EVM User's Guide: TPS7H4012EVM

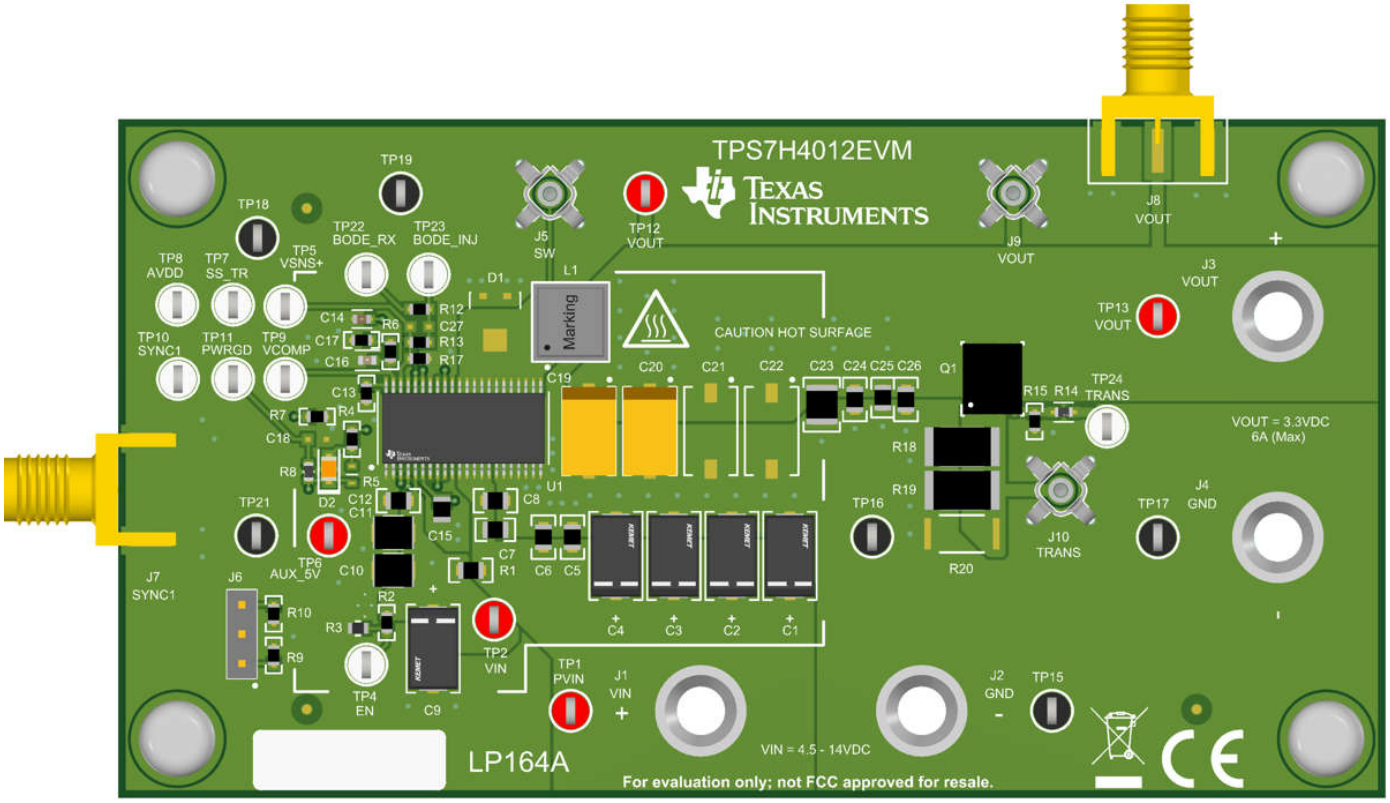
TPS7H4012EVM Evaluation Module

Description

The TPS7H4012EVM demonstrates the operation of a single TPS7H4012-SEP buck converter (plastic package). The board provides footprints that can be populated with additional components to allow for testing of customized configurations, as well as jumpers and test points for easy device configuration, and performance validation.

Features

- Input voltage range from 4.5V to 14V
- 6A maximum output current
- Selectable switching frequency
- High-current transient test circuit
- 0.6V ± 0.83% voltage reference over line, temperature, and radiation



EVM Board

1 Evaluation Module Overview

1.1 Introduction

The TPS7H4012EVM is the evaluation module (EVM) for the plastic package versions of the TPS7H4012 and provides a platform to electrically evaluate its 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 TPS7H401x data sheet to calculate values of any passives that need to be changed.

1.2 Kit Contents

- TPS7H4012EVM Board (1)

1.3 Specification

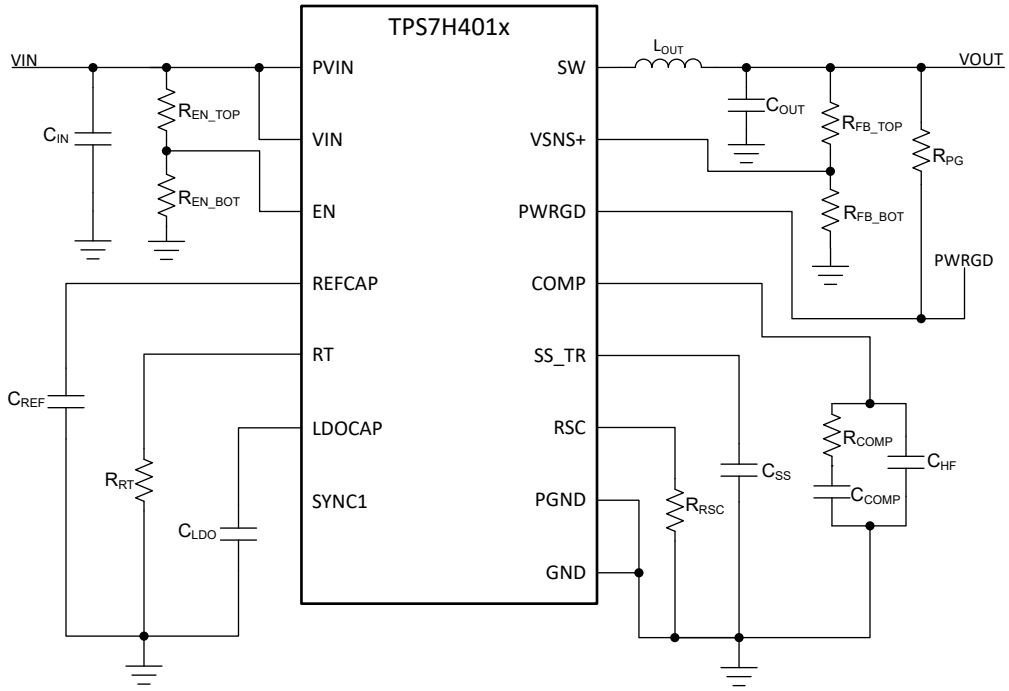


Figure 1-1. Simplified Schematic

Table 1-1. Default Configuration Options

SPECIFICATION	VALUE	DESCRIPTION
Input voltage VIN	12V	Falls within the recommended device input voltage range of 4.5V to 14V.
Output voltage VOUT	3.3V	Common power rail voltage within the device output capability. Configurable by changing R13 or R17.
Slope compensation resistor RSC	200kΩ	Configurable by changing R7.
Switching frequency FSW	1MHz or 500kHz	Configurable using a jumper on the EVM.

1.4 Device Information

The TPS7H4012 is a 14V, 6A synchronous buck converter optimized for use in a space environment. High efficiency and reduced component count are achieved through peak current mode control. The wide voltage range of the TPS7H4012 enables it to be used as a point of load regulator to convert directly from a 12V rail.

Further information about the TPS7H4012 can be found in the device data sheet.

2 Hardware

2.1 Setup

2.1.1 Transient Load Circuit

The TPS7H4012EVM provides a transient load circuit using CSD16408Q5 N-Channel Power MOSFET, along with a 600mΩ load resistance created by 2, 1.2Ω chip resistors connected in parallel. While the CSD16408Q5 power MOSFET is capable of conducting the full 6A output current of the TPS7H4012, the chip resistors are each rated for only 1W. When utilizing the transient circuit on the TPS7H4012EVM, the signal sent to the MOSFET gate through TP24 (TRANS) can be modulated to keep the average power through the load resistors below the 1W rating.

For additional information on operation of the power MOSFET, please see the CSD16408Q5 data sheet.

2.2 Connector Descriptions

Table 2-1 provides the connector descriptions for the TPS7H4012EVM.

Table 2-1. Connector Descriptions

REFERENCE DESIGNATOR	FUNCTION	
J1	PVIN	Power input connectors
J2	GND	
J3	VOUT	Power output connectors
J4	GND	
J7	SYNC1	SMA connector
J8	VOUT	
TP1	PVIN	Test point
TP2	VIN	
TP4	EN	
TP6	AUX_5V	
TP7	SS_TR	
TP8	AVDD	
TP9	VCOMP	
TP10	SYNC1	
TP11	PWRGD	
TP12, TP13	VOUT	
TP15, TP16, TP17, TP18, TP19, TP21	GND	
TP22	BODE_RX	
TP23	BODE_INJ	
TP24	TRANS	
J5	SW	Compact probe tip connector
J9	VOUT	
J10	TRANS	
J6	FSW_SEL	Jumper for mode selection

2.3 Best Practices

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

WARNING

Hot surface! Contact can cause burns. Do not touch!

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.

3 Implementation Results

3.1 Default Configuration Results

The following tests were performed using the TPS7H4012EVM in the default configuration with detailed settings shown in Table 3-1 unless otherwise noted.

Table 3-1. Test Settings

SPECIFICATION	VALUE
VIN	12V
VOUT	3.3V
FSW	500kHz
IOUT	6A

3.2 Soft Startup

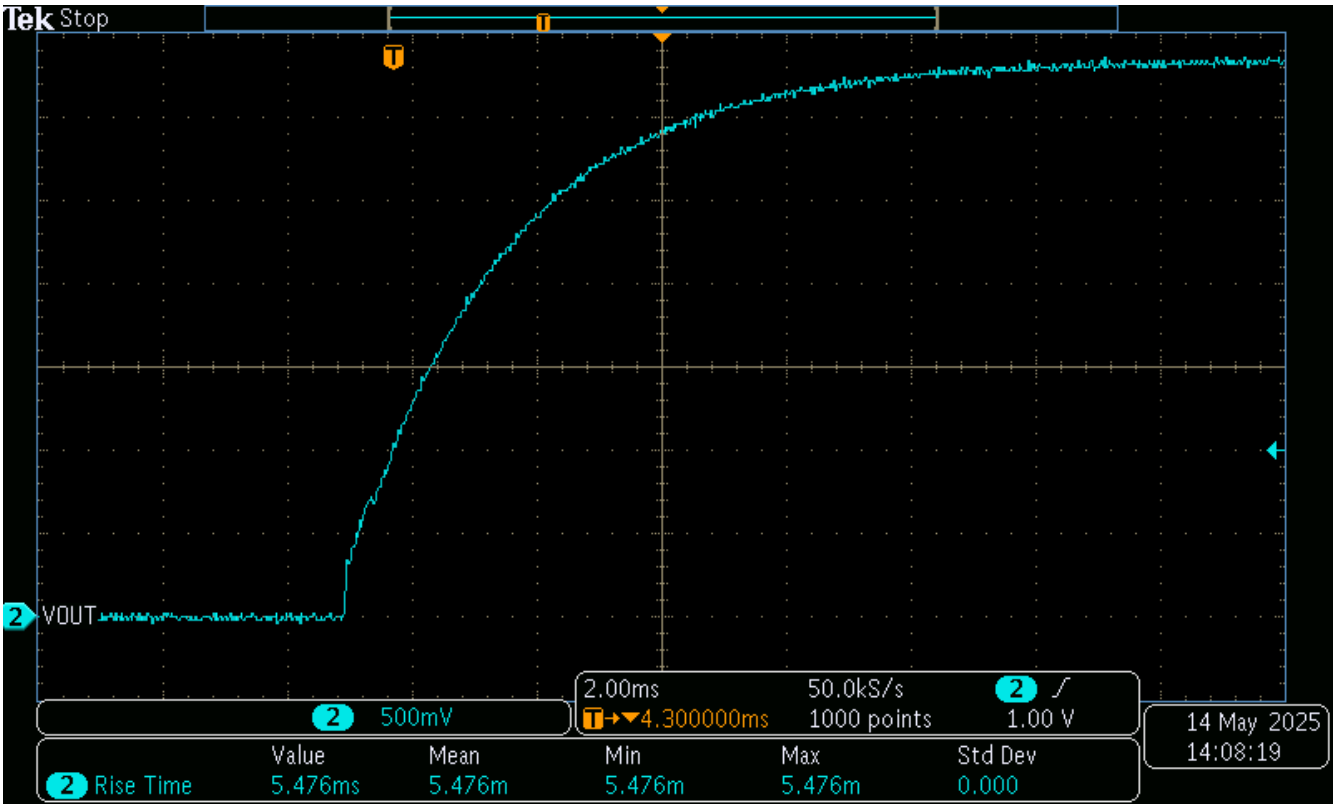


Figure 3-1. Soft Startup Into 550mΩ Load

3.3 Voltage Ripple on VOUT

Note

To avoid coupled noise from the switch node, output voltage ripple was measured across C20 using a "tip-and-barrel" method with a coil wire ground.

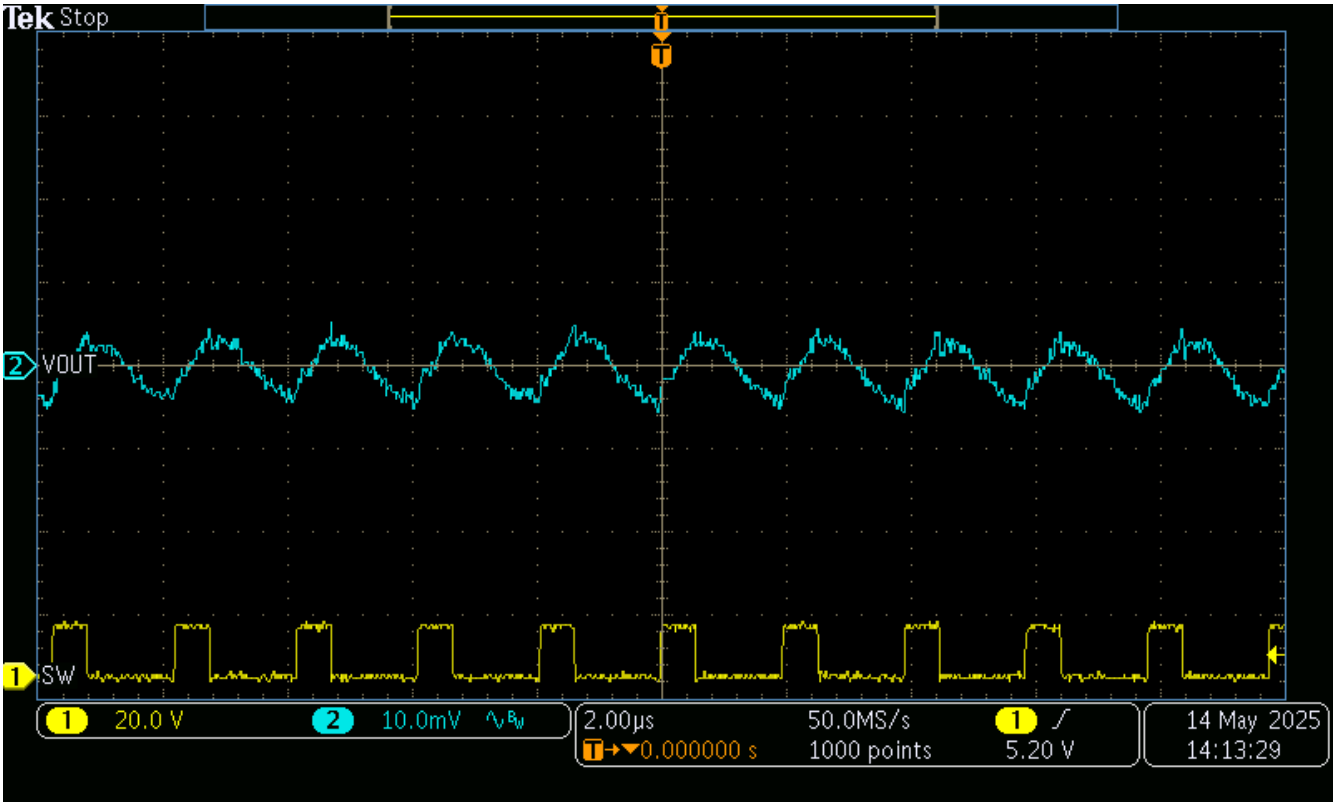


Figure 3-2. Output Voltage Ripple

3.4 Load Step

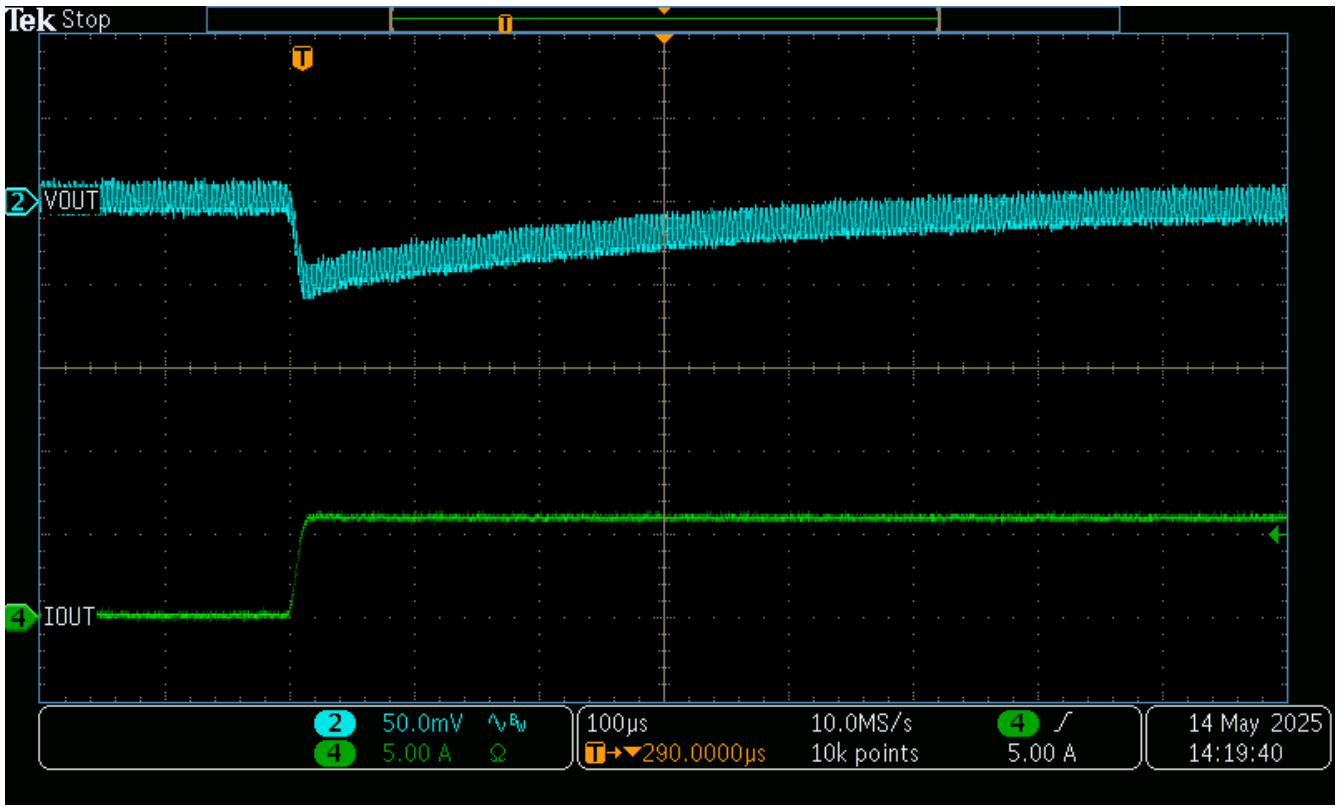


Figure 3-3. Transiant Response to Load Step 100mA to 6A at 8A/µs

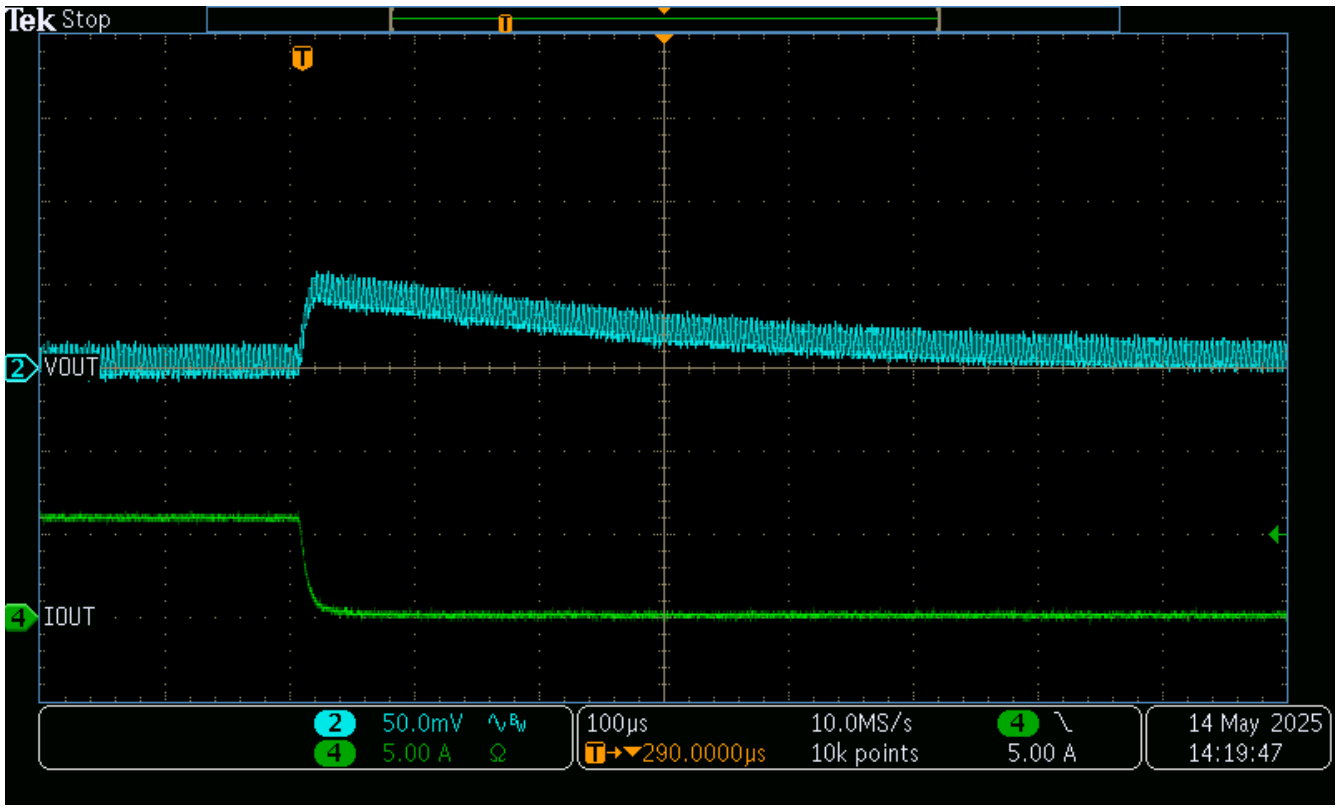


Figure 3-4. Transiant Response to Load Step 6A to 100mA at 8A/µs

3.5 Frequency Response

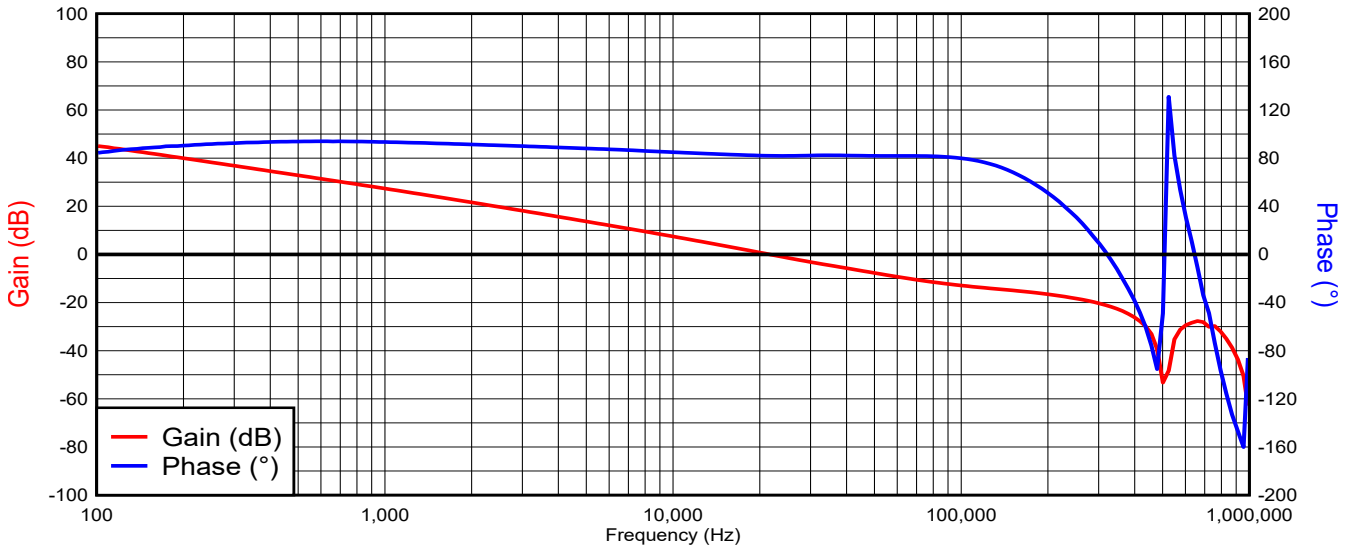


Figure 3-5. Frequency Response IOUT = 6A

4 Hardware Design Files

4.1 Schematics

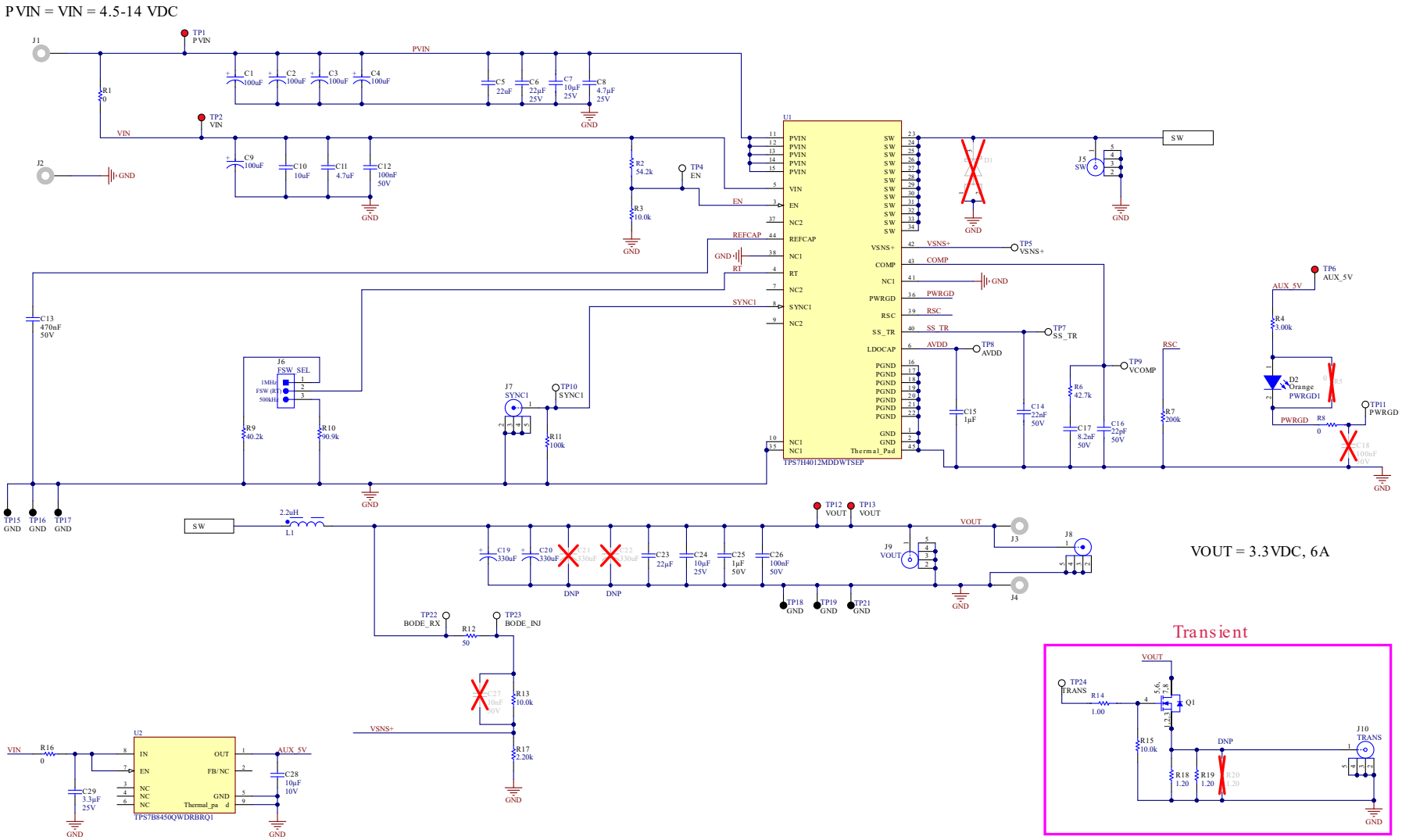


Figure 4-1. Default EVM Schematic

4.2 PCB Layouts

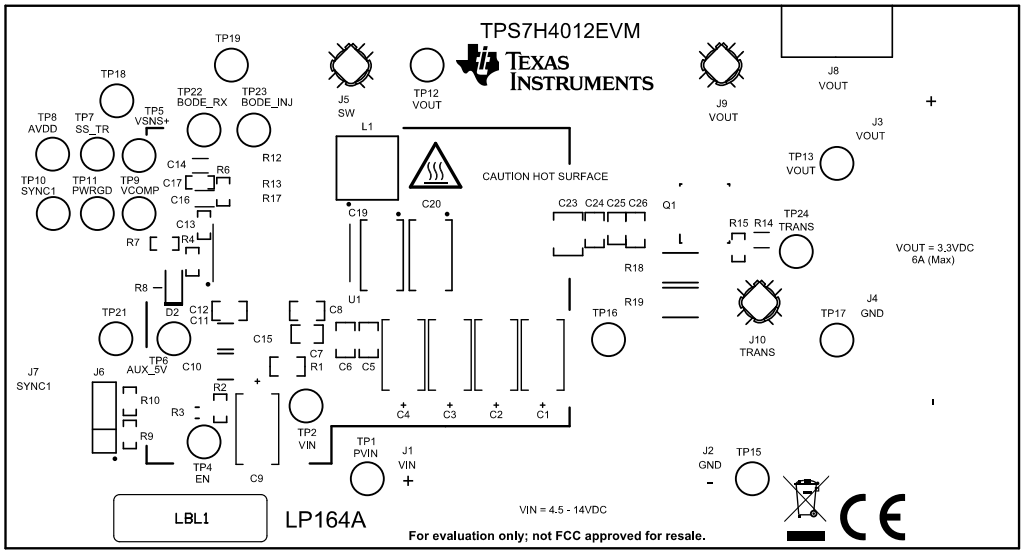


Figure 4-2. Top Overlay

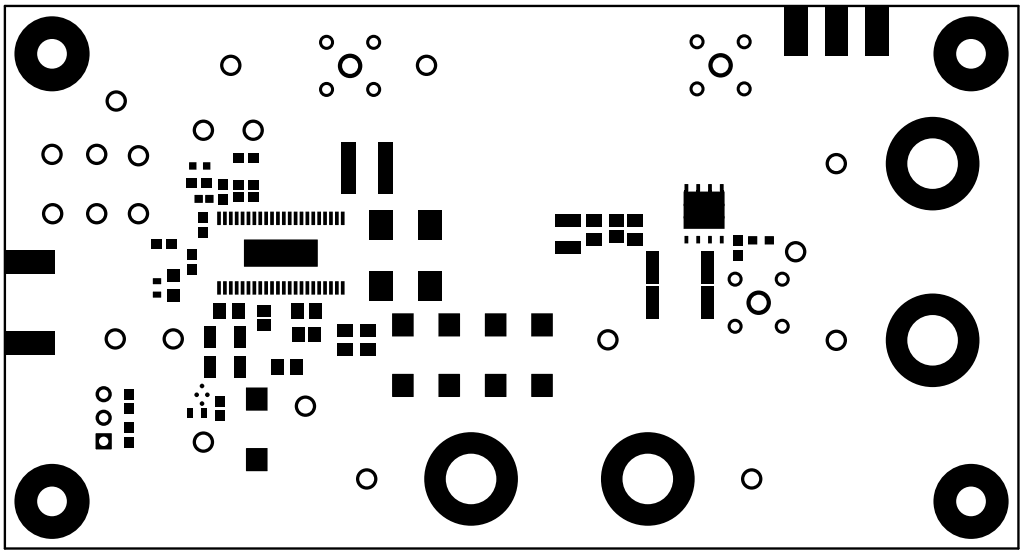


Figure 4-3. Top Solder Mask

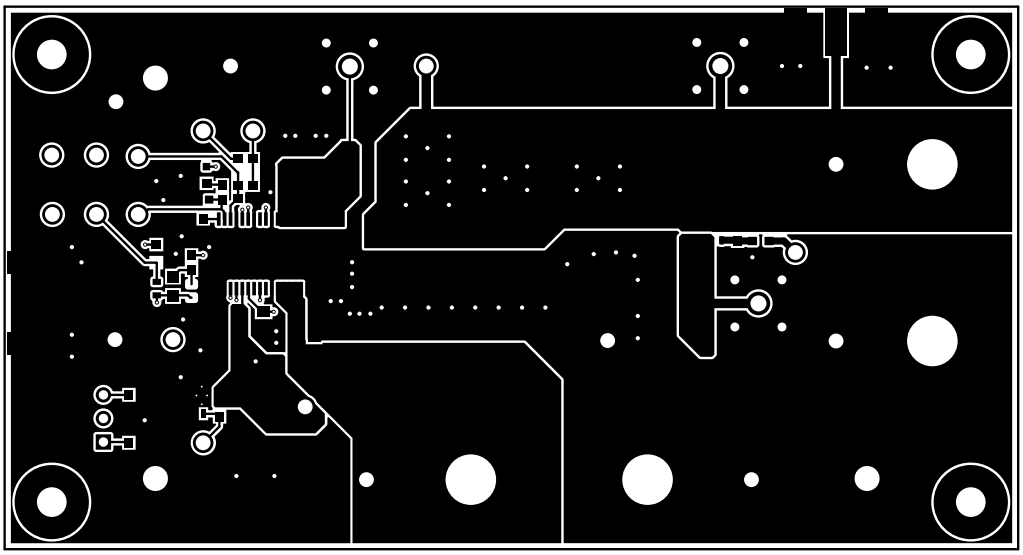


Figure 4-4. Layer 1 (Top)

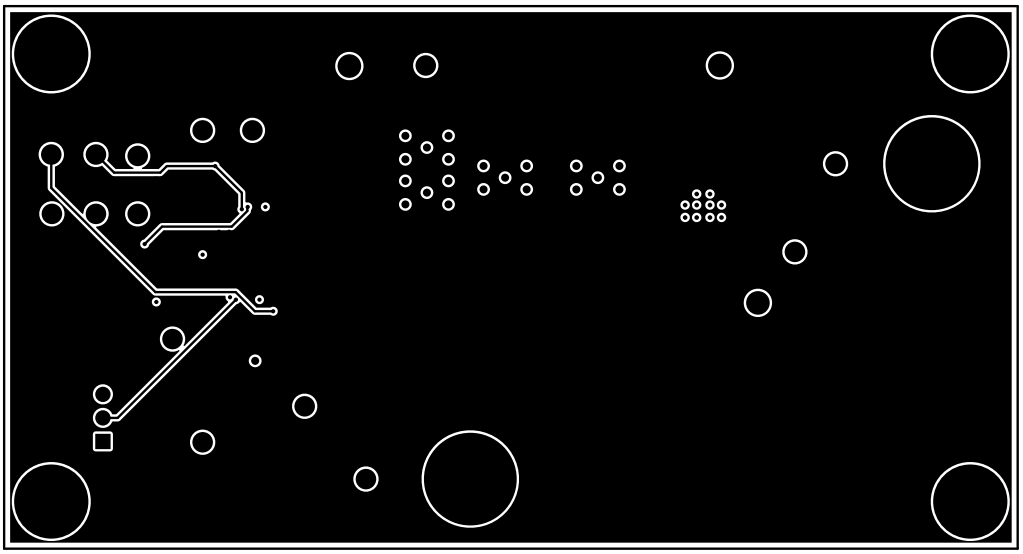


Figure 4-5. Layer 2

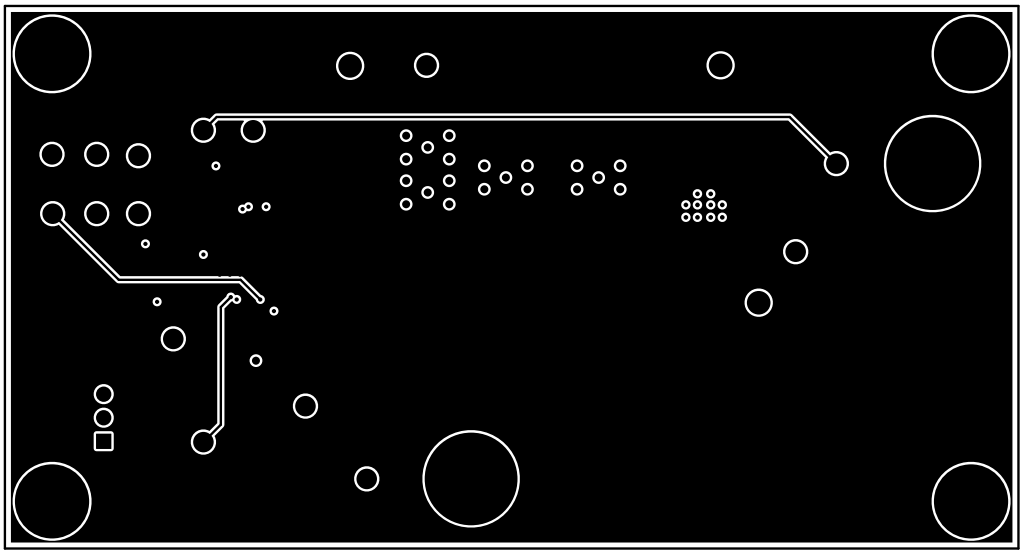


Figure 4-6. Layer 3

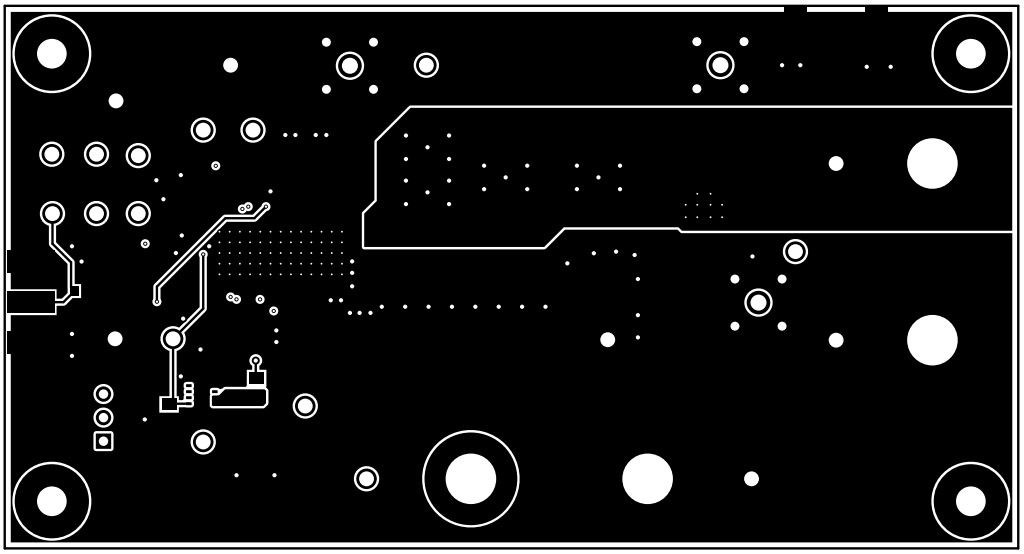


Figure 4-7. Layer 4 (Bottom)

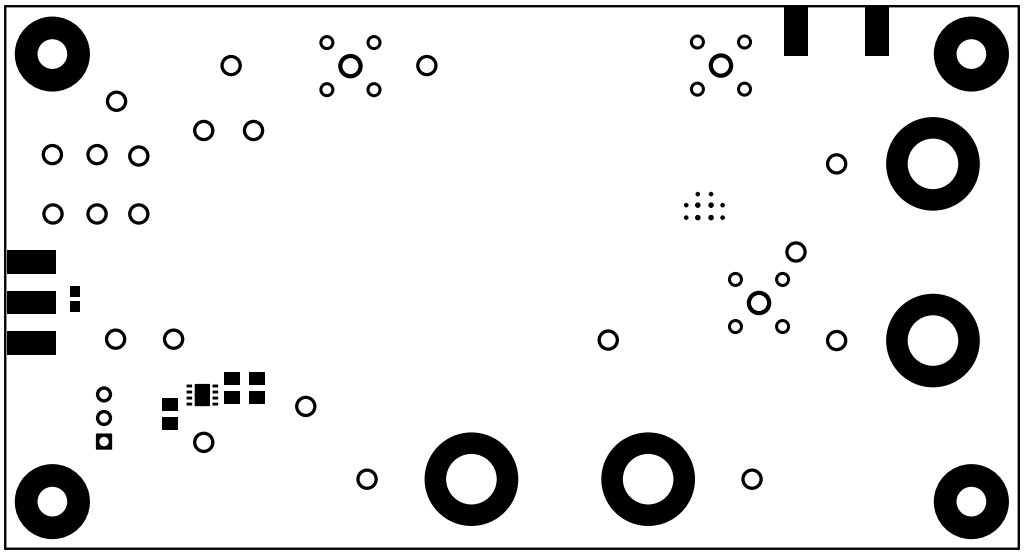


Figure 4-8. Bottom Solder Mask

Figure 4-9. Bottom Overlay

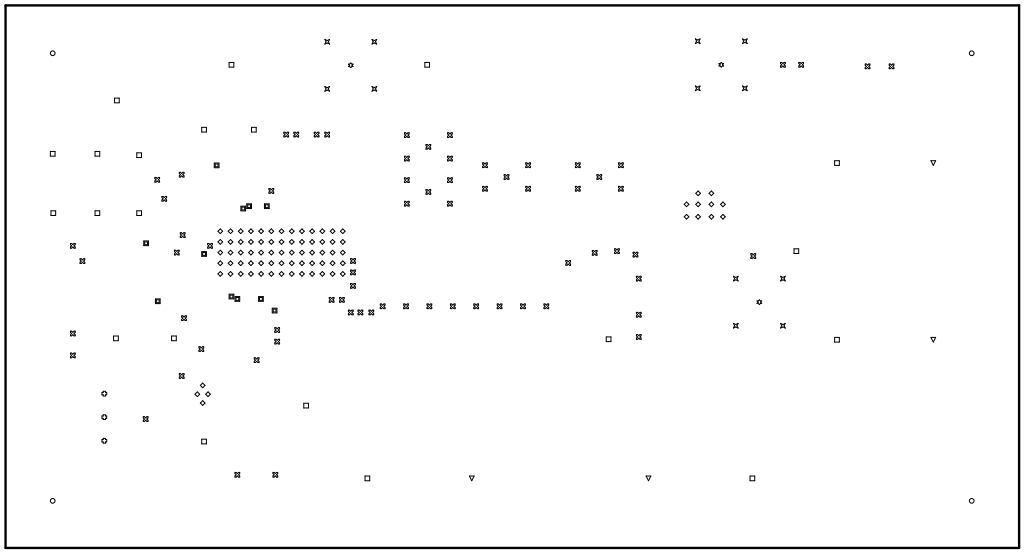


Figure 4-10. Drill Drawing

4.3 Bill of Materials (BOM)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C1, C2, C3, C4, C9	5	100µF	Cap Tant Polymer 100uF 25VDC D CASE 20% (7.3 X 4.3 X 2.8mm) SMD 7343-31 0.04 Ohm 105C T/R	2917	T521D107M025ATE040	KEMET
C5, C6	2	22uF	CAP, CERM, 22 uF, 25 V, +/- 20%, X5R, 0805	0805	GRM21BR61E226ME44L	MuRata
C7	1	10µF	CAP0805 X7R 10UF 10% 25V	0805	GMC21X7R106K25NT	Cal-Chip Electronics
C8	1	4.7uF	CAP, CERM, 4.7 µF, 25 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	CGA4J1X7R1E475K125AC	TDK
C10	1	10uF	CAP, CERM, 10 uF, 25 V, +/- 10%, X7R, 1210	1210	12103C106KAT2A	AVX
C11	1	4.7uF	CAP, CERM, 4.7 uF, 50 V, +/- 10%, X7R, 1210	1210	C3225X7R1H475K250AB	TDK
C12, C26	2	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 0, 0805	0805	C0805C104K5RACAUTO	Kemet
C13	1	0.47uF	CAP, CERM, 0.47 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H474K080AC	TDK
C14	1	22nF	0.022 µF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	8.85012E+11	Wurth Electronics
C15, C25	2	1uF	CAP, CERM, 1 µF, 50 V,+/- 10%, X7R, 0805	0805	CL21B105KBFNFNE	Samsung
C16	1	22pF	Cap Ceramic 22pF 50V NP0 5% Pad SMD 0603 +150°C Automotive T/R	0603	CGA3E2NP01H220J080AA	TDK
C17	1	8200pF	CAP, CERM, 8200 pF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCD188R71H822KA01D	MuRata
C19, C20	2	330µF	Cap Tant Polymer 330uF 10VDC X Case 20% (7.3 X 4.3 X 4Mm) SMD 7343-43 0.005 Ohm 125°C T/R	2917	T530X337M010ATE005	Kemet
C23	1	22uF	CAP, CERM, 22 µF, 16 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210	CL32B226KOJVPNE	Samsung Electro-Mechanics
C24	1	10uF	CAP, CERM, 10 uF, 25 V, +/- 10%, X7R, 0805	0805	GRM21BZ71E106KE15L	MuRata
C28	1	10uF	CAP, CERM, 10 µF, 10 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	GCJ21BR71A106KE01L	MuRata
C29	1	3.3uF	CAP, CERM, 3.3 uF, 25 V, +/- 10%, X7R, 0805	0805	C2012X7R1E335K125AB	TDK
D2	1	Orange	LED, Orange, SMD	LED_0805	LTST-C170KFKT	Lite-On
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2, J3, J4	4		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J5, J9, J10	3		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
J6	1		Header, 100mil, 3x1, Gold, TH	Header, 100mil, 3x1, TH	HTSW-103-07-G-S	Samtec
J7, J8	2		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
L1	1	2.2uH	WE-XHMI SMT Power Inductor, size 6060, 2.2uH, 10.6A, 5.58mOhm	6060	74439346022	Wurth Elektronik
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	25V	MOSFET, N-CH, 25 V, 113 A, DQH0008A (VSON-CLIP-8)	DQH0008A	CSD16408Q5	Texas Instruments
R1, R16	2	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R2	1	54.2k	54.2 kOhms ±0.1% 0.21W Chip Resistor 0603 (1608 Metric) Anti-Sulfur, Automotive AEC-Q200, Moisture Resistant Thin Film	0603	TNPW060354K2BEEN	Vishay
R3	1	10.0k	RES, 10.0 k, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW060310K0BEEA	Vishay-Dale
R4	1	3.00k	RES, 3.00 k, 0.1%, 0.1 W, 0603	0603	RG1608P-302-B-T5	Susumu Co Ltd
R6	1	42.7k	42.7 kOhms ±0.1% 0.21W Chip Resistor 0603 (1608 Metric) Anti-Sulfur, Automotive AEC-Q200, Moisture Resistant Thin Film	0603	TNPW060342K7BEEA	Vishay
R7	1	200k	RES, 200 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD07200KL	Yageo America
R8	1	0	0 Ohms ±1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Anti-Sulfur Thick Film	0603	D1TFAS0603WJUMPF-T5	Thin Film Technology
R9	1	40.2k	RES, 40.2 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0740K2L	Yageo America
R10	1	90.9k	RES, 90.9 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0790K9L	Yageo America
R11	1	100k	RES, 100 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD07100KL	Yageo America
R12	1	50	RES, 50, 0.1%, 0.125 W, 0603	0603	FC0603E50R0BTBST1	Vishay Thin Film
R13, R15	2	10.0k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0710KL	Yageo America

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R14	1	1	1 Ohms ±0.1% 0.063W, 1/16W Chip Resistor 0603 (1608 Metric) Thin Film	0603	CPF0603B1R0E1	TE Connectivity
R17	1	2.20k	RES, 2.20 k, 0.1%, 0.1 W, 0603	0603	RG1608P-222-B-T5	Susumu Co Ltd
R18, R19	2	1.2	RES, 1.20, 1%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25121R20FKEG	Vishay-Dale
TP1, TP2, TP6, TP12, TP13	5		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP4, TP5, TP7, TP8, TP9, TP10, TP11, TP22, TP23, TP24	10		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
TP15, TP16, TP17, TP18, TP19, TP21	6		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	1		4.5V to 14V Input, 6A, Radiation Hardened Synchronous Buck Converter	HTSSOP44	TPS7H4012MDDWTSEP	Texas Instruments
U2	1		Linear Voltage Regulator IC Positive Fixed 1 Output 150mA 8-SON (3x3)	VSON8	TPS7B8450QWDRBRQ1	Texas Instruments
C18	0	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet
C21, C22	0	330µF	Cap Tant Polymer 330uF 10VDC X Case 20% (7.3 X 4.3 X 4Mm) SMD 7343-43 0.005 Ohm 125°C T/R	2917	T530X337M010ATE005	Kemet
C27	0	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	0603	C0603X103K5RACTU	Kemet
D1	0		Diode 40 V 10A Surface Mount TO-277A (SMPC)	SMPC	SS10P4-M3/86A	Vishay
R5	0	0	0 Ohms ±1% Chip Resistor 0603 (1608 Metric) Thick Film	0603	CR160000F	Meritek Electronics
R20	0	1.2	RES, 1.20, 1%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW25121R20FKEG	Vishay-Dale

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 Related Documentation

- Texas Instruments, TPS7H401x-SP and TPS7H401x-SEP 4.5V to 14V Input, 3A and 6A, Radiation Hardened Synchronous Buck Converter
- Texas Instruments, *N-Channel NexFET™ Power MOSFET* (CSD16408Q5) data sheet

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.

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。

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.

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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/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。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.

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, INDEMITY 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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