TPSM846C23, 35-A, PMBus, SWIFT™ Power Module Evaluation Module

This user's guide contains information for the TPSM846C23EVM-806 evaluation module (PWR806). Also included are the performance specifications, schematic, bill of materials, and layout of the EVM.

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Trademarks

SWIFT is a trademark of Texas Instruments.

1 Description

The TPSM846C23 is a highly integrated, PMBus enabled, synchronous buck power module that combines a 35-A DC/DC converter with power MOSFETs, a shielded inductor, some input and output capacitors, and passives into a low profile package. The input voltage range is 4.5 V to 15 V. The output voltage ranges is 0.35 V to 2 V. The PMBus interface provides for converter configuration as well as monitoring of key parameters including output voltage, output current, and the internal die temperature, as well as many user-programmable configuration options.

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This evaluation module is designed to demonstrate the ease-of-use and small printed circuit board area that may be achieved when designing with the TPSM846C23 power module. Monitoring test points are provided to allow measurement of efficiency, power dissipation, input ripple, output ripple, line and load regulation, and transient response. Additionally, control test points are provided for use of the power good, enable control, and synchronization features of the device. The EVM uses a recommended PCB layout that maximizes thermal performance and minimizes output ripple and noise.

2 Getting Started

Figure 1 highlights the user interface items associated with the EVM. The polarized input power terminal block (TB1) is used for connection to the host input supply. TB2 allows 2 terminals for VOUT and TB3 allows 2 terminals for PGND for connection to the load. These terminal blocks can except up to 10 AWG wire.

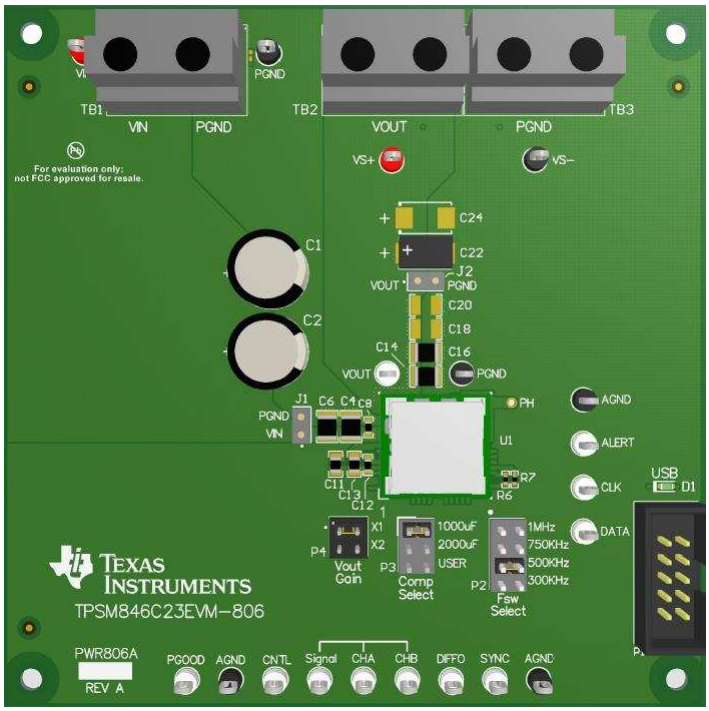


Figure 1. EVM User Interface

The VIN Monitor (VIN and PGND) test points and VOUT Monitor (VS+ and VS-) test points located near the input terminal block and the output terminal blocks are intended to be used as voltage monitoring points where voltmeters can be connected to measure the input and output voltages. Do not use these VIN and VOUT monitoring test points as the input supply or output load connection points. The PCB traces connecting to these test points are not designed to support high currents.

The VIN Scope (J1) and VOUT Scope (J2) test points can be used to monitor VIN and VOUT waveforms with an oscilloscope. These test points are intended for use with un-hooded scope probes outfitted with a low-inductance ground lead (ground spring) mounted to the scope probe barrel. The two sockets of each test point are on 0.1 inch centers. The scope probe tip should be inserted into the socket labeled VIN or VOUT, and the scope ground lead should be inserted into the hole of the socket labeled PGND.

The test points located along the bottom of the EVM are made available to test the features of the device. Any external connections made to these test points should be referenced to one of the AGND test points. Refer to the Section 3 section of this guide for more information on the individual control test points.

The PMBus connector (P1) is provided to connect the USB to GPIO interface pod to the EVM. The USB to GPIO interface pod connects the EVM to a computer USB port which allows the TI “Fusion” Graphical User Interface (GUI) to communicate and control the EVM. To download the latest software visit, http://www.ti.com/tool/fusion_digital_power_designer.

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The ALERT, DATA, CLK and CNTL test points are used to monitor the PMBus signals. Reference the TPSM846C23 datasheet for details on the supported PMBus commands.

The PMBus address is set by resistors R6 and R7. The PMBus address is 27 (decimal), 1B (hex).

The Vout Gain jumper (P4) is used to set the output voltage range. Select X1 for output voltages between 0.35 V - 1.65 V and select X2 for output voltages between 1.65 V - 2.0 V. The default loading is the X1 position.

The Comp Select jumper (P3) sets the proper frequency compensation for the total amount of output capacitance present on the V_{OUT} bus. The EVM is shipped with approximately 1000 µF of output capacitance loaded on the board. Locations are provided on the board to add additional output capacitance (C18-C21, C24, C25). The default Comp Select jumper is loaded in the 1000 µF position which is the correct setting for output capacitance from 1000 µF to 1500 µF. The jumper position labeled 2000 µF selects compensation components for 1500 µF to 3000 µF of output capacitance. The jumper position labeled USER selects compensation components for 3000 µF to 5000 µF of output capacitance. See the TPSM846C23 datasheet for more information on selecting compensation components.

The Fsw Select jumper (P2) is used to set the switching frequency. Select from 300 kHz, 500 kHz, 750 kHz, and 1 MHz. The default jumper loading is the 500 kHz position.

3 Test Point Descriptions

Wire-loop test points and scope probe test points are provided as convenient connection points for digital voltmeters (DVM) or oscilloscope probes to aid in the evaluation of the device. A description of each test point follows:

Table 1. Test Points

VIN	Input voltage monitor. Connect DVM across this point and PGND for measuring efficiency.
VS+	Supply path output voltage monitor. Connect DVM positive lead to this point for line and load regulation.
VS-	Return path output voltage monitor. Connect DVM negative lead to this point for measuring line and load regulation.
VOUT	Output voltage monitor. Connect DVM to this point and PGND for measuring efficiency.
PGND	Input and output voltage monitor grounds. Reference the VIN and VOUT DVMs to these ground points.
VIN MON (J1)	Input voltage scope monitor. Connect an oscilloscope to this set of points to measure input ripple voltage.
VOUT MON (J2)	Output voltage scope monitor. Connect an oscilloscope to this set of points to measure output ripple voltage and transient response.
AGND	Analog ground point. Use any of the AGND test points as the ground reference for the control signals.
ALERT	PMBus ALERT line. Used to monitor the ALERT signal.
CLK	PMBus CLK line. Used to monitor the CLK signal.
DATA	PMBus DATA line. Used to monitor the DATA signal.
PGOOD	Monitors the power good signal of the device. This is an open drain signal that has an on-board 10 kΩ pullup resistor to 3.3V.
CNTL	Control pin. Pull to GND to stop power conversion. Float or pull to 3.3V to enable power conversion. An internal 10 kΩ pull-up resistor to 3.3V is present on the EVM.
Signal	Signal injection point for Bode plot analyzer. Inject from Signal to CHB.
CHA	Input signal monitoring point for Bode plot analyzer.
CHB	Output signal monitoring point for Bode plot analyzer.
DIFFO	Output of remote sense differential amplifier.
SYNC	Connects to the SYNC pin of the device. An external clock signal can be applied to this point to synchronize the device to an appropriate frequency.
PH	Switch node of the TPSM846C23 device. Use an un-hooded scope probe to monitor this point.

NOTE: Refer to the product datasheet (SLVSDF3) for absolute maximum ratings associated with features in Table 1.

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4 Operation Notes

In order to operate the EVM, apply a valid input voltage of 4.5 V to 15 V. The power supply providing the input voltage must be rated for sufficient input current. The under voltage lock out (UVLO) can be programmed using the PMBus commands.

The output voltage is set at the factory to 0.6 V. It can be programmed over the allowable output voltage range by using the PMBus VOUT_COMMAND.

The TPSM846C23 is a 35-A device. When connecting the EVM to the external load, use wiring capable of safely handling 35 A of output current.

The Power Good (PGOOD) indicator of the EVM will assert high when the output voltage is within ±5% of the programmed output voltage value. A 10-kΩ pull-up resistor (R11) is populated between the PGOOD pin and the BP3 pin.

The TPSM846C23 EVM is set-up to operate at 500 kHz, but the switching frequency can be adjusted using the P2 jumper. If an exact switching frequency is required, the device can be synchronized to an external clock over the frequency range of 300 kHz to 1 MHz. Refer to the product datasheet for further information on synchronization.

The TPSM846C23 EVM includes both input and output capacitors. The EVM includes footprints for adding additional input and output capacitors to the EVM. Adding additional capacitance will improve transient response. The actual capacitance required will depend on the input and output voltage conditions of the particular application, along with the desired transient response. Refer to the product datasheet for further information on input and output capacitance and transient response.

The EVM uses remote sense connections to regulate the output voltage at the output terminals of the EVM. The remote sense connections are made through 0 Ω resistors, R16 and R18. If remote sense is required at a different point, R16 and R18 can be replaced with 10 Ω resistors and VS+ and VS- test points can be extented to the new sense point.

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5 Performance Data

V_{IN} = 12 V, F_{sw} = 500 kHz, C_{OUT} = 4x 47 µF ceramic plus 2x 470 µF polymer

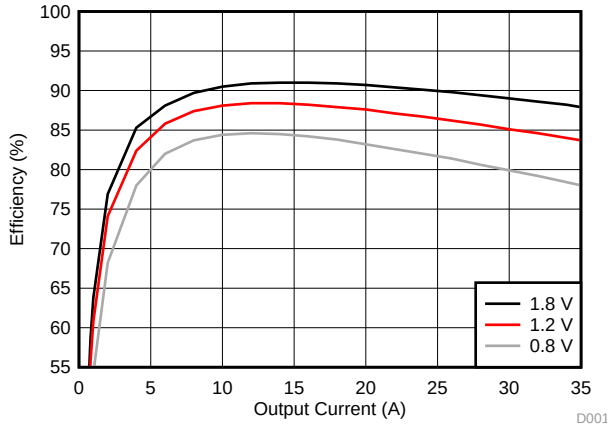


Figure 2. Efficiency

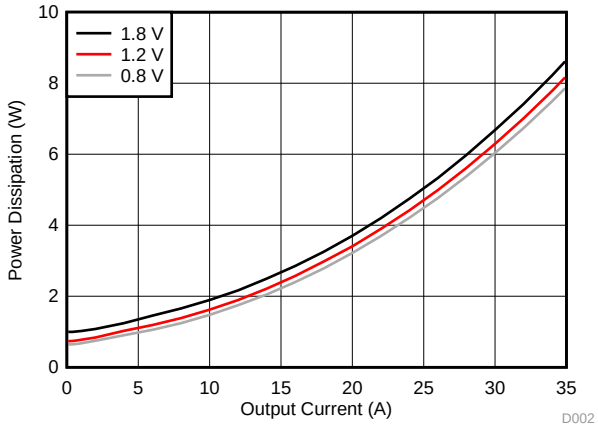


Figure 3. Power Dissipation

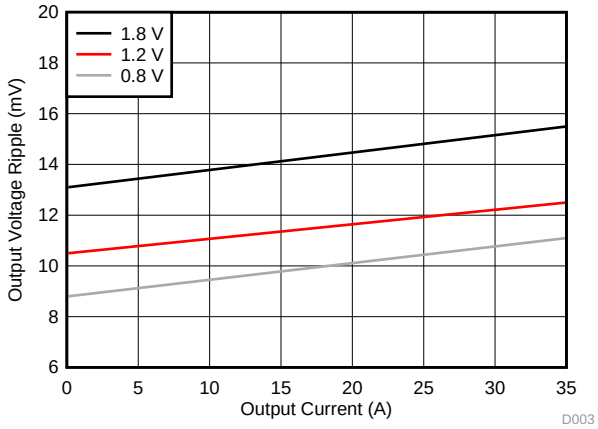


Figure 4. Output Voltage Ripple

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6 Schematic

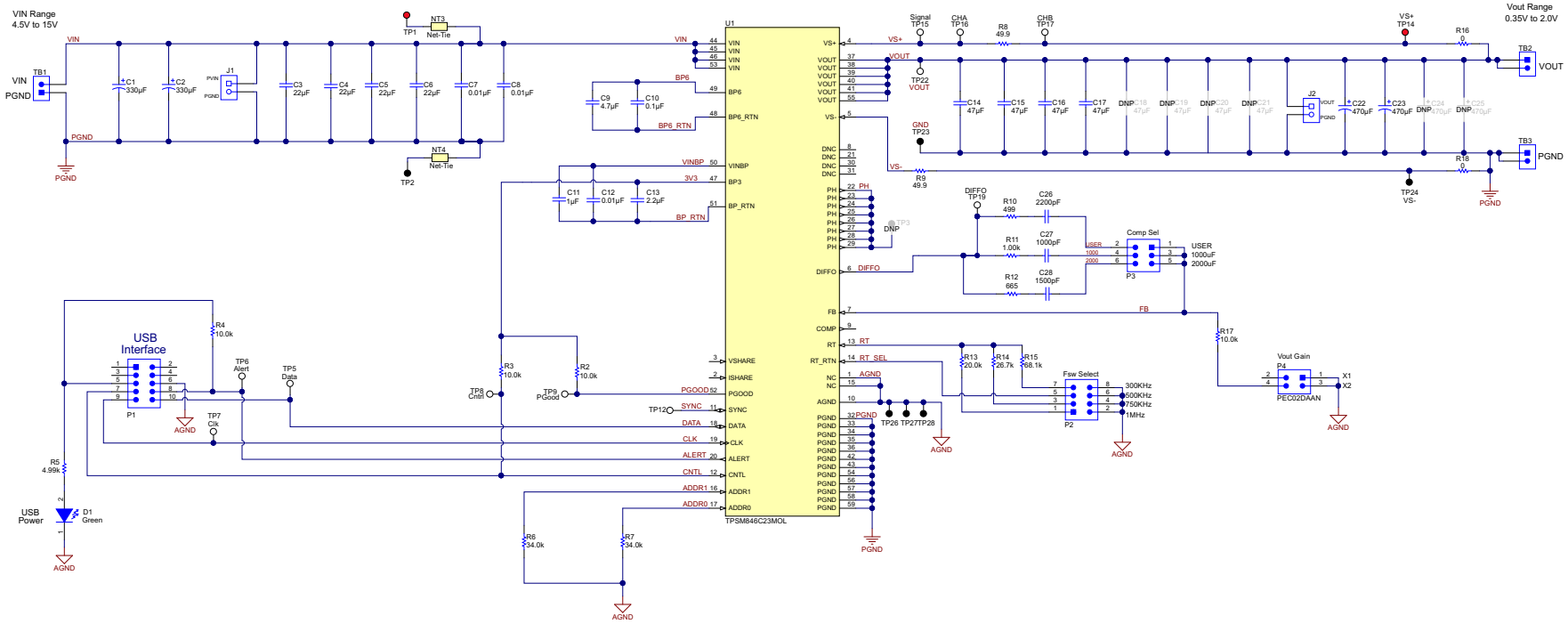


Figure 5. TPSM846C23EVM Schematic

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7 Bill of Material

Table 2. TPSM846C23EVM Bill of Material

DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
PCB	1	Printed Circuit Board	74-01196	Any
U1	1	TPSM846C23	TPSM846C23MOL	Texas Instruments
C1, C2	2	CAP, AL, 330 µF, 25 V, +/- 20%, 0.053 ohm, TH	25ZL330MEFC10X12.5	Rubycon
C3, C4, C5, C6	4	CAP, CERM, 22 µF, 25 V, +/- 10%, X5R, 1210	GRM32ER61E226KE15L	MuRata
C7, C8, C12	3	CAP, CERM, 0.01 µF, 50 V, +/- 10%, X7R, 0603	GRM188R71H103KA01D	MuRata
C9	1	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X5R, 0805	GRM21BR61C475KA88L	MuRata
C10	1	CAP, CERM, 0.1 µF, 16 V, +/- 10%, X7R, 0603	GRM188R71C104KA01D	MuRata
C11	1	CAP, CERM, 1 µF, 25 V, +/- 10%, X7R, 0805	GRM21BR71E105KA99L	MuRata
C13	1	CAP, CERM, 2.2 µF, 16 V, +/- 10%, X7R, 0805	GRM21BR71C225KA12L	MuRata
C14, C15, C16, C17	4	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 1210	GRM32ER60J476ME20L	MuRata
C18, C19, C20, C21	0	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 1210	GRM32ER60J476ME20L	MuRata
C22, C23	2	CAP, Tantalum Polymer, 470 µF, 6.3 V, +/- 20%, 0.01 ohm, 7343-40 SMD	6TPF470MAH	Panasonic
C24, C25	0	CAP, Tantalum Polymer, 470 µF, 6.3 V, +/- 20%, 0.01 ohm, 7343-40 SMD	6TPF470MAH	Panasonic
C26	1	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0402	GRM155R71H222KA01D	MuRata
C27	1	CAP, CERM, 1000 pF, 16 V, +/- 10%, X7R, 0402	GRM155R71C102KA01D	MuRata
C28	1	CAP, CERM, 1500 pF, 50 V, +/- 10%, X7R, 0402	GRM155R71H152KA01D	MuRata
D1	1	LED, Green, SMD	150060GS75000	Wurth Elektronik
J1, J2	2	Socket Strip, 2x1, 100mil, Black, Tin, TH	310-43-102-41-001000	Mill-Max
P1	1	Header, 100mil, 5x2, Tin, TH	PEC05DAAN	Sullins Connector Solutions
P2	1	Header, 100mil, 4x2, Tin, TH	PEC04DAAN	Sullins Connector Solutions
P3	1	Header, 100mil, 3x2, Tin, TH	PEC03DAAN	Sullins Connector Solutions
P4	1	Header, 100mil, 2x2, Tin, TH	PEC02DAAN	Sullins Connector Solutions
R2, R3, R4, R17	4	RES, 10.0 k, 1%, 0.063 W, 0402	CRCW040210K0FKED	Vishay-Dale
R5	1	RES, 4.99 k, 1%, 0.063 W, 0402	CRCW04024K99FKED	Vishay-Dale
R6, R7	2	RES, 121 k, 1%, 0.063 W, 0402	CRCW0402121KFKED	Vishay-Dale
R8, R9	2	RES, 49.9, 1%, 0.1 W, 0603	CRCW060349R9FKEA	Vishay-Dale
R10	1	RES, 499, 1%, 0.063 W, 0402	CRCW0402499RFKED	Vishay-Dale
R11	1	RES, 1.00 k, 1%, 0.063 W, 0402	CRCW04021K00FKED	Vishay-Dale
R12	1	RES, 665, 1%, 0.063 W, 0402	CRCW0402665RFKED	Vishay-Dale
R13	1	RES, 20.0 k, 1%, 0.063 W, 0402	CRCW040220K0FKED	Vishay-Dale
R14	1	RES, 26.7 k, 1%, 0.063 W, 0402	CRCW040226K7FKED	Vishay-Dale
R15	1	RES, 68.1 k, 1%, 0.063 W, 0402	CRCW040268K1FKED	Vishay-Dale
R16, R18	2	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
TB1, TB2, TB3	3	Terminal Block, 30A, 9.52mm (.375) Pitch, 2-Pos, TH	OSTT7022150	On-Shore Technology
TP5, TP6, TP7, TP8, TP9, TP12, TP15, TP16, TP17, TP19,TP22	11	Test Point, Multipurpose, White, TH	5012	Keystone
TP2, TP23, TP24, TP26, TP27, TP28	6	Test Point, Multipurpose, Black, TH	5011	Keystone
TP1, TP14	2	Test Point, Multipurpose, Red, TH	5010	Keystone

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8 PCB Layout

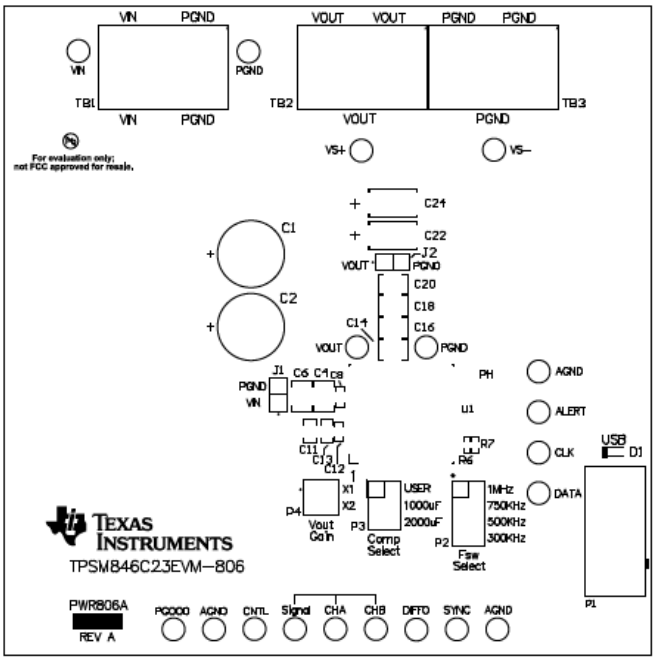


Figure 6. Top Components

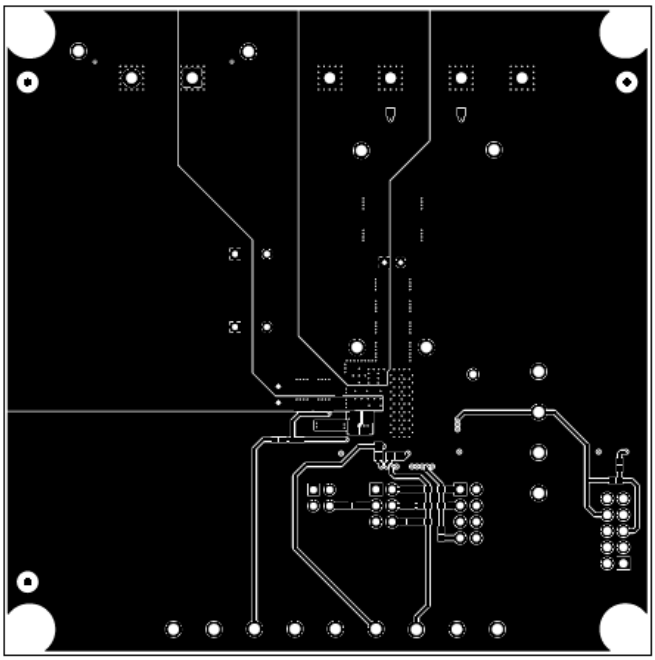


Figure 7. Topside Copper

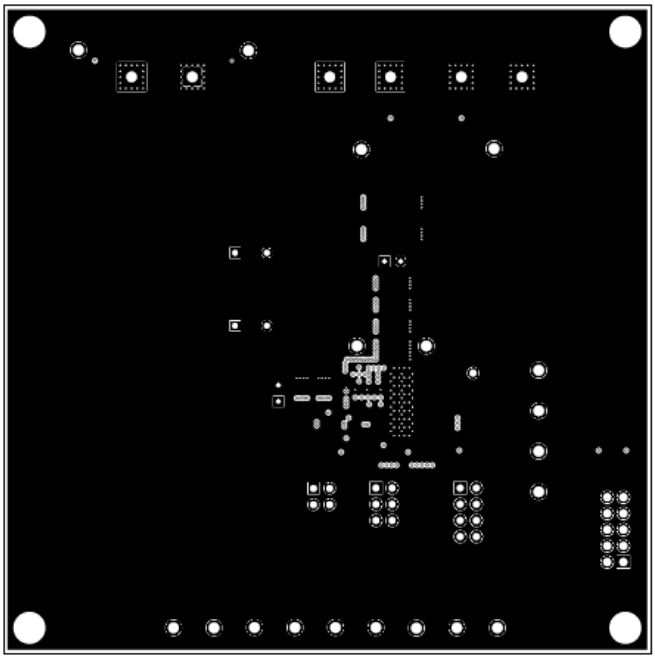


Figure 8. Layer 2 Copper

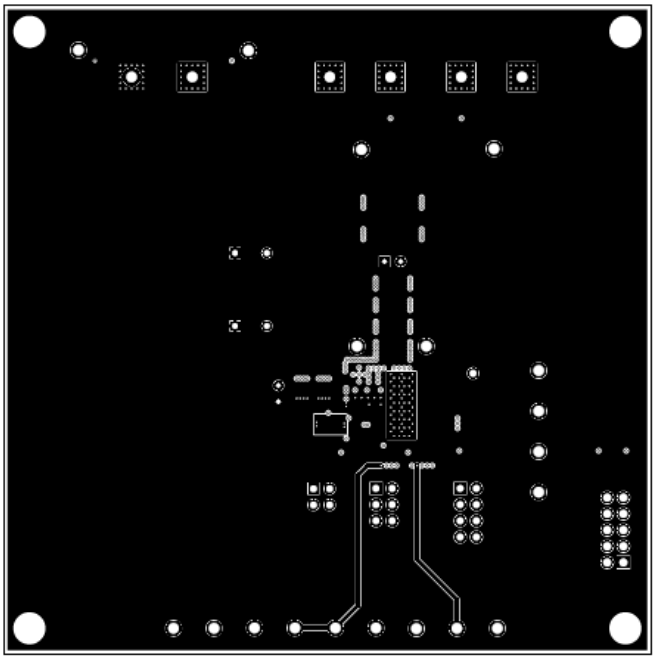


Figure 9. Layer 3 Copper

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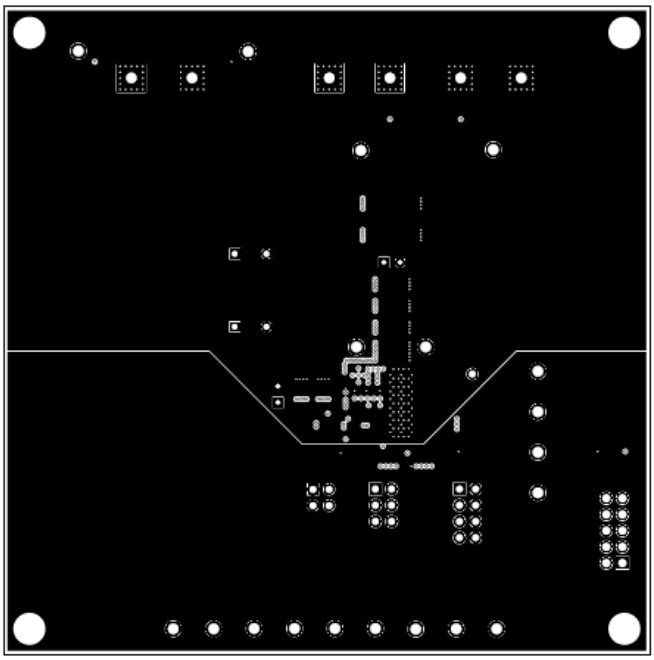


Figure 10. Layer 4 Copper

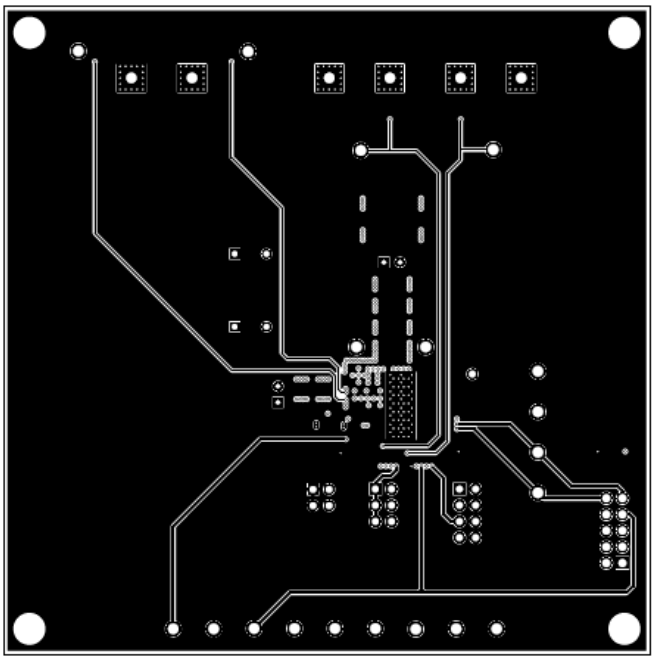


Figure 11. Layer 5 Copper

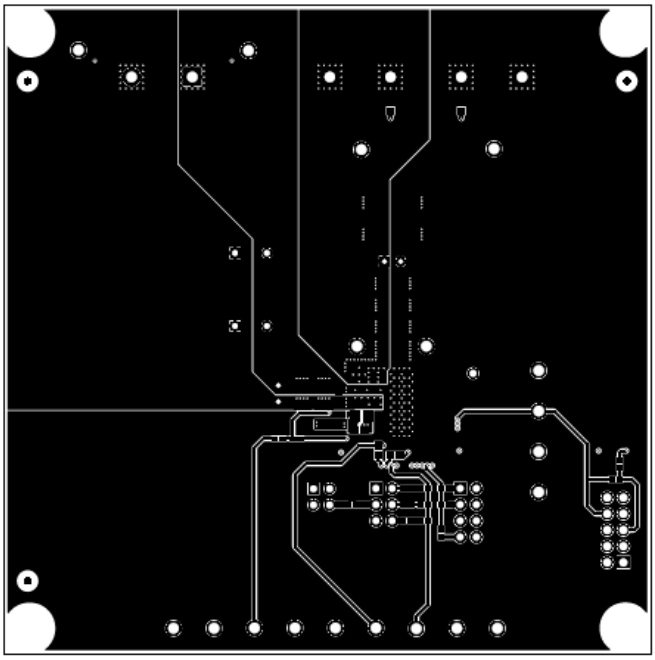


Figure 12. Bottom-Side Copper

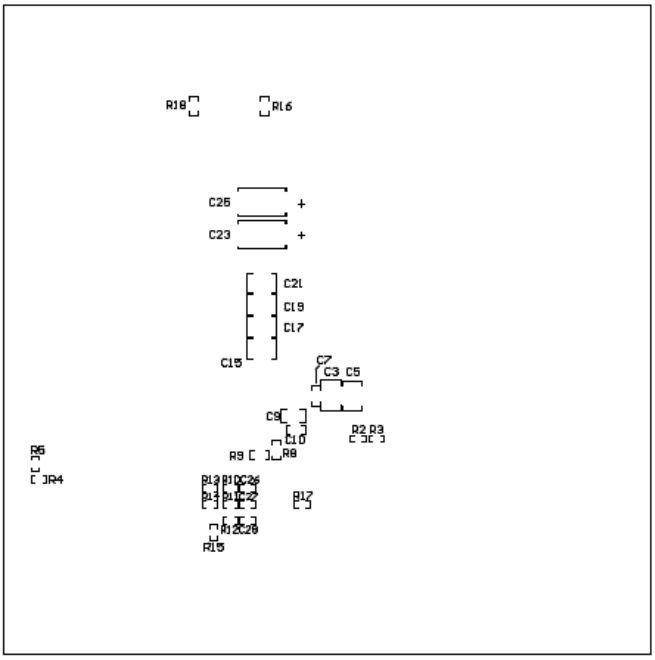


Figure 13. Bottom Components

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Revision History

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

Changes from Original (March 2017) to A Revision	Page
• Changed link to http://www.ti.com/tool/fusion_digital_power_designer	2

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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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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。

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東京都新宿区西新宿６丁目２４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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

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.

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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.

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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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