TEA2096T

GreenChip 双路同步整流器控制器

修订版：1——2022 年 9 月 9 日 产品数据手册

1 简介

TEA2096T 是针对开关型电源的新一代同步整流器(SR)控制器 IC。它采用自适应栅极驱动器方法，以便在任意负载下达到最高效率。

TEA2096T 是一款专门设计给谐振电源次级整流的控制 IC。它具有两个驱动器，可以同时驱动两个同步整流 MOSFET，这样可以将变压器次级绕组抽头出来的电压进行整流。这两个驱动器级有它们自己的监测控制，可以独立工作。

TEA2096T 在效率方面经过优化使其能在极低阻抗的 MOSFET 和高频下工作。

TEA2096T 采用绝缘硅片(SOI)工艺制成。

2 特性和优势

2.1 能效特性

- 在任何负载下能自适应调节门极驱动以实现最大化效率
- 节能工作模式下的供电电流为 80 μA
- 检测电压为-29 mV 用于驱动低阻抗的 MOSFET

2.2 应用特性

- 漏极检测电压高达 200 V
- 宽的供电电压范围：4.5 V 至 38 V
- 两个同步整流控制器适合 LLC 谐振变换器
- 支持 5 V 工作，所以可以选择逻辑电平的同步整流 MOSFET
- 每个同步整流 MOSFET 采用的是差分输入检测，包括漏极和源极电压
- SO8 封装

2.3 控制特性

- 同步控制没有最小导通时间
- 在导通结束时栅极能够自适应快速关断
- 欠压锁定(UVLO)保护，带有源栅极下拉关断
- 互锁功能可防止外部 MOSFET 同时导通
- 支持 1 MHz 的开关频率

3 应用

TEA2096T 适用于配合谐振变换式电源。在此类应用中，它能驱动次级的两个外置 MOSFET 管，这些 MOSFET 管用以代替传统的二极管来实现更高的效率，所以 TEA2096T 能够用于如下场合：

- 适配器
- 台式电脑和一体机电源
- 电视电源
- 服务器电源
- 工业应用电源

4 订购信息

表 **1.** 订购信息

型号	封装		
	名称	说明	版本
TEA2096T/1	SO8	塑料小型封装；8 引脚；体宽 3.9 mm	SOT96-1

5 标示

表 **2.** 标示

型号	标记代码
TEA2096T/1	TEA2096

6 功能框图

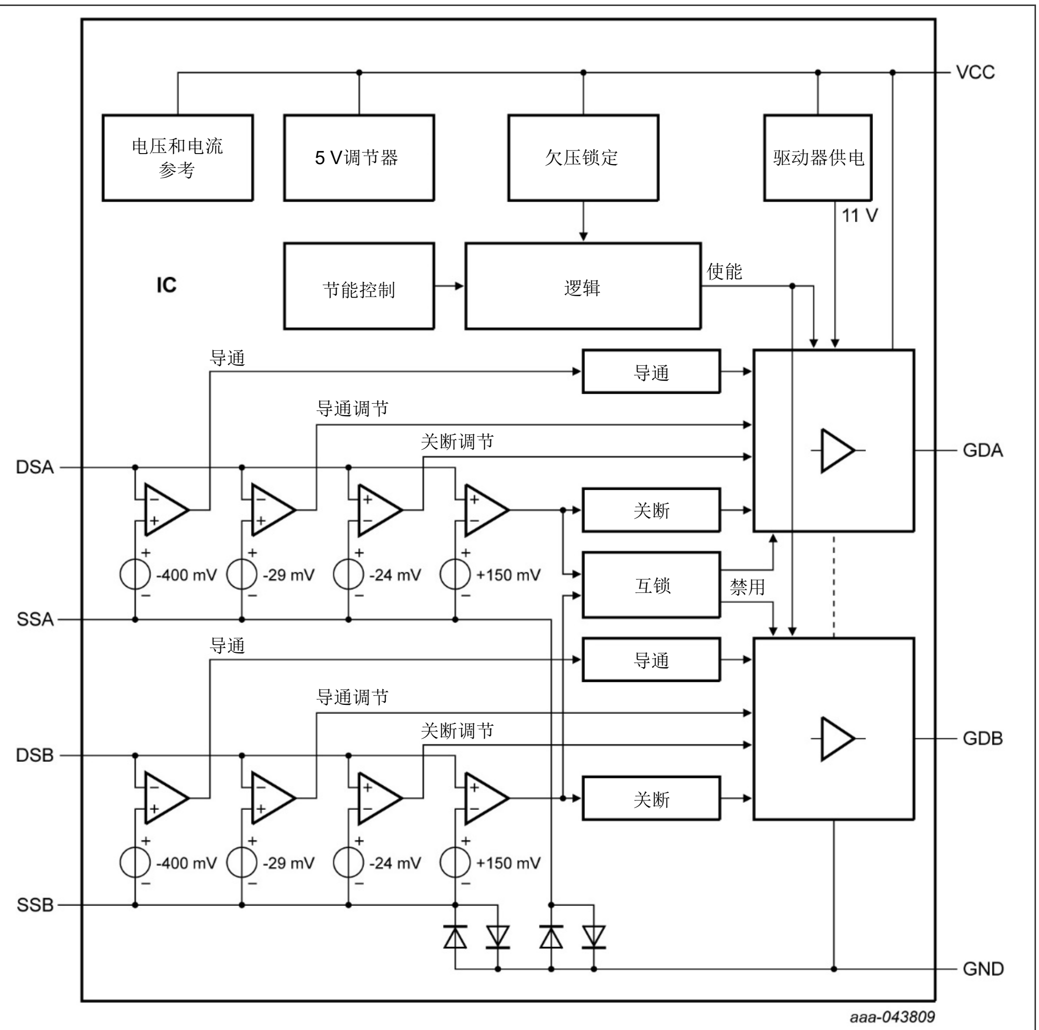


图 1. TEA2096T 功能框图

7 引脚信息

7.1 引脚分布

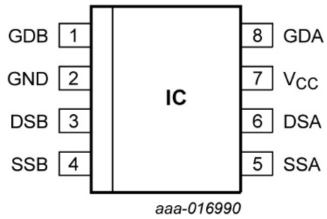


图 **2. TEA2096T** 引脚分布

7.2 引脚说明

表 **3.** 引脚说明

符号	引脚	说明
GDB	1	MOSFET B 栅极驱动
GND	2	地
DSB	3	MOSFET B 漏极检测（同步时序控制）
SSB	4	MOSFET B 源极检测
SSA	5	MOSFET A 源极检测
DSA	6	MOSFET A 漏极检测（同步时序控制）
V_{CC}	7	IC 供电
GDA	8	MOSFET A 栅极驱动

8 功能说明

8.1 简介

TEA2096T 是用于同步整流的控制器 IC，非常适合用于谐振变换器应用。它可以在变压器的次级侧绕组的中心抽头来驱动两个同步整流器 MOSFET。图 3 显示了典型配置。

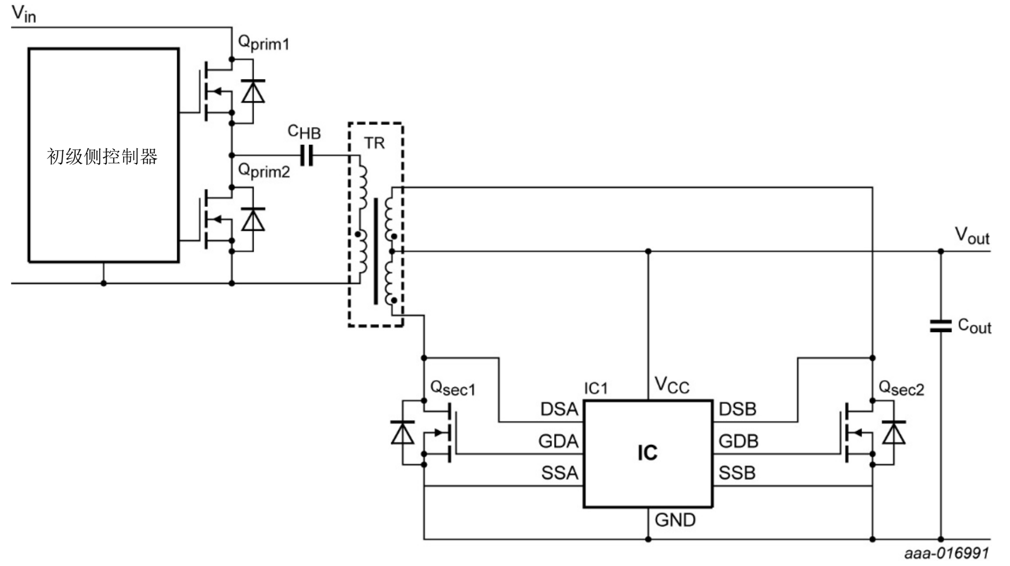


图 3. TEA2096T 典型配置

8.2 启动和欠压锁定（V_{CC} 引脚）

当 V_{CC} 引脚上的电压超过 V_{start} 时，IC 会脱离 UVLO 状态并激活 SR 电路。当电压跌到 V_{stop} 以下时，IC 重新进入 UVLO 状态。同步整流 MOSFET 驱动器输出会被有源地保持为低电平。为了有一个合适的工作状态，V_{CC} 引脚到 GND 必须用另外的电容来进行去耦（而不只是 V_{CC}）。为了减少寄生电感的影响，外加的电容必须靠近 IC。

8.3 漏极检测（DSA 和 DSB 引脚）

漏极检测引脚的电压承受能力高达 200 V。当检测到正向的漏极电压时，驱动器关闭拉低栅极驱动引脚（引脚 GDA 或 GDB）。在检测到负向漏极电压时，IC 使能 MOSFET 管开通，通过检测漏源极之间的差分电压实现同步整流。

8.4 同步整流（SR；DSA、SSA、DSB 和 SSB 引脚）

IC 检测漏极检测引脚（DSA 和 DSB 引脚）与源极检测引脚（SSA 和 SSB 引脚）之间的压差。而这个同步整流 MOSFET 漏源之间的差分电压用于驱动同步整流 MOSFET。

当此绝对电压差大于 $V_{act(drv)}$时，对应的栅极驱动输出即开通同步整流 MOSFET。当外部的同步 MOSFET 管导通时，漏源极检测引脚之间的绝对电压差会跌到 $V_{act(drv)}$以下。调节过程是紧接着导通过程。

在调节阶段，IC 会调节漏源检测之间的压差($V_{reg(drv)}$)。当绝对压差大于 $V_{reg(drv)}$时，栅极驱动器输出将增加外部同步整流 MOSFET 的栅极电压，直到达到 $V_{reg(drv)}$。同步整流 MOSFET 在低电流时不会关闭。IC 没有最小导通时间的限制，因而可以一直工作。

当绝对压差小于 $V_{deact(drv)}$时，栅极驱动器输出会降低外部同步整流 MOSFET 的栅极电压。同步整流 MOSFET 栅极驱动电压波形跟随同步整流 MOSFET 上流过的电流波形。当同步整流 MOSFET 上流过电流到零时，同步整流 MOSFET 会迅速关断。

在同步整流 MOSFET 关断后，漏极电压开始增加。当漏极电压高于 V_{swoff}时，因为栅极下拉电阻 $R_{pd(G)}$的存在，同步整流 MOSFET 会一直处于关断状态。

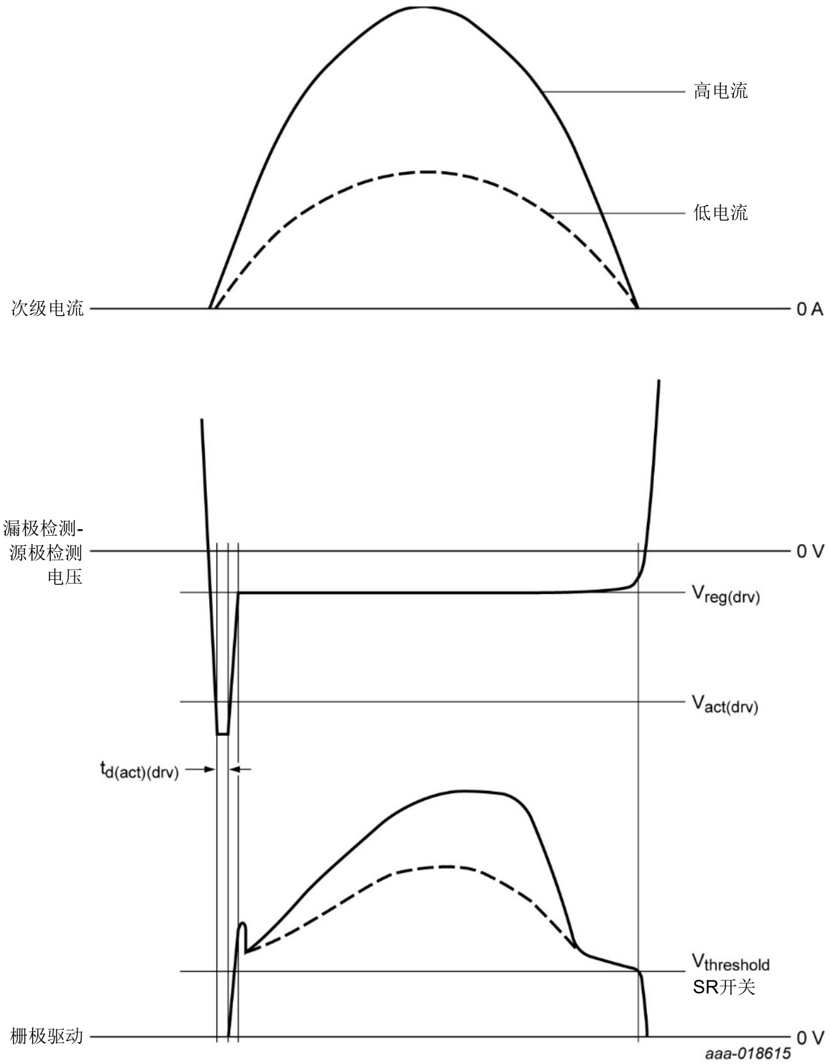


图 4. 同步整流信号

8.5 栅极驱动器（GDA 和 GDB 引脚）

栅极驱动器电路在电流的上升部分期间为外部同步整流 MOSFET 的栅极充电。在电流下降部分期间，驱动器电路将栅极放电。栅极驱动器的灌电流通常为 I_{source}，而抽电流通常为 I_{sink}。灌电流和抽电流可以实现同步整流 MOSFET 快速导通和快速关断。

最大栅极驱动被电压限制为 $V_{G(max)}$。较高的驱动电压可以用来驱动不同品牌的 MOSFET，并达到最小的导通电阻。

在为 IC 提供 5 V 电源的应用中，驱动器的最大输出电压限制为 5V。可以使用逻辑电平同步整流 MOSFET。

在启动(V_{CC} < V_{start})和欠压保护 UVLO 时，驱动器输出电压将被有源拉低。

8.6 源极检测连接（SSA 和 SSB 引脚）

IC 有额外的源极检测引脚（SSA 和 SSB）。这些引脚用于测量同步整流 MOSFET 漏源电压。源极检测引脚必须尽量靠近同步整流 MOSFET 的源极。这样可以减少由于寄生电感以及大 dI/dt 导致的电压误差。

8.7 互锁功能

TEA2096T 具有互锁功能。互锁功能可避免两个栅极驱动器同时打开。

关断一个栅极驱动后，IC 通常等待 200 ns ($t_{d(interlock)}$)，然后再打开另一个栅极驱动。

9 限值

表 4. 限值

依据绝对最大额定值系统(IEC 60134)。

符号	参数	条件		最小值	最大值	单位
电压						
V_{CC}	供电电压			-0.4	+38	V
$V_{sense(D)A}$	漏极检测电压 A	DC		-0.8	+200	V
$V_{sense(D)B}$	漏极检测电压 B	DC		-0.8	+200	V
$V_{sense(S)A}$	源极检测电压 A	DC		-0.4	+0.4	V
$V_{sense(S)B}$	源极检测电压 B	DC		-0.4	+0.4	V
V_{GDA}	GDA 引脚电压	DC	[1]	-0.4	+12.0	V
V_{GDB}	GDB 引脚电压	DC	[1]	-0.4	+12.0	V
概览						
f_{max}	最大频率	（如果不受 T_j 的限制）		-	1	MHz
T_{stg}	存储温度			-55	+150	°C
T_j	芯片结温			-40	+150	°C
静电放电(ESD)						
V_{ESD}	静电放电电压	人体模型(HBM)	[2]	-	2000	V
		充电设备模型(CDM)	[3]	-	500	V

[1] 输出引脚：不由电压驱动。
[2] 人体模型：等效于 100 pF 电容通过 1.5 kΩ 串联电阻放电。
[3] 充电设备模型：等效于通过 1 Ω 电阻为 IC 充电并使每个引脚放电。

10 建议工作条件

表 5. 建议工作条件

符号	参数	条件	最小值	最大值	单位
V_{CC}	供电电压		4.75	38	V
T_j	芯片结温		-40	+125	°C

11 热特性

表 6. 热特性

符号	参数	条件	典型值	单位
$R_{th(j-a)}$	从结点到环境的热阻值	SO8 封装；PCB 1 层；35 µm Cu；60 mm x 125 mm	135	K/W
$R_{th(j-c)}$	从结点到机壳的热阻值	SO8 封装	50	K/W

12 特性

表 7. 特性

T_{amb} = 25 °C；V_{CC} = 12 V；C_{GDA}/C_{GDB} = 10 nF（GDA 与 GND 之间以及 GDB 与 GND 之间的电容）。所有电压测试参考点均是 IC 的地（引脚 2）。除非另有说明，流入 IC 的电流为正电流。

符号	参数	条件	最小值	典型值	最大值	单位
供电电压管理（V_{CC} 引脚）						
V_{start}	启动电压		4.3	4.5	4.7	V
V_{stop}	关断电压		4.0	4.2	4.4	V
$I_{CC(oper)}$	工作电流	节能	60	80	100	μA
		正常工作（无栅极充电）	0.6	0.8	1.1	mA
$t_{act(es)}$	节能模式激活时间		85	110	135	μs
同步整流检测（DSA、SSA、DSB 和 SSB 引脚）						
$V_{act(drv)}$	栅极驱动启动电压	$V_{sense(S)A}/V_{sense(S)B}$ = 0 V	-450	-400	-350	mV
$V_{reg(drv)}$	栅极驱动调节电压	$V_{sense(S)A}/V_{sense(S)B}$ = 0 V	-36	-29	-23	mV
V_{swoff}	关断电压	$V_{sense(S)A}/V_{sense(S)B}$ = 0 V	60	150	200	mV
$t_{d(act)(drv)}$	驱动激活延迟时间	$V_{sense(S)A}/V_{sense(S)B}$ = 0 V； 正常工作； 从达到 V_{DSA}/V_{DSB}（2 V 至-0.5 V）上升到 V_{GDA}/V_{GDB}（10%最终值时）的时间	-	80	-	ns
$t_{d(deact)(drv)}$	驱动关闭延迟时间	$V_{sense(S)A}/V_{sense(S)B}$ = 0 V； 正常工作； 从达到 V_{DSA}/V_{DSB}（-0.5 V 至 2 V）降低到 V_{GDA}/V_{GDB}（90%开始值时）的时间	-	40	-	ns
t_d	延迟时间	互锁延迟时间	-	200	-	ns
栅极驱动器（GDA 和 GDB 引脚）						
I_{source}	灌电流	峰值电流位于 V_{DS} = −0.5 V 时； V_G = 0 V	-	-0.3	-	A
I_{sink}	抽电流	调节电流位于 V_{DS} = 0 V 时； V_G = 5 V	-	1	-	A
		峰值电流位于 V_{DS} = 0.25 V 时； V_G = 5 V	-	2	-	A
$R_{pd(G)}$	栅极下拉阻抗	V_{DS} = 12 V；I_G = 100 mA	2	2.5	3	Ω
$V_{G(max)}$	最大栅极电压	V_{GDA}/V_{GDB}（V_{CC} 时）= 5 V	4.98	4.99	5	V
		V_{GDA}/V_{GDB}（V_{CC} 时）= 12 V	10.4	10.7	11.0	V
		V_{GDA}/V_{GDB}（V_{CC} 时）= 38 V	10.6	10.9	11.2	V

13 应用信息

谐振转换模式电源结构包含了一个初级侧半桥、一个变压器、一个谐振电容和一个输出级。为了实现低的导通损耗，在输出端采用同步整流 MOSFET。TEA2096T 可以用来控制同步整流 MOSFET 管。

用于驱动同步 MOSFET 的驱动电压是来自于其对应的漏极和源极之间的差分电压。

需要特别注意漏极检测和源极检测的连接方式，因为这些电压是用来驱动MOSFET管的。测量、检测错误的话，栅极驱动过高或过低，会导致驱动效率低下。连接点不应该在功率回路走线相互干扰。功率走线回路存在较高 dI/dt，由于寄生电感的存在，感应电压很容易导致检测错误。独立的源极检测引脚可以用来直接检测外部同步 MOSFET 的源极电压。不能也不要利用现成的功率回路的地来进行测量。

如果输出电压低于 38 V，V_{CC} 引脚可以直接连接到 V_{out}。

如果输出电压超过 38 V，可以通过线性或分立式稳压器来生成 V_{CC} 电压（参见图 6）。或者，也可以通过专用电源生成（参见图 7）。

13.1 谐振应用

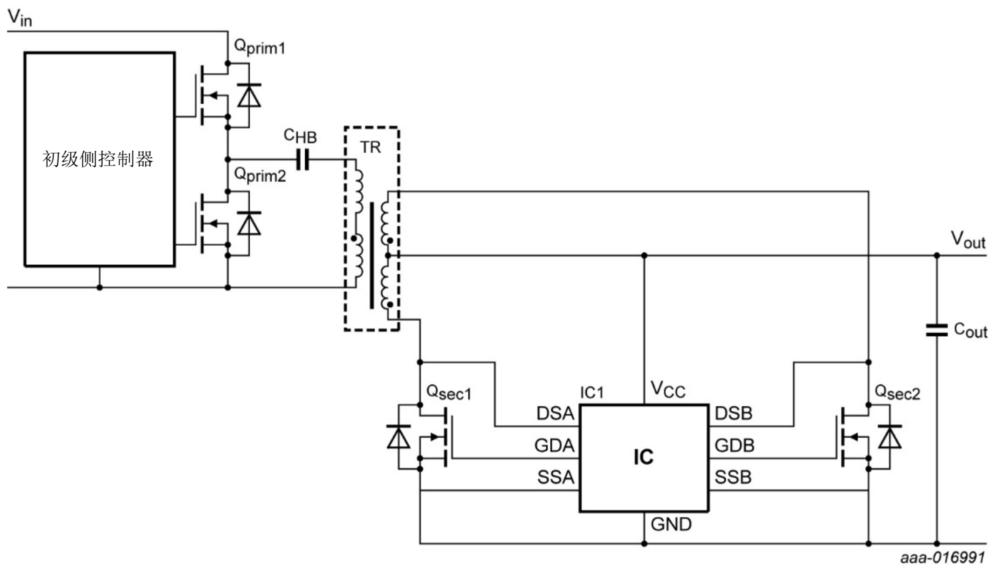


图 5. 采用 TEA2096T 的典型谐振应用

13.2 采用分立式 Vcc 电源的应用

通过增加小信号 MOS 晶体管，可以向采用分立式 Vcc 电源的应用添加一个禁用/使能输入。在无需同步整流的情况下，该晶体管会拉低 Vcc 电源并禁用 SR 操作。

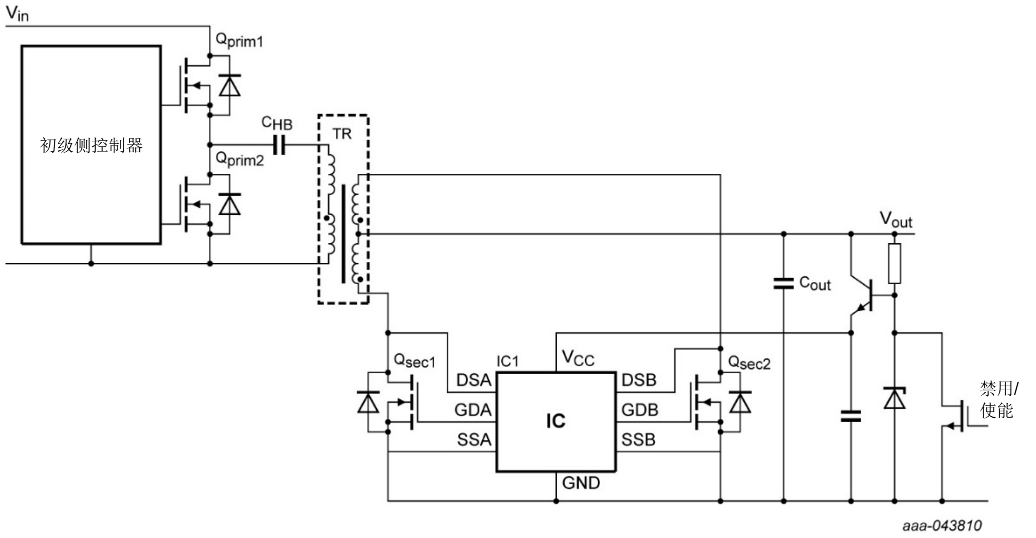


图 6. 采用分立式 Vcc 电源并集成禁用/使能输入的 **TEA2096T** 应用

13.3 采用专用 Vcc 电源的应用

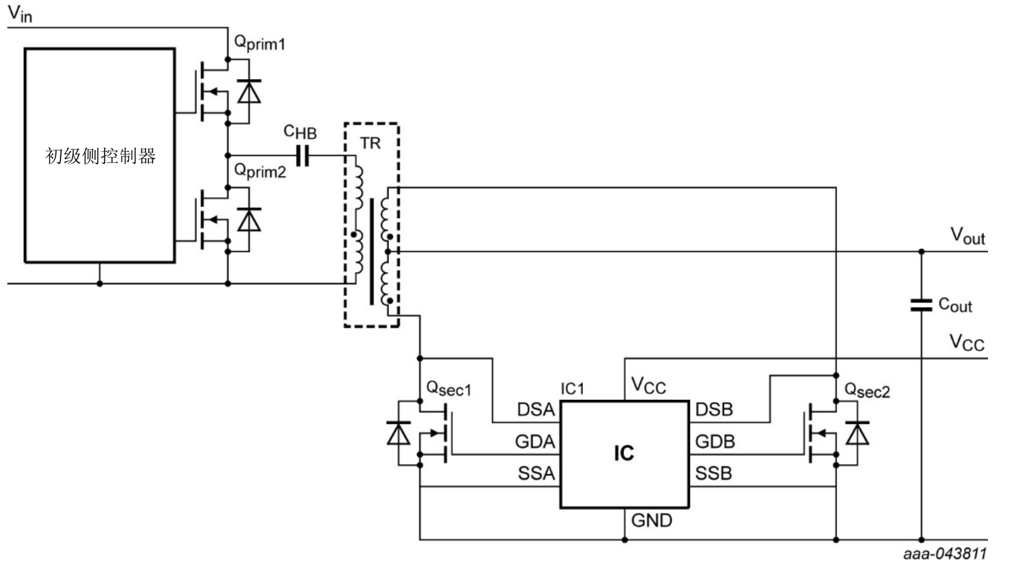
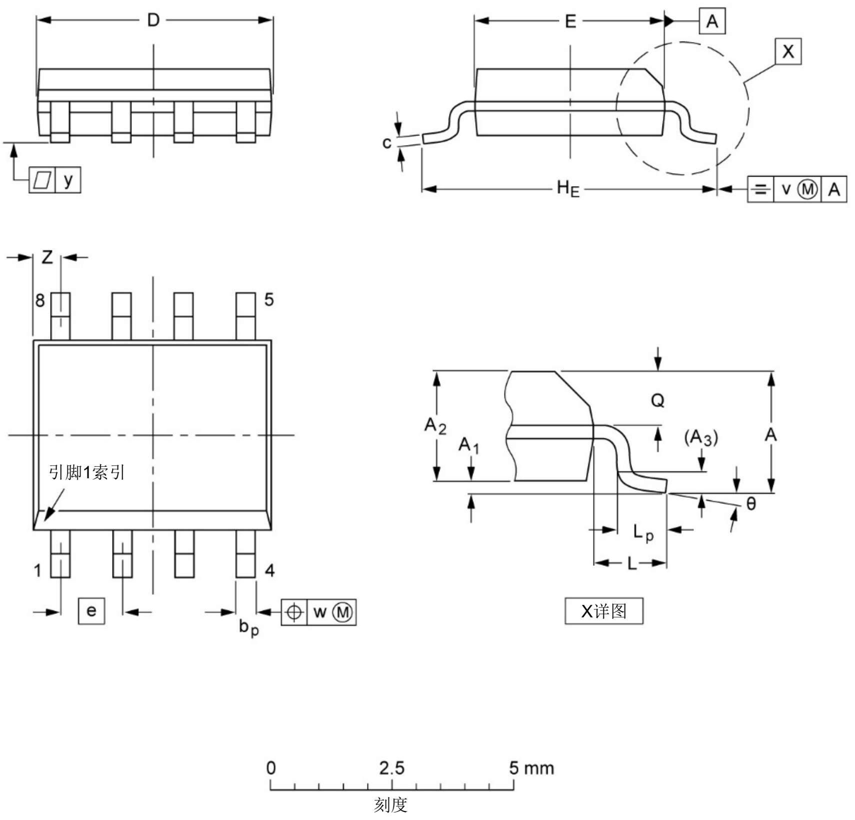


图 7. 采用专用 Vcc 电源的 **TEA2096T** 应用

14 封装尺寸

SO8：塑料小型封装；8 引脚；体宽 3.9 mm **SOT96-1**



尺寸（以英寸为单位的尺寸从原始mm尺寸转换而来）

单位	A的最大值	A_1	A_2	A_3	b_p	c	D(1)	E(2)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
英寸	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

备注

1. 不包括每边最大为0.15 mm（0.006英寸）的塑料或金属突起部分。
2. 不包括每边最大为0.25 mm（0.01英寸）的塑料或金属突起部分。

尺寸版本	参考文献				第一角投影	发行日期
	IEC	JEDEC	JEITA			
SOT96-1	076E03	MS-012				~~99-12-27~~ 03-02-18

图 8. 封装尺寸：**SOT96-1(SO8)**

15 缩略词

表 8. 缩略词

首字母缩略词	说明
CDM	充电设备模型
ESD	静电放电
HBM	人体模型
MM	机器模型
MOSFET	金属氧化物半导体场效应晶体管
SOI	绝缘硅片
SR	同步整流
UVLO	欠压锁定

16 修订记录

表 **9.** 修订记录

文档 **ID**	发布日期	数据手册状态	更改说明	取代版本
TEA2096T v.1	20220909	产品数据手册	-	-

17 Legal information

17.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

17.2 Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Short data sheet — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

Product specification — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

17.3 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at http://www.nxp.com/profile/terms, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

17.4 Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

GreenChip — is a trademark of NXP B.V.

目录

发布日期：2022 年 9 月 9 日
文档编号：TEA2096T