TPS563209EVM-652 3-A, SWIFT™ Regulator Evaluation Module

This user's guide contains information for the TPS563209 as well as support documentation for the TPS563209EVM-652 evaluation module. Included are the performance specifications, schematic, and the bill of materials of the TPS563209EVM-652.

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1 Introduction

The TPS563209 is a single, adaptive on-time, D-CAP2™ mode, synchronous buck converter requiring a very low external component count. The D-CAP2 control circuit is optimized for low-ESR output capacitors such as POSCAP, SP-CAP, or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 650 kHz. Forced CCM operation maintains constant frequency at light load conditions. The high-side and low-side switching MOSFETs are incorporated inside the TPS563209 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS563209 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS563209 dc/dc synchronous converter is designed to provide up to a 3-A output from an input voltage source of 4.5 V to 17 V. The output voltage range is from 0.8 V to 6.5 V. Rated input voltage and output current ranges for the evaluation module are given in Table 1.

The TPS563209EVM-652 evaluation module (EVM) is a single, synchronous buck converter providing 1.05 V at 3 A from 4.5-V to 17-V input. This user's guide describes the TPS563209EVM-652 performance.

Table 1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS563209EVM-652	V_{IN} = 4.5 V to 17 V	0 A to 3 A

2 Performance Specification Summary

A summary of the TPS563209EVM-652 performance specifications is provided in Table 2. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.05 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2. TPS563209EVM-652Performance Specifications Summary

Specifications		Test Conditions	Min	Typ	Max	Unit
Input voltage range (V_{IN})			4.5	12	17	V
CH1	Output voltage			1.05		V
	Operating frequency	V_{IN} = 12 V, I_O = 3 A		650		kHz
	Output current range		0		3	A
	Over current limit	V_{IN} = 12 V, L_O = 1.5 µH				A
	Output ripple voltage	V_{IN} = 12 V, I_O = 3 A		20		mV_{PP}

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3 Modifications

These evaluation modules are designed to provide access to the features of the TPS563209. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, it is necessary to change the value of resistor R1. Changing the value of R1 can change the output voltage above 0.765 V. The value of R1 for a specific output voltage can be calculated using Equation 1.

$$R1 = \frac{R2 \times (V_{OUT} - 0.765\ V)}{0.765\ V} \quad (1)$$

Table 3 lists the R5 values for some common output voltages. Note that the values given in Table 3 are standard values and not the exact value calculated using Table 3.

Table 3. Output Voltages

Output Voltage (V)	R1 (kΩ)	R2 (kΩ)	L1 (µH)			C5 + C6 +C7 (µF)
			Min	Typ	Max	
1.0	3.09	10.0	1.5	2.2	4.7	20 - 68
1.05	3.74	10.0	1.5	2.2	4.7	20 - 68
1.2	5.76	10.0	1.5	2.2	4.7	20 - 68
1.5	9.53	10.0	1.5	2.2	4.7	20 - 68
1.8	13.7	10.0	1.5	2.2	4.7	20 - 68
2.5	22.6	10.0	2.2	3.3	4.7	20 - 68
3.3	33.2	10.0	2.2	3.3	4.7	20 - 68
5.0	54.9	10.0	3.3	4.7	4.7	20 - 68
6.5	75.0	10.0	3.3	4.7	4.7	20 - 68

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4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS563209EVM-652. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start-up, and switching frequency.

4.1 Input/Output Connections

The TPS563209EVM-652 is provided with input/output connectors and test points as shown in Table 4. A power supply capable of supplying 3 A must be connected to J1 through a pair of 20-AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 3 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the V_{IN} input voltages with TP2 providing a convenient ground reference. TP7 is used to monitor the output voltage with TP8 as the ground reference.

Table 4. Connection and Test Points

Reference Designator	Function
J1	V_{IN} (see Table 1 for V_{IN} range)
J2	V_{OUT}, 1.05 V at 3-A maximum
JP1	EN control. Shunt EN to GND to disable, shunt EN to V_{IN} to enable.
TP1	V_{IN} positive monitor point
TP2	GND monitor test point
TP3	EN test point
TP4	Switch node test point
TP5	Test point for loop response measurements
TP6	V_{OUT} positive monitor point
TP7	GND monitor test point

4.2 Start-Up Procedure

1. Ensure that the jumper at JP1 (Enable control) pins 1 and 2 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate V_{IN} voltage to VI (J1-2) and GND (J1-1).
3. Move the jumper at JP1 (Enable control) from pins 1 and 2 (EN and GND), to pins 2 and 3 (EN and V_{IN}) enabling the output.

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4.3 Efficiency

Figure 1 shows the efficiency for the TPS563209EVM-652 at an ambient temperature of 25°C.

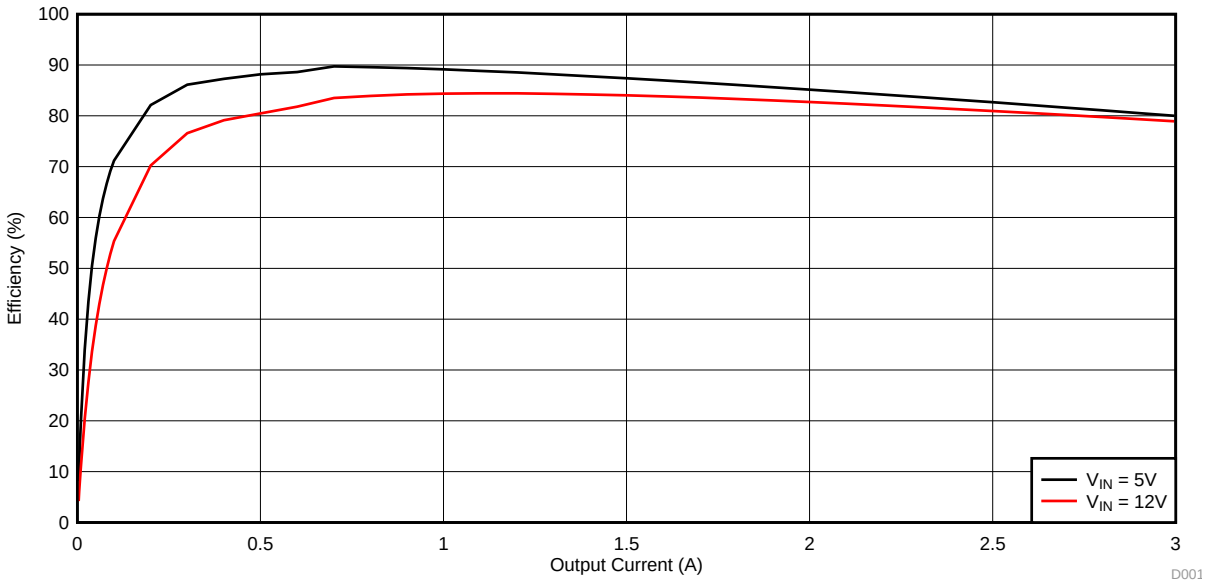


Figure 1. TPS563209EVM-652 Efficiency

Figure 2 shows the efficiency at light loads for the TPS563209EVM-652 at an ambient temperature of 25°C.

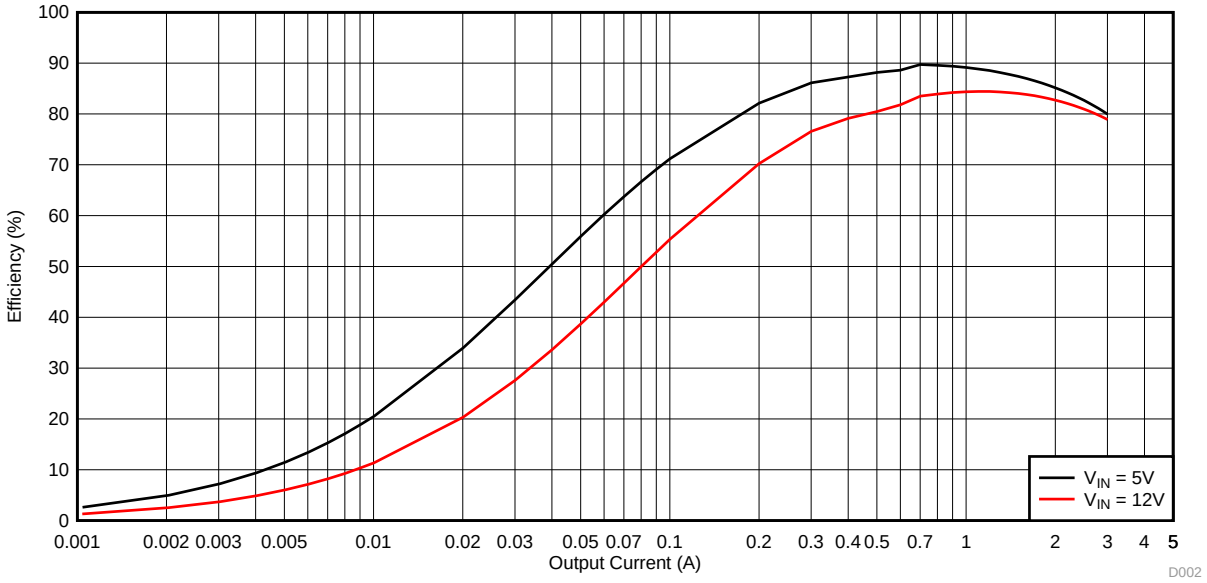


Figure 2. TPS563209EVM-652 Light Load Efficiency

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4.4 Load Regulation

The load regulation for the TPS563209EVM-652 is shown in Figure 3 and Figure 4.

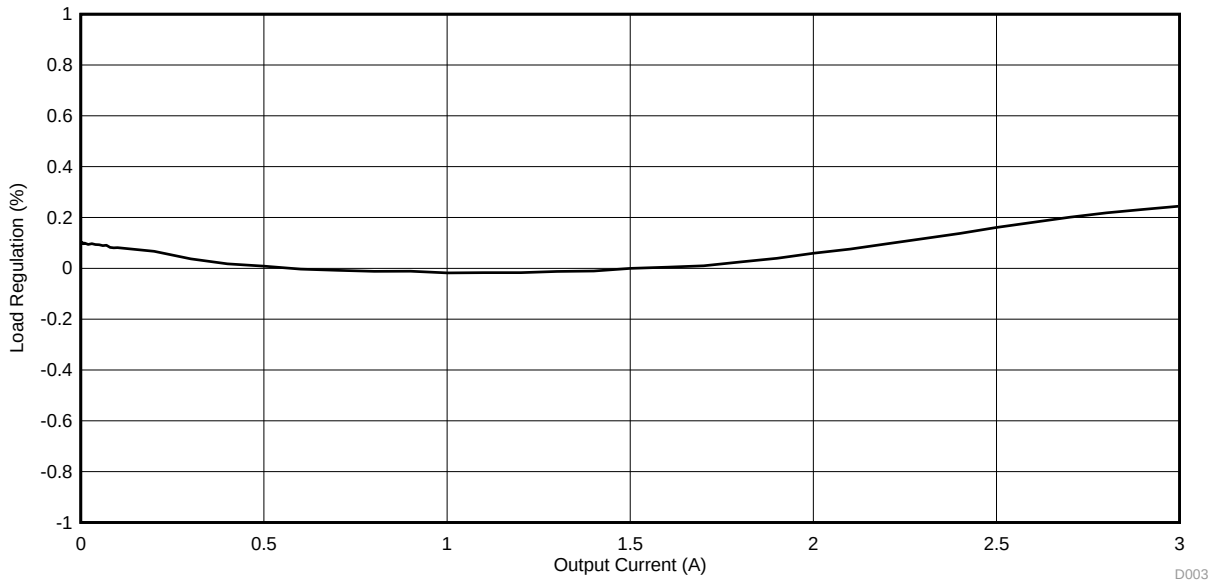


Figure 3. TPS563209EVM-652 Load Regulation, 5-V Input

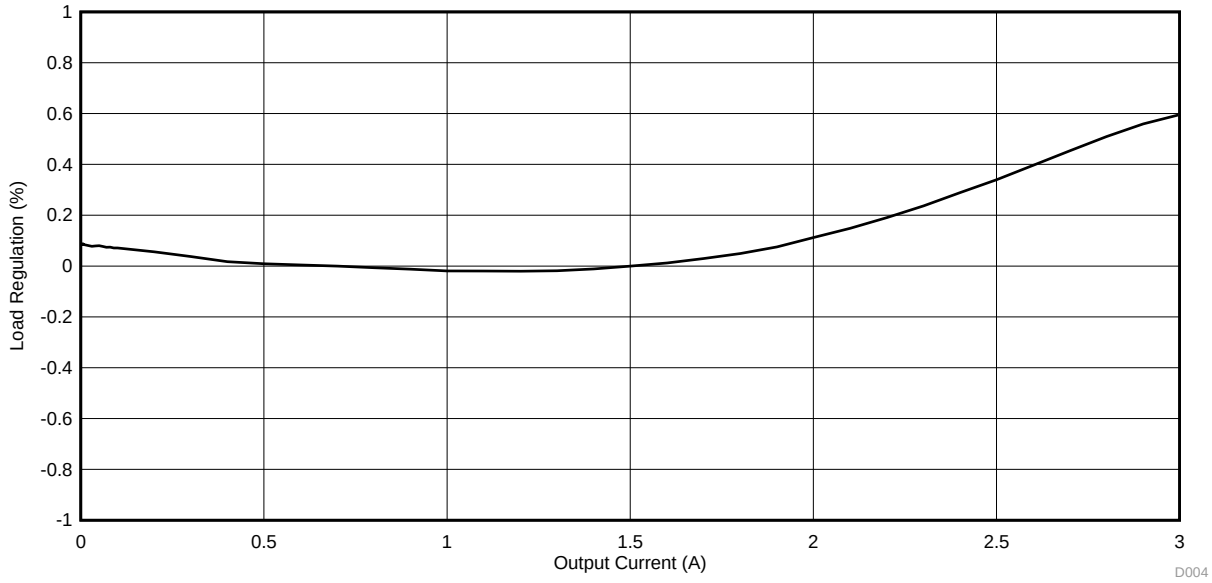


Figure 4. TPS563209EVM-652 Load Regulation, 12-V Input

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4.5 Line Regulation

The line regulation for the TPS563209EVM-652 is shown in Figure 5.

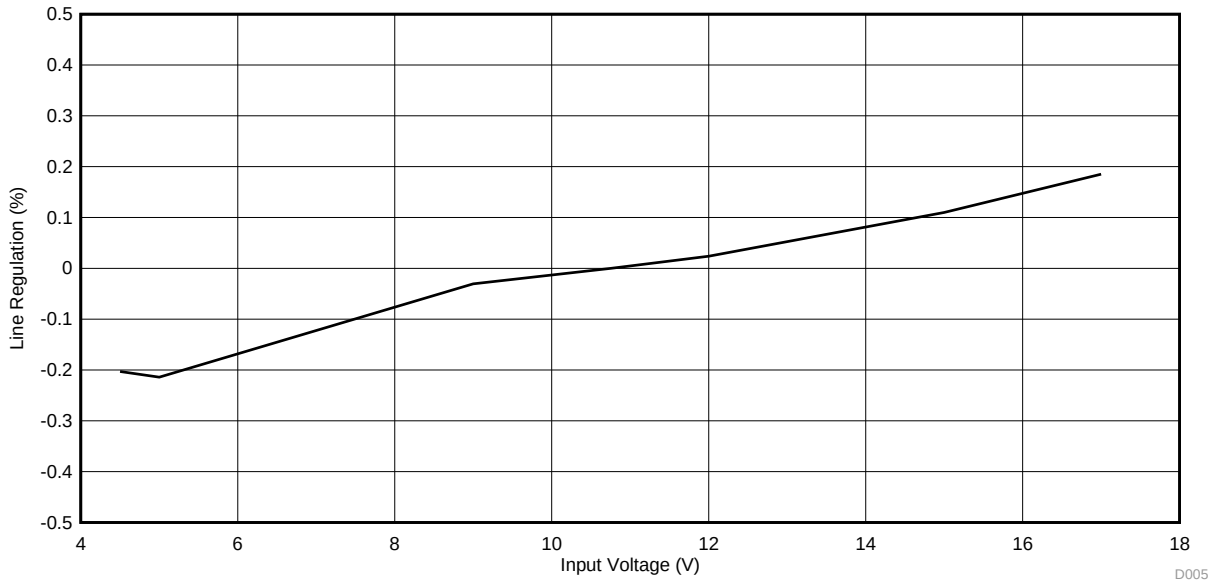


Figure 5. TPS563209EVM-652 Line Regulation

4.6 Load Transient Response

The TPS563209EVM-652 response to load transient is shown in Figure 6. The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown.

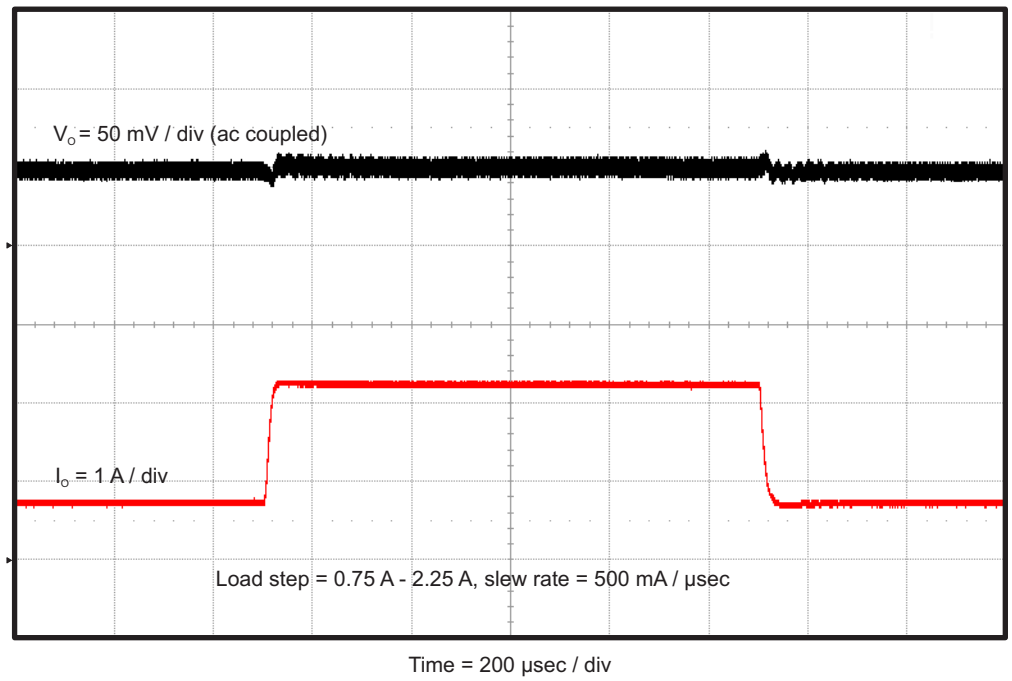


Figure 6. TPS563209EVM-652 Load Transient Response, 25% to 75% Load Step

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4.7 Output Voltage Ripple

The TPS563209EVM-652 output voltage ripple is shown in Figure 7, and Figure 8. The output currents are as indicated.

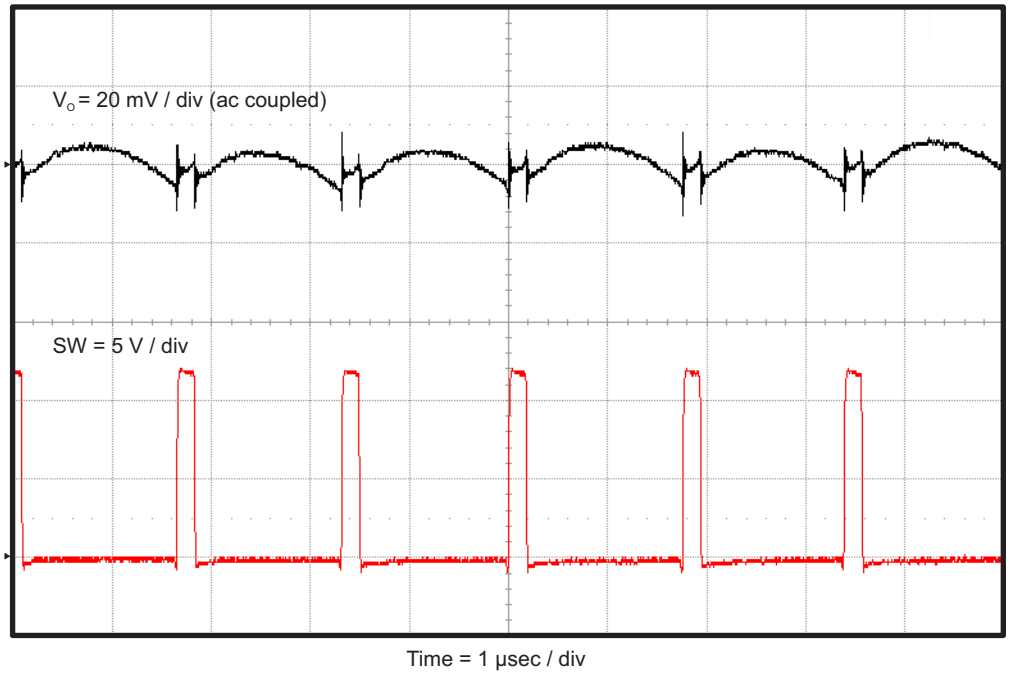


Figure 7. TPS563209EVM-652 Output Voltage Ripple, I_{OUT} = 3 A

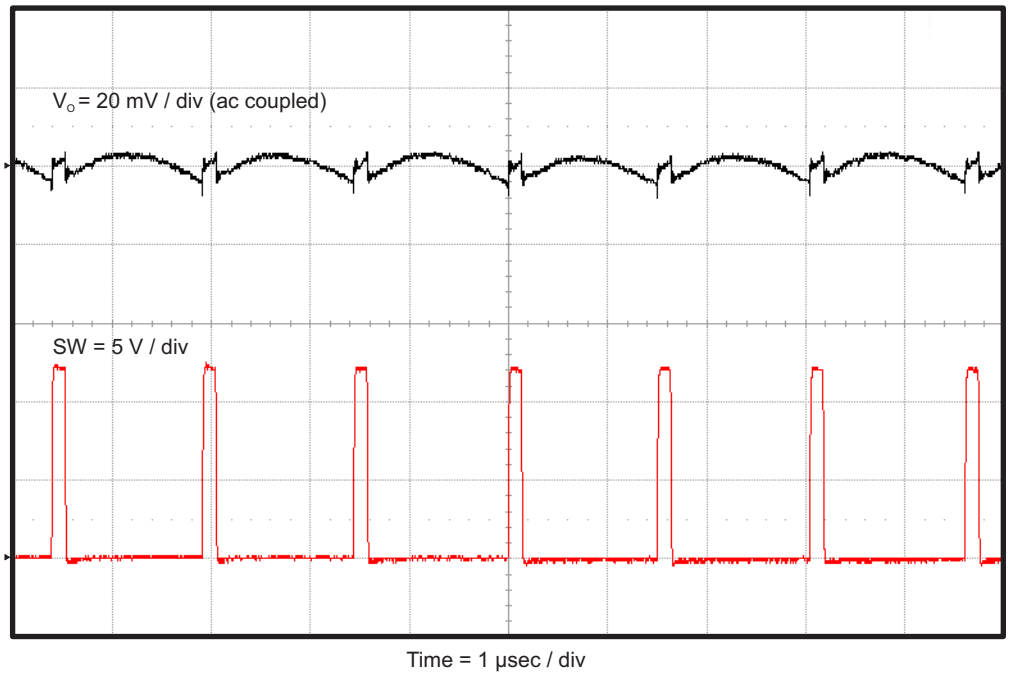


Figure 8. TPS563209EVM-652 Output Voltage Ripple, I_{OUT} = 0 mA

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4.8 Input Voltage Ripple

The TPS563209EVM-652 input voltage ripple is shown in Figure 9. The output current is as indicated.

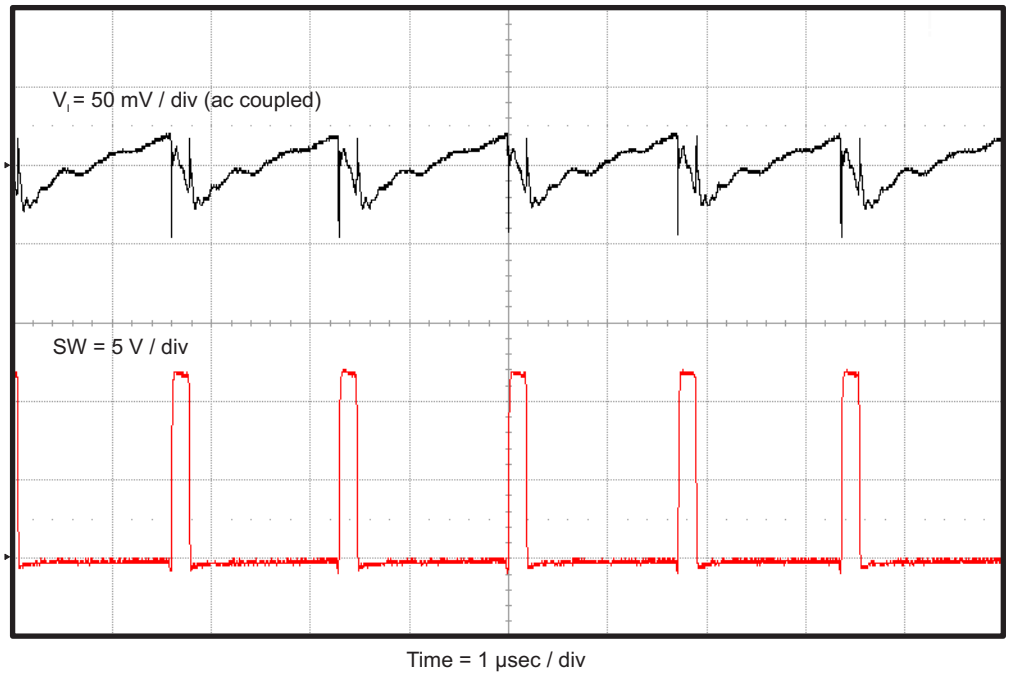


Figure 9. TPS563209EVM-652 Input Voltage Ripple, I_{OUT} = 3 A

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4.9 Start-Up

The TPS563209EVM-652 start-up waveform relative to V_{IN} is shown in Figure 10. Load = 1 Ω resistive.

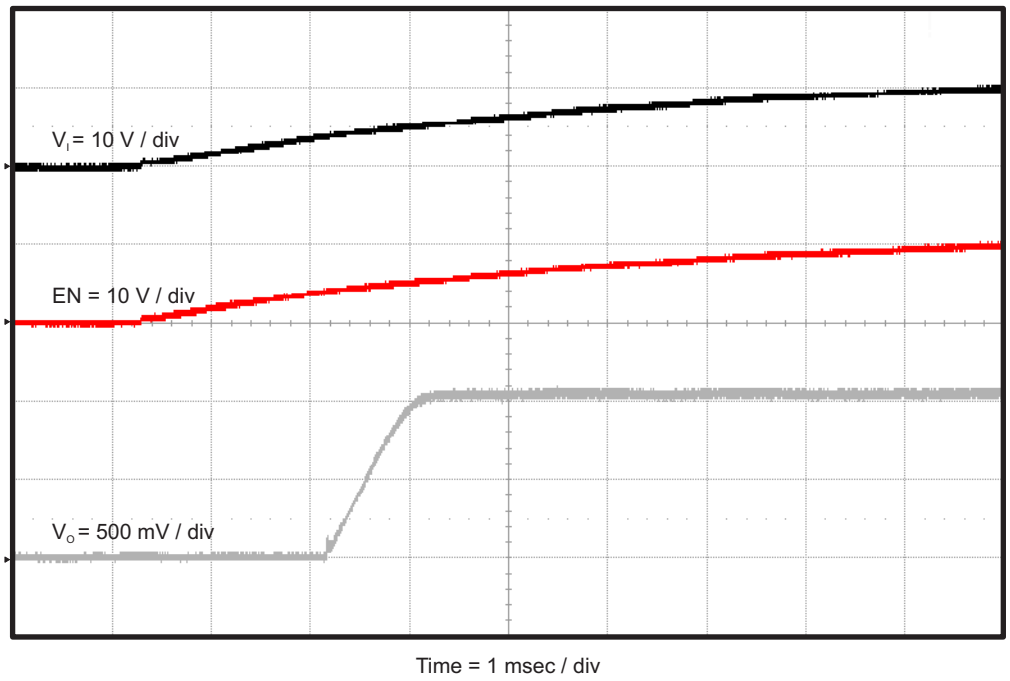


Figure 10. TPS563209EVM-652 Start-Up Relative to V_{IN}

The TPS563209EVM-652 start-up waveform relative to enable (EN) is shown in Figure 11. Load = 1 Ω resistive.

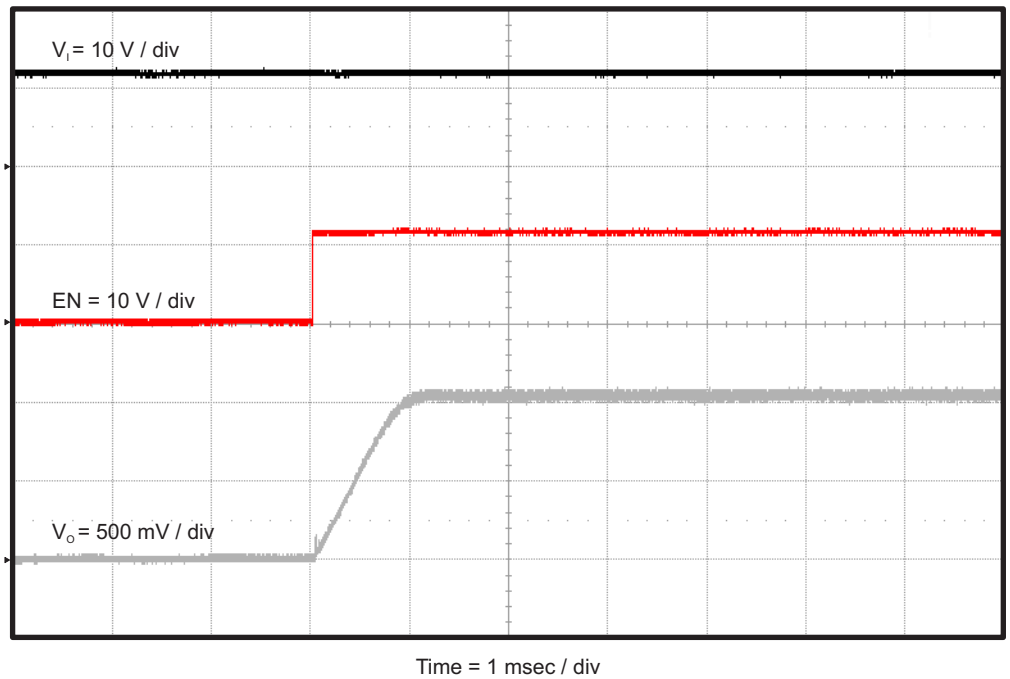


Figure 11. TPS563209EVM-652 Start-Up Relative to EN

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4.10 Shut-Down

The TPS563209EVM-652 shut-down waveform relative to V_{IN} is shown in Figure 12. Load = 1 Ω resistive.

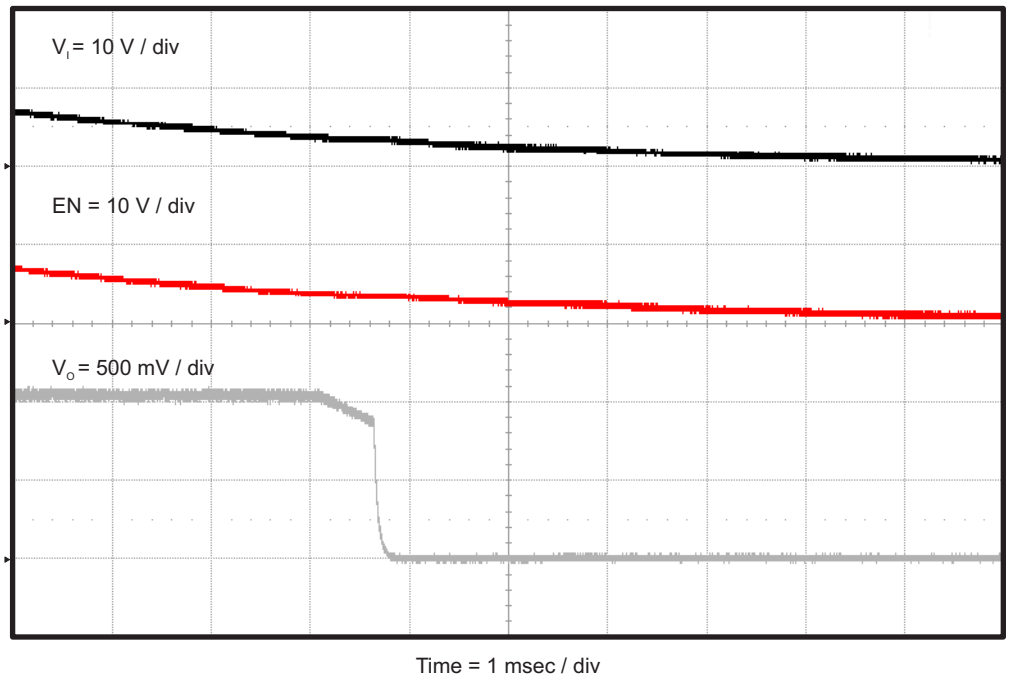


Figure 12. TPS563209EVM-652 Shut-Down Relative to V_{IN}

The TPS563209EVM-652 shut-down waveform relative to EN is shown in Figure 13. Load = 1 Ω resistive.

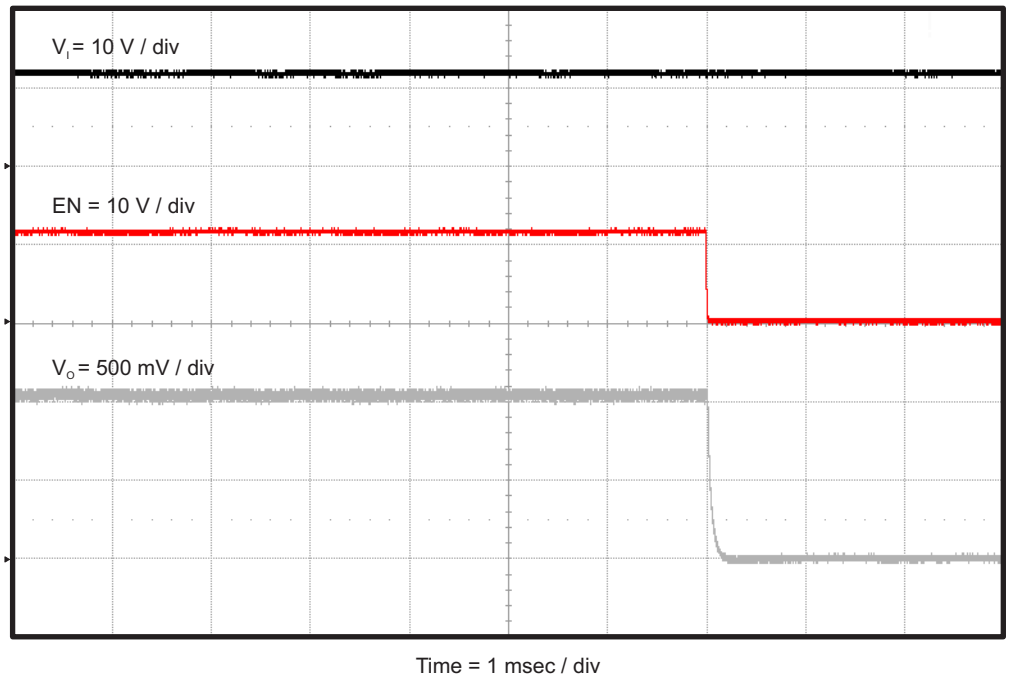


Figure 13. TPS563209EVM-652 Shut-Down Relative to EN

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5 Board Layout

This section provides a description of the TPS563209EVM-652, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS563209EVM-652 is shown in Figure 14, Figure 15, and Figure 16. The top layer contains the main power traces for VIN, VOUT, and ground. Also on the top layer are connections for the pins of the TPS563209 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C1, C2, and C3 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the switching node copper fill, signal ground copper fill and the feed back trace from the point of regulation to the top of the resistor divider network.

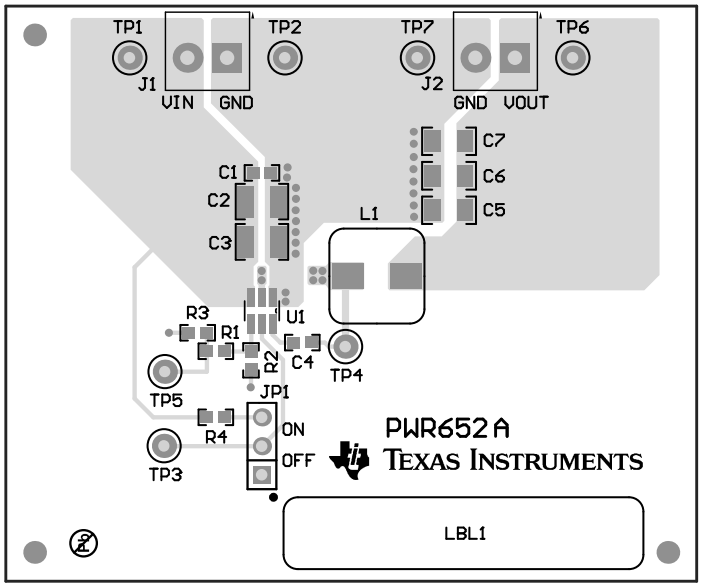


Figure 14. Top Assembly

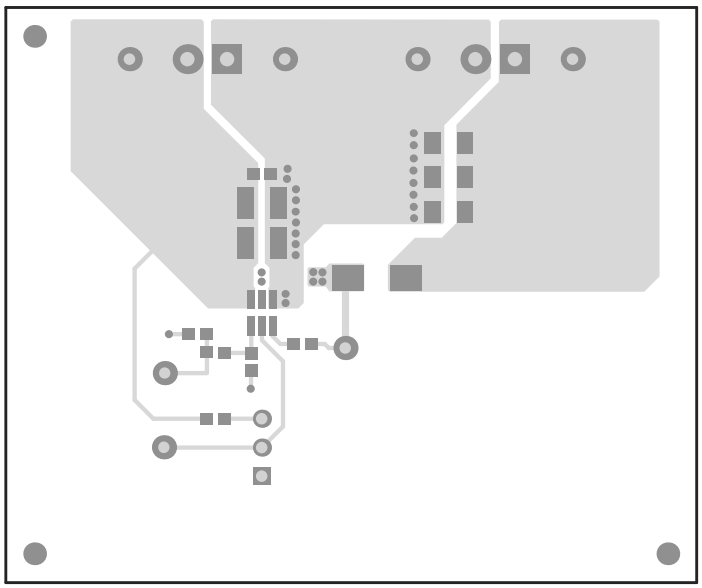


Figure 15. Top Layer

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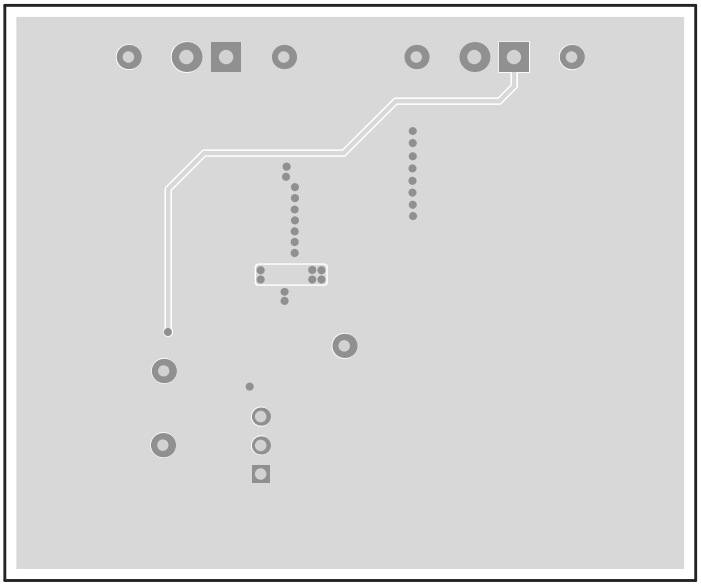


Figure 16. Bottom Layer

6 Schematic, Bill of Materials, and Reference

6.1 Schematic

Figure 17 is the schematic for the TPS563209EVM-652.

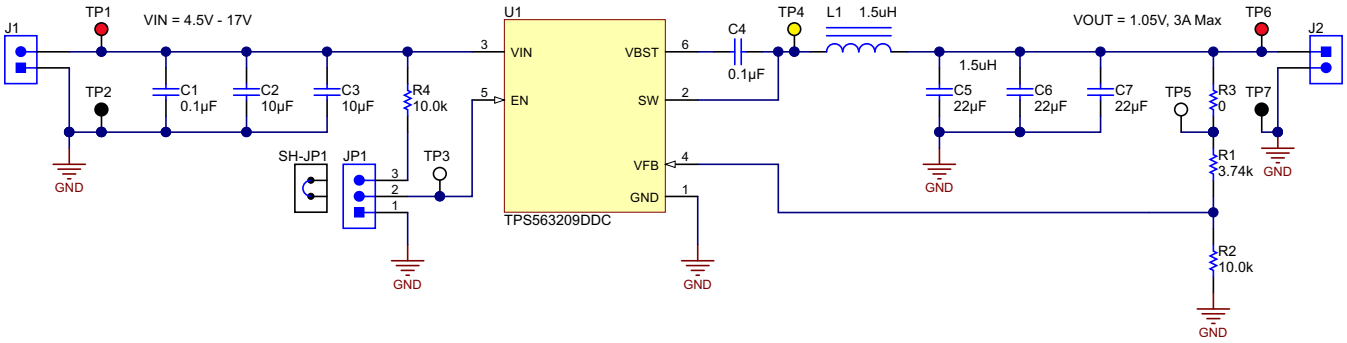


Figure 17. TPS563209EVM-652 Schematic Diagram

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6.2 Bill of Materials

Table 5. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PWR652	Any
C1, C4	2	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X5R, 0603	0603	GRM188R61E104KA01D	MuRata
C2, C3	2	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 1210	1210	GRM32DR61E106KA12L	MuRata
C5, C6, C7	3	22uF	CAP, CERM, 22uF, 10V, +/-10%, X7R, 1206	1206	GRM31CR71A226KE15L	MuRata
J1, J2	2		Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology
JP1	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
L1	1	1.5uH	Inductor, Shielded Drum Core, Superflux, 1.5uH, 11A, 0.0078 ohm, SMD	WE-HC4	744311150	Wurth Elektronik eiSos
LBL1	1		Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	PCB Label 1.25"H x 0.250"W	THT-13-457-10	Brady
R1	1	3.74k	RES, 3.74k ohm, 1%, 0.1W, 0603	0603	CRCW06033K74FKEA	Vishay-Dale
R2, R4	2	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R3	1	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic
SH-JP1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP1, TP6	2	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP2, TP7	2	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
TP3, TP5	2	White	Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP4	1	Yellow	Test Point, Miniature, Yellow, TH	Yellow Miniature Testpoint	5004	Keystone
U1	1		TPS563209 4.5V to 17 V Input, 3-A Synchronous Step-Down Voltage Regulator in SOT-23, DDC0006A	DDC0006A	TPS563209DDC	Texas Instruments

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6.3 Reference

1. *TPS562209 2-A, TPS563209 3-A, 4.5-V to 17-V Input, Synchronous Step-Down Voltage Regulator in 6 pin SOT-23* data sheet (SLVSCM5)

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10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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 its own expense.

FCC Interference Statement for Class B EVM devices

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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

http://www.tij.co.jp

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