

# EVM User's Guide: MC121EVM

## MC121 单相 BLDC EVM



### 说明

MC121EVM 可供用户评估 MC121 和 MC121-Q1 单相 BLDC 驱动器的性能。EVM 包括一个板载 FTDI 芯片，用于将 USB 通信从 PC 转换至 UART。板载 MSP430FR2355 微控制器 (MCU) 将 UART 通信转换为控制信号或 I2C 格式的数据，然后发送到应用 PCB 中的 MC121 或 MC121-Q1。提供的多个可供用户选择的跳线、电阻、连接器和测试点可协助评估 MC121 或 MC121-Q1 的许多特性并实现可配置的器件特定设置。

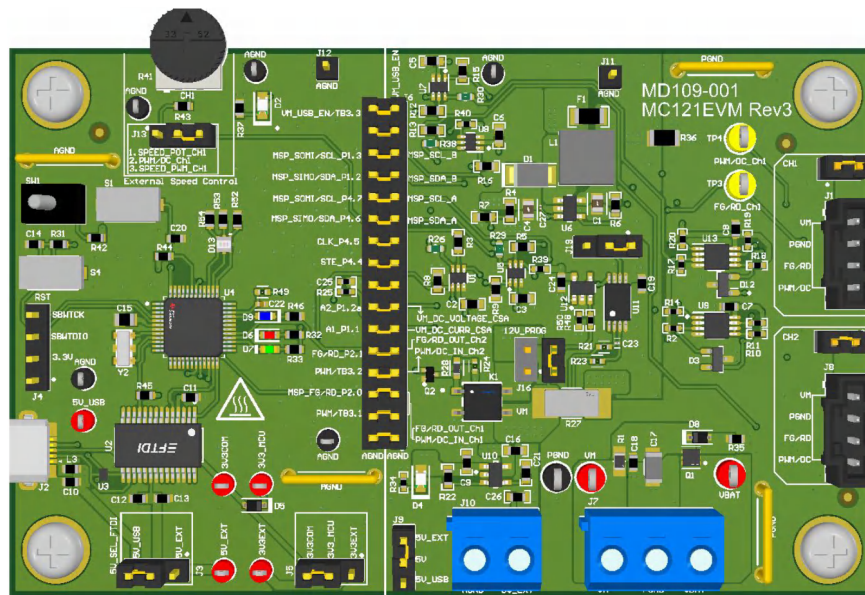
MotorStudio 是用于控制 MC121EVM 的 GUI。

### 特性

- 一次性可编程 (OTP) 写入功能
- 用于简化 MC121 和 MC121-Q1 调优过程和性能评估的 GUI 软件

### 应用

- LED 前照灯冷却风扇
- 信息娱乐系统冷却风扇
- ADAS ECU/传感器冷却风扇
- 无线充电器冷却风扇
- 电器风扇
- 工业冷却风扇



## 1 评估模块概述

### 1.1 简介

本用户指南详细介绍了如何设置、配置和操作 Motor Studio GUI 和 MC121EVM。本文档中的评估板、评估模块和 EVM 等所有术语均指 MC121EVM。本文档还提供了有关此 EVM 的操作过程、输入和输出连接、电气原理图、印刷电路板 (PCB) 布局图和物料清单 (BOM) 的信息。

### 1.2 套件内容

表 1-1 中详细列出了 EVM 套件的内容。如果缺少任何元件，请与离您最近的德州仪器 (TI) 产品信息中心联系。TI 强烈建议用户查看 TI 网站 <https://www.ti.com>，以验证是否使用了相关软件的最新版本

表 1-1. 套件内容

条目	数量
MC121EVM	1
USB-A 转 USB-B Micro 电缆	1

### 1.3 规格

MC121EVM 的额定工作电压为 35V (绝对最大值)，峰值电流高达 2A。为防止人身伤害、电击危险、损坏 EVM 或以上几种情况，请确保不能超出 EVM 的电压和电流规格。

### 1.4 器件信息

MC121-Q1 和 MC121 是一款额定电压为 40V、额定电阻为 850mΩ 的集成式电机驱动器，具有适用于单相无刷直流电机的 N 沟道全桥 MOSFET、电荷泵、霍尔传感器、换向控制逻辑和保护电路。霍尔传感器向换向逻辑提供转子位置信息，以保持转子连续运动。可以针对方波或软 PWM 波形对换向逻辑进行编程，从而降低声学噪声或最大限度地提高速度/效率。

## 2 硬件

### 2.1 快速设置 - 电机运行模式

MC121EVM 需要一个建议工作电压范围为 4.5V 至 35V 的电源。要设置 EVM 并为其供电，以及运行电机 PCB 中安装的电机，请按照以下顺序操作：

1. 使用 J1 将电机 PCB (不包含在 EVM 中) 上 MC121 或 MC121-Q1 的 VM、GND、FG/RD 和 PWM/直流引脚连接到 MC121EVM。
2. 将直流电源连接到连接器 J7 上的 VBAT/VM 和 PGND。请勿打开电源。
  - a. 连接至 VBAT，以启用反极性保护。
  - b. 若要禁用反极性保护，请连接到 VM。
3. 选择 J3 为 5V\_USB 和 J5 为 3V3COM 以便通过 USB 电源为 MSP430 供电。
4. 使用 micro-USB 电缆将 EVM 连接到 PC。
5. 如下图所示，在引脚 1 和引脚 2 之间设置 J13 中的跳线，以启用到 MCU 的 PWM/直流连接。
6. 在引脚 2 和引脚 3 之间的 J19 中设置跳线，将 ADC 测量设置为单极输出，用于 GUI 电流绘图。
7. 移除 J16 上的跳线以禁用板载 12V 升压电源和 VM 之间的连接，因为运行电机需要外部电源。
8. 打开电机电源。
9. 启动 MotorStudio GUI 以连接到 MC121 或 MC121-Q1。

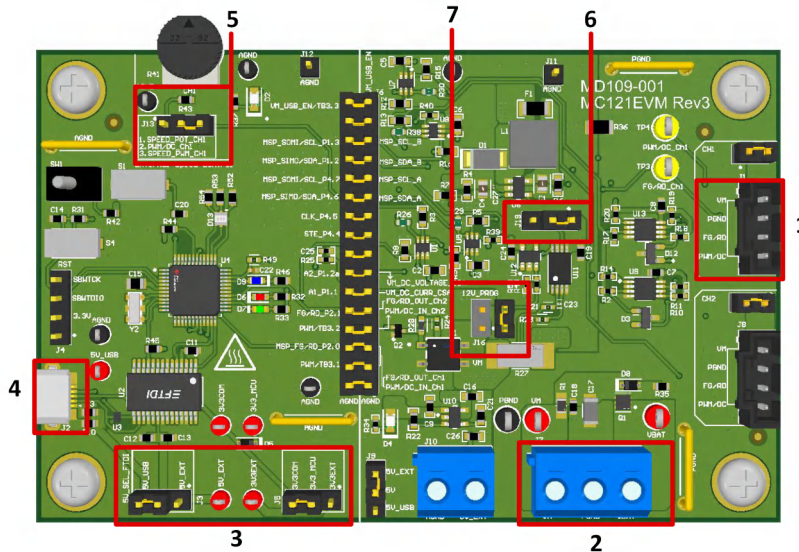


图 2-1. MC121EVM 的默认跳线配置

### 2.2 快速设置 - OTP 编程模式

在编程模式下，MC121EVM 需要一个建议工作电压范围为 8V 至 35V 的电源。若要设置 EVM 并为其供电，以及对器件的一次性可编程 (OTP) 存储器进行编程，请按照以下顺序操作：

1. 使用 J1 将电机 PCB (不包含在 EVM 中) 上 MC121 或 MC121-Q1 的 VM、GND、FG/RD 和 PWM/直流引脚连接到 EVM。
2. 将直流电源连接到连接器 J7 上的 VBAT/VM 和 PGND。请勿打开电源。
  - a. 连接至 VBAT，以启用反极性保护。
  - b. 若要禁用反极性保护，请连接到 VM。
3. 选择 J3 为 5V\_USB 和 J5 为 3V3COM 以便通过 USB 电源为 MSP430 供电。
4. 使用 micro-USB 电缆将 EVM 连接到 PC。
5. 如下图所示，在引脚 1 和引脚 2 之间设置 J13 中的跳线，以启用到 MCU 的 PWM/直流

连接。

6. 如果没有外部电源可用于对 MC121 或 MC121-Q1 的 OTP 存储器进行编程，请设置 J16 上的跳线以启用板载 12V 升压电源与 VM 的连接。
7. 启动 MotorStudio GUI 以连接和配置 MC121 或 MC121-Q1。
8. 在 MotorStudio GUI 的“Fault”（故障）选项卡中，禁用“Auto read all registers”（自动读取所有寄存器）和“Auto read faults”（自动读取故障）。
9. 在“Controls”（控制）选项卡中，启用“Control Via I2C”（通过 I2C 控制），在“I2C speed control”（I2C 速度控制）中输入 0%，然后单击“Set”（设置）按钮停止电机。
10. 根据电机所需的性能和功能，通过 GUI 配置相关寄存器。
11. 将杆开关 SW1 从默认左侧位置设置到右侧位置，并轻轻按一次 S1 以对 OTP 存储器进行编程。

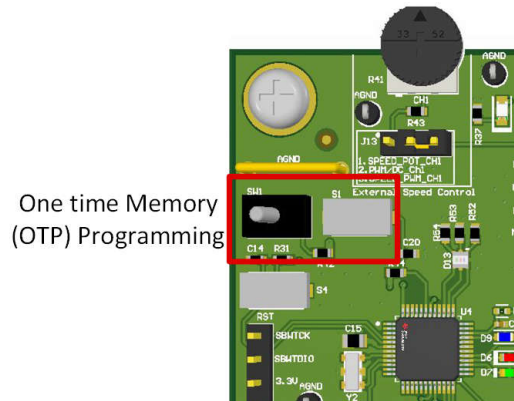


图 2-2. 禁用 OTP 编程模式时的默认控制杆开关 (SW1) 配置

### 2.3 硬件概述

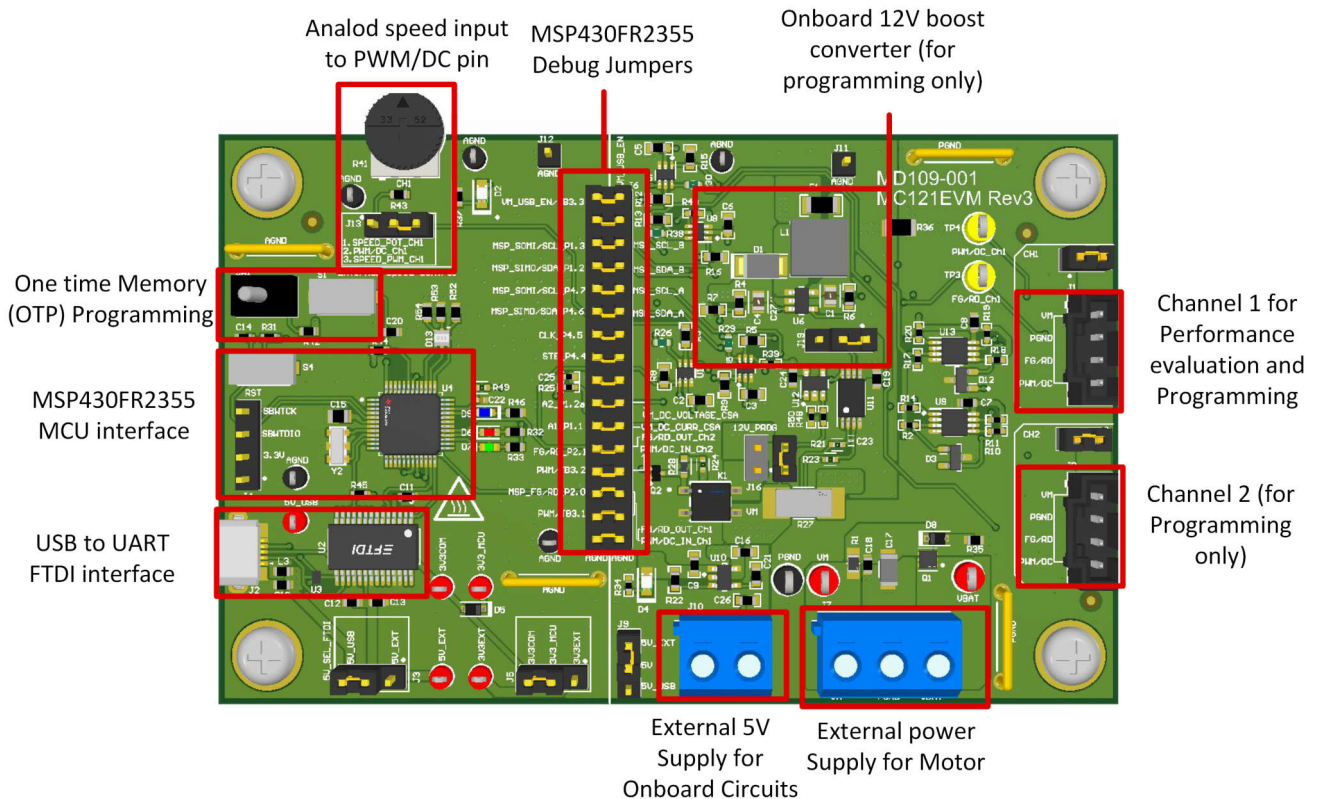


图 2-3. MC121EVM 硬件概览

### 2.3.1 电机 PCB 与 MC121EVM 的连接

图 2-4 展示了与单相 BLDC 电机的连接。MC121 或 MC121-Q1 位于电机 PCB 上，不驻留在 EVM 上。用户需要为电机设计带有 MC121 或 MC121-Q1 的 PCB，并使用 MC121EVM 评估电机性能。

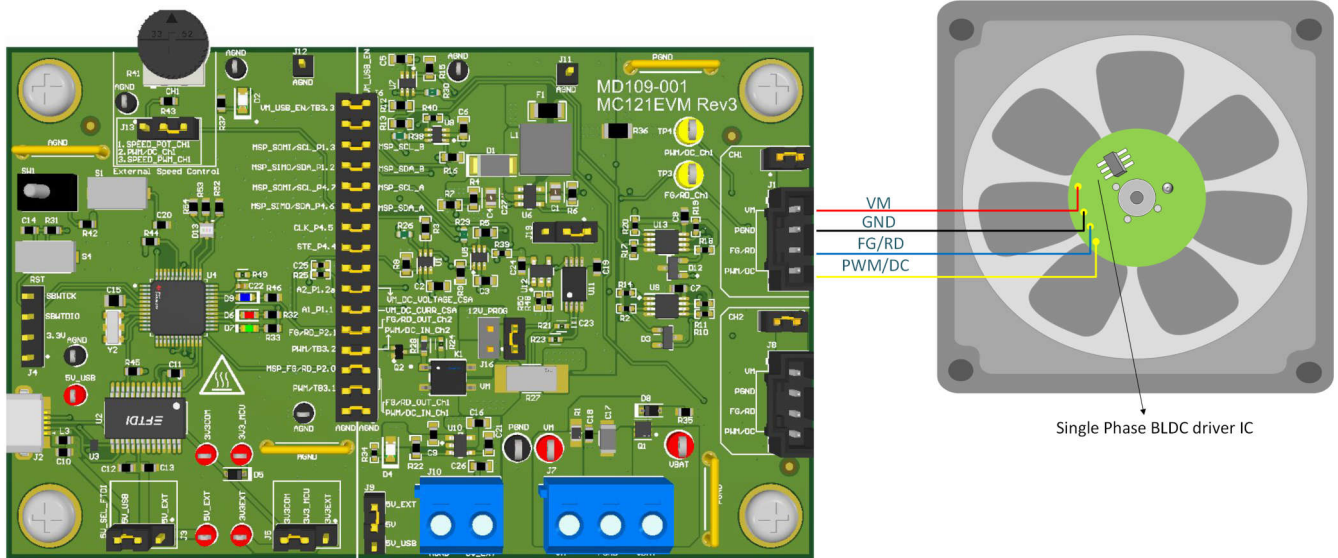


图 2-4. EVM 和电机 PCB 连接

该 EVM 上提供了所有必要的上拉电阻和保护电路。MC121 电机 PCB 的推荐原理图示例如下所示：

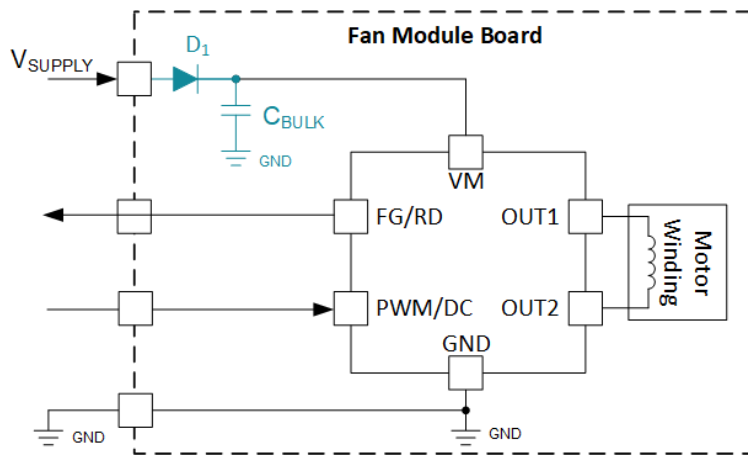


图 2-5. 建议的电机 PCB 原理图

### 2.3.2 外部模拟速度输入

也可以通过外部电位器向器件提供速度输入 (DIN)。连接到器件后，设置 Interface Configuration (接口配置) 下的 “Speed pin configuration” (速度引脚配置)，以接受模拟电压，从而控制电机转速。将 “control via I2C” (通过 I2C 控制) 设置为 “Disabled” (禁用)。

使用 J13，在模拟输入到 PWM/直流引脚之间进行选择。旋转 R41 电位器以设置不同速度。

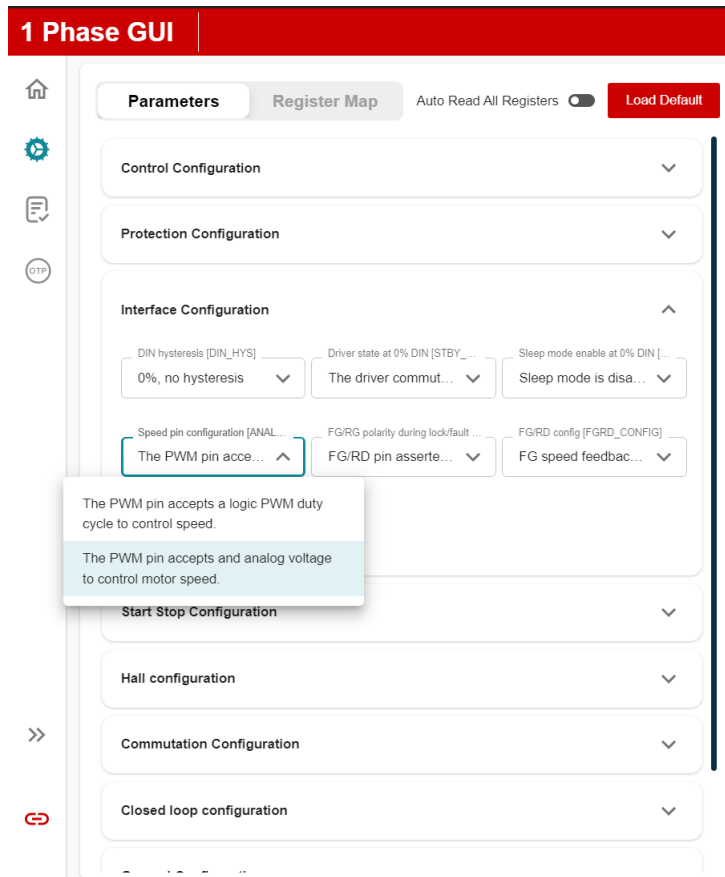


图 2-6. 将 PWM/直流输入改为接受模拟电压的选项

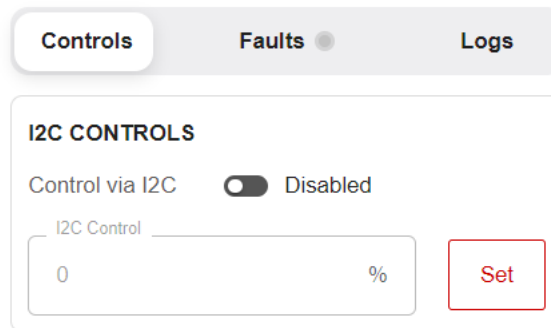


图 2-7. 禁用“通过 I2C 控制”的选项

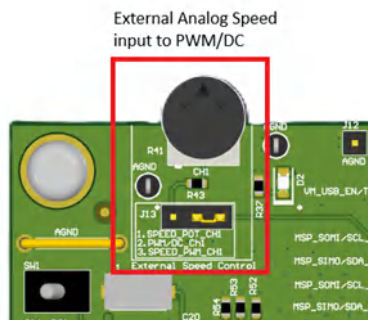


图 2-8. 至 PWM/DC 引脚的外部模拟速度控制输入

### 2.3.3 板载 12V 升压电路

提供的板载升压电路仅用于寄存器读写操作。该升压转换器不支持运行电机。连接 J16 中的跳线，以使能到 VM 的 12V 升压电源输出。升压转换器将 5V 转换为 12V。可使用跳线 J9 在 USB 输入或外部 5V 电压之间选择升压转换器的 5V 输入。如果使用外部 5V 电源，则将该电源连接到 J10。

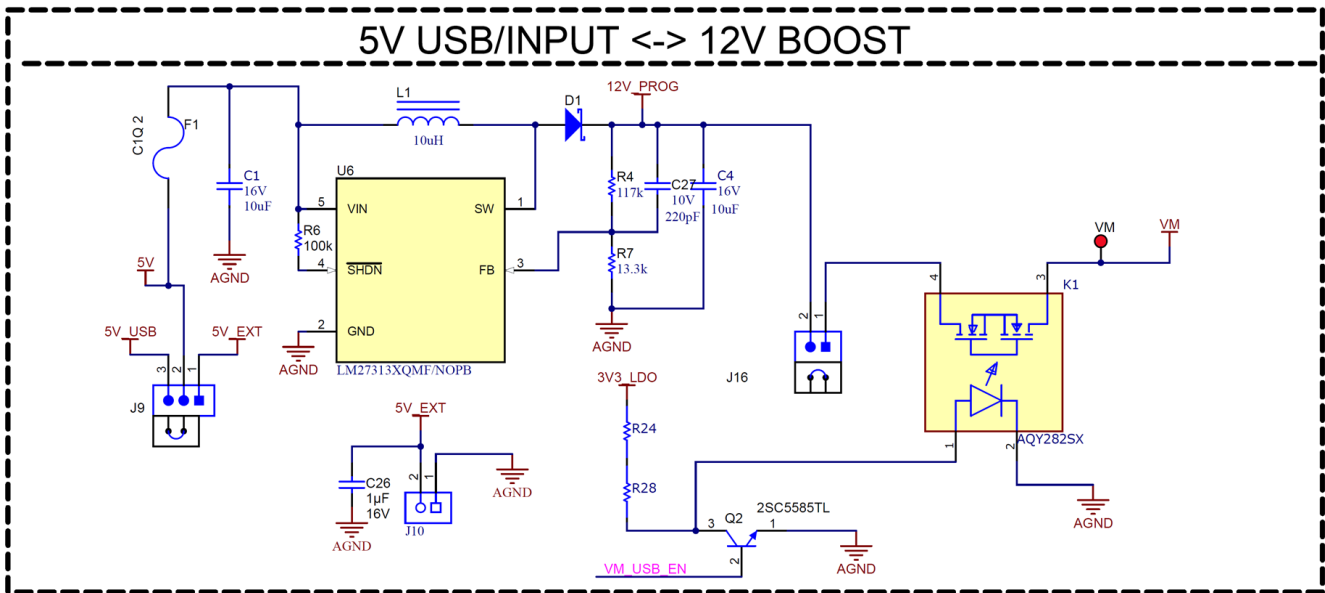


图 2-9. 板载 12V 升压电路原理图

## 2.4 MSP430FR2355 微控制器

MC121EVM 包括 MSP430FR2355 低功耗 MCU ( 如下图所示 )，以便通过 I2C 与 MC121 或 MC121-Q1 器件通信。

要对 MSP430FR2355 进行编程，必须将外部 MSP430 编程器连接到 Spy-Bi-Wire (SBW) 接口连接器 J4。许多 MSP430 LaunchPad™ 提供板载 eZ-FET 调试探针，可通过跳线连接到 MC121EVM，从而将固件刷入板载 MSP430FR2355 微控制器中。

用户可以随时使用 S4 复位 (RST) 按钮重启 MCU 程序。

32 引脚分流跳线桥 J6 连接微控制器和 EVM 电路之间的所有信号。

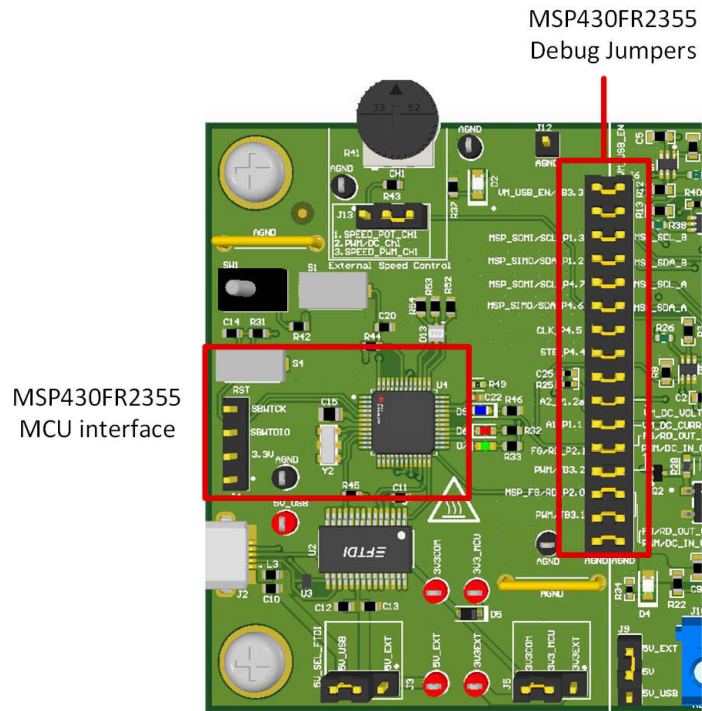


图 2-10. MSP430FR2355 MCU 接口和调试



## 3 软件

### 3.1 EVM 固件

MC121EVM 包含一个 USB 转 UART 接口 ( 使用 MSP430FR2355 微控制器 ) ，该接口作为主机 PC 与 MC121 或 MC121-Q1 器件之间的通信桥，用于配置各种器件设置和读取故障诊断信息。

MOTORSTUDIO GUI 支持 MC121EVM，可使用该 GUI 通过此通信接口配置 MC121 或 MC121-Q1。MOTORSTUDIO GUI 提供引导式调优说明和用于实时变量监控的虚拟示波器等，简化了 MC121 或 MC121-Q1 的调优过程。

默认情况下，板载 MSP430 微控制器已包含与 Motor Studio GUI 进行通信所需的固件。如有固件更新，或 GUI 未连接到 EVM，则用户必须按照节 2.4 中概述的步骤，将固件代码刷入 MSP430FR2355。

要将固件代码刷入 MSP430，需要一个集成开发环境 (IDE) 或 UniFlash 工具。

### 3.2 GUI 安装

下载并安装最新版本的 MOTORSTUDIO，以便与 MC121EVM 配合使用。请参阅此 [e2e 常见问题解答](#)，以维持 GUI 的可靠安装。

### 3.3 Motorstudio for MC121 入门指南

**Step1。** 启动 MOTORSTUDIO GUI 并选择 “Single Phase Motor” ( 单相电机 ) ，以选择单相 BLDC 驱动器。

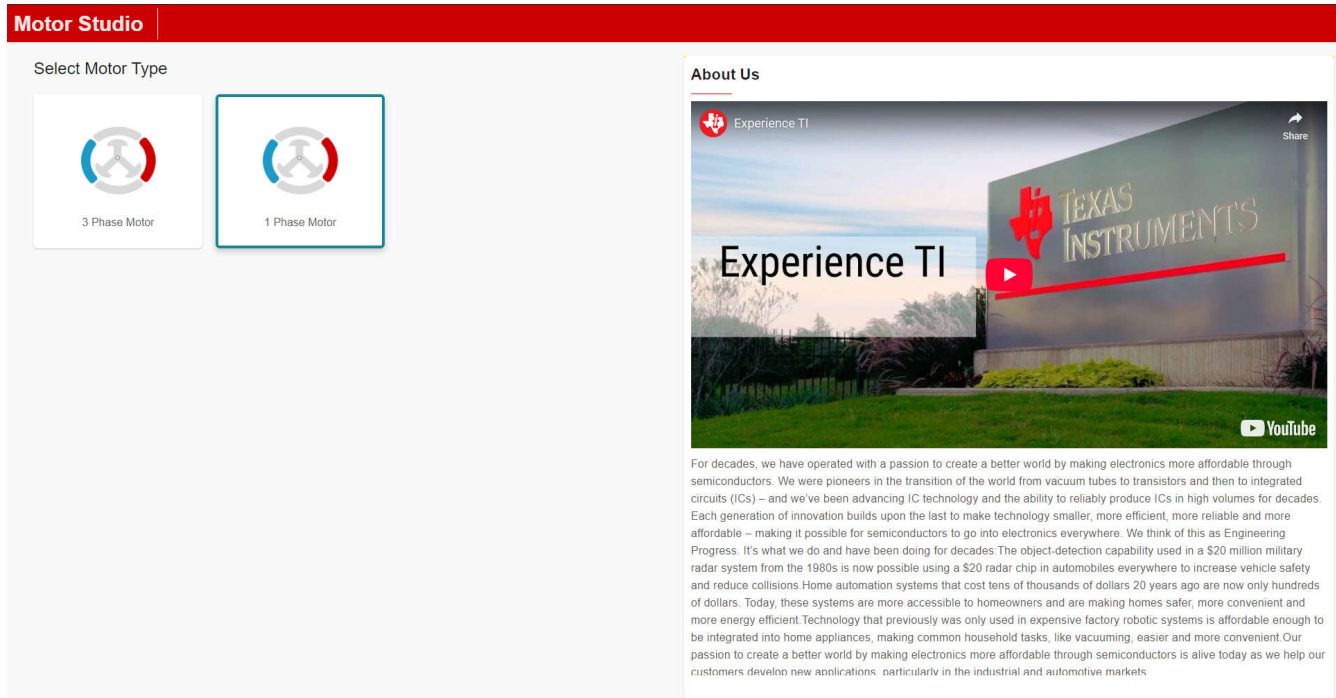


图 3-1. MOTORSTUDIO 单相电机 GUI

**Step2。** 是否根据第 2 节要求正确进行了所有硬件连接。系统会自动检测到器件

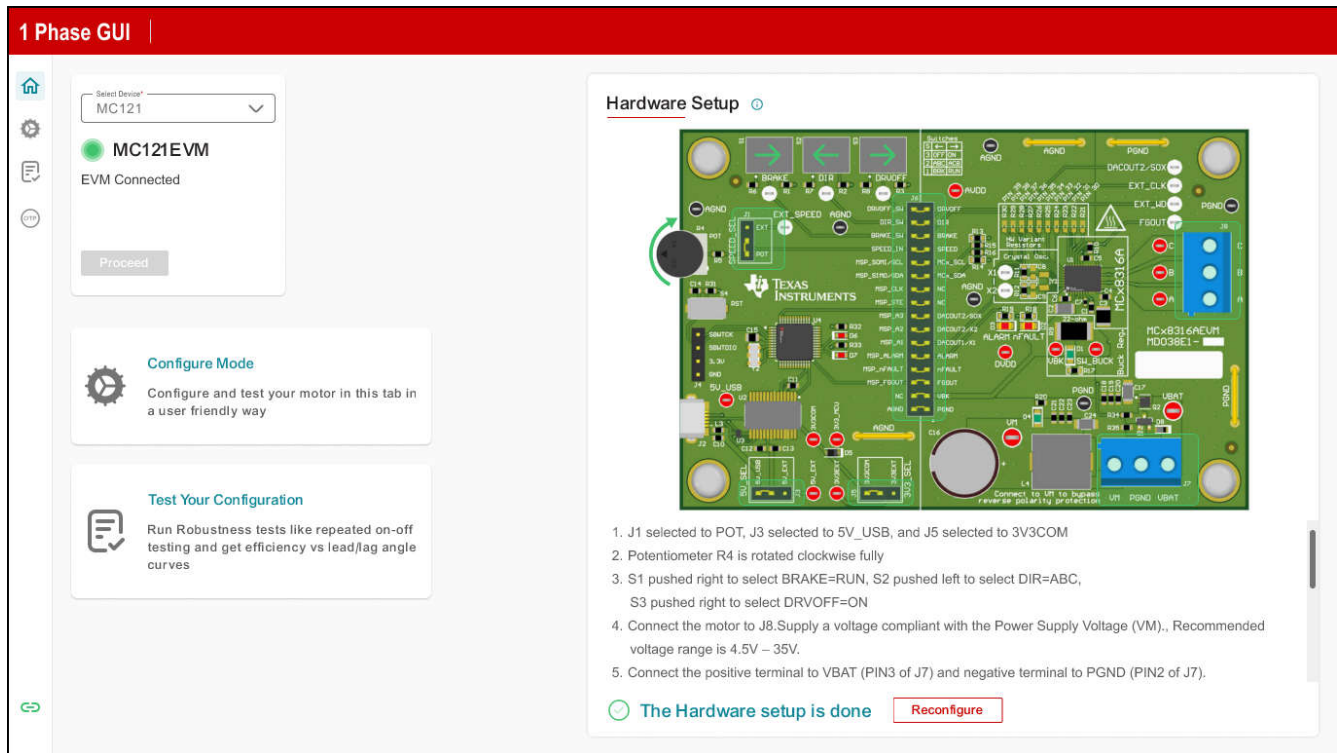


图 3-2. 自动检测 MC121 或 MC121-Q1

**Step3.** 现在进入“Configure Mode”（配置模式），以配置 MC121 并根据应用情况进行调优。单相图形用户界面提供以下选项来对器件和电机进行调优和评估。

1. 通过“Parameters and Register Map”（参数与寄存器映射）部分配置设置。
2. “I2C Controls”（I2C 控制），以向电机提供速度命令。

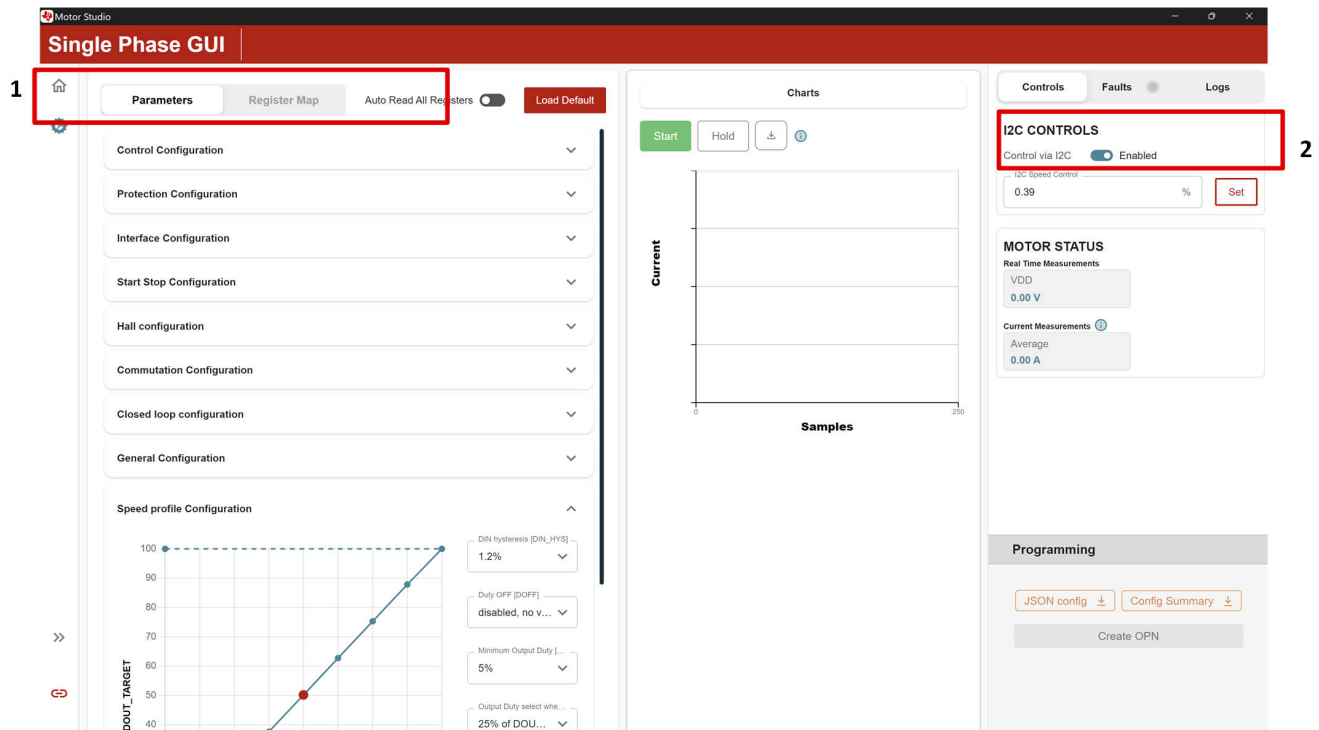


图 3-3. 单相 GUI 中的“Parameters”（参数）选项卡、“Register Map”（寄存器映射）选项卡和 I2C 控制

## 4 硬件设计文件

### 4.1 原理图

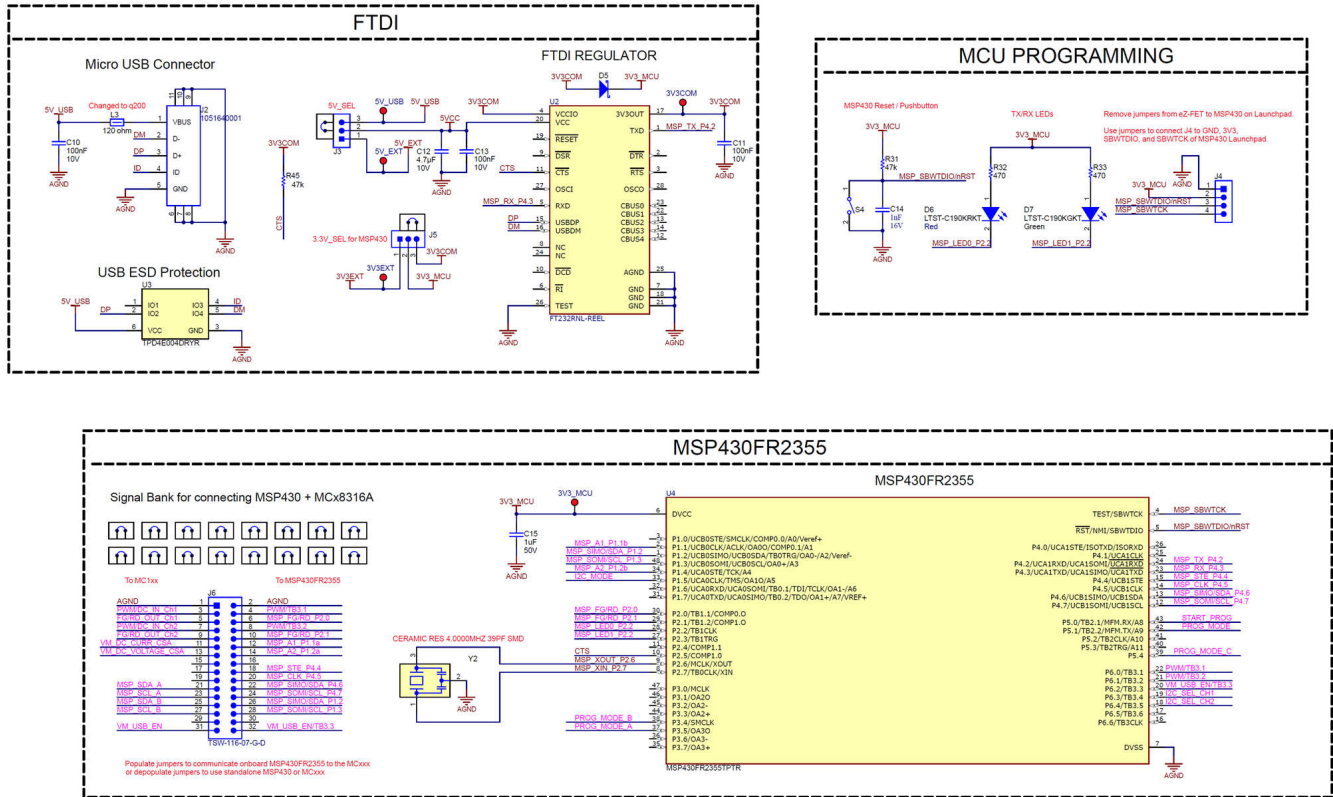


图 4-1. MC121EVM 原理图 — FTDI、MSP430FR2355 和 MCU 编程

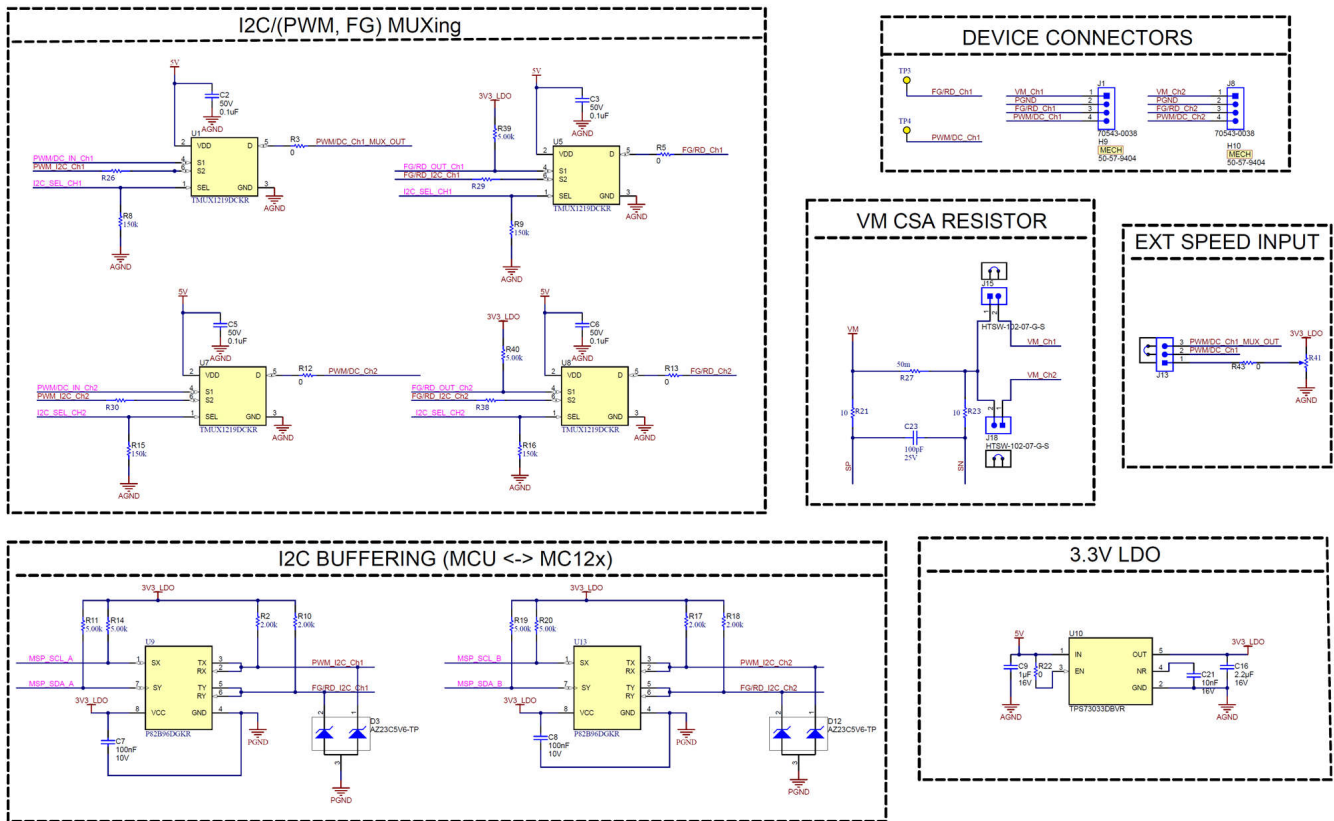


图 4-2. MC121EVM 原理图 — I2C 多路复用器、I2C 缓冲器、LDO 和连接器

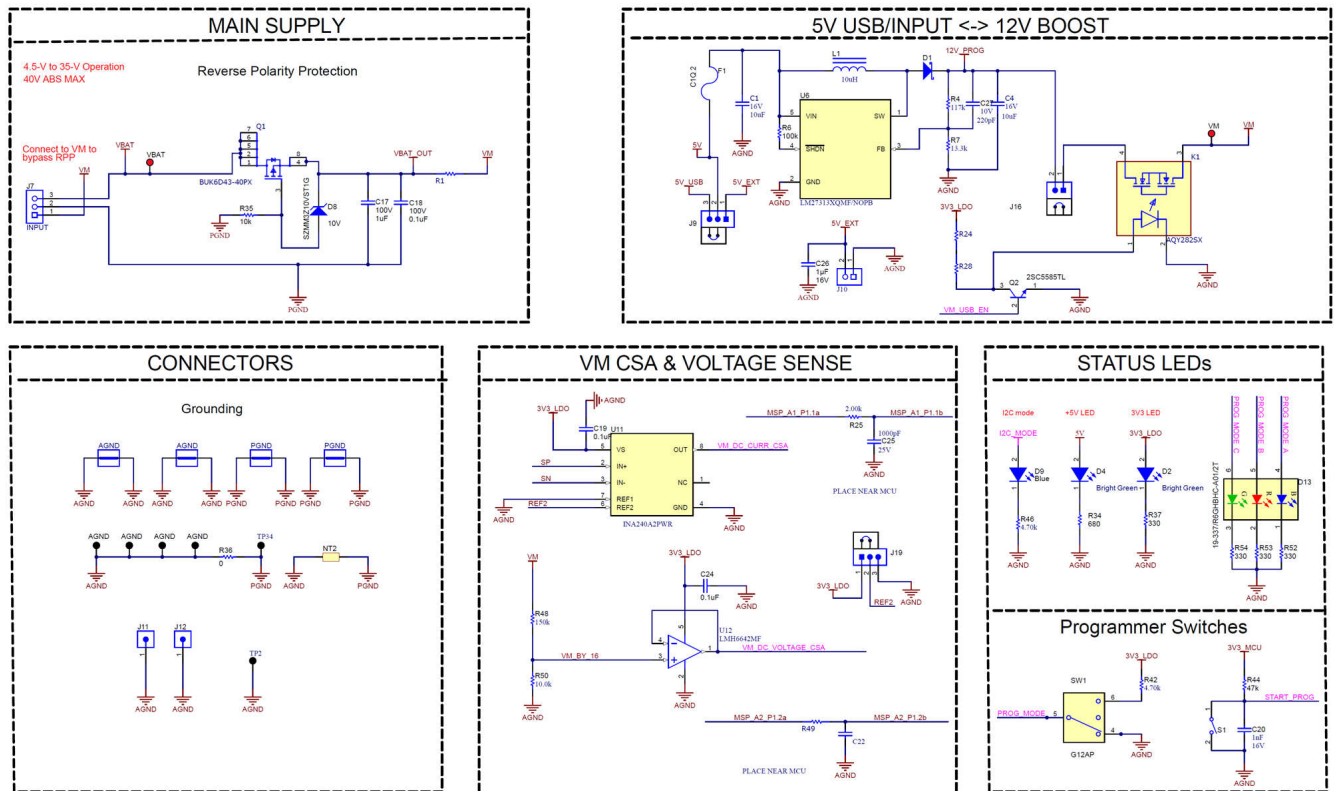


图 4-3. MC121EVM 原理图 — 电源、升压转换器、电流和电压检测

## 4.2 PCB 布局

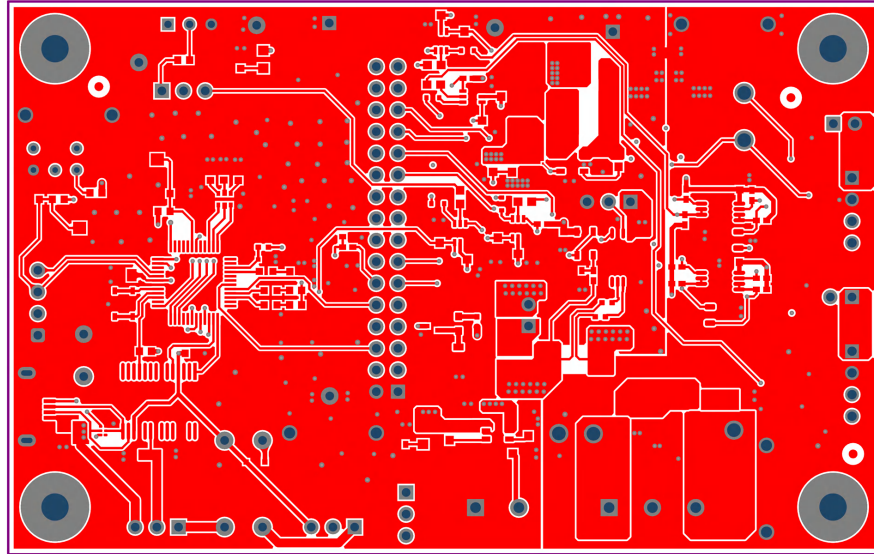


图 4-4. PCB 层 1

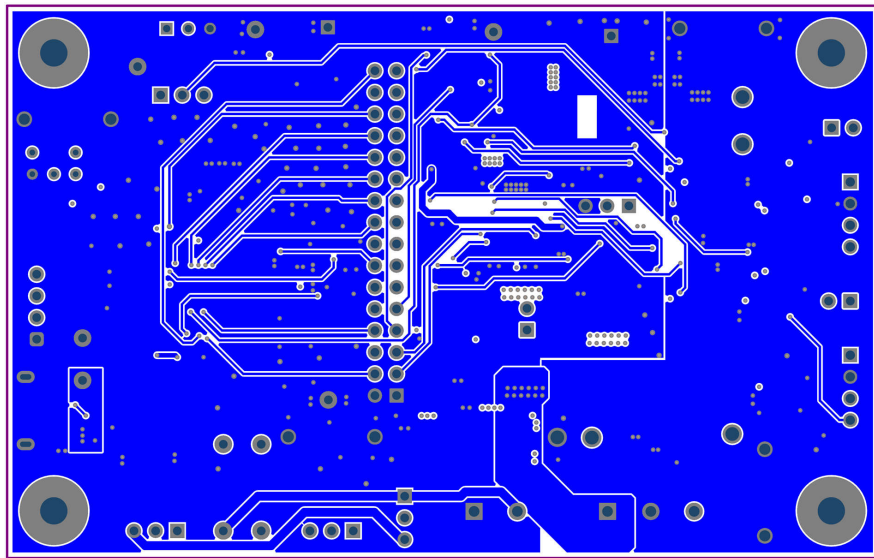


图 4-5. PCB 层 2

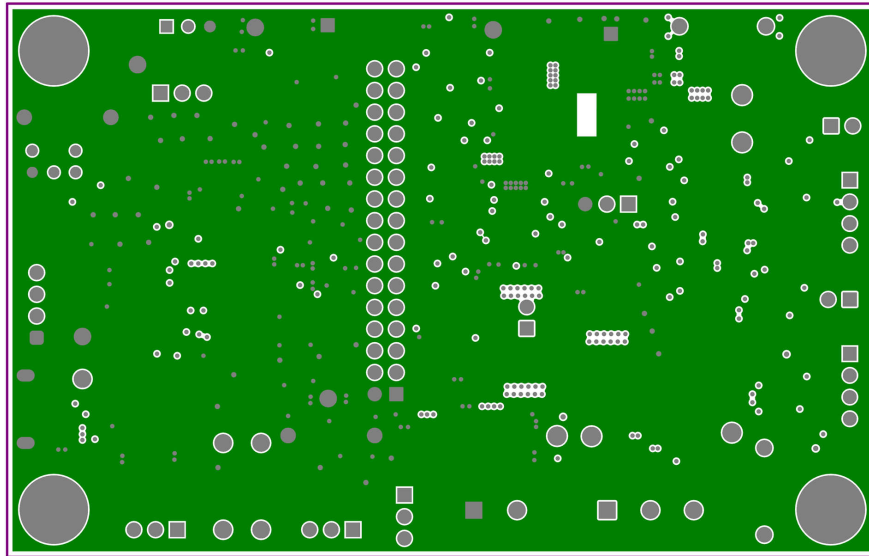


图 4-6. PCB 层 3

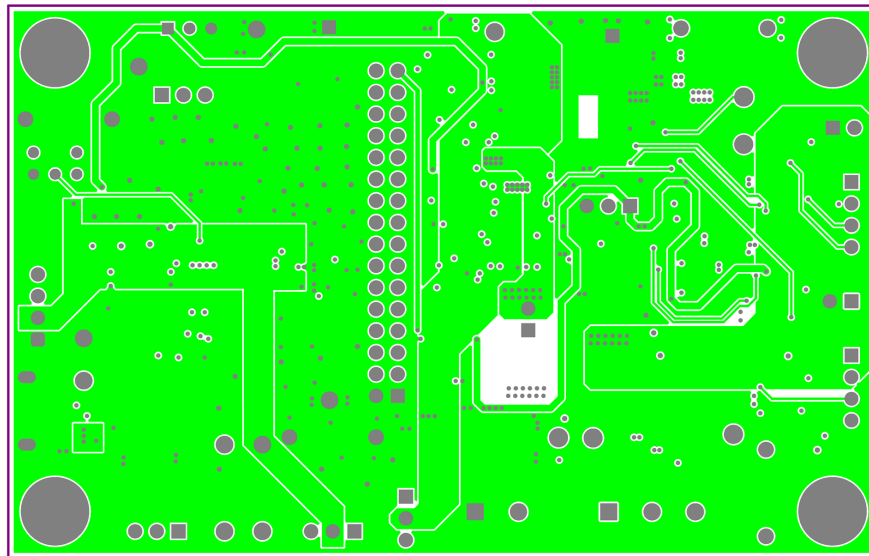


图 4-7. PCB 层 4

### 4.3 物料清单 (BOM)

表 4-1 列出了 MC121EVM 的物料清单

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		MC121EVM	不限
C1, C4	2	10 $\mu$ F	CL21 系列 0805 10uF 16V $\pm$ 10% 容差 X7S 多层陶瓷片式电容器	0805	CL21Y106KQ4PNE	Samsung
C2、C3、C5、C6	4	0.1 $\mu$ F	电容, 陶瓷, 0.1 $\mu$ F, 50V, $\pm$ 10%, X8R, AEC-Q200 0 级, 0603	0603	CGA3E3X8R1H104K080AB	TDK

**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
C7、C8、 C10、C11、 C13	5	0.1uF	电容, 陶瓷, 0.1 $\mu$ F, 10V, +/-10%, X7R, 0603	0603	0603ZC104KAT2A	AVX
C9、C26	2	1uF	电容, 陶瓷, 1 $\mu$ F, 16V, +/-10%, X7R, AEC-Q200 1 级, 0603	0603	EMK107B7105KAHT	Taiyo Yuden
C12	1	4.7uF	电容, 陶瓷, 4.7 $\mu$ F, 10V, +/-20%, X7R, 0603	0603	GRM188Z71A475ME1 5D	MuRata
C14、C20	2	1000pF	电容, 陶瓷, 1000pF, 16V, +/-10%, X7R, 0603	0603	8.85012E+11	Würth Elektronik
C15	1	1uF	电容, 陶瓷, 1 $\mu$ F, 50V, +/-10%, X7R, 0805	0805	8.85012E+11	Würth Elektronik
C16	1	2.2uF	电容, 陶瓷, 2.2 $\mu$ F, 16V, +/-10%, X7R, 0603	0603	EMK107BB7225KA-T	Taiyo Yuden
C17	1	1uF	电容, 陶瓷, 1 $\mu$ F, 100V, +/-10%, X7R, 1206	1206	CL31B105KCHNNNE	Samsung
C18、C19、 C24	3	0.1uF	电容, 陶瓷, 0.1 $\mu$ F, 100V, +/-10%, X7S, AEC-Q200 1 级, 0603	0603	CGA3E3X7S2A104K0 80AB	TDK
C21	1	0.01uF	电容, 陶瓷, 0.01 $\mu$ F, 16V, +/-10%, X7R, 0603	0603	8.85012E+11	Würth Elektronik
C22	1		WCAP-CSGP 多层陶瓷贴片电容器, 通用, 尺寸 0402, NP0, 47pF, 10VDC			Würth Elektronik
C23	1	100pF	通用片状多层陶瓷电容器, 0201, 100pF, COG, 30ppm/°C, 2%, 50V	0201	GRM0335C1H101GA0 1D	Murata
C25	1	1000pF	电容, 陶瓷, 1000pF, 25V, +/-5%, COG/NP0, 0402	0402	C0402C102J3GACTU	Kemet
C27	1	220pF	电容, 陶瓷, 220pF, 10V, +/-10%, X7R, 01005	01005	GRM022R71A221KA0 1	MuRata
D1	1	40V	二极管, 肖特基, 40V, 3A, SOD-128	SOD-128	RBR3LAM40ATR	Rohm
D2、D4	2	亮绿色	LED, 亮绿色, SMD	LED_0805	150080VS75000	Würth Elektronik
D3、D12	2	5.6V	二极管, 齐纳, 5.6V, 300mW, SOT-23	SOT-23	AZ23C5V6-TP	Micro Commercial Components
D5	1	40V	二极管, 肖特基, 40V, 0.75A, AEC-Q101, SOD-323	SOD-323	BAT165E6327HTSA1	Infineon Technologies
D6	1	红色	LED, 红色, SMD	红色 LED, 1.6mm x 0.8mm x 0.8mm	LTST-C190KRKT	Lite-On
D7	1	绿色	LED, 绿色, SMD	1.6x0.8x0.8mm	LTST-C190KGKT	Lite-On
D8	1	10V	二极管, 齐纳, 10V, 300mW, AEC-Q101, SOD-323	SOD-323	SZMM3Z10VST1G	ON Semiconductor

**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
D9	1	蓝色	LED, 蓝色, SMD	LED_0603	150060BS75000	Wurth Elektronik
D13	1	RGB	LED, RGB, TH	1.6x1.6mm	19-337/R6GHBHC-A01/2T	Everlight
F1	1		保险丝, 2A, 125VAC, 63VDC, SMD	1206	C1Q 2	百富电子 (Bel Fuse)
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		机械螺钉, 圆头, #4-40 x 1/4, 尼龙, 飞利浦盘形头	螺钉	NY PMS 440 0025 PH	B&F Fastener Supply
H5、H6、H7、H8	4		六角螺柱, 0.5"L #4-40, 尼龙	螺柱	1902C	Keystone
H9、H10	2		矩形外壳连接器, 4 位, 2.54mm		50-57-9404	Molex
J1、J8	2		接头 (有罩), 2.54mm, 4x1, 锡, TH	接头 (有罩), 2.54mm, 4x1, TH	70543-0038	Molex
J2	1		插座, USB 2.0, Micro B, 5 个位置, R/A, SMT	插座, USB 2.0, Micro B, 5 位, 0.65mm 间距, R/A, SMT	1051640001	Molex
J3、J5、J9、J13、J19	5		接头, 100mil, 3x1, 金, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J4	1		接头, 100mil, 4x1, 金, TH	4x1 接头	TSW-104-07-G-S	Samtec
J6	1		接头, 100mil, 16x2, 金, TH	16x2 接头	TSW-116-07-G-D	Samtec
J7	1		端子块, 5.08mm, 3x1, 黄铜, TH	3x1 5.08mm 端子块	ED120/3DS	On-Shore Technology
J10	1		端子块, 5.08mm, 2x1, 黄铜, TH	2x1 5.08mm 端子块	ED120/2DS	On-Shore Technology
J11、J12	2		接头, 100mil, 1pos, 金, TH	测试点	TSW-101-07-G-S	Samtec
J15、J16、J18	3		接头, 100mil, 2x1, 金, TH	接头, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
K1	1		SSR 继电器 SPST-NO 500mA 0-60V	SOP4	AQY282SX	Panasonic
L1	1	10uH	电感, 绕制, 铁氧体, 10μH, 3.4A, 0.047 Ω, SMD	6x6m	VLS6045EX-100M	TDK
L3	1		电感器, 铁氧体磁珠, 铁氧体, 3A, 120 Ω, AEC-Q200 1 级, SMD	0603	BLM18SG121TZ1D	MuRata
LBL1	1			PCB 标签, 0.650 x 0.200 英寸	THT-14-423-10	Brady
Q1	1		P 沟道 40V 6A (Ta) 15W (Tc) 表面贴装 DFN2020MD-6	SOT1220	BUK6D43-40PX	Nexperia



**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
Q2	1	12V	晶体管, NPN, 12V, 0.5A, SOT-416	SOT-416	2SC5585TL	Rohm
R1	1	0	0Ω 跳线 0.5W, 1/2W 片式电阻器 0805 (公制 2012) 车规级 AEC-Q200 金属箔	0805	HCJ0805ZT0R00	Stackpole
R2、R10、R17、R18	4	2.00k	电阻, 2.00k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF2001X	Panasonic
R3、R5、R12、R13、R22、R43	6	0	电阻, 0, 5%, 0.1W, AEC-Q200 0 级, 0603	0603	ERJ-3GEY0R00V	Panasonic
R4	1	117k	电阻, 117k, 0.5%, 0.1W, 0603	0603	RT0603DRE07117KL	Yageo America
R6	1	100k	电阻, 100k, 5%, 0.1W, AEC-Q200 0 级, 0603	0603	CRCW0603100KJNEA	Vishay-Dale
R7	1	13.3k	电阻, 13.3k, 0.5%, 0.1W, 0603	0603	RT0603DRE0713K3L	Yageo America
R8、R9、R15、R16	4	150k	电阻, 150k, 1%, 0.1W, AEC-Q200 0 级, 0603	0603	CRCW0603150KFKEA	Vishay-Dale
R11、R14、R19、R20、R39、R40	6	5.00k	电阻, 5.00k, 0.1%, 0.05W, 0402	0402	PNM0402E5001BST1	Vishay-Dale
R21、R23	2	10	10Ω, ±0.1%, 0.05W, 1/20W 片上电阻 0402 (公制 1005), 射频, 高频薄膜	0402	FC0402E10R0BST0	Vishay Dale
R24、R49	2	100	100Ω, ±0.1%, 0.05W, 1/20W 片式电阻 0402 (公制 1005), 射频, 高频薄膜	0402	FC0402E1000BST0	Vishay Dale
R25	1	2.00k	电阻, 2.00k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW04022K00FKED	Vishay-Dale
R26、R29、R30、R38	4	100	100Ω ±5% 0.2W, 1/5W 片上电阻 0603 (公制 1608), 汽车 AEC-Q200, 防潮, 可承受脉冲, 厚膜	0603	SG73S1JTDD101J	KOA Speer
R27	1	50m	50mΩ, ±1%, 2W, 片式电阻 2512 (公制 6432), 电流检测, 阻燃耐火涂层, 安全金属元件	2512	MCS3264R050FER	Ohmite
R28	1	500	500Ω ±0.1% 0.1W, 1/10W 片式电阻器 0603 (公制 1608) 薄膜	0603	RT0603BRC07500RL	YAGEO
R31、R44、R45	3	47k	电阻, 47k, 5%, 0.1W, 0603	0603	RC0603JR-0747KL	Yageo
R32、R33	2	470	电阻, 470, 5%, 0.1W, 0603	0603	RC0603JR-07470RL	Yageo
R34	1	680	电阻, 680, 5%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW0402680RJNED	Vishay-Dale
R35	1	10k	电阻, 10k, 5%, 0.1W, AEC-Q200 0 级, 0603	0603	CRCW060310K0JNEA	Vishay-Dale

**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
R36	1	0	电阻, 0, 5%, 0.25W, AEC-Q200 0 级, 1206	1206	RCA12060000ZSEA	Vishay-Dale
R37、R52、R53、R54	4	330	电阻, 330, 1%, 0.1W, 0603	0603	RC0603FR-07330RL	Yageo
R41	1	25k $\Omega$	微调电位计, 25k $\Omega$ , 0.5W, TH	9.53mm x 8.89mm	3352T-1-253LF	Bourns
R42、R46	2	4.70k	电阻, 4.70k, 0.1%, 0.1W, 0603	0603	RT0603BRD074K7L	Yageo America
R48	1	150k	电阻, 150k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ-2RKF1503X	Panasonic
R50	1	10.0k	电阻, 10.0k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	AC0402FR-0710KL	Yageo America
S1、S4	2		开关, 触控式, SPST, 12V, SMD	SMD, 6mm x 3.9mm	4.34121E+11	Würth Elektronik
SH-J2、SH-J5、SH-J9、SH-J13、SH-J15、SH-J16、SH-J18、SH-J19、SH-J20、SH-J21、SH-J22、SH-J23、SH-J24、SH-J25、SH-J26、SH-J27、SH-J28、SH-J29、SH-J30、SH-J31、SH-J32、SH-J33、SH-J34、SH-J35	24	1x2	分流器, 100mil, 镀金, 黑色	分流器	SNT-100-BK-G	Samtec
SW1	1		开关, 切换, SPDT 1Pos, TH	7 X 11 X4.5mm	G12AP	NKK 开关
TP1、TP23	2		测试点, 紧凑, 红色, TH	红色紧凑型测试点	5005	Keystone
TP2、TP30、TP31、TP32、TP33	5		测试点, 微型, 黑色, TH	黑色微型测试点	5001	Keystone
TP3、TP4	2		测试点, 紧凑, 黄色, TH	黄色紧凑型测试点	5009	Keystone Electronics
TP18、TP19、TP20、TP21、TP22	5		测试点, 微型, 红色, TH	红色微型测试点	5000	Keystone
TP26、TP27、TP28、TP29	4		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
TP34	1		测试点, 紧凑型, 黑色, TH	黑色紧凑型测试点	5006	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
U1、U5、U7、U8	4		具有 1.8V 逻辑控制、DCK0006A (SOT-SC70-6) 的单通道、2:1 通用模拟多路复用器	DCK0006A	TMUX1219DCKR	德州仪器 (TI)
U2	1		UART 接口 IC USB 全速至串行 UART IC, 包含振荡器和 EEPROM, SSOP-28	SSOP28	FT232RNL-REEL	FTDI
U3	1		适用于高速数据接口的 4 通道 ESD 保护阵列, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	德州仪器 (TI)
U4	1		CPU16 MSP430™ FRAM 微控制器 IC, 16 位 24MHz 32KB (32K x 8) FRAM 48-LQFP (7x7)	LQFP48	MSP430FR2355TPTR	德州仪器 (TI)
U6	1		具有 30V 内部 FET 开关并采用 SOT-23 封装的 1.6MHz 升压转换器, DBV0005A (SOT-23-5)	DBV0005A	LM27313XQMF/NOPB	德州仪器 (TI)
U9、U13	2		双路双向总线缓冲器、DGK0008A (VSSOP-8)	DGK0008A	P82B96DGKR	德州仪器 (TI)
U10	1		低噪声、高 PSRR、射频 200mA 低压降线性稳压器, DBV0005A (SOT-23-5)	DBV0005A	TPS73033DBVR	德州仪器 (TI)
U11	1		具有增强型 PWM 抑制功能、高/低侧、双向零漂移电流检测放大器, PW0008A (TSSOP-8)	PW0008A	INA240A2PWR	德州仪器 (TI)
U12	1		低功耗、130MHz、75mA 轨到轨输出放大器, DBV0005A (SOT-23-5)	DBV0005A	LMH6642MF/NOPB	德州仪器 (TI)
Y2	1		谐振器, 4MHz, 39pF, AEC-Q200 1 级, SMD	4.5mm x 1.2mm x 2mm	CSTCR4M00G55B-R0	MuRata

## 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 DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.**

### 3 Regulatory Notices:

#### 3.1 United States

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

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

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

#### **CAUTION**

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

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

#### **FCC Interference Statement for Class A EVM devices**

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

#### **FCC Interference Statement for Class B EVM devices**

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

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

#### 3.2 Canada

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

#### **Concerning EVMs Including Radio Transmitters:**

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

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

#### **Concernant les EVMs avec appareils radio:**

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

#### **Concerning EVMs Including Detachable Antennas:**

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

### Concernant les EVMs avec antennes détachables

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

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

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

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

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

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、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

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lstds/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.
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