EVM User's Guide: TRF1218EVM

TRF1218 评估模块

说明

TRF1218 评估模块 (EVM) 用于评估 TRF1218 器件。

开始使用

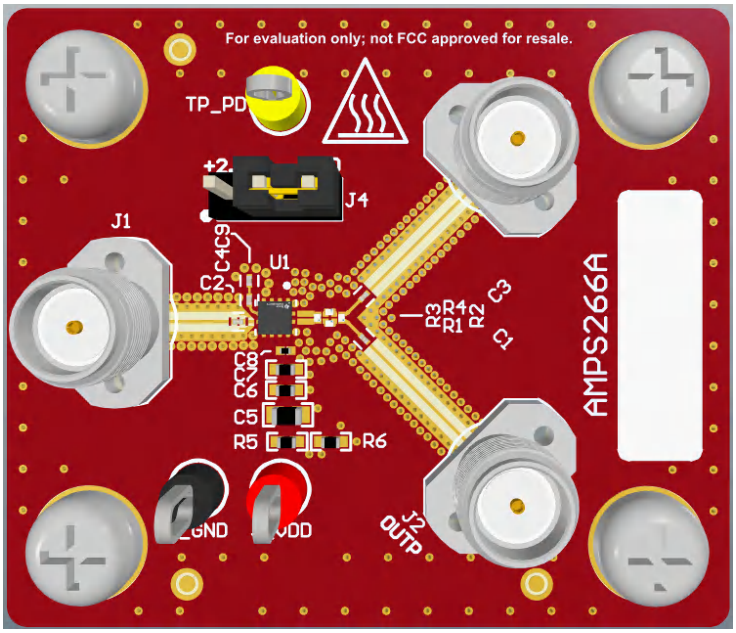
1. 订购 TRF1218EVM。
2. 从 TRF1218EVM 工具文件夹下载综合参考设计文件。

特性

- 由 5V 单电源供电
- 专为单端 50Ω 输入匹配而设计
- TRF1218 50Ω 差分输出通过板载 Pi 电阻网络与 100Ω 差分输出进行匹配。
- 可通过板载 2.92mm 射频连接器轻松连接到输入端和输出端
- 借助跳线，电路板可提供断电选项

应用

- 射频采样或 GSPS ADC 驱动器
- 航空航天与国防
- 电子对抗战
- 雷达导引头前端
- 相控阵雷达
- 软件定义的无线电
- 测试和测量
- 高速数字转换器
- 矢量信号收发器 (VST)
- 无线通信测试



TRF1218EVM

1 评估模块概述

1.1 简介

本文档介绍了确保 TRF1218EVM 正确运行和快速设置所需的基本步骤和功能。本文档还包含原理图、物料清单 (BOM)、印刷电路板 (PCB) 布局和测试方框图。除非特别说明，否则本文档中的缩写词 *EVM*、*TRF1218 EVM* 以及术语 *评估模块* 均代表 TRF1218EVM。

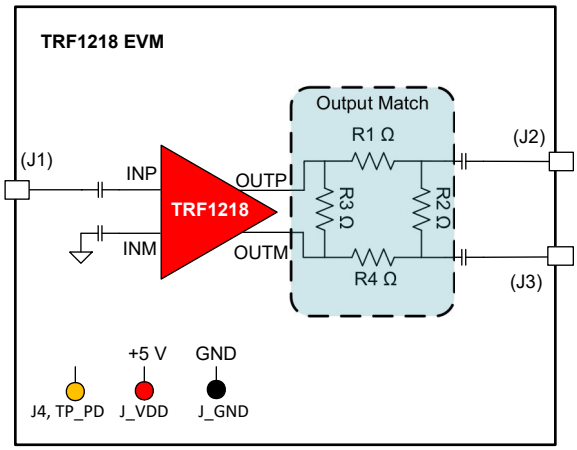


图 1-1. TRF1218 EVM 功能方框图

小心

表面高温。接触会导致烫伤。请勿触摸。

1.2 套件内容

- TRF1218EVM

1.3 规格

TRF1218EVM 的规格如下表所列。

连接器	参数	值
J1	单端输入射频端口	最大 10dBm
J2、J3	差分输出射频端口	
J_VDD	电源电压	5V
J4	断电引脚控制	将 J4.1-J4.2 短接以禁用，将 J4.2-J4.3 短接以启用。
TP_PD	断电电压控制	

1.4 器件信息

TRF1218 是一款超高性能射频 (RF) 放大器，专门针对射频应用进行了优化。在驱动高性能 AFE7960 等射频采样模数转换器 (ADC) 时，此器件非常适合需要进行单端转差分的交流耦合应用。有关更多详细信息，请参阅 TRF1218 数据表。

2 硬件

2.1 设置

2.1.1 一般用途

本节提供 TRF1218EVM 的一般使用信息。有关作为后续说明基准点的一般单音设置图，请参阅节 2.1.2.1（为清晰起见，省略了某些元件，如电源旁路电容器）：

1. 建议的加电序列：
   a. 在将电源电缆连接到 EVM 之前，将直流输出电源设置为 5V。
   b. 将直流输出电源的电流限制设置为 250mA。
   c. 确保关闭电源，然后将电源电缆连接到 EVM 的 J_VDD 和 J_GND 连接器。
   d. 打开 V_{CC} = 5V 的直流电源。从电源汲取的静态电流 (I_Q) 典型值为 190mA。
   e. 如果电源电流较低，请验证器件是否通过 PD 引脚 (J4) 禁用。
2. 断电选项：
   a. 要使器件断电，请将 J4.1 连接至 J4.2 或向 TP_PD 施加 2.8V 电压
3. 匹配注意事项：
   a. TRF1218 输出端的电阻阻抗匹配网络将 50Ω 差分输出转换为更常见的 100Ω 差分阻抗；然而，该网络会引入 9.6dB 的衰减，必须在信号链中加以补偿。TRF1218EVM 上的其他无源器件可能会导致进一步的信号损耗和 SNR 下降 — 有关 R1、R2、R3 和 R4 值的信息，请参阅物料清单。
   b. 请注意，使用 TRF1218 直接驱动 50Ω 差分输入 ADC 时，不需要电阻衰减。此 EVM 上仅包含电阻匹配网络，以适应标准同轴电缆和 2.92mm 射频连接器的 50Ω 单端特性。
   c. 有关更多详细信息，请参阅 *TRF1218* 数据表。

2.1.2 测试设置图

本节包含测量 TRF1218 器件时有关增益、OP1dB、S 参数、噪声系数和双音 OIP3 设置的一般建议。

2.1.2.1 增益和 OP1dB 测试设置

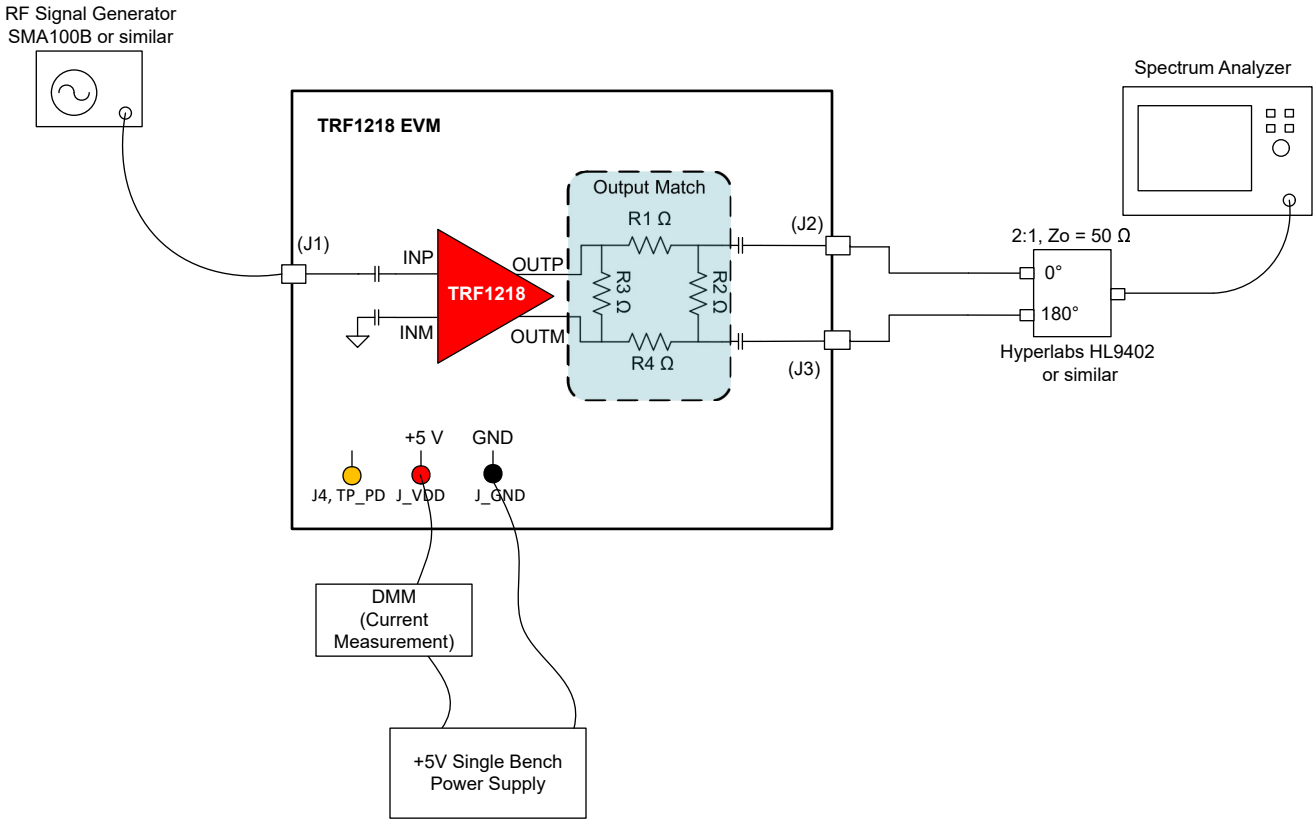


图 2-1. 增益和 OP1dB 测试设置

单频测量设置建议：

1. 将射频信号发生器连接到输入 2.92mm 射频连接器 J1。
2. 要测试 TRF1218EVM，使用的射频信号发生器必须支持高于 20GHz 的信号频率。
3. TRF1218EVM 器件输入在通带内为 50Ω。
4. J2 和 J3 2.92mm 射频连接器处的 EVM 输出为全差分（或 180° 异相）输出。TRF1218EVM 具有 100Ω 差分匹配输出阻抗。pi 电阻网络（R1、R2、R3、R4）用于将 TRF1218 的 50Ω 输出差分阻抗转换为 100Ω 差分阻抗。
5. 当连接到频谱分析仪时，必须使用外部无源平衡-非平衡变压器将 EVM 发出的差分信号转换为单端信号，如节 2.1.2.1 所示。
6. 最后，正确表征和补偿射频同轴电缆、50Ω 至 100Ω 匹配损耗 (9.6dB) 和无源平衡-非平衡变压器的插入损耗，以便准确测量器件的增益和功率等级。

2.1.2.2 噪声系数测试设置

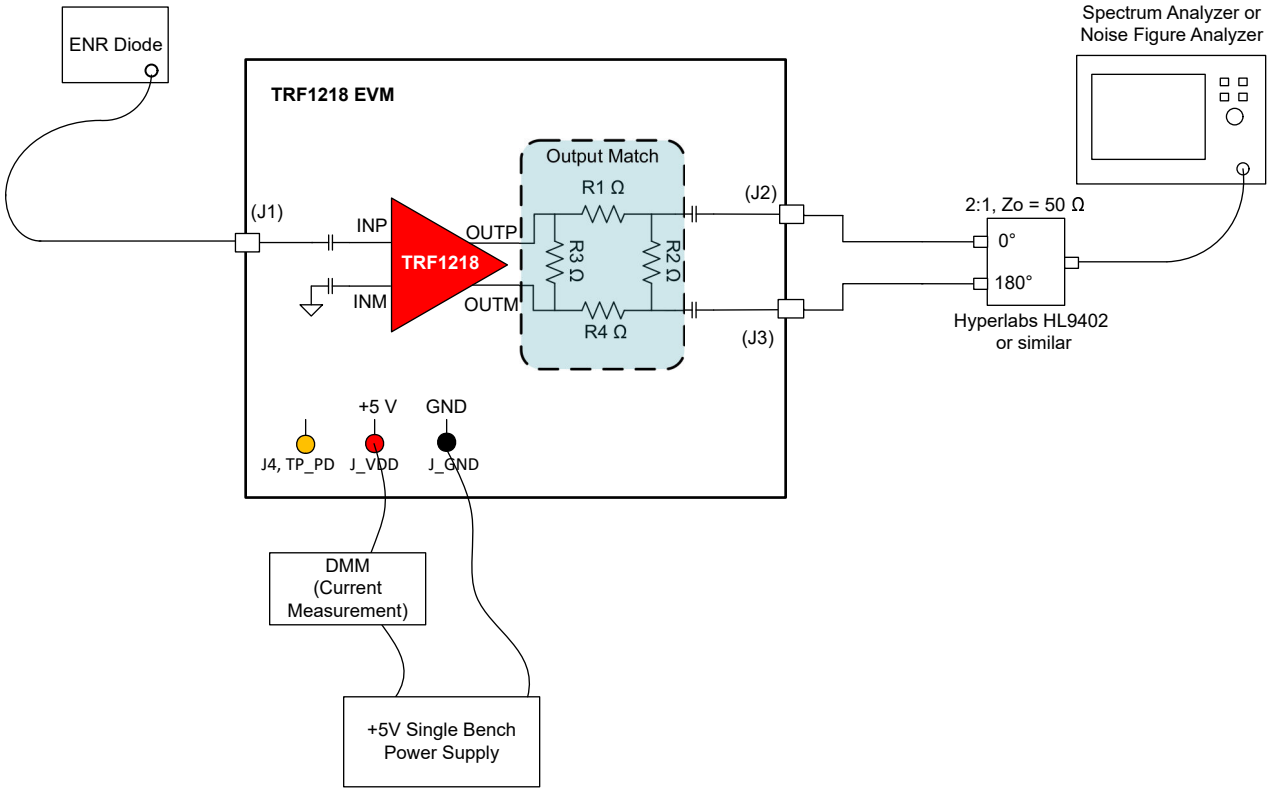


图 2-2. 噪声系数测试设置

请按照以下指南进行噪声系数 (NF) 测量：

1. 图 2-2 所示为使用噪声二极管和频谱分析仪（或噪声系数分析仪），利用传统 Y 系数法进行 NF 测量。
2. 在测量时，考虑到 EVM 的任何射频电缆损耗。为了匹配而添加的任何外部输入衰减器会导致 NF 按比例下降，必须在测量中进行校准。
3. NF 测量中必须包含器件输入引脚处输入布线的板载损耗。
4. 如果由于板载 pi 网络，器件输出端之后的损耗比较显著 (9.6dB)，则必须将输出损耗包含到 NF 测量中。方程式 1 展示了用于根据所测量的总噪声因子 (NF) 来计算器件 NF 的级联噪声因子 *Friis* 方程。然后，可以提取器件的噪声系数 F_1 并将其转换为对数刻度以给出 TRF1218 NF。

$$F_{total} = F_1 + \frac{F_2 - 1}{G_1} \quad (1)$$

其中

- F_{total} = 测得的总噪声系数
- F_1 = 器件的噪声系数
- G_1 = 器件的增益
- F_2 = 输出端损耗的噪声系数

2.1.2.3 双音 OIP3 测试设置

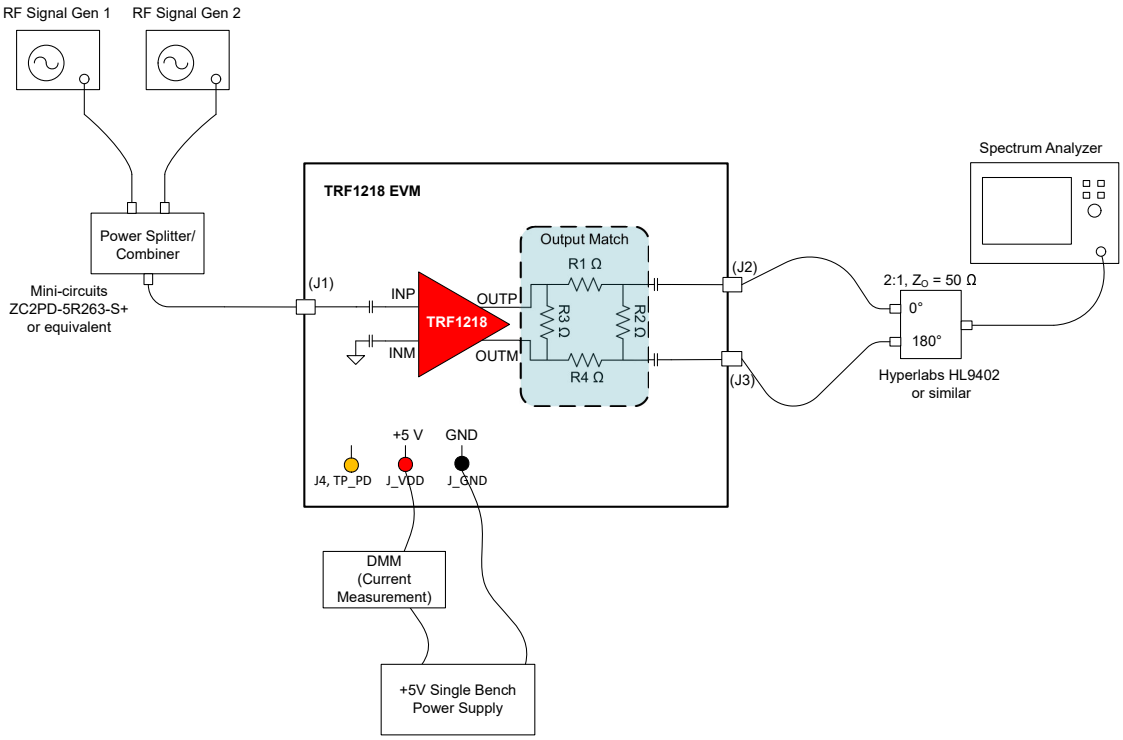


图 2-3. OIP3 测试设置

请按照以下指南进行双音 OIP3 测量：

1. 图 2-3 展示了使用同相功率分离器和组合器合并两个信号发生器输出。可选择对信号发生器输出使用 3dB 至 6dB 衰减器，以防发生器相互作用，并导致信号发生器 IMD3 杂散。
2. 将两个信号发生器输出设置为适当的功率级别和频率间隔，以便信号发生器在器件上产生所需的输出功率 P_{OUT}。
3. 将输出功率级别保持在 TRF1218 线性工作范围内。一般情况下，将总输出功率级别保持在比 1dB 压缩点低约 6dB 至 8dB。有关支持的输出功率级别，请参阅器件数据表。
4. 对于 OIP3 测试，两个音调可以间隔指定的频率。
5. 相应地设定频谱分析仪衰减设置，使频谱分析仪非线性度不影响测量。
6. 使频谱分析仪 RBW 和 VBW 设置对主音和 IM3 产物保持相同。

对于输出 IP3 计算，考虑到 TRF1218EVM 输出与频谱分析仪输入之间所需频带下的合并损耗。合并功率损耗 (P_{LOSS}) 源于 DUT 输出、PCB 输出走线、射频同轴电缆、180° 无源平衡-非平衡变压器以及出于外部匹配目的而使用的任何衰减器垫上的电阻匹配。方程式 2 给出了计算出的 OIP3。

$$\text{Output IP3} = \left(P_{IN\_SA} - \text{IMD3}\right)/2 + P_{IN\_SA} + P_{LOSS} \quad (2)$$

其中

- P_{IN_SA} = 频谱分析仪的输入功率/子载波
- P_{LOSS} = 器件输出至频谱分析仪输入之间的功率损耗
- IMD3 = 在 2f1 – f2 或 2f2 – f1 处记录的两个互调失真产物的较高功率
- $P_{IN\_SA} + P_{LOSS} = P_{OUT}$ 是放大器输出功率/子载波

3 硬件设计文件

3.1 原理图

图 3-1 显示了 TRF1218EVM 原理图。

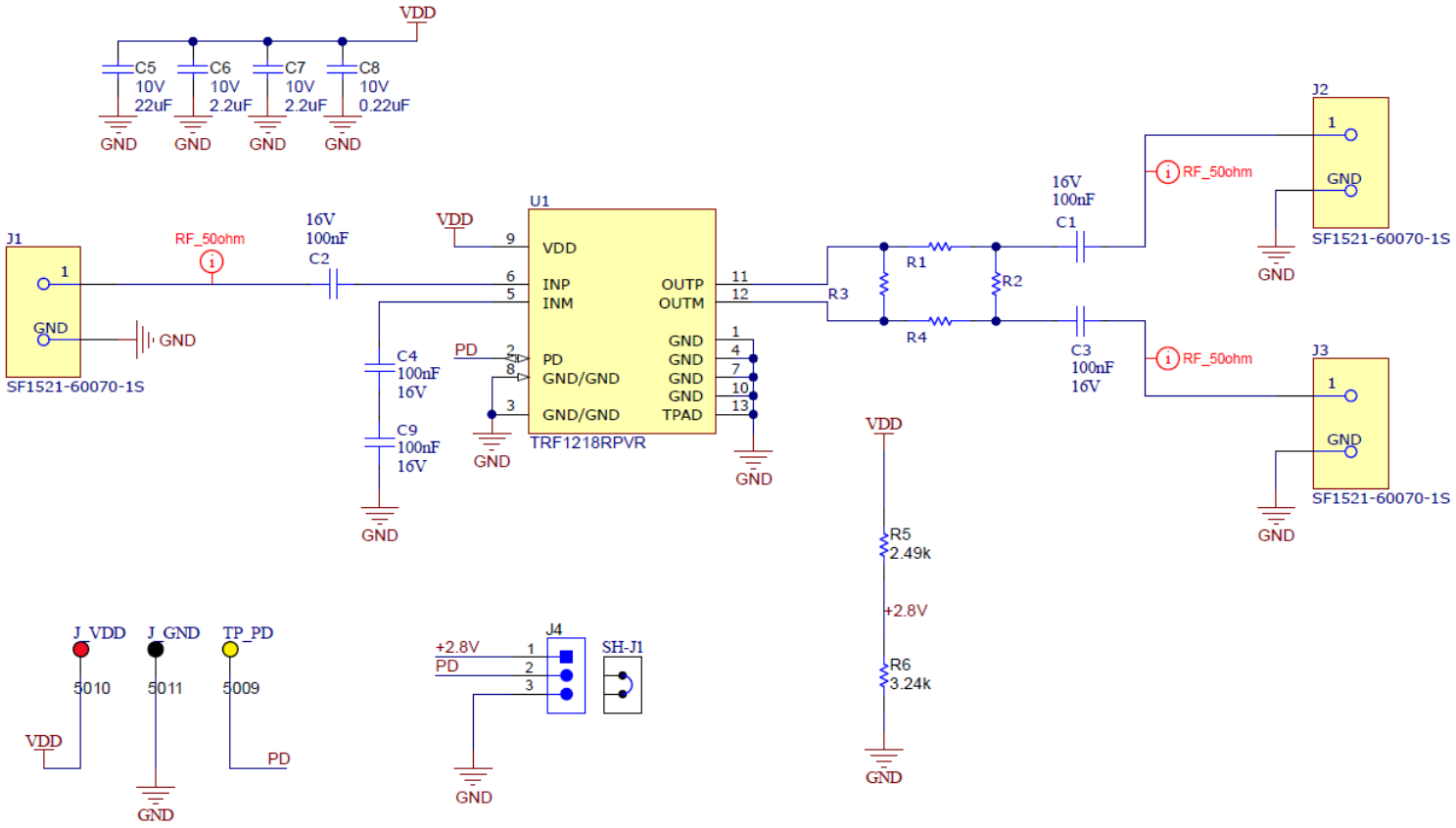


图 3-1. TRF1218EVM 原理图

3.2 PCB 布局

图 3-2 至 图 3-5 显示了此 EVM 的 PCB 板层。

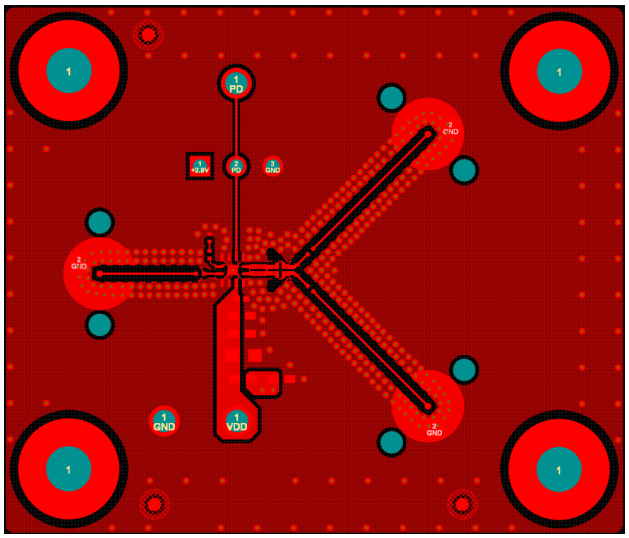


图 3-2. 顶层

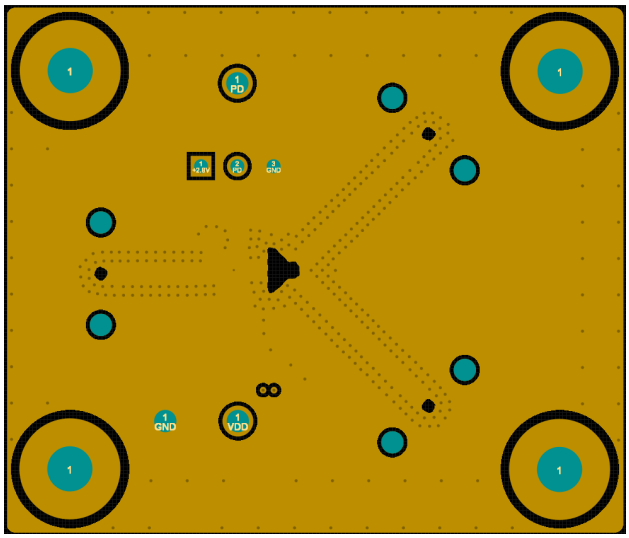


图 3-3. 第 2 层

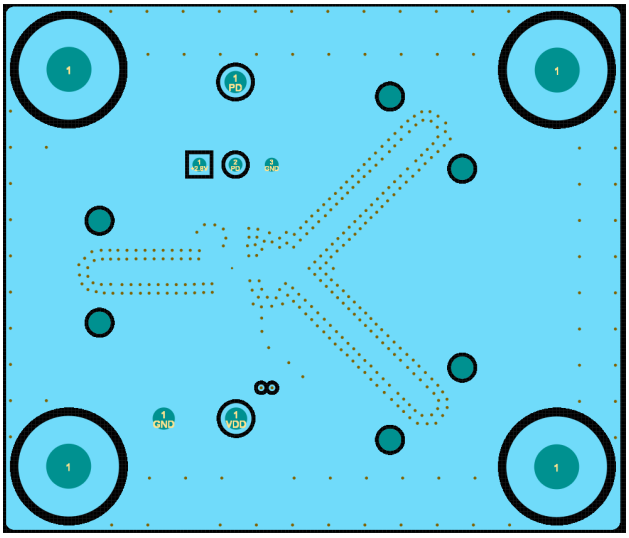


图 3-4. 第 3 层

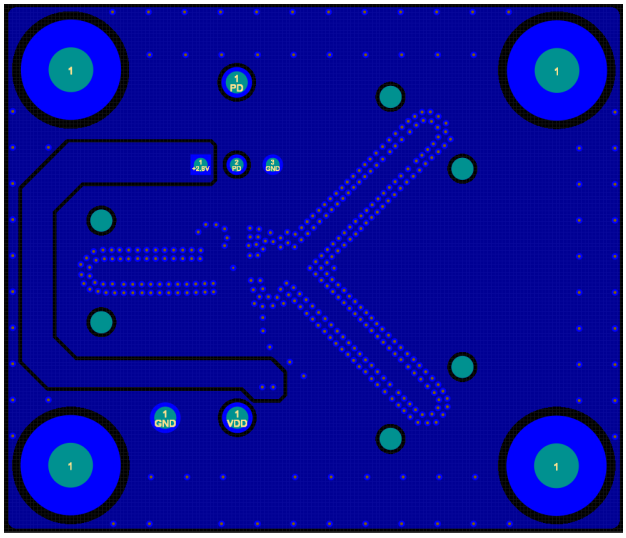


图 3-5. 底层

3.2.1 堆叠和材料

TRF1218EVM 是一款四层电路板，材料类型为 Rogers® 4350B。顶层是电源布线、接地布线以及 2.92mm 射频连接器与器件之间的信号布线。第二层是参考射频接地层。信号布线阻抗目标为 50Ω。底部 3 层是接地层。表 3-1 列出了 EVM 堆叠。

表 3-1. TRF1218EVM 堆叠

层	名称	材料	厚度 (mil)	介电常数
	顶层丝印层			
	顶部焊锡层	阻焊剂	1.00	3.5
1	顶层	铜	1.40	
	电介质 1	Rogers 4350B	4.00	3.48
2	GND	铜	1.40	
	电介质 2	IT180A	46	4.2
3	GND	铜	1.40	
	电介质 3	IT180A	4	4.2
4	底层	铜	1.40	
	底部焊锡层	阻焊剂	1.00	3.5
	底层丝印层			

3.3 物料清单 (BOM)

表 3-2 列出了 BOM。

表 3-2. 物料清单 (BOM)

位号	数量	值	说明	封装参考	器件型号	制造商
!PCB	1		印刷电路板		AMPS266A	不限
C1、C2、C3、C4、C9	5	100nF	0.1µF ±20% 16V 陶瓷电容器 0201（公制 0603）	0201	560Z104MTT	KYOCERA AVX
C5	1	22uF	电容，陶瓷，22µF，10V，+/-20%，X5R，0603	0603	CL10A226MP8NUNE	Samsung Electro-Mechanics
C6、C7	2	2.2 µ F	电容，陶瓷，2.2µF，10V，+/-10%，X7S，0402	0402	C1005X7S1A225K050BC	TDK
C8	1	0.22uF	电容，陶瓷，0.22 µ F，10V，+/-20%，X5R，0201	0201	LMK063BJ224MP-F	Taiyo Yuden
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、J3	3		2.92mm 连接器插孔，母插座，50Ω，表面贴装压缩	SMAF_COMP	SF1521-60070-1S	SV Microwave
J4	1		接头，100mil，3x1，锡，TH	接头，3 引脚，100mil，锡	PEC03SAAN	Sullins Connector Solutions
J_GND	1		测试点，多用途，黑色，TH	黑色通用测试点	5011	Keystone Electronics
J_VDD	1		测试点，多用途，红色，TH	红色通用测试点	5010	Keystone Electronics
LBL1	1		热转印打印标签，0.650"（宽）x 0.200"（高）- 10,000/卷	PCB 标签，0.650 x 0.200 英寸	THT-14-423-10	Brady

表 3-2. 物料清单 (BOM) （续）

位号	数量	值	说明	封装参考	器件型号	制造商
R1	1	50	50Ω，±2%，0.03W，1/32W，片式电阻 02016（公制 0504），射频，高频薄膜	02016	CH02016-50RGFT	Vishay Sfernice
R2	1	500	500Ω，±2%，0.03W，1/32W，片式电阻 02016（公制 0504），射频，高频薄膜	02016	CH02016-500RGFT	Vishay
R3	1	75	75Ω，±2%，0.03W，1/32W，片式电阻 02016（公制 0504），射频，高频薄膜	02016	CH02016-75RGFT	Vishay
R4	1	50	薄膜表面贴装电阻，02016 封装，50Ω，±2%，0.03W，±100ppm/°C	02016	CH02016-50RGFT	Vishay
R5	1	2.49k	电阻，2.49k，1%，0.063W，AEC-Q200 0 级，0402	0402	CRCW04022K49FKED	Vishay-Dale
R6	1	3.24k	电阻，3.24k，1%，0.063W，AEC-Q200 0 级，0402	0402	CRCW04023K24FKED	Vishay-Dale
SH-J1	1	1x2	分流器，100mil，镀金，黑色	分流器	SNT-100-BK-G	Samtec
TP_PD	1		测试点，紧凑，黄色，TH	黄色紧凑型测试点	5009	Keystone Electronics
U1	1		射频 IC	WQFN-FCRLF12	TRF1218RPVR	德州仪器 (TI)
FID1、FID2、FID3	0		基准标记。没有需要购买或安装的元件。	不适用	不适用	不适用

4 其他信息

商标

Rogers® is a registered trademark of Isola USA Corporation.
所有商标均为其各自所有者的财产。

5 相关文档

如要查看相关文件，请参阅以下内容：

- 德州仪器 (TI)，*TRF1218* 数据表。

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。

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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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最后更新日期：2025 年 10 月