

EVM User's Guide: CSD967201-Q1EVM

CSD967201-Q1 同步降压功率级评估模块



说明

CSD967201-Q1EVM 旨在演示 CSD967201-Q1 器件在单相低输出电压应用中的运行情况，同时提供许多测试点来评估器件的性能。CSD967201-Q1 是一款专为汽车认证、高密度、同步降压应用而设计的功率级。

开始使用

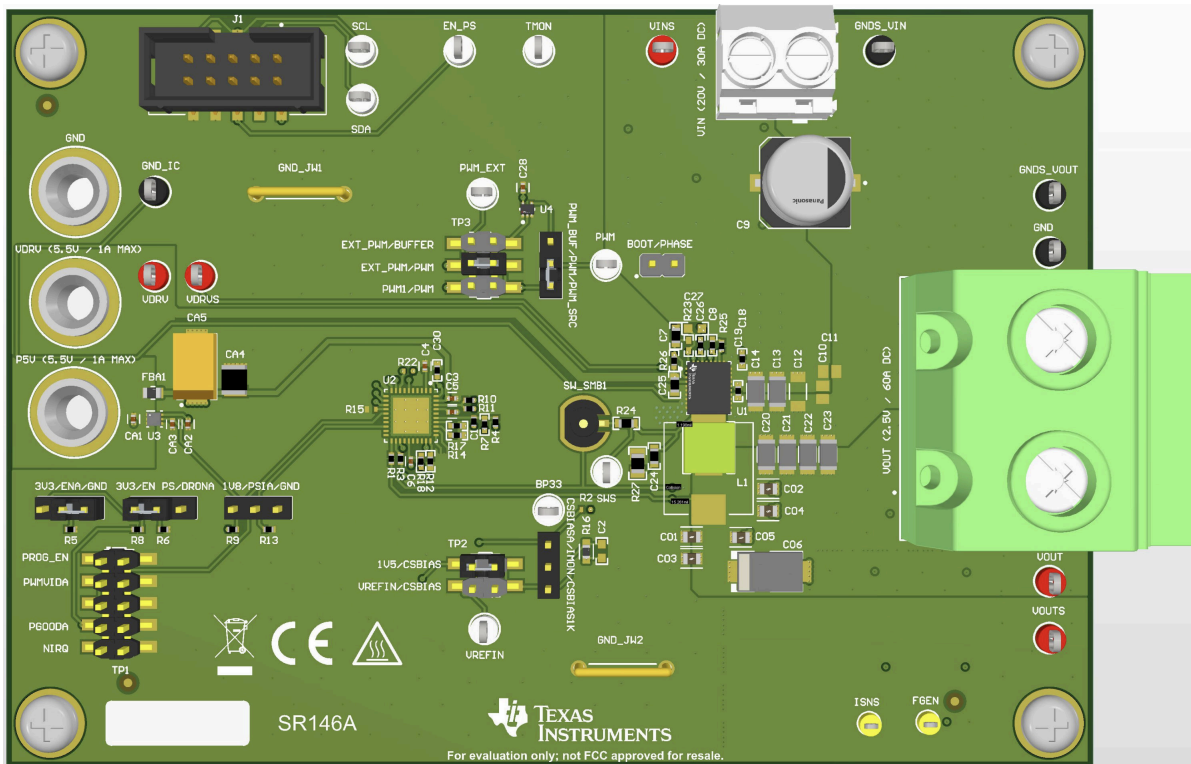
1. 在 [ti.com](https://www.ti.com) 上订购 CSD967201-Q1EVM
2. 下载 [CSD967201-Q1](#) 数据表
3. 请参阅 [ti.com](https://www.ti.com) 上的最新信息
4. 访问 [E2E™](#) 技术支持论坛

特性

- 高效单相功率级
- 通过控制器配置为开环或闭环
- 用于功率级测量的单独输入电源端子
- 板载负载瞬变测试仪
- 通用封装兼容板

应用

- 汽车 ADAS
- 汽车信息娱乐系统与仪表组
- 软件定义车辆：高性能计算



CSD967201-Q1EVM 硬件板

1 评估模块概述

1.1 简介

SR146A 评估板支持评估 CSD967201-Q1 功率级器件及控制器或者评估开环中的该器件。本手册介绍该评估板的设置和配置。

1.2 套件内容

该套件包含 CSD967201-Q1EVM。

1.3 规格

节 2.1 列出了 25°C 室温下的电气性能规格。除非另有说明，否则这些特性针对 $V_{IN} = 12V$ 输入电压。

1.4 器件信息

CSD967201-Q1 功率级是经过高度优化的设计，可用于汽车级高功率、高密度同步降压应用。此产品可将驱动器 IC 和功率 MOSFET 集成在一个无铅单片设计中，以完善功率级开关功能。这种组合可在小型工业标准外形尺寸封装中提供高电流、高效率 and 高速开关功能。

CSD967201-Q1EVM 评估模块还集成了准确电流检测和温度感测功能，可简化系统设计并提高准确度。保护功能包括逐周期过流和负过流限制、过热关断、HS FET 短路保护以及对 VCC、VIN 和 BOOT 进行 UVLO 监测。

CSD967201-Q1EVM 评估模块与 TPS64300Q VRS-11 控制器以及其他标准 VRS-11 控制器兼容。

2 硬件

2.1 电源要求

表 2-1. CSD967201-Q1EVM 电气性能规格

参数	测试条件	最小值	典型值	最大值	单位
输入特性					
电压范围	VIN 电压	3	12	20	V
	VDRV 电压	4.5	5	5.5	V
	P5V 电压	4.5	5	5.5	V
输入电流	VIN = 12V, IOU = 0A, EN > 2.5V		35		mA
	VIN = 12V, IOU = 60A, EN > 2.5V		5.5		A
	VDRV = 5V, Fsw = 650kHz, IOU = 60A, EN > 2.5V		40		mA
	P5V = 5V, Fsw = 650kHz, IOU = 60A, EN > 2.5V		24		mA
输出特性					
输出电压, VOUT	VIN = 12V, IOU = 60A		0.8		V
输出负载电流, IOU	直流负载电流		30	60	A
系统特性					
开关频率	VIN = 12V, VOUT = 0.8V, IOU = 60A		650		kHz
峰值效率	VIN = 12V, VOUT = 0.8V		88.6		%
满负载效率	VIN = 12V, VOUT = 0.8V, IOU = 60A		81.5		
工作温度			25		°C

2.2 接头信息

表 2-2. 接头和跳线信息

测试点	类型	名称	说明
3V3/ENA/GND	100mil、3x1、TH	3V3/ENA/GND	控制器使能选择。 PWM 配置 ：将跳线从 ENA 布置到 GND 以禁用控制器。这是默认配置。 控制器配置 ：将跳线从 3V3 布置到 ENA 以启用控制器。
3V3/EN_PS/DRONA	100mil、3x1、TH	3V3/EN_PS/DRONA	功率级使能选择。 PWM 配置 ：将跳线从 3V3 布置到 EN_PS 以启用功率级。这是默认配置。 控制器配置 ：将跳线从 EN_PS 布置到 DRONA 以允许控制器启用功率级。
J1	连接器接头表面贴装 10 位	J1	可使用插座对插座跳线来连接串行接口适配器。
TP1	2.54mm、5x2、SMT	TP1	用于控制器引脚 29、引脚 15、引脚 11、引脚 12 以及 3.3V 和 1.8V 电源的测试点。请勿短接。
TP2	接头, 2.54mm, 3x2, SMT	TP2	IMON 测量的基准电压选择。 采用板载 1kΩ 电阻器的 PWM 配置 。使用差分探头测量 IMON 和 CSBIAS1K 之间的 IMON： 1. 将跳线从 1V5 布置到 CSBIAS 以便在 CSBIAS1K 引脚上提供 1.5V 基准电压。这是默认配置。 2. 将跳线从 VREFIN 布置到 CSBIAS 以便将测试点 VREFIN 上的电压提供到 CSBIAS1K 引脚。 控制器配置 ：移除 TP2 上的所有跳线并使用差分探头测量 CSBIASA 和 IMON 之间的 IMON。

表 2-2. 接头和跳线信息 (续)

测试点	类型	名称	说明
CSBIASA/IMON/ CSBIAS1K	接头, 100mil, 3x1, 金, TH	CSBIASA/IMON/CSBIAS1K	电流监测器输出。 PWM 配置 : 使用 TP2 选择 CSBIAS1K 输入, 并使用差分探头测量 IMON 和 CSBIAS1K 之间的 IMON。 控制器配置 : 移除 TP2 上的所有跳线并使用差分探头测量 IMON 和 CSBIASA 之间的 IMON。
TP3	接头, 2.54mm, 3x2, SMT	TP3	PWM 源选择。 PWM 配置 : <ol style="list-style-type: none"> 将跳线从 EXT_PWM 布置到 BUFFER, 以便通过缓冲器将施加到 PWM_EXT 测试点的信号路由到 PWM_BUF 引脚。 将跳线从 EXT_PWM 布置到 PWM, 以便将施加到 PWM_EXT 测试点的信号路由到 PWM_SRC 引脚。这是默认配置。
PWM_BUF/PWM/ PWM_SRC	接头, 100mil, 3x1, 金, TH	PWM_BUF/PWM/ PWM_SRC	路由 PWM 输入和输出。 用于控制器或 PWM 配置的非缓冲 PWM : 将跳线从 PWM 布置到 PWM_SRC。这是默认配置。 用于控制器或 PWM 配置的缓冲 PWM : 将跳线从 PWM_BUF 布置到 PWM。 <p style="text-align: center;">备注</p> <p>仅对于控制器配置, 可以通过组装 R22 来绕过该接头和跳线, R22 将控制器的 PWM1 输出直接连接到功率级的 PWM 输入。只有在使用跳线配置功率级的 PWM 输入出现过多的噪声时, 才进行这种连接。</p>
1V8/PSIA/GND	100mil、3x1、TH	1V8/PSIA/GND	仅为控制器供电的电源轨默认为开路。
BOOT/PHASE	接头, 100mil, 2x1, 金, TH	BOOT/PHASE	启动测量默认为开路。请勿短接。

2.3 接口

表 2-3. 接口信息

测试点	类型	名称	说明
J1	连接器接头表面贴装 10 位	J1	可使用插座对插座跳线来连接串行接口适配器。 SCL : 引脚 5、引脚 9 SDA : 引脚 3、引脚 7 GND : 引脚 8、引脚 10
J2	端子块, 6.35mm, 2x1, TH	J2	用于输入电源的端子块 (30A)
J3	端子块 0.591" (15.00mm) 穿孔	J3	用于将输出加载到电子负载的端子块 (125A)
VDRV	香蕉插孔	VDRV	连接 +5V 外部电源来提供驱动器电压
P5V	香蕉插孔	P5V	连接 +5V 外部电源用于控制器和辅助控制
GND	香蕉插孔	GND	用于 VDRV 和 P5V 电源的接地连接

2.4 测试点

表 2-4. 测试点功能

类型	名称	说明
T-H 环路	BP33	功率级内部 3.3V 电压
T-H 环路	EN_PS	功率级使能
T-H 环路	FGEN	函数发生器输入
T-H 环路	GND	输出端子处的接地检测
T-H 环路	GND_IC	IC 接地基准
T-H 环路	GNDS_VIN	开尔文检测输入电压接地
T-H 环路	GNDS_VOUT	开尔文检测输出电压接地
T-H 环路	ISNS	电流检测 (12.5mV/A)
T-H 环路	PWM	向功率级发送的 PWM 信号
T-H 环路	PWM_EXT	外部 PWM 输入
T-H 环路	SCL	连接到 SCL 引脚
T-H 环路	SDA	连接到 SDA 引脚
SMB	SW_SMB1	连接到 SW 节点的 SMB 连接器
T-H 环路	SWS	开关节点
T-H 环路	TMON	温度监视器
T-H 环路	VDRV	端子上的驱动器电压测量
T-H 环路	VDRVS	VDRV 引脚上的驱动器电压检测测量
T-H 环路	VINS	开尔文检测输入电压
T-H 环路	VOUT	端子上的输出电压检测
T-H 环路	VOUTS	输出电容器上输出电压的开尔文检测
T-H 环路	VREFIN	基准输入电压

2.5 最佳实践

为确保使用 CSD967201-Q1EVM 或在其附近工作的任何人的安全，请注意以下警告和注意事项。请遵循所有安全防护措施。



注意

表面高温。接触会导致烫伤。请勿触摸！电路模块在运行期间会因散热而变烫。切勿接触电路板。请遵守适用于相关实验室的所有适用安全规程。



注意

请勿在无人照看的情况下使该 EVM 通电。

警告

电路模块的板底上有信号迹线、元件和元件引线。这可能会导致电压、高温表面和尖锐的边缘暴露在外面。操作过程中请勿触摸电路板的底部。

警告

外部连接：对于系统中连接的所有硬件和元件，与硬件的所有外部连接必须保持在建议的工作条件和预期用途范围内。

小心

电路模块可能会因过热而损坏。为避免损坏，请在评估期间监控温度并提供冷却。

小心

某些电源会因施加外部电压而损坏。如果使用一个以上的电源，请检查您的设备要求并使用阻断二极管或其他隔离技术，以防止设备损坏。

小心

EVM 上的通信接口未进行隔离。请确保计算机和 EVM 之间没有接地电位。请注意计算机以 EVM 的电池电位为基准。

3 实现结果

3.1 评估设置

所需设备

- 大电流 12V 电源 (TI 建议电流能力大于 30A)
- 两个 5V 电源 (每个 $\geq 1A$)
- 一个函数发生器 (如果配置为使用外部 PWM 输入)
- 一个函数发生器 (如果使用板载负载瞬态电路执行负载瞬态测试)
- 电子负载 (能提供大于 60A 的电流)
- 插座对到插座跳线 (如果使用控制器, 则用于连接串行接口适配器)
- 示波器 (可选, 用于 SW 节点或波形探测)
- DMM, 用于测量功率级输入、输出和驱动器输入电压

电源时序要求

VIN 和 VDRV 可按任何顺序上供电。当 VDRV 超过 VDRV_UVLO_RISING 时, TMON/FLT 和 IMON 会在 tStartup-Delay 时间过后开始上升。CSD967201-Q1 功率级器件必须在施加 PWM 信号之前上电并启用; 在启用后等待 75 μ s, 然后再施加 PWM 信号。

板载负载瞬变测试仪

该 EVM 有一条负载瞬变电路, 在此电路中四个并联 50m Ω 电阻器和两个并联 CSD17579Q5A N 沟道 MOSFET 串联。这种设置需要使用任意波形发生器和示波器探头。为了限制热应力, 负载瞬态只能用于频率为 100Hz 或更低的短暂的 1ms 或更短脉冲。将示波器探头连接到 ISNS 测试点, 并将接地引线夹到 GND_JW2 接地棒条。应用能够独立控制脉冲上升和下降时间的任意波形发生器或函数发生器。开始使用 100 μ s 上升和下降时间的 1ms 脉冲, 其频率为 100Hz, 振幅为 0.5V, 并监测示波器 ISNS 的电压, 然后调整振幅以获得所需的负载电流。电流检测增益为 12.5mV/A。设置负载电流后, 调整上升和下降时间以获得所需的压摆率。

测量直流/直流降压应用的效率

TI 建议闭环完成效率测量, 因为这可以在整个工作范围内提供最准确、最一致的结果。效率测量还可以在 PWM 配置中进行, 但必须随着负载条件的变化调整占空比, 并且难以获得一致的结果。

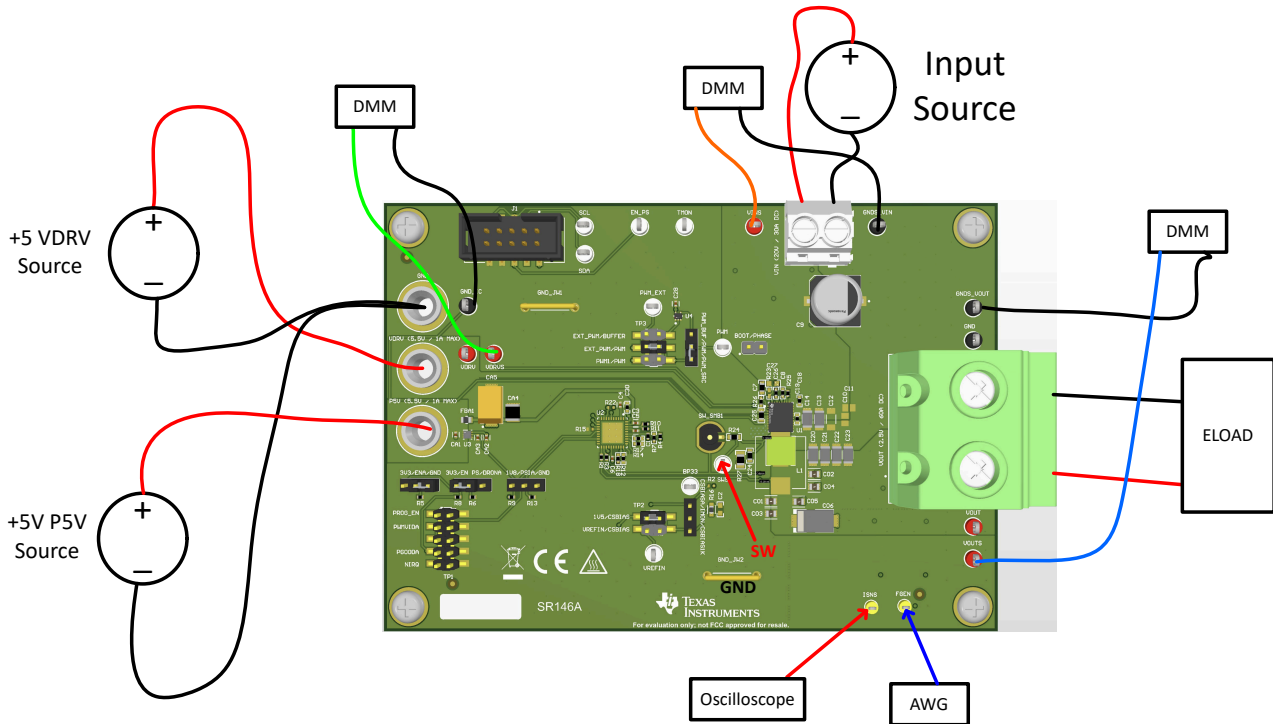
将电子负载连接到 J3 端子, 并特别注意 GND 和 VOUT 的方向。将 12V 电压源连接到 J2 端子。将 5V 电压源连接到 VDRV 和 GND 插头, 为栅极驱动电路供电。将 5V 电压源连接到 P5V 和 GND 插头, 为电路板上的辅助控制电路供电。单独的 P5V 电源通过将控制器和辅助控制功率损耗与功率级损耗分离来精确测量功率级效率。开尔文检测对于准确的效率测量至关重要。

效率可以通过两种方式测量:

1. 电路板效率 — 包括功率级和电感器 DCR 产生的损耗。使用 VOUTS、GNDS_VOUT、VINS、GNDS_VIN、GND_IC 和 VDRVS 测试点。要设置评估板以测量直流/直流降压应用的效率, 请连接 DMM 以使用以下测试点测量输出电压: VOUTS 和 GNDS_VOUT。VOUTS 通过开尔文连接到 CO1 和 CO3 电容器附近的 VOUT 覆铜。GNDS_VOUT 测试点在 CO1 处采用开尔文连接。要测量输入电压, 请将 DMM 连接到 VINS 和 GNDS_VIN。VINS 通过开尔文连接到 C18 电容器附近, GNDS_VIN 连接到器件引脚 19 附近的接地覆铜上。要测量驱动电压, 请将 DMM 连接到 VDRVS 和 GND_IC。VDRVS 通过开尔文连接到器件引脚 4, GND_IC 通过开尔文连接到 GND 引脚 9。

$$P_{loss} = V_{IN_S} \times I_{IN} + V_{DRV_S} \times I_{VDRV} - (V_{out} \times I_{out})$$
2. 器件效率 — 仅包括功率级产生的损耗。对于该测量, 移动 DMM 探针以测量 SWS 而不是 VOUTS。它使用 DMM 的平均值功能计算电感器之前 SW 节点电压的平均值, 因此电感器 DCR 损耗不包括在损耗计算中。

$$P_{loss_ps} = V_{IN_S} \times I_{IN} + V_{DRV_S} \times I_{VDRV} - (V_{SWavg} \times I_{out})$$



开环测试设置

将函数发生器连接到 PWM_EXT 测试点并将 GND_JW1 作为接地。将频率设置为 650kHz。输入电压为 12V 时，占空比必须设置在 8% 至 9% 之间。PWM_EXT 脉冲宽度必须大于 30ns。该输出电容器的额定电压应为 2.5V。外部 PWM 振幅必须为 3V。

备注

在 PWM 配置下运行 EVM 时，请先启用 CSD967201 器件，然后再启用 PWM 输入。此外，如果在 PWM 模式下运行时出现过热 (OT)，请在 TMON/FLT 电压升高到 3V 以上时停止 PWM 输入。这样，器件可以在温度下降到低于 OT 阈值后重新启动，而无需运行 PWM。

测量 IMON

在控制器配置中，在所提供接头上的 CSBIAS 和 IMON 测试点之间使用差分探头。IMON 输出在控制器的内部 $1k\Omega$ 电阻器上进行缩放，以便在使用差分探头从 IMON 到 CSBIAS 测量时提供 $5mV/A$ 灵敏度。IMON 波形是与电感器电流类似的三角波形。控制器使用波形的平均值来获得平均电流。如果使用无源示波器探头添加寄生电容，电容器将对三角波形的上沿进行圆滑处理，使得平均电流低于实际值。

在 PWM 配置中，在所提供接头上的 CSBIAS1k 和 IMON 测试点之间使用差分探头。IMON 输出在电路板上 $1k\Omega$ 电阻器上进行缩放，以便在使用差分探头从 IMON 到 CSBIAS 测量时提供 $5mV/A$ 灵敏度。IMON 波形是与电感器电流类似的三角波形。如果使用无源示波器探头添加寄生电容，电容器将对三角波形的上沿进行圆滑处理，使得平均电流低于实际值。

测量 TMON

在正常运行期间，TMON/FLT 引脚可为功率级芯片温度提供高精度的模拟温度测量。要测量 TMON，请连接 TMON 测试点。TMON 电压与裸片温度成正比，温度系数为 $8mV/^\circ C$ 。TMON 输出具有内置 ORing 功能，允许将多个器件连接在一起。当连接多个器件的 TMON/FLT 引脚时，TMON/FLT 总线会自动在所有器件之间读取最高 TMON/FLT 电压。在 $25^\circ C$ 时，TMON 电压通常为 $800mV$ (范围为 $776mV$ 至 $824mV$)。该 ORing 功能简化了

多相应用中的温度检测和故障报告，在此类应用中可以使用单条 TMON/FLT 总线来监测最热器件的温度。TMON/FLT 引脚可驱动高达 470pF 的电容以适应控制器侧滤波，从而提高精度和抗噪性。

备注

将带有长引线的示波器探头连接到 PWM 测试点，可能会成为噪声源并影响 SW 节点抖动。

4 硬件设计文件

4.1 原理图

图 4-1 展示了采用的 SR146A CSD967201-Q1EVM 的原理图。

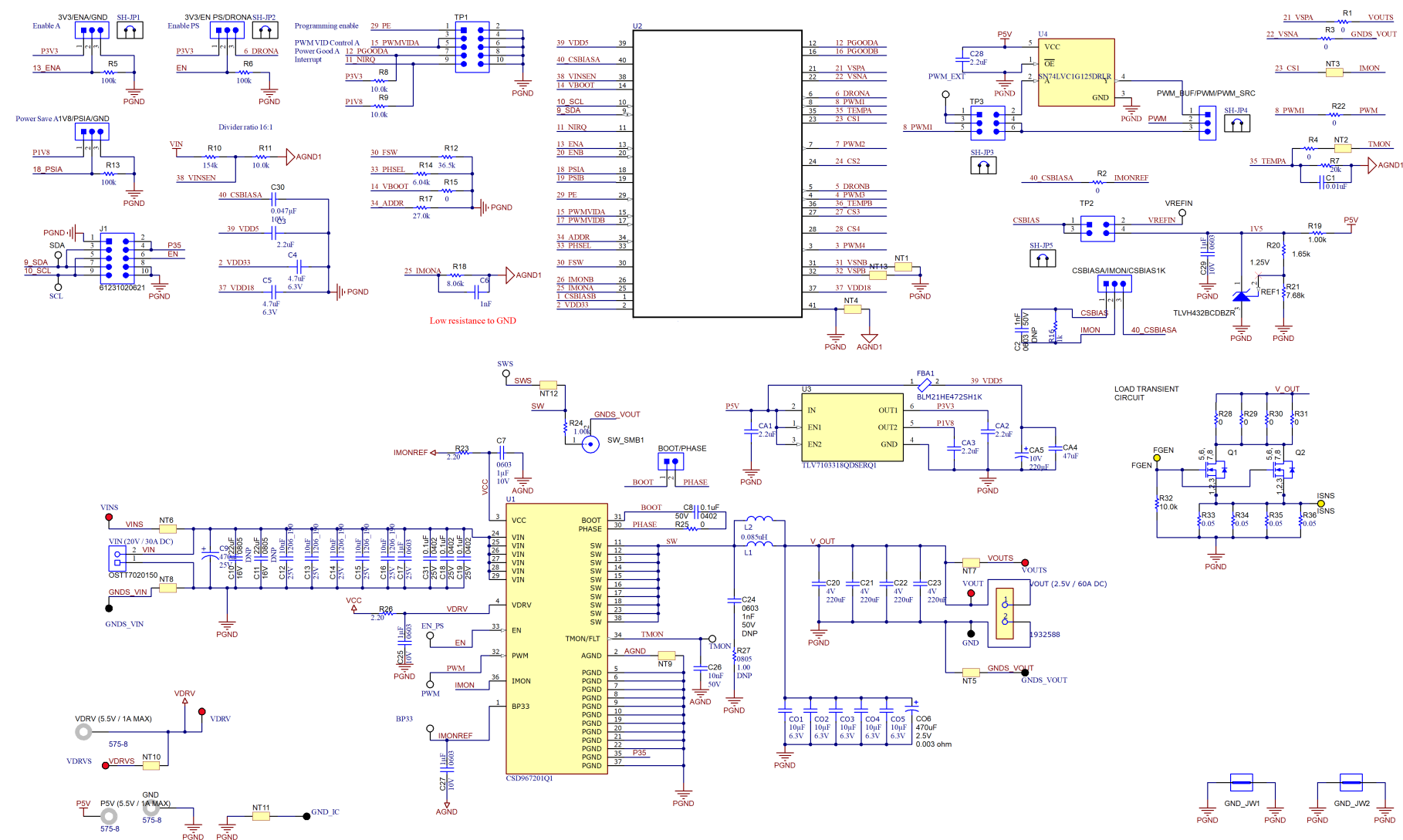


图 4-1. 进行配置的 CSD967201-Q1EVM

4.2 PCB 布局

图 4-2 至图 4-16 展示了 SR146A CSD967201-Q1EVM 印刷电路板的设计。

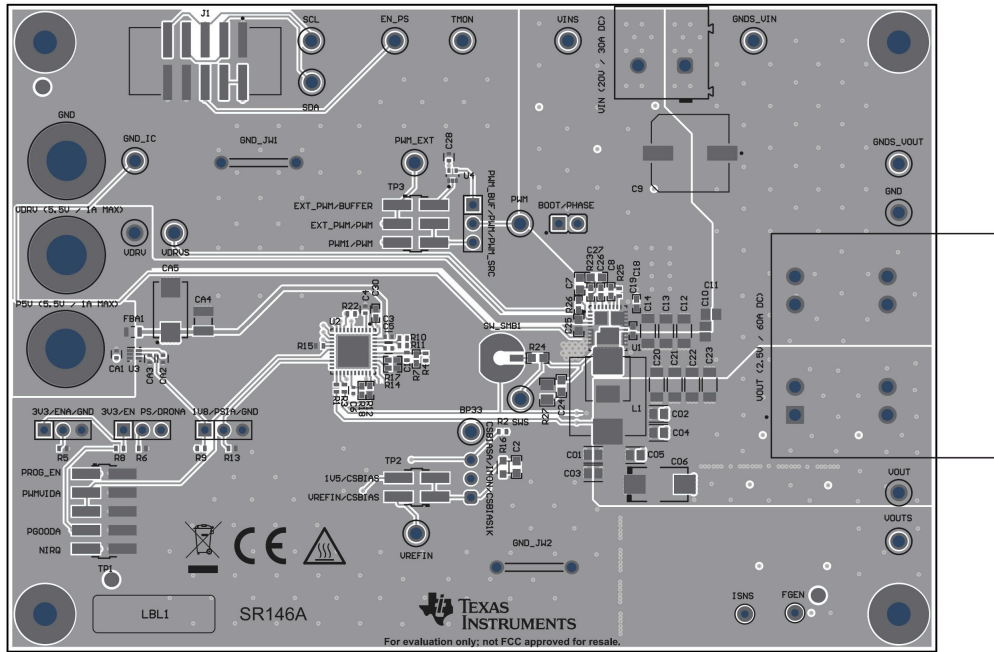


图 4-2. SR146A CSD967201-Q1EVM 元件视图 (顶视图)

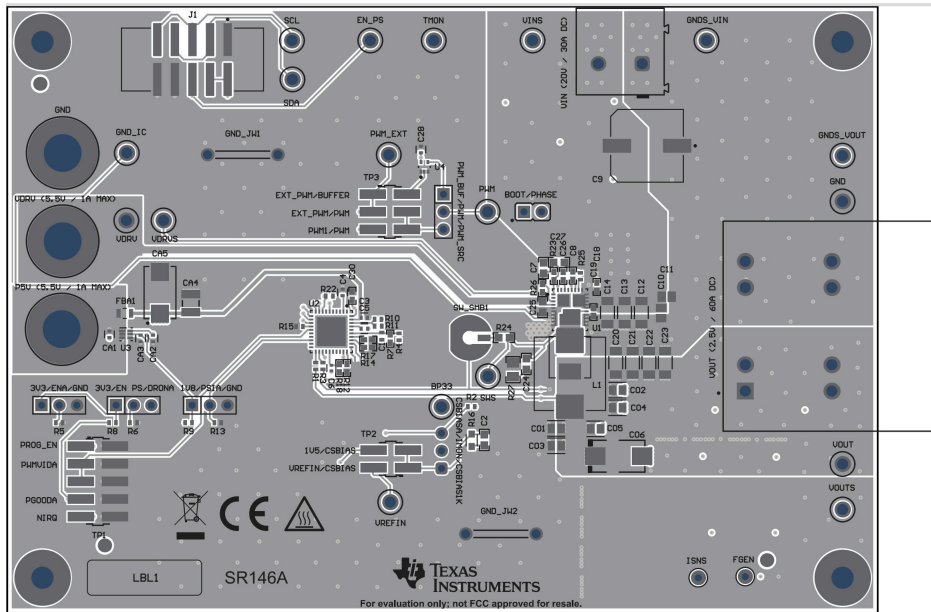


图 4-3. SR146A CSD967201-Q1EVM 顶部复合视图 (顶视图)

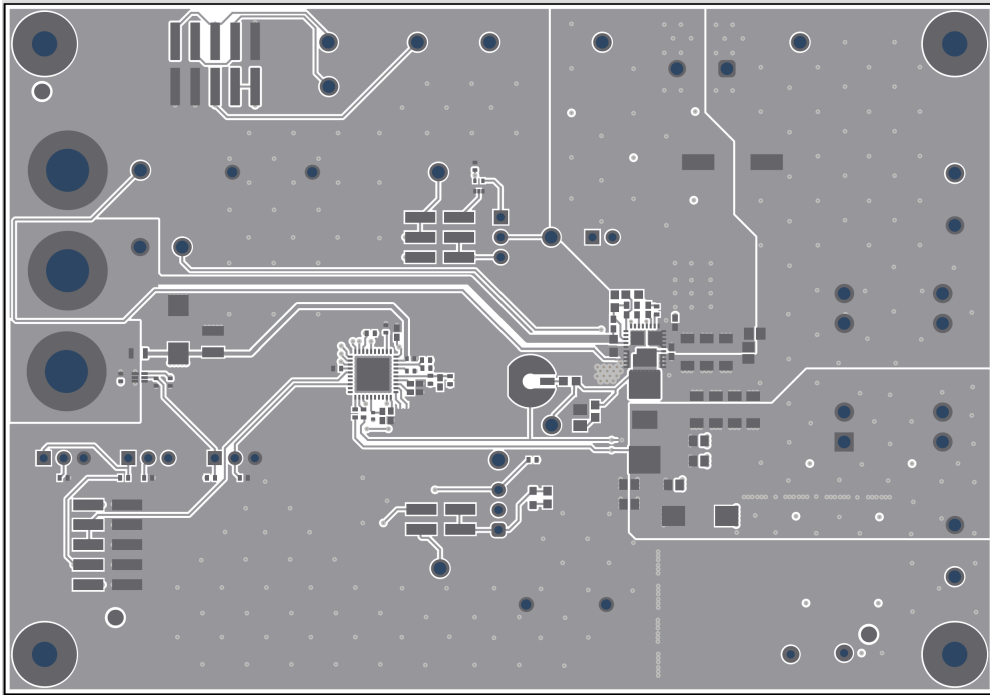


图 4-4. SR146A CSD967201-Q1EVM 顶部掩膜 (顶视图)

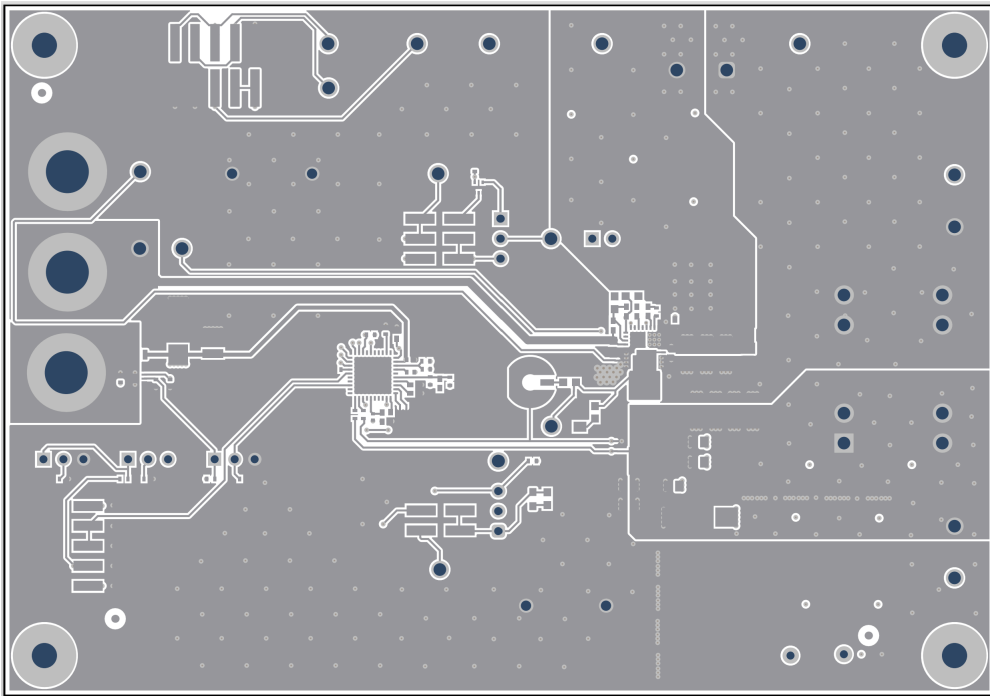


图 4-5. SR146A CSD967201-Q1EVM 顶层 (顶视图)

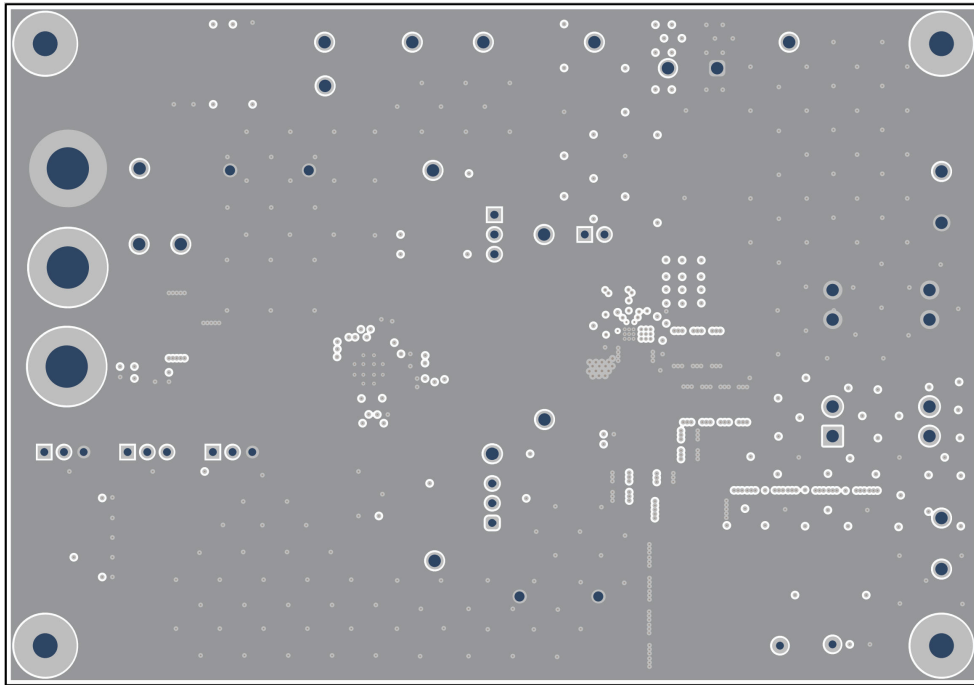


图 4-6. SR146A CSD967201-Q1EVM 信号层 1 (顶视图)

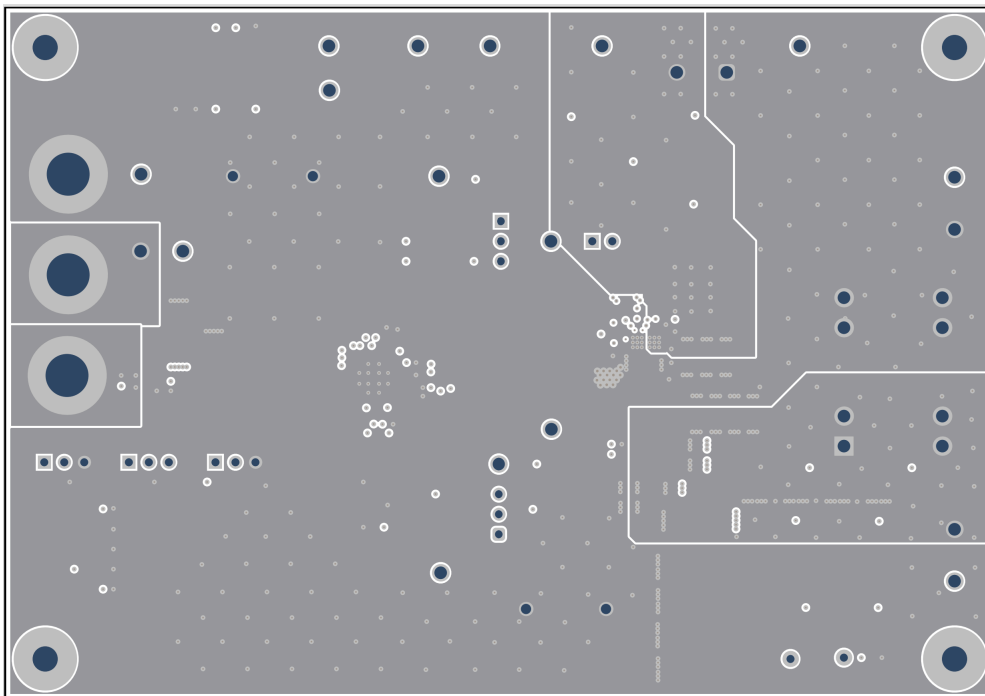


图 4-7. SR146A CSD967201-Q1EVM 信号层 2 (顶视图)

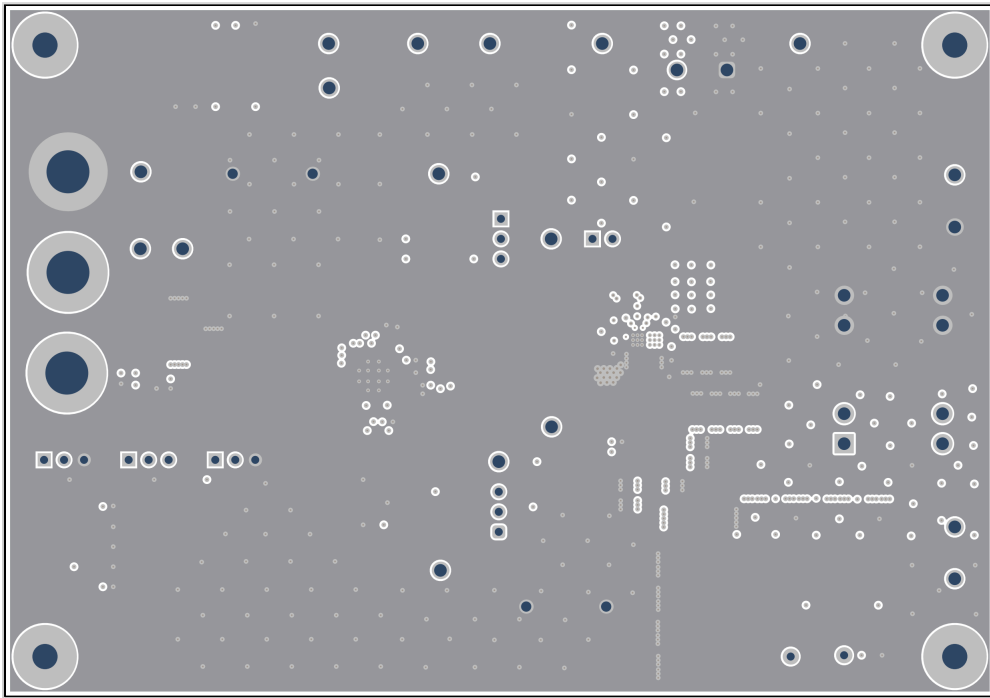


图 4-8. SR146A CSD967201-Q1EVM 信号层 3 (顶视图)

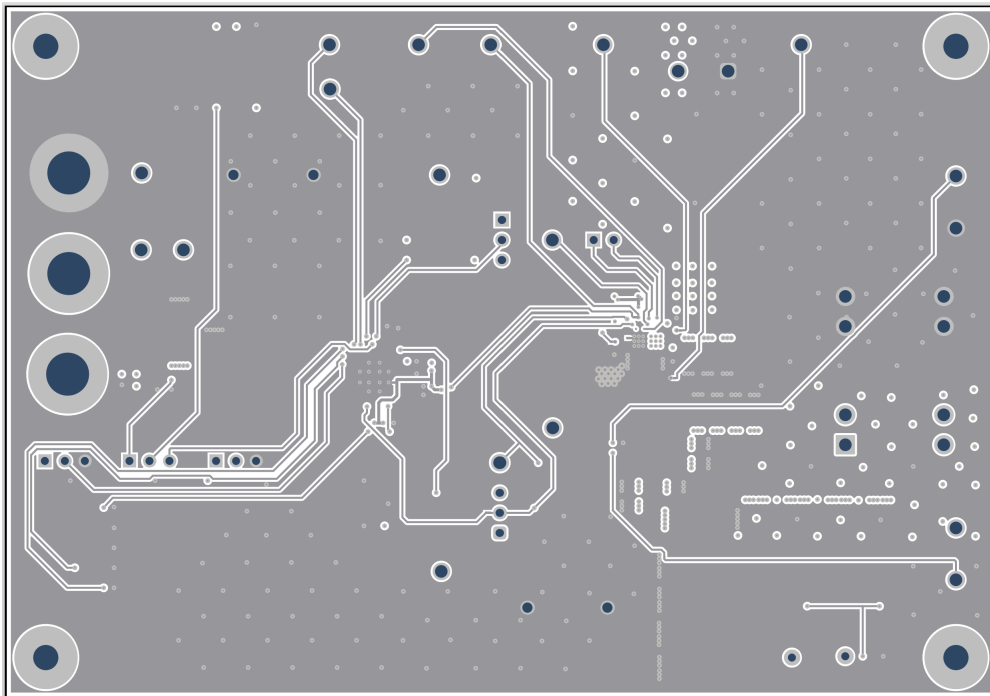


图 4-9. SR146A CSD967201-Q1EVM 信号层 4 (顶视图)

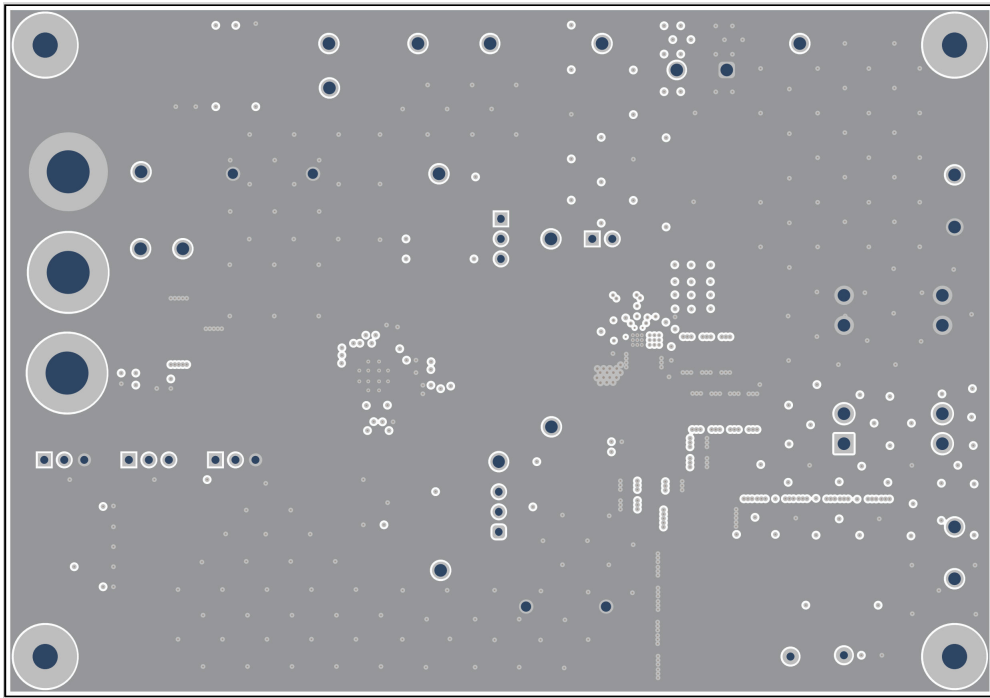


图 4-10. SR146A CSD967201-Q1EVM 信号层 5 (顶视图)

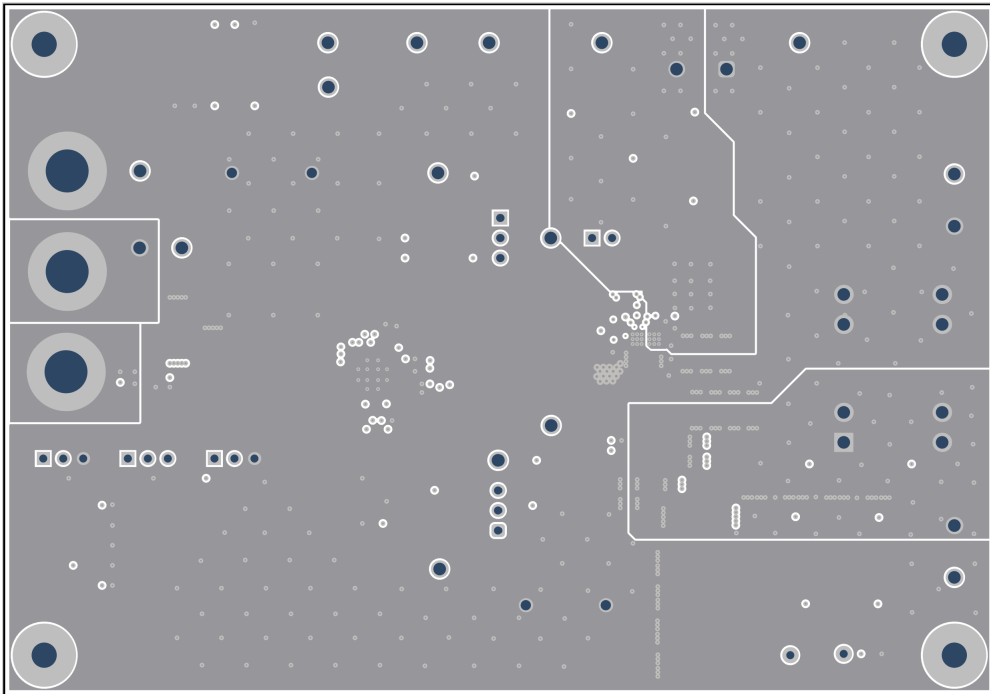


图 4-11. SR146A CSD967201-Q1EVM 信号层 6 (顶视图)

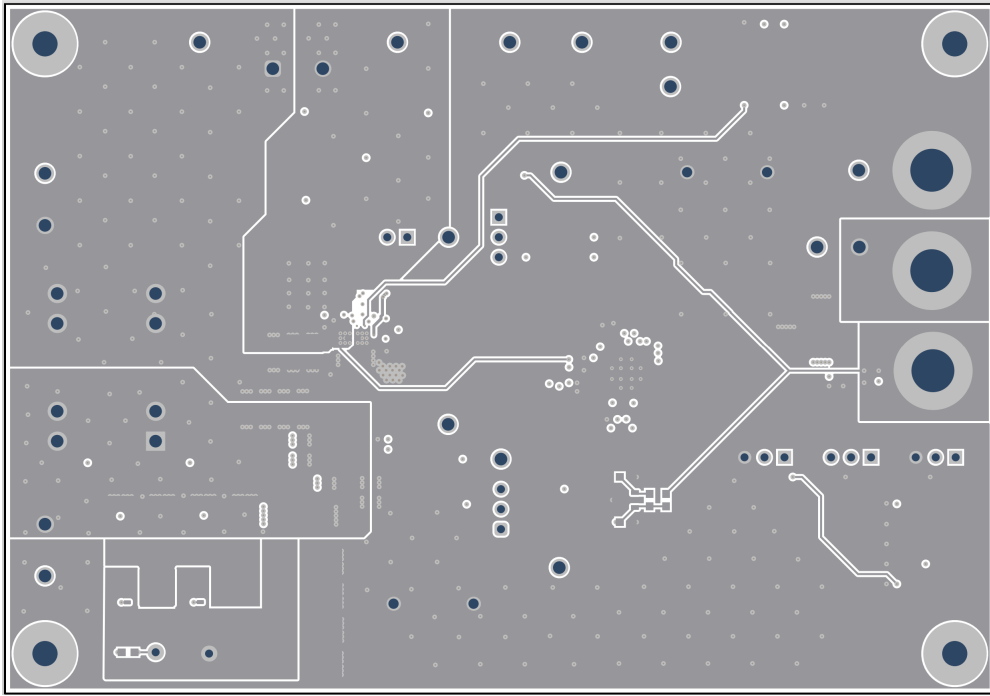


图 4-12. SR146A CSD967201-Q1EVM 底层视图 (底视图)

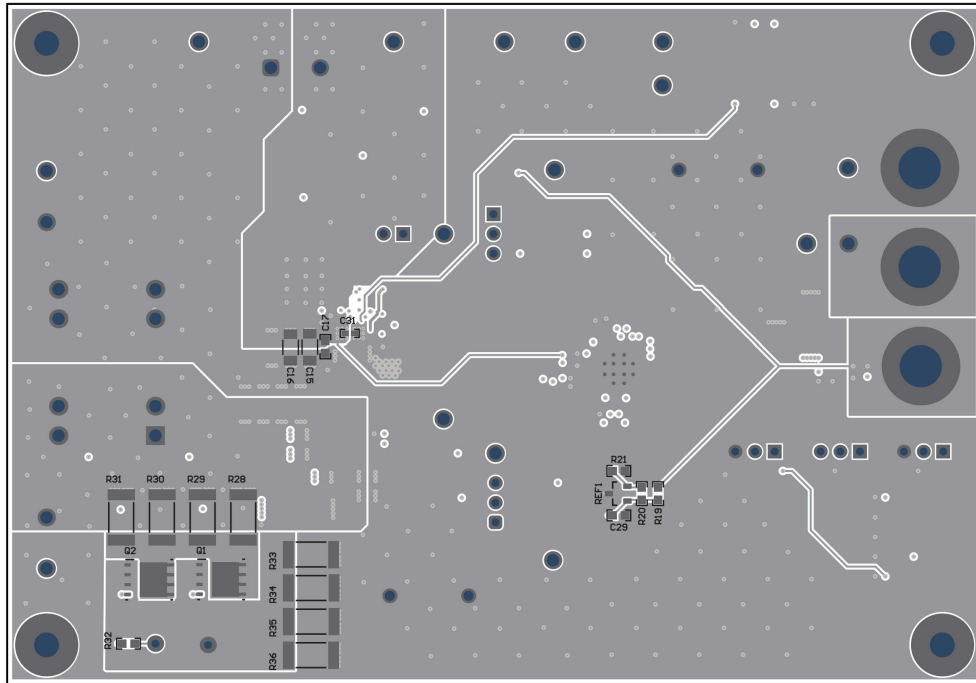


图 4-13. SR146A CSD967201-Q1EVM 底部元件 (底视图)

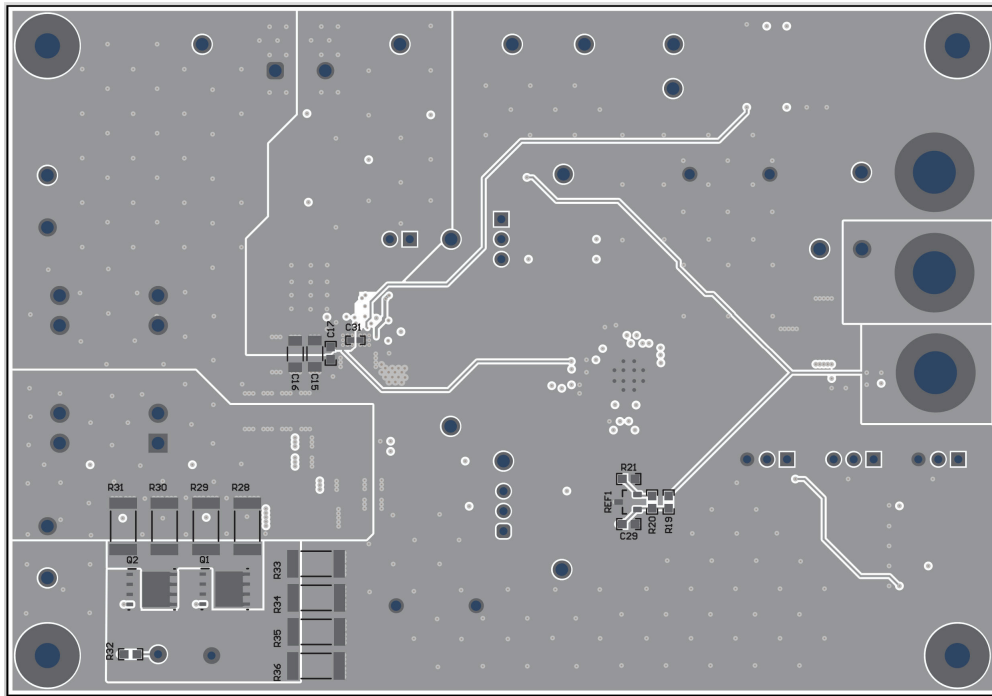


图 4-14. SR146A CSD967201-Q1EVM 底部复合视图 (底视图)

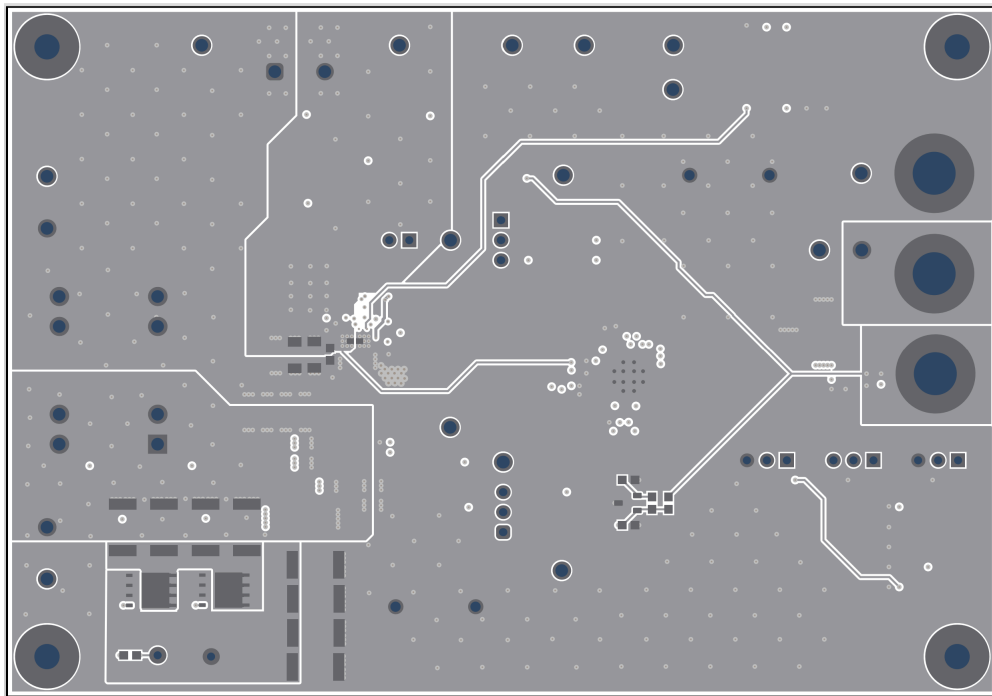


图 4-15. SR146A CSD967201-Q1EVM 底部掩模视图 (底视图)

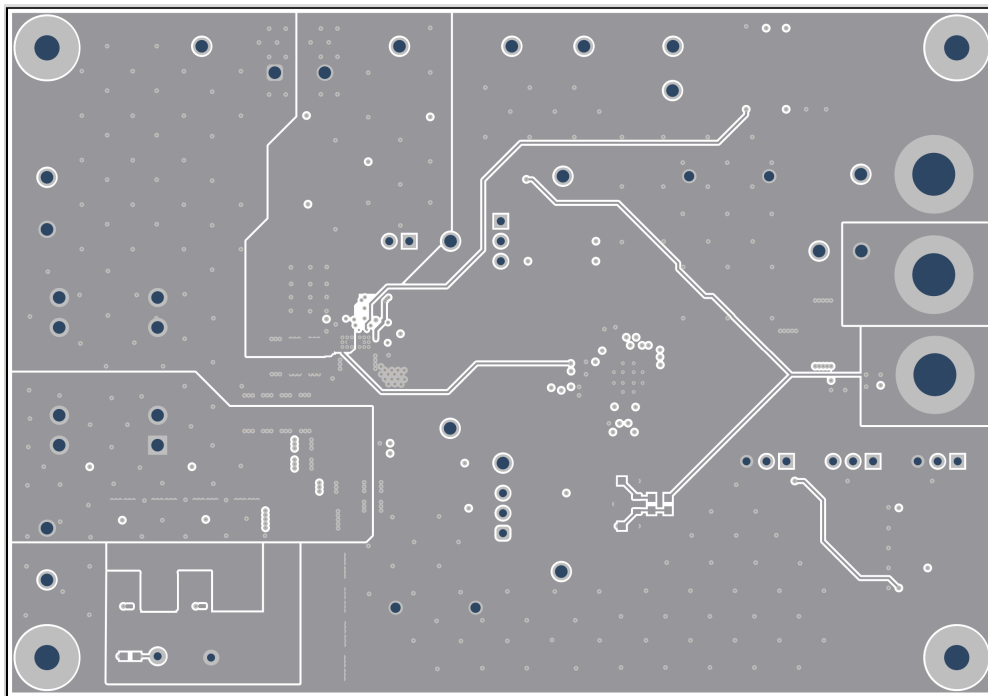


图 4-16. SR146A CSD967201-Q1EVM 底层 (底视图)

4.3 物料清单 (BOM)

表 4-1. CSD967201-Q1EVM 物料清单

位号	数量	值	说明	封装	器件型号	制造商
!PCB	1	-	印刷电路板	-	SR146A	不限
1V8/PSIA/GND、3V3/EN PS/DRONA、3V3/ENA/GND、PWM_BUF/PWM/PWM_SRC	4	-	接头, 100mil, 3x1, 金, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
BOOT/PHASE	1	-	接头, 100mil, 2x1, 金, TH	Sullins 100mil, 1x2, 绝缘体上方 230mil	PBC02SAAN	Sullins Connector Solutions
BP33、EN_PS、PWM、PWM_EXT、SCL、SDA、SWS、TMON、VREFIN	9	-	测试点, 通用, 白色, TH	白色通用测试点	5012	KeyStone Electronics , Keystone
C1	1	0.01μF	电容, 陶瓷, 0.01μF, 25V, ±10%, X7R, 0402	0402	GCM155R71E103KA37D	MuRata
C3、C28、CA1、CA2、CA3	5	2.2μF	多层陶瓷电容器, 2.2μF, 10V, X7S ±10%, 0402, 纸质 T/R	0402	GRT155C71A225KE13D	Murata
C4、C5	2	4.7μF	4.7μF ±20% 6.3V 陶瓷电容器 X7T 0402 (公制 1005)	0402	GRT155D70J475ME13J	Murata
C6	1	1nF	汽车级陶瓷电容器, 1nF, ±2%, 50VDC, C0G, 0402, 纸质 T/R	0402	GCM1555C1H102GA16J	Murata
C7、C25、C29	3	1uF	电容, 陶瓷, 1μF, 10V, ±10%, X7R, AEC-Q200 1级, 0603	0603	LMK107B7105KAHT	Taiyo Yuden
C8	1	0.1μF	电容, 陶瓷, 0.1μF, 50V, ±10%, X6S, 0402	0402	C1005X6S1H104K050BB	TDK
C9	1	470μF	470μF 25V 铝制电解电容器, 径向, Can - SMD - 2000 小时, 105°C	SMD2	EEEFK1E471AP	Panasonic
C13、C14、C15、C16	4	10μF	电容, 陶瓷, 10μF, 25V, ±10%, X7S, AEC-Q200 1级, 1206_190	1206_190	GCM31CC71E106KA03L	MuRata
C17	1	1μF	电容, 陶瓷, 1μF, 25V, ±10%, X7R, AEC-Q200 1级, 0603	0603	GCM188R71E105KA64D	MuRata
C18、C19、C31	3	0.1μF	电容, 陶瓷, 0.1μF, 25V, ±10%, X7R, 0402	0402	GRM155R71E104KE14D	MuRata
C20、C21、C22、C23	4	220μF	电容, 陶瓷, 220μF, 4V, ±20%, X5R, 1206_190	1206_190	GRM31CR60G227ME11L	MuRata
C24	1	1000pF	电容, 陶瓷, 1000pF, 50V, ±5%, X7R, 0603	0603	CL10C102JB8NNNC	Samsung Electro-Mechanics
C26	1	0.01μF	电容, 陶瓷, 0.01μF, 50V, ±10%, X7R, AEC-Q200 1级, 0402	0402	CGA2B3X7R1H103K050BB	TDK
C27	1	100nF	汽车级电容, 100 nF, 25V, ±10%, X7R, 0603, 5mm 弯曲	0603	CL10B104KA8VPJC	Samsung
C30	1	0.047μF	电容, 陶瓷, 0.047μF, 10V, ±5%, X8L, AEC-Q200 0级, 0402	0402	C0402C473J8NACTU	Kemet
CA4	1	47μF	电容, 陶瓷, 47μF, 10V, ±20%, X7R, 1210	1210	GRM32ER71A476ME15L	MuRata
CA5	1	220μF	电容, 钽, 220μF, 10V, ±10%, 0.5Ω, SMD	7343-43	T491X227K010AT	Kemet
CO1、CO2、CO3、CO4、CO5	5	10μF	CL21 系列 0805 10uF 6.3V ±10% 容差 X7R 多层陶瓷片式电容器	0805	CL21B106KQNNNE	Samsung

表 4-1. CSD967201-Q1EVM 物料清单 (续)

位号	数量	值	说明	封装	器件型号	制造商
CO6	1	470μF	电容, 铝聚合物, 470μF, 2.5V, ±20%, 0.003Ω, SMD_7.3x1.9x4.3mm SMD	SMD_7.3x1.9x4.3mm	EEF-GX0E471R	Panasonic
CSBIASA/IMON/CSBIAS1K	1	-	接头, 100mil, 3x1, 金, TH	3x1 接头	TSW-103-07-G-S	Samtec
FBA1	1	-	1 个 4.7kΩ (100MHz 时) 信号线铁氧体磁珠 0805 (2012 公制) 850mA 400mΩ	0805	BLM21HE472SH1K	Murata
FGEN、ISNS	2	-	测试点, 微型, 黄色, TH	黄色微型测试点	5004	Keystone
GND、GND_IC、GNDS_VIN、GNDS_VOUT	4	-	测试点, 多用途, 黑色, TH	黑色通用测试点	5011	Keystone Electronics
GND、P5V (5.5V/1A 最大值)、VDRV (5.5V/1A 最大值)	3	-	标准香蕉插头, 非绝缘, 8.9mm	Keystone575-8	575-8	Keystone
GND_JW1、GND_JW2	2	-	1mm 非绝缘短路插头, 10.16mm 间距, TH	短路插头, 10.16mm 间距, TH	D3082-05	Harwin
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
J1	1	-	连接器接头表面贴装 10 位 0.100" (2.54mm)	CONN_HDR10	61231020621	Würth Electroins
L1	1	0.085μH	汽车级功率电感器, 0.085μH 20% 1MHz, 0.36mΩ, 53A, 5.8x5.8x3.8mm SMT	SMT_IND_5MM8_5MM8	IHLL242NDZEZ85NMAZ	Vishay
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
Q1、Q2	2	30V	MOSFET, N 沟道, 30V, 25A, DQJ0008A (VSONP-8)	DQJ0008A	CSD17579Q5A	德州仪器 (TI)
R1、R3、R4、R25	4	0	电阻, 0, 5%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R5、R6、R13	3	100k	电阻, 100k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R7	1	20k	电阻, 20k, 5%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW040220K0JNED	Vishay-Dale
R8、R9、R11	3	10.0k	电阻, 10.0k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R10	1	154k	电阻, 154k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW0402154KFKED	Vishay-Dale
R12	1	36.5k	电阻, 36.5k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW040236K5FKED	Vishay-Dale
R14	1	6.04k	电阻, 6.04k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW04026K04FKED	Vishay-Dale
R16	1	1k	1kΩ ±0.01% 0.1W, 1/10W 片上电阻器 0603 (1608 公制), 汽车 AEC-Q200 薄膜	0603	RNCF0603TKW1K00	Stackpole Electronics
R17	1	27.0k	电阻, 27.0k, 1%, 0.1W, AEC-Q200 0 级, 0402	0402	ERJ2RKF2702X	Panasonic
R18	1	8.06k	电阻, 8.06k, 1%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW04028K06FKED	Vishay-Dale
R19、R24	2	1.00k	电阻, 1.00k, 1%, 0.1W, 0603	0603	RC0603FR-071KL	Yageo
R20	1	1.65k	电阻, 1.65k, 0.1%, 0.1W, 0603	0603	RG1608P-1651-B-T5	Susumu Co Ltd
R21	1	7.68k	电阻, 7.68k, 1%, 0.1W, AEC-Q200 0 级, 0603	0603	CRCW06037K68FKEA	Vishay-Dale
R26	1	2.2	电阻, 2.2, 1%, 0.2W, 0402	0402	RCS04022R20FKED	Vishay-Dale
R27	1	1	电阻, 1.00, 1%, 0.125W, AEC-Q200 0 级, 0805	0805	ERJ-6RQF1R0V	Panasonic
R28、R29、R30、R31	4	0	电阻, 0, 5%, 1W, AEC-Q200 0 级, 2512	2512	CRCW25120000Z0EG	Vishay-Dale

表 4-1. CSD967201-Q1EVM 物料清单 (续)

位号	数量	值	说明	封装	器件型号	制造商
R32	1	10.0k	电阻, 10.0k, 1%, 0.1W, 0603	0603	ERJ-3EKF1002V	Panasonic
R33、R34、R35、R36	4	0.05	电阻, 0.05, 1%, 3W, 2512	2512	CRA2512-FZ-R050ELF	Bourns
REF1	1	-	低压可调精度并联稳压器, 129ppm/°C, 80mA, 0°C 到 70°C, 3 引脚 SOT-23 (DBZ), 绿色环保 (RoHS, 无镉/溴)	DBZ0003A	TLVH432BCDBZR	德州仪器 (TI)
SH-JP1、SH-JP2、SH-JP3、SH-JP4、SH-JP5	5	-	分流器, 2.54mm, 金, 黑色	分流器, 2.54mm, 黑色	60900213421	Würth Elektronik
SW_SMB1	1	-	连接器, 插座, 50Ω, TH	SMB 连接器	SMBR004D00	JAE Electronics
TP1	1	-	接头, 2.54mm, 5x2, 金, SMT	接头, 2.54mm, 5x2, SMT	TSM-105-01-L-DV-P	Samtec
TP2	1	-	接头, 2.54mm, 2x2, 金, SMT	接头, 2.54mm, 2x2, SMT	TSM-102-01-L-DV	Samtec
TP3	1	-	接头, 2.54mm, 3x2, 金, SMT	接头, 2.54mm, 3x2, SMT	TSM-103-01-L-DV	Samtec
U1	1	-	同步降压智能功率级	WQFN-FCRLF38	CSD967201Q1	德州仪器 (TI)
U3	1	-	用于便携式器件的汽车类双路 200mA、低 IQ、低压降稳压器, DSE0006A (WSON-6)	DSE0006A	TLV7103318QDSERQ1	德州仪器 (TI)
U4	1	-	IC 缓冲器同相 5.5V SOT5	-	-	-
VDRV、VDRVS、VINS、VOUT、VOUTS	5	-	测试点, 多用途, 红色, TH	红色通用测试点	5010	Keystone Electronics
VIN (20V/30A 直流)	1	-	端子块, 6.35mm, 2x1, TH	On-Shore_OSTT7020150	OSTT7020150	On-Shore Technology
VOUT (2.5V/60A 直流)	1	-	2 位, 线至板, 端子块, 与板齐平, 0.591" (15.00mm), 穿孔	CONN_TERM_BLOCK	-	Phoenix Contact
C2	0	1000pF	电容, 陶瓷, 1000pF, 50V, ±5%, X7R, 0603	0603	CL10C102JB8NNNC	Samsung Electro-Mechanics
C10、C11	0	22μF	电容, 陶瓷, 22 μF, 16V, ±20%, X6S, 0805	0805	GRM21BC81C226ME44L	MuRata
C12	0	10μF	电容, 陶瓷, 10μF, 25V, ±10%, X7S, AEC-Q200 1 级, 1206_190	1206_190	GCM31CC71E106KA03L	MuRata
FID1、FID2、FID3	0	-	基准标记。没有需要购买或安装的元件。	不适用	不适用	不适用
L2	0	0.22μH	电感器 0.22μH 20% 100kHz, 0.75mΩ, 50A, 10.3x10.0x4.0mm SMT, AEC-Q200	SMT_IND_10MM3_10MM0	MMD110DZIR22M	MAG 板层
R2、R15、R22	0	0	电阻, 0, 5%, 0.063W, AEC-Q200 0 级, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R23	0	2.2	电阻, 2.20, 1%, 0.2W, 0402	0402	RCS04022R20FKED	Vishay-Dale
U2	0	-	具有 I2C 接口的双通道、(N+M) ≤ 4 相、降压汽车多相控制器	VQFN40	不限	不限

5 其他信息

5.1 已知硬件或软件问题

发布的原理图、BOM 或布局没有更改。

5.2 商标

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 - 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/llds/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

ンスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/llds/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.

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- 4 *EVM Use Restrictions and Warnings:*
 - 4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
 - 4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
 - 4.3 *Safety-Related Warnings and Restrictions:*
 - 4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
 - 4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
 - 4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.
 5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

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

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

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

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

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