

# ULQ200xA-Q1 高电压大电流达林顿晶体管阵列

## 1 特性

- 符合汽车应用要求
- ESD 保护超过 200V (使用机器放电模型, C = 200pF, R = 0)
- 500mA 额定集电极电流 (单路输出)
- 高电压输出: 50V
- 输出钳位二极管
- 可兼容各类逻辑的输入
- 继电器驱动器应用

## 2 应用

- 继电器驱动器
- 步进电机驱动器和有刷直流电机驱动器
- 灯驱动器
- 显示屏驱动器 (LED 和气体放电元件)
- 线路驱动器
- 逻辑缓冲器

## 3 说明

ULQ200xA-Q1 器件为高电压大电流达林顿晶体管阵列, 均由 7 个 NPN 达林顿对组成, 这些达林顿对具有高压输出, 带有用于开关感性负载的共阴极钳位二极管。单个达林顿对的集电极电流额定值为 500mA。将达林顿对并联可以实现更大的电流。

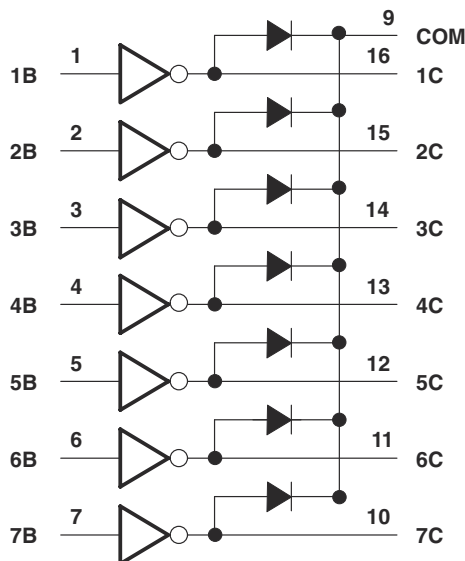
ULQ2003A-Q1 的每个达林顿对都具有一个 2.7kΩ 的串联基极电阻, 可直接与 TTL 或 5V CMOS 器件一起运行。ULQ2004A-Q1 具有一个 10.5kΩ 串联基极电阻, 可直接从使用 6V 至 15V 电源电压的 CMOS 器件上运行。ULQ2004A-Q1 所需的输入电流低于 ULQ2003A-Q1 的输入电流。

### 封装信息

器件型号	封装 <sup>(1)</sup>	封装尺寸 <sup>(2)</sup>
ULQ2003A-Q1	SOIC (16)	9.90mm × 3.90mm
	TSSOP (16)	5.00mm × 4.40mm
	SOT (16)	4.20mm × 2.00mm
ULQ2004A-Q1	SOIC (16)	9.90mm × 3.90mm

(1) 如需了解所有可用封装, 请参阅数据表末尾的可订购产品附录。

(2) 封装尺寸 (长 × 宽) 为标称值, 并包括引脚 (如适用)。



简化版方框图



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## 4 Pin Configuration and Functions

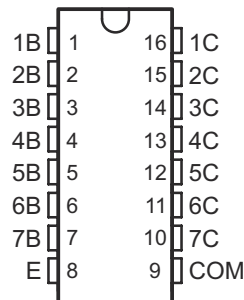


图 4-1. D or PW Package, 16-Pin SOIC or TSSOP (Top View)

表 4-1. Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	1B	I	Channel 1 through 7 Darlington base input.
2	2B		
3	3B		
4	4B		
5	5B		
6	6B		
7	7B		
8	E	—	Common emitter shared by all channels (typically tied to ground).
9	COM	—	Common cathode node for flyback diodes (required for inductive loads).

**表 4-1. Pin Functions (续)**

PIN		I/O	DESCRIPTION
NO.	NAME		
10	7C	O	Channel 1 through 7 Darlington collector output.
11	6C		
12	5C		
13	4C		
14	3C		
15	2C		
16	1C		

## 5 Specifications

### 5.1 Absolute Maximum Ratings

at 25°C free-air temperature (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT	
V <sub>CE</sub>	Collector-emitter voltage		50	V	
	Clamp diode reverse voltage <sup>(2)</sup>		50	V	
V <sub>I</sub>	Input voltage <sup>(2)</sup>		30	V	
	Peak collector current	See 图 8-2	500	mA	
I <sub>OK</sub>	Output clamp current		500	mA	
	Total emitter-terminal current		- 2.5	A	
P <sub>D</sub>	Continuous total power dissipation		See 节 5.8		
T <sub>A</sub>	Operating free-air temperature	ULQ200xAT	- 40	105	°C
		ULQ200xAQ	- 40	125	
T <sub>J</sub>	Junction temperature		150	°C	
T <sub>stg</sub>	Storage temperature	- 65	150	°C	

- (1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under 节 5.3 is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.

### 5.2 ESD Ratings

		VALUE	UNIT	
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup>	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±500	

- (1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V <sub>CE</sub>	Collector-emitter voltage	0	50	V
T <sub>J</sub>	Junction temperature	- 40	125	°C

### 5.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		ULQ2003A-Q1, ULQ2004A-Q1			UNIT
		D (SOIC)	PW (TSSOP)	DYY (SOT)	
		16 PINS	16 PINS	16 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	87.9	112.9	119.4	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	49.4	49.2	56.9	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	49.1	58.1	52.3	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	11.9	9.1	2.8	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	48.6	57.6	51.9	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 5.5 Electrical Characteristics, ULQ2003AT and ULQ2003AQ

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{I(on)}$	On-state input voltage	$V_{CE} = 2\text{ V}$ , see 图 6-8	$I_C = 200\text{ mA}$			2.7	V
			$I_C = 250\text{ mA}$			2.9	
			$I_C = 300\text{ mA}$			3	
$V_{CE(sat)}$	Collector-emitter saturation voltage	$I_I = 250\text{ }\mu\text{A}, I_C = 100\text{ mA}$ , see 图 6-7	ULQ2003AT		0.9	1.2	V
			ULQ2003AQ		1	1.3	
		$I_I = 350\text{ }\mu\text{A}, I_C = 200\text{ mA}$ , see 图 6-7	ULQ2003AT		1	1.4	
			ULQ2003AQ		1	1.5	
		$I_I = 500\text{ }\mu\text{A}, I_C = 350\text{ mA}$ , see 图 6-7	ULQ2003AT		1.2	1.7	
			ULQ2003AQ		1.2	1.8	
$I_{CEX}$	Collector cutoff current	$V_{CE} = 50\text{ V}$ , $I_I = 0$ , see 图 6-1	$T_A = 25^\circ\text{C}$			100	$\mu\text{A}$
			$T_A = 105^\circ\text{C}$ , ULQ2003AT			165	
$V_F$	Clamp forward voltage	$I_F = 350\text{ mA}$ , see 图 6-6			1.7	2.2	V
$I_{I(off)}$	Off-state input current	$V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$ , see 图 6-3		30	65		$\mu\text{A}$
$I_I$	Input current	$V_I = 3.85\text{ V}$ , see 图 6-4			0.93	1.35	mA
$I_R$	Clamp reverse current	$V_R = 50\text{ V}$ , $T_A = 25^\circ\text{C}$ , see 图 6-5				100	$\mu\text{A}$
$C_i$	Input capacitance	$V_I = 0$ , $f = 1\text{ MHz}$			15	25	pF

## 5.6 Electrical Characteristics, ULQ2004AT

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{I(on)}$	On-state input voltage	$V_{CE} = 2\text{ V}$ , see 图 6-8	$I_C = 125\text{ mA}$			5	V
			$I_C = 200\text{ mA}$			6	
			$I_C = 275\text{ mA}$			7	
			$I_C = 350\text{ mA}$			8	
$V_{CE(sat)}$	Collector-emitter saturation voltage		$I_I = 250\text{ }\mu\text{A}, I_C = 100\text{ mA}$ , see 图 6-7		0.9	1.1	V
			$I_I = 350\text{ }\mu\text{A}, I_C = 200\text{ mA}$ , see 图 6-7		1	1.3	
			$I_I = 500\text{ }\mu\text{A}, I_C = 350\text{ mA}$ , see 图 6-7		1.2	1.6	
$I_{CEX}$	Collector cutoff current	$V_{CE} = 50\text{ V}$ , $I_I = 0$ , see 图 6-1	$T_A = 25^\circ\text{C}$			50	$\mu\text{A}$
			$T_A = 105^\circ\text{C}$				
		$V_{CE} = 50\text{ V}$ , see 图 6-2	$I_I = 0$			100	
			$V_I = 1\text{ V}$			500	
$V_F$	Clamp forward voltage	$I_F = 350\text{ mA}$ , see 图 6-6			1.7	2.1	V
$I_{I(off)}$	Off-state input current	$V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$ , see 图 6-3		50	65		$\mu\text{A}$
$I_I$	Input current	$V_I = 5\text{ V}$ , see 图 6-4			0.35	0.5	mA
		$V_I = 12\text{ V}$ , see 图 6-4			1	1.45	
$I_R$	Clamp reverse current	$V_R = 50\text{ V}$ , see 图 6-5	$T_A = 25^\circ\text{C}$			50	$\mu\text{A}$
			$T_A = 105^\circ\text{C}$			100	
$C_i$	Input capacitance	$V_I = 0$ , $f = 1\text{ MHz}$			15	25	pF

### 5.7 Switching Characteristics, ULQ2003A and ULQ2004A

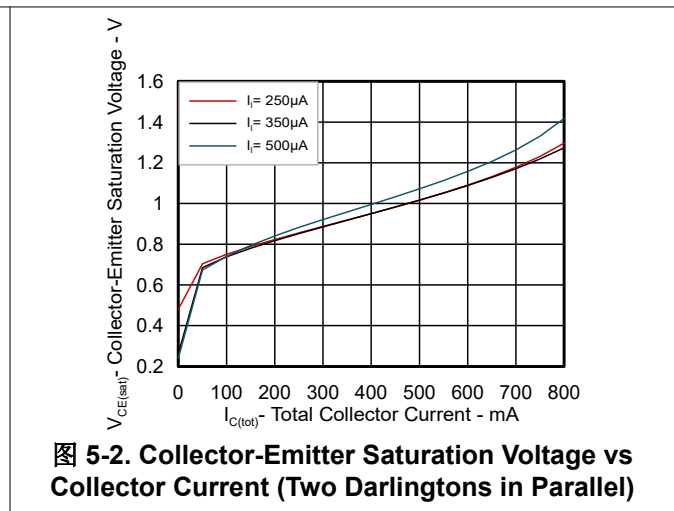
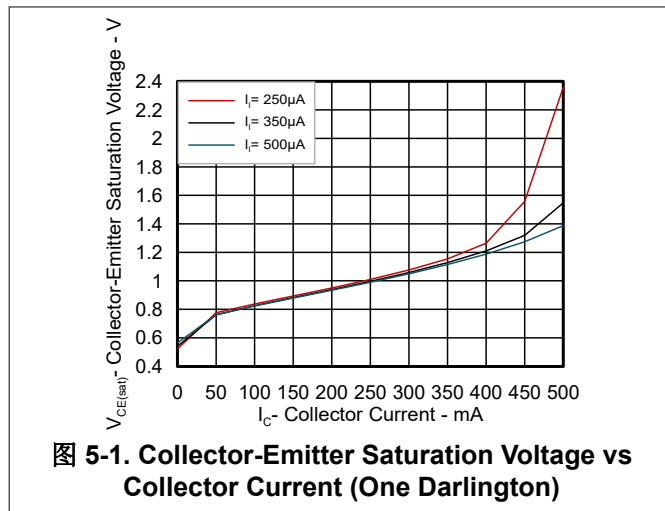
over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{PLH}$	Propagation delay time, low- to high-level output	See 图 6-9		1	10	$\mu s$
$t_{PHL}$	Propagation delay time, high- to low-level output	See 图 6-9		1	10	$\mu s$
$V_{OH}$	High-level output voltage after switching	$V_S = 50 V, I_O = 300 mA$ , see 图 6-10	$V_S - 500$			mV

### 5.8 Dissipation Ratings

PACKAGE	$T_A = 25^\circ C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ C$	$T_A = 85^\circ C$ POWER RATING	$T_A = 105^\circ C$ POWER RATING	$T_A = 125^\circ C$ POWER RATING
D	950 mW	7.6 mW/ $^\circ C$	494 mW	342 mW	190 mW

### 5.9 Typical Characteristics



## 6 Parameter Measurement Information

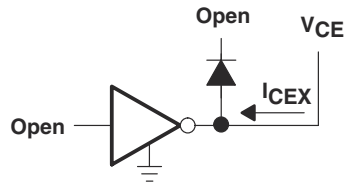


图 6-1.  $I_{CEX}$  Test Circuit

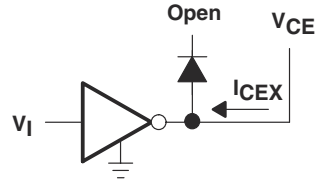


图 6-2.  $I_{CEX}$  Test Circuit

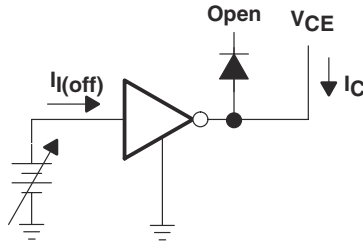


图 6-3.  $I_{I(off)}$  Test Circuit

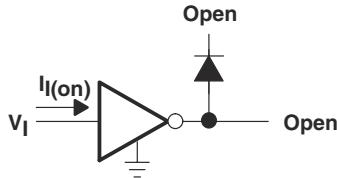


图 6-4.  $I_I$  Test Circuit

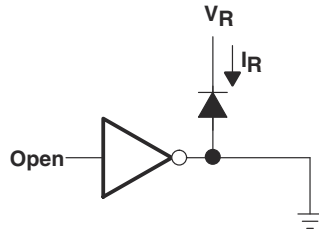


图 6-5.  $I_R$  Test Circuit

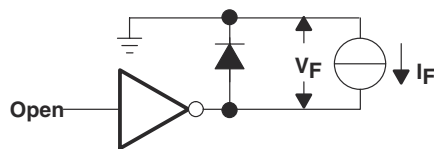
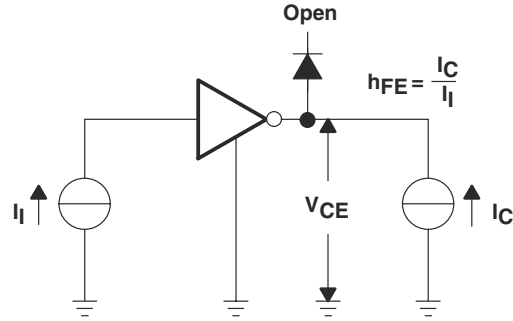


图 6-6.  $V_F$  Test Circuit





A.  $I_i$  is fixed for measuring  $V_{CE(sat)}$ , variable for measuring  $h_{FE}$ .

图 6-7.  $h_{FE}$ ,  $V_{CE(sat)}$  Test Circuit

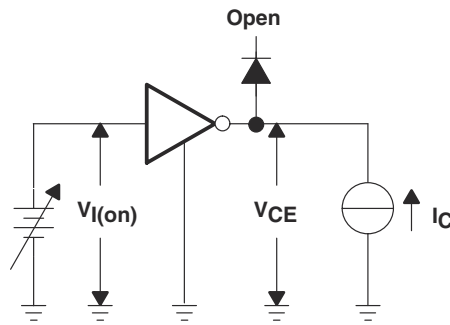


图 6-8.  $V_{I(on)}$  Test Circuit

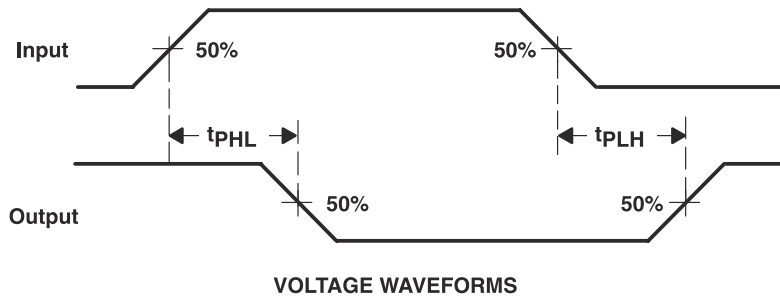
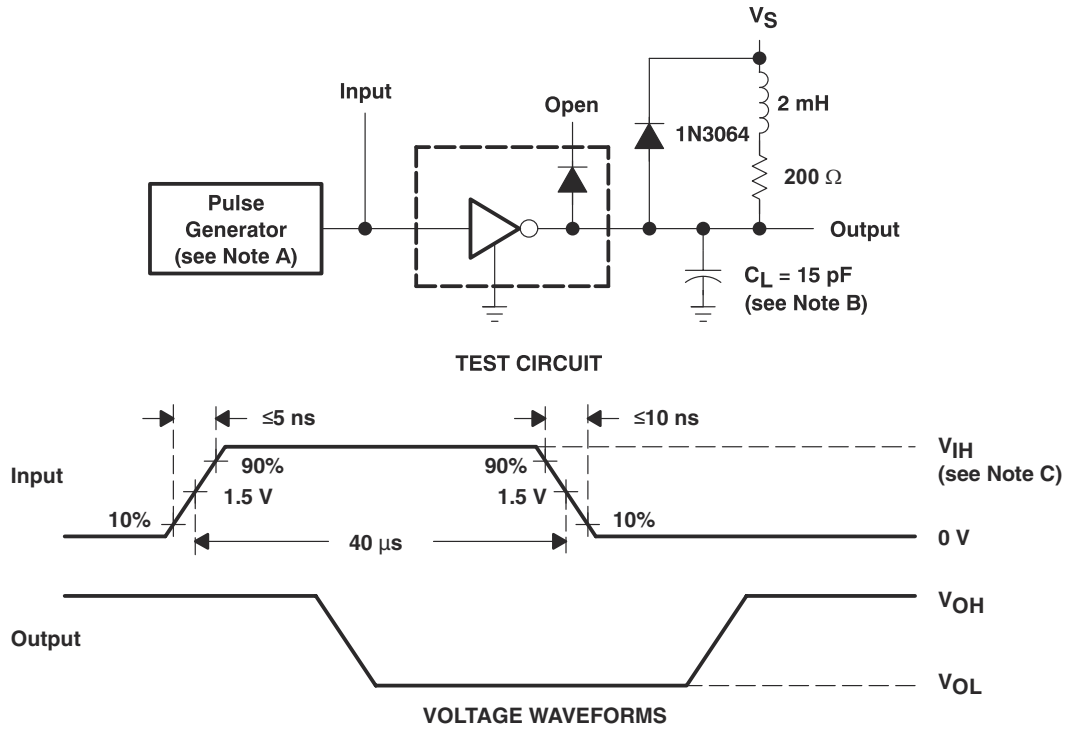


图 6-9. Propagation Delay-Time Waveforms



- A. The pulse generator has the following characteristics: PRR = 12.5 kHz,  $Z_O = 50 \Omega$ .
- B.  $C_L$  includes probe and jig capacitance.
- C. For testing the ULQ2003A,  $V_{IH} = 3 \text{ V}$ ; for the ULQ2004A,  $V_{IH} = 8 \text{ V}$ .

图 6-10. Latch-Up Test Circuit and Voltage Waveforms

## 7 Detailed Description

### 7.1 Overview

This standard device has proven ubiquity and versatility across a wide range of applications. This is due to integration of 7 Darlington transistors of the device that are capable of sinking up to 500 mA and wide GPIO range capability.

The ULQ200xA-Q1 devices comprise seven high-voltage, high-current NPN Darlington transistor pairs. All units feature a common emitter and open collector outputs. To maximize their effectiveness, these units contain suppression diodes for inductive loads. The ULNQ200xA-Q1 devices have a series base resistor to each Darlington pair, thus allowing operation directly with TTL or CMOS operating at supply voltages of 5 V or 3.3 V. The ULQ2003xA-Q1 device offers solutions to a great many interface needs, including solenoids, relays, lamps, small motors, and LEDs. Applications requiring sink currents beyond the capability of a single output may be accommodated by paralleling the outputs.

This device can operate over a wide temperature range ( - 40°C to 105°C for ULQ200xAT or - 40°C to 125°C for ULQ2003AQ).

### 7.2 Functional Block Diagram

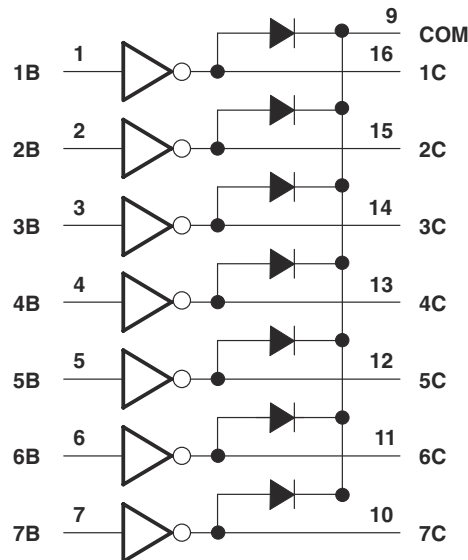
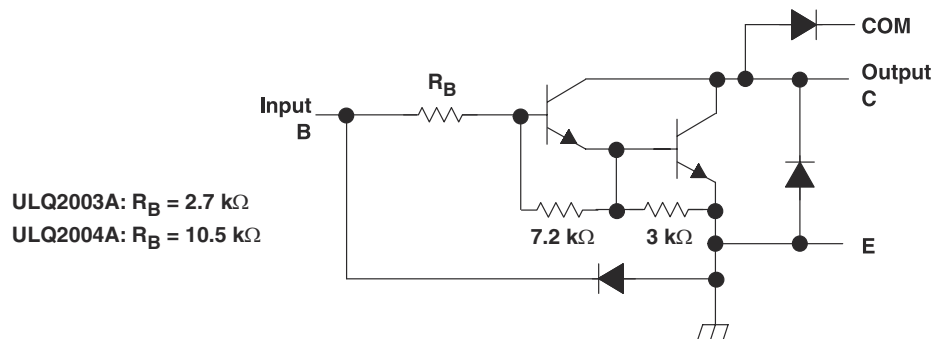


图 7-1. Logic Diagram



- A. All resistor values shown are nominal.
- B. The collector-emitter diode is a parasitic structure and should not be used to conduct current. If the collector(s) go below ground an external Schottky diode should be added to clamp negative undershoots.

图 7-2. Schematics (Each Darlington Pair)

## 7.3 Feature Description

Each channel of the ULQ200xA-Q1 devices consist of Darlington connected NPN transistors. This connection creates the effect of a single transistor with a very high-current gain ( $\beta^2$ ). This can be as high as 10,000 A/A at certain currents. The very high  $\beta$  allows for high-output current drive with a very low input current, essentially equating to operation with low GPIO voltages.

The GPIO voltage is converted to base current through the 2.7-k $\Omega$  or 10.5-k $\Omega$  resistor connected between the input and base of the predriver Darlington NPN. The 7.2-k $\Omega$  and 3-k $\Omega$  resistors connected between the base and emitter of each respective NPN act as pulldowns and suppress the amount of leakage that may occur from the input.

The diodes connected between the output and COM pin is used to suppress the kick-back voltage from an inductive load that is excited when the NPN drivers are turned off (stop sinking) and the stored energy in the coils causes a reverse current to flow into the coil supply through the kick-back diode.

In normal operation the diodes on base and collector pins to emitter will be reversed biased. If these diodes are forward biased, internal parasitic NPN transistors will draw (a nearly equal) current from other (nearby) device pins.

## 7.4 Device Functional Modes

### 7.4.1 Inductive Load Drive

When the COM pin is tied to the coil supply voltage, ULQ200xA-Q1 devices are able to drive inductive loads and suppress the kick-back voltage through the internal free-wheeling diodes.

### 7.4.2 Resistive Load Drive

When driving a resistive load, a pullup resistor is needed in order for the ULQ200xA-Q1 devices to sink current and for there to be a logic high level. The COM pin can be left floating for these applications.

## 8 Application and Implementation

### 备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

### 8.1 Application Information

Typically, the ULQ200xA-Q1 device drives a high-voltage or high-current (or both) peripheral from an MCU or logic device that cannot tolerate these conditions. This design is a common application of ULQ200xA-Q1 device, driving inductive loads. This includes motors, solenoids and relays. 图 8-1 shows an example of driving multiple inductive loads.

### 8.2 Typical Application

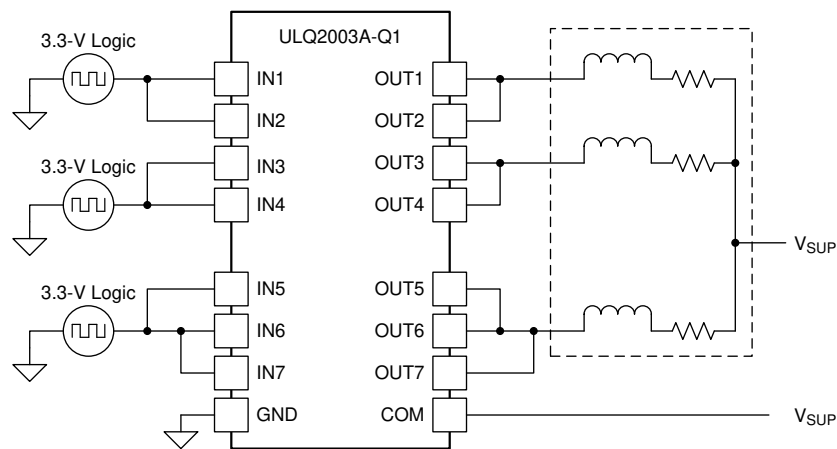


图 8-1. ULQ2003A-Q1 Device as Inductive Load Driver

#### 8.2.1 Design Requirements

For this design example, use the parameters listed in 表 8-1 as the input parameters.

表 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
GPIO voltage	3.3 V or 5 V
Coil supply voltage	12 V to 48 V
Number of channels	7
Output current ( $R_{COIL}$ )	20 mA to 300 mA per channel
Duty cycle	100%

## 8.2.2 Detailed Design Procedure

When using ULQ2003A-Q1 device in a coil driving application, determine the following:

- Input voltage range
- Temperature range
- Output and drive current
- Power dissipation

### 8.2.2.1 Drive Current

The coil voltage ( $V_{SUP}$ ), coil resistance ( $R_{COIL}$ ), and low-level output voltage ( $V_{CE(SAT)}$  or  $V_{OL}$ ) determine the coil current.

$$I_{COIL} = (V_{SUP} - V_{CE(SAT)}) / R_{COIL} \quad (1)$$

### 8.2.2.2 Low-Level Output Voltage

The low-level output voltage ( $V_{OL}$ ) is the same as  $V_{CE(SAT)}$  and can be determined by, [图 5-1](#) or [图 5-2](#).

### 8.2.2.3 Power Dissipation and Temperature

The number of coils driven is dependent on the coil current and on-chip power dissipation. The number of coils driven can be determined by [图 8-2](#).

For a more accurate determination of number of coils possible, use [方程式 2](#) to calculate ULQ200xA-Q1 device on-chip power dissipation  $P_D$ :

$$P_D = \sum_{i=1}^N V_{OLi} \times I_{Li} \quad (2)$$

where

- $N$  is the number of channels active together
- $V_{OLi}$  is the  $OUT_i$  pin voltage for the load current  $I_{Li}$ . This is the same as  $V_{CE(SAT)}$

To ensure reliability of ULQ200xA-Q1 device and the system, the on-chip power dissipation must be lower than or equal to the maximum allowable power dissipation ( $PD_{(MAX)}$ ) dictated by [方程式 3](#).

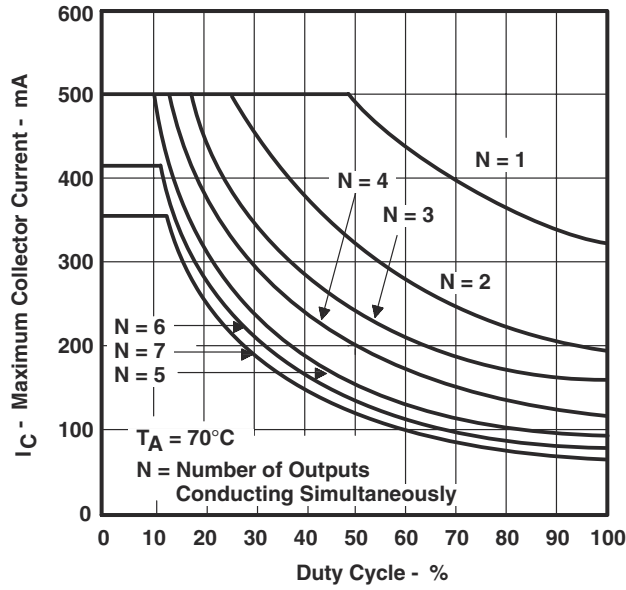
$$PD_{(MAX)} = \frac{(T_{J(MAX)} - T_A)}{\theta_{JA}} \quad (3)$$

where

- $T_{J(max)}$  is the target maximum junction temperature
- $T_A$  is the operating ambient temperature
- $R_{\theta JA}$  is the package junction to ambient thermal resistance

Limit the die junction temperature of the ULQ200xA-Q1 device to less than 125°C. The IC junction temperature is directly proportional to the on-chip power dissipation.

**8.2.3 Application Curve**



**图 8-2. D Package Maximum Collector Current vs Duty Cycle**

## 8.3 System Examples

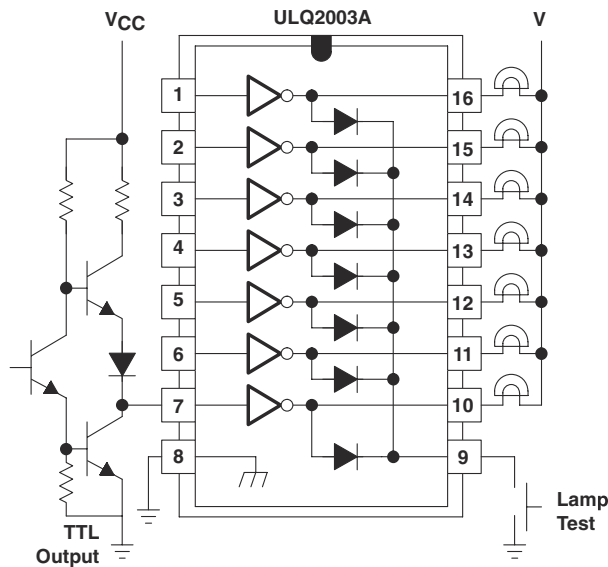


图 8-3. TTL to Load

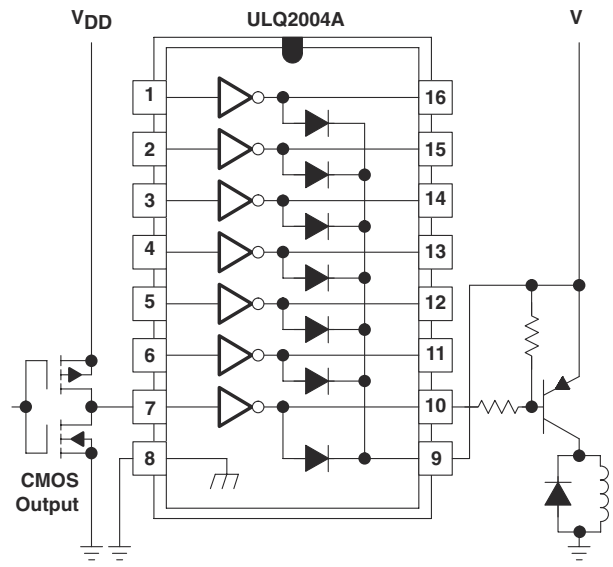


图 8-4. Buffer for Higher Current Loads

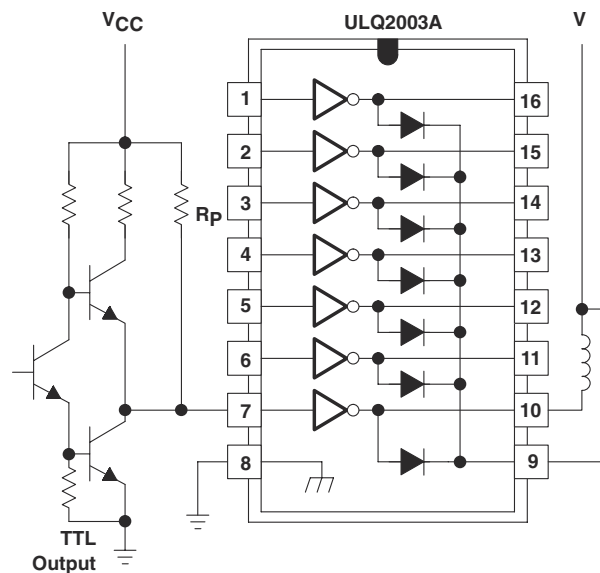


图 8-5. Use of Pullup Resistors to Increase Drive Current

## 8.4 Power Supply Recommendations

This device does not need a power supply. However, the COM pin is typically tied to the system power supply. When this is the case, it is very important to ensure that the output voltage does not heavily exceed the COM pin voltage. This discrepancy heavily forward biases the fly-back diodes and causes a large current to flow into COM, potentially damaging the on-chip metal or over-heating the device.

## 8.5 Layout

### 8.5.1 Layout Guidelines

Thin traces can be used on the input due to the low-current logic that is typically used to drive the ULQ200xA-Q1 devices. Take care to separate the input channels as much as possible, as to eliminate crosstalk. TI



recommends thick traces for the output to drive whatever high currents that may be needed. Wire thickness can be determined by the current density of the trace material and desired drive current.

Because all of the channels currents return to a common emitter, it is best to size that trace width to be very wide. Some applications require up to 2.5 A.

### 8.5.2 Layout Example

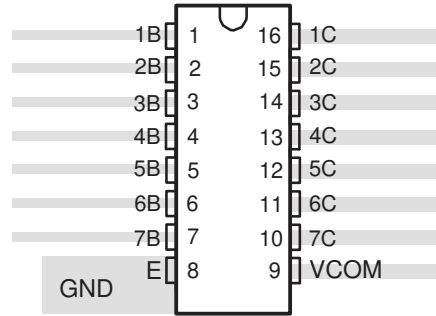


图 8-6. Package Layout

## 9 Device and Documentation Support

### 9.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

表 9-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
ULQ2003A-Q1	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>
ULQ2004A-Q1	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>	<a href="#">Click here</a>

### 9.2 支持资源

TI E2E™ 中文支持论坛是工程师的重要参考资料，可直接从专家处获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题，获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的使用条款。

### 9.3 Trademarks

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### 9.4 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 9.5 术语表

TI 术语表 本术语表列出并解释了术语、首字母缩略词和定义。

## 10 Revision History

注：以前版本的页码可能与当前版本的页码不同

### Changes from Revision E (November 2014) to Revision F (June 2024) Page

- 更新了整个文档中的表格、图和交叉参考的编号格式..... 1
- 在整个数据表中添加了 DYY 封装..... 1

### Changes from Revision D (April 2010) to Revision E (November 2014) Page

- 添加了引脚配置和功能部分、ESD 等级表、特性说明部分、器件功能模式、应用和实施部分、电源相关建议部分、布局部分、器件和文档支持部分以及机械、封装和可订购信息部分..... 1

## 11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
ULQ2003AQDRQ1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	ULQ2003AQ	<a href="#">Samples</a>
ULQ2003ATDG4Q1	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 105	ULQ2003AT	
ULQ2003ATDQ1	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 105	ULQ2003AT	
ULQ2003ATDRG4Q1	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 105	ULQ2003AT	
ULQ2003ATDRQ1	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI	-40 to 105	ULQ2003AT	
ULQ2003ATPWRQ1	ACTIVE	TSSOP	PW	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 105	U2003AT	<a href="#">Samples</a>
ULQ2004ATDRG4Q1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULQ2004AT	<a href="#">Samples</a>
ULQ2004ATDRQ1	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 105	ULQ2004AT	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF ULQ2003A-Q1, ULQ2004A-Q1 :**

- Catalog : [ULQ2003A](#), [ULQ2004A](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## 重要声明和免责声明

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