Texas Instruments

TPS2490 and TPS2491

+48 V Hot Swap Power Manager Evaluation Kit

User's Guide

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Chapter 1

Introduction

The +48 V hot swap power manager evaluation module (EVM) is a two-board platform that enables designers to rapidly learn about and evaluate the performance of the TPS2490 or TPS2491. Texas Instruments (TI) TPS2490 and TPS2491 +48 V hot swap power manager integrated circuits (ICs) ensure the hot-swap safety and add protection during fault conditions for boards or modules in +48 V hot swap environments. The ICs feature programmable current and power limiting, electronic circuit breaker, adjustable undervoltage-lock enable input, and power-good reporting output. The +48 V hot swap EVM is a PCB-based tool used to demonstrate the performance and operation of the TPS2490 and TPS2491 ICs in simulated live insertion and removal actions.

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1.1 Features

The following list highlights some of the features of the TPS2490 and TPS2491 IC.

- Allows Safe Board Insertion and Removal From a Live Backplane
- High-Side Drive for Low-$R_{DS(on)}$ External N-channel MOSFET
- Programmable Current Limiting and Power Limiting for Complete SOA Protection
- Programmable Fault Timer to Eliminate Nuisance Shutdowns
- Programmable Undervoltage Lockout
- High-voltage Operating Range: 9 V to 80 V
- 100−V Maximum Input Voltage
- Power Good Open-Drain Output
- Input Undervoltage Lockout
- Latched Operation Mode (TPS2490)
- Automatic Retry Mode (TPS2491)
- Available in 10-pin MSOP
- −40°C to 85°C Ambient Temperature Range
- 2-kV Human-Body-Model, 500-V CDM Electrostatic Discharge Protection

1.2 Applications

- Boards or Modules in +48 V Hot Swap Environments

1.3 Description

The TPS2490 and TPS2491 +48 V hot swap power manager (HSPM) provides highly integrated supply control of 9−V to 80−V positive supplies with a minimum number of external components. These hot-swap controllers operate an external N-channel MOSFET device to safely switch power to downstream loads. A power MOSFET can be destroyed if operated outside its safe operating area (SOA) curve, which typically includes limitations on current, voltage and power. In order to assure that the SOA is not exceeded, the hot-swap controller contains independently adjustable current- and power-limit circuitry. If a fault persists beyond a user-defined period of time, the HSPM turns off the power MOSFET. Depending upon which design option is chosen, the part either remains latched off (TPS2490) until the enable is cycled, or it automatically restarts (TPS2491) after a time delay.

These devices can be used on plug-in cards and on back-planes to limit inrush current, control load turn-on, enable down-stream dc-to-dc converters, isolate faulted loads, and eliminate nuisance shutdowns.

Chapter 2

The +48 V Hot Swap EVM Kit

The main evaluation board (TI part number HPA016) contains the power interface section of a plug-in card as it may be implemented in a typical, compliant hot swap system. The EVM backplane board (TI part number HPA018) provides a mechanism for simulating hot swap events by abruptly applying power, ground, and control signals on the backplane board to their corresponding inputs on the main EVM board inserted into the backplane board P1B connector.

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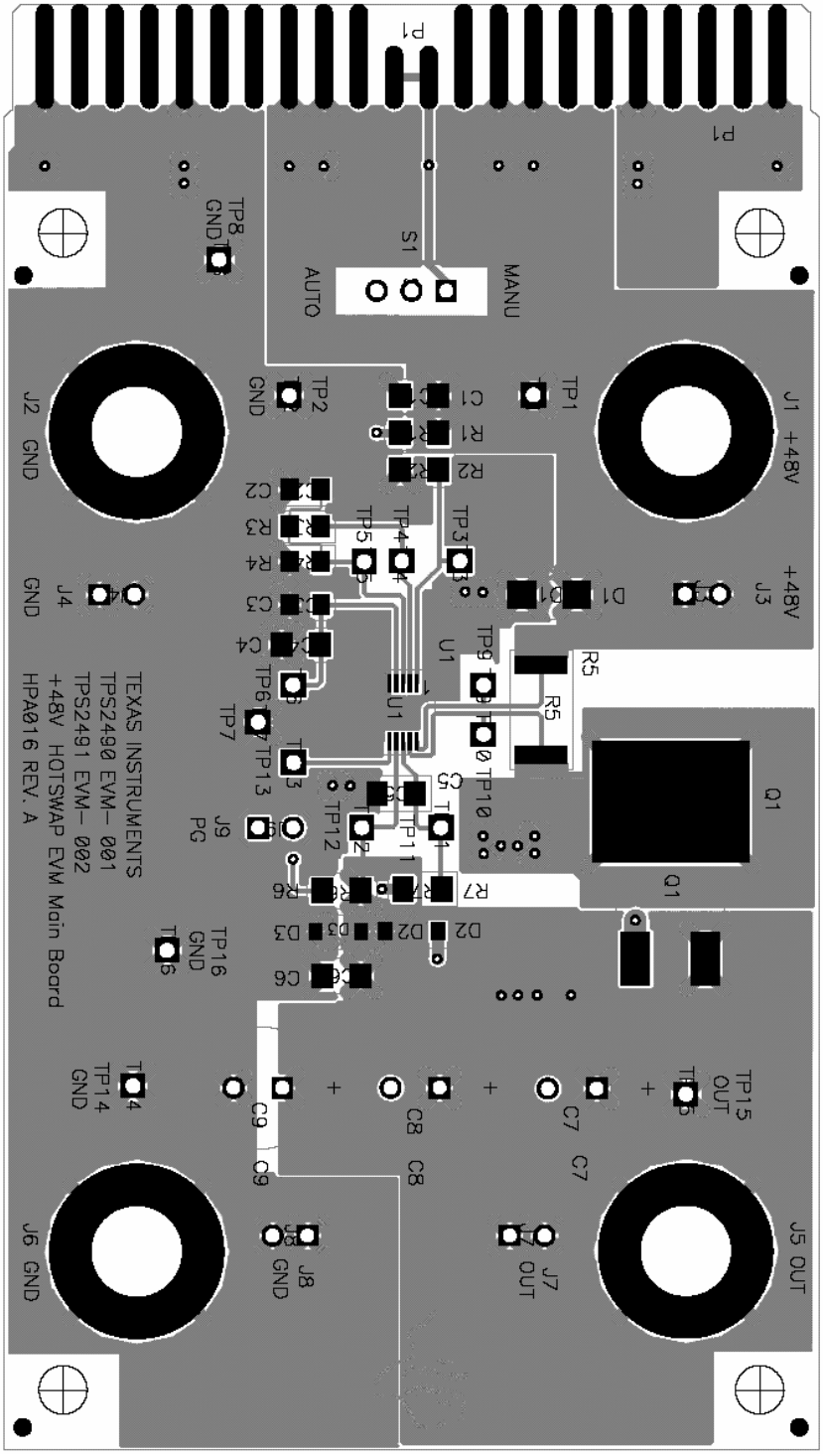
2.1 The +48 V Hot Swap EVM Main Board

2.1.1 Module Description

The +48 V EVM main board contains the power isolation and control electronics comprising a hot swap interface that may be incorporated in a +48 V hot swap plug-in board. The EVM main board contains a TPS2490 or TPS2491 48-V HSPM IC, a power MOSFET switch, and some configuration capacitors. In addition, the main board contains some additional switches, jacks, headers, and components that can be used to facilitate device testing and for quick modifications of the plug-in characteristics.

The layout of the EVM main board top assembly is shown in Figure 2−1.

Figure 2−1. Evaluation Module Main Board Top Assembly

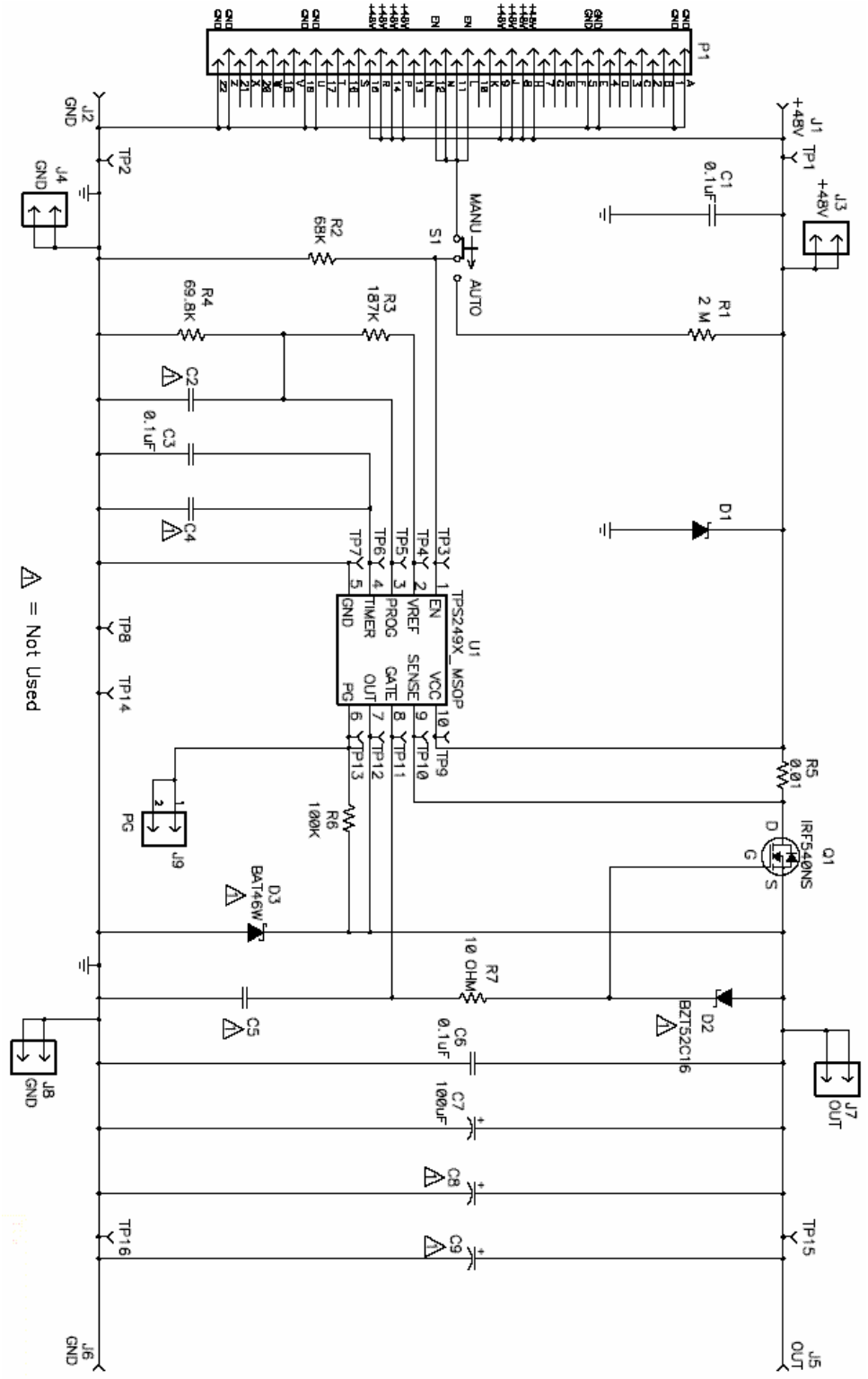


Test points are provided throughout the EVM main board for monitoring. The test points are listed in Table 4−2.

2.1.2 EVM Schematic Diagram and Bill of Materials

The EVM main board schematic diagram is shown in Figure 2−2.

Figure 2−2. +48 V Hot-Swap Power Manager Evaluation Module Main Board Schematic



The +48 V Hot Swap EVM Main Board Bill of Materials (BOM) is shown in Table 2−1.

Table 2−1. +48 V Hot-Swap Evaluation Module Main Board Bill of Materials (HPA016−001, −002)

Count		RefDes	Description	Size	Part Number	MFR
−002	−001					
2	2	C1, C6	Capacitor, ceramic, 0.1 μF, 100 V, X7R, 10%	1206	ECJ−3YBZA104K	Panasonic
0	0	C2	Capacitor	805		
1	1	C3	Capacitor, Ceramic, 0.1 μF, 16 V, 10%	805	ECJ−ZVF1C104Z	Panasonic
0	0	C4, C5	Capacitor	1206		
1	1	C7,	Capacitor, Panasonic, 100 μF, 100 V, 20%	TH	ECA−ZAM101	Panasonic
0	0	C8,C9	Capacitor center 140 mil	TH		
1	1	D1	Diode, Zener, 80 V, 400 W	SMA	SMAT70A	Diodes
0	0	D2	Diode	SM		
0	0	D3	Diode	SM		
4	4	J1, J2, J5, J6	Connector, banana jack, uninsulated		3267	Pomona
5	5	J3, J4, J7, J8, J9	Header, 2-pin, 100 mil spacing		PTC36SAAN	Sullins
1	1	Q1	Transistor, NFET, 100 V, 33 A, 44 mΩ	D2PAK	IRF540NS	IR
1	1	R1	Resistor, chip, 2 MΩ, 1/8 W, 1%	1206	Std	Std
1	1	R2	Resistor, chip, 68 kΩ, 1/4 W, 1%	1206	Std	Std
1	1	R3	Resistor, chip, 187 kΩ, 1/10 W, 1%	805	Std	Std
1	1	R4	Resistor, chip, 69.8 kΩ, 1/10 W, 1%	805	Std	Std
1	1	R5	Resistor, metal strip, 0.01 Ω, 2 W, 1%	2512	LCR-LRF2512-01-R010-F	IRC
1	1	R6	Resistor, chip, 100 kΩ, 1/8 W, 5%	1206	Std	Std
1	1	R7	Resistor, chip, 10 Ω, 1/8 W, 5%	1206	Std	Std
1	1	S1	Switch, 1P2T, slide, PC-mount, 200 mA		EG1218	E_Switch
11	11	TP1, TP3, TP4, TP5, TP6, TP9, TP10, TP11, TP12, TP13, TP15	Test point, red, 1 mm		240−345	Farnell
5	5	TP2, TP7, TP8, TP14, TP16	Test point, black, 1 mm		240−333	Farnell
0	1	U1	IC TPS2490DGS	DGS10	TPS2490DGS	TI
1	0	U1	IC TPS2491DGS	DGS10	TPS2491DGS	TI
1	1	−−	PCB, 3.816 in × 2.336 in × 0.062 in		HPA016	Any
4	4	NA	Spacer, nylon, Hex, #6−32, 0.625		14HTSP020	
4	4	NA	Screw, nylon, and HD, #6−32, 0.025		010632R025	
1	1		**HPA018 ASSEMBLY REQUIRED**			

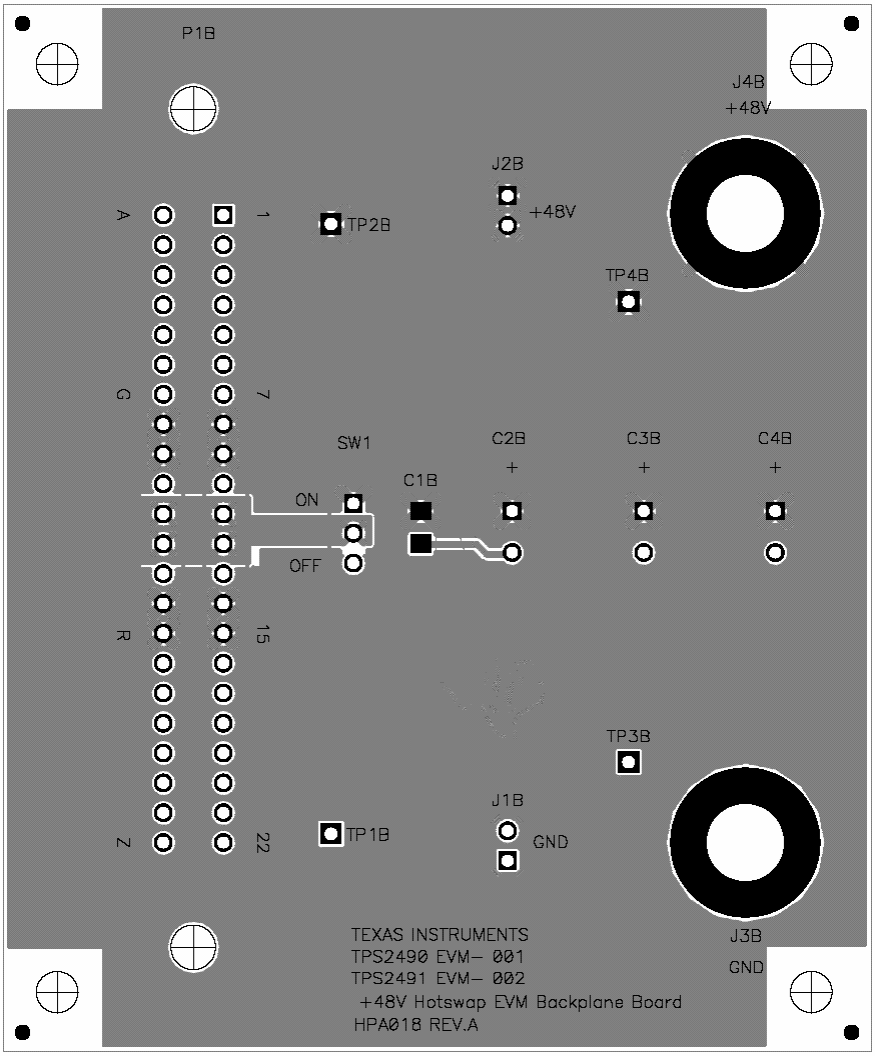
2.2 The +48 V EVM Backplane Board

2.2.1 Description

The EVM backplane board is used to present the backplane of a +48 V hot-swap system. The backplane contains banana jacks and headers for the connection of a +48 V power supply. The board has a 44-pin PCB edge connector (P1B). Inserting and removing the EVM main board into and out of the backplane board P1B connector simulates hot-swap events.

The pictorial of the EVM backplane board top assembly is shown in Figure 2−3.

Figure 2−3. EVM Backplane Board Top Assembly

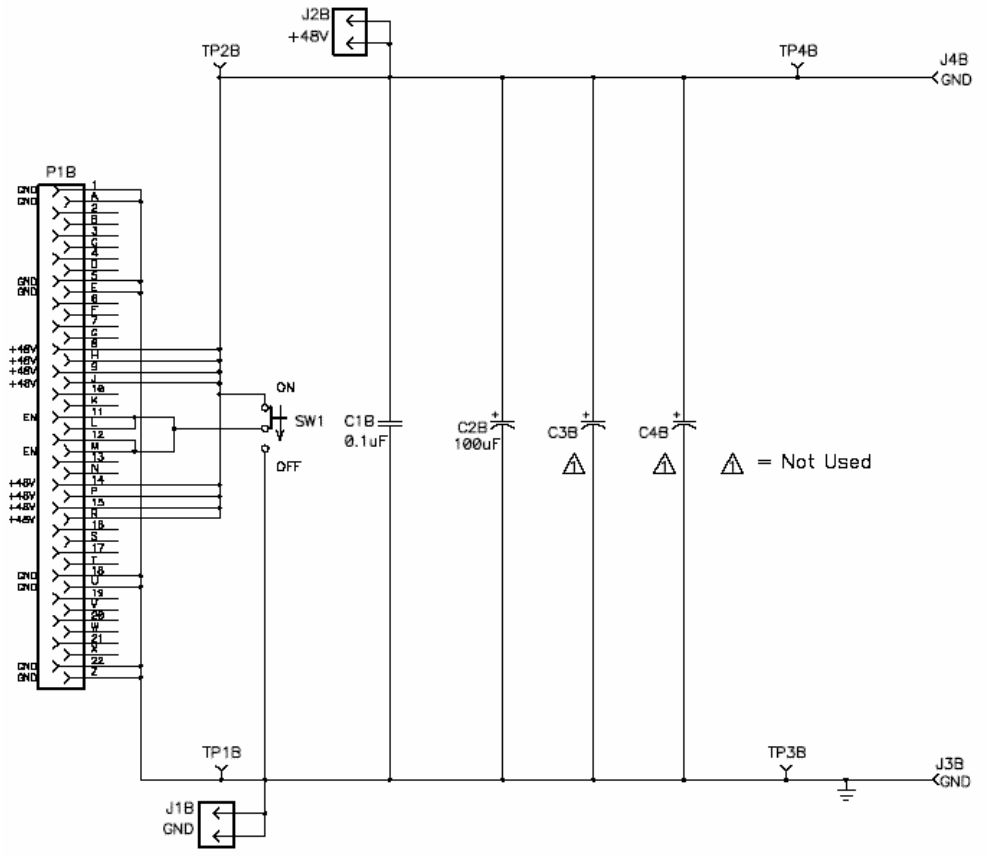


Test points are also provided throughout the EVM backplane board for monitoring as listed in Table 4−1.

2.2.2 Backplane Board Schematic Diagram and Bill of Materials (BOM)

The EVM backplane board schematic diagram is shown in Figure 2−4.

Figure 2−4. EVM Backplane Board Schematic



The EVM backplane board bill of materials (BOM) is shown in Table 2−2.

Table 2−2. +48 V Hot-Swap Evaluation Module Backplane Board Bill of Materials (HPA018−001)

Count	RefDes	Description	Size	Part Number	MFR
1	C1B	Capacitor, ceramic, 0.1 μF, 100 V, X7R, 10%	1206	ECJ−3YB2A104K	Panasonic
1	C2B,	Capacitor, Panasonic, 100 μF, 100 V, 20%	TH	ECA−ZAM101	Panasonic
0	C3B, C4B	Capacitor center 140 mils	TH		
2	J1B, J2B	Header, 2-pin, 100 mil spacing	TH	PTC36SAAN	Sullins
2	J3B, J4B	Connector, banana jack, uninsulated		3267	Pomona
1	P1B	Connector, 44-pin edge with mtg tabs (for 0.062 PCB)”	TH	50−22SN−11	Cinch
1	SW1	Switch, 1P2T, slide, PC-mount, 200 mA	TH	EG1218	E_Switch
2	TP1B,TP3B	Test point, black, 1 mm	TH	240−333	Farnell
2	TP2B,TP4B	Test point, red, 1 mm	TH	240−345	Farnell
1	NA	PCB, 2.9 In × 3.5 In × 0.062 In		HPA018	Any
4	NA	Spacer, nylon, Hex, #6−32, 0.625		14HTSP020	Eagle
4	NA	Screw, nylon, and, Hd, #6−32, 0.25		010632R025	Eagle

2.3 +48 V Hot-Swap EVM Operating Specifications

The EVM main board and backplane board were designed for some degree of user reconfiguration, as described later in Chapter 4, when using the EVM to evaluate the TPS2490 and TPS2491 HSPM ICs. This includes modifications for different load current requirements. However, under no circumstances should the EVM kit be operated beyond the input supply and load currents specified in Table 2−3.

Table 2−3. EVM Absolute Maximum Ratings

Parameter	Min	Max	Units
Supply voltage range, J4B (+48VIN)	−0.3	100	V
Load current, J5 (OUT)	0	Limited	A
Ambient operating temperature range	−40	85	°C

Notes: 1) All voltages are with respect PCB GND node, J1B, J3B, J4 or J6.
2) Currents are positive into and negative out of the specified terminal.
3) The EVM contains clamping circuitry to clamp the voltage of the TPS2490 and TPS2491 V_{CC} input below 80 V. The EVM can survive transient voltage excursions at J5 and J6 beyond the dc limits specified in Table 2−3.

Component selection for the EVM was done to configure the circuit for a typical +48 V application. As such, the target operating conditions, to the factory-installed component values, are as shown in Table 2−4.

Table 2−4. +48 V EVM Recommended Operating Conditions

Parameter		Min	Nom	Max	Units
Nominal supply voltage, +48VIN	Enabling by SW1, S1 in MANU	10	48	70	V
	Enabling by S1, SW1 in OFF	42	48	70	V
Load current, OUT		0		4	A

Notes: 1) All voltages are with respect PCB GND node, J1B, J3B, J4 or J6.
2) Currents are positive into and negative out of the specified terminal.

Chapter 3

Getting Started

This chapter describes the test environment for using the EVM. Other required test equipment includes a lab power supply, oscilloscope, and multiple digital voltmeters.

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3.1 Equipment Requirements

The following test equipment is required to use the EVM kit.

- ❑ Power supply, 60 VDC at 6 amp minimum
- ❑ Oscilloscope, 4 channel preferred (3 voltage probes and 1 current probe)
- ❑ Digital voltmeter (DVM)

The availability of additional DVMs simplifies EVM use.

3.2 Verifying the EVM Operation

The following procedure steps may be used to verify functional operation of the EVM after receipt.

3.2.1 Equipment Setup

1) Do not connect the power supply to the EVM boards (HPA016 and HPA018).

2) If installed, remove the EVM main board (HPA016) from the P1B connector of the EVM backplane board (HPA018).

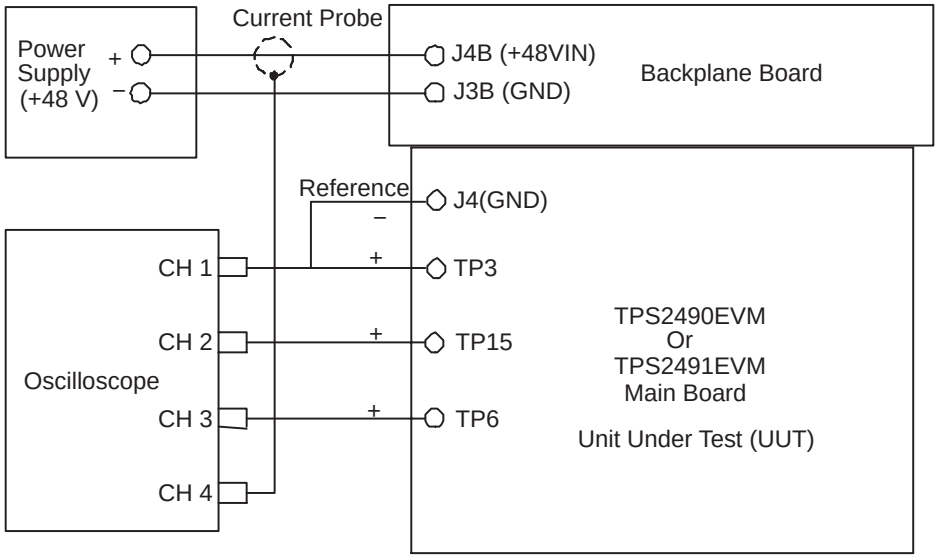
3) On the EVM main board (HPA016), set switch S1 to MANU.

4) On the EVM backplane board (HPA018), set switch SW1 to OFF.

5) Turn on the power supply. Set the output voltage of the supply to 48 ± 0.2 VDC. On the supply, verify the output current limit control is set to allow sourcing of at least 6 A.

6) Turn off the power supply. Connect the power supply to the EVM backplane board (HPA018) as shown in Figure 3−1.

Figure 3−1. +48 V Hot-Swap EVM Setup



3.2.2 Functional Test

1) Plug the EVM main board (HPA016) into the EVM backplane board (HPA018) P1B connector. Due to the symmetric design of the connector, the board can be inserted in either direction.

2) Connect the oscilloscope probes as shown in Figure 3−1.

3) Set the oscilloscope channel amplifiers to the following scale settings:

   a) CH1: 50 V/div at first line

   b) CH2: 20 V/div at fourth line

   c) CH3: 2 V/div at fifth line

   d) CH4: 2 A/div at position just above the bottom line (eighth line)

4) Set the oscilloscope timebase to 1 ms/div.

5) Set the scope to trigger on the rising edge of Channel 1 at about a 20-V level and 10% horizontal trigger position.

6) Set the mode to NORMAL.

7) Turn on the power supply. Verify that the voltages shown in Table 3−1 are obtained on each DMM display.

Table 3−1. TPS2490EVM or TPS2491EVM DMM Readings—Output OFF

DMM #	Test Points	Voltage Reading
DMM1	On HPA018: TP2B +, TP1B – (INPUT Voltage)	48± 0.5 VDC
DMM2	On HPA016: TP12 +, TP16 − (OUT Voltage)	0 ± 1.0 VDC
DMM3	On HPA016: TP5 +, TP8 − (PROG Voltage)	0 ± 0.1 VDC
DMM4	On HPA016: TP13 +, TP14 − (PG Voltage)	0 ± 0.1 VDC
DMM5	On HPA016: TP4 +, TP2 − (VREF Voltage)	4.0 ± 0.1 VDC
DMM6	On HPA016: TP11 +, TP7 − (GATE Voltage)	0 ± 0.1 VDC

8) On the EVM backplane board (HPA018), place the SW1 switch in the ON position. Moving the DMM lead connections as required, verify that the voltages shown in Table 3−2 are obtained on each DMM display.

Table 3−2. TPS2490EVM or TPS2491EVM DMM Readings—Output ON

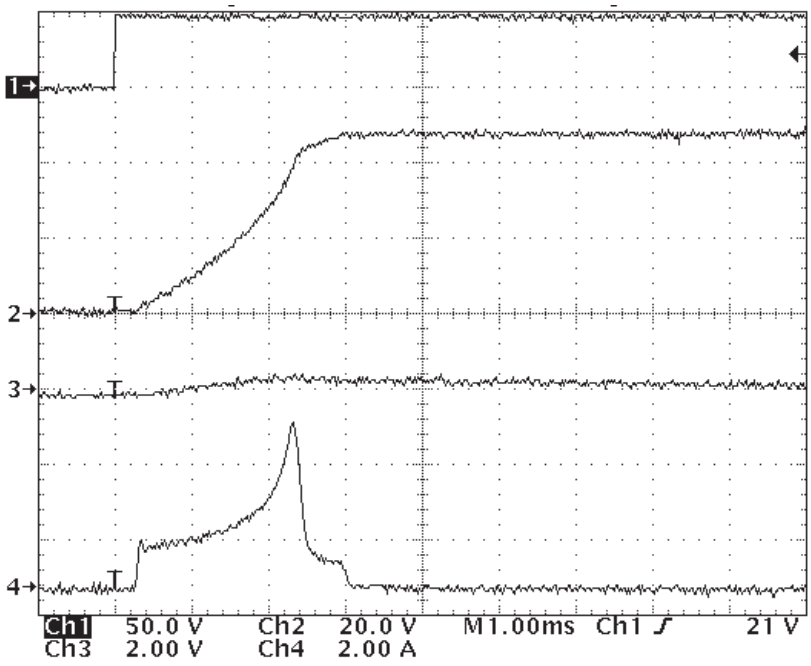
DMM #	Test Points	Voltage Reading
DMM1	On HPA018: TP2B +, TP1B – (INPUT Voltage)	48± 0.5 VDC
DMM2	On HPA016: TP12 +, TP16 − (OUT Voltage)	48 ± 1.0 VDC
DMM3	On HPA016: TP5 +, TP8 − (PROG Voltage)	1.05 ± 0.1 VDC
DMM4	On HPA016: TP13 +, TP14 − (PG Voltage)	48 ± 0.1 VDC
DMM5	On HPA016: TP4 +, TP2 − (VREF Voltage)	4.0 ± 0.1 VDC
DMM6	On HPA016: TP11 +, TP7 − (GATE Voltage)	62 ± 2.0 VDC

9) On the oscilloscope, verify a sweep was obtained which is similar to the one shown in Figure 3−2. Verify that the total turnon time, t_{ST}, as defined in Figure 3−2, is 2.5 ± 1.0 ms.

10) Return SW1 to OFF position. Unplug the EVM main board (HPA016) from the P1B socket of the EVM backplane board.

11) Turn off the power supply and disconnect the cables from the EVM boards if no further tests are planned.

Figure 3−2. Output Ramp-Up Sequence Waveforms Without Resistive Load, Enabled by SW1



Chapter 4

Using the EVM Kit to Evaluate the TPS2490/91 HSPM IC

Procedures similar to the steps of Section 3.2.2 for functional test of the EVM can also be used to evaluate the TPS2490 or TPS2491 controller. Additional details about the EVM features are provided in this section.

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4.1 Test Points

The EVM contains numerous test points located throughout the circuit for waveform monitoring. Lists of the EVM main board and backplane board test points and their associated signals are given in Table 4−1 and Table 4−2 respectively.

Table 4−1. +48 V Hot Swap EVM Backplane Board Test Points

Test Point No.	Signal Name	Description
TP1B	GND	Ground
TP2B	48V	48 V supply input
TP3B	GND	Ground
TP4B	48V	48 V supply input

Table 4−2. +48 V Hot Swap EVM Main Board Test Points

Test Point No.	Signal Name	Description
TP1	48V	Voltage input
TP2	GND	Ground
TP3	EN	Device EN pin
TP4	VREF	Device VREF pin
TP5	PROG	Device PROG pin
TP6	TIMER	Device TIMER pin
TP7	GND	Device GND pin
TP8	GND	Ground
TP9	VCC	Device VCC pin
TP10	SENSE	Device SENSE pin
TP11	GATE	Device GATE pin
TP12	OUT	Device OUT pin
TP13	PG	Device PG pin
TP14	GND	Ground
TP15	OUT	Voltage output
TP16	GND	Ground

4.2 Input and Output Capacitors

Two spare bulk capacitor footprints are provided on both the backplane board (C3B and C4B) and the main board (C8 and C9) to increase the input capacitance on the supply end and/or the output capacitance on the load. When adding any of the large aluminum electrolytic capacitors, select capacitors with an appropriate voltage rating, and to observe the polarity marking on the PCB silkscreen. The recommended voltage rating for these capacitors is 100 V.

4.3 TIMER Capacitor

On the EVM main board, a 0.1–μF ceramic capacitor (C3) is placed on the TIMER pin of the device. Besides, a spare capacitor footprint (C4) is provided to add additional capacitance on TIMER when needed. For example, if capacitors are placed on C8 and/or C9, the 0.1–μF TIMER capacitor may not be large enough, and it would need to add additional capacitance on TIMER through C4.

4.4 PROG Capacitor

A spare ceramic-capacitor footprint (C2) is provided on the EVM main board for adding capacitance on the PROG pin of the device. When a small capacitor is placed on C2, the initial turnon inrush current slew rate is reduced, but the overall turnon time is longer.

4.5 GATE Capacitor

A spare ceramic capacitor footprint (C5) is provided to add capacitance on the GATE pin of the device. Although the device is designed for power-limiting hotswap control, the TPS2490 or TPS2491 can be used as a dV/dt hot-swap controller by removing resistor R4 and adding a gate capacitor on C5. Increasing the value of C5 increases the output voltage ramp-up time. The recommended capacitance range of C5 is 5 nF to 1 μF. When using power-limiting control as the EVM is designed for, no capacitor should be placed on C5. The recommended voltage rating for the GATE capacitor is 100 V.

4.6 Evaluation Without the Backplane Board

The EVM main board alone can be used to evaluate all the functions of the TPS2490 or TPS2491 device except the performance in a live hot-swap event. Switch S1 on main board serves almost the same functionality of the switch SW1 on the backplane board. The difference is that the SW1 switches the EN signal of the device between the input voltage VIN and the ground, but the switch S1 only switches the EN signal between 0.033 VIN and ground. When using the EVM main board only, configure as listed below:

- ❑ Connect input power supply between jacks J1 and J2.
- ❑ Add a 100-V, 100 μF (or larger) input capacitor between J1 and J2.
- ❑ Use switch S1 to turn on (placed in AUTO position) or turn off (placed in MANU position) the device.
- ❑ Input supply voltage must be at least 42 V as defined in Table 2−4.

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Microcontrollers	microcontroller.ti.com	Secruity	www.ti.com/security
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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 9−80 V and the output voltage range of 9 V and 80 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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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 DEGREDATION 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/lsds/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。

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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/lsds/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.

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, INDEMITY 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

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