

# TPA2028D1YZFEVM

## Contents

1	Introduction .....	1
2	Operation .....	2
3	TPA2028D1YZFEVM Schematic .....	7
4	TPA2028D1YZFEVM PCB Layers .....	9
5	TPA2028D1YZFEVM Parts List .....	10

## List of Figures

1	Place Shunts Horizontally Across SDA and SCL.....	2
2	<b>Found New Hardware Wizard</b> Advisory Screen.....	3
3	Starting the Software .....	4
4	Software Interface.....	5
5	Connect I <sup>2</sup> C Controls to JP3.....	6
6	TPA2028D1YZFEVM – YZF-Device Schematic, Page 1 .....	7
7	TPA2028D1YZFEVM – YZF-Device Schematic, Page 2 .....	8
8	TPA2028DYZF1EVM – YZF-Device Top Layer .....	9
9	TPA2028D1YZFEVM – YZF-Device Bottom Layer.....	9

## List of Tables

1	Bill of Materials for TPA2028D1YZFEVM .....	10
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## 1 Introduction

### 1.1 Description

The TPA2028D1 is a mono, filter-free Class-D audio power amplifier with automatic gain control (AGC), dynamic range compression (DRC) and I<sup>2</sup>C digital volume control. The AGC and DRC functions enhance the perceived audio loudness, and at the same time prevent speaker damage from overdrive. The TPA2028D1 has independent software shutdown control and a 30-step volume control. Availability in the WCSP package makes TPA2028D1 an ideal choice for both cellular handsets and PDAs.

The TPA2028D1 evaluation module (EVM) is a complete, stand-alone audio board. It contains the TPA2028D1 WCSP (YZF) Class-D audio power amplifier.

All components and the EVM are Pb free.

## 1.2 TPA2028D1YZFEVM Specifications

$V_{DD}$	Supply voltage range	-0.3 V to 6 V
$I_{DD}$	Supply current	2 A Maximum
$P_o$	Continuous output power per channel, 8 $\Omega$ , $V_{DD} = 5.0$ V, THD + N = 10%	1.7 W
$V_i$	Audio Input Voltage	0.5 V to $V_{DD} - 0.5$ V
RL	Minimum load impedance	8 $\Omega$

## 2 Operation

The TPA2028D1YZFEVM can be evaluated in a stand-alone mode or when connected to existing circuits with I<sup>2</sup>C controls.

### 2.1 Quick Start List for Stand-Alone Operation

A desktop or laptop computer with Windows™ XP installed is required in the stand-alone operation. Install the software before connecting the EVM to a computer with a USB cable. The inputs accept standard RCA plugs and the outputs accept banana connectors.

#### 2.1.1 Software Installation Sequence

1. Insert the CD provided.
2. Unzip the files to a temporary folder.
3. Install TPA2028D1 software by executing setup.exe located in *TPA2028D1 Interface*.

Accept license agreement and defaults, and complete the installation. Note: you can uninstall later with Add/Remove Programs.

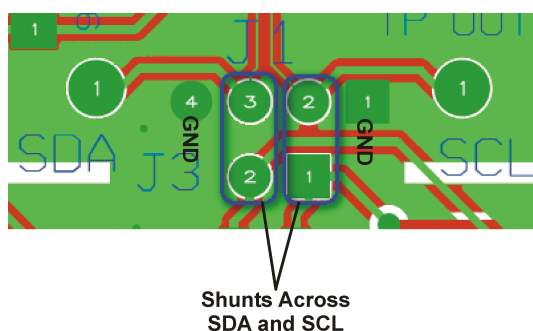
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**NOTE:** It is unnecessary to repeat the steps in [Section 2.1.1](#), once the software is installed.

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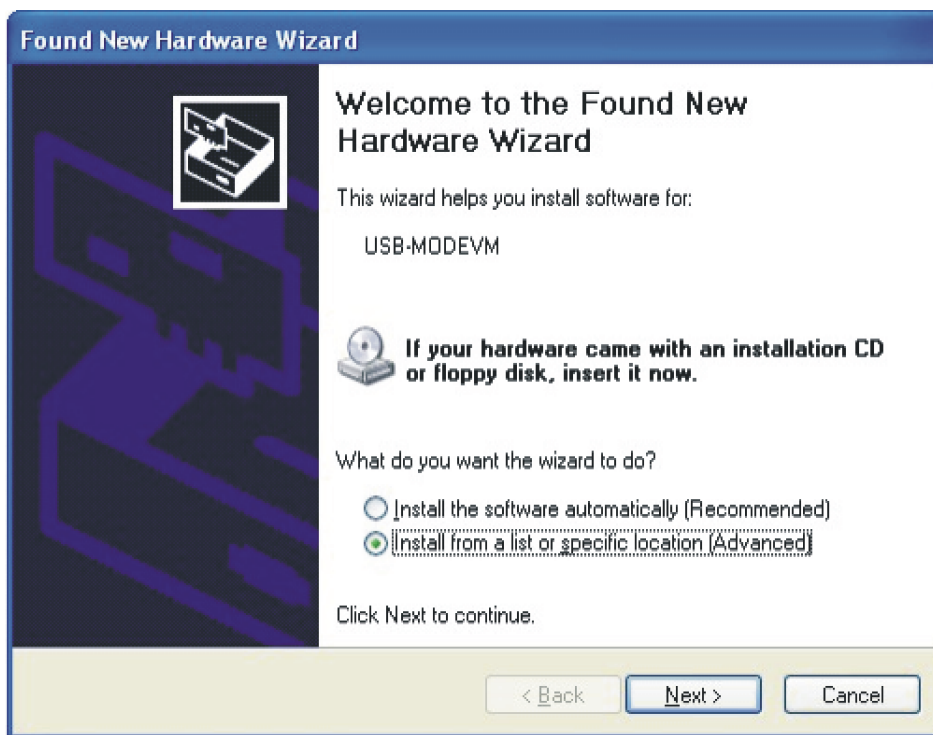
#### 2.1.2 Evaluation Module Preparations

1. Ensure that all external power sources are set to OFF.
2. Install shunt in jumper JP4;
3. Install shunts in jumpers JP2 when single-ended audio input is used; this ties IN- to ground.
4. Install shunts in J1 and J3 as shown in [Figure 1](#). This sets the TPA2028D1 to accept I<sup>2</sup>C inputs from the EVM itself.



**Figure 1. Place Shunts Horizontally Across SDA and SCL**

5. Powering the EVM:
  - The EVM can be powered via USB connection or by external power supply:
    - (a) Via USB power: Install shunt for USBPWR if USB power is used.
    - (b) External power supply: connect an external regulated power supply adjusted for 2.5 V–5.5 V to the VDD and GND banana jacks, taking care to observe marked polarity. Make sure USBPWR is removed in this case.
 Note:
    - (a) USB interface may not be able to provide enough current. For best audio performance, use external power supply.
    - (b) Make sure only one power source is used. Connecting two power sources will cause damage to the device and the supply.
6. Connect audio source to RCA jacks IN.
7. Connect speakers (8  $\Omega$  to 32  $\Omega$ ) to the output banana jacks OUTP and OUTM.
8. Plug in USB.
9. Turn on the power supply.
10. If this is the first time a TPA2028D1YZFEVM is plugged in after installing the software, follow the Windows dialog (Figure 2), questions, and selections:
  - (a) Select "Install from a list or specific location (Advanced)", then click next.<sup>(1)</sup>
  - (b) Browse to the folder where the TPA2028D1 interface is installed then click ok.
  - (c) Windows will automatically install the driver.



**Figure 2. Found New Hardware Wizard Advisory Screen**

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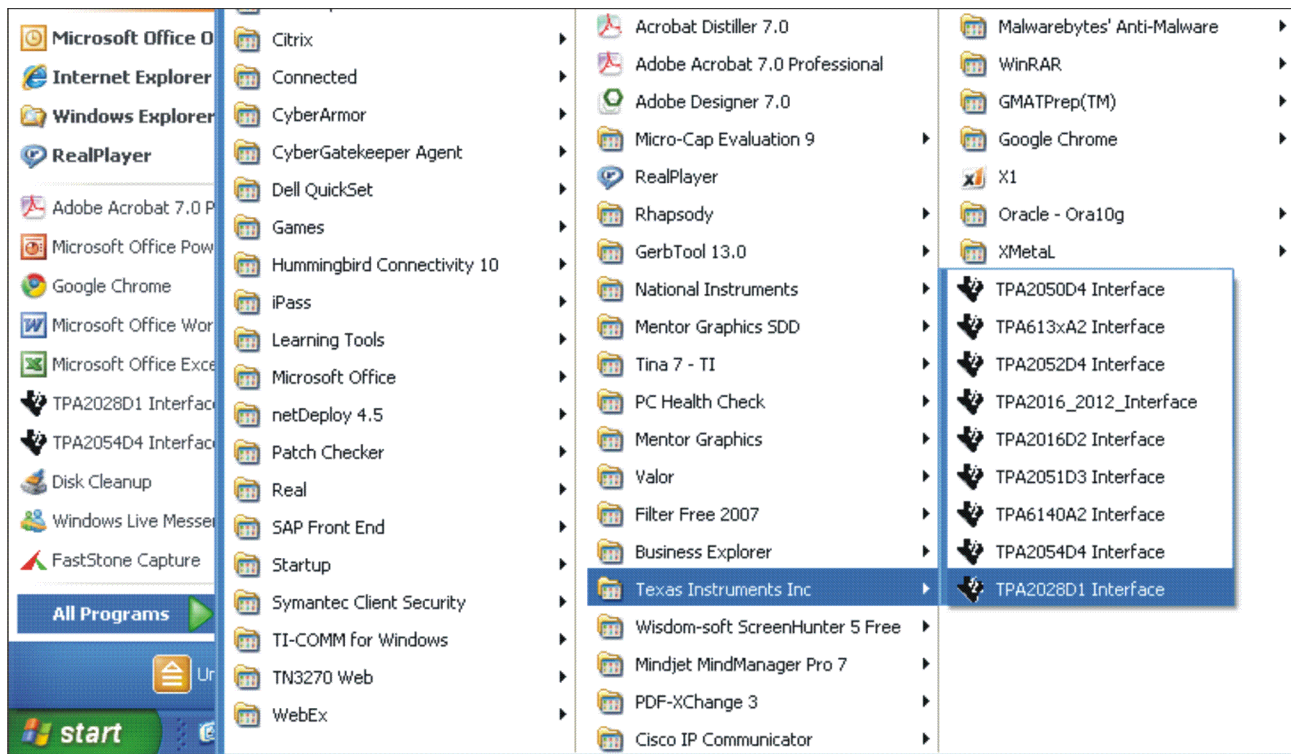
**NOTE:** It is not necessary to repeat steps 10. a. to c., once the driver is installed.

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<sup>(1)</sup> Computer screen images showing Windows XP interface are courtesy of Microsoft Corporation

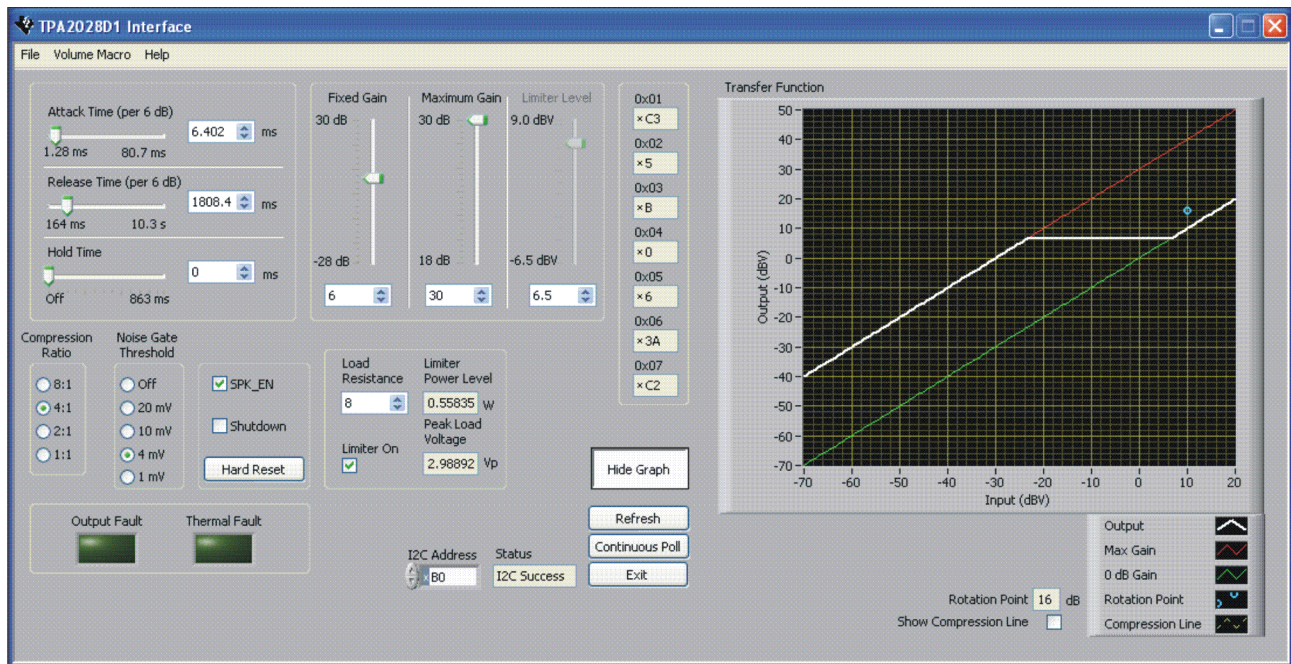
### 2.1.3 Using the Software

1. Start the TPA2028D1 Interface by clicking the *Start* menu and clicking on the *TPA2028D1 Interface* icon.



**Figure 3. Starting the Software**

2. The TPA2028D1 software interface is as shown in [Figure 4](#).



**Figure 4. Software Interface**

**NOTE:** The TPA2028D1 powers up with the amplifier in software shutdown. To hear an output, uncheck shutdown.

3. Uncheck and check *SPK\_EN* to place the Class-D output in and out of CHANNEL SHUTDOWN.
4. Click *Shutdown* to place the TPA2028D1 in and out of SOFTWARE SHUTDOWN.
5. Adjust the *Attack Time*, *Release Time* and *Hold Time* by sliding the bar or clicking the tap in the GUI. You can also type a value in the box; in that case, the value will be rounded to the closest available setting.
6. Adjust the *Fixed Gain*, *Maximum Gain* and *Limiter Level* by dragging the bar or clicking the tap in the GUI. You can also type a value in the box; in that case, the value will be rounded to the closest available setting.
7. Adjust *Compression Ratio* and *Noise Gate Threshold* by clicking the value.
8. The Limiter Power Level can be calculated by selecting the Load Resistance.
9. *I<sup>2</sup>C Status* box reports the status of I<sup>2</sup>C communications. An error or failure has occurred if it shows *I<sup>2</sup>C failure*.
10. To read the I<sup>2</sup>C status, click Refresh.
11. *Thermal* box reports the status of thermal failure. A thermal fault has occurred if it turns red.
12. Click *Show Graph* to display the AGC transfer function. The transfer function is automatically updated with the current AGC parameters (fixed gain, maximum gain, limiter level and compression) in GUI. Click *Hide Graph* to hide the transfer function.
13. Volume Macro simulates volume control by changing fixed gain, limiter level and maximum gain simultaneously. Follow the steps below to use the Volume Macro.
  - At the top left corner of the GUI, select Volume Macro.
  - Slide the volume bar to adjust the volume.
  - Click Volume Macro again to go back to GUI.
  - Click refresh to update the AGC parameters.
14. The GUI has a built-in I<sup>2</sup>C programming interface. Follow the steps below to use the I<sup>2</sup>C programming function.
  - At the top left corner of the GUI, click *File* to access the I<sup>2</sup>C programming interface.



- *Save Script* can record the current register values. Select Save Script >> Click the folder icon to browse to the place where you want to save the script >> name the file in text format, then select OK to save.
- *Load Script* can load the previously saved script to program the entire register file. Select Load Script >> Click the folder icon to browse to the place where the script is located >> Select the file then click OK >> Click Load.
- *I<sup>2</sup>C interface* can program individual register value of TPA2028D1. Select I<sup>2</sup>C Interface >> I<sup>2</sup>C address is xB0, which is the address of TPA2028D1. Device address is from 1 to 7, which is the register address of TPA2028D1.

### 2.1.4 Shutdown Control

The TPA2028D1 EVM provides independent hardware shutdown controls for the Class-D power amplifier and the USB controller.

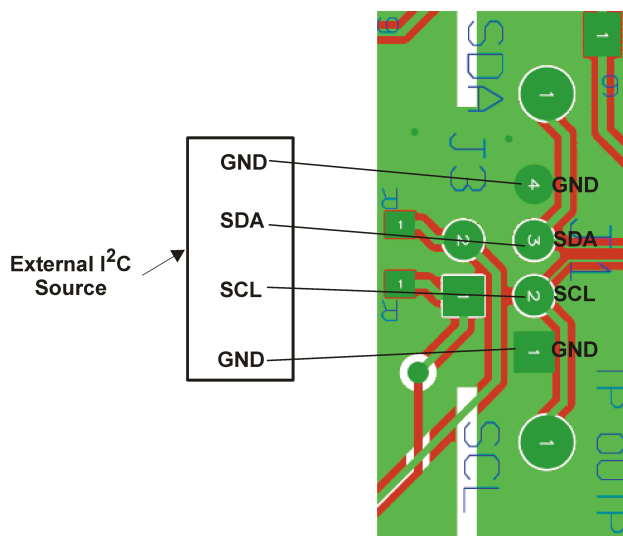
1. Press and hold push button S1 to shutdown TPA2028D1. Release S1 to activate TPA2028D1.
2. Press and hold push button S2 to shutdown the USB controller. Release S2 to activate the USB controller.

## 2.2 Quick Start List When Connected to Existing Circuits With I<sup>2</sup>C Controls

The TPA2028D1YZFEVM can be easily connected to existing circuits with I<sup>2</sup>C controls. Connections to the EVM module can be made using banana plugs for the power supply. The inputs accept standard RCA plugs and the outputs accept banana connectors.

### 2.2.1 Evaluation Module Preparations

1. Ensure that all external power sources are set to OFF.
2. Install shunts in jumpers JP4.
3. Remove shunts between J1 and J3 and connect I<sup>2</sup>C controls to J1 as shown in [Figure 5](#).



**Figure 5. Connect I<sup>2</sup>C Controls to JP3**

4. Install shunts in jumpers JP2 when single-ended audio input is used; this ties IN– to ground.
5. Remove USBPWR.
6. Connect an external regulated power supply adjusted for 2.5 V–5.5 V to the VDD and GND banana jacks, taking care to observe marked polarity.
7. Connect audio source to IN.
8. Connect speakers (8 Ω to 32 Ω) to the output banana jacks OUTP and OUTM.
9. Turn on power supply.



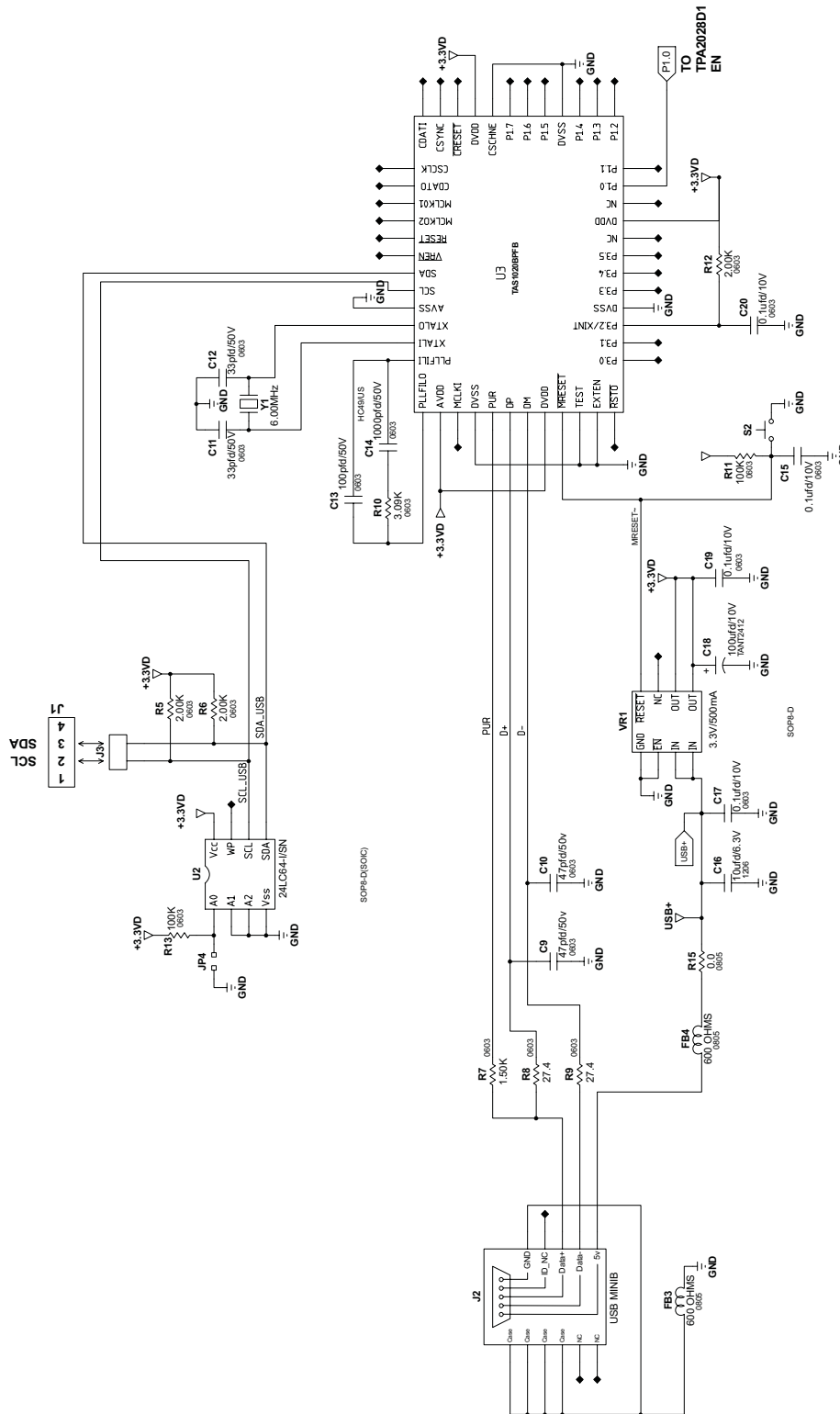


Figure 7. TPA2028D1YZFEVM – YZF-Device Schematic, Page 2



4 TPA2028D1YZFEVM PCB Layers

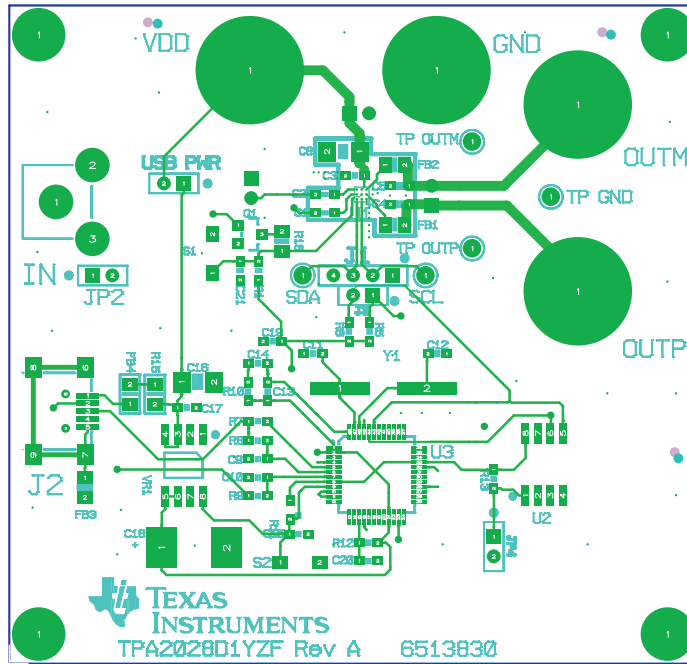


Figure 8. TPA2028DYZF1EVM – YZF-Device Top Layer

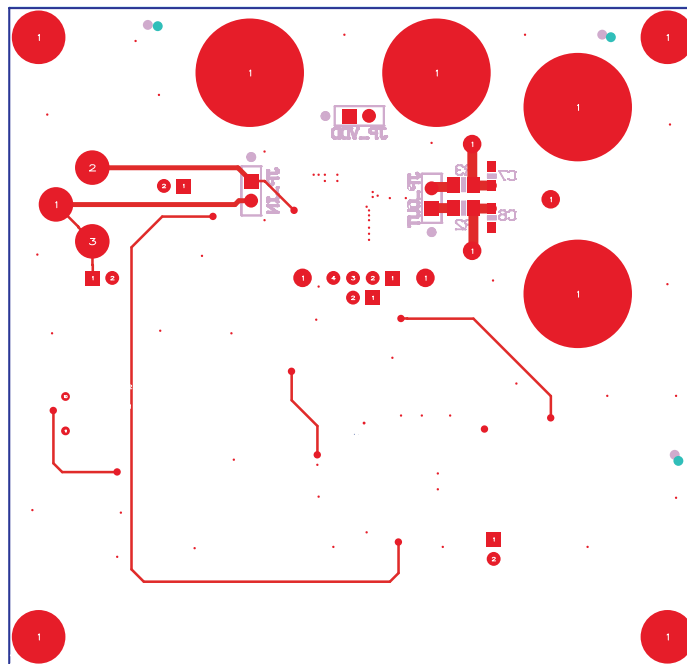


Figure 9. TPA2028D1YZFEVM – YZF-Device Bottom Layer

**5 TPA2028D1YZFEVM Parts List**
**Table 1. Bill of Materials for TPA2028D1YZFEVM**

Ref Des	Description	QTY	MFR Part No.	MFR	Vendor Part No.	Vendor
<b>TI SEMICONDUCTORS</b>						
U5	1.7 W Mono speaker driver W/AGC I2C CTRL, WCS9P9-YZF ROHS	1	TPA2028D1YZF	Texas Instruments	TPA2028D1YZF	Texas Instruments
VR1	VOLT REG 3.3V 500mA LDO fast transient response SOP8-D ROHS	1	TPS77533D	Texas Instruments	296-2776-5	Digi-Key
U4	USB Streaming controller TQFP48-PFB ROHS	1	TAS1020BPFB	Texas Instruments	296-13041-5	Digi-Key
<b>SEMICONDUCTORS</b>						
U2	64K I2C SERIAL EEPROM SOP8-D	1	24LC64-I/SN	Microchip	24LC64-I/SN	Digi-Key
Q1	N-CH Enhancement mode VERT DMOS FET SOT23-DBV3 ROHS	1	BSS138TA	Zetex	BSS138ZXCT	Digi-Key
Y1	Crystal, 6.000 MHz, SMT-HC49/US CSM-7 ROHS	1	ECS-60-32-5PXD-N-TR	ECS	XC1295CT	Digi-Key
<b>CAPACITORS</b>						
C11,C12	CAP 33 pF 50V 5% CERM 0603 NPO ROHS	2	ECJ-1VC1H330J	Panasonic	PCC330ACVCT	Digi-Key
C9, C10	CAP 47 pF 50V 5% CERM 0603 NPO ROHS	2	ECJ-1VC1H470J	Panasonic	PCC470ACVCT	Digi-Key
C13	CAP 100 pF 50V 5% CERM 0603 NPO ROHS	1	ECJ-1VC1H101J	Panasonic	PCC101ACVCT	Digi-Key
C14	CAP 1000 pF 50V 5% CERM 0603 COG ROHS	1	C1608C0G1H102J	TDK Corp.	445-1293-1	Digi-Key
C6, C7	CAP 4700 pF 50V CERM 0603 X7R ROHS	2	ECJ-1VB1H472K	Panasonic	PCC1780CT	Digi-Key
C15, C17, C19, C20	CAP SMT0603 CERM 0.1µF 10V 5% X7R ROHS	4	C0603C104K8RACTU	Kemet	399-1095-1	Digi-Key
C1-C3	CAP 1.0 µF 10V 10% CERM 0603 X5R ROHS	3	ECJ-1VB1A105K	Panasonic	PCC2174CT	Digi-Key
C8, C16	CAP 10 µF 6.3V 10% CERM 1206 X5R ROHS	2	C3216X5R0J106K	TDK	445-1388-1	Digi-Key
C18	CAP TANT2412 100 µF 10V 10% B45197A ROHS	1	B45197A2107K309	Kemet	495-1528-1	Digi-Key
<b>RESISTORS</b>						
R15, R16	RES 0Ω 1/8W 5% SMD 0805 ROHS	2	ERJ-6GEY0R00V	Panasonic	P0.0ACT	Digi-Key
R8, R9	RESISTOR SMD0603 27.4 Ω 1/10W 1% ROHS	2	CRCW060327R4FKEA	Vishay	541-27.4HCT	Digi-Key
R7	RES SMD0603 1.50 kΩ 1/10W 1% ROHS	1	ERJ-3EKF1501V	Panasonic	P1.50KHCT	Digi-Key
R5, R6, R12	RES 2.00 kΩ 1/16W 1% SMD 0603 ROHS	3	ERJ-3EKF2001V	Panasonic	P2.00KHCT	Digi-Key
R10	RES 3.09kΩ 1/10W 1% SMD 0603 ROHS	1	ERJ-3EKF3091V	Panasonic	P3.09KHCT	Digi-Key
R1, R11, R13	RES 100 kΩ 1/16W 1% SMD 0603 ROHS	3	ERJ-3EKF1003V	Panasonic	P100KHCT	Digi-Key
<b>FERRITE BEADS</b>						
FB3, FB4	Ferrite SMD0805 600 Ω 0.24 A RDC=0.14 ROHS	2	MMZ2012R601A	TDK	445-1554-1	Digi-Key
FB1, FB2	Ferrite bead SMD0805 80 Ω at 100 MHz 5A ROHS	2	HI0805R800R-10	Steward	240-2395-1	Digi-Key
<b>HEADERS AND JACKS</b>						
J3, JP2, JP4, USB PWR	Header 2 Pin, PCB 2,0 mm ROHS	4	26630201RP2	Norcomp	2663S-02	Digi-Key
J1	Header 4 Pin, PCB 2,0 mm ROHS	1	26630401RP2	Norcomp	2663S-04	Digi-Key
IN	Jack, RCA 3-Pin PCB-RA Black ROHS	1	PJAN1X1U01X	Switchcraft	65K7770	NEWARK
J2	Jack USB MINIB SMT-RA 5Pin ROHS	1	UX60-MB-5ST	Hirose	H2959CT	Digi-Key

**Table 1. Bill of Materials for TPA2028D1YZFEVM (continued)**

Ref Des	Description	QTY	MFR Part No.	MFR	Vendor Part No.	Vendor
<b>TESTPOINTS AND SWITCHES</b>						
SCL, SDA, TP OUTM, TP OUTP	PC Testpoint, white, ROHS	4	5002	Keystone Electronics	5002K	Digi-Key
TP GND	PC Testpoint, black, ROHS	1	5001	Keystone Electronics	5001K	Digi-Key
S1, S2	Switch, MOM, 160G SMT 4X3MM ROHS	2	TL1015AF160QG	E-Switch	EG4344CT	Digi-Key
<b>SHUNTS</b>						
JP2, JP4	Shunt, black AU Flash 2mmLS	2	810-002-SP2L001	Norcomp INC.	SP2-001E	Digi-Key
<b>BINDING POSTS</b>						
GND, VDD,OUTM, OUTP	Binding-post, NONINS, THRU, ROHS	4	111-2223-001	Emerson NPCS	J587	Digi-Key
<b>STANDOFFS AND HARDWARE</b>						
HW1-HW4	Standoff ,4-40 0.5 in 3/16 in Diameter ALUM RND F-F	4	2027	Keystone	2027K	Digi-Key
HW1-HW4	4-40 Screw, Steel 0.250 IN	4	PMS 440 0025 PH	Building Fasteners	H342	Digi-Key
<b>COMPONENTS NOT ASSEMBLED</b>						
C21, C4, C5, R2, R3, JP_VDD, JP_VOUT, JP_VIN						

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### EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the supply voltage range of  $-0.3\text{ V}$  to  $6\text{ V}$  and the input voltage range of  $-0.3\text{ V}$  to  $V_{DD} + 0.3$ .

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  $85^{\circ}\text{C}$ . The EVM is designed to operate properly with certain components above  $85^{\circ}\text{C}$  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.

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