## 1. DESCRIPTION

The XL2803CD device is a 50-V, 500-mA Darlington transistor array. The device consists of eight NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of each Darlington pair is 500 mA. The Darlington pairscan be connected in parallel for higher current capability.

Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. The XL2803CD device has a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

## 2. FEATURES

- 500-mA-rated collector current
  (single output)
- High-voltage outputs: 50 V
- Output clamp diodes
- Inputs compatible with various types of logic
- Package option: XL2803CD (SOP20)

## 3. APPLICATIONS

- Factory automation and control
- Building automation
- Appliances
- IP network camera
- HVAC valve & actuator control
- Relay, solenoid, and lamp driving
- Stepper motor driving

## 4. PIN CONFIGURATIONS AND FUNCTIONS

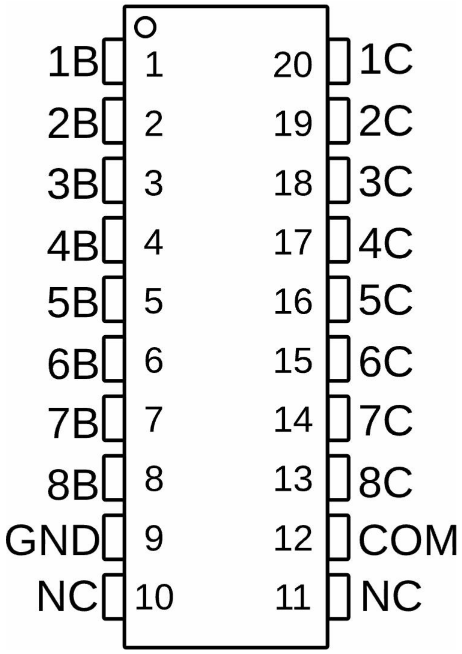
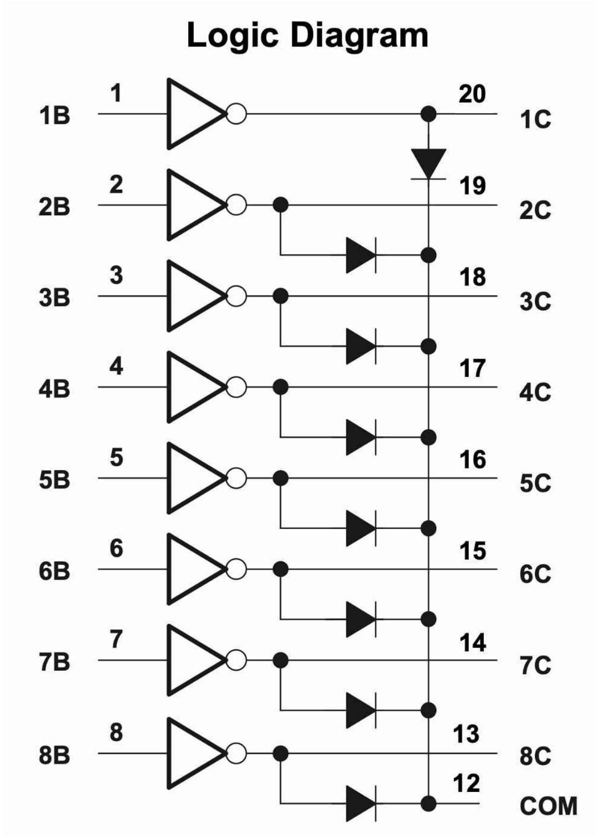



**Table 5-1. Pin Functions**

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| 1B | 1 | I | Channel 1 through 8 Darlington base input |
| 2B | 2 | | |
| 3B | 3 | | |
| 4B | 4 | | |
| 5B | 5 | | |
| 6B | 6 | | |
| 7B | 7 | | |
| 8B | 8 | | |
| 1C | 20 | O | Channel 1 through 8 Darlington collector output |
| 2C | 19 | | |
| 3C | 18 | | |
| 4C | 17 | | |
| 5C | 16 | | |
| 6C | 15 | | |
| 7C | 14 | | |
| 8C | 13 | | |
| GND | 9 | — | Common emitter shared by all channels (typically tied to ground) |
| COM | 12 | I/O | Common cathode node for flyback diodes (required for inductive loads) |
| NC | 10, 11 | — | No connect pin |

## 5. LOGIC DIAGRAM



# 6. SPECIFICATIONS

## 6.1 Absolute Maximum Ratings

at 25°C free-air temperature (unless otherwise noted)[1]

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{CE}$ | Collector-emitter voltage | | 50 | V |
| $V_I$ | Input voltage[2] | | 30 | V |
| | Peak collector current | | 500 | mA |
| I(clamp) | Output clamp current | | 500 | mA |
| | Total substrate-terminal current | | –2.5 | A |
| $T_J$ | Junction temperature | –65 | 150 | °C |
| $T_{stg}$ | Storage temperature | –65 | 150 | °C |

[1] Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute MaximumRatings do not imply functional operation of the device at these or any other conditions beyond those listedunder Recommended Operating Conditions. If used outside the Recommended Operating Conditions but withinthe Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability,functionality, performance, and shorten the device lifetime.

[2] All voltage values, unless otherwise noted, are with respect to the emitter/substrate terminal GND.

## 6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1] | ±2000 | V |
| | | Charged device model (CDM), per ANSI/ESDA/ JEDEC JS-002[2] | ±500 | |

**[1]** JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

**[2]** JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## 6.3 Recommended Operating Conditions

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

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{CE}$ | Collector-emitter voltage | 0 | 50 | V |
| $T_A$ | Ambient temperature | –40 | 85 | °C |

## 6.4 Thermal Information

| THERMAL METRIC[1] | | XL2803CD | UNIT |
|---|---|---|---|
| | | SOP20 | |
| | | 20 PINS | |
| $R_{θJA}$ | Junction-to-ambient thermal resistance | 68.8 | °C/W |
| $R_{θJC(top)}$ | Junction-to-case (top) thermal resistance | 34.3 | °C/W |
| $R_{θJB}$ | Junction-to-board thermal resistance | 37.5 | °C/W |
| $ψ_{JT}$ | Junction-to-top characterization parameter | 10.7 | °C/W |
| $ψ_{JB}$ | Junction-to-board characterization parameter | 37.0 | °C/W |
| $R_{θJC(bot)}$ | Junction-to-case (bottom) thermal resistance | N/A | °C/W |

## 6.5 Electrical Characteristics

at $T_A$ = 25°C free-air temperature (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | XL2803CD | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $I_{CEX}$ | Collector cutoff current | $V_{CE}$ = 50 V, see Figure 7-1 | $I_I$ = 0 | | | 50 | µA |
| $I_{I(off)}$ | Off-state input current | $V_{CE}$ = 50 V, $T_A$ = 70°C | $I_C$ = 500 µA, see Figure 7-2 | 50 | 65 | | µA |
| $I_{I(on)}$ | Input current | $V_I$ = 3.85 V, | See Figure 7-3 | | 0.93 | 1.35 | mA |
| $V_{I(on)}$ | On-state input voltage | $V_{CE}$ = 2 V, see Figure 7-4 | $I_C$ = 200 mA | | | 2.4 | V |
| | | | $I_C$ = 250 mA | | | 2.7 | |
| | | | $I_C$ = 300 mA | | | 3 | |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $I_I$ = 250 µA, see Figure 7-5 | $I_C$ = 100 mA | | 0.9 | 1.1 | V |
| | | $I_I$ = 350 µA, see Figure 7-5 | $I_C$ = 200 mA | | 1 | 1.3 | |
| | | $I_I$ = 500 µA, see Figure 7-5 | $I_C$ = 350 mA | | 1.3 | 1.6 | |
| $I_R$ | Clamp diode reverse current | $V_R$ = 50 V, | see Figure 7-6 | | | 50 | µA |
| $V_F$ | Clamp diode forward voltage | $I_F$ = 350 mA | see Figure 7-7 | | 1.7 | | V |
| $C_i$ | Input capacitance | $V_I$ = 0, | f = 1 MHz | | 15 | 25 | pF |

## 6.6 Switching Characteristics

$T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{PLH}$ | Propagation delay time, low- to high-level output | $V_S$ = 50 V, $C_L$ = 15 pF, $R_L$ = 163 Ω, See Figure 7-8 | | 130 | | ns |
| $t_{PHL}$ | Propagation delay time, high- to low-level output | | | 20 | | |
| $V_{OH}$ | High-level output voltage after switching | $V_S$ = 50 V, $I_O$ = 300 mA, see Figure 7-9 | $V_S$ – 20 | | | mV |

## 6.7 Typical Characteristics

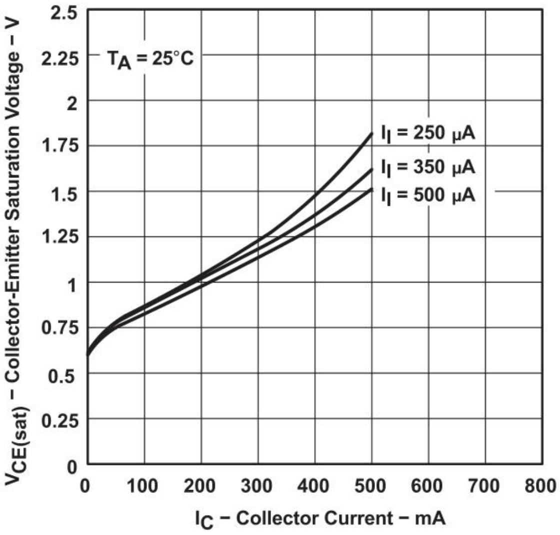



Figure 6-1. Collector-Emitter Saturation Voltage vs Collector Current (One Darlington)

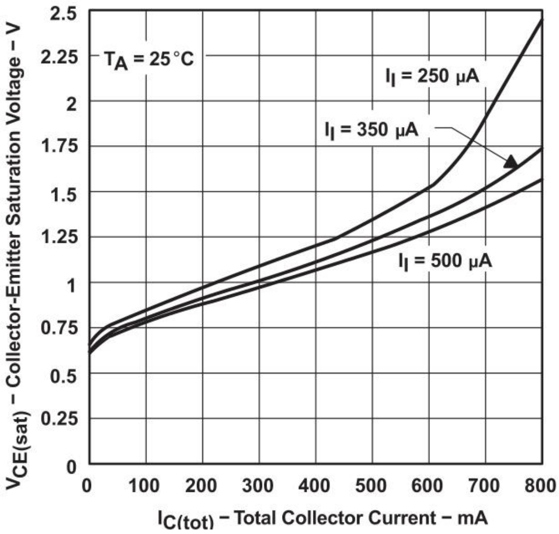



Figure 6-2. Collector-Emitter Saturation Voltage vs Total Collector Current (Two Darlingtons in Parallel)

## 7. PARAMETER MEASUREMENT INFORMATION

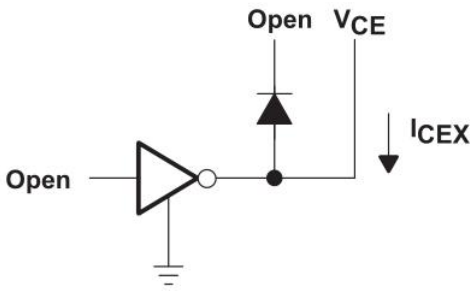



Figure 7-1. $I_{CEX}$ Test Circuit

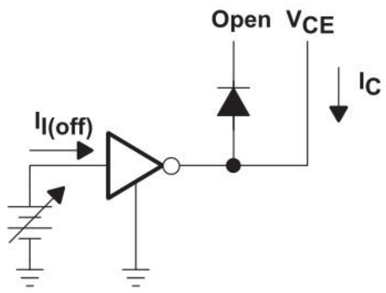



Figure 7-2. $I_{I(off)}$ Test Circuit

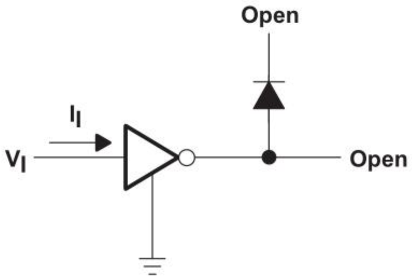



Figure 7-3. $I_{I(on)}$ Test Circuit

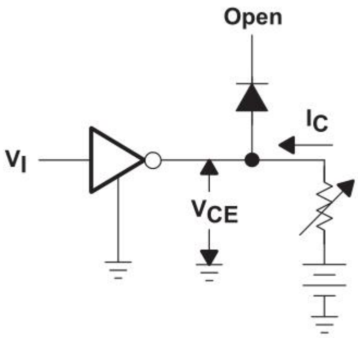



Figure 7-4. $V_{I(on)}$ Test Circuit

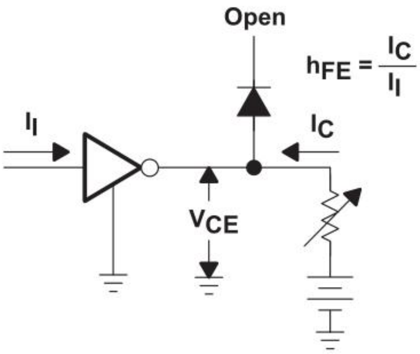



Figure 7-5. $h_{FE}$, $V_{CE(sat)}$ Test Circuit

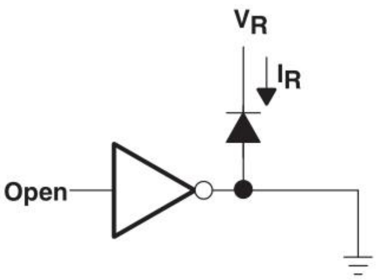



Figure 7-6. IR Test Circuit

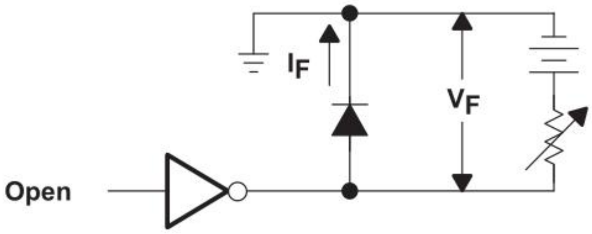
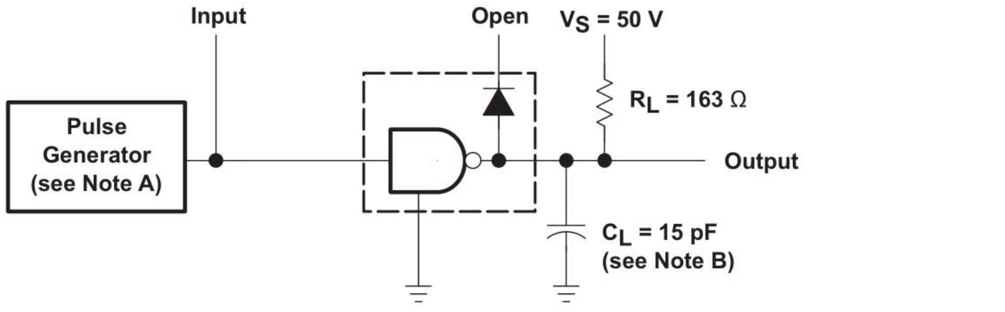
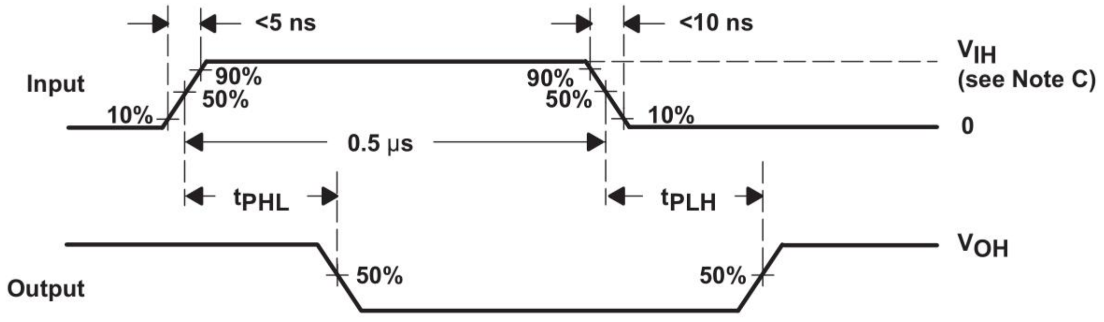



Figure 7-7. $V_F$ Test Circuit




Test Circuit

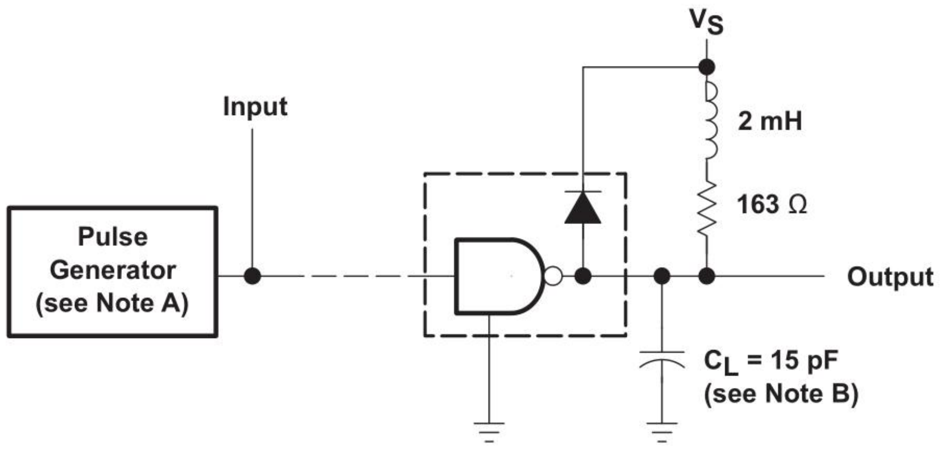



A. The pulse generator has the following characteristics: PRR = 12.5 kHz, $Z_O$ = 50 Ω.

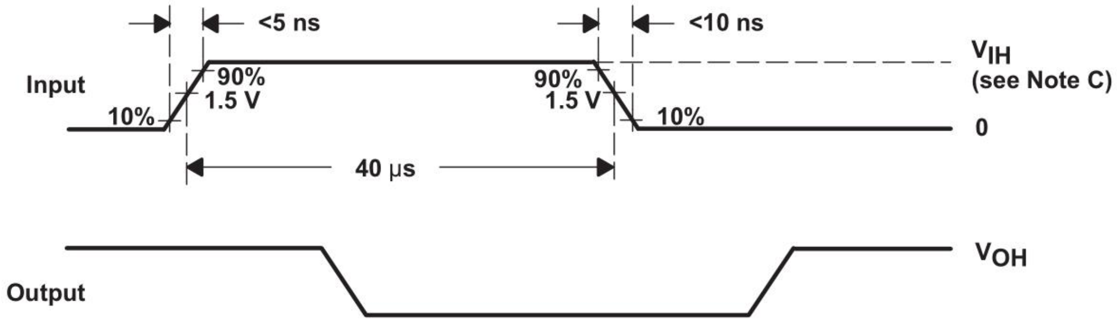
B. $C_L$ includes probe and jig capacitance.

C. $V_{IH}$ = 3 V.

**Figure 7-8. Propagation Delay Times**




Test Circuit




Voltage Waveforms

A. The pulse generator has the following characteristics: PRR = 12.5 kHz, $Z_O$ = 50 Ω.

B. $C_L$ includes probe and jig capacitance.

C. $V_{IH}$ = 3 V.

**Figure 7-9. Latch-Up Test**

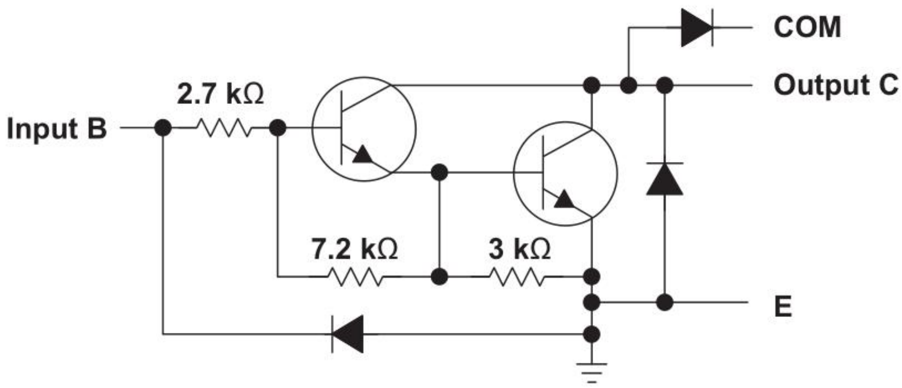
# 8. DETAILED DESCRIPTION

## 8.1. Overview

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

The XL2803CD is comprised of eight 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 XL2803CD has 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 XL2803CD 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 can be accommodated by paralleling the outputs.

## 8.2. Functional Block Diagram




## 8.3. Feature Description

Each channel of XL2803CD consists of Darlington connected NPN transistors. This connection creates the effect of a single transistor with a very-high current gain. The very high β 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-kΩ resistor connected between the input and base of the predriver Darlington NPN.

The diodes connected between the output and COM pin are used to suppress the kickback 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 kickback diode.

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

## 8.4. Device Functional Modes

### 8.4.1 Inductive Load Drive

When the COM pin is tied to the coil supply voltage, XL2803CD can drive inductive loads and suppress the kickback voltage through the internal free wheeling diodes.

### 8.4.2 Resistive Load Drive

When driving resistive loads, COM can be left unconnected or connected to the load voltage supply. If multiple supplies are used, connect to the highest voltage supply.

# 9. APPLICATION AND IMPLEMENTATION

**Note**

Information in the following applications sections is not part of the Xinluda component specification, and Xinluda does not warrant its accuracy or completeness. Xinluda's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## 9.1. Application Information

XL2803CD is typically used to drive a high-voltage or current peripherals from an MCU or logic device that cannot tolerate these conditions. The following design is a common application of XL2803CD, driving inductive loads. This includes motors, solenoids, and relays. Each load type can be modeled by what is seen in Figure 9-1.

## 9.2. Typical Application

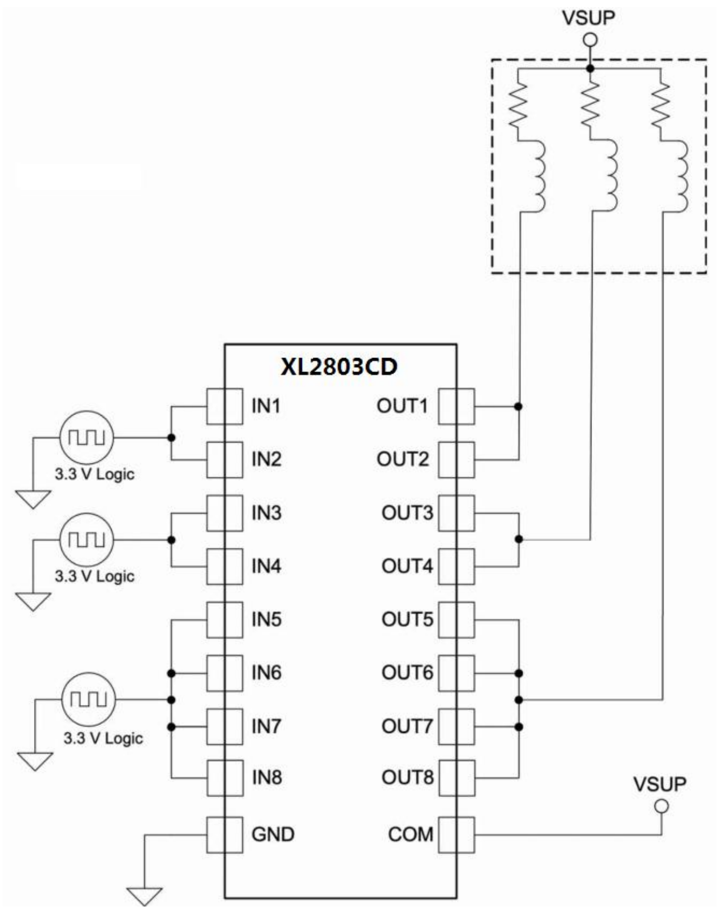



**Figure 9-1. XL2803CD as Inductive Load Driver**

### 9.2.1 Design Requirements

For this design example, use the parameters listed in Table 9-1 as the input parameters.

**Table 9-1. Design Parameters**

| DESIGN PARAMETER | EXAMPLE VALUE |
|---|---|
| GPIO voltage | 3.3 or 5 V |
| Coil supply voltage | 12 to 50 V |
| Number of channels | 8 |
| Output current (RCOIL) | 20 to 300 mA per channel |
| Duty cycle | 100% |

### 9.2.2 Detailed Design Procedure

When using XL2803CD in a coil driving application, determine the following:

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

#### *9.2.2.1 Drive Current*

The coil current is determined by the coil voltage (VSUP), coil resistance, and output low voltage ($V_{OL}$ or $V_{CE(SAT)}$).

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

#### *9.2.2.2 Output Low Voltage*

The output low voltage ($V_{OL}$) is the same thing as $V_{CE(SAT)}$ and can be determined by Figure 6-1, Figure 6-2, or

#### *9.2.2.3 Power Dissipation and Temperature*

The number of coils driven is dependent on the coil current and on-chip power dissipation. To determine the number of coils possible, use Equation 2 to calculate XL2803CD on-chip power dissipation $P_D$.

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

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 the reliability of XL2803CD and the system, the on-chip power dissipation must be lower that or equal to the maximum allowable power dissipation ($P_D$) dictated by Equation 3.

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

where

- $T_{J(MAX)}$ is the target maximum junction temperature.
- $T_A$ is the operating ambient temperature.
- $\theta_{JA}$ is the package junction to ambient thermal resistance.

XINLUDA recommends to limit the XL2803CD IC die junction temperature to < 125°C. The IC junction temperature is directly proportional to the on-chip power dissipation.

#### 9.2.3 Application Curves

The following curves are generated with XL2803CD driving an OMRON G5NB relay – Vin = 5.0 V; Vsup= 12 V and RCOIL= 2.8 kΩ.

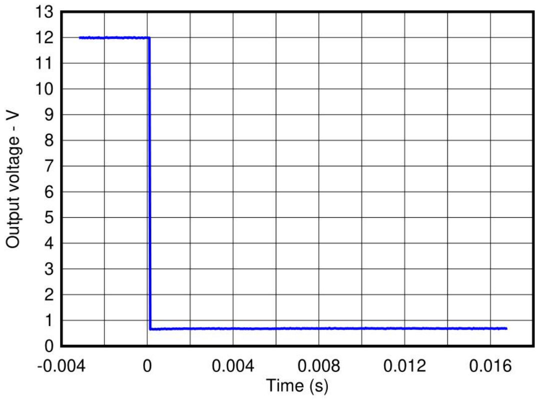



**Figure 9-2. Output Response with Activation of Coil (Turn-On)**

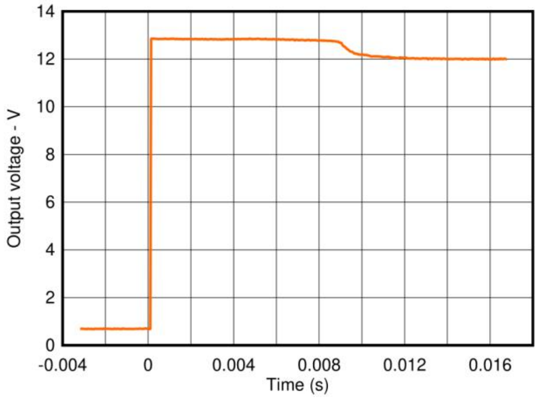



**Figure 9-3. Output Response with De-activation of Coil (Turn Off)**

## 9.3. Power Supply Recommendations

This devicedoes not need a power supply; however, the COM pin is typically tied to the system power supply. With this case, make sure that the output voltage does not heavily exceed the COM pin voltage. This action can heavily forward bias the flyback diodes and cause a large current to flow into COM, potentially damaging the on-chip metal or overheating the part.

## 9.4. Layout

### 9.4.1 Layout Guidelines

Thin traces can be used on the input due to the low current logic that is typically used to drive XL2803CD. Take care to separate the input channels as much as possible, as to eliminate crosstalk. TI recommends thick traces for the output to drive high currents as desired. Wire thickness can be determined by the trace material current density and desired drive current.

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

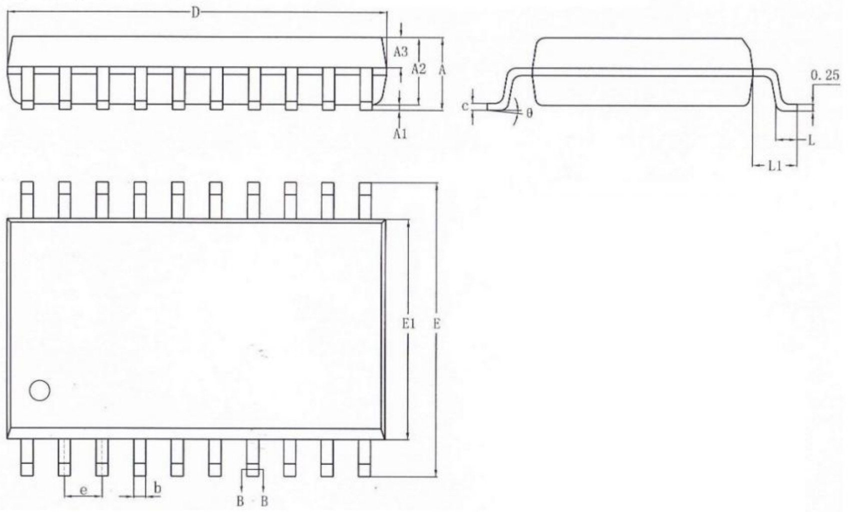
## 10. ORDERING INFORMATION

**Ordering Information**

| Part Number | Device Marking | Package Type | Body size (mm) | Temperature (℃) | MSL | Transport Media | Package Quantity |
|---|---|---|---|---|---|---|---|
| XL2803CD | XL2803CD | SOP20 | 12.90 ∗ 7.5 | -40 to 85 | MSL3 | T&R | 1000 |

## 11. DIMENSIONAL DRAWINGS

**SOP20**




| SYMBOL | MILLIMETER | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | — | — | 2.65 |
| A1 | 0.10 | — | 0.30 |
| A2 | 2.25 | 2.30 | 2.35 |
| A3 | 0.97 | 1.02 | 1.07 |
| b | 0.35 | — | 0.43 |
| b1 | 0.34 | 0.37 | 0.40 |
| c | 0.25 | — | 0.29 |
| c1 | 0.24 | 0.25 | 0.26 |
| D | 12.70 | 12.80 | 12.90 |
| E | 10.10 | 10.30 | 10.50 |
| E1 | 7.40 | 7.50 | 7.60 |
| e | 1.27BSC | | |
| L | 0.70 | — | 1.00 |
| L1 | 1.40REF | | |
| θ | 0 | — | 8° |