

Using the TPS2492/3EVM Hot Swap Controller

User's Guide



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Using the TPS2492/3 Hot Swap Controller

This User's Guide describes the setup and operation of the TPS2492/3 System Test Board.

1 Introduction

This User's Guide describes the features of the TPS2492/3EVM. The TPS2492/3 schematic, layout and List of Materials are provided.

2 Description

The EVM is a 9-V to 80-V module using the TPS2492/3 hot swap controller with external MOSFET. At power on, the output is power limited to control inrush current and protect the MOSFET. On an over-current condition, the controller interrupts power to the load at high speed and signals load status. Operating current, MOSFET power dissipation, and fault timer settings are hardware programmable.

2.1 Applications

- Server
 - Plug-In Circuit Boards
 - RAID / Disk Drive
- Telecom
 - ATCA
 - Micro-ATCA
- General Hot Plug

2.2 Features

- 9-V to 80-V Operation
- Controlled Inrush Current
- Fast Circuit Breaker Control
- Hardware Programmable
 - MOSFET Power Limit
 - Fault Current
 - Fault Timer to Avoid Nuisance Tripping
 - TPS2492 Latch Off or TPS2493 Retry
- LED Status Display
 - FAULT
 - POWER GOOD
- Slide Switch Controlling the ENABLE Signal.
- 25-A Nominal Operation with Thermal Characteristics for Proper MOSFET Operation
- On-Board transorb for Over-Voltage Input Protection
- Common Output Diode Prevents Negative Spiking if the Load is Removed While Powered On.
- IMON Output Signal Voltage Representing Load Current.
- Test Points for Circuit Operation Monitoring

2.3 Equipment supplied

- EVM-491
- The datasheet and this users guide is available on the TPS2492/3 product page at www.ti.com.

2.4 Equipment Required

- Power Supply is able to output twice the steady state current for pulse duration. For the 12-V factory set EVM, steady state power is 25-A nominal.
- Oscilloscope
- Current Probe

2.5 EVM Documentation

The manufacturing and engineering documentation for the EVM is shown in sections 3 to 6. The EVM is orderable in 12-V or 48-V configurations, latched off or retry on fault.

2.6 EVM Configuration

Components may be changed for operation at voltage or current not configured as supplied. The List of Materials, , shows the parts to change to configure the EVM to 48 V at 5-A operation. Configure the circuit board for other operating current to 50 A maximum. Changing the sense resistor, the power limit programming components, and possibly the number of MOSFETs as required.

Use the List of Material as a guide when changing module configurations. The TPS2492/93 datasheet has design example describing how to select parts based on specifications. A calculator tool is also available from the product page at www.ti.com.

2.7 Other EVM Options

There are EVM options not described in the other TPS2492/3 documentation. These are described in this section. They involve the not populated components of the EVM.

2.7.1 Trip Point Trim Resistors

R15 and R16 are added to fine tune the sense current when the required current cannot be achieved with standard sense resistors. These resistors form a divider across the sense main sense resistor to increase the trip point from the main sense setting. These are low power rated components. They should be kept below 100 Ω to minimize the set point error.

For example, to select 30 A nominal,

- Bracket the setpoint. A 0.001- Ω sense resistor selects 50 A and a 0.002 Ω selects 25 A.
- Use the larger value sense resistor. In this case 0.002 Ω .
- At 30 A, the voltage across the 0.002- Ω sense resistor is 60 mV.
- R15 and R16 make a standard voltage divider. Use the formula $(60 \text{ mV} \times R16) / (R15 + R16) = 50 \text{ mV}$.
- Let R16 = 33 Ω , solve for R15. In this case, R15 = 6.6 Ω , use standard value R = 6.55 Ω .

2.7.2 dv/dt Control

When the VPROG calculates below the 0.4 V minimum, one option is to use dv/dt control to start the uncharged output capacitor. In this way, the power limiting is not used on power up. R11 and C4, (see schematic [Figure 2](#) for component reference), are normally not populated and control the power turn on with a dv/dt soft start. Recommendation for R11 is at 1 kΩ. C4 can be calculated by knowing the output capacitor, selecting the charge current and calculating the start time. Calculation is done by the capacitor V I relationship equation, $I = C \, dv/dt$.

- Assume a 12-V system with a 1000-μF output capacitor. Select the charge at 0.5 A. Use the formula to solve for time. $T = CV/I$, $T = 24 \text{ ms}$.
- Since the output FET is a gate follower, the time calculated applies to the gate rise time. Use the same formula to solve for C_t but this time the current is the gate sourcing current in the datasheet specifications section, 22 μA nominal.
- The voltage, again from the datasheet is the output VGS, 14 V.
- $C_t = IT / V = 22 \text{ μA} \times 24 \text{ ms} / 14 = 37.7 \text{ nF}$, use standard value 39 nF.

2.7.3 Disable Power Limit

It's not usually done, but sometimes because of high voltage with high current the power limit may be disabled on over load. TPS2492 can be configured to run in current limit only. To disable power limit remove R3 and install 47 kΩ in R2, (see schematic [Figure 2](#) for component reference). With power limit disabled, dv/dt start outlined in the previous section would be used for power on.

3 EVM Block Diagram TPS2492EVM-491

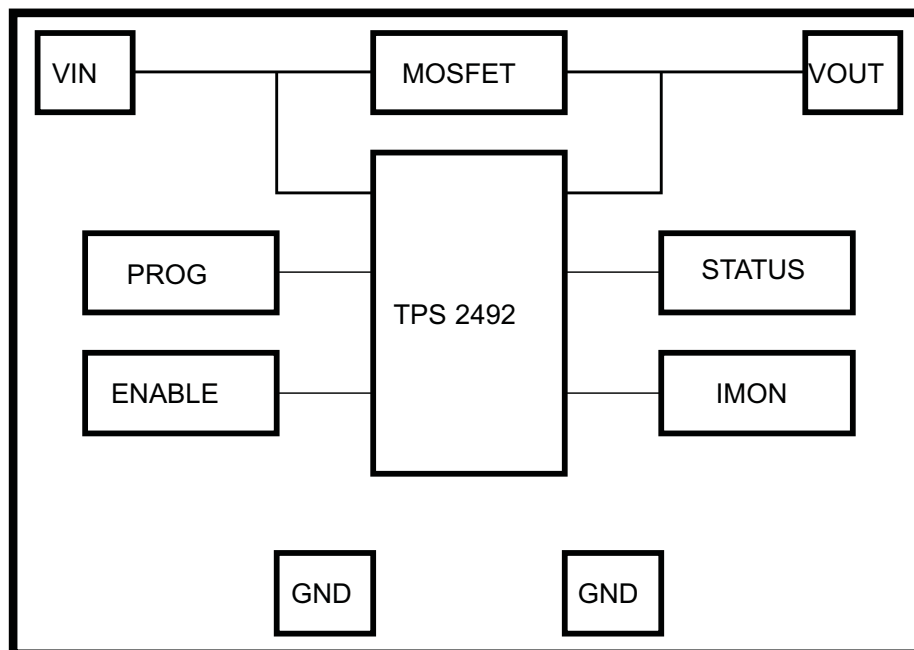


Figure 1. EVM Block Diagram

4 Schematic

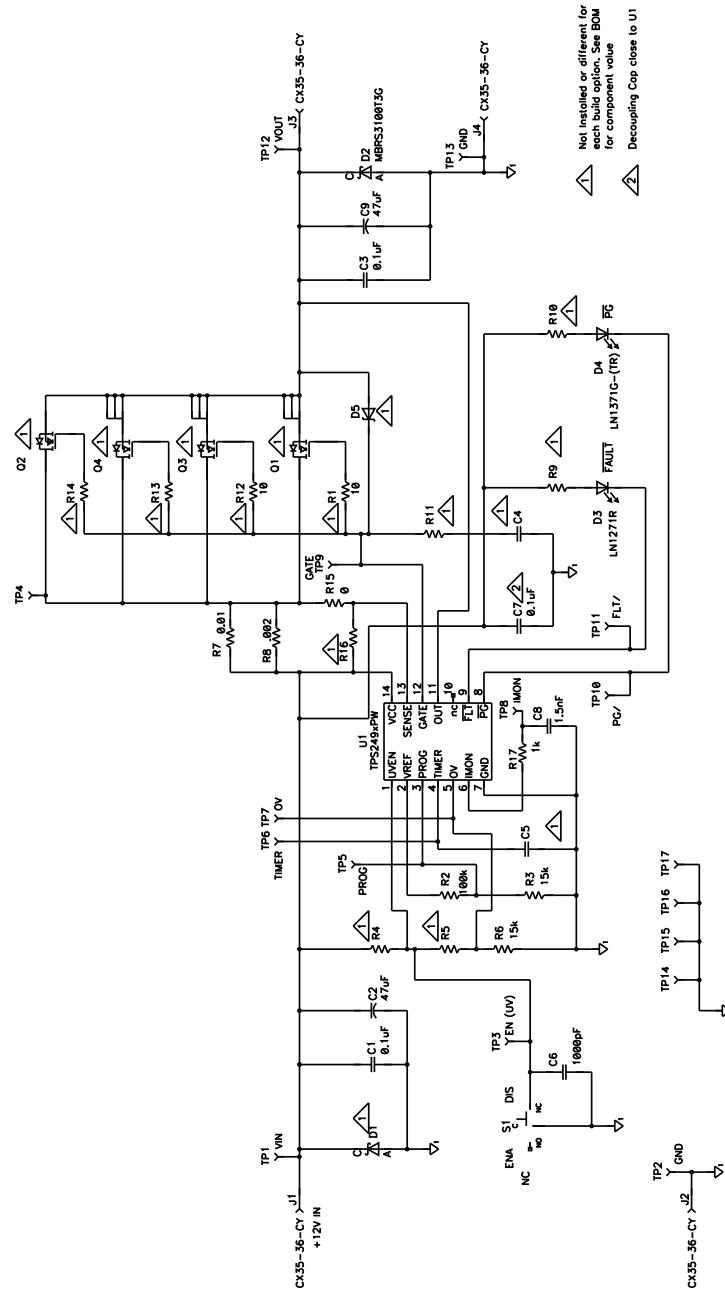


Figure 2. HPA270A Schematic, TPS2420EVM

5 Test Points

Table 1. TPS249xEVM Test Points

TEST POINT	NAME	DESCRIPTION
TP1	VIN	Input voltage power supply
TP2	GND	Ground
TP3	EN-UV	Enable signal, high true (and under-voltage detection)
TP4	None	
TP5	PROG	Program input
TP6	CT	Fault timer capacitor
TP7	OV	Over-voltage detection
TP8	IMON	Output current monitor
TP9	GATE	Gate output
TP10	PG	Power good signal, low true
TP11	FLT	Fault signal, low true
TP12	VOUT	Output voltage
TP13	GND	Scope ground test point
TP14	GND	Scope ground test point
TP15	GND	Scope ground test point
TP16	GND	Scope ground test point
TP17	GND	Scope ground test point
TP18	SENSE	Low-side sense resistor

6 Connectors

Table 2. Connectors

CONNECTOR	DESCRIPTION
J1	Main power input, VIN
J3	Main power ground, GND
J2	Load
J4	Load ground, GND

7 Jumpers

None.

8 Switches

8.1 Enable Switch, S1

The Enable slide switch turns on the hot plug controller to ramp the output voltage. When the switch is off, the output is off.

9 Indicators

- Green LED indicator for Power Good (PG)
- Red LED indicator for FAULT (FLT)

11 List of Materials

11.1 12-V TPS2492EVM-001/TPS2493EVM-002

This is the List of Material for the 12-V TPS2492EVM-001/TPS2493EVM-002.

Table 3. 12-V TPS2492EVM-001/TPS2493EVM-002⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

-001	-002	REF DES	DESCRIPTION	PART NUMBER	MFR
3	3	C1, C3, C7	Capacitor, ceramic, 100 V, X7R, 10%, 0.1 μ F, 0805	Std	Std
1	1	C5	Capacitor, ceramic, 25 V, X7R, 10%, 3.3 nF, 0805	Std	Std
2	2	C2, C9	Capacitor, aluminum, 100 VDC, \pm 20%, 47 μ F, 0.670 inch x 0.750 inch	EEVFK2A470Q	Panasonic
1	1	C6	Capacitor, ceramic, 25 V, X7R, 10%, 1000 pF, 0603	Std	Std
1	1	C8	Capacitor, ceramic, 25 V, X7R, 10%, 1.5 nF, 0603	Std	Std
1	1	D1	Diode, SMT TVS 400W, 1 A, 15 V, SMA	SMAJ15A-13F	Diodes
1	1	D2	Diode, Schottky 3 A, 100 V, SMC	MBRS3100T3G	On Semi
1	1	D3	Diode, LED, red, 20 mA, 0.9 mcd, 0.068 inch x 0.049 inch	LN1271R	Panasonic
1	1	D4	Diode, LED, green, 20 mA, 0.9 mcd, 0.068 inch x 0.049 inch	LN1371G-(TR)	Panasonic
4	4	J1, J2, J3, J4	Lug, copper, 35 A, 0.380 inch x 1.020 inch	CX35-36-CY	Panduit
2	2	Q1, Q3	MOSFET, N-channel, 25 V, 37 A, 1.3 m Ω , QFN 5X6 mm	CSD16401Q5A-R	Ciclon
2	2	R1, R12	Resistor, chip, 1/16 W, 1%, 10 Ω , 0603	Std	Std
1	1	R15	Resistor, chip, 1/16 W, 1%, 0 Ω , 0603	Std	Std
1	1	R17	Resistor, chip, 1/16 W, 1%, 1 k Ω , 0603	Std	Std
1	1	R2	Resistor, chip, 1/16 W, 1%, 100 k Ω , 0603	Std	Std
2	2	R3, R6	Resistor, chip, 1/16 W, 1%, 15 k Ω , 0603	Std	Std
1	1	R4	Resistor, chip, 1/16 W, 1%, 143 k Ω , 0603	Std	Std
1	1	R5	Resistor, chip, 1/16 W, 1%, 7.32 k Ω , 0603	Std	Std
1	1	R8	Resistor, power metal strip, 3 W, \pm 1%, 0.002 Ω , 4527	WSR-32L000FE A	Vishay Dale
2	2	R9, R10	Resistor, chip, 1/16 W, 1%, 5.1 k Ω , 0603	Std	Std

⁽¹⁾ These assemblies are ESD sensitive, ESD precautions shall be observed.

⁽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⁾ Ref designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.

Table 3. 12-V TPS2492EVM-001/TPS2493EVM-002⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾ (continued)

-001	-002	REF DES	DESCRIPTION	PART NUMBER	MFR
1	1	S1	Switch, SPDT, slide, PC mount, 500 mA, 0.400 inch x 0.100 inch	09.03201.0 2	EAO
17		TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17	Test point, white, thru hole, 5012, 0.125 inch x 0.125 inch	5012	Keystone
1	0	U1	Positive High-Voltage Power-Limiting Hotswap Controller, TSSOP-14	TPS2492P W	TI
0	1	U1	Positive High-Voltage Power-Limiting Hotswap Controller, TSSOP-14	TPS2493P W	TI
4	4		Screw, panhead	#10-32	0.500 inch
4	4		Washer, flat	#10	
4	4		Washer, split	M5	
4	4		Nut, hex	#10-32	
1	1	--	PCB, 5.4 inch x 3.3 inch x 0.06 inch	HPA491	Any
4	4	--	Bumpons, cylindrical, black	SJ5514-0	3M

12 48-V TPS2492EVM-003/TPS2493EVM-004

This is the List of Material for the 48-V TPS2492EVM-003/TPS2493EVM-004.

Table 4. 48-V TPS2492EVM-003/TPS2493EVM-004⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

-003	-004	REF DES	DESCRIPTION	PART NUMBER	MFR
3	3	C1, C3, C7	Capacitor, ceramic, 100 V, X7R, 10%, 0.1 μ F, 0805	Std	Std
1	1	C5	Capacitor, ceramic, 25 V, X7R, 10%, 0.1 μ F, 0805	Std	Std
2	2	C2, C9	Capacitor, aluminum, 100 VDC, \pm 20%, 47 μ F, 0.670 inch x 0.750 inch	EEVFK2A470Q	Panasonic
1	1	C6	Capacitor, ceramic, 25 V, X7R, 10%, 1000 pF, 0603	Std	Std
1	1	C8	Capacitor, ceramic, 25 V, X7R, 10%, 1.5 nF, 0603	Std	Std
1	1	D1	Diode, SMT TVS 400 W, 1 A, 70 V, SMA	SMAJ70A-13F	Diodes
1	1	D2	Diode, Schottky 3 A, 100 V, SMC	MBRS3100T3G	On Semi
1	1	D3	Diode, LED, red, 20 mA, 0.9 mcd, 0.068 inch x 0.049 inch	LN1271R	Panasonic
1	1	D4	Diode, LED, green, 20 mA, 0.9 mcd, 0.068 inch x 0.049 inch	LN1371G-(TR)	Panasonic
4	4	J1, J2, J3, J4	Lug, copper, 35 A, 0.380 inch x 1.020 inch	CX35-36-CY	Panduit
1	1	Q2	Transistor, NFET, 100 V, 33 A, 44 m Ω , D2PAK	IRF540NS-PBF	IR
1	1	R14	Resistor, chip, 1/16 W, 1%, 10 Ω , 0603	Std	Std
1	1	R15	Resistor, chip, 1/16 W, 1%, 0 Ω , 0603	Std	Std
1	1	R17	Resistor, chip, 1/16 W, 1%, 1 k Ω , 0603	Std	Std
1	1	R2	Resistor, chip, 1/16 W, 1%, 100 k Ω , 0603	Std	Std
2	2	R3, R6	Resistor, chip, 1/16 W, 1%, 15 k Ω , 0603	Std	Std
1	1	R4	Resistor, chip, 1/16 W, 1%, 604 k Ω , 0603	Std	Std
1	1	R5	Resistor, chip, 1/16 W, 1%, 4.42 k Ω , 0603	Std	Std
1	1	R7	Resistor, metal strip, 0.01 Ω , 2 W, 1%, 0.01, 2512	LRC-LRF2512L F-01-R010-F	IRC
2	2	R9, R10	Resistor, chip, 1/16 W, 1%, 20 k Ω , 0603	Std	Std

⁽¹⁾ These assemblies are ESD sensitive, ESD precautions shall be observed.

⁽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⁾ Ref designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.

Table 4. 48-V TPS2492EVM-003/TPS2493EVM-004⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾ (continued)

-003	-004	REF DES	DESCRIPTION	PART NUMBER	MFR
1	1	S1	Switch, SPDT, slide, PC mount, 500 mA, 0.400 inch x 0.100 inch	09.03201.0 2	EAO
		TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17	Test point, white, thru hole, 5012, 0.125 inch x 0.125 inch	5012	Keystone
1	0	U1	Positive High-Voltage Power-Limiting Hotswap Controller, TSSOP-14	TPS2492P W	TI
0	1	U1	Positive High-Voltage Power-Limiting Hotswap Controller, TSSOP-14	TPS2493P W	TI
4	4		Screw, panhead	#10-32	0.500 inch
4	4		Washer, flat	#10	
4	4		Washer, split	M5	
4	4		Nut, hex	#10-32	
1	1	--	PCB, 5.4 inch x 3.3 inch x 0.06 inch	HPA491	Any
4	4	--	Bumpons, cylindrical, black	SJ5514-0	3M

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 9 V to 80 V and the output voltage range of 9 V to 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 50° C. The EVM is designed to operate properly with certain components above 65° 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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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。

<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/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。 <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.
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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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