EVM User's Guide: TPS7H5020FLYEVM

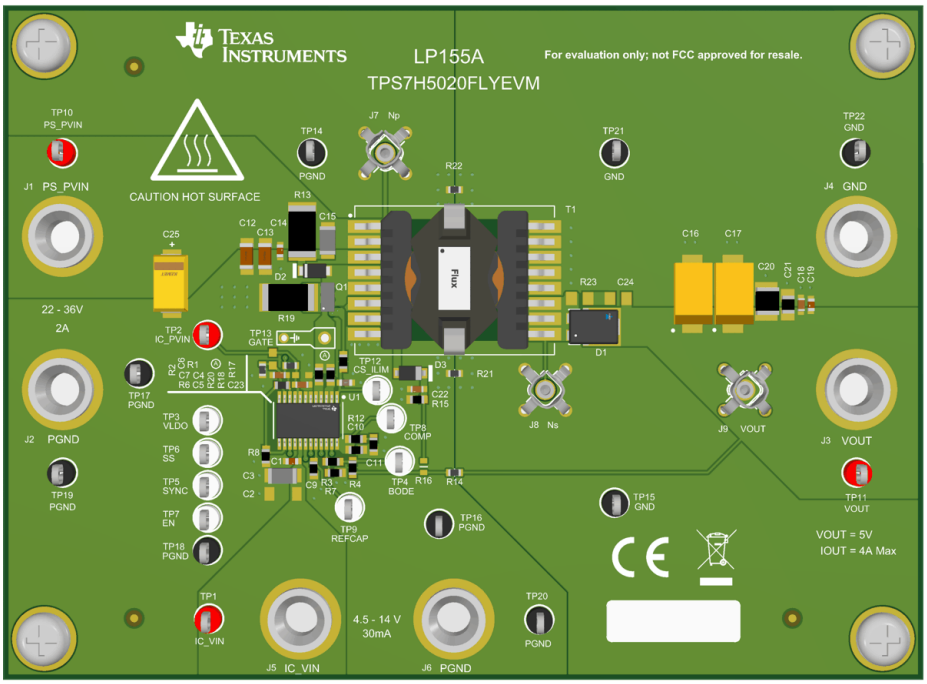
TPS7H5020-SEP Evaluation Module

Description

The TPS7H5020FLYEVM demonstrates the operation of a TPS7H5020-SEP PWM controller driving a GaN FET switching element in a flyback converter topology. The EVM provides flexibility to allow for testing of customized configurations. Tests points and extra component footprints are provided for easy device configuration, and performance validation.

Features

- Power stage input voltage range from 22V to 36V
- Independent 4.5V to 14V controller power input
- 4A maximum output current
- GaN FET switching element
- 0.6V ± 1% voltage reference over line, temperature, and radiation



EVM Board

1 Evaluation Module Overview

1.1 Introduction

The TPS7H5020FLYEVM is an evaluation module (EVM) for the TPS7H5020-SEP and provides a platform to electrically evaluate the features. The EVM demonstrates the TPS7H5020-SEP PWM controller implemented in a flyback topology. This user's guide provides details about the EVM, including the configuration, schematics, and bill of materials.

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, refer to the TPS7H502x-SP and TPS7H502x-SEP Radiation-Hardened 1MHz Current Mode PWM Controller With Integrated Gate Driver data sheet to calculate values of any passives that need to be changed.

1.2 Kit Contents

- TPS7H5020FLYEVM Board (1)

1.3 Specification

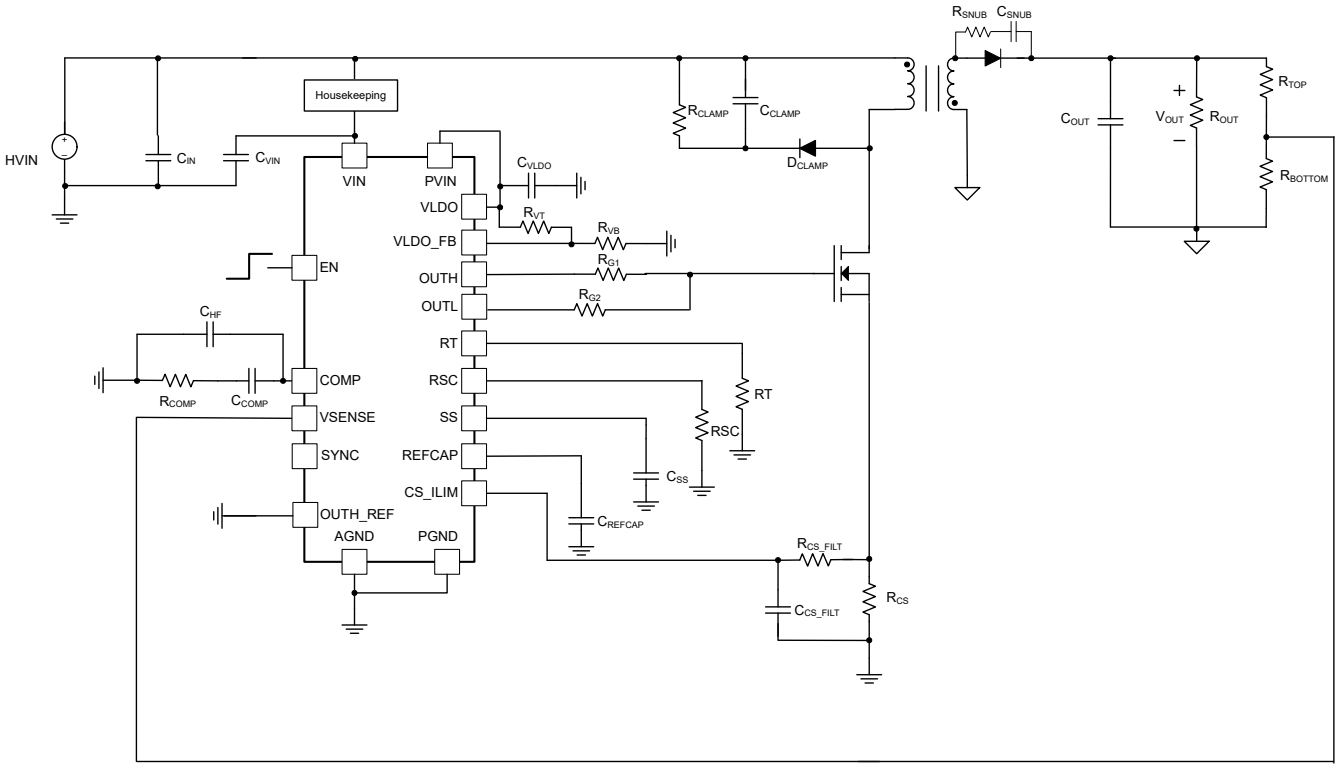


Figure 1-1. Simplified Schematic

Table 1-1. Default Configuration Options

SPECIFICATION	VALUE	DESCRIPTION
Power stage input voltage PS_PVIN	28V	Input voltage to the power stage, primary side of the transformer.
Controller input voltage	12V	Common power rail voltage within the device output capability
Output voltage VOUT	5V	Default configured output voltage.
Switching frequency FSW	500kHz	Switching frequency configured using the device RT pin. Configurable by changing R10.
Gate drive voltage	5V	Output of VLDO, input to IC_PVIN. R1 can be removed to provide IC_PVIN through TP2.

1.4 Device Information

The TPS7H5020 is a 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 optimized for use in a space environment. The driver stage for the controller has a wide input voltage range from 4.5V to 14V and supports peak source and sink currents up to 1.2A. The programmable regulator, VLDO, can also be connected directly to the input of the driver stage (PVIN) to supply well-controlled gate voltage for operation with GaN FETs

Further information about the TPS7H5020 can be found in the TPS7H502x-SP and TPS7H502x-SEP Radiation-Hardened 1MHz Current Mode PWM Controller With Integrated Gate Driver data sheet.

2 Hardware

2.1 Setup

2.1.1 Primary Side Regulation

The TPS7H5020FLYEVM offers two feedback modes: a non-isolated direct feedback mode and Primary Side Regulation (PSR). By default, the direct feedback mode is implemented. To change feedback modes from direct to PSR, the 0Ω resistor on R14 must be moved to the empty footprint at R16.

The transformer used on the TPS7H5020FLYEVM incorporates an auxiliary winding on the primary side to support PSR. This auxiliary winding has the same 2:1 ratio with the primary as the secondary winding, allowing the same feedback divider to regulate both direct and PSR feedback.

To isolate the output of the EVM from the input, PSR must be used. Additionally, the 0Ω jumpers connecting the two GND planes together, R21 and R22, must be removed to achieve isolation.

When using PSR, a minimum load of 50mA and a maximum load of 1A are recommended to keep the output regulated around the 5V. Outside of this current range, the output voltage begins to deviate significantly from the setpoint.

2.2 Connector Descriptions

Table 2-1 provides the connector descriptions for the TPS7H5020FLYEVM.

Table 2-1. Connector Descriptions

REFERENCE DESIGNATOR	FUNCTION	
J1	PS_PVIN	Power stage input connectors
J2	PGND	
J3	VOUT	Power output connectors
J4	GND	
J5	IC_VIN	Controller power input connectors
J6	PGND	
J7	Np	Compact probe tip connector
J8	Ns	
J9	VOUT	
TP1	IC_VIN	Test point
TP2	IC_PVIN	
TP3	VLDO	
TP4	BODE	
TP5	SYNC	
TP6	SS	
TP7	EN	
TP8	COMP	
TP9	REFCAP	
TP10	PS_PVIN	
TP11	VOUT	
TP12	CS_ILIM	
TP14, TP15, TP16, TP17, TP18, TP19, TP21, TP22	GND	

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.

CAUTION

The TPS7H5020FLYEVM uses separate power connectors for the power stage and controller power. When powering on the EVM, remember to supply power to the power stage though connectors J1 and J2 before powering (or enabling if using an external enable signal) the TPS7H5020 device. Reversing this order can cause the power stage to be shorted through the GaN FET, possibly causing damage to the EVM or lab equipment.

3 Implementation Results

3.1 Default Configuration Results

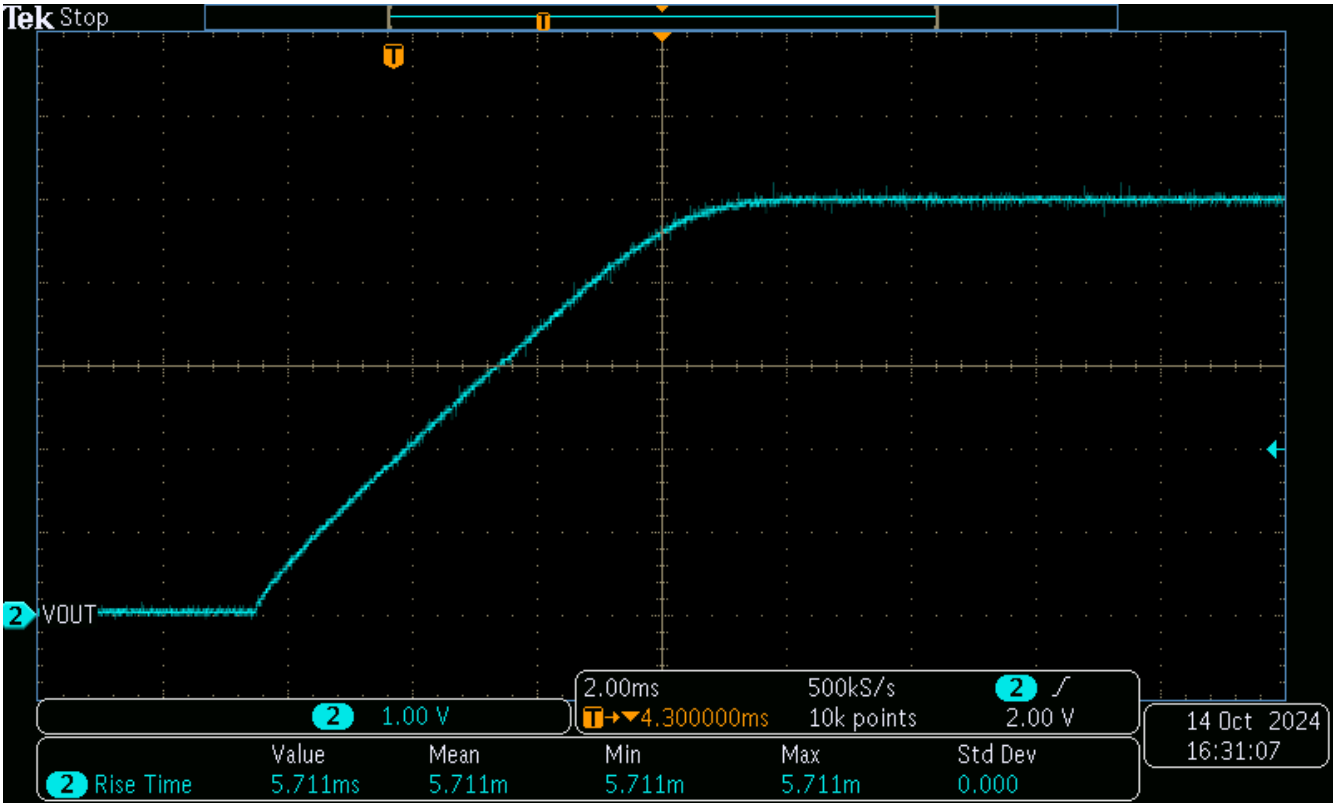
The following tests were performed using the TPS7H5020FLYEVM in the default configuration with detailed settings shown in Table 3-1 unless otherwise noted.

Table 3-1. Test Settings

SPECIFICATION	VALUE
VIN	28V
VOUT	5V
FSW	500kHz
IOUT	4A
Feedback Method	Direct (Non-isolated)

3.2 Soft Startup

Soft Startup Into 100mA Load



3.3 Voltage Ripple on VOUT

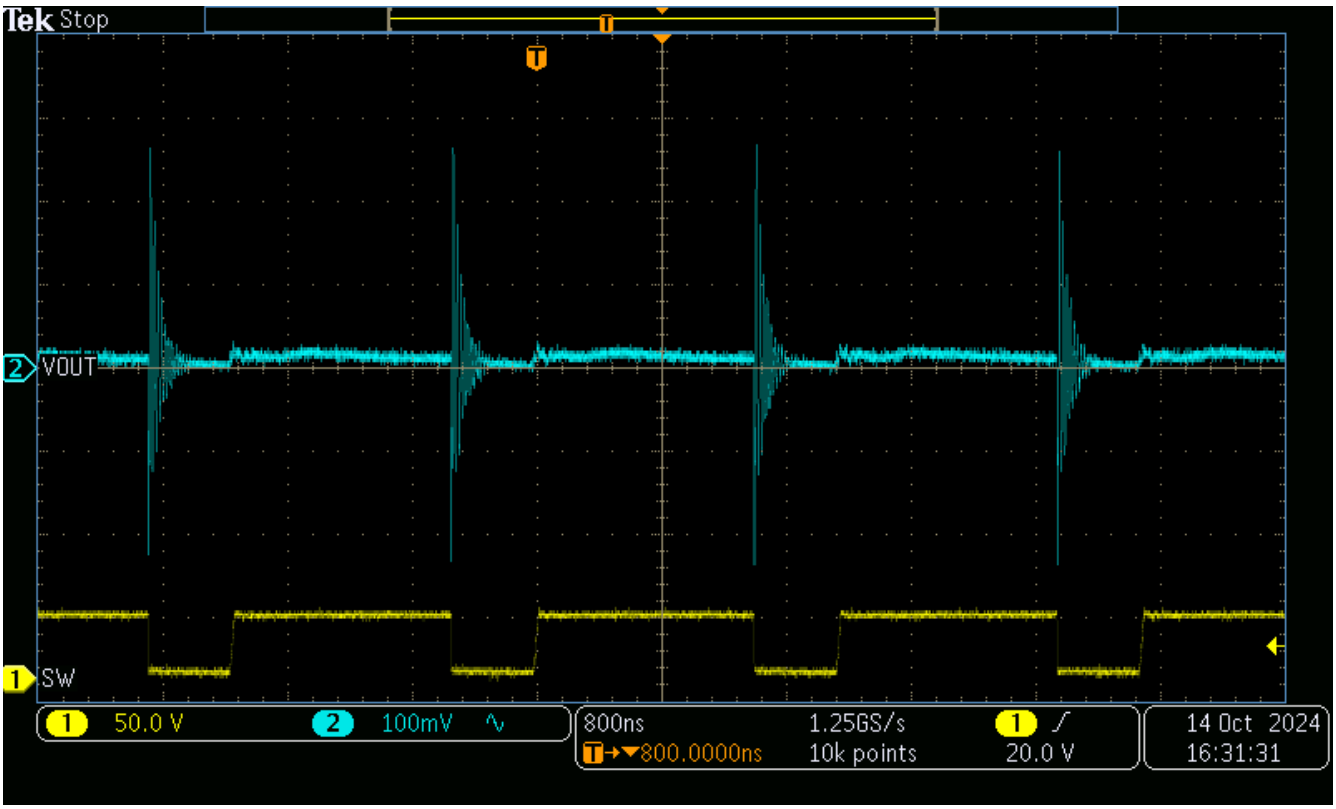


Figure 3-1. Output Voltage Ripple - IOUT = 1A

3.4 Load Step

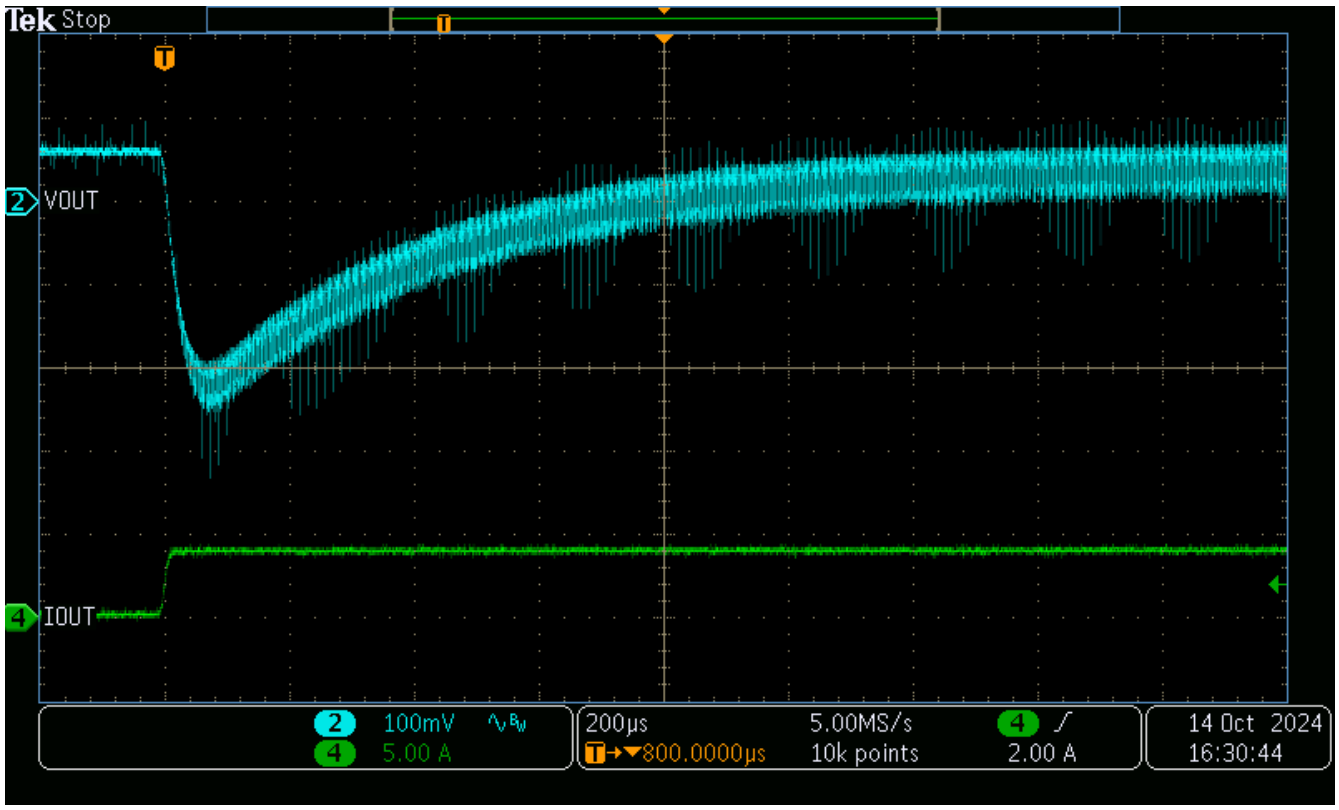


Figure 3-2. Transient Response to Load Step 100mA to 4A at 8A/µs

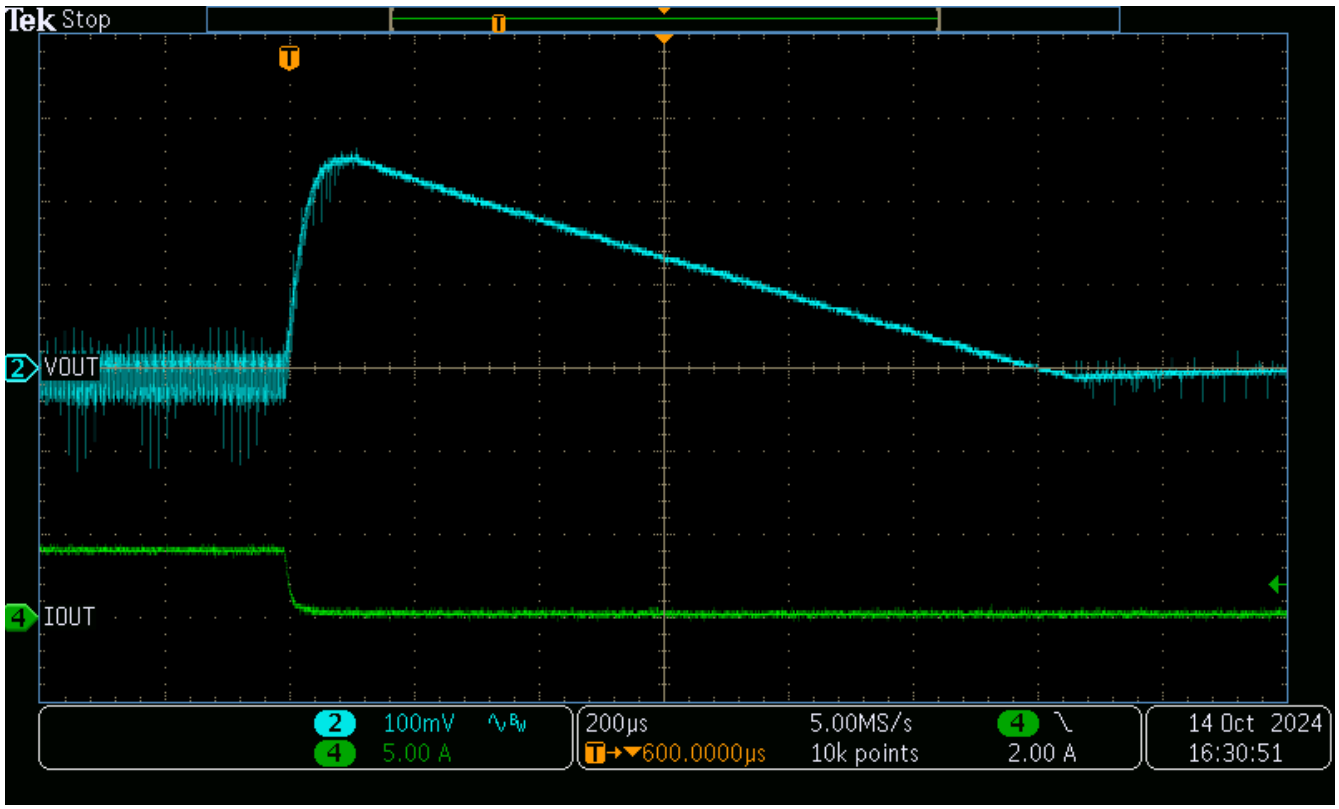


Figure 3-3. Transient Response to Load Step 4A to 100mA at 8A/µs

3.5 Frequency Response

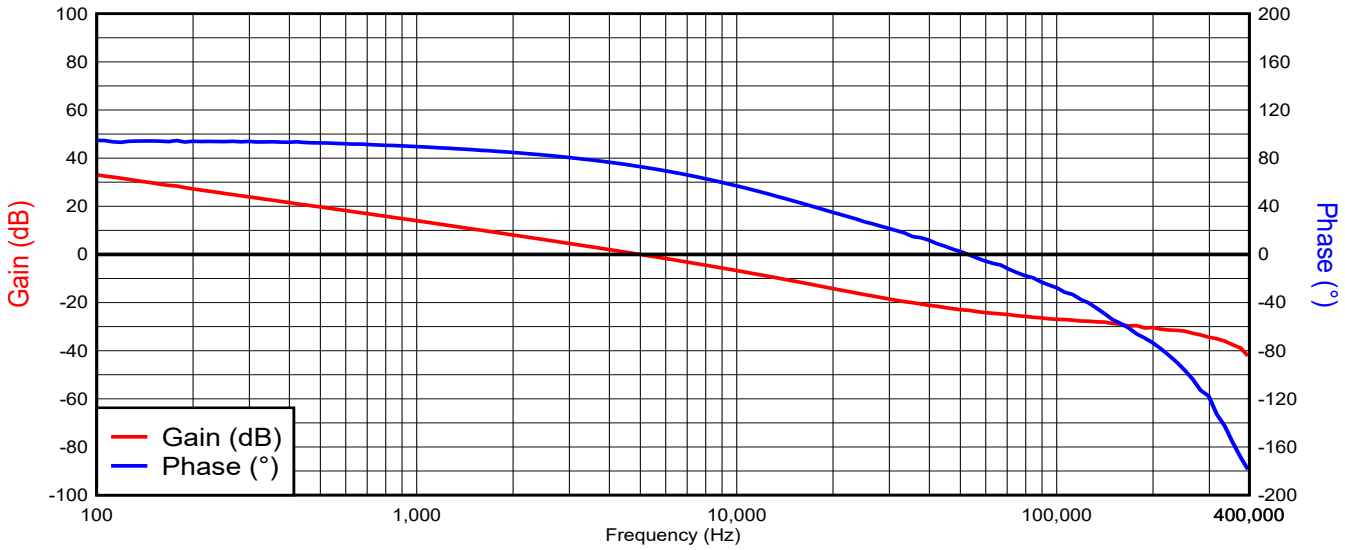


Figure 3-4. Frequency Response IOUT = 4A

3.6 Efficiency

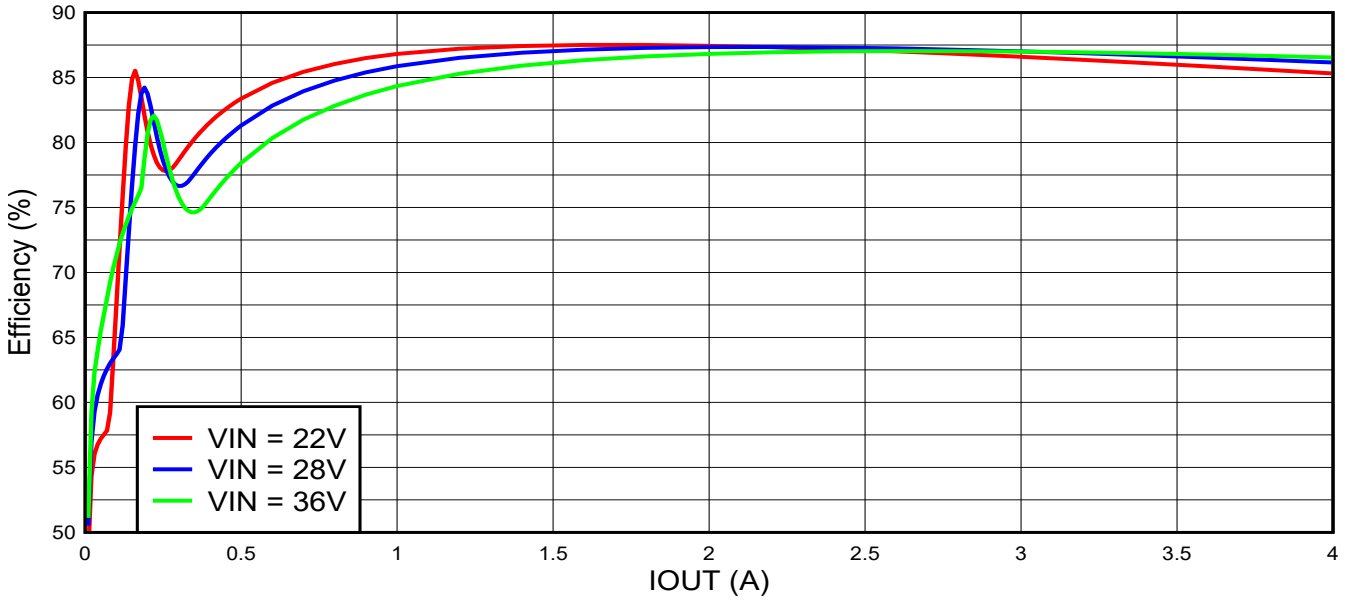


Figure 3-5. Efficiency Across VIN

4 Hardware Design Files

4.1 Schematics

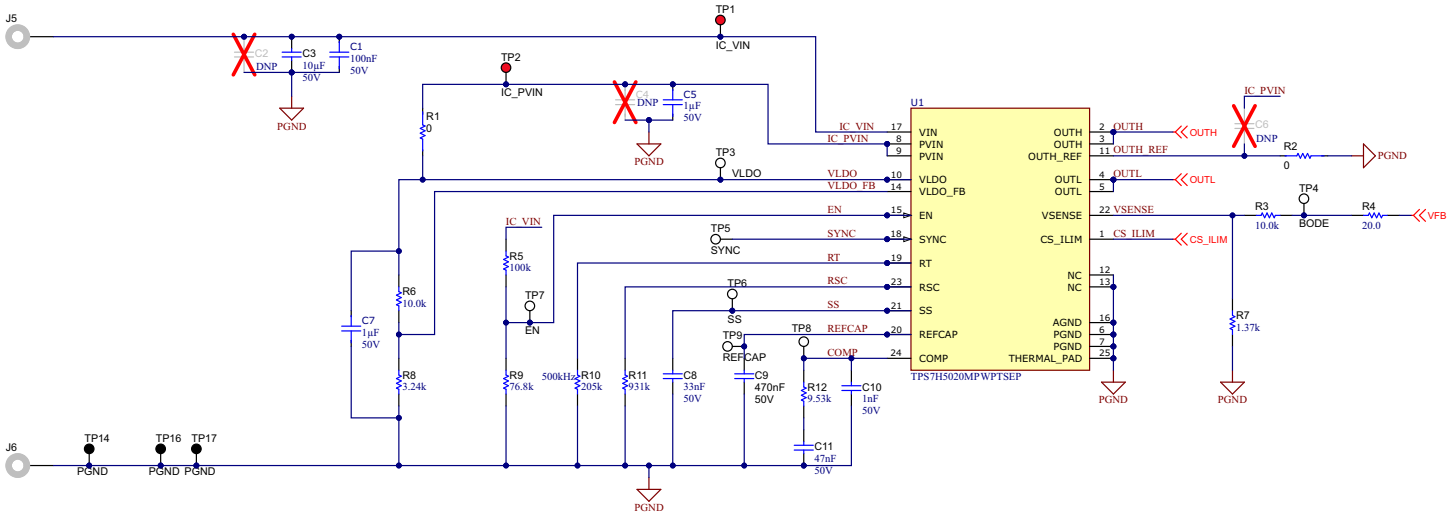


Figure 4-1. Controller Schematic

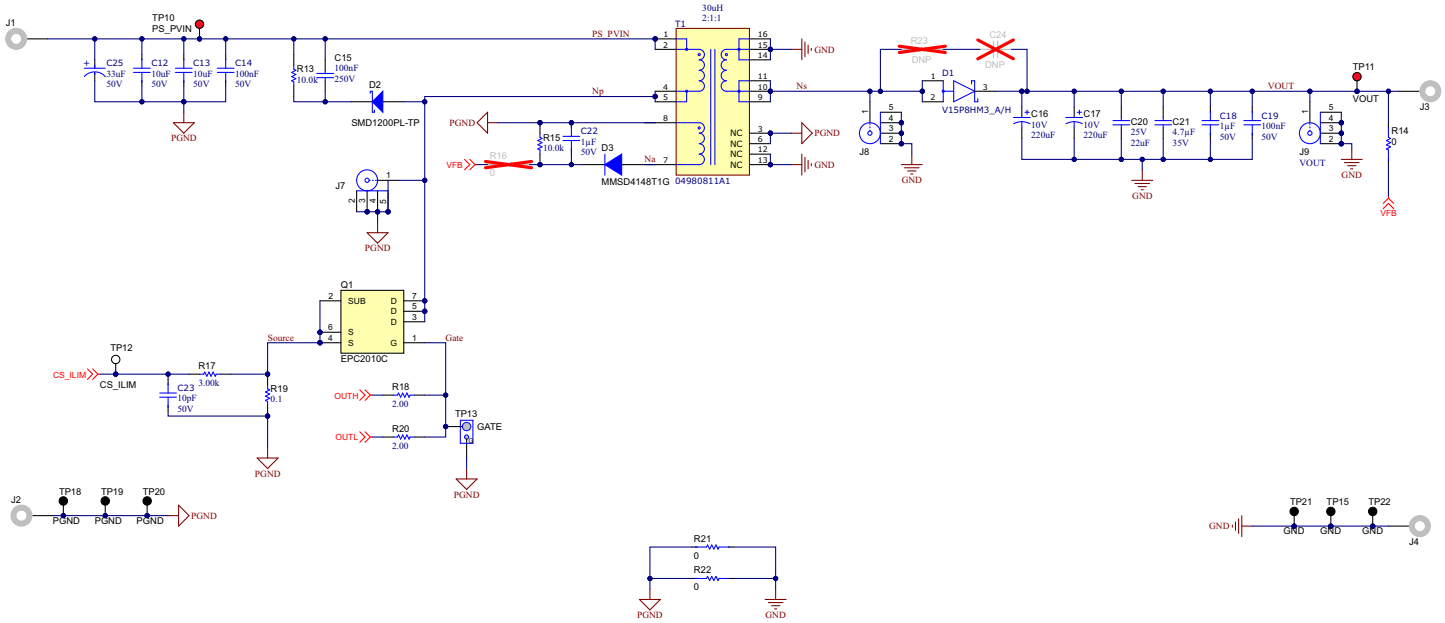


Figure 4-2. Power Stage Schematic

4.2 PCB Layouts

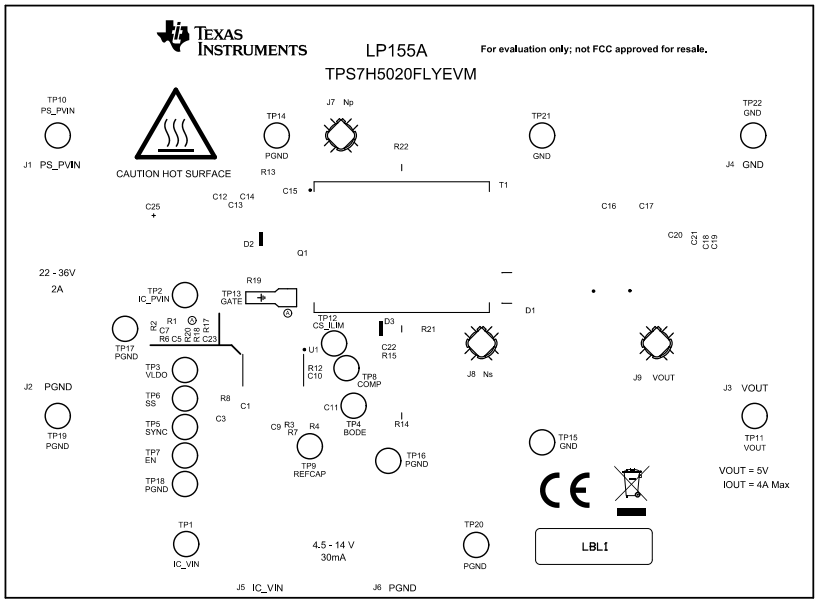


Figure 4-3. Top Overlay

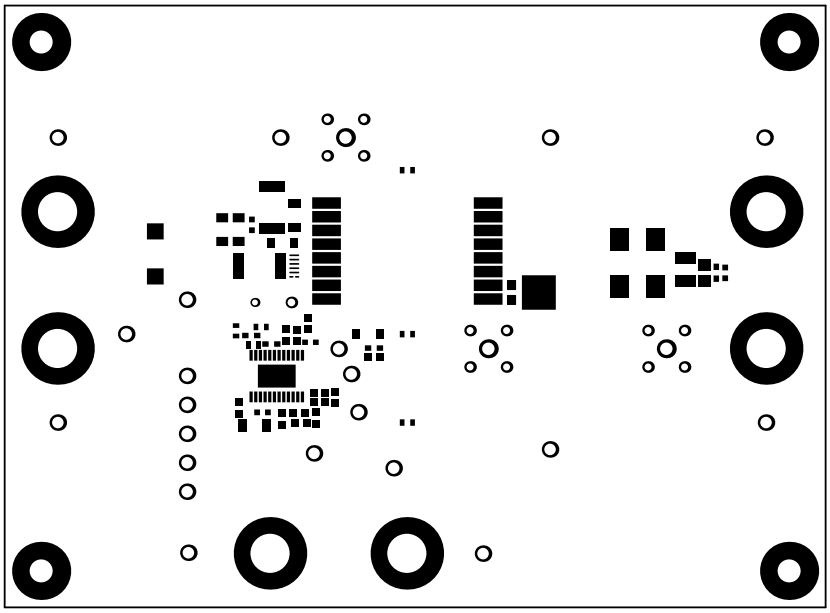


Figure 4-4. Top Solder Mask

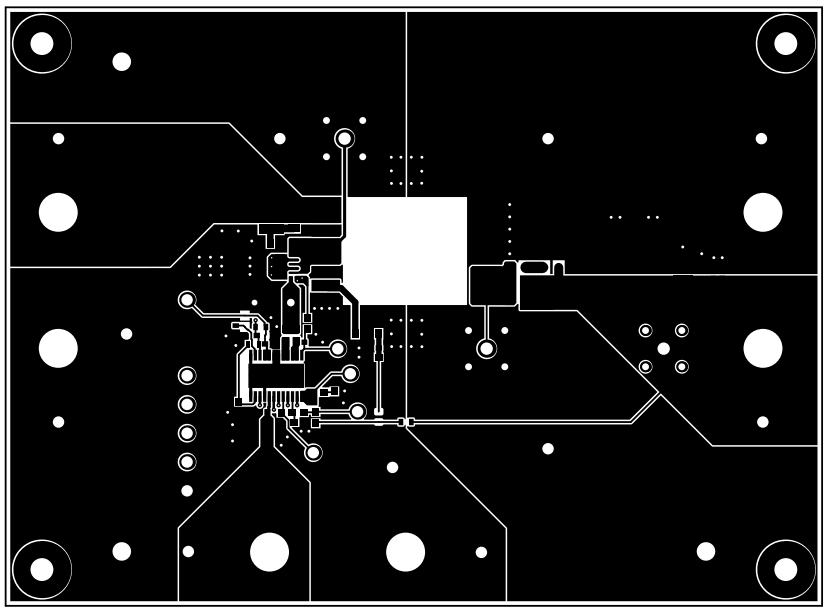


Figure 4-5. Layer 1 (Top)

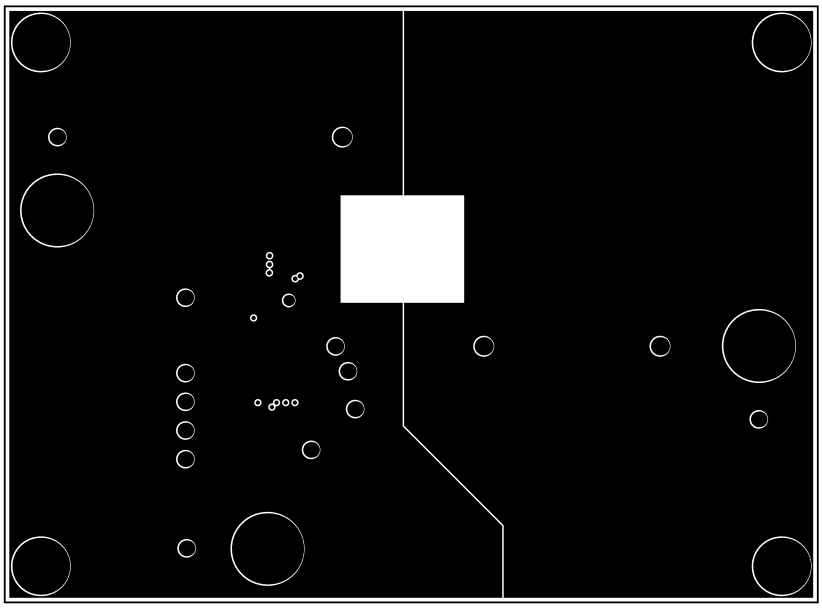


Figure 4-6. Layer 2

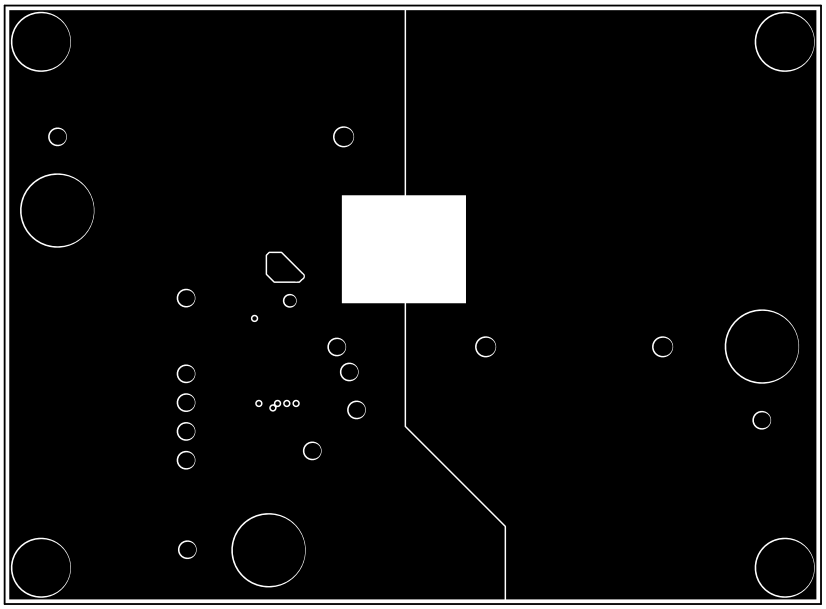


Figure 4-7. Layer 3

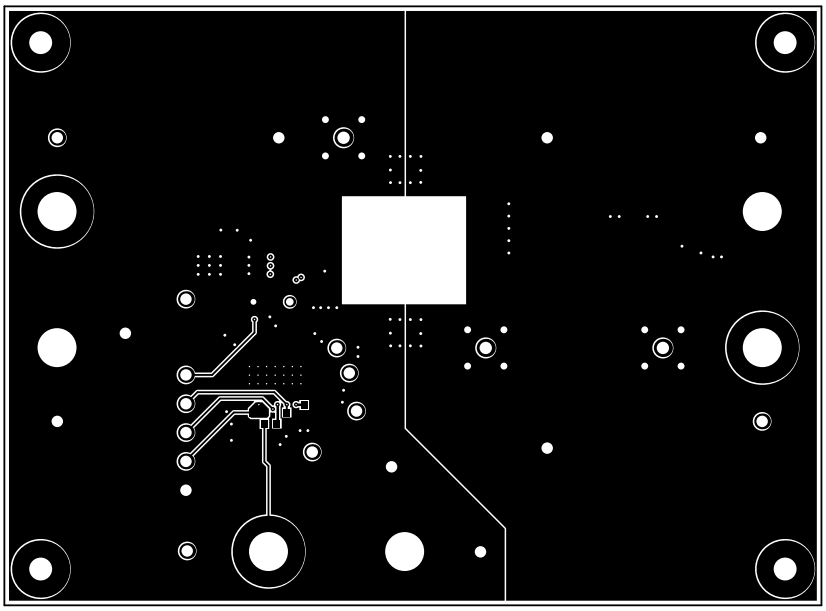


Figure 4-8. Layer 4 (Bottom)

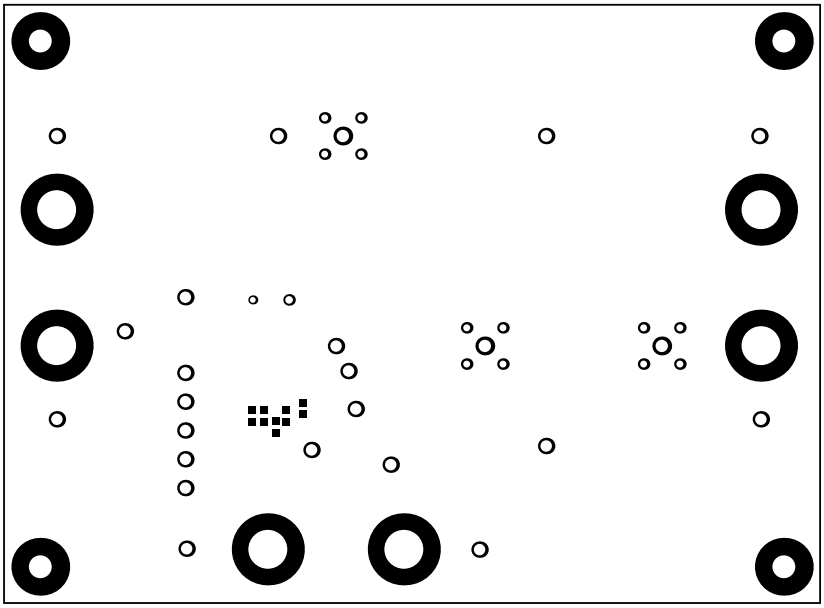


Figure 4-9. Bottom Solder Mask

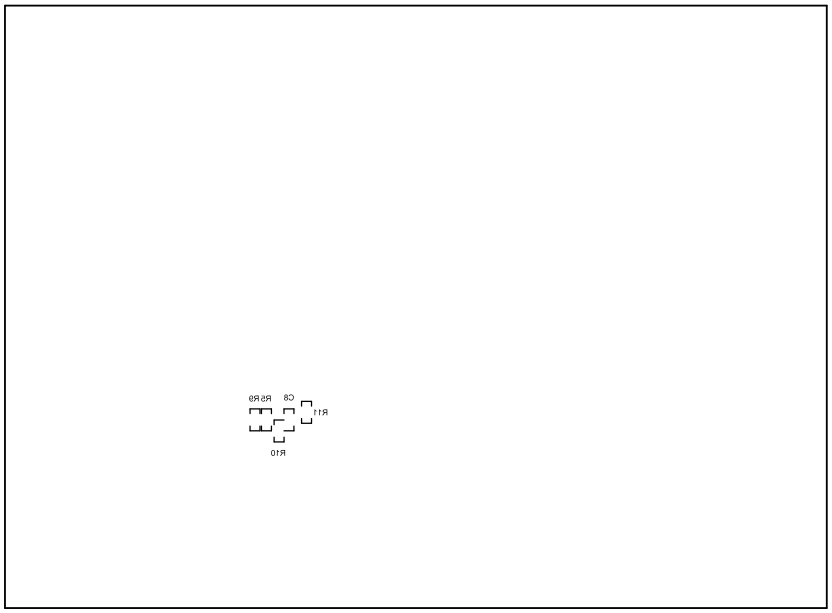
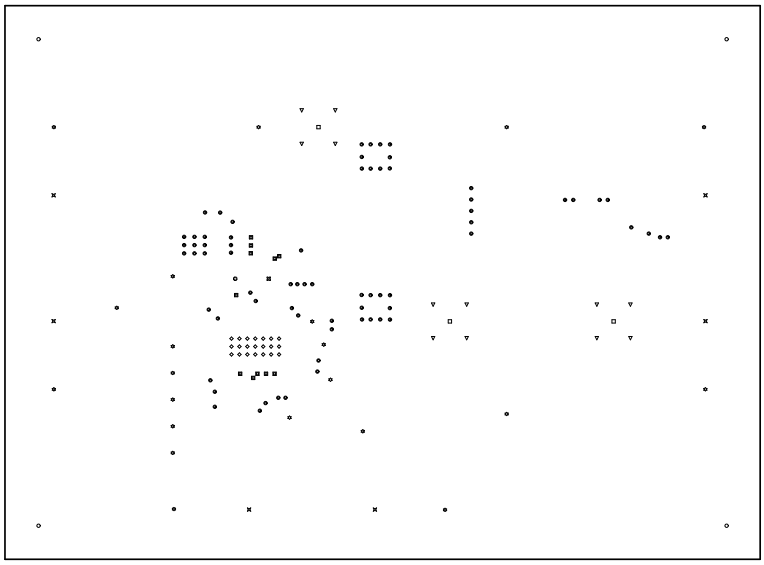


Figure 4-10. Bottom Overlay



Symbol	Quantity	Finished Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
◇	21	7.87mil (0.200mm)	PTH	Round	Top Layer - Bottom Layer	
▣	11	8.00mil (0.203mm)	PTH	Round	Top Layer - Bottom Layer	
◎	70	16.00mil (0.406mm)	PTH	Round	Top Layer - Bottom Layer	
✪	1	32.00mil (0.813mm)	PTH	Round	Top Layer - Bottom Layer	
▽	12	38.00mil (0.965mm)	PTH	Round	Top Layer - Bottom Layer	
⊠	1	42.00mil (1.067mm)	PTH	Round	Top Layer - Bottom Layer	
✡	21	63.00mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	
□	3	68.00mil (1.727mm)	PTH	Round	Top Layer - Bottom Layer	
○	4	125.98mil (3.200mm)	PTH	Round	Top Layer - Bottom Layer	
⊠	6	214.57mil (5.450mm)	PTH	Round	Top Layer - Bottom Layer	
	150 Total					

Figure 4-11. Drill Drawing

4.3 Bill of Materials (BOM)

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
C1, C14, C19	3	100nF	0.1µF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	8.85012E+11	Wurth
C3	1	10uF	CAP, CERM, 10µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L1X7R1H106K160AC	TDK
C5, C7, C18, C22	4	1µF	1µF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	GMC10X7R105K50NT	Cal-Chip Electronics
C8	1	0.033uF	CAP, CERM, 0.033uF, 50V, +/- 5%, X7R, 0603	0603	06035C333JAT2A	AVX
C9	1	0.47uF	CAP, CERM, 0.47uF, 50V, +/- 10%, X7R, 0603	0603	C1608X7R1H474K080AC	TDK
C10	1	1000pF	CAP, CERM, 1000pF, 50V, +/- 5%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C102J5RACAUTO	Kemet
C11	1	0.047uF	CAP, CERM, 0.047uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1H473K080AA	TDK
C12, C13	2	10µF	10µF ±10% 50V Ceramic Capacitor X7R 1206 (3216 Metric)	1206	GMC31X7R106K50NT	Cal-Chip Electronics
C15	1	0.1uF	CAP, CERM, 0.1uF, 250V, +/- 10%, X7R, 1206	1206	GRM31CR72E104KW03L	MuRata
C16, C17	2	220uF	CAP, Tantalum Polymer, 220 uF, 10V, +/- 20%, 0.025 ohm, AEC-Q200 Grade 1, 7343-31 SMD	7343-31	T598D227M010ATE025	Kemet
C20	1	22uF	CAP, CERM, 22uF, 25V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210	TMK325B7226KMHT	Taiyo Yuden
C21	1	4.7uF	CAP, CERM, 4.7µF, 35V,+/- 20%, X7R, 0805	0805	C2012X7R1V475M125AC	TDK
C23	1	10pF	10pF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	06035C100KAT2A	KYOCERA AVX
C25	1	33µF	Cap Tant Solid 33uF 50V X CASE 20% (7.3 X 4.3 X 4mm) SMD 7343-43 0.04 Ohm 105°C T/R	2917	T543X336M050ATE040	KEMET
D1	1		Diode 80V 15A Surface Mount TO-277A (SMPC)	SMPC	V15P8HM3_A/H	Vishay
D2	1	200V	Diode, Schottky, 200V, 1A, SOD-123FL	SOD-123FL	SMD1200PL-TP	Micro Commercial Components
D3	1	100V	Diode, Switching, 100V, 0.2A, SOD-123	SOD-123	MMSD4148T1G	ON Semiconductor
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
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2, J3, J4, J5, J6	6		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
J7, J8, J9	3		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
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

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
Q1	1	200V	MOSFET, N-CH, 200V, 22A, 1.632x3.554mm	1.632x3.554mm	EPC2010C	EPC
R1, R2, R14, R21, R22	5	0	0 Ohms ±1% Chip Resistor 0603 (1608 Metric) Thick Film	0603	CR160000F	Meritek Electronics
R3	1	10.0k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0710KL	Yageo America
R4	1	20	RES, 20.0, 0.1%, 0.1 W, 0603	0603	RT0603BRD0720RL	Yageo America
R5	1	100k	RES, 100 k, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW0603100KBEEA	Vishay-Dale
R6	1	10.0k	RES, 10.0 k, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW060310K0BEEA	Vishay-Dale
R7	1	1.37k	RES, 1.37 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD071K37L	Yageo America
R8	1	3.24k	RES, 3.24 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERA-3AEB3241V	Panasonic
R9	1	76.8k	RES, 76.8 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0776K8L	Yageo America
R10	1	205k	RES, 205 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD07205KL	Yageo America
R11	1	931k	RES, 931 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603931KFKEA	Vishay-Dale
R12	1	9.53k	RES, 9.53 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD079K53L	Yageo America
R13	1	10.0k	RES, 10.0 k, 1%, 3 W, 2512	2512	352210KFT	TE Connectivity
R15	1	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R17	1	3.00k	RES, 3.00 k, 0.1%, 0.1 W, 0603	0603	RG1608P-302-B-T5	Susumu Co Ltd
R18, R20	2	2	RES, 2.00, 0.5%, 0.1 W, 0603	0603	RT0603DRE072RL	Yageo America
R19	1	0.1	RES, 0.1, 1%, 2 W, 2512	2512	CRM2512-FX-R100ELF	Bourns
T1	1		LP155 Flyback Transformer	SMT_XFRMR_24MM8_18MM5	14179033-1-M	FLUX
TP1, TP2, TP10, TP11	4		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP12	8		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22	9		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
U1	1		Radiation Tolerant 1MHz Current Mode PWM Controller with Integrated Gate Driver	HTSSOP24	TPS7H5020MPWPTSEP	Texas Instruments
C2	0			1206		
C4	0			0603		
C6	0			0603		
C24	0			0805		

Designator	Quantity	Value	Description	Package Reference	PartNumber	Manufacturer
R16	0			0603		
R23	0			0805		

5 Compliance Information

- Texas Instruments, TPS7H5020FLYEVM 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, TPS7H401TPS7H502x-SP and TPS7H502x-SEP Radiation-Hardened 1MHz Current Mode PWM Controller With Integrated Gate Driver, data sheet
- FLUX, 14179033-1-M, LP155 Flyback Transformer

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。

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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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