EVM User's Guide: LM3478EVM-FLY

LM3478 评估模块

说明

LM3478 评估模块 (EVM) 能够展示具有 400kHz 固定开关频率、适合宽输入电压范围的初级侧调节反激式控制器。PCB 可实现高转换效率，并具有两层，其中元件组装在一侧。

开始使用

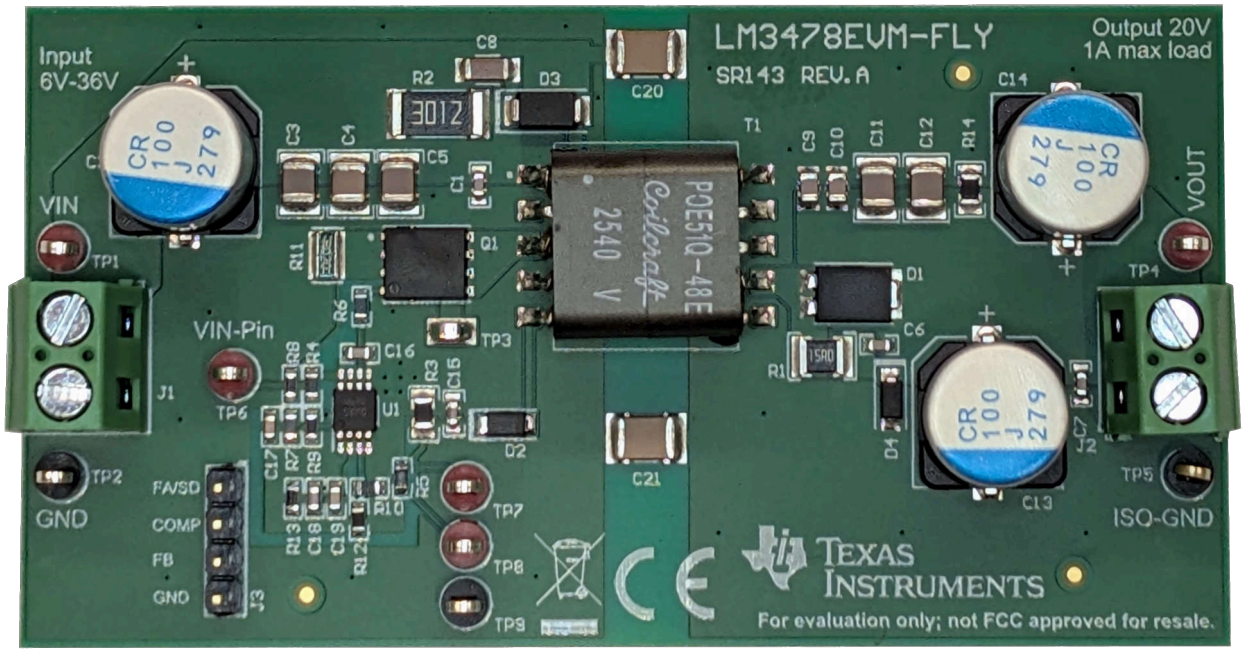
1. 将 EVM 连接到电源和负载。
2. 给应用加电。

特性

- 初级侧调节反激式控制器
- 隔离式 20V 输出电压轨
- 14W 输出功率
- 辅助绕组调节至 5V
- 可编程开关频率
- 可编程逐周期电流限制
- 关断引脚

应用

- 电池管理系统



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1 评估模块概述

1.1 简介

该 LM3478EVM-FLY 评估模块展示了 LM3478 的功能和性能，该器件是一款具有初级侧调节和宽输入电压范围的隔离型反激式控制器。标准配置旨在通过 7V 至 36V 的输入提供功率为 700mA 的 20V 稳压输出，开关频率为 400kHz。该 EVM 提供 20V 输出电压，额定功率为 14W。该评估模块旨在简化配置，使用户能够评估同一模块上的许多不同应用。PCB 分为两层，元件仅组装在一侧。无需跳线设置即可运行。

1.2 套件内容

- LM3478EVM-FLY PCB 组装
- EVM 免责声明自述文件

1.3 规格

表 1-1. EVM 规格

参数	条件	最小值	典型值	最大值	单位
输入电压	运行	7	12	36	V
输出电压	连接的负载		20		V
输出功率	V_{IN} > 11V			700	mA
	V_{IN} > 7V			500	mA
开关频率	R9 = 49.9kΩ		400		kHz
效率	V_{IN} = 7V，I_{OUT} = 500mA		86%		
	V_{IN} = 12V，I_{OUT} = 700mA		87%		

1.4 器件信息

LM3478 是一款适用于开关稳压器的多功能低侧 N 沟道 MOSFET 控制器。电流模式控制提供出色的带宽和瞬态响应以及逐周期电流限制。LM3478 具有内置功能，如热关断、短路保护、过压保护和节能关断模式，可将总电源电流降低到 5μA。内部软启动会限制启动时的浪涌电流。

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2 硬件

2.1 接头信息

LM3478EVM-FLY 提供了接头和测试点，用于测量器件信号并注入外部信号以使用关断特性或执行小信号稳定性分析。

表 2-1. EVM 接头

连接器	引脚	说明
J1	1	电源电压（正极）
	2	电源电压（负极）
J2	1	输出电压（负极）
	2	输出电压（正极）
J3	1	FA/SD 引脚。将该引脚拉至 1.4V 以上可激活器件关断特性。
	2	COMP 引脚
	3	FB 引脚
	4	GND 基准

2.2 测试点

表 2-2. EVM 测试点

连接器	名称	说明
TP1	V_{IN}	V_{IN} 的测试点
TP2	GND（非隔离式）	GND 的测试点
TP3	SW	开关节点的测试点
TP4	V_{OUT}	V_{OUT} 的测试点
TP5	GND（隔离式）	GND 的测试点
TP6	V_{IN}-引脚	如果需要为功率级和控制器器件提供独立的电源，请移除 R4 并通过该测试点连接第二个电源。
TP7	V_{AUX}+	V_{AUX} 测试点，稳定性分析注入
TP8	V_{AUX}-	稳定性分析注入
TP9	GND（非隔离式）	GND 的测试点

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3 实现结果

3.1 评估设置

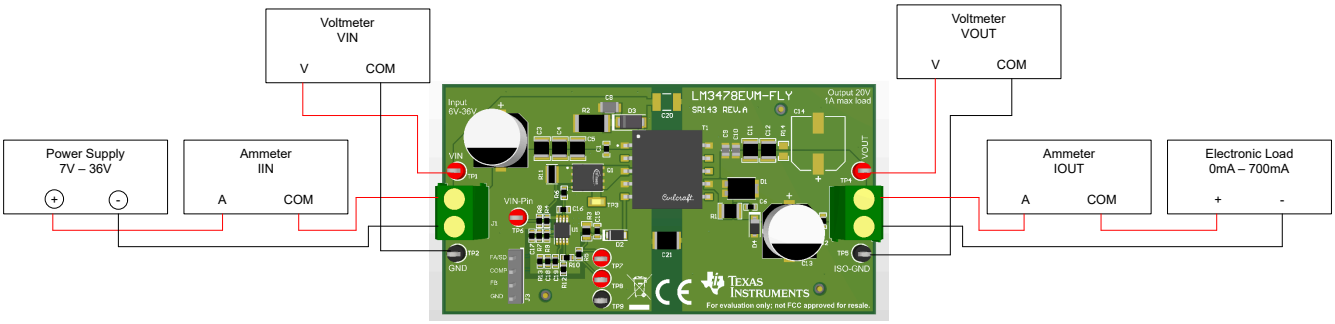


图 3-1. EVM 测试设置

测试设置

需要以下测试设备：

- 电源
- 电子（或电阻）负载
- 示波器：最小 200MHz 带宽
- 万用表（可选）
  - 电压表 1 (V_{IN})
  - 电压表 2 (V_{OUT})
  - 电流表 1 (I_{IN})
  - 电流表 2 (I_{OUT})

测试程序

1. 按照图 3-1 将电源和负载连接至相应的 EVM 连接。
2. 将电源电压设置为 12V，将电子负载设置为 0.1A。电子负载电压必须通过标称 20V 输出进行调节。

备注

如果 EVM 在没有负载的情况下运行，则存在由于初级侧调节而导致输出电压失控的风险。TI 不建议在零负载条件下运行该 EVM。在输出端安装一个齐纳二极管 (D4)，可防止过压。

3. 根据需要更改负载电流和输入电源电压。

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3.2 性能数据和结果

效率

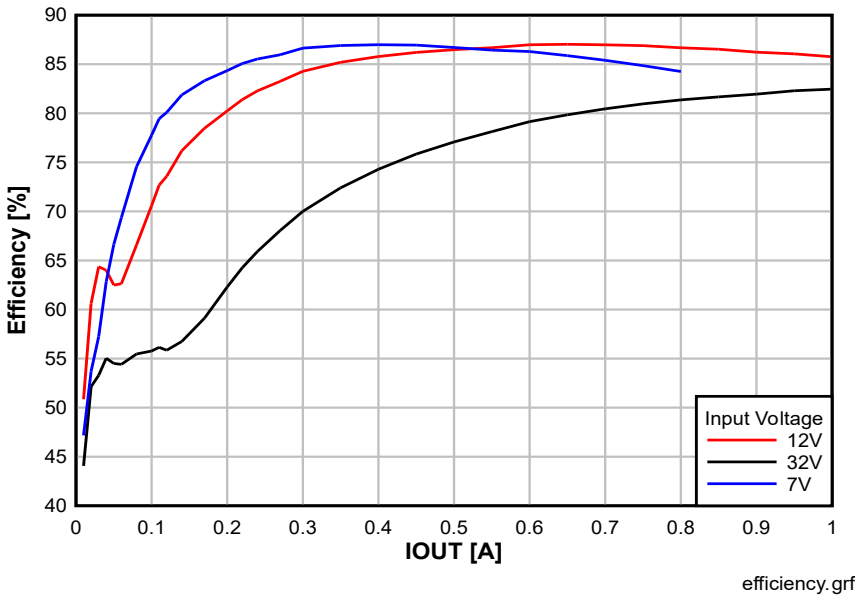


图 3-2. 效率与输出电流的关系

启动波形

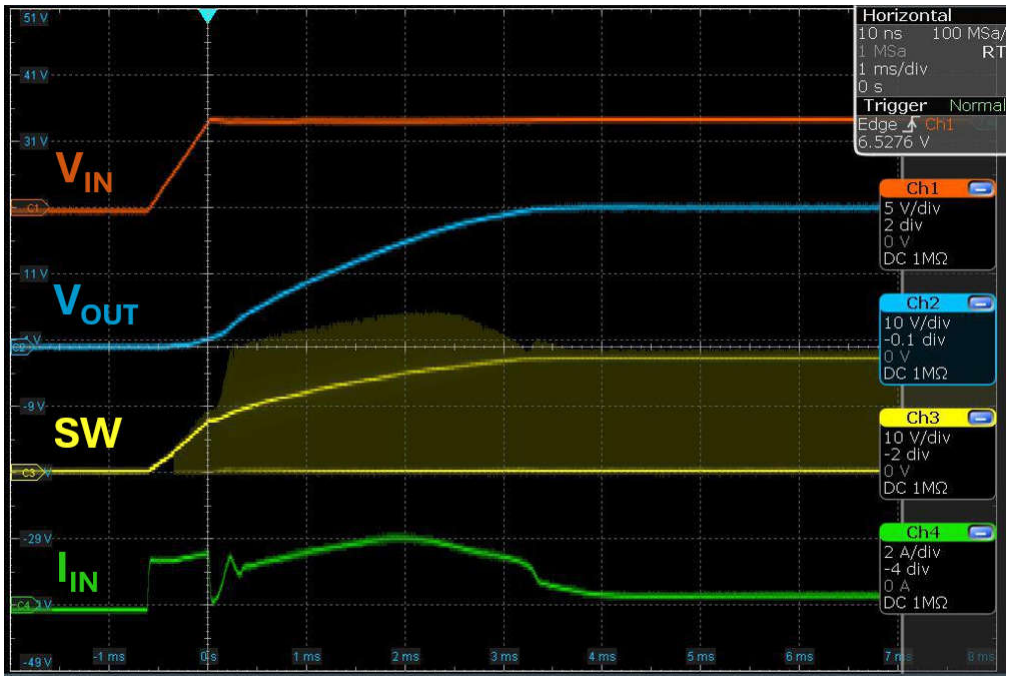


图 3-3. 启动波形，V_{IN} = 7V，I_{OUT} = 20mA

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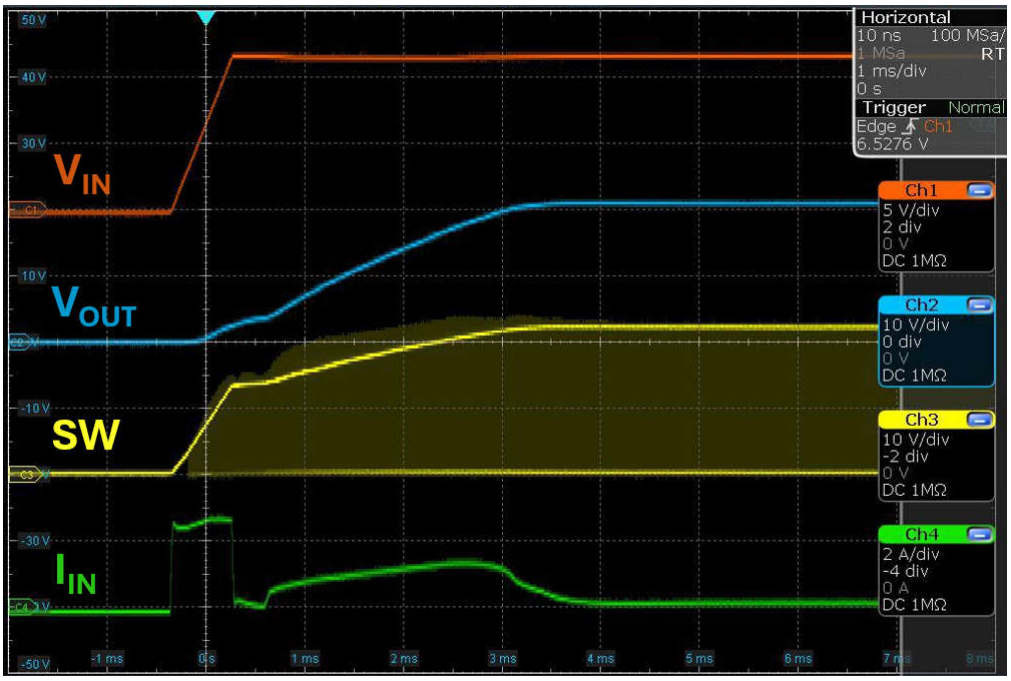


图 3-4. 启动波形，V_{IN} = 12V，I_{OUT} = 20mA

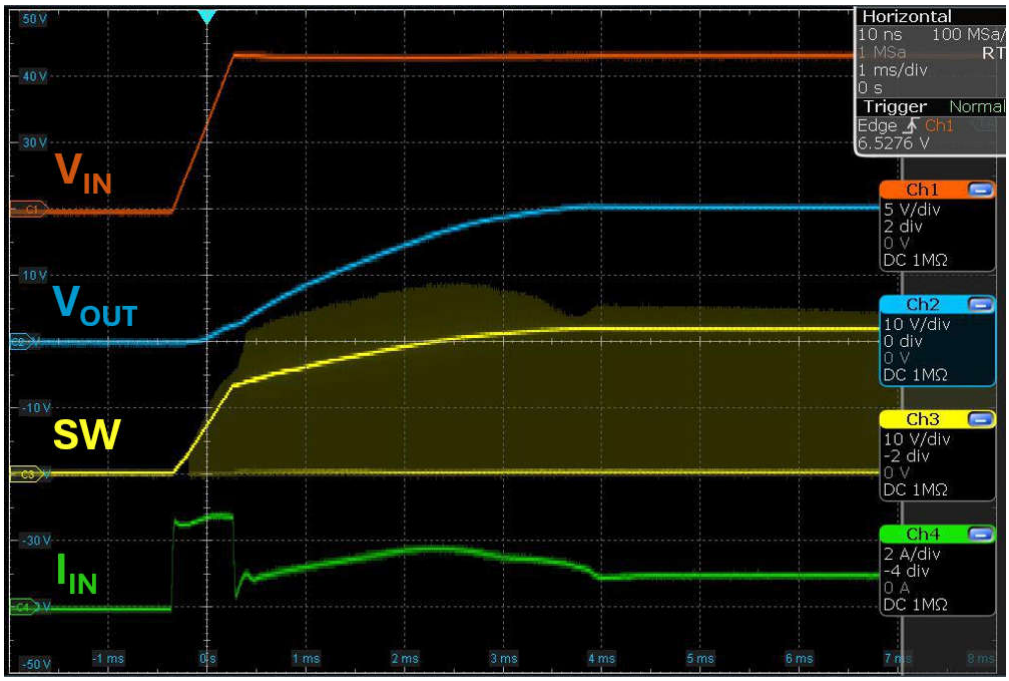


图 3-5. 启动波形，V_{IN} = 12V，I_{OUT} = 500mA

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稳态运行情况

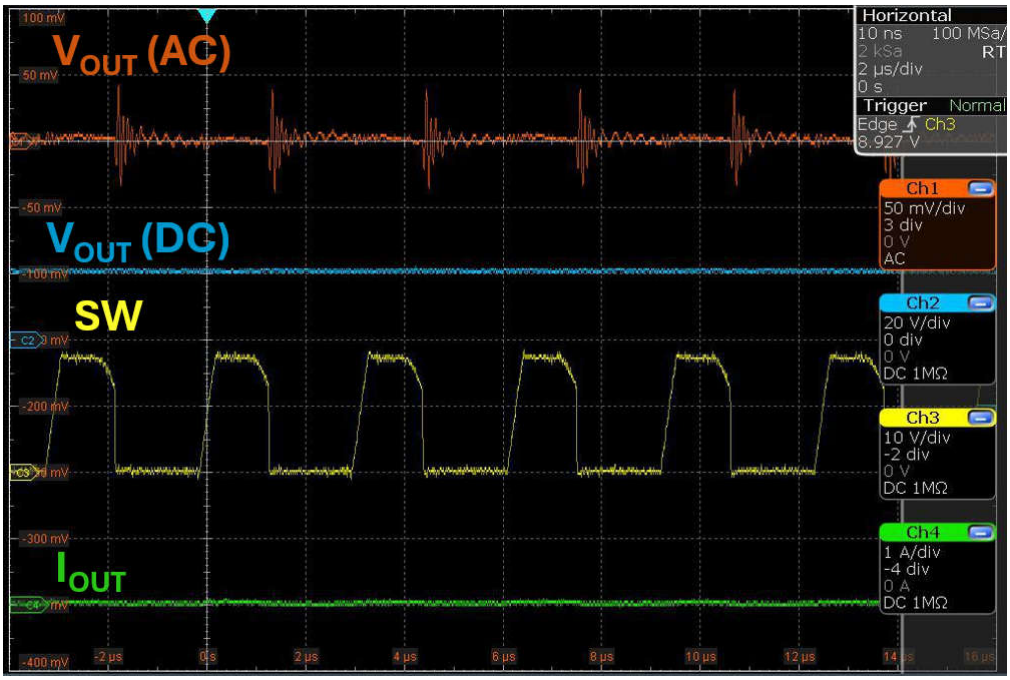


图 3-6. 稳态，V_{IN} = 7V，I_{OUT} = 20mA

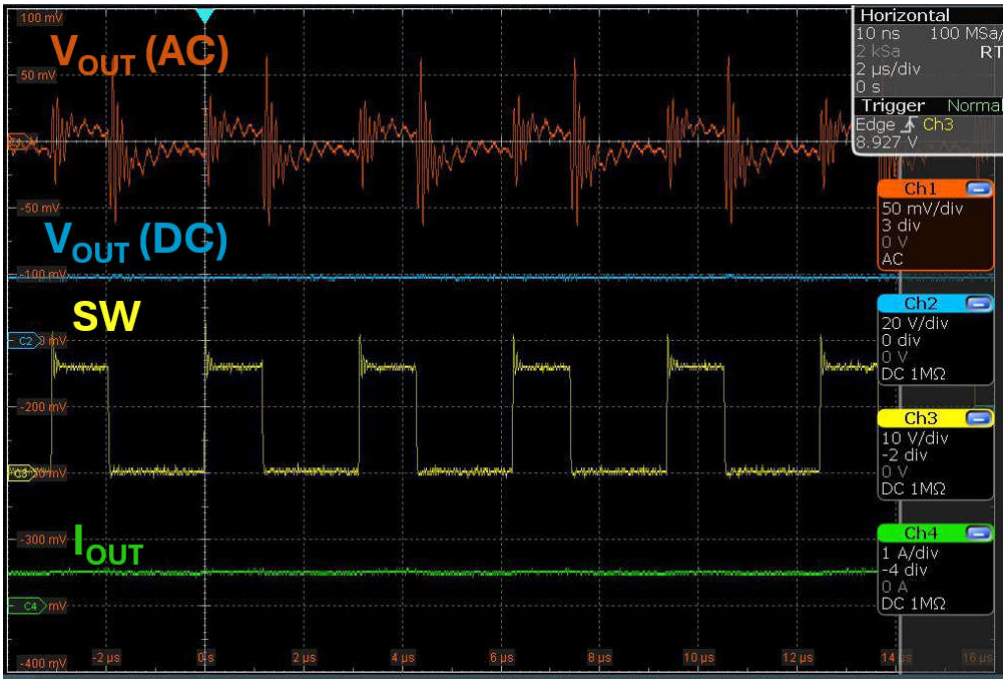


图 3-7. 稳态，V_{IN} = 7V，I_{OUT} = 500mA

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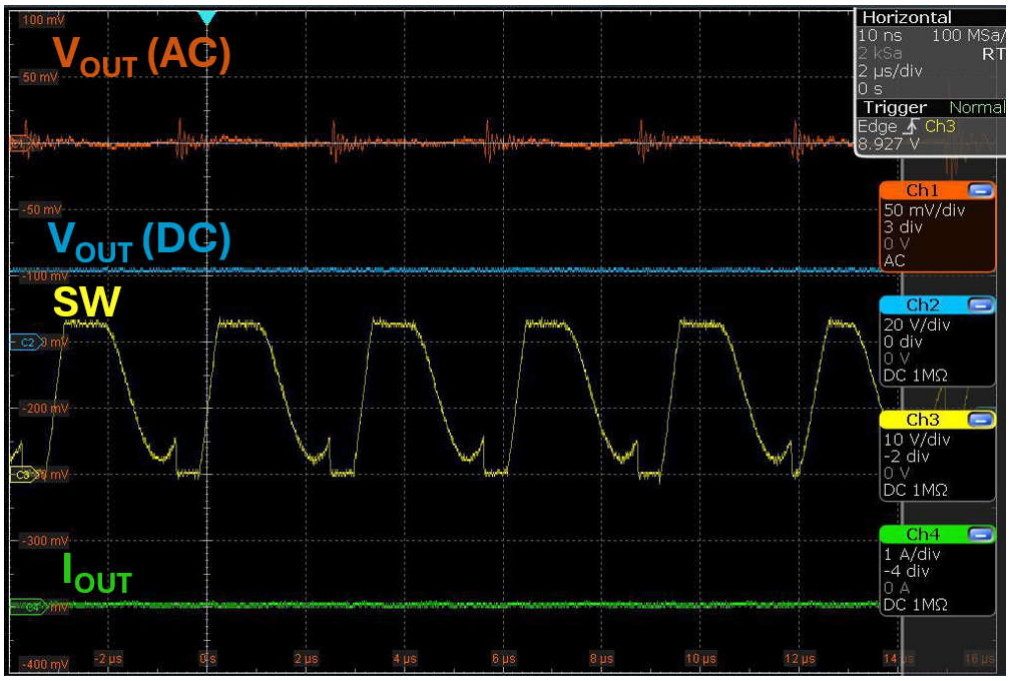


图 3-8. 稳态，V_{IN} = 12V，I_{OUT} = 20mA

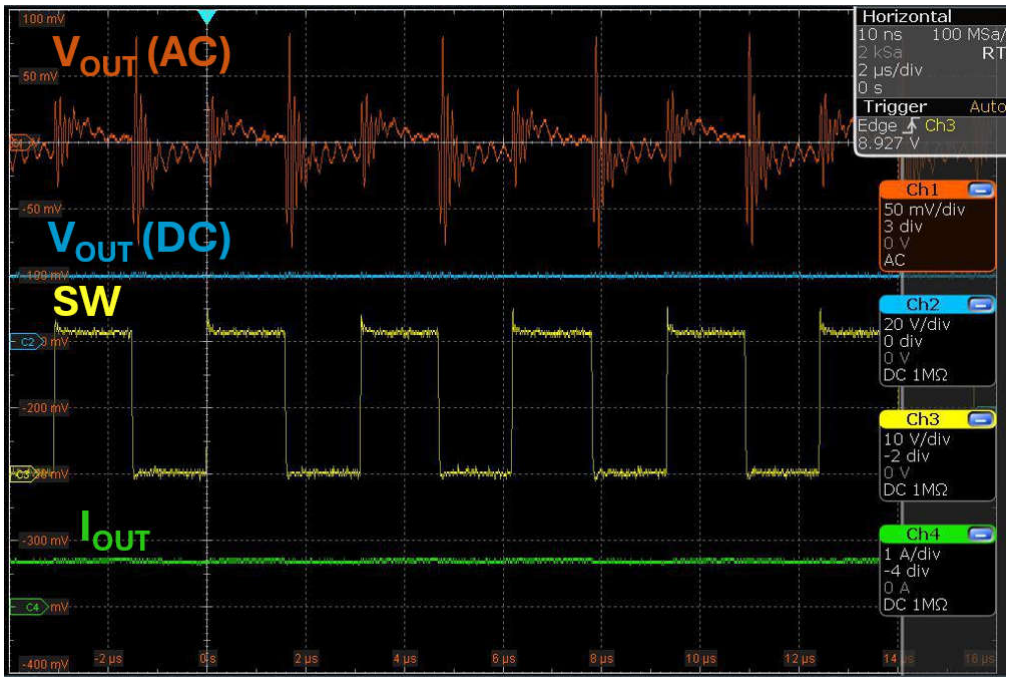


图 3-9. 稳态，V_{IN} = 12V，I_{OUT} = 700mA

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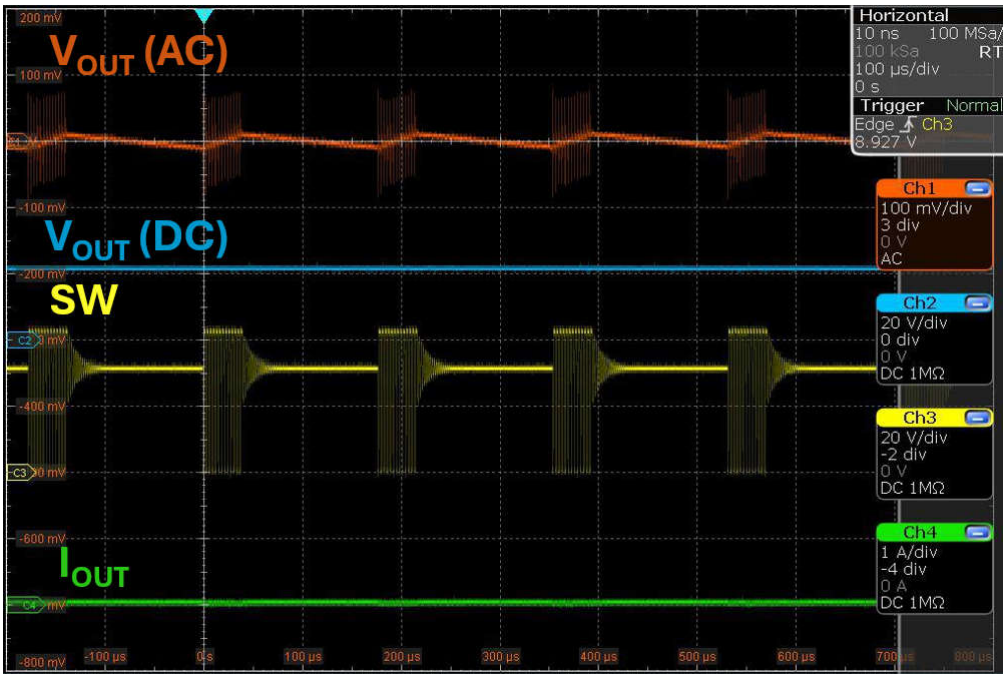


图 3-10. 稳态，V_{IN} = 32V，I_{OUT} = 20mA

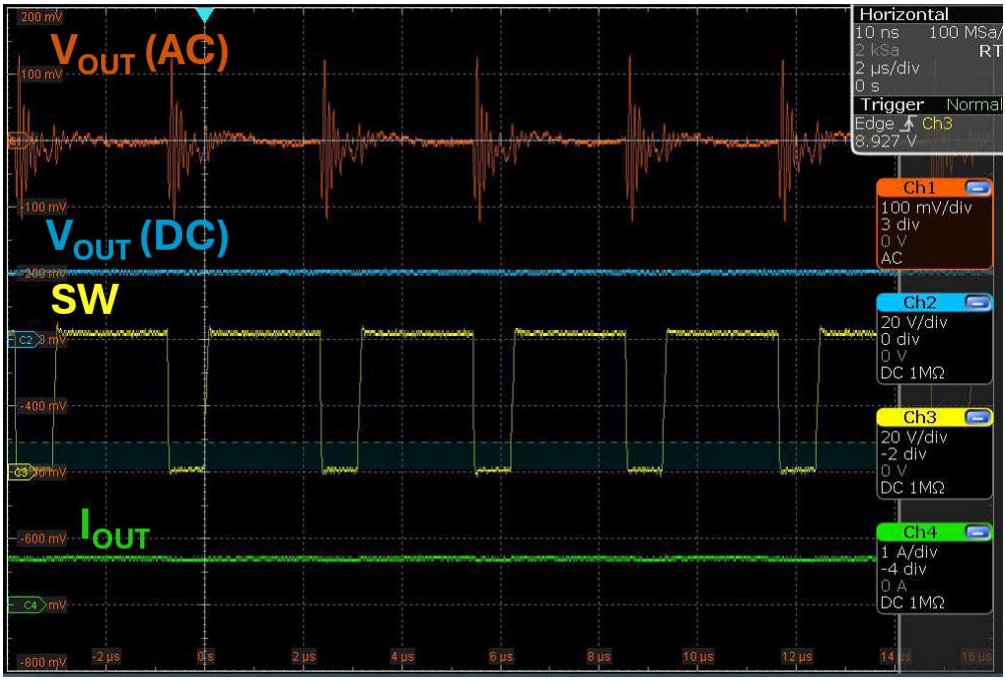


图 3-11. 稳态，V_{IN} = 32V，I_{OUT} = 700mA

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阶跃负载响应

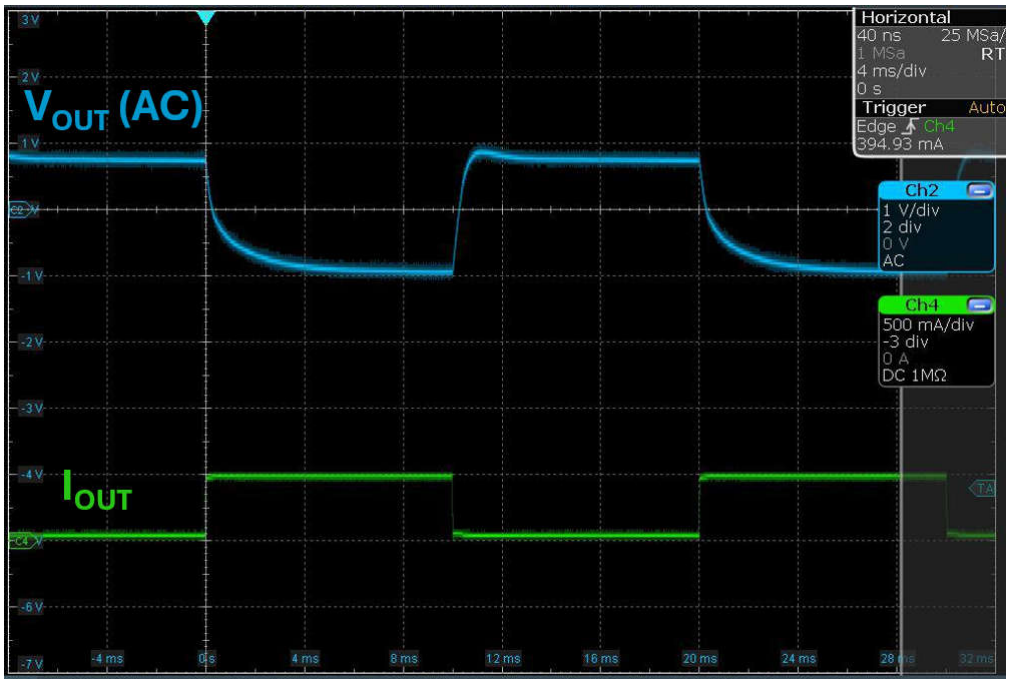


图 3-12. 负载瞬态，1A/μs 时 V_{IN} = 7V，I_{OUT} = 0mA 至 500mA

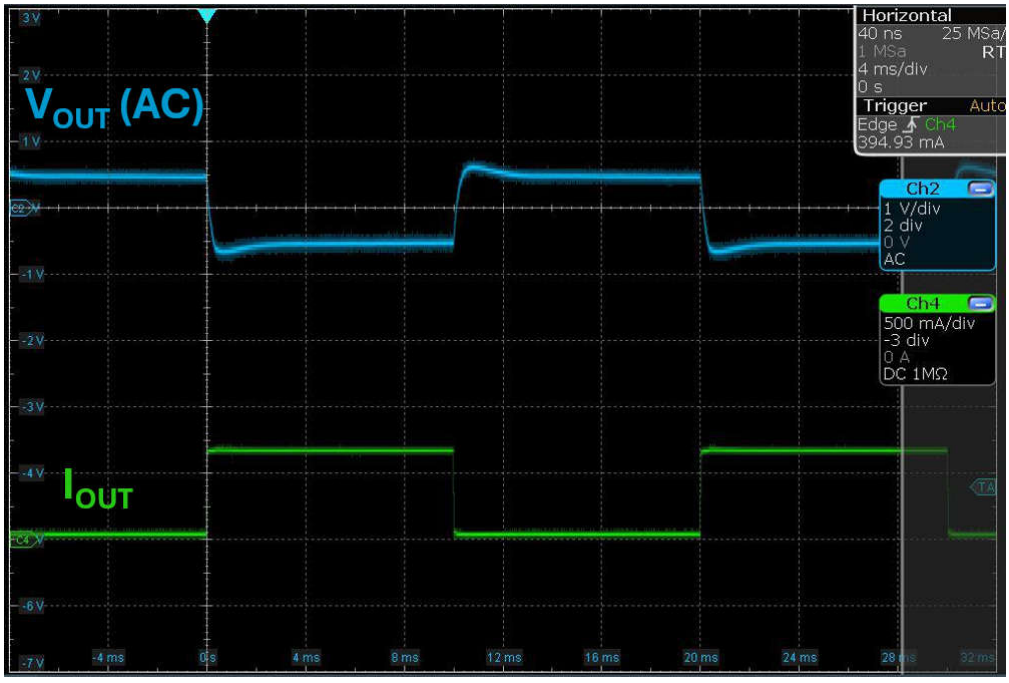


图 3-13. 负载瞬态，1A/μs 时 V_{IN} = 12V，I_{OUT} = 0mA 至 700mA

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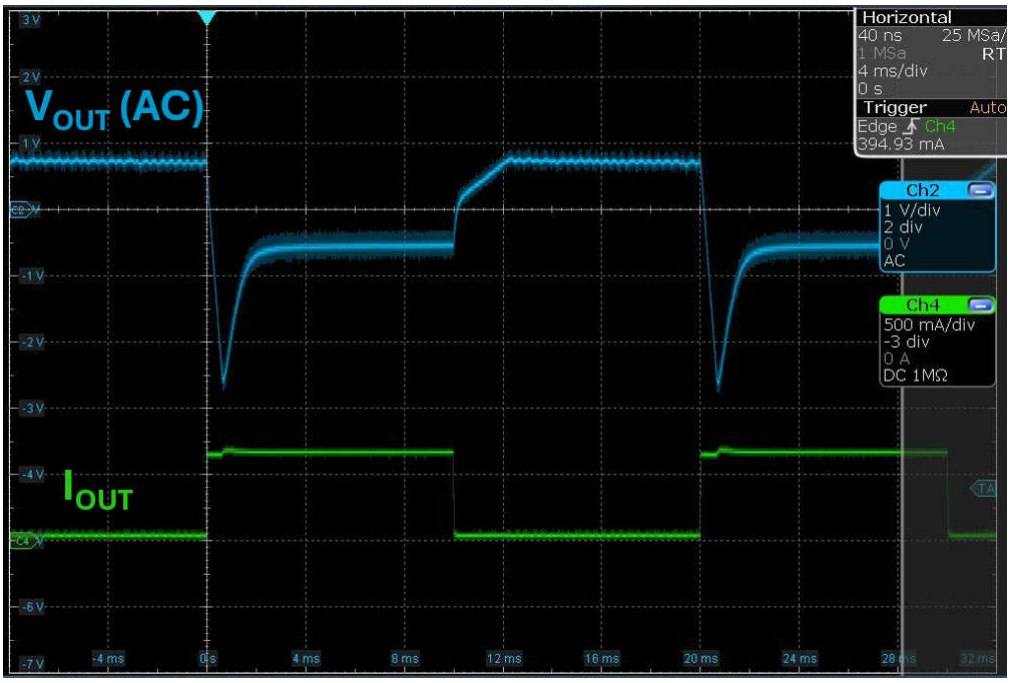


图 3-14. 负载瞬态，1A/μs 时 V_{IN} = 32V，I_{OUT} = 0mA 至 700mA

交流环路响应曲线

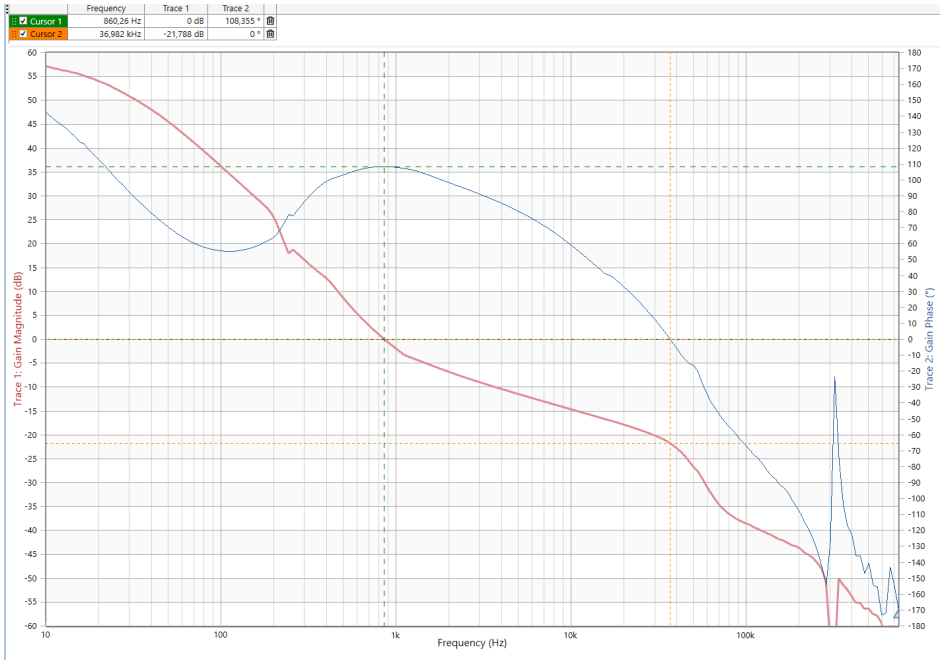


图 3-15. 波特图，V_{IN} = 12V，V_{OUT} = 20V，I_{OUT} = 500mA

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热性能

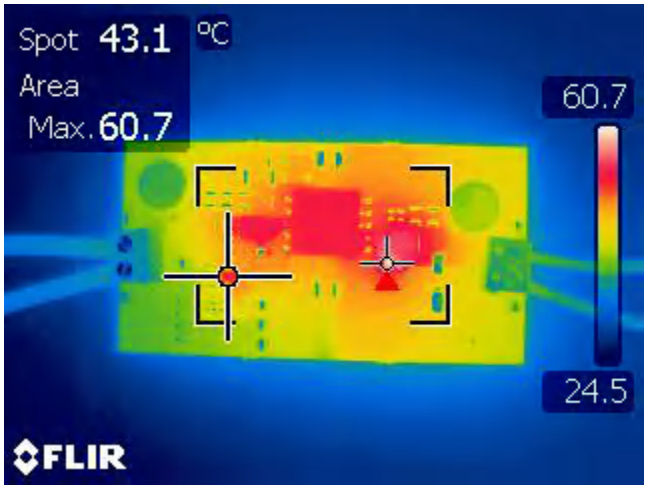


图 3-16. 温度测量，V_{IN} = 7V，I_{OUT} = 500mA

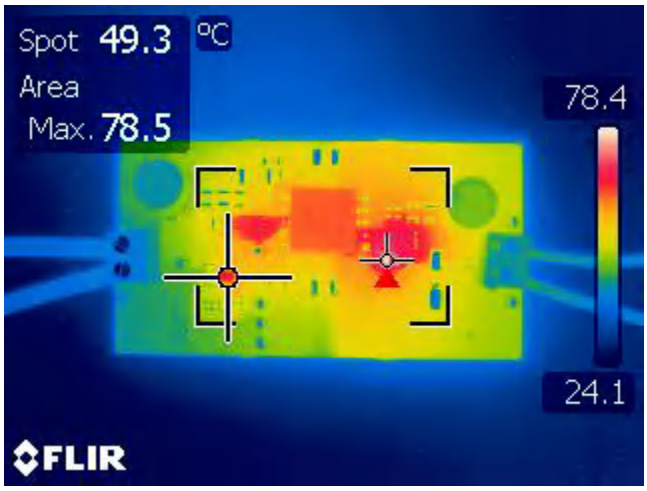


图 3-17. 温度测量，V_{IN} = 12V，I_{OUT} = 700mA

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4 硬件设计文件

4.1 原理图

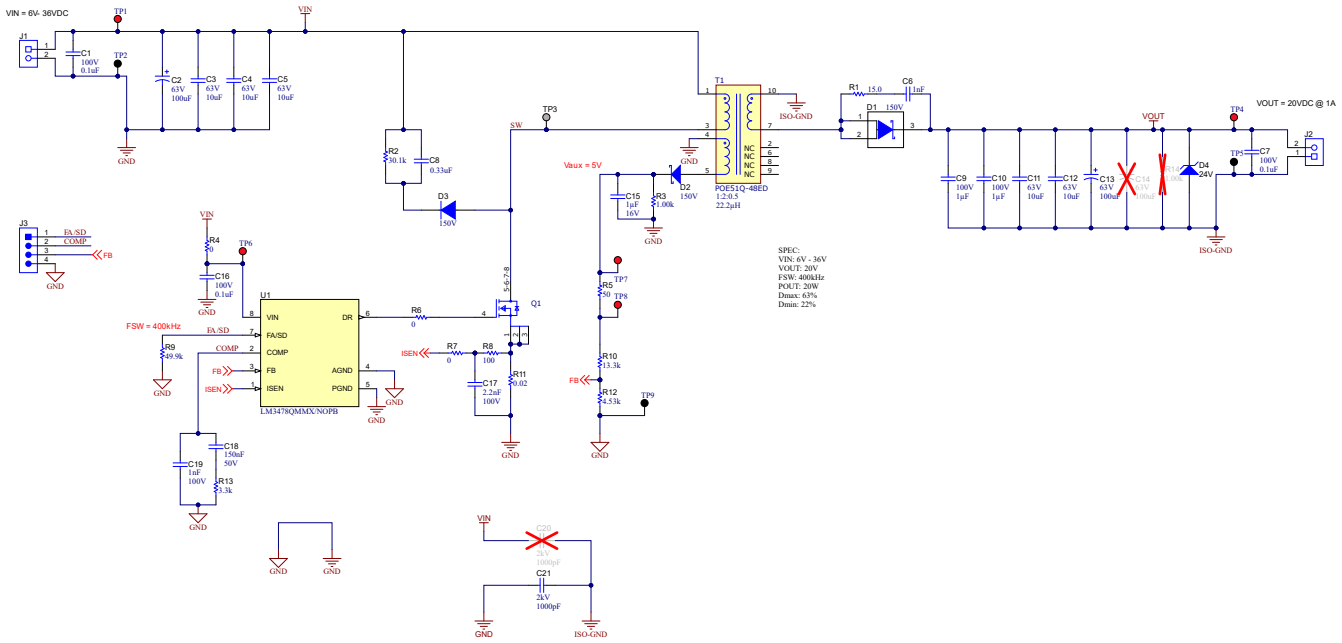


图 4-1. LM3478EVM-FLY 原理图

4.2 PCB 布局

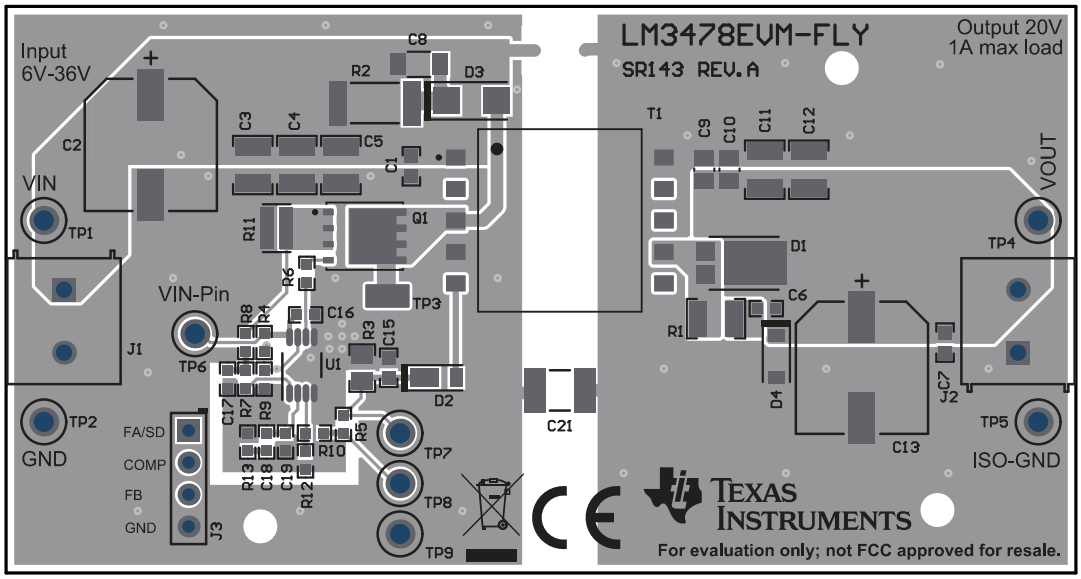


图 4-2. 顶层丝网印刷层

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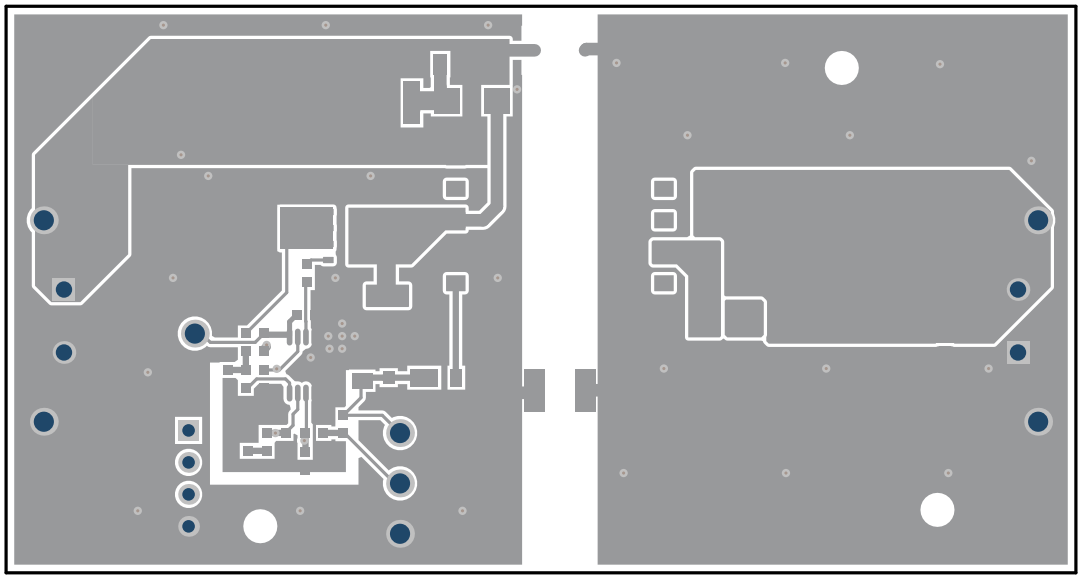


图 4-3. 顶层

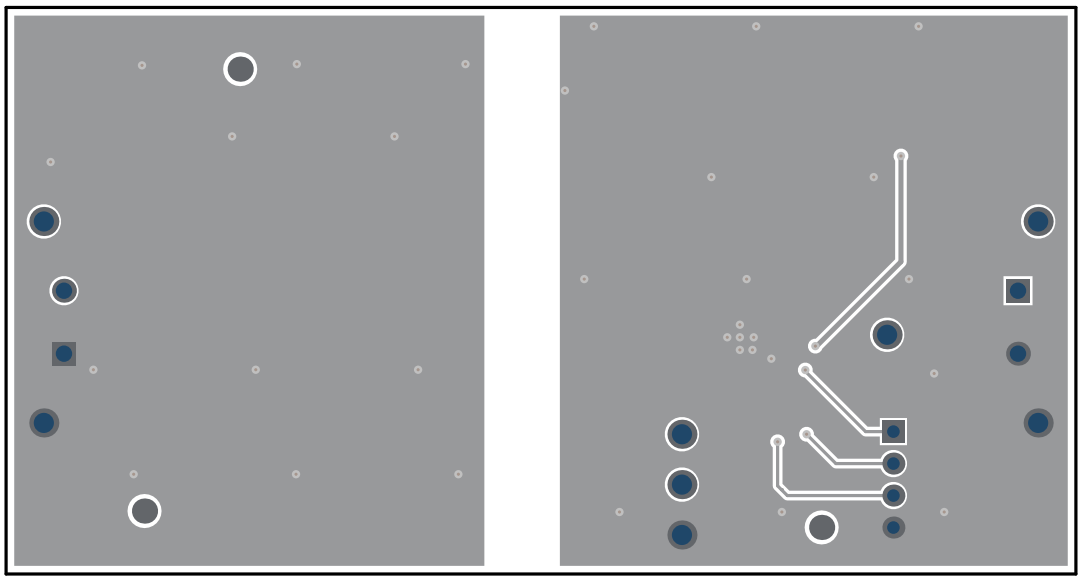


图 4-4. 底层

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4.3 物料清单 (BOM)

表 4-1. 物料清单

参考指示符	数量	值	器件型号	制造商	说明
C1、C7、C16	3	0.1µF	CGA3E3X7S2A104K080AB	TDK	电容，陶瓷，0.1µF，100V，+/– 10%，X7S，AEC-Q200 1 级，0603
C2、C13	2	100µF	PCR1J101MCL1GS	Nichicon	电容，铝聚合物，100µF，63V，+/-20%，0.024Ω，SMD，2 引线，直径 10.5mm，引脚间距 8mm SMD
C3、C4、C5、C11、C12	5	10µF	GRM32ER71H106KA12L	MuRata	电容，陶瓷，10µF，50V，+/-10%，X7R，1210
C6、C19	2	1000pF	CGA3E2X7R2A102K080AA	TDK	电容，陶瓷，1000pF，100V，+/– 10%，X7R，AEC-Q200 1 级，0603
C8	1	0.33µF	C3216X7R2A334K130AA	TDK	电容，陶瓷，0.33µF，100V，+/- 10%，X7R，
C9、C10	2	1µF	KAF21KR72A105KU	AVX	电容，陶瓷，1µF，100V，+/-10%，X7R，AEC-Q200 1 级，0805
C15	1	1µF	C1608X7R1C105K080AC	TDK	电容，陶瓷，1µF，16V，+/-10%，X7R，0603
C17	1	2200pF	CGA3E2X7R2A222K080AA	TDK	电容，陶瓷，2200pF，100V，+/– 10%，X7R，AEC-Q200 1 级，0603
C18	1	0.15µF	CGA3E3X7R1H154K080AB	TDK	电容，陶瓷，0.15µF，50V，+/– 10%，X7R，AEC-Q200 1 级，0603
C21	1	1000pF	1812GC102KAT1A	AVX	电容，陶瓷，1000pF，2000V，+/-10%，X7R，1812
D1	1	150V	PDS4150Q-13	Diodes Inc.	二极管，肖特基，150V，4A，AEC-Q101，PowerDI5
D2	1	150V	DFLS1150-7	Diodes Inc.	二极管，肖特基，150V，1A，PowerDI123
D3	1	150V	ES1C-13F	Diodes Inc.	二极管，超快速整流器，150V，1A，SMA
D4	1	24V	DDZ24C-7	Diodes Inc.	二极管，齐纳，24V，500mW，SOD-123
FID4、FID5、FID6	3		不适用	不适用	基准标记。没有需要购买或安装的元件。
H1、H2、H3、H4	4		SJ61A1	3M	缓冲垫，圆柱形，0.312 × 0.200，黑色
J1、J2	2		ED350/2	On-Shore Technology	端子块，5mm，2 极点，TH
J3	1		PEC04SAAN	Sullins Connector Solutions	接头，100mil，4x1，锡，TH
Q1	1		BSC027N06LS5ATMA1	Infineon	N 沟道 60V 100A (Tc) 83W (Tc) 表面贴装 PG-TDSON-8-7
R1	1	15	RC1210FR-0715RL	Yageo	电阻，15.0，1%，0.5W，1210
R2	1	30.1k	CRCW251230K1FKEG	Vishay-Dale	电阻，30.1k，1%，1W，AEC-Q200 0 级，2512
R3	1	1.00k	CRCW08051K00FKEA	Vishay-Dale	电阻，1.00k，1%，0.125W，AEC-Q200 0 级，0805
R4、R6、R7	3	0	CRCW06030000Z0EA	Vishay-Dale	电阻，0，5%，0.1W，AEC-Q200 0 级，0603
R5	1	50	CRCW060350R0FKEA	Vishay-Dale	电阻，50，1%，0.1W，AEC-Q200 0 级，0603
R8	1	100	ERJ-3EKF1000V	Panasonic	电阻，100，1%，0.1W，AEC-Q200 0 级，0603
R9	1	49.9k	ERJ-3EKF4992V	Panasonic	电阻，49.9k，1%，0.1W，AEC-Q200 0 级，0603
R10	1	13.3k	CRCW060313K3FKEA	Vishay-Dale	电阻，13.3k，1%，0.1W，AEC-Q200 0 级，0603
R11	1	0.02	PRL1632R020F-T1	Susumu Co Ltd	电阻，0.02，1%，1W，0612

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表 4-1. 物料清单（续）

参考指示符	数量	值	器件型号	制造商	说明
R12	1	4.53k	CRCW06034K53FKEA	Vishay-Dale	电阻，4.53k，1%，0.1W，AEC-Q200 0 级，0603
R13	1	3.3k	CRCW06033K30JNEA	Vishay-Dale	电阻，3.3k，5%，0.1W，AEC-Q200 0 级，0603
T1	1		POE51Q-48ED	Coilcraft	变压器反激式 PoE 51W 22.2µH 48V 4.7A
TP1、TP4、TP6、TP7、TP8	5		5005	Keystone Electronics	测试点，紧凑，红色，TH
TP2、TP5、TP9	3		5006	Keystone Electronics	测试点，紧凑型，黑色，TH
TP3	1		5017	Keystone Electronics	PC 测试点，SMT
U1	1		LM3478QMMX/NOPB	德州仪器 (TI)	适用于开关稳压器的 40V 宽输入电压低侧 N 沟道控制器，DGK0008A (VSSOP-8)

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5 其他信息

5.1 商标

所有商标均为其各自所有者的财产。

6 修订历史记录

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision * (September 2026) to Revision A (September 2026)	Page
• 通过更正拼写和语法错误，更新了*说明*	1

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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.

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.

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

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

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

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/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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