EVM User's Guide: TPSM65660EVM

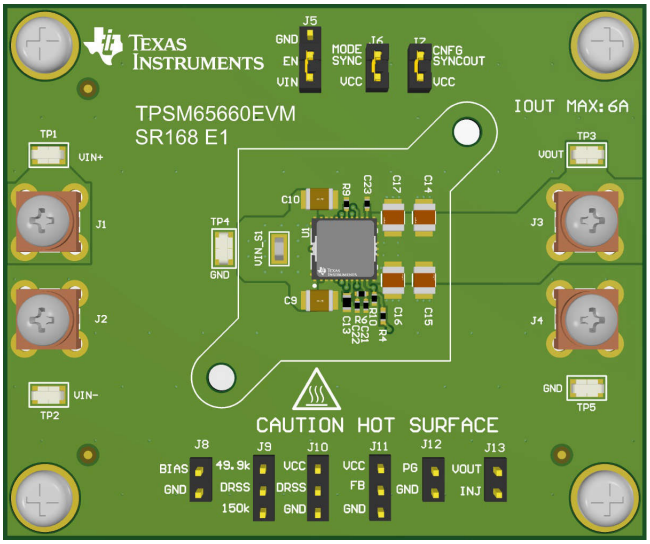
TPSM65660 Evaluation Module

Description

The TPSM65660EVM evaluation module (EVM) helps designers evaluate the operation and performance of the TPSM65660 IC of wide input voltage buck modules.

Features

- 3.5V to 65V wide input voltage range
- Fixed 3.3V, 5V, and adjustable output voltage options
- Up to 6A output current
- 300kHz to 2.2MHz switching frequency
- Minimized switch node ringing to reduce electromagnetic interference (EMI)
- Two modules can be set up in an interleaved mode (paralleled outputs) with accurate current sharing for supporting output current up to 12A



TPSM65660EVM

1 Evaluation Module Overview

1.1 Introduction

The TPSM65660EVM can be configured to deliver optional 3.3V, 5V, or adjustable output to a load of up to 6A. The TPSM65660EVM can be used in many different configurations by re-configuring the board components. See also Section 1.4.

1.2 Kit Contents

This kit includes one TPSM65660EVM.

1.3 Specification

Performance characteristics for the TPSM65660EVM are found in Section 3.2.

Unless otherwise stated: V_{IN} = 24V, V_{OUT} = 5V, T_A = 25ºC.

1.4 Device Information

The TPSM65660 IC is an easy to use, synchronous, step-down module capable of supplying up to 6A of load current from an input voltage as high as 65V. The default EVM features the TPSM65660VCLR. Table 1-1 provides a list of additional devices that can be used with the TPSM65660EVM. Appropriate passive component changes must be made to use these devices in the EVM.

Table 1-1. TPSM65660EVM Device Options

Device OPN	V_{IN} (MAX)	V_{OUT} (MAX)	I_{OUT} (MAX)	External COMP, External Soft Start
TPSM65660VCLR	65V	24V	6A	Yes

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

Always follow TI's set-up and application instructions, including use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to verify that your personal safety and those working around you. For further information, contact TI's Product Information Center http://ti.com/customer support.

Save all warnings and instructions for future reference.

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

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

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observers must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and non-conductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety:
   a. As a precautionary measure, a good engineering practice is to assume that the entire EVM can have fully accessible and active high voltages.
   b. De-energize the TI HV EVM and all the inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   c. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   d. Once EVM readiness is complete, energize the EVM as intended.

   WARNING
   While the EVM is energized, never touch the EVM or the electrical circuits, as the EVM or the electrical circuits can be at high voltages capable of causing electrical shock hazard.
3. Personal Safety
   a. Wear personal protective equipment, for example, latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

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

2 Hardware

2.1 Additional Images

Figure 2-1 and Figure 2-2 show the front and back image of TPSM65660EVM respectively

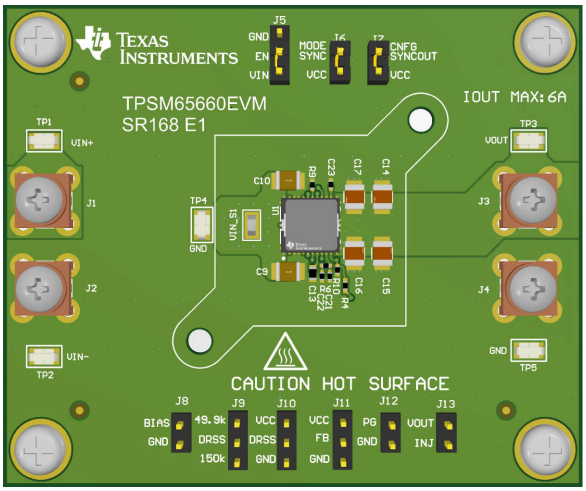


Figure 2-1. TPSM65660EVM Top Side

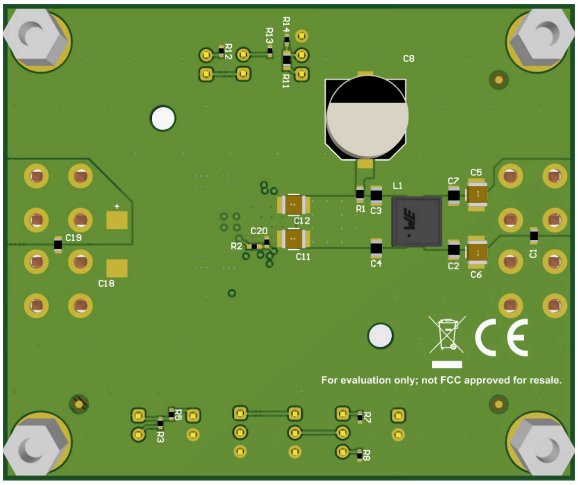


Figure 2-2. TPSM65660EVM Bottom Side

2.2 Power Requirements

Any power source in the range of 3.5V to 65V, and capable of delivering 6A, can be used to evaluate the TPSM65660EVM, under normal conditions.

2.3 Setup and Operation

This section describes the connectors, test points, and jumpers on the EVM and how to properly connect, set up, and use the TPSM65660EVM. See Figure 2-3 for location of connectors and jumpers and typical setup.

Signal	Connector and Test Points	Description
VIN	J1, TP1, VIN_S1	The terminal block J1 is used as the input of the module. Apply input voltage between J1 and J2. TP1 and VIN_S1 can be used as positive DMM connection for VIN sensing. TP2 is used as the negative DMM connection for VOUT sensing.
VOUT	J3, TP3	The terminal block J3 is used as the output of the module. Connect the output load between J3 and J4. TP3 (S+) is used as the positive DMM connection for VOUT sensing. TP5 (S–) is used as the negative DMM connection for VOUT sensing.

Signal	Connector and Test Points	Description
GND	TP2, TP4, TP5	Ground of the converter. TP4 can be used as any ground connector as needed.
EN	J5	The EN jumper (J5) is used to enable or disable the EVM. To use the external UVLO feature, populate R11 and R14 and remove the EN jumper shunt. Note that for accurate shutdown quiescent current measurement, these resistors must be removed (if used) and the EN jumper shunt moved to OFF.
MODE/SYNC	J6	The MODE jumper (J6) is used to select the operating mode. With MODE jumper removed, MODE pin in grounded and device operates in the auto mode. The device operates in automatic PFM/ FPWM mode depending on load current. With MODE jumper installed, MODE pin is connected to VCC and device operates in FPWM mode, the device operates at fixed frequency under all load conditions. The MODE/SYNC pin is also the frequency synchronization input. To synchronize the device to an external clock, remove the MODE jumper shunt and apply the clock between the MODE/SYNC pin of J6 and GND
PGOOD	J12	The PGOOD J12 is used to monitor the power-good indicator. This flag indicates whether the output voltage has reached the regulation level. PGOOD is an open-drain output that is tied to VCC through a 100kΩ resistor (R5) on the EVM.
FB Connections	J11	The jumper J11 is used to select the EVM output voltage setting. In the factory default configuration, the EVM is configured for external adjustable setting for 12V output. Keep jumper open for configuring in adjustable output voltage. Install jumper between FB Pin and VCC for 5V fixed output and between FB and GND for 3.3V. **Note:** install R2 for fixed output configuration to close the loop.
CNFG/SYNCOUT	J7	Resistor to GND for the primary device with external comp. Short to VCC for Primary device with internal comp. Do not float if R12 is removed. **Note:** for this EVM, while using external comp, remove two output caps.
BIAS	J8	The BIAS Jumper (J8) acts as an auxiliary input to the internal LDO regulator. C20 helps bypassing the switching noise. In the EVM factory default configuration, BIAS is connected to VOUT through R2. To change the LDO input to an available external supply from 3.3V to 30V, depopulate R2, and connect this pin to the external supply directly. If configured for fixed output voltage of 3.3V or 5V output, R2 must be installed to close the control loop. See also the TPSM65660 datasheet.
Loop response plot	J13, TP4	When using the adjustable output voltage mode, a Bode plot measurement can be taken using the connection shown in Figure 2-4. R3 must be populated for this test, and probes must have a ground connection to TP4. In the fixed 3.3V or 5V output voltage configuration, a Bode plot measurement cannot be taken. TI suggests to run a step load response to evaluate the loop stability.
DRSS/MCOMM	J9, J10	Dual Random Spread-Spectrum (DRSS) select pin. See also Table 2-1 for available DRSS options. If configured for dual-phase operation, this pin becomes a mode communication pin between a primary and a secondary device. For dual-phase operation, tie together the MCOMM pins of the primary and secondary devices.

Table 2-1. DRSS/MCOMM Selection

DRSS/MCOMM Pin	DRSS	Slew Rate Control
Short to VCC	Enabled, ±10%, 6kHz	Enabled
Float	Enabled, ±10%, 6kHz	Enabled
150kΩ to PGND	Enabled, ±10%, 6kHz	Disabled
49.9kΩ to PGND	Disabled	Disabled
Short to PGND	Disabled	Disabled

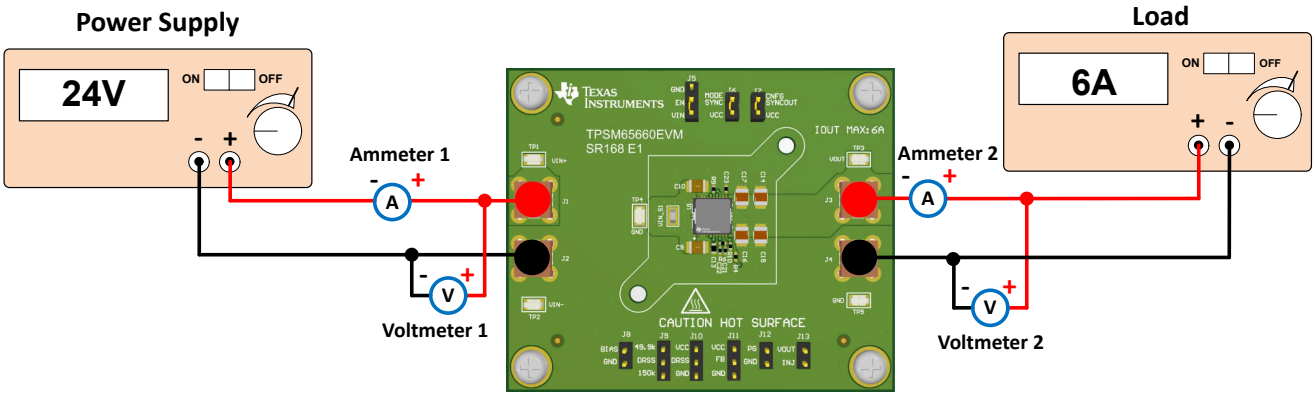


Figure 2-3. TPSM65660EVM Setup

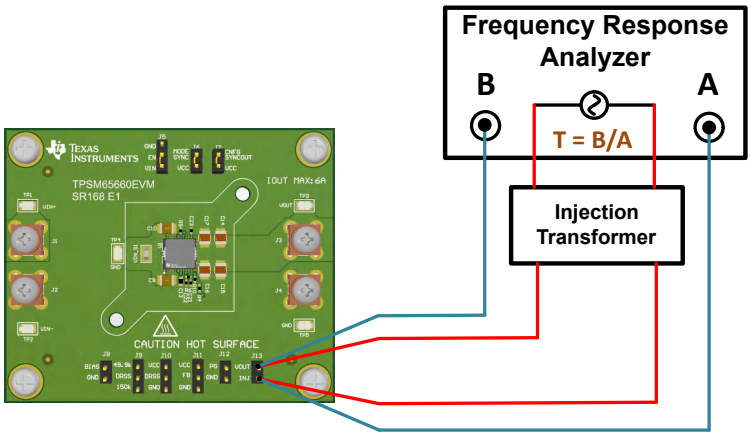


Figure 2-4. TPSM65660EVM Bode Connections

3 Implementation Results

3.1 Evaluation Setup

The TPSM65660EVM is used to take the following data with the setup shown in Figure 2-3.

3.2 Performance Data and Results

Unless otherwise specified the following condition apply: T_A = 25ºC, V_{IN} = 24V, 400kHz.

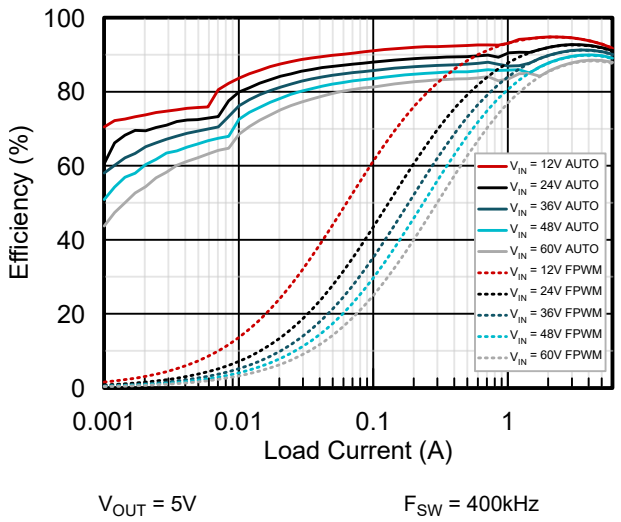


Figure 3-1. Efficiency

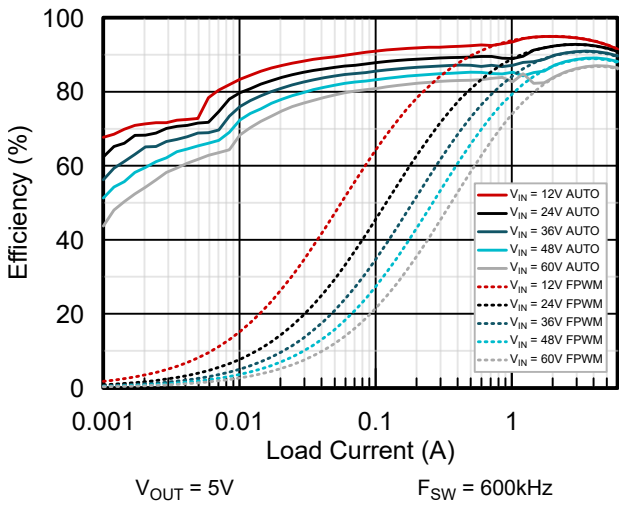


Figure 3-2. Efficiency

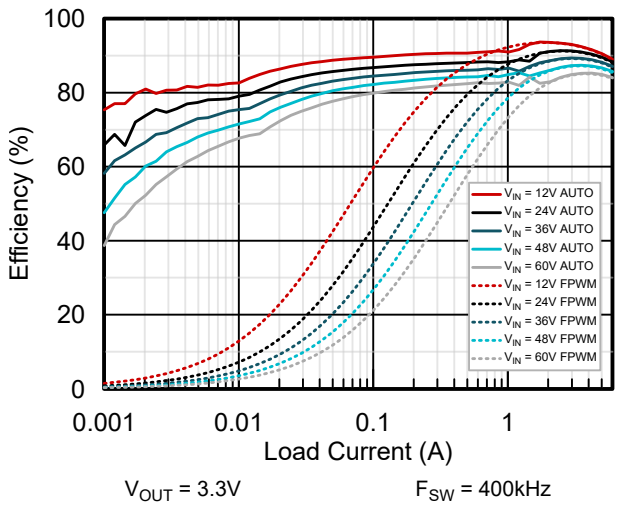


Figure 3-3. Efficiency

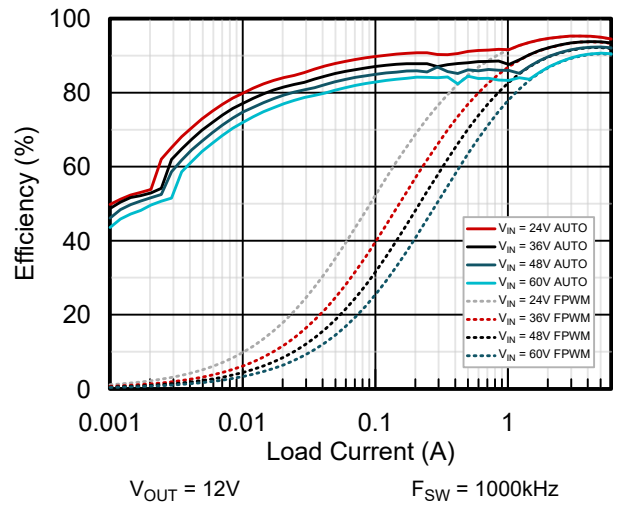
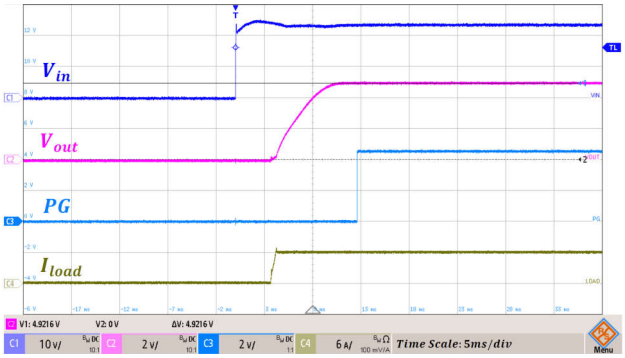
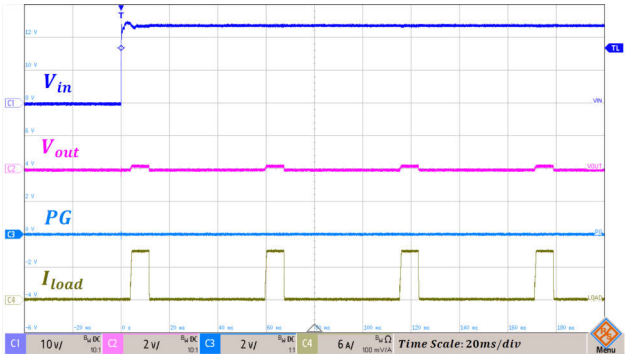


Figure 3-4. Efficiency



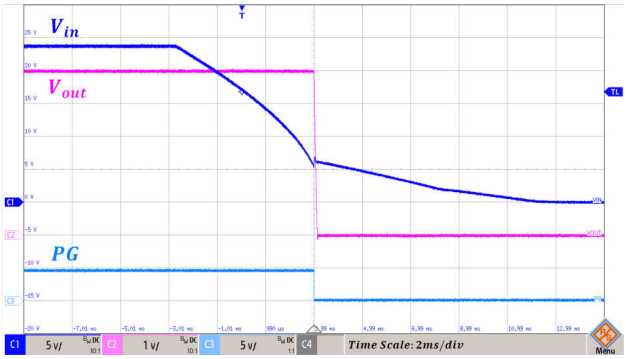
I_{OUT} = 6A V_{IN} = 24V AUTO V_{OUT} = 5V

Figure 3-5. Start-Up With Full Load



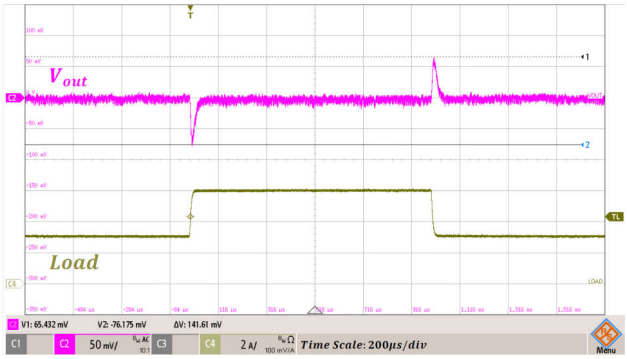
V_{IN} = 24V AUTO V_{OUT} = 5V

Figure 3-6. Start-Up With Output Shorted



I_{OUT} = 6A V_{IN} = 24V AUTO V_{OUT} = 5V

Figure 3-7. Shutdown



I_{OUT} = 3 to 6A V_{IN} = 24V AUTO V_{OUT} = 5V

Figure 3-8. Load Transient

4 Hardware Design Files

4.1 Schematics

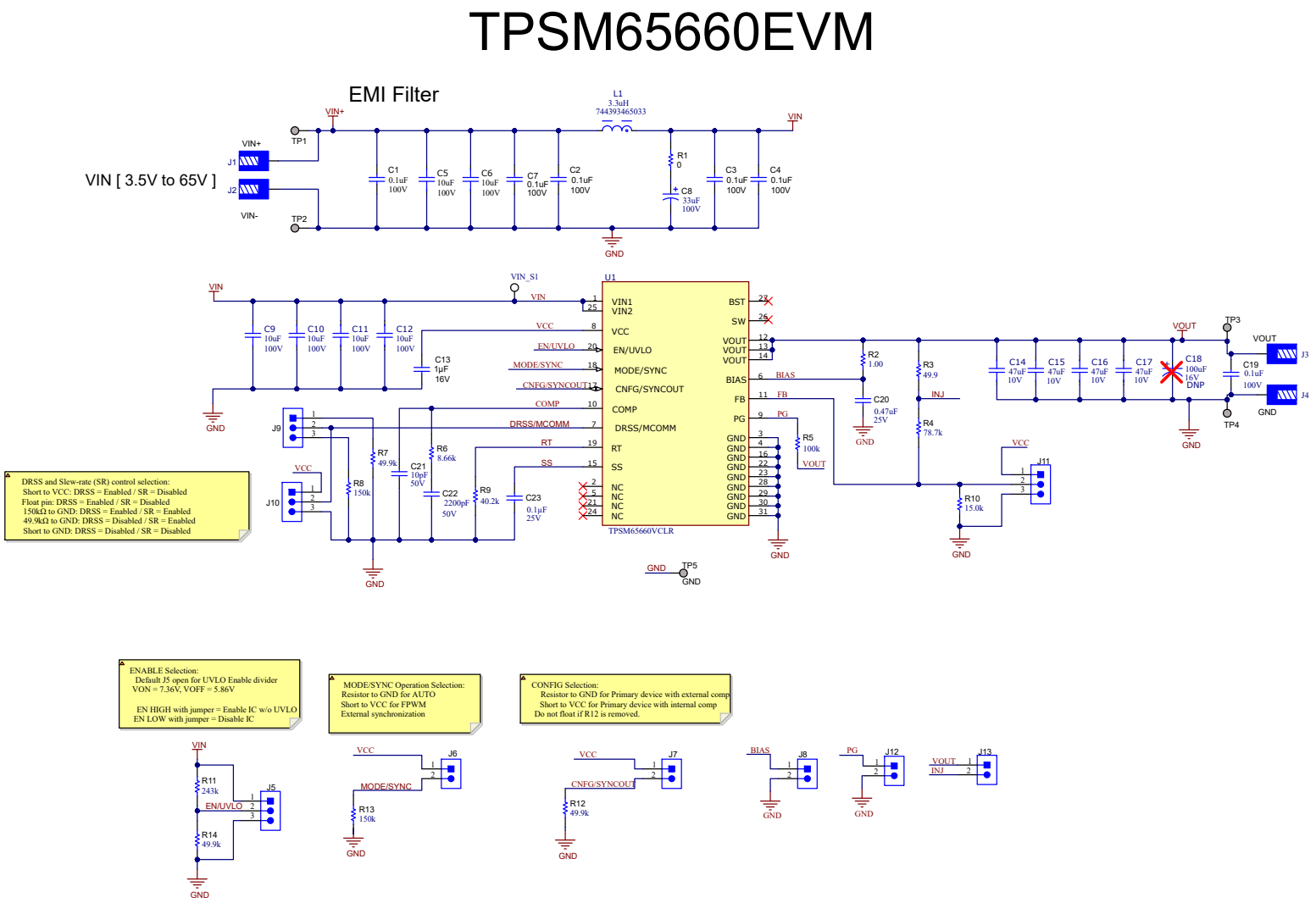


Figure 4-1. TPSM65660EVM Schematic

4.2 PCB Layouts

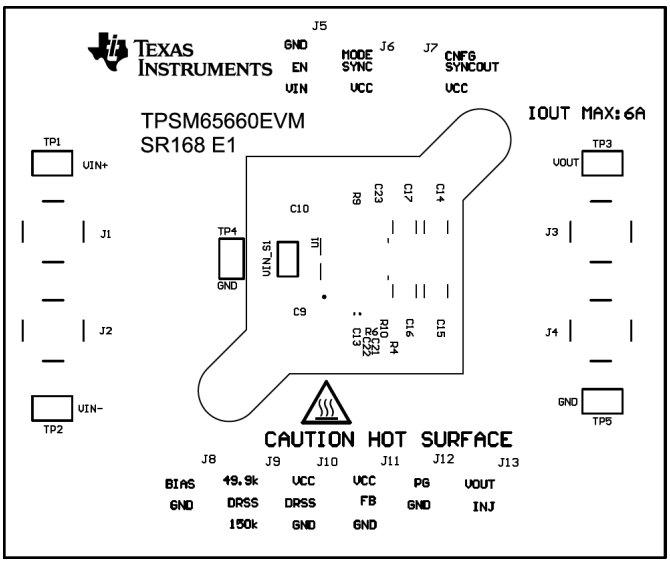


Figure 4-2. PCB Top Silkcreen

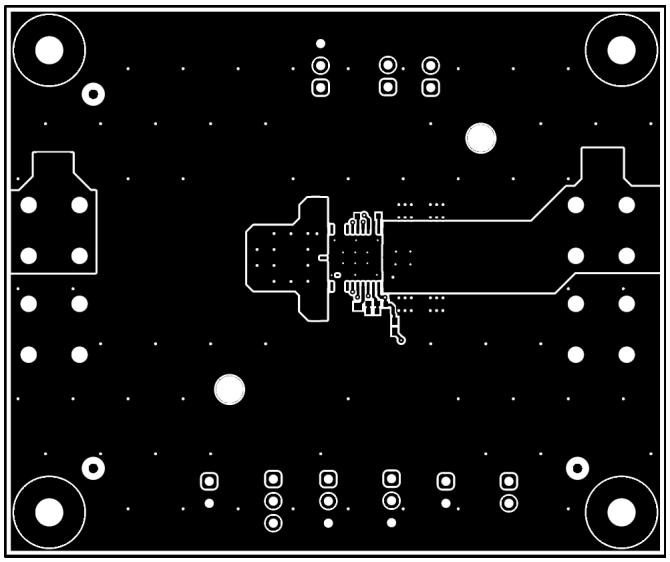


Figure 4-3. PCB Top Layer

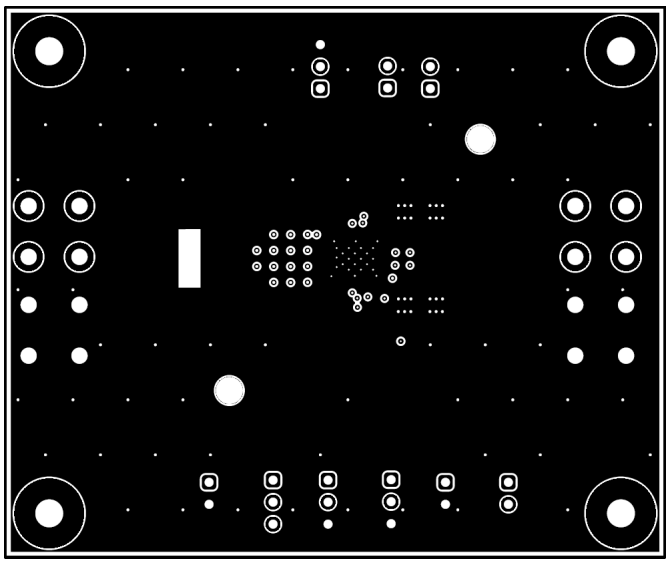


Figure 4-4. PCB Signal Layer 1

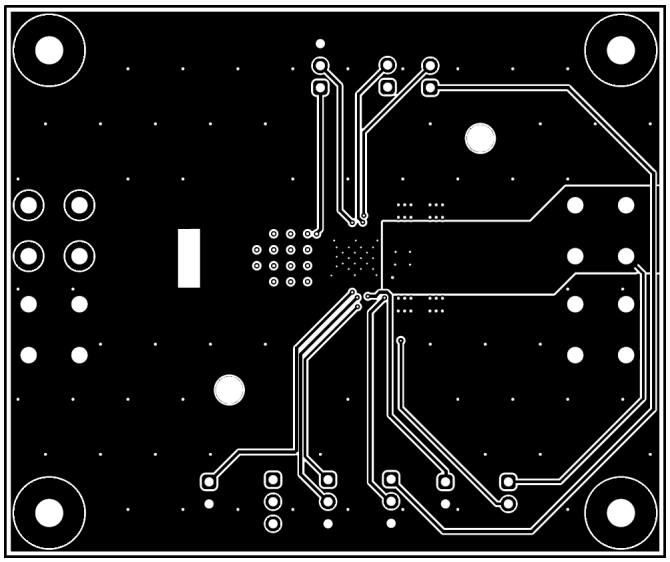


Figure 4-5. PCB Signal Layer 2

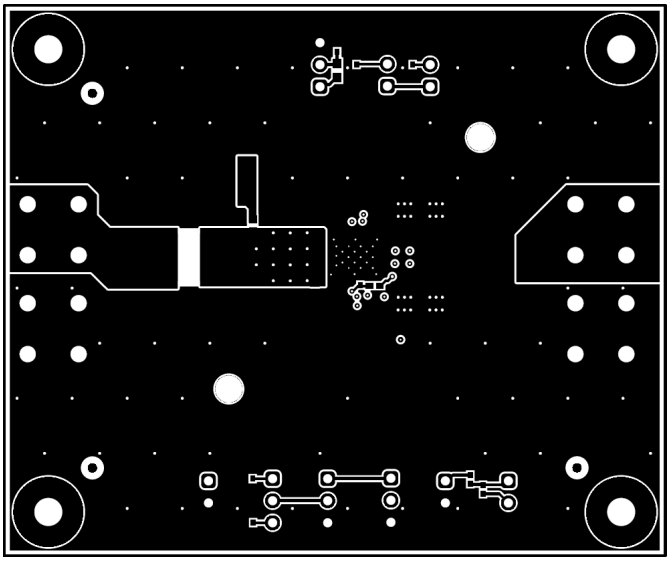


Figure 4-6. PCB Bottom Layer

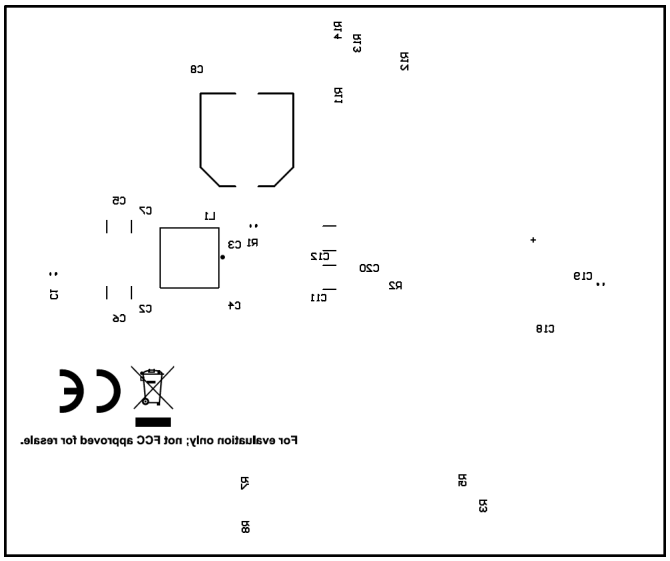


Figure 4-7. PCB Bottom Silkcreen

4.3 Bill of Materials (BOM)

Table 4-1. TPSM65660EVM BOM

Ref Des	Qty	Value	Description	Part Number	Manufacturer
C1, C19	2	0.1µF	CAP, CERM, 0.1uF, 100V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	GCJ188R72A104KA01D	MuRata
C2, C3, C4, C7	4	0.1µF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	CGA4J2X7R2A104K125AA	TDK
C5, C6, C9, C10, C11, C12	6	10µF	10µF ±10% 100V Ceramic Capacitor X7R 1210 (3225 Metric)	CGA6P1X7R2A106K250AC	TDK
C8	1	33µF	CAP, AL, 33uF, 100V, +/- 20%, 0.7ohm, AEC-Q200 Grade 2, SMD	EEE-FK2A330P	Panasonic
C13	1	1µF	CAP, CERM, 1uF, 16V, +/- 20%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71C105MA64D	MuRata
C14, C15, C16, C17	4	47µF	Ceramic Capacitor for Automotive 47uF ±10% 10VDC X7S 1210 Embossed T/R	GCM32EC71A476KE02K	Murata
C20	1	0.47µF	CAP, CERM, 0.47uF, 25V,+/- 10%, X5R, 0402	GRM155R61E474KE01D	MuRata
C21	1	10pF	CAP, CERM, 10pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	CGA2B2C0G1H100D050BA	TDK
C22	1	2200pF	CAP, CERM, 2200pF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	GCM155R71H222KA37D	MuRata
C23	1	0.1µF	CAP, CERM, 0.1µF, 25V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	CGA2B3X7R1E104K050BB	TDK
H1, H2, H3, H4	4		Machine Screw, Round, #4-40x 1/4, Nylon, Philips panhead	NY PMS 440 0025PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C	Keystone
H9, H10, H11, H12	4		MACHINE SCREW PAN PHILLIPS M3 5mm	MPMS 003 0005PH	B&F Fastener Supply
J1, J2, J3, J4	4		REDCUBE WP-THRBU	74650173	Würth Elektronik
J5, J9, J10, J11	4		Header, 100mil, 3x1, Gold, TH	TSW-103-07G-S	Samtec
J6, J7, J8, J12, J13	5		Header, 100mil, 2x1, Gold, TH	TSW-102-07G-S	Samtec
L1	1	3.3µH	Shielded Power Inductors 3.3uH 20% tol, 6.5mOhm 16.6A	XGL6060-332MEC	Coilcraft
R1	1	0	RES, 0, 1%, 0.1W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R2	1	1	RES, 1.00, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW04021R00FKED	Vishay-Dale
R3	1	49.9	RES, 49.9, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW040249R9FKED	Vishay-Dale
R4	1	205k	RES, 205k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW0402205KFKED	Vishay-Dale
R5	1	100k	RES, 100k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW0402100KFKED	Vishay-Dale
R6	1	8.66k	RES, 8.66k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW04028K66FKED	Vishay-Dale
R7, R12, R14	3	49.9k	RES, 49.9k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW040249K9FKED	Vishay-Dale
R8, R13	2	150k	RES, 150k, 5%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW0402150KJNED	Vishay-Dale
R9	1	40.2k	RES, 40.2k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW040240K2FKED	Vishay-Dale
R10	1	15.0k	RES, 15.0k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW040215K0FKED	Vishay-Dale
R11	1	243k	RES, 243k, 1%, 0.1W, 0603	RC0603FR-07243KL	Yageo
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP5	5		Test Point, Miniature, SMT	5019	Keystone
U1	1		TPSM65660VCLR	TPSM65660VCLR	Texas Instruments
VIN_S1	1		Test Point, Miniature, SMT	5015	Keystone

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI 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。
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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.

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Last updated 10/2025