

TPS7B4261-Q1 General-Purpose Tracker LDO Evaluation Module



Description

The TPS7B4261EVM-151 evaluation module (EVM) that helps design engineers evaluate the operation and performance of the TPS7B4261-Q1 tracker low-dropout (LDO) linear regulator for use in circuit applications. The configuration of the TPS7B4261EVM-151 contains pads for external components for correct functionality of the TPS7B4261-Q1 and test points for easy testing. An added high-performance load transient circuit is included to improve the measurement capability of the low-dropout regulator.

Get Started

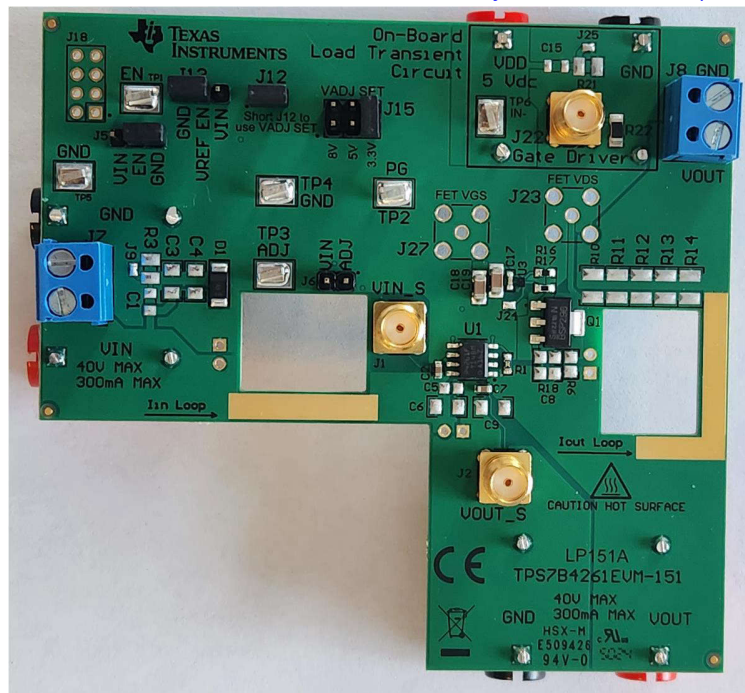
1. Order the [TPS7B4261EVM-151 evaluation module](#).
2. Read this EVM user's guide.

Features

- Qualified for automotive applications
- On-board load transient circuit

Applications

- [Powertrain pressure sensors](#)
- [Powertrain temperature sensors](#)
- [Powertrain exhaust sensors](#)
- [Body control module \(BCM\)](#)



TPS7B4261EVM-151 Hardware Board

1 Evaluation Module Overview

1.1 Introduction

This evaluation board contains a TPS7B4261-Q1 as well as pads for input and output capacitors and feedback resistors.

This user's guide describes the operational use of the TPS7B4261EVM-151 evaluation module (EVM) as a reference design for engineering demonstration and evaluation of TI's tracker low-dropout linear regulators (LDOs). Included in this user's guide are setup and operating instructions, thermal and layout guidelines, a printed-circuit board (PCB) layout, a schematic diagram, and a bill of materials (BOM).

Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TPS7B4261EVM-151.

1.2 Kit Contents

This EVM kit includes:

- TPS7B4261EVM-151 evaluation module (EVM) version 1.0
- EVM Disclaimer Read Me
- Antistatic foam

1.3 Specification

In addition, there is a TPS7B84-Q1 device on-board to provide a reference voltage to the tracker LDO, and other connectors if the user wants to supply the reference voltage externally. There is also an optional on-board load transient circuit as well as current loops that fit most current probes to make fast and accurate load transient measurements.

Figure 1-1 shows a functional block diagram for the TPS7B4261EVM-151 with the optional load transient circuit.

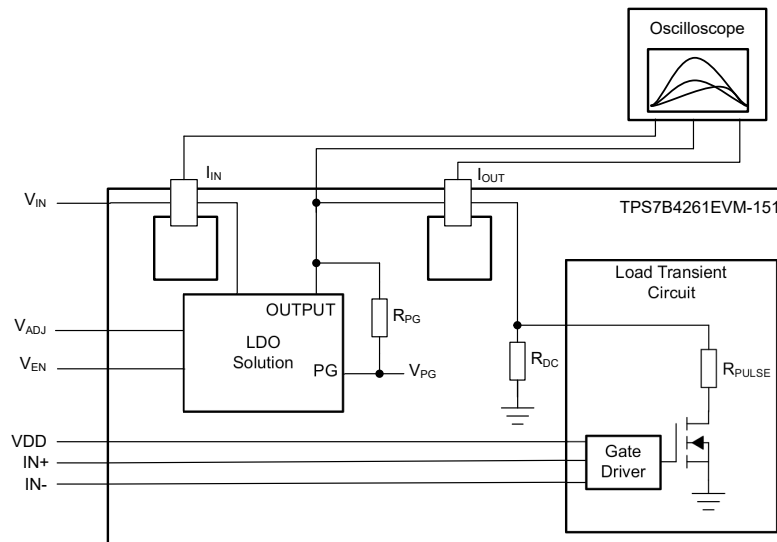


Figure 1-1. TPS7B4261EVM-151 Functional Block Diagram

1.4 Device Information

Table 1-1. Device Information

EVM ORDERABLE NUMBER	V _{OUT}	PART NAME	PACKAGE
TPS7B4261EVM-151	Tracking	TPS7B4261-Q1	HSOIC-8

1.5 Before You Begin

This evaluation module is not encapsulated and has exposed terminals with voltages that are connected to the main power supply. The following warnings are noted for the safety of anyone using or working close to the TPS7B4261EVM-151. Observe all safety precautions.

WARNING

Failure to adhere to these steps or to not heed the safety requirements at each step can lead to shock, injury, and damage to the hardware. Texas Instruments is not responsible or liable in any way for shock, injury, or damage caused by negligence or failure to heed advice. If users are not trained in the proper safety of handling and testing power electronics, then do not test this evaluation module.

CAUTION



Do not leave EVM powered when unattended.

CAUTION



Contact can cause burns. Do not touch. Please take the proper precautions when operating.

2 Hardware

2.1 Power Requirements

This EVM comes populated with a TPS7B84-Q1 LDO to provide a DC reference voltage to the tracker LDO if the user does not have an external supply to provide the reference voltage. The power supply requirement for the TPS7B84-Q1 depends on the output voltage setting chosen with J13; a 10V, 100mA current limit supply covers all of the default output voltage settings for the on-board TPS7B84-Q1. This supply is the same as the input supply for the tracker LDO.

This EVM also includes an onboard load transient circuit that is driven by the LM1020 gate driver. The LM1020 requires a nominal 5V supply that must not exceed 5.4V and must be no less than 4.75V.

2.2 Setup

This section describes the jumpers and connectors on the EVM, and how to properly connect, set up, and use the TPS7B4261EVM-151.

2.3 Connector Information

2.3.1 VIN and GND

VIN and GND are the connection terminals for the input supply. The VIN terminal is the positive connection, and the GND terminal is the negative (that is, ground) connection.

2.3.2 VOUT and GND

VOUT and GND are the connection terminals for the output load. The VOUT terminal is the positive connection, and the GND terminal is the negative (that is, ground) connection.

2.4 Jumper Information

2.4.1 J13 EN

EN is a 3-pin header used to enable or disable the TPS7B84-Q1, which in turn supplies ADJ for the TPS7B4261-Q1.

The center pin of the 3-pin header is tied to the TPS7B84-Q1 EN input. When the 2-pin shunt is placed across the right two pins of the header, VIN is shorted to EN and the TPS7B84-Q1 is enabled. When the 2-pin shunt is placed across the left two pins of the header, GND is shorted to EN and the TPS7B84-Q1 is disabled.

If the TPS7B84-Q1 is not to be used to supply the ADJ signal for the populated tracker, remove jumper J12 and use TP3 to drive ADJ directly, or a combination of J6, R2, R4, C10 to configure ADJ to be a function of the input voltage.

2.4.2 J16

J16 is an optional connection for the user to make measurements or apply loads to the output of the LDO.

2.4.3 J19

J19 is an optional connection to insert a damping circuit across the load transient MOSFET drain to source voltage.

2.4.4 J20

J20 is an optional connection to insert capacitance or additional load across the drain to source of the load transient MOSFET.

2.4.5 J22

J22 is the connection for the function generator to drive the gate driver device. J21 is terminated by the 50Ω resistor, R21.

2.4.6 J23

J23 is a high-frequency kelvin connection that allows accurate measurements of the load transient MOSFET drain to source voltage.

2.4.7 J24

Short J24 to enable the gate driver.

2.4.8 J27

J27 is a high-frequency kelvin connection that allows accurate measurements of the load transient MOSFET gate to source voltage.

2.5 Test Points

2.5.1 TP1

TP1 along with TP4 or TP5 (GND) can be used to enable the TPS7B4261-Q1 with an external signal.

2.5.2 TP2

TP2 along with TP4 or TP5 (GND) can be used to probe the PG signal.

2.5.3 TP3

TP3 along with TP4 or TP5 (GND) can be used to supply ADJ with an external supply. Disconnect jumper J12 if TP3 is used.

2.6 TPS7B4261EVM-151 Operation and Component Selection

The TPS7B4261EVM-151 evaluation module contains one TPS7B4261-Q1, and pads for input and output capacitors. The prepopulated capacitors are sized to verify the minimum capacitance requirements are maintained under all normal operating conditions. Optional pads are available to test the LDO with additional setpoint options, as well as input and output capacitors beyond what is already installed on the EVM.

Setpoint resistors are prepopulated on the TPS7B4261EVM-151 to configure the TPS7B84-Q1 LDO with an output voltage of 3.3V, 5V, or 8V. With a shunt placed across the pins of jumper J12, the output of the TPS7B84-Q1 supplies the ADJ pin of the TPS7B4261-Q1. If a different voltage than the TPS7B84-Q1 output is desired to drive the ADJ pin, remove the shunt from jumper J12 and use a combination of J6, R2, R4, and C10 to configure the ADJ pin to be a function of the input voltage. Alternatively, TP3 and TP4 or TP5 (GND) can be used to directly drive ADJ with an external voltage source.

The TPS7B84-Q1 LDO can be enabled or disabled by using the J13 3-pin header:

- Place a 2-pin shunt across the header to tie VIN to EN to enable the device.
- Place a 2-pin shunt across the header to tie GND to EN to disable the device.

If desired, then a current probe can be inserted in the EVM as illustrated in [Figure 2-1](#) to measure the input and output current. The slots were sized to fit most current probes, such as the LeCroy™ AP015 or CP031 current probes.

The board layout is designed such that the I_{in} current probe slot does not detect any current that goes to the TPS7B84-Q1 circuit or the peripherals during start up or during any other operational mode. Thus, the I_{in} current probe slot can be used to isolate and accurately measure current into the tracker LDO device.

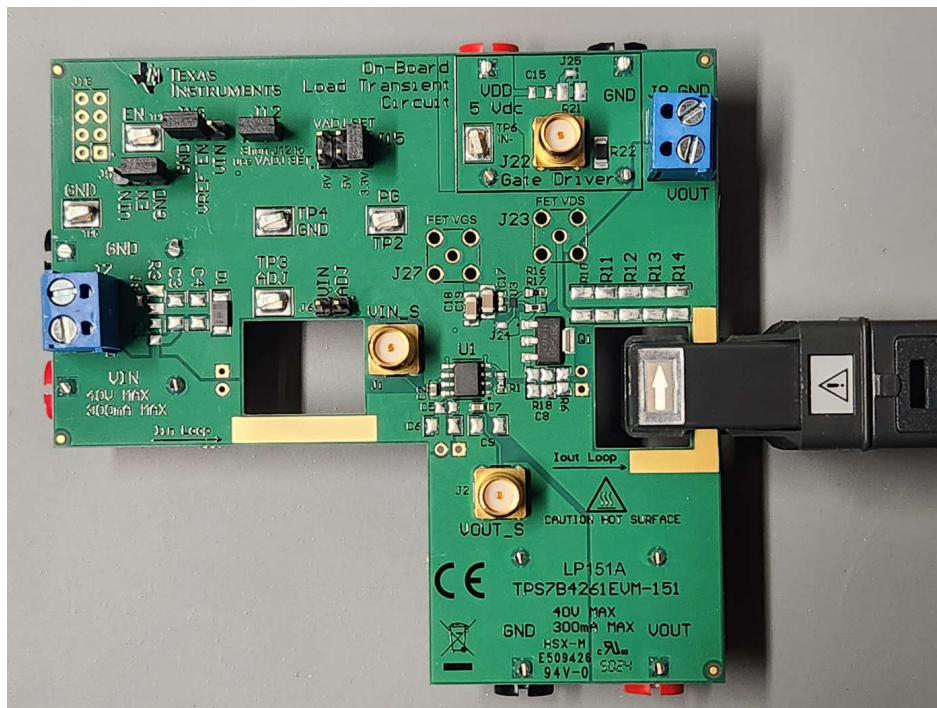


Figure 2-1. TPS7B4261EVM-151 With Current Probes Attached

The user has two options for providing a DC load on the output of the TPS7B4261-Q1. J8 can be used to place a DC load that flows through the current sense path on the output of the LDO. Alternatively, the J4 (VOUT) and J11 (GND) banana connectors can be used for external measurements and loading; however, the I_{OUT} loop does not sense current flowing through these connectors. In cases where very fast transient tests are performed, ringing can occur on VIN or VOUT as a result of the PCB parasitic inductance. Placing a strip of wire on the exposed copper in the current path can reduce this ringing. 10 AWG wire can be used as needed. If ringing persists, then install damping networks by adding a series resistor and capacitor in parallel with VIN. Locations where damping can be installed include C2 and R4, and C16 and R22.

WARNING

Current probe sensors can be tied to GND and must not come into contact with energized conductors. See the user manual of your current probe for details. If your current probe has this limitation, use a thin strip of electrical or Kapton® tape to isolate the current sense path from the current probe.

Optional kelvin sense points are provided using the SMA connectors J1 (VIN) and J2 (VOUT).

2.7 Optional Load Transient Circuit Operation

The TPS7B4261EVM-151 evaluation module contains an optional high-performance load transient circuit to allow efficient testing of the tracker LDO load transient performance. To use the optional load transient circuit, install the correct components in accordance with the application. Modify the input and output capacitance connected to the tracker LDO to match the expected operating conditions. Determine the desired peak current to test and modify the parallel resistor combination of R10, R11, R12, R13, R14 as shown:

$$I_{Peak} = \frac{V_{OUT}}{R_{10} \parallel R_{11} \parallel R_{12} \parallel R_{13} \parallel R_{14}} + I_{DC} \quad (1)$$

The slew rate of the load step can be adjusted by C20, R16, R17, and R19. In this section, only R16 and R17 are adjusted to set the slew rate. Use [Table 2-1](#) to select a value of R16 and R17 that results in the desired rise or fall time.

Table 2-1. Suggested Ramp Rate Resistor Values

R16	R17	Rise, Fall Time
3.4kΩ	2.1kΩ	700ns
1.69kΩ	1.1kΩ	350ns
604Ω	383Ω	140ns
332Ω	169Ω	70ns
121Ω	69.8Ω	35ns
37.4Ω	0Ω	14ns

After the EVM is modified (if needed), connect a power supply to banana connectors J21 (VDD) and J26 (GND) with a 5V DC supply and a 1A DC current limit. Use a pulse-duration limit of 1ms to prevent excessive heating of the pulsed resistors (R10, R11, R12, R13, and R14). Configure a function generator for the 50Ω output, in a 0V DC to 5V DC square pulse. If necessary, then burst mode can be configured in the function generator for repetitive, low duty cycle, load transient testing.

3 Hardware Design Files

3.1 Schematic

Figure 3-1 shows the schematic for the TPS7B4261EVM-151. The optional load transient circuit is enclosed in the red box.

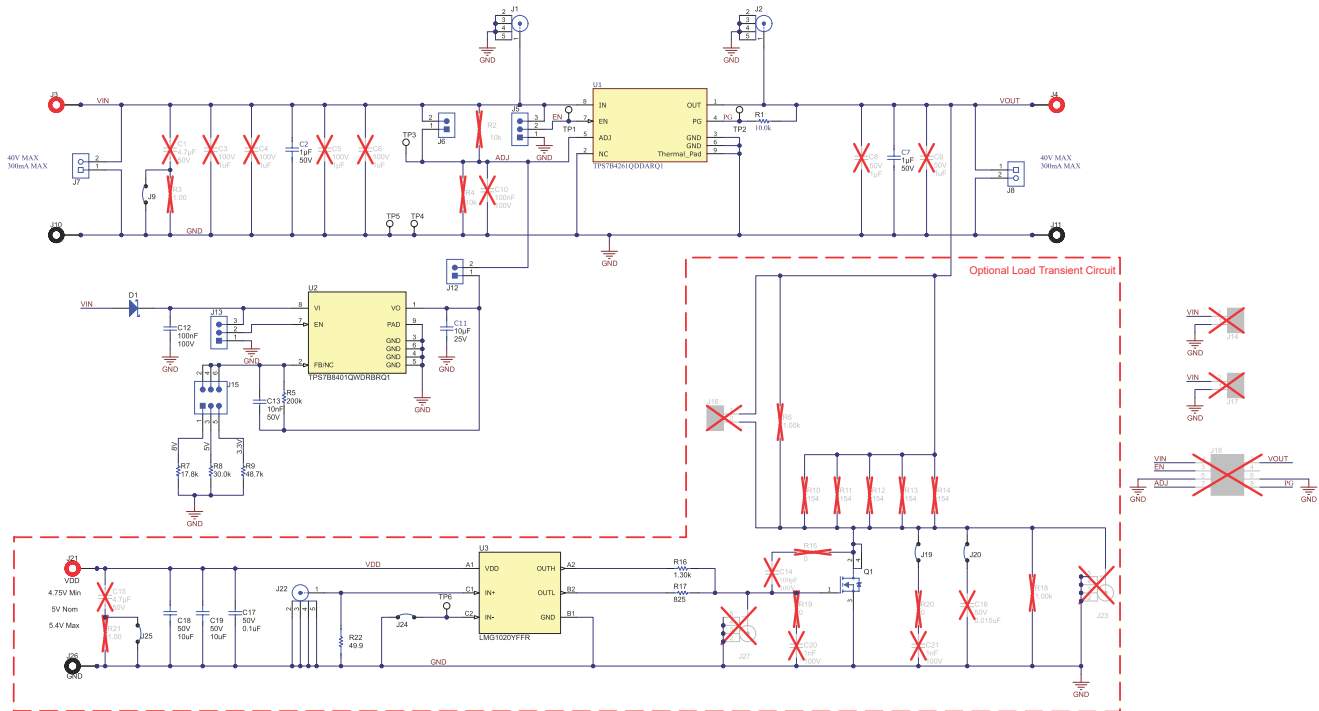


Figure 3-1. TPS7B4261EVM-151

3.2 Board Layout

Figure 3-2 through Figure 3-9 illustrate the board layout for the TPS7B4261EVM-151 PCB.

The TPS7B4261EVM-151 dissipates power, which can cause some components to experience an increase in temperature. The populated tracker LDO and pulsed resistors R10, R11, R12, R13, and R14 are most at risk of raising the junction temperature during normal operation. The LDO can become hot to the touch during normal operation; see the thermal impedance discussion in the TPS7B4261-Q1 data sheet.

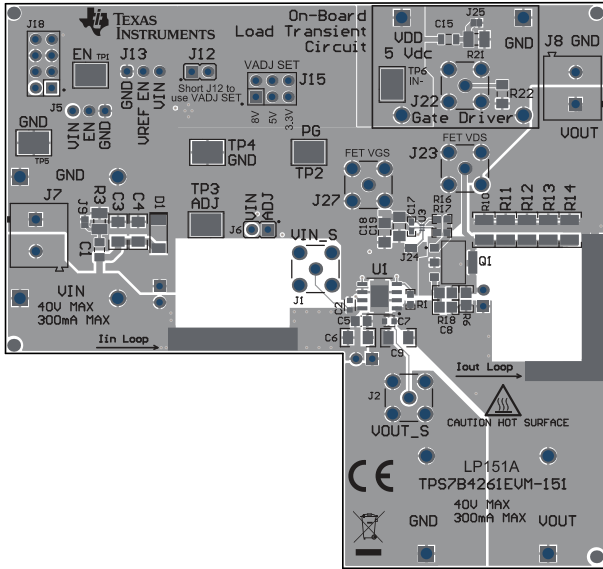


Figure 3-2. Top Assembly Layer and Silkscreen

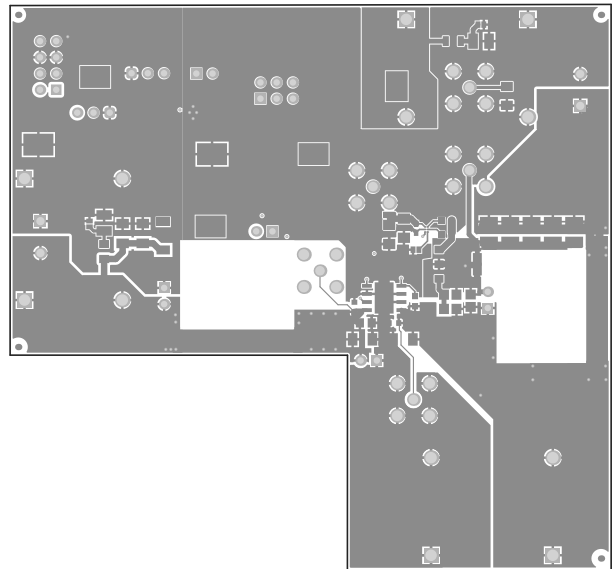


Figure 3-3. Top Layer Routing

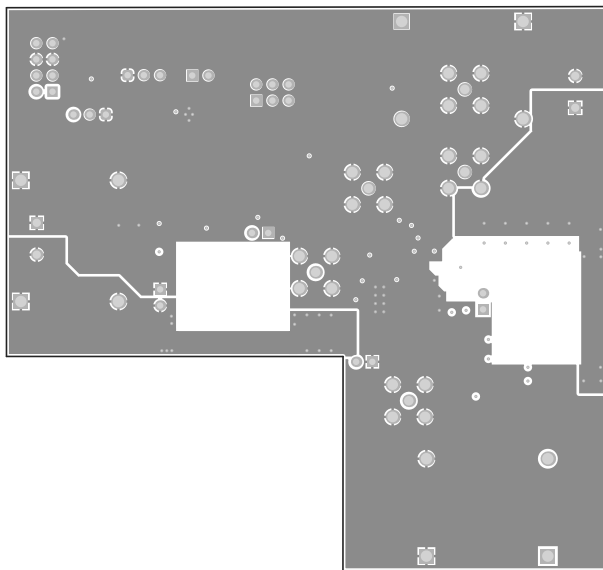


Figure 3-4. Internal Layer 1

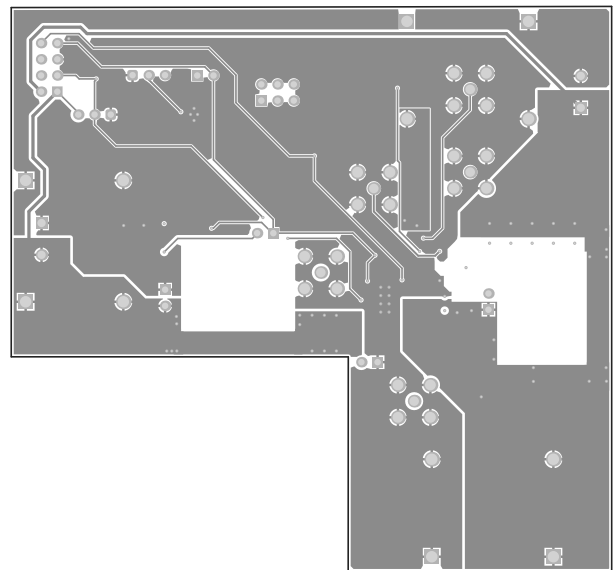


Figure 3-5. Internal Layer 2

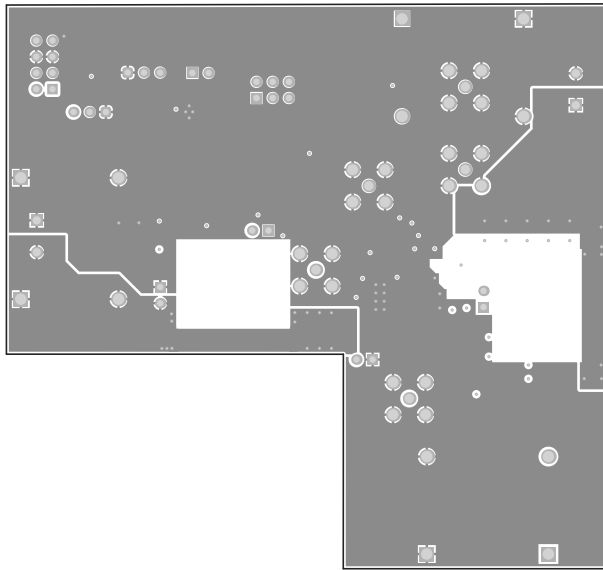


Figure 3-6. Internal Layer 3

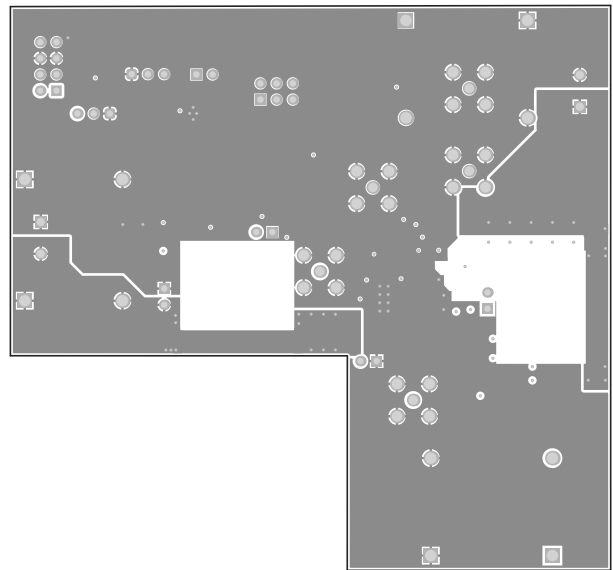


Figure 3-7. Internal Layer 4

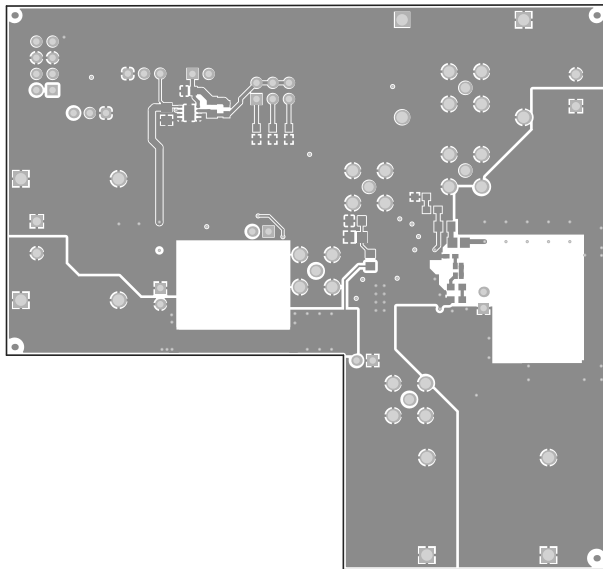


Figure 3-8. Bottom Layer Routing

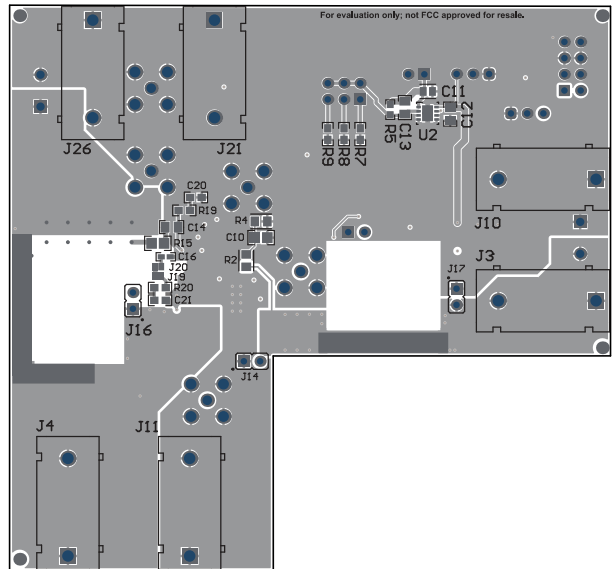


Figure 3-9. Bottom Assembly Layer and Silkscreen

3.3 Bill of Materials (BOM)

Table 3-1 lists the bill of materials for TPS7B4261EVM-151.

Table 3-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		LP151	Any		
C2, C7	2	1 μ F	1 μ F \pm 10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	CC0603KRX7R9BB105	YAGEO		
C11	1	10 μ F	CL21 Series 0805 10uF 25V \pm 10% Tolerance X7R Multilayer Ceramic Chip Capacitor	0805	CL21B106KAYQNNE	Samsung		
C12	1	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, 0805	0805	HMK212B7104KG-T	Taiyo Yuden		
C13	1	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 10%, X7R, 0805	0805	08055C103KAT2A	AVX		
C17	1	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, 0402	0402	C1005X7R1H104K050BB	TDK		
C18, C19	2	10 μ F	10 μ F \pm 10% 50V Ceramic Capacitor X7R 1206 (3216 Metric)	1206	GMC31X7R106K50NT	Cal-Chip Electronics		
D1	1	60V	Diode, Schottky, 60V, 3A, SOD-128	SOD-128	PMEG6030EP,115	Nexperia		
FID1, FID2, FID3, FID4, FID8	5		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
J1, J2, J22	3		SMA Straight Jack, Gold, 50 Ohm, TH	SMA Straight Jack, TH	901-144-8RFX	Amphenol RF		
J3, J4, J21	3		Standard Banana Jack, insulated, 10A, red	571-0500	571-0500	DEM Manufacturing		
J5, J13	2		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec		
J6, J12	2		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
J7, J8	2		Terminal Block, 5mm, 2x1, Tin, TH	Terminal Block, 5mm, 2x1, TH	691 101 710 002	Würth Elektronik		
J9, J19, J20, J24, J25	5		Jumper, SMT	shorting jumper, SMT	JMP-36-30X40SMT	Any		
J10, J11, J26	3		Standard Banana Jack, insulated, 10A, black	571-0100	571-0100	DEM Manufacturing		
J15	1		Header, 100mil, 3x2, Gold, TH	3x2 Header	TSW-103-07-G-D	Samtec		

Table 3-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
Q1	1		N-Channel 100V 1.2A (Ta) 1.8W (Ta) Surface Mount PG- SOT223-4	SOT223	BSP296NH6327XTSA1	Infineon		
R1	1	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	M55342K12B10E0T	TT Electronics/IRC		
R5	1	200k	RES, 200 k, 1%, 0.1 W, AEC- Q200 Grade 0, 0603	0603	CRCW0603200KFKEA	Vishay-Dale		
R7	1	17.8k	RES, 17.8 k, 1%, 0.1 W, 0603	0603	RC0603FR-0717K8L	Yageo		
R8	1	30.0k	RES, 30.0 k, 1%, 0.1 W, AEC- Q200 Grade 0, 0603	0603	ERJ-3EKF3002V	Panasonic		
R9	1	48.7k	RES, 48.7 k, 1%, 0.1 W, 0603	0603	RC0603FR-0748K7L	Yageo		
R16	1	1.30k	RES, 1.30 k, 1%, 0.1 W, 0603	0603	RC0603FR-071K3L	Yageo		
R17	1	825	RES, 825, 1%, 0.1 W, AEC- Q200 Grade 0, 0603	0603	CRCW0603825RFKEA	Vishay-Dale		
R22	1	49.9	RES Thick Film, 49.9Ω, 1%, 0.75W, 100ppm/°C, 1206	1206	CRCW120649R9FKEAHP	Vishay Dale		
TP1, TP2, TP3, TP4, TP5, TP6	6		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone		
U1	1		Automotive, 300mA, 40V, Voltage Tracking LDO With PG	HSOIC8	TPS7B4261QDDARQ1	Texas Instruments		
U2	1		150mA, wide VIN, low IQ, low- dropout regulator, DRB0008F (VSON-8)	DRB0008F	TPS7B8401QWDRBRQ1	Texas Instruments		Texas Instruments
U3	1		5V, 7A/5A Low Side GaN Driver With 60MHz/1ns Speed, YFF0006AEAE (DSBGA-6)	YFF0006AEAE	LMG1020YFFR	Texas Instruments	LMG1020YFFT	Texas Instruments
C1, C15	0	4.7μF	Cap Ceramic 4.7uF 50V X7R 10% Pad SMD 0805 +125°C Automotive T/R	0805	CGA4J1X7R1H475K125A C	TDK Corporation		
C3, C4, C6	0	1uF	CAP, CERM, 1uF, 100V, +/- 10%, X7R, 1206	1206	C3216X7R2A105K160AA	TDK		
C5	0	1uF	CAP, CERM, 1μF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	08051C105K4Z2A	AVX		
C8	0	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, 0805	0805	C2012X7R1H105K085AC	TDK		
C9	0	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H105K160A B	TDK		
C10	0	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, 0805	0805	C2012X7R2A104K125AA	TDK		

Table 3-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
C14	0	100pF	CAP, CERM, 100pF, 100V, +/- 5%, X7R, 0805	0805	C0805C101J1RACTU	Kemet		
C16	0	0.015uF	CAP, CERM, 0.015uF, 50V, +/- 10%, X7R, 0402	0402	GRM155R71H153KA12D	MuRata		
C20, C21	0	1000pF	CAP, CERM, 1000pF, 100V, +/- 5%, X7R, 0603	0603	06031C102JAT2A	AVX		
FID5, FID6, FID7	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
J14, J16, J17	0		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions		
J18	0		Header, 100mil, 4x2, Gold, TH	4x2 Header	TSW-104-07-G-D	Samtec		
J23, J27	0		SMA Straight Jack, Gold, 50 Ohm, TH	SMA Straight Jack, TH	901-144-8RFX	Amphenol RF		
R2, R4	0		10 kOhms \pm 1% 0.333W, 1/3W Chip Resistor 0805 (2012 Metric) Thick Film	0805	CRGH0805F10K	TE Connectivity		
R3, R21	0	1	RES, 1.00, 1%, 0.333 W, AEC-Q200 Grade 1, 0805	0805	RL1220S-1R0-F	Susumu Co Ltd		
R6, R18	0	1.00k	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF1001V	Panasonic		
R10, R11, R12, R13, R14	0	154	RES, 154, 1%, 0.5 W, 1210	1210	RC1210FR-07154RL	Yageo		
R15	0	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6GEY0R00V	Panasonic		
R19, R20	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc		

4 Additional Information

4.1 Trademarks

LeCroy™ is a trademark of Teledyne LeCroy.

Kapton® is a registered trademark of DuPont.

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

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 semiconductor 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 DEGRADATION 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/llds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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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.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL 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 HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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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