EVM User's Guide: LM51772Q1EVM-HP

LM51772Q1 降压/升压控制器评估模块

TEXAS INSTRUMENTS

说明

LM51772Q1EVM-HP 演示了一款采用 LM51772Q1 的高功率灵活降压/升压设计。该评估模块经配置，可在 9V 至 30V 的输入电压范围内运行，并提供 12V 稳压输出，负载电流高达 17A。该 EVM 的工作开关频率为 400kHz。该器件的大多数设置可通过跳线轻松调整或设置，例如：工作模式（PSM 或 fPWM）、辅助电源和外部时钟同步。

开始使用

1. 将 EVM 连接到电源和负载
2. 如需使用配置 GUI 和 I2C 操作，可以使用 USB2ANY 适配器
3. 安装 LM51772 配置 GUI
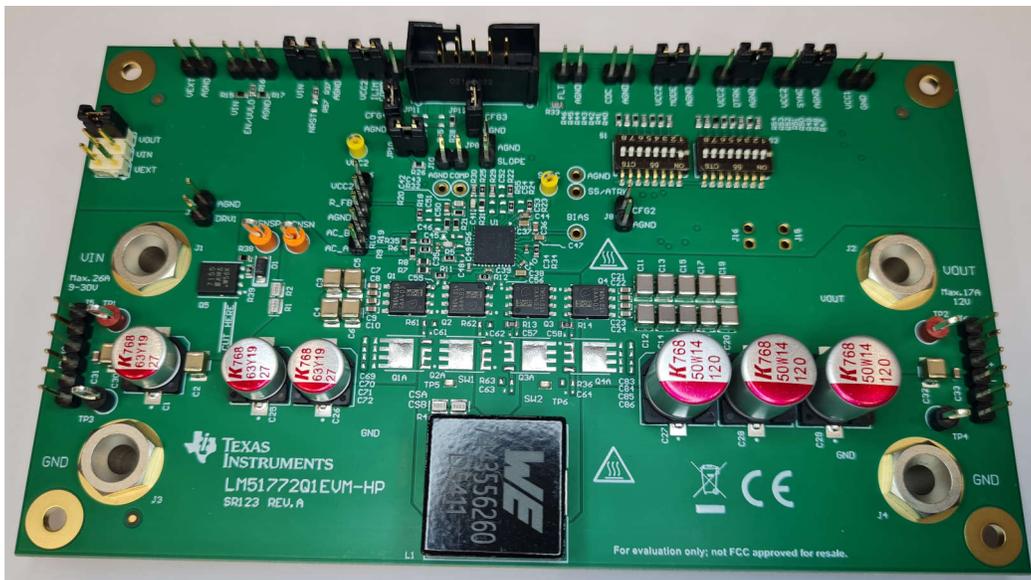
特性

- 宽输入电压范围

- 超高 (> 95%) 峰值电源转换效率
- 可使用反馈电阻或 I2C 接口来调节输出电压
- 可选同步 (SYNC)
- 可轻松配置电流监控器或限制器
- 支持电缆压降补偿
- 输出断开支持
- 可编程输入欠压锁定 (UVLO) 阈值和迟滞
- 输出恒压 (CV) 和恒流 (CC) 选项
- 具有 USB2ANY 和 GUI 的 I2C 接口
- 通过 DIP 开关设置配置电阻器 R_{CFG2}

应用

- 汽车 ADAS 域控制器
- 汽车信息娱乐、数字驾驶舱
- 汽车传感器融合
- USB-PD EPR（扩展功率范围）
- 汽车储能、电池/超级电容器备用

LM51772Q1 降压/升压控制器评估模块   1

1 评估模块概述

1.1 简介

LM51772Q1EVM-HP 汽车评估模块 (EVM) 旨在便捷地评估 LM51772Q1 宽 VIN 降压/升压控制器。LM51772Q1 是一款宽 V_{IN} 四开关降压/升压控制器。无论输入电压是高于、等于还是低于调节后的输出电压，该器件均可提供稳定的输出电压。在省电模式下，该器件支持在整个输出范围内实现出色的效率。

通过可选使用 I2C 接口，该器件涵盖了用于配置和调整开关模式电源运行的附加参数。

为了检查性能，I2C 接口还便于轻松测量降压/升压控制器的典型信号。

1.2 套件内容

- 该 EVM 包含一个 LM51772Q1EVM-HP PCB
- EVM 免责声明自述文件

未包含的内容

该 EVM 不包含 USB2ANY 接口。

可通过 USB2ANY 接口适配器 订购 USB2ANY 接口。

1.3 规格

表 1-1. 评估板规格

参数	值
输入电压	9.0V 至 30V
输出电压	12V
最大输出电流	17A
默认开关频率	400kHz
电路板尺寸（四层）	5.6inch × 3.2inch

1.4 器件信息

LM51772Q1 是一款四开关降压/升压控制器。无论输入电压是高于、等于还是低于调节后的输出电压，该器件均可提供稳定的输出电压。在省电模式下，该器件支持在整个输出范围内实现出色的效率。

- 宽输入电压范围为 3.5V 至 55V（EVM 最小值为 9V 且最大值为 30V）
- 输出电压为 3.3V 至 55V（EVM 固定输出为 12V）
- 峰值电流调节方案
- 输出电压动态跟踪
  - 数字 PWM 跟踪输入
  - 模拟跟踪输入
  - 通过 I2C 接口编程
- 最小静态电流
  - 3μA 的低关断 IQ
  - 25μA 的低工作 IQ
- 可实现高轻负载效率的运行模式选择
  - 省电突发模式
  - μSleep 省电模式
- 集成高压电源 LDO

2 硬件

2.1 连接器、测试点和选择开关说明

本节提供了 EVM 的 I/O 连接器、跳线和测试点。

电源必须连接到输入连接器 J1 和 J3。

负载必须连接到输出连接器 J2 和 J4。

2.1.1 连接器说明

表 2-1. 连接器

参考指示符	说明
J1	输入电压正连接
J2	输出电压正连接
J3	输入电压 GND 连接
J4	输出电压 GND 连接
J5	输入电压正和输入电压 GND 测试点
J6	输出电压正和输出电压 GND 测试点
J7	外部 BIAS 输入连接
J8	CFG2 连接
J9	FLT 外部连接
J10	RT 外部输入连接
J11	DRV1 测量和外部输入连接器
J12	I2C/USB2ANY 连接器
J13	VCC1 输出连接器
J14	CDC 输出连接器
J15	基准电压
J16	反向 CV 调节输出

2.1.2 跳线说明

表 2-2. 跳线

参考指示符	引脚	说明	默认连接
JP1	引脚 2 至引脚 1 (AGND)	跳线处于 AGND 位置，省电模式 (PSM) 已启用。	
	引脚 2 至引脚 3 (VCC)	跳线处于 VCC 位置，FPWM 模式已启用。	*
JP2	引脚 2 连接至引脚 1 或引脚 3 (AGND 或 VCC)	跳线处于 VCC 或 AGND 位置（SYNC 引脚连接至 VCC 或 AGND），频率同步已禁用。	*
	开路	跳线已移除，在 SYNC 引脚上馈入外部时钟。SYNC 已启用。	
JP3	引脚 2 连接至引脚 1 或引脚 3 (AGND 或 VCC)	跳线处于 AGND 或 VCC 位置（DTRK 引脚连接至 AGND 或 VCC），数字电压跟踪已禁用。	*
	开路	跳线已移除，在 DTRK 引脚上馈入电压。如果 DTRK 引脚上的电压高于 VT (DTRK) 的上升阈值，则启用 DTRK。	
JP4	引脚 1 至引脚 2 (VEXT)	跳线处于 VEXT 位置，来自 J7-VEXT 的输入连接至 BIAS 引脚。	
	引脚 3 至引脚 4 (VIN)	跳线处于 VIN 位置。VIN (J1) 连接至 BIAS 引脚。	*
	引脚 5 至引脚 6 (VOUT)	跳线处于 VOUT 位置。VOUT (J2) 连接至 BIAS 引脚。	
JP5	引脚 1 至引脚 2 (AGND)	跳线处于 AGND 位置（EN/UVLO 引脚连接至 AGND）。LM51772 已禁用。	
	开路	跳线已移除（EN 引脚连接至由 R14 和 R15 组成的电阻分压器网络）。通过电阻分压器网络设置 EN/UVLO 阈值。	*
	引脚 2 至引脚 3 (VIN)	跳线处于 VCC 位置（EN/UVLO 引脚连接至 VCC）。LM51772 已启用。	
JP6	引脚 1/引脚 2	环路稳定性测量的连接点（波特图）。	
	引脚 3	AGND	
	引脚 4 至引脚 5	跳线就位选择内部反馈分压器。	
	开路	选择外部反馈分压器	*
JP7	引脚 2 至引脚 1 (AGND)	将 nRST 设置为 AGND：禁用器件。	
	引脚 2 至引脚 3 (Vin)	将 nRST 设置为 Vin：启用器件。	*
JP8	引脚 1 至引脚 2	启用 I2C 并设置 I2C 地址 6A	
	开路	移除跳线以禁用 I2C 操作并设置斜率配置	*
JP9	引脚 2 至引脚 3 (VCC)	ILIMCOMP 连接至 VCC。禁用 ILIMCOMP	*
	开路	请勿设置跳线，可用于测量 ILIMCOMP 信号	
JP10	引脚 1 至引脚 2	设置跳线以启用不用于 DAC 的 ILIM 滤波器	*
	开路	设置用于 DAC 操作的简单 ILIM 滤波器。复合滤波器可以通过填充 R17 和 C40 来设置。	
JP11	引脚 1 至引脚 2	设置跳线以启用无 I2C 配置的 Config 设置	*
	开路	移除 I2C 操作的跳线	

表 2-2. 跳线（续）

参考指示符	引脚	说明	默认连接
JP12	引脚 1 至引脚 2	设置跳线以启用无 I2C 操作的 Config 设置	*
	开路	移除 I2C 操作的跳线	

2.1.3 测试点说明

表 2-3. 测试点

参考指示符	说明
TP1 (VIN)	输入电压正测试点
TP2 (VOUT)	输出电压正测试点
TP3 (GND)	输入电压返回测试点
TP4 (GND)	输出电压返回测试点
TP5	SW1 测试点
TP6	SW2 测试点
TP7	ISNSP 测试点
TP8	ISNSN 测试点
TP9	AGND
TP10	VCC2 测试点
TP11	SYNC 测试点
TP12	SS/ATRK 测试点
TP13	COMP 测试点
TP14	AGND
TP15	BIAS 电压测试点

2.1.4 选择开关说明

2.1.4.1 S1 和 S2 CFG 设置

这些开关可以设置 CFG2 引脚的电阻器。有关详细信息，请参阅 *LM51772Q1* 数据表。

表 2-4. CFG2 引脚配置概述

#	EN_SYNC_OUT	SYNC_IN_FALLING	VDET_EN	PCM_HYST_30
1	禁用	禁用	禁用	禁用
2	启用			
3	禁用	启用		
4	启用			
5	禁用	禁用	启用	
6	启用			
7	禁用	启用		
8	启用			
9	禁用	禁用	禁用	启用
10	启用			
11	禁用	启用		
12	启用			
13	禁用	禁用	启用	
14	启用			
15	禁用	启用		
16	启用			

备注

只能关闭一个开关！

English Document: SNVU949

其余配置输入已设置为以下设置：

- CFG1：
  - 斜率因子：1.5

- CFG3：
  - VCC1：启用
  - INDUCT De-rate：禁用 (30%)
  - SCALE_DT：禁用
  - CONST_TDEAD：启用

- CFG4：
  - DRSS：禁用
  - SCP – 断续模式：禁用
  - 负电流限制：禁用
  - 电流限制：启用

备注

LM51772Q1EVM-HP 已配置为禁用 I2C 操作，未设置 JP8。斜率补偿可通过 I2C 命令或使用相应的电阻器替换 R20 进行调整，其默认设置为 1.5。

2.1.5 I2C 操作

默认情况下，该 EVM 设置为独立模式（无 I2C 操作）。

若要配置 EVM 以支持 I2C 操作，请更改以下跳线设置：

- 设置 JP8
- 移除 JP11
- 移除 JP12

如果 I2C 控制器未提供 I2C 接口的上拉电阻，则添加 R22/R23。

备注

对 EVM 进行优化，以使 V_{in} = 9V-30V、V_{out} = 12V 且 $I_{out, max}$ = 17A。通过 I²C 将输出电压调整为高于或低于 12V 且 V_{in} = 9V 的值时，需要进一步优化。但是，输出电压和功率需要限制为：
- 在 P_{out} = 150W ($I_{out, max}$ = 5A) 时，$V_{out, max}$ = 30V
- 在 P_{out} = 200W ($I_{out, max}$ = 17A) 时，$V_{out, nom}$ = 12V
- 在 P_{out} = 82W ($I_{out, max}$ = 25A) 时，$V_{out, min}$ = 3.3V

备注

请勿将输入电压设置为低于 9V，同时通过 I²C 将输出电压调整至 12V 以上，因为 EVM 未针对这些数值进行优化。

备注

使用 I²C 时，请勿将输出电压设置为高于 32V，因为 EVM 所用的输出电容额定电压仅为 35V。

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3 实现结果

3.1 测试装置和过程

3.1.1 测试设置

图 3-1 展示了用于评估 LM51772Q1EVM-HP 的典型测试设置。
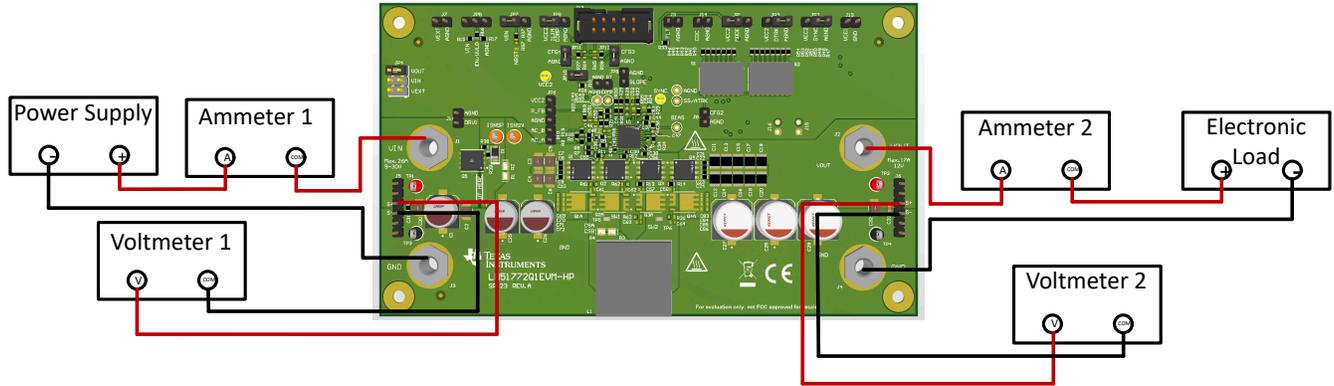
图 3-1. 典型的 EVM 连接图

3.1.2 测试程序

1. 将电源电流限值设置为 35A。关闭电源。将电源的正输出连接到 J1，负输出连接到 J3。
2. 将负载连接到 J2 实现正连接，连接到 J4 实现负连接。
3. 将电源电压设置为 9V，将电子负载设置为 0.1A。电子负载电压必须通过标称 12V 输出进行调节。
4. 缓慢增大负载，同时监控 J6-VOUT 和 J6-GND 之间的输出电压。当负载增加到 17A 时，电压必须保持标称 12V 输出的稳压。
5. 从 9V 至 30V 缓慢扫描输入电压。输出电压必须通过标称 12V 输出进行调节。
6. 从 30V 至 9V 缓慢扫描输入电压。输出电压必须通过标称 12V 输出进行调节。
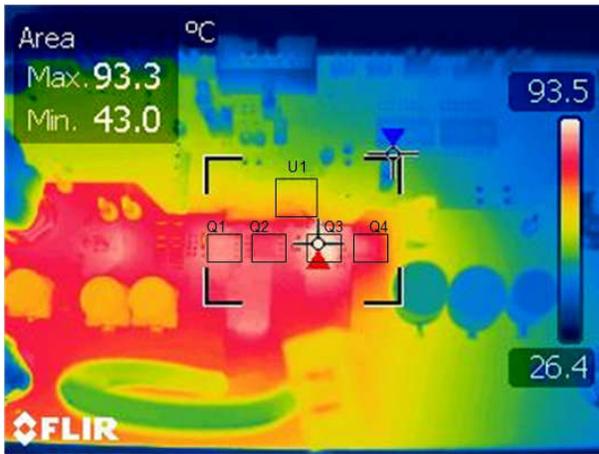7. 将负载降至 1A。
8. 将输入电压降至 0V 以关闭降压/升压转换器，然后关闭负载。

3.2 测试数据和性能曲线

3.2.1 热性能

图 3-2. 热像图：V_{IN} = 9V，I_{OUT} = 17A，无强制空气冷却
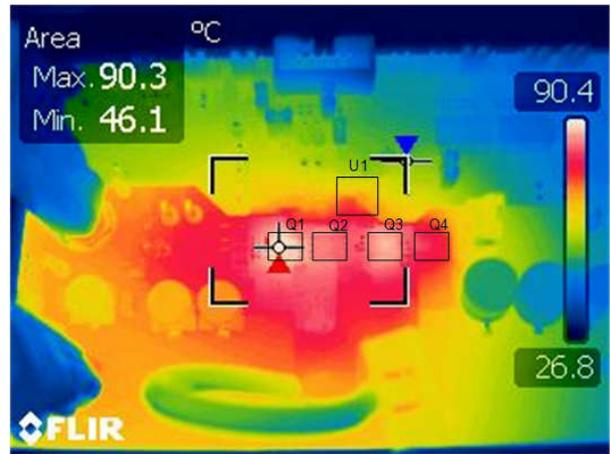
图 3-3. 热像图：V_{IN} = 12V，I_{OUT} = 17A，无强制空气冷却
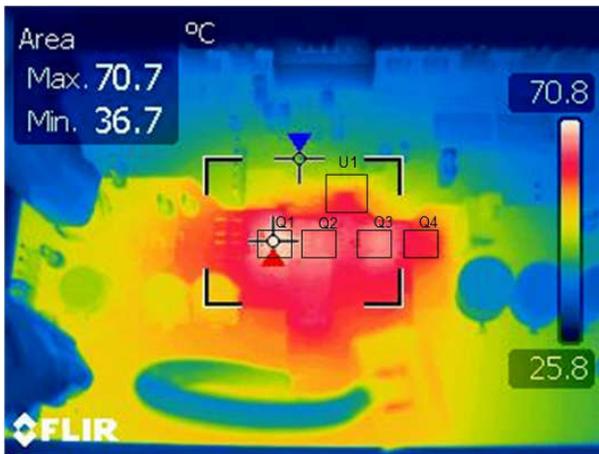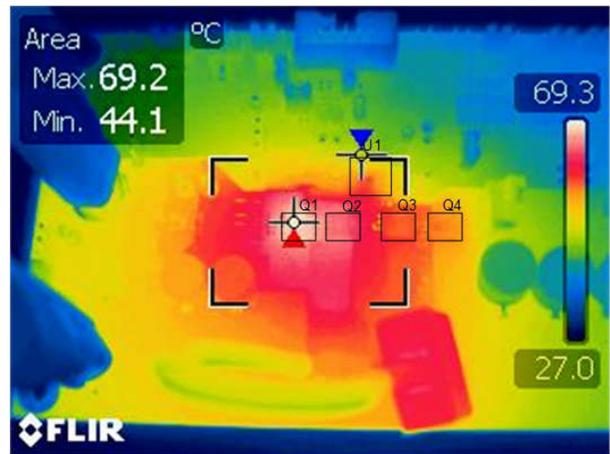

图 3-4. 热像图：V_{IN} = 16V，I_{OUT} = 17A，无强制空气冷却

图 3-5. 热像图：V_{IN} = 20V，I_{OUT} = 17A，无强制空气冷却
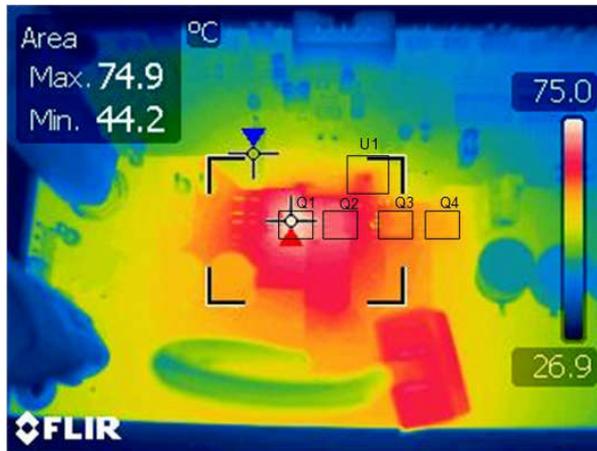

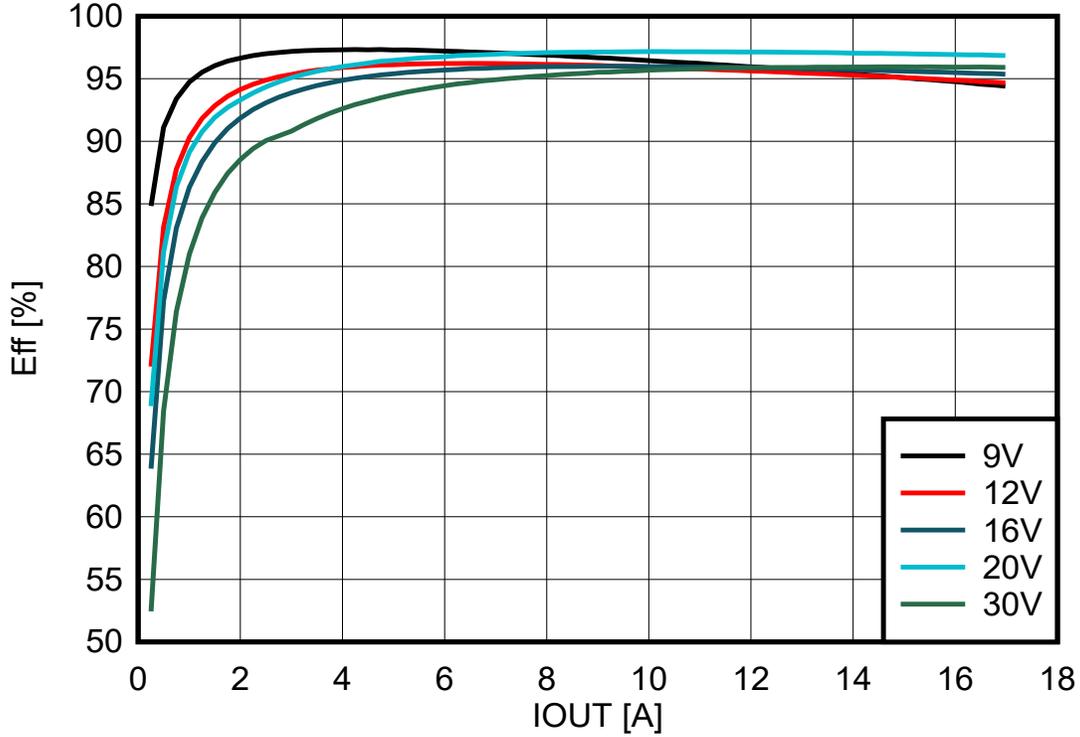图 3-6. 热像图：V_{IN} = 30V，I_{OUT} = 17A，无强制空气冷却
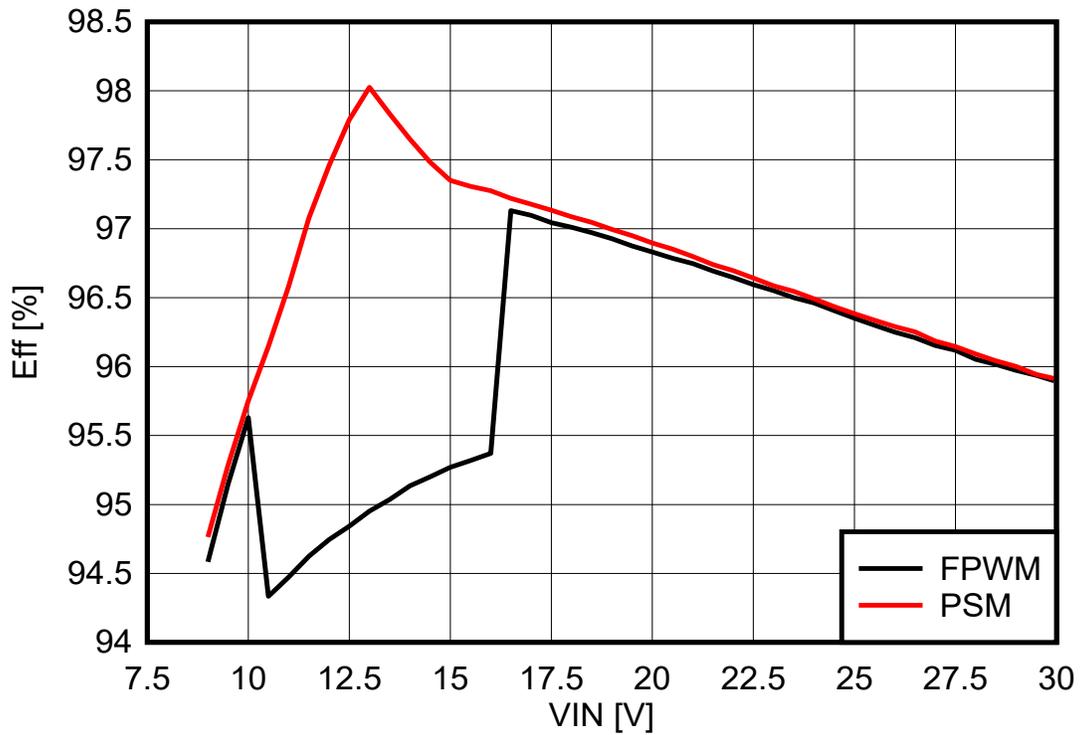
3.2.2 效率

图 3-7. 效率与输出电流间的关系，V_O = 12V
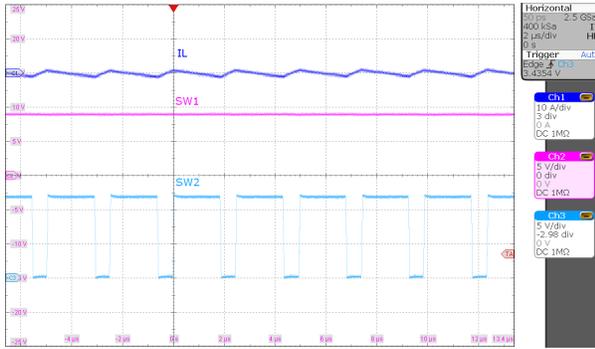
图 3-8. 效率与输入电压间的关系，V_O = 12V，I_O = 17A

3.2.3 稳态波形
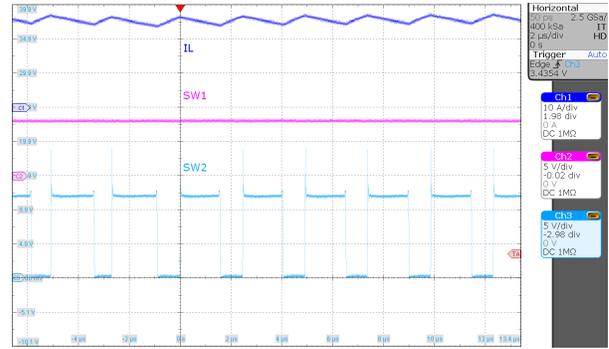

图 3-9. SW1、SW2、I_L（V_{IN} = 9V，I_{OUT} = 0A）

图 3-10. SW1、SW2、I_L（V_{IN} = 9V，I_{OUT} = 17A）

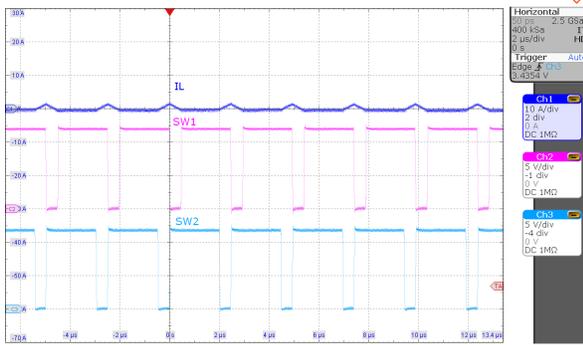图 3-11. SW1、SW2、I_L（V_{IN} = 12V，I_{OUT} = 0A）
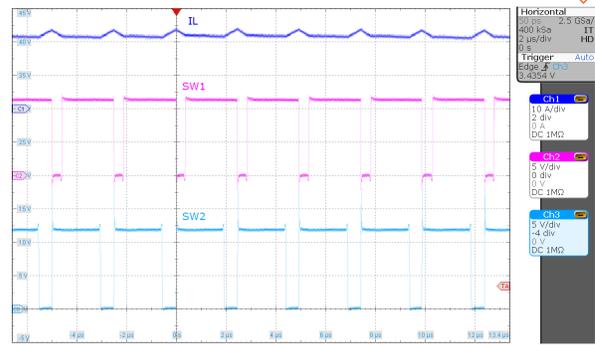
图 3-12. SW1、SW2、I_L（V_{IN} = 12V，I_{OUT} = 17A）
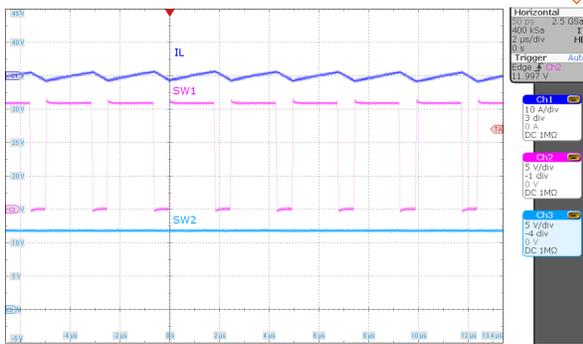
图 3-13. SW1、SW2、I_L（V_{IN} = 16V，I_{OUT} = 0A）
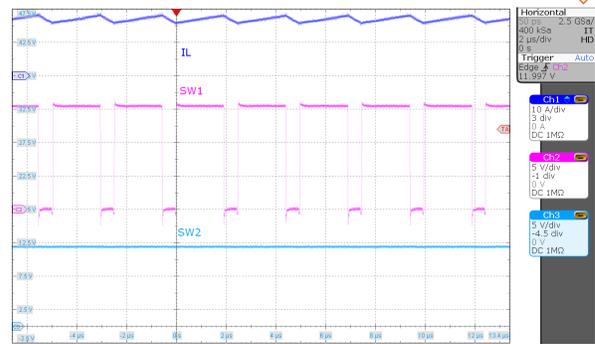
图 3-14. SW1、SW2、I_L（V_{IN} = 16V，I_{OUT} = 17A）

3.2.3 稳态波形（续）
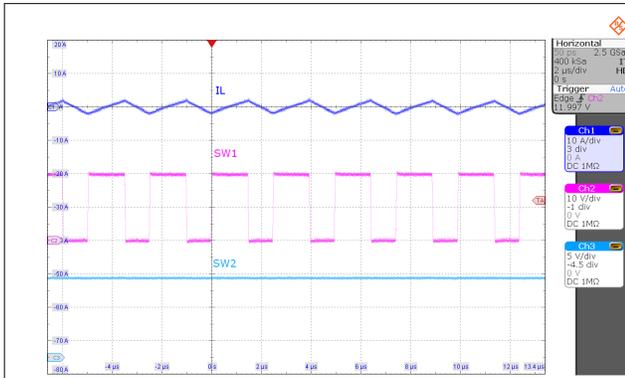
图 3-15. SW1、SW2、I_L（V_{IN} = 20V，I_{OUT} = 0A）
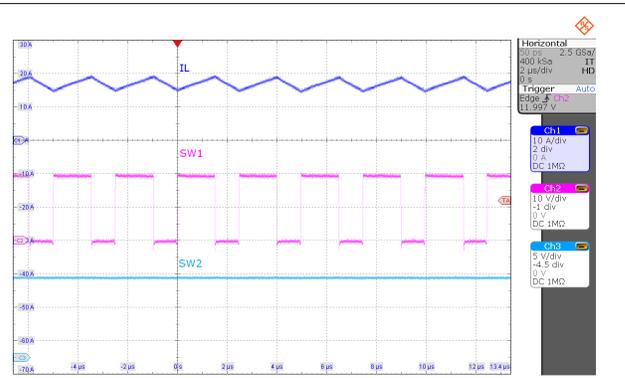
图 3-16. SW1、SW2、I_L（V_{IN} = 20V，I_{OUT} = 17A）
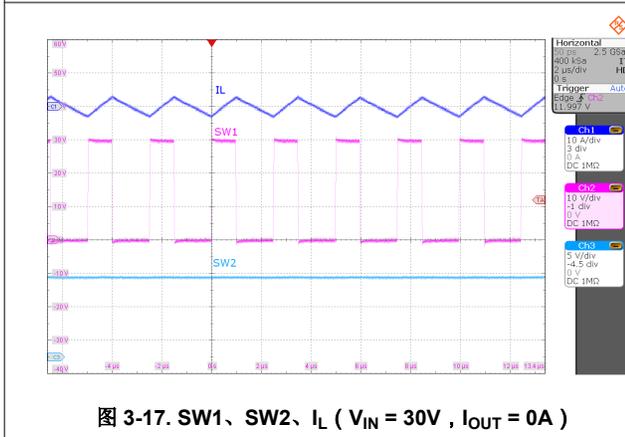
图 3-17. SW1、SW2、I_L（V_{IN} = 30V，I_{OUT} = 0A）
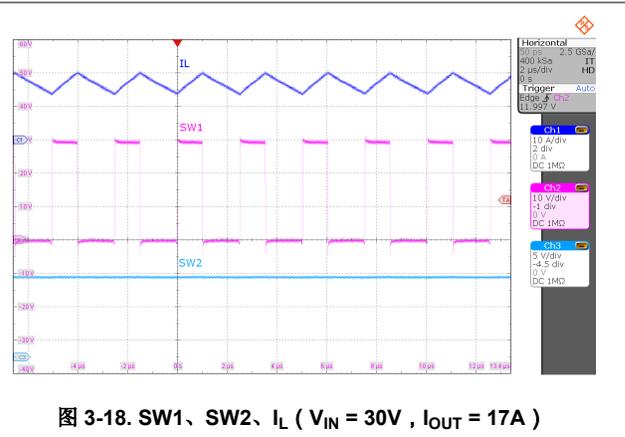
图 3-18. SW1、SW2、I_L（V_{IN} = 30V，I_{OUT} = 17A）

3.2.4 阶跃负载响应
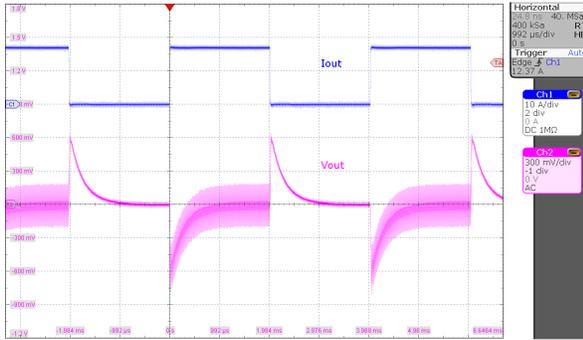
图 3-19. 负载阶跃（V_{IN} = 9V，I_{OUT} = 0A 至 17A）
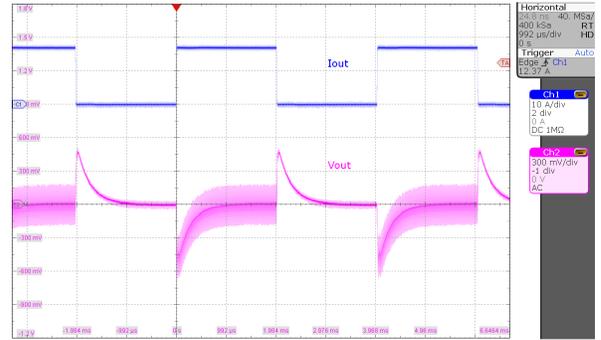
图 3-20. 负载阶跃（V_{IN} = 12V，I_{OUT} = 0A 至 17A）
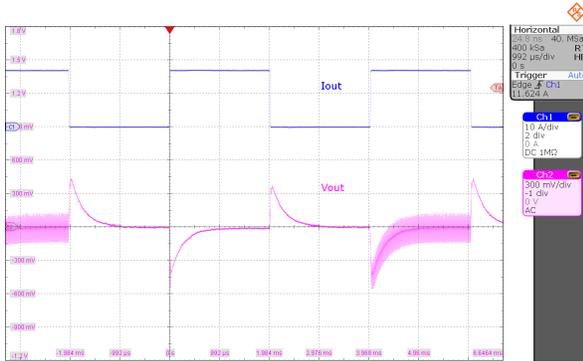
图 3-21. 负载阶跃（V_{IN} = 16V，I_{OUT} = 0A 至 17A）
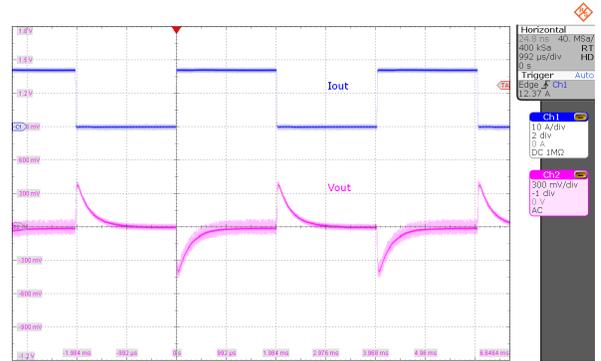
图 3-22. 负载阶跃（V_{IN} = 20V，I_{OUT} = 0A 至 17A）
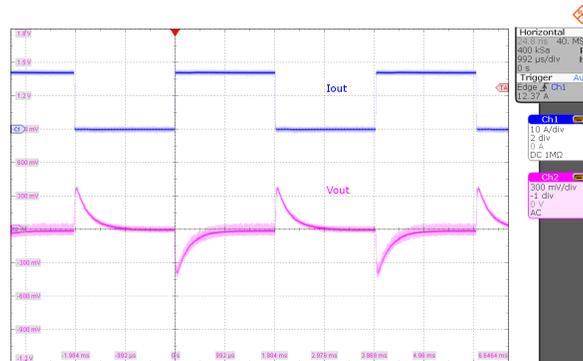
图 3-23. 负载阶跃（V_{IN} = 30V，I_{OUT} = 0A 至 17A）

3.2.5 峰值电流限制

该 EVM 的峰值电感器电流限制为 30A。
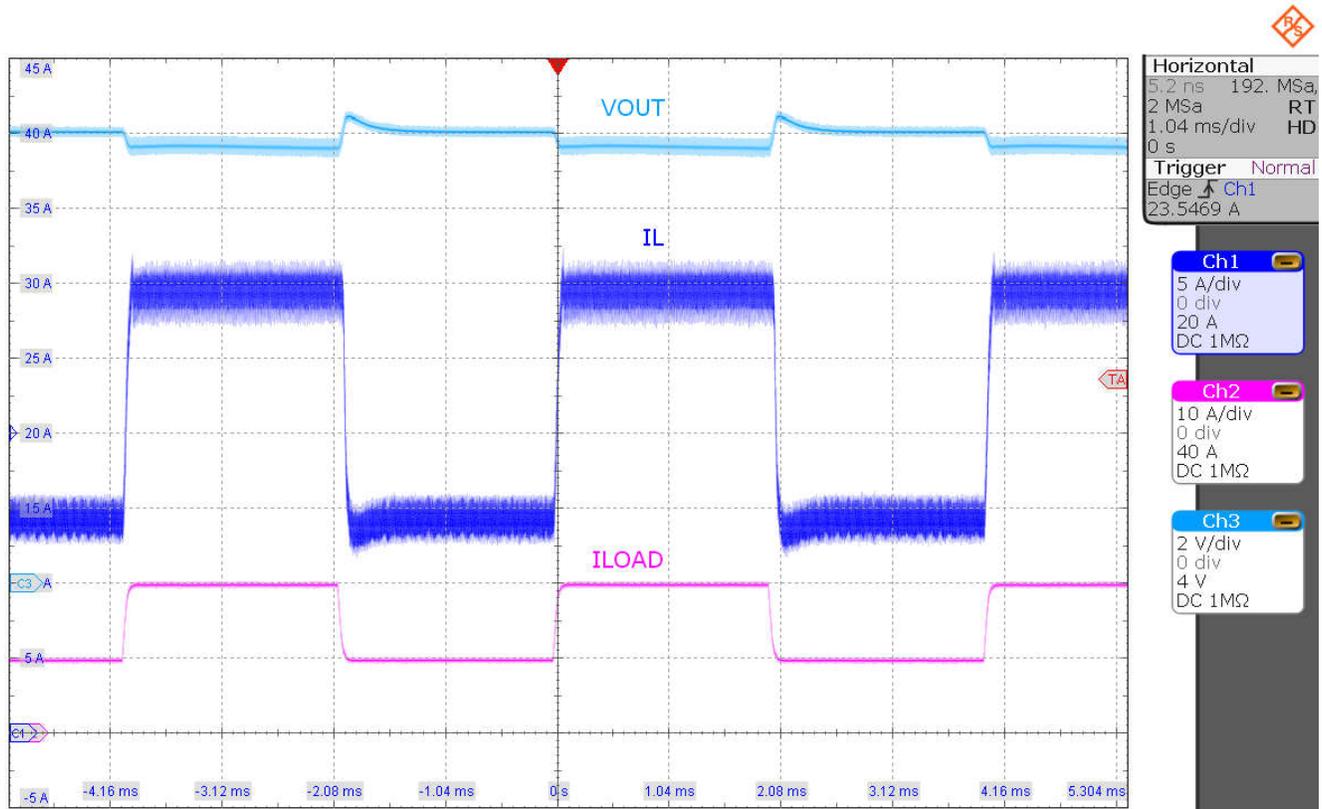
图 3-24. 30A 时的峰值电流限制，负载阶跃 (Vin=9V、Iout = 10A-20A)

3.2.6 交流环路响应曲线
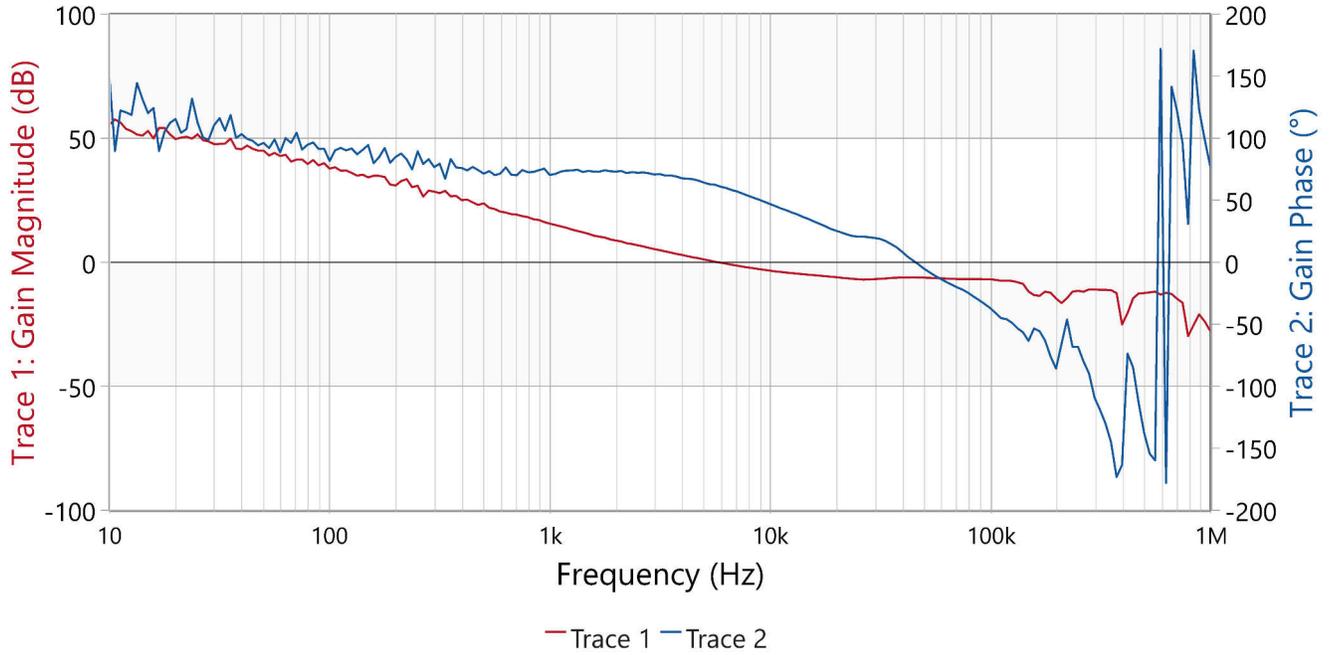
图 3-25. 控制回路响应，VIN = 9.0V，IOUT = 17A

4 硬件设计文件

4.1 原理图

图 4-1. 4 开关降压/升压控制器原理图

Optional external components
- Beard board circuits

This sheet contains footprint placeholder for compoents to extend the
controller functions. Components and values are generic and can be

Optional external components
e.g. Reverse CV Regulation
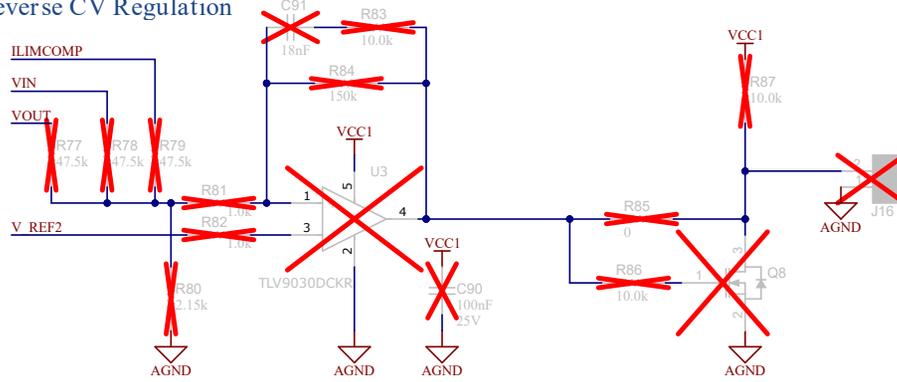
Reverse CV Regulation (opt.)

Optional external components
- Beard board circuits

Place close
to LM5177

Note: OPA310IDCKR (OPAMP)
and TLV9030DCKR (Comp.) have
same footprint and pin assignment

Reference Voltage

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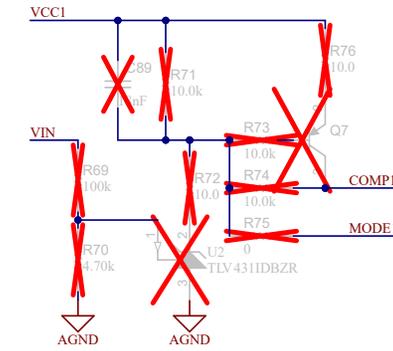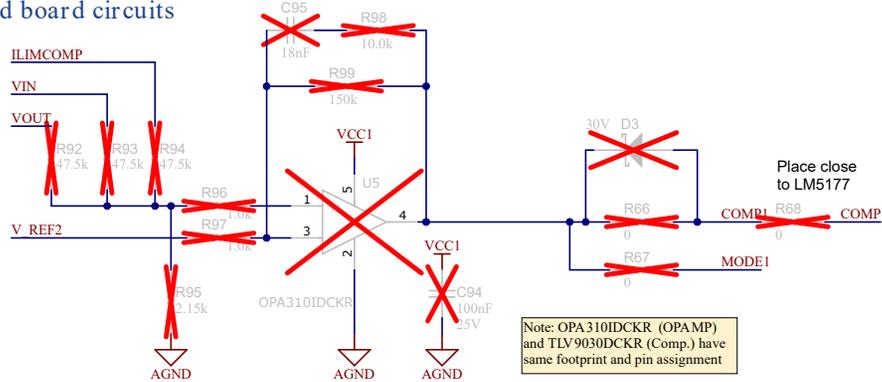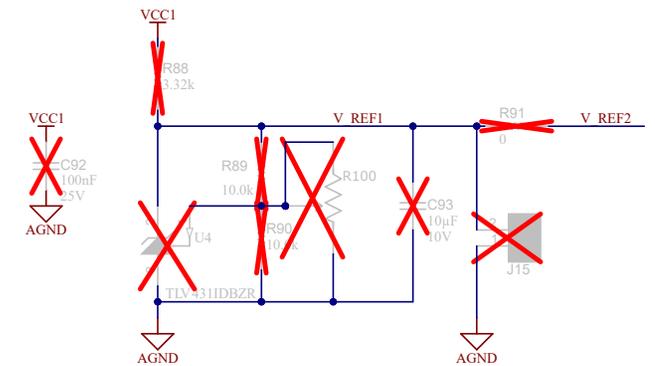
4.2 PCB 布局

图 4-2 至图 4-7 展示了 LM51772EVM-HP PCB 的设计。

图 4-2. 顶部丝印

图 4-3. 底部丝印

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4.2 PCB 布局（续）

展示了 LM51772EVM-HP PCB 的设计。
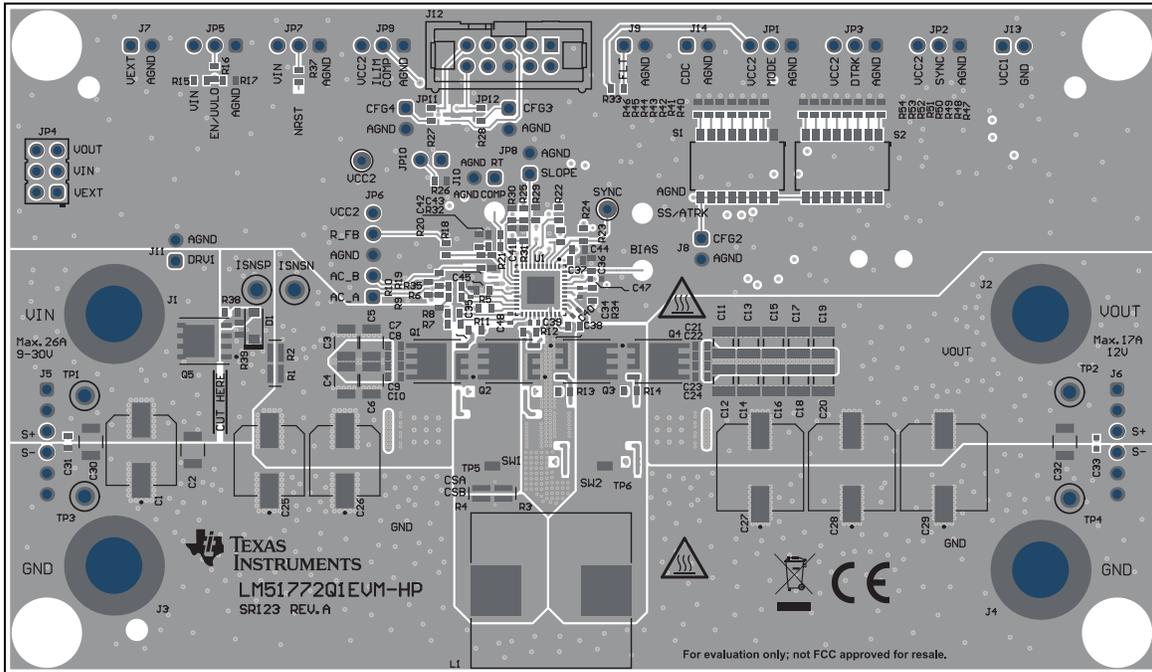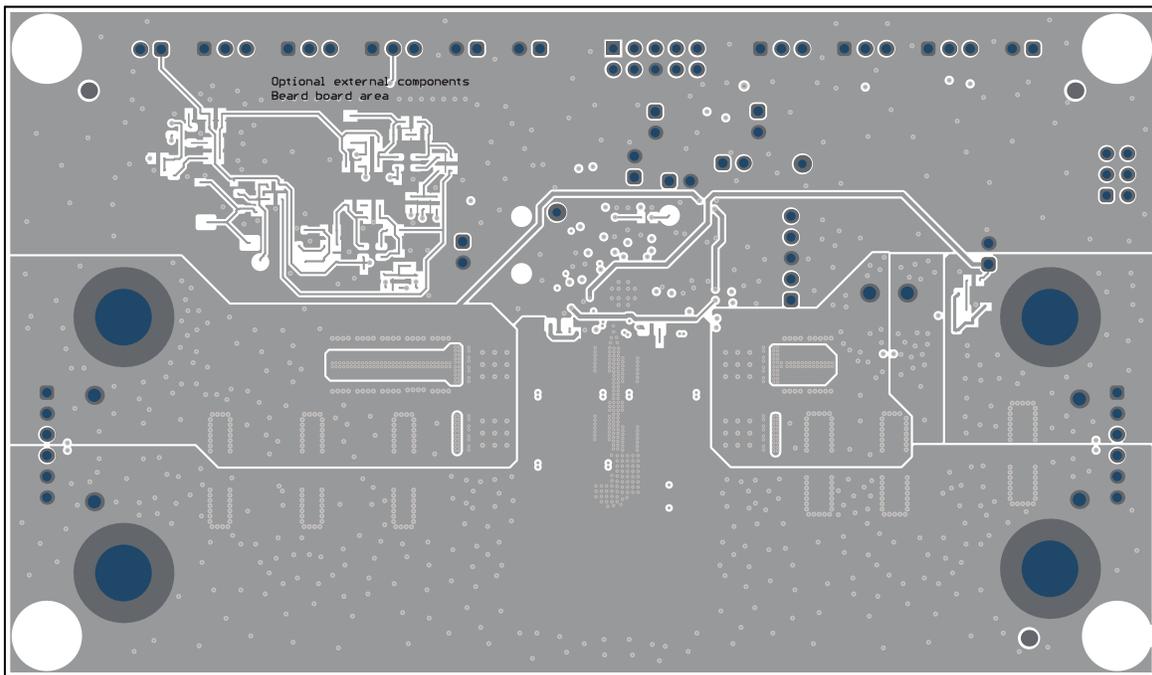
图 4-4. 顶层

图 4-5. 中间层 1

4.2 PCB 布局（续）

图 4-2 至图 4-7 展示了 LM51772EVM-HP PCB 的设计。
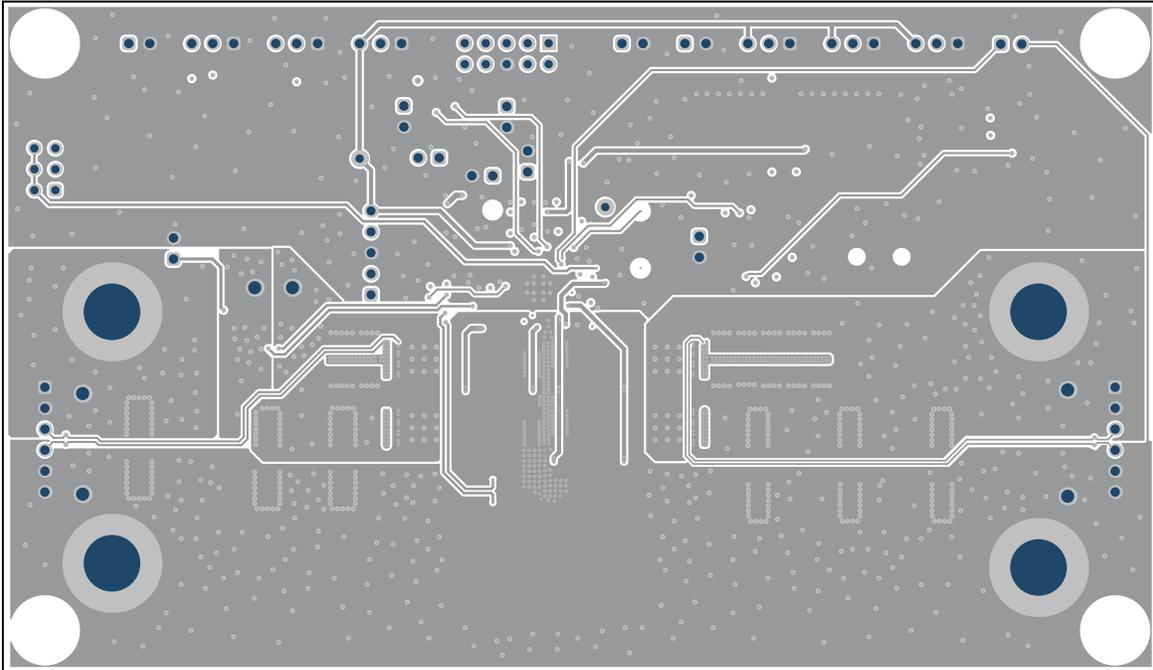
图 4-6. 中间层 2
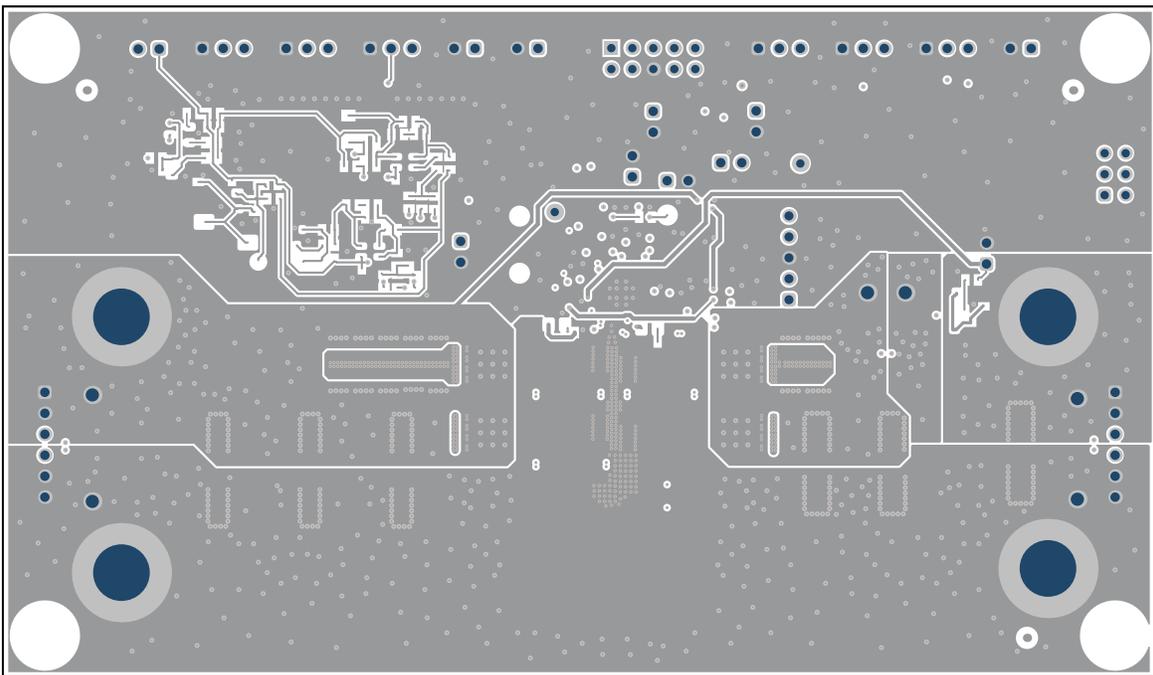
图 4-7. 底层

4.3 物料清单

表 4-1. 物料清单

位号	数量	值	器件型号	制造商	说明
C1、C25、C26	3	27µF	A768KE276M1JLAE054	KEMET	电容铝制聚合物 27uF 63V 20% 焊接圆柱形 54mΩ 1175mA 2000 小时 125°C T/R
C2、C3、C4、C5、C6、C30、C32	7	10µF	C3225X7R2A106K250AC	TDK	10µF ±10% 100V 陶瓷电容器 X7R 1210（公制 3225）
C7、C8、C9、C10、C21、C22、C23、C24、C31	9	0.1uF	GCJ188R72A104KA01D	MuRata	电容，陶瓷，0.1µF，100V，+/-10%，X7R，AEC-Q200 1 级，0603
C11、C12、C13、C14、C15、C16、C17、C18、C19、C20	10	22uF	GMK325BJ226MM-P	Taiyo Yuden	电容，陶瓷，22µF，35V，+/-20%，X5R，1210
C27、C28、C29	3	120µF	A768MS127M1HLAE024	KEMET	120µF 50V 铝聚合物电容径向，Can - SMD 24mΩ 2000 小时 @ 125°C
C33、C47	2		GCM188L81H104KA57D	Murata Electronics North America	0.1µF ±10% 50V 陶瓷电容器 X8L 0603（公制 1608）
C34、C35	2	0.1uF	GRM155R62A104KE14D	MuRata	电容，陶瓷，0.1µF，100V，+/-10%，X5R，0402
C36	1	0.1uF	CGA3E3X7S2A104K080AB	TDK	电容，陶瓷，0.1uF，100V，+/-10%，X7S，AEC-Q200 1 级，0603
C37、C38	2	22µF	GRT188R61A226ME13D	Murata	多层陶瓷电容器，22uF，10V，X5R ±20%，0603，纸质 T/R
C39、C40	2	0.1uF	GCM155R71H104KE02D	MuRata	电容，陶瓷，0.1uF，50V，+/-10%，X7R，AEC-Q200 1 级，0402
C41	1	56pF	06035A560FAT2A	AVX	电容，陶瓷，56pF，50V，+/-1%，C0G/NP0，0603
C42	1	0.022uF	C0603X223K5RACTU	Kemet	电容，陶瓷，0.022µF，50V，+/-10%，X7R，0603

表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
C43	1	56pF	06035A560JAT2A	AVX	电容，陶瓷，56pF，50V，+/-5%，C0G/NP0，0603
C44	1	0.033uF	06035C333JAT2A	AVX	电容，陶瓷，0.033uF，50V，+/-5%，X7R，0603
C45	1	33pF	CL10C330FB8NNNC	Samsung Electro-Mechanics	电容，陶瓷，33pF，50V，+/-5%，C0G/NP0，0603
C48	1	100pF	GRM1555C1H101JA01D	MuRata	电容，陶瓷，100pF，50V，+/-5%，C0G/NP0，0402
D1	1	10V	MMSZ4697T1G	ON Semiconductor	二极管，齐纳，10V，500mW，SOD-123
J1、J2、J3、J4	4		108-0740-001	Cinch Connectivity	标准香蕉插孔，非绝缘，15A
J5、J6	2		61300611121	Wurth Elektronik	接头，2.54mm，6x1，金，TH
J7、J8、J9、J10、J11、J13、J14、JP8、JP10、JP11、JP12	11		61300211121	Wurth Elektronik	接头，2.54mm，2x1，金，TH
J12	1		N2510-6002-RB	3M	接头（有罩），100mil，5x2，高温，镀金，TH
JP1、JP2、JP3、JP5、JP7、JP9	6		61300311121	Wurth Elektronik	接头，2.54mm，3x1，金，TH
JP4	1		HTSW-103-07G-D	Samtec	接头，2.54mm，3x2，金，TH
JP6	1		61300511121	Wurth Elektronik	接头，2.54mm，5x1，金，TH
L1	1	2.6uH	7443556260	Wurth Elektronik	电感器，屏蔽鼓芯，WE-Superflux200，2.6uH，31.5A，0.0016Ω，SMD
Q1、Q2、Q3、Q4	4		IAUCN04S7L014ATMA1	Infineon	N 通道 40V 120A 表面贴装 PG-TDSON-8-34
Q5	1		SI7155DP-T1-GE3	Vishay	转型 MOSFET P 通道 -40V-100A 8 引脚 SOIC-卷带包装

表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
R1、R2	2	4m	KRL2012E-M-R004F-T5	Susumu	4mΩ，±1%，1W，片上电阻，宽，0805（公制 2012），0508，汽车 AEC-Q200，电流检测，金属箔
R3、R4	2	3m	KRL2012E-M-R003F-T5	Susumu	3mΩ，±1%，1W，片上电阻，宽，0805（公制 2012），0508，汽车 AEC-Q200，电流检测，金属箔
R5、R6、R11、R12、R14、R16、R18、R22、R23、R24、R25、R34、R35、R37	14	0	RMCF0603ZT0R00	Stackpole Electronics Inc	电阻，0，1%，0.1W，AEC-Q200 0 级，0603
R7、R8	2	10	CRCW060310R0FKEAHP	Vishay-Dale	电阻，10.0，1%，0.25W，AEC-Q200 0 级，0603
R9、R20	2	82.0k	RC0603FR-0782KL	Yageo	电阻，82.0k，1%，0.1W，0603
R10、R21	2	7.32k	CRCW06037K32FKEA	Vishay-Dale	电阻，7.32k，1%，0.1W，AEC-Q200 0 级，0603
R13	1	2	MCT06030C2008FP500	Vishay/Beyschlag	电阻，2.00，1%，0.125W，0603
R15	1	75.0k	RC0603FR-0775KL	Yageo	电阻，75.0k，1%，0.1W，0603
R17	1	19.6k	CRCW060319K6FKEA	Vishay-Dale	电阻，19.6k，1%，0.1W，AEC-Q200 0 级，0603
R19	1	10	RC0603FR-0710RL	Yageo	电阻，10.0，1%，0.1W，0603
R26	1	23.4k	RT0603BRD0723K4L	Yageo America	电阻，23.4k，0.1%，0.1W，0603
R27、R29、R47	3	8.25k	RC0603FR-078K25L	Yageo	电阻，8.25k，1%，0.1W，0603
R28、R44	2	3.83k	CRCW06033K83FKEA	Vishay-Dale	电阻，3.83k，1%，0.1W，AEC-Q200 0 级，0603

表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
R30	1	78.7k	CRCW060378K7FKEA	Vishay-Dale	电阻，78.7k，1%，0.1W，AEC-Q200 0 级，0603
R31	1	50.5k	RT0603BRD0750K5L	Yageo America	电阻，50.5k，0.1%，0.1W，0603
R32、R48	2	10.5k	CRCW060310K5FKEA	Vishay-Dale	电阻，10.5k，1%，0.1W，AEC-Q200 0 级，0603
R33	1	10.0k	RT0603BRD0710KL	Yageo America	电阻，10.0k，0.1%，0.1W，0603
R38	1	43k	CRCW060343K0JNEA	Vishay-Dale	电阻，43k，5%，0.1W，AEC-Q200 0 级，0603
R39	1	180k	CRCW0603180KJNEA	Vishay-Dale	电阻，180k，5%，0.1W，AEC-Q200 0 级，0603
R40	1	511	CRCW0603511RFKEA	Vishay-Dale	电阻，511，1%，0.1W，AEC-Q200 0 级，0603
R41	1	1.15k	CRCW06031K15FKEA	Vishay-Dale	电阻，1.15k，1%，0.1W，AEC-Q200 0 级，0603
R42	1	1.87k	RC0603FR-071K87L	Yageo	电阻，1.87k，1%，0.1W，0603
R43	1	2.70k	RC0603FR-072K7L	Yageo	电阻，2.70k，1%，0.1W，0603
R45	1	5.10k	RC0603FR-075K1L	Yageo	电阻，5.10k，1%，0.1W，0603
R46	1	6.49k	RC0603FR-076K49L	Yageo	电阻，6.49k，1%，0.1W，0603
R49	1	13.3k	RC0603FR-0713K3L	Yageo	电阻，13.3k，1%，0.1W，0603
R50	1	16.2k	CRCW060316K2FKEA	Vishay-Dale	电阻，16.2k，1%，0.1W，AEC-Q200 0 级，0603
R51	1	20.5k	RC0603FR-0720K5L	Yageo	电阻，20.5k，1%，0.1W，0603
R52	1	24.9k	CRCW060324K9FKEA	Vishay-Dale	电阻，24.9k，1%，0.1W，AEC-Q200 0 级，0603

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表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
R53	1	30.1k	CRCW060330K1FKEA	Vishay-Dale	电阻，30.1k，1%，0.1W，AEC-Q200 0 级，0603
R54	1	35.7k	CRCW060335K7FKEA	Vishay-Dale	电阻，35.7k，1%，0.1W，AEC-Q200 0 级，0603
S1、S2	2		218-8LPST	CTS Electrocomponents	SPST 开关，8 芯，25mA，24VDC，SMD
TP1、TP2	2		5010	Keystone Electronics	测试点，多用途，红色，TH
TP3、TP4	2		5011	Keystone Electronics	测试点，多用途，黑色，TH
TP5、TP6	2		S2761-46R	Harwin	本色 PC 测试点，黄铜，SMT
TP7、TP8	2		5013	Keystone Electronics	测试点，通用，橙色，TH
TP10、TP11	2		5004	Keystone Electronics	测试点，微型，黄色，TH
U1	1		LM51772RHARQ1	德州仪器 (TI)	具有 I2C 接口的 48V 4 开关降压/升压控制器
C46	0		GCM188L81H104KA57D	Murata Electronics North America	0.1μF ±10% 50V 陶瓷电容器 X8L 0603（公制 1608）
C49	0	0.1uF	0402BB104KW500	Passive Plus	电容，陶瓷，0.1μF，50V，+/-10%，X7R，0402
C50	0	20pF	GRM1885C2A200JA01D	MuRata	电容，陶瓷，20pF，100V，+/-5%，C0G/NP0，0603
C51	0	150pF	GRM1885C1H151JA01D	MuRata	电容，陶瓷，150pF，50V，+/-5%，C0G/NP0，0603
C52、C53、C54	0	1000pF	06031C102JAT2A	AVX	电容，陶瓷，1000pF，100V，+/-5%，X7R，0603
C55、C56、C57、C61、C62、C63	0	680pF	GCM1555C1H681FA16D	MuRata	电容器，陶瓷，680pF，50V，+/-1%，C0G/NP0，AEC-Q200 1 级，0402
C58、C64	0	4700pF	GRM155R71H472KA01D	MuRata	电容，陶瓷，4700pF，50V，+/-10%，X7R，0402
C59	0	680pF	GRM2195C2A681JA01D	MuRata	电容，陶瓷，680pF，100V，+/-5%，C0G/NP0，0805

表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
C60	0	3000pF	GRM2165C2A302JA01D	MuRata	电容，陶瓷，3000pF，100V，+/-5%，C0G/NP0，0805
C65、C66、C67、C68	0	10μF	C3225X7R2A106K250AC	TDK	10μF ±10% 100V 陶瓷电容器 X7R 1210（公制 3225）
C69、C70、C71、C72、C83、C84、C85、C86、C87、C88	0	0.1uF	GCJ188R72A104KA01D	MuRata	电容，陶瓷，0.1μF，100V，+/-10%，X7R，AEC-Q200 1 级，0603
C73、C74、C75、C76、C77、C78、C79、C80、C81、C82	0	22uF	GMK325BJ226MM-P	Taiyo Yuden	电容，陶瓷，22μF，35V，+/-20%，X5R，1210
C89、C91、C95	0	0.018uF	C0603C183K1RACTU	Kemet	电容，陶瓷，0.018uF，100V，+/-10%，X7R，0603
C90、C92、C94	0	0.1uF	C0603X104K3RACTU	Kemet	电容，陶瓷，0.1μF，25V，+/-10%，X7R，0603
C93	0	10uF	GRM188R61A106KE69D	MuRata	电容，陶瓷，10μF，10V，+/- 10%，X5R，0603
D2	0		BAS70-04E3-18	Vishay	二极管阵列，1 对串联肖特基，70V，200mA (DC)，表面贴装 TO-236-3，SC-59，SOT-23-3
D3	0	30V	BAT54T1G	ON Semiconductor	二极管，肖特基，30V，0.2A，SOD-123
H1、H2、H3、H4	0		NY PMS 440 0025 PH	B&F Fastener Supply	机械螺钉，圆头，#4-40 x 1/4，尼龙，飞利浦盘形头
H5、H6、H7、H8	0		1902C	Keystone	六角螺柱，0.5"L #4-40，尼龙
J15、J16	0		61300211121	Wurth Elektronik	接头，2.54mm，2x1，金，TH
Q1A、Q2A、Q3A、Q4A	0		IAUCN04S7L014ATMA1	Infineon	N 通道 40V 120A 表面贴装 PG-TDSON-8-34
Q6	0	60V	CSD18540Q5B	德州仪器 (TI)	MOSFET，N 沟道，60V，100A，DNK0008A (VSON-CLIP-8)

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表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
Q7	0	45V	BC807-40LT1G	ON Semiconductor	晶体管，PNP，45V，0.5A，AEC-Q101，SOT-23
Q8	0	60V	2N7002W-7F	Diodes Inc.	MOSFET，N 沟道，60V，0.115A，SOT-323
R36、R56、R57、R61、R62、R66、R67、R68、R75、R85、R91	0	0	RMCF0603ZT0R00	Stackpole Electronics Inc	电阻，0，1%，0.1W，AEC-Q200 0 级，0603
R55	0	2.7k	CRCW06032K70JNEA	Vishay-Dale	电阻，2.7k，5%，0.1W，AEC-Q200 0 级，0603
R58	0	5.10k	RC0603FR-075K1L	Yageo	电阻，5.10k，1%，0.1W，0603
R59、R60	0	3	CRCW06033R00JNEA	Vishay-Dale	电阻，3.0，5%，0.1W，AEC-Q200 0 级，0603
R63	0	2	MCT06030C2008FP500	Vishay/Beyschlag	电阻，2.00，1%，0.125W，0603
R64、R65	0	2.00k	RC0603FR-072KL	Yageo	电阻，2.00k，1%，0.1W，0603
R69	0	100k	RC0603FR-07100KL	Yageo	电阻，100k，1%，0.1W，0603
R70	0	4.70k	RC0603FR-074K7L	Yageo	电阻，4.70k，1%，0.1W，0603
R71、R73、R74、R83、R98	0	10.0k	CRCW060310K0FKEA	Vishay-Dale	电阻，10.0k，1%，0.1W，AEC-Q200 0 级，0603
R72、R76	0	10	RC0603FR-0710RL	Yageo	电阻，10.0，1%，0.1W，0603
R77、R78、R79、R92、R93、R94	0	47.5k	RC0603FR-0747K5L	Yageo	电阻，47.5k，1%，0.1W，0603
R80、R95	0	2.15k	RC0603FR-072K15L	Yageo	电阻，2.15k，1%，0.1W，0603
R81、R82、R96、R97	0	1.0k	RC0603JR-071KL	Yageo	电阻，1.0k，5%，0.1W，0603

表 4-1. 物料清单（续）

位号	数量	值	器件型号	制造商	说明
R84、R99	0	150k	RC0603FR-07150KL	Yageo	电阻，150k，1%，0.1W，0603
R86、R87、R89、R90	0	10.0k	RT0603BRD0710KL	Yageo America	电阻，10.0k，0.1%，0.1W，0603
R88	0	3.32k	RC0603FR-073K32L	Yageo	电阻，3.32k，1%，0.1W，0603
R100	0	10kΩ	ST-5ETW103	Nidec Copal Electronics（日产科宝电子有限公司）	10kΩ 0.25W，1/4W 鸥翼表面贴装微调电位器金属陶瓷 14.0 转顶部调节
TP9、TP14	0		5001	Keystone Electronics	测试点，微型，黑色，TH
TP12、TP13、TP15	0		5004	Keystone Electronics	测试点，微型，黄色，TH
U2、U4	0		TLV431IDBZR	德州仪器 (TI)	低压可调精度并联稳压器，39ppm/°C，15mA，-40°C 至 85°C，3 引脚 SOT-23 (DBZ)，绿色环保（RoHS，无锑/溴）
U3	0		TLV9030DCKR	德州仪器 (TI)	具有推挽输出 5-SC70 和 -40 至 125°C 的汽单路低电压比较器
U5	0		OPA310IDCKR	德州仪器 (TI)	单通道、5.5V、3MHz 高输出电流 (150mA) 快速关断 (1µs) 运算放大器 5-SC70 -40℃ 至 125℃

5 其他信息

5.1 商标

所有商标均为其各自所有者的财产。

STANDARD TERMS FOR EVALUATION MODULES

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

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

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

2 *Limited Warranty and Related Remedies/Disclaimers*:

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

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

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

WARNING

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

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

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

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3   *Japan*

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

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

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

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

1.   Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2.   Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or

3.   Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1.   電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。

2.   実験局の免許を取得後ご使用いただく。

3.   技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。 上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

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

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

3.4   *European Union*

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

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

4   *EVM Use Restrictions and Warnings:*

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

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

   4.3   *Safety-Related Warnings and Restrictions:*

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

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

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

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

6.   *Disclaimers:*

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

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

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

8. *Limitations on Damages and Liability:*

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

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

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

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

重要通知和免责声明