

TPA2051D3EVM

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1 Introduction

1.1 Description

The TPA2051D3 is a mono Class-D power amplifier along with a stereo DirectPath™ headphone amplifier and bypass switch. TPA2051D3 has SmartGain™ technology to prevent output clipping. The input channels have 32-step volume control and the DirectPath headphone amplifier has a 9-step level gain control. The volume is controlled through an I²C™ interface. All amplifiers have output short-circuit and thermal-overload protection.

The TPA2051D3EVM (evaluation module) is a complete, stand-alone audio board. It contains the TPA2051D3 WCSP(YFP) Class-D audio subsystem.

All components and the EVM are lead free.

DirectPath, SmartGain are trademarks of Texas Instruments.
 Windows is a trademark of Microsoft Corporation.
 I²C is a trademark of Philips Electronics.

1.2 TPA2051D3EVM Specifications

PARAMETER		VALUE	UNITS
V _{DD}	Supply voltage range	-0.3 to 6	V
I _{DD}	Supply current	1.5 Maximum	A
P _O	Speaker Continuous output power per channel, 8 Ω, V _{DD} = 5 V, THD + N = 1%	1.25	W
	Headphone Continuous output power per channel, 16 Ω, V _{DD} = 5 V, THD + N = 1%	25	mW
R _L	Minimum load impedance (Speaker)	4	Ω
	Minimum load impedance (Headphone)	16	Ω

2 Operation

The TPA2051D3EVM can be evaluated in a stand-alone mode or when connected to existing circuits with I²C controls.

2.1 Quick Start for Stand-Alone Operation

A desktop or laptop computer running the Windows™ XP operating system is required for the stand-alone operation. Connect the EVM to a computer using a USB cable. A jumper (USBPWR) provides the option for the TPA2051D3 to receive power from the USB or an external supply using banana plugs. The inputs accept standard RCA plugs. The speaker output connection accepts banana plugs. The headphone output connection accepts standard 3.5 mm headphone plugs.

2.1.1 Software Installation Sequence

1. Insert the *TPA2051D3EVM Software Installation CD* provided.
2. Unzip the files to a temporary folder onto a PC.
3. Install TPA2051D3 software by double-clicking the filename **setup.exe** located in *TPA2051D3 Setup* folder.
4. Accept license agreement and defaults; then complete the installation.

Note: Uninstall the TPA2051D3 software at a later time using the **Add/Remove Programs** found under the Windows **Control Panel**. It is unnecessary to repeat the preceding steps, once the software is installed.

2.1.2 Evaluation Module Setup

1. Configure the jumpers using [Table 1](#) for the default settings:

Table 1. Jumpers Default Setting

Jumper	Default Setting
DVDD, JP10	Shunt
J1, J2	Shunt across each other
JP6, JP7, JP8, JP9	As shown in Figure 2
USBPWR, JP1, JP2, JP3, JP4, JP5	Remove

2. Configure the input according to the desired TPA2051D3 operation mode:

a. **Differential Modes**

Install shunts and connect RCA plugs as shown in [Figure 1](#).

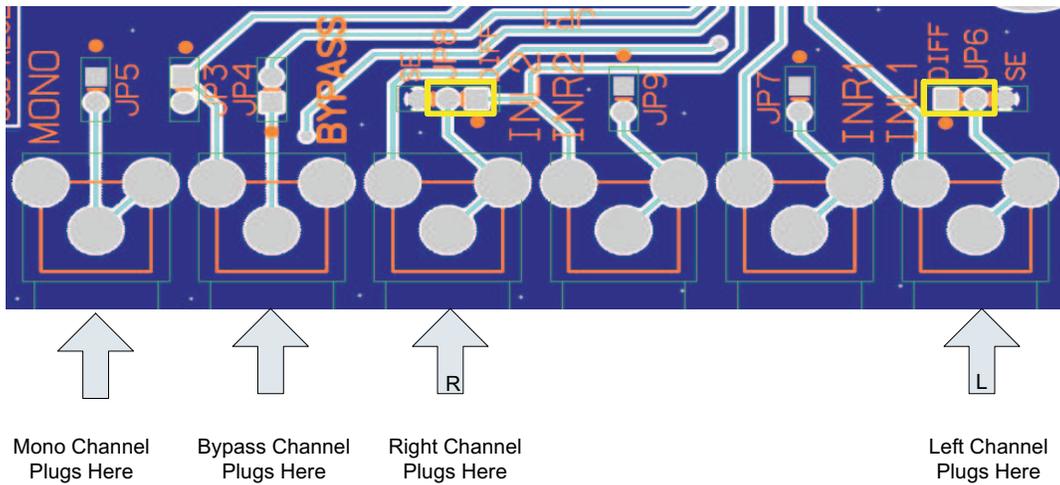


Figure 1. Stereo Differential Mode Input Configuration

b. **For single-ended modes**, install shunts and connect RCA plugs as shown in [Figure 2](#).

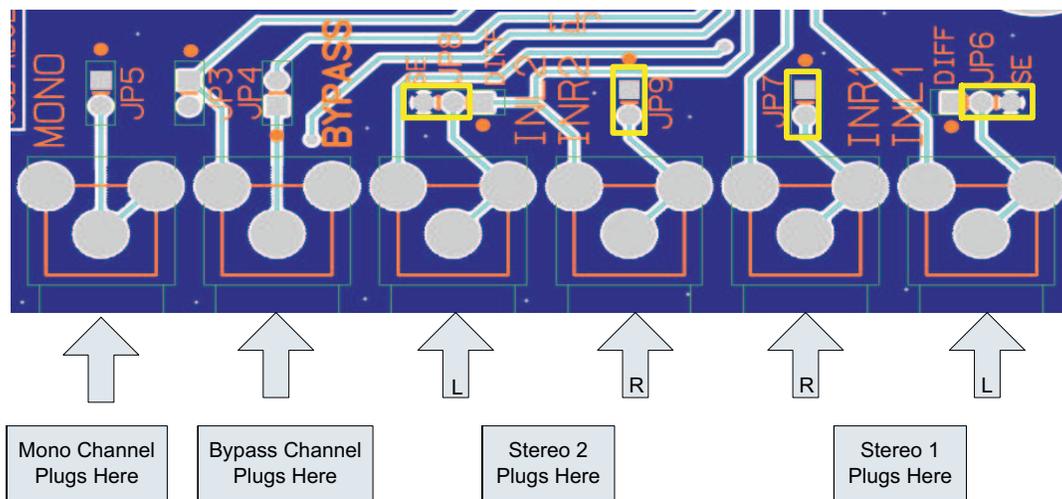


Figure 2. Non-Differential Mode Input Configuration

3. Shunt JP3 to connect BYPASS+ input to MONO+. Shunt JP4 to connect BYPASS- input to MONO- input.
4. Remove shunts of JP1 and JP2 to allow R1 and R2 in series with bypass switch. Shunt JP1 and JP2 to short R1 and R2.
5. Install shunts in J1 and J2 as shown in [Figure 3](#). This sets the TPA2051D3 to accept I²C inputs from the EVM itself.

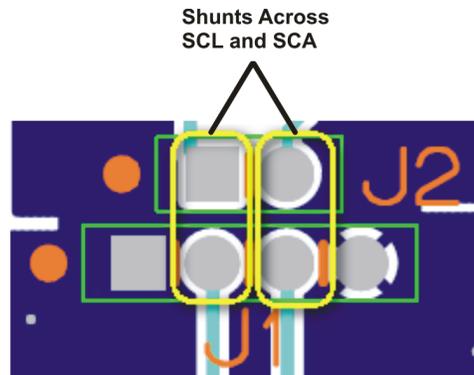


Figure 3. Place Shunts Horizontally Across SCL and SDA

6. Ensure all external power sources are set to OFF.
7. Connect an external regulated power supply adjusted from 2.5 V to 5.5 V to the VDD and GND banana jacks, taking care to observe the marked polarity.
8. Install shunt in jumper DVDD if DVDD is powered by the 1.8 V regulated supply from the EVM itself. If DVDD is powered by another supply (between 1.8 V and 3.3 V), remove shunt in jumper DVDD and connect the supply at pin 2 of the jumper.
9. Connect audio source as mentioned in step two.
10. Connect headphones.
11. Connect speakers ($8\ \Omega$ to $32\ \Omega$) to the output banana jacks OUTP and OUTM.
12. Turn on power sources.
13. Plug in the USB.
14. Press button S2 and release to reset TPA2051D3.
15. The TPA2051D3 can also be powered by USB cable if the audio amplifier output power is less than 100mW. Shunt USBPWR and remove the power supply at VDD and GND for USB power option.

2.1.3 Using the Software

1. Start the TPA2051D3 Interface by clicking the *Start* menu and clicking the *All Programs* → *Texas Instruments Inc* → *TPA2051D3 Interface* cascading menus shown in [Figure 4](#).

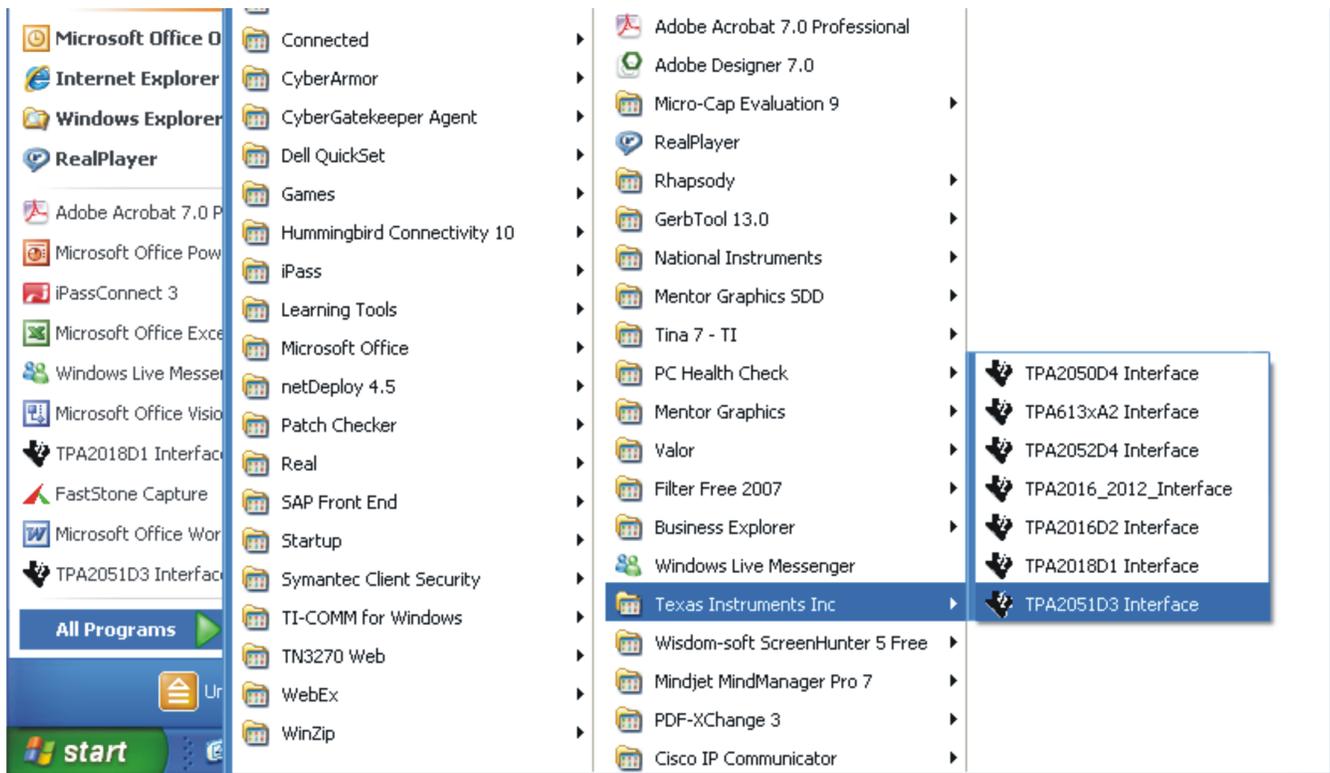


Figure 4. Starting the TPA2051D3 Interface

- The TPA2051D3 software graphical user interface displays as shown in [Figure 5](#).



Figure 5. TPA2051D3EVM Graphical User Interface

Note: The TPA2051D3 powers up with the amplifiers disabled. To hear an output, enable and remove the disable for each channel, increase the gain to a higher value.

- Follow these steps only if using a PC is both the music source and the computer on which the TPA2051D3 GUI is run. When using WinXP, if after initially installing the software, the PC does not play music out of the headphone jack:
 - Display the *Control Panel*.
 - Select the *Sounds, Speech, and Audio Device* item under the Control Panel.
 - Click *Sounds and Audio Device Properties* link.
 - Select the *Audio* tab.
 - Verify that the Default device under Sound playback is the audio driver of the PC HW, not the USBMODEVM TPA2051D3 GUI driver.
 - Change the driver in the menu to the *PC Audio HW* driver.
 - Click *OK*.
- Click the *HW Reset* button to reset the device.
- Turn off *Software Shutdown*.
- Toggle *Class-D Enable/Disable* to enable/disable speaker output.
- Toggle *Headphone Enable/Disable* to enable/disable headphone output.
- Select input mode in *Mode*.

9. Adjust the volume for input amplifiers by sliding the bar in *Stereo 1 Volume*, *Stereo 2 Volume* or *Mono Volume*.
10. Select the Class-D gain at *Speaker Gain*.
11. Adjust the headphone gain by sliding the bar in *Headphone Gain*.
12. *Total System Gain* shows the total gain of speaker output and headphone output.
13. Toggle *Limiter Enable/Disable* to enable/disable limiter.
14. Select the Class-D limiter level by clicking *Class-D Limiter* and select the levels at *Class-D limiter*.
15. The Class-D limiter power level is calculated at *Class-D Limiter*. Change *Load Resistance* value to calculate different limiter power.
16. Select the headphone limiter level by clicking *Headphone Limiter* and select the levels at *HP limiter*.
17. The headphone limiter power level is calculated at *Headphone Limiter*. Change *Load Resistance* value to calculate different limiter power.
18. Change the *attack time and release time* at *Limiter Response*.
19. *I2C Status* box reports the status of I²C communications. An error or failure has occurred if it turns red.
20. *Thermal* box reports the status of thermal failure. A thermal fault has occurred if it turns red.
21. *PA Fault* reports the status of Class-D amplifier. A short-circuit fault has occurred if it turns red.

2.1.4 Using the I²C Programming Function

The GUI has a built-in I²C programming interface. It has a log feature to record the configuration selections made in the GUI.

To use the I²C programming function:

1. At the top left corner of the GUI, click *File* to access the I2C programming interface.
2. To save the current register values in a script.
 - a. Select *Save Script* button.
 - b. Click the folder icon to navigate to the folder where the script is to be stored.
 - c. Provide a name for the file and save as text (txt) format.
 - d. Select *OK* to save.
3. To load the previously saved script to program the entire register file.
 - a. Select *Load Script* button.
 - b. Click the folder icon to navigate to the folder where the script text file is located.
 - c. Select the desired filename.
 - d. Click *OK*.
 - e. Click *Load* button.
4. *I2C interface* can program individual register values of TPA2051D3. Select I2C Interface >> I2C address is xE0, which is the address of TPA2051D3. Device address is from 1 to 6, which is the register address of TPA2051D3.
5. To record all the changes made in the GUI and store the changes in a text file.
 - a. Select *Record Script* button.
 - b. Click the folder icon to navigate to the folder where the GUI changes are recorded.
 - c. Provide a name for the file and save as text (txt) format.
 - d. Click *Record Off* that toggles to *Record On*. The green light turns red to indicate active recording of the GUI changes.
 - e. Click *Exit* button.
 - f. Make changes in the TPA2051D3 software GUI.
 - g. Select *Record Script* button.
 - h. Click *Record On* that toggles to *Record Off*. The red light turns green to indicate the GUI changes are no longer recording.
 - i. Click *Exit* button. All the changes are recorded in the selected text file that was named in the third step.

2.2 Quick Start List When Connected to External I²C Controller

The TPA2051D3EVM can be connected to existing circuits with I²C controls. Connections to the EVM module can be made using banana plugs for the power supply. The inputs accept standard RCA plugs. The output connection accepts standard 3.5-mm headphone plugs.

2.2.1 Evaluation Module Setup

1. Install shunts in jumpers JP10. Remove shunts in J1 and JP2 and connect I²C controls to JP3 as shown in [Figure 6](#).
2. The two options to power DVDD:
 - Connect USB cable to supply 1.8V for DVDD.
 - Disconnect USB cable. Remove shunt for jumper DVDD and connect an external power supply (from 1.75 V to 1.95 V) at pin 2 of jumper DVDD.

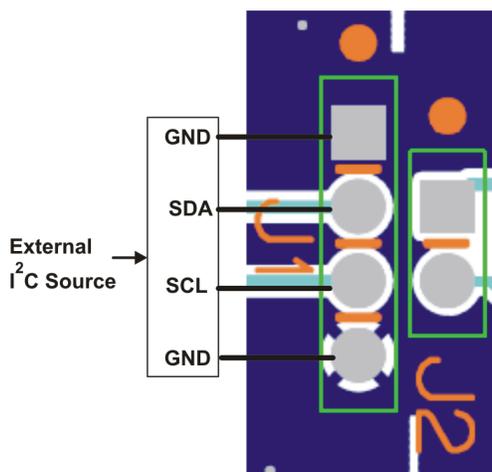


Figure 6. Connect I²C Controls to JP3

3. For all the other connections, follow the steps in [Evaluation Module Setup](#).

3 TPA2051D3EVM Schematic

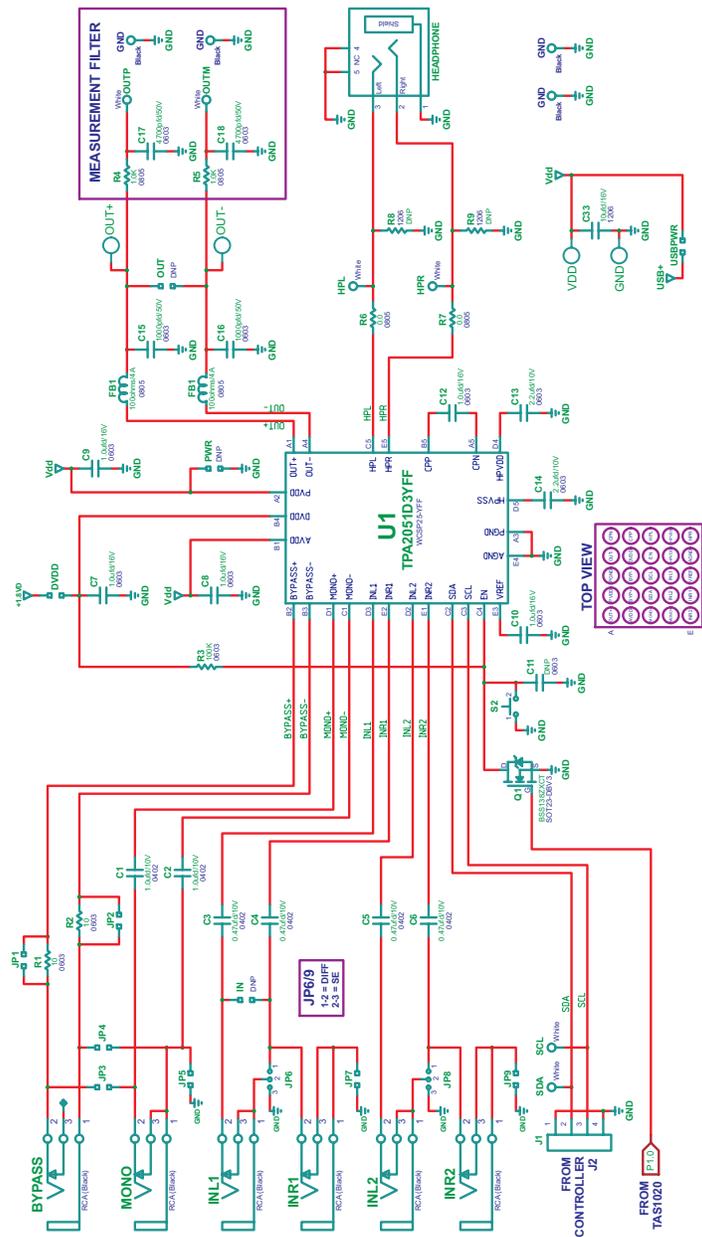


Figure 7. TPA2051D3EVM Schematic

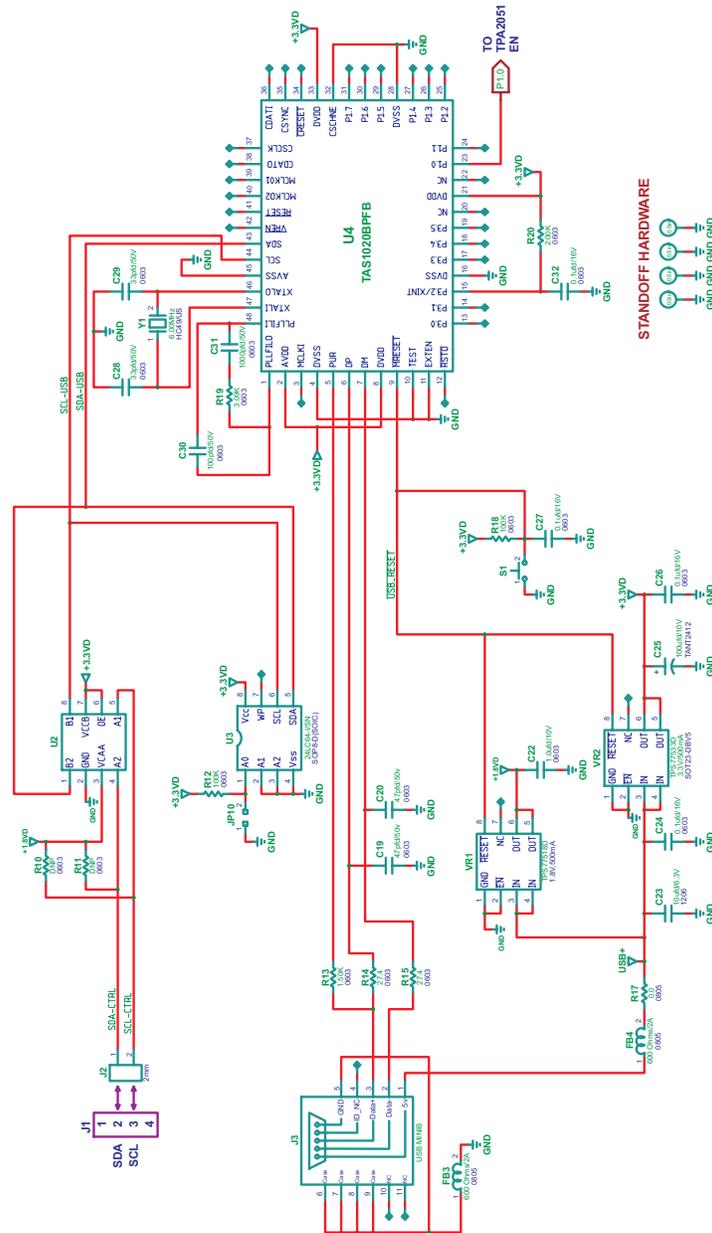


Figure 8. TPA2051D3EVM Schematic

4 TPA2051D3EVM PCB Layers

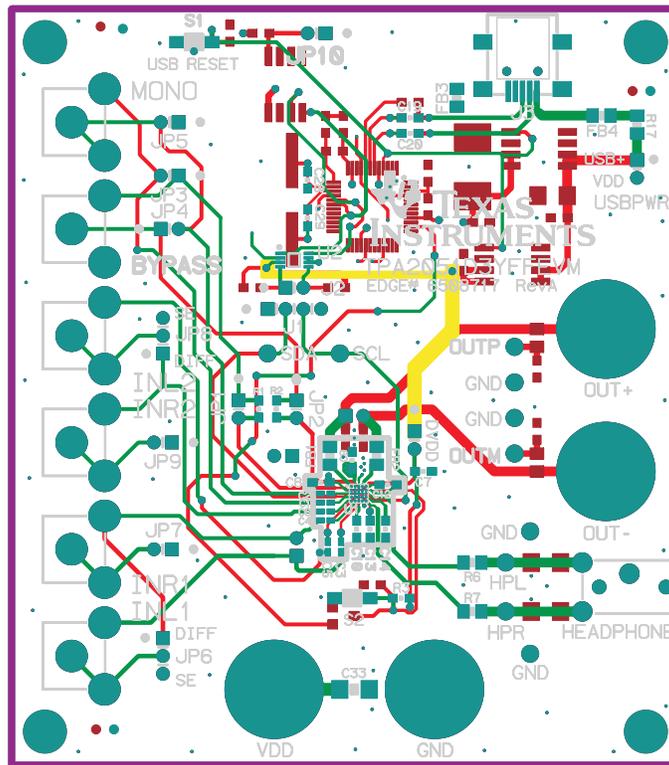


Figure 9. TPA2051D3EVM – Top Layer

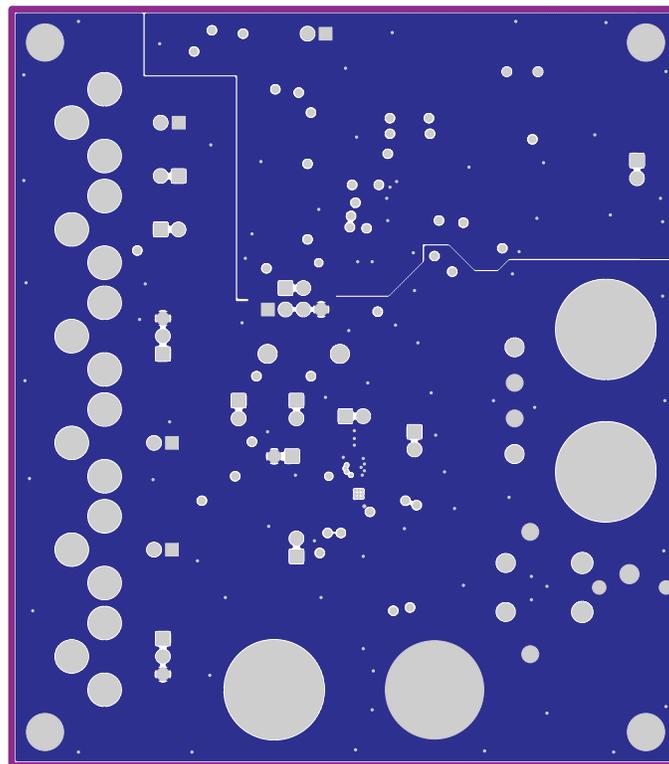


Figure 10. TPA2051D3EVM – Layer 2

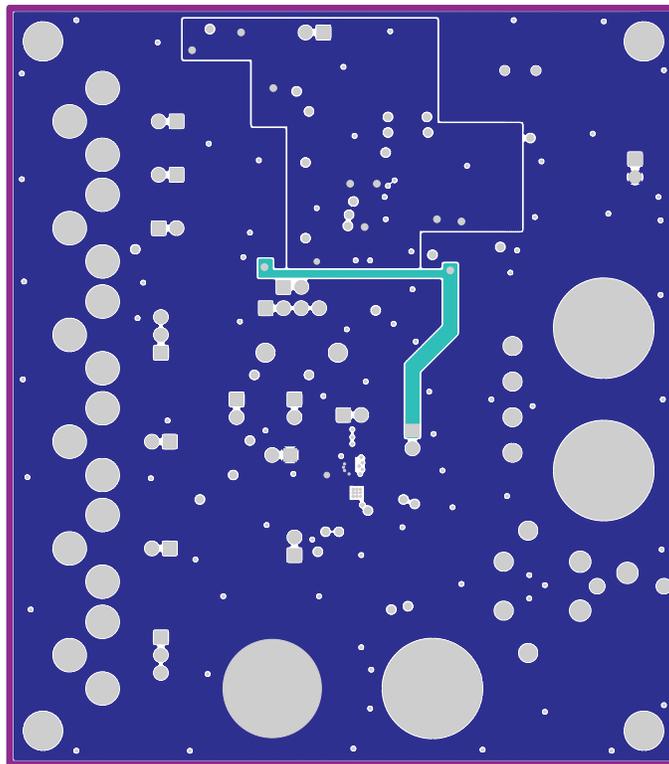


Figure 11. TPA2051D3EVM – Layer 3

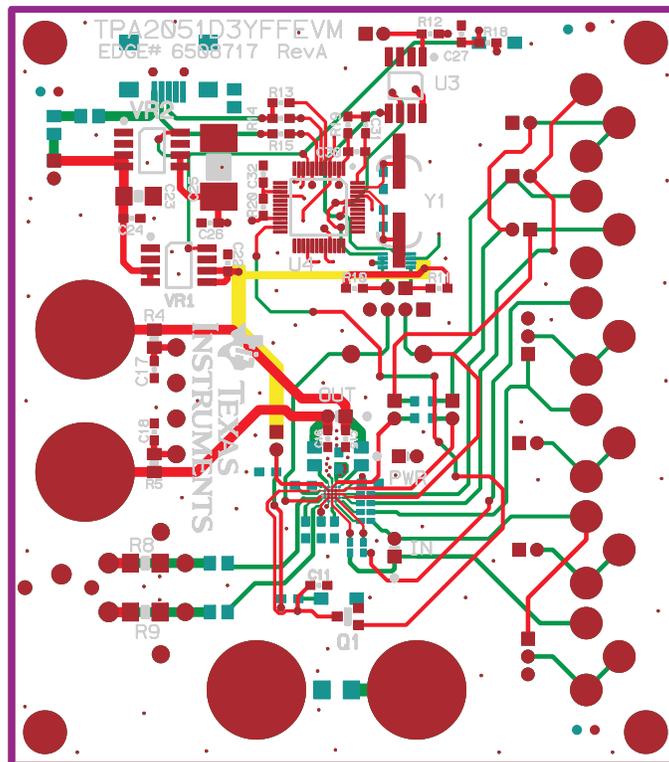


Figure 12. TPA2051D3EVM – Bottom Layer

5 TPA2051D3EVM Parts List

Table 2. TPA2051D3EVM Parts List

QTY	Ref Des	Description	Vendor	Vendor Part No.	MANU	MANU Part No.
TI-SEMICONDUCTORS						
1	U1	AUDIO SUBSYSTEM, MONO CLASS-D DIRECTPATH AMPS WCSP25-YFF ROHS	Texas Instruments	TPA2051D3YFF	Texas Instruments	TPA2051D3YFF
1	U2	2-BIT BIDIR LEVEL TRANSLATOR VSSOP8-DCU ROHS	Digi-Key	296-21931-1	Texas Instruments	TXS0102DCUR
1	U4	USB STREAMING CONTROLLER TQFP48-PFB ROHS	Digi-Key	296-13041-5	Texas Instruments	TAS1020BPFB
1	VR1	VOLT REG 1.8V 500mA LDO FAST TRANSIENT RESPONSE SOP8-D ROHS	Digi-Key	296-2774-5	Texas Instruments	TPS77518D
1	VR2	VOLT REG 3.3V 500mA LDO FAST TRANSIENT RESPONSE SOP8-D ROHS	Digi-Key	296-2776-5	Texas Instruments	TPS77533D
1	U3	64K I2C SERIAL EEPROM SOP8-D	Digi-Key	24LC64-I/SN	Microchip	24LC64-I/SN
1	Q1	N-CH ENHANCEMENT MODE VERT DMOS FET SOT23-DBV3 ROHS	Digi-Key	BSS138ZCXT	Zetex	BSS138TA
1	Y1	CRYSTAL, 6.000MHz, SMT-HC49/US CSM-7 ROHS	Digi-Key	XC1295CT	ECS	ECS-60-32-5PXDNDN-TR
SEMICONDUCTORS						
2	C28, C29	CAP SMD0603 33pF 50V 5% CERM NPO ROHS	Digi-Key	PCC330ACVCT	Panasonic	ECJ-1VC1H330J
2	C19, C20	CAP SMD0603 47pF 50V 5% CERM NPO ROHS	Digi-Key	PCC470ACVCT	Panasonic	ECJ-1VC1H470J
1	C30	CAP SMD0603 100pF 50V 5% CERM NPO ROHS	Digi-Key	PCC101ACVCT	Panasonic	ECJ-1VC1H101J
4	C24, C26, C27, C32	CAP SMT0603 0.1µF 16V 10% CERM X7R ROHS	Digi-Key	PCC1762CT	Panasonic	ECJ-1VB1C104K
6	C1-C6	CAP SMD0402 1.0µF 10V 20% CERM X5R ROHS	Digi-Key	PCC2364CT	Panasonic	ECJ-0EB1A105M
1	C22	CAP SMD0603 1.0µF 10V 10% CERM X5R ROHS	Digi-Key	PCC2174CT	Panasonic	ECJ-1VB1A105K
5	C7-C10, C12	CAP SMD0603 1.0µF 16V 10% CERM X5R ROHS	Digi-Key	399-5090-1	Kemet	C0603C105K4PACTU
2	C13, C14	CAP SMD0603 2.2µF 10V 10% CERM X7R ROHS	Digi-Key	490-4520-1	Murata	GRM188R71A225KE15D
1	C31	CAP SMD0603 1000pF 50V 10% CERM X7R ROHS	Digi-Key	PCC1772CT	Panasonic	ECJ-1VB1H102K
2	C17, C18	CAP SMD0603 4700pF 50V CERM X7R ROHS	Digi-Key	PCC1780CT	Panasonic	ECJ-1VB1H472K
1	C33	CAP SMD1206 10µF 16V 10% CERM X5R ROHS	Digi-Key	399-5091-1	Kemet	C1206C106K4PACTU
1	C23	CAP SMD1206 10µF 6.3V 10% CERM X5R ROHS	Digi-Key	445-1388-1	TDK	C3216X5R0J106K
1	C25	CAP TANT2412 10µFD10V 10% B45197A ROHS	Digi-Key	495-1528-1	Kemet	B45197A2107K309
RESISTORS						
3	R6, R7, R17	RESISTOR SMD0805 0 Ω 1/8W 5% ROHS	Digi-Key	P0.0ACT	Panasonic	ERJ-6GEY0R00V
2	R1, R2	RESISTOR SMD0603 10 Ω 1/10W 5% ROHS	Digi-Key	311-10GRCT	Yageo	RC0603JR-0710RL
2	R14, R15	RESISTOR SMD0603 27.4 Ω 1/10W 1% ROHS	Digi-Key	541-27.4HCT	Vishay	CRCW060327R4FKEA
0	R4, R5	RESISTOR SMD0805 1.0K 5% 1/8W ROHS	Digi-Key	P1.0KACT	Panasonic	ERJ-6GEYJ102V
1	R13	RESISTOR SMD0603 1.50 kΩ 1/10W 1% ROHS	Digi-Key	P1.50KHCT	Panasonic	ERJ-3EKF1501V
1	R20	RESISTOR SMD0603 2.00 kΩ 1/16W 1% ROHS	Digi-Key	P2.00KHCT	Panasonic	ERJ-3EKF2001V
1	R19	RESISTOR SMD0603 3.09 kΩ 1/10W 1% ROHS	Digi-Key	P3.09KHCT	Panasonic	ERJ-3EKF3091V
3	R3, R12, R18	RESISTOR SMD0603 100 kΩ 1/10W 5% ROHS	Digi-Key	P100KGCT	Panasonic	ERJ-3GEYJ104V
FERRITE BEADS						
2	FB3, FB4	FERRITE SMD0805 600 Ω 0.24 A RDC=0.14 ROHS	Digi-Key	445-1554-1	TDK	MMZ2012R601A
2	FB1, FB2	FERRITE BEAD SMD0805 80 Ω at 100MHz 5A ROHS	Digi-Key	240-2395-1	Steward	HI0805R800R-10
HEADERS AND JACKS						
11	J2, JP1-JP5, JP7, JP9, DVDD, JP10, USBPWR	HEADER 2 PIN, PCB 2,0 mm ROHS	Digi-Key	2663S-02	Norcomp	26630201RP2
2	JP6, JP8	HEADER 3 PIN, PCB 2,0 mm ROHS	Digi-Key	2663S-03	Norcomp	26630301RP2
1	J1	HEADER 4 PIN, PCB 2,0 mm ROHS	Digi-Key	2663S-04	Norcomp	26630401RP2
1	J3	JACK USB MINIB SMT-RA 5 PIN ROHS	Digi-Key	H2959CT	Hirose	UX60-MB-5ST
6	INL1, INL2, INR1, INR2, MONO, BYPASS	JACK, RCA 3-PIN PCB-RA BLACK ROHS	Newark	65K7770	Switchcraft	PJRN1X1U01X
1	HEADPHONE	JACK, MINI-STEREO, ROHS	Mouser	806-STX-3000	Kycon	STX-3000
TESTPOINTS AND SWITCHES						
4	GNDx4	PC TESTPOINT, BLACK, ROHS	Digi-Key	5001K	Keystone Electronics	5001
6	HPL, HPR, SCL, SDA, OUTM, OUTP	PC TESTPOINT, WHITE, ROHS	Digi-Key	5002K	Keystone Electronics	5002
2	S1, S2	SWITCH, MOM, 160G SMT 4x3 mm ROHS	Digi-Key	EG4344CT	E-Switch	TL1015AF160QG

Table 2. TPA2051D3EVM Parts List (continued)

QTY	Ref Des	Description	Vendor	Vendor Part No.	MANU	MANU Part No.
BINDING POSTS						
4	GND, VDD,OUT+, OUT-	BINDING-POST,NONINS,THRU,ROHS	Digi-Key	J587	Emerson NPCS	111-2223-001
SHUNTS						
	USBPWR,JP10, J1, J2,DVDD, JP7, JP9, JP6(SE), JP8(SE)	SHUNT, BLACK AU FLASH 2mmLS	Digi-Key	SP2-001E	Norcomp Inc.	810-002-SP2L001
STANDOFFS AND HARDWARE						
4	SO1-SO4	4-40 SCREW, STEEL 0.250 IN	Digi-Key	H342	Building Fasteners	PMS 440 0025 PH
4	SO1-SO4	STANDOFF, 4-40, 0.5 in 3/16 in, ALUM RND F-F	Digi-Key	2027K	Keystone Electronics	2027
	Component Count	107				
COMPONENTS NOT ASSEMBLED						
C11, R8, R9, R10, R11, C15, C16, R4, R5, OUT, PWR, IN						

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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 0.6 V and the output voltage range of -0.3 V to VDD +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°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.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
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