LM5141-Q1 EVM User's Guide

User's Guide

Literature Number: SNVU522A
July 2016–Revised January 2018

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LM5141-Q1 EVM User's Guide

The LM5141-Q1 evaluation module helps designers evaluate the operation and performance of the LM5141-Q1 synchronous buck controller. The EVM operates over the input voltage range of 5.5 V to 42 V. The EVM provides a 5-V output with a maximum load current of 5 A. The device offers configurability and can be set up to switch at 440 kHz or 2.2 MHz.

1 Features and Performance

The EVM supports the following features and performance capabilities:

- The LM5141-Q1 is qualified to AEC-Q100 Grade 1 (–40ºC to +125ºC operating junction temperature)
- V_{IN} 5.5 to 42 V
- Fixed 5-V output or adjustable from 1.5 V to 15 V
- Shutdown mode I_Q: 10 µA
- Low IQ standby: 42 µA typical (output in regulation, no load)
- Fixed 2.2-MHz or 440-kHz oscillator frequency
- Oscillator can shift from the fundamental with a resistor from the RT pin to ground, or an analog
- Voltage of 0 V to 0.6 V
- The internal oscillator can be synchronized to an external clock
- Spread spectrum
- EN enable output
- Hiccup mode for sustained overload
- Power good
- Gate drive with slew-rate control
- Diode emulation or forced pulse-width modulation

Table 1 shows the electrical performance data for this EVM.

Table 1. Electrical Performance

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS					
Input voltage	5-V output	5.5	42		V
OUTPUT CHARACTERISTICS					
Output voltage 2	I_{LOAD} = 5 A	4.95	5	5.05	V
Output current				5	A
SYSTEM CHARACTERISTICS					
Switching frequency		2	2.2	2.4	MHz
Full load efficiency	V_{IN} = 12 V, V_{OUT} 5 V at 5 A		81%		

2 Setup

This section describes the input and output connections to the LM5141-Q1 HD EVM and other functional settings.

Table 2. Jumpers and Test Points

PIN NAME	DESCRIPTION	COMMENTS
J1-1	The + (positive) V_{IN} power for the EVM.	
J1-2	The - (negative) V_{IN} power for the EVM.	
J2 (1-2)	PG indicator open collector output which goes low if V_{OUT} is outside the regulation window.	Factory default open
J3 (1-2)	FPWM (Forced PWM	
J3 (2-3)	DEMB (Diode Emulation)	Factory default setting
J4 (1-2)	VCCX connected to V_{OUT}	Factory default setting
J5 (1-2)	Spread Spectrum	Factory default setting disabled (remove header to enable)
J6 (1-2)	EN-Enable V_{OUT}	
J6 (2-3)	EN-Disable V_{OUT}	Factory default setting
J7 (1-2)	Feedback divider resistors	Factory default open
J8 (1-2)	Disable RT	Factory fault setting
J8 (2-3)	Enable RT	
J9 (1-2)	V_{OUT} 3.3 V	
J9 (2-3)	V_{OUT} 5 V	Factory default setting
TP1	SYNC IN	
TP2	PG an open collector output which goes low if V_{OUT} is outside the regulation window.	
TP3	$+V_{OUT}$ regulated output voltage	
TP4	$-V_{OUT}$ ground (GND) connection	
TP5	Sets RT= 44.2 kΩ	
TP6	Sets RT = 50.1 kΩ	
TP7	VRT input 0 V to 0.6 V	

3 Setup Input and Loads

The input voltage range for the EVM is 5.5 V to 42 V. The EVM output is configured for 5 V and is rated for 5-A continuous.

3.1 Enabling the Outputs

To enable V_{OUT} place a header from J6 (2-3) to J6 (1-2). The EVM outputs can be enabled before or after V_{IN} has be applied.

4 Test Equipment

4.1 Power Supply

The Power Supply should be capable of 50 V / 10 A.

4.2 Electronic Loads

The Electronic Load should be capable of 10 V / 10 A used in constant current mode.

4.3 Meters

A current meter is required to measure the input current accurately. The maximum current rating of the meter should be carefully considered. The input current can be as high as 4.5 A with the output at full load at the minimum input voltage. The output voltage should be monitored with a voltage meter capable of monitoring up to 10 V.

4.4 Oscilloscope

A oscilloscope and 10x probes with at least 20-MHz bandwidth is required.

5 Test Procedure

Read the LM5141-Q1 data sheet (SNVSAJ6) before using the EVM. The power supply and loads must be capable of handling the input and output voltage and current rating of the board.

NOTE: Prior to applying power to the EVM, make sure that jumpers J3, J4, J5, J6, J7, J8, and J9 are set in the correct positions, see Table 2.

1. Connect the power supply and ground connections V_{IN} (J1-2) and GND (J1-2) to the power supply
2. Connect an ammeter in series with the input, if needed.
3. Connect a DVM from TP3 (+) to TP4 (–).
4. Connect a resistive load or an electronic load across terminals (V_{OUT}) TP3 (+) and GND (TP4).
5. An ammeter can be inserted in series with the load to observe the load current.
6. Refer to Table 2 for the jumper setting to enable V_{OUT}.
7. With the load initially set to no load, set the power supply to 12 V and turn on the power supply. Check for V_{OUT} 5 V at the output.
8. Once the output is at the expected target (5 V), increase the load gradually within the operating range.

6 Test Setup

Figure 1 shows the test setup for the LM5141-Q1 EVM.

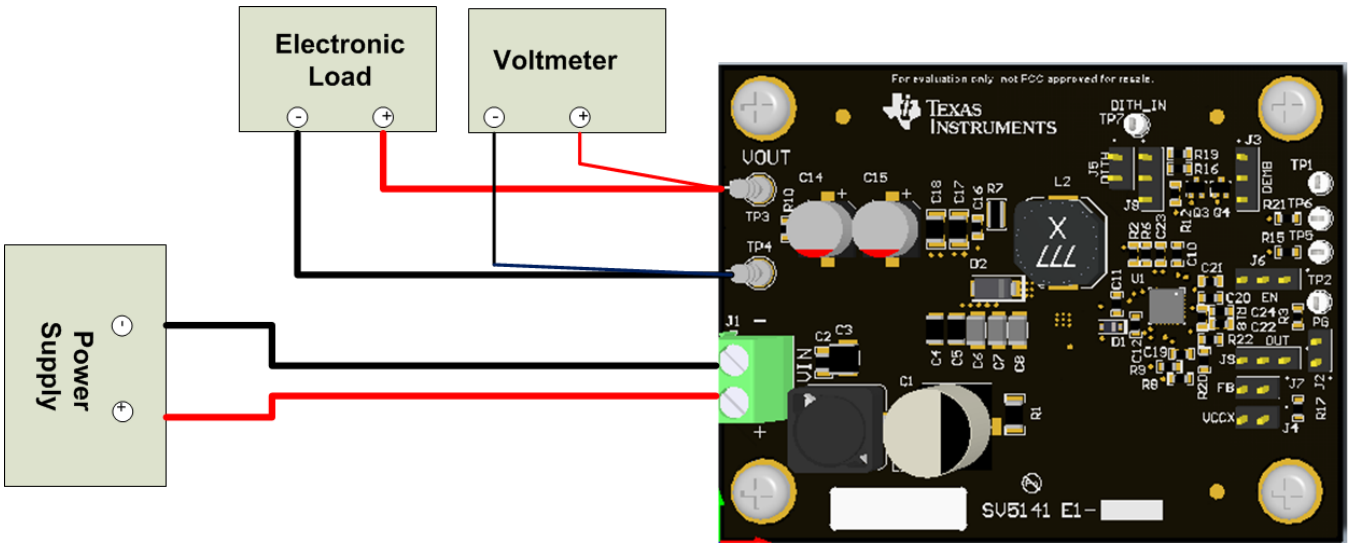

Figure 1. EVM Connections

7 Test Data

7.1 Efficiency

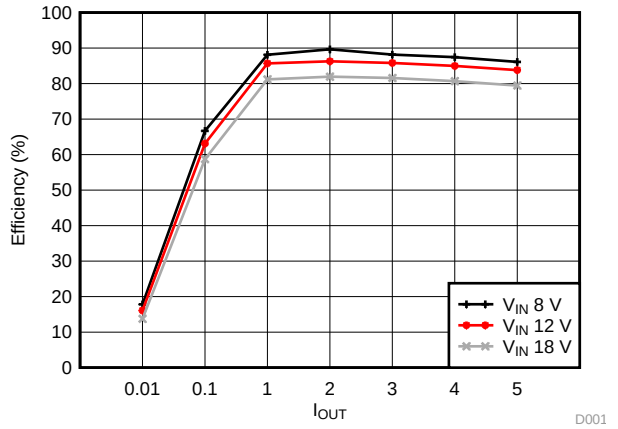

Figure 2. Efficiency FPWM Load 100 mA to 5 A, 2.2 MHz

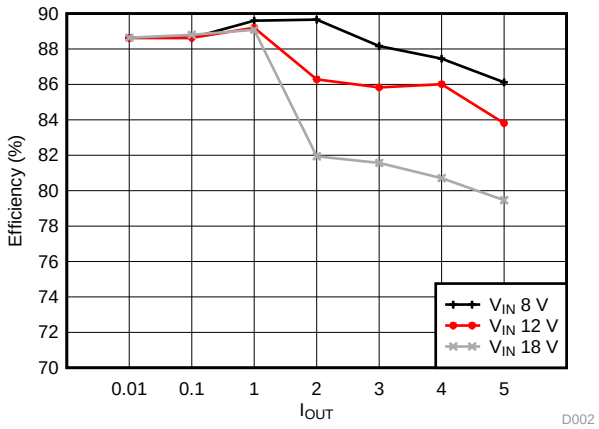

Figure 3. Efficiency DEMB Load 100 mA to 5 A

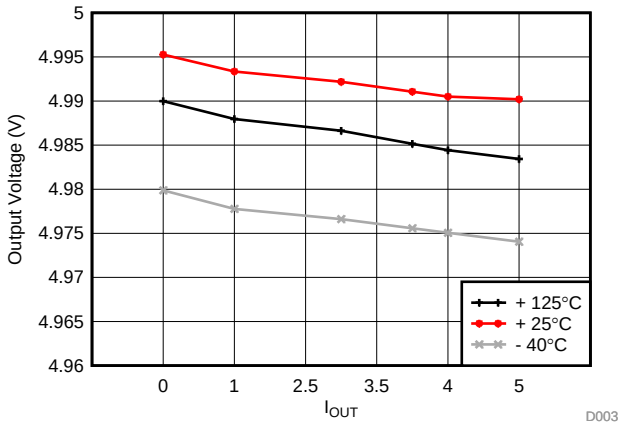

Figure 4. 5-V Output Voltage Regulation

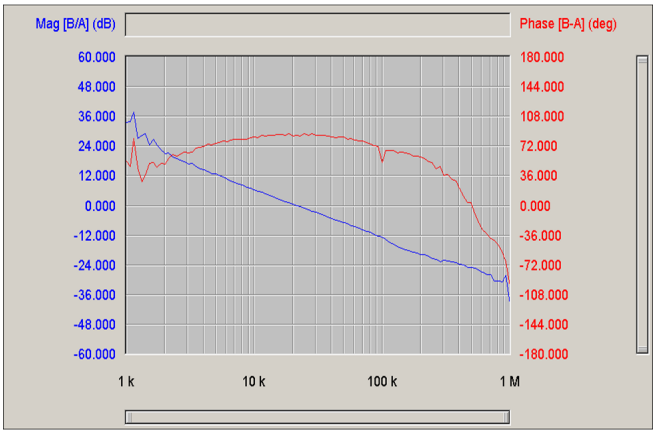

Figure 5. Bode Plot 5-V Output 5-A Load

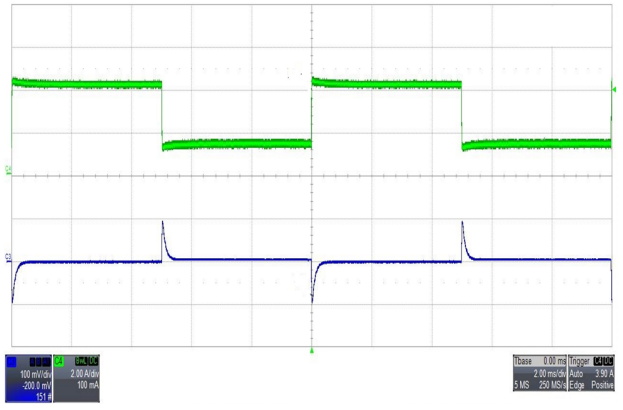

Figure 6. 5-V Output Transient Response 2 A to 4 A (0.5 A/µs)

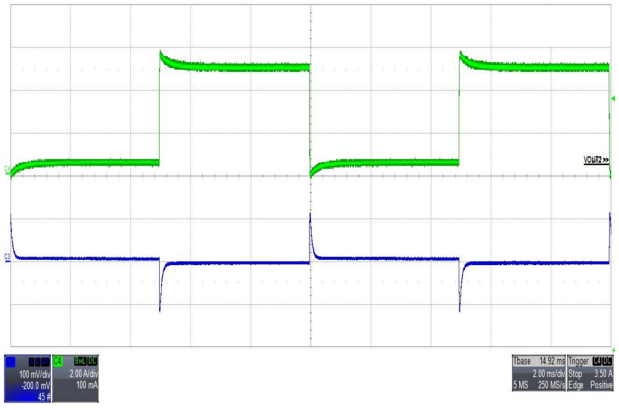

Figure 7. 5-V Output Transient Response 0 A to 5 A (0.5 A/µs)

7.2 CISPR 25 Class 5 LM5141 EVM 2.2 MHz

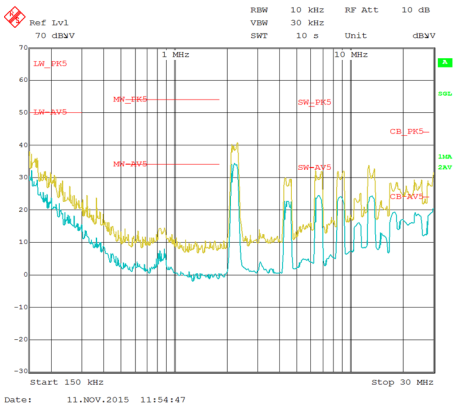

Figure 8. CISPR 25 Class 5 Peak Detection 150 kHz to 30 MHz

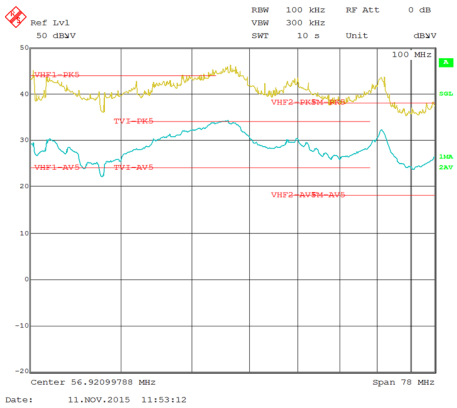

Figure 9. CISPR 25 Class 5 Peak Detection 30 MHz to 108 MHz

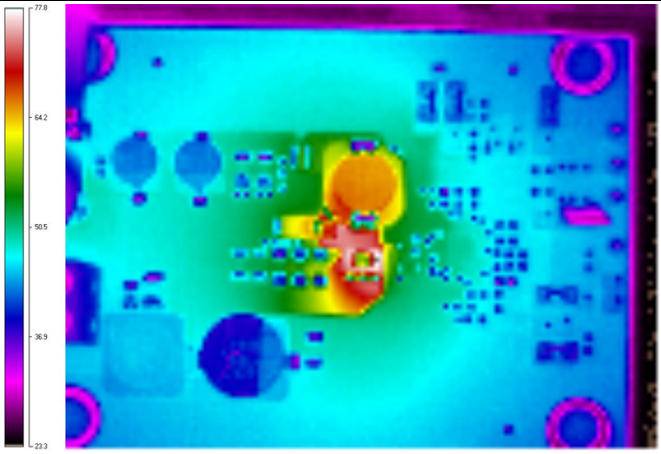

Figure 10. Thermal Image PCB Top Side

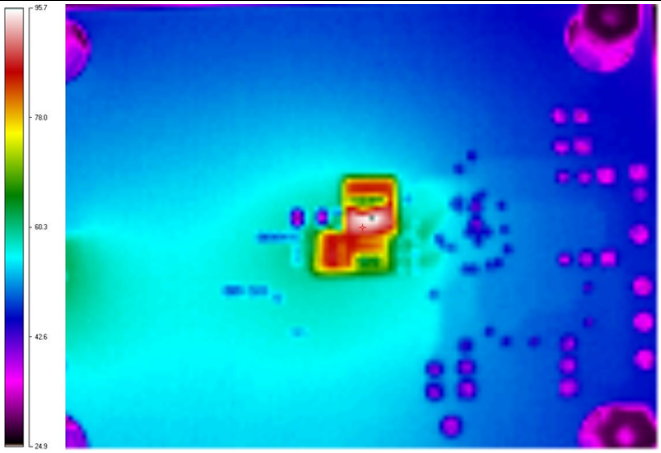

Figure 11. Thermal Image PCB Bottom Side

8 Design Files

8.1 Schematics

To download the schematics for each board, see the design files at http://www.ti.com/tool

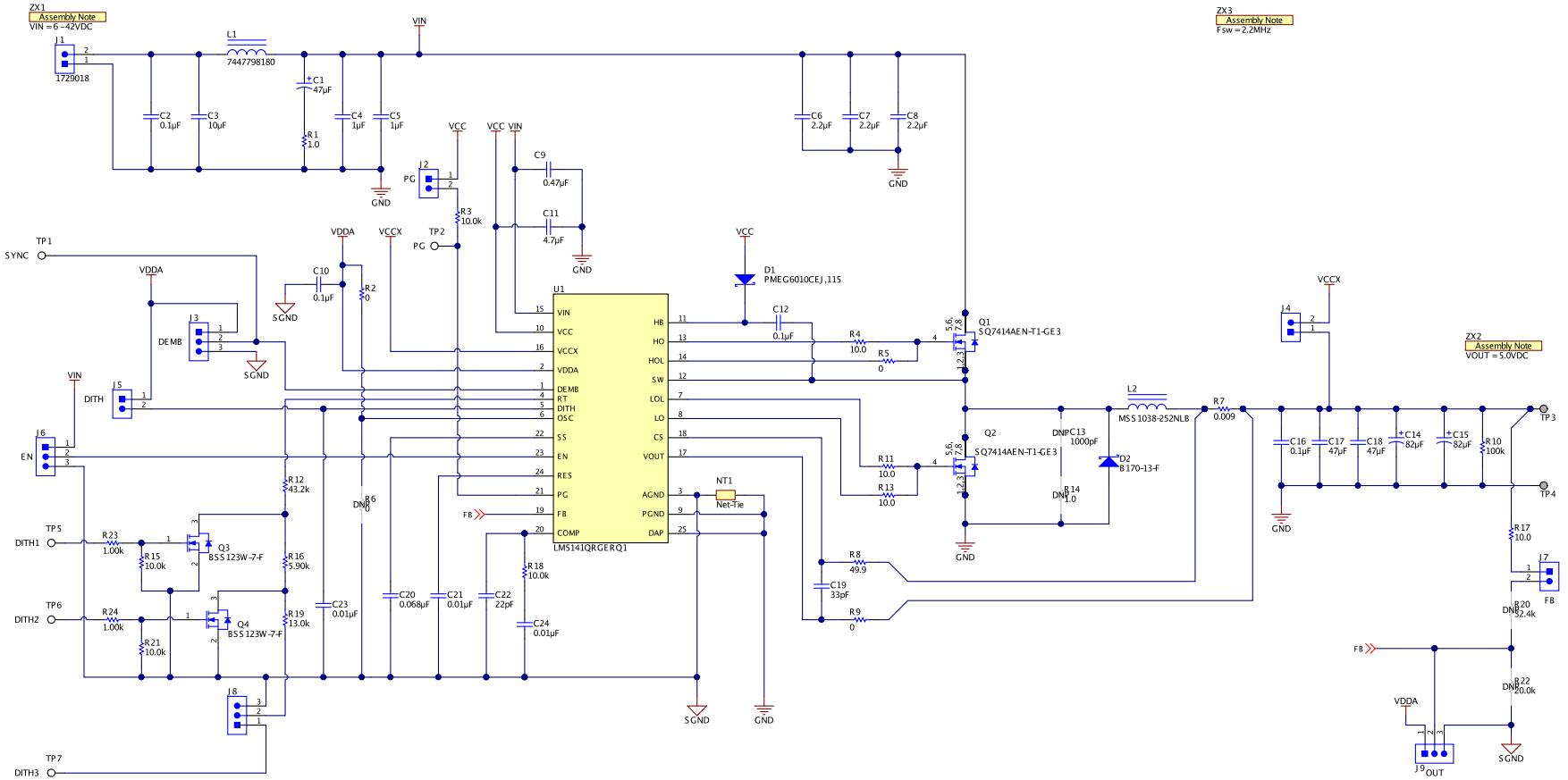

Figure 12. EVM Schematic 2.2 MHz

8.2 Bill of Materials

Table 3. Bill of Materials

DESCRIPTION	DESIGNATOR	PART NUMBER	QUANTITY	MANUFACTURER
Printed Circuit Board	!PCB1	SV601264	1	Any
CAP, AL, 47 µF, 50 V, ±20%, 0.3 Ω, SMD	C1	EEE-FC1H470P	1	Panasonic
CAP, CERM, 0.1 µF, 100 V, ±10%, X7R, 0805	C2	C0805C104K1RACTU	1	Kemet
CAP, CERM, 10 µF, 50 V, ±20%, x7R, 1210	C3	C3225X7R1H106M250AC	1	TDK
CAP, CERM, 1 µF, 100 V, ±20%, X7R, 1206	C4, C5	C3216X7R2A105M160AA	2	TDK
CAP, CERM, 2.2 µF, 100 V, ±10%, X7R, 1206_190	C6, C7, C8	CL31B225KCHSNNE	3	Samsung Electro-Mechanics
CAP, CERM, 0.47 µF, 100 V, ±10%, x7R, 0805	C9	GRM21BR72A474KA73L	1	MuRata
CAP, CERM, 0.1 µF, 50 V, ±10%, x7R, 0603	C10, C12, C16	C0603C104K5RACTU	3	Kemet
CAP, CERM, 4.7 µF, 25 V, ±10, X5R, 0603	C11	GRM188R61E475KE11D	1	MuRata
CAP, Aluminum Polymer, 82 µF, 16 V, ±20%, 0.03 Ω, D6.3 × L5.8 mm SMD	C14, C15	875105344009	2	Wurth Elektronik
CAP, CERM, 47 µF, 16 V, ±15%, X5R, 1206	C17, C18	C3216X5R1C476M160AB	2	TDK
CAP, CERM, 33 pF, 50 V, ±5%, C0G/NP0, 0603	C19	06035A330JAT2A	1	AVX
CAP, CERM, 0.068 µF, 25 V, ±10%, X7R, 0603	C20	GRM188R71E683KA01D	1	MuRata
CAP, CERM, 0.01 µF, 50 V, ±10%, X7R, 0603	C21, C23, C24	GCM188R71H103KA37D	3	MuRata
CAP, CERM, 22 pF, 50 V, ±5%, C0G/NP0, 0603	C22	GRM1885C1H220JA01D	1	MuRata
Diode, Schottky, 60 V, 1 A, SOD-323F	D1	PMEG6010CEJ,115	1	NXP Semiconductor
Diode, Schottky, 70 V, 1 A, SMA	D2	B170-13-F	1	Diodes Inc.
Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	H1, H2, H3, H4	NY PMS 440 0025 PH	4	B&F Fastener Supply
Standoff Hex, 0.5"L #4-40 Nylon	H5, H6, H7, H8	1902C	4	Keystone
TERM BLOCK 2POS 5mm, TH	J1	1729018	1	Phoenix Contact
Header, 100mil, 2x1, Gold, TH	J2, J4, J5, J7	61300211121	4	Wurth Elektronik
Header, 100mil, 3x1, Gold, TH	J3, J6, J8, J9	61300311121	4	Wurth Elektronik
Inductor, Shielded, Metal Composite, 1.8 µH, 12.8 A, 0.0038 ohm, SMD	L1	7447798180	1	Wurth Elektronik
Inductor, Shielded Drum Core, Ferrite, 2.5 µH, 6.65 A, 0.01Ω, SMD	L2	MSS1038-252NLB	1	Coilcraft
MOSFET, N-CH, 60 V, 20 A, PG-TSDSON-8	Q1, Q2	SQ7414AEN-T1-GE3	2	Vishay-Dale
MOSFET, N-CH, 100 V, 0.17 A, SOT-323	Q3, Q4	BSS123W-7-F	2	Diodes Inc.
RES, 1.0, 5%, 0.25 W, 1206	R1	CRCW12061R00JNEA	1	Vishay-Dale

Table 3. Bill of Materials (continued)

DESCRIPTION	DESIGNATOR	PART NUMBER	QUANTITY	MANUFACTURER
RES, 0, 5%, 0.1 W, 0603	R2, R5, R9	CRCW06030000Z0EA	3	Vishay-Dale
RES, 10.0 k, 1%, 0.1 W, 0603	R3, R15, R18, R21	CRCW060310K0FKEA	4	Vishay-Dale
RES, 10.0, 1%, 0.25 W, 0603	R4, R11, R13, R17	CRCW060310R0FKEAHP	4	Vishay-Dale
RES, 0.009, 1%, 1 W, 0612	R7	PRL1632-R009-F-T1	1	Susumu Co Ltd
RES, 49.9, 1%, 0.1 W, 0603	R8	CRCW060349R9FKEA	1	Vishay-Dale
RES, 100 k, 1%, 0.1 W, 0603	R10	CRCW0603100KFKEA	1	Vishay-Dale
RES, 43.2 k, 1%, 0.1 W, 0603	R12	CRCW060343K2FKEA	1	Vishay-Dale
RES, 5.90 k, 1%, 0.1 W, 0603	R16	CRCW06035K90FKEA	1	Vishay-Dale
RES, 23.7 k, 1%, 0.1 W, 0603	R19	CRCW060313K0FKEA	1	Vishay-Dale
RES, 1.00 k, 1%, 0.1 W, 0603	R23, R24	RC0603FR-071KL	2	Yageo America
Shunt, 2.54mm, Gold, Black	SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6	60900213421	6	Wurth Elektronik
Test Point, Miniature, White, TH	TP1, TP2, TP5, TP6, TP7	5002	5	Keystone
Terminal, Turret, TH, Triple	TP3, TP4	1598-2	2	Keystone
IC, PWM, Buck Controller	U1	LM5141	1	Texas Instruments

9 Board Layout

The EVM offers resistors and PWB mounted switches to program the output voltage, oscillator frequency, and DEM/FPWM of operation. Figure 13 to Figure 18 show the board layout for the PCB. The QFN-25 package allows for a compact leadless IC package for a synchronous buck converter solution. See the LM5140-Q1 datasheet (SNVSAJ6) for details.

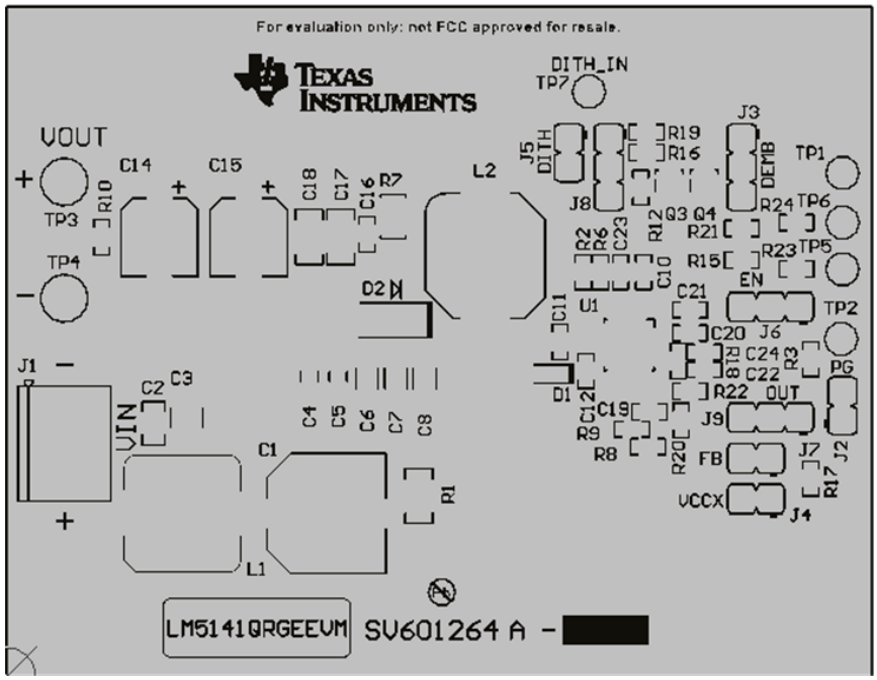

Figure 13. EVM Top Layer Silkscreen

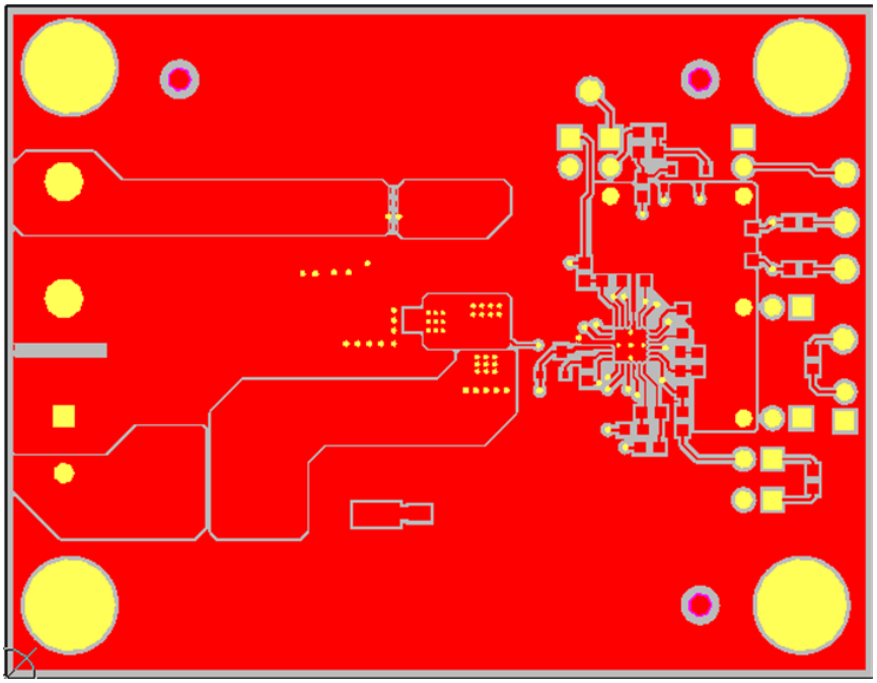

Figure 14. EVM Top Layer Copper

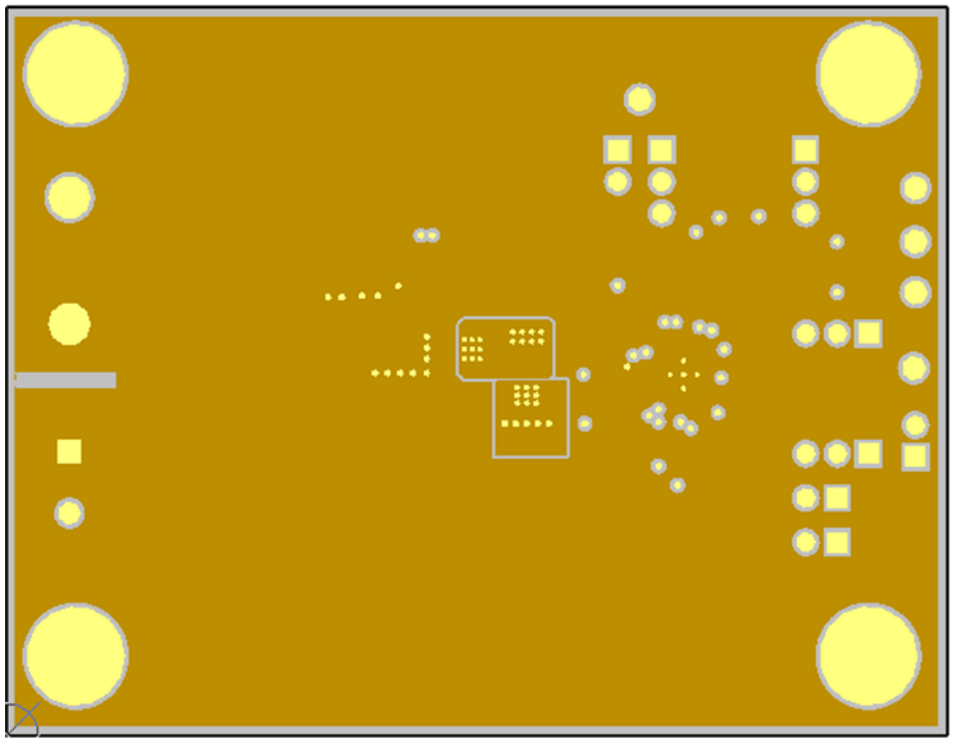

Figure 15. EVM Middle Layer 1

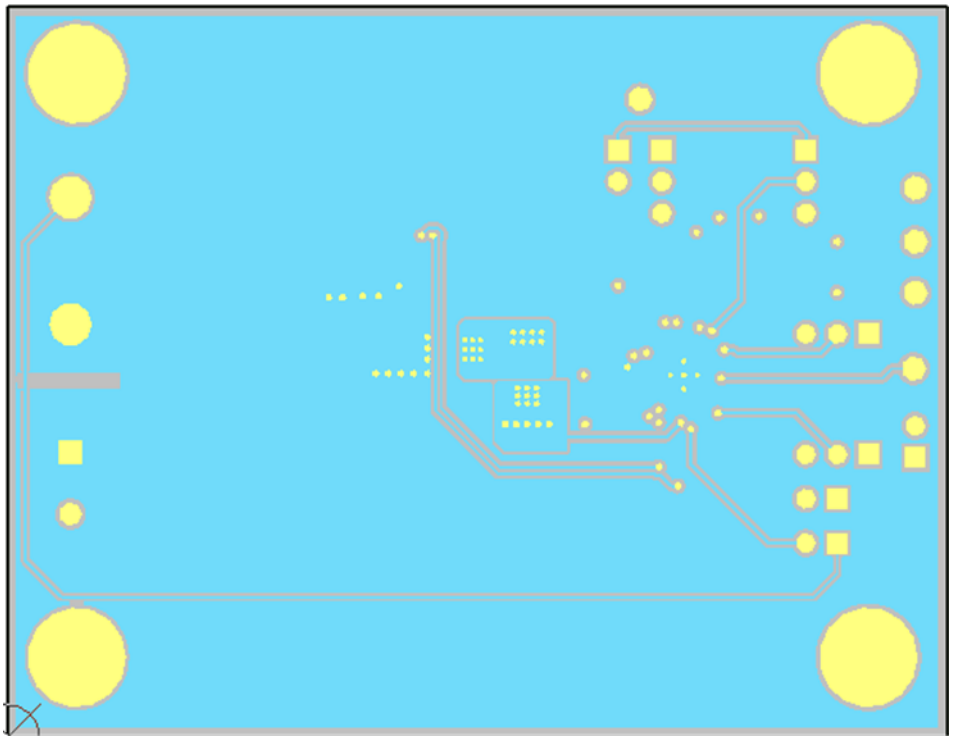

Figure 16. EVM Middle Layer 2

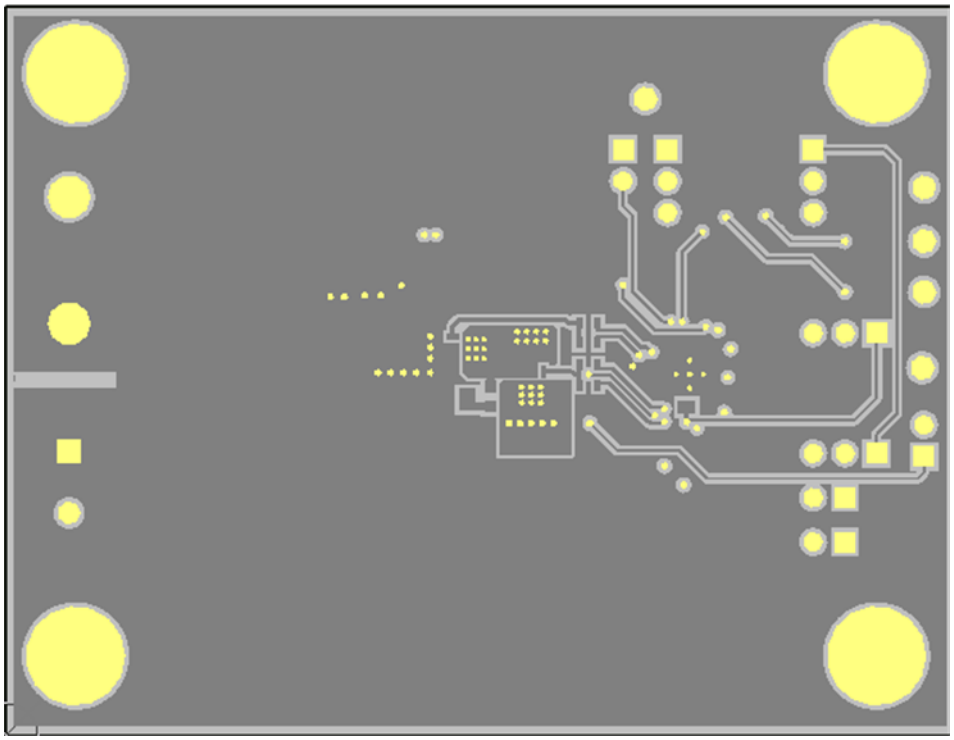

Figure 17. EVM Bottom Layer Copper

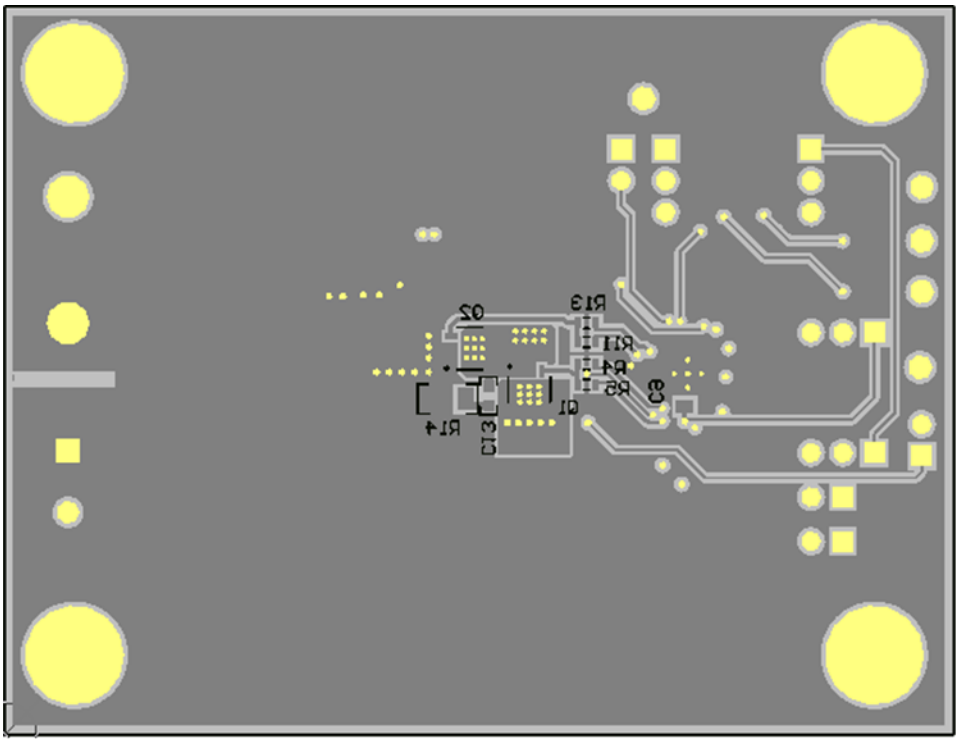

Figure 18. EVM Bottom Layer Silkscreen

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (July 2016) to A Revision	Page
• Changed title of Y axis in Figure 4	7

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.

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

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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.

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.

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