

EVM User's Guide: LM654B0EVM-1PH

LM654B0 评估模块

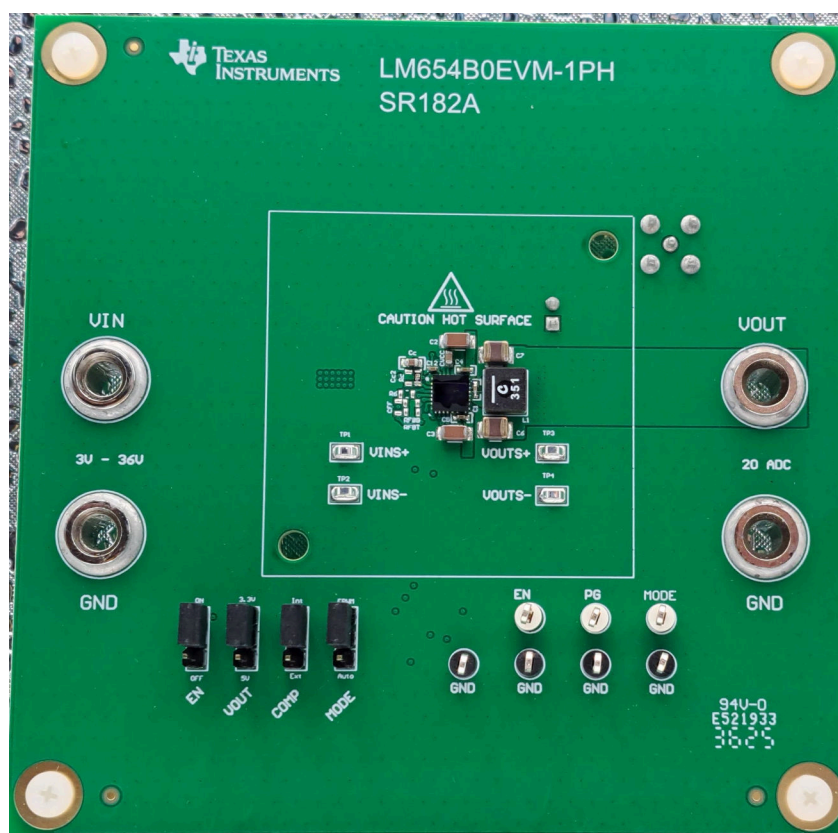


说明

德州仪器 (TI) LM654B0EVM-1PH 评估模块 (EVM) 可帮助设计人员评估 LM654xx 系列宽输入电压降压转换器的运行情况和性能。

特性

- 3V 到 36V 的宽输入电压范围
- 5V、3.3V 和 ADJ 电压
- 峰值输出电流高达 25A
- 300kHz 至 2.2MHz 开关频率
- 超低开关节点振铃以降低电磁干扰 (EMI)



LM654B0EVM-1PH 电路板图像

1 评估模块概述

1.1 简介

LM654B0EVM-1PH 配置为向需要 15A 或更小电流的负载提供 5V 输出。通过代替其他版本的 LM654xx 并重新配置电路板元件和跳线，LM654B0EVM-1PH 可用于许多不同的配置中。另请参阅 [设备信息](#)。

1.2 套件内容

该套件包含一个 LM654B0EVM-1PH 和一个散热器。

1.3 规格

[表 1-1](#) 介绍了 LM654B0EVM-1PH 和 LM654B0 的性能特性。

除非另有说明： $V_{IN} = 12V$ ， $V_{OUT} = 5V$ ， $T_A = 25^\circ C$ ，无散热器。

表 1-1. LM654B0EVM-1PH 电气性能特性

参数	测试条件		最小值	典型值	最大值	单元
输入特性						
输入电压范围, V_{VIN}	EVM 输入电压工作范围		6	12	36	V
空载时的输入电流, $I_{IN(NL)}$	$I_{OUT} = 0A$	自动模式		23		μA
输入电流 (禁用) , $I_{IN(OFF)}$	$V_{EN/UVLO} = 0V$, 无 EN 分压器	$V_{IN} = 12V$		1.2		μA
输出特性						
输出电压, V_O	$I_{OUT} = 0A$, 自动模式			5.022		V
	$I_{OUT} = 15A$			5.002		V
输出电压调节, ΔV_{OUT}	负载调整, 自动模式	$I_{OUT} = 0A$ 至 15A		20		mV
输出电压调节, ΔV_{OUT}	负载调整, FPWM 模式	$I_{OUT} = 0A$ 至 15A		10		
输出电压调节, ΔV_{OUT}	线性调整率, $V_{IN} = 9V$ 至 36V	$I_{OUT} = 15A$		3.8		
最大输出电流	$V_{IN} = 12V$			20		A
系统特性						
开关频率	$I_{OUT} = 1A$			2100		kHz
峰值效率	$I_{OUT} = 8A$	$V_{IN} = 12V$		94.5%		
满负载效率	$I_{OUT} = 15A$	$V_{IN} = 12V$		93.1%		

1.4 器件信息

默认 EVM 包含 LM654B0。[表 1-2](#) 列出了可与 LM654B0VM 一同使用的其他器件。要在 EVM 中使用其他器件，必须进行适当的无源器件更改。

表 1-2. LM654B0EVM-1PH 器件选项

器件 GPN	峰值输出电流
LM654A0	10A
LM654A2	12A
LM654A5	15A
LM654B0	20A

2 硬件

2.1 其他图像

图 2-1 和图 2-2 分别展示了 LM654B0EVM-1PH 的正面和背面。

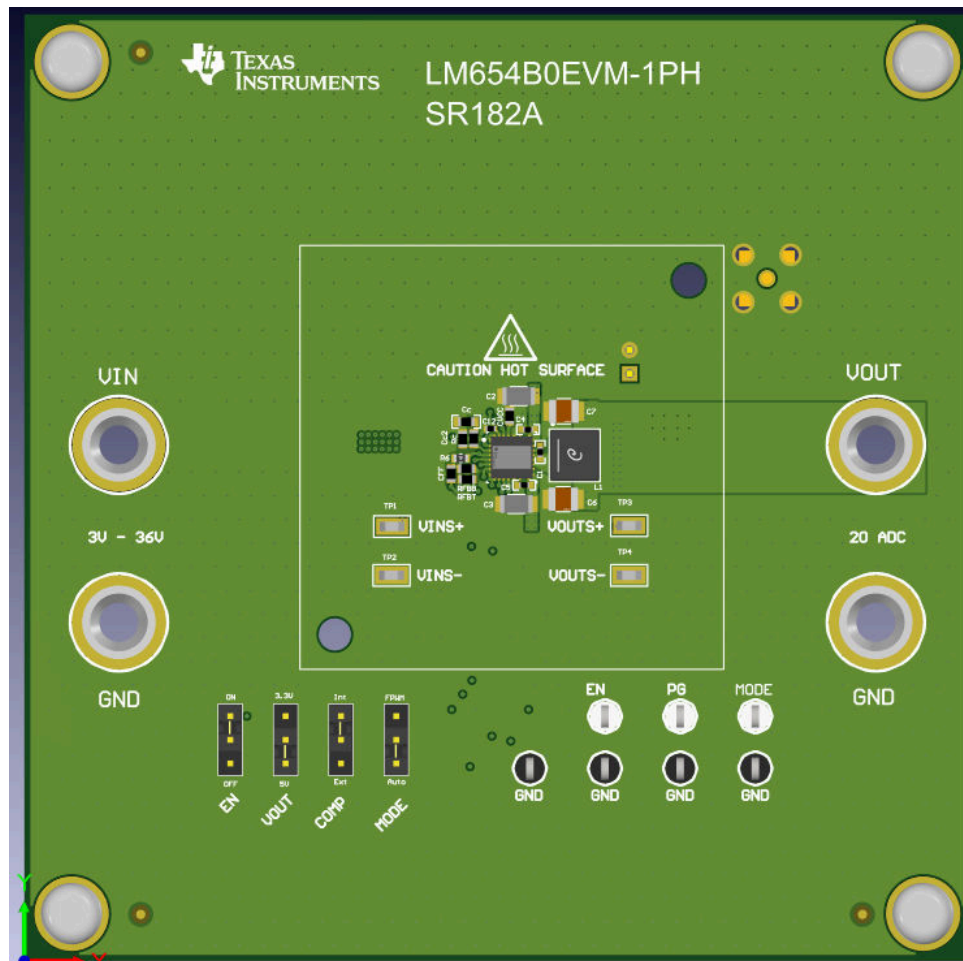


图 2-1. LM654B0EVM-1PH 顶面

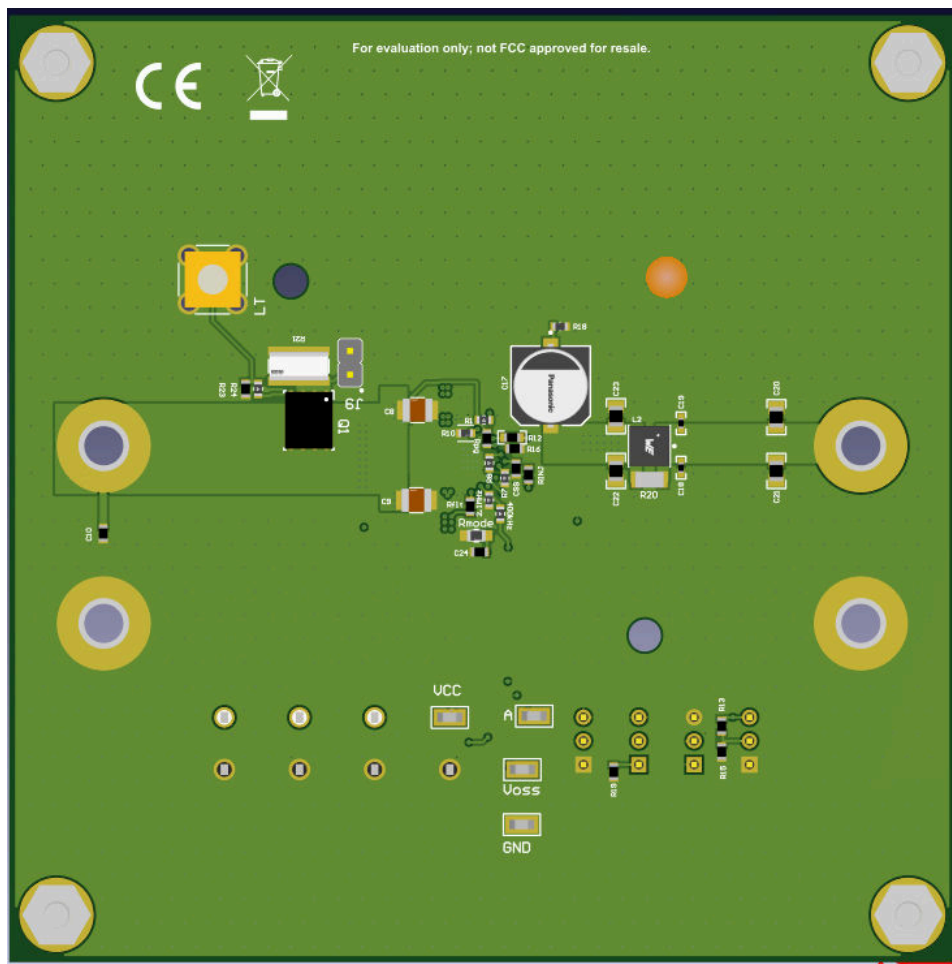


图 2-2. LM654B0EVM-1PH 底部

2.2 电源要求

6V 至 36V 范围内且能够提供 15A 电流的任何电源均可用于评估 LM654B0EVM-1PH。

2.3 设置

本节对 EVM 上的连接器、测试点和跳线作出了描述，并对如何正确地连接、设置和使用 LM654B0EVM-1PH 进行了说明。有关连接器和跳线的位置以及典型设置，请参阅图 2-3。

该 EVM 设置为在 2.1MHz 下以单相运行，并提供 5V 或 3.3V 的输出电压。套件中提供了散热器，有助于在以大负载电流运行时降低器件温度。请注意，稳压器和散热器之间需要一个散热焊盘，套件中未提供散热焊盘。更多详细信息，请参阅 BOM。

EVM 上提供了负载瞬态发生器。将合适的脉冲发生器连接到 "LT" SMB 连接器，并根据需要调整负载电流脉冲幅度和持续时间。脉冲占空比必须保持在较低水平，以免损坏 MOSFET。电流脉冲通过 "Isense" 跳线 (J9) 进行监测，而输出电压必须直接在输出电容器两端进行监测。TI 建议使用高速差分探头。另请参阅图 2-5。

普通香蕉型电缆的典型额定电流约为 5A。如果使用该 EVM 测试更大的负载电流，则必须将多根电缆堆叠在一起。EVM 上的插孔额定电流为 15A。

VOUT	转换器的输出电压。 VOUT 香蕉接线柱。向此连接器施加负载。
VIN	转换器的输入电压。 VIN 香蕉接线柱。向此连接器施加输入电压。

GND	转换器接地 GND 香蕉接线柱。向这些连接器施加负载接地和输入电压接地。各种 GND 测试点用于输入电压和输出电压测量中的接地检测。
VOULTS+	VOULTS+ 测试点用作 VOUT 检测的正极 DMM 连接。
VOULTS-	VOULTS- 测试点用作 VOUT 检测的负级 DMM 连接。
VINS+	VINS+ 测试点用作 VOUT 检测的正极 DMM 连接。
VINS-	VINS- 测试点用作 VOUT 检测的负级 DMM 连接。
EN	EN 跳线的使用方法一目了然。 要向器件的 EN 输入端提供外部信号，请移除 EN 跳线分流器并将信号施加到 EN 测试点。 要使用外部 UVLO 功能，请根据需要填充 Rent (R13) 和 Renb (R15) 并移除 EN 跳线分流器。请注意，为了准确测量关断电流，必须移除这些电阻器（如果使用）并将 EN 跳线分流器移至“OFF”位置。
VOUT	该跳线选择 5V 或 3.3V 的默认输出电压。有关更多信息，请参阅反馈连接。
COMP	该跳线为稳压器环路选择使用内部或外部频率补偿。 当跳线处于 "Int" 位置时，内部环路补偿处于活动状态；此为默认情况。 当跳线处于 "Ext" 位置时，用户必须提供补偿元件 Rc、Cc 和 Cc2 来提供环路补偿。有关更多详细信息，请参阅 LM654B0 数据表。
模式	MODE 跳线用于选择器件的运行模式。MODE 处于 AUTO 位置时，器件根据负载电流在自动 PFM/FPWM 模式下运行。MODE 处于 FPWM 位置时，器件在所有负载电流下以固定频率运行。 MODE 引脚也是频率同步输入。要将器件与外部时钟同步，请移除 MODE 跳线分流器，并将时钟应用于 MODE 测试点。
反馈连接	默认 EVM 通过 "VOUT" 跳线设置为 5V 或 3.3V 输出，在 R8 安装 0 Ω 电阻器，R6 保持开路。 要使用可调节输出电压选项，请在 R6 安装 0 Ω 电阻器，R8 保持开路，并在 RFBT (R4) 和 RFBB (R9) 安装具有相应阻值的电阻器。基准电压为 0.8V。有关反馈电阻器的相应阻值，请参阅 LM654B0 数据表。 使用可调输出电压模式时，可以使用 Rinj (R2) 电阻器绘制波德图。该电阻器成为频率响应分析器的注入点，从而能够以常规方式获取环路频率响应。在固定输出电压模式下，无法获取波德图。
RT	默认 EVM 设置为在 2.1MHz 下运行，在 "2.1MHz" 位置放置一个 0 Ω 电阻器。要将频率设置为 400kHz、请将 0 Ω 电阻器置于 "400kHz" 位置，并移除 "2.1MHz" 位置的 0 Ω 电阻器。 要使用可调节频率选项，请在 "2.1MHz" 位置安装具有适当阻值的电阻器。有关频率与 RT 值间的关系，请参阅 LM654B0 数据表。
PGOOD	PGOOD 测试点用于监控电源正常状态指示器。该标志指示输出电压是否已达到调节电平。PGOOD 是一个开漏输出端，通过 100k Ω 电阻器 Rpg (R3) 连接到 VOUT。
VCC	VCC 测试点 VCC 引脚是内部 LDO 的输出。VCC 电压通常为 3.3V。该点可用于逻辑输入和上拉。不要连接至外部负载。
BIAS	LDO 辅助输入 通过 EVM 上的 0 Ω Rbias (R1) 连接到 VOUT。要更改 LDO 的输入电源，请移除 Rbias (R1) 并根据需要将外部电源连接至 BIAS 引脚或接地 BIAS 引脚。使用外部偏置电源时，填充 Cbias (C12)。如需了解更多信息，请参阅 LM654B0 数据表。
PHASE	Rph (R7) 安装了 0 Ω 电阻器以进行单相运行。有关更多信息，请参阅 LM654B0 数据表。
DRSS	Rdrss (R10) 安装了 150k Ω 电阻器。有关更多信息，请参阅 LM654B0 数据表。
Css	Css (C14) 保持开路。有关更多信息，请参阅 LM654B0 数据表。
波特图	在使用可调输出电压模式时，可以使用图 2-4 中所示的连接来绘制波德图。必须填充 Rinj (R2)。
EMI 滤波器	EMI 滤波器安装在 EVM 上，但与 R20 短接。要使用 EMI 滤波器进行测试，请移除 R20。

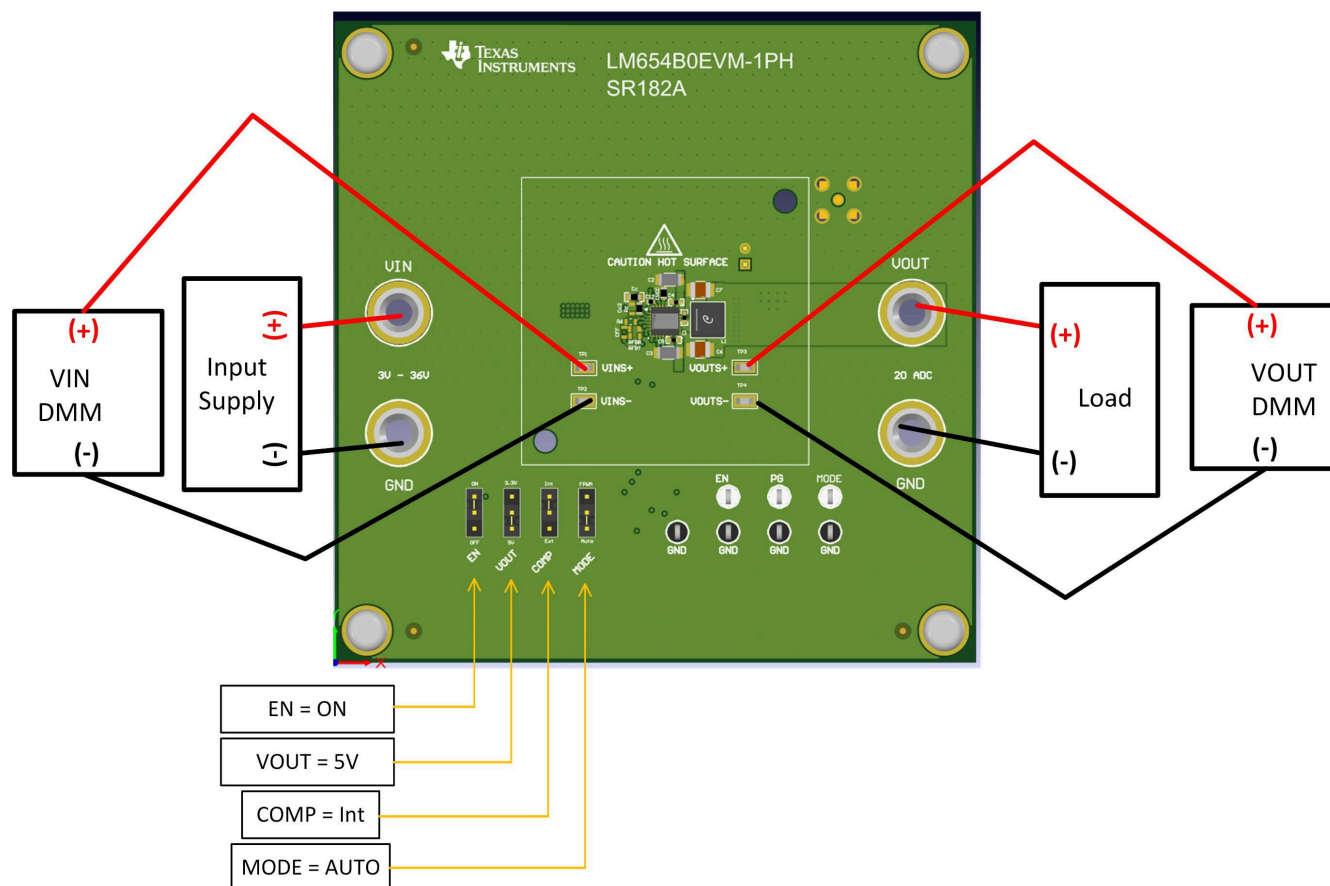


图 2-3. LM654B0 设置和测试连接

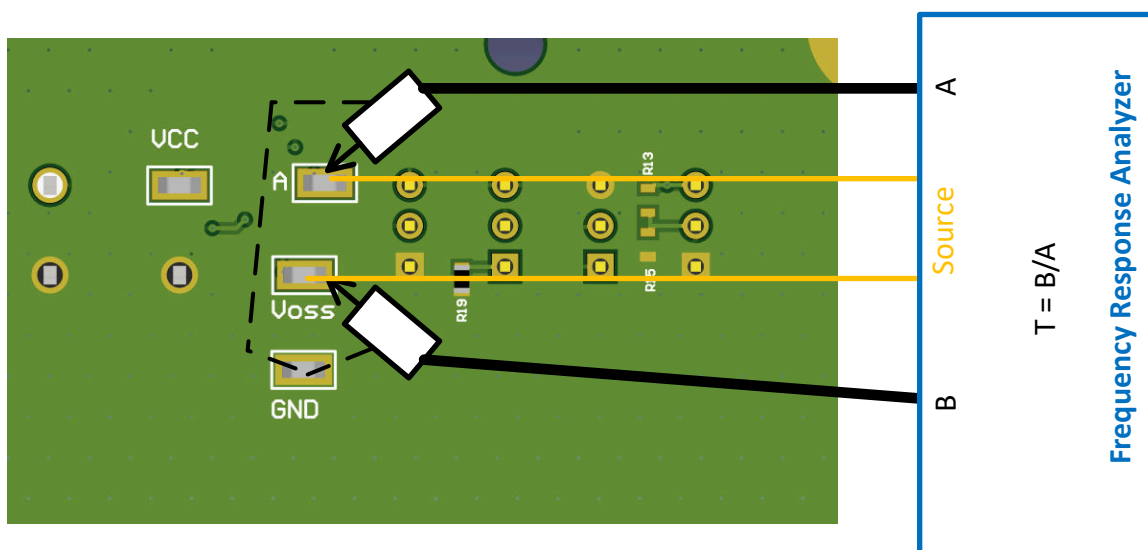


图 2-4. LM654B0 环路响应连接

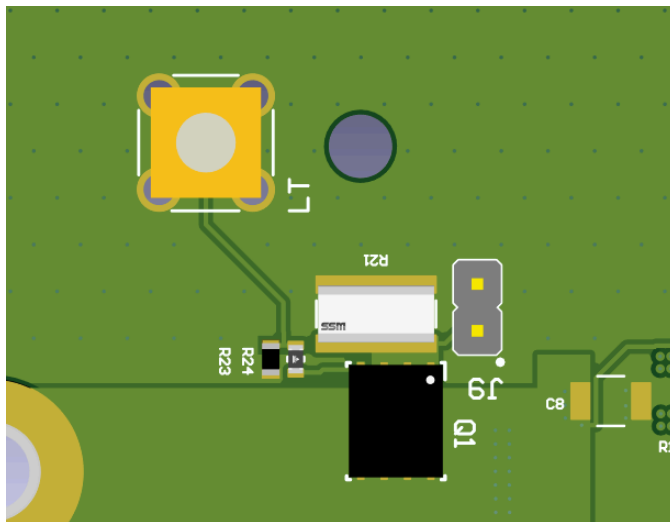
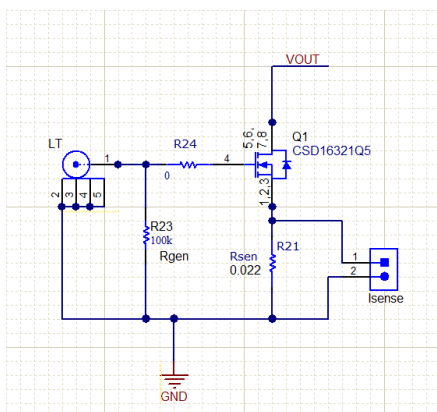


图 2-5. 负载瞬态发生器

3 实现结果

3.1 性能数据和结果

除非另有说明，否则以下条件适用： $T_A = 25^\circ\text{C}$ ， $V_{IN} = 12\text{V}$ ， $F_{SW} = 2100\text{kHz}$ 。无散热器。

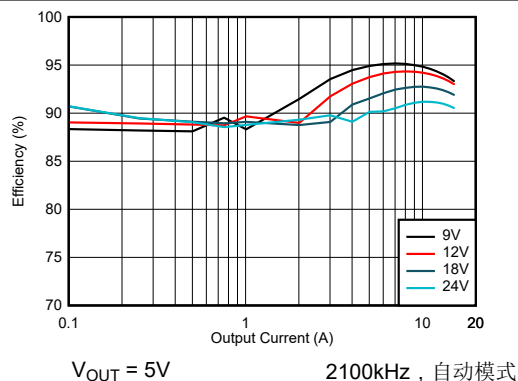


图 3-1. 效率

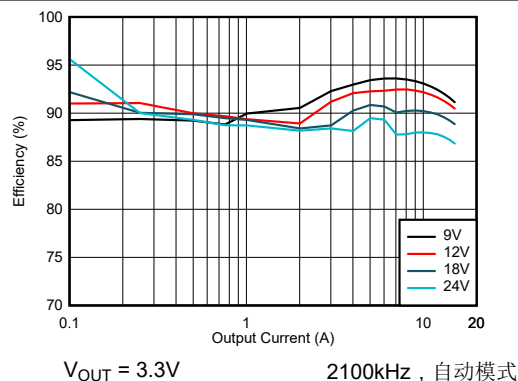


图 3-2. 效率

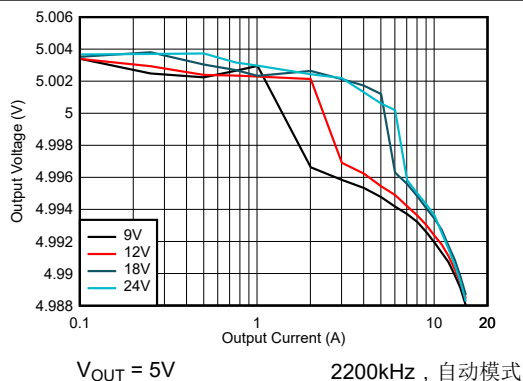


图 3-3. 线性 and 负载调整率

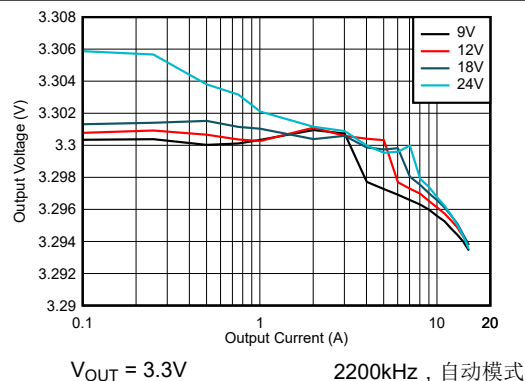


图 3-4. 线性 and 负载调整率

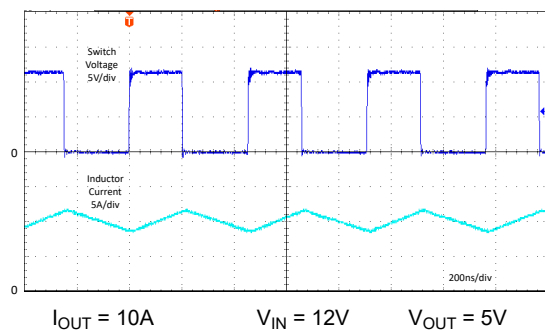


图 3-5. PWM 中的典型开关波形

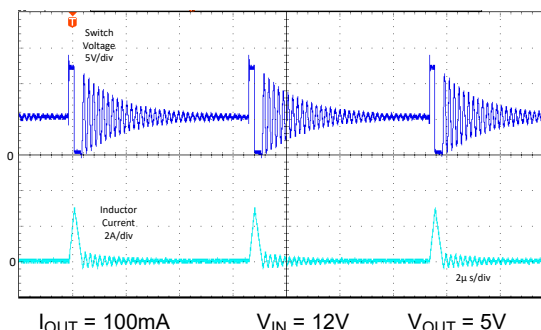
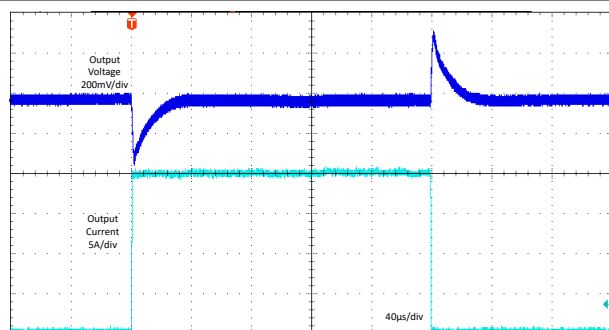
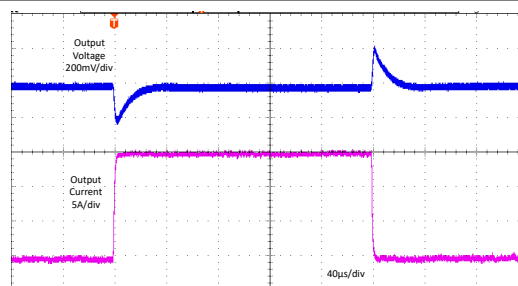


图 3-6. PFM 中的典型开关波形



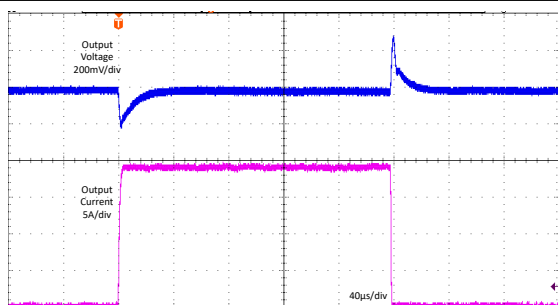
$I_{OUT} = 0A$ 至 $20A$ $V_{IN} = 12V$ FPWM 模式

图 3-7. 负载瞬态



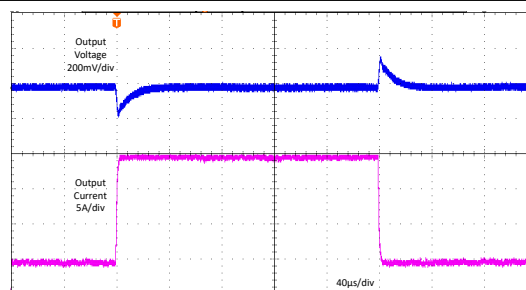
$I_{OUT} = 5A$ 至 $20A$ $V_{IN} = 12V$ FPWM 模式
 $V_{OUT} = 5V$

图 3-8. 负载瞬态



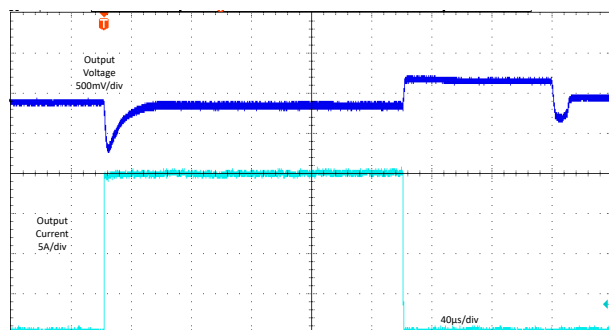
$I_{OUT} = 0A$ 至 $20A$ $V_{IN} = 12V$ FPWM 模式
 $V_{OUT} = 3.3V$

图 3-9. 负载瞬态



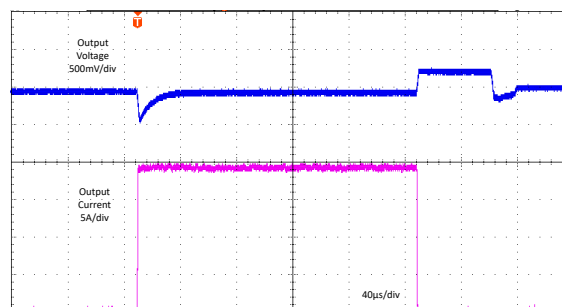
$I_{OUT} = 5A$ 至 $20A$ $V_{IN} = 12V$ FPWM 模式
 $V_{OUT} = 3.3V$

图 3-10. 负载瞬态



$I_{OUT} = 0A$ 至 $20A$ $V_{IN} = 12V$ 自动模式
 $V_{OUT} = 5V$

图 3-11. 负载瞬态



$I_{OUT} = 0A$ 至 $20A$ $V_{IN} = 12V$ 自动模式
 $V_{OUT} = 3.3V$

图 3-12. 负载瞬态

实现结果

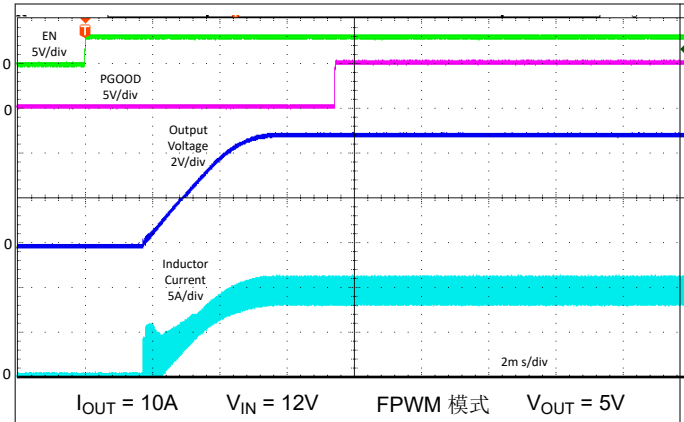


图 3-13. 启动

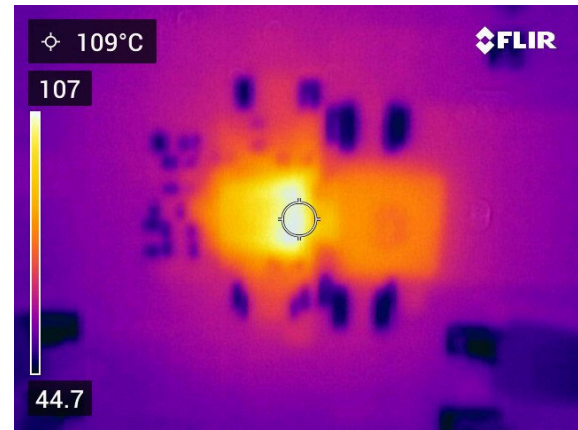


图 3-14. 热像图

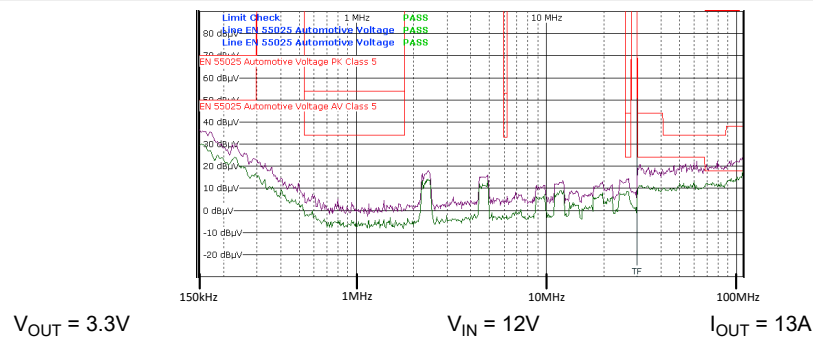


图 3-15. 传导 EMI

4.2 PCB 布局

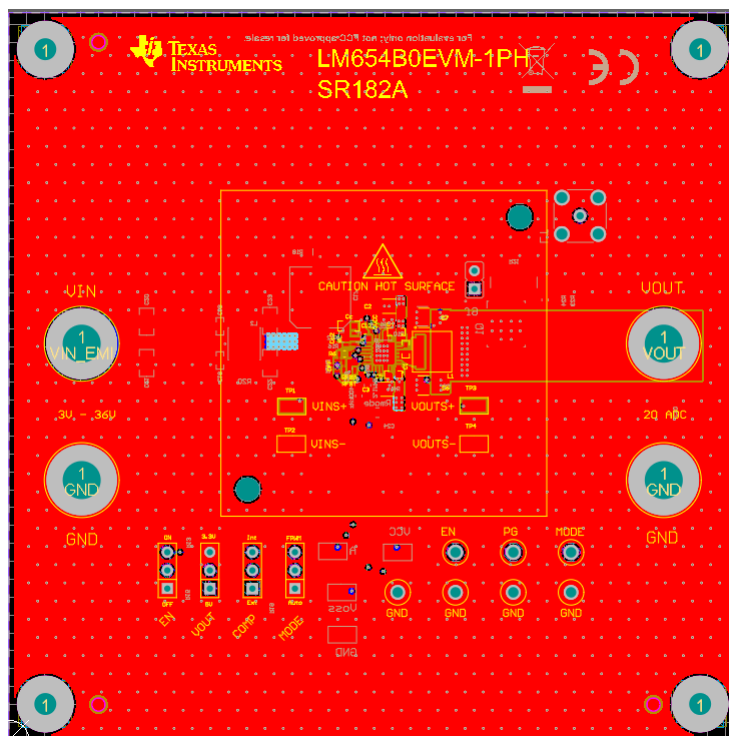


图 4-2. PCB 顶层丝印

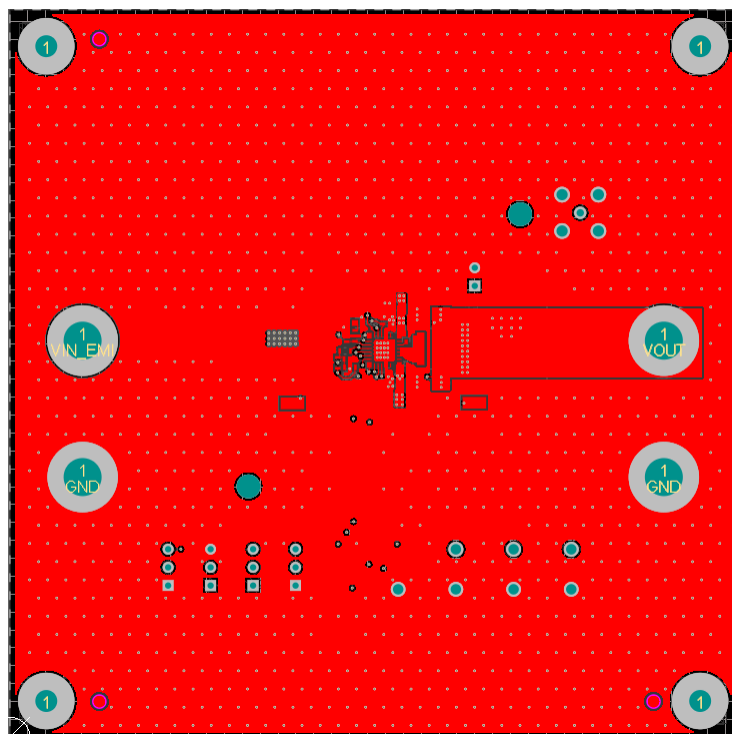


图 4-3. PCB 顶视图

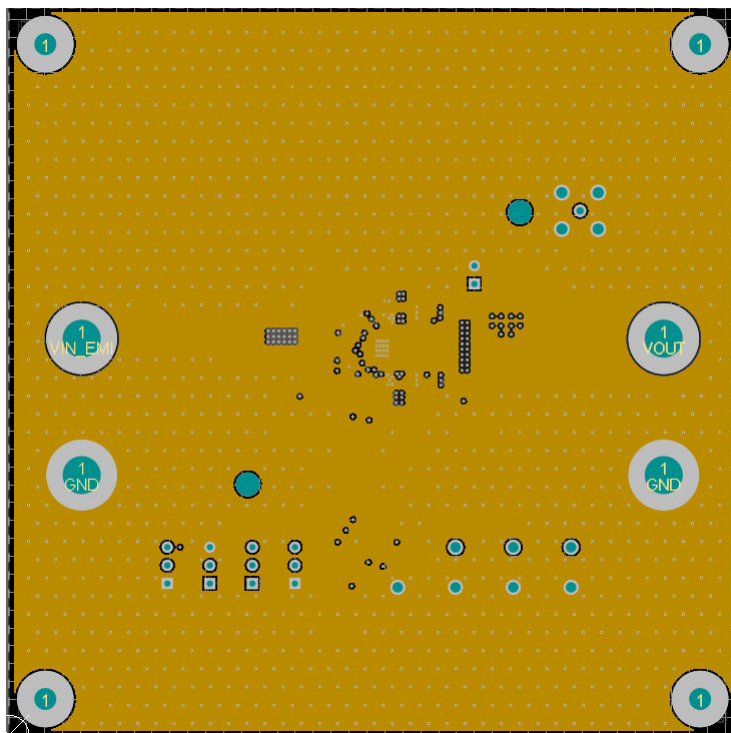


图 4-4. PCB 第一接地层

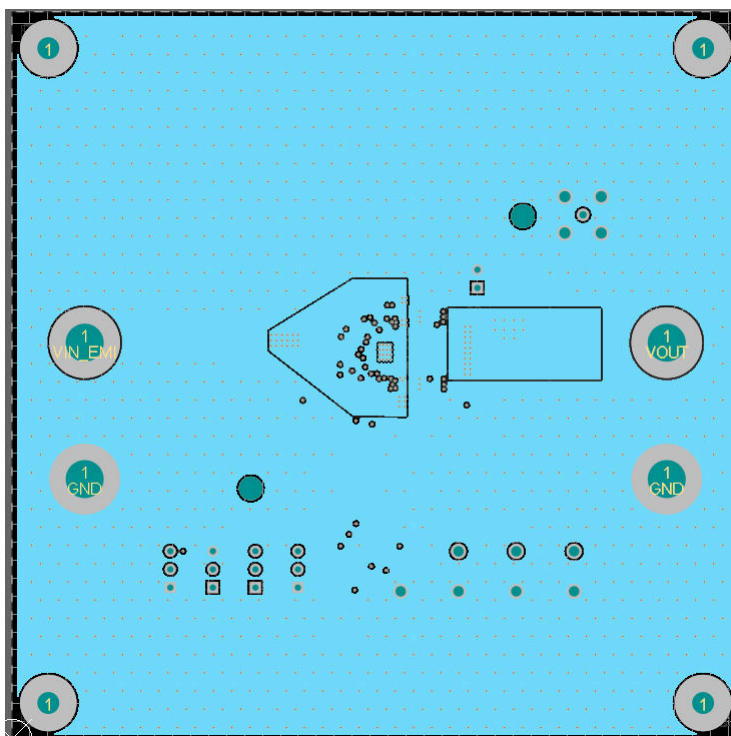


图 4-5. PCB 第一信号层

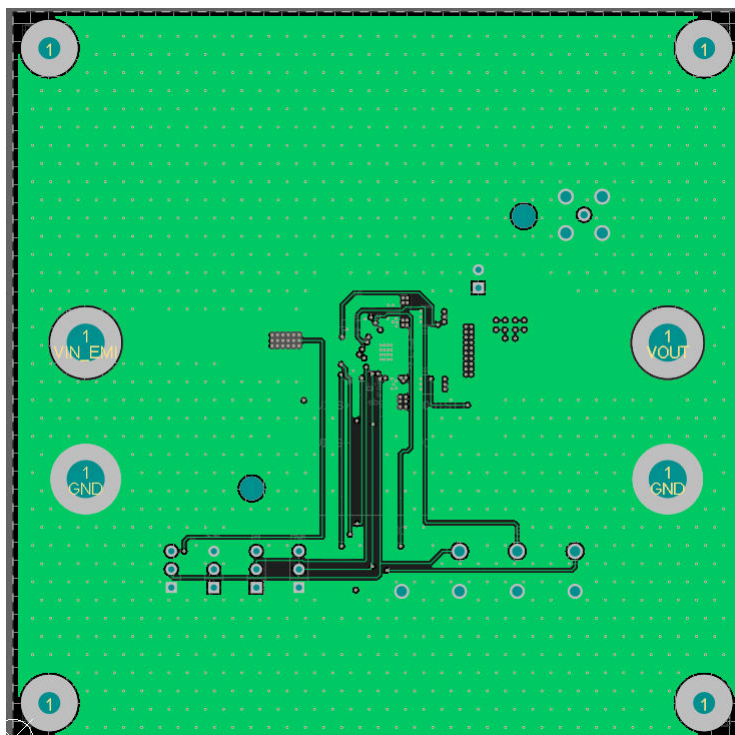


图 4-6. PCB 第二信号层

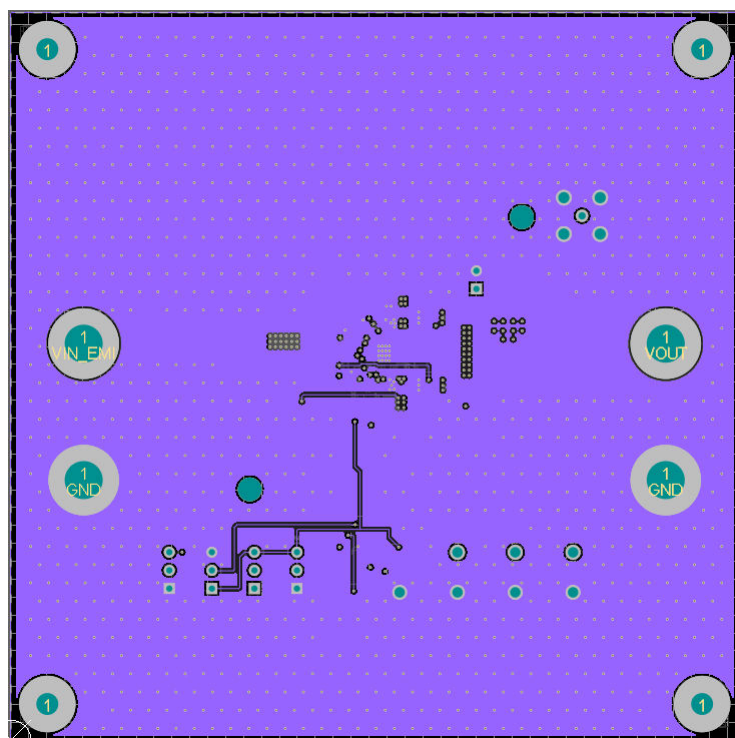


图 4-7. PCB 第三信号层

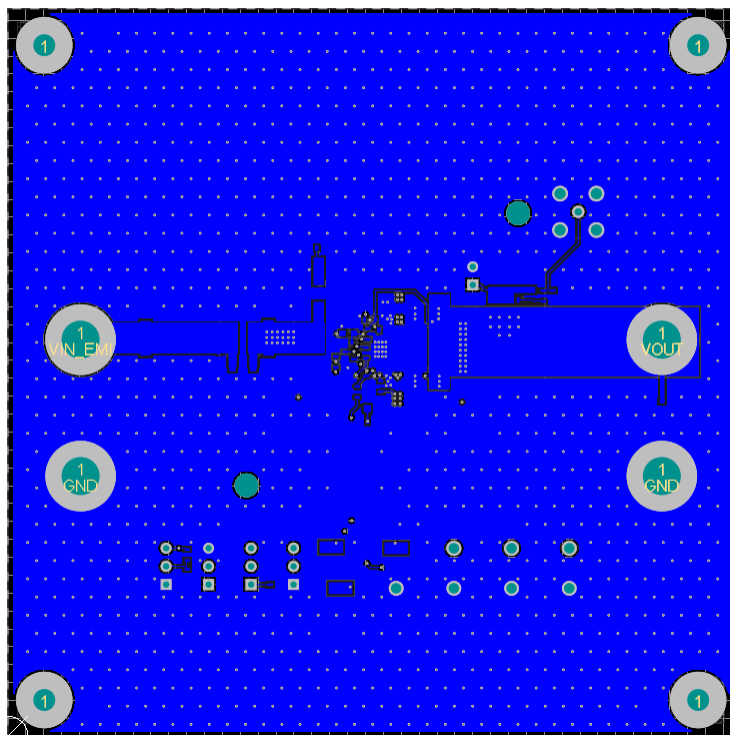


图 4-8. PCB 底层

4.3 物料清单 (BOM)

表 4-1. LM654B0EVM-1PH BOM (配有多个选项)

位号	别名	数量	值	说明	器件型号
C1		1	0.22uF	电容, 陶瓷, 0.22uF, 16V, +/-10%, X7R, 0402	GRM155R71C224KA12D
C2、C3		2	10uF	电容, 陶瓷, 10uF, 50V, +/-10%, X7R, AEC-Q200 1 级, 1206	CGA5L1X7R1H106K160AC
C4、C5、C12、C18、C19		5	0.1uF	电容, 陶瓷, 0.1uF, 50V, +/-10%, X7R, AEC-Q200 1 级, 0402	CGA2B3X7R1H104K050BB
C6、C7		2	47μF	汽车用陶瓷电容器, 47uF, ±10%, 10VDC, X7S, 1210, 压纹 T/R	GCM32EC71A476KE02K
C10		1	0.1uF	电容, 陶瓷, 0.1μF, 100V, +/-10%, X7R, AEC-Q200 1 级, 0603	GCJ188R72A104KA01D
C11	CVCC	1	1uF	电容, 陶瓷, 1μF, 16V, +/- 20%, X7R, AEC-Q200 1 级, 0603	GCM188R71C105MA64D
C16	Cc	1	2000pF	电容, 陶瓷, 2000pF, 50V, +/-5%, C0G/ NP0, 0603	GRM1885C1H202JA01D
C17		1		电容, 铝, 47UF, 20%, 50V, SMD	EEEFK1H470P
C20、C21、C22、C23		4	4.7μF	电容, 陶瓷, 4.7uF, 50V, +/-20%, X5R, AEC-Q200 3 级, 0805	CGA4J3X5R1H475M125AB
J1、J2、J3、J4		4		标准香蕉插头, 非绝缘, 8.9mm	575-8
J5、J6、J7、J8		4		接头, 100mil, 3x1, 金, TH	PCC03SAAN
J9		1		接头, 100mil, 2x1, 金, TH	PBC02SAAN
J10		1		连接器, SMB, 垂直 RCP 0-4GHz, 50ohm, TH	131-3701-261
L1		1	0.35uH	350nH 屏蔽模压电感器, 22.8A, 最大 2.2mOhm, 非标准	XGL5030-351MEC
L2		1	0.47uH	470nH 屏蔽模压电感器, 17.1A, 最大 4.5mOhm, 非标准	744393240047
Q1		1	25V	MOSFET, N 沟道, 25V, 100A, DQH0008A (VSON-CLIP-8)	CSD16321Q5
R1	Rbias	1	0	CRCW 系列 0603 0.1W 0Ohm 跳线表面贴装厚膜片上电阻	CRCW06030000Z0EAC
R7、R8、R24		3	0	CRCW 系列 0603 0.1W 0Ohm 跳线表面贴装厚膜片上电阻	CRCW06030000Z0EAC
R2	Rinj	1	49.9	电阻, 49.9, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW060349R9FKEA
R3	Rpg	1	100k	电阻, 100k, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW0603100KFKEA
R23		1	100k	电阻, 100k, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW0603100KFKEA
R10		1	150k	150k Ω ±1% 0.1W 0603 厚膜片上电阻, 符合 AEC-Q200 标准	RMCF0603FT150K
R11	2.1MHz	1	0	CRCW 系列 0603 0.1W 0Ohm 跳线表面贴装厚膜片上电阻	CRCW06030000Z0EAC
R14	Rc	1	8.66k	电阻, 8.66k, 1%, 0.1W, 0603	RC0603FR-078K66L
R18		1	0	0Ohms ±1% 片式电阻器 0603 (公制 1608) 厚膜	CR160000F
R19		1	49.9k	电阻, 49.9k, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW060349K9FKEA

表 4-1. LM654B0EVM-1PH BOM (配有多个选项) (续)

位号	别名	数量	值	说明	器件型号
R20		1	0	电阻, 0, 1%, 0.5W, 1206	5108
R21		1	0.022	22mOhms, $\pm 1\%$, 3W, 片上电阻, 宽, 2512 (公制 6432), 1225, 汽车类 AEC-Q200, 电流感流, 金属箔	KRL6432E-M-R022-F-T1
SH-J1、SH-J2、SH-J3、SH-J4		4		单操作 2.54mm 间距开顶跳线插座	M7582-05
TP1、TP2、TP3、TP4、TP5、TP6、TP7、TP16		8		测试点, 微型, SMT	5015
TP8、TP9、TP15		3		测试点, 通用, 白色, TH	5012
TP11、TP12、TP13、TP14		4		测试点, 多用途, 黑色, TH	5011
U1		1		LM654B0 20A 可堆叠降压转换器	LM654B0TVDARQ1
C8、C9		0	47 μ F	汽车用陶瓷电容器, 47 μ F, $\pm 10\%$, 10VDC, X7S, 1210, 压纹 T/R	GCM32EC71A476KE02K
C13		0	10pF	电容, 陶瓷, 10pF, 50V, $\pm 5\%$, C0G/ NP0, AEC-Q200 1 级, 0603	CGA3E2C0G1H100D080AA
C14		0	0.1 μ F	电容, 陶瓷, 0.1 μ F, 50V, $\pm 10\%$, X7R, 0603	GCM188R71H104KA57D
C15、C24		0	10pF	电容, 陶瓷, 10pF, 50V, $\pm 5\%$, C0G/ NP0, 0603	GRM1885C1H100JA01D
MP1		0		散热器, BGA, 铝合金, 9.7W, 75°C, 顶部贴装型	HSB43-454515P
R4		0	100k	电阻, 100k, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW0603100KFKEA
R5、R15		0	49.9k	电阻, 49.9k, 1%, 0.1W, AEC-Q200 0 级, 0603	CRCW060349K9FKEA
R6、R22		0	0	CRCW 系列 0603 0.1W 0Ohm 跳线表面贴装厚膜片上电阻	CRCW06030000Z0EAC
R9、R16		0	19.1k	电阻, 19.1k, 1%, 0.1W, 0603	RC0603FR-0719K1L
R12		0	4.87k	电阻, 4.87k, 1%, 0.1W, 0603	RC0603FR-074K87L
R13		0	187k	电阻, 187k, 1%, 0.1W, 0603	RC0603FR-07187KL
R17		0	150k	电阻薄膜, 0805, 150KOhm, 0.1%, 1/8W, $\pm 25\text{ppm}/^\circ\text{C}$, 模制 SMD, SMD 穿孔载体, T/R	ERA-6AEB154V

5 其他信息

5.1 商标

所有商标均为其各自所有者的财产。

6 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 * (October 2025) to Revision A (July 2026)	Page
• 首次公开发布的 EVM 用户指南.....	1
• 更新了电路板说明措辞.....	1
• 更新了硬件图标题.....	1
• 更新了简介中的重新配置电路板措辞.....	2
• 更新了整个文档中的措辞以反映 LM654B0EVM-1PH GPN.....	4
• 更新了设置中的 VCC 连接措辞.....	4
• 向性能数据和结果中的图添加了数据测试条件.....	8

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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.

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:*

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最后更新日期：2025 年 10 月