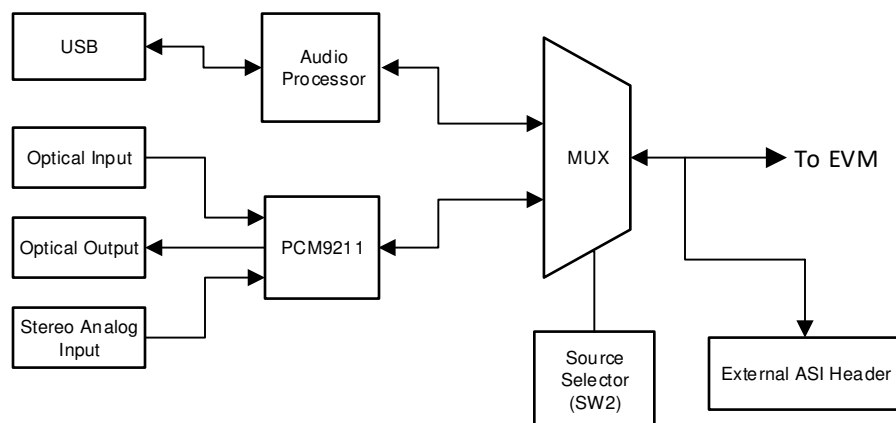

Figure 3-2. AC-MB Audio Serial Interface Routing

Switch SW2 on the AC-MB selects the audio serial bus that interfaces with the TAS2020EVM daughter card. Next to switch SW2, the AC-MB has a quick reference table to identify the audio serial interface source options and switch settings. The AC-MB acts as the controller for the audio serial interface, with three different modes of operation: USB, optical or analog, or external ASI.

3.6.2 USB Audio AC-MB Settings

The serial interface clocks and data are provided from the USB interface. The sampling rate and format are determined by the USB audio class driver on the operating system.

The default settings for the USB audio interface are 32-bit frame size, 48kHz sampling rate, BCLK and FSYNC ratio is 256, and the format is time division multiplexing (TDM).

The AC-MB is detected by the OS as an audio device with the name TI USB Audio UAC2.0. The AC-MB audio setting for the USB mode of operation is shown in Figure 3-2.
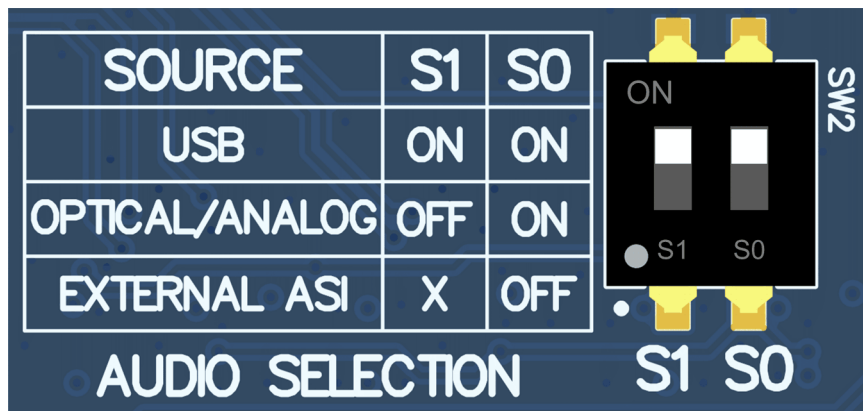
Figure 3-3. AC-MB USB Audio Setting

3.6.3 External Audio AC-MB Settings

In this mode, the audio serial interface clocks for the evaluation board are provided through connector J7 from an external source. This architecture allows the use of an external system to communicate with the evaluation board, such as a different host processor or test equipment (for instance, Audio Precision PSIA). The clocks generated from the USB interface and PCM9211 are isolated with this setting. The AC-MB audio setting for the external mode of operation is shown in Figure 3-3.
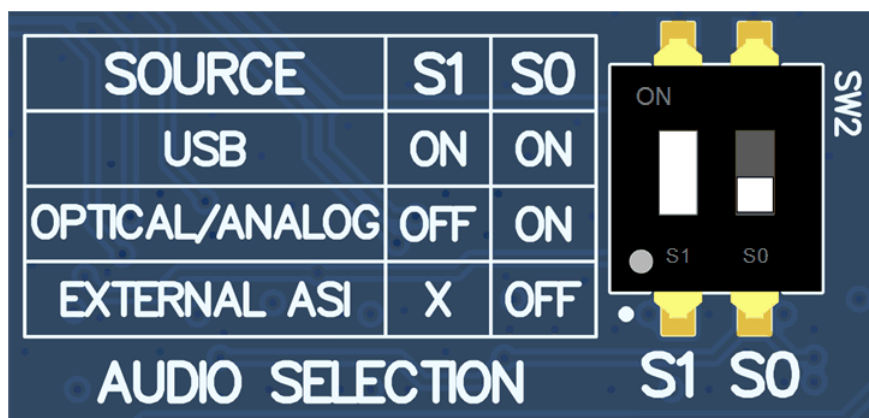

Figure 3-4. AC-MB External Audio Setting

How to connect the external audio interface with the bottom row for the ground and the top row for signals is shown in Figure 3-4.
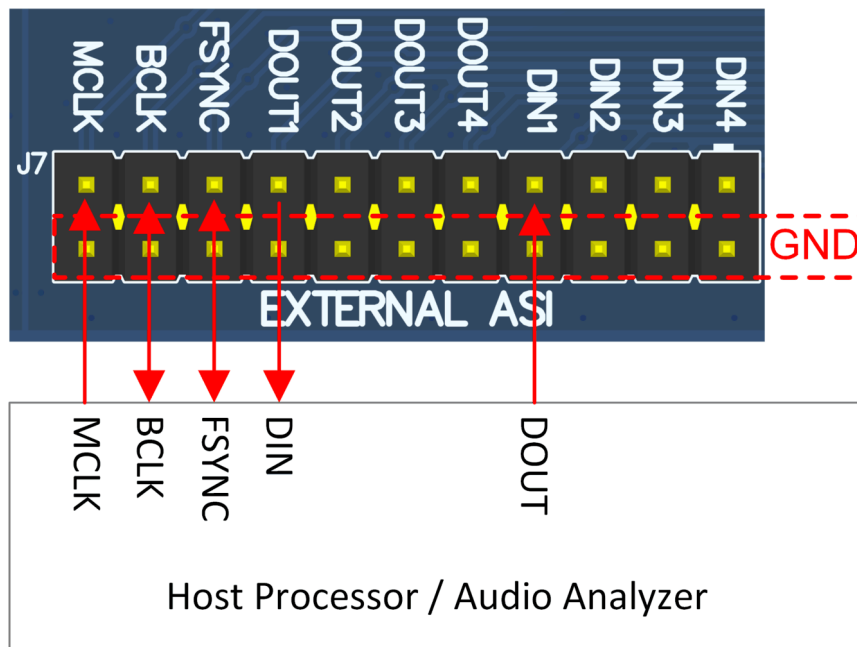
Figure 3-5. AC-MB Connection with External Audio Serial Interface

3.7 AC-MB Power Supply

The AC-MB motherboard is powered from a single 5V power supply. However, the motherboard has different low-dropout regulators (LDOs) integrated that provide the required power supplies to the different blocks of the board. The block diagram depicting the power structure of the AC-MB is shown in Figure 3-5. The AC-MB can be powered from the host computer by using the USB 5V power supply (VBUS) by shorting header J5, USB POWER. Additionally, the AC-MB can be powered from an external power supply connected to terminal J4, EXTERNAL POWER. Header J5 must be open for external supply operation. The IOVDD voltage for the digital signals that is provided to the evaluation module is generated on the motherboard from the main power supply (USB or external). The voltage levels available are 1.2V, 1.8V and 3.3V, and can be selected via the J3 header IOVDD. Default setting for TAS2020EVM operation is 3.3V; **1.2V operation cannot be used for TAS2020EVM**. When the motherboard is fully powered and the power supplies from the onboard LDOs are correct, the green POWER LED (D3) turns ON. The USB READY LED indicates that a successful USB communication is established between the AC-MB and the host computer.
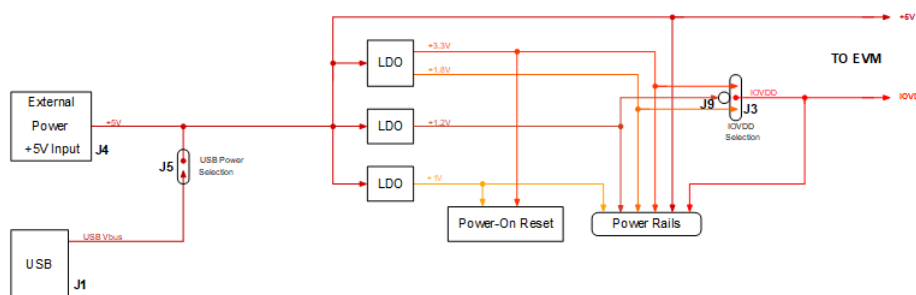

Figure 3-6. Power -Supply Distribution of the AC-MB

3.8 2-Channel Configuration

Two mono EVMs can be interconnected using J2 and J6 headers, place the EVMs side by side and connect J6 from the first EVM to J2 on the second EVM.

CAUTION

When 2 EVMs are interconnected, both EVMs must be set to the same mode, that is, either both EVMs are in Hardware mode or both EVMs are in Software mode. Mixed configuration is not supported. Use the same jumper settings for both EVMs.

CAUTION

Make sure to short J54 jumper on the secondary EVM, ie. the EVM that is not connected to the AC-MB controller board.

CAUTION

The power supplies used on the main EVM can be connected to the seccondary EVM using the banana connectors.
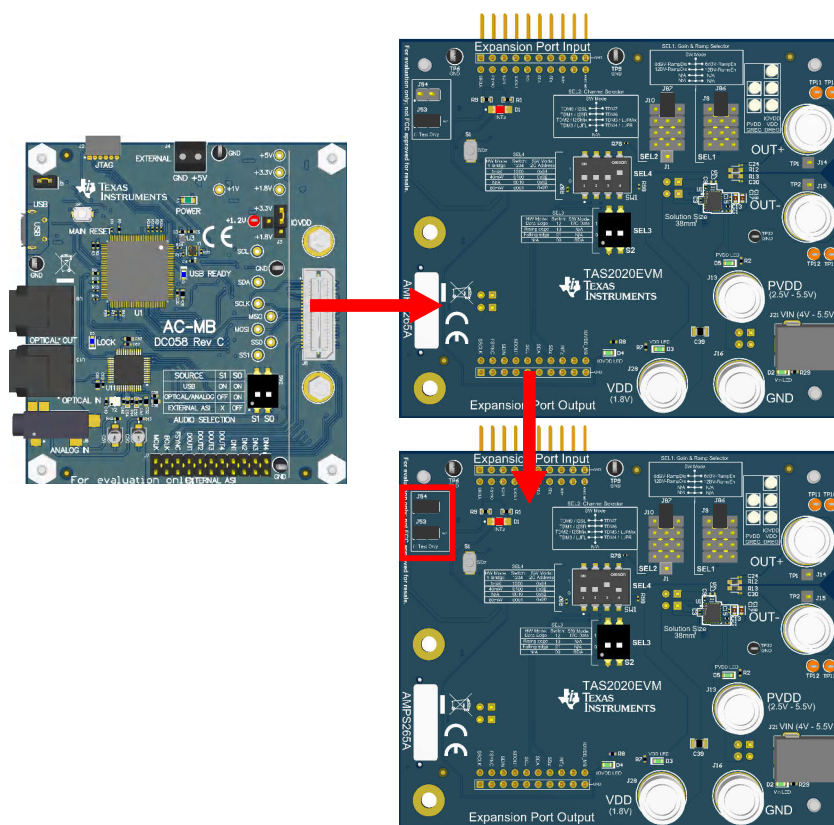
Figure 3-7. 2-Channel EVM Interconnection

3.9 4-Wire Measurement of Load

TAS2020EVM has been designed such that the dummy load or speaker load connected to the device can be measured very accurately directly from the device pin including board parasitic and connector contact resistance using 4-wire method in digital multimeter. Pin header have been provided to be able to connect digital multimeter in 4-wire mode as shown below Figure 3-9.

Connect HI of DMM to TP10 and HI_SNS of DMM to TP11.
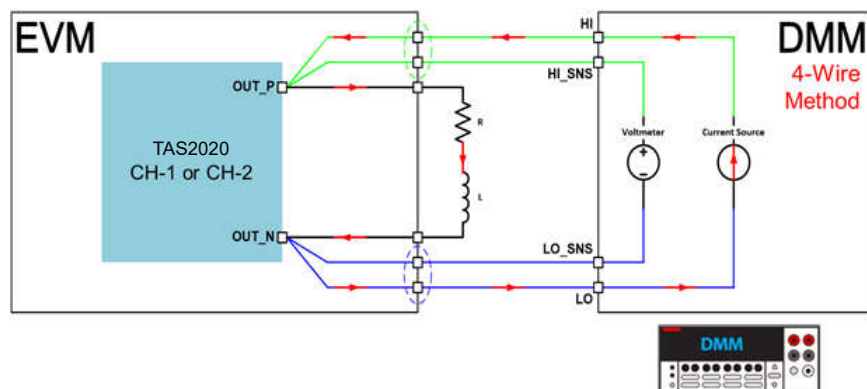
Connect LO of DMM to TP13 and LO_SNS of DMM to TP12.

Figure 3-8. Load DC Resistance Measurement in 4-Wire Mode using Digital Multimeter

4 Troubleshooting

This section provides a series of resolutions for possible errors during the evaluation of TAS2020EVM.

- EVM connects to PPC3 but shows invalid hardware error:
  - Make sure J3-IOVDD on the companion AC-MB board is set to either 3.3V or 1.8V. Please note 1.2V is not supported by TAS2020 and is not to be used.
  - Make sure J54 on TAS2020EVM is open. This is an optional jumper that are only be used in special cases when connecting 2 EVMs together as described in Section 3.8.
  - Make sure J18 and J19 at the bottom side of TAS2020EVM are shorted. These are I2C SDA and SCL related jumpers and are to be open only when evaluating TAS2020 in Hardware mode.
  - Make sure EEPROM is properly programmed to work correctly for TAS2020EVM. Use I2C Master tool within PPC3 to run these couple of commands:
    - w a0 00 00
    - r a0 00 1a

  Compare the resulting values with the ones below:

  54 41 53 32 30 32 30 2d 45 56 4d 00 52 45 56 2d 41 00 53 2f 4e 2d 30 30 30 30

  If the values are not the same, run this command:

  w a0 00 00 54 41 53 32 30 32 30 2d 45 56 4d 00 52 45 56 2d 42 00 53 2f 4e 2d 30 30 30 30
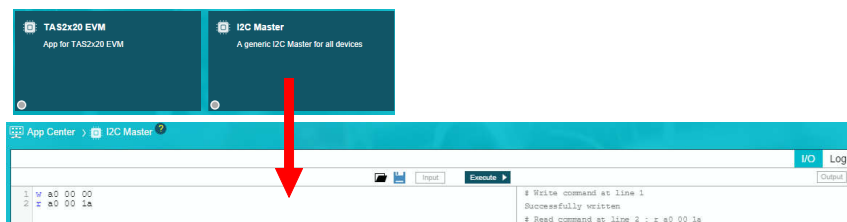
Figure 4-1. EEPROM Programming Script

- EVM connects and configures correctly but there is no audio output:
  - TAS2020EVM operate as a sound-card. Make sure the volume is properly set and that the device is not muted.
  - Make sure the EVM is selected as the playback device.
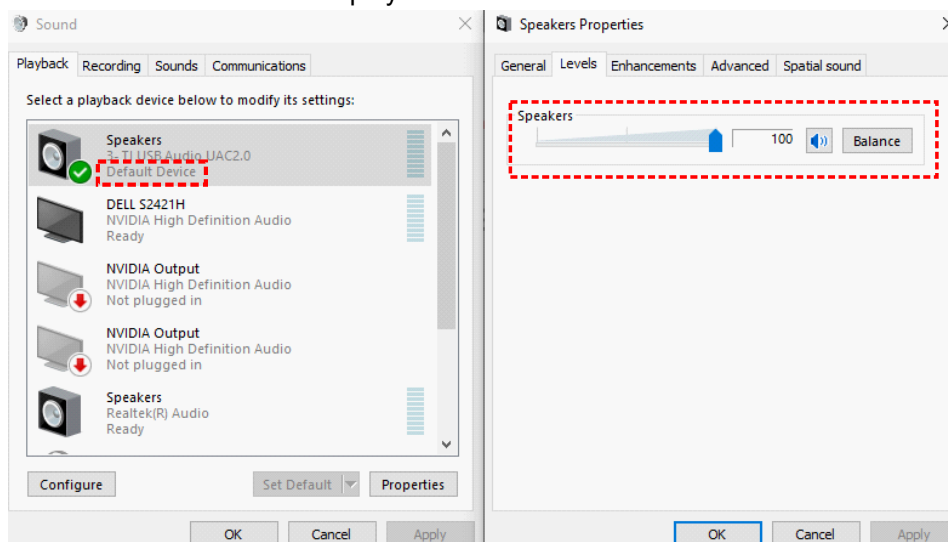
Figure 4-2. Device Selection and Volume Settings

5 Hardware Design Files

5.1 Schematics
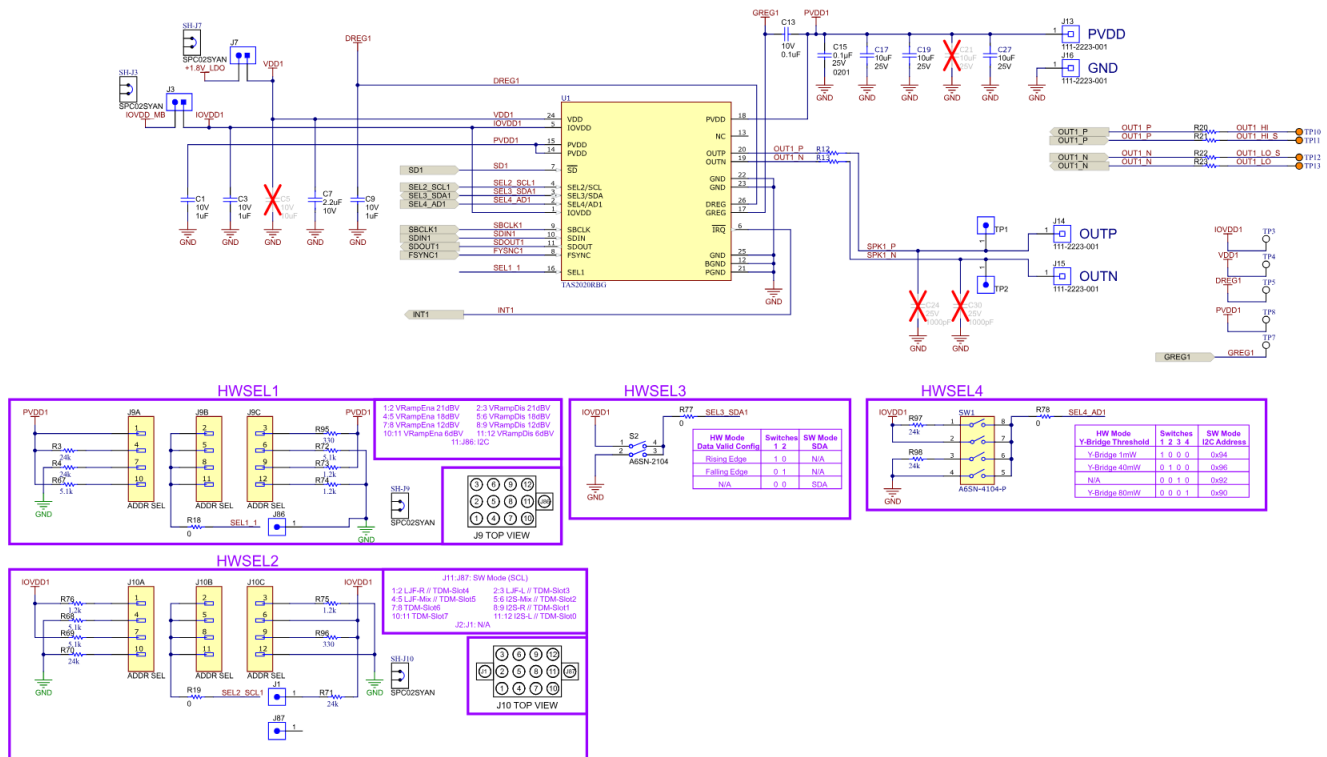
Figure 5-1. TAS2020EVM Schematic (Sheet 1 of 4)
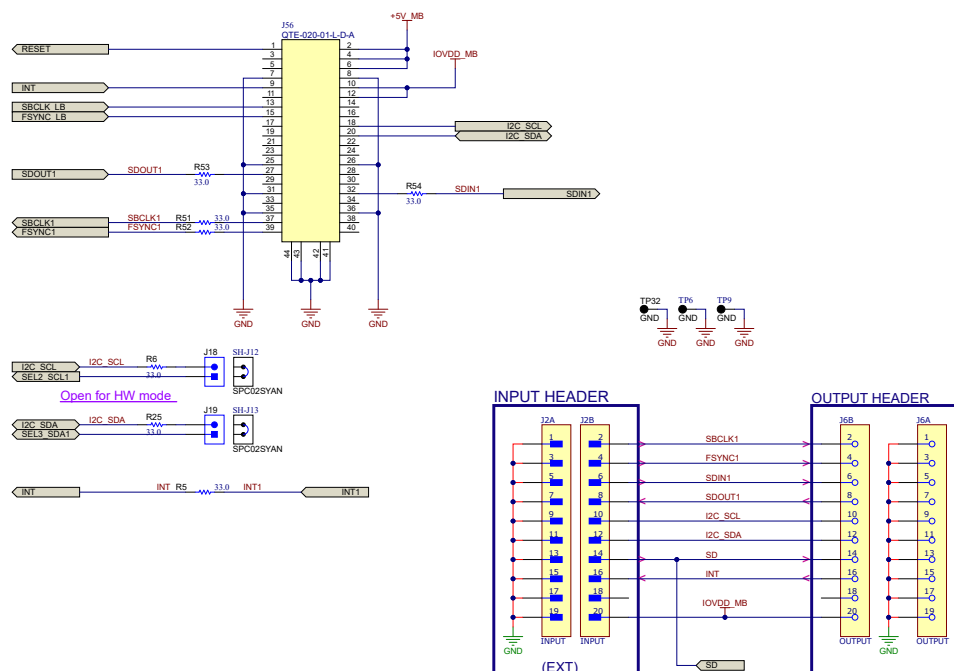
Figure 5-2. TAS2020EVM Schematic (Sheet 2 of 4)
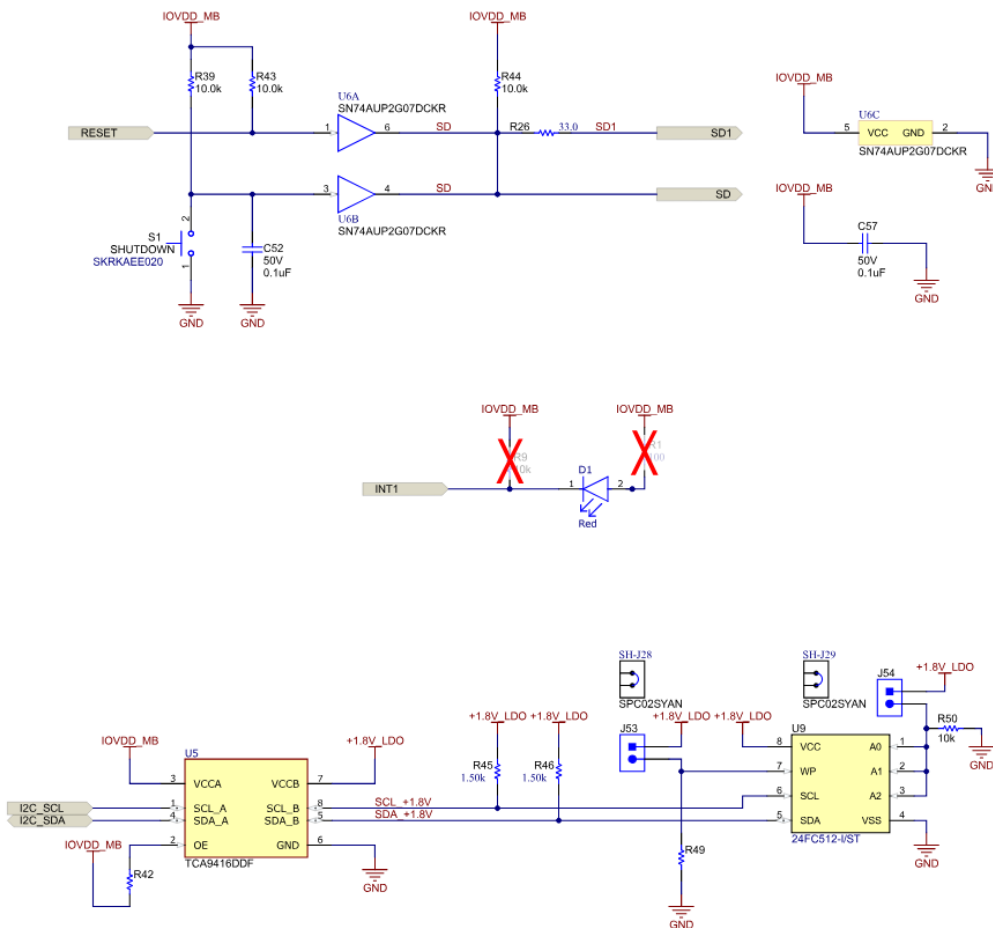
Figure 5-3. TAS2020EVM Schematic (Sheet 3 of 4)
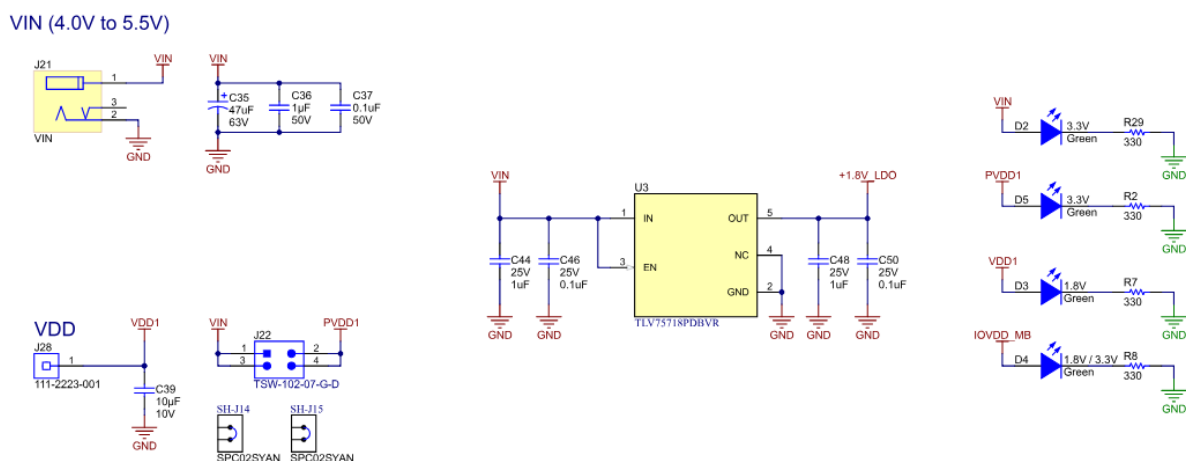
Figure 5-4. TAS2020EVM Schematic (Sheet 4 of 4)

5.2 PCB Layouts

Figure 5-5. TAS2020EVM Top Overlay

Figure 5-6. TAS2020EVM Top Solder Mask

Figure 5-7. TAS2020EVM Top Layer

Figure 5-8. TAS2020EVM Layer 2
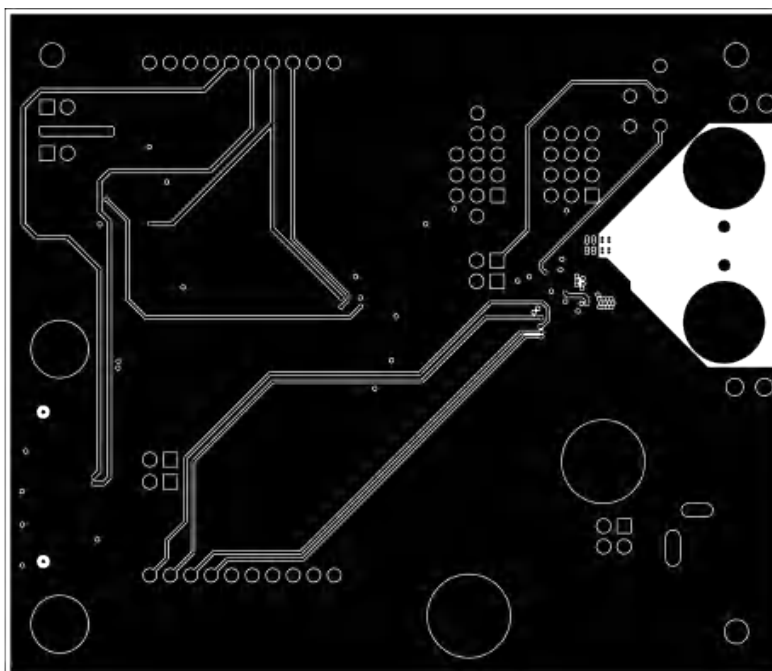
Figure 5-9. TAS2020EVM Layer 3
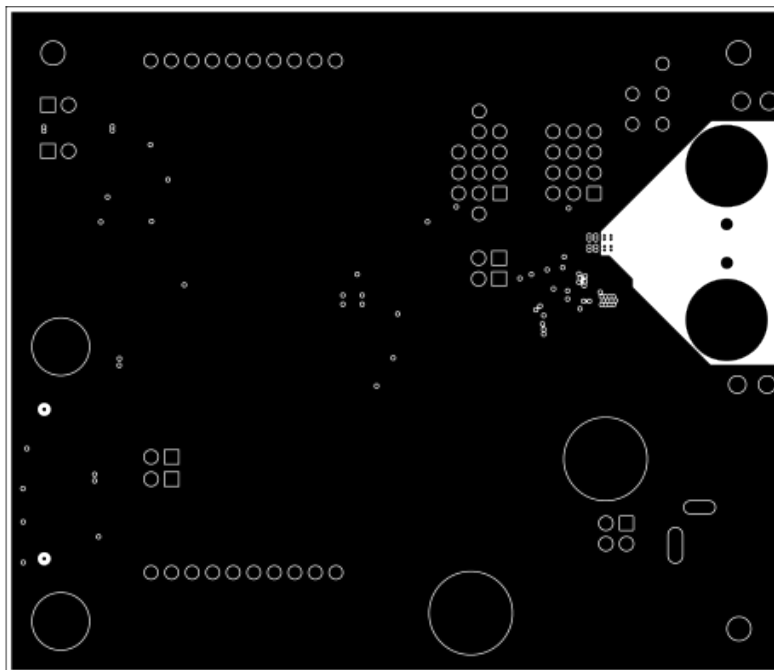
Figure 5-10. TAS2020EVM Layer 4
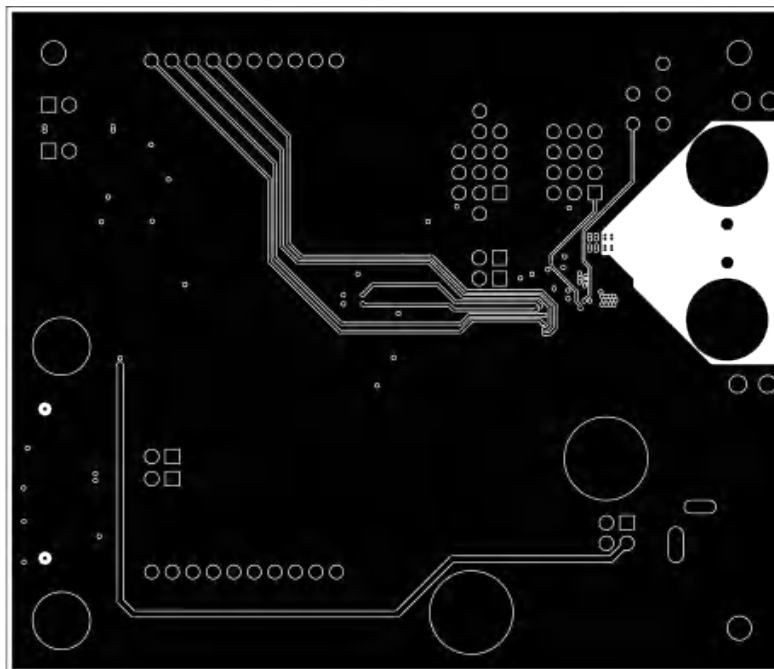
Figure 5-11. TAS2020EVM Layer 5
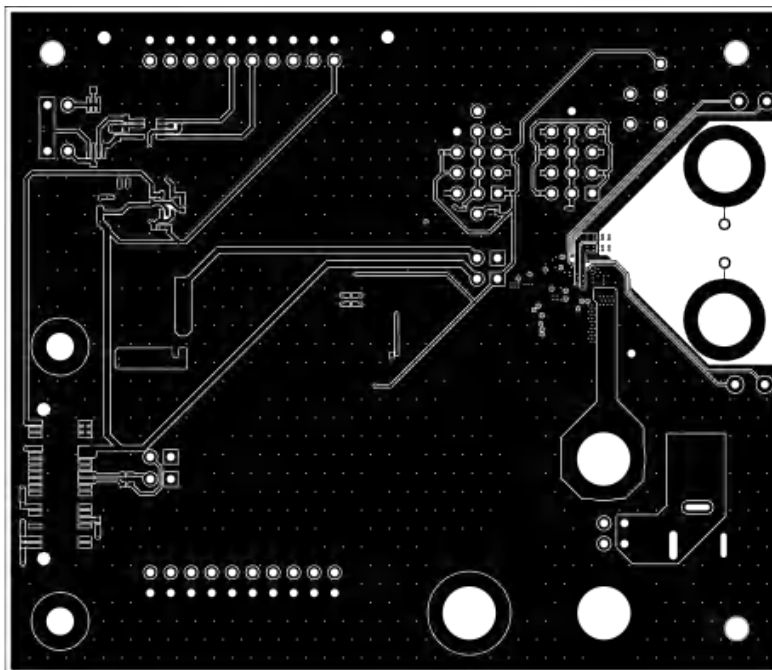
Figure 5-12. TAS2020EVM Bottom Layer
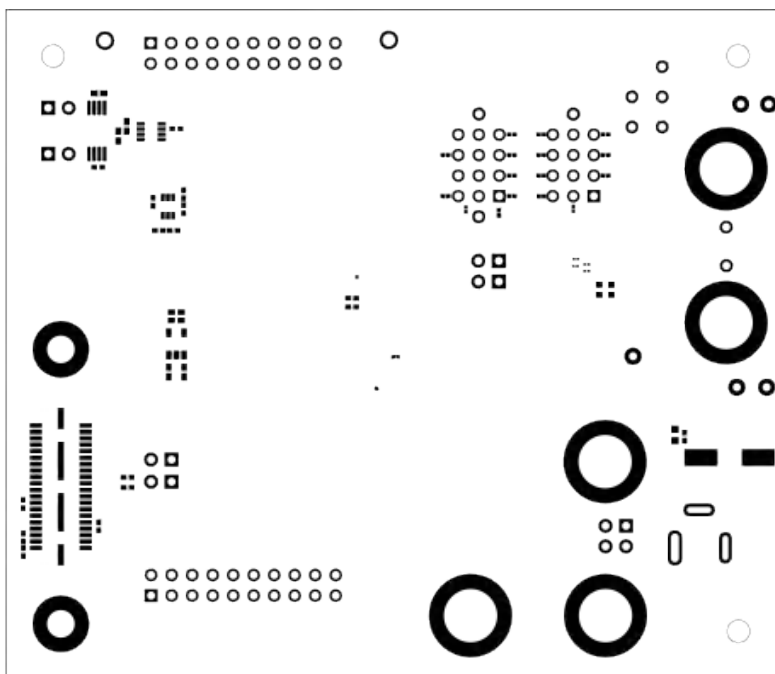
Figure 5-13. TAS2020EVM Bottom Solder Mask
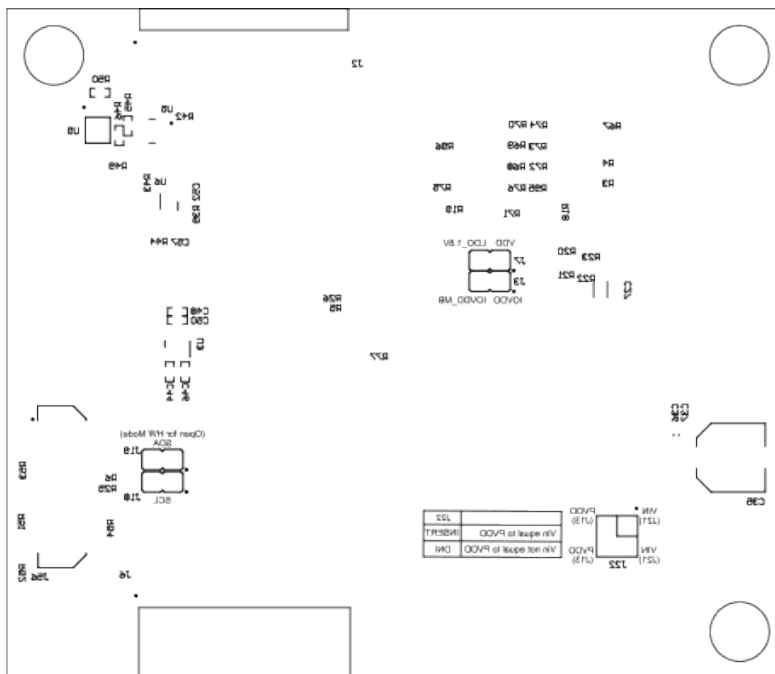
Figure 5-14. TAS2020EVM Bottom Overlay

5.3 Bill of Materials

Table 5-1. Bill of Materials

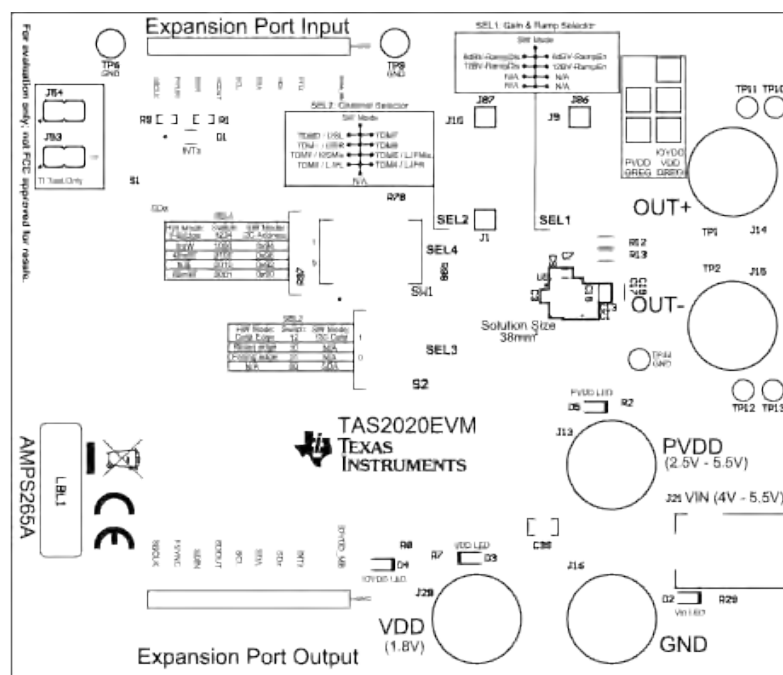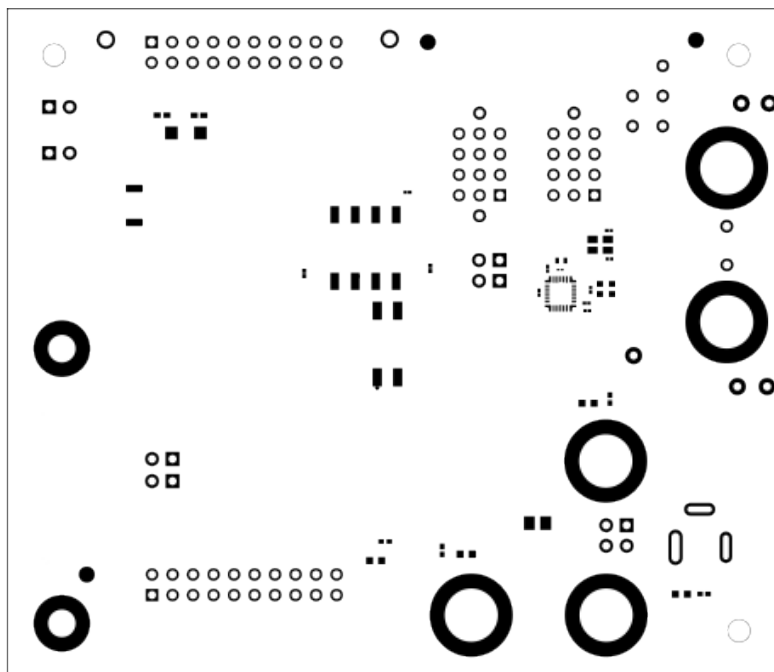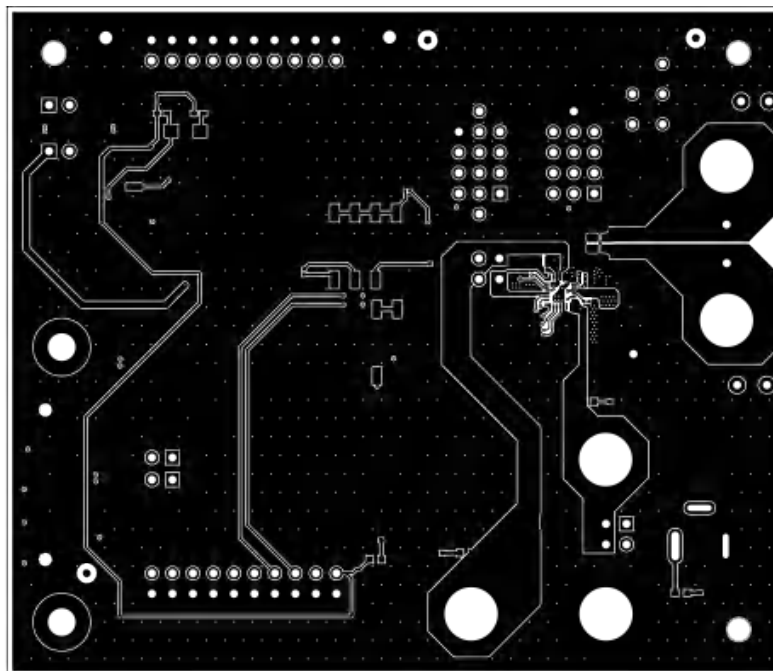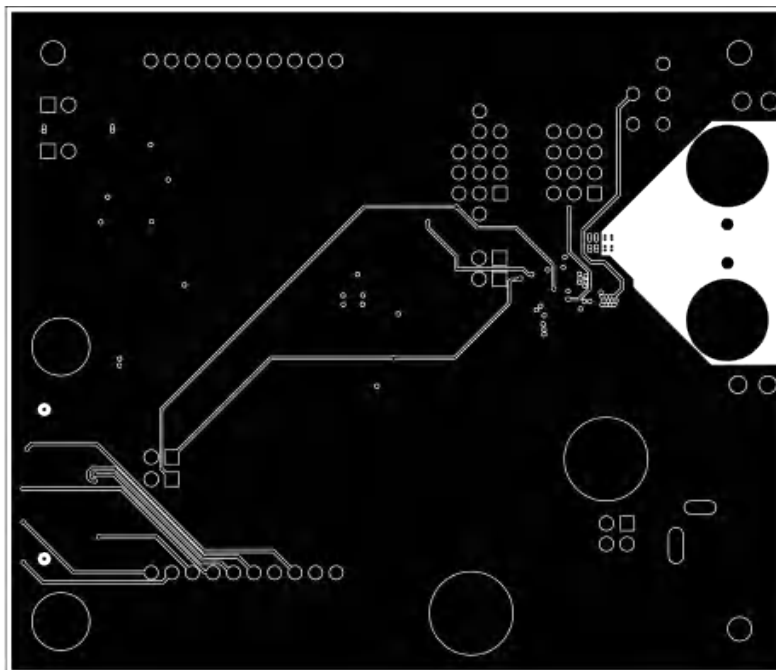| Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB	1		Printed Circuit Board		AMPS265	Any		
C1, C3, C9	3	1uF	CAP, CERM, 1 uF, 10 V, +/- 20%, X5R, 0201	0201	CL03A105MP3NSNC	Samsung Electro-Mechanics		
C7	1	2.2µF	Cap Ceramic 2.2uF 10V X5R ±20% Pad SMD 0201 +85°C T/R	0201	CL03A225MP3CRNC	Samsung		
C13	1	0.1uF	CAP, CERM, 0.1 uF, 10 V, +/- 10%, X5R, 0201	0201	CL03A104KP3NNNC	Samsung Electro-Mechanics		
C15	1	0.1uF	CAP, CERM, 0.1 µF, 10 V,+/- 10%, X5R, 0201	0201		SAMSUNG ELECTRO-MECHANICS		
C17, C19, C27	3	10µF	Cap Ceramic 10uF 25V X5R ±20% Pad SMD 0603 +85°C T/R	0603	CL10A106MA8NRNC	Samsung		
C35	1	47uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1J470P	Panasonic		
C36	1	1uF	CAP, CERM, 1 µF, 50 V,+/- 20%, X5R, AEC-Q200 Grade 3, 0603	0603	CGA3E3X5R1H105M080AB	TDK		
C37, C52, C57	3	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK		
C39	1	10uF	CAP, CERM, 10 µF, 10 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCJ21BR71A106KE01L	MuRata		
C44, C48	2	1uF	CAP, CERM, 1 uF, 25 V, +/- 10%, X5R, 0402	0402	C1005X5R1E105K050BC	TDK		
C46, C50	2	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X5R, 0402	0402	GRM155R61E104KA87D	MuRata		
D1	1		Red 630nm LED Indication - Discrete 1.5V 1206 (3216 Metric)	1206	CTL1206FRD1T-CT	Venkel		
D2, D3, D4, D5	4	Green	LED, Green, SMD	LED_0603	LTST-C191KGKT	Lite-On		
H1, H3, H7	3				HNSS440	B&F Fastener Supply		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
H2, H4, H8	3		Standoff; 1/4 Hex Male/female; 4-40 Thread; Stainless Steel; .750LENGTH	HEX_STANDOFF	4538-440-SS	RAF Electronic Hardware		
J1, J86, J87	3		Header, 2.54mm, 1x1, Gold, TH	Header, 2.54mm, 1x1, TH	HTSW-101-07-G-S	Samtec		
J2	1			HDR20	TSW-110-08-G-D-RA	Samtec		
J3, J7, J18, J19, J53, J54	6		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
J6	1		20 Position Receptacle Connector Through Hole, Right Angle	HDR20	SSQ-110-02-G-D-RA	SAMTEC		
J9, J10	2			HDR12	TSW-104-07-G-T	Samtec		
J13, J14, J15, J16, J28	5		Binding Post, Nickel, TH	Receptacle, 1x1 Position, Dia 9.8mm, TH	111-2223-001	Cinch Connectivity		
J21	1		Power Jack, mini, 2.5mm OD, R/A, TH	Jack, 14.5x11x9mm	RAPC712X	Switchcraft		
J22	1		Header, 100mil, 2x2, Gold, TH	2x2 Header	TSW-102-07-G-D	Samtec		
J56	1		Connector, Header, High Speed, 20 pairs, SMT	QTE-020-01-X-D-A	QTE-020-01-L-D-A	Samtec		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady		
R2, R7, R8, R29	4	330	RES, 330, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF3300X	Panasonic		
R3, R4, R70, R71, R97, R98	6	24k	RES, 24 k, 5%, 0.05 W, 0201	0201	RC0201JR-0724KL	Yageo America		
R5, R6, R25, R26, R51, R52, R53, R54	8	33	RES, 33.0, 1%, 0.1 W, 0402	0402	ERJ-2RKF33R0X	Panasonic		
R50	1	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ103X	Panasonic		
R12, R13	2	0	RES 0 OHM JUMPER 1/4W 0603	0603	HCJ0603ZT0R00	Stackpole Electronics		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R18, R19, R77, R78	4	0	RES, 0, 5%, 0.05 W, 0201	0201	CRCW02010000Z0ED	Vishay-Dale		
R20, R21, R22, R23	4		RES SMD 0 OHM JUMPER 1/20W 0201	0201 (0603 Metric)	RC0201JR-070RL	Yageo		
R39, R42, R43, R44, R49	5	10.0k	RES, 10.0 k, 1%, 0.063 W, 0402	0402	RC0402FR-0710KL	Yageo America		
R45, R46	2	1.50k	RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	RMCF0402FT1K50	Stackpole Electronics Inc		
R67, R68, R69, R72	4	5.1k	RES, 5.1 k, 5%, 0.05 W, 0201	0201	RC0201JR-075K1L	Yageo America		
R73, R74, R75, R76	4	1.2k	RES, 1.2 k, 5%, 0.05 W, 0201	0201	RC0201JR-071K2L	Yageo America		
R95, R96	2	330	RES, 330, 5%, 0.05 W, 0201	0201	RC0201JR-7D330RL	Yageo America		
S1	1		Switch, SPST-NO, 0.05 A, 12 VDC, SMT	3.9x2.9mm	SKRKAEE020	Alps		
S2	1		Switch, Slide, 2 SPST, Off-On, 0.025 A, 24 VDC, SMT	7x7.5mm	A6SN-2104	Omron Electronic Components		
SH-J3, SH-J7, SH-J9, SH-J10, SH-J12, SH-J13, SH-J14, SH-J15, SH-J28, SH-J29	10	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions		
SW1	1		Dip Switch SPST 4 Position Surface Mount Slide (Standard) Actuator 25mA 24VDC	SW	A6SN-4104-P	Omron Electronics Inc-EMC Div		
TP1, TP2	2		Header, 2.54mm, 1x1, Gold, TH	Header, 2.54mm, 1x1, TH	TSW-101-08-G-S	Samtec		
TP3, TP4, TP5, TP7, TP8	5		Test Point, Miniature, White, TH	Test-Point, Dia 100mil, TH	TP105-01-09	Components Corporation		
TP6, TP9	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics		

Table 5-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
TP10, TP11, TP12, TP13	4		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone Electronics		
TP32	1		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
U1	1		TAS2020RBG	VQFN-HR26	TAS2020RBG	Texas Instruments		
U3	1		1A low-Iq small-size low-dropout (LDO) regulator, DBV0005A (SOT-23-5)	DBV0005A	TLV75718PDBVR	Texas Instruments	TLV75718PDBVT	Texas Instruments
U5	1		TCA9416DDF	SOT23-8	TCA9416DDF	Texas Instruments		
U6	1		Low-Power Dual Buffer/Driver With Open-Drain Outputs, DCK0006A (SOT-SC70-6)	DCK0006A	SN74AUP2G07DCKR	Texas Instruments		
U9	1		512K I2C Serial EEPROM, TSSOP	TSSOP-8	24FC512-I/ST	Microchip		

6 Additional Information

6.1 Trademarks

PurePath™ is a trademark of Texas Instruments.

Windows® is a registered trademark of Microsoft Corporation.

All trademarks are the property of their respective owners.

7 Revision History

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

DATE	REVISION	NOTES
August 2025	*	Initial Release

STANDARD TERMS FOR EVALUATION MODULES

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

    1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

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

2. *Limited Warranty and Related Remedies/Disclaimers*:

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

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

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

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3   *Regulatory Notices:*

3.1   *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2   *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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

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

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or

3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

　　　上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

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

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

4   *EVM Use Restrictions and Warnings:*

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

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

4.3   *Safety-Related Warnings and Restrictions:*

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

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

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

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

6.   *Disclaimers:*

6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2   EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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 OR THE USE OF THE EVMS , 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 TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

    8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM 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.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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 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, TI's General Quality Guidelines, 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. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

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