

EVM User's Guide: TPS7H1302EVM-CVAL

TPS7H1302-SP 评估模块

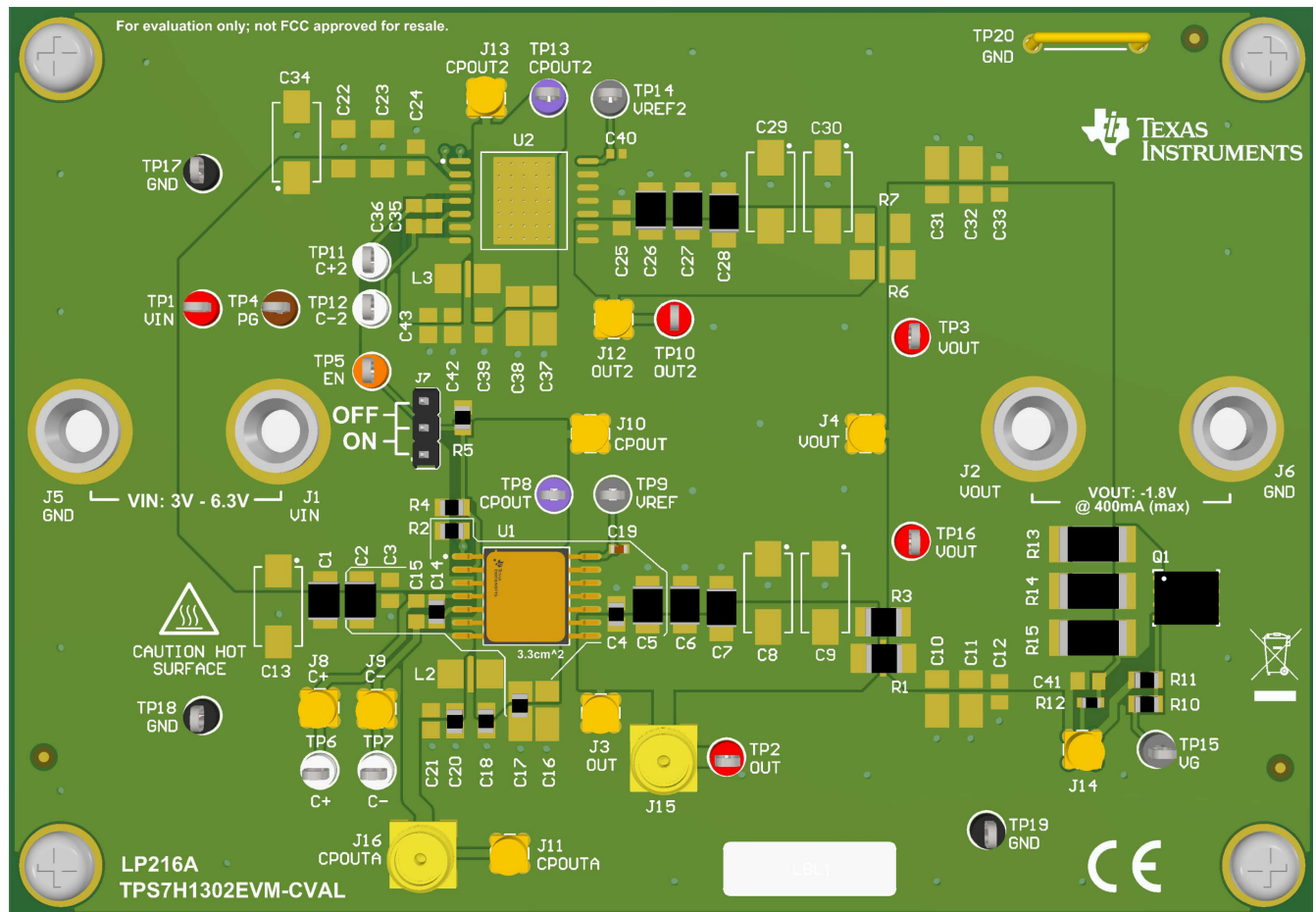


说明

TPS7H1302EVM-CVAL 演示了具有集成低压降稳压器（陶瓷封装）的单个 TPS7H1302-SP 开关电容器电压逆变器的运行情况。该电路板提供可用于组装额外元件的空间，可实现对定制配置的测试。

特性

- 灵活的配置选项，包括配置并联器件的功能
- 板载负载瞬态电路



1 评估模块概述

1.1 简介

TPS7H1302EVM-CVAL 是适用于 TPS7H1302 陶瓷封装选项的评估模块 (EVM)，提供了一个对其特性进行电气评估的平台。本用户指南提供了有关 EVM 的详细信息，其中包括配置、原理图 和 BOM。该 EVM 旨在通过用于外部元件的焊盘和用于并联配置的额外 IC 焊盘，支持您根据需要灵活地配置器件。默认情况下，EVM 中的器件配置如 TPS7H1302EVM-CVAL 默认配置 和默认 EVM 原理图 所示。若要在一个不同的配置下设置器件，请参阅 TPS7H1302 数据表 来计算器件周围需要更改的无源器件的值。

1.2 套件内容

- EVM 电路板 (1)
- EVM 套件用户指南 (1)

1.3 规格

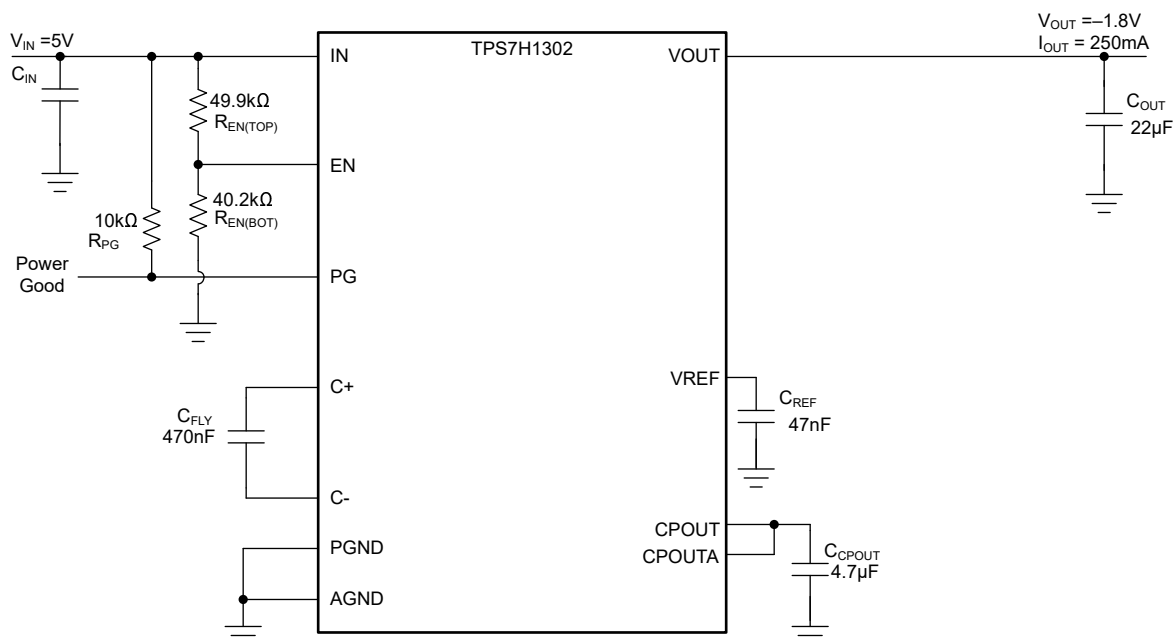


表 1-1. 默认 EVM 配置

规格	值	说明
输入电压 VIN	5V	处于建议的器件输入电压范围 3V 至 6.3V 内。
输出电压 VOUT	-1.8V	固定输出
负载电流 IOUT	250mA	每个器件允许的最大输出电流为 400mA。
使能电压	3.89V	使 EN 高于导通阈值的 VIN 值。 设置方式： R4 = 54.9kΩ R5 = 10kΩ
禁用电压	3.25V	使 EN 低于关断阈值的 VIN 值。 设置方式： R4 = 54.9kΩ R5 = 10kΩ
开关频率 fsw	1MHz	内部开关电容阵列的固定开关频率。

1.4 器件信息

TPS7H1302 是一款低噪声稳压开关电容器电压逆变器，具有一个输入电压范围为 3V 至 6.3V 的集成低压降稳压器，TPS7H1302 能够提供 400mA 的输出电流和固定的 -1.8V 输出。TPS7H1302 使用 1MHz 的内部开关频率。

2 硬件

2.1 电源要求

TPS7H1302EVM-CVAL 需要一个正电源轨 (VIN)。

- $3V \leq VIN \leq 6.3V$

2.2 跳线信息

位号	功能	
J1	VIN	VIN 的正电压电源输入
J5	GND	
J2	VOUT	VOUT 的负电压电源输出
J6	GND	
J7	EN	通过跳线将 EN 连接到 VIN 或 GND，以实现简单的使能/禁用控制。

2.3 测试点

位号	功能	
TP1	VIN	VIN 测试点。
TP2	OUT	主器件的 OUT 测试点。
TP10	OUT2	次级器件的 OUT 测试点。
TP3	VOUT	主器件和次级器件的共享 VOUT 的测试点。
TP4	PG	主器件和次级器件的共享 PG 信号的测试点。
TP5	EN	主器件和次级器件的共享 EN 信号的测试点。
TP6	C+	主器件飞跨电容器正极终端的测试点。
J8		主器件飞跨电容器正极终端的 MMCX 连接器。
TP11	C+2	次级器件飞跨电容器正极终端的测试点。
TP7	C-	主器件飞跨电容器负极终端的测试点。
J9		主器件飞跨电容器负极终端的 MMCX 连接器。
TP12	C-2	次级器件飞跨电容器负极终端的测试点。
TP8	CPOUT	主器件的 CPOUT 测试点。
J10		主器件的 CPOUT 的 MMCX 测试点。
TP13	CPOUT2	次级器件的 CPOUT 测试点。
J13		次级器件的 CPOUT 的 MMCX 测试点。
J11	CPOUTA	主器件的 CPOUTA 的 MMCX 测试点。
J16		主器件 CPOUTA 的 SMA 连接器。
TP9	VREF	主器件的 VREF 测试点。
TP14	VREF2	次级器件的 VREF 测试点。
TP17、TP18、TP19、TP20	GND	GND 的测试点。
TP15	VG	用于控制负载瞬态电路中使用的栅极信号的测试点。
TP16	VOUT	
J14	TRANS	MMCX 连接器 用于检测负载瞬态电路所需负载。

2.4 最佳实践

- 选择 VIN 和 VOUT 时，计算预期负载下的预期 VDroop 和 VDropout 需求。
- 确保负电源轨上的元件（例如钽电容器）的方向正确。

- 在选择输入电容时，确定 VIN 纹波要求。
- 注意电路板在运行过程中可能会发热的区域。



3 实现结果

下面显示了以下行为的波形：

1. 启动
2. 关断
3. 电荷泵运行情况

3.1 启动

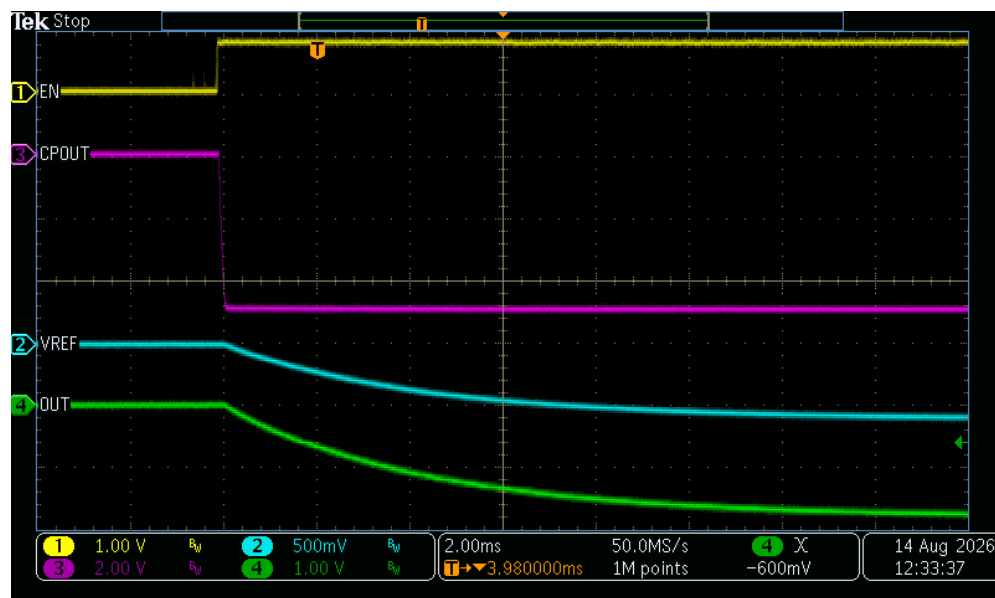


图 3-1. EN 独立驱动为高电平

EN 跟随上升的 VIN。当 EN 超过导通阈值时，CPOUT 导通，然后在 VIN 进一步上升时继续跟随 VIN。当 CPOUT 的幅度达到 VIN 幅度量级的 $\approx 60\text{-}80\%$ 且电荷泵退出频率折返模式后，VOUT 就会导通。

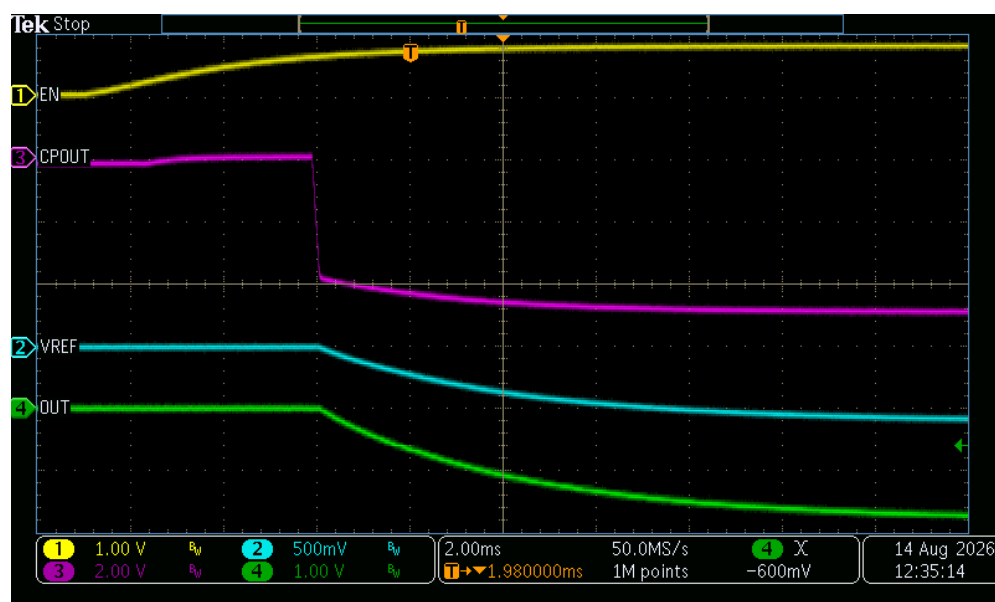


图 3-2. EN 通过电阻分压器连接至上升的 VIN

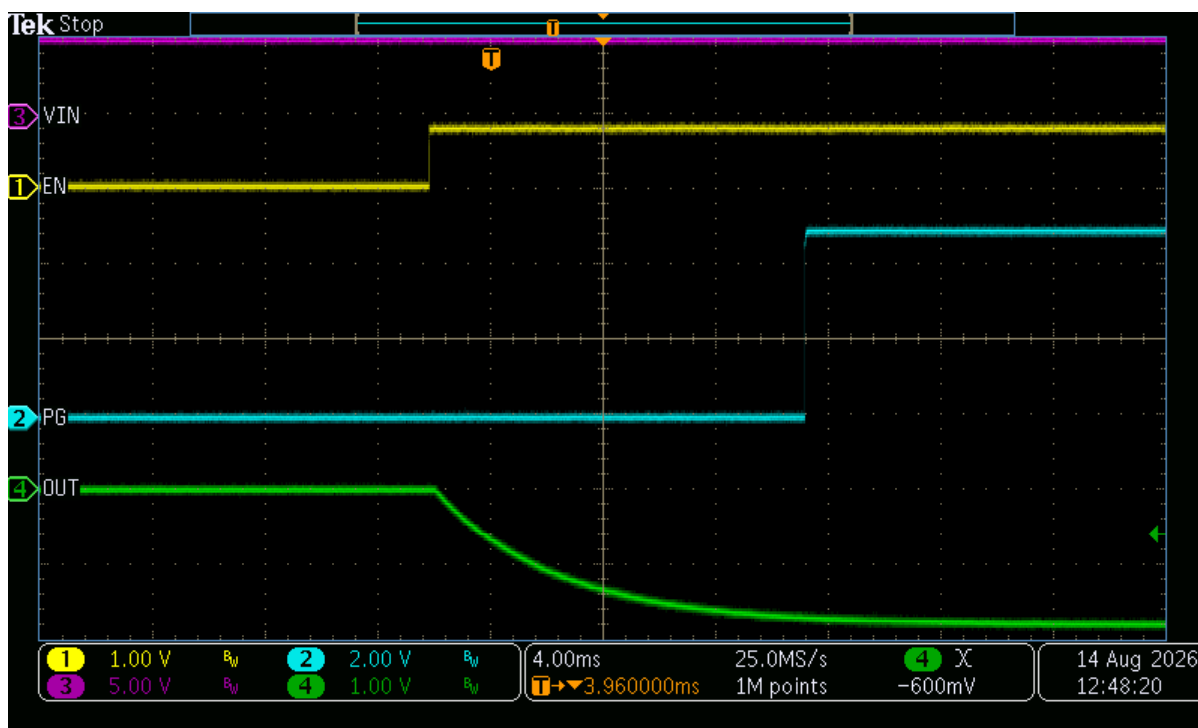


图 3-3. 电源正常置为有效 — EN 独立驱动为高电平

由于 VIN 在此波形中上升下降，因此当 VIN 低于 VIN_MIN_PG (标称 0.8V) 时，可能会观察到 PG 输出短暂处于某种状态。

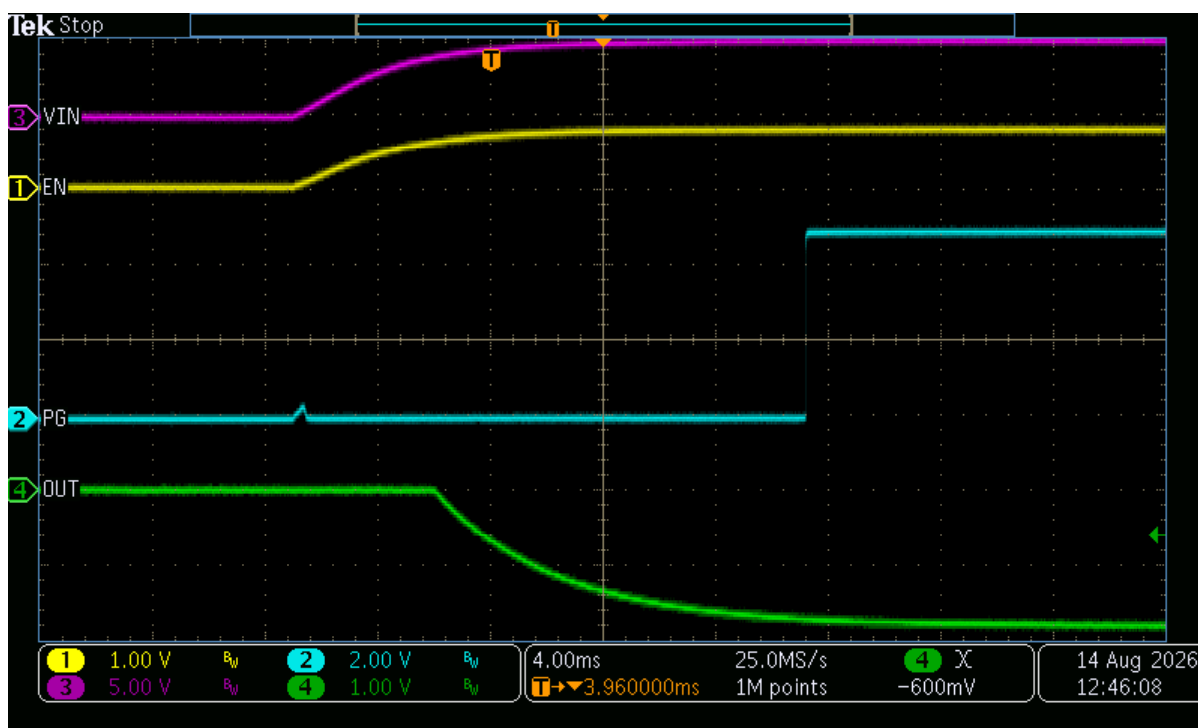


图 3-4. 电源正常置为有效 — EN 通过电阻分压器连接至上升的 VIN

3.2 关断

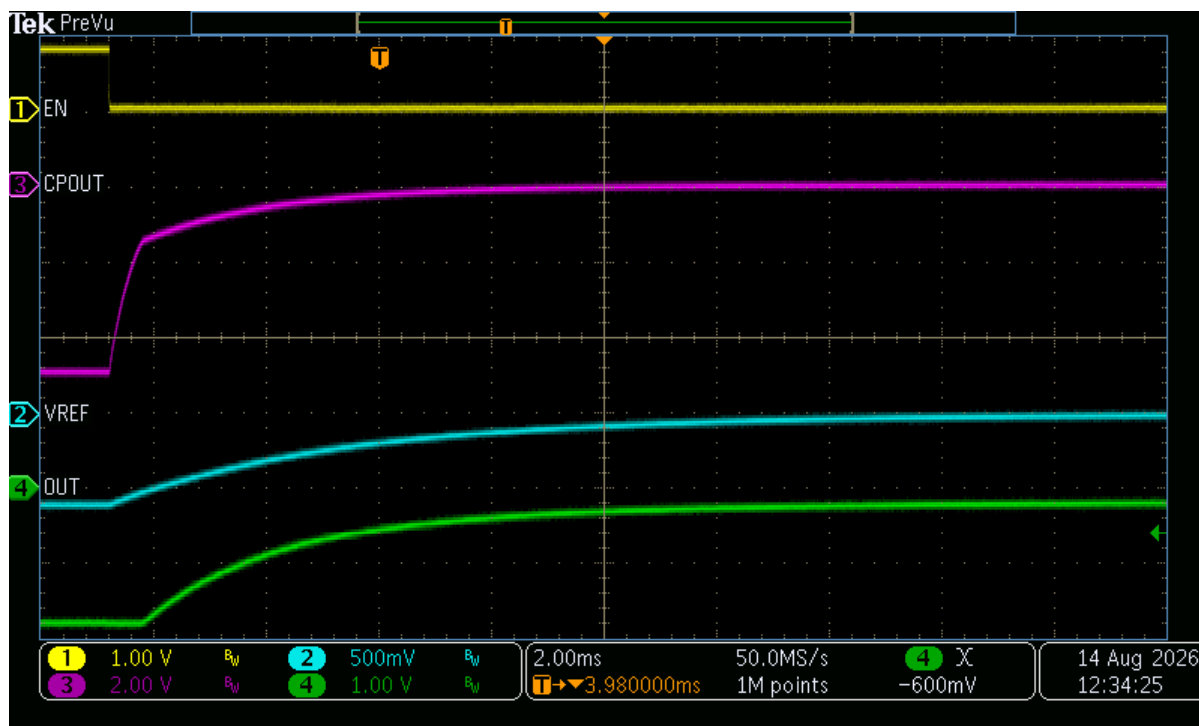


图 3-5. EN 独立驱动为低电平

CPOUT 和 EN 会跟随 VIN 下降电压，直至 EN 达到关断阈值，从而禁用 CPOUT 和 VOUT。

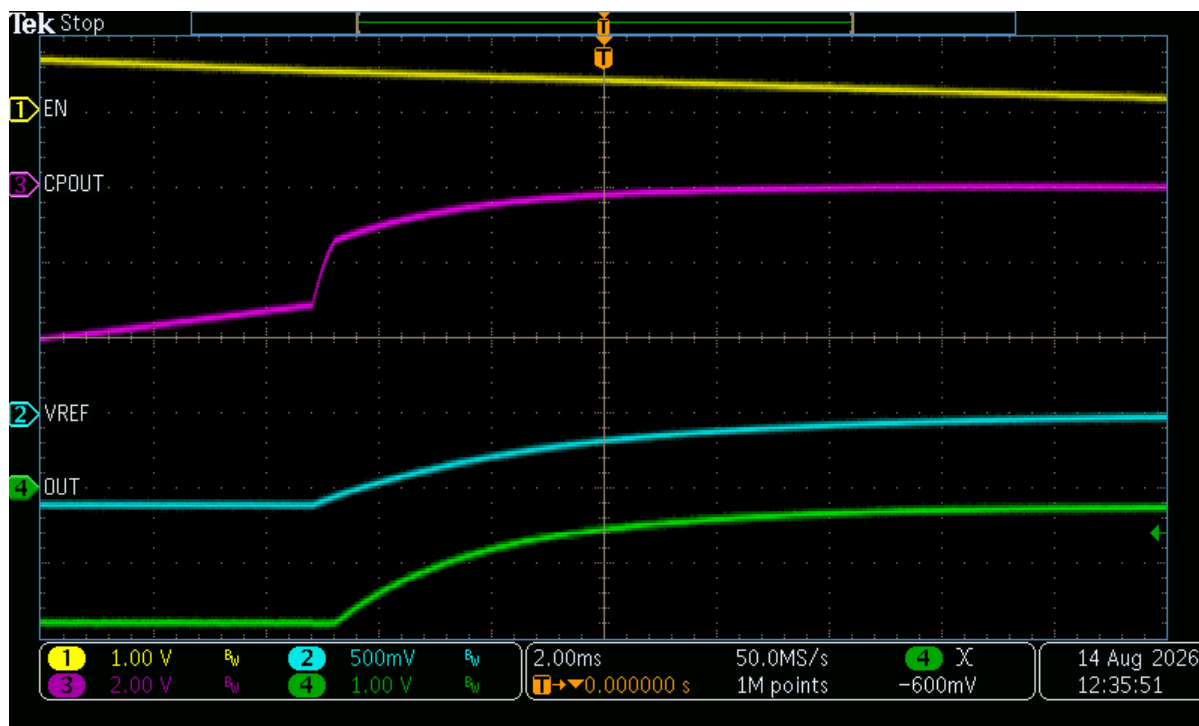


图 3-6. EN 通过电阻分压器连接至下降的 VIN



图 3-7. 电源正常置为无效 — EN 独立驱动为低电平

PG 上拉至 VIN 并跟随 VIN，直到 VIN 足够低，从而使 EN 达到关断阈值。由于 VIN 在此波形中下降，因此当 VIN 低于 VIN_MIN_PG (标称 0.8V) 时，可能会观察到 PG 输出短暂处于某种状态。



图 3-8. 电源正常置为无效 — EN 通过电阻分压器连接至下降的 VIN

3.3 电荷泵运行情况

在 CPOUT 启动充电期间，C+ 和 C- 显示电荷泵的折返开关频率，随后进入标称 1MHz 开关频率。

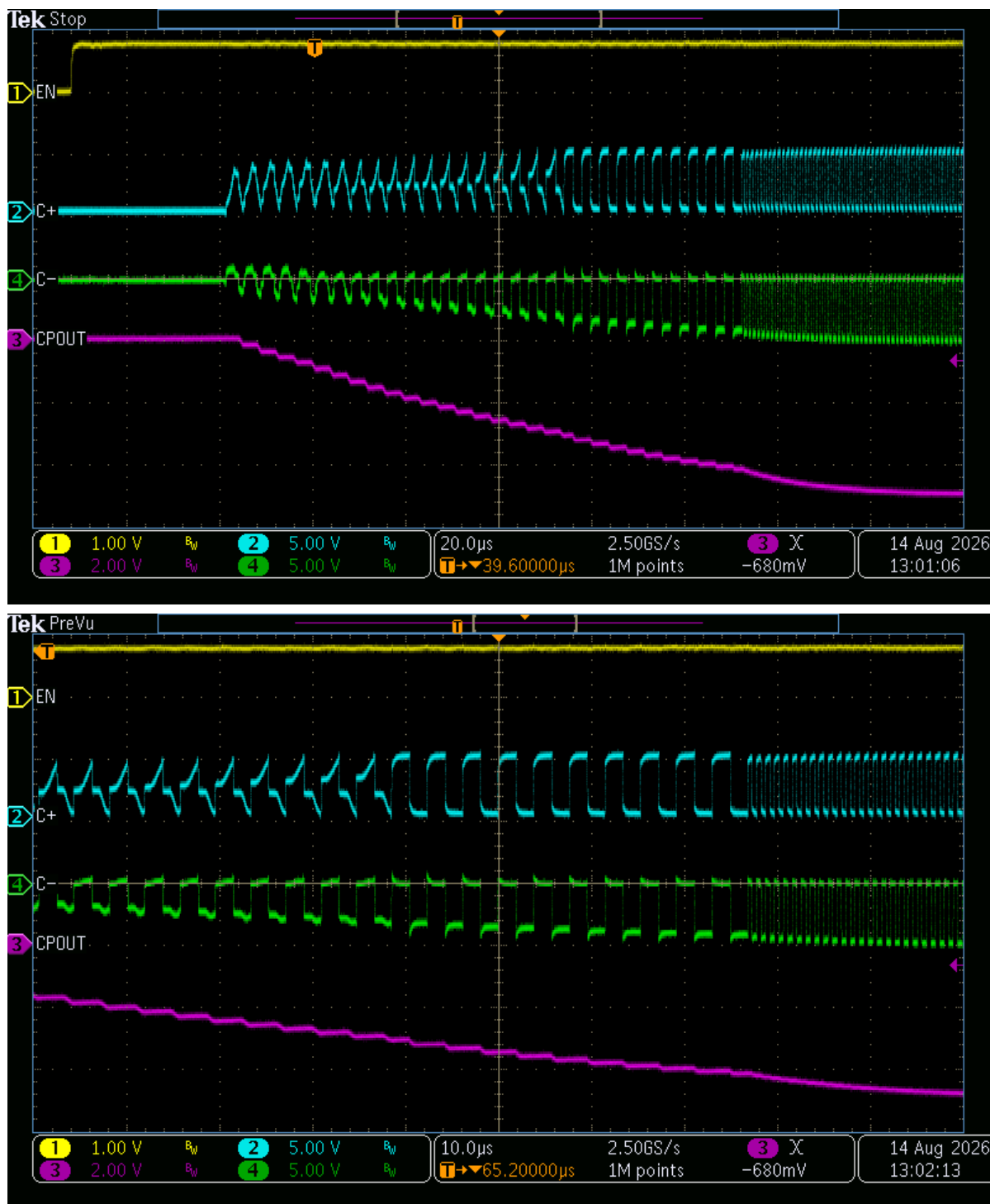


图 3-9. 启动

电荷泵所需的电流会在 VIN 上产生纹波。如有需要（例如在 VIN 为共享导轨的情况下），选择大容量电容器和旁路电容器有助于缓解这种纹波。

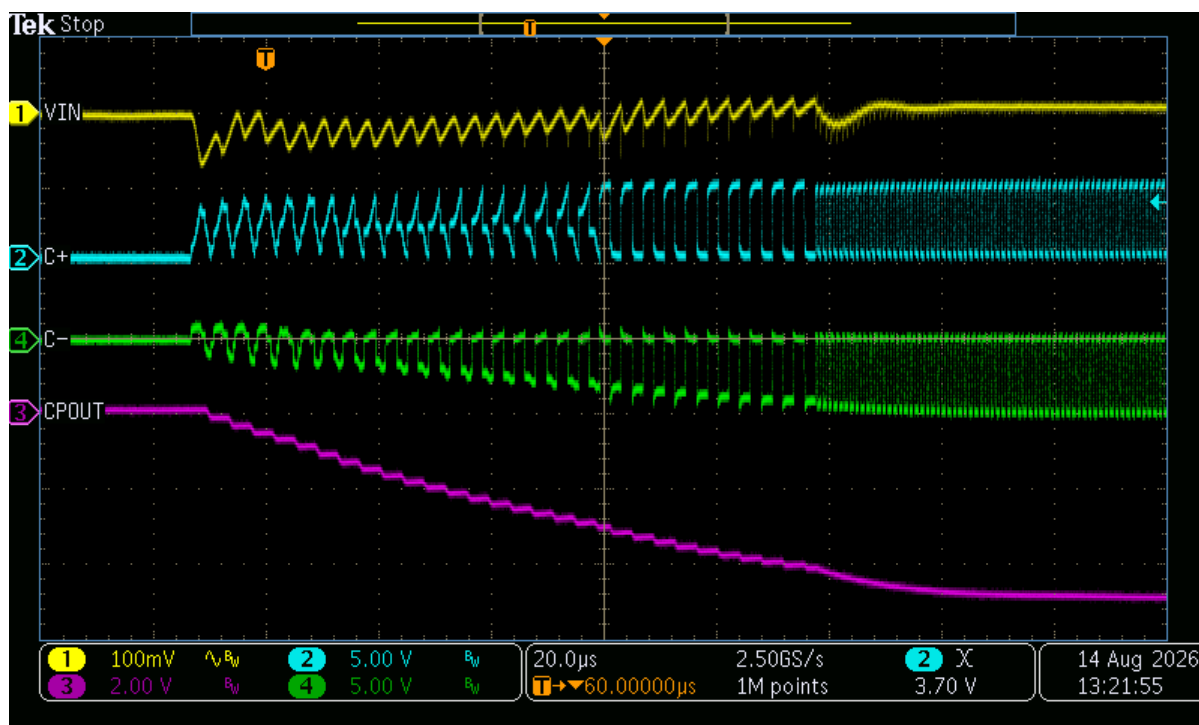


图 3-10. VIN 纹波

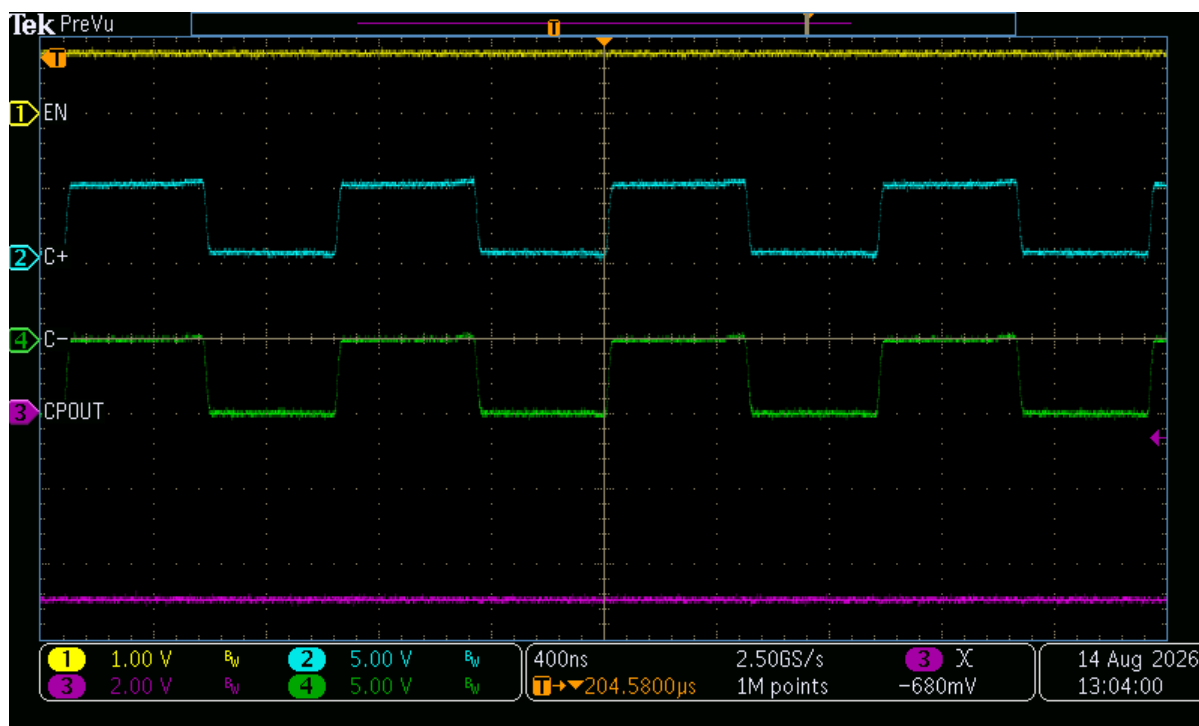


图 3-11. 稳定状态

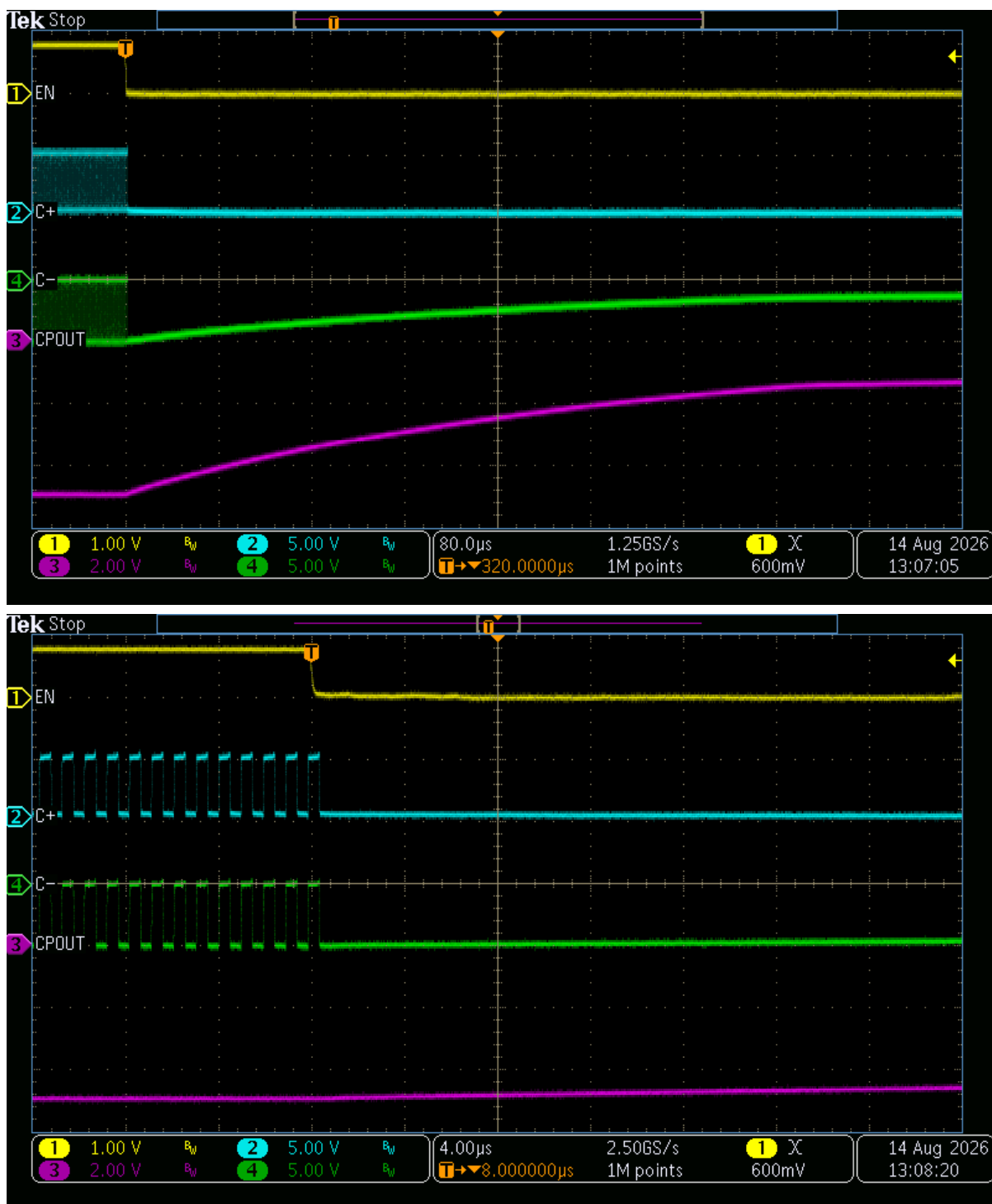
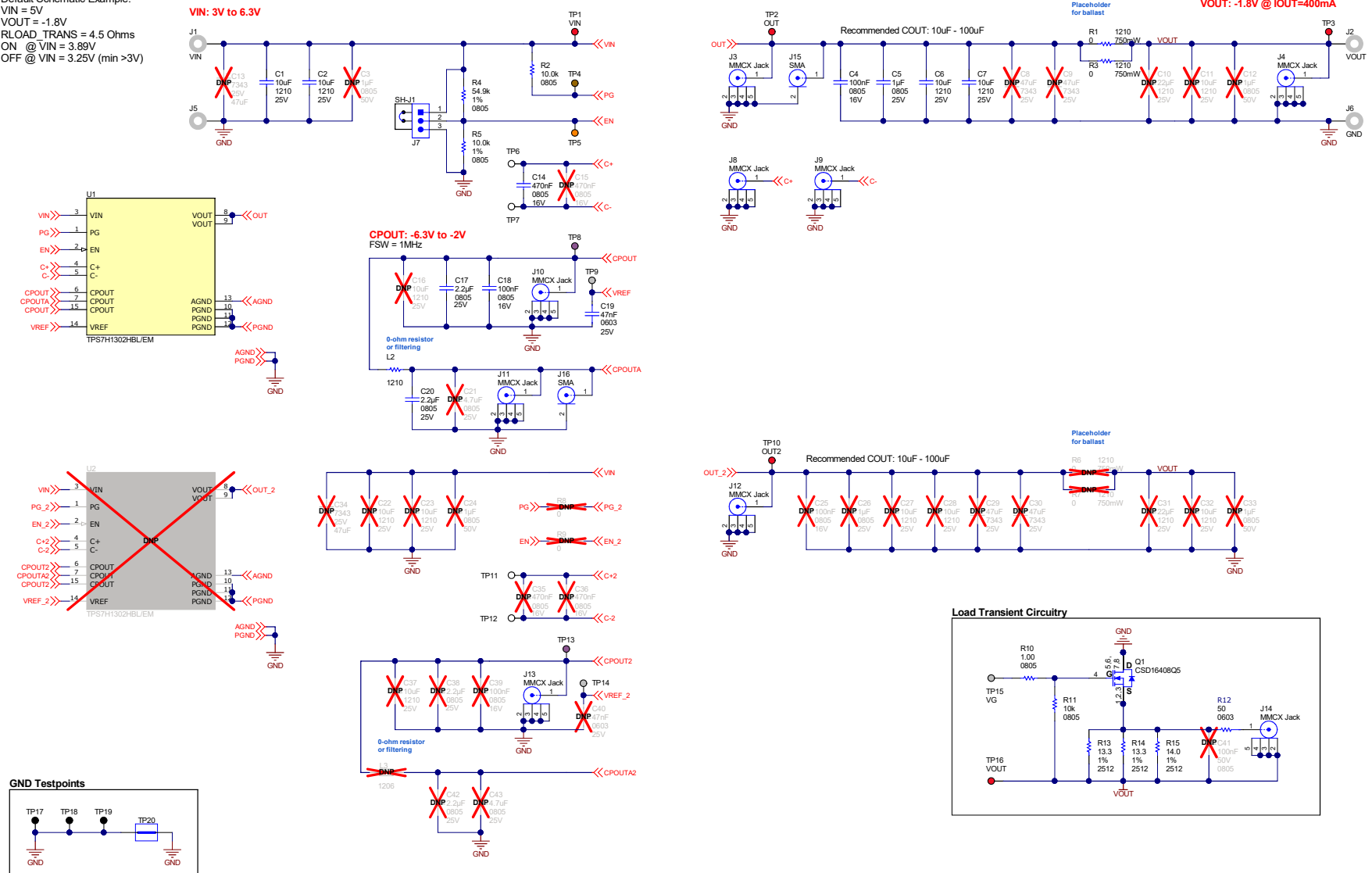


图 3-12. 关断

4 硬件设计文件

4.1 原理图

Default Schematic Example:
VIN = 5V
VOUT = -1.8V
RLOAD_TRANS = 4.5 Ohms
ON @ VIN = 3.89V
OFF @ VIN = 3.25V (min >3V)



下面的原理图显示了一个示例，说明如何为并联器件设计配置 TPS7H1302。

Default Schematic Example:
VIN = 5V
VOUT = -1.8V
RLOAD_TRANS = 4.5 Ohms
ON @ VIN = 3.89V
OFF @ VIN = 3.25V (min >3V)

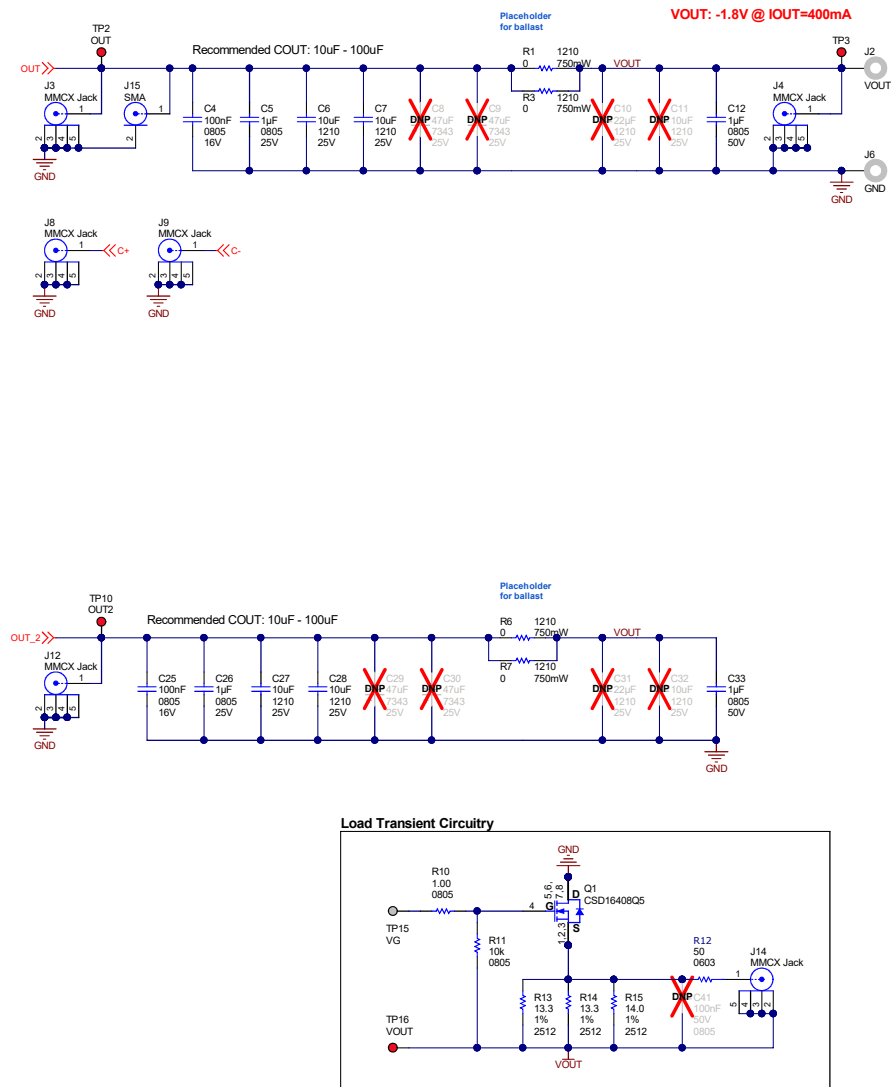
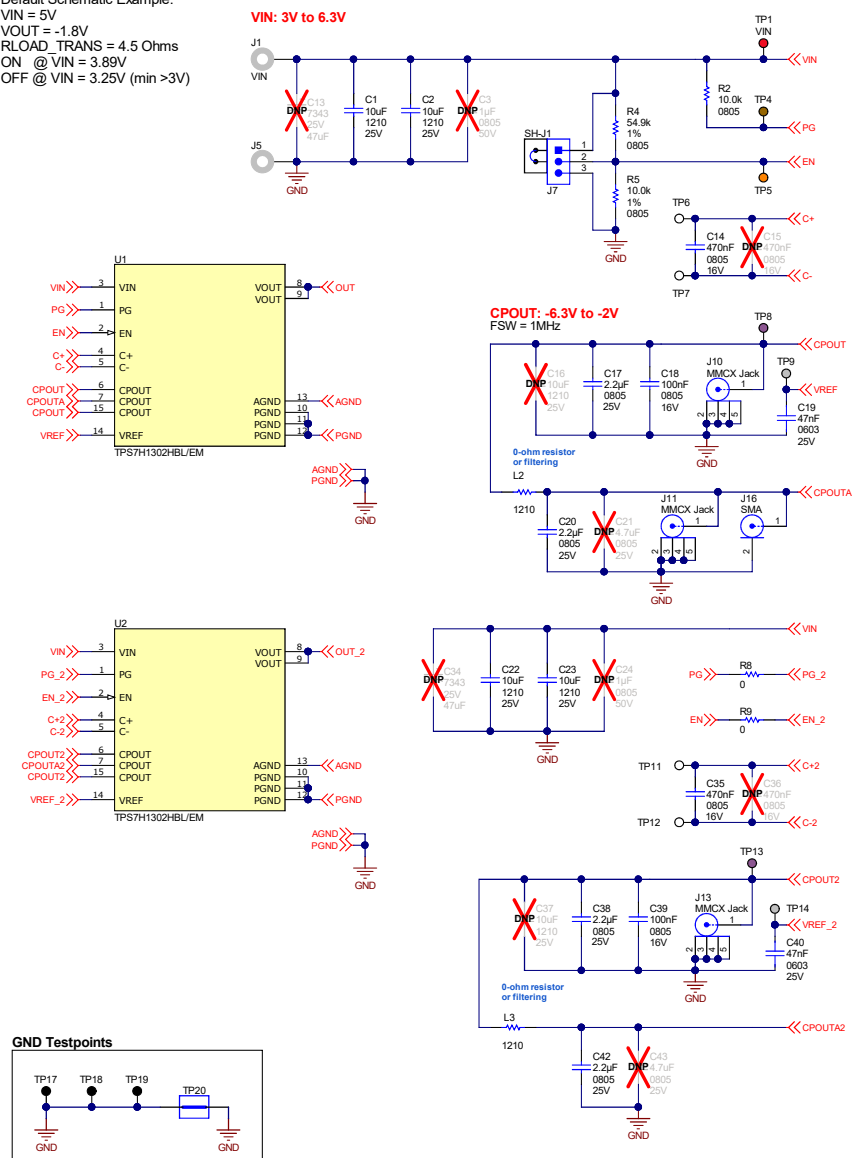


图 4-2. 示例原理图：并联 TPS7H1302-SP

4.2 PCB 布局

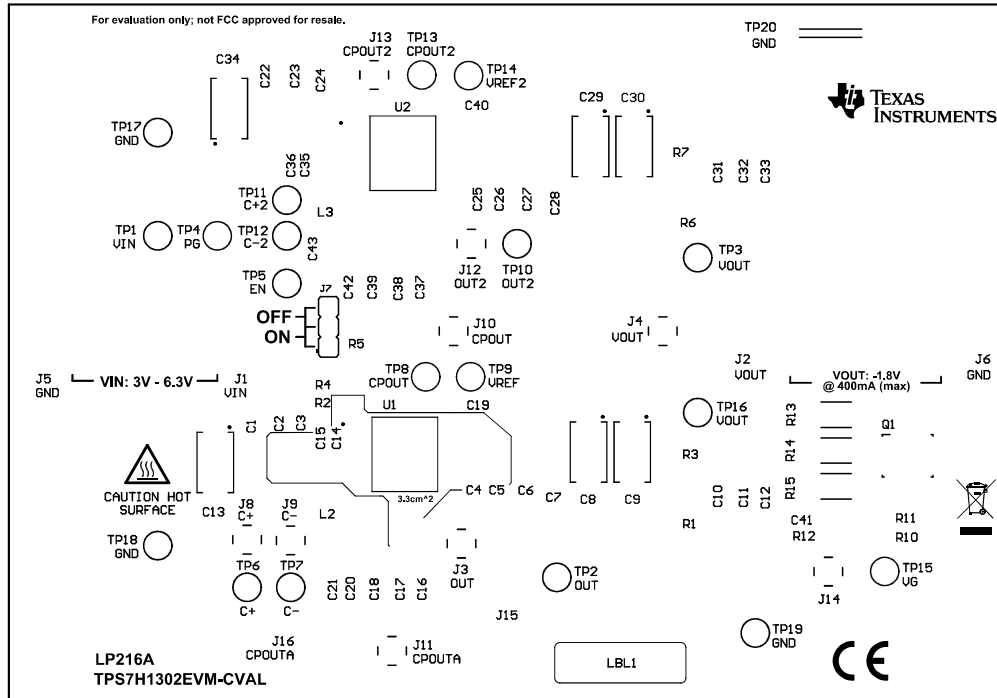


图 4-3. 顶部丝印

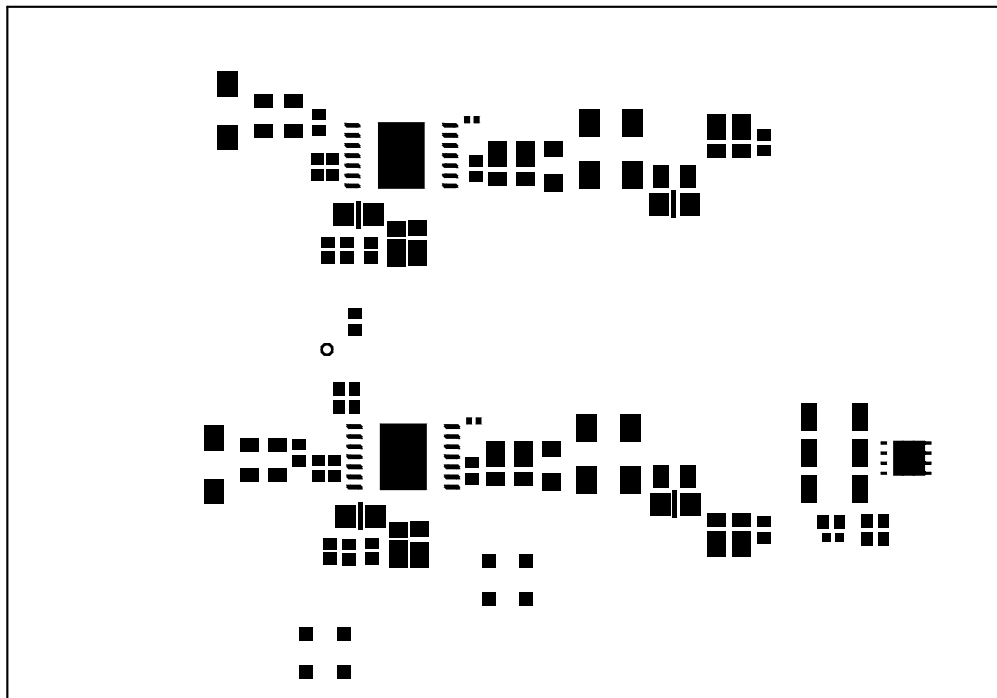


图 4-4. 顶部阻焊层

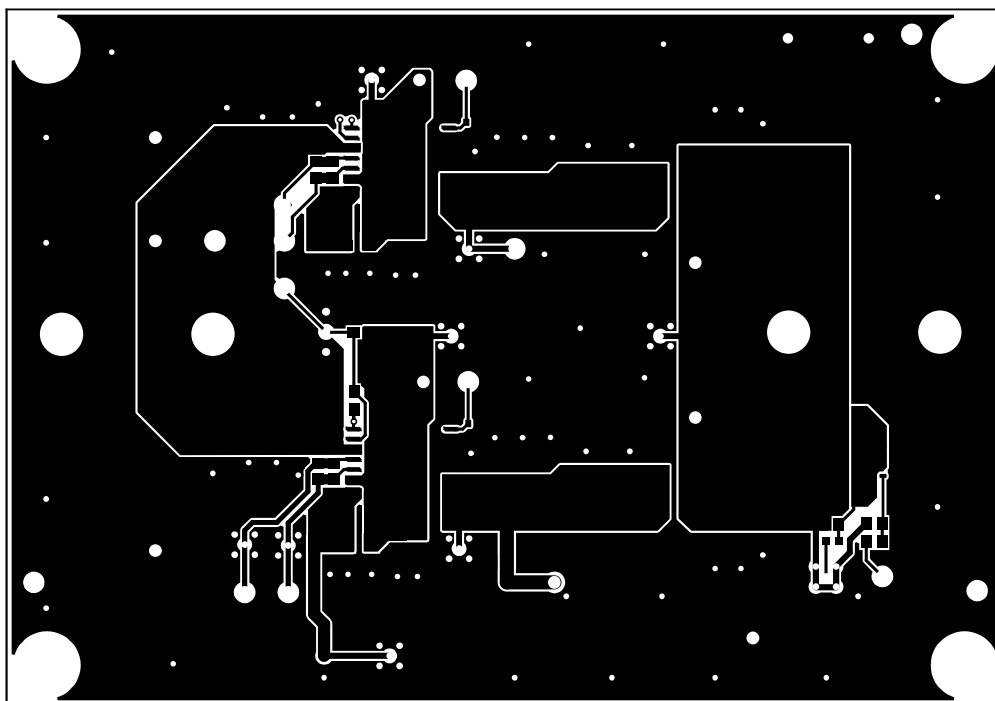


图 4-5. 顶层

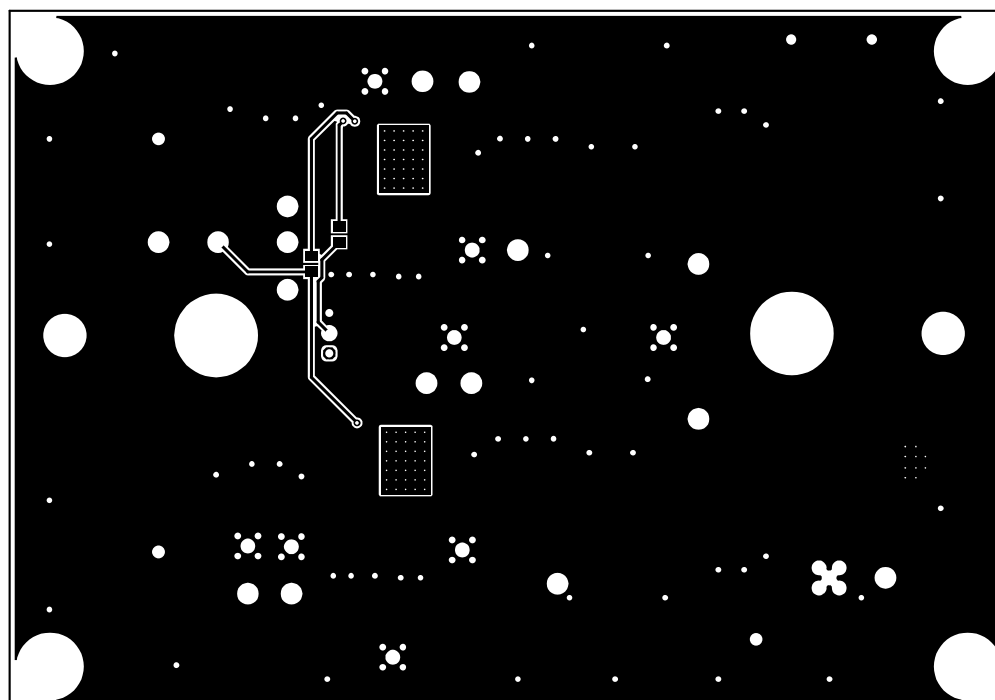


图 4-6. 底层

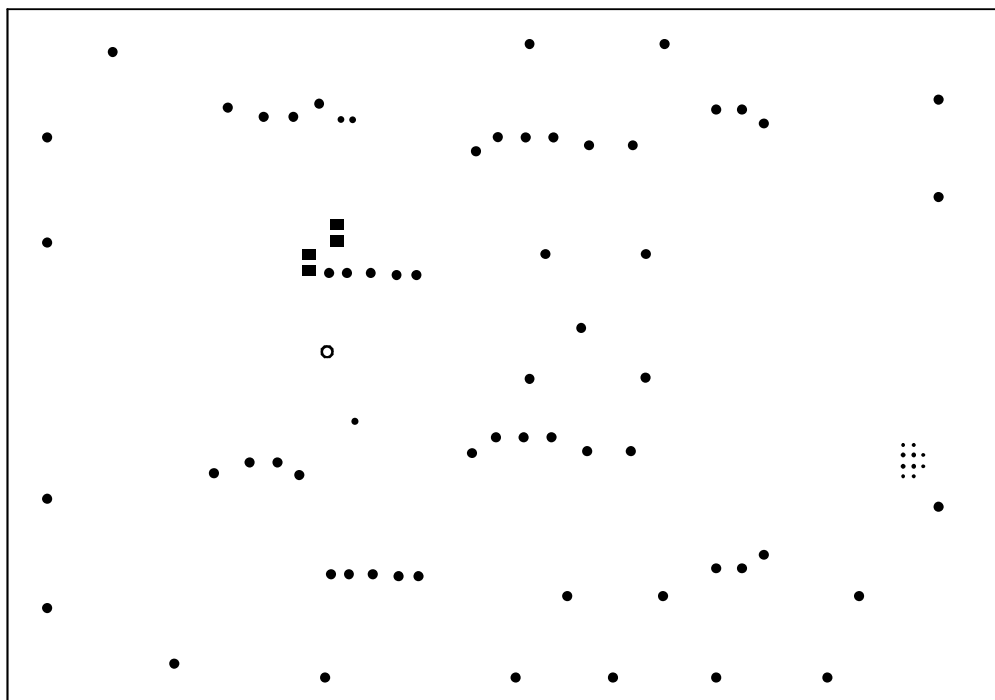


图 4-7. 底部阻焊层

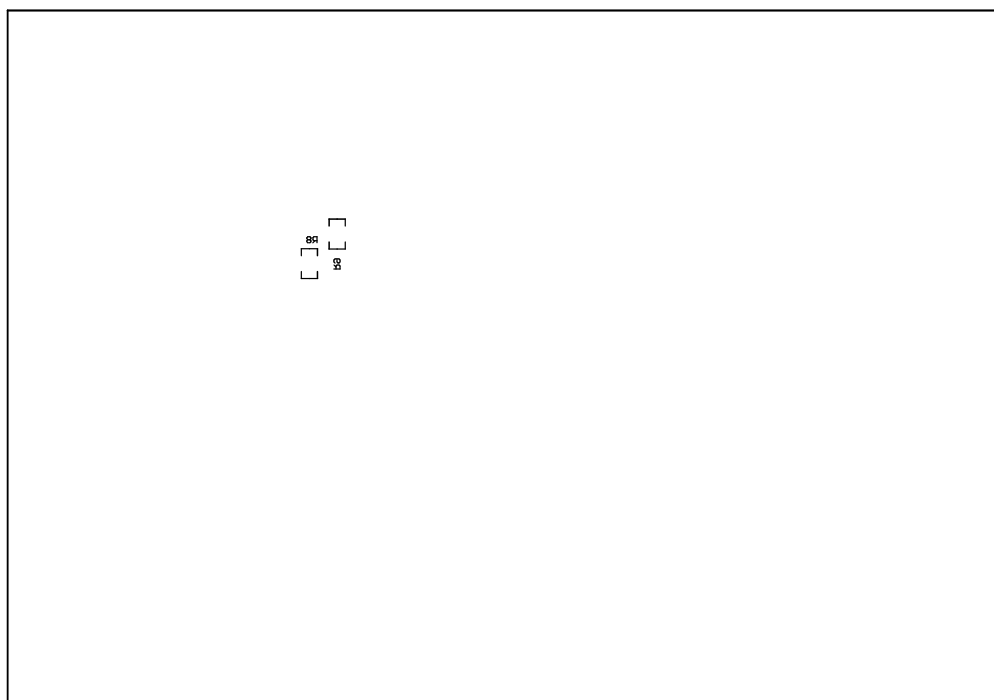
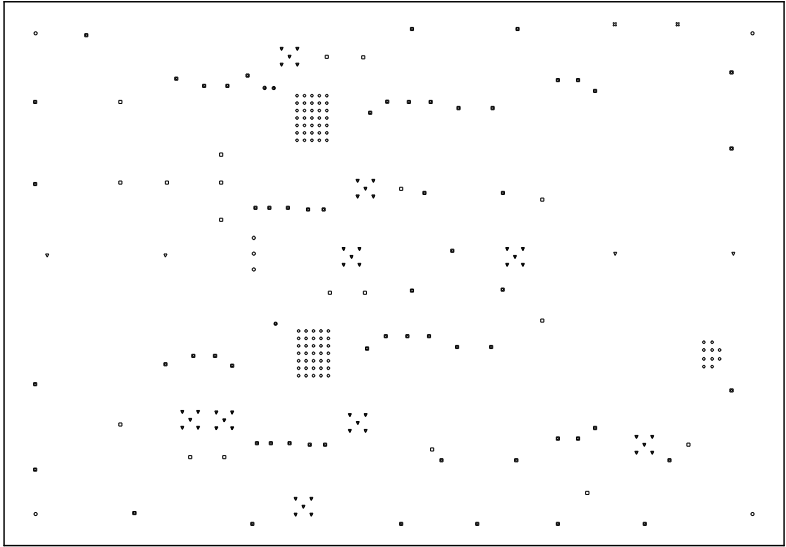


图 4-8. 底部丝印



Symbol	Quantity	Finished Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
◇	80	7.87mil (0.200mm)	PTH	Round	Top Layer - Bottom Layer	
○	3	18.00mil (0.457mm)	PTH	Round	Top Layer - Bottom Layer	
■	60	28.00mil (0.711mm)	PTH	Round	Top Layer - Bottom Layer	
▼	45	33.07mil (0.840mm)	PTH	Round	Top Layer - Bottom Layer	
⊗	3	40.16mil (1.020mm)	PTH	Round	Top Layer - Bottom Layer	±1.97mil
⊗	2	51.18mil (1.300mm)	PTH	Round	Top Layer - Bottom Layer	
□	19	63.06mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	
○	4	125.98mil (3.200mm)	PTH	Round	Top Layer - Bottom Layer	
▽	4	214.57mil (5.450mm)	PTH	Round	Top Layer - Bottom Layer	
220 Total						

图 4-9. 钻孔图

4.3 物料清单 (BOM)

位号	数量	值	说明	封装参考	器件型号	制造商
C1、C2、C6、C7	4	10 μ F	电容, 陶瓷, 10 μ F, 25V, +/-10%, X7R, 1210	1210	12103C106KAT2A	AVX
C4、C18	2	0.1 μ F	电容, 陶瓷, 0.1 μ F, 16V, +/-10%, X7R, 0805	0805	C0805C104K4RACTU	Kemet
C5	1	1 μ F	电容, 陶瓷, 1 μ F, 25V, +/-10%, X7R, 0805	0805	C0805C105K3RACTU	Kemet
C14	1	0.47 μ F	电容, 陶瓷, 0.47 μ F, 16V, +/-5%, X7R, 0805	0805	0805YC474JAT2A	AVX
C17、C20	2	2.2 μ F	电容, 陶瓷, 2.2 μ F, 25V, +/-10%, X7R, 0805	0805	C0805C225K3RAC	Kemet
C19	1	47nF	电容, 陶瓷, 0.047 μ F, 25V, +/-10%, X7R, 0603	0603	C0603C473K3RAC7867	Kemet
H1、H2、H3、H4	4		机械螺钉, 圆头, #4-40 x 1/4, 尼龙, 飞利浦盘形头	螺钉	NY PMS 440 0025 PH	B&F Fastener Supply
H5、H6、H7、H8	4		六角螺柱, 0.5"L #4-40, 尼龙	螺柱	1902C	Keystone
J1、J2、J5、J6	4		标准香蕉插头, 非绝缘, 5.5mm	Keystone_575-4	575-4	Keystone
J3、J4、J8、J9、J10、J11、J12、J13、J14	9		MMCX 插孔, 50 Ω , 金, TH	MMCX 插孔, 金, TH	0734151471	Molex
J7	1		接头, 2.54mm, 3x1, 锡, TH	接头, 2.54mm, 3x1, 锡, TH	22284030	Molex
J15、J16	2		连接器, SMA 插孔, 垂直, 金色, SMD	SMA	142-0711-201	Cinch Connectivity
L2、R1、R3	3	0 Ω	电阻, 0, 1%, 0.75W, AEC-Q200 0 级, 1210	1210	CRCW12100000Z0E AHP	Vishay-Dale
Q1	1		MOSFET, N 沟道, 25V, 113A, DQH0008A (VSON-CLIP-8)	DQH0008A	CSD16408Q5	德州仪器 (TI)
R2、R5	2	10k	电阻, 10.0k, 1%, 0.125W, AEC-Q200 0 级, 0805	0805	CRCW080510K0FKE A	Vishay-Dale
R4	1	54.9k	电阻, 54.9k, 1%, 0.125W, AEC-Q200 0 级, 0805	0805	CRCW080554K9FKE A	Vishay-Dale
R10	1	1	电阻, 1.00, 1%, 0.125W, 0805	0805	RC0805FR-071RL	Yageo America
R11	1	10k	电阻, 10k, 5%, 0.125W, AEC-Q200 0 级, 0805	0805	CRCW080510K0JNE A	Vishay-Dale
R12	1	50	50 Ω $\pm$ 0.1% 0.1W, 0603 (公制 1608) 薄膜	0603	RT0603BRE0750RL	Yageo
R13、R14	2	13.3	电阻, 13.3, 1%, 1W, AEC-Q200 0 级, 2512	2512	CRCW251213R3FKE G	Vishay-Dale
R15	1	14	电阻, 14.0, 1%, 1W, AEC-Q200 0 级, 2512	2512	CRCW251214R0FKE G	Vishay-Dale

位号	数量	值	说明	封装参考	器件型号	制造商
SH-J1	1		连接器跳线 S2 (1x 2) 位置并联连接器，黑色，顶部开口，0.100" (2.54mm)，镀金短接，0.100"	跳线	QPC02SXGN-RC	Sullins
TP1、TP2、TP3、TP10、TP16	5		测试点，多用途，红色，TH	通用测试点	5010	Keystone
TP4	1		测试点，通用，棕色，TH	通用测试点	5125	Keystone
TP5	1		测试点，通用，橙色，TH	通用测试点	5013	Keystone
TP6、TP7、TP11、TP12	4		测试点，通用，白色，TH	通用测试点	5012	Keystone
TP8、TP13	2		测试点，通用，紫色，TH	通用测试点	5129	Keystone
TP9、TP14、TP15	3		测试点，通用，灰色，TH	通用测试点	5128	Keystone
TP17、TP18、TP19	3		测试点，多用途，黑色，TH	通用测试点	5011	Keystone
TP20	1		1mm 非绝缘短路插头，10.16mm 间距，TH	短路插头， 10.16mm 间距， TH	D3082-05	Harwin
U1	1		TPS7H1302HBL/EM	CFP14	TPS7H1302HBL/EM	德州仪器 (TI)

5 合规信息

5.1 合规性和认证

- 德州仪器 (TI) , [TPS7H1302EVM-CVAL EU RoHS 符合性声明 \(DoC\)](#)

6 其他信息

6.1 商标

所有商标均为其各自所有者的财产。

7 相关文档

- 德州仪器 (TI) , [标准评估模块条款](#)

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

WARNING

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

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

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/sds/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/sds/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, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.
10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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