EVM User's Guide: TPS2HC120EVM

TPS2HC120-Q1 Evaluation Module

Description

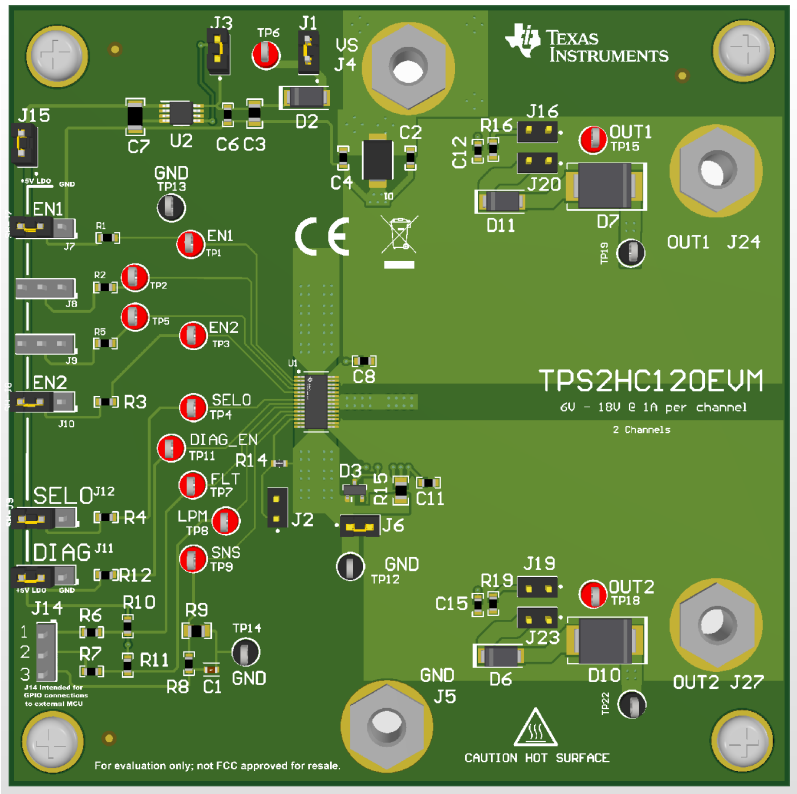
The TPS2HC120EVM is a hardware evaluation module (EVM) used to evaluate the functionality and performance of the TPS2HC120-Q1 high side switch. The evaluation module is fully equipped to test the TPS2HC120-Q1 to ease the device integration to various power system applications. The TPS2HC120EVM is designed to be used as a standalone board with an attached voltage supply and output load. Features such as overcurrent, short-to-ground, open-load, and short-to-battery detection are enabled for use on the evaluation module.

Features

- Operating voltage: 3V–28V
- Ambient operating temperature: –40 to 125°C
- Highly accurate current sense
- Adjustable current limit with external resistor
- Overcurrent, short-to-ground, open-load, and short-to-battery detection
- Onboard LDO allowing for control signal manipulation
- Output jumper to support inductive discharge configurations
- Tested according to AECQ100-12
- Certification of ISO7637-2 and ISO16750-2

Applications

- Multichannel LED drivers, bulb drivers
- Multichannel high-side power switches
- Multichannel high-side relay drivers



TPS2HC120EVM

1 Evaluation Module Overview

1.1 Introduction

The TPS2HC120-Q1 evaluation module (EVM) contains a TPS2HC120-Q1 integrated circuit (IC), supporting quad-channel high-side switch applications. The purpose of this EVM is to facilitate evaluation of the TPS2HC120-Q1 for resistive, capacitive, and inductive load. The TPS2HC120-Q1 evaluation module is designed to evaluate the TPS2HC120-Q1 integrated circuit. This user's guide provides the connectors and test point description, the schematic, bill of materials, and board layout of the EVM. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TPS2HC120EVM.

1.2 Kit Contents

The contents of the EVM kit is listed in Table 1-1. Contact the Texas Instruments Product Information Center nearest if any component is missing.

Table 1-1. Kit Contents

Item	Quantity
TPS2HC120EVM	1

1.3 Specification

The TPS2HC120EVM is compatible with the TPS2HC120-Q1 device. The unit that is populated to the EVM is listed in Table 1-2. Please refer to the device data sheet for more detailed specifications.

Table 1-2. Device Specifications

Part Number	Continuous Load Current (All Channels Enabled)	Channel Count	Package
TPS2HC120-Q1	1A	2	DGQ (HVSSOP, 28)

1.4 Device Information

The TPS2HC120-Q1 family is a fully-protected quad-channel, high-side power switch, with integrated NMOS power FET and charge pump.

Full diagnostics and high accuracy current sense features enable intelligent control of the load. The device diagnostic reporting has two versions to support both digital status output and analog current sense report. The diagnostics can be disabled for multiplexing the sense pin between different devices. Thermal shutdown behaviors as latch off or auto-retry are internally fixed in the part.

External programmable current limit improves the whole system’s reliability by limiting the inrush or overload current.

2 Hardware

2.1 Connection Descriptions

This section describes the connectors on the EVM and how to properly connect, set up, and use the TPS2HC120-Q1 EVM.

2.1.1 Connections and Test Points

Connector and Test Point	Description
J4, TP6	Supply voltage VS
J24, TP15	Output voltage OUT1
J27, TP18	Output voltage OUT2
J5, TP13, TP14, and TP19–TP22	System GND
TP12	GND_IC test point
TP1, TP3	ENABLE test points EN1 and EN2
TP4, TP5	SELx test points SEL0 and SEL1
TP11	DIAG_EN test point
TP7	FLT test point
TP8	LPM test point
TP9	SNS test point
J14 (GPIO connection)	1 connects to FLT pin, 2 connects to LPM pin, and 3 connects to SNS pin.

2.1.2 Jumper Configurations

Jumper	Function, Settings
J1	Connect 1 and 2 to power LDO from VS.
J3	Connect 1 and 2 to enable LDO.
J15	Connect 1 and 2 to power device I/O pins.
J16	Connect 1 and 2 to pull-up for open load detection (OUT1).
J20	Connect 1 and 2 to route to GND through TVS diode network (OUT1).
J19	Connect 1 and 2 to pull-up for open load detection (OUT4).
J23	Connect 1 and 2 to route to GND through TVS diode network (OUT4).
J2	Connect 1 and 2 to bypass RILIM. Disconnect to use RILIM.
J6	Connect 1 and 2 to bypass the GND network. Disconnect to use GND network.
J7	Connect 1 and 2 to GND EN1. Connect 2 and 3 to power EN1 from LDO.
J8	Route to GND.
J9	Route to GND.
J10	Connect 1 and 2 to GND EN2. Connect 2 and 3 to power EN2 from LDO.
J11	Connect 1 and 2 to GND DIAG_EN. Connect 2 and 3 to power DIAG_EN from LDO.
J12	Connect 1 and 2 to GND SEL0. Connect 2 and 3 to power SEL0 from LDO.
J14	GPIO connections for FLT (1), LPM (2), and SNS (3).

3 Implementation Results

3.1 Variable Resistor for CS and CL

3.1.1 Current Sense Resistor

The current sense function is internally implemented by a current mirror. This is reflected as an external resistor between the SNS pin and GND. The TPS2HC120-Q1 evaluation module resistor is located on pad R9. This can be adjusted externally but do take into consideration temperature and supply voltage.

3.1.2 Adjustable Current Limit

The current limit regulates the output current to a set value. The EVM can be designed to hold different current limit values through an external resistor on the ILIM pin. There are 9 settings that can be set based on RLIM. 1% tolerance resistors needs to be used in this application. R14 is the pad used for the adjustable current limit control.

Table 3-1. Current Limit Setting Through External Resistor

Resistor Value	Voltage Input	ILIM Threshold
43.2kΩ	0.117V	500mA
31.6kΩ	0.234V	750mA
23.2kΩ	0.396V	1A
16.5kΩ	0.557V	1.25A
9.76kΩ	0.758V	1.5A
4.87kΩ	1.037V	1.75A
2.49kΩ	1.382V	2A
Short to GND	0V	2.25A
Open (>80kΩ)	2.2V	5A

4 Hardware Design Files

4.1 TPS2HC120EVM Schematic

The EVM schematic is illustrated in Figure 4-1.

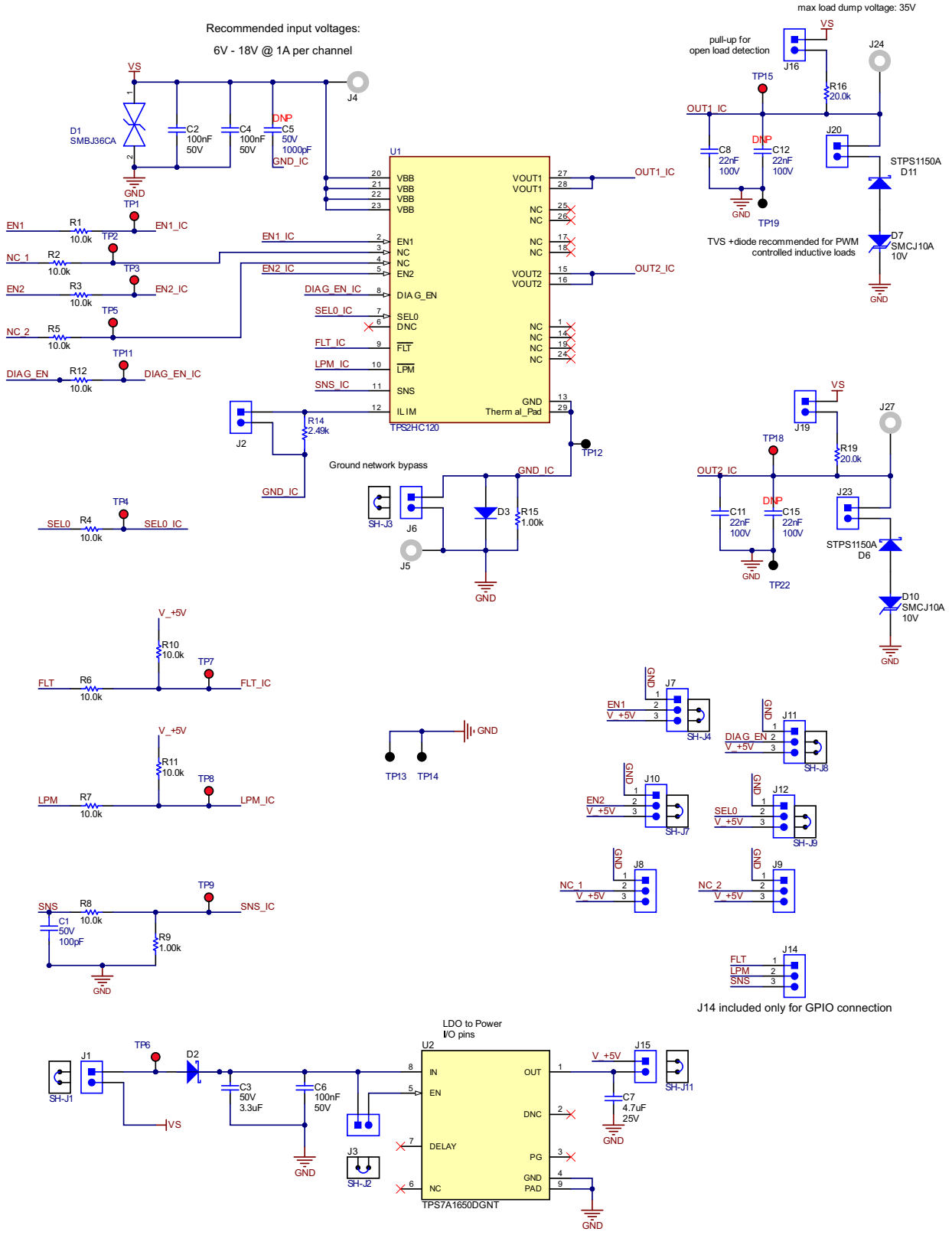


Figure 4-1. TPS2HC120EVM Schematic

4.2 TPS2HC120EVM Assembly Drawings and Layout

The design of the TPS2HC120-Q1 printed-circuit board (PCB) is shown in Figure 4-2 to Figure 4-5. The EVM is designed using FR4 material, four-layer (2s2p), 2 × 70µm cubic inch top and bottom layers, and 2 × 35µm cubic inch internal plane layers. All components are in an active area on the top side and all active traces to the top and bottom layers to allow the user to easily view, probe, and evaluate. Moving components to both sides of the PCB offers additional size reduction for space-constrained systems.

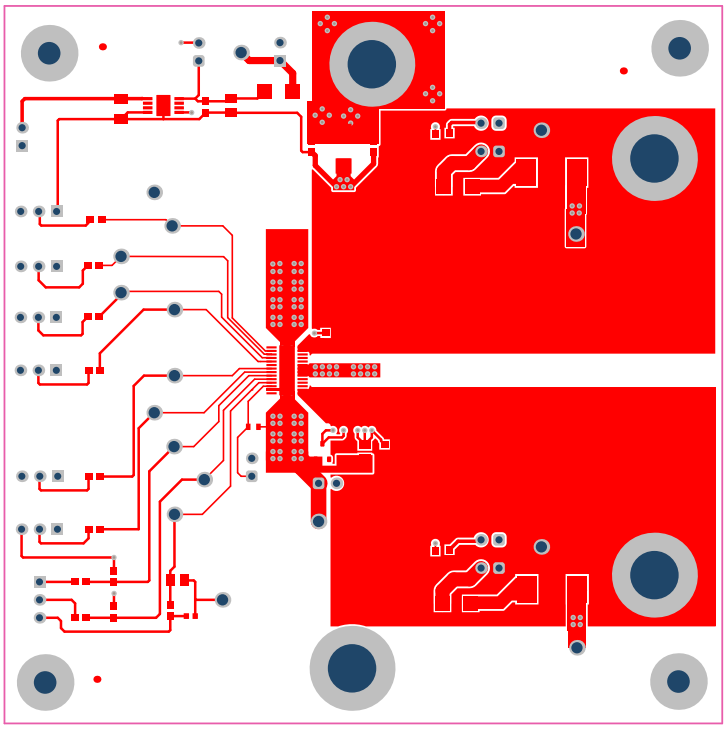


Figure 4-2. TPS2HC120EVM First Layer (Top View)

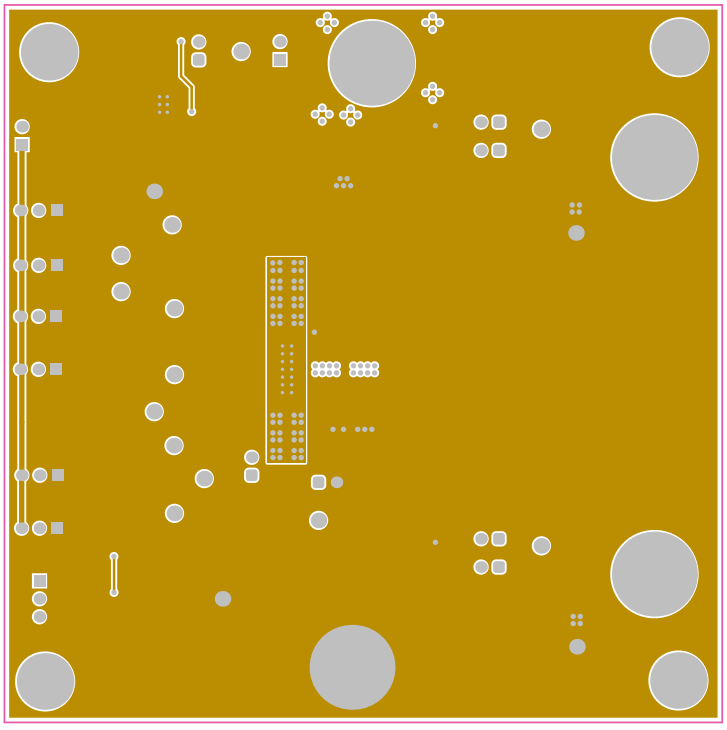


Figure 4-3. TPS2HC120EVM Second Layer GND (Top View)

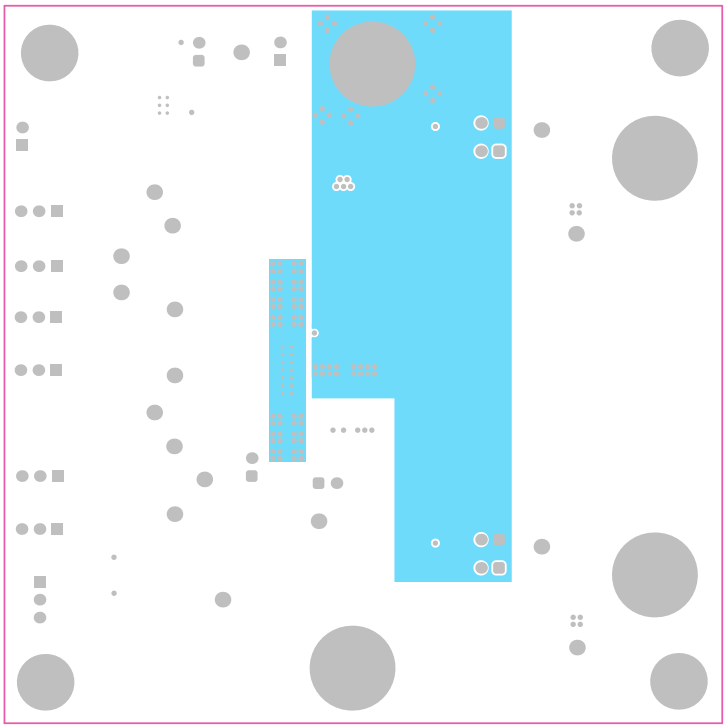


Figure 4-4. TPS2HC120EVM Third Layer VCC (Top View)

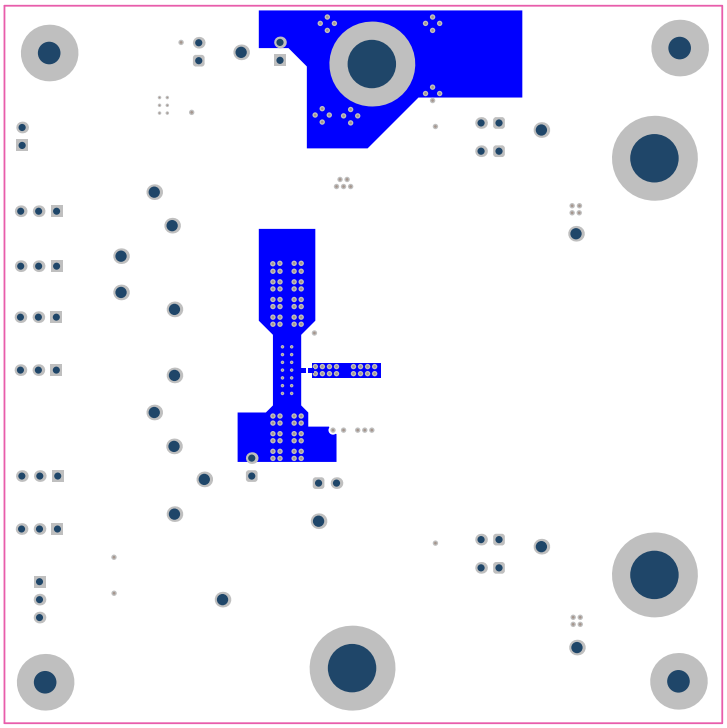


Figure 4-5. TPS2HC120EVM Fourth Layer (Top View)

4.3 Bill of Materials (BOM)

Table 4-1 lists the bill of materials (BOM).

Table 4-1. Bill of Materials

Designator	Quantity	Value	Part Number	Package Reference	Manufacturer
C2, C6	2	0.1uF	C0603C104K5RACAUTO	0603	Kemet
C3	1	3.3uF	C2012X5R1H335K125AB	0805	TDK
C7	1	4.7uF	12063D475KAT2A	1206	AVX
C8, C11	2	0.022uF	C1608X7R2A223K080AA	0603	TDK
D1	1		SMBJ36CA	DO-214AA	Littelfuse
D2	1	50V	B150-13-F	SMA	Diodes Inc.
D3	1	200V	BAS21-7-F	SOT-23	Diodes Inc.
D6, D11	2	150V	STPS1150A	SMA	STMicroelectronics
D7, D10	2	10V	SMCJ10A	SMC	Bourns
H1, H3, H5, H7	4		1902C	Standoff	Keystone
H2, H4, H6, H8	4		NY PMS 440 0025 PH	Screw	B&F Fastener Supply
J1, J15	2		90120-0122	Header 2x1	Molex
J2, J3, J6, J16, J19, J20, J23	7		TSW-102-07-G-S	2x1 Header	Samtec
J4, J5, J24, J27	4		108-0740-001	Banana Jack	Cinch Connectivity
J7, J8, J9, J10, J11, J12, J14	7		5-146278-3	Header, 3x1, 100mil, TH	TE Connectivity
R1, R2, R3, R4, R5, R6, R7, R8, R10, R11, R12	11	10.0k	CRCW060310K0FKEA	0603	Vishay-Dale
R9	1	1.00k	ERJ-P06F1001V	0805	Panasonic
R14	1	2.49k	ERJ-3EKF2491V	0603	Panasonic
R15	1	1.00k	CRCW08051K00FKEA	0805	Vishay-Dale
R16, R19	2	20.0k	CRCW060320K0FKEA	0603	Vishay-Dale
SH-J1, SH-J2, SH-J3, SH-J4, SH-J7, SH-J8, SH-J9, SH-J11	8	1x2	SNT-100-BK-G	Shunt	Samtec
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP11, TP15, TP18	12		5010	Red Multipurpose Testpoint	Keystone
TP12, TP13, TP14, TP19, TP22	5		5011	Black Multipurpose Testpoint	Keystone
U1	1		TPS2HC120	VSSOP28	Texas Instruments
U2	1		TPS7A1650DGNT	DGN0008C	Texas Instruments

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Part Number	Package Reference	Manufacturer
FID1, FID2, FID3	0		N/A	N/A	N/A

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

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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.

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   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.

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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:*

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