EVM User's Guide: BQ25640EVM

BQ25640 评估模块

说明

BQ25640EVM 评估模块 (EVM) 是适用于 BQ25640 IC 的完整评估系统，后者是一款采用 WQFN 封装，具有 3.9V 至 18V 输入范围和 NVDC 电源路径管理的开关模式单节降压电池充电器。

BQ25640EVM 的最大工作输入电压为 18V，最大充电电流为 5A。

开始使用

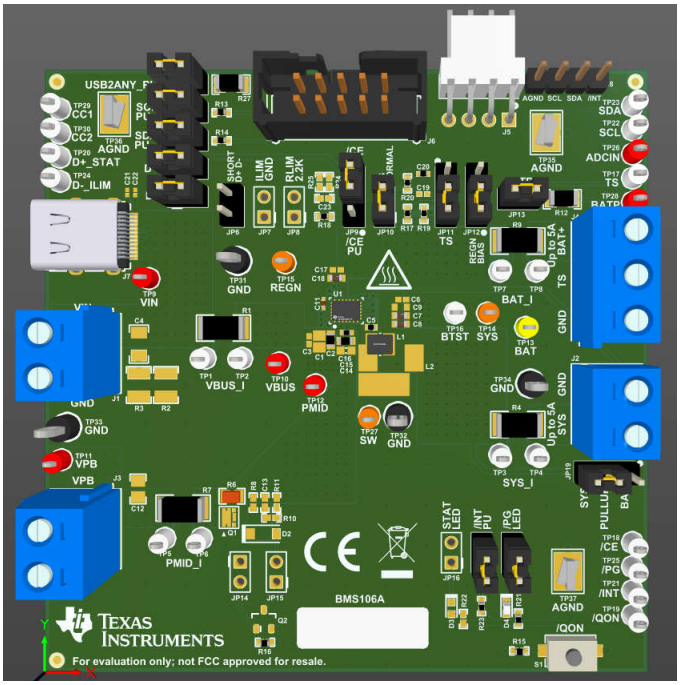
1. 在 ti.com 上订购 EVM。
2. 订购 EV2400 以用于与 EVM 通信。
3. 下载 BQ25640 BQZ 文件。
4. 在 ti.com 上下载 BQ25640 EVM 设计文件。

特性

- 窄 VDC (NVDC) 电源路径管理，用于系统供电和电池充电。
- 支持用于系统配置和状态报告的 I2C 通信。
- 关键信号的测试点可用于测试用途。
- 使用跳线轻松进行配置。
- 通过可调节计时器实现单按钮唤醒和重置输入。
- 用于 USB Type-C 检测评估的 USB Type-C 连接器。
- EV2400 和 USB2ANY 的连接。

应用

- 消费类可穿戴设备、智能手表
- 便携式扬声器、TWS 耳机
- IP 摄像头、EPOS
- 便携式医疗设备



BQ25640EVM 硬件板

1 评估模块概述

1.1 简介

BMS106 评估模块 (EVM) 是一个完整的充电器模块，用于评估 BQ25640 器件。BQ25640 是具有 NVDC 电源路径管理、集成 ADC、USB Type-C 检测和 OTG 模式输出的 I^2C 控制型单节电池充电器。

本用户指南提供了 BQ25640 评估模块 (EVM) 的详细测试说明。此外还包括对必要设备、设备设置和测试流程的说明。参考文档包含印刷电路板布局布线、原理图和物料清单 (BOM)。

除非另有说明，否则本用户指南中的所有缩写词 *EVM*、*BQ25640EVM*、*BMS106* 以及术语 *评估模块*与 BMS106 评估模块具有相同的含义。

	**注意**	**注意：表面高温。 接触会导致烫伤。 请勿触摸！**

1.2 套件内容

套件包括：

- 1 块 BQ25640 EVM

1.3 规格

表 1-1 列出了该 EVM 的建议运行条件。

表 1-1. 建议运行条件

符号	说明	最小值	典型值	最大值	单位
V_{VBUS}、V_{VIN}	施加到 VBUS 引脚的输入电压	3.9		18.0	V
V_{BAT}	施加到 BAT 引脚的电池电压			4.8	V
I_{VBUS}	VBUS 的输入电流			3.2	A
I_{SW}	从 SW 流入 SYS 引脚负载和 BAT 引脚上电池的输出电流			5.0	A
I_{BAT}	BAT 引脚上流入电池的快速充电电流			5.0	A
	流经内部 BATFET 的持续 RMS 放电电流			10	A

1.4 器件信息

此 EVM 不包含 EV2400 或 USB2ANY 接口板。若要评估 EVM，必须单独订购 EV2400 以评估具有 BQ25640 bqz GUI 的 EVM。

有关详细特性和运行情况，请参阅 表 1-2 以了解相应的数据表。

表 1-2. 器件数据表

器件	数据表	EVM 标签
BQ25640	SLVSIK1	BQ25640EVM

2 硬件

2.1 接头信息

表 2-1 列出了此 EVM 上提供的输入和输出连接及相应的说明。

表 2-1. EVM I/O 连接

插孔	说明
J1(1) - VIN	充电器输入电压的正电源轨
J1(2) - GND	接地
J2(1) - SYS	充电器系统输出电压的正电源轨，通常连接到系统负载
J2(2) - GND	接地
J3(1) - VPB	反向升压模式 (OTG) 下移动电源应用的充电器输出电压正电源轨。在正向降压模式下，该输出还与 VIN 输入轨共享电源轨
J3(2)-GND	接地
J4(3) - BAT+	充电器电池输入的正电源轨，连接到外部电池的正极端子
J4(2) - TS	如果需要，可连接外部热敏电阻
J4(1) - GND	接地
J5	适用于 EV2400 接口板的 I^2C 连接器
J6	适用于 USB2ANY 接口板的 I^2C 连接器
J7	输入源 USB Type-C 端口
J8	4 引脚连接器可用于 I^2C 线路和 INT（如果与 MCU 接合）

2.2 跳线信息

表 2-2 列出了此 EVM 上提供的跳线和分流器安装装置及相应的说明。

表 2-2. EVM 跳线分流器和开关装置

插孔	说明	BQ25640 设置
JP1	USB2ANY 上拉电源轨。如果使用 EV2400，则不需要。	已安装
JP2	SCL 上拉电源轨。如果使用 EV2400，则不需要。	已安装
JP3	SDA 上拉电源轨。如果使用 EV2400，则不需要。	已安装
JP4	USB Type C 端口输入 D+ 连接至充电器 D+ 引脚。	已安装
JP5	USB Type C 端口输入 D- 连接至充电器 D- 引脚。	已安装
JP6	短接充电器 D+ 和 D- 引脚。在此项以模拟 USB BC1.2 定义的 DCP 型 USB 端口的连接。	未安装
JP7	D-_ILIM 接地。	未安装
JP8	D-_ILIM 至 2.2kΩ 连接。	未安装
JP9	$\overline{CE}$ 引脚接地或上拉，以启用/禁用充电。当 $\overline{CE}$ 连接到上拉电阻时，短接引脚 1-2，禁用充电。	引脚 2-3 短接
JP10	将 10kΩ 电阻器与 TS 电阻器网络并联以模拟 25°C 下的电池。如果使用外部热敏电阻，则断开连接。	已安装
JP11	充电器 TS 引脚和 ADCIN 之间的选择器。	引脚 2-3 短接
JP12	引脚 7 和引脚 19 之间的选择器用作 TS 电阻器网络的上拉电阻。	引脚 2-3 短接
JP13	BATP 引脚连接至 J4 上的 BAT+。	已安装
JP14	$\overline{PG}$ 引脚连接至 REGN。	未安装
JP16	连接 D+_STAT 引脚和 LED 指示器。	未安装
JP17	$\overline{INT}$ 引脚连接到上拉电源轨。	已安装
JP18	连接 $\overline{PG}$ 引脚和 LED 指示器。在支持 $\overline{PG}$ 的充电器上，这指示电源正常状态。	已安装
JP19	I/O 上拉电源轨选择。选择使用 BAT 或 SYS 作为上拉电源轨。	引脚 2-3 短接
S1	$\overline{QON}$ 控制开关。按下可退出运输模式或系统复位。	默认关闭

2.3 设备

本节列出了在此 EVM 上执行测试时所需的电源。

1. **电源：**1 号电源 (PS #1)：需要一个能够提供 5V 电压、3.5A 电流的电源。虽然此器件可以处理更大的电压和电流，但在此过程中无需这样。
2. **负载 1 用于模拟电池：**四象限电源，恒定电压 < 4.5V）“Kepco”负载，BOP，20-5M，0V 至 ±20V 直流电压，0A 至 ±5A 电流（或更高）
   替代选项：一个 0 – 20V/0 – 3.5 A、> 30W 的直流电子负载设置为恒定电压负载模式
3. **负载 2 用于在反向/OTG 模式下模拟 SYS 处的负载或 VBUS 处的负载：**电子或电阻负载能够在高达 9V（或更高）的电压下提供高达 5A 的灌电流
4. **仪表：**4 个“Fluke 75”万用表（性能相当或更高）。
   替代选项：（2 个）等效电压表和（2 个）等效 5A 或额定值更高的电流表。
5. **计算机：**至少有一个 USB 端口和一条 USB 电缆的 Windows 10 或 11 计算机。必须已安装 Battery Management Studio 的最新版本。
6. **USB-TO-GPIO 通信套件：**EV2400 基于 USB 的 PC 接口板。
7. **软件：**BQStudio 软件，包含德州仪器 (TI) 提供的适用于 BQ25640 的最新 .bqz 文件。从 https://www.ti.com.cn/tool/cn/BQSTUDIO 下载 bqStudio 并安装该软件。

2.4 硬件设置

使用以下列表来设置 EVM 测试设备：

1. 请查看表 2-2 中的 EVM 跳线连接。
2. 将 PS #1 设置为 5V 直流、2A 电流限值，然后关闭电源。
3. 将 PS#1 的输出与一个电流表串联在一起，然后连接到 J1（VIN 和 PGND）。
4. 在 TP10 (VBUS) 和 TP31 (PGND) 之间或 J1 上连接一个电压表。
5. 打开负载 #1，设置为恒压模式并将输出设置为 2.5V。禁用负载。如图 2-1 中所示，将负载与电流表（万用表）串联到 J4（BAT 和 PGND）接地侧，不使用具有电流测量功能的源表。
6. 在 TP13 (BAT) 和 TP32 (PGND) 之间或者在 J4-3 和 J4-1 之间连接一个电压表，如图 2-1 中所示。
7. 在 TP14 (SYS) 和 TP32 (PGND) 之间或者在 J2-1 和 J2-2 之间连接一个电压表，如图 2-1 中所示。
8. 在 TP12 (PMID) 和 TP32 (PGND) 之间连接一个电压表。
9. 使用 USB 电缆将 EV2400 USB 接口板连接到计算机，使用 4 引脚电缆从 I2C 端口连接到 J10，如图 2-1 所示。
10. 按表 2-2 中所示安装分流器。请注意，图 2-1 中的分流器不一定按照表进行安装。

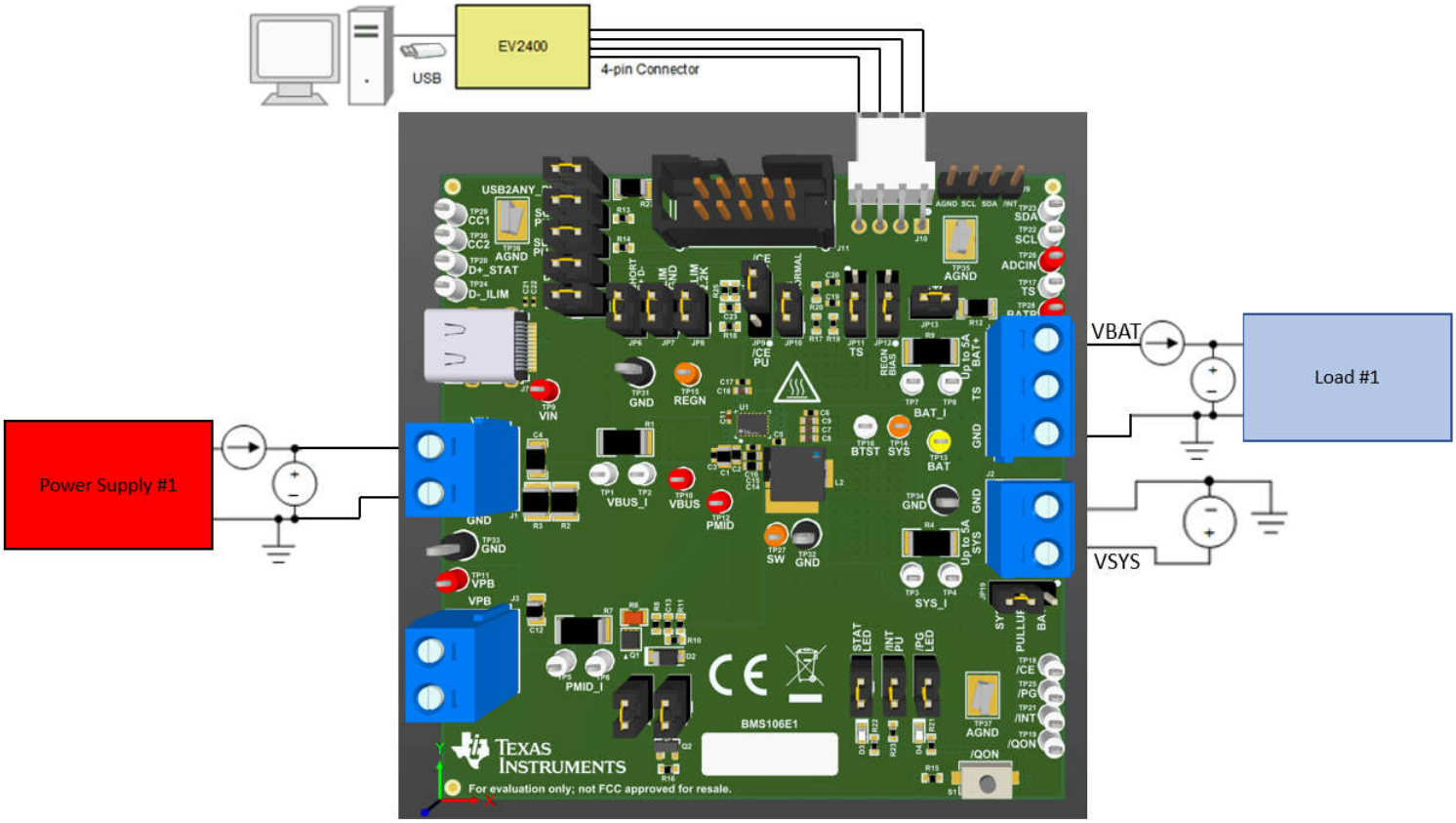


图 2-1. BQ25640 EVM 的测试设置

3 软件

3.1 软件设置

使用以下列表来设置 EVM 测试软件：

1. 在连接到 EV2400 接口板的计算机上，启动 Battery Management Studio (BQStudio)。如图 3-1 中所示选择“Charger”。

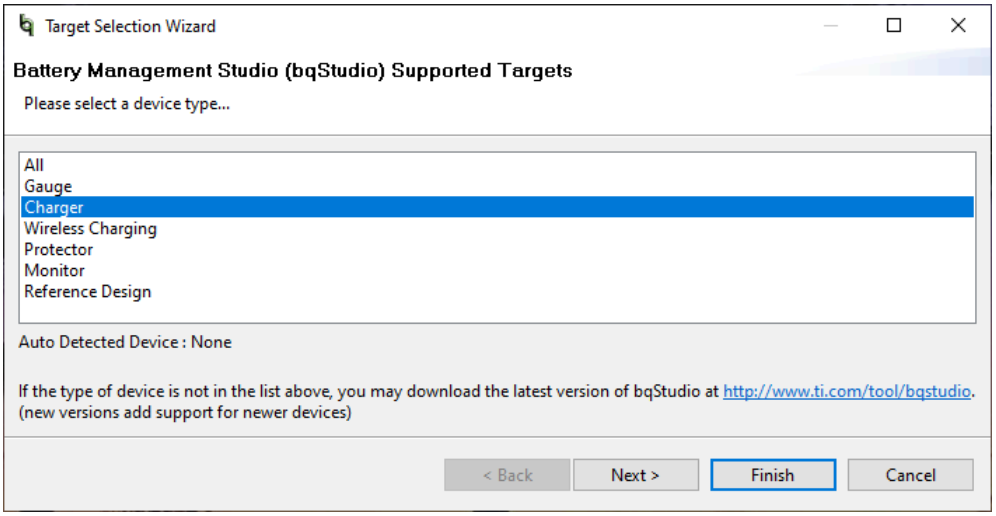


图 3-1. BQStudio 器件类型选择窗口

2. 从图 3-2 中所示的窗口中根据器件 BQ25640 选择适当的配置文件。

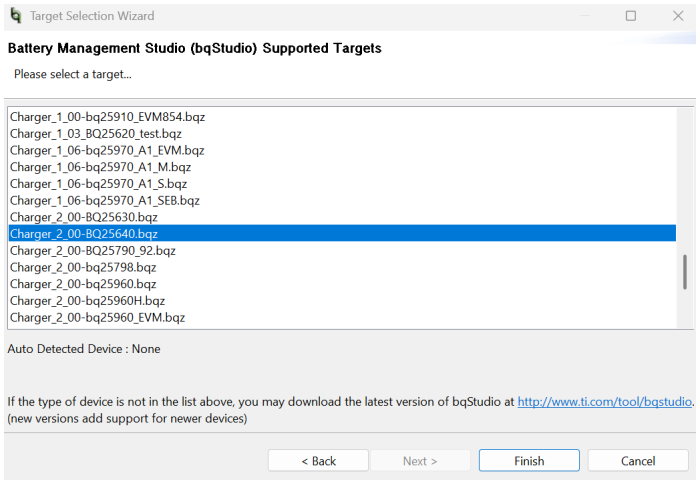
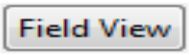


图 3-2. BQStudio 充电器选择窗口（选择 Charger_2_00-bq25640.bqz）

3. 在随即显示的窗口中选择 

，然后出现 BQ25640 EVM 软件的主窗口，如图 3-3 中所示。

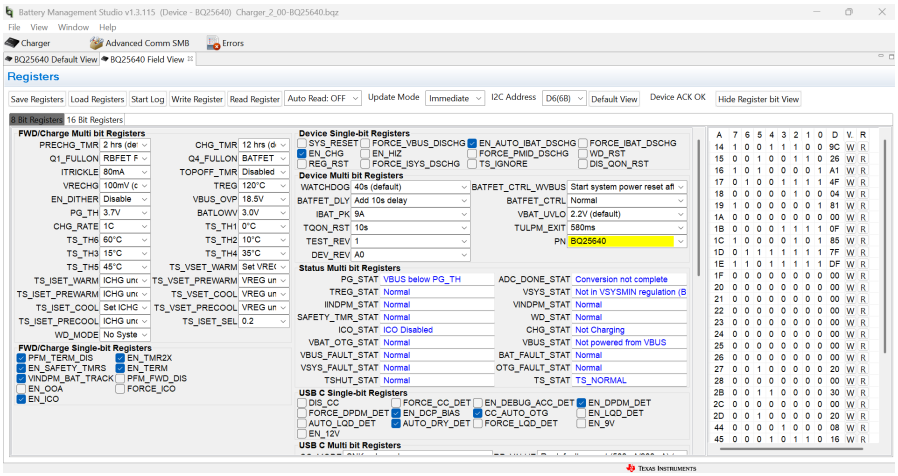


图 3-3. BQ25640 EVM 软件的主窗口

3.2 测试程序

3.2.1 初始上电

执行以下步骤来启用 EVM 测试设置：

1. 确保已遵循节 2.4 中的步骤。
2. 确保已遵循节 3.1 中的步骤。
3. 打开 PS #1：
   - **测量** →V_{SYS}（SYS-TP19 和 PGND-TP21）= 3.70V ±0.2V

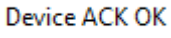
备注

如果检测到不同的值，则将负载 #1 与 BATTERY 连接完全断开。

3.2.2 I^2C 寄存器通信验证

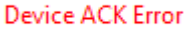
执行以下步骤进行通信验证：

1. 在 EVM 软件中，点击 

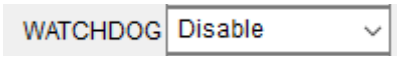
按钮
   - 验证 GUI 在右上角是否显示 

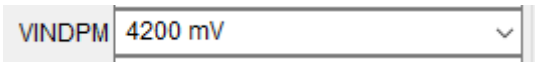
。

备注

如果器件显示 

，确认已执行节 2.4 和节 3.2.1 中的步骤。

2. 在 Field View（请参阅图 3-3）中，根据需要进行以下更改：
   - 设置 

   - 设置 

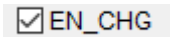
   - 设置 

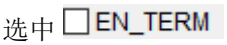
   - 设置 

   - 设置 

   - 设置 

   - 设置 

   - 选中 

   - 取消选中 

3.2.3 充电器模式验证

执行以下步骤进行充电器模式验证：

1. 从节 3.2.1 打开 PS #1。在 EVM 软件中，选择 Read Register 两次。
   - 验证所有故障状态是否均显示为*正常*。

Status Multi bit Registers

PG_STAT	VBUS above PG_TH	ADC_DONE_STAT	Conversion not complete
TREG_STAT	Normal	VSYS_STAT	In VSYSMIN regulation (BAT < VS
IINDPM_STAT	Normal	VINDPM_STAT	Normal
SAFETY_TMR_STAT	Normal	WD_STAT	Normal
ICO_STAT	ICO Routine Suspended	CHG_STAT	Pre-charge
VBAT_OTG_STAT	Normal	VBUS_STAT	Unknown adaptor (3.2A or result c
VBUS_FAULT_STAT	Normal	BAT_FAULT_STAT	Normal
VSYS_FAULT_STAT	Normal	OTG_FAULT_STAT	Normal
TSHUT_STAT	Normal	TS_STAT	TS_NORMAL

2. 要确认 SYS 电压调节，请启用负载 1（请参阅节 2.4）并按如下方式进行 DMM 测量：
   - **测量** → V_{SYS}（SYS-TP14 和 PGND-TP27 或 TP29）= 3.75V ±0.3V。
   - **测量** → V_{BAT}（BAT-TP13 和 PGND-TP27 或 TP29）= 2.5V ±0.2V。
   - **测量** → I_{BAT} = 200mA ±50mA。
3. 要确认电池充电电流调节，请将负载 1 更改为 3.7V 并按如下方式进行 DMM 测量：
   - **测量** → V_{SYS}（SYS-TP14 和 PGND-TP27 或 TP29）= 3.8V ±0.3V。
   - **测量** → V_{BAT}（BAT-TP13 和 PGND-TP27 或 TP29）= 3.7V ±0.2V。
   - **测量** → I_{BAT} = 480mA ±100mA。
4. 要确认输入电流限制操作，请在 EVM 软件的 16 位选项卡中，将快速充电电流设置为 1040mA，然后进行 DMM 测量（如果准确，则进行 PS #1 测量），如下所示：
   - **测量** → I_{IN} = 500mA ±200mA。

3.2.4 升压模式验证

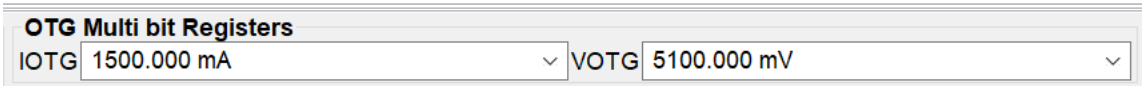
执行以下步骤进行升压模式验证：

1. 关闭并断开 1 号 PS。
2. 将负载 1（电池模拟器）设置为 3.7V 和 2A 的电流限值。

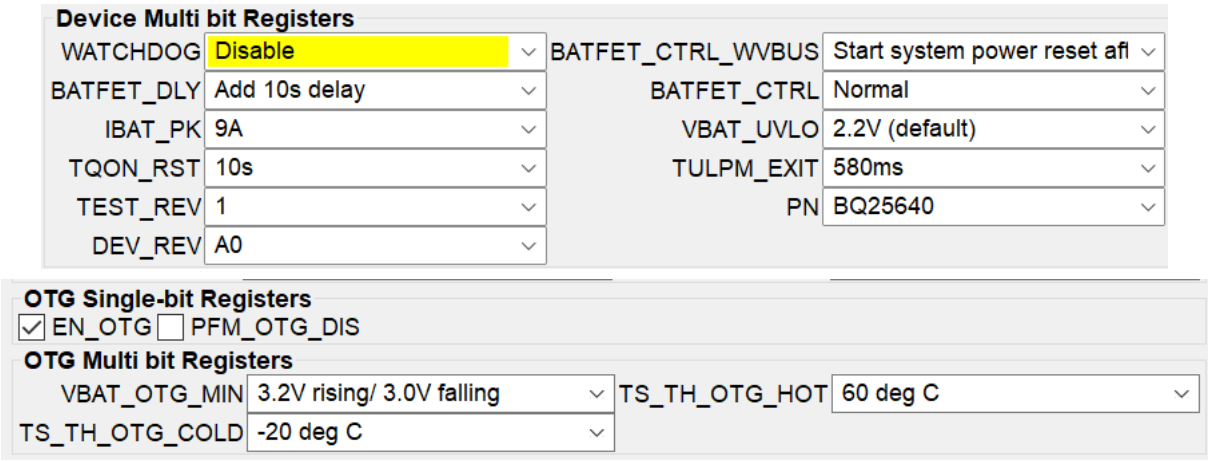
备注

如果从 BATTERY-J4(3) 连接到 GND-J4(1) 的负载 1 不是四象限电源，则移除负载 1 并使用 PS #1，设置为 3.7V、2A 电流限制，并连接到 BATTERY-J4(3) 和 GND-J4(1)。

3. 在 EVM 软件的 16 位选项卡上，确认将 OTG 调节电压 VOTG 设置为 5040mV，并将 OTG 电流限制 IOTG 设置为 1000mA。



4. 在 EVM 软件的 8 位选项卡上，禁用看门狗，然后勾选 EN_OTG。



5. 将负载 2 连接到 VPB-J3 (1)和 PGND-J3 (2) 之间或者 VIN-J1 (2) 和 PGND-J1 (1) 之间
6. 将负载 2 设置为 500mA 恒流负载并打开负载。
7. 为确认 VOTG 调节，
   - **测量→** V_{BUS} = 5100mV + 155mV
8. 关闭并断开电源。
9. 断开负载 2 的连接。

3.2.5 实用技巧

1. 连接到各种电源、电池和负载的导线和电缆都具有电阻。电流表也具有串联电阻。充电器会根据 VBUS 引脚（使用 VINDPM 功能）、BAT 引脚（作为正常端接的一部分）和 TS 引脚（通过电池热敏电阻的电池温度监控功能）处检测到的电压，动态减小充电电流。因此，必须使用电压表在尽可能靠近 IC 引脚的位置测量电压，而不要依赖于电源的数字读数。如果电池热敏电阻不可用，则会对 JP13 进行分流。
2. 使用可像电池模拟器那样拉出和灌入电流的源表时，TI 强烈建议在 EVM BATTERY 和 GND 连接器处添加一个 (>=1000+ μF) 大电容器，以防 BAT 引脚处因为充电器输出和源表输入在各自调节环路带宽内的阻抗不匹配而出现振荡。通过将源表配置用于 4 线检测，便无需单独的电压表来测量 BAT 引脚处的电压。采用 4 线检测时，应始终确保正确连接检测导线，以防电源线上意外出现过压。
3. 为了精确测量输入和输出电流，尤其是在靠近端接时，与电池或电池模拟器串联的电流表不得设置为自动量程，而需要完全移除。测量充电电流的另一种方法是使用带有霍尔效应电流探针的示波器或通过在 BQ25640EVM 上组装的相关检测电阻上进行差分电压测量。

4 硬件设计文件

4.1 原理图

图 4-1 展示了该 BQ25640EVM 的原理图。

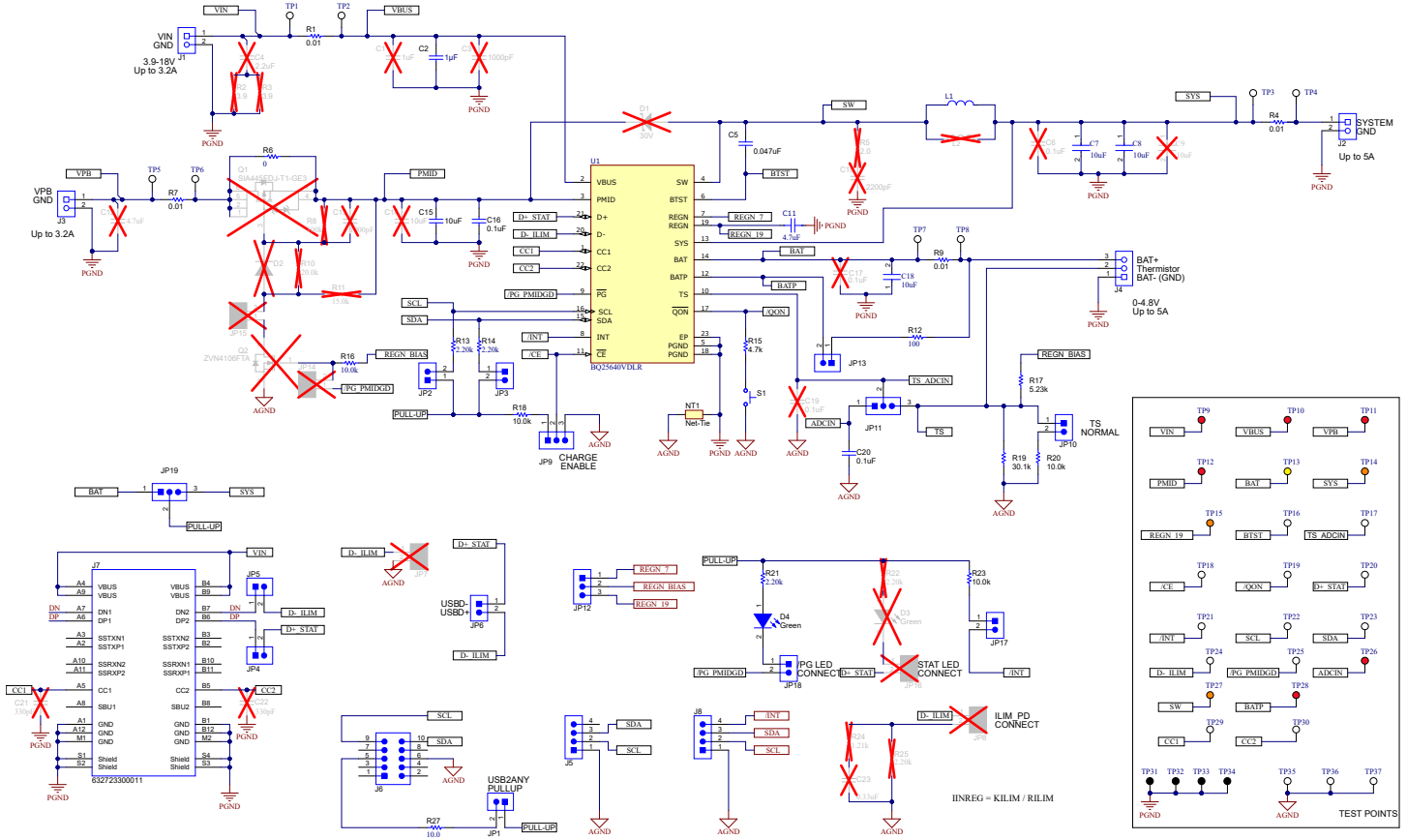


图 4-1. BQ25640EVM 原理图

English Document: SLVUDD7

4.2 PCB 布局

以下各图展示了 PCB 板层。

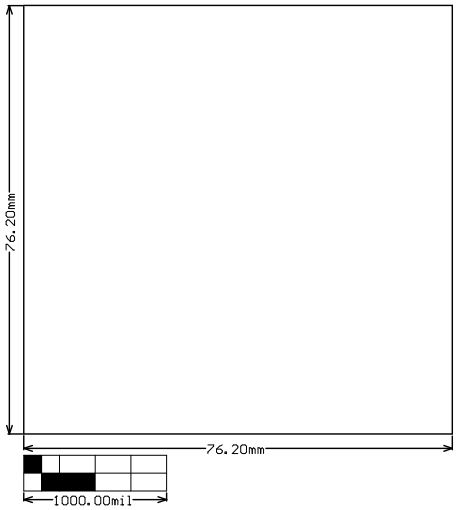


图 4-2. BMS106 电路板尺寸

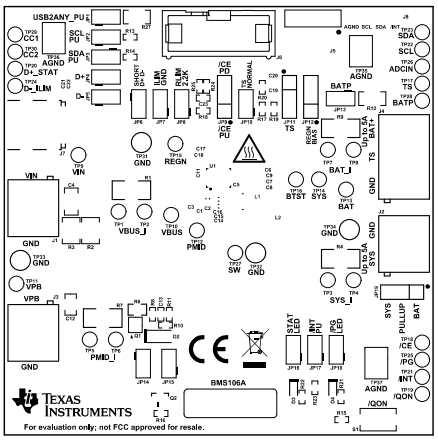


图 4-3. BMS106 顶部丝印

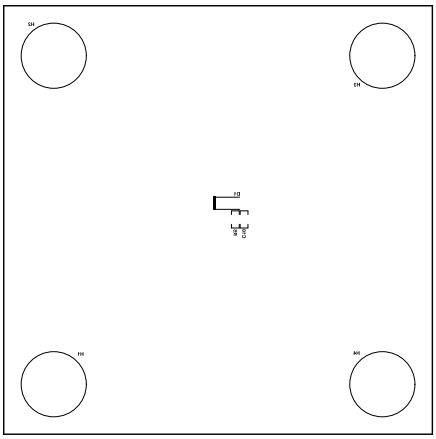


图 4-4. BMS106 底部覆盖层

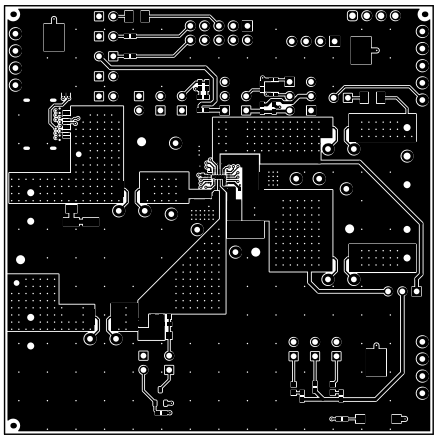


图 4-5. BMS106 顶层

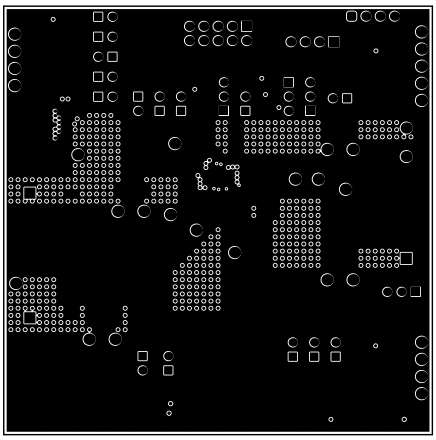


图 4-6. BMS106 信号层 1

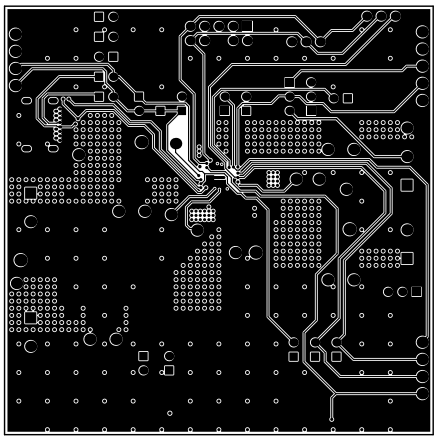


图 4-7. BMS106 信号层 2

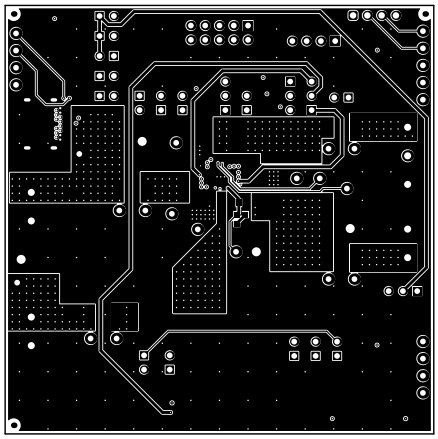


图 4-8. BMS106 底层

4.2.1 PCB 布局指南

为了尽可能减少开关损耗，必须尽可能缩短开关节点的上升和下降时间。为了防止电场和磁场辐射以及高频谐振问题，采用合适的元件布局来尽可能简化高频电流路径环路非常重要。请仔细按照以下特定顺序来实现正确的布局。

1. 将输入电容器尽可能靠近 PMID 引脚和 GND 引脚连接放置，并使用尽可能短的覆铜线迹连接或 GND 层。
2. 将电感器输入引脚放置在尽可能靠近 SW 引脚的位置。最大限度地减小此布线的覆铜面积，以减少电场和磁场辐射，但应确保该布线足够宽，能够承载充电电流。不要为此连接并联使用多个层。更大限度地降低从此区域到任何其他布线或平面的寄生电容。
3. 将输出电容器靠近电感器和器件放置。需要通过短铜引线连接或 GND 平面将接地接头连接至 IC 接地端。
4. 将去耦电容器靠近 IC 引脚放置，并尽量缩短引线连接。
5. 确保过孔的数量和尺寸允许给定电流路径有足够的铜。

如需了解建议的元件放置方式以及布线和过孔位置，请参阅 EVM 设计。

4.3 物料清单 (BOM)

表 4-1. 物料清单

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		BMS106	
C2	1	1μF	电容，陶瓷，1μF，35V，+/– 10%，X7R，AEC-Q200 0 级，0603	603	GMK107AB7105KAHT	Taiyo Yuden
C5	1	0.047μF	电容，陶瓷，0.047μF，25V，+/-10%，X7R，0402	402	GRM155R71E473KA88D	MuRata
C11	1	4.7μF	4.7μF +/-20% 16V 陶瓷电容器 X5R 0402（公制 1005）	402	0402YD475MAT2A	KYOCERA AVX
C7、C8、C18	3	10μF	通用片状多层陶瓷电容器，0603，10μF，X7T，+22%/-33%，10%，10V	603	GRM188D71A106KA73D	MuRata
C15	1	10μF	电容，陶瓷，10μF，25V，+/-20%，X5R，0603	603	GRT188R61E106ME13D	MuRata
C16、C20	2	0.1μF	电容，陶瓷，0.1μF，50V，+/-10%，X7R，0402	402	C1005X7R1H104K050BE	TDK
D4	1	绿色	LED，绿色，SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
FID1、FID2、FID3、FID4、FID5、FID6	6		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		Bumpon，半球形，0.44 × 0.20，透明	透明 Bumpon	SJ-5303 (CLEAR)	3M
J1、J2、J3	3		端子块，5.08mm，2x1，黄铜，TH	2x1 5.08mm 端子块	ED120/2DS	On-Shore Technology
J4	1		端子块，5.08mm，3x1，黄铜，TH	3x1 5.08mm 端子块	ED120/3DS	On-Shore Technology
J7	1		连接器，插口，USB Type C，R/A，THT/SMT	8.54x2.96x11.2mm	632723300011	Wurth Elektronik
J8	1		接头，2.54mm，4x1，金，TH	4x1 接头	61300411121	Wurth Elektronik
J6	1		接头（有罩），100mil，5x2，高温，镀金，TH	5x2 有罩接头	N2510-6002-RB	3M
J5	1		接头（摩擦锁），100mil，4x1，R/A，TH	4x1 R/A 接头	22053041	Molex
JP1、JP2、JP3、JP4、JP5、JP6、JP10、JP13、JP17、JP18	10		接头，100mil，2x1，锡，TH	接头，2 引脚，100mil，锡	PEC02SAAN	Sullins Connector Solutions
JP9、JP11、JP12、JP19	4		接头，100mil，3x1，锡，TH	接头，3 引脚，100mil，锡	PEC03SAAN	Sullins Connector Solutions
L1	1	1μH	屏蔽绕线电感器 1μH 20% 6.7A 0.019Ω DCR 1210	1210	DFE322520F-1R0M=P2	MuRata
LBL1	1		热转印可打印标签，0.650"（宽）× 0.200"（高）- 10,000/卷	PCB 标签 0.650 × 0.200 英寸	THT-14-423-10	Brady

表 4-1. 物料清单（续）

位号	数量	值	说明	封装参考	器件型号	制造商
R1、R4、R7、R9	4	0.01	电阻，0.01，1%，1W，2010	2010	WSL2010R0100FEA18	Vishay-Dale
R16、R18、R20 R23	4	10.0k	电阻，10.0k，1%，0.063W，AEC-Q200 0 级，0402	402	CRCW040210K0FKED	Vishay-Dale
R13、R14、R21	3	2.20k	电阻，2.20k，1%，0.063W，AEC-Q200 0 级，0402	402	CRCW04022K20FKED	Vishay-Dale
R27	1	10	电阻，10.0，1%，0.25W，AEC-Q200 0 级，1206	1206	CRCW120610R0FKEA	Vishay-Dale
R17	1	5.23k	电阻，5.23k，1%，0.063W，AEC-Q200 0 级，0402	402	CRCW04025K23FKED	Vishay-Dale
R15	1	4.7k	电阻，4.7k，5%，0.063W，AEC-Q200 0 级，0402	402	CRCW04024K70JNED	Vishay-Dale
R19	1	30.1k	电阻，30.1k，1%，0.063W，AEC-Q200 0 级，0402	402	CRCW040230K1FKED	Vishay-Dale
R12	1	100	电阻，100，1%，0.25W，AEC-Q200 0 级，1206	1206	CRCW1206100RFKEA	Vishay-Dale
R6	1	0	电阻，0，1%，0.5W，0805	0805	5106	Keystone
S1	1		开关，常开，2.3N 力，200k 次运行，SMD	KSR	KSR221GLFS	C&K Components
SH-JP1、SH-JP2、SH-JP3、SH-JP4、SH-JP5、SH-JP9、SH-JP10、SH-JP11、SH-JP12、SH-JP13、SH-JP17、SH-JP18、SH-JP19	13	1x2	分流器，100mil，镀金，黑色	分流器	SNT-100-BK-G	Samtec
TP1、TP2、TP3、TP4、TP5、TP6、TP7、TP8、TP16、TP17、TP18、TP19、TP20、TP21、TP22、TP23、TP24、TP25、TP29、TP30	20		测试点，微型，白色，TH	白色微型测试点	5002	Keystone Electronics
TP9、TP10、TP11、TP12、TP26、TP28	6		测试点，微型，红色，TH	红色微型测试点	5000	Keystone Electronics
TP13	1		测试点，微型，黄色，TH	黄色微型测试点	5004	Keystone Electronics
TP14、TP15、TP27	3		测试点，微型，橙色，TH	橙色微型测试点	5003	Keystone Electronics
TP31、TP32、TP33、TP34	4		测试点，多用途，黑色，TH	黑色通用测试点	5011	Keystone Electronics

表 4-1. 物料清单（续）

位号	数量	值	说明	封装参考	器件型号	制造商
TP35、TP36、TP37	3		测试点，紧凑型，SMT	Testpoint_Keystone_Compact	5016	Keystone Electronics
U1	1		具有 NVDC 电源路径管理和 USB Type-C 检测的 I2C 控制型 5A、最大 18V 输入充电器	WQFN 22	BQ25640VDLR	德州仪器 (TI)

5 其他信息

商标

所有商标均为其各自所有者的财产。

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

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

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

NOTE:

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

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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

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

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

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

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做出任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 TI 销售条款)、TI 通用质量指南 或 ti.com 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。 除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

最后更新日期：2025 年 10 月