

EVM User's Guide: LP-MSPM0L2228

MSPM0L2228 评估模块



说明

MSPM0L2228 LaunchPad™ 开发套件是适用于 MSPM0L2228 微控制器 (MCU) 的易用型评估模块 (EVM)。LaunchPad 套件包含在 MSPM0Lx22x 微控制器平台上开始开发所需要的全部资源，包括用于编程、调试和 EnergyTrace™ 技术的板载调试探针。该板还具有多个板载按钮、多个 LED、一个 RGB LED、一个 7 段 LCD 面板，以及一个 100mF 超级电容器。

开始使用

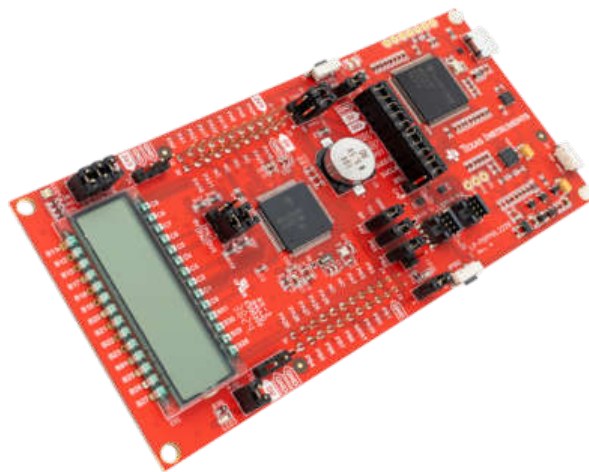
1. 从 ti.com 订购 [LP-MSPM0L2228](#)。
2. 转到 dev.ti.com 浏览代码示例。
3. 使用提供的 USB 电缆将 LP-MSPM0L2228 插入 PC。
4. 使用 Code Composer Studio™ (CCS) Cloud 将代码直接从浏览器下载到 MSPM0L2228。
5. 下载用于桌面集成开发环境的 [CCS](#)。
6. 下载用于桌面存储示例、演示和软件库的 [MSPM0 SDK](#)。

特性

- 板载 XDS110 调试探针
- 反向通道通用异步接收器/发送器 (UART) 通过通用串行总线 (USB) 连接到 PC
- USB 供电
- 40 引脚 BoosterPack™ 接头
- 硬件用户界面
 - 两个按钮：1 个 LCD 面板、1 个 RGB LED、1 个红色 LED
- 外部时钟晶体
- 电池或超级电容器选项

应用

- [能源基础设施](#)
- [工业自动化](#)
- [电器](#)
- [医疗和保健](#)
- [测试和测量](#)



LP-MSPM0L2228

1 评估模块概述

1.1 简介

MSPM0L2228 是一款 Arm® Cortex® 32 位 M0+ CPU，频率高达 32MHz。该器件采用具有 32KB SRAM 和 32B 备用存储器的 256KB 双存储体闪存。该器件还具有内部模拟功能，例如内部 ADC、电压基准和具有 8 位 DAC 的比较器。MSPM0L2228 是具有 LCD 控制器的先进 MSPM0 器件，可支持 1 至 8 路复用器 LCD 面板。最后，器件有一个 VBAT 岛，用于支持需要单独电源平面的应用。VBAT 岛上有看门狗计时器、RTC、TamperIO 和一个低频振荡器或 32kHz 晶振输入。

MSPM0L2228 是一款 Arm 32 位 Cortex-M0+ CPU，具有 LCD 控制器和增强的安全特性。该器件可用于各种任务，从具有 80 引脚的简单通用 MCU 到采用单相电子计量的完整应用级任务。开始使用 MSPM0L2228 的简单方法是使用 LP-MSPM0L2228 LaunchPad。该 LaunchPad 具有加载代码、调试和原型设计所需的所有开箱即用功能。

40 引脚 BoosterPack™ 插件模块接头简化了快速原型设计，支持市面上的多种 BoosterPack 插件模块。用户可以快速添加无线连接、图形显示、环境检测等功能。您还可以设计您自己的 BoosterPack 插件模块，或者从 TI 和第三方开发商已提供的众多插件模块中进行选择。

为使原型设计更加轻松，TI 提供了 MSPM0 软件开发套件 (SDK)，该套件包含各种用于演示如何使用内部外设的代码示例。

还提供免费的软件开发工具，例如 TI Code Composer Studio™ IDE。我们还支持 IAR Embedded Workbench® IDE 和 Arm®Keil® μ Vision® IDE 等第三方 IDE。在与 MSPM0L2228 LaunchPad 开发套件配套使用时，Code Composer Studio IDE 支持 EnergyTrace 技术。有关 LaunchPad 开发套件、配套 BoosterPack 插件模块和可用资源的更多信息，请访问 TI LaunchPad 开发套件门户。要快速入门并了解 MSPM0 软件开发套件 (SDK) 中的可用资源，请访问 TI 开发人员专区。MSPM0 MCU 还有各种在线配套资料、MSPM0 Academy 培训，以及通过 TI E2E 支持论坛提供的在线支持。

1.2 套件内容

- LP-MSPM0L2228 LaunchPad 开发套件
- USB 线缆
- 快速入门指南

1.3 规格

LP-MSPM0L2228 旨在与运行 Code Composer Studio (CCS) 的 PC、Mac® 或 Linux® 工作站配合使用。CCS 可以在工作stations上独立运行，也可通过 Web (CCS Cloud) 访问，无需安装软件。此外，LP-MSPM0L2228 附带一个已加载的示例，可以通过 GUI 进行控制。请参阅下面的开箱即用说明。

该器件可以由内置 USB 电源以外的电源供电。这允许用户放弃 PC 连接。电源可直接施加到 3.3V 电压轨。使用外部电源时，请确保不能超过 3.3V。利用板载 Arm 10 引脚连接器，可以使用单独的 XDS110 外部调试器从外部完成编程。

1.4 器件信息

LP-MSPM0L2228 使用德州仪器 (TI) 的以下器件。

表 1-1. 器件信息

器件名称	说明	用途
MSP432E401YTPDT	具有以太网™、CAN、1MB 闪存和 256kB RAM 的 SimpleLink™ 32 位 ARM Cortex-M4F MCU	XDS110 主机器件
MSPM0L2228SPNR	具有 32MHz Arm Cortex 32 位 M0+ CPU、256kB 闪存和 32kB SRAM 的混合信号微控制器	评估器件
MSP430G2452IRSA16R	具有 16 位 RISC CPU、8kB 闪存和 256B SRAM 的混合信号微控制器	用于 EnergyTrace 技术的直流/直流控制器
TPD4E004RSER	用于高速数据接口的 4 通道 ESD 保护阵列	通过 USB 连接器保护 LP-MSPM0L2228 免受 ESD 损坏
TPS73533DRBT	500mA、可调节、低静态电流、低噪声、高 PSRR、单路输出 LDO 稳压器	3.3V 电源 XDS110 和 MSPM0L2228
TPS2102DBVR	2.7V 至 4V 电源多路复用器、双输入、单输出电源开关	切换 XDS110 电源

2 硬件

2.1 硬件概述

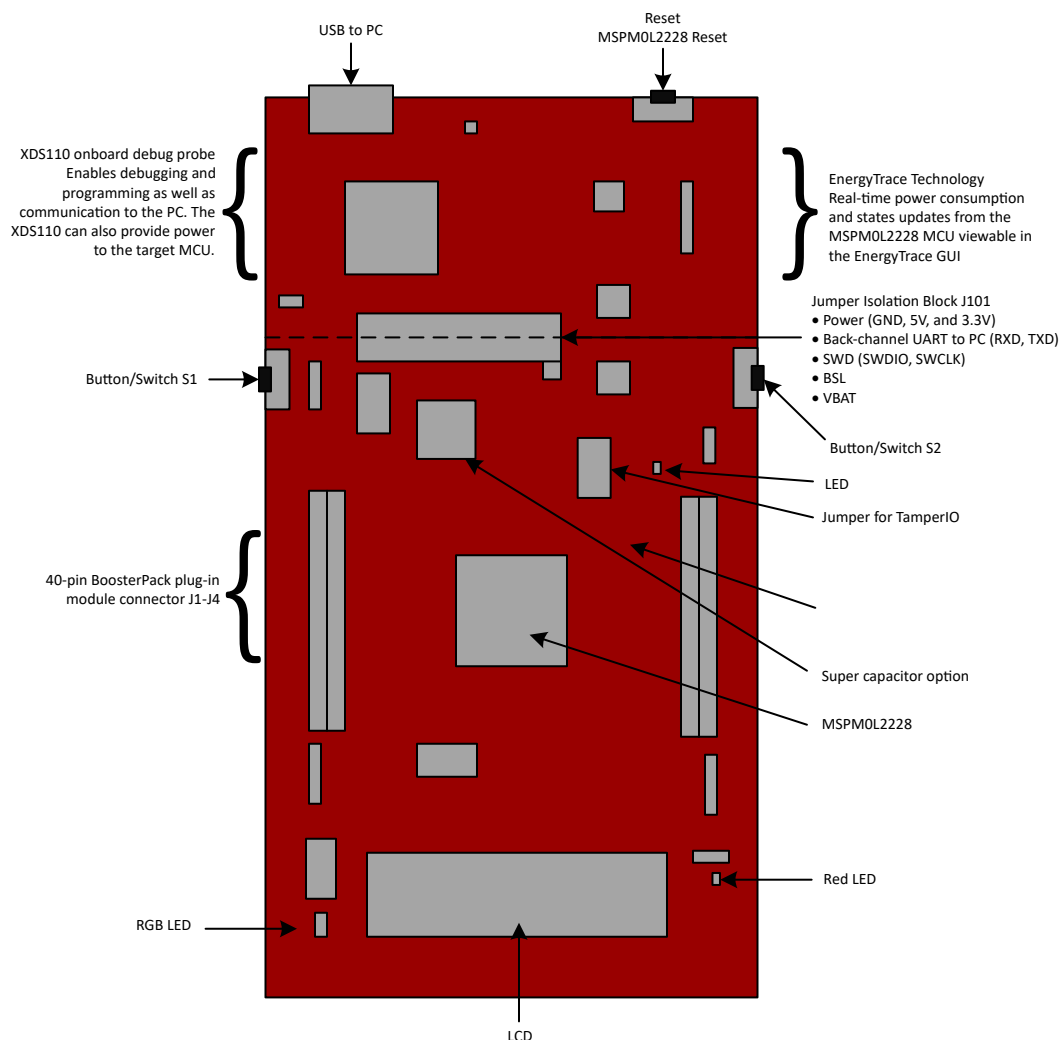


图 2-1. LP-MSPM0L2228 跳线和连接器图

LP-MSPM0L2228 具有许多硬件特性，允许用户完全访问 MSPM0L2228 引脚，同时仍提供板载连接以方便使用。分流连接为用户提供了一种轻松更改 LaunchPad 配置的方法。图 2-1 展示了这些分流器的位置。表 2-1 描述了每个分流器的连接。

表 2-1. 跳线信息

跳线	说明	默认设置	连接的信号
J7	开漏 IO 上拉	右侧和中间连接	PA0 : 4.7k 上拉电阻器连接到 5V 或 2.2k 上拉电阻器连接到 3.3V，具体取决于设置
J8	开漏 IO 上拉	右侧和中间连接	PA1 : 4.7k Ω 上拉电阻器连接到 5V 或 2.2k Ω 上拉电阻器连接到 3.3V，具体取决于设置
J9	红色 LED 连接 (LED3)	已组装	通过 LED 和 470 Ω 电阻器连接到 PA0 的 3.3V 电压
J10	RGB 蓝色连接	已组装	PA23 经过 220 Ω 电阻器并将 LED 接地。
J11	RGB 红色连接	已组装	PB10 经过 220 Ω 电阻器并将 LED 接地
J12	RGB 绿色连接	已组装	PB9 经过 220 Ω 电阻器并将 LED 接地
J13	PB3/TIO 连接	中间和底部连接	PB3 boosterpack 连接到 PB3 引脚和 TamperIO

表 2-1. 跳线信息 (续)

跳线	说明	默认设置	连接的信号
J14	PB2/TIO 连接	中间和底部连接	PB2 boosterpack 连接到 PB2 引脚和 TamperIO
J15	PA7/TIO 连接	中间和底部连接	PA7 boosterpack 连接到 PA7 引脚和 TamperIO
J16	红色 LED 连接 (LED5)	未组装	经过 470 Ω 电阻器并将 LED 接地
J17	UART RX	顶部和中间连接	PA11 连接到 XDS PA11 连接到 PA11 boosterpack
J18	UART TX	顶部和中间连接	PA10 连接到 XDS PA10 连接到 PA10 boosterpack
J19	BSL 按钮	已组装	PA18 : 47k Ω 下拉电阻器, 开关上拉至 3.3V
J20	开关连接 (S2)	已组装	PB8 : 开关下拉至 GND

2.2 电源要求

LP-MSPM0L2228 只需插入 USB 并填充调试器跳线块即可为器件供电。借助板载 LDO，5V USB 电源通过 500mA 电源转换为 3.3V。也可以通过外部电源并使用 3.3V 或 5V 接头为 LaunchPad 供电。3.3V 轨上的电压不能超过 3.3V，5V 轨上的电压不能超过 5V。为了运行低频子系统模块 (LFSS)，需要组装 BAT 跳线或使用 1.65 - 3.3V 电源供电。

图 2-2 展示了 LP-MSPM0L2228 上的电源接头。

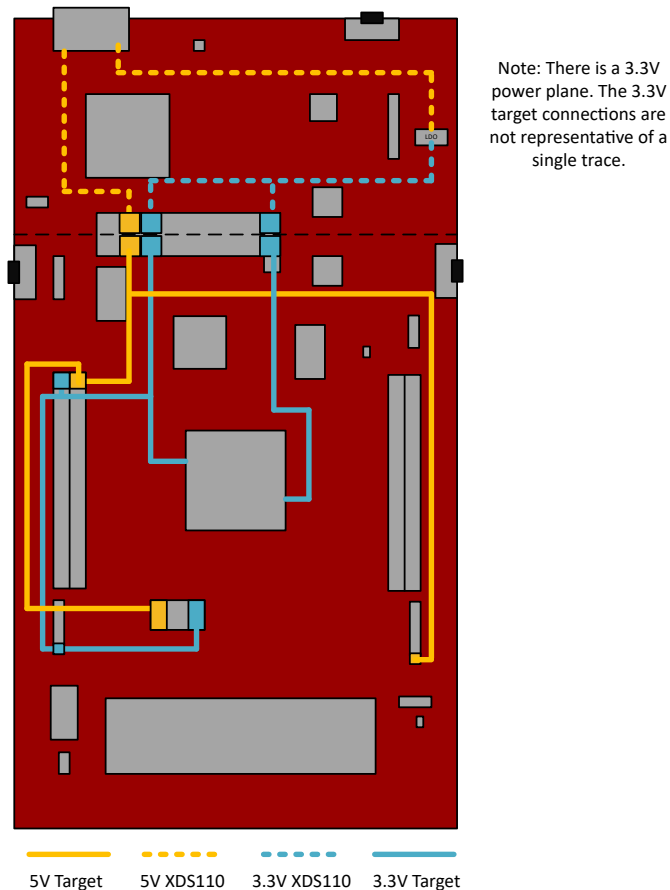


图 2-2. LP-MSPM0L2228 电源接头

2.3 XDS110 调试探针

LP-MSPM0L2228 具有板载调试探针，可简化原型设计。此 LaunchPad 上使用的调试器是 XDS110 型号，它支持所有 MSPM0 器件衍生产品。集成式 XDS110 调试探针与 MSPM0L2228 电路的其余部分分离，如 LaunchPad 上的虚线丝印所示。除了公共接地之外，XDS110 只能通过经过 J101 的信号进行连接。

2.3.1 隔离跳线块

利用隔离跳线块 J101，用户可以连接或断开从 XDS110 域进入 MSPM0L2228 目标域的信号。这包括 XDS110 SWD 信号、应用 UART 信号、3.3V 和 5.5V 电源、复位和 VBAT 源。

表 2-2. 隔离跳线块

跳线	说明
5V	来自 USB 的 5V 电源轨
3V3	来自 LDO 的 3.3V 电源轨
RXD<<	反向通道 UART：目标 MSPM0L2228 通过该信号接收数据。箭头指示信号的方向。
TXD>>	反向通道 UART：目标 MSPM0L2228 通过该信号发送数据。箭头指示信号的方向。
NRST	复位信号
SWDIO	串行线调试：SWDIO 数据信号。
SWCLK	串行线调试：SWCLK 时钟信号。
BSL	为引导加载程序调用引脚。允许 XDS110 调用 BSL。
VBAT	XDS110 侧的 LDO 与 MSPM0L2228 的 VBAT 引脚之间的 VBAT 连接。
CAP	超级电容器的 CAP 连接。

在正常原型设计期间，大多数分流器均已组装。但是，在某些情况下用户需要打开这些连接：

- 完全消除 XDS110 调试探针的影响，以实现高精度目标功率测量
- 控制 XDS110 和目标域之间的 3.3V 和 5V 功率流
- 释放目标 MCU 引脚，用于除板载调试和应用 UART 通信以外的其他目的。
- 提供 XDS110 的编程和 UART 接口，使其可用于板载 MCU 以外的器件。
- 利用其他 VBAT 选项

2.3.2 应用 (反向通道) UART

借助该反向通道 UART，可以与不属于目标应用主要功能的 USB 主机进行通信。这在开发过程中非常有用，而且还能提供与 PC 主机侧进行通信的通道。这可以用于在与 LaunchPad 开发套件通信的 PC 上创建图形用户界面 (GUI) 和其他程序。

在主机侧，当 LaunchPad 开发套件在主机上进行枚举时，将生成一个用于应用反向通道 UART 的虚拟 COM 端口。您可以使用任何与 COM 端口连接的 PC 应用程序 (包括 HyperTerminal 或 Docklight 等终端应用程序) 来打开该端口并与目标应用程序通信。用户需要找出对应于反向通道的 COM 端口。在使用 Windows 操作系统的 PC 上，设备管理器可以提供协助。

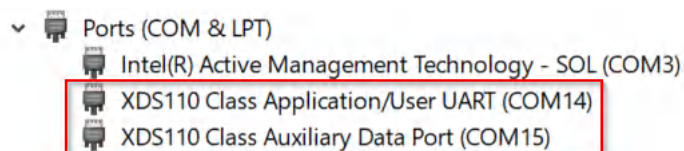


图 2-3. 设备管理器中的应用反向通道 UART

反向通道 UART 为 XDS110 Class Application/User UART 端口。此时，图 2-3 展示了 COM14，但该端口可能因主机 PC 而异。确定了正确的 COM 端口后，请根据文档在主机应用中配置该端口。然后，用户可以打开该端口并开始与主机进行通信。

在目标 MSPM0L2228 侧，反向通道 UART 连接到 UART0 (PA10、PA11)。XDS110 具有可配置的波特率；因此，PC 应用程序配置的波特率必须是同一波特率。

2.4 测量 MSPM0L2228 的电流消耗

要使用万用表测量 MSPM0L2228 MCU 的电流消耗，请使用 J101 跳线隔离块上的 3V3 跳线。测量的电流包括目标器件和 LaunchPad 电路消耗的电流以及任何通过 BoosterPack 插件模块接头消耗的电流。要测量超低功耗，请按照下列步骤操作：

- 拆下 J101 隔离块中的 3V3 跳线，并在该跳线上连接一个电流表。
- 应考虑反向通道 UART 和任何连接到 MSPM0L2228 的电路可能对电流消耗产生的影响。考虑在隔离跳线块上断开这些器件和电路，或者至少在最终测量中考虑灌电流和拉电流能力。
- 确保 MSPM0L2228 上没有悬空输入/输出 (I/O)。这会引起不必要的额外电流消耗。每个 I/O 都会进行驱动，如果 I/O 是输入，则将其拉或驱动至高电平或低电平。
- 开始执行目标。
- 要实现更准确的电流测量，请将器件置于“Free Run”模式，并断开 MSPM0L2228 与电路板调试部分 (接头 J101) 之间的编程信号。
- 测量电流。请记住，如果电流出现波动，则可能难以获得稳定的测量结果。在静态状态下进行测量会更轻松。

要测量 VBAT 域的电流消耗，请执行以下操作：

- 拆下 J101 隔离块中的 BAT 跳线，并在该跳线上连接一个电流表。
- 为了与其他电流消耗源隔离，TI 建议使用来自 VDD 的单独电源进行供电。要执行此操作，请将电压施加到电路板 MSP 侧的 BAT 引脚。
- 测量电流。

备注

对于 XMSPM0L2228 器件，VBAT 电流消耗高于预期。此问题已在器件的发布版本中得到修复。此器件的发布版本在丝印上没有 X 标识。

2.5 计时

内部 SYSOSC 默认为 32MHz (精度为 2.5%)。默认情况下，MCLK 以 32MHz SYSOSC 为源。CPUCLK 在 RUN 模式下直接以 MCLK 为源，在其他模式下禁用。低功耗时钟 (ULPCLK) 可以 MCLK 为源，并通过配置在 RUN 和 SLEEP 模式下激活。该器件还包含内部 32kHz 振荡器 LFOSC，这是默认的低频源。该 LaunchPad 包含两个时钟晶体选项，即 1 个高频 32MHz 晶体 (HFXT) 和 1 个低频 32.728kHz 晶体 (LFXT)。在应用程序编程期间，可以选择晶体作为高频和低频时钟的时钟源。

有关时钟树的更多详细信息，请参阅 [MSPM0L 系列微控制器技术参考手册](#) 的第 2.3 节 *时钟模块 (CKM)*。

2.6 BoosterPack 插接模块引脚布局

LaunchPad 开发套件遵循 40 引脚 LaunchPad 开发套件引脚排列标准 (如果引脚可用)。对于 TI 生态系统而言，创建标准旨在帮助实现 LaunchPad 开发套件与 BoosterPack 插件模块之间的兼容性。

虽然大多数 BoosterPack 插接模块符合该标准，但仍有些不符合标准。如果 BoosterPack 插件模块的经销商或所有者没有明确指出该模块与 MSPM0L2228 LaunchPad 开发套件的兼容性，请将候选 BoosterPack 插件模块的原理图与 LaunchPad 开发套件进行比较，以验证兼容性。可以通过在软件中更改 MSPM0L2228 器件的引脚功能配置来解决冲突。

2.7 液晶显示器 (LCD)

LP-MSPM0L2228 中包含一个板载 7 段 LCD。LCD 由 MSPM0L2228 的内部 LCD 驱动器驱动。LaunchPad 包含无源器件，可支持电荷泵或内部电阻梯配置。[图 2-4](#) 展示了 LCD 段布局布线，[表 2-3](#) 展示了 LCD 段映射。

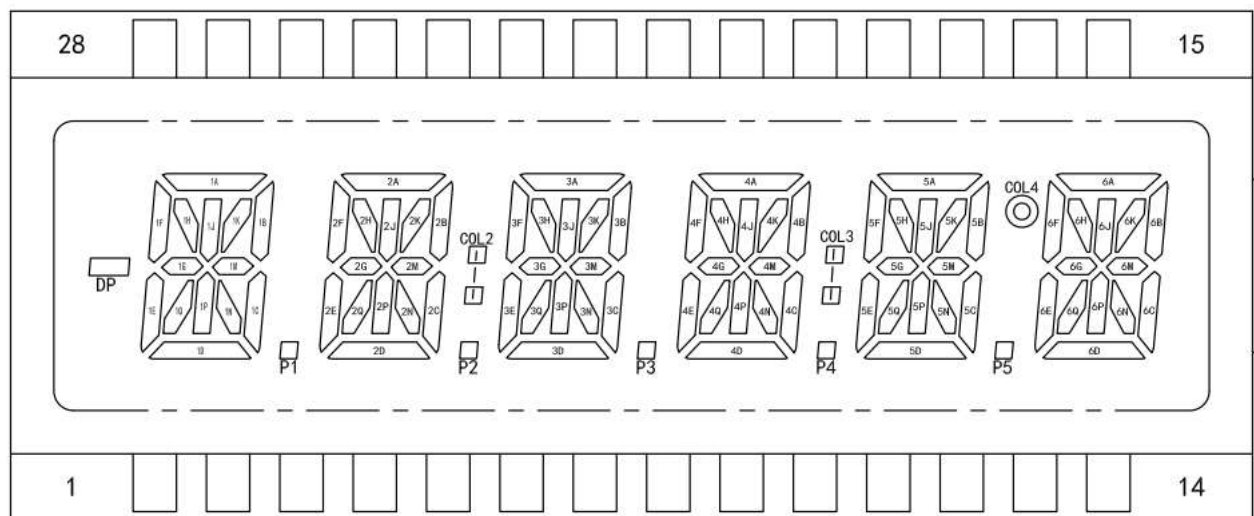


图 2-4. LCD 段布局

表 2-3. LCD 段映射

LP 引脚	引脚功能	LCD 引脚	COM1	COM2	COM3	COM4
PB11	LCD36	1	2D	2E	2F	-
PB12	LCD37	2	2Q	2G	2H	2A
PB13	LCD38	3	2N	2P	2J	2K
PB17	LCD18	4	P2	2C	2M	2B
PB18	LCD19	5	3D	3E	3F	COL2
PB19	LCD20	6	3Q	3G	3H	3A
PB20	LCD23	7	3N	3P	3J	3K
PB21	LCD39	8	P3	3C	3M	3B
PB22	LCD40	9	4D	4E	4F	-
PB23	LCD41	10	4Q	4G	4H	4A
PB24	LCD24	11	COM1	-	-	-
PB25	LCD42	12	-	COM2	-	-
PB26	LCD43	13	-	-	COM3	-
PB27	LCD44	14	-	-	-	COM4
PB28	LCD45	15	-	6C	6M	6B
PB29	LCD46	16	6N	6P	6J	6K
PB30	LCD47	17	6Q	6G	6H	6A
PB31	LCD48	18	6D	6E	6F	COL4
PC0	LCD49	19	P5	5C	5M	5B
PC1	LCD50	20	5N	5P	5J	5K
PC2	LCD51	21	5Q	5G	5H	5A
PC3	LCD52	22	5D	5E	5F	COL3
PC4	LCD53	23	P4	4C	4M	4B
PC5	LCD54	24	4N	4P	4J	4K
PC6	LCD55	25	P1	1C	1M	1B
PC7	LCD56	26	1N	1P	1J	1K
PC8	LCD57	27	1Q	1G	1H	1A
PC9	LCD58	28	1D	1E	1F	DP

LaunchPad 配备了一个 100mF 超级电容器，可用于为 VBAT 供电。为了让超级电容器为 LFSS 模块供电，J101 上的跳线必须连接到 VBAT 和 CAP。启用图 2-5 可将超级电容器充电至 VDD，同时确保在 VDD 降至 VBAT 以下时电路会关闭。请注意，启用此电路会将 VBAT 连接到 VDD，即使未连接隔离跳线也是如此。

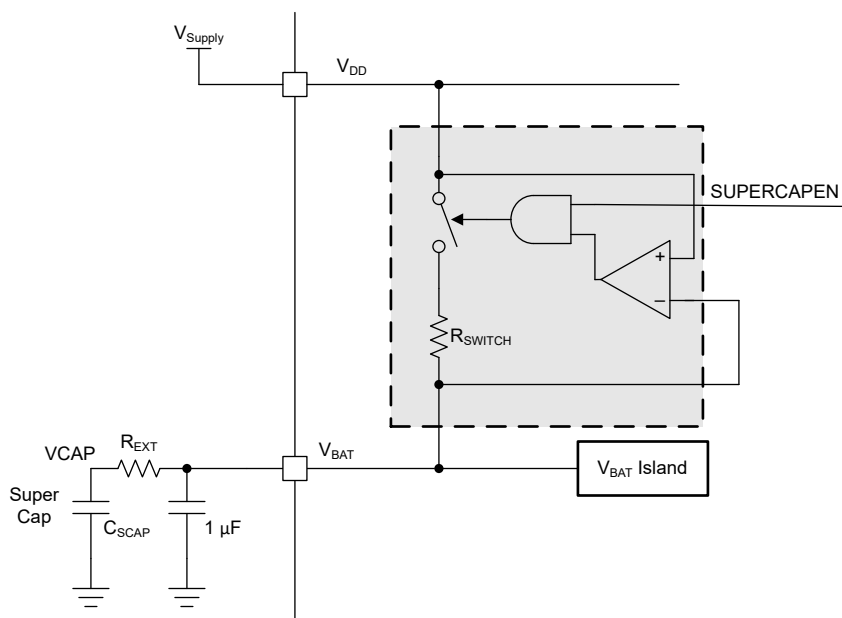


图 2-5. 超级电容器充电电路

3 软件

3.1 软件开发选项

使用 LP-MSPM0L2228 进行原型设计的方法有多种：

1. [Code Composer Studio Cloud \(CCS Cloud\)](#) — 选择此选项可快速开始，只需极少的安装。
2. [Code Composer Studio \(CCS\)](#) — 选择此选项可脱机工作并拥有对调试功能的完全访问权限。要开始使用，请参阅 [CCS Theia](#) 文档。
3. [Code Composer Studio Eclipse](#) — 支持此选项，但它是个旧工具，本指南中未涉及。

3.2 CCS Cloud

1. 前往 dev.ti.com。用户可能需要安装 CCS Cloud Agent。如果是，请按照以下步骤完成此安装。
2. 使用 micro-USB 电缆插入 LP-MSPM0L2228。TI 开发人员专区会自动检测 LP-MSPM0L2228 是否已插入。
3. 点击 **Browse software and examples**，这将在新窗口中打开 MSPM0 SDK。
4. 在左侧栏中，转到基于 Arm 的微控制器 > Embedded Software > MSPM0 SDK > Examples > Development Tools > DriverLib > gpio_toggle_output > No RTOS > TI Clang Compiler > gpio_toggle_output。
5. 点击屏幕右上角的 **Import** 按钮。此操作会将工程导入到 CCS Cloud 中并在新窗口中打开。
6. 在 CCS Cloud 中，点击左侧栏中的调试图标以打开调试视图。
7. 点击 **play** 按钮将代码部署到器件并打开调试会话。默认情况下，调试器会暂停第一行代码。
8. 点击蓝色的 **play** 按钮启动应用程序。
9. LP-MSPM0L2228 上的 RGB LED 需要闪烁。

现在，用户可以通过修改代码或导入不同的示例代码来开始原型设计。

4 硬件设计文件

4.1 原理图

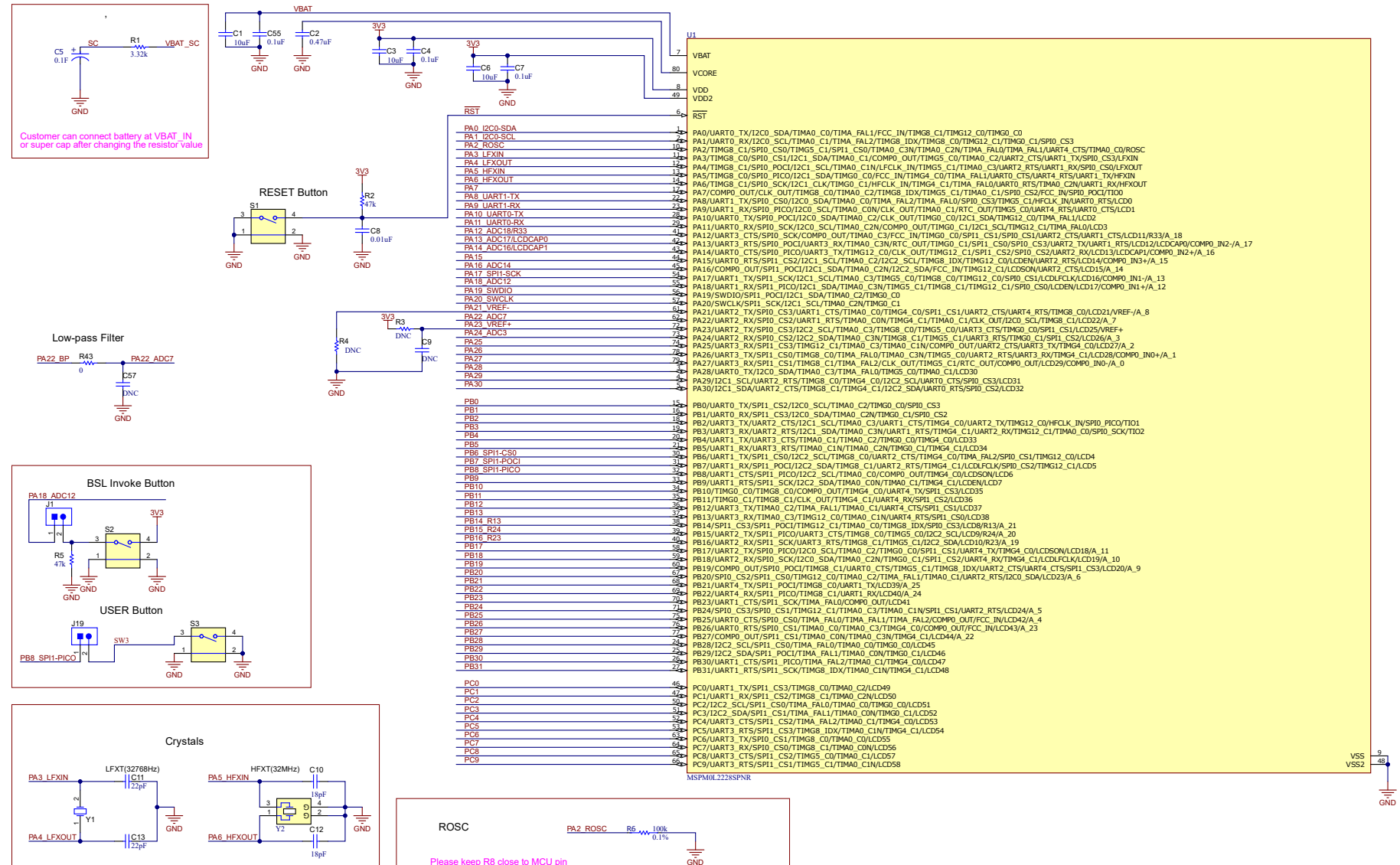
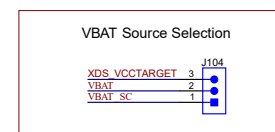
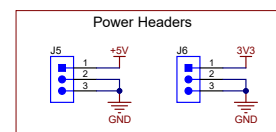
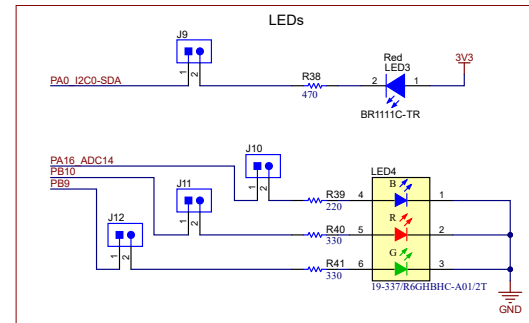
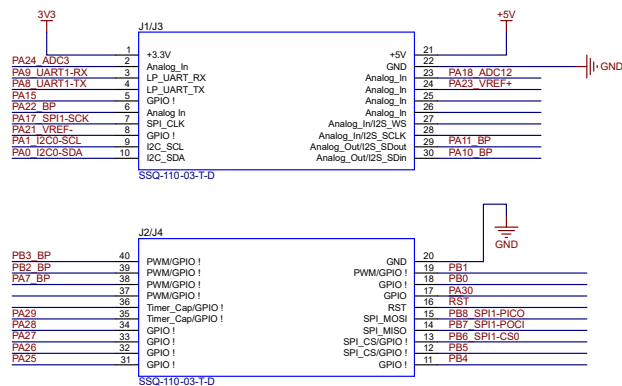


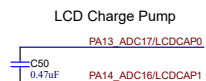
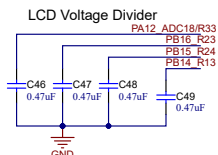
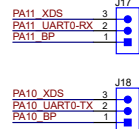
图 4-1. MSPM0L2228 目标器件原理图

BoosterPack Connectors



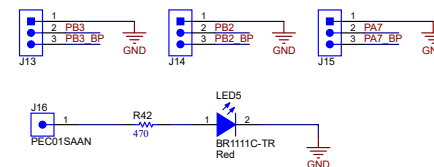
LCD setting

PA10 and PA11 Options



PC8	27	DS1
PC7	26	1Q/1G/1H/1A
PC9	25	1N/1P/1J/1K
PC6	24	1D/1E/1F/1P
		P1/1C/1M/1B
PB12	2	2Q/2G/2H/2A
PB13	3	2N/2P/2J/2K
PB11	1	2D/2E/2F
PB17	4	P2/2C/2M/2B
PB19	6	3Q/3G/3H/3A
PB20	7	3N/3P/3J/3K
PB18	5	3D/3E/3F/3P
PB21	8	P3/3C/3M/3B
PB23	10	4Q/4G/4H/4A
PC5	24	4N/4P/4J/4K
PB22	9	4D/4E/4F
PC4	23	P4/4C/4M/4B
PC2	21	5Q/5G/5H/5A
PC1	20	5N/5P/5J/5K
PC3	22	5D/5E/5F/5P
PC0	19	P5/5C/5M/5B
PB30	17	6Q/6G/6H/6A
PB29	16	6N/6P/6J/6K
PB31	18	6D/6E/6F/6P
PB28	15	6C/6M/6B
PB24	11	COM1
PB25	12	COM2
PB26	13	COM3
PB27	14	COM4
		GDH-1638WP

TamperIO Jumpers



5V and 3.3V Pullup for Open-Drain IOs

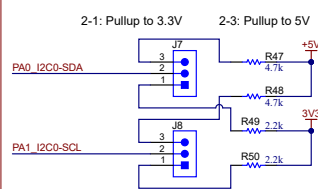


图 4-2. BoosterPack 连接器



Energy measurement method protected under U.S. Patent Application 13/329,073 and subsequent patent applications



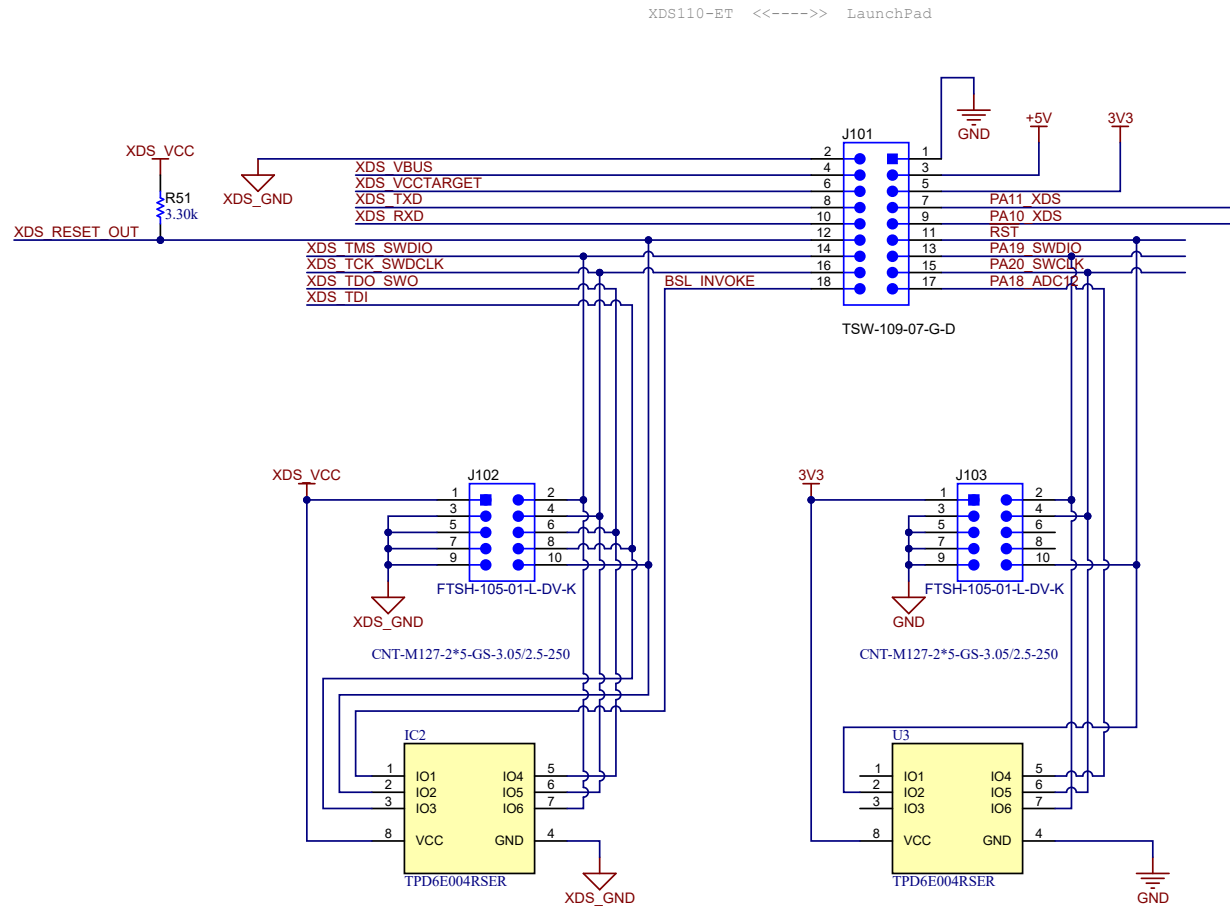


图 4-5. XDS110 目标接口原理图

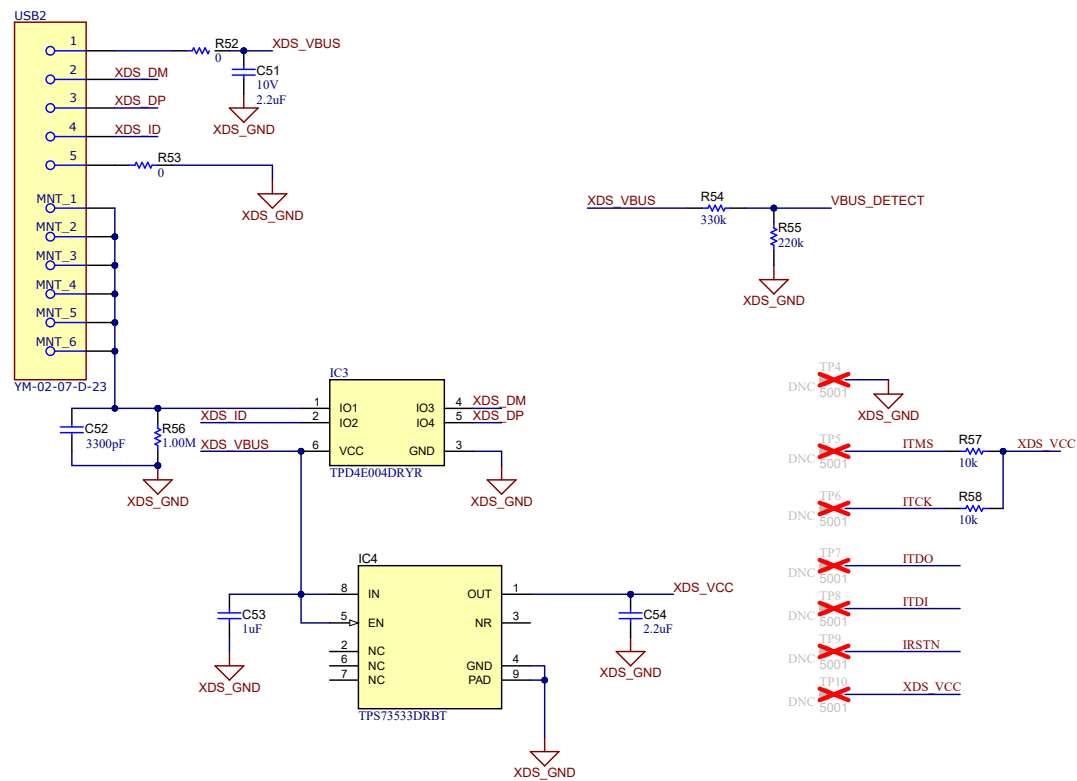


图 4-6. XDS110 USB 电源原理图

4.2 PCB 板层

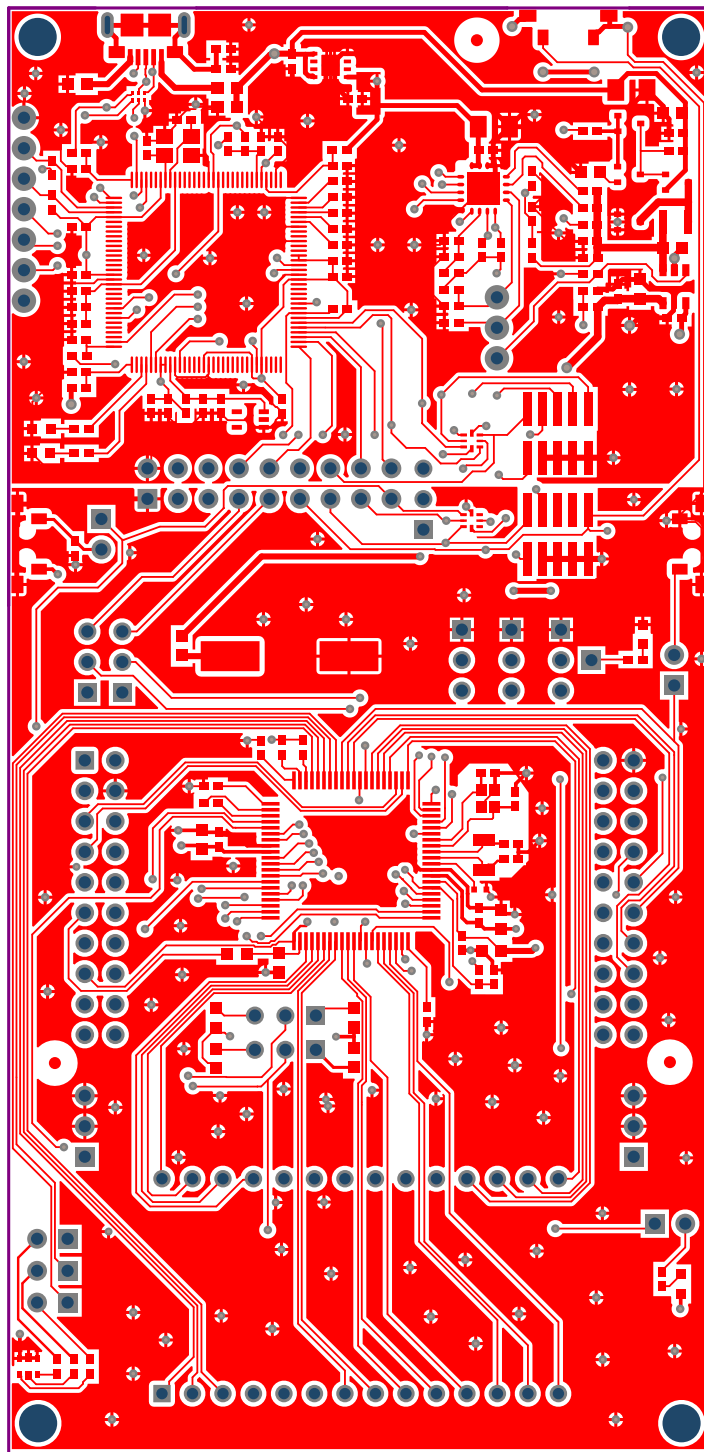


图 4-7. PCB 顶层

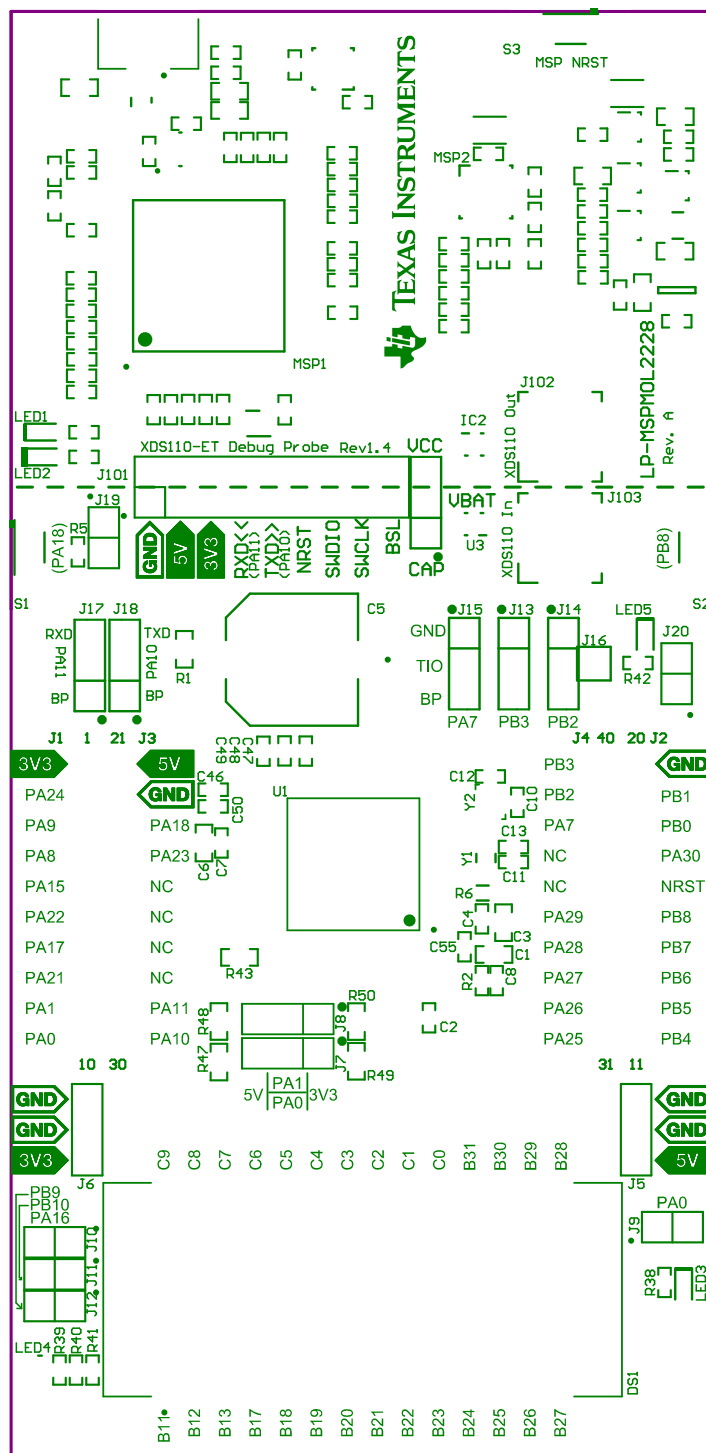


图 4-8. PCB 顶部覆盖层

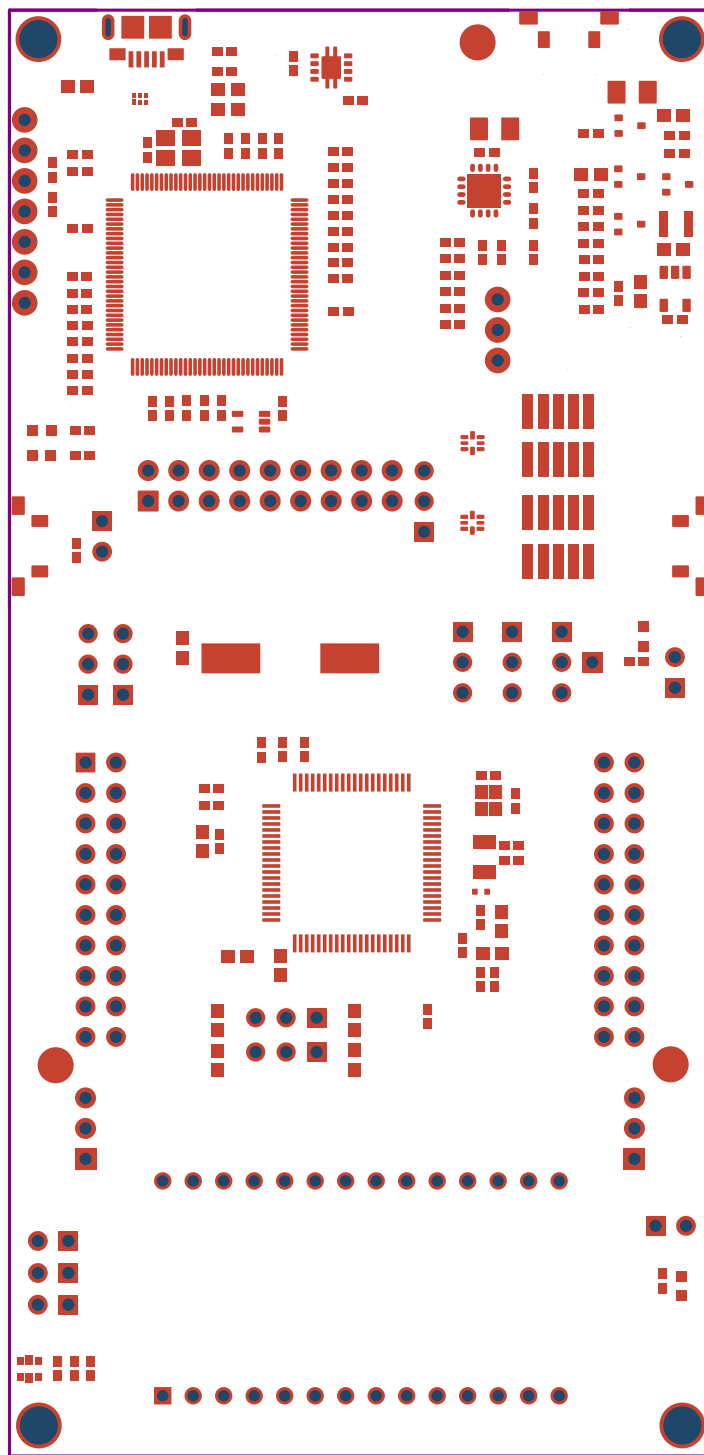


图 4-9. PCB 顶部焊接层

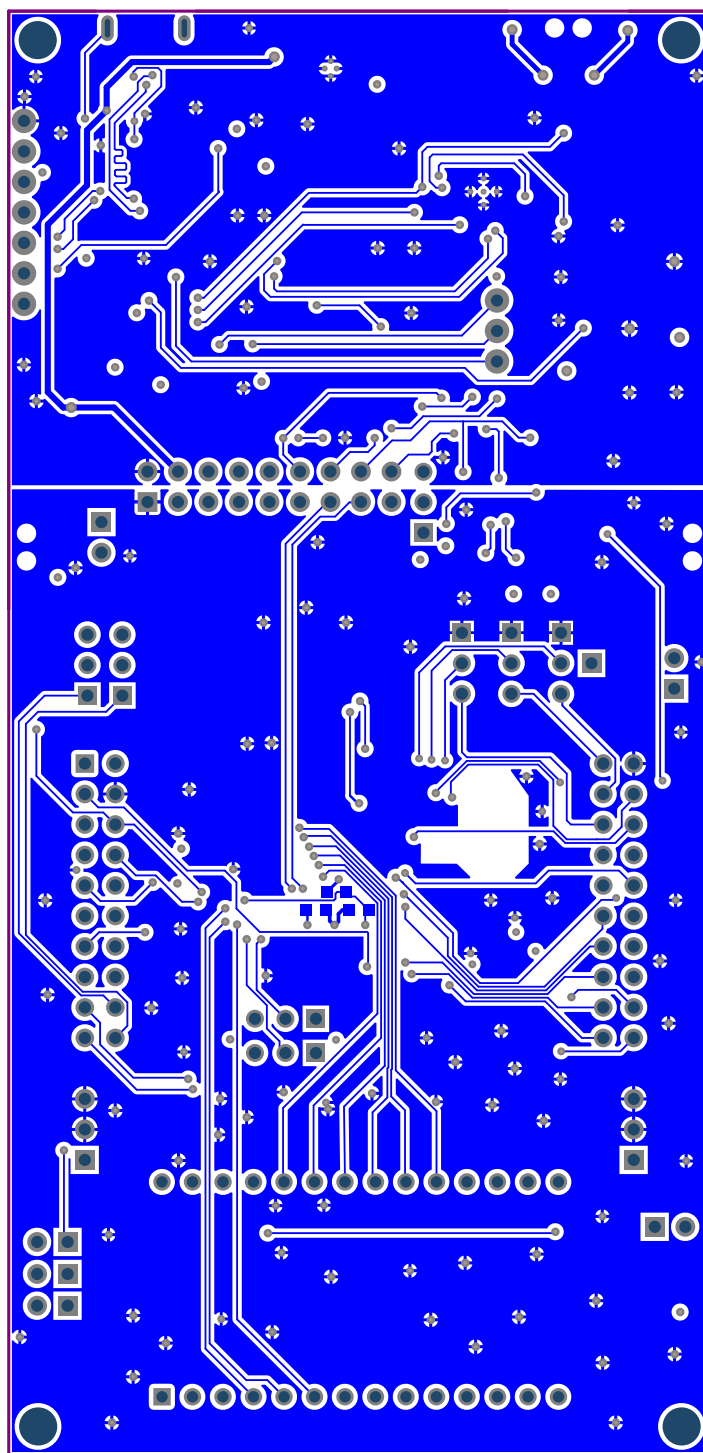


图 4-10. PCB 底层



图 4-11. PCB 底部覆盖层

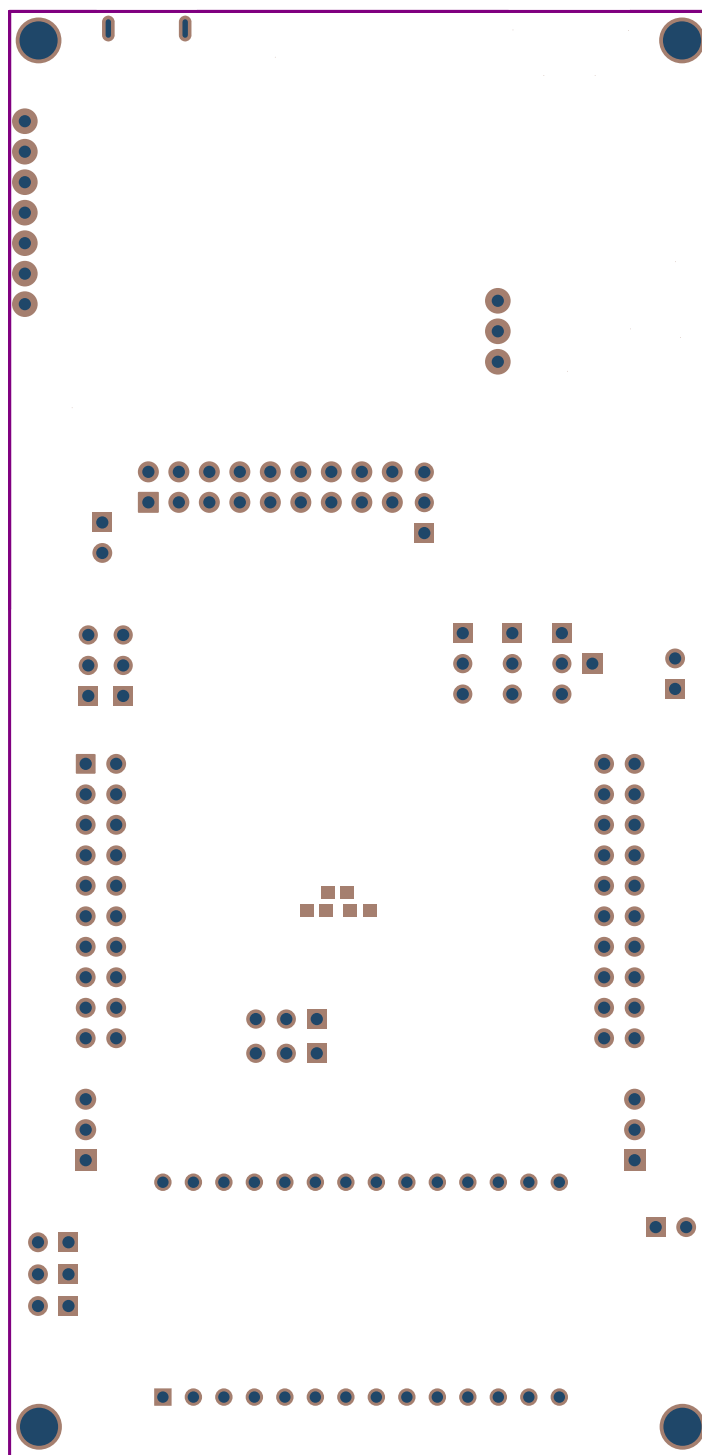


图 4-12. PCB 底部焊接层

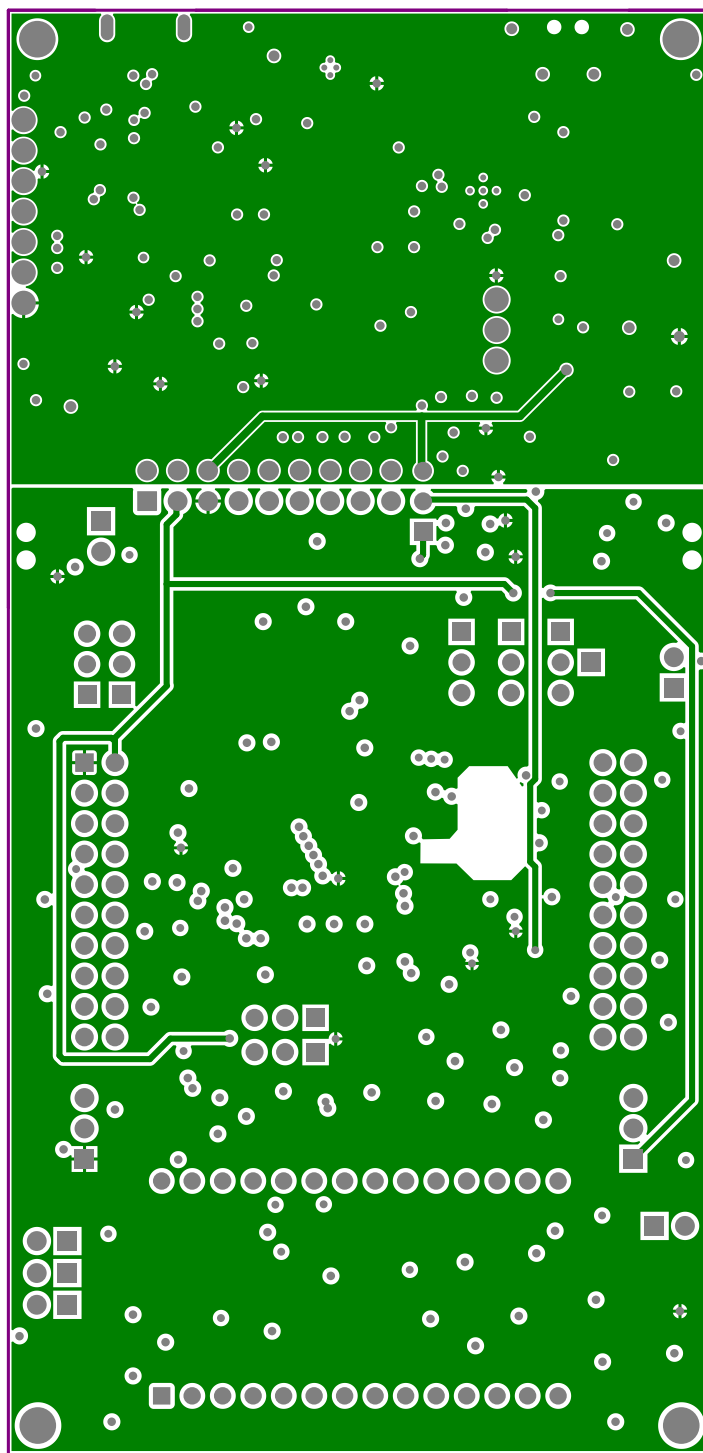


图 4-13. PCB VCC 平面

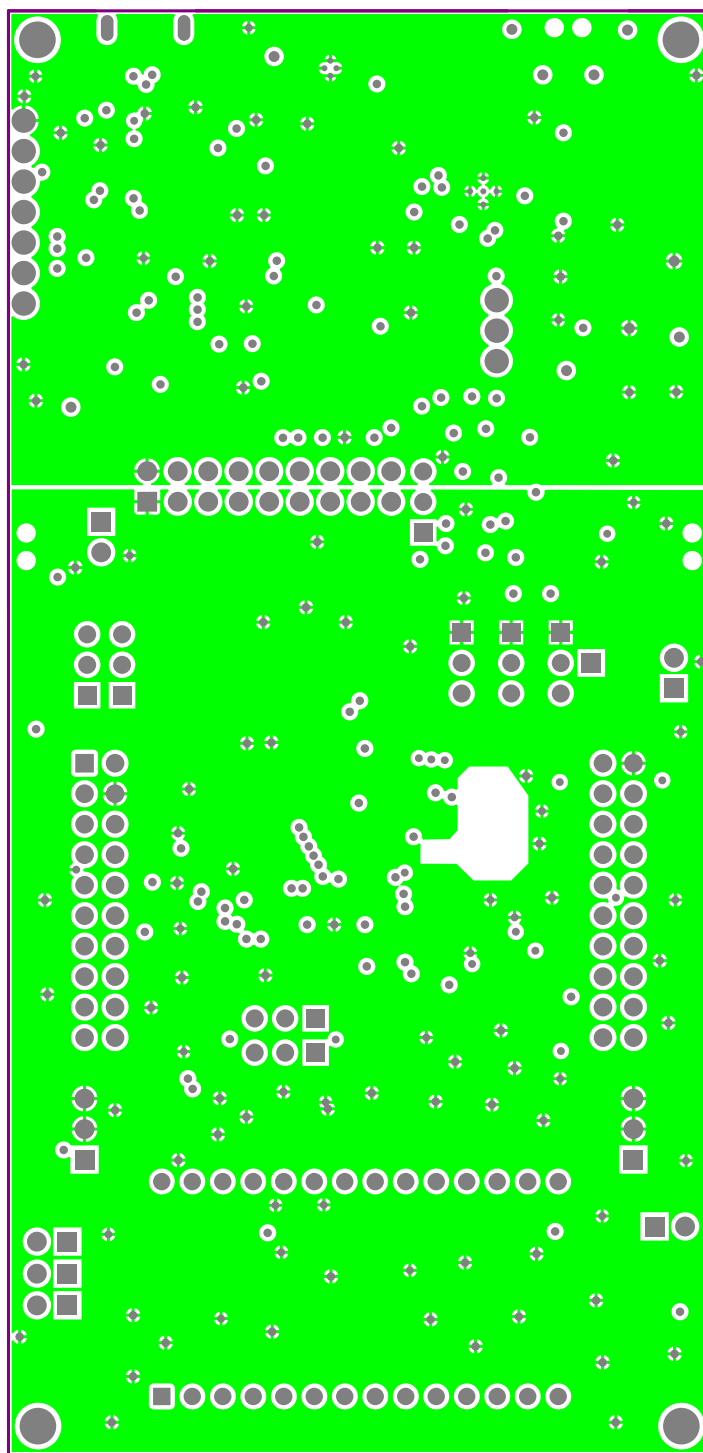


图 4-14. PCB GND 平面

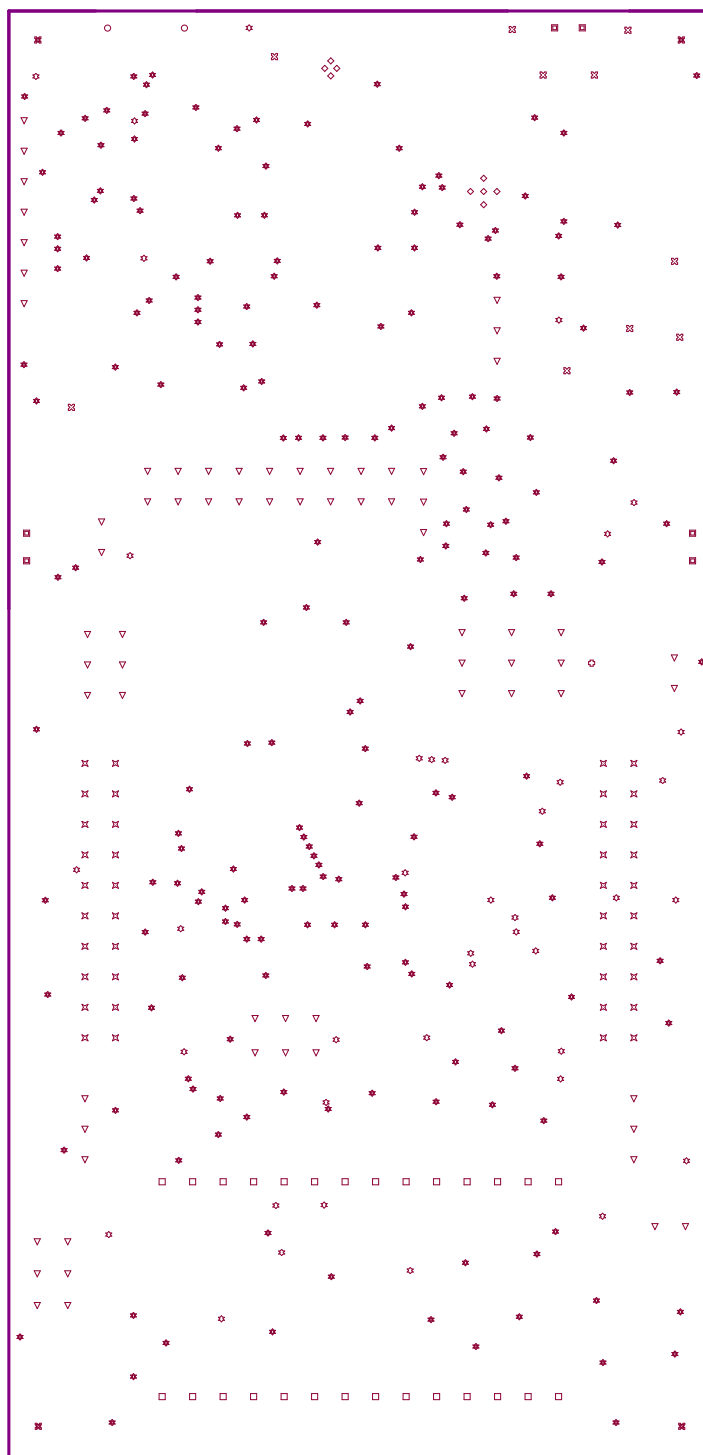


图 4-15. PCB 钻孔图

4.3 物料清单 (BOM)

表 4-1. 物料清单

指示符	数量	值	说明	器件型号	制造商
!PCB1	1		印刷电路板		不限
C1、C3、C6	3	10 μ F	电容, 陶瓷, 10 μ F, 6.3V, $\pm$ 20%, X5R, 0603	GRM188R60J106ME84	MuRata
C2、C46、C47、C48、C49、C50	6	0.47 μ F	电容, 陶瓷, 0.47 μ F, 6.3V, $\pm$ 10%, X5R, 0402	GRM155R60J474KE19D	MuRata
C4、C7、C55	3	0.1 μ F	电容, 陶瓷, 0.1 μ F, 50V, $\pm$ 20%, X5R, 0402	GRM155R61H104ME14D	MuRata
C5	1	100mF	100mF (EDLC) 超级电容器 5.5V 径向、CAN - SMD 25 Ω , 1kHz	FC0H104ZFTBR24	KEMET
C8	1	0.01 μ F	电容, 陶瓷, 0.01 μ F, 16V, $\pm$ 10%, X5R, 0402	GRM155R61C103KA01D	MuRata
C10、C12	2	18pF	电容, 陶瓷, 18pF, 50V, $\pm$ 5%, C0G/NP0, 0402	CL05C180JB5NNNC	Samsung Electro-Mechanics
C11、C13	2	22pF	电容, 陶瓷, 22pF, 50V, $\pm$ 5%, C0G/NP0, 0402	GRM1555C1H220JA01D	MuRata
C14、C18、C19、C21、C25、C28、C29、C34、C39、C40、C45	11	0.1 μ F	电容, 陶瓷, 0.1 μ F, 6.3V, $\pm$ 10%, X7R, 0402	GRM155R70J104KA01D	MuRata
C15、C16、C17、C23、C27	5	0.01 μ F	电容, 陶瓷, 0.01 μ F, 25V, $\pm$ 10%, X7R, 0402	GRM155R71E103KA01D	MuRata
C20、C22、C26、C53	4	1 μ F	电容, 陶瓷, 1 μ F, 25V, $\pm$ 10%, X5R, 0402	C1005X5R1E105K050BC	TDK
C24、C54	2	2.2 μ F	电容, 陶瓷, 2.2 μ F, 6.3V, $\pm$ 10%, X5R, 0402	GRM155R60J225KE95D	MuRata
C30、C31	2	12pF	电容, 陶瓷, 12pF, 50V, $\pm$ 5%, C0G/NP0, 0402	GRM1555C1H120JA01D	MuRata
C32、C35	2	33pF	电容, 陶瓷, 33pF, 50V, $\pm$ 5%, C0G/NP0, 0402	GRM1555C1H330JA01D	MuRata
C33、C37	2	4.7 μ F	电容, 钽, 4.7 μ F, 16V, $\pm$ 10%, 4 Ω , SMD	TAJA475K016RNJ	AVX
C36	1	1000pF	电容, 陶瓷, 1000pF, 50V, $\pm$ 10%, X7R, AEC-Q200 1级, 0402	GCM155R71H102KA37D	MuRata
C38、C44	2	4.7 μ F	电容, 陶瓷, 4.7 μ F, 16V, $\pm$ 10%, X5R, 0603	GRM188R61C475KAAJ	MuRata

表 4-1. 物料清单 (续)

指示符	数量	值	说明	器件型号	制造商
C41	1	47 μ F	电容, 陶瓷, 47 μ F, 6.3V, $\pm$ 20%, X5R, 0603	GRM188R60J476ME15D	MuRata
C42、C43	2	0.22 μ F	电容, 陶瓷, 0.22 μ F, 16V, $\pm$ 10%, X7R, 0402	GRM155R71C224KA12D	MuRata
C51	1	2.2 μ F	电容, 陶瓷, 2.2 μ F, 10V, $\pm$ 10%, X5R, 0603	C0603C225K8PACTU	Kemet
C52	1	3300pF	电容, 陶瓷, 3,300pF, 50V, $\pm$ 10%, X7R, 0402	GRM155R71H332KA01D	MuRata
D1、D2	2	40V	二极管, 肖特基, 40V, 0.12A, AEC-Q101, SOT-323	BAS40-05W,115	Nexperia
DS1	1		GDH-1638WP	GDH-1638WP	Xiamen Ocular Optics
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
H1、H2	2		垫片支架, 尼龙 66	MAE-10	Kang Yang
IC1	1		2.7V-4V 双路输入/单路输出 MOSFET, 0.5A 主输入/0.1A 辅助输入, 低电平有效使能端, 通信温度, DBV0005A (SOT-23-5)	TPS2102DBVR	德州仪器 (TI)
IC2、U3	2		用于高速数据接口的低电容 $\pm$ 15kV ESD 保护阵列, 6 通道, -40°C 至 +85°C, 8 引脚 UQFN (RSE), 绿色环保 (符合 RoHS 标准, 无镉/无溴)	TPD6E004RSER	德州仪器 (TI)
IC3	1		用于高速数据接口的 ESD 保护阵列, 4 通道, -40°C 至 +85°C, 6 引脚 SON (DRY), 绿色环保 (符合 RoHS 标准, 无镉/溴)	TPD4E004DRYR	德州仪器 (TI)
IC4	1		500mA、可调节、低静态电流、低噪声、高 PSRR、单路输出 LDO 稳压器、DRB0008A (VSON-8)	TPS73533DRBT	德州仪器 (TI)
J1/J3、J2/J4	2		插座, 2.54mm, 10x2, 锡, TH	SSQ-110-03-T-D	Samtec
J5、J6、J7、J8、J13、J14、J15、J17、J18、J104	10		接头, 100mil, 3x1, 锡, TH	PEC03SAAN	Sullins Connector Solutions
J9、J10、J11、J12、J19、J20	6		接头, 100mil, 2x1, 锡, TH	90120-0122	Molex
J16	1		接头, 1x1, 锡, TH	PEC01SAAN	Sullins Connector Solutions

表 4-1. 物料清单 (续)

指示符	数量	值	说明	器件型号	制造商
J101	1		接头, 100mil, 9x2, 金, TH	TSW-109-07-G-D	Samtec
J102、J103	2		接头 (有罩), 1.27mm, 5x2, 金, SMT	FTSH-105-01-L-DV-K	Samtec
L1	1	2.2 μ H	电感, 绕线型, 陶瓷, 2.2 μ H, 0.89A, 0.13 Ω , SMD	CBC2518T2R2M	Taiyo Yuden
LED1、LED3、LED5	3	红色	LED, 红色, SMD	BR1111C-TR	Stanley Electric Co., LTD
LED2	1	绿色	LED, 绿色, SMD	LTST-C190GKT	Lite-On
LED4	1	Rgb	LED, RGB, SMD	19-337/R6GHBHC-A01/2T	Everlight
MSP1	1		MSP432E401YTPDT、PDT0128A (TQFP-128)	MSP432E401YTPDTR	德州仪器 (TI)
MSP2	1		MSP430G2x52、MSP430G2x12 混合信号微控制器, RSA0016B (VQFN-16)	MSP430G2452IRSA16R	德州仪器 (TI)
R1	1	3.32k	电阻, 3.32k, 1%, 0.1W, 0603	RC0603FR-073K32L	Yageo
R2、R5	2	47k	电阻, 47k, 5%, 0.063W, 0402	CRCW040247K0JNED	Vishay-Dale
R6	1		电阻薄膜, 0402, 100K Ω , 0.1%, 1/16W, $\pm$ 25ppm/ $^{\circ}$ C, 模制 SMD, SMD 穿孔载体, T/R	ERA-2AEB104X	Panasonic
R7、R8、R9、R17	4	1.0k	电阻, 1.0k, 5%, 0.063W, 0402	CR	Vishay-Dale
R11	1	100	电阻, 100, 5%, 0.063W, AEC-Q200 0 级, 0402	CRCW0402100RJNED	Vishay-Dale
R12、R13、R31、R38、R42	5	470	电阻, 470, 5%, 0.063W, 0402	CRCW0402470RJNED	Vishay-Dale
R14、R57、R58	3	10k	电阻, 10k, 5%, 0.063W, 0402	CRCW040210K0JNED	Vishay-Dale
R15	1	4.87k	电阻, 4.87k, 1%, 0.063W, AEC-Q200 0 级, 0402	CRCW04024K87FKED	Vishay-Dal
R16	1	100	电阻, 100, 5%, 0.063W, 0402	CRCW0402100RJNED	Vishay-Dale
R18	1	51	电阻, 51, 5%, 0.063W, AEC-Q200 0 级, 0402	CRCW040251R0JNED	Vishay-Dale
R19、R20、R26、R27、R34、R37、R55	7	220k	电阻, 220k, 1%, 0.0625W, 0402	RC0402FR-07220KL	Yageo America

表 4-1. 物料清单 (续)

指示符	数量	值	说明	器件型号	制造商
R21、R51	2	3.30k	电阻, 3.30k, 1%, 0.1W, AEC-Q200 0 级, 0402	ERJ-2RKF3301X	Panasonic
R22	1	2.20k	电阻, 2.20k, 1%, 0.063W, 0402	CRCW04022K20FKED	Vishay-Dale
R23	1	6.81k	电阻, 6.81k, 1%, 0.063W, 0402	CRCW04026K81FKED	Vishay-Dale
R24、R25	2	4.7k	电阻, 4.7k, 5%, 0.063W, 0402	CRCW04024K70JNED	Vishay-Dale
R28、R29、R32	3	47.0k	电阻, 47.0k, 1%, 0.0625W, 0402	RC0402FR-0747KL	Yageo America
R30	1	820	电阻, 820, 1%, 0.063W, 0402	RC0402FR-07820RL	Yageo America
R35、R43、R52、R53	4	0	电阻, 0, 5%, 0.1W, 0603	RC0603JR-070RL	Yageo
R39	1	220	电阻, 220, 5%, 0.063W, 0402	CRCW0402220RJNED	Vishay-Dale
R40、R41	2	330	电阻, 330, 5%, 0.063W, 0402	CRCW0402330RJNED	Vishay-Dale
R47、R48	2	4.7k	电阻, 4.7k, 5%, 0.1W, 0603	RC0603JR-074K7L	Yageo
R49、R50	2	2.2k	电阻, 2.2k, 5%, 0.1W, 0603	RC0603JR-072K2L	Yageo
R54	1	330k	电阻, 330k, 1%, 0.0625W, 0402	RC0402FR-07330KL	Yageo America
R56	1	1.00Meg	电阻, 1.00M, 1%, 0.063W, 0402	CRCW04021M00FKED	Vishay-Dale
S1、S2、S3	3		开关, SPST, 0.05A, 12VDC, SMD	1188E-1K2-V-TR	Diptronics
SH-J1	1	J101 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J2	1	J101 : 3-4	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J3	1	J101 : 5-6	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J4	1	J101 : 7-8	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J5	1	J101 : 9-10	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J6	1	J101 : 11-12	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J7	1	J101 : 12-13	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J8	1	J101 : 15-16	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J9	1	J101 : 17-18	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec

表 4-1. 物料清单 (续)

指示符	数量	值	说明	器件型号	制造商
SH-J10	1	J1 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J11	1	J2 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J12	1	J8 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J13	1	J15 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J14	1	J25 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J15	1	J26 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J16	1	J27 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J17	1	J13 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J18、SH-J21、SH-J22、SH-J23	4	J10 : 2-3	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J19	1	J11 : 2-3	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
SH-J20	1	J19 : 1-2	分流器, 100mil, 镀金, 黑色	SNT-100-BK-G	Samtec
T1	1	-20V	MOSFET, P 沟道, -20V, -0.82A, SOT-323	DMG1013UW-7	Diodes Inc.
T2	1	45V	晶体管, NPN, 45V, 0.1A, SOT-323	BC850CW,115	NXP Semiconductor
U1	1		MSPM0L2228SPNR	MSPM0L2228SPNR	德州仪器 (TI)
U2	1		精密低功耗并联电压基准、0.5% 精度、2.5V、15ppm/°C、15mA、-40°C 至 85°C、5 引脚 SC70 (DCK)、绿色环保 (RoHS, 无锡/溴)	LM4040C25IDCKR	德州仪器 (TI)
USB1	1		电缆, USB-A 至微型 USB-B, 0.3m	AK67421-0.3	Assman WSW
USB2	1		Micro USB 5F B 型 Smt	YM-02-07-D-23	Yang Ming
Y1	1		晶振, 32.768KHz, 12.5pF, SMD	X1A0001410014	Epson
Y2	1		晶振, 32MHz, 10pF, SMD	Q22FA1280009200	Epson
Y3	1		晶振, 16MHz, 8pF, SMD	NX3225GA-16.000M-STD-CRG-1	NDK
R3、R4	0	DNC	电阻, 0, 5%, 0.1W, 0603	RC0603JR-070RL	Yageo

5 其他信息

5.1 商标

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6 相关文档

6.1 补充内容

以下各项是开始使用 MSPM0 的重要学习材料。

- [MSPM0 Academy](#)
- [MSPM0-SDK 代码示例](#)
- [TI 高精度实验室](#)

7 修订历史记录

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision A (September 2025) to Revision B (September 2026)	Page
• 将 MSPM0 器件型号更正为 MSPM0L2228SPNR.....	3
• 将 MSPM0 器件型号更正为 MSPM0L2228SPNR.....	11
• 更新了图 4-1.....	11
• 将 MSPM0 器件型号更正为 MSPM0L2228SPNR.....	26

Changes from Revision * (May 2024) to Revision A (September 2025)	Page
• 在“说明”部分中添加了新超级电容器的说明。.....	1
• 更新了 LaunchPad 图像。.....	1
• 更新了节 2.1 中的跳线和连接器图和表。.....	4
• 更新了节 2.2 中的电源连接图。.....	5
• 在节 2.8 中添加了超级电容器的信息。.....	9
• 删除了节 3.1 中的开箱即用 GUI 选项。.....	10
• 在节 4.2 中添加了 PCB 板层。.....	17

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

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

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

NOTE:

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

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 Canada

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 Japan

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

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

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

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

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

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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.

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