User's Guide
SLOU310–September 2011

TPA2025D1 Audio Power Amplifier Evaluation Module

This document describes the operation of the TPA2025D1 evaluation module that users may use to evaluate the TPA2025D1 Audio Power Amplifier. Included are the TPA2025D1EVM schematic, board art, and bill of materials.

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1 Introduction

This section provides an overview of the Texas Instruments (TI) TPA2025D1 audio power amplifier evaluation module (EVM). It includes a brief description of the module and a list of specifications.

1.1 Description

The TPA2025D1 is a high-efficiency, class-D, audio power amplifier and an integrated boost converter. It drives up to 2 W into a 4-Ω speaker from low supply voltages.

The TPA2025D1 audio power amplifier EVM is a complete, stand-alone audio amplifier. It contains the TPA2025D1 WCSP (YZG) Class-D audio power amplifier with an integrated boost converter. All components and the EVM are Pb-Free.

1.2 TPA2025D1 Specifications

V_{BAT}	Supply voltage range	2.5 V to 5.2 V
I_{DD}	Supply current	3 A Maximum
P_O	Continuous output power per channel, 4 Ω, V_{BAT} = 3.6 V	2 W
V_I	Audio input voltage	0 V to V_{BAT}
R_L	Minimum load impedance	4 Ω

2 Operation

This section describes how to operate the TPA2025D1EVM.

2.1 Quick-Start List for Stand-Alone Operation

Use the following steps when operating the TPA2025D1EVM as a stand-alone or when connecting the EVM into existing circuits or equipment.

2.1.1 Power and Ground

1. Ensure the external power sources are set to OFF.
2. Set the power supply voltage between 2.3 V and 5.2 V. When connecting the power supply to the EVM, attach the power supply ground connection to the GND connector first, and then connect the positive supply to the VDD connector. Verify that correct connections are made to the banana jacks.

2.1.2 Audio

1. Ensure that the audio source is set to the minimum level.
2. Connect the audio source to the input RCA jack **IN**. In case of differential audio input, ensure that the jumper, **JP SE**, is not inserted. In case of a single-ended audio input, ensure that the jumper, **JP SE,** is inserted, thereby grounding IN+ through the input capacitor C2.
3. Connect a speaker (4 Ω to 32 Ω) to the output banana jacks, **OUT+** and **OUT**–.
4. **FLT Out+** and **FLT OUT-** test points allow the user to connect the outputs of the amplfier through an RC filter for audio measurements. (Many audio analyzers will not give the correct readings on a Class-D amplifier without additional filtering.) Note that the user must provide the necessary resistors, R7 and R8 to complete the filters. The typical value for R7 and R8 is 1.0 kΩ.
5. The filtered output of the TPA2025D1 can be measured between test points **FILT OUT**– and **FILT OUT+**

2.1.3 AGC Control

The TPA2025D1 has three selectable inflection point settings: 3.25 V, 3.55 V, and 3.75 V.

1. Remove the jumper, **AGC**, to select the 3.25-V inflection point (AGC1).
2. Install the jumper, **AGC**, between pins 2 and 3 to select the 3.55-V inflection point (AGC2).
3. Install the jumper, **AGC,** between pins 1 and 2 to select the 3.75-V inflection point (AGC3).

2.1.4 Amplifier Gain

The TPA2025D1 has a fixed setting of 20 dB.

2.1.5 Shutdown Controls

1. The TPA2025D1 provides shutdown control for the Class-D amplifier and the boost converter. The EN pin enables the boost converter and Class-D amplifier. It is active high.
2. Press and hold pushbutton **S1** to place the boost converter and the Class-D amplifier in shutdown. Release pushbutton **S1** to activate the Class-D amplifier and boost converter. The boost converter only turns on if an audio signal (> 2 V_{PEAK}) is present at one of the outputs (OUT+ or OUT-).

NOTE: The TPA2025D1 has an auto pass-through mode. Under normal operation (EN = HIGH), the boost converter automatically turns off if no audio signal is present at one of the inputs (IN+ or IN-).

2.2 Boost Settings

The default voltage for the boost converter is 5.9 V (unloaded) and cannot be changed. If no audio signal is present, the boost converter is automatically disabled. Once the audio signal is present at IN+ and IN-, the boost converter enables automatically, when the output signal exceeds 2 V_{PEAK}.

2.2.1 Boost Terms

The following is a list of terms and definitions:

C_{MIN}	Minimum boost capacitance required for a given ripple voltage on PVOUT (PVDD)
L	Boost inductor
f_{boost}	Switching frequency of the boost converter
I_{PVDD}	Current pulled by the class-D amplifier from the boost converter
I_{PVDD}	Current pulled by the class-D amplifier from the boost converter
I_L	Current through the boost inductor.
PVDD (PVOUT)	Supply voltage for the class-D amplifier (Voltage generated by the boost converter output)
VBAT (VDD)	Supply voltage to the TPA2025D1 (Supply voltage to the EVM).
ΔI_L	Ripple current through the inductor.
ΔV	Ripple voltage on PVOUT (PVDD) due to capacitance

2.2.2 Changing the Boost Inductor

Working inductance decreases as inductor current increases. If the drop in working inductance is severe enough, it may cause the boost converter to become unstable, or cause the TPA2025D1 to reach its current limit at a lower output power than expected. Inductor vendors specify currents at which inductor values decrease by a specific percentage. This can vary by 10% to 35%. Inductance is also affected by dc current and temperature.

Inductor current rating is determined by the requirements of the load. The inductance is determined by two factors: the minimum value required for stability and the maximum ripple current permitted in the application.

Use Equation 1 to determine the required current rating. Equation 1 shows the approximate relationship between the average inductor current, I_L, to the load current, load voltage, and input voltage (I_{PVDD}, PVOUT, and VBAT, respectively.) Insert I_{PVDD}, PVDD, and VBAT into Equation 1 to solve for I_L. The inductor must maintain at least 90% of its initial inductance value at this current.

$$I_L = I_{PVDD} \times \left(\frac{PVDD}{VBAT \times 0.8} \right) \tag{1}$$

The minimum working inductance is 1.3 μH. A lower value may cause instability.

Ripple current, ΔI_L, is peak-to-peak variation in inductor current. Smaller ripple current reduces core losses in the inductor as well as the potential for EMI. Use Equation 2 to determine the value of the inductor, L. Equation 2 shows the relationships among inductance L, VBAT, PVDD, the switching frequency, f_{boost}, and ΔI_L. Insert the maximum acceptable ripple current into Equation 2 to solve for L.

$$L = \frac{VBAT \times (PVDD - VBAT)}{\Delta I_L \times f_{BOOST} \times PVDD} \tag{2}$$

ΔI_L is inversely proportional to L. Minimize ΔI_L as much as is necessary for a specific application. Increase the inductance to reduce the ripple current. Note that making the inductance too large prevents the boost converter from responding to fast load changes properly. Typical inductor values for the TPA2025D1 are 2.2 µH to 4.7 µH.

Select an inductor with a small dc resistance, DCR. DCR reduces the output power due to the voltage drop across the inductor.

2.2.3 Changing the Boost Capacitor

The value of the boost capacitor is determined by the minimum value of working capacitance required for stability and the maximum voltage ripple allowed on PVOUT in the application. The minimum value of working capacitance is 4.7 µF. Do not use any component with a working capacitance less than 4.7 µF. Working capacitance is defined as the rated capacitance reduced by the DC Bias factor, temperature, and aging parameters of the capacitor being used. It may be necessary to request these parameters from the capacitor manufacturer. For best performance, only consider ceramic capacitors with X5R or X7R dielectric.

For X5R or X7R ceramic capacitors, Equation 3 shows the relationships among the boost capacitance, C, to load current, load voltage, ripple voltage, input voltage, and switching frequency (I_{PVOUT}, PVOUT, ΔV, VDD, f_{boost} respectively). Insert the maximum allowed ripple voltage into Equation 3 to solve for C. A factor of about 1.5 is included to account for capacitance loss due to dc voltage and temperature.

$$C = 1.5 \times \frac{I_{PVDD} \times (PVDD - VBAT)}{\Delta V \times f_{BOOST} \times PVDD} \quad (3)$$

For aluminum or tantalum capacitors, Equation 4 shows the relationships among the boost capacitance, C, to load current, load voltage, ripple voltage, input voltage, and switching frequency (I_{PVOUT}, PVOUT, ΔV, VDD, f_{boost} respectively). Insert the maximum allowed ripple voltage into Equation 4 to solve for C. Solve this equation assuming ESR is zero.

$$C = \frac{I_{PVDD} \times (PVDD - VBAT)}{\Delta V \times f_{BOOST} \times PVDD} \quad (4)$$

Capacitance of aluminum and tantalum capacitors is normally insensitive to applied voltage, so no factor of 1.5 is included in Equation 4. However, the ESR in aluminum and tantalum capacitors can be significant. Choose an aluminum or tantalum capacitor with an ESR around 30 mΩ. For best performance with tantalum capacitors, use at least a 10-V rating. Note that tantalum capacitors must generally be used at voltages of half their ratings or less.

2.3 Power Up

1. Verify that the correct connections are as described in Section 2.1.
2. Verify that the voltage setting of the power supply is between 2.5 V and 5.2 V, and turn on the power supply. Proper operation of the EVM begins.
3. Adjust the audio signal source as needed.

3 Reference

This section includes the EVM schematic, board layout reference, and parts list.

3.1 TPA2025D1EVM Schematic

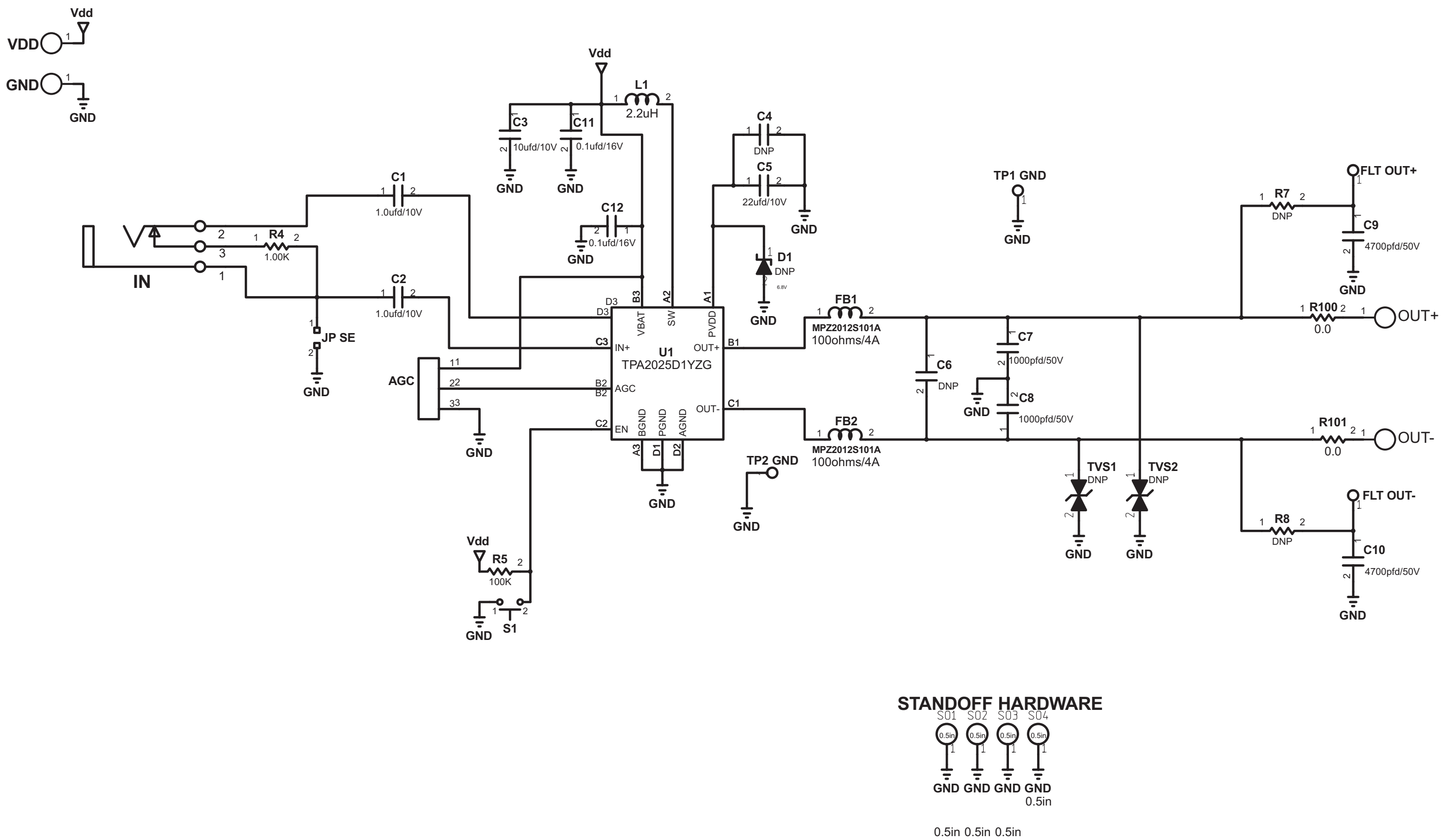

Figure 1. TPA2025D1EVM Schematic

3.2 TPA2025D1EVM PCB Layers

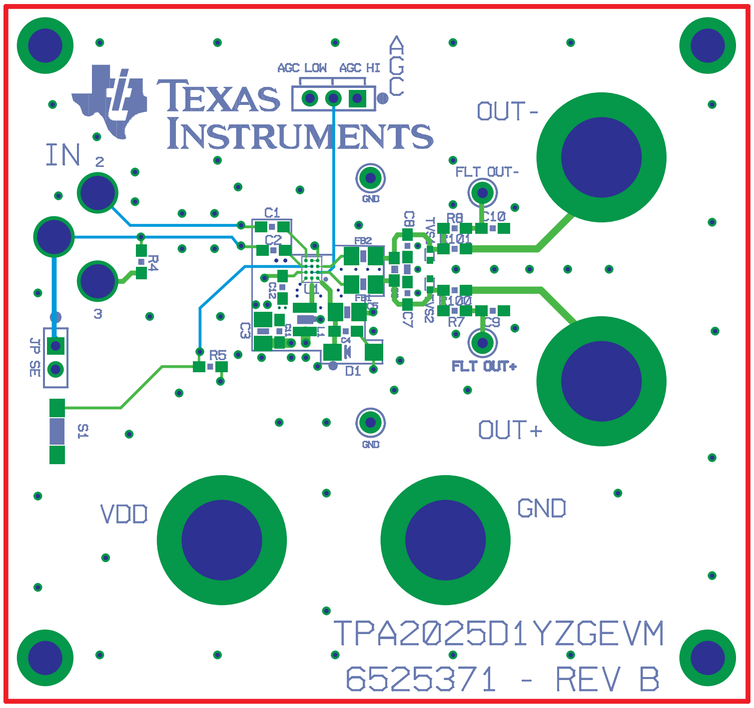

Figure 2. EVM Assembly Layer

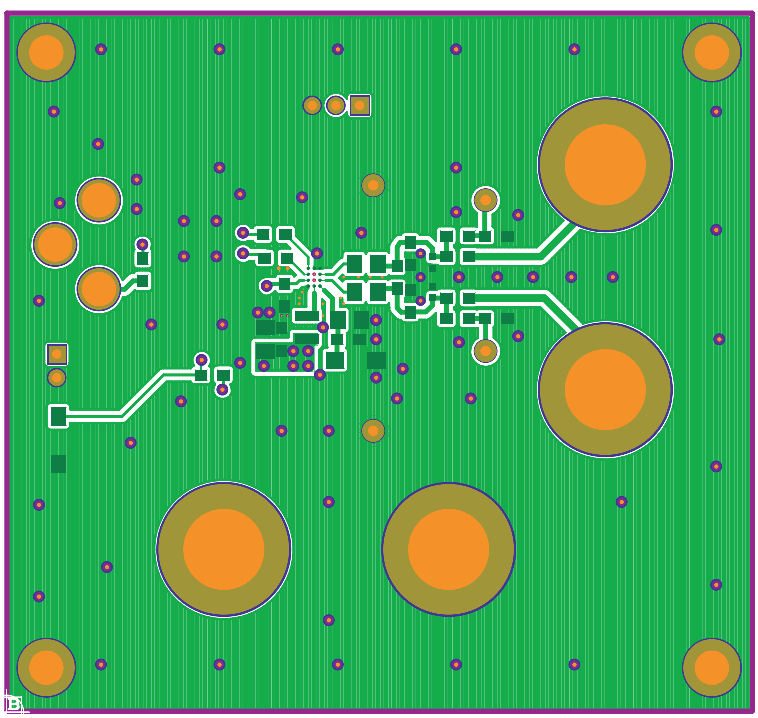

Figure 3. EVM Top Layer

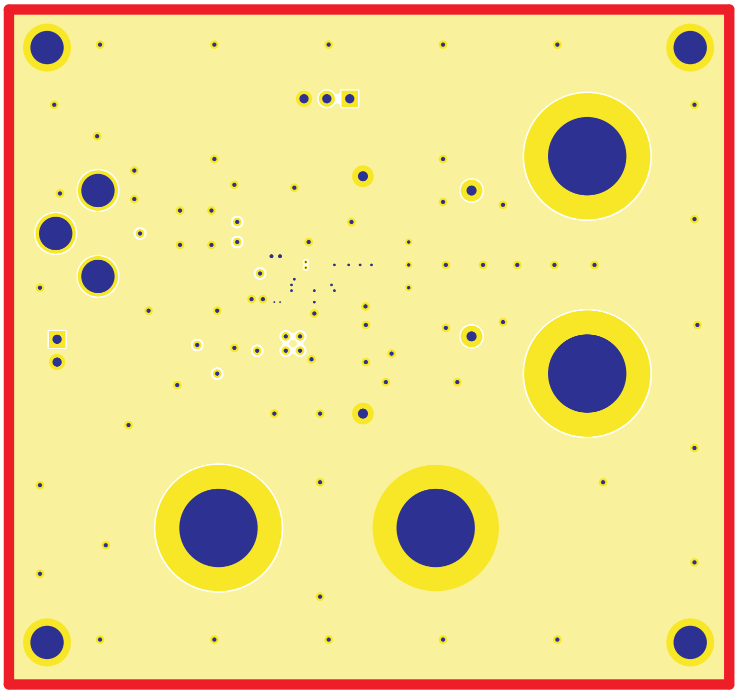

Figure 4. EVM Layer 2

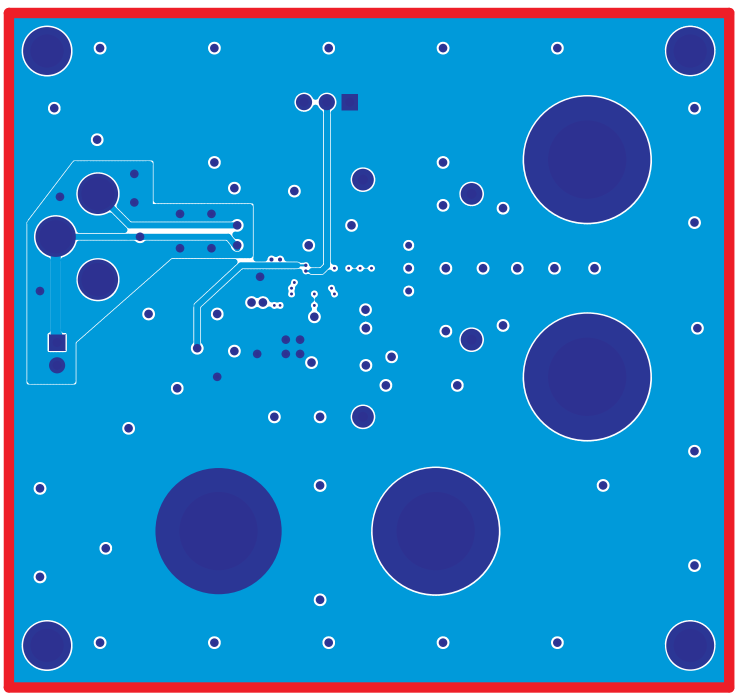

Figure 5. EVM Layer 3

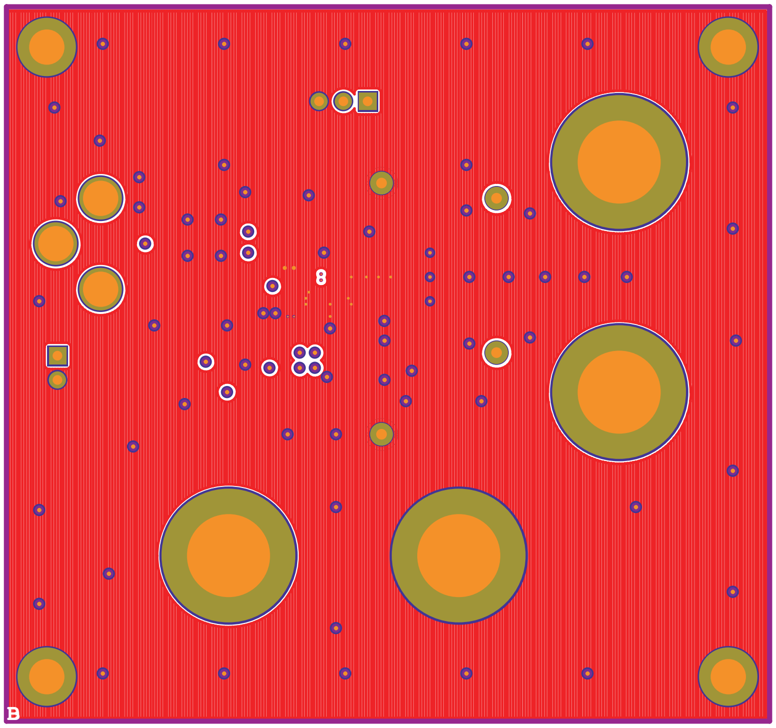

Figure 6. EVM Bottom Layer

3.3 TPA2025D1EVM Bill of Materials

Table 1. TPA2025D1EVM Bill of Materials

ITEM	MANU PARTNUM	QTY	REF DESIGNATORS	VENDOR PARTNUM	DESCRIPTION	VENDOR	MANUFACTURER
1	TPA2025D1YZG	1	U1	TPA2025D1YZG	Audio Power Amplifier	TEXAS INSTRUMENTS	TEXAS INSTRUMENTS
				SEMICONDUCTORS			
2	ESDALC6V1-1BT2	(0) DNP	TVS1,TVS2	ESDALC6V1-1BT2	TRANSIENT VOLTAGE SUPPRESSION BIDIR 6.1V 9A SOD-882 ROHS	MOUSER	ST MICROELECTRONICS
				CAPACITORS			
3	C1608C0G1H102J	2	C7,C8	445-1293-1	CAP SMD0603 CERM 1000PFD 50V 5% COG ROHS	DIGI-KEY	TDK CORP.
4	ECJ-1VB1H472K	2	C9,C10	PCC1780CT	CAP SMD0603 CERM 4700PFD 50V 10% X7R ROHS	DIGI-KEY	PANASONIC
5	GRM21BR71A106KE51L	1	C3	490-3905-1	CAP SMD0805 CERM 10UFD 10V10% X7R ROHS	DIGI-KEY	MURATA
6	LMK212BJ226MG-T	1	C5	587-1958-1	CAP SMD0805 CERM 22UFD 10V 20% X5R ROHS	DIGI-KEY	TAIYO YUDEN
7	ECJ-1VB1C104K	2	C11,C12	PCC1762CT	CAP SMD0603 CERM 0.1UFD 16V 10% X7R ROHS	DIGI-KEY	PANASONIC
8	GRM185R61A105KE36D	2	C1,C2	490-3893-1	CAP SMD0603 CERM 1.0UFD 10V 10% X5R ROHS	DIGI-KEY	MURATA
				RESISTORS			
9	ERJ-3GEYJ104V	1	R5	P100KGCT	RESISTOR SMD0603 100K OHM 5% THICK FILM 1/10W ROHS	DIGI-KEY	PANASONIC
10	RC0603FR-071KL	1	R4	311-1.00KHRCT	RESISTOR SMD0603 THICK FILM 1.00K OHM 1% 1/10W ROHS	DIGI-KEY	YAGEO
11	ERJ-3GEY0R00V	2	R100,R101	P0.0GCT	RESISTOR SMD0603 0.0 OHM 5% THICK FILM 1/10W ROHS	DIGI-KEY	PANASONIC
				INDUCTORS			
12	1239AS-H-2R2N=P2	1	L1	1239AS-H-2R2N=P2	INDUCTOR POWER SMD1008 2.2uH RDC=80mOHMS 2.3A DFE252012C ROHS	TOKO JAPAN	TOKO JAPAN
13	MMSZ5235BT1	(0) DNP	D1		ZENER DIODE,6.8V,SMT SOD-123		
14	MPZ2012S101A	2	FB1,FB2	445-1567-1	FERRITE BEAD, 100 Ohms 4A 100MHz SM0805 ROHS	DIGI-KEY	TDK

Table 1. TPA2025D1EVM Bill of Materials (continued)

ITEM	MANU PARTNUM	QTY	REF DESIGNATORS	VENDOR PARTNUM	DESCRIPTION	VENDOR	MANUFACTURER
				HEADERS, JACKS, AND SHUNTS			
15	26630301RP2	1	AGC	2663S-03	HEADER 3 PIN, PCB 2.0MM ROHS	DIGI-KEY	NORCOMP
16	26630201RP2	1	JP SE	2663S-02	HEADER 2 PIN, PCB 2.0MM ROHS	DIGI-KEY	NORCOMP
17	PJRAN1X1U01X	1	IN	65K7770	JACK, RCA 3-PIN PCB-RA BLACK ROHS	NEWARK	SWITCHCRAFT
18	810-002-SP2L001	2	JP SE, AGC(1)	SP2-001E	SHUNT, BLACK AU FLASH 2 MM ROHS	DIGI-KEY	NORCOMP
				TESTPOINTS AND SWITCHES			
19	5002	1	FLT OUT-	5002K	PC TESTPOINT, WHITE, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
20	5001	2	TP1 GND,TP2 GND	5001K	PC TESTPOINT, BLACK, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
21	5000	1	FLT OUT+	5000K	PC TESTPOINT, RED, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
				STANDOFFS AND HARDWARE			
22	TL1015AF160QG	1	S1	EG4344CT	SWITCH, MOM, 160G SMT 4X3MM ROHS	DIGI-KEY	E-SWITCH
23	2027	4	SO1,SO2,SO3,SO4	2027K	STANDOFF,4-40,0.5INx3/16IN,ALUM RND F-F	DIGI-KEY	KEYSTONE ELECTRONICS
24	111-2223-001	4	GND, VDD, OUT+, OUT-	J587	BINDING-POST,NONINS,THRU,ROHS	DIGI-KEY	EMERSON NPCS
				COMPONENTS NOT ASSEMBLED			
25	R0603_DNP	2	R7, R8				
26	C0603_DNP	2	C4, C6				

(1) Place Shunts Only On Pin2 of JP SE and on Pin3 of AGC

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of –0.3 V to 6 V and the output voltage range of –0.3 V to VDD +0.3 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.