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Trademarks

HotRod™ is a trademark of Texas Instruments.
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1 Setup

Figure 1-1 shows a typical setup with the EVM. The VIN power terminal block (J1) is used for connection to the host input supply and the VOUT power terminal block (J4) is used for connection to the load.

1.1 Test Points

The test points on the top of the board can be used for connecting to the input and output of the EVM. Table 1-1 describes each test point.

Table 1-1. Test Point Descriptions

Test Point ⁽¹⁾	Description
VINS+	Sense line for measuring the input voltage. Not meant to be used to power the device.
VINS-	Ground test point located near the ground terminal of the high frequency bypass capacitor. Meant to be connected to the ground sense line for VIN, but can be used in place of a general ground test point.
VOUTS+	Sense line test point for the output voltage. Do not connect to an output load.
VOUTS-	Ground test point located near the ground terminal of the output capacitors. Meant to be connected to the ground sense line for VOUT, but can be used in place of a general ground test point.
GND	Test points for ground connection. Not meant to be used as a ground connection for the input power supply.
EN	Input voltage scope monitor. Connect an oscilloscope probe to this set of points to measure input ripple voltage.
PGOOD	This test point is connected to the PGOOD pin from the IC. This test point is an open-drain output of the PGOOD pin. In this EVM configuration, the pin is pulled up to VOUT by R4.
EN	This test point is connected to the EN pin. By default, there is a pullup resistor R2 (RENT) to VIN to enable the IC.
SYNC	This test point is connected to the RT pin of the IC when the R4 (RMODE) is installed. In a MODE/SYNC trimmed part, this test point is connected to the SYNC pin of the IC. This can be connected to an external clock to synchronize the IC. In a MODE/SYNC configuration, make sure J6 is configured to the SYNC setting in order to hookup to an external clock signal.
VCC	This test point is connected to the VCC pin.

(1) Refer to the product data sheet for absolute maximum ratings associated with the features in this table.

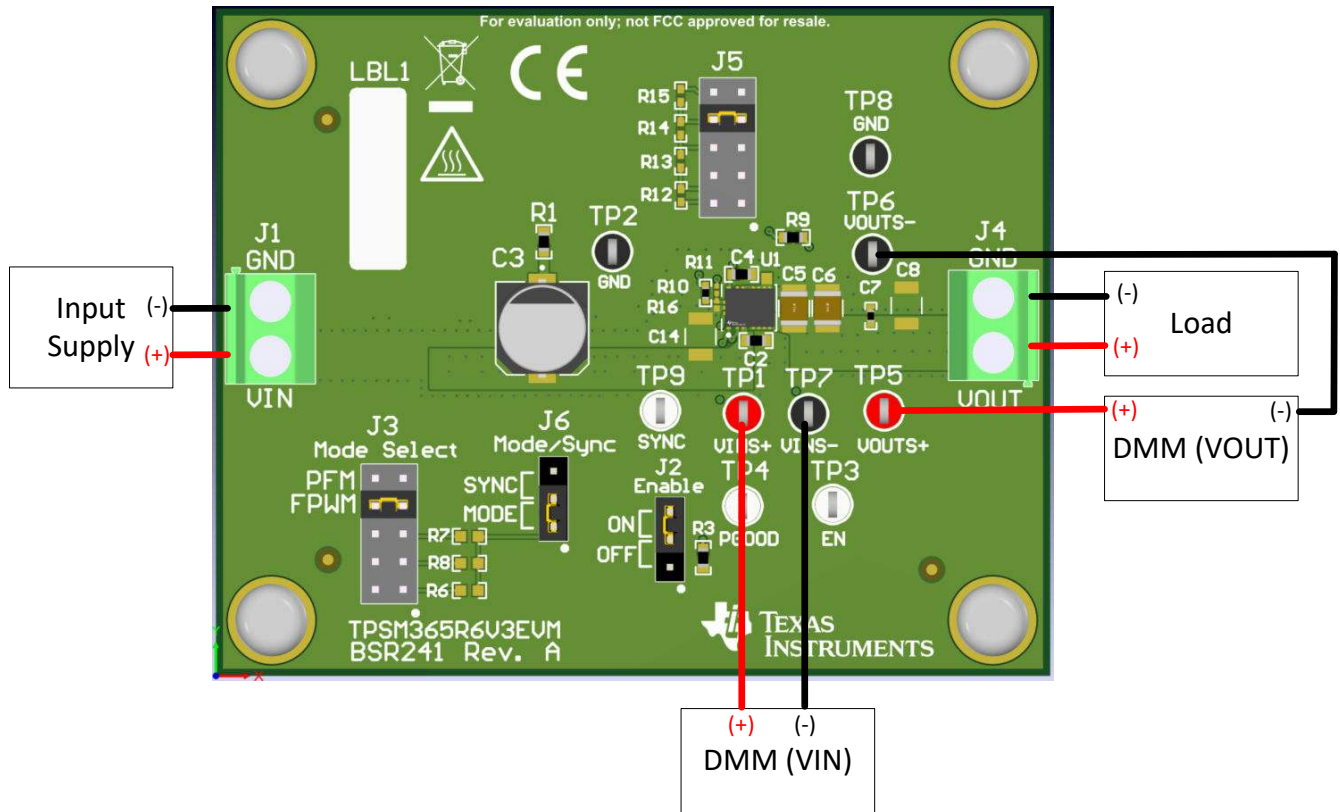


Figure 1-1. EVM Board Connections

2 Operation

2.1 Quick Start

1. Make sure that a jumper is connected to one of the frequencies on the frequency select header. The device does not function properly if this is not connected.
2. Connect the load between the VOUT and GND points on J4. Make sure GND is connected on the top terminal, and VOUT is located on the bottom terminal.
3. Set the supply voltage at an appropriate level between 3.0 V to 65 V. Set the current limit of the supply to an appropriate level.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides $V_{OUT} = 3.3$ V.
5. Monitor the output voltage. The maximum load current is limited to 0.6 A with the TPSM36506 device.
6. Connect the voltage supply between the VIN and GND points on J1.

3 Schematic

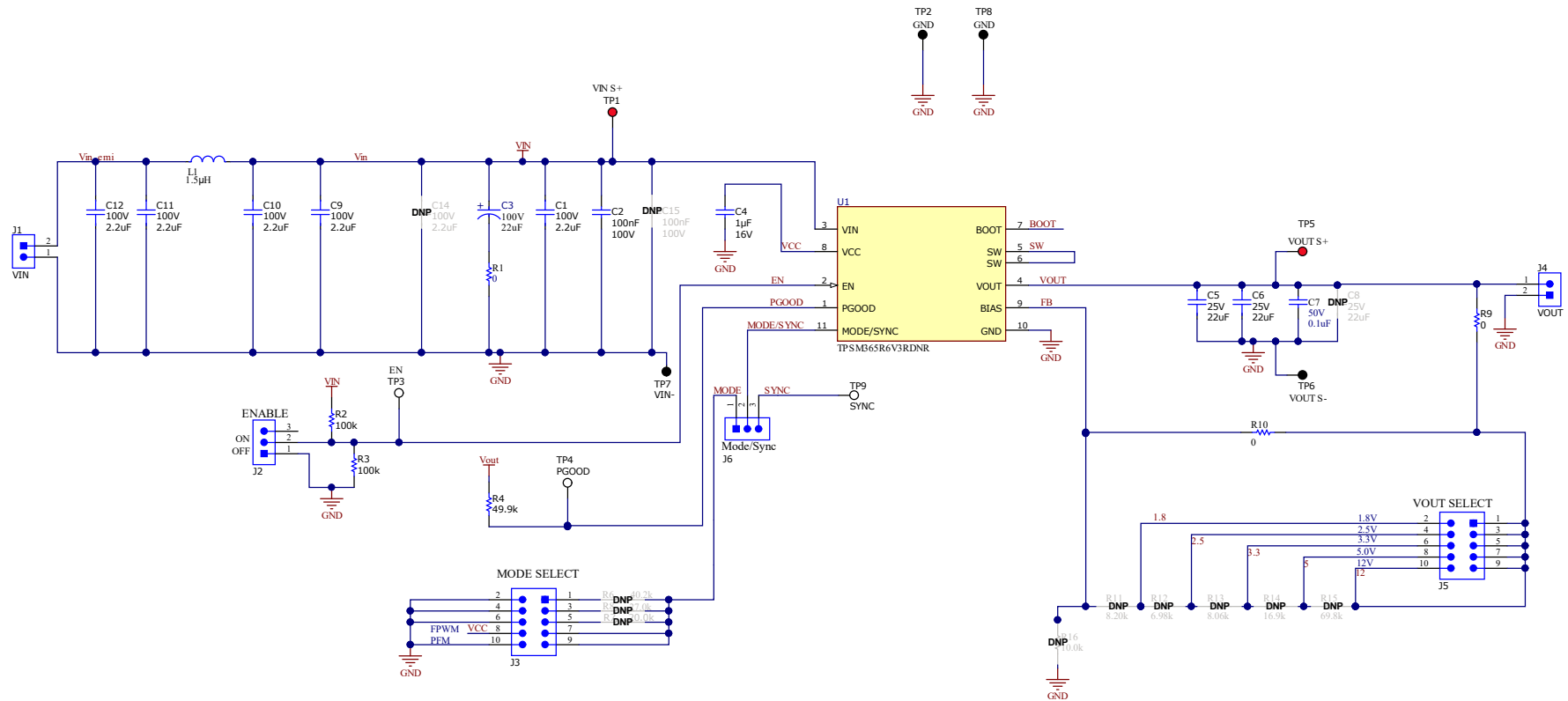


Figure 3-1. TPSM365R6V3EVM Schematic

4 Board Layout

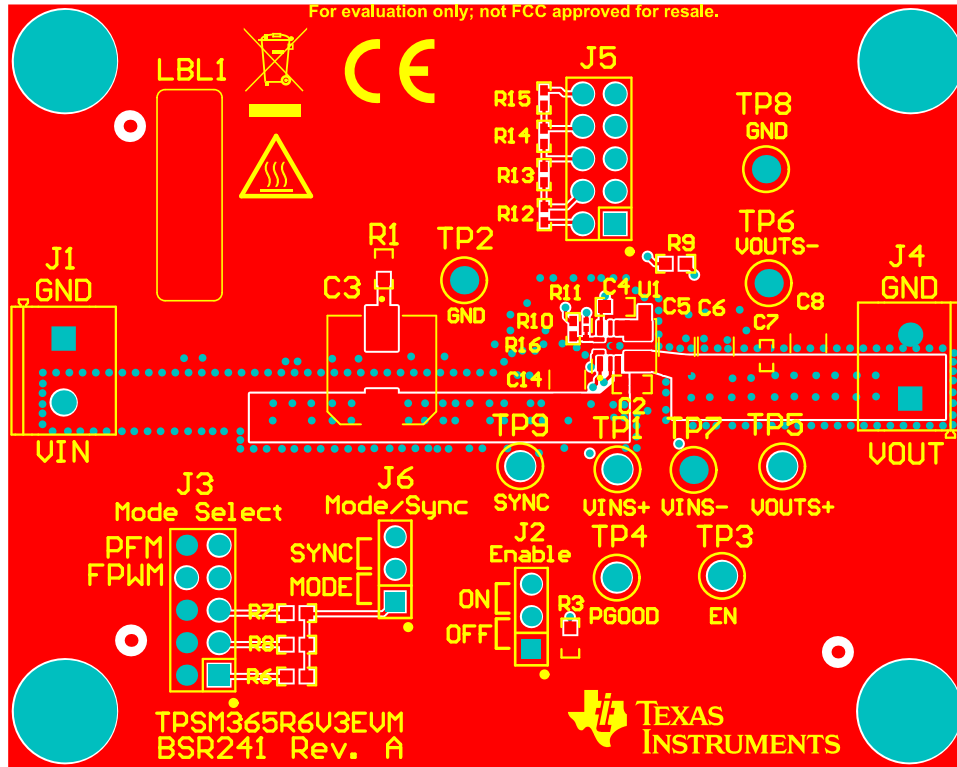


Figure 4-1. Top View of EVM

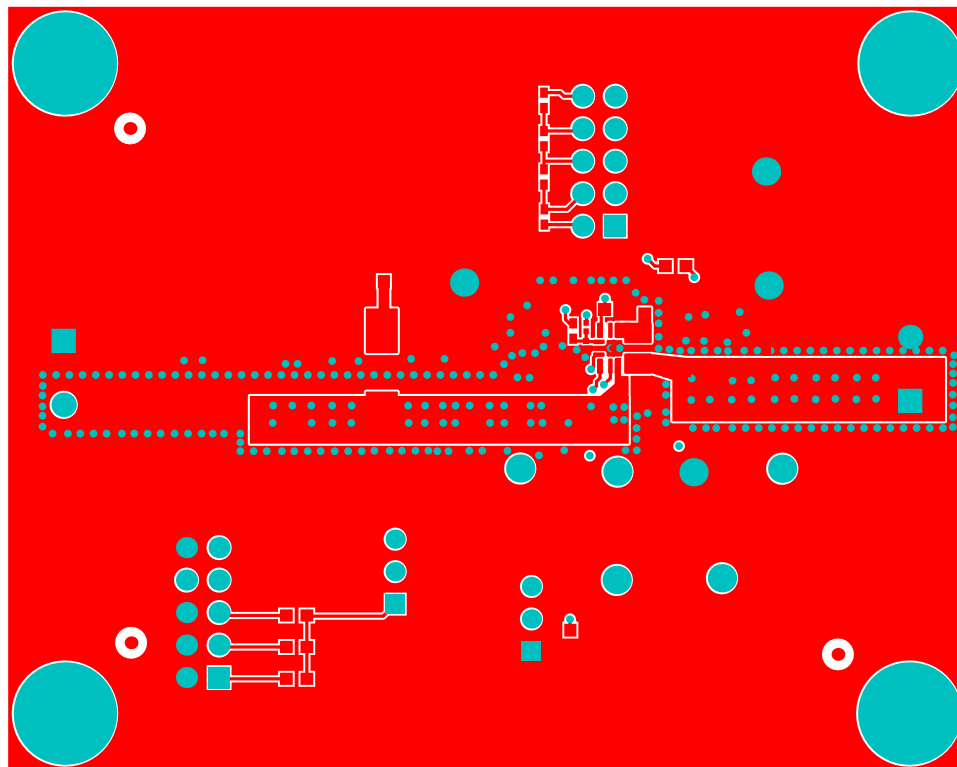


Figure 4-2. EVM Top Copper Layer

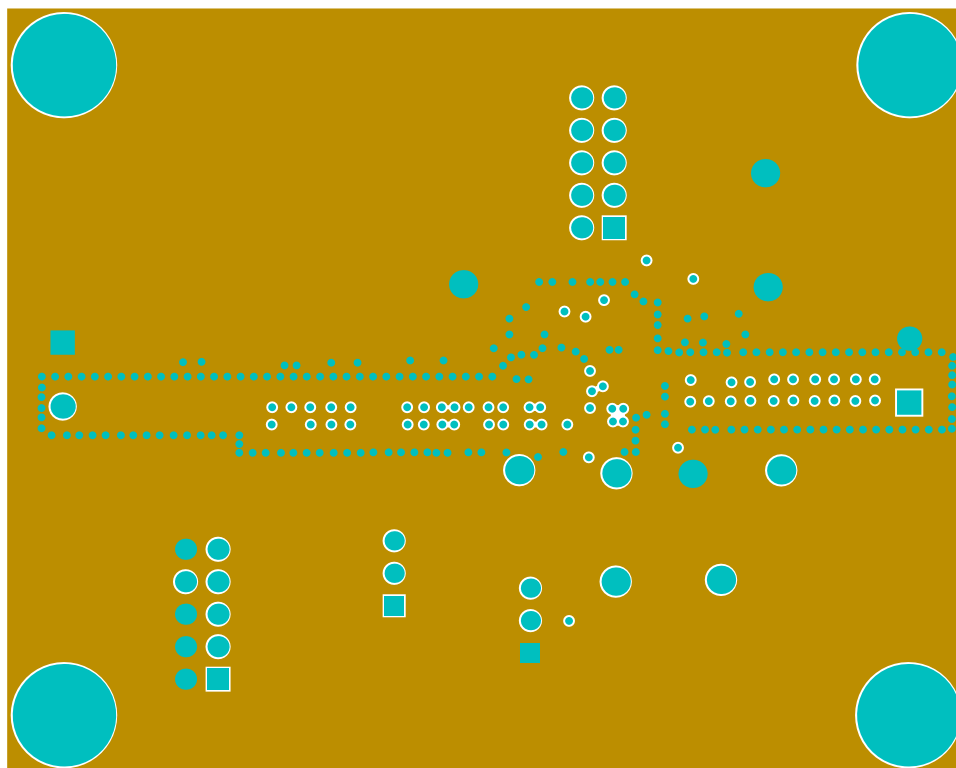


Figure 4-3. EVM Mid Layer One

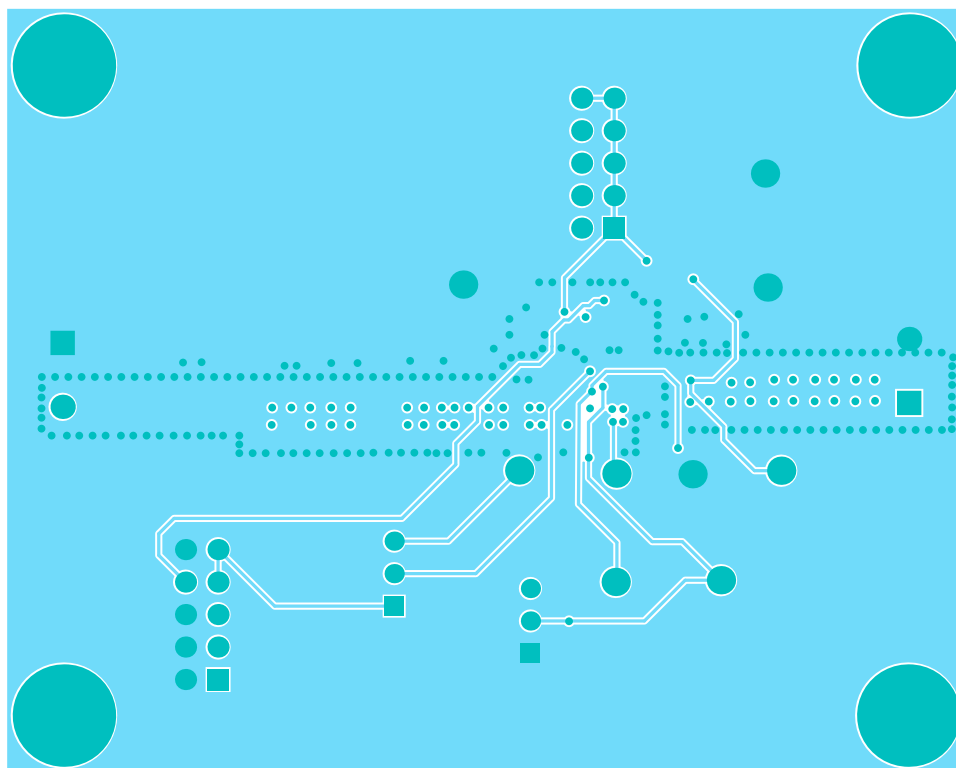


Figure 4-4. EVM Mid Layer Two

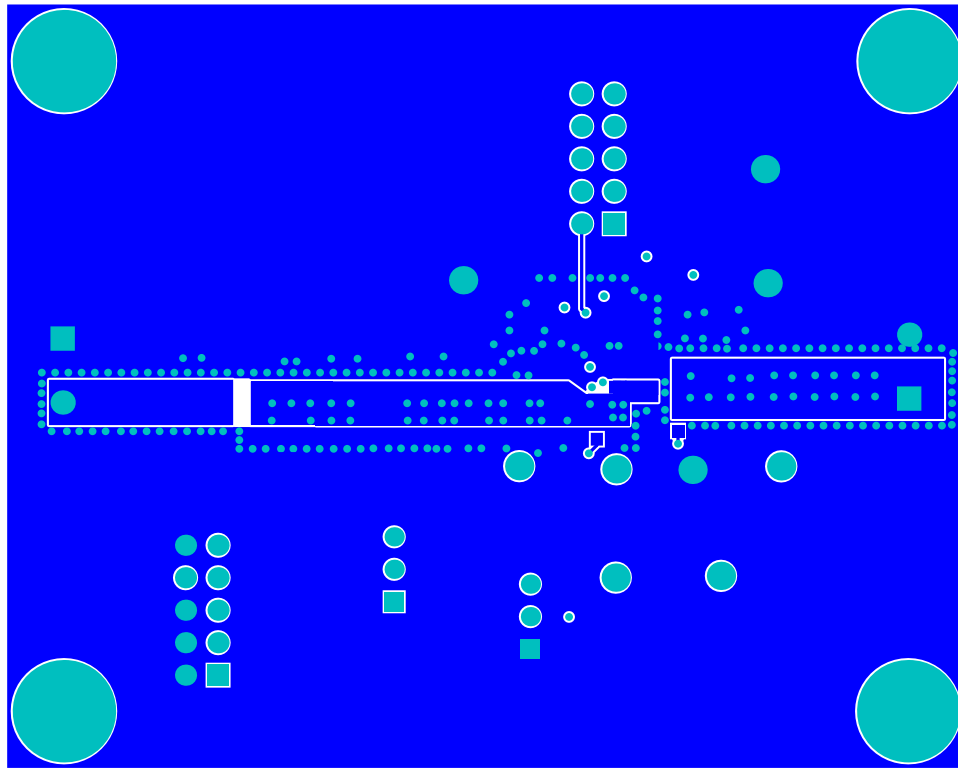


Figure 4-5. EVM Bottom Copper Layer

5 Bill of Materials

Table 5-1. Bill Of Materials

DESIGNATOR	PARTNUMBER	DESCRIPTION	MANUFACTURER	QUANTITY
C1, C9, C10, C11, C12	C3225X7R2A225K230AB	Multilayer Ceramic Capacitors 2.2uF ±10% 100V X7R SMD 1210	TDK	5
C2	GRM188R72A104KA35J	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	MuRata	1
C3	UT226M100HFKTA	Cap Aluminum 22uF 100V 20% (8 X 10.2mm) SMD 1.3 Ohm 70mA 2000h 125 C T/R	Aillen	1
C4	C1608X7R1C105K080AC	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	TDK	1
C5, C6	C3225X7R1E226M250AB	Cap Ceramic 22uF 25V X7R 20% Pad SMD 1210 125C T/R	TDK	2
C7	C1005X7R1H104K050BE	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0402	TDK	1
C8	C3225X7R1E226M250AB	Cap Ceramic 22uF 25V X7R 20% Pad SMD 1210 125C T/R	TDK	0
C14	C3225X7R2A225K230AB	Multilayer Ceramic Capacitors 2.2uF ±10% 100V X7R SMD 1210	TDK	0
C15	GRM188R72A104KA35J	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	MuRata	0
J1, J4	1729018	TERM BLOCK 2POS 5mm, TH	Phoenix Contact	2
J2, J6	PEC03SAAN	Header, 100mil, 3x1, Tin, TH	Sullins Connector Solutions	2
J3, J5	PEC05DAAN	Header, 100mil, 5x2, Tin, TH	Sullins Connector Solutions	2
L1	XGL4020-152MEC	Shielded Power Inductors	Coilcraft	1
R1, R9	RC0603JR-070RL	RES, 0, 5%, 0.1 W, 0603	Yageo	2
R2, R3	CRCW0603100KJNEAC	RES, 100 k, 5%, 0.1 W, 0603	Vishay-Dale	2
R4	RC0603FR-0749K9L	RES, 49.9 k, 1%, 0.1 W, 0603	Yageo	1
R6	RC0603FR-0740K2L	RES, 40.2 k, 1%, 0.1 W, 0603	Yageo	0
R7	RC0603FR-0720KL	RES, 20.0 k, 1%, 0.1 W, 0603	Yageo	0
R8	RC0603FR-0727KL	RES, 27.0 k, 1%, 0.1 W, 0603	Yageo	0
R10	CRCW04020000Z0EDHP	RES, 0, 0%, 0.2 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	1
R11	RC0201FR-078K2L	RES, 8.20 k, 1%, 0.05 W, 0201	Yageo America	0
R12	CRCW04026K98FKED	RES, 6.98 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	0
R13	CRCW04028K06FKED	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	0
R14	CRCW040216K9FKED	RES, 16.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	0
R15	CRCW040269K8FKED	RES, 69.8 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	0
R16	RC0201FR-7D10KL	RES, 10.0 k, 1%, 0.05 W, 0201	Yageo America	0
SH-J1, SH-J2, SH-J3, SH-J4	SNT-100-BK-G	Shunt, 100mil, Gold plated, Black	Samtec	4
TP1, TP5	5010	Test Point, Multipurpose, Red, TH	Keystone	2
TP2, TP6, TP7, TP8	5011	Test Point, Multipurpose, Black, TH	Keystone	4
TP3, TP4, TP9	5012	Test Point, Multipurpose, White, TH	Keystone	3
U1	TPSM365R6V3RDNR	3 V to 65 V Input, 1 V to 13 V Output, 600-mA Synchronous Buck Converter Power Module in a HotRod™ QFN Package	Texas Instruments	1

6 Typical Characteristics

Unless otherwise specified, the following conditions apply: $T_A = 25^\circ\text{C}$, $V_{IN} = 24\text{ V}$

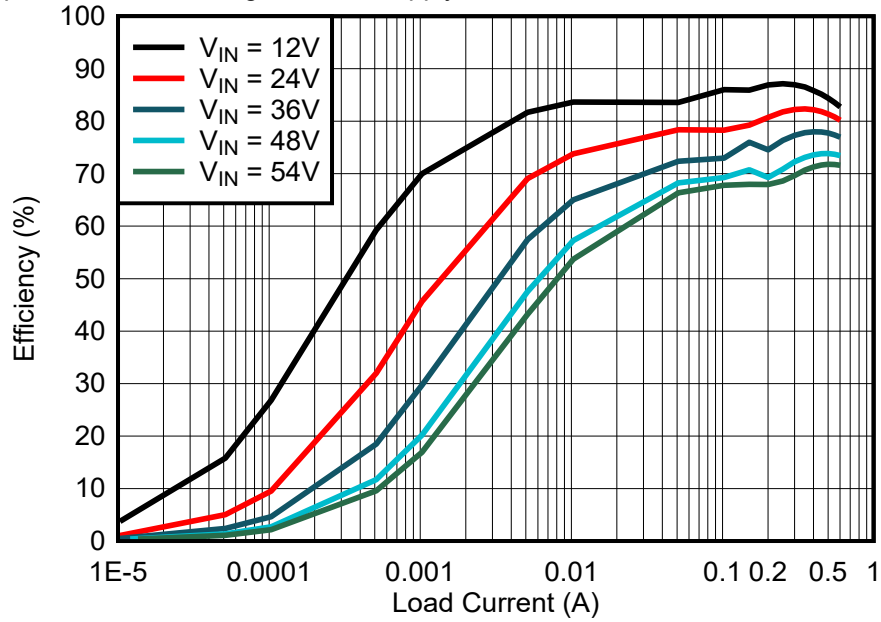


Figure 6-1. Efficiency 3.3-V Output, $F_{SW} = 1\text{ MHz}$, Auto Mode

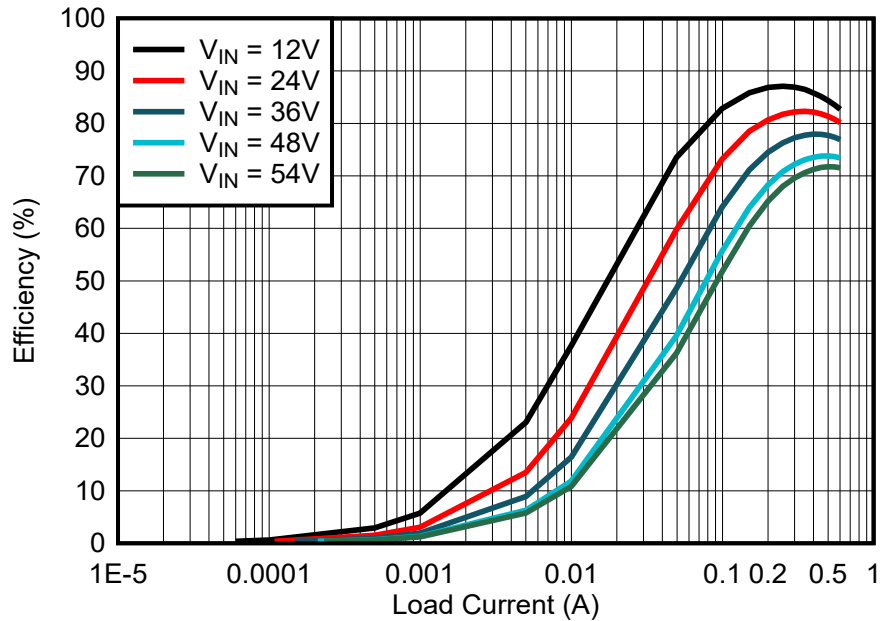


Figure 6-2. Efficiency 3.3-V Output, $F_{SW} = 1\text{ MHz}$, FPWM

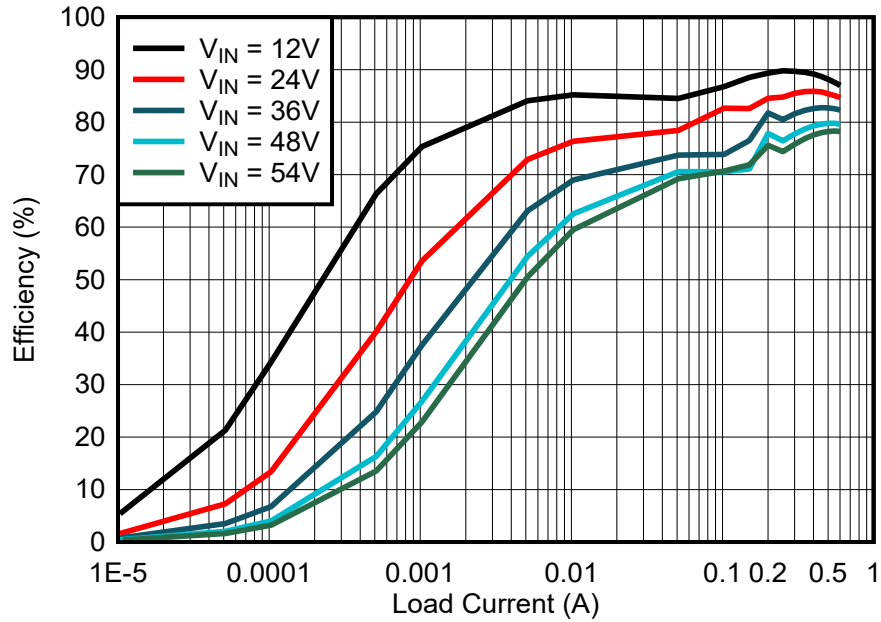


Figure 6-3. Efficiency 5-V Output, $F_{SW} = 1$ MHz, Auto Mode

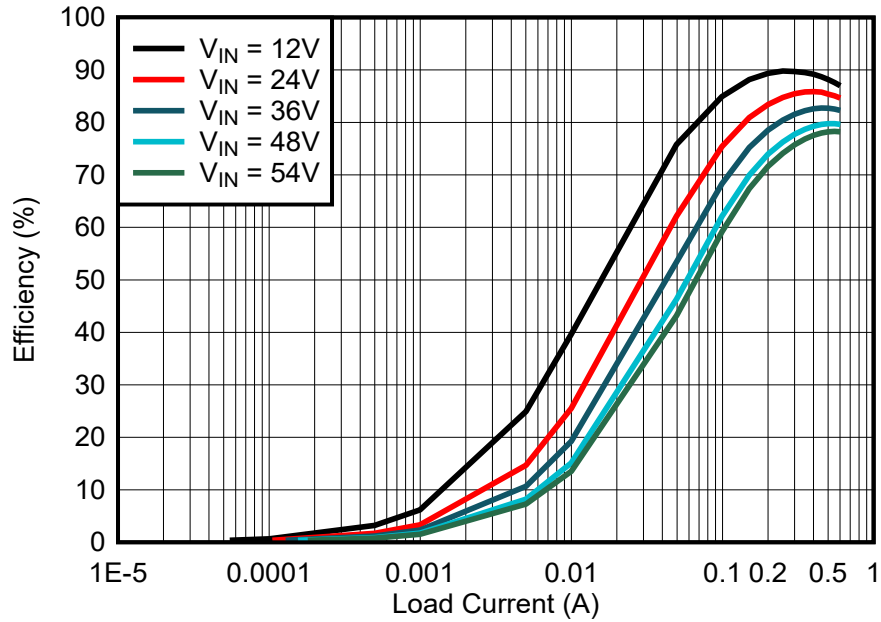


Figure 6-4. Efficiency 5-V Output, $F_{SW} = 1$ MHz, FPWM

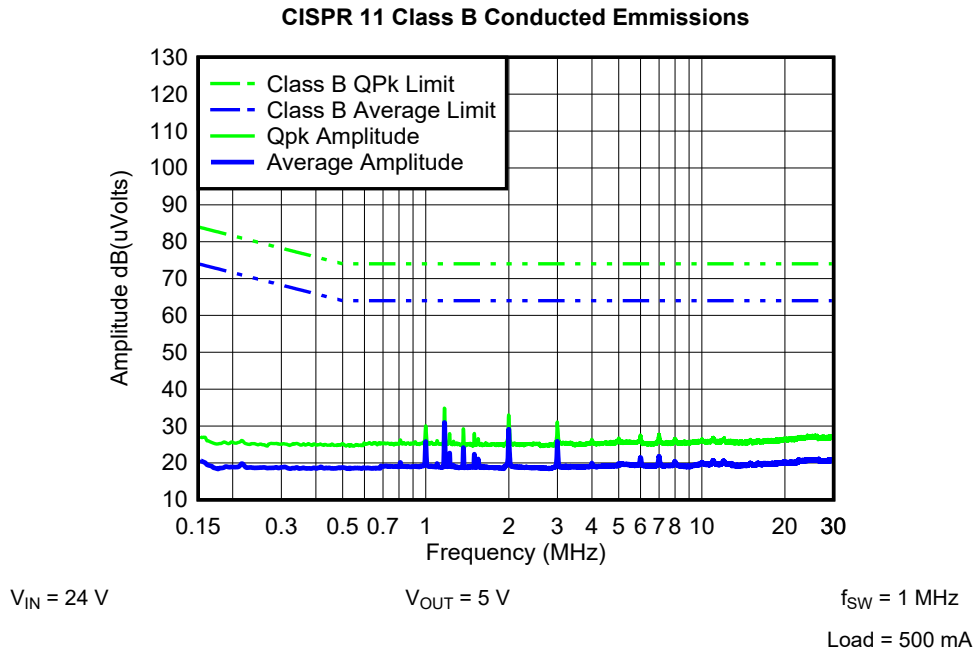


Figure 6-5. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz with EMI Filter (Standard EVM Layout and BOM)

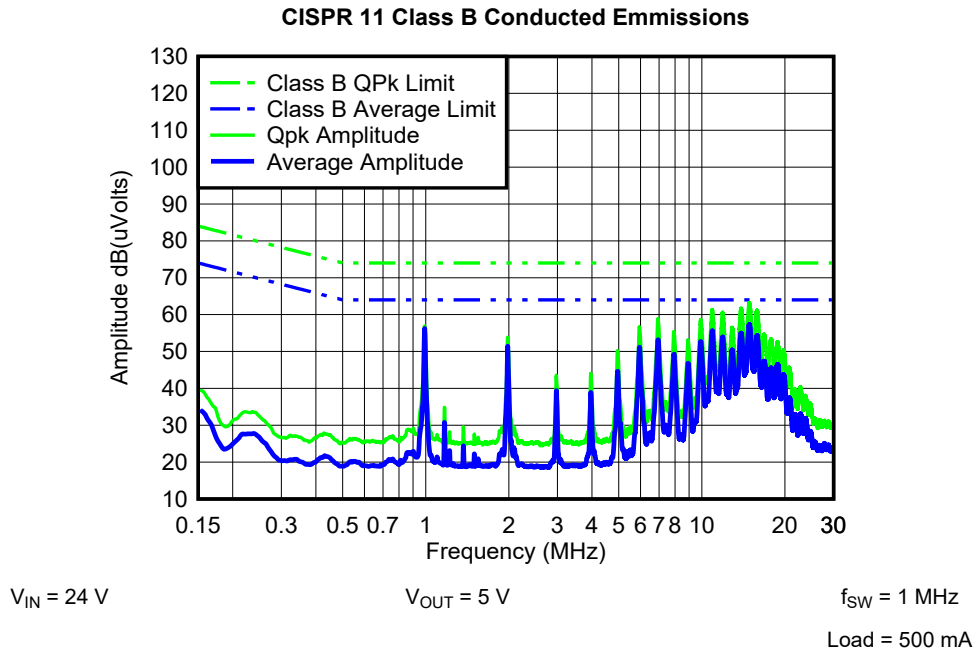
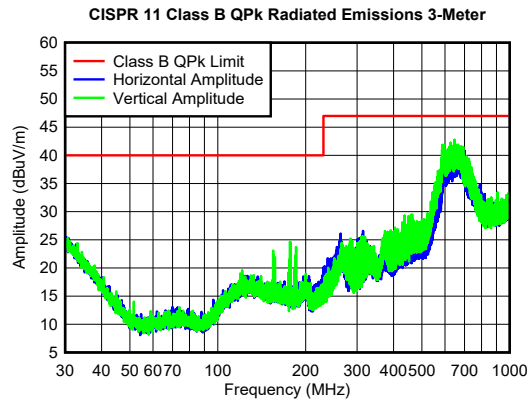


Figure 6-6. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz without EMI Filter (Standard EVM Layout and BOM)



$V_{IN} = 24\text{ V}$

$V_{OUT} = 5\text{ V}$

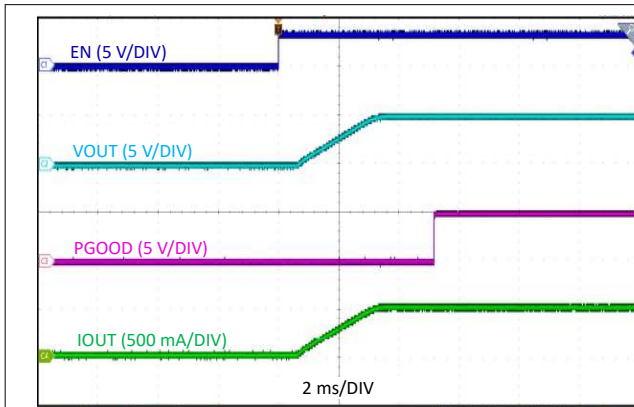
$f_{SW} = 1\text{ MHz}$

Load = 500 mA

Figure 6-7. Typical CISPR 11 Class B Radiated EMI 30 kHz - 1000 MHz (Standard EVM Layout and BOM, Input Filter Removed)

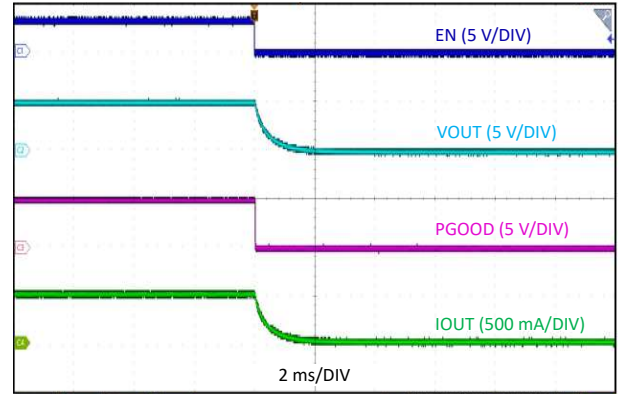
7 Application Curves

Unless otherwise indicated, $V_{IN} = 24\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_{OUT} = 0.5\text{ A}$, and $F_{SW} = 1\text{ MHz}$



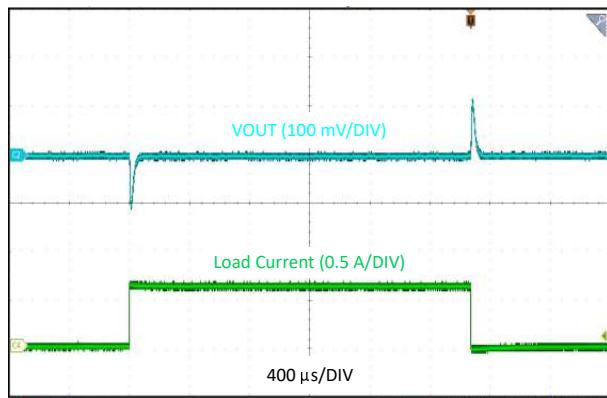
$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$

Figure 7-1. Start-Up Waveforms



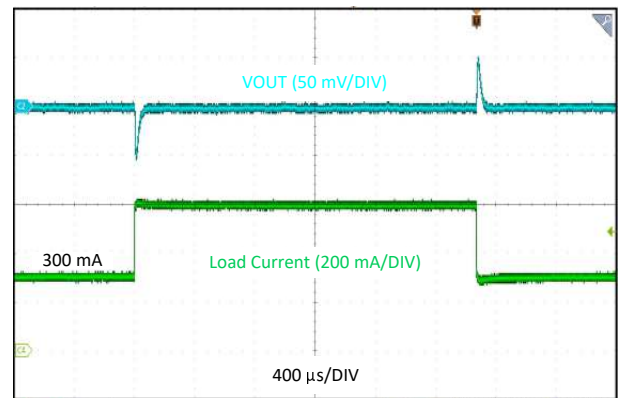
$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$

Figure 7-2. Shutdown Waveforms



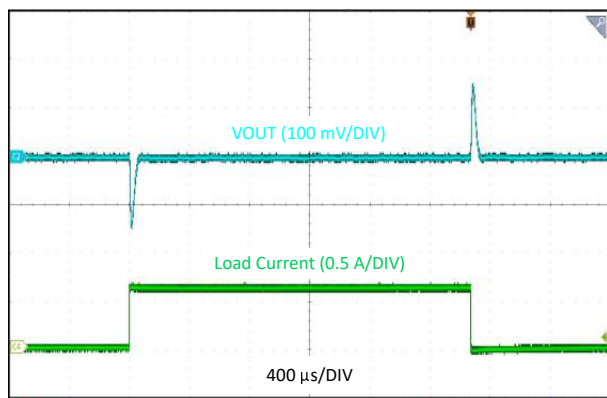
$V_{IN} = 24\text{ V}$ $V_{OUT} = 3.3\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-3. Load Transient, 0 A to 0.6 A, 1 A/μs



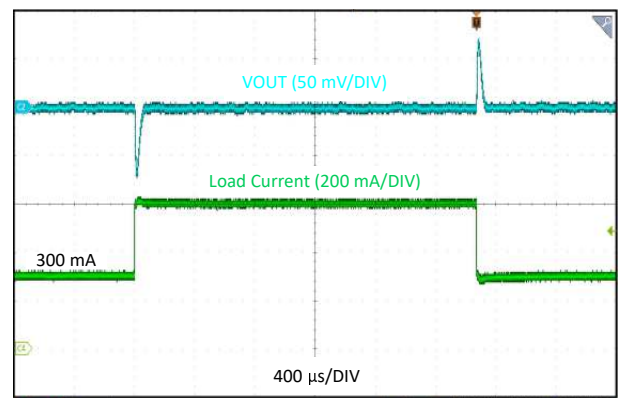
$V_{IN} = 24\text{ V}$ $V_{OUT} = 3.3\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-4. Load Transient, 0.3 A to 0.6 A, 1 A/μs



$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-5. Load Transient, 0 A to 0.6 A, 1 A/μs



$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-6. Load Transient, 0.3 A to 0.6 A, 1 A/μs

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.
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 - 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.

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NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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。
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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.
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