

TPA2080D1 Audio Power Amplifier Evaluation Module

This document describes the operation of the TPA2080D1 evaluation module that users can use to evaluate the TPA2080D1 Audio Power Amplifier. Included are the TPA2080D1EVM schematic, board art, and bill of materials.

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1 Introduction

This section provides an overview of the Texas Instruments (TI) TPA2080D1 audio power amplifier evaluation module (EVM). It includes a brief description of the module and a list of specifications.

1.1 Description

The TPA2080D1 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 TPA2080D1 audio power amplifier EVM is a complete, stand-alone audio amplifier. It contains the TPA2080D1 WCSP (YZG) class-D audio power amplifier with an integrated boost converter. All components and the EVM are Pb-free.

1.2 TPA2080D1 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 TPA2080D1EVM.

2.1 Quick-Start List for Stand-Alone Operation

Use the following steps when operating the TPA2080D1EVM as a stand-alone or when connecting the EVM into existing circuits or equipment.

2.1.1 Power and Ground

1. Ensure that 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 amplifier through an RC filter for audio measurements. (Many audio analyzers do 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 k Ω .
5. The filtered output of the TPA2080D1 can be measured between test points **FILT OUT-** and **FILT OUT+**

2.1.3 Amplifier Gain

The TPA2080D1 has a fixed setting of 20 dB.

2.1.4 Shutdown Controls

1. The TPA2080D1 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 TPA2080D1 has an auto passthrough 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 TPA2080D1 (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 TPA2080D1 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 also is 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.

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

The minimum working inductance is 1.3 μ H. 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.

$$L = \frac{V_{\text{BAT}} \times (P_{\text{VDD}} - V_{\text{BAT}})}{\Delta I_L \times f_{\text{BOOST}} \times P_{\text{VDD}}} \quad (2)$$

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 TPA2080D1 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 PVOOUT 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_{PVOOUT} , PVOOUT, 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.

$$C = 1.5 \times \frac{I_{\text{PVDD}} \times (P_{\text{VDD}} - V_{\text{BAT}})}{\Delta V \times f_{\text{BOOST}} \times P_{\text{VDD}}} \quad (3)$$

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_{PVOOUT} , PVOOUT, 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.

$$C = \frac{I_{\text{PVDD}} \times (P_{\text{VDD}} - V_{\text{BAT}})}{\Delta V \times f_{\text{BOOST}} \times P_{\text{VDD}}} \quad (4)$$

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 m Ω . 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 TPA2080D1EVM Schematic

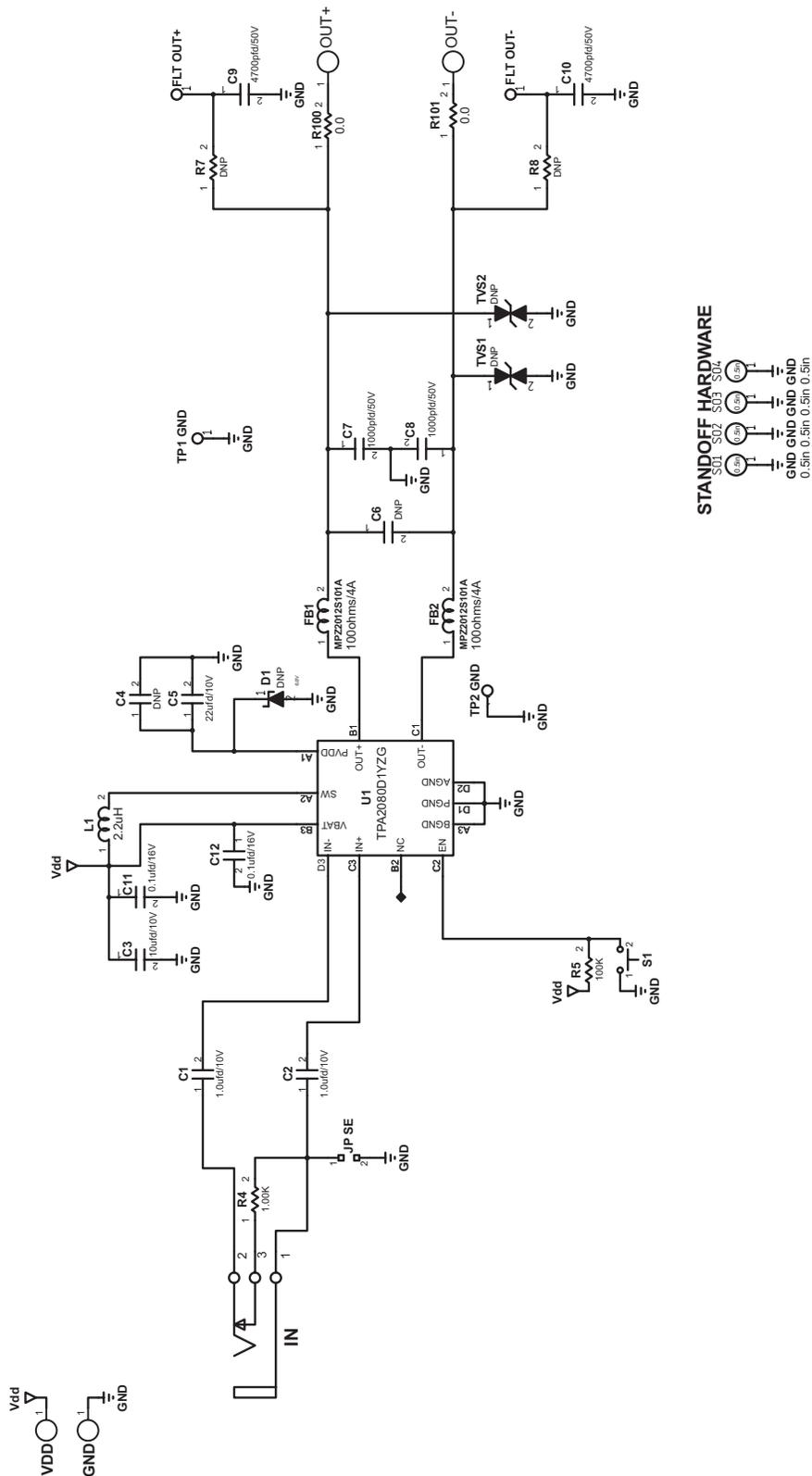


Figure 1. TPA2080D1EVM Schematic

3.2 TPA2080D1EVM PCB Layers

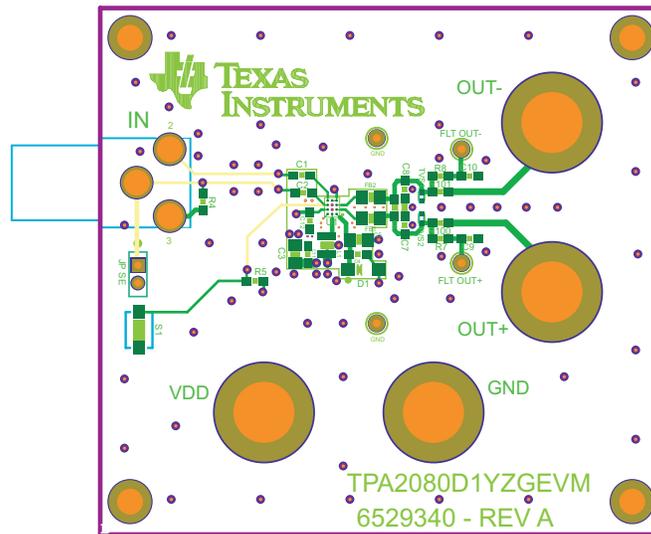


Figure 2. EVM Assembly Layer

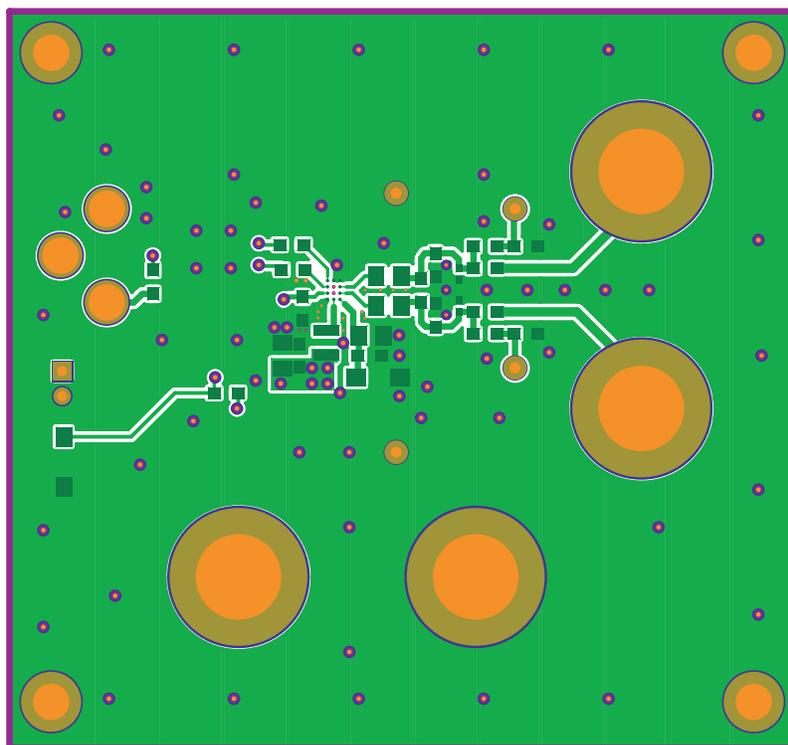


Figure 3. EVM Top Layer

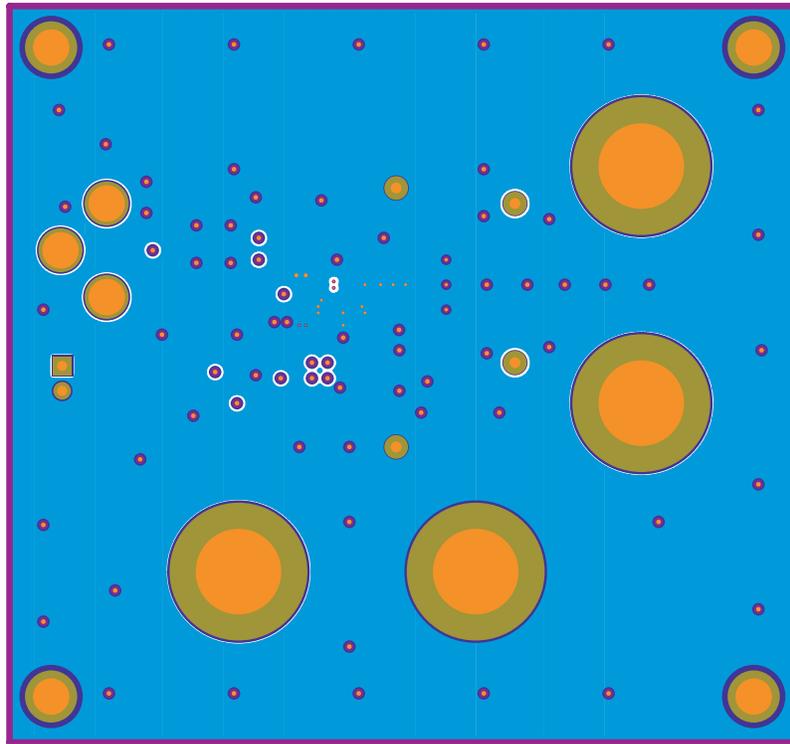


Figure 4. EVM Layer 2

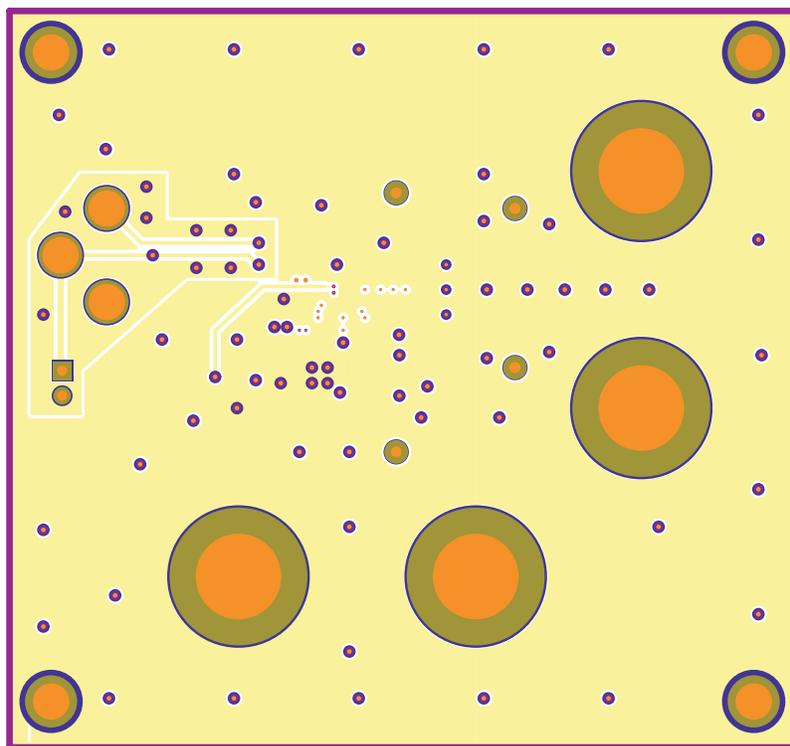


Figure 5. EVM Layer 3

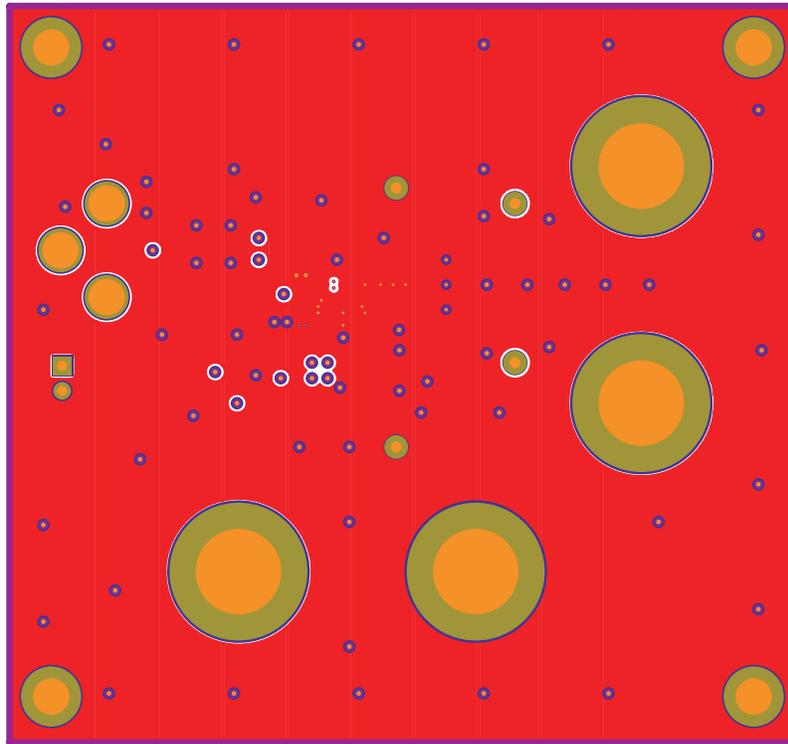


Figure 6. EVM Bottom Layer

3.3 TPA2080D1EVM Bill of Materials

Table 1. TPA2080D1EVM Bill of Materials

Item	Mfr Part No.	QTY	Ref Des	Vendor Part No.	Description	Vendor	Manufacturer
1	TPA2080D1YZG	1	U1	TPA2080D1YZG	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-3GEYOR00V	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
HEADERS, JACKS, AND SHUNTS							
15	26630201RP2	1	JP SE	2663S-02	HEADER 2 PIN, PCB 2.0MM ROHS	DIGI-KEY	NORCOMP
16	PJРАН1X1U01X	1	IN	65K7770	JACK, RCA 3-PIN PCB-RA BLACK ROHS	NEWARK	SWITCHCRAFT
TESTPOINTS AND SWITCHES							
17	5002	1	FLT OUT-	5002K	PC TESTPOINT, WHITE, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
18	5001	2	TP1 GND,TP2 GND	5001K	PC TESTPOINT, BLACK, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
19	5000	1	FLT OUT+	5000K	PC TESTPOINT, RED, ROHS	DIGI-KEY	KEYSTONE ELECTRONICS
20	TL1015AF160QG	1	S1	EG4344CT	SWITCH, MOM, 160G SMT 4X3MM ROHS	DIGI-KEY	E-SWITCH
STANDOFFS AND HARDWARE							
21	2027	4	SO1,SO2,SO3,SO4	2027K	STANDOFF,4-40,0.5INx3/16IN,ALUM RND F-F	DIGI-KEY	KEYSTONE ELECTRONICS
22	111-2223-001	4	GND,VDD,OUT+,OUT-	J587	BINDING-POST,NONINS,THRU,ROHS	DIGI-KEY	EMERSON NPCS
	Component Count	41					
COMPONENTS NOT ASSEMBLED							
23	R0603_DNP	2	R7,R8		R0603_DNP		
24	C0603_DNP	2	C4,C6		C0603_DNP		

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this is strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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.

REGULATORY COMPLIANCE INFORMATION (continued)

FCC Interference Statement for Class B EVM devices

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. 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 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

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The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. 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 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

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TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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