

EVM User's Guide: TPS7N59EVM-184

TPS7N59EVM-184 评估模块

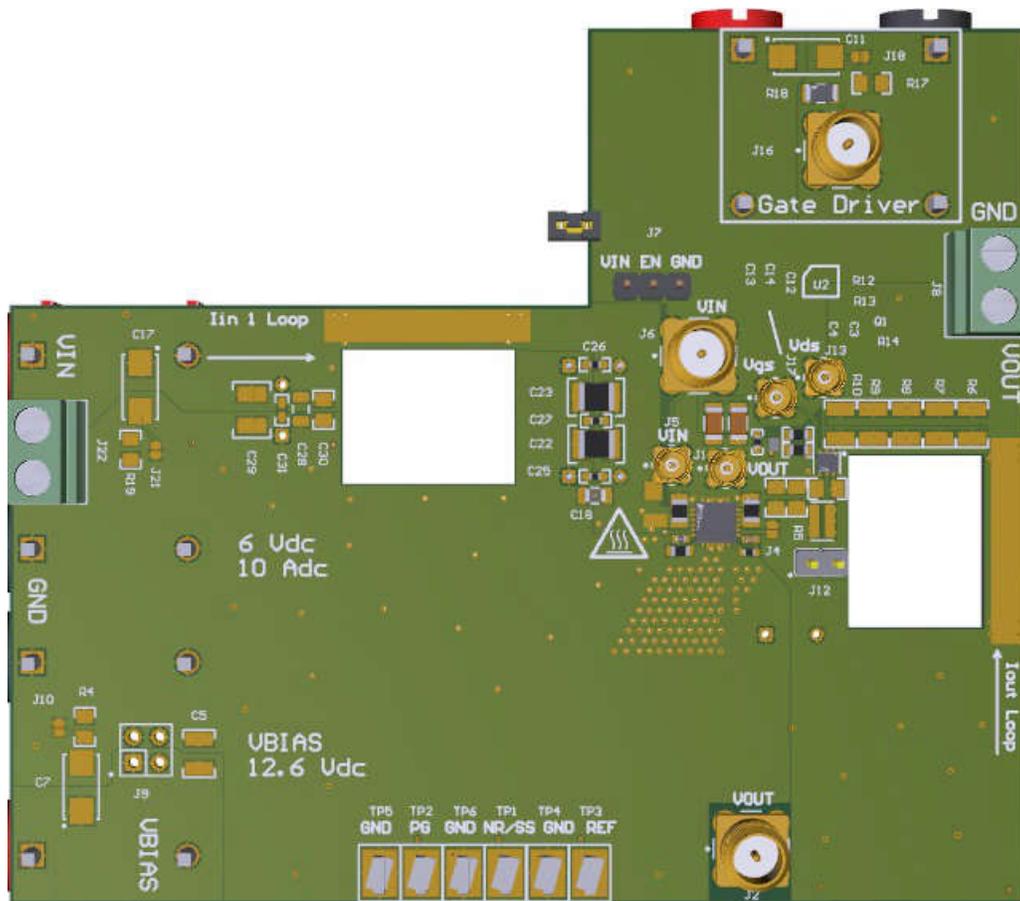


说明

TPS7N59EVM-184 评估模块 (EVM) 可用作 TPS7N59 工程演示和评估的参考设计，后者是一款超低噪声、超高 PSRR、可驱动 10A 的射频低压降 (LDO) 线性稳压器。本用户指南包含设置和操作说明、散热和布局指南、印刷电路板 (PCB) 布局、原理图和物料清单 (BOM)。

特性

- 评估模块中包含嵌入式高速负载瞬态电路。



TPS7N59EVM-184 评估模块

1 评估模块概述

1.1 简介

本用户指南介绍了 TPS7N59EVM-184 评估模块 (EVM) 的操作使用方法，该 EVM 可用作 TPS7N5901RTWR 工程演示和评估的参考设计，后者是一款超低噪声、高电流、超高 PSRR、射频低压降 (LDO) 线性稳压器。本用户指南包含设置和操作说明、散热和布局指南、印刷电路板 (PCB) 布局、原理图和物料清单 (BOM)。

本文档中的 *演示套件*、*评估板* 和 *评估模块* 等术语指的是 TPS7N59EVM-184。

德州仪器 (TI) 的 TPS7N59EVM-184 可帮助设计工程师评估 TPS7N5901RTWR 线性稳压器的运行与性能，以探索其在终端用户电路中的应用潜力。此特定 EVM 配置包含一个高精度、小尺寸、可调线性稳压器，适用于各种应用。该稳压器能够向具有低 V_{IN} 至 V_{OUT} 降压电压的负载提供最大 10A 的电流。为了实现稳定性，应在输出端使用最小 22 μ F 的电容器。

[相关文档](#) 列出了可通过德州仪器 (TI) 网站 www.ti.com 获得的相关文档。

表 1-1. 相关文档

器件	文献编号
TPS7N5901RTWR	SBVS470

1.2 套件内容

该评估模块包含以下套件组件：

- TPS7N59 高性能 LDO 评估模块。

1.3 规格

可调节的 TPS7N59EVM-184 可接受 0.7V 至 6.0V 的输入电压，并提供 0.5V 至 5.2V 之间的输出电压。TPS7N59 是一款 10A LDO (10A 时为 150mV 压降 (典型值))，具有超低输出电压噪声 (2.5 μ VRMS)、高精度 (整个线路，负载和温度范围内 1% (最大值) 精度) 和高电源抑制比 (1kHz 时为 -84dB、10kHz 时为 -64dB、100kHz 时为 -49dB、1MHz 时为 -30dB)。TPS7N59 还提供可调软启动浪涌控制和开漏电源正常 (PG) 信号。小型 24 引脚 WQFN 封装 (4mm \times 4mm) 具有出色的热阻，可支持高功率运行。TPS7N59EVM-184 的 $R_{\theta JA}$ 为 14.3 $^{\circ}$ C/W。

1.4 器件信息

1.4.1 TPS7N59

TPS7N59 是一款低噪声 ($2.5 \mu\text{V}_{\text{RMS}}$)、超低压降线性稳压器 (LDO)，可提供 10A 电流，压降仅为 150mV (独立于输出电压)。该器件的输出电压可通过单个外部电阻进行调节，范围为 0.5V 至 5.2V。TPS7N59 集低噪声、高 PSRR (1MHz 时为 -30dB) 和高输出电流能力等特性于一体，专为雷达电源、通信和成像应用中的噪声敏感型组件 (例如射频放大器、雷达传感器、SERDES 和模拟芯片组) 供电而设计。

需要以低输入和低输出 (LILO) 电压运行的数字负载 (例如应用特定集成电路 (ASIC)、现场可编程门阵列 (FPGA) 和数字信号处理器 (DSP)) 还能够从出色精度 (在负载、线路和温度范围内可达 1%)、遥感功能、出色的瞬态性能和软启动功能中受益，以提供出色的系统性能。凭借多功能性、高性能和小尺寸设计，该 LDO 成为模数转换器 (ADC)、数模转换器 (DAC) 和成像传感器等高电流模拟负载以及串行器/解串器 (SerDes)、FPGA 和 DSP 等数字负载的理想选择。

1.4.2 LMG1020 低侧驱动器

LMG1020 器件是一款单通道低侧驱动器，专为驱动高速应用 (包括激光雷达、飞行时间、面部识别和任何涉及低侧驱动器的电源转换器) 中的 GaN FET 和逻辑电平 MOSFET 而设计。LMG1020 的设计简易性可实现 2.5 纳秒的极快传播延迟和 1 纳秒的最小脉冲宽度。通过分别在 GATE 和 OUTH 和 OUTL 之间连接外部电阻，可针对上拉沿和下拉沿独立调节驱动强度。

该驱动器具有应对过载或故障情况的欠压锁定 (UVLO) 和过热保护 (OTP) 功能。

LMG1020 的 $0.8\text{mm} \times 1.2\text{mm}$ WCSP 封装可更大限度地降低栅极回路电感并更大限度地提高高频应用的功率密度。

2 硬件

2.1 EVM 设置

本节介绍了如何正确连接和设置 TPS7N59EVM-184，包括 EVM 板上的跳线和连接器。

2.1.1 LDO 输入/输出连接器说明

2.1.1.1 VIN 和 GND

VIN 和 GND 是输入电源的连接端子。VIN 端子是正极连接，GND 端子是负极（即接地）连接。

2.1.1.2 BIAS 和 GND

BIAS 和 GND 是辅助电源的连接端子。BIAS 端子是正极连接，GND 端子是负极（即接地）连接。

2.1.1.3 VOUT 和 GND

VOUT 和 GND 是输出负载的连接端子。VOUT 端子是正极连接，GND 端子是负极（即接地）连接。

2.1.1.4 EN

EN 是用于启用或禁用 TPS7N59 的 3 引脚接头。

该 3 引脚接头的中心引脚连接到 TPS7N59 EN 输入端。当 2 引脚分流器放置在该接头顶部的两个引脚之间时，VIN 短接至 EN 并且 TPS7N59 启用。当 2 引脚分流器放置在该接头底部的两个引脚之间时，GND 短接至 EN 并且 TPS7N59 禁用。

使用非板载电源或信号发生器驱动 EN 端子时，施加的电压必须保持在 0V 和 6V 之间。

2.1.2 可选负载瞬态输入/输出连接器说明

2.1.2.1 VDD 和 GND

VDD 和 GND 是负载瞬态电路输入电源的连接端子。VDD 端子是正极连接，GND 端子是负极（即接地）连接。

2.1.2.2 J12

J12 是一个可选连接，供用户进行测量或向 LDO 的输出端施加小型负载。

2.1.2.3 J14

J14 是一个可选连接，用于在负载瞬态 MOSFET 漏源电压之间插入一个阻尼电路。

2.1.2.4 J16

J16 是函数发生器用于驱动栅极驱动器器件的连接。J16 由 50 Ω 电阻器 R18 端接。

2.1.2.5 J13

J13 是高频开尔文连接，可以准确测量负载瞬态 MOSFET 漏源电压。

2.1.2.6 J17

J17 是高频开尔文连接，可以准确测量负载瞬态 MOSFET 栅源电压。

2.1.3 TPS7N59 LDO 的操作

TPS7N59EVM-184 评估模块包含 TPS7N59 LDO，并安装了输入、偏置和输出电容器。这些元件提供了所需的最小解决方案尺寸，如硬件示意图中白框标注所示。除了 EVM 上已安装的器件之外，还安装了额外焊盘，用于使用额外的输入、偏置和输出电容器来测试 LDO。可以使用 J7 3 引脚接头启用或禁用 TPS7N59 LDO：

1. 在接头上放置一个 2 引脚分流器，将 VIN 连接到 EN 可启用器件。
2. 在接头上放置一个 2 引脚分流器，将 GND 连接到 EN 可禁用器件。

[TPS7N59EVM-184 导通](#) 展示了 TPS7N59EVM-184 在导通期间的结果。

1. 通道 1（蓝色迹线）是输入电压 (VIN)。
2. 通道 2（红色迹线）是输出电压 (VOUT)。

- 通道 3 (橙色迹线) 是输出电流 (IOUT)。
- 通道 4 (绿色迹线) 是使能电压。

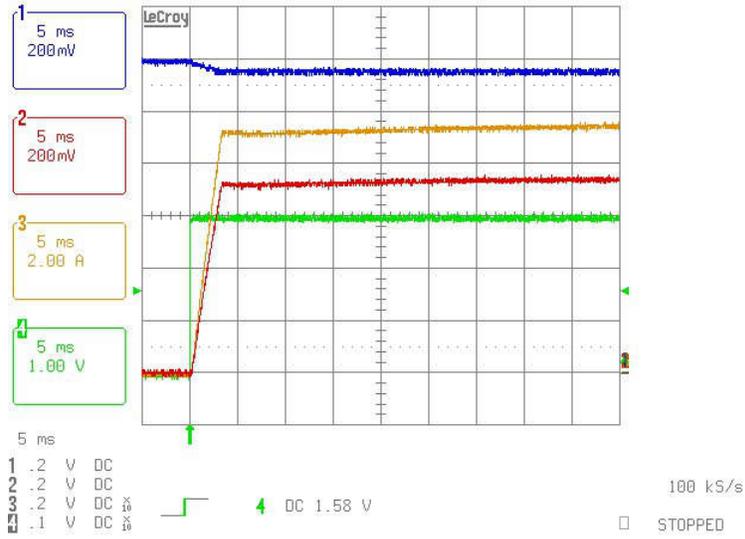


图 2-1. TPS7N59EVM-184 导通

如有需要，可以将电流探头插入 EVM 中（如连接了电流探头的 [TPS7N59EVM-184](#) 所示），以测量输入和输出电流。插槽的尺寸适合大多数电流探头，例如 LeCroy™ AP015 或 CP031 电流探头。

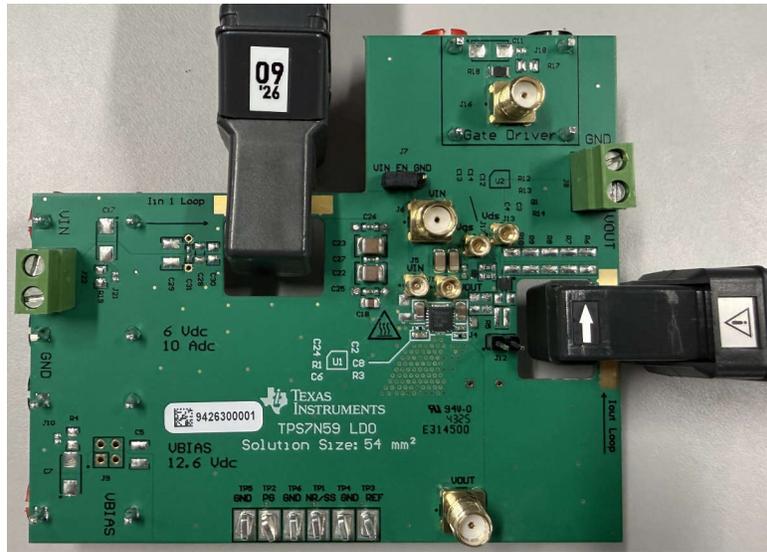


图 2-2. 连接了电流探头的 TPS7N59EVM-184

使用 J8 放置流经 LDO 输出端电流检测路径的直流负载。在执行非常快速的瞬态测试时，由于 EVM 的 PCB 内存在寄生电感，VIN 或 VOUT 上可能会出现振铃。在电流路径中的裸铜上放置一条导线有助于减少这种振铃。选择正确尺寸的附加导线来填充当前探头的体积。对于大多数电流探头，可使用 10 AWG 导线。

警告

一些电流探头的传感器连接到 GND，无法与带电导体接触。有关详细信息，请参阅电流探头的用户手册。如果您的电流探头有此限制，请使用一条薄电工胶带或 Kapton® 胶带将电流检测路径与电流探头相隔离。

使用 SMA 连接器 J6 (VIN) 和 J2 (VOUT) 以及 MMCX 连接器 J5 (VIN) 和 J1 (VOUT) 提供了可选的开尔文检测点。

2.1.4 可选负载瞬态电路的操作

TPS7N59EVM-184 评估模块包含一个可选的高性能负载瞬态电路，用于高效测试 TPS7N59 LDO 的负载瞬态性能。要使用该可选的负载瞬态电路，请根据应用安装相应的元件。修改连接到 TPS7N59 LDO 的输入和输出电容，以匹配预期的工作条件。确定要测试的峰值电流，并修改 R6、R7、R8、R9 和 R10 的并联电阻器组合，如下所示：

$$I_{PEAK} = \frac{V_{OUT}}{R6 || R7 || R8 || R9 || R10} \quad (1)$$

可通过 C10、R11、R12 和 R13 调整负载阶跃的压摆率。通常情况下，仅需调节 R12 和 R13 来设置转换率，而 C10 和 R11 无需安装元件。

在修改 EVM (如果需要) 之后，将电源连接到香蕉连接器 J15 (VDD) 和 J19 (GND)，直流电源电压限制为 5V，直流电流限制为 1A。TPS7N59 瞬态响应非常快，输出电压在初始负载瞬态后远低于 1ms 的时间内恢复。因此，使用 1ms 的负载瞬态脉冲持续时间限制可防止脉冲电阻器 (R6、R7、R8、R9 和 R10) 过热。在 0V 直流至 5V 直流方波脉冲中为 50Ω 输出配置一个函数发生器。如有必要，可以在函数发生器中配置突发模式，以进行重复、低占空比、负载瞬态测试。

2.1.5 输入/输出连接器和跳线说明

2.1.5.1 J20、J22 - IN

带接地连接的输入电源电压连接器。

2.1.5.2 J8 - OUT

通过接地连接实现的稳压输出电压。

2.1.5.3 TP1 - REF

参考电压检测测试点。

2.1.5.4 TP2 - PG

电源正常感测连接。

2.1.5.5 TP3 - NR/SS

NR/SS 感测引脚测试点连接。

2.1.5.6 TP4、TP5、TP6 - GND

接地引脚测试点连接。

2.1.6 焊接指南

为避免损坏器件，请使用热风系统执行任何焊接返修，从而修改 EVM，以实现维修或其他应用目的。

2.1.7 设备连接

按以下步骤连接设备：

1. 将输入电源设置为最高 6V，然后关闭电源。
2. 将偏置电源设置为最高 12V，然后关闭电源。
3. 将电源线连接到 EVM 的 J20 或 J22 V_{IN} 连接器。
4. 将电源线连接到 EVM 的 J3V_{BIAS} 连接器。
5. 打开 V_{IN} 和 V_{BIAS} 辅助电源。
6. 在 OUT 和 GND 之间连接 0A 至 10A 的负载。

3 硬件设计文件

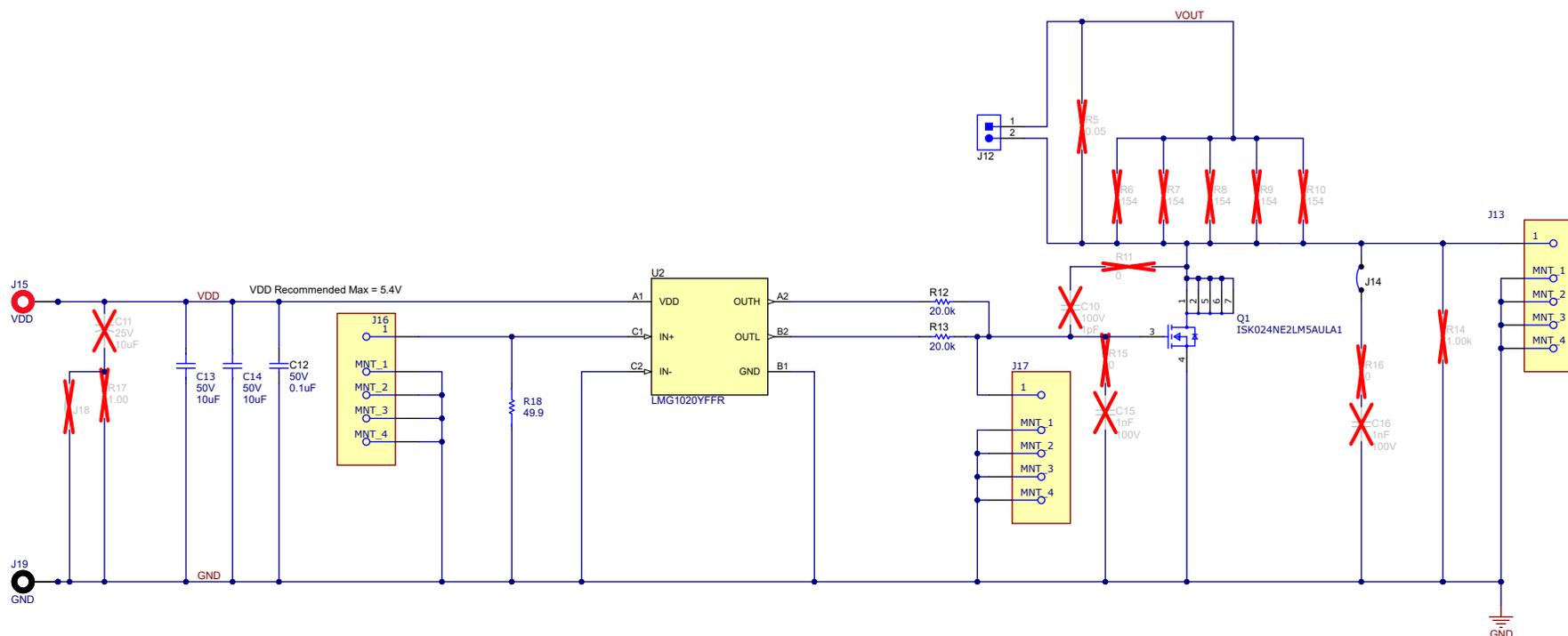


图 3-3. TPS7N59EVM-184 负载瞬态电路原理图

3.2 PCB 布局

图 3-4 至图 3-13 说明了该 EVM 的 PCB 布局。

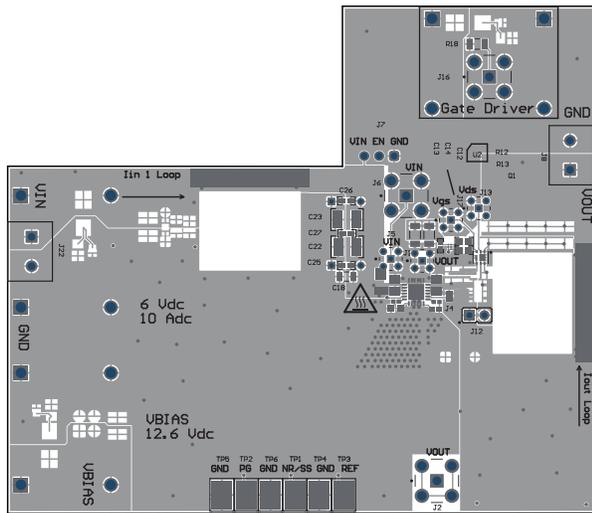


图 3-4. 顶层装配层

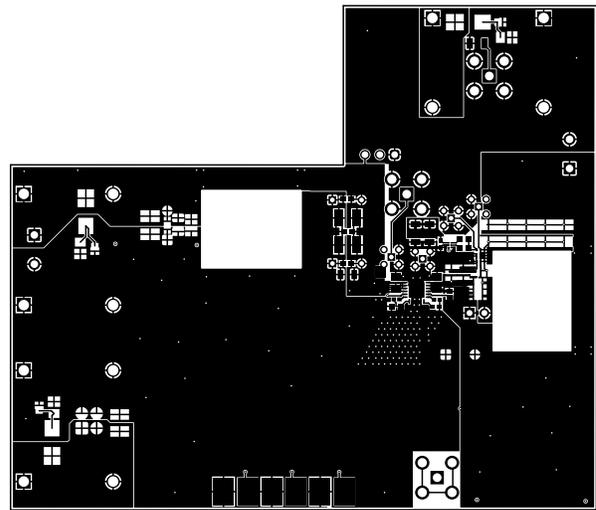


图 3-5. 顶层布线

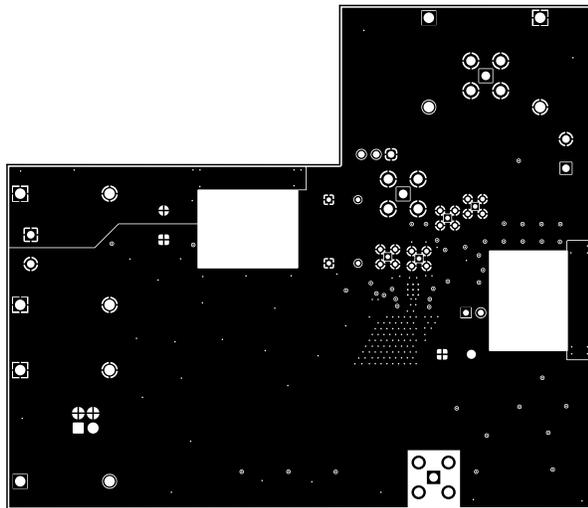


图 3-6. 第一个中间层

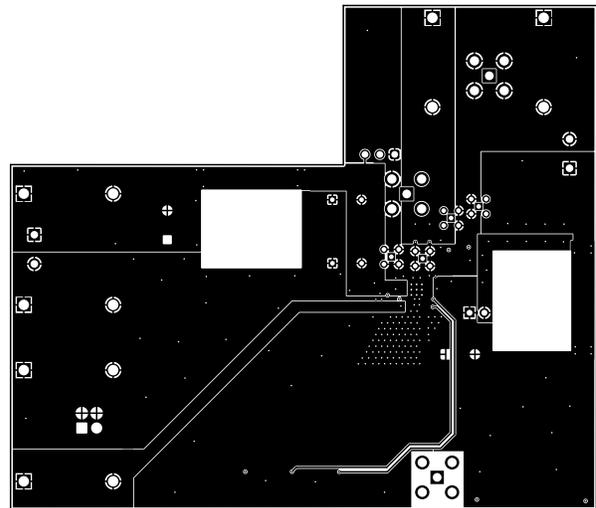


图 3-7. 第二个中间层

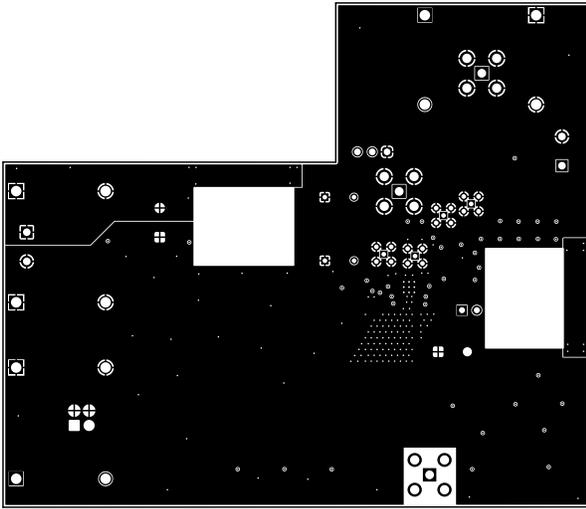


图 3-8. 第三中间层

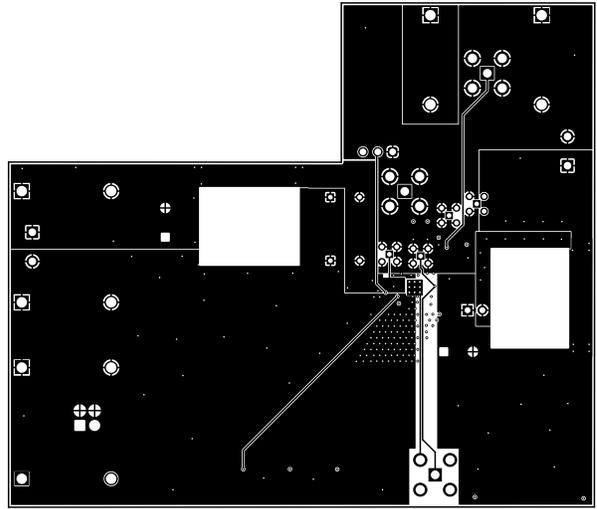


图 3-9. 第四中间层

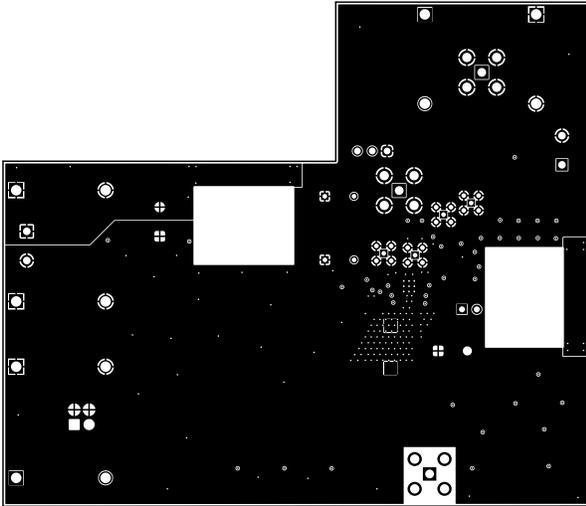


图 3-10. 第五中间层

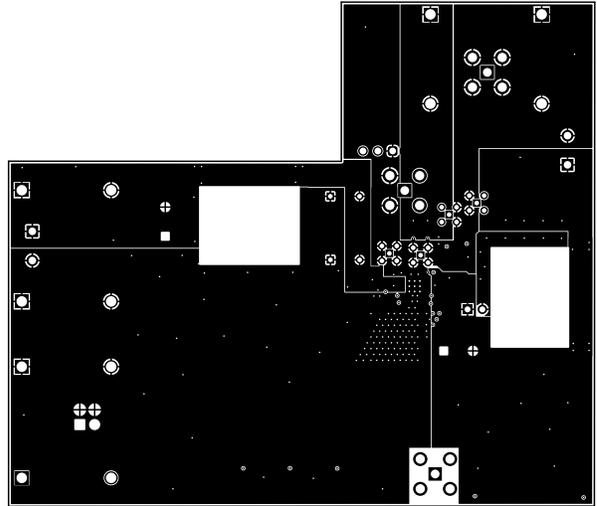


图 3-11. 第六中间层

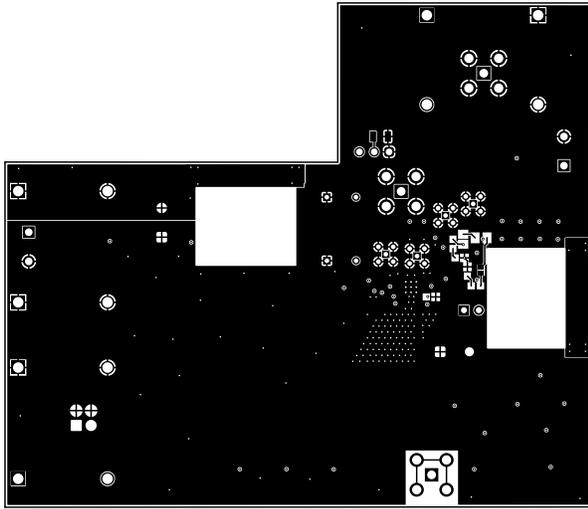


图 3-12. 底层布线

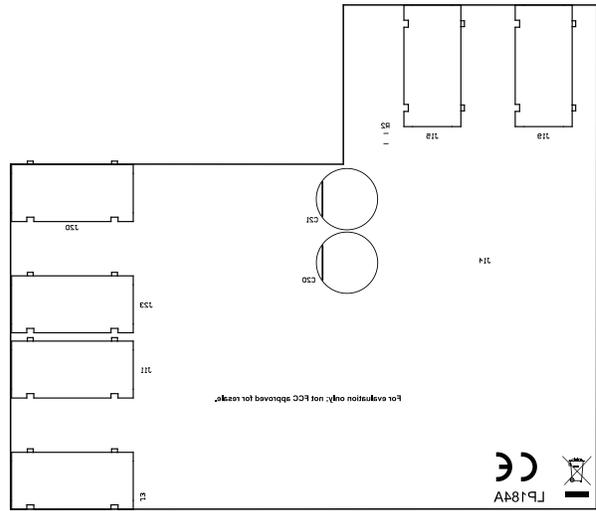


图 3-13. 底层装配层

3.3 物料清单 (BOM)

表 3-1 显示了此 EVM 的物料清单 (BOM)。

表 3-1. TPS7N59EVM-184 BOM (1) (2) (3) (4)

说明	指示符	器件型号	数量	制造商	封装参考	值	备选制造商	备选器件型号
印刷电路板	!PCB1	LP184	1	不限				
电容, 陶瓷, 22uF, 10V, +/-20%, X7R, 0805	C2, C24	GRM21BZ71A226ME15L	2	MuRata	0805	22uF		
电容, 陶瓷, 4.7uF, 10V, +/-10%, X5R, 0603	C6	C0603C475K8PAC TU	1	Kemet	0603	4.7uF		
1μF ±10% 10V 陶瓷电容器 X7R 0402 (公制 1005)	C8	GMC04X7R105K1 ONT	1	Cal-Chip Electronics	0402	1μF		
电容, 陶瓷, 0.1μF, 50V, +/-10%, X7R, 0402	C12	C1005X7R1H104K050BB	1	TDK	0402	0.1uF		
10μF ±10% 50V 陶瓷电容器 X7R 1206 (公制 3216)	C13, C14	GMC31X7R106K5 ONT	2	Cal-Chip Electronics	1206	10μF		
电容, 陶瓷, 4.7 μ F, 50V, X7R, 10%, 焊盘, SMD, 0805, +125°C, 汽车, T/R	C18	CGA4J1X7R1H475K125AC	1	TDK Corporation	0805	4.7μF		
电容铝聚合物 560uF 20VDC 20% (10X 13mm) 径向 5mm 0.012 Ω 1700mA 1000 小时 125C	C20, C21	20SEF560M	2	Panasonic	径向	560μF		
电容, 陶瓷, 22μF, 25V, +/-10%, X7R, 1210	C22, C23	CL32B226KAJNFN E	2	Samsung Electro-Mechanics	1210	22uF		
电容, 陶瓷, 0.1μF, 50V, +/-20%, X7R, 0402	C25, C26, C27	UMK105B7104MV-FR	3	Taiyo Yuden	0402	0.1uF		
MMCX 连接器插孔, 母插座, 50Ohm, 穿孔焊接	J1, J5, J13, J17	RF12-07H-T-00-50G	4	Adam Tech	CONN_MMCX			
SMA 连接器插孔, 母插座, 50Ohm, 穿孔焊接	J2, J6, J16	RF2-04A-T-00-50G	3	Adam Tech	CONN_RF_7MM00_7MM00			
标准香蕉插孔, 绝缘, 10A, 红色	J3, J15, J20	571-0500	3	DEM Manufacturing	571-0500			
跳线, SMT	J4, J14	JMP-36-30X40SMT	2	不限	短接跳线, SMT			
接头, 2.54mm, 3x1, 金, TH	J7	61300311121	1	Würth Elektronik	接头, 2.54mm, 3x1, TH			
端子块 2POS 侧面插入 5MM PCB	J8, J22	691137710002	2	Würth Elektronik	HDR2			
标准香蕉插孔, 绝缘, 10A, 黑色	J11, J19, J23	571-0100	3	DEM Manufacturing	571-0100			
接头, 100mil, 2x1, 金, TH	J12	PBC02SAAN	1	Sullins Connector Solutions	Sullins 100mil, 1x2, 绝缘体上方 230mil			
40V optiMOS 功率晶体管, 表面贴装 6-PQFN 双通道 (2x2)	Q1	ISK024NE2LM5AULA1	1	Infineon	VSON6			
1k Ω, ±1%, 0.063W, 100/16W, 片上电阻, 0402 (1005 公制), 厚膜	R1	CRCW0402100KF KEDC	1	Vishay	0402	100k		
电阻厚膜, 49.9 Ω, 1%, 0.75W, 100ppm/°C, 1206	R2, R18	CRCW120649R9F KEAHP	2	Vishay Dale	1206	49.9		
电阻, 15.0k, 1%, 0.063W, 0402	R3	RC0402FR-0715K L	1	Yageo America	0402	15.0k		
电阻, 20.0k, 1%, 0.1W, 0603	R12, R13	RC0603FR-0720K L	2	Yageo	0603	20.0k		

表 3-1. TPS7N59EVM-184 BOM (1) (2) (3) (4) (续)

说明	指示符	器件型号	数量	制造商	封装参考	值	备选制造商	备选器件型号
分流器, 100mil, 镀金, 黑色	SH-J1	SNT-100-BK-G	1	Samtec	分流器	1x2	3M	969102-0000-DA
测试点, 紧凑型, SMT	TP1、TP2、TP3、TP4、TP5、TP6	5016	6	Keystone	Testpoint_Keystone_Compact			
TPS7N5901RTWR	U1	TPS7N5901RTWR	1	德州仪器 (TI)	WQFN-24			
具有 60MHz/1ns 速度的 5V、7A/5V 低侧 GaN 驱动器, YFF0006AEAE (DSBGA-6)	U2	LMG1020YFFR	1	德州仪器 (TI)	YFF0006AEAE		德州仪器 (TI)	LMG1020YFFT
电容铝聚合物 560uF 20VDC 20% (10X 13mm) 径向 5mm 0.012Ω 1700mA 1000 小时 125C	C1, C19	20SEF560M	0	Panasonic	径向	560μF		
电容, 陶瓷, 22uF, 10V, +/-20%, X7R, 0805	C3, C4	GRM21BZ71A226ME15L	0	MuRata	0805	22uF		
电容, 陶瓷, 10μF, 35V, +/- 10%, X7R, 1210	C5	GRM32ER7YA106KA12K	0	MuRata	1210	10uF		
电容, 钽, 10uF, 25V, +/- 20%, 0.5ohm, SMD	C7、C11、C17	TPSC106M025R0500	0	AVX	6032-28	10uF		
电容, 陶瓷, 4.7uF, 16V, +/-10%, X7R, 0603	C9	GRM188Z71C475KE21D	0	MuRata	0603	4.7uF		
电容, 陶瓷, 1pF, 100V, +/-5%, C0G/NP0, 0805	C10	GQM2195C2A1R0CB01D	0	MuRata	0805	1pF		
电容, 陶瓷, 1000pF, 100V, +/-5%, X7R, 0603	C15, C16	06031C102JAT2A	0	AVX	0603	1000pF		
电容, 陶瓷, 4.7μF, 50V, X7R, 10%, 焊盘, SMD, 0805, +125°C, 汽车, T/R	C28	CGA4J1X7R1H475K125AC	0	TDK Corporation	0805	4.7μF		
电容, 陶瓷, 22μF, 25V, +/-10%, X7R, 1210	C29	CL32B226KAJNFN E	0	Samsung Electro-Mechanics	1210	22uF		
电容, 陶瓷, 1μF, 16V, +/-10%, X7R, AEC-Q200 1 级, 0805	C30	C0805C105K4RAC AUTO	0	Kemet	0805	1uF		
电容, 陶瓷, 0.1μF, 50V, +/-20%, X7R, 0402	C31	UMK105B7104MVF-R	0	Taiyo Yuden	0402	0.1uF		
接头, 100mil, 2x2, 金, TH	J9	TSW-102-07G-D	0	Samtec	2x2 接头			
跳线, SMT	J10、J18、J21	JMP-36-30X40SMT	0	不限	短接跳线, SMT			
电阻, 1.00, 1%, 0.333W, AEC-Q200 1 级, 0805	R4、R17、R19	ERJ-6BQF1R0V	0	Panasonic	0805	1.00		
电阻, 0.05, 1%, 1W, AEC-Q200 0 级, 0612	R5	ERJ-B2CFR05V	0	Panasonic	0612	0.05		
电阻, 154, 1%, 0.5W, 1210	R6、R7、R8、R9、R10	RC1210FR-07154RL	0	Yageo	1210	154		
电阻, 0, 5%, 0.125W, AEC-Q200 0 级, 0805	R11	ERJ-6GEY0R00V	0	Panasonic	0805	0		
电阻, 1.00k, 1%, 0.125W, AEC-Q200 0 级, 0805	R14	ERJ-6ENF1001V	0	Panasonic	0805	1.00k		
电阻, 0, 1%, 0.1W, AEC-Q200 0 级, 0603	R15, R16	RMCF0603ZTOR00	0	Stackpole Electronics Inc	0603	0		

- (1) 该组件对 ESD 敏感; 应遵守 ESD 预防措施。
- (2) 该组件必须是干净的且没有焊剂和任何污染物。不允许使用免清洗焊剂。
- (3) 该组件必须符合工艺标准 IPC-A-610 2 级。
- (4) 除非备选器件型号或备选制造商栏中另有说明, 否则所有器件均可替换为等效产品。

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 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/lstds/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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ンスツルメンツ株式会社

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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3.4 European Union

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

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

-
- 4 *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
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 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.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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最后更新日期：2025 年 10 月