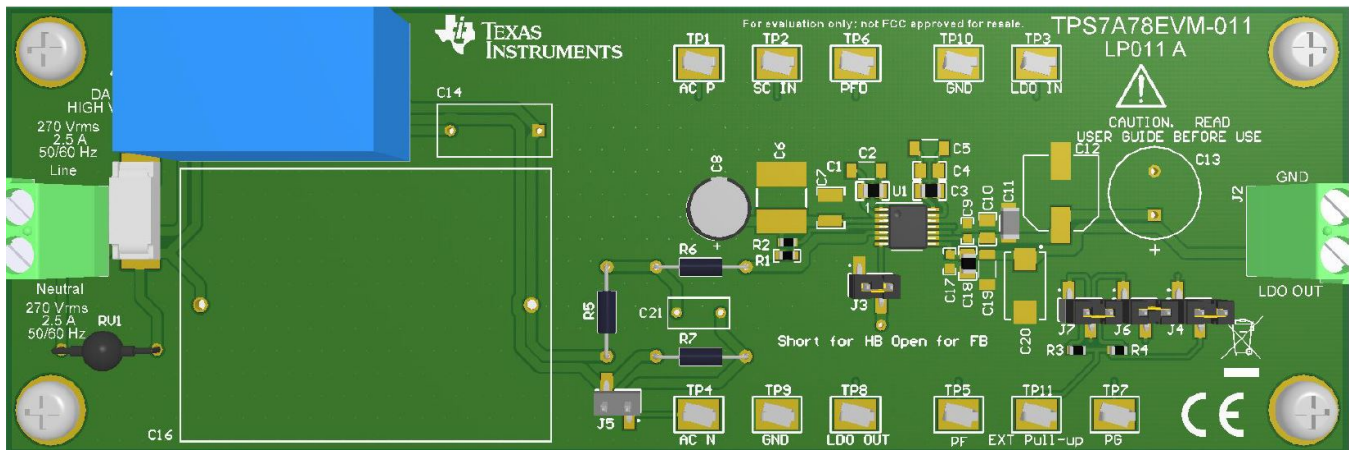


TPS7A78EVM-011 Evaluation module



This user's guide describes the operational use of the TPS7A78EVM-011 evaluation module (EVM) as a reference design for engineering demonstration and evaluation of the TPS7A78, non-isolated smart linear voltage regulator (LDO). 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 *demonstration kit*, *evaluation board*, and *evaluation module* are synonymous with the TPS7A78EVM-011.

The following related documents are available through the Texas Instruments web site at www.ti.com.

Table 1. Related Documentation

Device	Literature Number
TPS7A78	SBVS343

Contents

1	General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines	2
2	Introduction	4
3	Electrical Performance Specifications.....	5
4	Schematic.....	5
5	EVM Setup.....	6
6	Equipment Connection and Operation	9
7	PCB Layout	11
8	Bill of Materials (BOM).....	13

List of Figures

1	TPS7A78EVM-011 Schematic	5
2	Startup: 120-V _{AC} Half-Bridge (HB) and 27-mA Load Current	8
3	Startup: 120-V _{AC} Full-Bridge (FB) and 55-mA Load Current	8
4	Startup: 230-V _{AC} Half-Bridge (HB) and 27-mA Load Current	8
5	Startup: 230-V _{AC} Full-Bridge (FB) and 55-mA Load Current	8
6	PF Signal Glitch.....	8
7	Proper Test Equipment Connections for the FB EVM Configuration	9
8	Proper Test Equipment Connections for the Half-Bridge (HB) EVM Configuration	10
9	Assembly Layer	11
10	Top Layer Routing	11
11	Bottom Layer Routing.....	12

List of Tables

1	Related Documentation	1
2	TPS7A78EVM-011 Electrical Performance Specifications	5
3	Test Point Functions	7
4	TPS7A78EVM-011 BOM	13

Trademarks

All trademarks are the property of their respective owners.

1 General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines



Always follow TI's setup and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center <http://support/ti.com> for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety

- a. Keep work area clean and orderly.
- b. Qualified observer(s) must be present anytime circuits are energized.
- c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
- d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
- e. Use stable and nonconductive work surface.
- f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. Electrical Safety

As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.

- a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
- b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment connection, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- c. After EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or its electrical circuits, as they could be at high voltages capable of causing electrical shock hazard.

3. Personal Safety

- a. Wear personal protective equipment (for example, latex gloves or safety glasses with side shields) or protect EVM in an adequate lucent plastic box with interlocks to protect from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

2 Introduction

Texas Instruments' TPS7A78EVM-011 helps design engineers evaluate the operation and performance of the TPS7A78 smart linear voltage regulator for possible use in their own circuit application. This particular EVM is intended for evaluation purposes and is not intended to be an end product. The EVM configuration contains a single 3.3-V output regulator optimized for e-metering applications. The TPS7A78EVM-011 regulates V_{AC} supply to 3.3-V DC supply and can source up to 27 mA (max) current.


The EVM also features a power-fail detection signal and a power-good indication signal to warrant a V_{AC} supply failure and to indicate to a microcontroller (MCU) that the regulated DC voltage is greater than 90% of the targeted regulation DC voltage.

2.1 Before You Begin

This evaluation module is not encapsulated and has exposed terminals with voltages that are connected to the main AC supply; the following warnings are noted for the safety of anyone using or working close to the TPS7A78EVM-011. Observe all safety precautions.

WARNING

Failure to adhere to these steps or to not heed the safety requirements at each step may 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 you are not trained in the proper safety of handling and testing power electronics please do not test this evaluation module.

	Danger High Voltage	<p>Electric shock possible when connecting board to live wire. Board should be handled with care by a professional.</p> <p>For safety, use of isolated test equipment with overvoltage/overcurrent protection is highly recommended.</p>
---	----------------------------	--

WARNING

Danger: HIGH VOLTAGE! This evaluation board is intended for professional use only. This board has exposed high voltages. Do not operate this board without proper high-voltage/high-current safety practices. Read this user guide carefully before testing with TPS7A78EVM-011. Use floating measurement equipment such as high-voltage differential scope probes and see [Section 5](#) and [Section 6](#) for proper EVM setup and test equipment connection.

3 Electrical Performance Specifications

Table 2 lists the electrical specifications for the TPS7A78EVM-011 evaluation board.

Table 2. TPS7A78EVM-011 Electrical Performance Specifications⁽¹⁾

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
INPUT CHARACTERISTICS						
V_{AC}	AC input (RMS)	70	120		V	
	Wall plug (RMS)	70	230			
f_{AC}	Line frequency		120			
$P_{STANDBY}$	Standby power	$V_{AC} = 120\text{ V (60 Hz)}$, $I_{OUT} = 0\text{ mA}$, R6 and R7 are shorted; see Section 4.		104	mW	
OUTPUT CHARACTERISTICS						
V_{LDO_OUT}	Output voltage	$V_{AC} = 120\text{ V (60 Hz)}$	3.201	3.3	3.399	V
V_{LDO_OUT} ripple	Output ripple voltage	$V_{AC} = 120\text{ V (60 Hz)}$		10		mVpp
I_{OUT}	Output current	$V_{AC} = 120\text{ V (60 Hz)}$	16 ⁽²⁾	27	55 ⁽³⁾	mA
SYSTEMS CHARACTERISTICS						
	Standby power	$V_{AC} = 120\text{ V (60 Hz)}$, $I_{OUT} = 0\text{ mA}$		104		mW

- (1) All measurements are done with a half-bridge (HB) default EVM setting (unless otherwise noted).
- (2) Output current level is determined by the size of the cap-drop (C_{15}), the size of the bulk capacitor (C_8), and the device configuration. When V_{AC} is 70 V (60 Hz), the EVM can source 16 mA (max); see Section 5 for EVM configuration and Section 6 for proper connection of test equipment.
- (3) When V_{AC} is 120 V (60 Hz), the EVM can source 55 mA (max) with a full-bridge configuration.

4 Schematic

Figure 1 shows a schematic for the TPS7A78EVM-011.

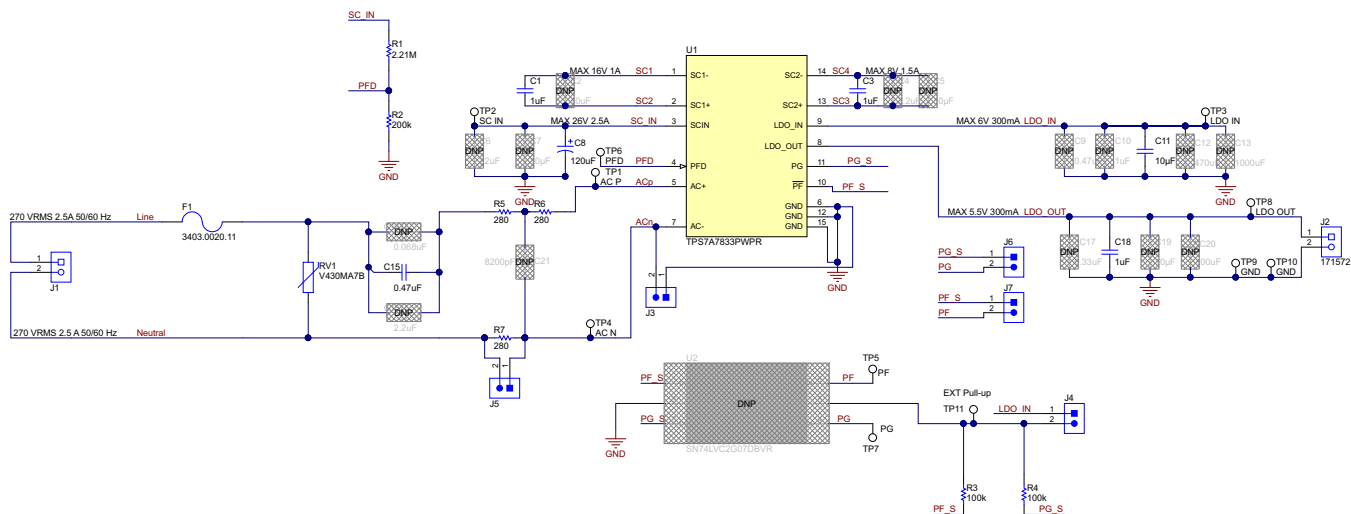


Figure 1. TPS7A78EVM-011 Schematic

5 EVM Setup

This section describes how to properly connect and setup the TPS7A78EVM-011, including the jumpers and connectors on the EVM board. See [Section 6](#) for the proper connections of test equipment.

5.1 Input/Output Connectors and Jumpers Descriptions

5.1.1 J1: V_{AC}

Input AC power-supply connector. Ensure that the AC input power supply is turned off before making the connection to the EVM. The AC supply line lead must be connected to the line pin on the J1 connector, whereas the neutral lead must be connected to the neutral pin on the J1 connector to ensure proper operation of the TPS7A78 LDO.

NOTE: If the AC supply line and neutral leads are flipped when connected to the J1 connector, then the TPS7A78 device GND pin is referenced to the AC supply line and only floating measurement equipment must be used.

5.1.2 J3: Full-Bridge (FB) and Half-Bridge (HB) Configurations

This EVM comes configured for half-bridge (HB) configuration usage, when J3 jumper is connected. However, to use the full-bridge (FB) configuration, leave jumper J3 open and see [Section 6](#) for the proper connections of test equipment.

HB configuration is achieved by tying V_{AC} neutral to the TPS7A78 device GND pin, whereas in FB configuration V_{AC} neutral is connected to the AC– pin and the device GND pin track V_{AC} neutral and therefore must be floating. See [Section 6](#) for the proper connections of test equipment.

NOTE: When FB configuration is used, the device GND must float (that is, the device GND must not be tied to Earth-GND). Floating the device GND is required to limit the shunted AC current (the excess AC current charging the bulk capacitor C8) while the device active bridge shunts this current to circulate this current back to neutral. Jumper J5 is open by default to limit the circulating current though neutral when the device GND is intentionally or accidentally connected to Earth-GND, such as when using regular scope probes or a bench digital multimeter (DMM) where such equipment have their GNDs always tied to Earth-GND. Use floating measurement equipment when the FB EVM configuration is used.

5.1.3 J4: Power-Good Indication and Power-Fail Detection Pullup Voltage

Jumper J4 pulls up the open-drain power-good and power-fail detection indicators to V_{LDO_IN} by the default EVM setting. An external DC pullup voltage can be used via test point TP11; however, jumper J4 must be open in order not to short the external pullup voltage to the LDO_IN pin.

NOTE: When an external DC voltage is used to pullup the PG and PF pins, this external supply must be a floating supply when FB configuration is used.

For HB configuration, the device GND can be tied to Earth-GND, and the external pullup supply can be referenced to the device GND.

5.1.4 J5: Second Surge Resistor (R7) Jumper

This EVM has three surge resistors, R5, R6, and R7. However, only one resistor R5 is required. R7 is needed when the device GND is tied to Earth-GND intentionally or accidentally when using regular scope probes.

R6 was populated for test purposes only. Capacitor C21 is a placeholder for conducting electromagnetic interference (EMI) filtering.

5.1.5 J6 and J7: Power-Good (PG) and Power-Fail (PF) Signals

The TPS7A78 device has two open-drain signals (power-good and power-fail) that are both pulled up to V_{LDO_IN} by default.

Because of the high-impedance open-drain logic, the AC supply frequency noise may be present on those signals when they are high. A low-impedance digital buffer isolation circuit is recommended, such as the U2 device in [Section 4](#), to obtain noise-free PG and PF signals. Jumpers J6 and J7 connect the device PG and PF signals directly to the TP7 and TP5 test points because the digital buffer circuit is not populated with the default EVM setting.

NOTE: When high-voltage differential scope probes are used when testing the TPS7A78EVM-011, the digital buffer circuit U2 in [Section 4](#) is recommended to be populated and jumpers J6 and J7 must be open to obtain noise-free PG and PF signals.

5.1.6 J2: V_{LDO_OUT}

Regulated DC output voltage connector.

NOTE: This EVM is optimized for a 3.3-V output and a 27-mA to 55-mA (max) load current. If your application requires higher output current, see the [TPS7A78 Application and Implementation](#) section for the proper setting of your application requirement.

5.2 Test Points

[Table 3](#) lists the test points for the TPS7A78EVM-011.

Table 3. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	AC_P	AC supply line input to the device after the cap-drop capacitor and surge resistor.
TP2	SC_IN	Rectified DC voltage pin; see the TPS7A78 Application and Implementation section for the proper setting of your application requirement.
TP3	LDO_IN	Charge-pump output pin.
TP4	AC_N	AC supply neutral input to the device after the cap-drop capacitor and surge resistor.
TP5	PF	Power-fail pin.
TP6	PFD	Power-fail detect pin.
TP7	PG	Power-good pin.
TP8	LDO_OUT	Regulated DC output pin.
TP9	GND	Device GND connected to the thermal pad.
TP10	GND	

5.3 Performance Data for the TPS7A78EVM-011

As specified in [Section 5.1.2](#), this EVM is configured for an HB 3.3-V output voltage and 27 mA of output current, and the EVM can also be configured for FB use.

5.3.1 Startup

Figure 2 to Figure 5 show various start-up plots for the TPS7A78EVM-011.

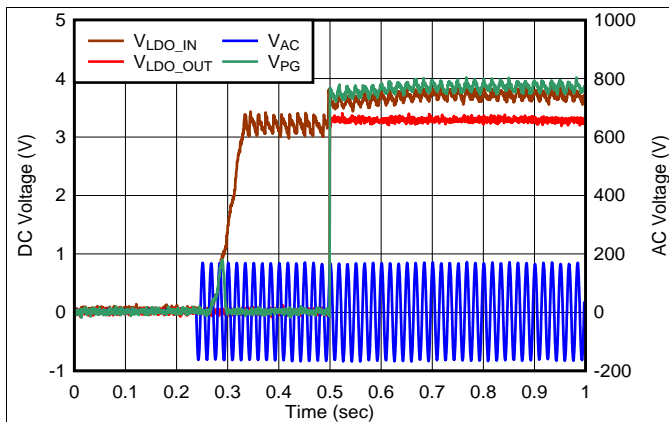


Figure 2. Startup: 120-V_{AC} Half-Bridge (HB) and 27-mA Load Current

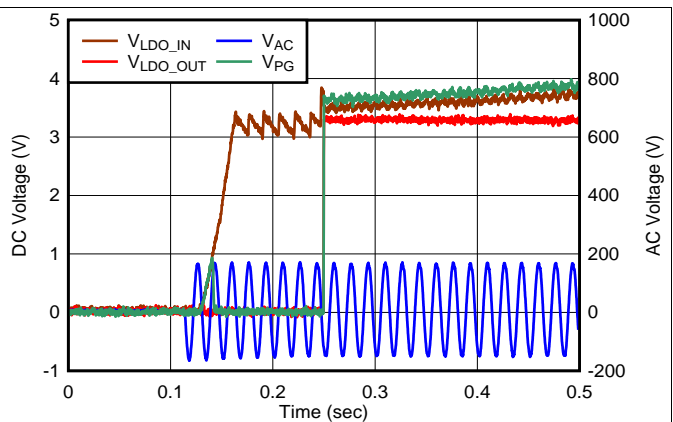


Figure 3. Startup: 120-V_{AC} Full-Bridge (FB) and 55-mA Load Current

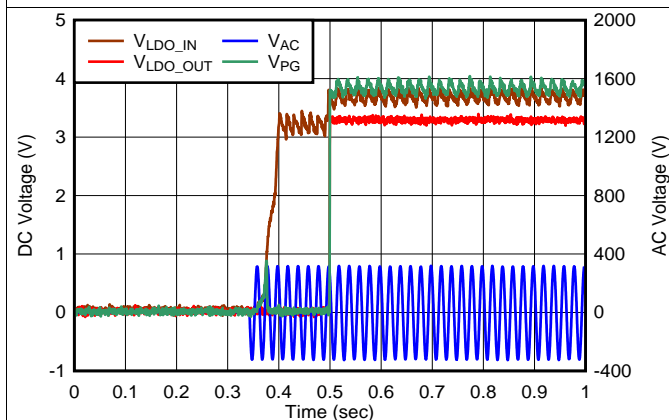


Figure 4. Startup: 230-V_{AC} Half-Bridge (HB) and 27-mA Load Current

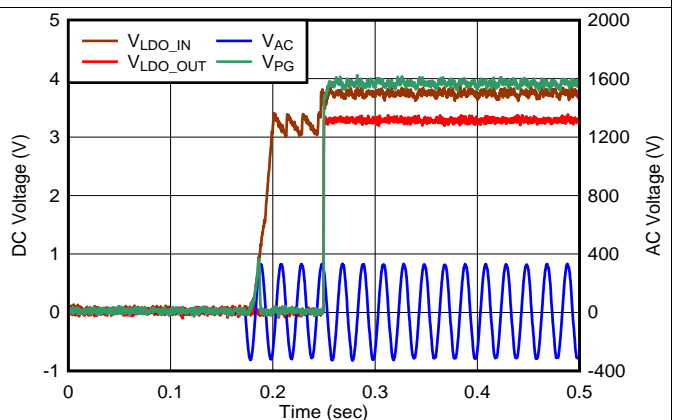


Figure 5. Startup: 230-V_{AC} Full-Bridge (FB) and 55-mA Load Current

In Figure 6, the power-fail detect (PFD) trace and resistor divider was placed close to the AC_P pin and as a result the power-fail (PF) signal glitches whenever there is a shunt event; see the [TPS7A78 Feature Description](#) section for details on the device active bridge control. Figure 6 shows the PF signal glitch.

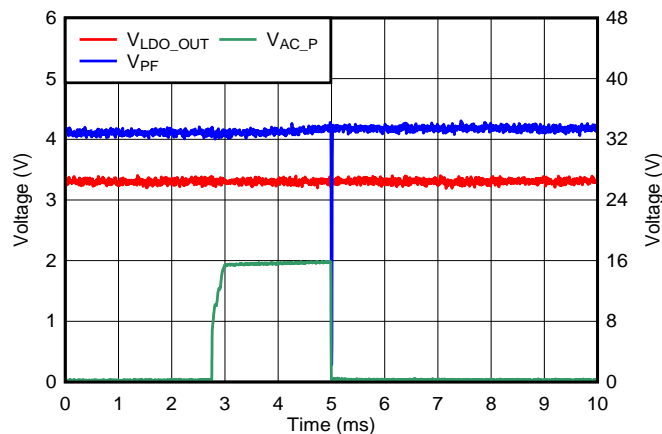


Figure 6. PF Signal Glitch

5.4 Soldering Guidelines

To avoid damaging the LDO, use a hot-air system for any solder rework to modify the EVM for the purpose of repair or other application reasons.

6 Equipment Connection and Operation

6.1 Equipment Connection

Connect test equipment as described in this section and follow the listed steps to properly take measurements:

NOTE: The FB configuration for the EVM requires a differential measurement. The TPS7A78 device GND must not be tied to Earth-GND.

6.1.1 Full-Bridge (FB) Test Equipment Connection

Figure 7 shows an FB connection diagram.

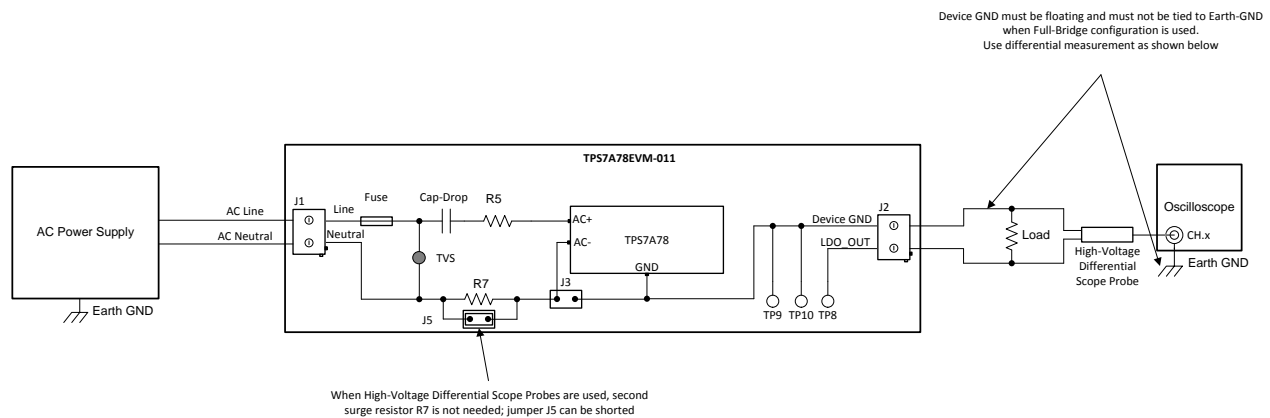


Figure 7. Proper Test Equipment Connections for the FB EVM Configuration

6.1.2 Half-Bridge (HB) Test Equipment Connection

Figure 8 shows an HB connection diagram.

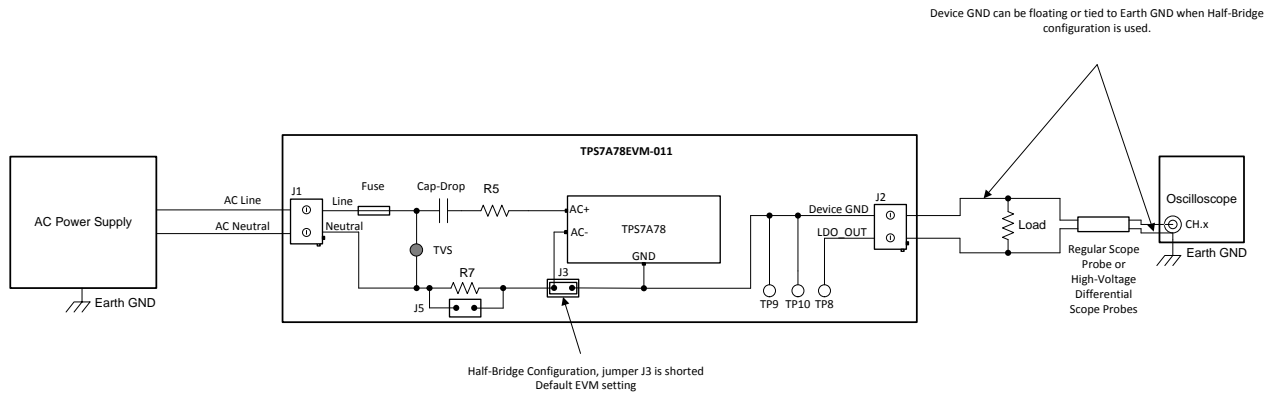


Figure 8. Proper Test Equipment Connections for the Half-Bridge (HB) EVM Configuration

To ensure proper connectivity:

1. Set the AC input power supply to 120 V_{AC} and 60 Hz, and turn the power supply off.
2. Connect the line lead from the AC power supply to the line pin on the J1 connector of the EVM.
3. Connect the neutral lead from the AC power supply to the neutral pin on the J1 connector of the EVM.
4. Connect a 0-mA to 27-mA load between J2 connector terminals of the EVM.

6.2 Equipment Operation

Operate the test equipment using the following steps:

1. Turn on the AC power supply.
2. Vary the respective load and input voltage, as necessary, for test purposes.

7 PCB Layout

Figure 9 to Figure 11 illustrate the PCB layout for this EVM.

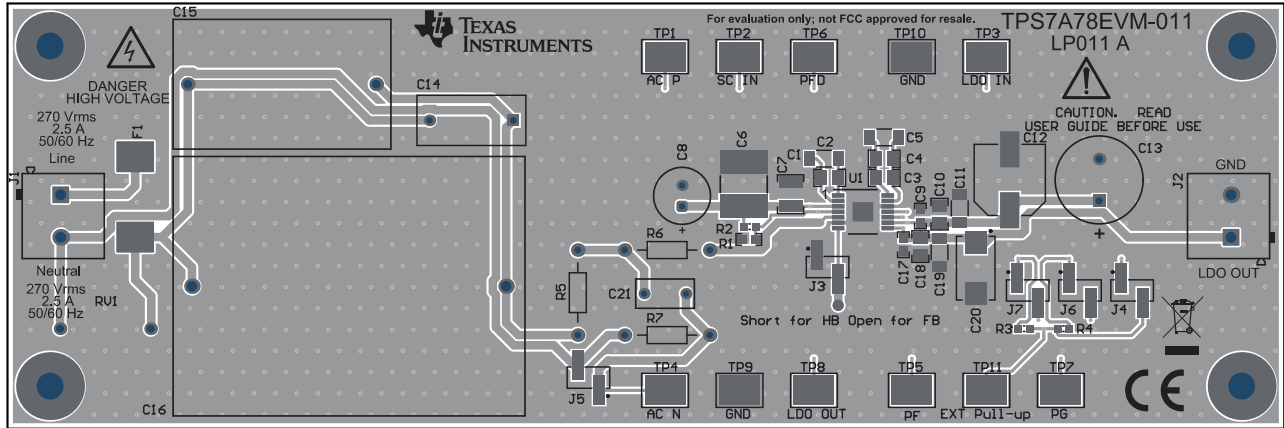


Figure 9. Assembly Layer

NOTE: The silk screens for resistors R1 and R2 are flipped in Figure 9.

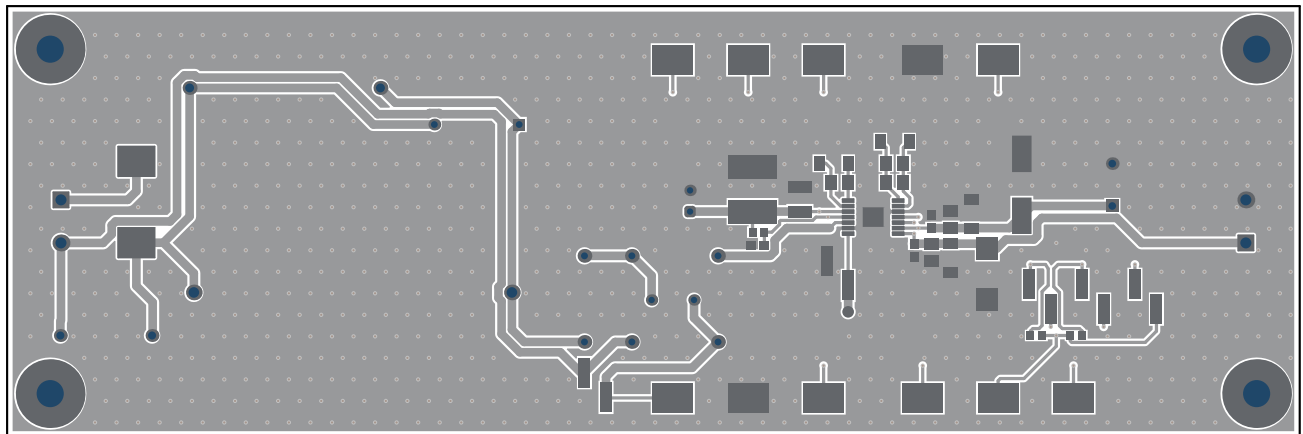


Figure 10. Top Layer Routing

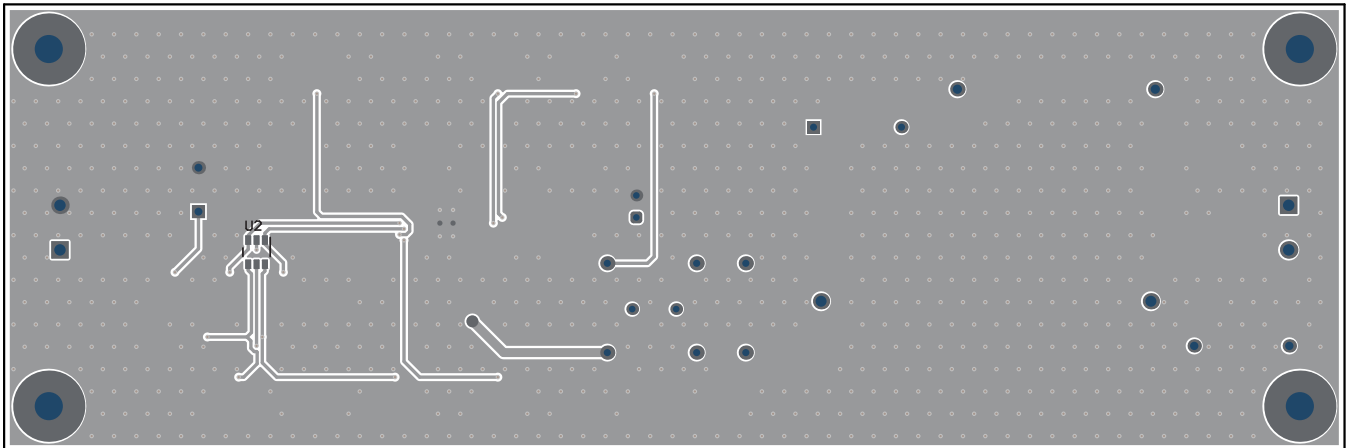


Figure 11. Bottom Layer Routing

8 Bill of Materials (BOM)

Table 4 shows the BOM for this EVM.

Table 4. TPS7A78EVM-011 BOM⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		LP011	Any		
C1	1	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	GRM21BR71H105KA12L	MuRata		
C3	1	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	GRM21BR71H105KA12L	MuRata		
C8	1	120 uF	CAP ALUM 120UF 20% 35V T/H	TH	35ZLQ120MEFC6.3X11	Rubycon		
C11	1	10 uF	CAP, CERM, 10 uF, 25 V,+/- 10%, X7R, 1206	1206	C3216X7R1E106K160AB	TDK		
C15	1	0.47 uF	CAP, Film, 0.47 uF, 1000 V, +/- 20%, TH	TH	PHE844RD6470MR30L2	Kemet		
C18	1	1 uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	GRM21BR71H105KA12	MuRata		
F1	1	2.5 A	Fuse, 2.5 A, 250VAC/VDC, SMD	SMD	3403.0020.11	Schurter		
J1, J2	2		Terminal Block, 5.08 mm, 2x1, TH	TH	1715721	Phoenix Contact		
J3, J4, J5, J6, J7	4		Header, 100mil, 2x1, Tin, SMD	SMD	TSM-102-01-T-SV-P-TR	Samtec		
R1	1	2.21 M	RES, 2.21 M, 1%, 0.1 W, 0603	0603	RC0603FR-072M21L	Yageo		
R2	1	200 k	RES SMD 200K OHM 1% 1/10W 0603	0603	RC0603FR-07200KL	Yageo		
R3, R4	2	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale		
R5, R6, R7	3	280	RES 280 OHM 1/4W 1% AXIAL	TH	CMF50280R00FHFB	Vishay-Dale		
RV1	1		VARISTOR 430V 100A SOD83A AXIAL	TH	V430MA7B	Littelfuse Inc.		
SH-J3, SH-J4, SH-J6, SH-J7	4	1x2	Shunt, 100 mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11	11		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone		
U1	1		100-mA Non-Isolated Line Power Voltage Regulator, PWP0014C (HTSSOP-14)	HTSSOP-14	TPS7A7833PWPR	Texas Instruments		Texas Instruments

⁽¹⁾ These assemblies are ESD sensitive, observe ESD precautions.

⁽²⁾ These assemblies must be clean and free from flux and all contaminants. Use of no-clean flux is not acceptable.

⁽³⁾ These assemblies must comply with workmanship standards IPC-A-610 Class 2.

⁽⁴⁾ Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

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 semiconductors 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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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/lstds/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。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

-
- 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated