EVM User's Guide: TPS922152EVM

TPS922152EVM 平均电流降压 LED 驱动器评估模块

说明

德州仪器 (TI) TPS922152EVM 评估模块 (EVM) 可帮助设计人员评估降压 LED（发光二极管）驱动程序 TPS922152 的运行情况和性能。TPS922152EVM 支持 4.5V 至 15V 的输入电压范围以及 60V 的总线电压，并提供默认 5A 的恒流输出以驱动外部 LED 负载。

开始使用

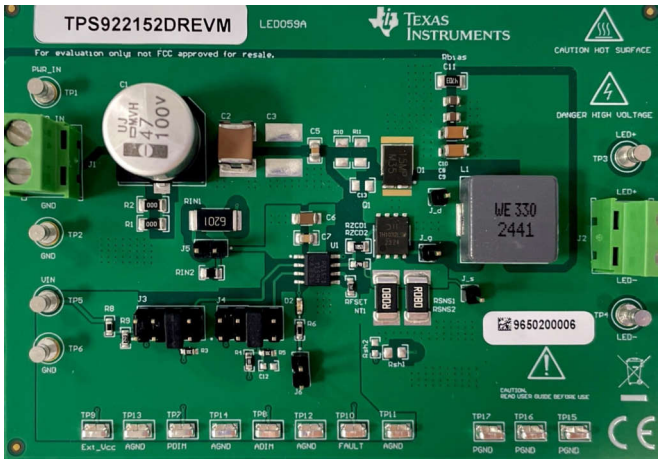
1. 在评估之前，请先完整阅读和学习本用户指南
2. 订购 TPS922152EVM 以进行评估（如果符合步骤 1 的要求）
3. 根据用户指南说明设置和测试 TPS922152EVM

特性

- 输入电压范围为 4.5V 至 15V
- 高达 500V 的宽应用电压
- LED 共阳极连接
- 可调开关频率：50kHz 至 1MHz
- 自适应关断时间模式
- 高级调光选项：
  - 模拟调光 (1000:1)
  - PWM 调光（50ns 脉冲宽度）
  - 灵活调光

应用

- 持续照明：
  - 室内外照明
  - 舞台和摄影灯光
  - 投影仪、激光电视、打印机、IP 摄像头
  - 高压 LED 驱动器
- 即时照明：
  - 机器视觉和摄像头闪光灯
  - 火警和频闪
- LED 背光：
  - 平板显示器
  - LCD 电视和监视器



TPS922152 评估模块

1 简介

TPS922152 EVM 评估模块 (EVM) 可帮助设计人员评估具有宽应用电压范围的 TPS922152 非同步平均电流控制降压 LED 驱动器的运行情况和性能。TPS922152 能够在自适应关断时间 (AOT) 模式下以高达 1MHz 的可调开关频率驱动外部开关 FET。AOT 模式可实现低 LED 电流纹波和快速瞬态响应，并具有较小的输出电容器。该器件还支持单层 PCB 设计和共阳极连接。

2 警告和注意事项

在使用 TPS922152EVM 时，请遵守以下预防措施。

警告

在选择 LED 元件（此 EVM 未随附）时，最终用户必须查阅 LED 制造商提供的 LED 数据表，确认 EN62471 风险分组等级，并评估所选 LED 可能对眼睛带来的危害。务必考虑并落实使用有效的滤光和防护墨镜，并在观察强光源时充分了解周围的实验室环境，更大程度地降低或消除上述风险，从而避免与暂时性失明相关的事故。

3 说明

TPS922152EVM 是一个 LED 驱动器，由 TPS922152 降压开关稳压器供电。该 EVM 默认输出电流设置为 5A，可在模拟和 PWM 调光选项下运行。通过在 PDIM 引脚上施加 0-100% 占空比的 PWM 信号，或在 ADIM 引脚上施加 0.2V 至 2.4V 的模拟电压，器件能够分别在 PWM 调光或模拟调光模式下运行。在模拟调光下，该 EVM 可以提供高达 1000:1 的调光比。在 PWM 调光下，该 EVM 可以输出低至 50ns 的脉冲宽度。为了进一步增加调光控制的灵活性，灵活调光模式也可用于独立控制 LED 电流值和开/关行为。TPS92215x 可提供宽电压范围、高额定电流和超深度调光等特性。

3.1 典型应用

此设计描述了 TPS922152 的 LED 驱动器应用，规格如下。对于具有不同输入电压范围或不同输出电压和电流的应用，请参阅 TPS922152 数据表。

表 3-1 列出了电气性能规格。

表 3-1. TPS922152EVM 电气性能规格

参数	测试条件	最小值	典型值	最大值	单位
输入总线电压范围 (V_{BUS})		54	60	66	V
LED 正向电压	单个白光 LED		3		V
输出电压，V_{OUT}	LED+ 到 LED-，取决于 V_{IN}		48		V
最大 LED 电流			5		A
输出电流纹波	V_{IN} = 60V，16 个白光 LED，5A 输出电流		100		mApp
模拟调光范围		0.2		2.4	V
PWM 调光范围	在 PDIM 引脚上施加 3.3V PWM 信号	0		100	%
PWM 调光频率		0.1		50	kHz
开关频率			400		kHz

4 测试设置

本节对 EVM 上的连接器和测试点进行了说明，并介绍了如何正确地连接、设置和使用 TPS922152EVM。

4.1 连接器说明

表 4-1. EVM 连接器和测试点

参考指示符	功能
J1	连接到 V_{BUS} 电源
J2	连接到 LED 负载
J3	PDIM 可选连接到 V_{IN_div}、外部 V_{CC}、TP7 或 GND
J4	ADIM 可选连接到 V_{IN_div}、外部 V_{CC}、TP8 或 GND
J5	可选择直接通过 V_{BUS} 为器件供电
J6	可选择将 FAULT 上拉至 V_{IN_div}
TP1、TP2	正和负电源 V_{BUS} 输入测试点
TP3、TP4	LED 负载阳极和阴极测试点
TP5、TP6	连接到 V_{IN} 电源
TP7	PDIM 信号输入
TP8	ADIM 信号输入
TP9	外部 V_{CC} 信号输入
TP10	FAULT 测试点
TP11、TP12、TP13、TP14	AGND 测试点
TP15、TP16、TP17	PGND 测试点

4.2 输入/输出连接

必须通过一对 20 AWG 导线将能够提供 10A 电流的电源连接到 J1。必须通过一对 20 AWG 导线将 LED 负载连接到 J2。LED 负载的正极须连接到 TP3 或 TP3 旁边的 J2 端子，LED 负载的负极须连接到 TP4 或 TP4 旁边的 J2 端子。导线必须捻在一起并尽可能短，以便尽可能减少压降、电感和 EMI 传输。TP7 和 TP8 是不同调光模式的控制信号输入端。有关调光模式配置，请参阅数据表。例如，图 4-1 展示了 TPS922152EVM 的连接图。

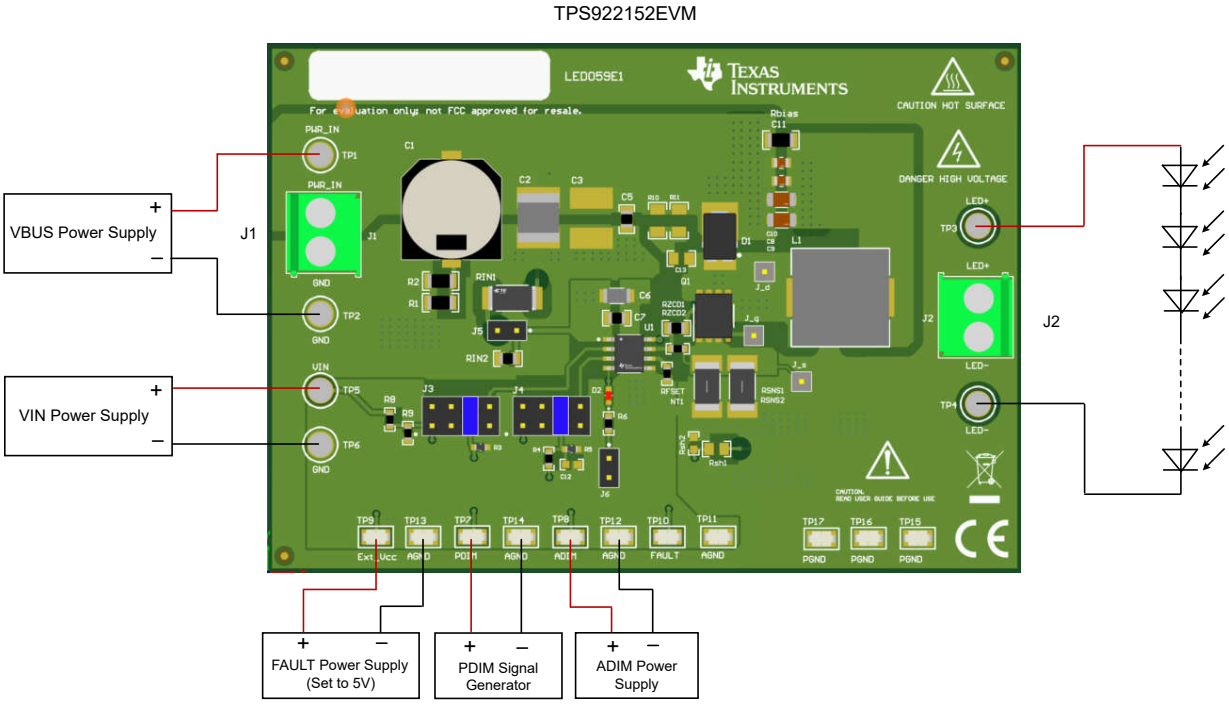


图 4-1. TPS922152EVM 的连接图

5 实现结果

5.1 测试结果

图 5-1 和图 5-2 分别展示了 PWM 从 1% 转换到 99% (20kHz) 时和从 99% 转换到 1% (20kHz) 时的 LED 电流瞬态波形。输入电压为 60V，串联 16 个白光 LED 作为负载。满标度 LED 电流设置为 5.0A。

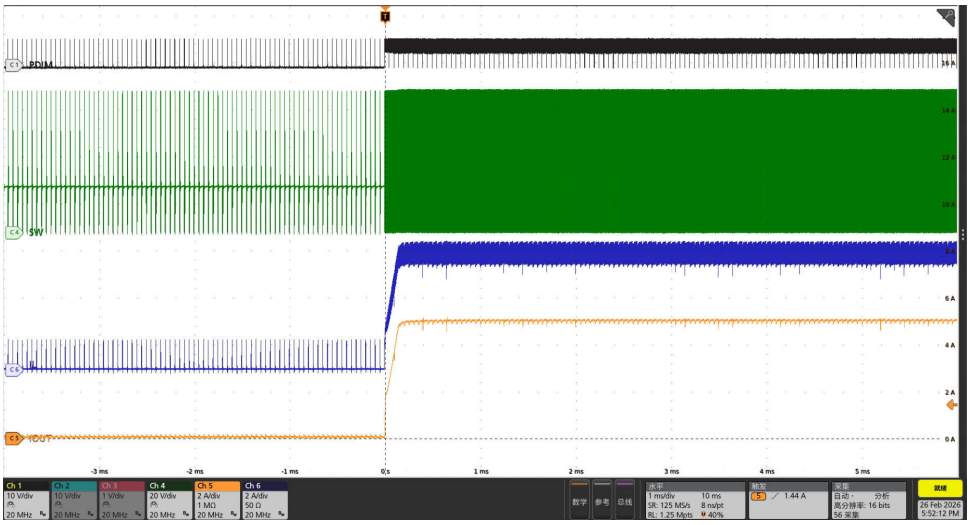


图 5-1. PWM 从 1% 转换到 99% (20kHz) 时的 LED 电流瞬态

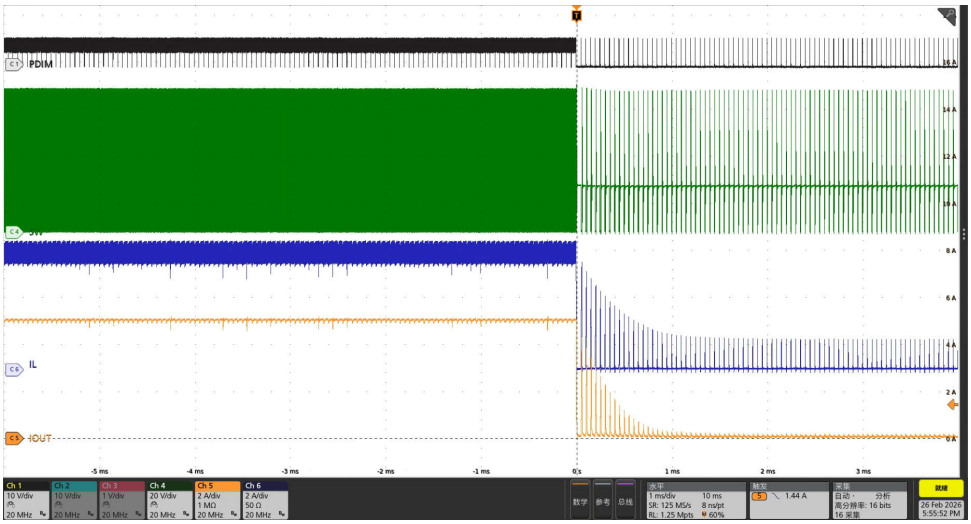


图 5-2. PWM 从 99% 转换到 1% (20kHz) 时的 LED 电流瞬态

6 原理图

图 6-1 所示为 TPS922152EVM 的原理图。

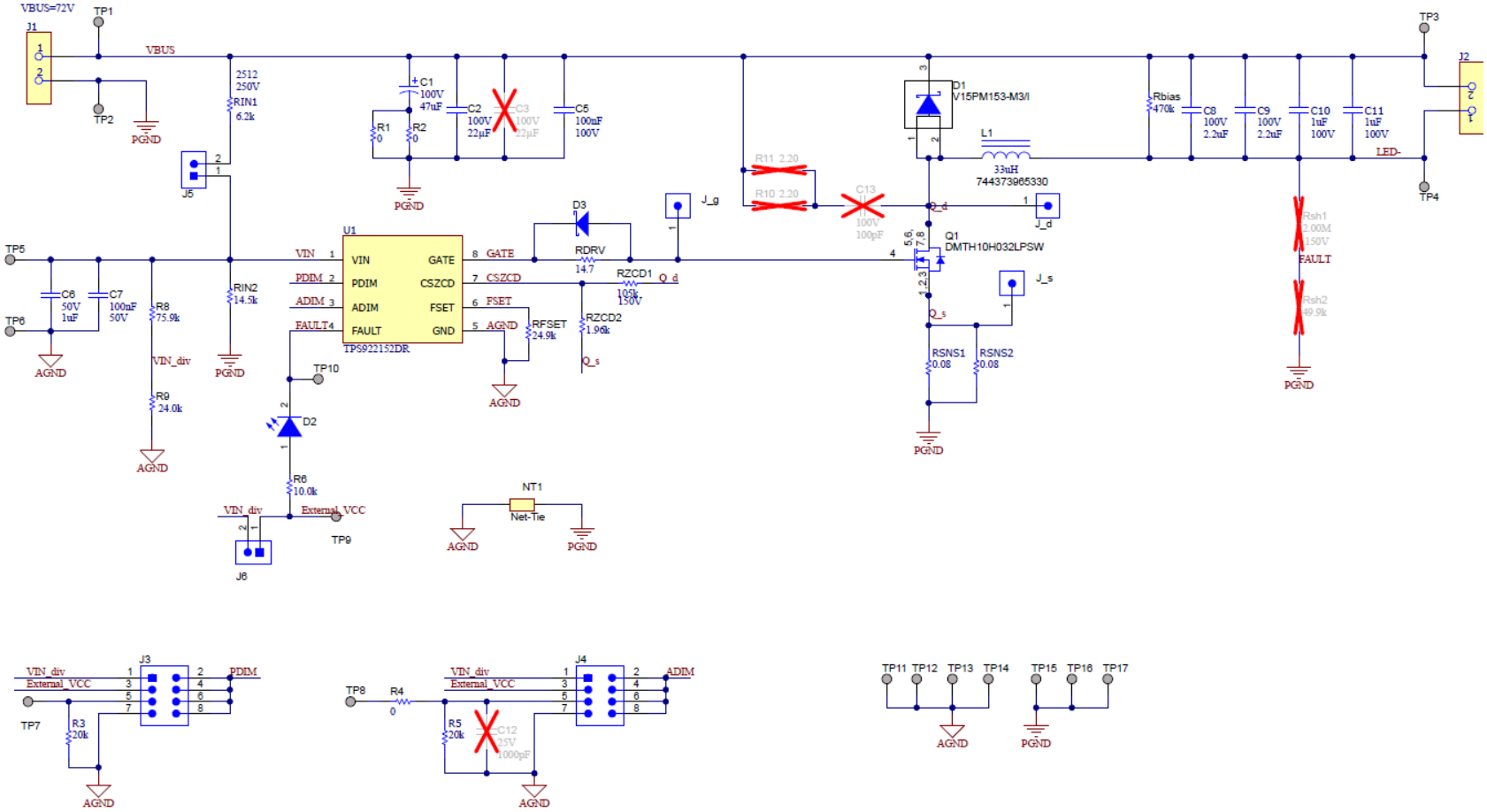


图 6-1. TPS922152EVM 原理图

7 布局

图 7-1、图 7-2、图 7-3 和图 7-4 显示了 TPS922152EVM 印刷电路板 (PCB) 的布局。

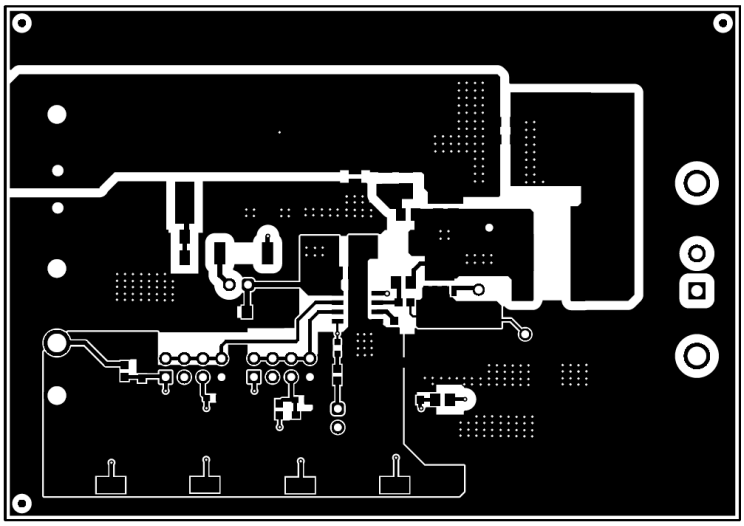


图 7-1. TPS922152EVM 顶层

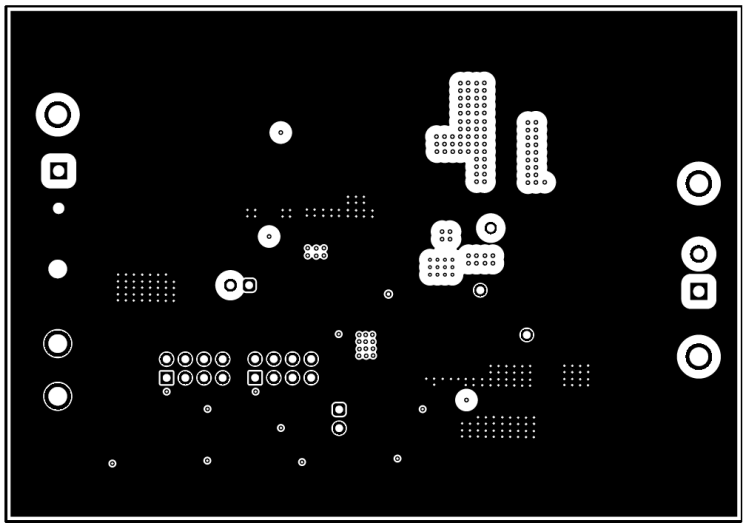


图 7-2. TPS922152EVM 内层 1

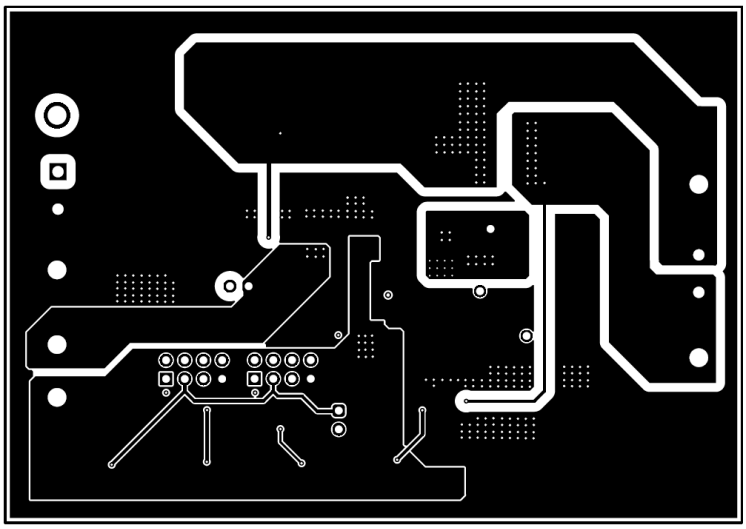


图 7-3. TPS922152EVM 内层 2

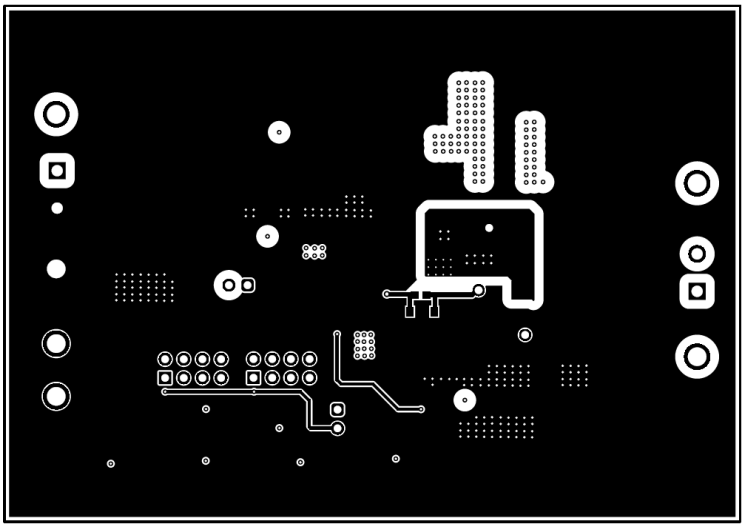


图 7-4. TPS922152EVM 底层

8 物料清单

表 8-1 显示了 TPS922152EVM 的物料清单。

表 8-1. TPS922152EVM 物料清单

位号	数量	说明	器件型号	制造商
!PCB1	1	印刷电路板	LED059	不限
C1	1	电容，铝，47uF，100V，+/-20%，0.33Ω，SMD	EMVH101ARA470MKE0S	Chemi-Con
C2	1	电容，陶瓷，22µF，VAC/100 VDC，+/-20%，X7R，6.1x6.4x5.3mm	KRM55WR72A226MH01L	MuRata
C5	1	电容，陶瓷，1µF，100V，+/-10%，X7R，AEC-Q200 0.1 级，0805	GCM21BR72A104KA37L	MuRata
C6	1	电容，陶瓷，1µF，50V，+/-10%，X7R，AEC-Q200 1 级，1206	CGA5L3X7R1H105K160AB	TDK
C7	1	电容，陶瓷，0.1µF，50V，+/-10%，X7R，0805	GRT21BR71H104KE01L	MuRata
C8、C9	2	2.2µF ±10% 100V 陶瓷电容器 X7R SMD，J 形引线	KRM31KR72A225KH01K	Murata
C10、C11	2	1µF ±10% 100V 陶瓷电容器 X7S 0805（公制 2012）	GRM21BC72A105KE01L	Murata
D1	1	二极管，肖特基，150V，15A，AEC-Q101，TO-277A	V15PM153-M3/I	Vishay-Semiconductor
D2	1	红色 625nm LED 指示 - 分立式 2V 0603（公制 1608）	150060RS75003	Wurth Electronics
D3	1	二极管，肖特基，30V，0.5A，SOD-123	MBR0530T1G	ON Semiconductor
J1、J2	2	2 位，线至板，端子块，与板齐平，0.200" (5.08mm)，穿孔	691216510002S	Wurth Elektronics
J3、J4	2	接头，100mil，4x2，金，TH	TSW-104-07-G-D	Samtec
J5、J6	2	接头，100mil，2x1，金，TH	TSW-102-07-G-S	Samtec
J_d、J_g、J_s	3	接头，2.54mm，1x1，金，TH	HTSW-101-07-G-S	Samtec
L1	1	电感器，线绕，铁粉，33uH，5.45A，48.7mΩ，SMD	7.44374E+11	Wurth Elektronik
LBL1	1	热转印打印标签，1.250"（宽）x 0.250"（高）- 10,000/卷	THT-13-457-10	Brady
Q1	1	MOSFET，N 沟道，100V，PowerPAK SO-8	DMTH10H032LPSW	二极管
R1、R2	2	电阻，0，5%，0.25W，1206	RC1206JR-070RL	Yageo America
R3、R5	2	电阻通用厚膜 0603 20KΩ 1% 1/10W ±100ppm/°C 模制 SMD Paper T/R	RC0603FR-0720KL	Yageo
R4	1	电阻，0，5%，0.1W，0603	ERJ-3GEY0R00V	Panasonic
R6	1	电阻，10.0k，1%，0.1W，AEC-Q200 0 级，0603	CRCW060310K0FKEA	Vishay-Dale
R8	1	电阻，75.9k，0.1%，0.1W，0603	RT0603BRD0775K9L	Yageo America
R9	1	电阻，24.0k，0.5%，0.1W，0603	RT0603DRE0724KL	Yageo America
Rbias	1	电阻，470k，1%，0.25W，1206	RC1206FR-07470KL	Yageo America
RDRV	1	电阻，14.7，1%，0.1W，0603	RC0603FR-0714R7L	Yageo
RFSET	1	电阻，24.9kΩ，0.5%，0.1W，0603	RT0603DRE0724K9L	Yageo America
RIN1	1	电阻通用厚膜 2512 6.2KΩ 1% 3W ±100ppm/°C 模制 SMD T/R	35216K2FT	TE Connectivity
RIN2	1	电阻，14.5k，0.1%，0.125 W，0805	RT0805BRD0714K5L	Yageo America
RSNS1	1	80 mOhm ±1% 3W 片上电阻 2512（公制 6332），汽车 AEC-Q200，电流检测，金属元件	CRA2512-FZ-R080ELF	Bourns
RSNS2	1	80 mOhm ±1% 1W 片上电阻 2512（公制 6332），汽车 AEC-Q200，电流检测，金属元件	CRA2512-FZ-R080ELF	Bourns
RZCD1	1	电阻，105k，1%，0.125W，0805	RC0805FR-07105KL	Vishay-Dale
RZCD2	1	电阻，1.96k，0.1%，0.1W，0603	RC0603FR-071K96L	Yageo America
SH-J1、SH-J2	2	分流器，2.54mm，金，黑色	60900213421	Wurth Elektronik
TP1、TP2、TP3、TP4、TP5、TP6	6	引脚，双转塔，TH	1502-2	Keystone
TP7、TP8、TP9、TP10、TP11、TP12、TP13、TP14、TP15、TP16、TP17	11	测试点，微型，SMT	5019	Keystone
U1	1	TPS922152DR	TPS922152DR	德州仪器 (TI)
C3	0	电容，陶瓷，22µF，VAC/100 VDC，+/-20%，X7R，6.1x6.4x5.3mm	KRM55WR72A226MH01L	MuRata

表 8-1. TPS922152EVM 物料清单（续）

C12	0	电容，陶瓷，1000pF，25V，+/-1%，C0G/NP0，0603	C0603C102F3GACTU	Kemet
C13	0	电容，陶瓷，100pF，100V，+/-1%，C0G，0805	C0805C101F1GACTU	Kemet
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
R10、R11	0	电阻，2.20，1%，0.25W，1206	RC1206FR-072R2L	Yageo America
Rsh1	0	电阻，2.00M，1%，0.125W，AEC-Q200 0 级，0805	CRCW08052M00FKEA	Vishay-Dale
Rsh2	0	电阻，49.9k，0.5%，0.1W，0603	RT0603DRE0749K9L	Yageo America

9 其他信息

商标

所有商标均为其各自所有者的财产。

STANDARD TERMS FOR EVALUATION MODULES

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

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

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

2 *Limited Warranty and Related Remedies/Disclaimers*:

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

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

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

WARNING

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

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

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE 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 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/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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做出任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 TI 销售条款)、TI 通用质量指南 或 ti.com 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。 除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

最后更新日期：2025 年 10 月