

EVM User's Guide: TPS7H5020EVM

TPS7H5020-SP Evaluation Module



Description

The [TPS7H5020EVM](#) demonstrates the operation of a single [TPS7H5020-SP](#) current mode PWM controller with integrated gate driver with a GaN FET in a boost configuration. The board provides footprints that can be populated with additional components and test points to allow for testing of customized configurations and performance validation.

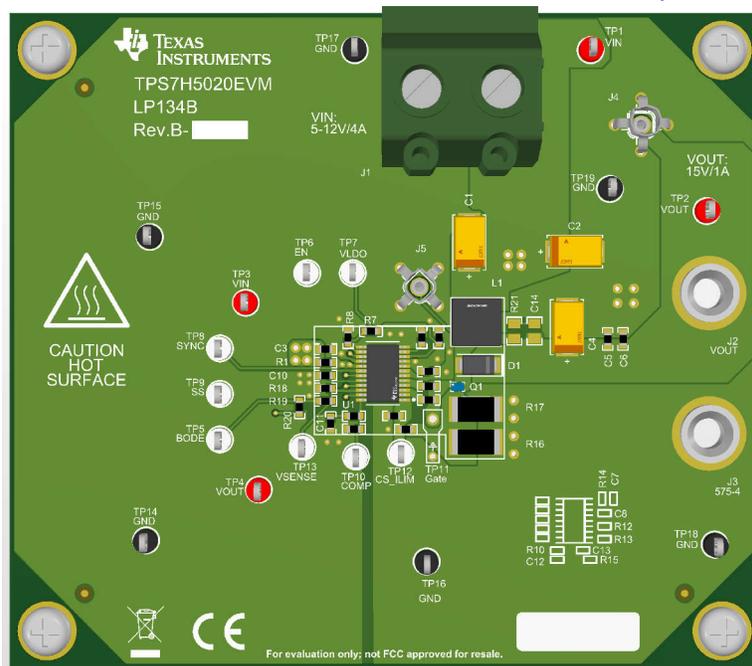
Features

This EVM has the following features:

- Input voltage range from 5V to 12V
- 15V at 1A output
- GaN FET
- 1MHz switching frequency
- $0.6V \pm 1\%$ voltage reference over temperature, radiation, and line and load regulation
- Adjustable slope compensation and soft start
- Optional PVIN connection to VIN or VLDO

Applications

- Space satellite power supplies
- [Communications payload](#)
- [Command and data handling](#)
- [Optical imaging payload](#)
- [Radar imaging payload](#)
- [Satellite electrical power system](#)



EVM Board

1 Evaluation Module Overview

1.1 Introduction

The TPS7H5020EVM is the Evaluation Module (EVM) the TPS7H5020-SP and provides a platform to electrically evaluate features. This user's guide provides details about the EVM, including the configuration, schematics, and BOM.

The EVM is designed to provide flexibility in configuring the device under different conditions. Footprints for additional components and multiple connection options for monitoring device pins are provided. To configure the device in a custom configuration, please refer to the [TPS7H5020-SP data sheet](#) to calculate values of any passives that need to be changed.

1.2 Kit Contents

- TPS7H5020EVM Board (1)

1.3 Specification

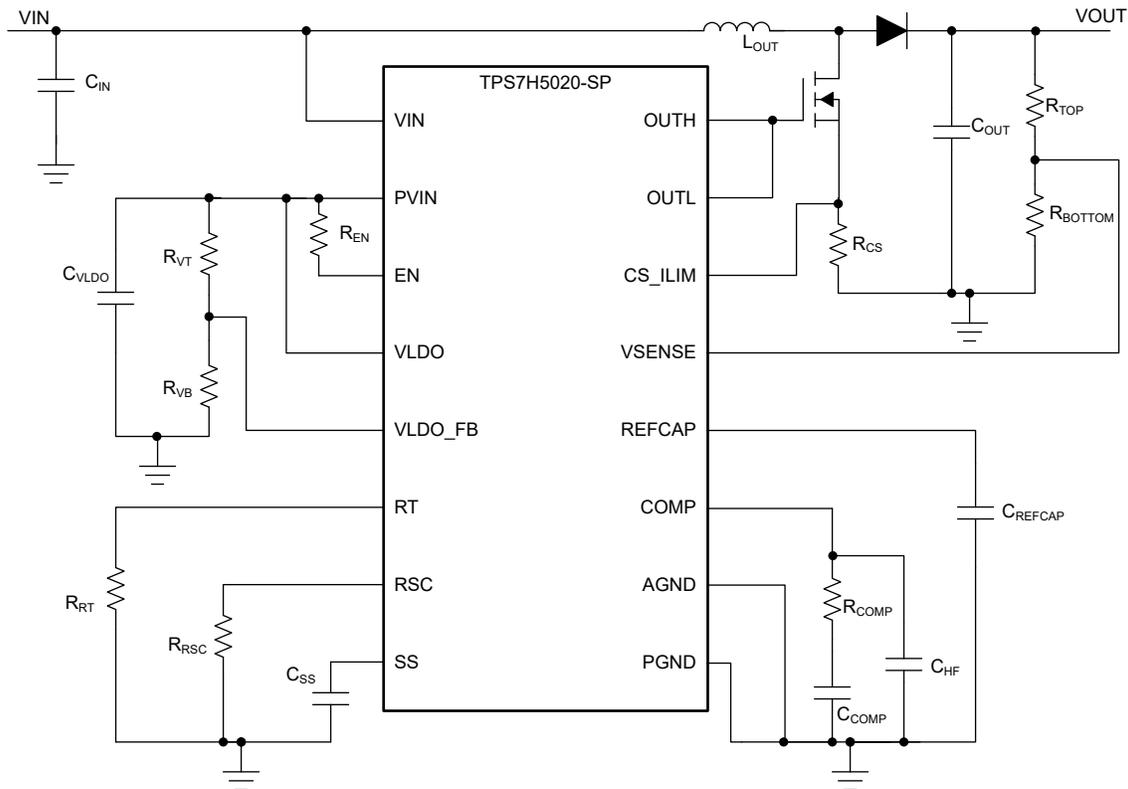


Figure 1-1. Simplified Schematic

Table 1-1. Default Configuration Options

Parameter	Specification	Description
Input voltage VIN	5V to 12V	Within device input voltage range of 4.5V to 14V.
Output VOUT	15V at 1A	Common power rail voltage within the device output capability. Configured by R18.
PVIN connection PVIN	PVIN connected to VLDO	Configurable to connect PVIN to VIN by populating R2 with 0Ω resistor and depopulating R3.
EN connection EN	EN connected to VLDO	Configurable to connect EN to VIN for UVLO by depopulating R4 and populating R5 and R6.

1.4 Device Information

The [TPS7H502x](#) is a radiation-hardness-assured, current mode, single-ended PWM controller with an integrated gate driver that can be utilized in both silicon and gallium nitride (GaN) power semiconductor based converter designs. The TPS7H502x integrates several key functions, such as soft-start, enable, and adjustable slope compensation while maintaining a small package size. The controller also features a $0.6V \pm 1\%$ voltage reference tolerance to support highly accurate power converter designs.

Further information about the TPS7H5020-SP can be found in the device [data sheet](#).

2 Hardware

2.1 EVM Connections and Test Points

Figure 2-1 shows which terminal is the positive and negative on J11. Connect the positive input voltage to the positive terminal and GND to negative terminal.

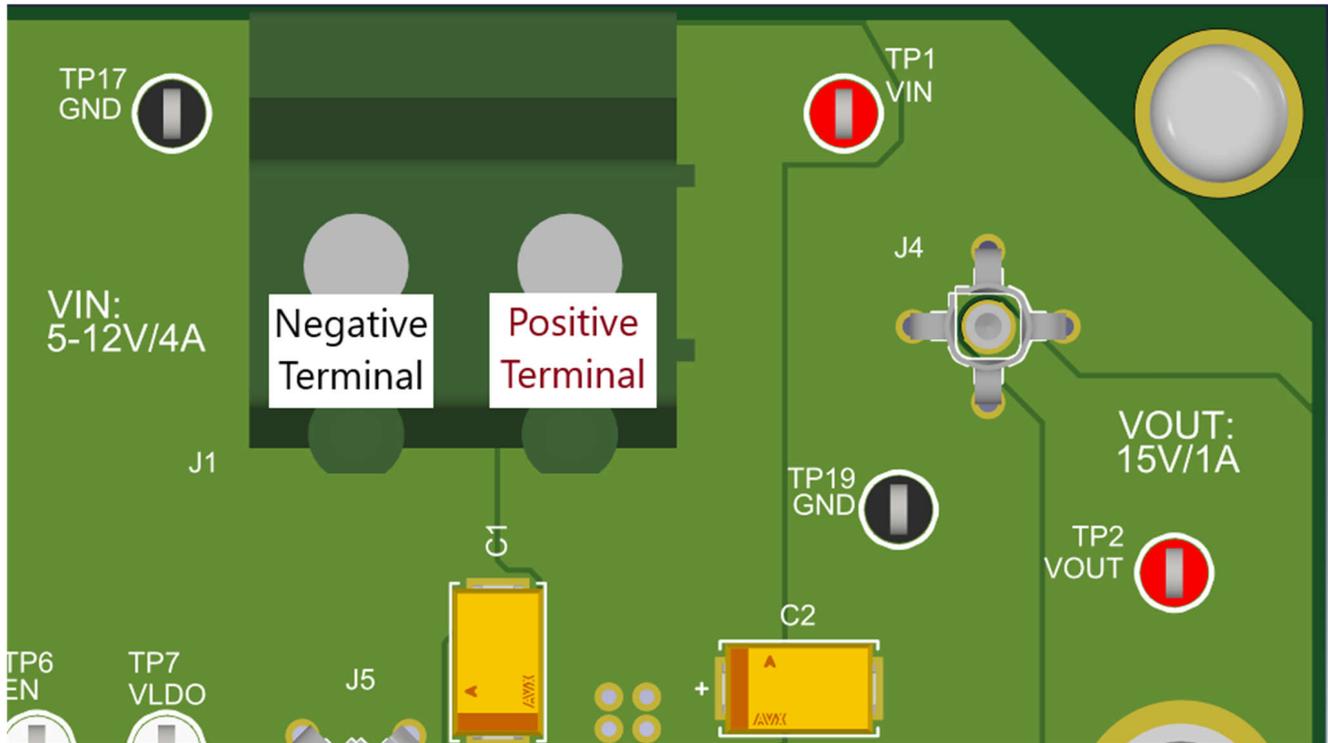


Figure 2-1. J1 Input Terminal

Table 2-1 is a list of connections on the board.

Table 2-1. EVM Board Connections

Reference Designator	Function	
J1	VIN	Power output connector
J2	VOUT	Power input connectors
J3	GND	
J4	VOUT	Compact probe tip connector
J5	SW	
TP1	VIN	Test point
TP2	VOUT	
TP3	VIN	
TP4	VOUT	
TP5	BODE	
TP6	EN	
TP7	VLDO	
TP8	SYNC	
TP9	SS	
TP10	COMP	

Table 2-1. EVM Board Connections (continued)

Reference Designator	Function	
TP11	Gate	Probe tip test point
TP12	CS_ILIM	Test point
TP13	VSENSE	
TP14, TP15, TP16, TP17, TP18, TP19	GND	

2.2 Best Practices

The following information is provided to convey best practices while operating this device.

	<p>WARNING</p> <p>HOT SURFACE! CONTACT CAN CAUSE BURNS. DO NOT TOUCH!</p> <p>Some components can reach high temperatures >55°C when the board is powered on. Do not touch the board at any point during operation or immediately after operating, as high temperatures can be present.</p>
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3 Implementation Results

Test results for 5V input and 12V input are shown in this section for the following:

- [Start Up](#)
- [Shutdown](#)
- [Output Voltage Ripple](#)
- [Loaded Step](#)
- [Frequency Response](#)

3.1 Evaluation Setup

The following sections represent tests performed using the TPS7H5020EVM in the default configuration. Detailed settings are shown in [Table 3-1](#).

Table 3-1. Test Settings

Specification	Value
VIN	5V or 12V
VOUT	15V
FSW	1MHz
R_CS	75m Ω
R_SC	145k Ω

3.2 Startup

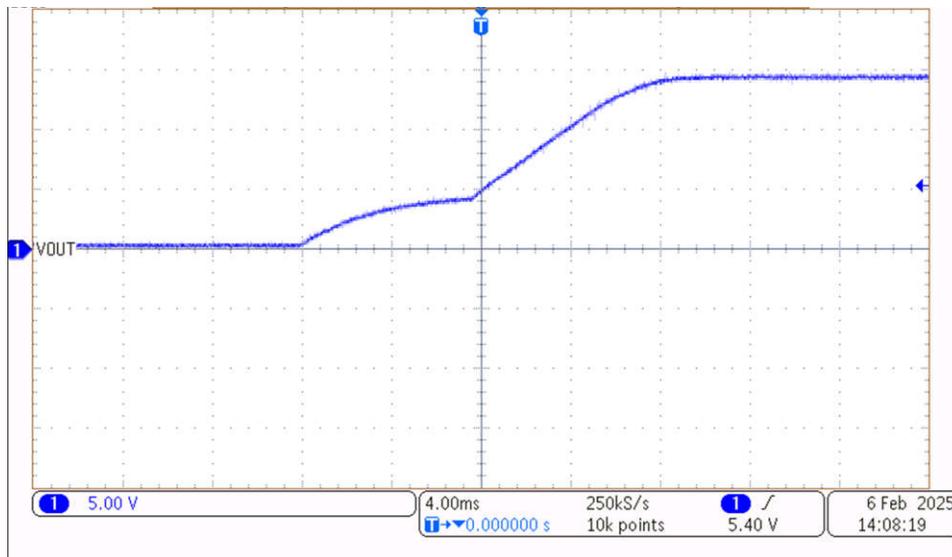


Figure 3-1. 5V Unloaded Start Up

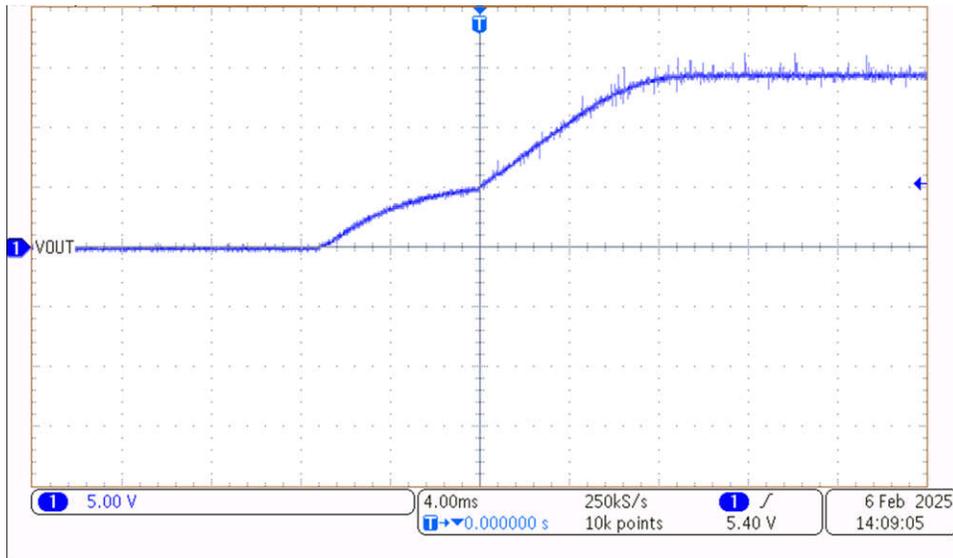


Figure 3-2. 5V Loaded Start Up

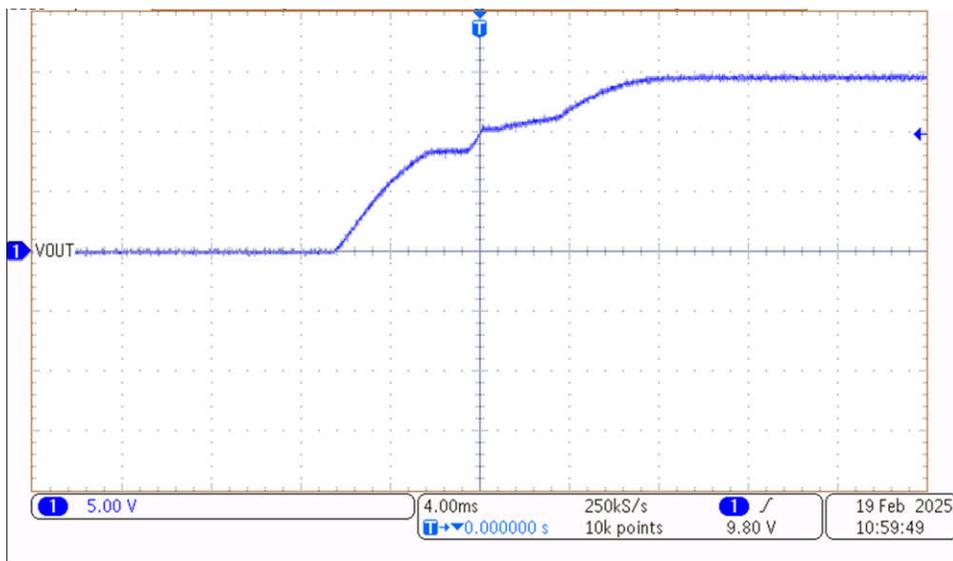


Figure 3-3. 12V Unloaded Start Up

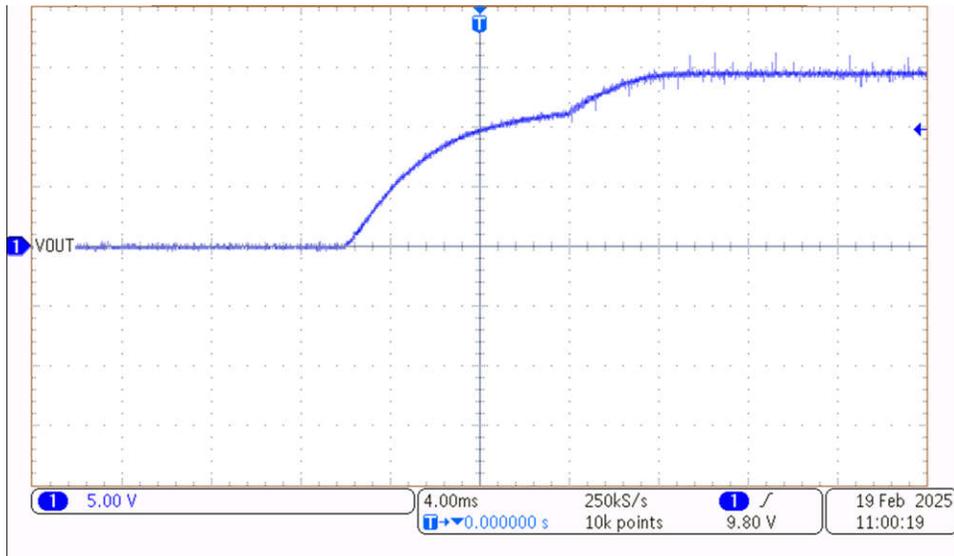


Figure 3-4. 12V Loaded Start Up

3.3 Shutdown

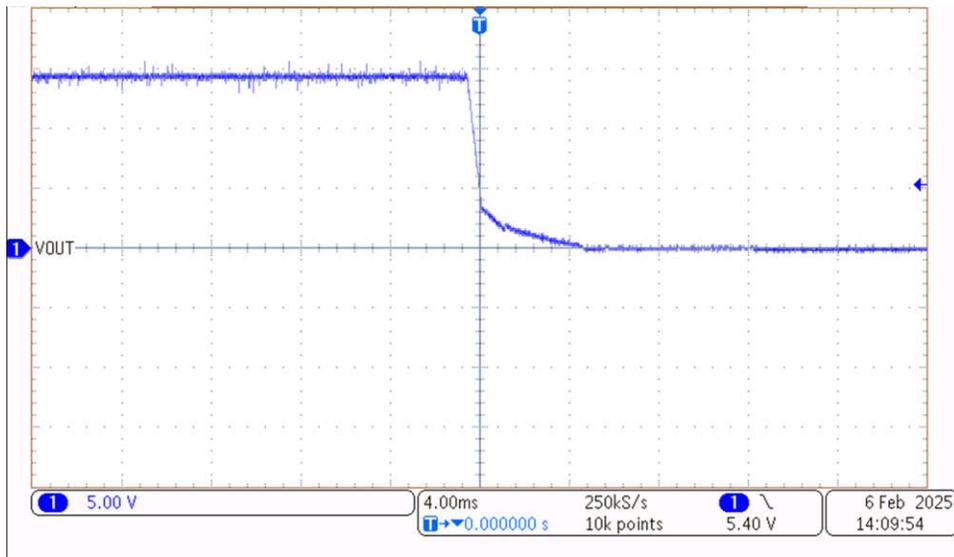


Figure 3-5. 5V Shutdown

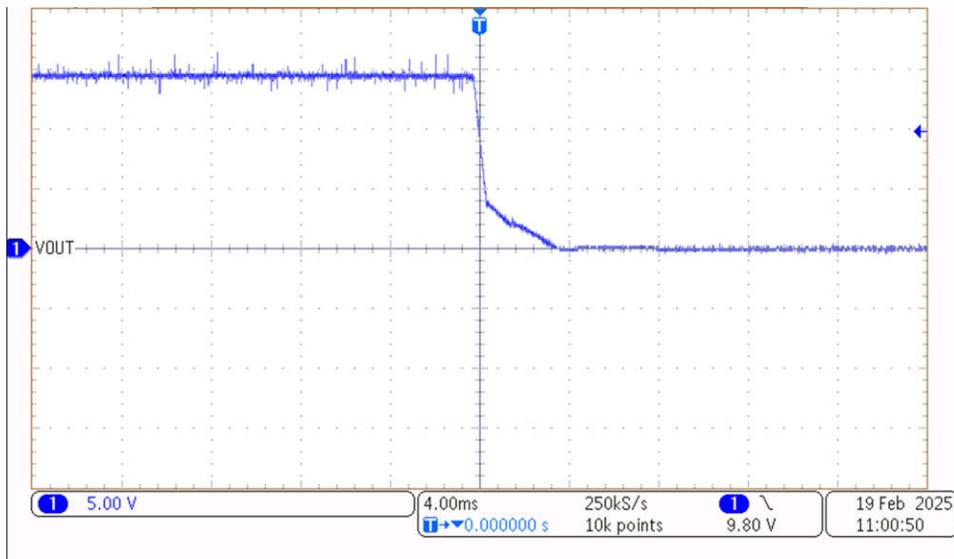


Figure 3-6. 12V Shutdown

3.4 Output Voltage Ripple

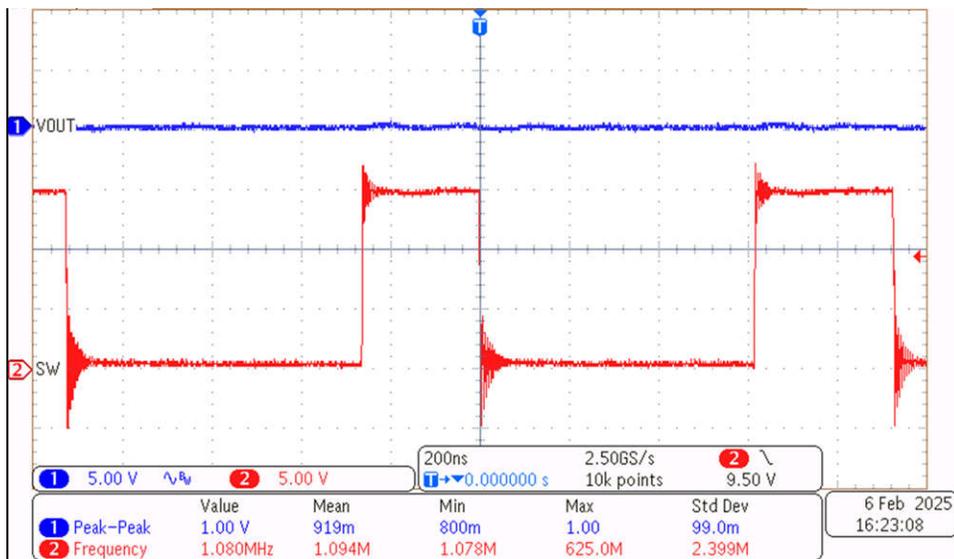


Figure 3-7. 5V Output Ripple

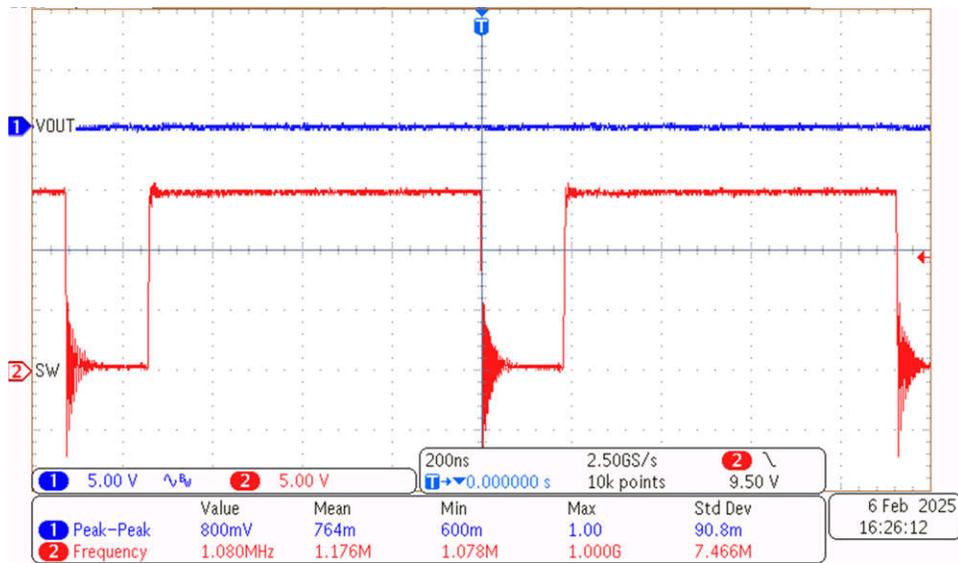


Figure 3-8. 12V Output Ripple

3.5 Load Step

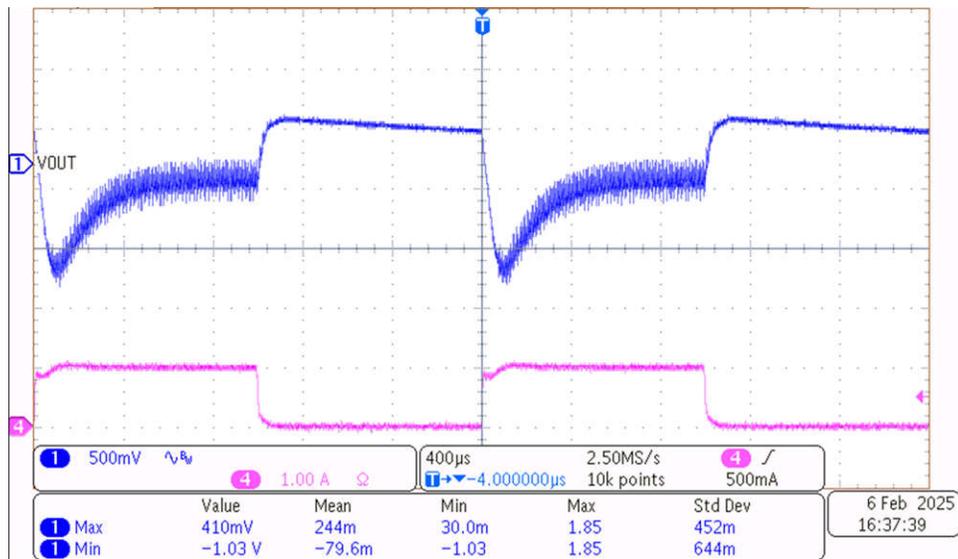


Figure 3-9. 5V Load Step

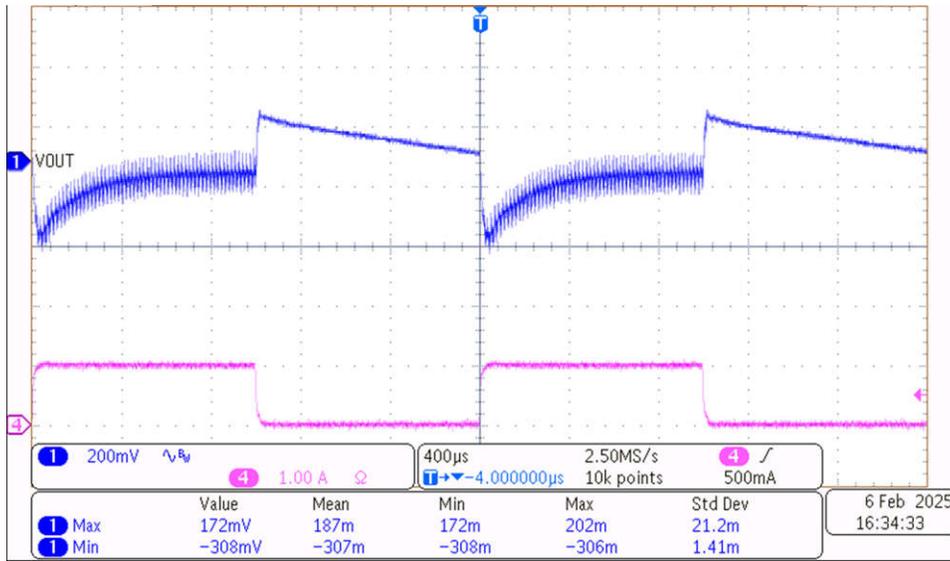


Figure 3-10. 12V Load Step

3.6 Frequency Response

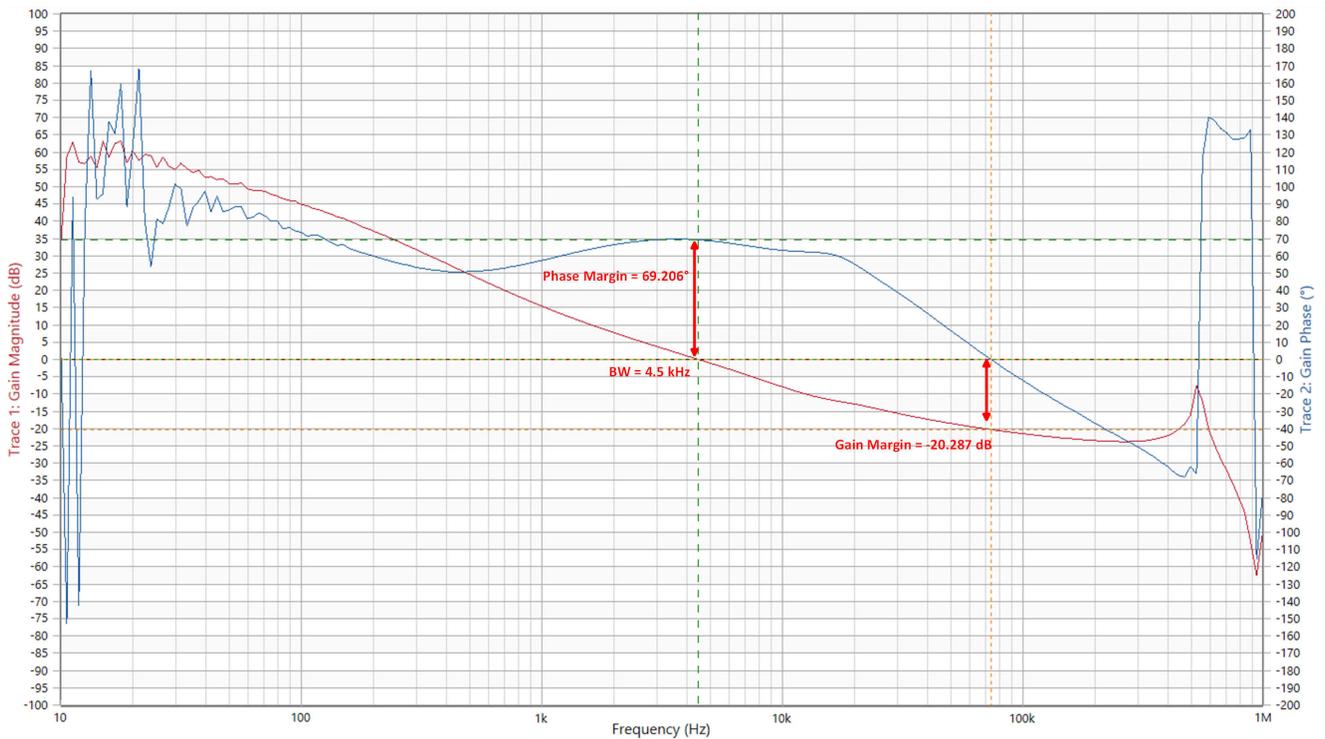


Figure 3-11. 5V Frequency Response

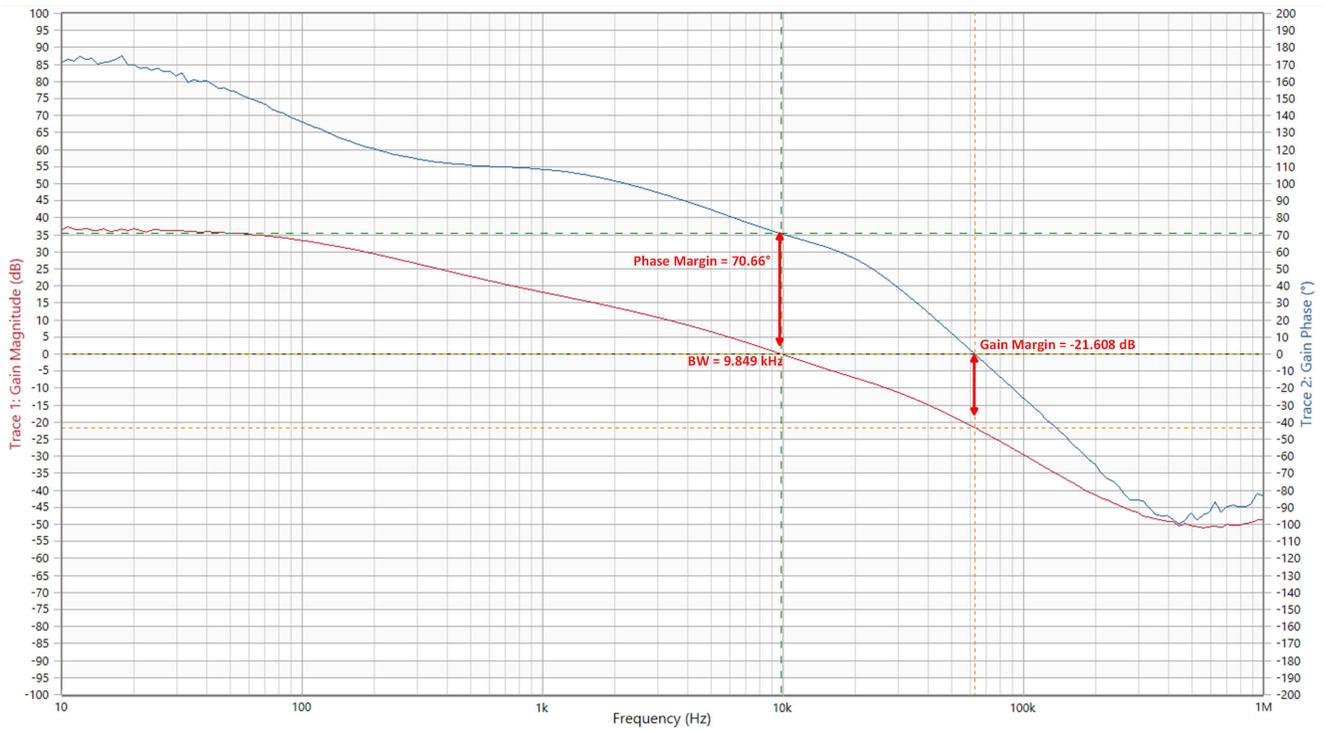


Figure 3-12. 12V Frequency Response

4 Hardware Design Files

4.1 Schematic

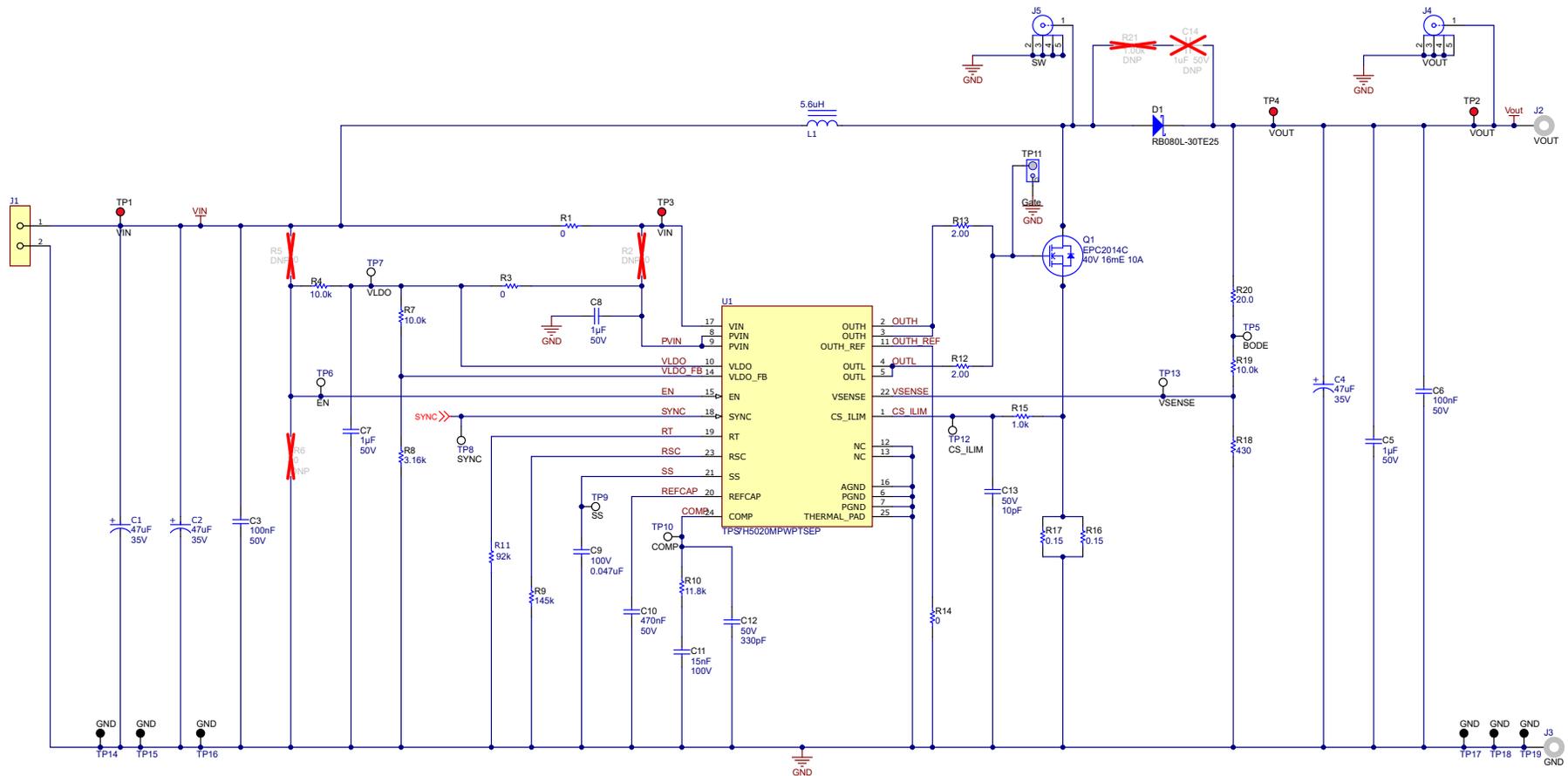


Figure 4-1. Default EVM Schematic

4.2 PCB Layouts

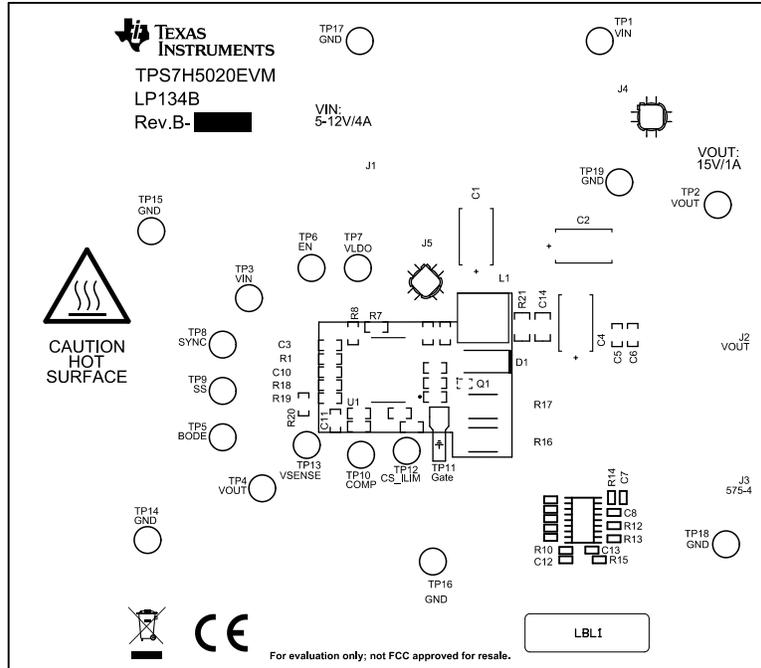


Figure 4-2. Top Overlay

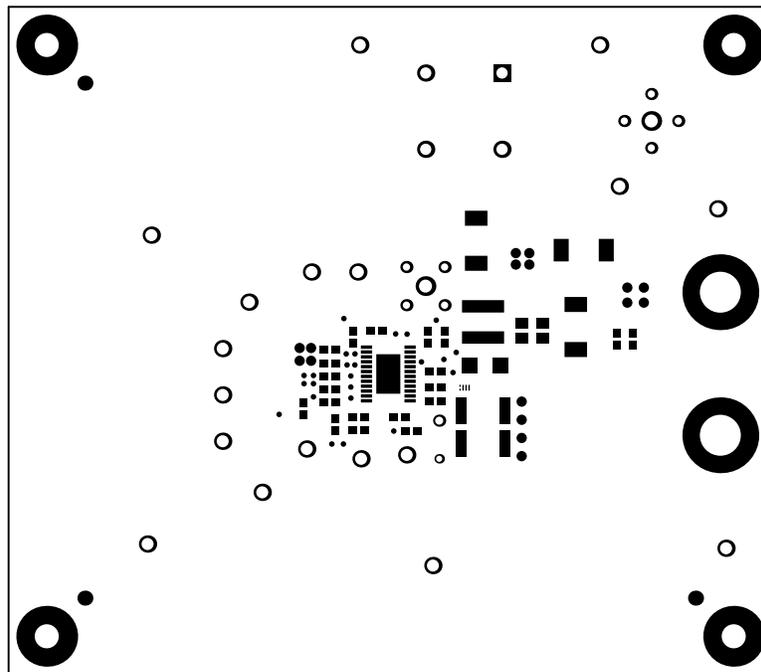


Figure 4-3. Top Solder Mask

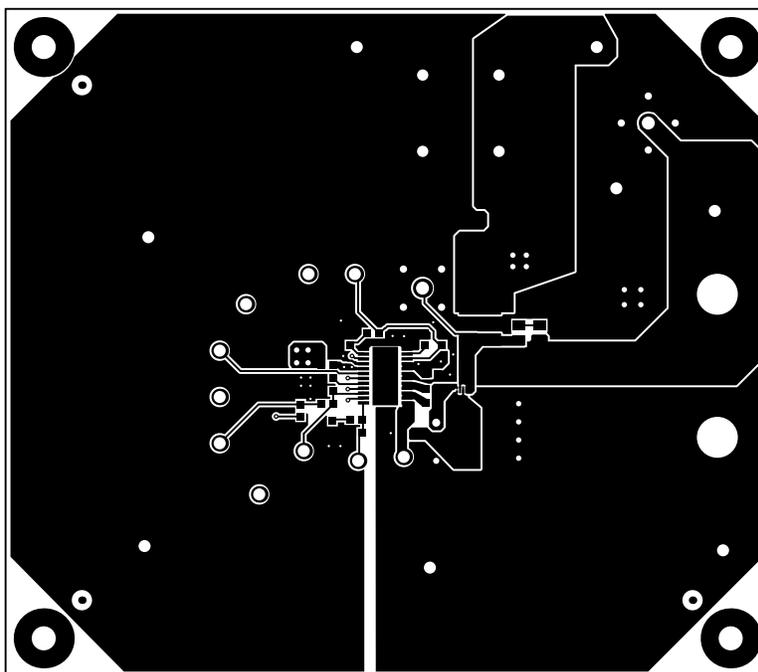


Figure 4-4. Layer 1 (Top)

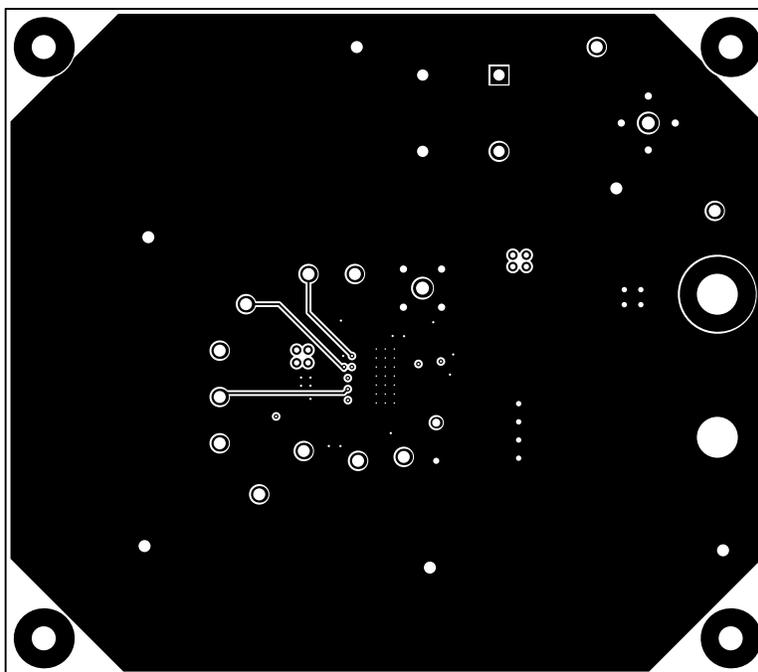


Figure 4-5. Layer 2

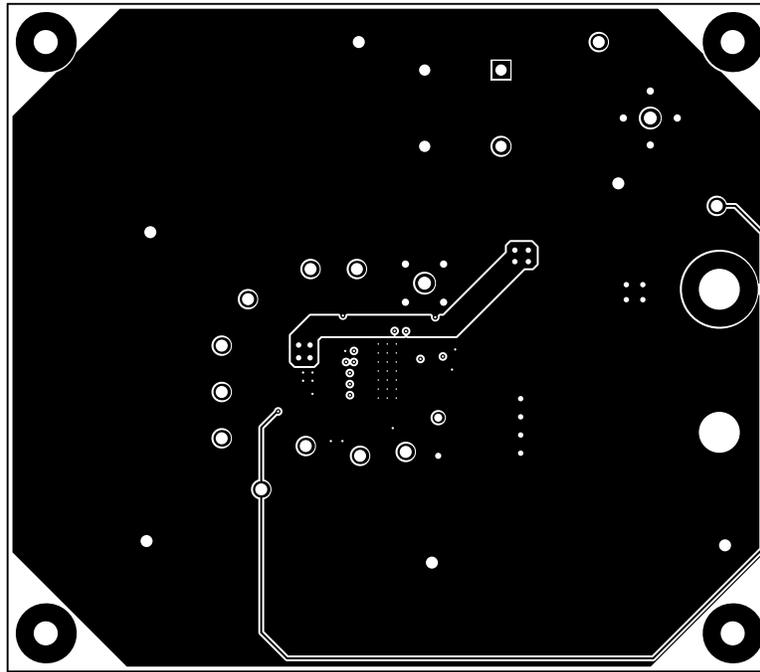


Figure 4-6. Layer 3

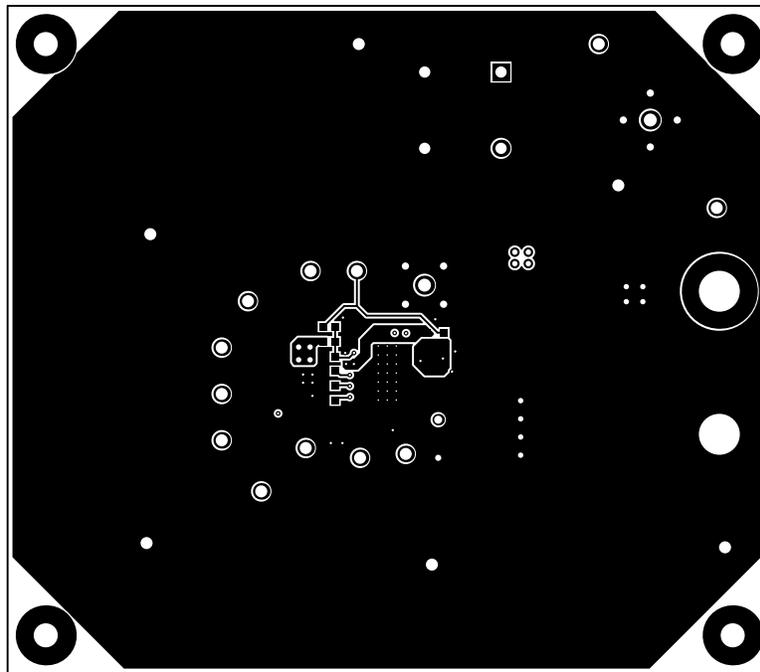


Figure 4-7. Layer 4 (Bottom)

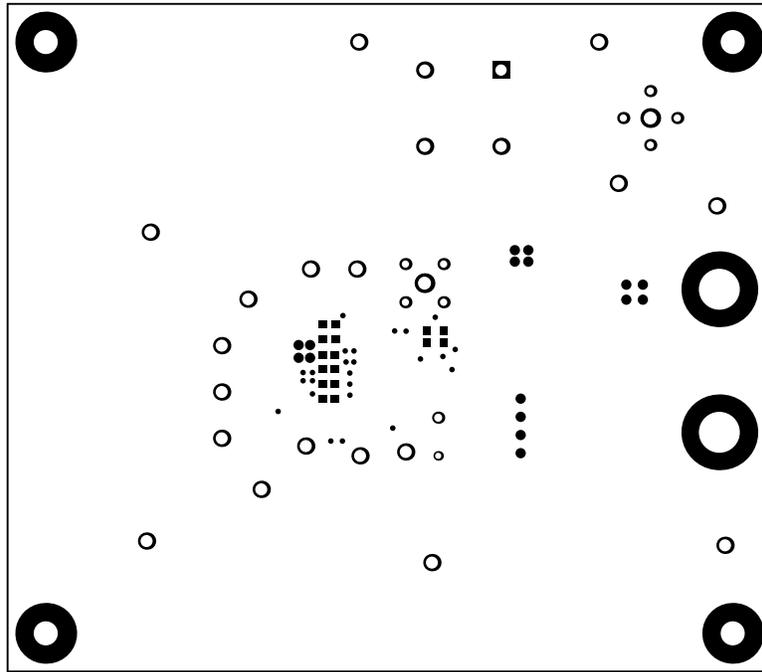


Figure 4-8. Bottom Solder Mask

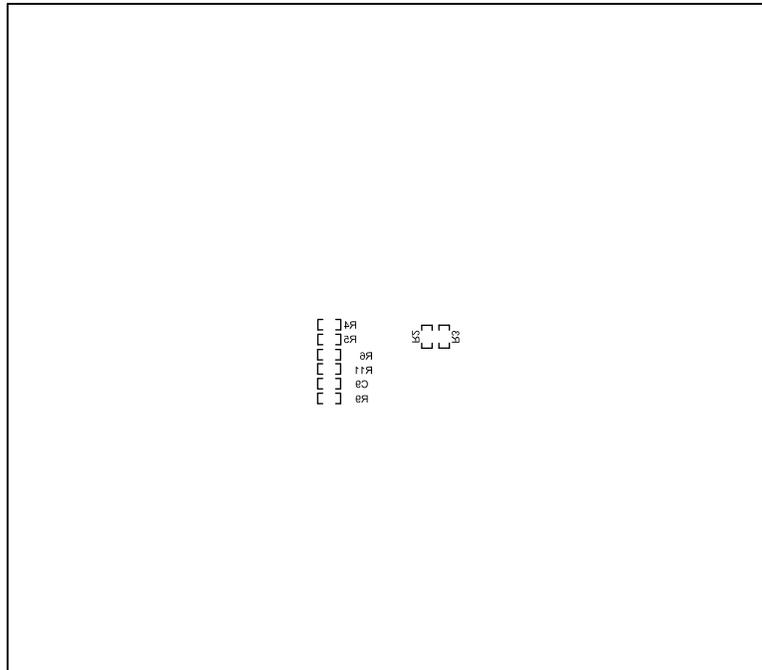


Figure 4-9. Bottom Overlay

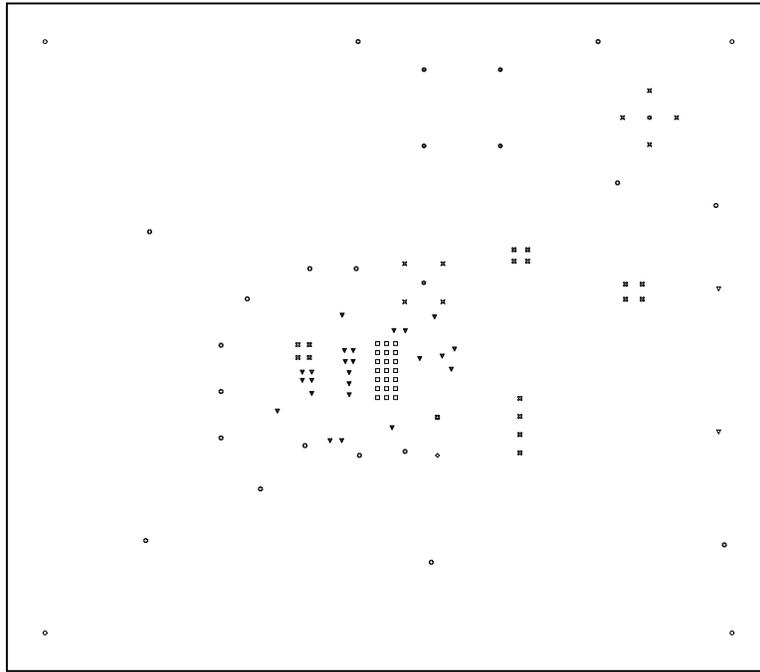


Figure 4-10. Drill Drawing

4.3 Bill of Materials (BOM)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C4	3	47 μ F	Cap Tant Solid 47uF 35V E CASE 10% (7.3 X 4.3 X 4.1mm) SMD 7343-43 0.055 Ohm 125 T/R	2917	TPME476K035R0055	KYOCERA AVX
C3, C6	2	0.1uF	CAP, CERM, 0.1 μ F, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	06035C104KAZ2A	AVX
C5, C7, C8	3	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0603	0603	UMK107AB7105KA-T	Taiyo Yuden
C9	1	0.047uF	CAP, CERM, 0.047 uF, 100 V, +/- 10%, X7S, 0603	0603	C1608X7S2A473K080AB	TDK
C10	1	0.47uF	CAP, CERM, 0.47 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1H474K080AE	TDK
C11	1	0.015uF	CAP, CERM, 0.015 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A153K080AA	TDK
C12	1	330pF	CAP, CERM, 330 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	C0603C331J5GACTU	Kemet
C13	1	10pF	CAP, CERM, 10 pF, 50 V, +/- 1%, C0G/NP0, 0603	0603	C0603C100F5GAC7867	Kemet
D1	1	30V	Diode, Schottky, 30 V, 5 A, SMA	SMA	RB080L-30TE25	Rohm
H1, H2, H3, H4	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
H5, H6, H7, H8	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Phillips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
J1	1		Fixed Terminal Blocks MKDSP 10 HV/ 2-10	HDR2	1929517	Phoenix Contact
J2, J3	2		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J4, J5	2		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
L1	1	5.6uH	5.6 μ H Shielded Drum Core, Wirewound Inductor 10 A 15.8mOhm Max Nonstandard	SMD2	SRP6060FA-5R6M	Bourns

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1	1		40V 16mE 10A	D0199	EPC2014C	EPC
R1, R3, R6, R14	4	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R4, R7, R19	3	10.0k	RES, 10.0 k, 0.01%, 0.1 W, 0603	0603	BLU0603-1002-TT10W	RCD Components
R8	1	3.16k	RES, 3.16 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD073K16L	Yageo America
R9	1	145k	RES, 145 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD07145KL	Yageo America
R10	1	11.8k	RES, 11.8 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0711K8L	Yageo America
R11	1	92k	92kΩ ±0.1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Moisture Resistant Thin Film	0603	RN73R1JTDD9202B25	KOA Speer
R12, R13	2	2	RES, 2.00, 1%, 0.125 W, 0603	0603	MCT06030C2008FP500	Vishay/Beyschlag
R15	1	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R16, R17	2	0.15	RES, 0.15, 1%, 2 W, 2512	2512	CRM2512-FX-R150ELF	Bourns
R18	1	430	RES, 430, 0.1%, 0.1 W, 0603	0603	RG1608P-431-B-T5	Susumu Co Ltd
R20	1	20	RES, 20.0, 0.1%, 0.1 W, 0603	0603	RT0603BRD0720RL	Yageo America
TP1, TP2, TP3, TP4	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP5, TP6, TP7, TP8, TP9, TP10, TP12, TP13	8		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
TP14, TP15, TP16, TP17, TP18, TP19	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		Radiation-Hardness-Assured 1-MHz Current Mode PWM Controller with Integrated Gate Driver	HTSSOP24	TPS7H5020MPWPTSEP	Texas Instruments
C14	0	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X6S, 0805, C2012X6S1H105K125AB	0805	C2012X6S1H105K125AB	TDK
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R2, R5	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic
R21	0	1.00k	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805, CRCW08051K00FKEA	0805	CRCW08051K00FKEA	Vishay-Dale

5 Compliance Information

Texas Instruments, [TPS7H5020EVM EU RoHS Declaration of Conformity \(DoC\)](#)

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

7 Related Documentation

Texas Instruments, [TPS7H502x-SP and TPS7H502x-SEP Radiation-Hardness-Assured 1MHz Current Mode PWM Controller With Integrated Gate Driver](#)

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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 - 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.
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 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE 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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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

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

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/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。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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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.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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