User's Guide

TPSM8291x Step-Down Power Module Evaluation Module

ABSTRACT

The TPSM8291xEVM (BSR213) facilitates the evaluation of the TPSM8291x 2-A and 3-A pin-to-pin compatible low-noise (< 20 μV_{RMS}) and low-ripple (< 10 μV_{RMS}) buck power modules in small 4.5-mm by 5.5-mm QFN packages. The BSR213-001 uses the 3-A TPSM82913 to output a 1.2-V output voltage from input voltages between 3 V and 17 V. The BSR213-002 uses the 2-A TPSM82912 to output a 3.3-V output voltage from input voltages up to 17 V. Due to its extremely low noise, the TPSM8291x is a high-efficiency alternative to low-dropout (LDO) linear regulators in noise-sensitive circuits, such as data converters, clocks, and amplifiers in telecom infrastructure, medical, test and measurement, and aerospace and defense applications.

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Trademarks

1 Introduction

The TPSM8291x family of devices are low-noise, low-ripple, synchronous, step-down power modules in a small 4.5-mm × 5.5-mm × 1.8-mm QFN package. Two different devices in this family support 2 A or 3 A of output current.

1.1 Performance Specification

Table 1-1 and Table 1-2 provides a summary of the TPSM8291xEVM performance specifications.

Table 1-1. TPSM82913EVM Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage	JP2 open or across 1 MHz and S-CONF	3	12	17	V
Output voltage setpoint			1.2		V
Output current		0		3	A
S-CONF (R7) setting	1 MHz with SYNC available, no spread spectrum, output discharge enabled		52.3		kΩ

Table 1-2. TPSM82912EVM Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage		3.5	12	17	V
Output voltage setpoint			3.3		V
Output current		0		2	A
S-CONF (R7) setting	2.2 MHz with SYNC available, no spread spectrum, output discharge enabled		27.4		kΩ

1.2 Modifications

The printed-circuit board (PCB) for this EVM is designed to accommodate some modifications by the user. Additional input and output capacitors can be added. Also, the input voltage at which the IC turns on can be adjusted with two resistors, the soft-start time and low frequency noise filtering can be changed, a feedforward capacitor can be added, and the switching frequency, output discharge setting, and spread spectrum setting can be changed. See the device *TPSM8291x 3-V to 17-V, 2-A/3-A Low Noise and Low Ripple Buck Power Module with Integrated Ferrite Bead Filter Compensation* data sheet for details of the various settings.

1.2.1 Input and Output Capacitors

C4 is provided for an additional input capacitor. This capacitor is not required for proper operation but can be used to reduce the input voltage ripple.

C10, C14, and C15 are provided for additional bulk output capacitors. These capacitors are not required for proper operation but can be used to reduce the output voltage ripple. The total output capacitance must remain within the recommended range in the *TPSM8291x 3-V to 17-V, 2-A/3-A Low Noise and Low Ripple Buck Power Module with Integrated Ferrite Bead Filter Compensation* data sheet for proper operation. C11 and C16 are provided for high-frequency bypass capacitors.

1.2.2 Configurable Enable Threshold Voltage

With J5 removed, R3 and R5 can be installed to set a user-selectable input voltage at which the IC turns on.

1.2.3 NR/SS Capacitor

There is an internal soft-start capacitor that sets the default start up time and filtering for the NRSS pin. C18 allows the addition of more capacitance to increase the soft-start time and the low frequency noise filtering.

1.2.4 Feedforward Capacitor

C17 is provided as a feedforward capacitor (C_{FF}). Installing this capacitor can reduce the low-frequency noise, especially for higher output voltages.

1.2.5 S-CONF Resistor

R7 selects the switching frequency, spread spectrum, output discharge, and clock synchronization settings. This resistor can be changed and J6 also selects different settings.

1.2.6 Single LC Filter Operation

For applications which do not require the lowest output voltage ripple, the TPSM8291x can be operated without the second LC filter. To operate with a single LC filter, replace FB1 with a 0-Ω resistor. C12 and C13 can be removed to reduce the amount of output capacitance. The total output capacitance must remain within the

recommended range in the *TPSM8291x 3-V to 17-V, 2-A/3-A Low Noise and Low Ripple Buck Power Module with Integrated Ferrite Bead Filter Compensation* data sheet for proper operation.

2 Setup

This section describes how to properly use the EVM.

2.1 Input and Output Connector Descriptions

J3, Pin 5 and 6 – V_{IN} Positive input connection from the input supply for the EVM.

J3, Pin 3 and 4 – S+/S- Input voltage sense connections. Measure the input voltage at this point.

J3, Pin 1 and 2 – GND Return connection from the input supply for the EVM.

J4, Pin 1 and 2 – V_{OUT}_FILT Filtered output voltage connection

J4, Pin 3 and 4 – S+/S- Output voltage sense connections. Measure the output voltage at this point.

J4, Pin 5 and 6 – GND Output return connection

J8 – PG/GND The PG output is on pin 1 of this header with a convenient ground on pin 2.

J1 – V_{OUT} Ripple Measurement Use this SMA connector to measure the output voltage ripple before the second LC filter.

J2 – V_{OUT}_FILT Ripple Measurement Use this SMA connector to measure the output voltage ripple after the second LC filter.

J5 – EN/SYNC EN/SYNC pin input jumper. Place the supplied jumper across ON and EN to turn on the IC. Place the jumper across OFF and EN to turn off the IC. Remove the jumper to set a configurable enable threshold voltage with R3 and R5.

With the jumper removed, a clock signal can be applied on J5 to synchronize the IC's switching. To allow the IC to accept the applied SYNC signal, the jumper on J6 needs to be removed before applying the input voltage.

J6 – S-CONF S-CONF pin input jumper. Place the supplied jumper across 2.2 MHz and S-CONF to operate the IC with a 2.2-MHz switching frequency without spread spectrum or output discharge. Place the jumper across 1 MHz and S-CONF to operate the IC with a 1-MHz switching frequency without spread spectrum or output discharge. Remove the jumper to operate the IC with the S-CONF settings set by R7 and to allow clock synchronization.

Note

Set the J6 jumper position before enabling the IC. Changing J6 after enabling the IC has no effect.

Note

When using the 2.2-MHz setting, ensure that the input voltage and output voltage do not violate the minimum on-time in the *TPSM8291x 3-V to 17-V, 2-A/3-A Low Noise and Low Ripple Buck Power Module with Integrated Ferrite Bead Filter Compensation* data sheet.

J7 – PG Pullup Voltage PG pin pullup voltage jumper. Place the supplied jumper on J7 to connect the PG pin pullup resistor to V_{OUT_FILT}. Alternatively, the jumper can be removed and a different voltage can be supplied on pin 2 to pull up the PG pin to a different level. This externally applied voltage must remain below 18 V.

2.2 Ripple Measurement Setup

The extremely low noise and low ripple levels of the TPSM8291x necessitate a low-noise test setup for accurately measuring the output voltage ripple. The SMA connectors, J1 and J2, must be used to measure the output voltage ripple, before and after the second LC filter. Do not use a normal 10x oscilloscope probe with a high-impedance termination to the oscilloscope. Instead, connect the SMA connector directly to the oscilloscope with a coaxial (coax) cable through a DC blocker. A DC blocker enables the use of the smallest V/div setting on the oscilloscope to view the ripple. To prevent noise pickup and block reflections on the coax cable, the oscilloscope must be set to full bandwidth (BW) and DC coupling with a 50-Ω termination.

3 Test Results

The TPSM8291xEVM was used to take all the data in the *TPSM8291x 3-V to 17-V, 2-A/3-A Low Noise and Low Ripple Buck Power Module with Integrated Ferrite Bead Filter Compensation* data sheet. See the device data sheet for the performance of this EVM.

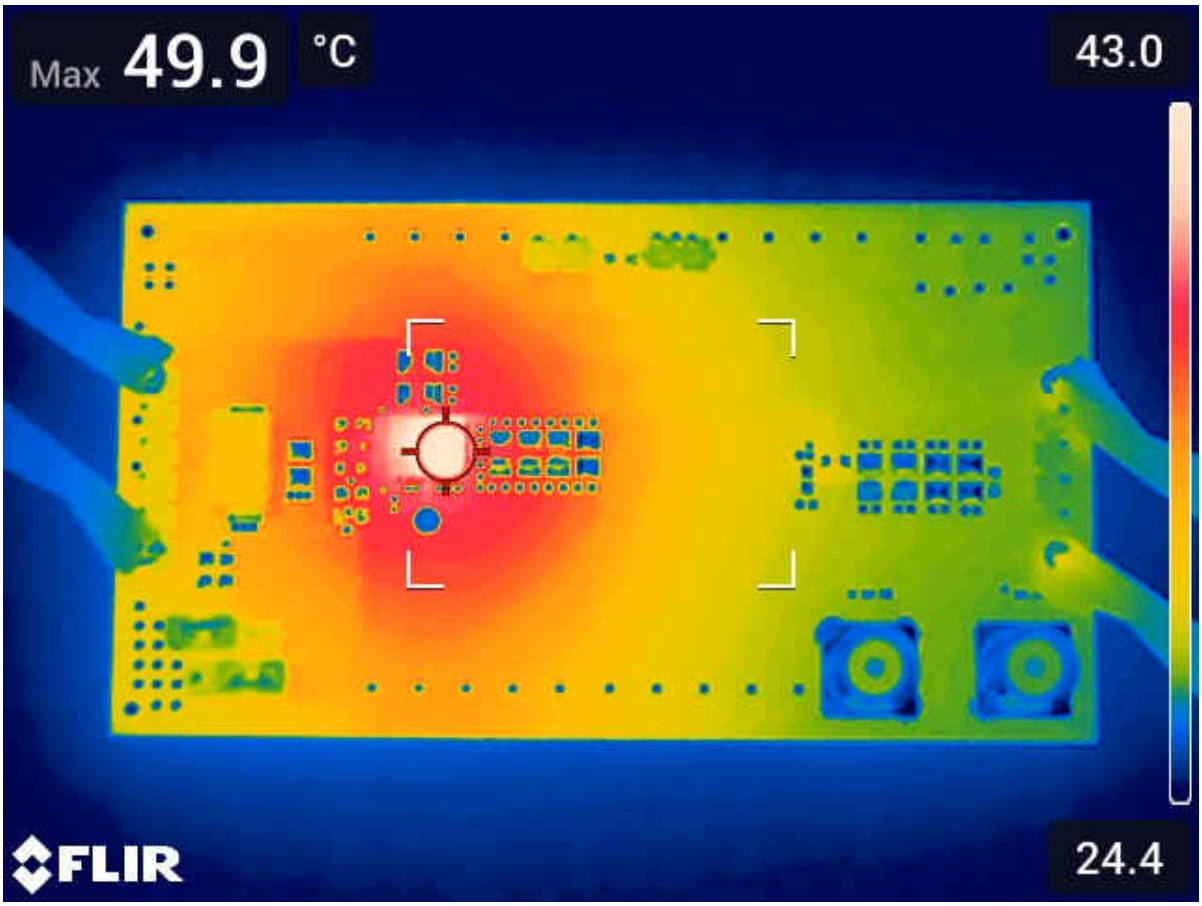

Figure 3-1. Thermal Performance (V_{IN} = 12 V, V_{OUT} = 1.2 V, I_{OUT} = 3000 mA, J6 to GND)

4 Board Layout

This section provides the EVM board layout and illustrations in Figure 4-1 through Figure 4-5. The Gerbers are available on the EVM product page.

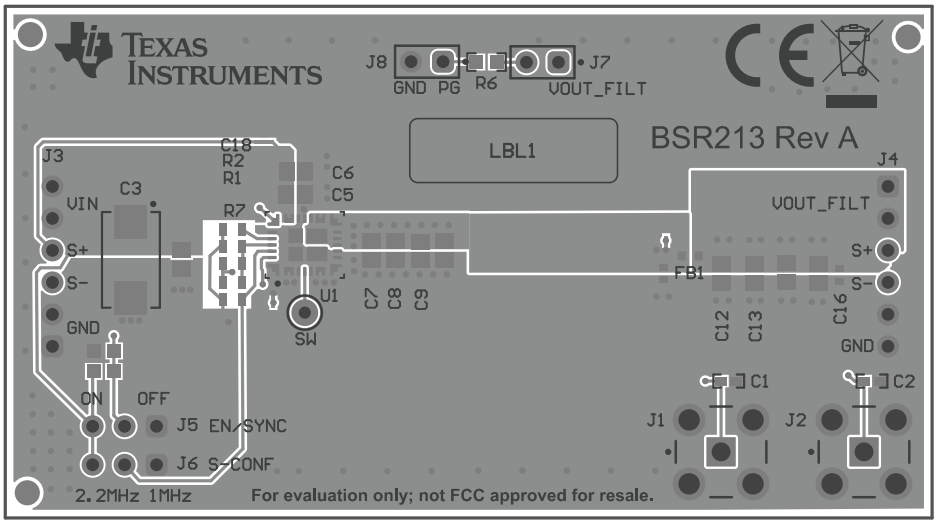

Figure 4-1. Top Assembly

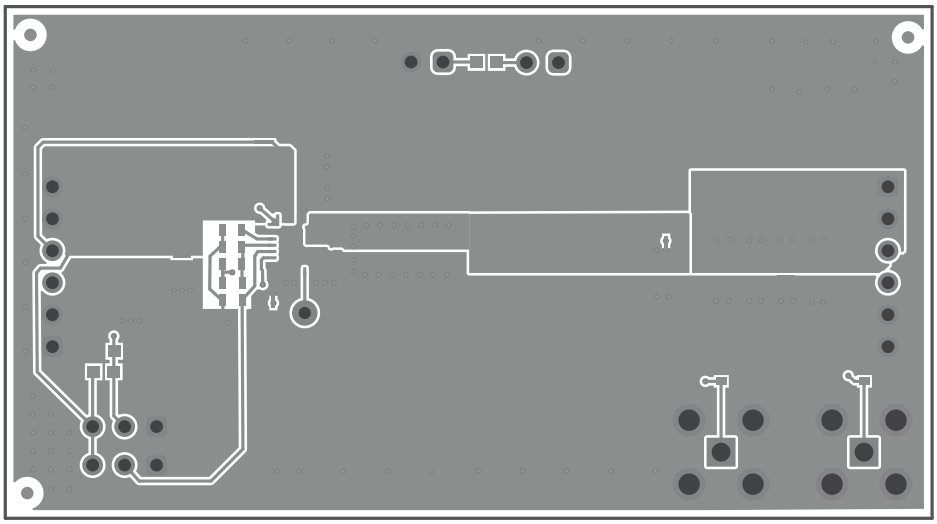

Figure 4-2. Top Layer

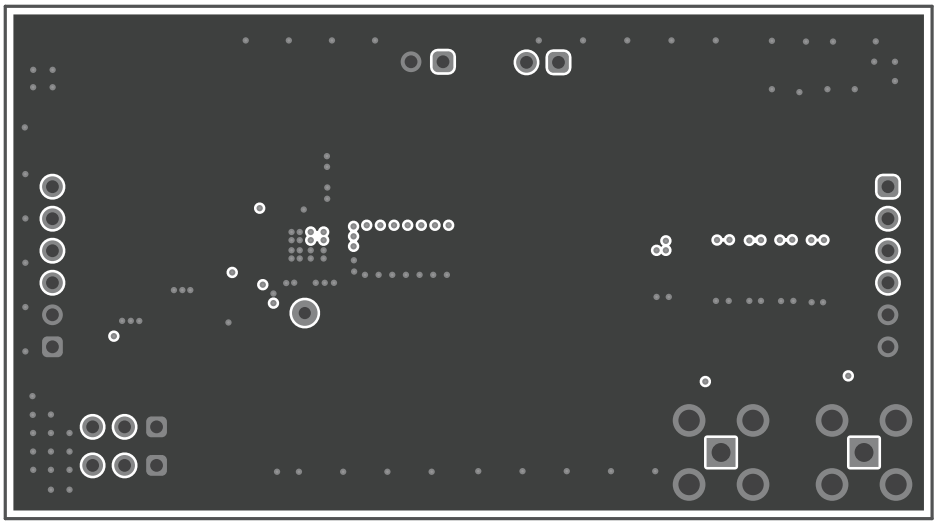

Figure 4-3. Internal Layer 1

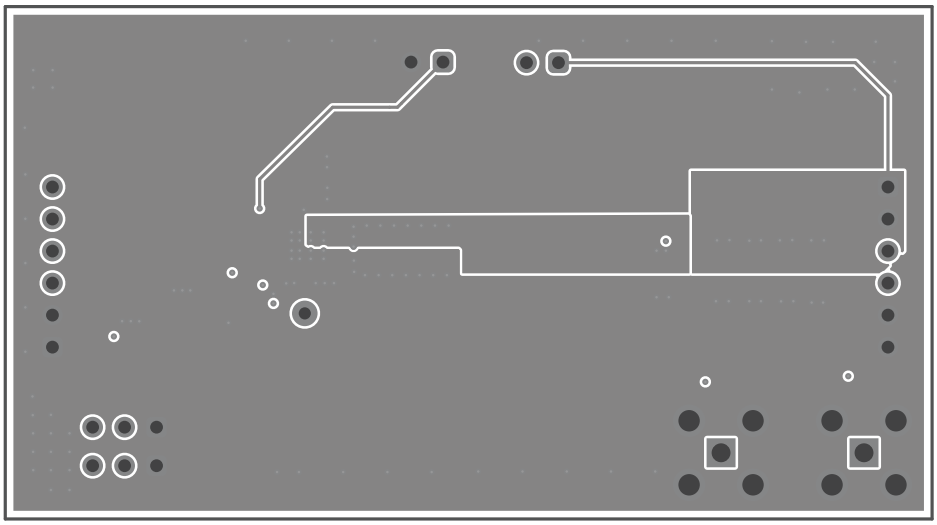

Figure 4-4. Internal Layer 2

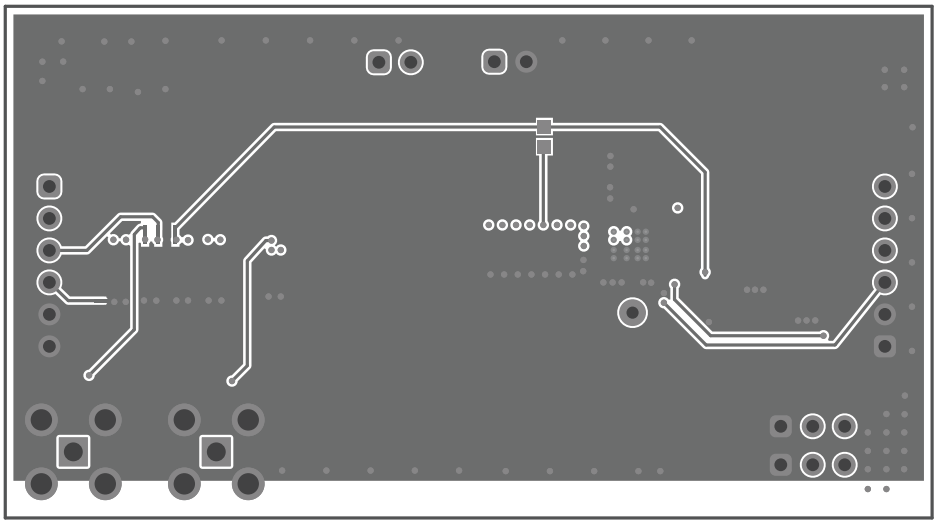

Figure 4-5. Bottom Layer

5 Schematic and Bill of Materials

This section provides the EVM schematic and bill of materials (BOM).

5.1 Schematic

Figure 5-1 and Figure 5-2 illustrate the EVM schematics.

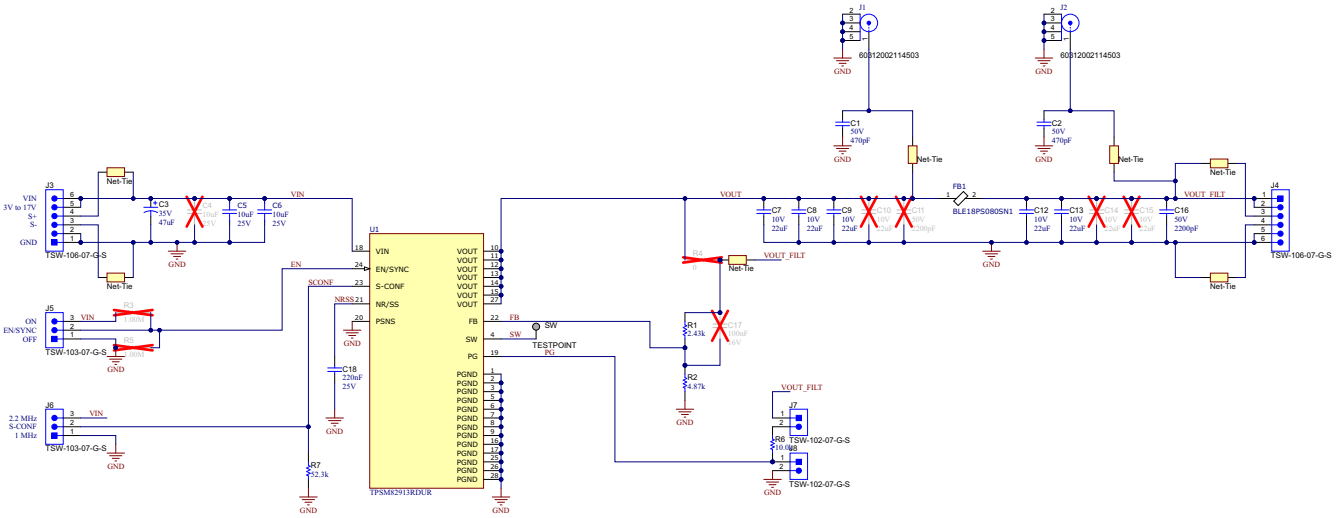

Figure 5-1. TPSM82913EVM Schematic

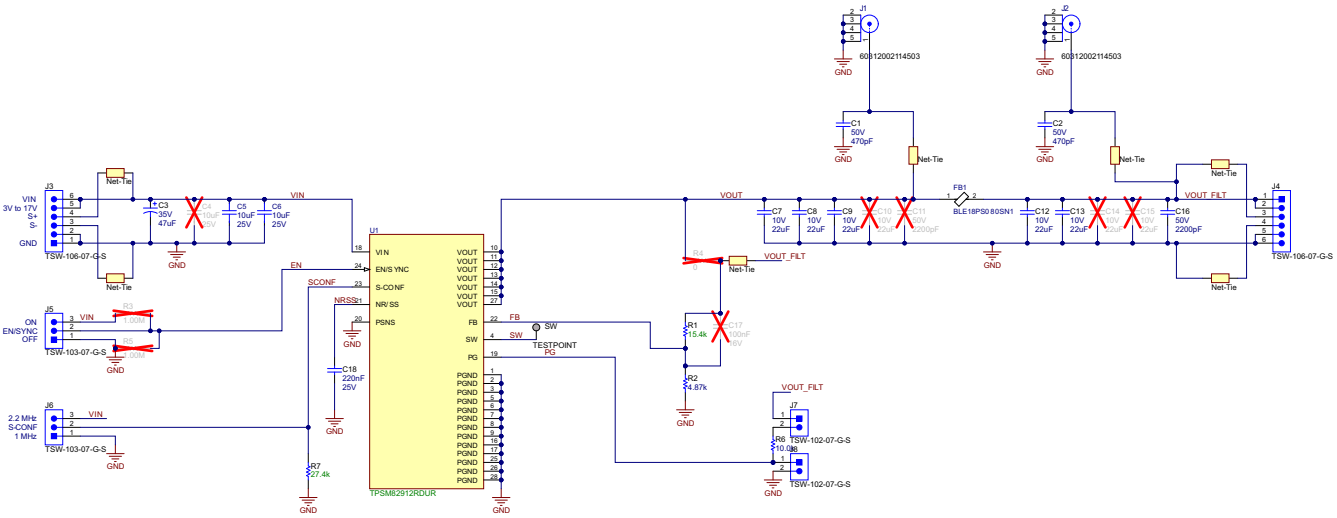

Figure 5-2. TPSM82912EVM Schematic

6 Bill of Materials

Table 6-1 lists the BOM for this EVM.

Table 6-1. TPSM8291xEVM-213 Bill of Materials

-002	-001	Reference Designator	Value	Description	Package	Part Number	Manufacturer
1	1	C16	2200 pF	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R	0402	GRM155R71H222KA01D	MuRata
2	2	C5, C6	10 µF	CAP, CERM, 10 µF, 25 V, +/- 10%, X7S	0805	C2012X7S1E106K125AC	TDK
5	5	C7, C8, C9, C12, C13	22 µF	CAP, CERM, 22 µF, 10 V, +/- 20%, X7S	0805	C2012X7S1A226M125AC	TDK
1	1	C18	0.22 µF	CAP, CERM, 0.22 µF, 25 V, +/- 10%, X7R	0603	C1608X7R1E224K080AC	TDK
1	1	C3	47 µF	CAP, TA, 47 µF, 35 V, +/- 10%, 0.3 Ω	7343-43	T495X476K035ATE300	Kemet
2	2	C1, C2	470 pF	CAP, CERM, 470 pF, 50 V, +/- 5%, C0G/NP0	0402	GRM1555C1H471JA01D	muRata
1	1	FB1		Ferrite bead, 8.5 Ω at 100 MHz, 4-mΩ DCR, 8A	0603	BLE18PS080SN1	muRata
0	1	R1	2.43 kΩ	RES, 2.43 kΩ, 1%, 0.1 W	0603	Std	Std
1	0	R1	15.4 kΩ	RES, 15.4 kΩ, 1%, 0.1 W	0603	Std	Std
1	1	R2	4.87 kΩ	RES, 4.87 kΩ, 1%, 0.1 W	0603	Std	Std
1	1	R6	10.0 kΩ	RES, 10.0 kΩ, 1%, 0.1 W	0603	Std	Std
1	0	R7	27.4 kΩ	RES, 27.4 kΩ, 1%, 0.1 W	0603	Std	Std
0	1	R7	52.3 kΩ	RES, 52.3 kΩ, 1%, 0.1 W	0603	Std	Std
1	0	U1	TPSM82912(1)	3 V to 17 V, 2-A Low Noise (20 μV_{RMS}) and Low Ripple (200 μV_{PP}) buck module	2 x 2 mm	TPS62912RPUR	Texas Instruments
0	1	U1	TPSM82913(1)	3 V to 17 V, 3 A Low Noise (20 μV_{RMS}) and Low Ripple (200 μV_{PP}) buck module	2 x 2 mm	TPS62913RPUR	Texas Instruments

(1) The TPSM8291xEVM can be populated with TPSM8291x (U1) devices that do not contain the correct top-side markings on the top of the device itself. These devices are still fully-tested TPSM8291x devices.

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 *Limited Warranty and Related Remedies/Disclaimers*:

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   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。
http://www.tij.co.jp/lsds/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/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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

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