EVM User's Guide: BQ25350EVM

BQ25350 评估模块

说明

BQ25350 评估模块 (EVM) 是适用于 BQ25350 集成电路的完整评估系统，BQ25350 集成电路是一款具有 2.5V 至 5.5V 输入范围和 NVDC 电源路径管理的单节降压/升压电池充电器。BQ25350EVM 的最大输入电压为 5.5V，最大充电电流为 3A。

开始使用

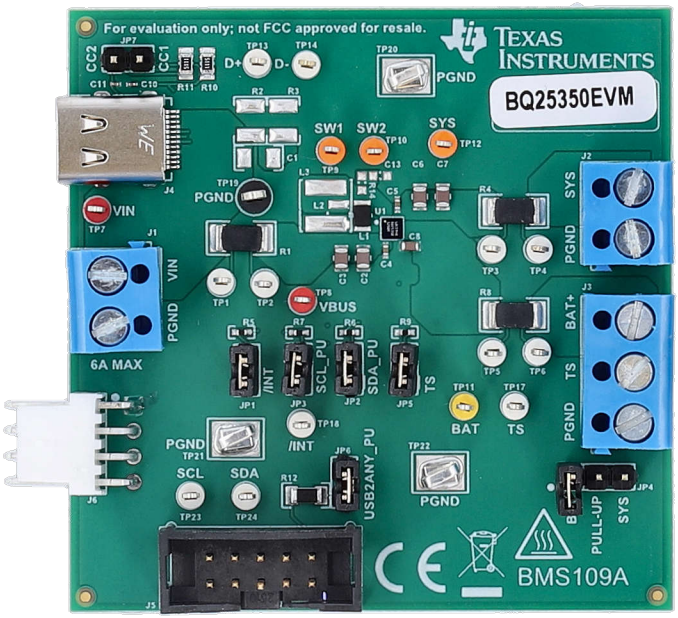
1. 在 ti.com 上订购 EVM。
2. 订购 EV2400 或 USB2ANY 以便与 EVM 通信。
3. 如果使用 EV2400，请下载 BQ25350 BQZ 文件。
4. 在 ti.com 上下载 BQ25350 EVM 设计文件。

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 I^2C 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
- EV2400 或 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



BQ25350EVM 硬件板

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1 评估模块概述

1.1 简介

BMS109 评估模块 (EVM) 是一个完整的充电器模块，用于评估 BQ25350 器件。BQ25350 是一款 I²C 控制型单节电池充电器，在运输模式下具有 0.7 µA 的超低 IQ，并且具有 NVDC 电源路径管理和 BATFET 控制功能，用于支持运输模式和完全系统复位。

本用户指南提供了 BQ25350 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 (PCB) 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*、*BQ25350EVM*、*BMS109* 及术语 *评估模块* 与 BMS109 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 BQ25350 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	2.5		5.5	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			3	A
I_{BAT}	BAT 引脚上流入电池的快速充电电流			3	A
	流经内部 BATFET 的持续 RMS 放电电流			5	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 或 USB2ANY 以评估具有 BQ25350 bqz GUI 或 TI Charger GUI 的 EVM。

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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) - GND	接地
J2(2) - SYS	充电器系统输出电压的正电源轨，通常连接到系统负载
J3(1) - GND	接地
J3(2) - TS	如果需要，可连接外部热敏电阻
J3(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	输入源 USB Type-C™ 端口
J5	适用于 USB2ANY 接口板的 I^2C 连接器
J6	适用于 EV2400 接口板的 I^2C 连接器

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	BQ25350 设置
JP1	/INT 上拉	已安装
JP2	SDA 上拉电源轨。如果使用 EV2400，则不需要	未安装
JP3	SCL 上拉电源轨。如果使用 EV2400，则不需要	未安装
JP4	I/O 上拉电源轨选择。选择使用 BAT 或 SYS 作为上拉电源轨	已安装 引脚 2-3 短接以上拉至 SYS
JP5	TS 引脚接 10kΩ 下拉电阻，用于模拟 TS 正常状态	已安装
JP6	USB2ANY 上拉电源轨。如果使用 EV2400，则不需要	未安装

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*：电源 #1 (PS #1)：需要一个能够提供 5V、3.2A 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. *用于模拟电池的负载 #1*：四象限电源，恒定电压 < 4.8V“Kepco”负载，BOP，20M - 5M，直流 0V 至 ±20V，0A 至 ±5A（或更高）
   备选方案：一台 0V – 20V/0V – 3.5A、> 30W 的直流电子负载，设置在恒定电压加载模式下
3. *用于模拟反向/OTG 模式下 SYS 端负载或 VBUS 端负载的负载 #2*：电子负载或电阻式负载，最大灌电流为 5A，支持最高 4.8V（或更高）的电压
4. *仪表*：四个“Fluke 75”万用表（性能相当或更高）。
   备选方案：（两个）等效电压表和（两个）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 计算机。如果使用 EV2400，必须已安装 Battery Management Studio 的最新版本。
6. *USB-TO-GPIO 通信套件*：具有最新固件的基于 USB 的 EV2400 PC 接口板或 USB2ANY。

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7. *软件*：BQStudio 软件，包含德州仪器 (TI) 提供的适用于 BQ25350 的最新 .bqz 文件（如果使用 EV2400）。从 https://www.ti.com.cn/tool/cn/BQSTUDIO 下载 bqStudio 并安装该软件。如果使用 USB2ANY，下载 TI Charger GUI。

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 TP8 (VBUS) 和 TP21 (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 J3（BAT+ 和 PGND）接地侧，不使用具有电流测量功能的源表。
6. 在 TP11 (BAT) 和 TP22 (PGND) 之间或者在 J3-3 和 J3-1 之间连接一个电压表，如图 2-1 中所示。
7. 在 TP12 (SYS) 和 TP27 (PGND) 之间或者在 J2-2 和 J2-1 之间连接一个电压表，如图 2-1 中所示。
8. 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 J6，如图 2-1 所示。

   对于 USB2ANY 接口，将带状电缆连接到 J5，并将 USB 电缆连接到计算机，如图 2-1 所示。
9. 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。

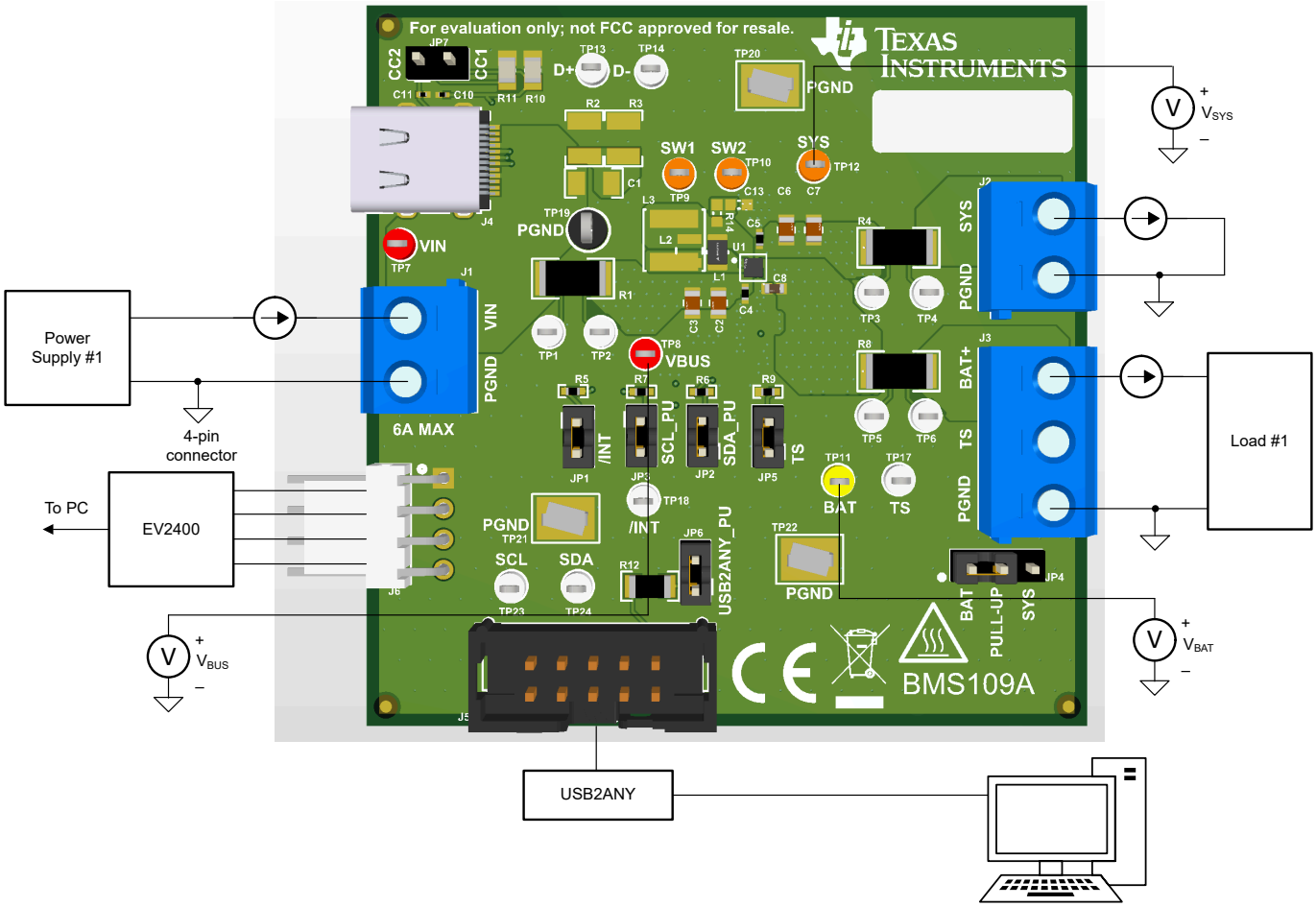


图 2-1. BQ25350 EVM 的测试设置

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3 软件

3.1 软件设置

3.1.1 EV2400 设置

使用以下步骤来设置 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 所示选择“Charger”。

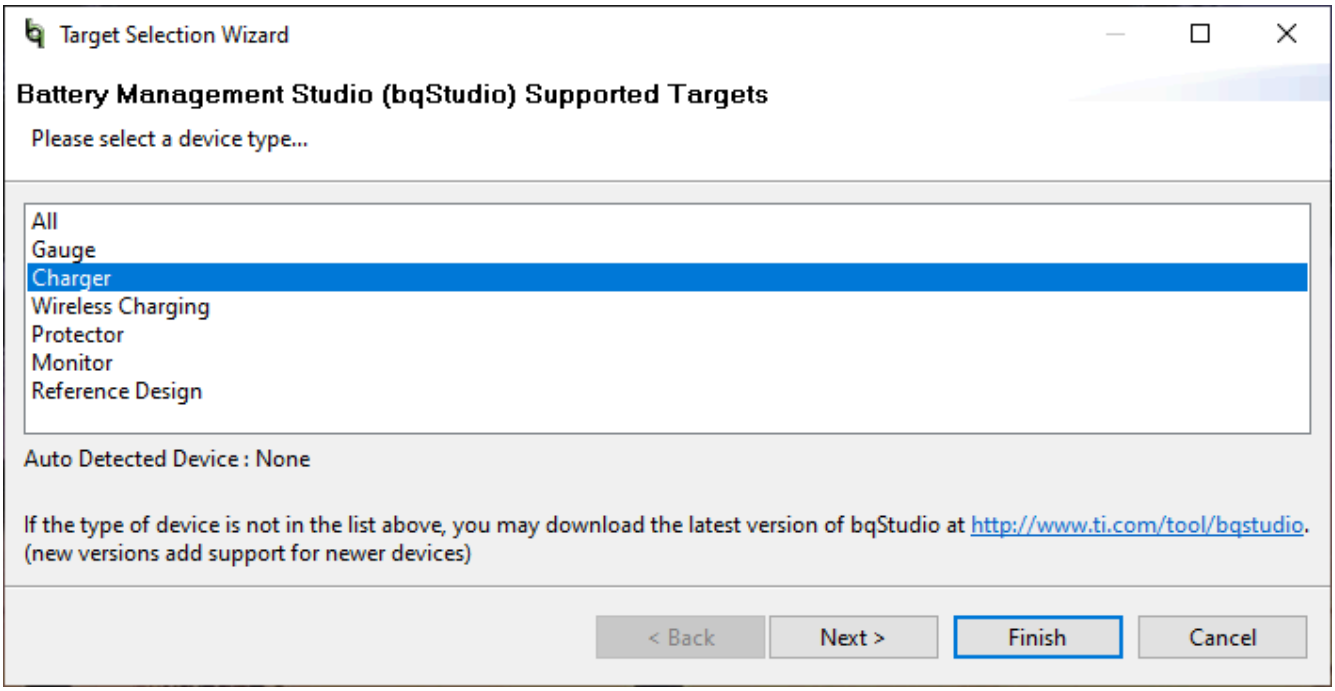


图 3-1. BQStudio 器件类型选择窗口

2. 从图 3-2 中所示的窗口中根据器件 BQ25350 选择适当的配置文件。

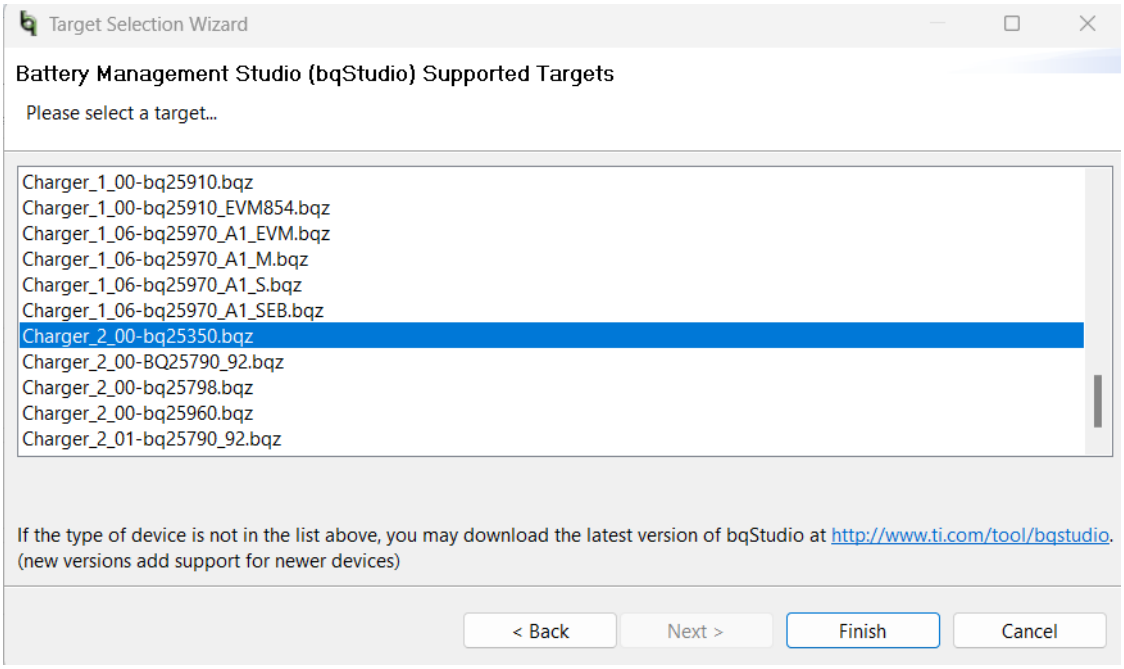


图 3-2. BQStudio 充电器选择窗口（选择 Charger_2_00-BQ25350.bqz）

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3. 在随即显示的窗口中选择 *Field View*，然后出现 BQ25350 EVM 软件的主窗口，如图 3-3 所示。

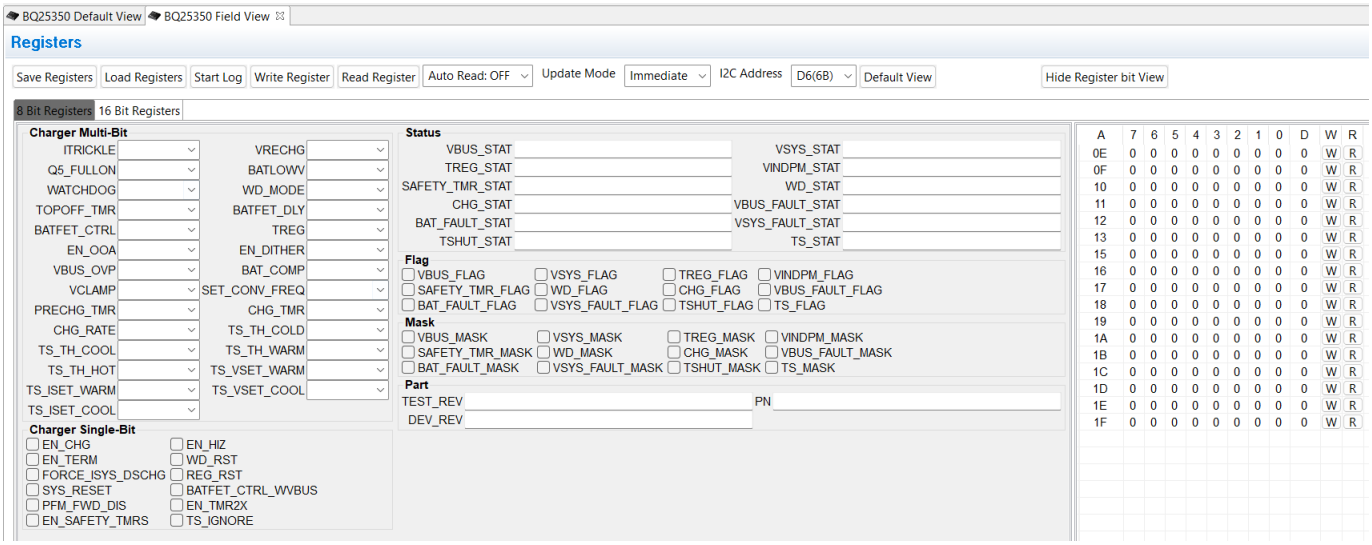


图 3-3. BQ25350 EVM 软件的主窗口

3.1.2 USB2ANY 设置

使用以下步骤来设置 EVM 测试软件：

1. 启动 TI Charger GUI，并从充电器选项中选择 *BQ25350*，如图 3-4 所示。

备注

如果电源（VIN 或 VBAT）关断，则需要重新启动 TI Charger GUI，以使正确的 I^2C 事务反映在 TI Charger GUI 中。

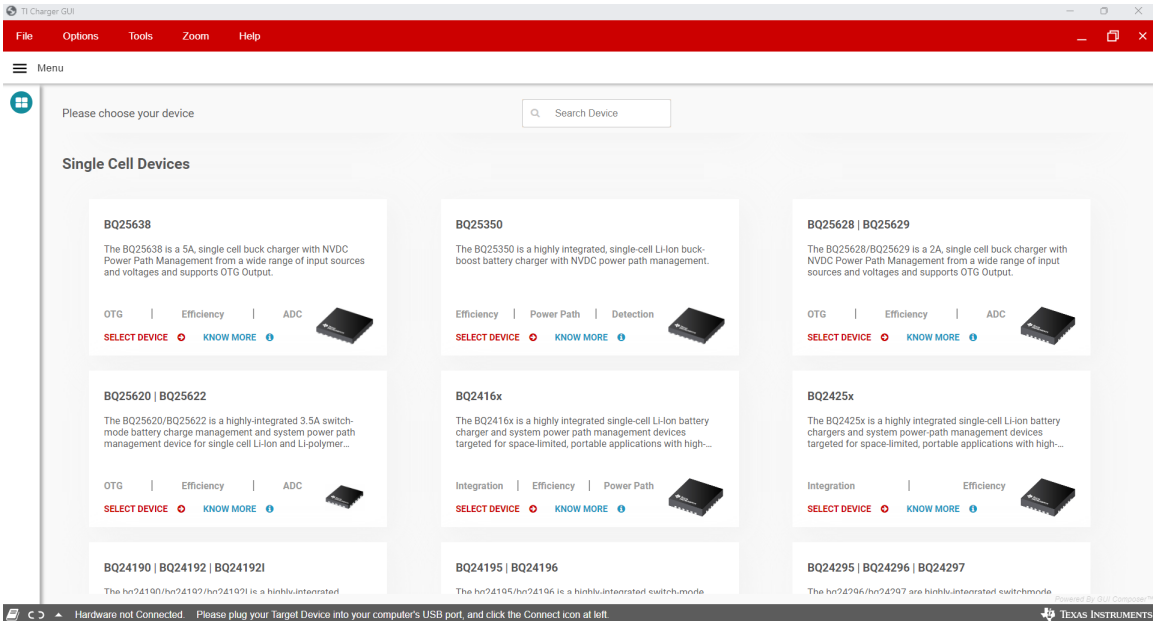


图 3-4. TI Charger GUI 器件选择

2. 使用边栏浏览不同的页面以更改配置、查看状态、标志和掩码，以及查看寄存器映射。有关充电器配置页面的示例，请参阅图 3-5。

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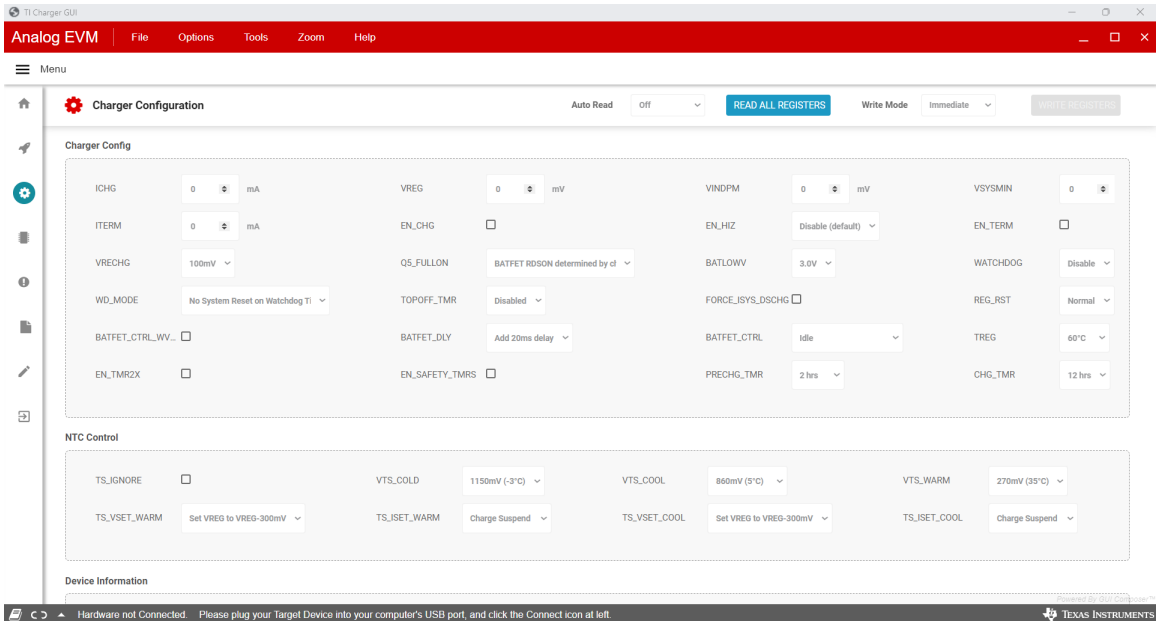


图 3-5. TI Charger GUI 配置页面

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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-TP12 和 PGND-TP20）= 3.52V ±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 I²C 寄存器通信验证

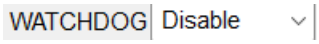
执行以下步骤进行通信验证：

1. 在 EVM 软件中，单击 *Read Register* 按钮。
   - 验证 GUI 在右上角是否显示 *Device ACK OK*。

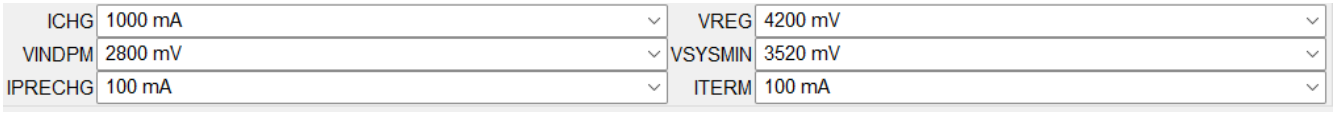
备注

如果器件显示 *Device ACK Error*，确认已执行节 2.4 和节 3.2.1 中的步骤。

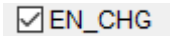
2. 在 Field View（请参阅图 3-3）中，根据需要进行以下更改：
   - 将看门狗设置为禁用



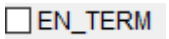
   - 按如下方式设置 16 位寄存器



   - 选中“Charge Enable”



   - 取消选中“Enable Termination”



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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，点击两次 *Read Register* 按钮。
   - 验证所有故障状态是否均显示为*正常*。

Status			
VBUS_STAT	Powered from VBUS	VSYS_STAT	In VSYSMIN regulation
TREG_STAT	Normal	VINDPM_STAT	Normal
SAFETY_TMR_STAT	Normal	WD_STAT	Normal
CHG_STAT	Fast Charge (CC)	VBUS_FAULT_STAT	Normal
BAT_FAULT_STAT	Normal	VSYS_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-TP12 和 PGND-TP20 或 TP22）= 3.52V ±0.3V。
   - 测量 → V_{BAT}（BAT-TP11 和 PGND-TP20 或 TP22）= 2.5V ±0.2V。
   - 测量 → I_{BAT} = 1000mA ±100mA。
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-TP12 和 PGND-TP20 或 TP22）= 3.8V ±0.3V。
   - 测量 → V_{BAT}（BAT-TP13 和 PGND-TP20 或 TP22）= 3.7V ±0.2V。
   - 测量 → I_{BAT} = 1000mA ±100mA。
4. 要确认输入电压限制操作，请在 EVM 软件的 16 位选项卡中，将输入电压限制 (VINDPM) 设置为 4800mV，然后进行 DMM 测量（如果准确，则进行 PS #1 测量），如下所示：
   - 测量 → V_{IN} = 4800mV ±300mV。

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3.2.4 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 BQ25350EVM 上组装的相关检测电阻上进行差分电压测量。

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4 硬件设计文件

4.1 原理图

图 4-1 显示了 BQ25350EVM 的原理图。

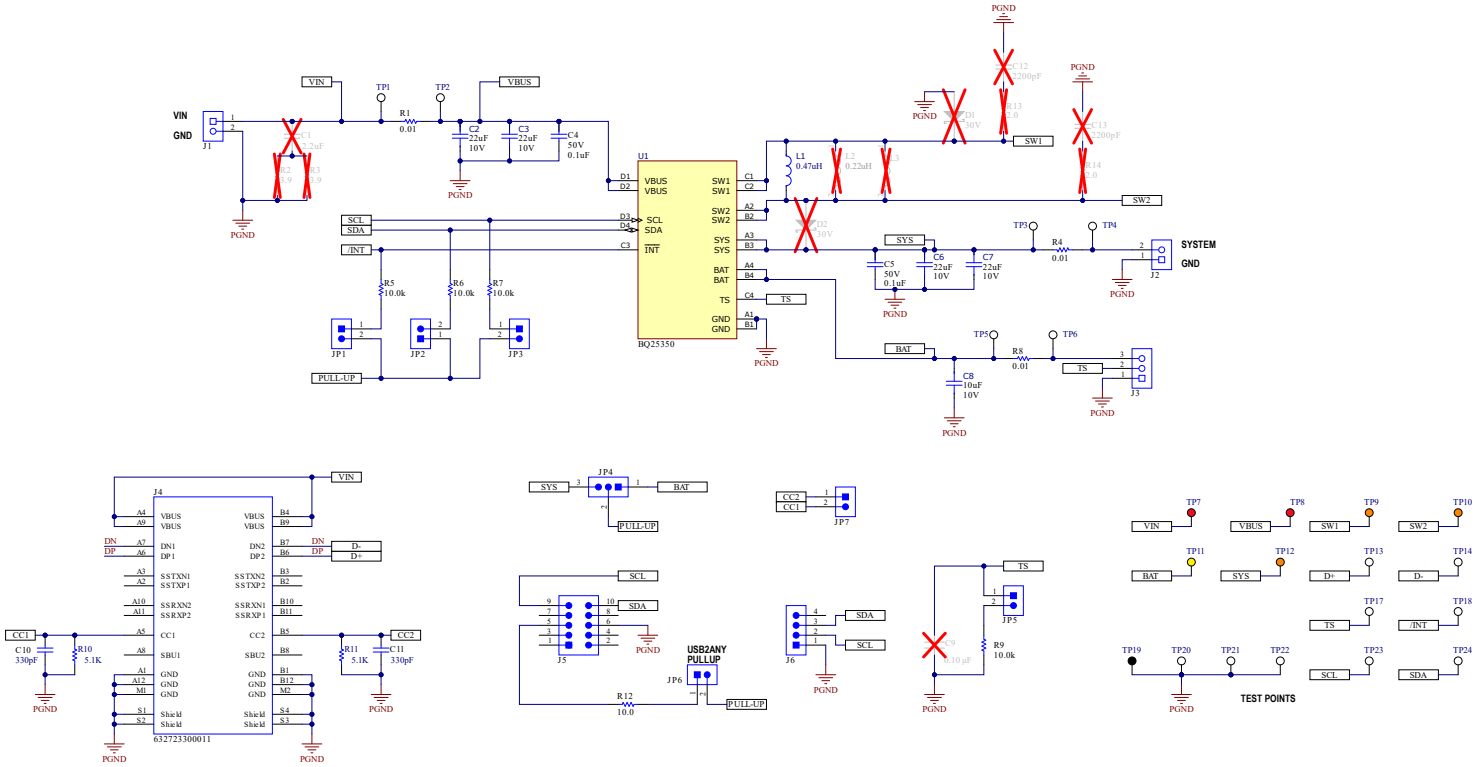


图 4-1. BQ25350EVM 原理图

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4.2 PCB 布局

以下各图展示了 PCB 板层。

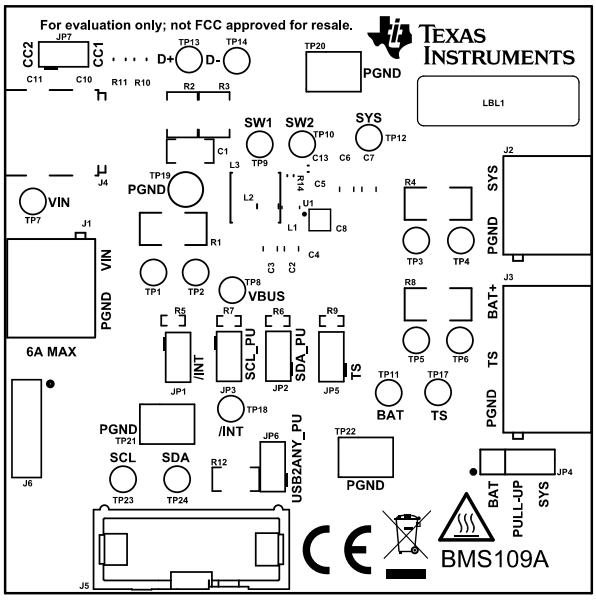


图 4-2. BMS109A 顶部丝印

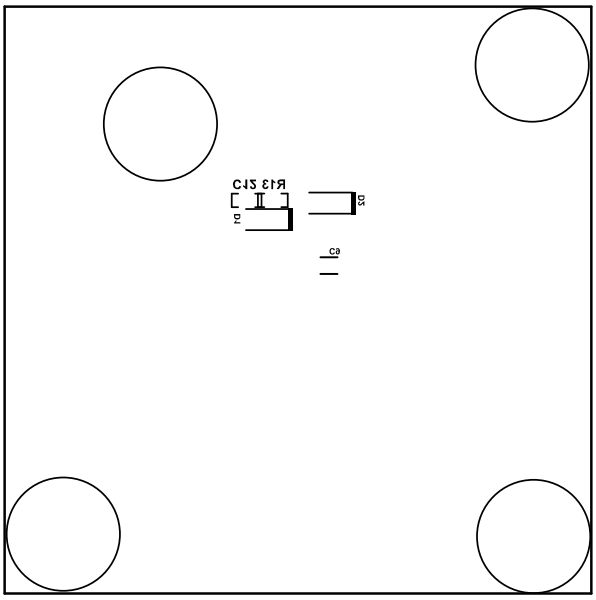


图 4-3. BMS109A 底部覆盖层

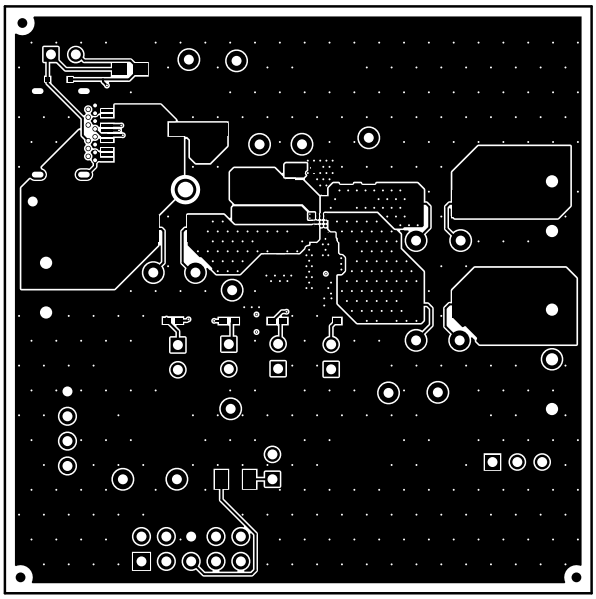


图 4-4. BMS109A 顶层

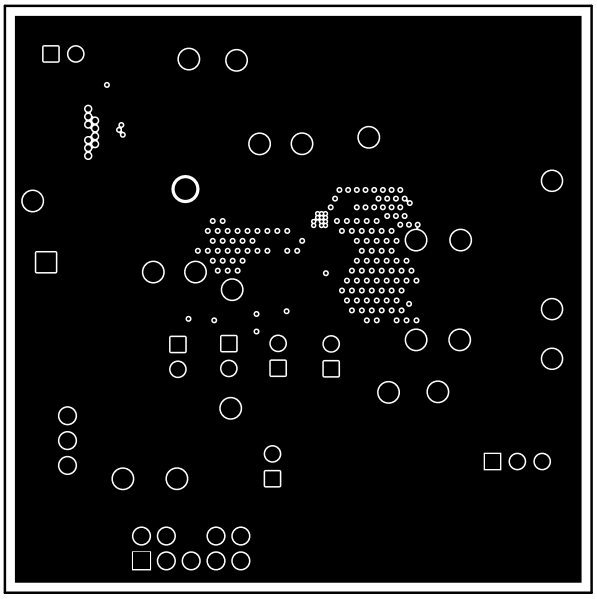


图 4-5. BMS109A 第 2 层

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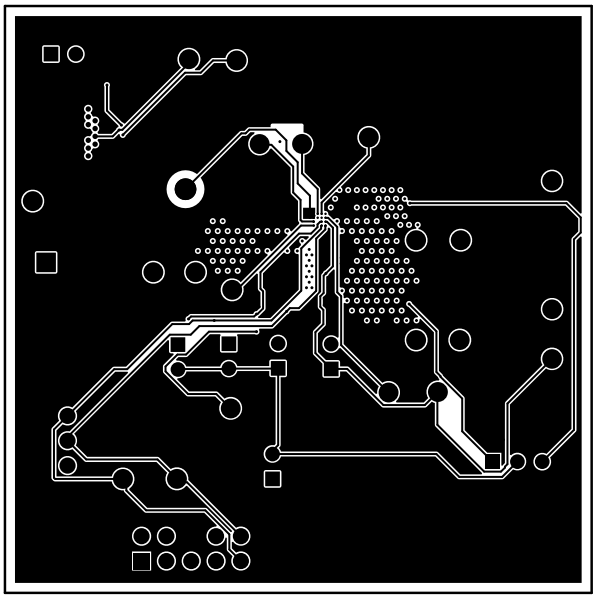


图 4-6. BMS109A 第 3 层

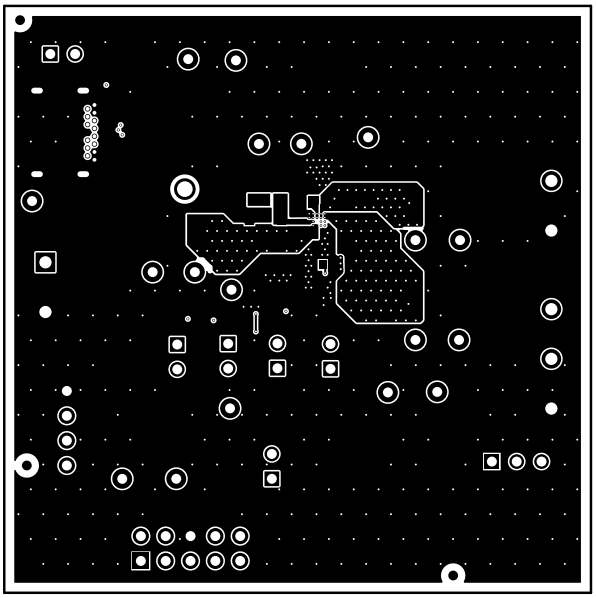


图 4-7. BMS109A 底层

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 VBUS 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引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。

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4.3 物料清单 (BOM)

表 4-1. 物料清单

指示符	数量	值	说明	封装参考	器件型号	制造商
C2、C3、C6、C7	4	22uF	通用片状多层陶瓷电容器，0805，22uF，X5R，15%，20%，10V	805	GRM21BR61A226ME44L	Murata
C4、C5	2	0.1uF	电容，陶瓷，0.1uF，50V，+/-10%，X7R，0402	0402	C1005X7R1H104K050BE	TDK
C8	1	10μF	通用片状多层陶瓷电容器，0603，10μF，X7T，+22%/-33%，10%，10V	0603	GRM188D71A106KA73D	Murata
C10、C11	2	330pF	电容，陶瓷，330pF，50V，+/-10%，X7R，0201	0201	GRM033R71H331KA12D	MuRata
H9、H10、H11、H12	4		Bumpon，半球形，0.44 X 0.20，透明	透明 Bumpon	SJ-5303 (CLEAR)	3M
J1、J2	2		端子块，5.08mm，2x1，黄铜，TH	2x1 5.08mm 端子块	ED120/2DS	On-Shore Technology
J3	1		端子块，5.08mm，3x1，黄铜，TH	3x1 5.08mm 端子块	ED120/3DS	On-Shore Technology
J4	1		连接器，插口，USB Type C，R/A	连接器，插口，USB Type C，R/A，THT/SMT	6.32723E+11	Wurth Elektronik
J5	1		接头（有罩），100mil，5x2，高温，镀金，TH	5x2 有罩接头	N2510-6002-RB	3M
J6	1		接头（摩擦锁），100mil，4x1，R/A，TH	4x1 R/A 接头	22/05/3041	Molex
JP1、JP2、JP3、JP5、JP6、JP7	6		接头，100mil，2x1，锡，TH	接头，2 引脚，100mil，锡	PEC02SAAN	Sullins Connector Solutions
JP4	1		接头，100mil，3x1，锡，TH	接头，3 引脚，100mil，锡	PEC03SAAN	Sullins Connector Solutions
L1	1	0.47uH	470nH 屏蔽模压电感器，4.8A，21mΩ，最大值 0806（2016 公制）	0806	AOTA-B201610SR47MT	Abracon
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
R1、R4、R8	3	0.01	电阻，0.01，1%，1W，2010	2010	WSL2010R0100FEA18	Vishay-Dale
R5、R6、R7、R9	4	10.0k	电阻，10.0k，1%，0.063W，AEC-Q200 0 级，0402	0402	CRCW040210K0FKED	Vishay-Dale
R10、R11	2	5.1K	电阻器，5.1KΩ，5%，1/8W，0805	0805	RC0805JR-075K1L	Yageo
R12	1	10	电阻，10.0，1%，0.25W，AEC-Q200 0 级，1206	1206	ERJ-8ENF10R0V	Panasonic
SH-JP1、SH-JP2、SH-JP3、SH-JP4、SH-JP5、SH-JP6	6		连接器跳线 S2 (1 x 2) 位置分流连接器黑色开孔顶部 0.100"(2.54mm) GoldHORTING .100" 金	跳线	QPC02SXGN-RC	Sullins

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表 4-1. 物料清单（续）

指示符	数量	值	说明	封装参考	器件型号	制造商
TP1、TP2、TP3、TP4、TP5、TP6、TP13、TP14、TP17、TP18、TP23、TP24	12		测试点，微型，白色，TH	白色微型测试点	5002	Keystone Electronics
TP7、TP8	2		测试点，微型，红色，TH	红色微型测试点	5000	Keystone Electronics
TP9、TP10、TP12	3		测试点，微型，橙色，TH	橙色微型测试点	5003	Keystone Electronics
TP11	1		测试点，微型，黄色，TH	黄色微型测试点	5004	Keystone Electronics
TP19	1		测试点，多用途，黑色，TH	黑色通用测试点	5011	Keystone Electronics
TP20、TP21、TP22	3		测试点，紧凑型，SMT	Testpoint_Keystone_Compact	5016	Keystone Electronics
U1	1		BQ25350	DSBGA16	BQ25350	德州仪器 (TI)

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5 其他信息

5.1 商标

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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.

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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

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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.

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

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

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

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