User's Guide

TPA3223 Evaluation Module

ABSTRACT

This user's guide describes the characteristics, operation, and use of the TPA3223 evaluation module. A complete printed-circuit board (PCB) description, schematic diagram, and bill of materials are also included.

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1 Quick Start (BTL MODE)

The following section describes the necessary hardware, connections, configuration, and steps to quick start the EVM into BTL mode with stereo audio playing out of two speakers.

Figure 1-1 illustrates the BTL mode output configuration.

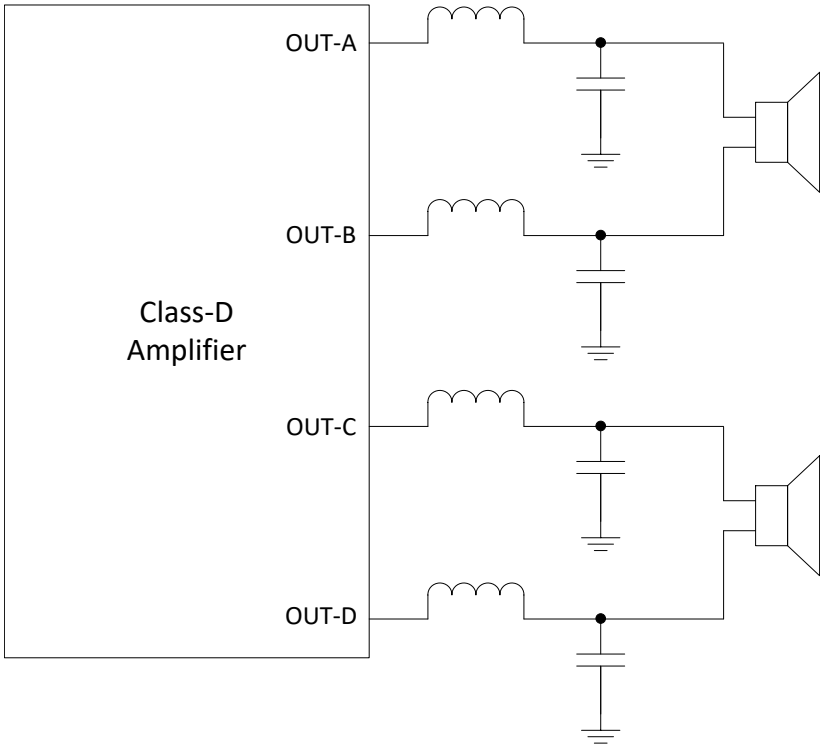

Figure 1-1. Output Configuration BTL

1.1 Required Hardware

The following hardware is required for this EVM:

- TPA3223EVM
- Power supply 5–14 A, 12–45 VDC
- Two 3–8 Ω speaker or resistor loads (make sure that speaker/load is appropriately sized for required wattage output)
- Four speaker, banana cables
- Four XLR or two RCA input cables
- Analog output audio source

1.2 Connections and Board Configuration (BTL MODE)

Figure 1-2 shows the EVM board.

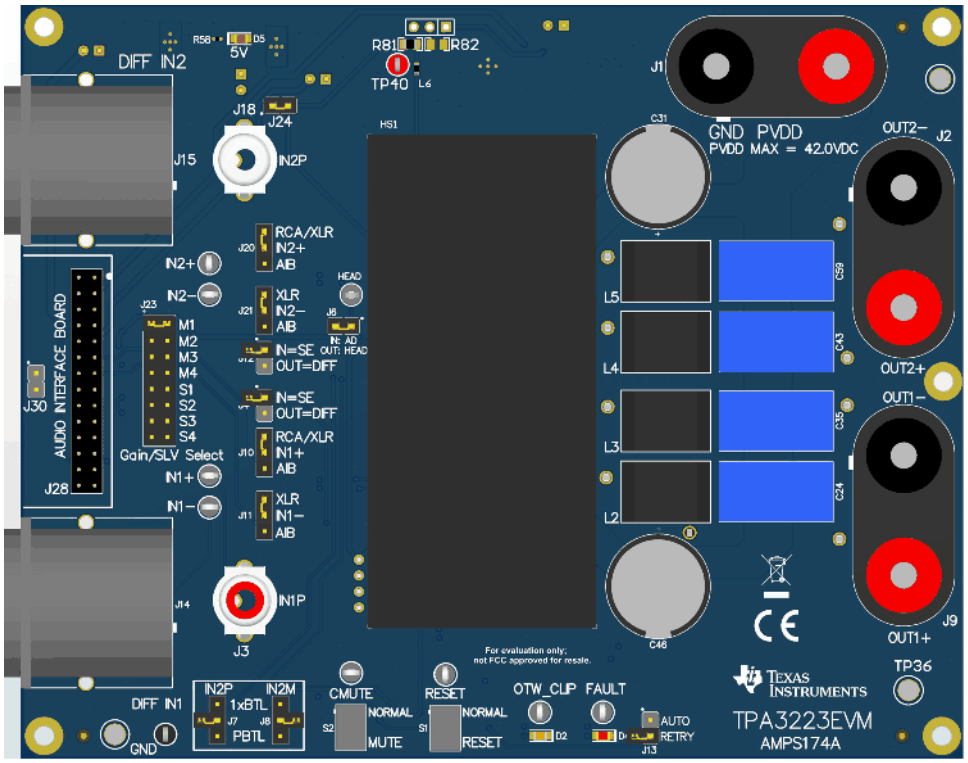

Figure 1-2. EVM Board (Top Side)

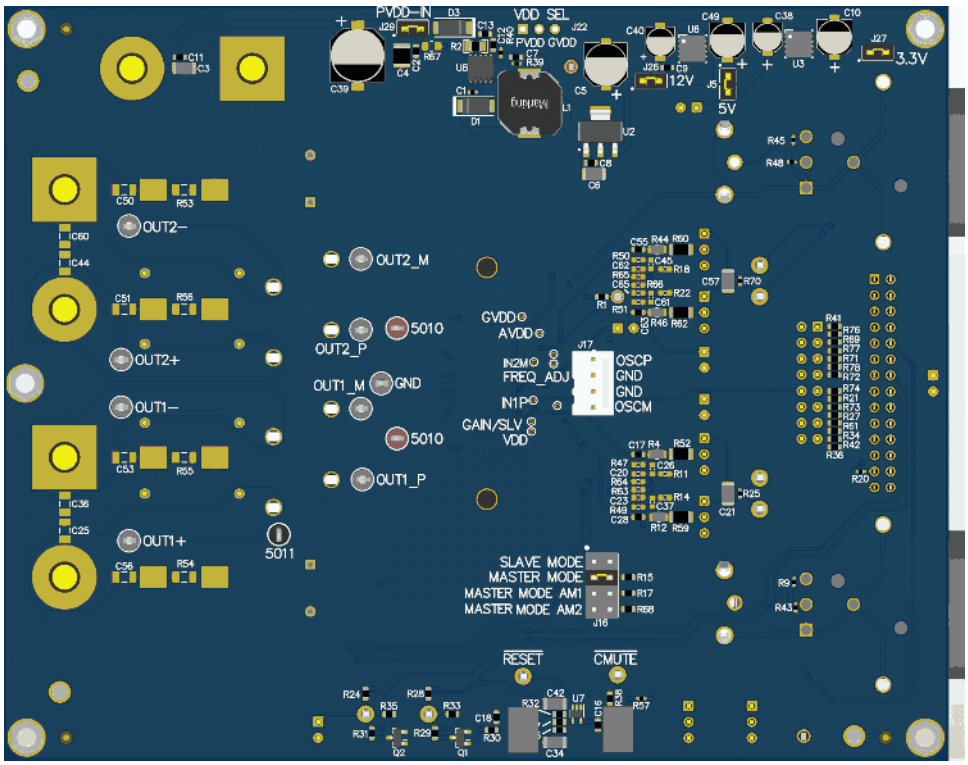

Figure 1-3. EVM Board (Bottom Side)

Use the following steps when connecting and configuring the board for BTL MODE:

1. Ensure the power supply is OFF. Connect the power supply positive terminal to J1 PVDD (red) and negative terminal to J1 GND (black).
2. Connect the left channel speaker, power resistor load (3–8 Ω) to the TPA3223EVM positive output terminal (J9 OUT1+ (red)) and other side of the speaker, power resistor to the TPA3223EVM negative output terminal (J9 OUT1– (black)).
3. Connect the right channel speaker, power resistor load (3–8 Ω) to the TPA3223EVM positive output terminal (J2 OUT2+ (red)) and other side of the speaker, power resistor to the TPA3223EVM negative output terminal (J2 OUT2– (black)).
4. Check to make sure that the power supply is connected to J1 only and speakers are connected to J9 or J2 only, as their colors are the same.
5. Input Configuration:
   a. **Differential Inputs:** connect one differential XLR audio input to each DIFF IN1 (J14) and DIFF IN2 (J15). Install jumpers J10, J11, J20, and J21 to position 1:2 which is labeled as **RCA** or **XLR**. Jumpers J4 and J12 must be uninstalled for DIFF input.
   b. **Single-Ended Inputs:** connect one single-ended RCA audio input to IN1P (J3) and IN2P (J18). Install jumpers J10, J11, J20, and J21 to position 1:2 which is labeled as **RCA** or **XLR**. Jumpers J4 and J12 must be installed for SE input.
   c. **Audio Interface Board Input:** Install jumpers J10, J11, J20, and J21 to position 2:3 which is labeled as **AIB**. Jumpers J4 and J12 must be installed for SE input from the AIB or uninstalled for DIFF input from the AIB.
6. Ensure that RESET S1 and MUTE S2 are in the lower positions of RESET and MUTE, respectively.
7. Check Table 1-1 for all jumper and switch configurations

Table 1-1. Jumper and Switch Configurations (BTL Mode)

Component	Component Description	Configuration for BTL
J23	Gain/CLKSYNC Select	MSTR (Primary) 20 dB
J24	N/A	IN
J4, J12	Input DIFF/SE Select	OUT = DIFF IN, IN = DIFF IN
J10, J11, J20, J21	AIB Input Select	Position 1:2 for XLR/RCA, Position 2:3 for AIB
J6	HEAD/AD Mode Select	IN
J7, J8	PBTL/BTL Select	OUT
S1	RESET Control	RESET
S2	MUTE Control	MUTE
J13	Auto Retry	OUT
J29	PVDD-IN	IN
J26	12V-IN	IN
J5	5V-IN	IN
J27	3.3V-IN	IN
J17	OSC Output	No Connection
J16	FREQ_ADJ	Position 3:4 MASTER (Primary) MODE

1.3 Power-Up

Ensure that required connections and configurations have been checked. The TPA3223EVM board can now be powered on.

1. Enable the power supply at 12 V to 45 V and ensure that LED D5 illuminates. LEDs D2 and D4 must not be illuminated.
2. Bring the EVM out of RESET state by switching RESET (S1) to NORMAL. You can see the FAULT LED (D4) blink once quickly, then remain unilluminated.
3. Bring the EVM out of MUTE state by switching MUTE (S2) to NORMAL.

4. Note that the EVM does not have volume control, configure your analog input for a reasonable audio level before beginning audio playback.
5. Enable audio input playback and the EVM begins driving audio out of the left and right speakers. If resistor loads are used for testing instead of speakers, then the load will now be energized.

2 Setup By Mode

The following sections describe the setup and configuration for each output mode. The TPA3223EVM allows for two output modes: Stereo BTL and Mono PBTL.

2.1 BTL MODE (Stereo - 2 Speaker Outputs)

This mode is the same as described in *Quick Start (BTL MODE)*.

2.2 PBTL MODE (Mono – 1 Speaker Output)

This mode provides one speaker output that is more powerful than each BTL output and is useful when mono audio is to be played or when more power is needed.

Figure 2-1 illustrates the PBTL mode output configuration with 4 inductors.

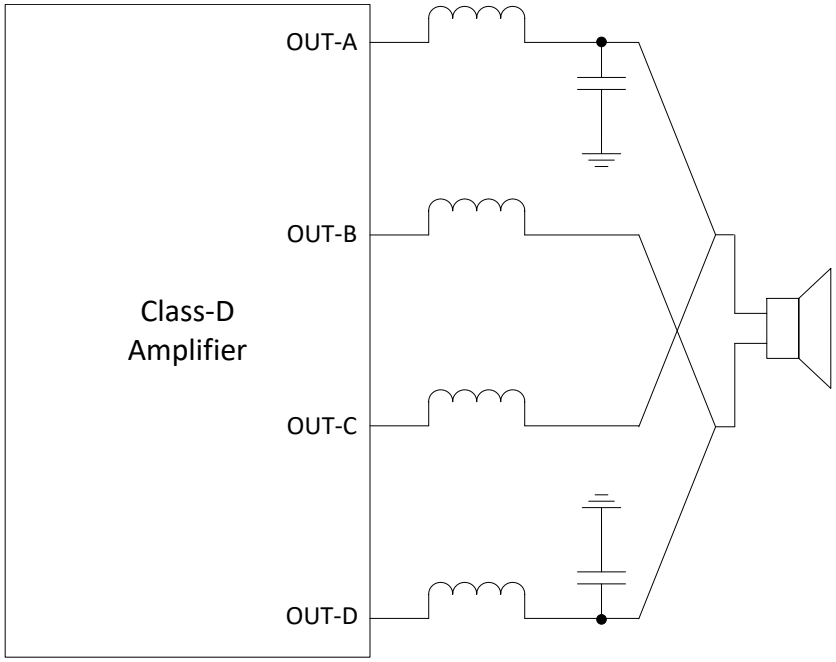

Figure 2-1. Output Configuration PBTL - 4 Inductors

2.2.1 Connections and Board Configuration

Figure 2-2 illustrates the connectors and jumpers on the EVM.

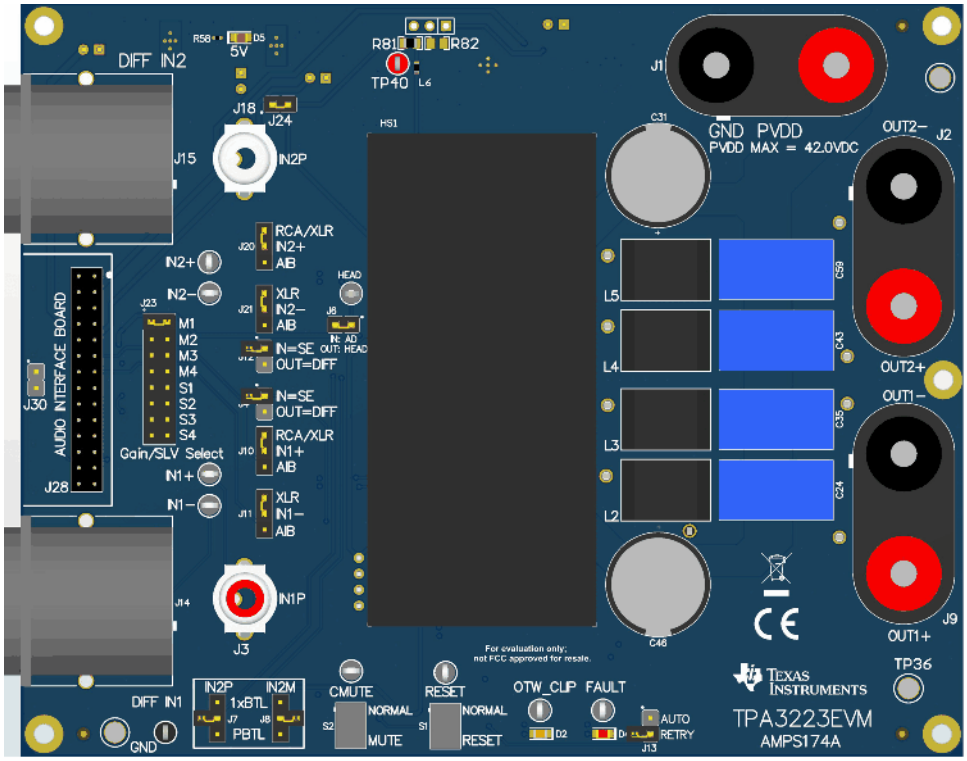

Figure 2-2. EVM Board With Connectors and Jumpers

Use the following steps when connecting and configuring the board:

1. Ensure the power supply is OFF. Connect power supply positive terminal to J1 PVDD (red) and negative terminal to J1 GND (black).
2. Connect one speaker, power resistor load (3–8 Ω) to TPA3223EVM positive output terminal (J9 OUT1+ (red)) and other side of speaker, power resistor to TPA3223EVM negative output terminal (J9 OUT1– (black)).
3. Use a short banana cable to connect J2 OUT2+ to J9 OUT1+ and a second short banana cable to connect J2 OUT2– to J9 OUT1–. This connection forms the parallel connection of both OUTx+ to the one side of the speaker and parallel connection of both OUTx– to the other side of the speaker.
4. Check to make sure that the power supply is connected to J1 only and the speaker is connected to J9 or J2 only, as the colors are the same.
5. Input Configuration:
   a. **Differential Inputs:** connect one differential XLR audio input to DIFF IN1 (J14). Install jumpers J10, J11, J20, and J21 to position 1:2, which is labeled as **RCA** or **XLR**. Jumpers J4 and J12 must be uninstalled for DIFF input.
   b. **Single-Ended Inputs:** connect one single-ended RCA audio input to IN1P (J3). Install jumpers J10, J11, J20, and J21 to position 1:2, which is labeled as **RCA** or **XLR**. Jumpers J4 and J12 must be installed for SE input.
   c. **Audio Interface Board Input:** Install jumpers J10, J11, J20, and J21 to position 2:3, which is labeled as **AIB**. Jumpers J4 and J12 must be installed for SE input from the AIB or uninstalled for DIFF input from the AIB.
6. Ensure that RESET S1 and MUTE S2 are in the lower positions of RESET and MUTE, respectively.
7. Check Table 2-1 for all jumper and switch configurations necessary.

Table 2-1. Jumper and Switch Configurations (PBTL Mode)

Component	Component Description	Configuration for PBTL
J23	Gain/CLKSYNC Select	MSTR(Primary) 20 dB
J24	5V	IN
J4, J12	Input DIFF/SE Select	OUT = DIFF IN, IN =SE IN
J10, J11, J20, J21	AIB Input Select	Position 1:2 for XLR/RCA, Position 2:3 for AIB
J6	HEAD/AD Mode Select	IN
J7, J8	PBTL/BTL Select	Position 2:3 for PBTL
S1	RESET Control	RESET
S2	MUTE Control	MUTE
J13	Auto Retry	OUT
J29	PVDD-IN	IN
J26	12V-IN	IN
J5	5V-IN	IN
J27	3.3V-IN	IN
J17	OSC Output	No Connection
J16	FREQ_ADJ	Position 3:4 MASTER(Primary) MODE

2.2.2 Power-Up

Ensure that required connections and configurations have been checked. The TPA3223EVM board can now be powered on.

1. Enable the power supply at 12 V to 45 V and ensure that LED D5 illuminates. LEDs D2 and D4 must not be illuminated.
2. Bring the EVM out of RESET state by switching RESET (S1) to NORMAL. You can see the FAULT LED (D4) blink once quickly, then remain unilluminated.
3. Bring the EVM out of MUTE state by switching MUTE (S2) to NORMAL.
4. Note that the EVM does not have volume control, configure your analog input for a reasonable audio level before beginning audio playback.
5. Enable audio input playback and the EVM should begin driving audio out of the left and right speakers. If resistor loads are used for testing instead of speakers, then the load will now be energized.

3 Hardware Configuration

3.1 Indicator Overview (OTW_CLIP and FAULT)

The TPA3223EVM is equipped with LED indicators that illuminate when the FAULT or OTW_CLIP pin goes low. See Table 3-1 and the TPA3223 data sheet (SLASEF0) for more details.

Table 3-1. Fault and Clip Overtemperature Status

FAULT LED Status	OTW_CLIP LED Status	Description
ON	ON	Overtemperature (OTE) or overload (OLP) or undervoltage (UVP). Junction temperature higher than 125°C (Overtemperature warning)
ON	OFF	Overload (OLP) or undervoltage (UVP). Junction temperature lower than 125°C
OFF	ON	Junction temperature higher than 125°C (Overtemperature warning)
OFF	OFF	Junction temperature lower than 125°C and no OLP or UVP faults (normal operation)

3.2 PWM Frequency Adjust

The TPA3223EVM allows for three oscillator frequency options by external configuration of the FREQ_ADJ pin. The frequency adjust can be used to reduce interference problems while using a radio receiver tuned within the AM band. These values must be chosen so that the nominal and the lower value switching frequencies together results in the fewest cases of interference throughout the AM band. The oscillator frequency can be selected by the value of the FREQ_ADJ resistor connected to GND in Primary mode according to Table 3-2.

Table 3-2. Frequency Adjust Primary Mode Selection (J16)

FREQ_ADJ (J16) Mode	Resistor Selected to GND or Pullup
Primary MODE	10 kΩ
Primary MODE AM1	30 kΩ
Primary MODE AM2	49.9 kΩ
Peripheral MODE	Pullup to 5 V

Selecting *Peripheral Mode* configures the OSC_I/O pins as inputs to be synchronized from an external differential clock. In a Primary or Peripheral system, interchannel delay is automatically set up between the switching phases of the audio channels, which can be illustrated by no idle channels switching at the same time. The audio output will not be influenced, but the switch timing is changed to minimize noise coupling between audio channels through the power supply. This configuration will optimize audio performance and result in better operating conditions for the power supply. The inter-channel delay will be set up for a peripheral device depending on the polarity of the OSC_I/O connection such that peripheral mode 1 (secondary) is selected by connecting the OSC_I/O of the Primary device with the OSC_I/O of the peripheral device with the same polarity (+ to + and – to –), while peripheral mode 2 (tertiary) is selected by connecting the OSC_I/Os with the inverse polarity (+ to – and – to +).

3.3 Modulation Modes (AD Mode and HEAD Mode)

The TPA3223EVM supports both AD modulation as well as HEAD modulation. In AD mode, each of the two half-bridge outputs are continuously switching. AD mode is the default mode for the TPA3223EVM. The EVM also supports HEAD mode modulation. HEAD mode also switches both half bridge outputs but also optimizes the switching for lower power loss at idle as well as increased EMI performance at cost of some performance. The device accomplishes this by reducing its duty cycle at idle and while playing small signals. At higher output levels HEAD mode will also reduce the switching on one of the half bridges. The modulation mode can be controlled through jumper J6 on the EVM as follows:

Table 3-3. HEAD and AD Mode Selection

J6 Jumper State	Modulation Mode
IN	AD Mode
OUT	HEAD Mode

More information on the differences between HEAD mode and AD mode as well as performance data is found in the TPA3223 data sheet (SLASEF0).

3.4 Output Mode Selection

The TPA3223 does not use discrete mode pins and therefore relies solely on the states of the IN2_M and IN2_P pins. Connecting the IN2_M and IN2_P pins to regular high output impedance audio outputs by removing J7 and J8 puts the TPA3223 into BTL mode (2 x stereo outputs). Tying the IN2_M and IN2_P pins to GND by installing J7 and J8 on pins 2-3 puts the TPA3223 into PBTL mode (1 x mono output). Tying the IN2_M and IN2_P pins to 5V by installing J7 and J8 on pins 1-2 puts the TPA3223 into 1x BTL mode (1 x mono output). This is summarized in Table 3-4:

Table 3-4. Output Mode and Modulation Mode Selection

Input Jumpers J7 and J8		Input Mode	Output Configuration	Description
IN2_M	IN2_P			
OUT	OUT	1N / 2N + 1	2 × BTL	Stereo, BTL output configuration
2-3 (GND)	2-3 (GND)		1 × PBTL	Mono, Paralleled BTL configuration. Connect OUT1+ to OUT2+ and OUT1– to OUT2–
1-2 (5V)	1-2 (5V)		1 × BTL	Mono, BTL configuration. OUT1+ and OUT1– active

3.5 Audio Front End

The TPA3223EVM includes options for single-ended or differential input signals. A configurable front end is built into the TPA3223 so that both single-ended and differential inputs can achieve the full scale output of the TPA3223 device without need for external front end op-amp. Note that when EVM RCA or XLR connectors are used, jumpers J11, J10, J21, and J20 must be installed in position 1:2 named **XLR** or **RCA**.

- Single-ended input can be provided through RCA to inputs J3 and J18. Uninstall jumpers J4 and J12 using SE input so that the TPA3223 front-end will be configured for SE input.
- Differential input can be provided through XLR to inputs J14 and J15. Install jumpers J4 and J12 when using DIFF input so that the TPA3223 front-end will be configured for DIFF input.

Input can also be provided through an audio plug-in board on J28. For this input type, change jumpers J11, J10, J21, and J20 to position 2:3 named **AIB**.

See the EVM schematic section (Section 1.4.3) for complete details.

3.6 EVM Power Tree

The TPA3223EVM includes a few options for power configuration so that various input types can be evaluated.

3.6.1 TPA3223 Supplies

The TPA3223 device has a few power supplies which each have their own voltage range and rules. Details for each supply are as shown:

- **PVDD** – This is the main device supply which accepts from 10 V to 45 V. Power output of the device is derived solely from PVDD and therefore it is important to configure this supply according to the chosen output configuration and load. Complete details are included in the TPA3223 datasheet.
- **VDD** – This supply is used for the non-PVDD power of the device for blocks such as the front-end and control circuitry. VDD is powered by 5 V directly and tied to GVDD and AVDD pins.
- **GVDD** and **AVDD** – These pins are used for the gate drive and analog supply of the device. GVDD and AVDD accept only 5 V which can be provided through the TP or the 5V through J24.

Table 3-5. Power Supply Summary

PVDD (V)	VDD (V)	AVDD (V)	GVDD (V)
10.0 to 45.0	5.0	5.0 (Tied to VDD)	5.0 (Tied to VDD)

3.6.2 TPA3223EVM Power Options

TPA3223 requires that 5 V is provided externally to VDD, AVDD, and GVDD. The major input configurations are listed in the following sections by the supplies available.

3.6.2.1 PVDD Only (12 V to 45 V)

This power mode is the default setup when the board is tested and shipped. The user can connect any valid supply voltage to J1 and the onboard LDOs will generate the required non-PVDD voltages. PVDD itself always connects directly to the TPA3223 PVDD pins. Setup for this mode is the same as described in *Quick Start (BTL MODE)*.

3.6.2.2 PVDD (12 V to 45 V) and One Non-5-V Supply

This power mode is useful for certain applications where a system has one higher voltage used for PVDD and a second lower voltage that may be used for device pullups and other supplies (VDD, GVDD, and AVDD). The PVDD voltage can still be connected to J1 but jumpers J29 and J26 must be removed.

In the case of the TPA3223EVM, only 12V can be accepted as a non-5-V Supply and should be connected to pin 2 of J26 (12V).

3.6.2.3 PVDD (12 V to 45 V) and 5-V Supply

This power mode is most useful for systems in which a 5-V supply is already available due to additional circuitry like an MCU or wireless module. On the EVM, this method is also the preferred way to measure efficiency of the TPA3223 device. The PVDD voltage can still be connected to J1 but jumper J29 must be removed. The 5-V supply must be connected to TP40.

The same 5-V input is used for the TPA3223 supplies (AVDD, VDD, and GVDD), the EVM reset control (U7), all TPA3223 device pullups ($\overline{\text{RESET}}$, HEAD, FREQ_ADJ, $\overline{\text{FAULT}}$, OTW_CLIP), and status LEDs D4 and D2.

The 5-V supply can be isolated by by disconnecting J24. Once J24 jumper is removed, 5 V can be fed to only the TPA3223 supplies through Pin 2 on the jumper and all other 5 V are being powered through 5 V LDO.

Either approach can be used to measure efficiency, but the most accurate numbers will be with the 5-V supply separated so the TPA3223 supply voltage is isolated and measured independently of board LEDs, reset control, and so forth.

3.7 LC Response and Overview

Included near the output of the TPA3223 device are four output LC filters. These output filters filter the PWM output leaving only the audio content at high power which is fed to the speakers. The board uses a Sagami 10-µH inductor and 1-µF film capacitor to form this LC filter. Using the equations listed in *LC Filter Design* (SLAA701), the filter low pass cut-off is as follows:

$$F_{cut-off} = \frac{1}{2\pi\sqrt{L \times C}} = \frac{1}{2\pi\sqrt{10\,\mu H \times 1\,\mu F}} = 50.3\ kHz \quad (2)$$

The frequency response of the filter per output load is illustrated in Figure 3-1.

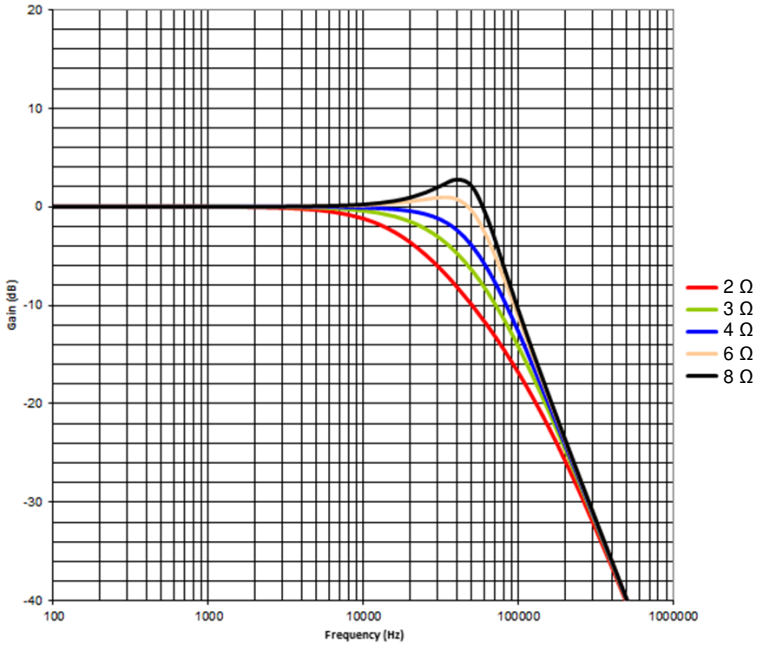

Figure 3-1. Filter Frequency Response

Figure 3-1 is taken directly from the *LC Filter Calculator* tool available on TI.com (SLAC729). The tool is configured for BTL common mode with values of 10 µH and 1 µF for the filter. This tool is also helpful when designing a different board featuring one of TI's class-D amplifiers.

The Sagami inductor used (7G14D-100M-R) has a saturation current of 15 A. This was selected for the EVM since the TPA3223 supports a maximum short-circuit output current of 9 A. The inductance versus current curve for a selected inductor is very important. It is essential for the inductor to maintain at least 5 µH of inductance at the maximum short-circuit current of the power amplifier. The Sagami inductance versus current curve is available in the 7G14D-100M-R data sheet on the Sagami web site.

Although not required, shielded inductors are used on the EVM to reduce EMI.

3.8 Reset Circuit and POR

The TPA3223EVM includes RESET supervision so that the TPA3223 device remains in reset until all power rails are up and stable. The RESET supervisor also maintains that the device is put into reset if one of the power rails experiences a brown out. This circuit combined with the RESET switch (S1) helps make sure that the TPA3223 can be placed in reset easily, as needed, or automatically if there is a power supply issue. Figure 3-2 illustrates the circuit.

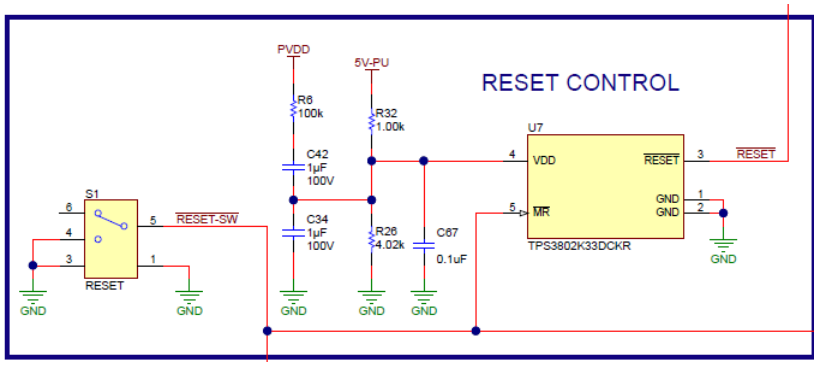

Figure 3-2. RESET Circuit

3.9 Analog-Input-Board Connector (J28)

The *Analog-Input-Board* (AIB) connector allows for cross compatibility with several *Analog Plug-in Modules* (APMs) offered by TI. This generic connector provides access to common board connections such as analog input, analog output, Fault and overtemperature warning (OTW) error reporting, common board voltages (12 V, 3.3 V, and so forth), and EVM reset. These plug-in modules allow for an application-specific front end to be plugged into the TPA3223EVM with ease. Examples of plug-in modules include front ends for guitar amplifier, karaoke, wireless sub-woofer, and front-end audio crossover.

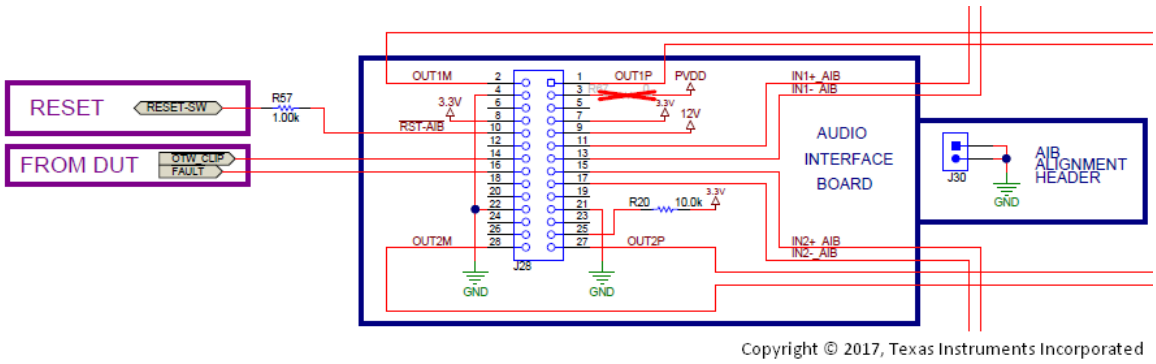

Figure 3-3. AIB EVM Connector

As Figure 3-3 shows, the AIB connector includes the following pins, associated specifications are listed in Table 3-7.

Table 3-6. AIB Connector (J28) Pinout

Pin #	Function	Description	Audio EVM Input/Output
1	Amp Out A	Speaker-level output from audio Class-D EVM (SE or one side of BTL)	O
2	Amp Out B	Speaker-level output from audio Class-D EVM (SE or one side of BTL)	O
3	PVDD	PVDD voltage supply from audio Class-D EVM (variable voltage depending on Class-D EVM use)	O
4	GND	Ground reference between audio plug-in module and audio class-D EVM	-
5	NC	-	-
6	NC	-	-
7	3.3 V	3.3-V supply from EVM; used for powering Audio Plug-in Module	O
8	3.3 V	3.3-V supply from EVM; used for powering Audio Plug-in Module	O
9	12 V	12-V supply from EVM; used for powering Audio Plug-in Module	O
10	EN and RESET	Assert enable and reset control for audio class-D EVM (active low)	I
11	Analog IN_A	Analog audio input A (analog in EVM) , MCLK I2S Bus (digital in EVM)	I
12	NC	-	-
13	Analog IN_B	Analog audio input B (analog in EVM) , BCLK I2S Bus (digital in EVM)	I
14	$\overline{\text{CLIP\_OTW}}$	Clipping detection, overtemperature warning, or both from audio class-D EVM (active low)	O
15	Analog IN_C	Analog audio input C (analog in EVM) , FS/LRCLK I2S Bus (digital in EVM)	I

Table 3-6. AIB Connector (J28) Pinout (continued)

Pin #	Function	Description	Audio EVM Input/Output
16	$\overline{\text{FAULT}}$	Fault detection from audio Class-D EVM (Active Low)	O
17	Analog IN_D	Analog audio Input D (analog in EVM) , SDIN I2S Bus (digital in EVM)	I
18	NC	-	-
19	NC	-	-
20	NC	-	-
21	GND	Ground reference between audio plug-in module and audio class-D EVM	-
22	GND	Ground reference between audio plug-in module and audio class-D EVM	-
23	NC	-	-
24	NC	-	-
25	NC	-	-
26	NC	-	-
27	Amp Out C	Speaker-level output from audio class-D EVM (SE or one side of BTL)	O
28	Amp Out D	Speaker-level output from audio class-D EVM (SE or one side of BTL)	O

Table 3-7. AIB Power Rail Specifications

EVM Power Rails	Always Available	Voltage Range	Max Current	Source
PVDD	Yes	15–80 V	500 mA	External Source
12 V	Yes	12 V	500 mA	LDO
3.3 V	Yes	3.3 V	100 mA	LDO

4 EVM Design Documents

This section contains the EVM board layouts, schematics, and bill of materials (BOM).

4.1 TPA3223 Board Layouts

Figure 4-1 and Figure 4-2 illustrate the EVM board layouts.

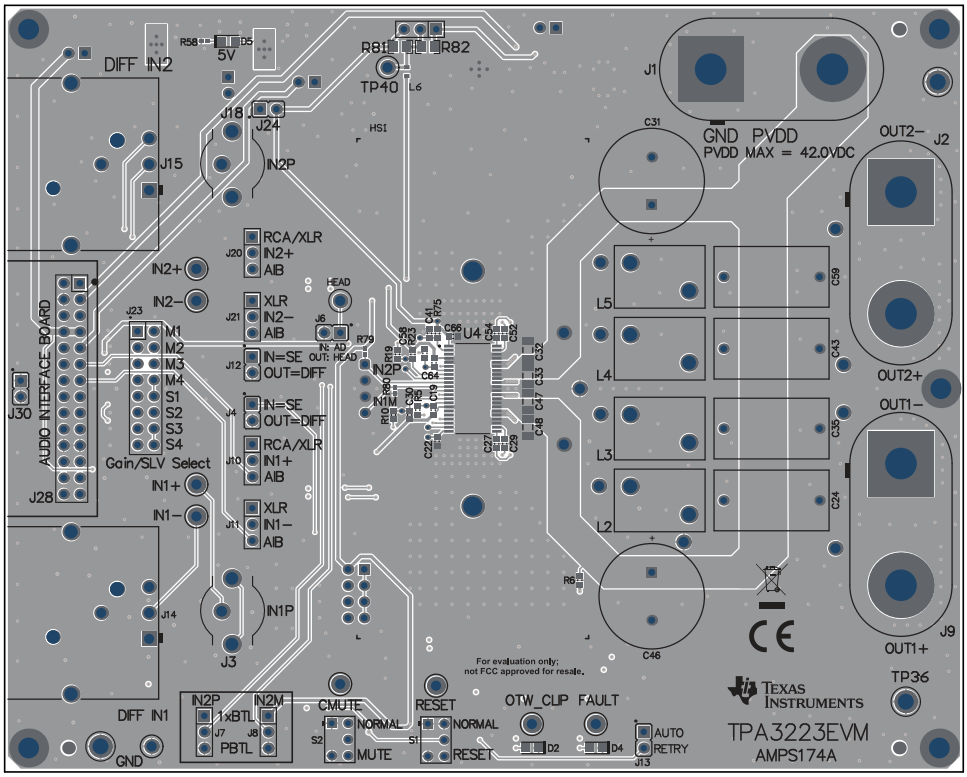

Figure 4-1. TPA3223EVM Top Composite Assembly

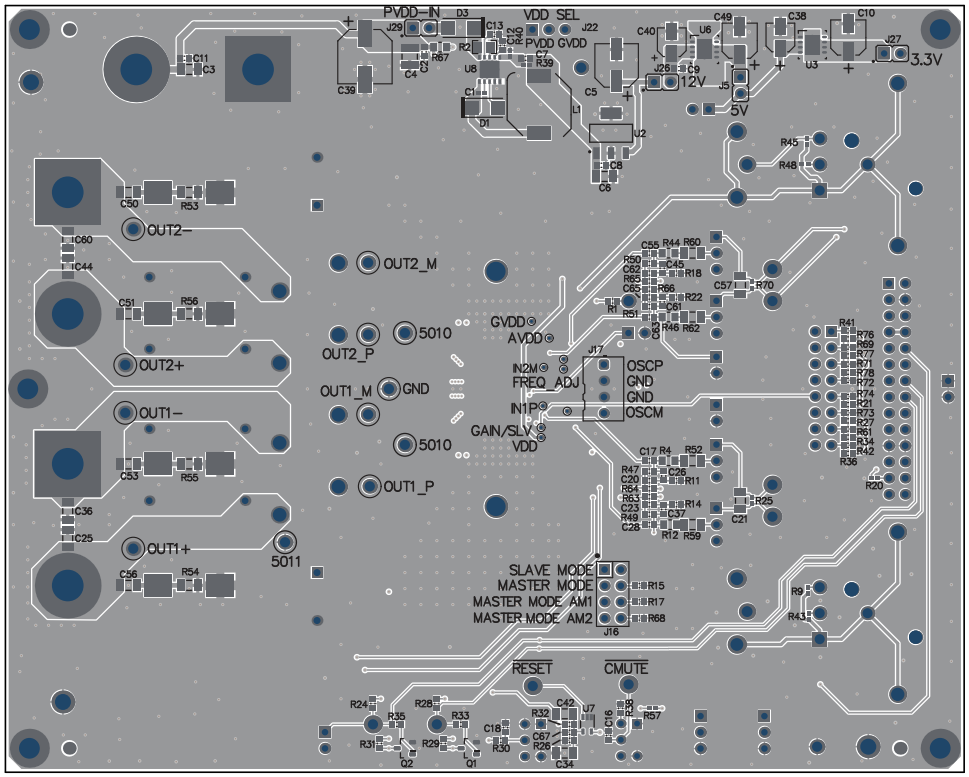

Figure 4-2. TPA3223EVM Bottom Composite Assembly

4.2 TPA3223 Board Layouts

Figure 4-3 shows the EVM board dimensions.

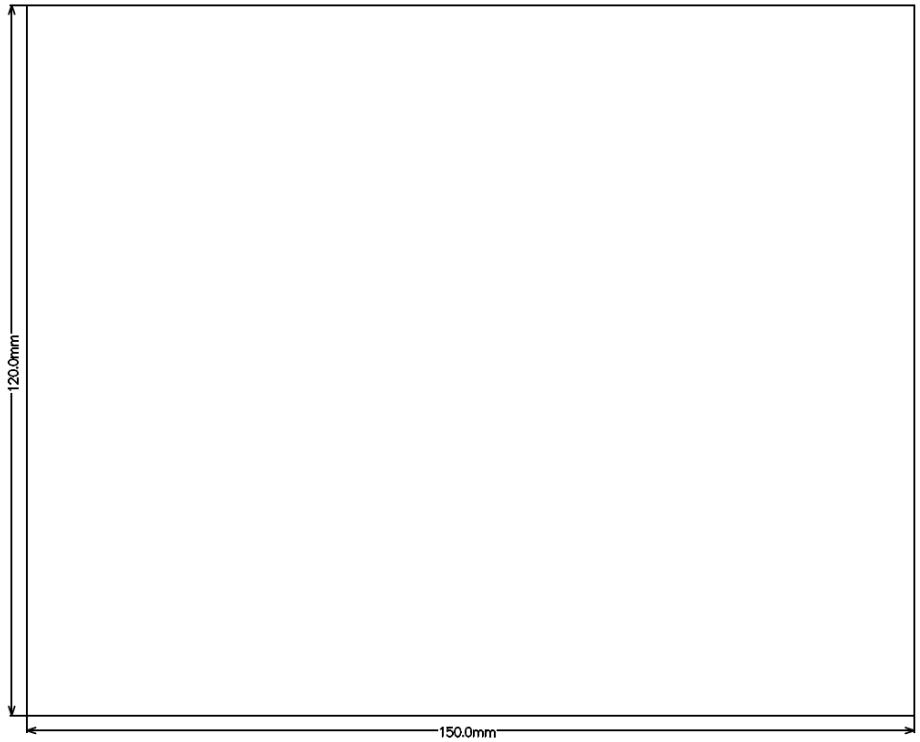

Figure 4-3. TPA3223 EVM Board Dimensions

4.3 TPA3223EVM Schematics

Figure 4-4 through Figure 4-6 illustrate the TPA3223 EVM schematics.

Note: TPA3223EVM with the AMPS174A marking have 5V-PU connected to 5V(5Vto3.3V) supply net externally via wire. This is required for A revision boards for proper operation.

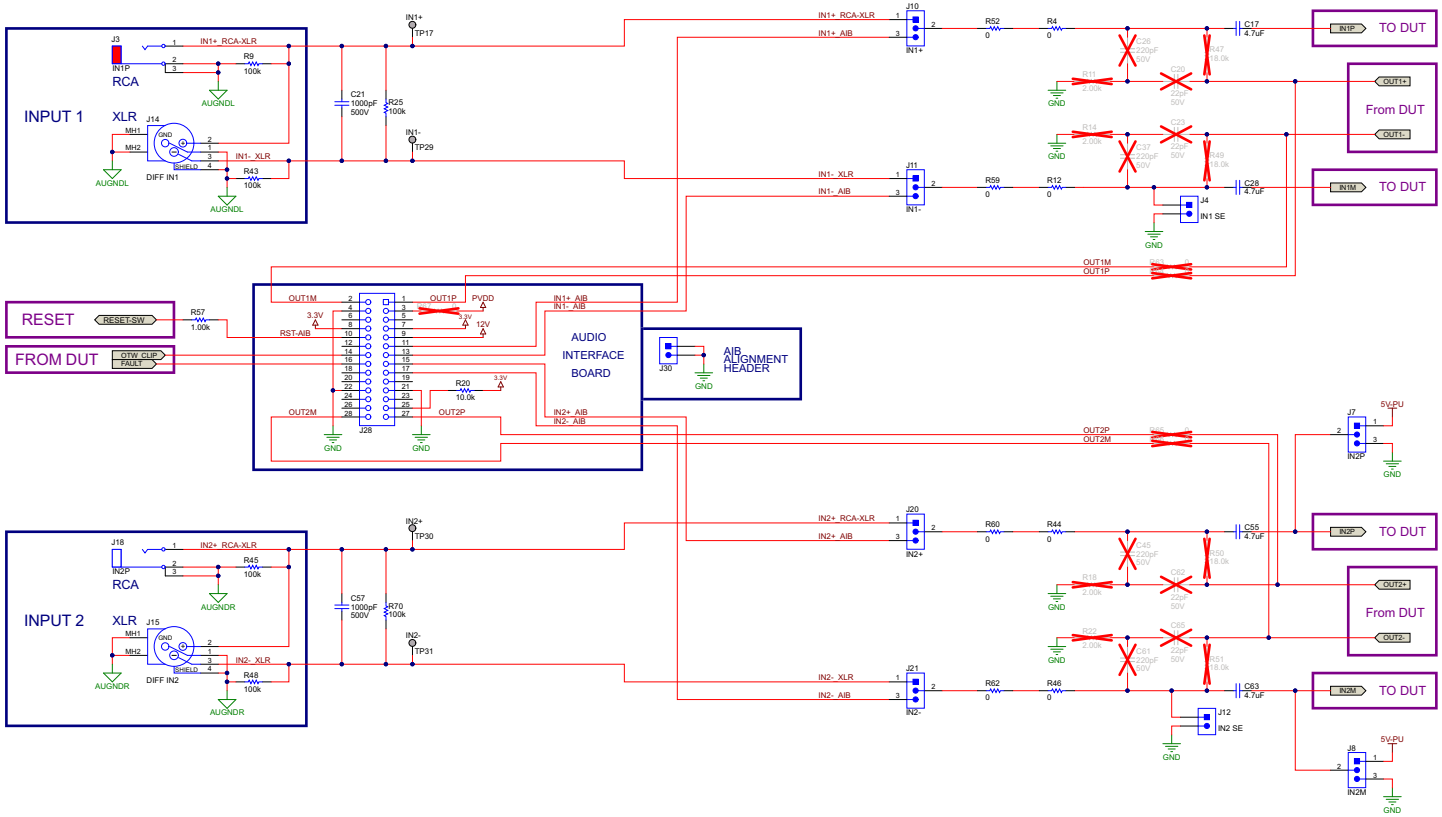

Figure 4-4. TPA3223EVM Schematic 1

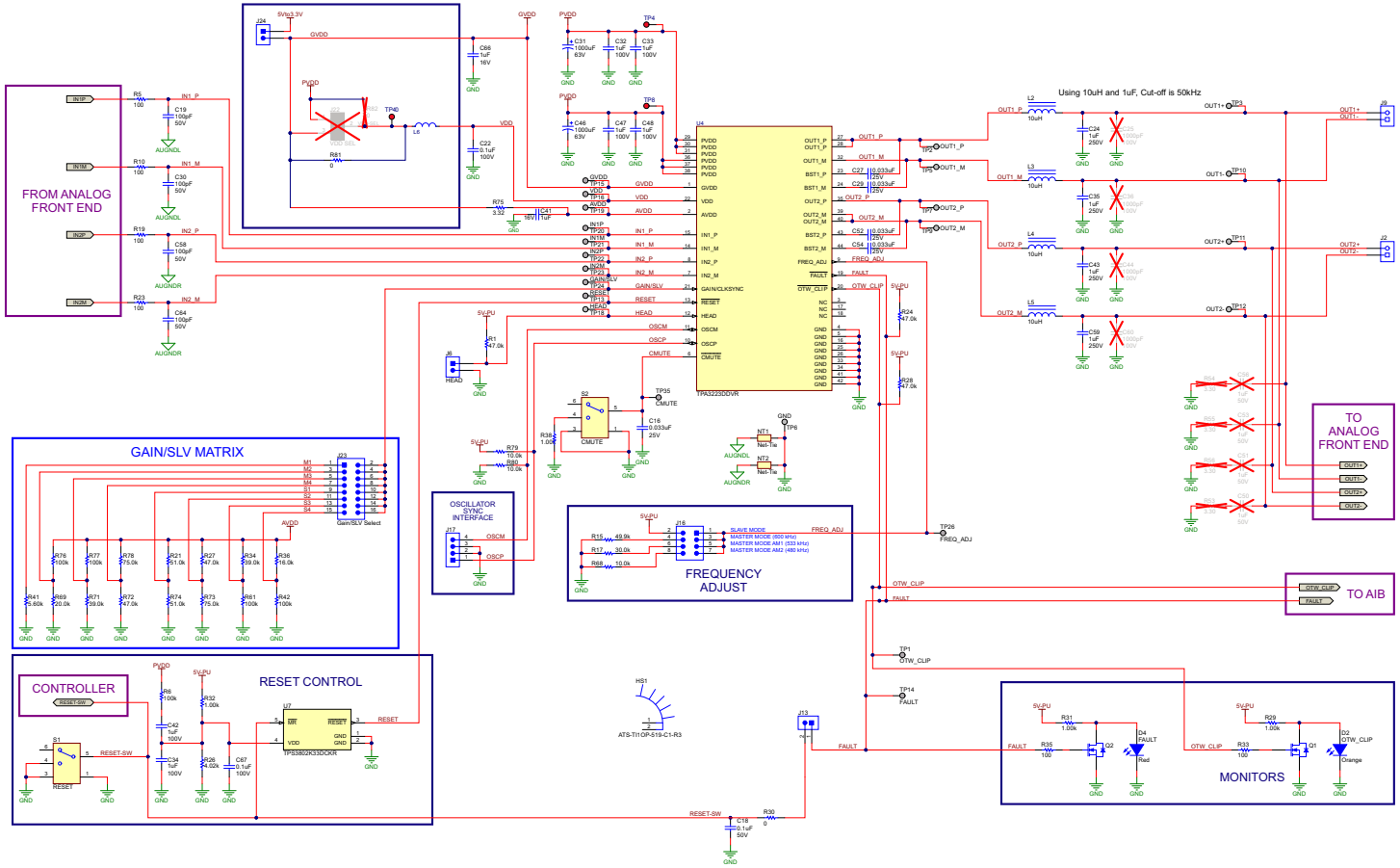

Figure 4-5. TPA3223EVM Schematic 2

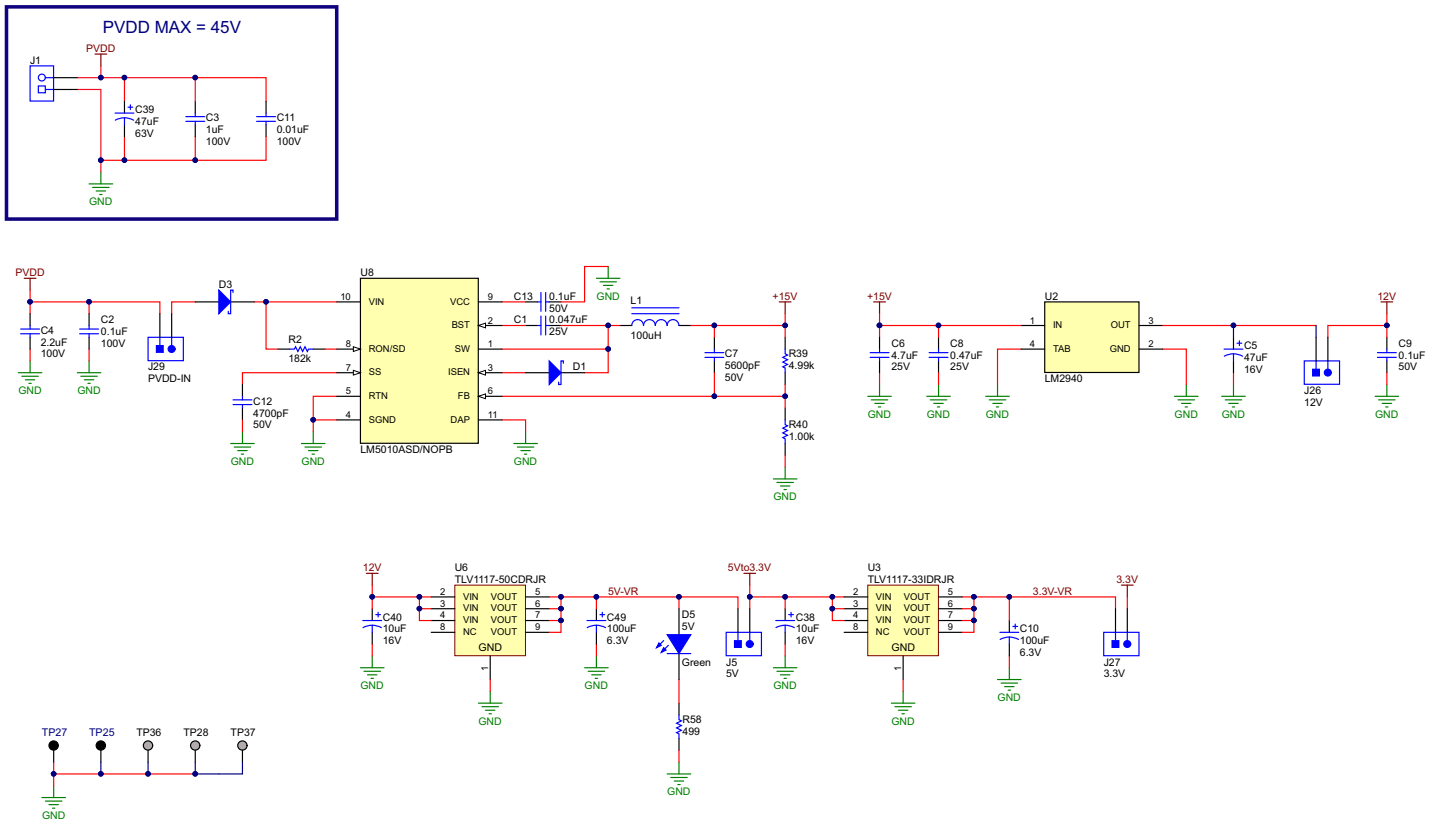

Figure 4-6. TPA3223EVM Schematic 3

4.4 TPA3223EVM Bill of Materials

Table 4-1 lists the TPA3223EVM BOM.

Table 4-1. TPA3223EVM Bill of Materials(1)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		AMPS174	Any
C1	1	0.047uF	CAP, CERM, 0.047 uF, 25 V, +/- 10%, X7R, 0402	402	C1005X7R1E473K050BC	TDK
C2, C22, C67	3	0.1uF	CAP, CERM, 0.1 uF, 100 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	GCJ188R72A104KA01D	MuRata
C3, C32, C33, C34, C42, C47, C48	7	1uF	CAP, CERM, 1 uF, 100 V, +/- 10%, X7R, 1206	1206	GRM31CR72A105KA01L	MuRata
C4	1	2.2uF	CAP, CERM, 2.2 uF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C5	1	47uF	CAP, AL, 47 uF, 16 V, +/- 20%, 0.36 ohm, AEC-Q200 Grade 2, SMD	SMT Radial D	EEH-ZT1J470P	Panasonic
C6	1	4.7uF	CAP, CERM, 4.7 uF, 25 V, +/- 10%, X7R, 1206	1206	C1206C475K3RAC7800	KEMET
C7	1	5600 pF	CAP, CERM, 5600 pF, 50 V, +/- 10%, X7R, 0603	603	CC0603KRX7R9BB562	Yageo
C8	1	0.47 uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, 0603	603	GRM188R71E474KA12D	MuRata
C9, C13, C18	3	0.1 uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	603	C0603C104K5RACTU	Kemet
C10, C49	2	100 uF	CAP, AL, 100 uF, 6.3 V, +/- 20%, 0.7 ohm, AEC-Q200 Grade 2, SMD	SMT Radial C	EEE-FK0J101UR	Panasonic
C11	1	0.01 uF	CAP, CERM, 0.01 uF, 100 V, +/- 10%, X7R, 0603	603	06031C103KAT2A	AVX
C12	1	4700 pF	CAP, CERM, 4700 pF, 50 V, +/- 10%, X7R, 0603	603	C0603X472K5RACTU	Kemet
C16, C27, C29, C52, C54	5	0.033 uF	CAP, CERM, 0.033 uF, 25 V, +/- 10%, X7R, 0603	603	CC0603KRX7R8BB333	Yageo
C17, C28, C55, C63	4	4.7 uF	CAP, CERM, 4.7 uF, 25 V, +/- 10%, X5R, 0603	603	GRM188R61E475KE11D	MuRata
C19, C30, C58, C64	4	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H101JA01D	MuRata
C21, C57	2	1000 pF	CAP, CERM, 1000 pF, 500 V, +/- 10%, X7R, 1206_190	1206_190	C1206C102KCRACTU	Kemet
C24, C35, C43, C59	4	1 uF	CAP, Film, 1 uF, 250 V, +/- 5%, TH	18x9.5x17.5mm	R75II41004040J	Kemet
C31, C46	2	1000 uF	CAP, AL, 1000 uF, 63 V, +/- 20%, 0.036 ohm, AEC-Q200 Grade 2, TH	D16xL35.5mm	ESW108M063AM3AA	Kemet
C38, C40	2	10 uF	CAP, AL, 10 uF, 16 V, +/- 20%, 1.35 ohm, AEC-Q200 Grade 2, SMD	SMT Radial B	EEE-FK1C100R	Panasonic
C39	1	47 uF	CAP, AL, 47 uF, 63 V, +/- 20%, 0.65 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	875105344006	Wurth Elektronik
C41, C66	2	1 uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	603	CL10B105KO8NNNC	Samsung Electro-Mechanics
D1	1	100 V	Diode, Schottky, 100 V, 1 A, SMA	SMA	B1100-13-F	Diodes Inc.
D2	1	Orange	LED, Orange, SMD	LED_0805	LTST-C170KFKT	Lite-On
D3	1	100 V	Diode, Schottky, 100 V, 3 A, SMA	SMA	SK310A-TP	Micro Commercial Components
D4	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D5	1	Green	LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On
H1, H2, H3, H4, H5	5		MACHINE SCREW PAN PHILLIPS M3	M3 Screw	RM3X8MM 2701	APM HEXSEAL
H6, H7, H8, H9, H10	5		Standoff, Hex,25mm Length, M3, Aluminum	Standoff M3	24438	Keystone
HS1	1		Heat Sink, Vertical	Heatsink	ATS-TI1OP-519-C1-R3	Advanced Thermal Solutions
J1, J2, J9	3		Dual Binding Posts with Base, 2x1, TH	Dual Binding Posts with Base, 2x1, TH	6883	Pomona Electronics
J3	1		RCA Jack, Vertical, Red, TH	RCA JACK, RED	RCJ-022	CUI Inc.

Table 4-1. TPA3223EVM Bill of Materials[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
J4, J5, J6, J12, J13, J24, J26, J27, J29, J30	10		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J7, J8, J10, J11, J20, J21	6		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J14, J15	2		Receptacle, 160mil, 3 Position, R/A, TH	Receptacle, 160mil, 3 Position, R/A, TH	PQG3FRA112	Switchcraft
J16	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions
J17	1		Header (friction lock), 100mil, 4x1, Gold, TH	Header 4x1 keyed	22112042	Molex
J18	1		RCA Jack, Vertical, White, TH	RCA JACK, WHITE	RCJ-023	CUI Inc.
J23	1		Header, 100mil, 8x2, Gold, TH	PBC08DAAN	PBC08DAAN	Sullins Connector Solutions
J28	1		Receptacle, 100mil, 14x2, Gold, TH	14x2 Receptacle	SSW-114-01-G-D	Samtec
L1	1	100uH	Inductor, Shielded Drum Core, Ferrite, 100 uH, 1.5 A, 0.165 ohm, SMD	SMD	7447714101	Wurth Elektronik
L2, L3, L4, L5	4	10uH	Inductor, 10 uH, 7 A, 0.0092 ohm, TH	14x9.6mm	7G14D-100M-R	Sagami Elec Co Ltd
L6	1		FIXED IND 10 UH 250 MA 1.05 OHM	0603 (1608 Metric)	MLZ1608M100WT000	TDK
Q1, Q2	2	60 V	MOSFET, N-CH, 60 V, 0.17 A, SOT-23	SOT-23	2N7002-7-F	Diodes Inc.
R1, R24, R27, R28, R72	5	47.0k	RES, 47.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0747KL	Yageo
R2	1	182k	RES, 182 k, 1%, 0.125 W, 0805	805	ERJ-6ENF1823V	Panasonic
R4, R12, R44, R46	4	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	805	ERJ-6GEY0R00V	Panasonic
R5, R10, R19, R23, R33, R35	6	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R6, R42, R61, R76, R77	5	100k	RES, 100 k, 1%, 0.1 W, 0603	603	RC0603FR-07100KL	Yageo
R9, R25, R43, R45, R48, R70	6	100k	RES, 100 k, 1%, 0.0625 W, 0402	402	RC0402FR-07100KL	Yageo America
R15	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	603	RC0603FR-0749K9L	Yageo
R17	1	30.0k	RES, 30.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0730KL	Yageo
R20, R79, R80	3	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	RMCF0402FT10K0	Stackpole Electronics Inc
R21, R74	2	51.0k	RES, 51.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0751KL	Yageo
R26	1	4.02k	RES, 4.02 k, 1%, 0.1 W, 0603	603	RC0603FR-074K02L	Yageo
R29, R31, R32, R38	4	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	603	ERJ-3EKF1001V	Panasonic
R30	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R34, R71	2	39.0k	RES, 39.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0739KL	Yageo
R36	1	16.0k	RES, 16.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0716KL	Yageo
R39	1	4.99k	RES, 4.99 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2RKF4991X	Panasonic
R40, R57	2	1.00k	RES, 1.00 k, 1%, 0.1 W, 0402	402	ERJ-2RKF1001X	Panasonic
R41	1	5.60k	RES, 5.60 k, 1%, 0.1 W, 0603	603	RC0603FR-075K6L	Yageo
R52, R59, R60, R62	4	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	ERJ-8GEY0R00V	Panasonic
R58	1	499	RES, 499, 0.1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	ERA-2AEB4990X	Panasonic
R68	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	603	ERJ-3EKF1002V	Panasonic
R69	1	20.0k	RES, 20.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3EKF2002V	Panasonic
R73, R78	2	75.0k	RES, 75.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0775KL	Yageo
R75	1	3.32	RES, 3.32, 1%, 0.1 W, 0603	603	RC0603FR-073R32L	Yageo
R81	1	0	RES, 0, 5%, 0.125 W, 0805	805	MCR10EZPJ000	Rohm
S1, S2	2		Switch, SPDT, On-On, 2 Pos, TH	Switch, 7x4.5mm	200USP1T1A1M2RE	E-Switch

Table 4-1. TPA3223EVM Bill of Materials[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18, SH-J19	17	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
TP1, TP13, TP14, TP17, TP29, TP30, TP31, TP35	8		Test Point, Compact, Grey, TH	TestPoint, Grey, 220mil, TH	5123	Keystone
TP2, TP3, TP5, TP6, TP7, TP9, TP10, TP11, TP12, TP18	10		Test Point, Multipurpose, Grey, TH	Grey Multipurpose Testpoint	5128	Keystone
TP4, TP8, TP40	3		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP25, TP27	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
TP28, TP36, TP37	3		Terminal, Turret, TH, Double	Keystone1502-2	1502-2	Keystone
U2	1		1 A Low Dropout Regulator, 4-pin SOT-223, Pb-Free	DCY0004A	LM2940IMP/NOPB	Texas Instruments
U3	1		LDO with 4.7 to 15 V Input and 3.3 V Output, -40 to 125 degC, 8-Pin SON (DRJ), Green (RoHS & no Sb/Br)	DRJ0008A	TLV1117-33IDRJR	Texas Instruments
U4	1		200-W Stereo, 400W Mono HD Analog-Input, Class-D Amplifier	HTSSOP44	TPA3223DDVR	Texas Instruments
U6	1		LDO with 6.4 to 15 V Input and 5 V Output, 0 to 125 degC, 8-Pin SON (DRJ), Green (RoHS & no Sb/Br)	DRJ0008A	TLV1117-50CDRJR	Texas Instruments
U7	1		Ultra-Small Supply Voltage Supervisor, 1 Supply Monitored, -40 to 85 degC, 5-pin SC70 (DCK), Green (RoHS & no Sb/Br)	DCK0005A	TPS3802K33DCKR	Texas Instruments
U8	1		6-75 V Wide Vin, 1 A Constant On-Time Non-Synchronous Buck Regulator, DPR0010A (WSON-10)	DPR0010A	LM5010ASD/NOPB	Texas Instruments
C20, C23, C62, C65	0	22 pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H220JA01D	MuRata
C25, C36, C44, C60	0	1000 pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, C0G/NP0, 1206	1206	12061A102JAT2A	AVX
C26, C37, C45, C61	0	220 pF	CAP, CERM, 220 pF, 50 V, +/- 5%, C0G/NP0, 0603	603	GRM1885C1H221JA01D	MuRata
C50, C51, C53, C56	0	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 1206	1206	GRM31MR71H105KA88L	MuRata
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J22	0		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
R11, R14, R18, R22	0	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	603	RC0603FR-072KL	Yageo
R47, R49, R50, R51	0	18.0k	RES, 18.0 k, 1%, 0.1 W, 0603	603	RC0603FR-0718KL	Yageo
R53, R54, R55, R56	0	3.3	RES, 3.30, 1%, 0.25 W, 1206	1206	ERJ-8RQF3R3V	Panasonic
R63, R64, R65, R66	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R67	0	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	805	ERJ-6GEY0R00V	Panasonic
R82	0	0	RES, 0, 5%, 0.125 W, 0805	805	MCR10EZPJ000	Rohm
C1	1	0.047uF	CAP, CERM, 0.047 µF, 25 V, +/- 10%, X7R, 0402	0402	GRM155R71E473KA88D	Murata
C2	1	0.1uF	CAP, CERM, 0.1 µF, 100 V, +/- 10%, X7R, 0603	0603	GRM188R72A104KA35J	Murata
C3, C32, C33, C34, C42, C47, C48	7	1uF	CAP, CERM, 1 µF, 100 V, +/- 10%, X7R, 1206	1206	GRM31CR72A105KA01L	Murata
C4, C14, C15	3	2.2uF	CAP, CERM, 2.2 µF, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RACTU	Kemet
C5	1	47uF	CAP, AL, 47 µF, 16 V, +/- 20%, 0.36 ohm, SMD	SMT Radial D	EEE-FK1C470P	Panasonic
C6	1	4.7uF	CAP, CERM, 4.7 µF, 25 V, +/- 10%, X7R, 1206	1206	GRM31CR71E475KA88L	Murata
C7	1	5600 pF	CAP, CERM, 5600 pF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H562KA01D	Murata
C8	1	0.47uF	CAP, CERM, 0.47 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E474KA12D	Murata
C9, C13, C18, C22, C67	5	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	C0603C104K5RACTU	Kemet
C10, C49	2	100uF	CAP, AL, 100 µF, 6.3 V, +/- 20%, 0.7 ohm, SMD	SMT Radial C	EEE-FK0J101UR	Panasonic
C11	1	0.01uF	CAP, CERM, 0.01 µF, 100 V, +/- 10%, X7R, 0603	0603	06031C103KAT2A	AVX
C12	1	4700 pF	CAP, CERM, 4700 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603X472K5RACTU	Kemet

Table 4-1. TPA3223EVM Bill of Materials[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C16, C27, C29, C52, C54	5	0.033uF	CAP, CERM, 0.033 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E333KA01D	Murata
C17, C28, C41, C55, C63, C66	6	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X7R, 0603	0603	GRM188R71C105KA12D	Murata
C19, C30, C58, C64	4	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H101JA01D	Murata
C21, C57	2	1000 pF	CAP, CERM, 1000 pF, 500 V, +/- 10%, X7R, 1206_190	1206_190	C1206C102KCRACTU	Kemet
C24, C35, C43, C59	4	1uF	CAP, Film, 1 µF, 250 V, +/- 5%, TH	18x9.5x17.5mm	PHE426HB7100JR06	Kemet
C31, C46	2	1000uF	CAP, AL, 1000 µF, 50 V, +/- 20%, 0.034 ohm, AEC-Q200 Grade 2, TH	D16xL25	EEU-FC1H102	Panasonic
C38, C40	2	10uF	CAP, AL, 10 µF, 16 V, +/- 20%, 1.35 ohm, SMD	SMT Radial B	EEE-FK1C100R	Panasonic
C39	1	47uF	CAP, AL, 47 µF, 63 V, +/- 20%, 0.65 ohm, SMD	SMT Radial F	EEE-FK1J470P	Panasonic
D1	1	100 V	Diode, Schottky, 100 V, 1 A, SMA	SMA	B1100-13-F	Diodes Inc.
D2	1	Orange	LED, Orange, SMD	LED_0805	LTST-C170KFKT	Lite-On
D3	1	100 V	Diode, Schottky, 100 V, 3 A, SMA	SMA	SK310A-TP	Micro Commercial Components
D4	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D5	1	Green	LED, Green, SMD	LED_0805	LTST-C171GKT	Lite-On
H1	1		HEATSINK TI TAS5612 AND TAS5614	HEATSINK TI TAS5612 AND TAS5614	ATS-TI1OP-563-C1-R0	Advanced Thermal Solutions
H2, H3, H4, H5, H6, H12, H13	7		MACHINE SCREW PAN PHILLIPS M3 5mm	Screw M3 Phillips head	MPMS 003 0005 PH	B&F Fastener Supply
H7, H8, H9, H10, H11	5		Standoff, Hex,25mm Length, M3, Aluminum	Standoff M3	24438	Keystone
J1, J2, J9	3		Dual Binding Posts with Base, 2x1, TH	Dual Binding Posts with Base, 2x1, TH	6883	Pomona Electronics
J3	1		RCA Jack, Vertical, Red, TH	RCA JACK, RED	RCJ-022	CUI Inc.
J4, J5, J6, J7, J8, J12, J13, J19, J24, J26, J27, J29, J30	13		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J10, J11, J20, J21, J22, J25	6		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J14, J15	2		Receptacle, 160mil, 3 Position, R/A, TH	Receptacle, 160mil, 3 Position, R/A, TH	PQG3FRA112	Switchcraft
J16	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions
J17	1		Header (friction lock), 100mil, 4x1, Gold, TH	Header 4x1 keyed	0022112042	Molex
J18	1		RCA Jack, Vertical, White, TH	RCA JACK, WHITE	RCJ-023	CUI Inc.
J23	1		Header, 100mil, 8x2, Gold, TH	PBC08DAAN	PBC08DAAN	Sullins Connector Solutions
J28	1		Receptacle, 100mil, 14x2, Gold, TH	14x2 Receptacle	SSW-114-01-G-D	Samtec
L1	1	100 uH	Inductor, Shielded Drum Core, Ferrite, 100 µH, 1.5 A, 0.165 ohm, SMD	SMD	7447714101	Wurth Elektronik
L2, L3, L4, L5	4	10 uH	Inductor, 10 µH, 4.6 A, 0.0234 ohm, TH	14x9.6mm	7G14J-100M-R	Sagami Elec Co Ltd
L6	1	10 uH	Inductor, Wirewound, 10 µH, 0.08 A, 0.36 ohm, SMD	0603	GLFR1608T100M-LR	TDK
Q1, Q2	2	60 V	MOSFET, N-CH, 60 V, 0.17 A, SOT-23	SOT-23	2N7002-7-F	Diodes Inc.
R1, R24, R28	3	47 k	RES, 47 k, 5%, 0.1 W, 0603	0603	RC0603JR-0747KL	Yageo America
R2	1	182 k	RES, 182 k, 1%, 0.125 W, 0805	0805	ERJ-6ENF1823V	Panasonic
R3, R30, R37	3	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R4, R12, R44, R46	4	0	RES, 0, 5%, 0.125 W, 0805	0805	ERJ-6GEY0R00V	Panasonic
R5, R10, R19, R23, R33, R35	6	100	RES, 100, 1%, 0.1 W, 0603	0603	CRCW0603100RFKEA	Vishay-Dale
R6, R42, R61, R76, R77	5	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R9, R25, R43, R45, R48, R70	6	100k	RES, 100 k, 1%, 0.063 W, 0402	0402	CRCW0402100KFKED	Vishay-Dale

Table 4-1. TPA3223EVM Bill of Materials[1] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
R15	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	RC0603FR-0749K9L	Yageo America
R17	1	30.0k	RES, 30.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0730KL	Yageo America
R20	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF1002X	Panasonic
R21, R74	2	51.0k	RES, 51.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0751KL	Yageo America
R26	1	4.02k	RES, 4.02 k, 1%, 0.1 W, 0603	0603	CRCW06034K02FKEA	Vishay-Dale
R27, R72	2	47.0k	RES, 47.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0747KL	Yageo America
R29, R31, R32, R38	4	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R34, R71	2	39.0k	RES, 39.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0739KL	Yageo America
R36	1	16.0k	RES, 16.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0716KL	Yageo America
R39	1	4.99k	RES, 4.99 k, 1%, 0.063 W, 0402	0402	CRCW04024K99FKED	Vishay-Dale
R40	1	1.00k	RES, 1.00 k, 1%, 0.063 W, 0402	0402	CRCW04021K00FKED	Vishay-Dale
R41	1	5.60k	RES, 5.60 k, 1%, 0.1 W, 0603	0603	RC0603FR-075K6L	Yageo America
R52, R59, R60, R62	4	0	RES, 0, 5%, 0.25 W, 1206	1206	CRCW12060000Z0EA	Vishay-Dale
R57	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF1001X	Panasonic
R58	1	499	RES, 499, 1%, 0.063 W, 0402	0402	CRCW0402499RFKED	Vishay-Dale
R68	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R69	1	20.0k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale
R73, R78	2	75.0k	RES, 75.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0775KL	Yageo America
R75	1	3.3	RES, 3.3, 5%, 0.1 W, 0603	0603	CRCW06033R30JNEA	Vishay-Dale
S1, S2	2		Switch, SPDT, On-On, 2 Pos, TH	Switch, 7x4.5mm	200USP1T1A1M2RE	E-Switch
SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11, SH12, SH13, SH14, SH15, SH16, SH17, SH18, SH19, SH20	20	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP1, TP13, TP14, TP17, TP29, TP30, TP31, TP35	8		Test Point, Compact, Grey, TH	TestPoint, Grey, 220mil, TH	5123	Keystone
TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP18, TP25, TP27, TP28, TP36	16		Test Point, Multipurpose, Grey, TH	Grey Multipurpose Testpoint	5128	Keystone
TP32	1		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone
TP33, TP34	2		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
U1	1		High Voltage 1 A Step Down Switching Regulator, 10-pin LLP, Pb-Free	SDC10A	LM5010ASD/NOPB	Texas Instruments
U2	1		1 A Low Dropout Regulator, 4-pin SOT-223, Pb-Free	MP04A	LM2940IMP-12/NOPB	Texas Instruments
U3	1		LDO with 4.7 to 15 V Input and 3.3 V Output, -40 to 125 degC, 8-Pin SON (DRJ), Green (RoHS & no Sb/Br)	DRJ0008A	TLV1117-33IDRJR	Texas Instruments
U4	1		100-W Stereo, 200-W Mono HD-Audio, Analog-Input, Class-D Amplifier, DDV0044D (TSSOP-44)	DDV0044D	TPA3221DDVR	Texas Instruments
U5	1		150-mA, 30-V, Ultra-Low IQ, Wide Input Low-Dropout Regulator with Reverse Current Protection, DRV0006A (WSON-6)	DRV0006A	TPS70950DRVR	Texas Instruments
U6	1		LDO with 6.4 to 15 V Input and 5 V Output, 0 to 125 degC, 8-Pin SON (DRJ), Green (RoHS & no Sb/Br)	DRJ0008A	TLV1117-50CDRJR	Texas Instruments
U7	1		ULTRA-SMALL SUPPLY VOLTAGE SUPERVISORS, DCK0005A	DCK0005A	TPS3802K33DCKR	Texas Instruments
C20, C23, C62, C65	0	22 pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H220JA01D	Murata
C25, C36, C44, C60	0	1000 pF	CAP, CERM, 1000 pF, 100 V, +/- 5%, C0G/NP0, 1206	1206	12061A102JAT2A	AVX

Table 4-1. TPA3223EVM Bill of Materials[(1)] (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C26, C37, C45, C61	0	220 pF	CAP, CERM, 220 pF, 50 V,+/- 5%, C0G/NP0, 0603	0603	GRM1885C1H221JA01D	Murata
C50, C51, C53, C56	0	1 uF	CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 1206	1206	GRM31MR71H105KA88L	Murata
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R7, R8	0	4.99k	RES, 4.99 k, 1%, 0.125 W, 0805	0805	CRCW08054K99FKEA	Vishay-Dale
R11, R14, R18, R22	0	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale
R13	0	1.00k	RES, 1.00 k, 1%, 0.125 W, 0805	0805	CRCW08051K00FKEA	Vishay-Dale
R16, R63, R64, R65, R66	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R47, R49, R50, R51	0	18.0k	RES, 18.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0718KL	Yageo America
R53, R54, R55, R56	0	3.30	RES, 3.30, 1%, 0.25 W, 1206	1206	ERJ-8RQF3R3V	Panasonic
R67	0	0	RES, 0, 5%, 0.125 W, 0805	0805	ERJ-6GEY0R00V	Panasonic

(1) Unless otherwise noted in the alternate part number or alternate manufacturer columns, all parts can be substituted with equivalents.

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

   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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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

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

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

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3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

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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.

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

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

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