

EVM User's Guide: TPSI31PXQ1EVM

TPSI31Px-Q1 评估模块



说明

TPSI31Px-Q1 评估模块 (EVM) 可帮助设计人员评估 TPSI31Px-Q1 器件系列的运行情况和性能。该电路板采用 TPSI31P1-Q1，这是一款具有集成式 17V 栅极电源和比较器的隔离式开关驱动器，可监控充电电流并以迟滞方式驱动栅极，完全位于次级侧，无需额外的逻辑。借助该功能，TPSI31P1 可以作为高侧有源预充电解决方案，在包括电动汽车 (EV) 或混合动力汽车 (HEV) 在内的任何应用中为直流链路电容器充电。

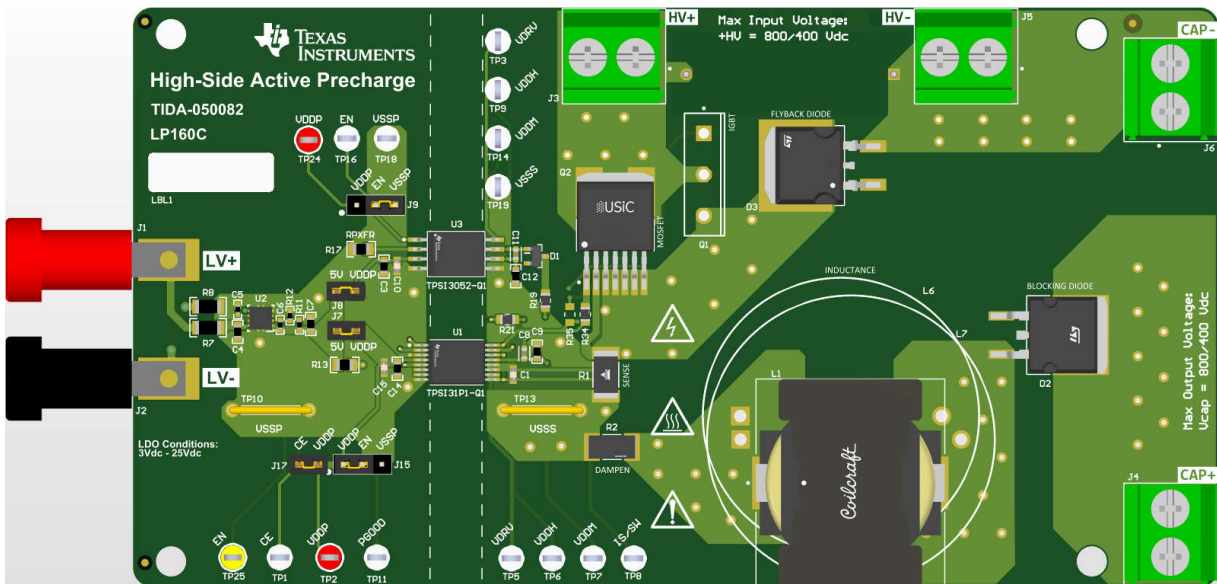
EVM 设计中包含了 TPSI3052，但并非必需器件，这是额外的开关电源。TPSI3052 是一款具有集成式 17V 栅极电源的隔离式开关驱动器，可用作辅助隔离式电源。该 EVM 采用基于高压电感器的降压拓扑。该 EVM 还包括一个具有 14nC 小栅极电荷的 N 通道碳化硅 (SiC) MOSFET，有助于我们更大限度地降低所需的总体开关功率。该电路板包含多个测试点来监测 TPSI31P1-Q1 功能。此外，该 EVM 还包含一个可调节 5V LDO 来实现灵活的电输入。

特性

- TPSI31PXQ1EVM 能够在 300ms ($5.5A_{AVG}$) 内将 2mF 电容器充电至 800V
- TPSI31PXQ1EVM-400 能够在 180ms ($4.5A_{AVG}$) 内将 2mF 电容器充电至 400V
- TPSI31P1-Q1 中集成了迟滞充电电流控制，无需额外逻辑
- 超低噪声 LDO (5V 至 20V 输入)，用于在可调电源不可用时为电路供电
- 无需隔离式次级电源
- 5kVRMS 增强型隔离
- 17V 栅极驱动电压，1.5A 峰值拉电流和 3A 峰值灌电流
- 具有集成电压基准 $\pm 1.5\%$ 的双通道隔离式高速比较器

应用

- 混合动力、电动和动力总成系统



PCB 顶视图 : TPSI31PXQ1EVM

1 评估模块概述

1.1 引言

TPSI31PxQ1EVM 是一款评估模块 (EVM)，旨在演示 TPSI31P1-Q1 器件在高侧有源预充电应用中 (用于为直流链路电容器充电) 的性能和功能。有源预充电中的拓扑与降压转换器的拓扑类似，使用一个串联的电感器来限制充电电流上升速率 (di/dt) 并通过迟滞控制来控制充电电流。TPSI31P1-Q1 集成了迟滞控制功能，无需外部逻辑即可完全控制预充电。

本用户指南介绍了该 EVM 的连接器、测试点描述、原理图、物料清单和电路板布局布线。

1.2 套件内容

- TPSI31Px-Q1 评估模块电路

1.3 规格

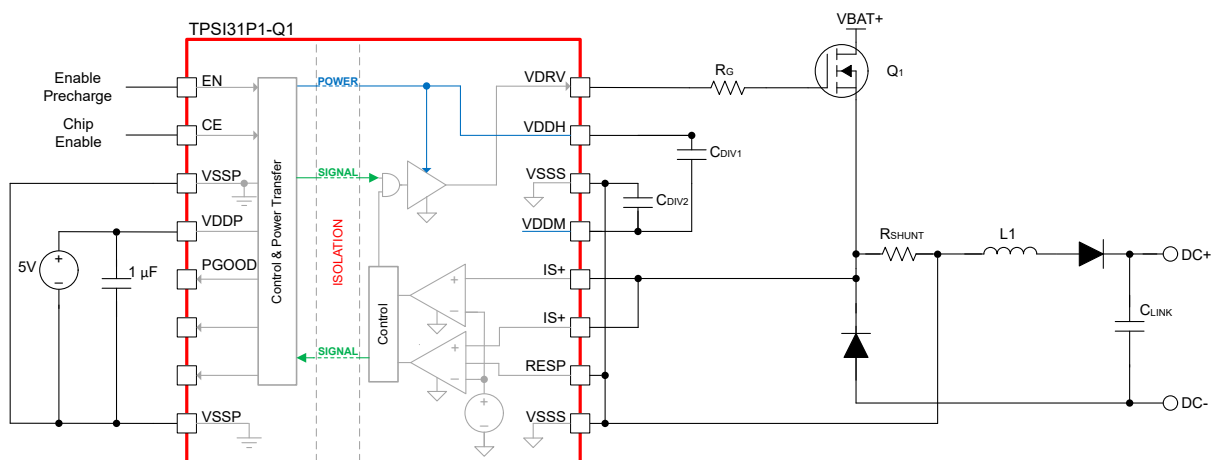


图 1-1. TPSI31P1-Q1 简化原理图

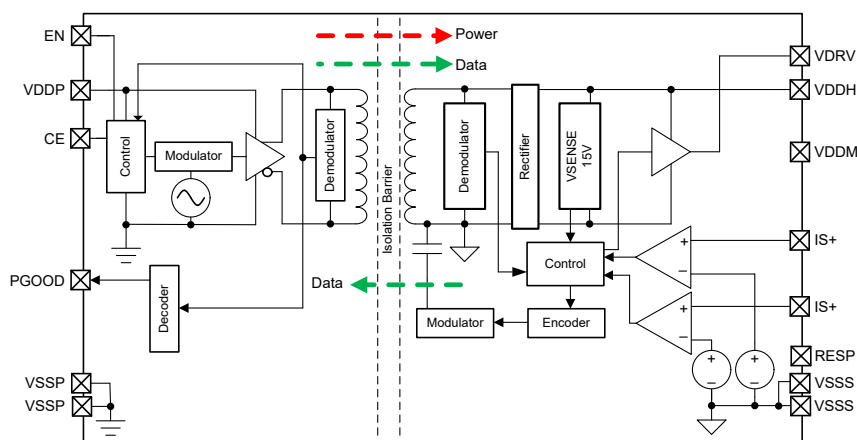


图 1-2. TPSI31P1-Q1 功能方框图

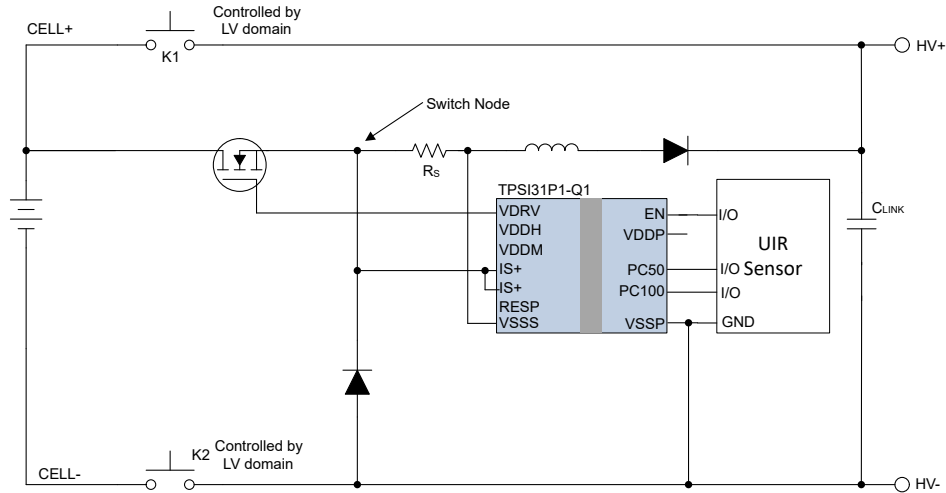


图 1-3. TPSI31P1-Q1 应用原理图

1.4 器件信息

TPSI31P1-Q1 器件是一款具有集成比较器的隔离式栅极驱动器，用于在为直流链路电容器充电中实现迟滞电流控制。当使能 (EN) 引脚变为高电平时，驱动器 (VDRV) 导通，直到比较器上的电压 (IS+) 超过 1.2V。一旦 IS+ 超过 1.2V，VDRV 会关断，直到 IS+ 降至 160mV 以下。IS+ 降至 160mV 以下后，VDRV 会导通，并且此循环会重复，直到直流链路电容器充满电为止。

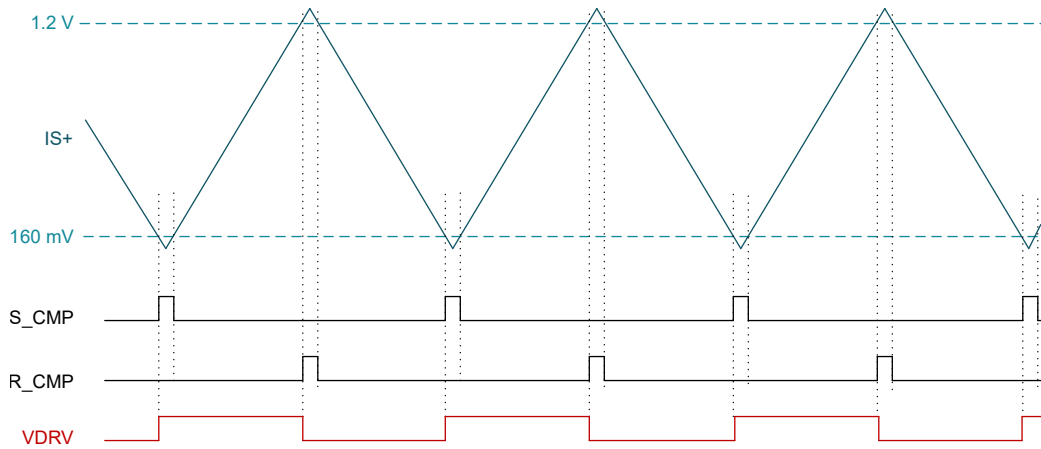


图 1-4. TPSI31P1-Q1 行为图

2 硬件

2.1 其他图像

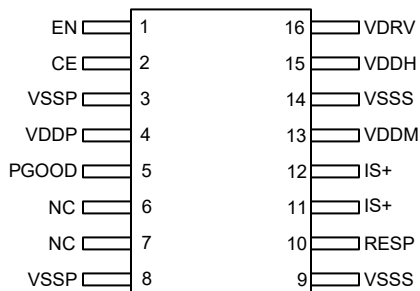


图 2-1. TPSI31P1-Q1 DVX 封装 16 引脚 SSOP (顶视图)

2.2 接头信息

名称	说明
J1	初级侧的正电源输入，香蕉插孔
J2	初级侧的负电源输入，香蕉插孔
J3	HV+ 电源输入，螺纹接线端子
J4	电容器- 输出，螺纹接线端子
J5	HV- 电源输入，螺纹接线端子
J6	电容器+ 输出，螺纹接线端子

2.3 跳线信息

名称	说明
J7	TPSI31Px-Q1 VDDP 断开连接
J8	TPSI3052-Q1 VDDP 断开连接
J9	TPSI3052-Q1 EN 选择
J15	TPSI31Px-Q1 EN 选择
J17	TPSI31Px-Q1 CE 断开连接

2.4 测试点

名称	说明
TP1	TPSI31P1-Q1 CE 信号测试点
TP2	TPSI31P1-Q1 VDDP 信号测试点
TP3	TPSI3052-Q1 VDRV 信号测试点
TP5	TPSI31P1-Q1 VDRV 信号测试点
TP6	TPSI31P1-Q1 VDDH 信号测试点
TP7	TPSI31P1-Q1 VDDM 信号测试点
TP8	TPSI31P1-Q1 IS/SW 信号测试点
TP9	TPSI3052-Q1 VDDH 信号测试点
TP11	TPSI31P1-Q1 PGOOD 信号测试点
TP14	TPSI3052-Q1 VDDM 信号测试点
TP16	TPSI3052-Q1 EN 信号测试点
TP18	TPSI3052-Q1 VSSP 信号测试点
TP19	TPSI3052-Q1 VSSS 信号测试点
TP24	TPSI3052-Q1 VDDP 信号测试点
TP25	TPSI31P1-Q1 EN 信号测试点

3 软件

TPSI31P1-CALC 是一款有助于估算预充电电路行为的计算器工具，可在器件产品文件夹中找到。借助该工具，用户可以输入常见的预充电要求，例如电压、电容、电感等，从而生成链路电压和电感器电流的输出波形。该软件还考虑了超过 **TPSI31P1-Q1** 电源传输能力的用户输入，并相应地估算了 **VDDH** 需要从 **UVLO** 恢复时产生的延迟。为了尽可能缩短或消除此延迟，用户可以选择添加 **TPSI3052-Q1**，通过连接 **J8** 来提供额外的 **79mW** 开关功率。

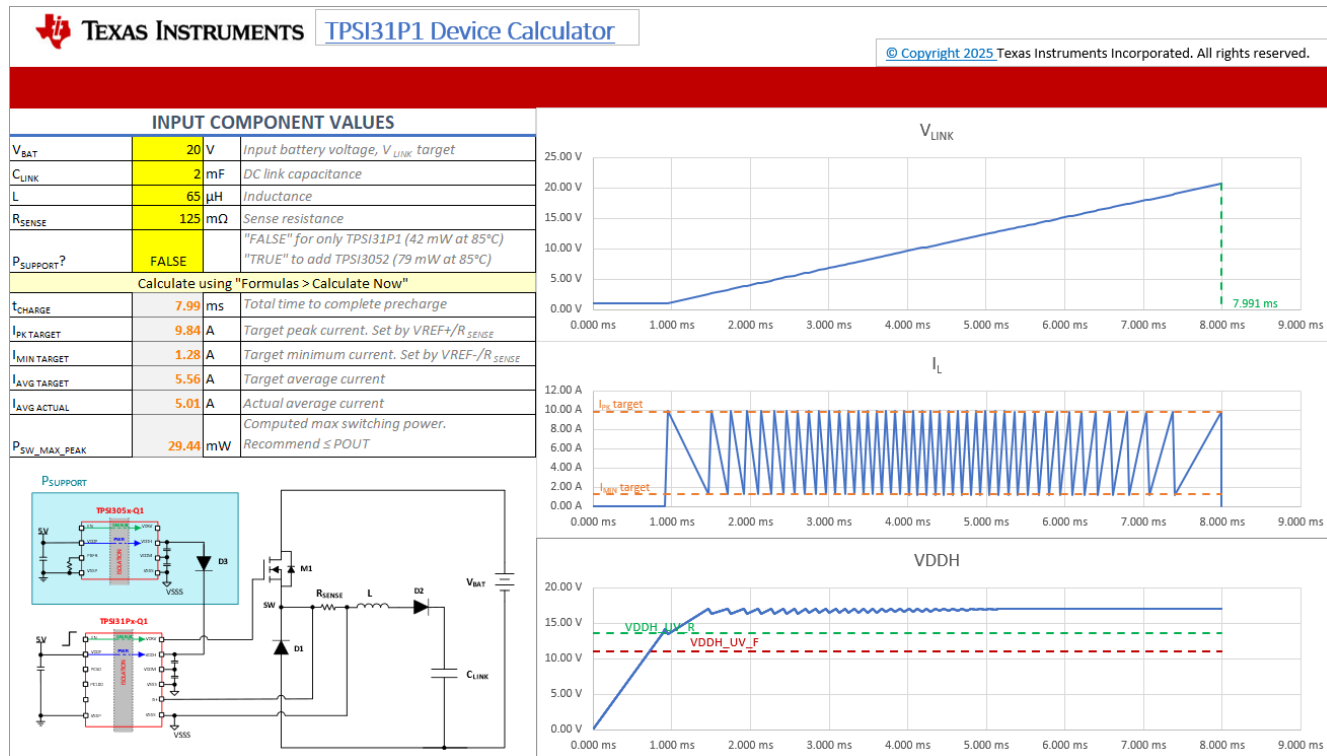


图 3-1. TPSI31P1 器件计算器示例 1，VDDH 未命中 UVLO

- 为了帮助清楚地说明蓝色波形中的电流充电行为，示例 1 描述了 20V 输入。请注意，输入不限于 20V。
- 为了帮助清楚地说明蓝色波形中的电流充电行为，示例 2 描述了 20V 输入。请注意，输入不限于 20V。

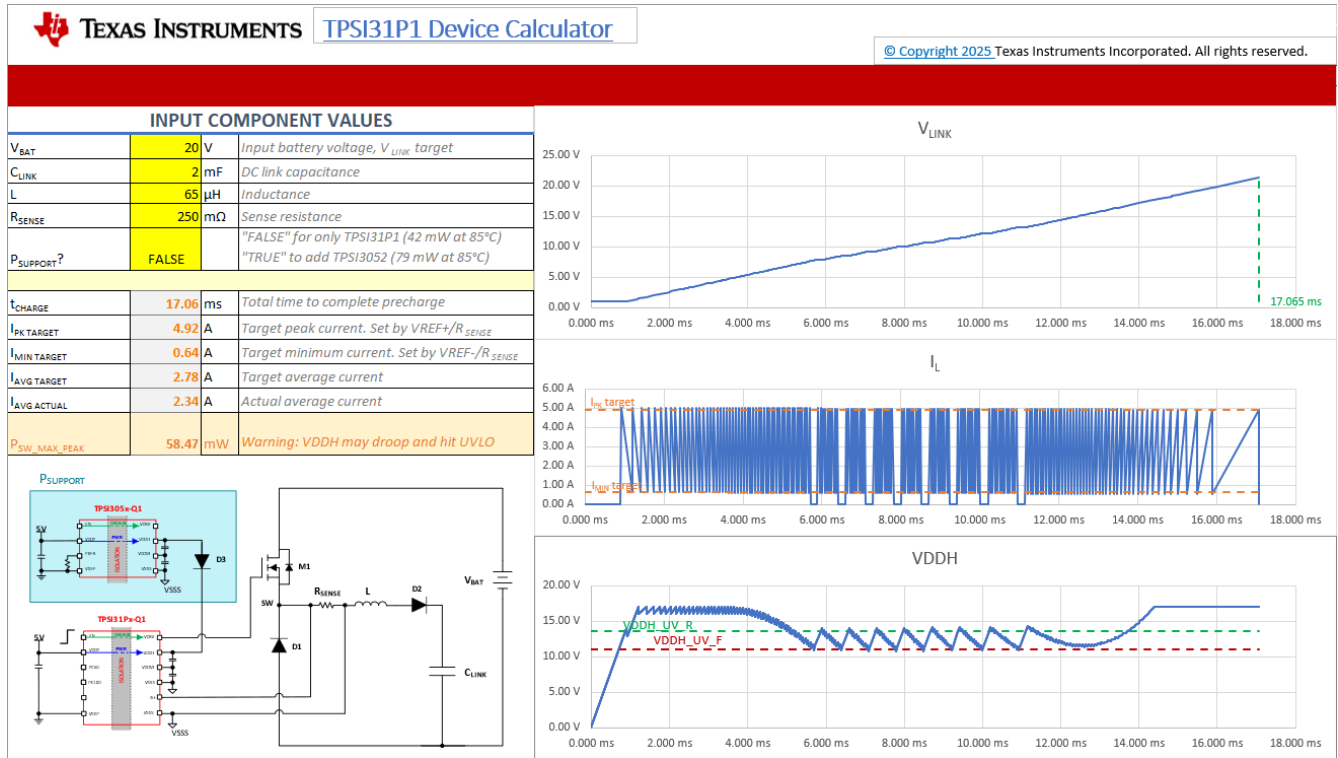


图 3-2. TPSI31P1 器件计算器示例 2 , VDDH 命中 UVLO

4 实现结果

4.1 评估设置

公式 1 展示了如何根据所需的充电电流选择分流电阻器。使用 $125\text{m}\Omega$ 分流电阻器可得到 5.5A_{AVG} 充电电流。使用 $150\text{m}\Omega$ 分流电阻器可得到 4.5A_{AVG} 充电电流。充电电流特性如 图 4-1 所示。

$$\begin{aligned} I_{\text{PEAK}} &= \frac{1.2 \text{ V}}{R_{\text{SHUNT}}} \\ I_{\text{MIN}} &= \frac{0.160 \text{ V}}{R_{\text{SHUNT}}} \\ I_{\text{AVG}} &= \frac{I_{\text{PEAK}} + I_{\text{MIN}}}{2} \end{aligned} \quad (1)$$

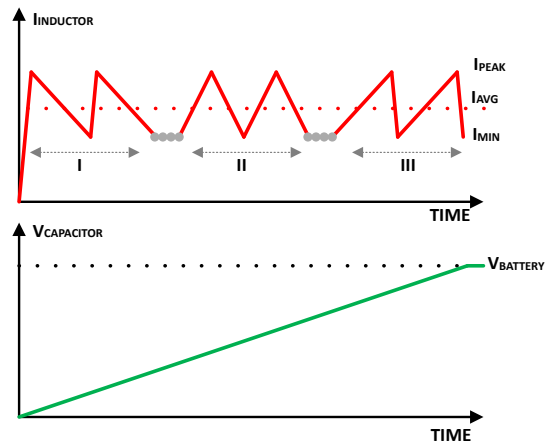


图 4-1. 有源预充电曲线

4.2 性能数据和结果

以下波形展示了 TPSI31PXQ1EVM 和 TPSI31PXQ1EVM-400 分别在 290ms 和 180ms 内将 2mF 电容器充电至 800V 与 400V。

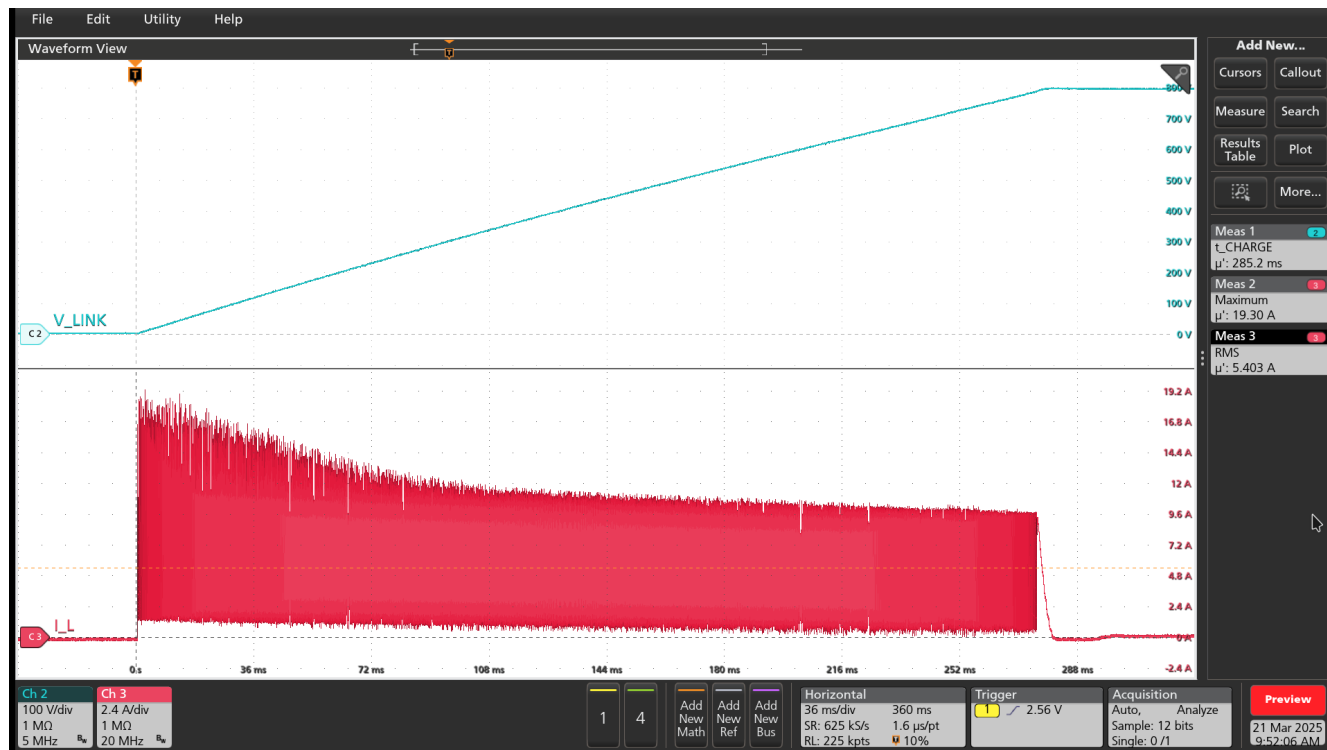


图 4-2. 在 290ms 内将 2mF 电容器充电至 800V (TPSI31PXQ1EVM)

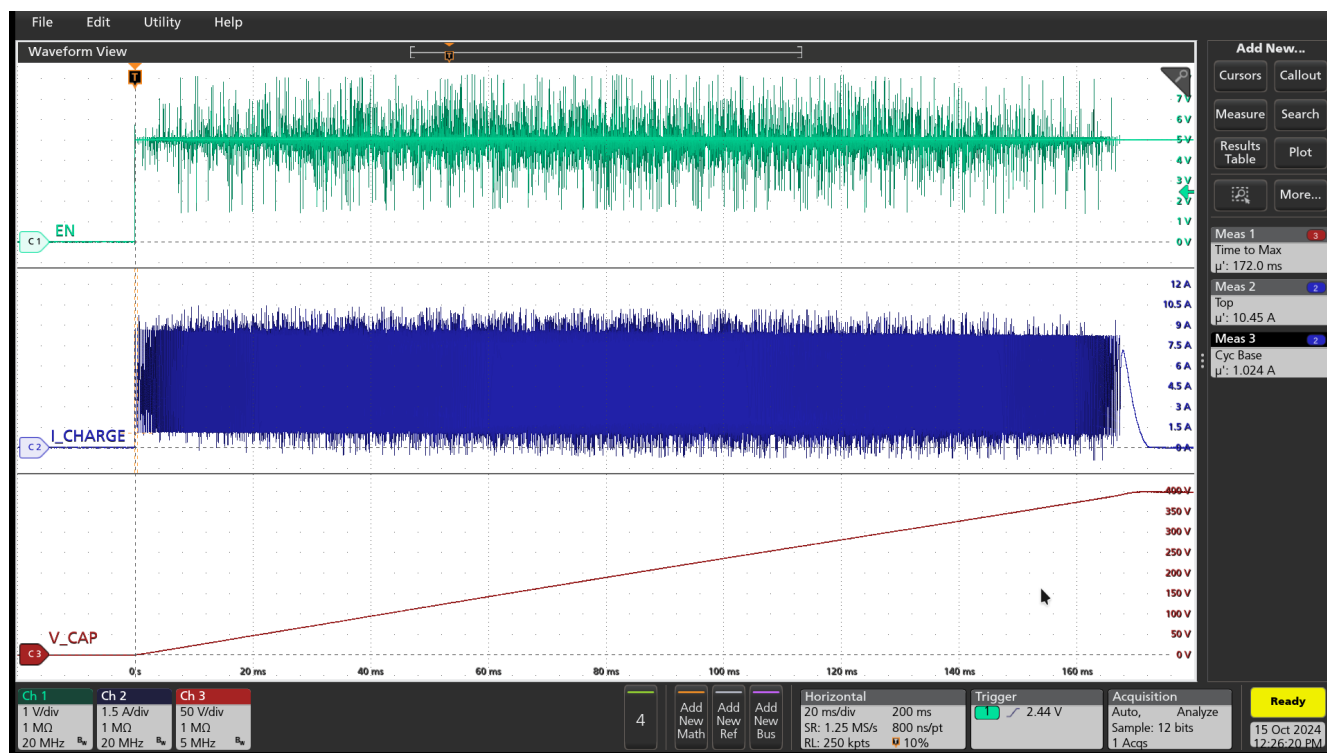


图 4-3. 在 180ms 内将 2mF 电容器充电至 400V (TPSI31PXQ1EVM-400)

5 硬件设计文件

5.1 原理图

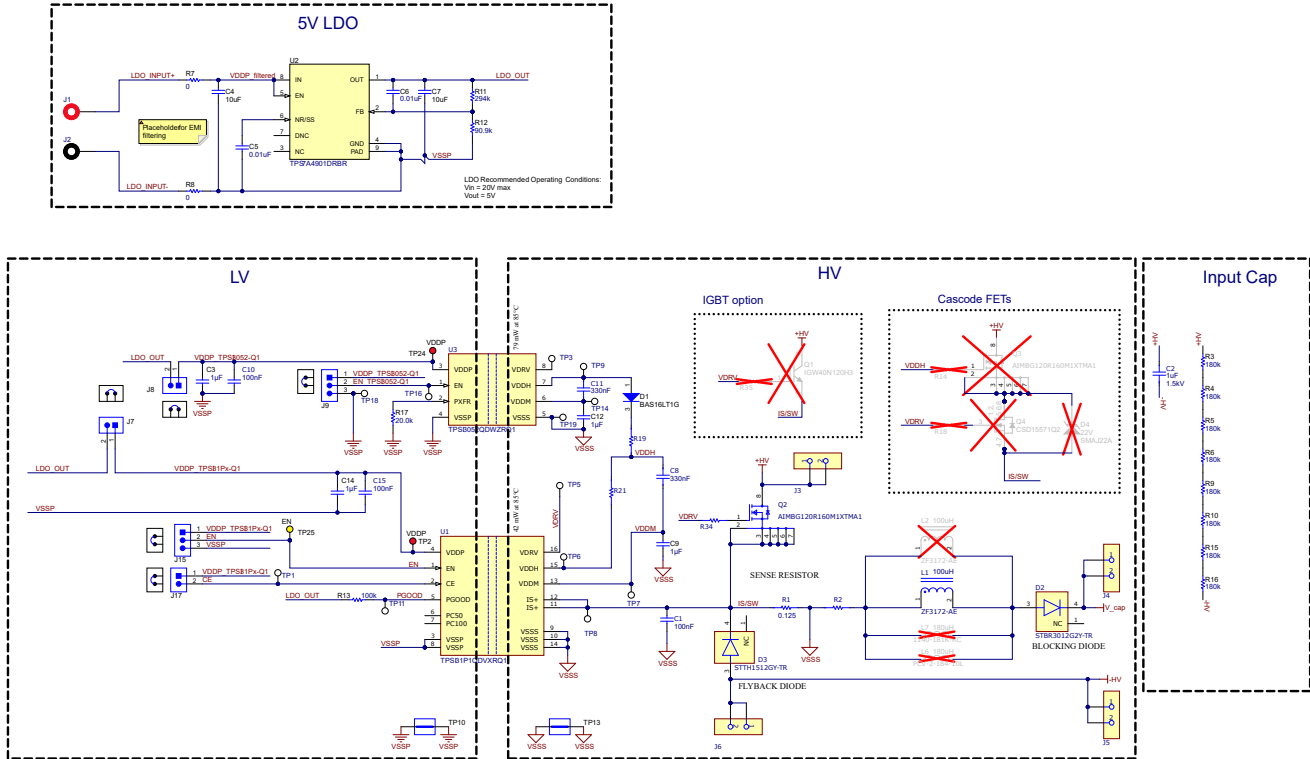


图 5-1. TPSI31PXQ1EVM 原理图

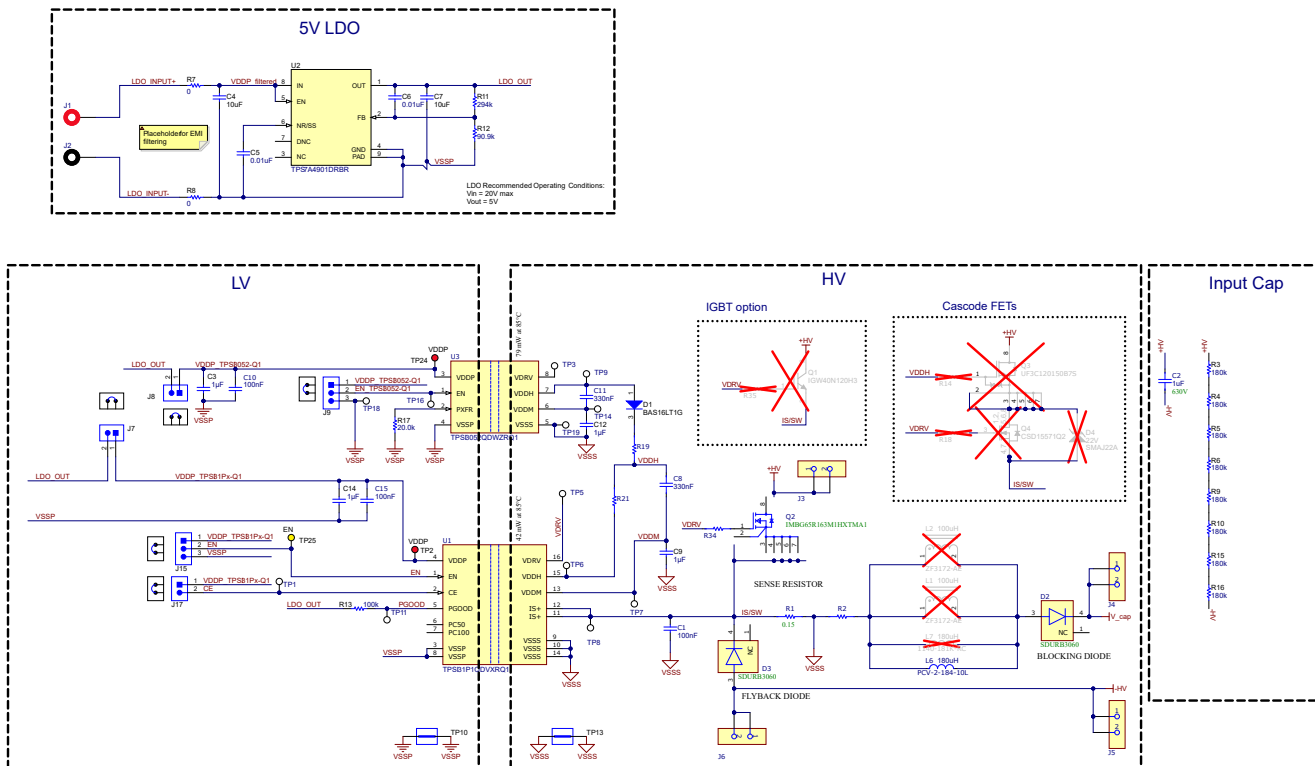


图 5-2. TPSI31PXQ1EVM-400 原理图

5.2 PCB 布局

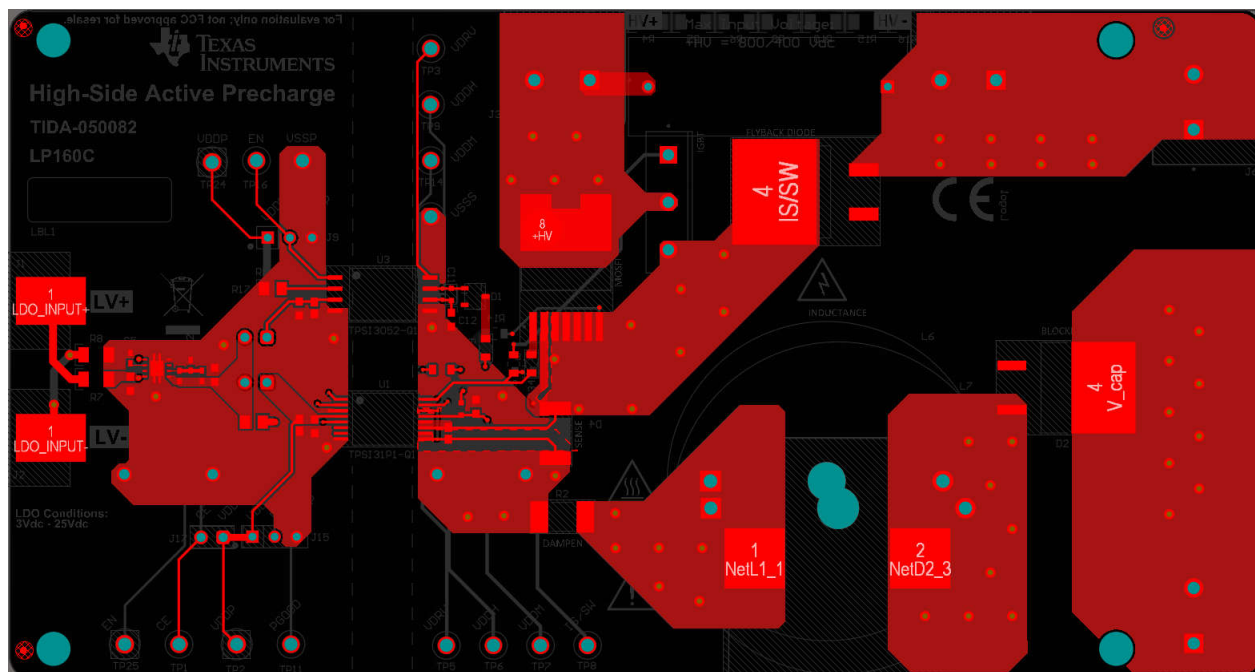


图 5-3. PCB 顶层

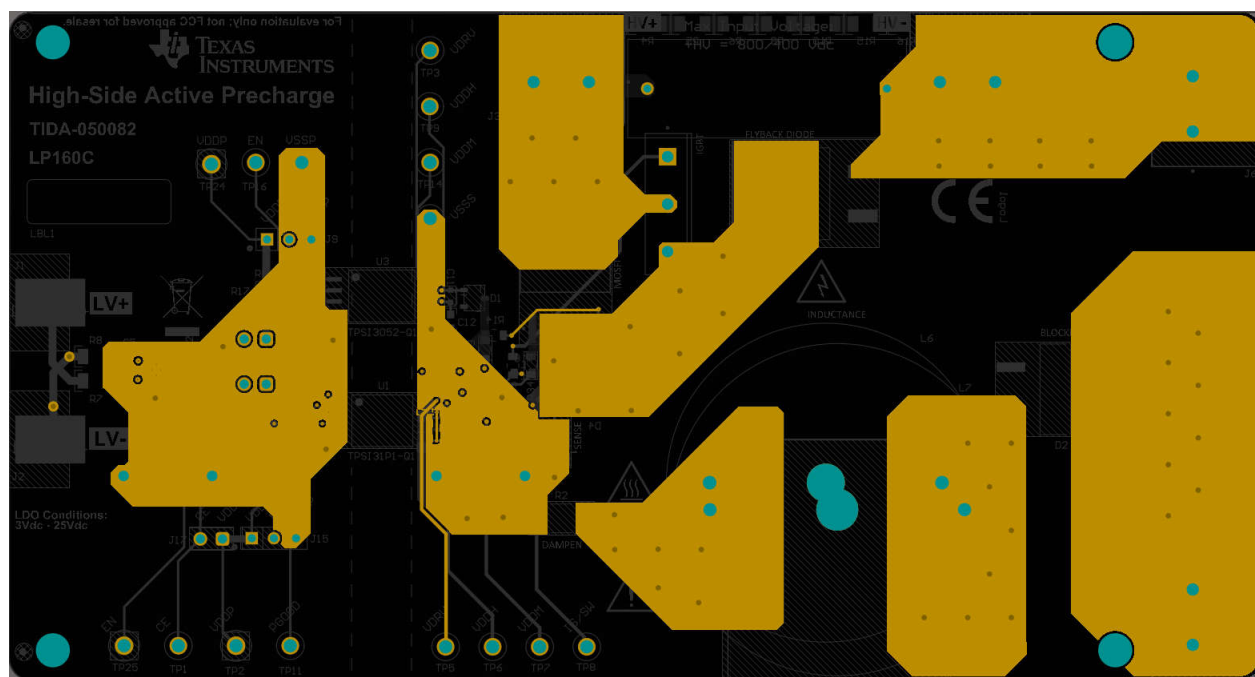


图 5-4. PCB 内层 1

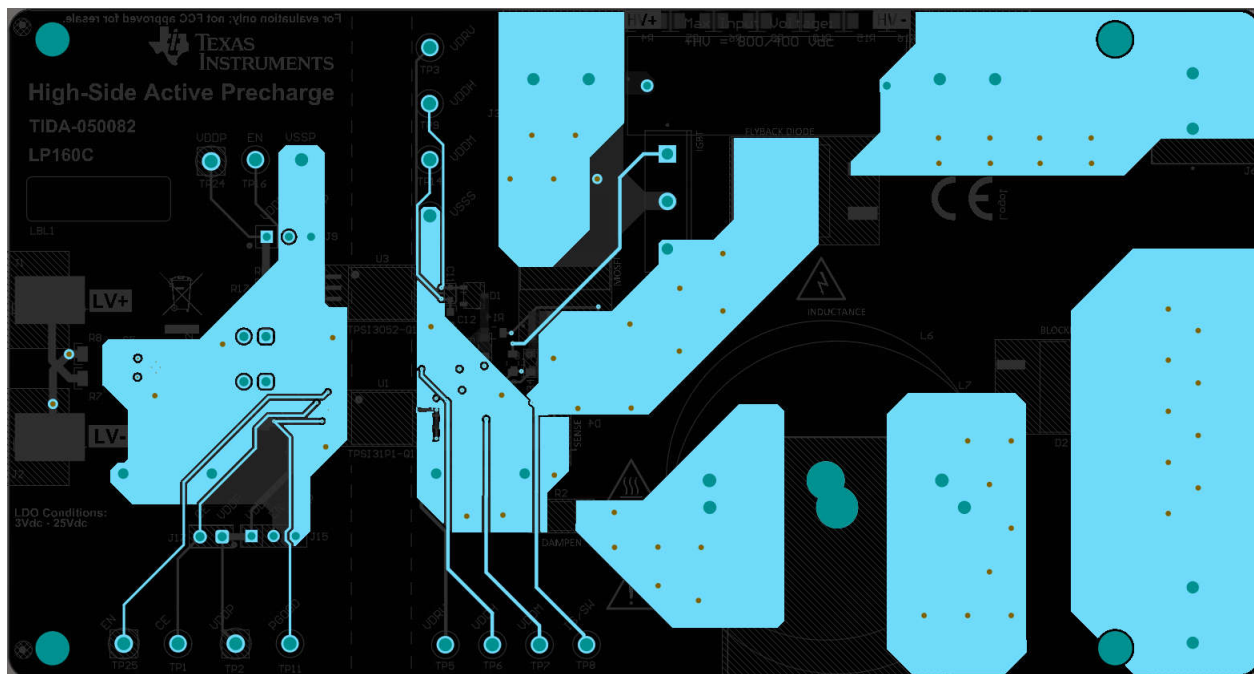


图 5-5. PCB 内层 2

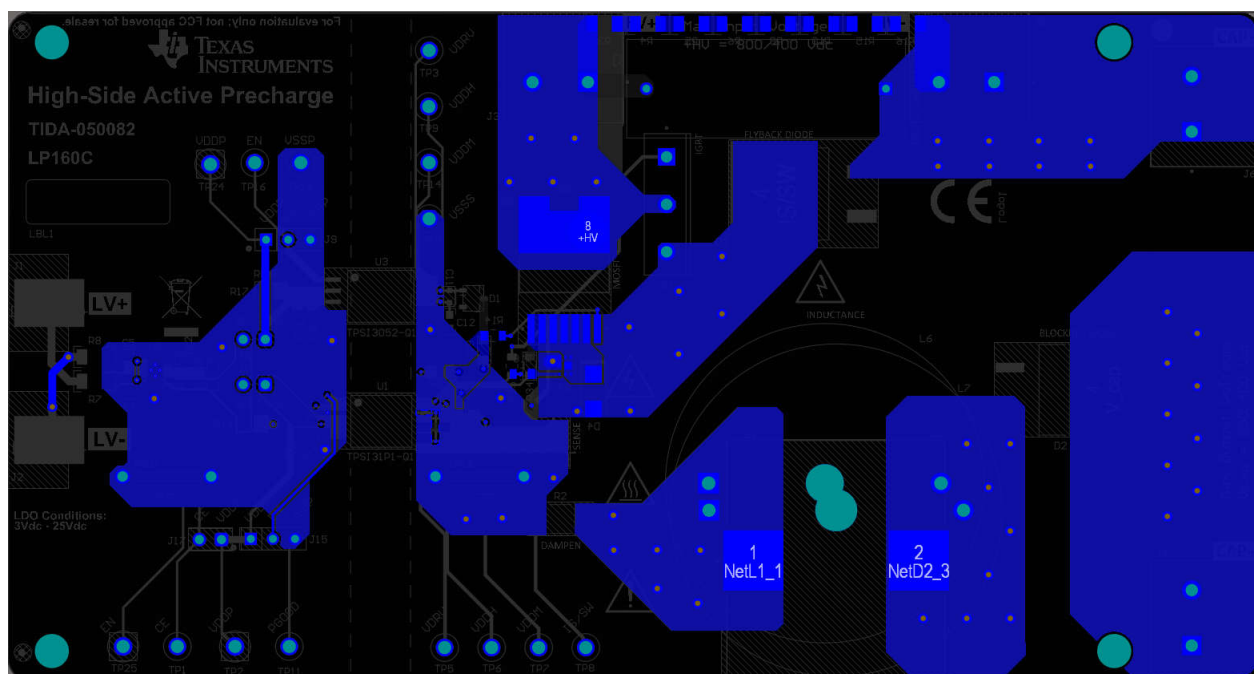


图 5-6. PCB 底层

5.3 物料清单 (BOM)

表 5-1. 物料清单 (TPSI31PXQ1EVM)

位号	数量	值	说明	封装参考	器件型号	制造商
!PCB1	1		印刷电路板		LP160	不限
C1、C10、C15	3		电容, 陶瓷, 0.1uF, 50V, X7R, 0603	0603	C0603R104K5RAC	Kemet
C2	1	1μF	1μF 薄膜电容器, 1500V (1.5kV), 聚丙烯 (PP), 金属化径向	径向	C4AQSBU4100A1WJ	KEMET
C3、C9、C12、C14	4	1uF	电容, 陶瓷, 1μF, 25V, +/-10%, X7R, AEC-Q200 1 级, 0603	0603	GCM188R71E105KA64D	MuRata
C4、C7	2	10uF	电容, 陶瓷, 10μF, 25V, +/-20%, X5R, 0603	0603	GRT188R61E106ME13D	MuRata
C5、C6	2	0.01uF	电容, 陶瓷, 0.01μF, 25V, +/- 10%, X7R, 0402	0402	GRM155R71E103KA01D	MuRata
C8、C11	2	330nF	电容, 陶瓷, 330nF, 25V, X7R, 10%, 焊盘 SMD, 0603, +125°C, 汽车 T/R	0603	CGA3E3X7R1E334K080AB	TDK
D1	1	100V	二极管, 开关, 100V, 0.2A, SOT-23	SOT-23	BAS16LT1G	ON Semiconductor
D2	1		整流二极管 1.2KV 30A 汽车类 3 引脚 (2+Tab) H2PAK T/R	D2PAK-HV	STBR3012G2Y-TR	STMicroelectronics
D3	1		整流二极管开关 1.2KV 15A 75ns 汽车类 3 引脚 (2+Tab) D2PAK T/R	D2PAK	STTH1512GY-TR	STMicroelectronics
H1、H2、H3、H4	4			250x1500mil	4810	Keystone
J1	1		香蕉插头, 红色绝缘尼龙, TH	香蕉插头, 红色绝缘尼龙, TH	108-0902-001	Cinch Connectivity

表 5-1. 物料清单 (TPSI31PXQ1EVM) (续)

位号	数量	值	说明	封装参考	器件型号	制造商
J2	1		香蕉插头, 黑色绝缘尼龙, TH	香蕉插头, 黑色绝缘尼龙, TH	108-0903-001	Cinch Connectivity
J3、J4、J5、J6	4			CONN_TERM_BLOCK2	6.91251E+11	Würth Electronics
J7、J8、J17	3		接头, 2.54mm, 2x1, 金, TH	接头, 2.54mm, 2x1, TH	61300211121	Würth Elektronik
J9、J15	2		接头, 100mil, 3x1, 锡, TH	接头, 3 引脚, 100mil, 锡	PEC03SAAN	Sullins Connector Solutions
L1	1	100uH	功率电感器, PQ26, SMD	SMD2	ZF3172-AE	Coilcraft
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
MP1、MP2、MP3、MP4	4			STANDOFF_HEX_THRD_4-40	14HTSP019	Essentra Components
Q2	1		N 沟道 1200V 17A (Tc) 106W (Tc) 表面贴装 PG-TO263-7-12	D2PAK7	AIMBG120R160M1	Infineon
R1	1	0.125	电阻, 金属条, 2512, 0.125 Ω , 1%, 1W, $\pm 75\text{ppm}/^\circ\text{C}$, 模制 SMD, SMD, 压纹, 塑料 T/R	2512	WSL2512R1250FEA	Vishay
R2	1	200 μ	0 Ω 跳线 100A 2W 片式电阻器 2512 (公制 6432) 金属元件	2512	JR2512X100E	Ohmite
R3、R4、R5、R6、R9、R10、R15、R16	8	180k	电阻, 180k, 5%, 0.25W, AEC-Q200 0 级, 1206	1206	CRCW1206180KJNEA	Vishay-Dale
R7、R8	2	0	电阻, 0, 5%, 0.25W, AEC-Q200 0 级, 1206	1206	ERJ-8GEY0R00V	Panasonic
R11	1	294k	电阻, 294k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF2943X	Panasonic

表 5-1. 物料清单 (TPSI31PXQ1EVM) (续)

位号	数量	值	说明	封装参考	器件型号	制造商
R12	1	90.9k	电阻, 90.9k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF9092X	Panasonic
R13	1	100k	电阻, 100k, 5%, 0.125W, AEC-Q200 0 级, 0805	0805	ERJ-6GEYJ104V	Panasonic
R17	1	20.0k	电阻, 20.0k, 1%, 0.125W, AEC-Q200 0 级, 0805	0805	ERJ-6ENF2002V	Panasonic
R19、R21、R34	3	0	电阻, SMD, 0 Ω , 跳 线, 1/8W, 0805	0805	RC0805FR-070RL	Yageo
SH-J1、SH-J2、SH-J3、 SH-J4、SH-J5	5	1x2	分流器, 100mil, 镀金, 黑色	分流器	SNT-100-BK-G	Samtec
TP1、TP3、TP5、TP6、 TP7、TP8、TP9、 TP11、TP14、TP16、 TP18、TP19	12		测试点, 白色, 穿孔, RoHS, 大容量	5012		Keystone
TP2、TP24	2		测试点, 多用途, 红色, TH	红色通用测试点	5010	Keystone Electronics
TP10、TP13	2		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
TP25	1		测试点, 通用, 黄色, TH	黄色通用测试点	5014	Keystone Electronics
U1	1		具有集成栅极驱动器和辅 助电源的隔离式汽车级有 源预充电控制器	SSOP16	TPSI31P1QDVXRQ1	德州仪器 (TI)
U2	1		3V 至 36V 输入电压、 150mA、超低噪声、高 PSRR、低压降 (LDO) 线 性稳压器 DRB0008A (VSON-8)	DRB0008A	TPS7A4901DRBR	德州仪器 (TI)
U3	1		具有集成式 15V 栅极电源 的汽车级增强型隔离式开 关驱动器	SOIC8	TPSI3052QDWZRQ1	德州仪器 (TI)

表 5-1. 物料清单 (TPSI31PXQ1EVM) (续)

位号	数量	值	说明	封装参考	器件型号	制造商
D4	0	22V	二极管, TVS, 单向, 22V, 35.5Vc, 400W, 11.3A, SMA	SMA	SMAJ22A	Littelfuse
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
L2	0	100uH	功率电感器, PQ26, SMD	SMD2	ZF3172-AE	Coilcraft
L6	0	180uH	电源扼流圈 180uH 10% 8A 0.048 欧姆	径向	PCV-2-184-10L	Coilcraft
L7	0	180uH	IND 高电流射频扼流圈线 轴磁芯 180uH 10% 1KHz 铁氧体 11.4A RDL	径向	1140-181K-RC	Bourns
Q1	0		1200V 高速开关系列第三 代, PG-TO247-3-44, 管 式, 绿色环保	PG-TO247-3-44_A	IGW40N120H3	Infineon
Q3	0		N 沟道 1200V 17A (Tc) 136W (Tc) 表面贴装 D2PAK-7	D2PAK7	UF3C120150B7S	UnitedSiC
Q4	0	20V	MOSFET, N 沟道, 20V, 10A, DQK0006C (WSON-6)	DQK0006C	CSD15571Q2	德州仪器 (TI)
R14、R18、R35	0	0	电阻, SMD, 0Ω, 跳 线, 1/8W, 0805	0805	RC0805FR-070RL	Yageo

表 5-2. 物料清单 (TPSI31PXQ1EVM-400)

位号	数量	值	说明	封装参考	器件型号	制造商	备选器件型号	备选制造商
!PCB1	1		印刷电路板		LP160	不限		
C1、C10、C15	3		电容, 陶瓷, 0.1UF, 50V, X7R, 0603	0603	C0603R104K5RAC	Kemet		
C2	1	1μF	薄膜电容器 1uF 630V PP 5% (31.5mm X 9.5mm X 18mm) 径向 27.5mm 110C 汽车大容 量	径向	ECW-FG2J105J	Panasonic		

表 5-2. 物料清单 (TPSI31PXQ1EVM-400) (续)

位号	数量	值	说明	封装参考	器件型号	制造商	备选器件型号	备选制造商
C3、C9、C12、C14	4	1uF	电容, 陶瓷, 1μF, 25V, +/-10%, X7R, AEC-Q200 1 级, 0603	0603	GCM188R71E105KA 64D	MuRata		
C4、C7	2	10uF	电容, 陶瓷, 10μF, 25V, +/-20%, X5R, 0603	0603	GRT188R61E106ME1 3D	MuRata		
C5、C6	2	0.01uF	电容, 陶瓷, 0.01μF, 25V, +/- 10%, X7R, 0402	0402	GRM155R71E103KA 01D	MuRata		
C8、C11	2	330nF	电容, 陶瓷, 330nF, 25V, X7R, 10%, 焊盘 SMD, 0603, +125°C, 汽车 T/R	0603	CGA3E3X7R1E334K0 80AB	TDK		
D1	1	100V	二极管, 开关, 100V, 0.2A, SOT-23	SOT-23	BAS16LT1G	ON Semiconductor		
D2、D3	2		二极管 600V 30A 表面贴装 D2PAK	D2PAK	SDURB3060	SMC 二极管解决方案		
FID1、FID2、FID3	3		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		
H1、H2、H3、H4	4			250x1500mil	4810	Keystone		
J1	1		香蕉插头, 红色绝缘尼龙, TH	香蕉插头, 红色绝缘尼龙, TH	108-0902-001	Cinch Connectivity		
J2	1		香蕉插头, 黑色绝缘尼龙, TH	香蕉插头, 黑色绝缘尼龙, TH	108-0903-001	Cinch Connectivity		
J3、J4、J5、J6	4			CONN_TERM_BLOC K2	6.91251E+11	Würth Electronics		
J7、J8、J17	3		接头, 2.54mm, 2x1, 金, TH	接头, 2.54mm, 2x1, TH	61300211121	Würth Elektronik		
J9、J15	2		接头, 100mil, 3x1, 锡, TH	接头, 3 引脚, 100mil, 锡	PEC03SAAN	Sullins Connector Solutions		
L6	1	180uH	电源扼流圈 180uH 10% 8A 0.048 欧姆	径向	PCV-2-184-10L	Coilcraft		
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 5-2. 物料清单 (TPSI31PXQ1EVM-400) (续)

位号	数量	值	说明	封装参考	器件型号	制造商	备选器件型号	备选制造商
MP1、MP2、MP3、MP4	4			STANDOFF_HEX_TH RD_4-40	14HTSP019	Essentra Components		
Q2	1		MOSFET N 沟道 650V 17A (Tc) 85W (Tc) 表面贴装 PG-TO263-7-12	D2PAK-7	IMBG65R163M1HXT MA1	Infineon		
R1	1	0.15	电阻厚膜 2512 0.15Ω 1% 2W ±200ppm/°C 模制 SMD 塑料 T/R	2512	CSRN2512FKR150	Stackpole Electronics		
R2	1	200μ	0Ω 跳线 100A 2W 片式电阻器 2512 (公制 6432) 金属元件	2512	JR2512X100E	Ohmite		
R3、R4、R5、R6、R9、R10、R15、R16	8	180k	电阻, 180k, 5%, 0.25W, AEC-Q200 0 级, 1206	1206	CRCW1206180KJNE A	Vishay-Dale		
R7、R8	2	0	电阻, 0, 5%, 0.25W, AEC-Q200 0 级, 1206	1206	ERJ-8GEY0R00V	Panasonic		
R11	1	294k	电阻, 294k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF2943X	Panasonic		
R12	1	90.9k	电阻, 90.9k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF9092X	Panasonic		
R13	1	100k	电阻, 100k, 5%, 0.125W, AEC-Q200 0 级, 0805	0805	ERJ-6GEYJ104V	Panasonic		
R17	1	20.0k	电阻, 20.0k, 1%, 0.125W, AEC-Q200 0 级, 0805	0805	ERJ-6ENF2002V	Panasonic		
R19、R21、R34	3	0	电阻, SMD, 0Ω, 跳线, 1/8W, 0805	0805	RC0805FR-070RL	Yageo		
SH-J1、SH-J2、SH-J3、SH-J4、SH-J5	5	1x2	分流器, 100mil, 镀金, 黑色	分流器	SNT-100-BK-G	Samtec	969102-0000-DA	3M
TP1、TP3、TP5、TP6、TP7、TP8、TP9、TP11、TP14、TP16、TP18、TP19	12		测试点, 白色, 穿孔, RoHS, 大容量	5012		Keystone		
TP2、TP24	2		测试点, 多用途, 红色, TH	红色通用测试点	5010	Keystone Electronics		

表 5-2. 物料清单 (TPSI31PXQ1EVM-400) (续)

位号	数量	值	说明	封装参考	器件型号	制造商	备选器件型号	备选制造商
TP10、TP13	2		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		
TP25	1		测试点，通用，黄色，TH	黄色通用测试点	5014	Keystone Electronics		
U1	1		具有集成栅极驱动器和辅助电 源的隔离式汽车级有源预充电 控制器	SSOP16	TPSI31P1QDVXRQ1	德州仪器 (TI)		
U2	1		3V 至 36V 输入电压、 150mA、超低噪声、高 PSRR、低压降 (LDO) 线性稳 压器 DRB0008A (VSON-8)	DRB0008A	TPS7A4901DRBR	德州仪器 (TI)	TPS7A4901DRBT	德州仪器 (TI)
U3	1		具有集成式 15V 栅极电源的汽 车级增强型隔离式开关驱动器	SOIC8	TPSI3052QDWZRQ1	德州仪器 (TI)		
D4	0	22V	二极管，TVS，单向，22V， 35.5Vc，400W，11.3A，SMA	SMA	SMAJ22A	Littelfuse		
L1、L2	0	100uH	功率电感器，PQ26，SMD	SMD2	ZF3172-AE	Coilcraft		
L7	0	180uH	IND 高电流射频扼流圈线轴磁 芯 180uH 10% 1KHz 铁氧体 11.4A RDL	径向	1140-181K-RC	Bourns		
Q1	0		1200V 高速开关系列第三代， PG-TO247-3-44，管式，绿色 环保	PG-TO247-3-44_A	IGW40N120H3	Infineon		
Q3	0		N 沟道 1200V 17A (Tc) 136W (Tc) 表面贴装 D2PAK-7	D2PAK7	UF3C120150B7S	UnitedSiC		
Q4	0	20V	MOSFET，N 沟道，20V， 10A，DQK0006C (WSON-6)	DQK0006C	CSD15571Q2	德州仪器 (TI)		无
R14、R18、R35	0	0	电阻，SMD，0Ω，跳线， 1/8W，0805	0805	RC0805FR-070RL	Yageo		

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 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 B (April 2025) to Revision C (January 2026)	Page
• 更新了“物料清单”	13

Changes from Revision A (January 2025) to Revision B (April 2025)	Page
• 更新了内容，以在整个文档中反映修订版 C 电路板的更改	1
• 添加了介绍 TPSI31P1-CALC 计算器工具的 <i>软件</i> 部分	6

Changes from Revision * (August 2024) to Revision A (January 2025)	Page
• 通篇更新了新型号 TPSI31PXQ1EVM 的内容	1

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 instructions, 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。

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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/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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