

## 1. DESCRIPTION

The XL/XDx39 and XL/XD2901 comparators feature low offset voltage, high supply voltage capability, low supply current, low input bias current, low propagation delay, and input ruggedness through dedicated ESD clamps.

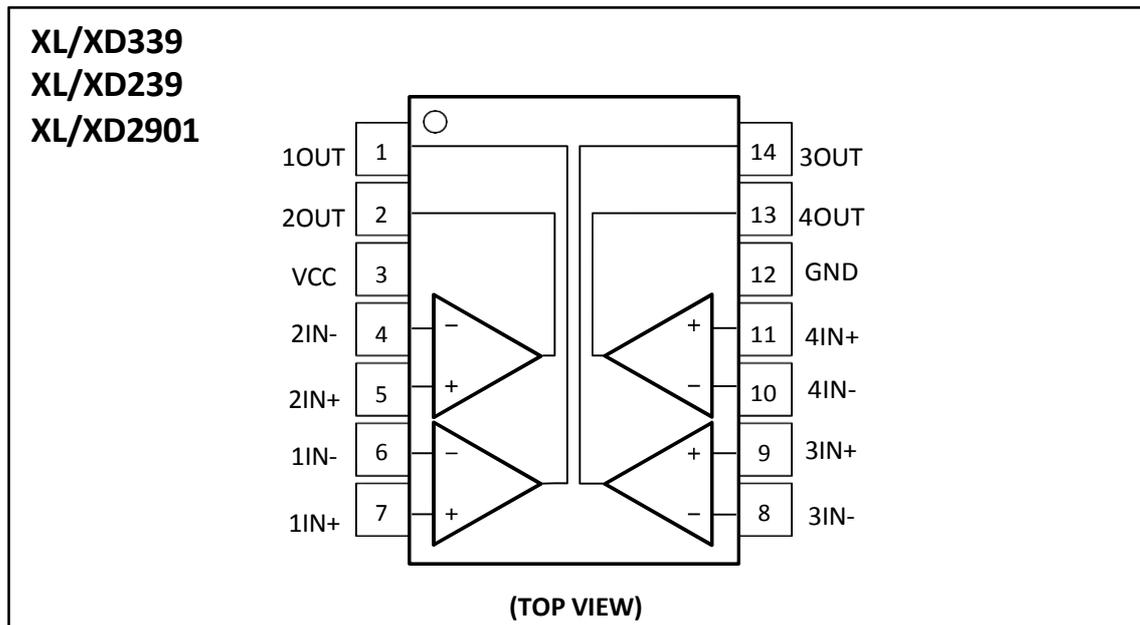
## 2. FEATURES

- Specifications for XL/XD239, XL/XD339, XL/XD2901
  - Maximum rating: up to 36 V
  - Low input offset: 2 mV
  - Low input bias current: 25 nA
  - Low supply-current: 300  $\mu$ A per comparator(TYP)
  - response time of 1  $\mu$ sec
- Common-mode input voltage range includes ground
- Differential input voltage range equal to maximum- rated supply voltage:  $\pm$ 36 V
- Low output saturation voltage
- Output compatible with TTL, MOS, and CMOS

## 3. Applications

- Vacuum robot
- Single phase UPS
- Server PSU
- Cordless power tool
- Wireless infrastructure
- Appliances
- Building automation
- Factory automation & control
- Motor drives
- Infotainment & cluster

#### 4. PIN CONFIGURATIONS AND FUNCTIONS

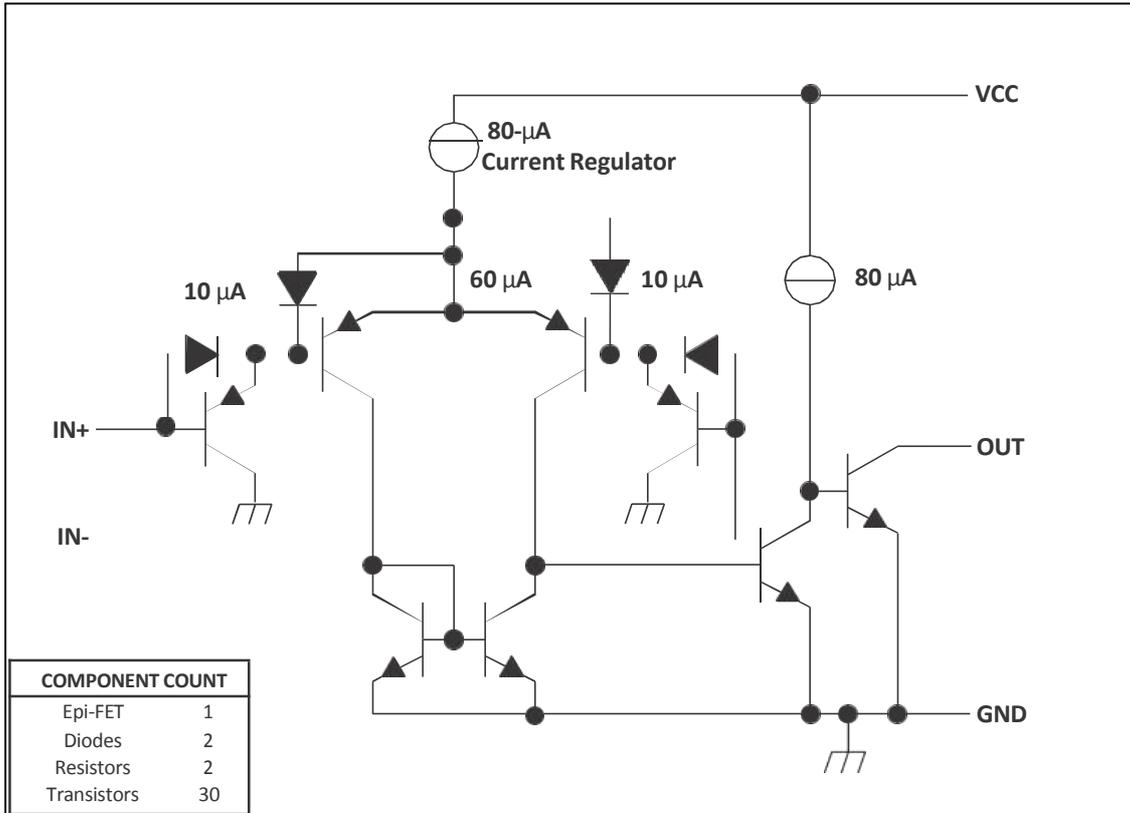


#### Pin Functions

PIN		I/O	DESCRIPTION
NAME <sup>(1)</sup>	SOP,DIP		
OUT1 <sup>(1)</sup>	1	Output	Output pin of the comparator 2
OUT2 <sup>(1)</sup>	2	Output	Output pin of the comparator 1
VCC	3	—	Positive supply
IN2 <sup>-(1)</sup>	4	Input	Negative input pin of the comparator 1
IN2 <sup>+(1)</sup>	5	Input	Positive input pin of the comparator 1
IN1 <sup>-(1)</sup>	6	Input	Negative input pin of the comparator 2
IN1 <sup>+(1)</sup>	7	Input	Positive input pin of the comparator 2
IN3 <sup>-</sup>	8	Input	Negative input pin of the comparator 3
IN3 <sup>+</sup>	9	Input	Positive input pin of the comparator 3
IN4 <sup>-</sup>	10	Input	Negative input pin of the comparator 4
IN4 <sup>+</sup>	11	Input	Positive input pin of the comparator 4
GND	12	—	Negative supply
OUT4	13	Output	Output pin of the comparator 4
OUT3	14	Output	Output pin of the comparator 3

[1] Some manufacturers transpose the names of channels 1 & 2. Electrically the pinouts are identical, just a difference in the channel naming convention.

## 5. FUNCTIONAL BLOCK DIAGRAM



**Block Diagram**  
(one-Fourth of Circuit Shown)

## 6. SPECIFICATIONS

### 6.1. Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage <sup>(2)</sup>		36	V
V <sub>ID</sub>	Differential input voltage <sup>(3)</sup>		±36	V
V <sub>I</sub>	Input voltage range (either input)	-0.3	36	V
I <sub>k</sub>	Input current <sup>(5)</sup>		-50	mA
V <sub>O</sub>	Output voltage		36	V
I <sub>o</sub>	Output current		20	mA
Duration of output short circuit to ground <sup>(4)</sup>			Unlimited	
T <sub>J</sub>	Operating virtual-junction temperature		150	°C
Case temperature for 60 s		SOP14	260	°C
Lead temperature 1.6 mm (1/16 in) from case for 60 s		DIP14	300	°C
T <sub>stg</sub>	Storage temperature	-50	150	°C

[2] 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 Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

[3] All voltage values, except differential voltages, are with respect to network ground.

[4] Differential voltages are at xIN+ with respect to xIN-.

[5] Short circuits from outputs to VCC can cause excessive heating and eventual destruction.

[6] Input current flows through parasitic diode to ground and will turn on parasitic transistors that will increase ICC and may cause output to be incorrect. Normal operation resumes when input is removed.

### 6.2. Thermal Information

THERMAL METRIC <sup>(1)</sup>	XL/XDx39, XL/XD2901		UNIT
	SOP	DIP	
R <sub>θJA</sub> Junction-to-ambient thermal resistance	98.8	79	°C/W
R <sub>θJC(top)</sub> Junction-to-case (top) thermal resistance	64.3	73.4	°C/W
R <sub>θJB</sub> Junction-to-board thermal resistance	59.7	58.7	°C/W
ψ <sub>JT</sub> Junction-to-top characterization parameter	25.7	48.3	°C/W
ψ <sub>JB</sub> Junction-to-board characterization parameter	59.3	58.5	°C/W
R <sub>θJC(bot)</sub> Junction-to-case (bottom) thermal resistance	—	—	°C/W

### 6.3. ESD Ratings

		VALUE	UNIT
V <sub>(ESD)</sub> Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±500	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±750	

[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.

## 6.4. Recommended Operating Conditions

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

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	Non-V devices		V
		2	30	
		V devices		
		2	32	
T <sub>J</sub>	Junction temperature	XL/XD239		°C
		-25	85	
		XL/XD339		
		-0	70	
		XL/XD2901		
		-40	85	

## 6.5. Electrical Characteristics for XL/XDx39

at specified free-air temperature, V<sub>CC</sub> = 5 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS(1)	T <sub>A</sub> (2)	XL/XD239, XL/XD339			UNIT	
			MIN	TYP	MAX		
V <sub>IO</sub>	Input offset voltage	V <sub>CC</sub> = 5 V to 30 V, V <sub>IC</sub> = V <sub>ICR</sub> min, V <sub>O</sub> = 1.4 V	25°C	3	9	mV	
			Full range	18			
I <sub>IO</sub>	Input offset current	V <sub>O</sub> = 1.4 V	25°C	5	50	nA	
			Full range	150			
I <sub>IB</sub>	Input bias current	V <sub>O</sub> = 1.4 V	25°C	-25	-250	nA	
			Full range	-400			
V <sub>ICR</sub>	Common-mode input voltage range(3)		25°C	0 to V <sub>CC</sub> - 1.5		V	
			Full range	0 to V <sub>CC</sub> - 2			
A <sub>VD</sub>	Large-signal differential-voltage amplification	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 1.4 V to 11.4 V, R <sub>L</sub> ≥ 15 kΩ to V <sub>CC</sub>	25°C	50	200	V/mV	
I <sub>OH</sub>	High-level output current	V <sub>ID</sub> = 1 V	V <sub>OH</sub> = 5 V	25°C	0.1	50	nA
			V <sub>OH</sub> = 30 V	Full range	1		μA
V <sub>OL</sub>	Low-level output voltage	V <sub>ID</sub> = -1 V, I <sub>OL</sub> = 4 mA	25°C	150	400	mV	
			Full range	700			
I <sub>OL</sub>	Low-level output current	V <sub>ID</sub> = -1 V, V <sub>OL</sub> = 1.5 V	25°C	6	16	mA	
I <sub>CC</sub>	Supply current (four comparators)	V <sub>O</sub> = 2.5 V, No load	25°C	1.2	3.5	mA	

[1] All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[2] Full range (MIN to MAX) for XL/XD239 is -25°C to +85°C, and for XL/XD339 is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[3] The voltage at either input or common-mode must not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is V<sub>CC</sub> - 1.5 V; however, one input can exceed V<sub>CC</sub>, and the comparator will provide a proper output state as long as the other input remains in the common-mode range. Either or both inputs can go to 30 V without damage.

## 6.6. Electrical Characteristics for XL/XD2901

at specified free-air temperature, VCC = 5 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	T <sub>A</sub> <sup>(2)</sup>	XL/XD2901			UNIT
			MIN	TYP	MAX	
V <sub>IO</sub> Input offset voltage	V <sub>IC</sub> = V <sub>ICR</sub> min, V <sub>O</sub> = 1.4 V, V <sub>CC</sub> = 5 V to MAX <sup>(3)</sup> Non-A devices	25°C		3	10	mV
		Full range			20	
I <sub>IO</sub> Input offset current	V <sub>O</sub> = 1.4 V	25°C		5	50	nA
		Full range			200	
I <sub>IB</sub> Input bias current	V <sub>O</sub> = 1.4 V	25°C		-25	-250	nA
		Full range			-500	
V <sub>ICR</sub> Common-mode input-voltage range <sup>(4)</sup>		25°C		0 to V <sub>CC</sub> - 1.5		V
		Full range		0 to V <sub>CC</sub> - 2		
A <sub>VD</sub> Large-signal differential-voltage amplification	V <sub>CC</sub> = 15 V, V <sub>O</sub> = 1.4 V to 11.4 V, R <sub>L</sub> ≥ 15 kΩ to V <sub>CC</sub>	25°C	25	100		V/mV
I <sub>OH</sub> High-level output current	V <sub>ID</sub> = 1 V	V <sub>OH</sub> = 5 V	25°C	0.1	50	nA
		V <sub>OH</sub> = V <sub>CC</sub> MAX <sup>(3)</sup>	Full range		1	
V <sub>OL</sub> Low-level output voltage	V <sub>ID</sub> = -1 V, I <sub>OL</sub> = 4 mA	Non-V devices	25°C	150	500	mV
		All devices	Full range		700	
I <sub>OL</sub> Low-level output current	V <sub>ID</sub> = -1 V, V <sub>OL</sub> = 1.5 V	25°C	6	16		mA
I <sub>CC</sub> Supply current (four comparators)	V <sub>O</sub> = 2.5 V, No load	V <sub>CC</sub> = 5 V	25°C	1.2	3.5	mA
		V <sub>CC</sub> = MAX <sup>(3)</sup>		2	5	

[1] All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[2] Full range (MIN to MAX) for XL2901 is -40°C to +85°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[3] V<sub>CC</sub> MAX = 30 V for non-V devices, and 32 V for V-suffix devices

[4] The voltage at either input or common-mode must not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is V<sub>CC</sub> + - 1.5 V; however, one input can exceed V<sub>CC</sub>, and the comparator will provide a proper output state as long as the other input remains in the common-mode range. Either or both inputs can go to V<sub>CC</sub> MAX without damage.

### 6.7. Switching Characteristics for XL/XDx39

VCC = 5 V, TA = 25°C

PARAMETER	TEST CONDITIONS	XL/XD239 XL/XD339	UNIT
		TYP	
Response time	RL connected to 5 V through 5.1 kΩ, CL = 15 pF(1) (2)	100-mV input step with 5-mV overdrive	1.3
		TTL-level input step	0.3

[1] CL includes probe and jig capacitance.

[2] The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

### 6.8. Switching Characteristics for XL/XD2901

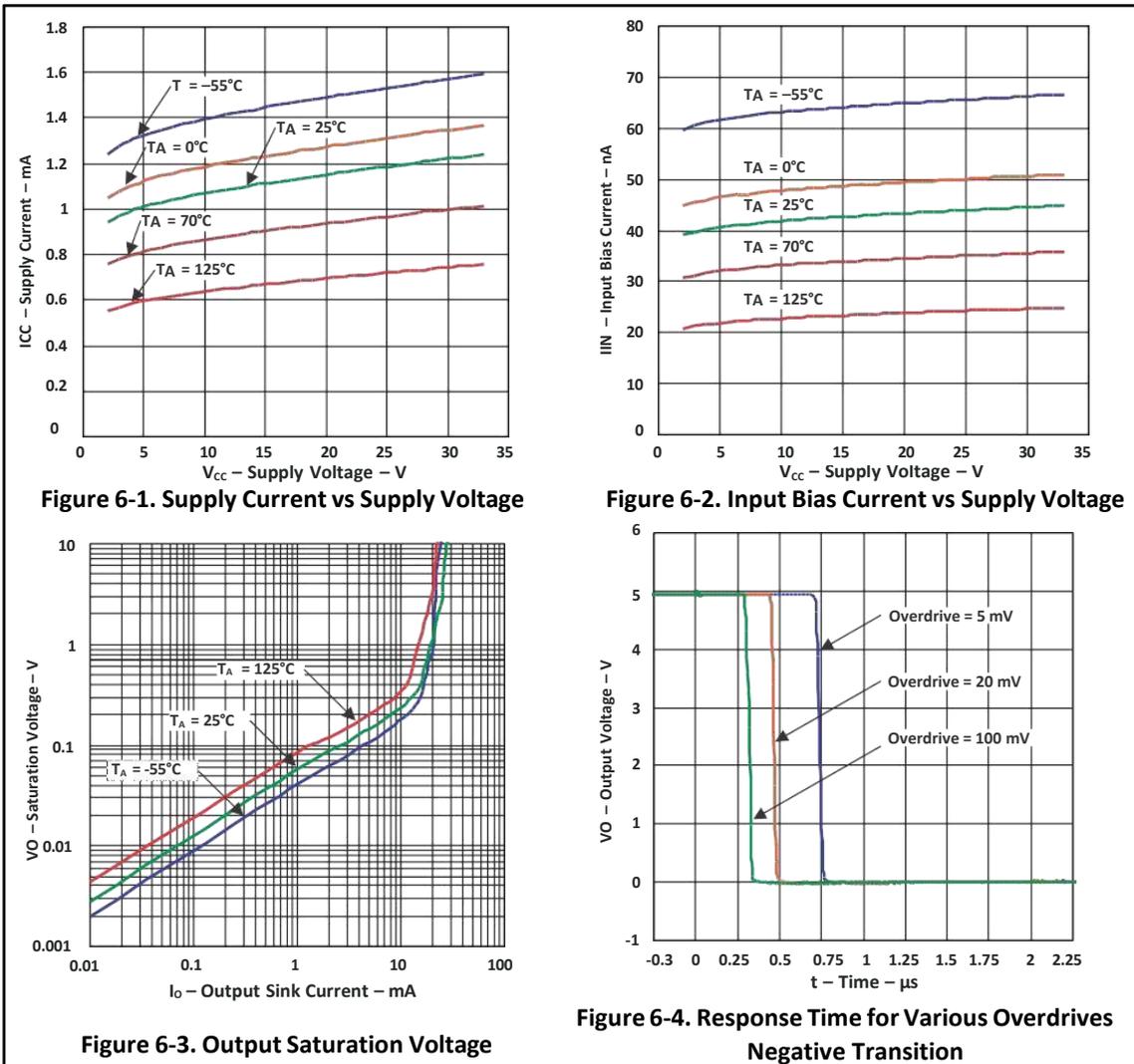
VCC = 5 V, TA = 25°C

PARAMETER	TEST CONDITIONS	XL2901	UNIT
		TYP	
Response time	RL connected to 5 V through 5.1 kΩ, CL = 15 pF(1) (2)	100-mV input step with 5-mV overdrive	1.3
		TTL-level input step	0.3

[3] CL includes probe and jig capacitance.

[4] The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

### 6.9. Typical Characteristics



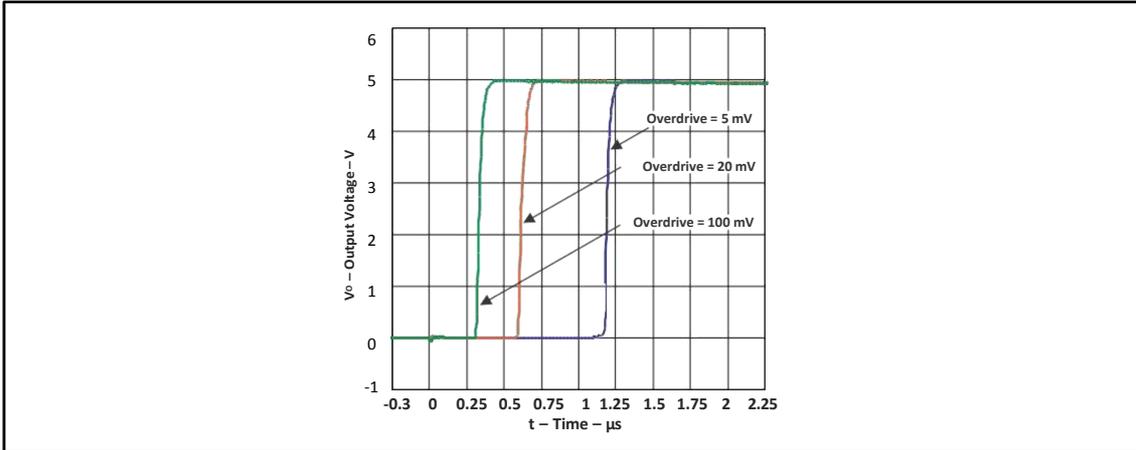


Figure 6-5. Response Time for Various Overdrives Positive Transition

## 7. Detailed Description

### 7.1. Overview

The XL/XDx39 and XL/XD2901 are quad comparators with the ability to operate up to an absolute maximum of 36 V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to very wide supply voltages range (2 V up to 32 V), low  $I_q$ , and fast response of the device.

The open-drain output allows the user to configure the output logic low voltage (VOL) and allows the comparator to be used in AND functionality.

### 7.2. Feature Description

The comparator consists of a PNP Darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common-mode voltage capability, allowing the comparator to accurately function from ground to  $(V_{CC} - 1.5 V)$  differential input. Allow for  $(V_{CC} - 2 V)$  at cold temperature.

The output consists of an open-collector NPN (pulldown or low-side) transistor. The output NPN sinks current when the negative input voltage is higher than the positive input voltage and the offset voltage. The VOL is resistive and scales with the output current. See the [Section 6](#) section for VOL values with respect to the output current.

### 7.3. Device Functional Modes

#### 7.3.1. Voltage Comparison

The comparator operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pullup) based on the input differential polarity.

## 8. Application and Implementation

### 8.1. Application Information

Typically, a comparator compares either a single signal to a reference, or to two different signals. Many users take advantage of the open-drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes XLx39 or XL/XD2901 optimal for level shifting to a higher or lower voltage.

### 8.2. Typical Application

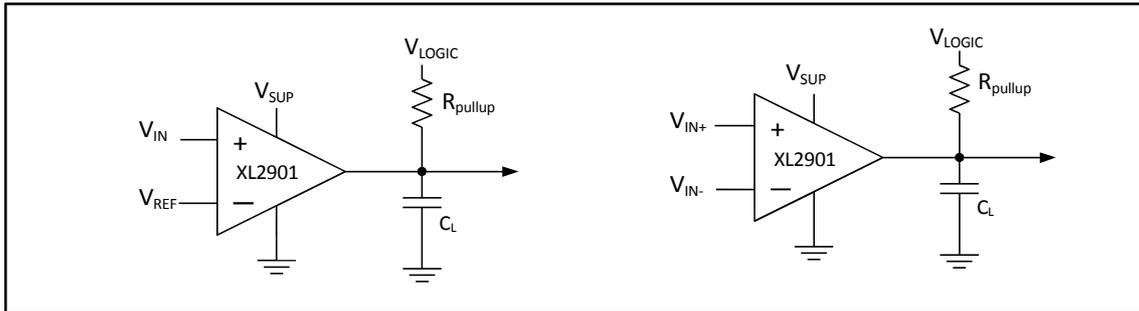


Figure 8-1. Single-ended and Differential Comparator Configurations

#### 8.2.1. Design Requirements

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

Table 8-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0 V to $V_{SUP}-1.5$ V
Supply Voltage	4.5 V to $V_{CC}$ maximum
Logic Supply Voltage	0 V to $V_{CC}$ maximum
Output Current ( $R_{PULLUP}$ )	1 $\mu$ A to 4 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance ( $C_L$ )	15 pF

#### 8.2.2. Detailed Design Procedure

When using the XLx39 in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current
- Response time

##### 8.2.2.1. Input Voltage Range

When choosing the input voltage range, the input common-mode voltage range ( $V_{ICR}$ ) must be taken in to account. If temperature operation is above or below 25°C the  $V_{ICR}$  can range from 0 V to  $V_{CC}-2$  V. This limits the input voltage range to as high as  $V_{CC}-2$  V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

The following list describes the outcomes of some input voltage situations.

- When both IN– and IN+ are both within the common-mode range:
- If IN– is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
- If IN– is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
- When IN– is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
- When IN+ is higher than common mode and IN– is within common mode, the output is high impedance and the output transistor is not conducting
- When IN– and IN+ are both higher than common mode, the output is low and the output transistor is sinking current

#### 8.2.2.2. Minimum Overdrive Voltage

Overdrive voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage ( $V_{IO}$ ). To make an accurate comparison, the overdrive voltage ( $V_{OD}$ ) must be higher than the input offset voltage ( $V_{IO}$ ). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 9-2 and Figure 9-3 show positive and negative response times with respect to overdrive voltage.

#### 8.2.2.3. Output and Drive Current

Output current is determined by the load and pullup resistance and logic and pullup voltage. The output current produces a low-level output voltage (VOL) from the comparator, where VOL is proportional to the output current.

The output current can also effect the transient response.

#### 8.2.2.4. Response Time

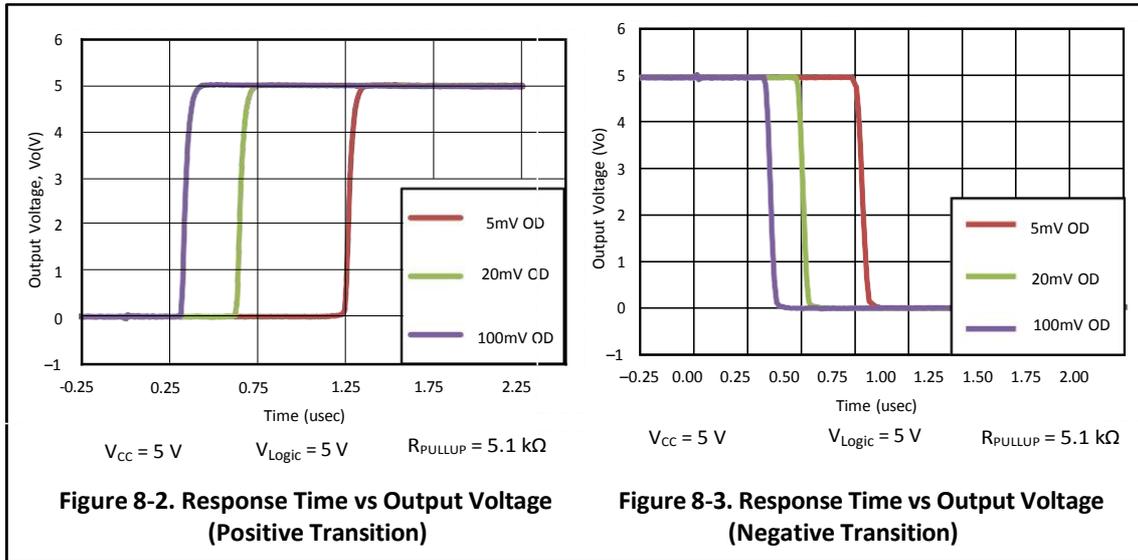
Response time is a function of input over-drive. See the [Section 6.9](#) graphs for typical response times. The rise and fall times can be determined by the load capacitance ( $C_L$ ), load/pull-up resistance ( $R_{PULLUP}$ ) and equivalent collector-emitter resistance ( $R_{CE}$ ).

- The rise time ( $\tau_R$ ) is approximately  $\tau_R \sim R_{PULLUP} \times C_L$
- The fall time ( $\tau_F$ ) is approximately  $\tau_F \sim R_{CE} \times C_L$

$R_{CE}$  can be determined by taking the slope of [Figure 6.3](#) in its linear region at the desired temperature, or by dividing the VOL by  $I_{OUT}$

### 8.2.3. Application Curves

Figure 8-2 and Figure 8-3 were generated with scope probe parasitic capacitance of 50 pF.



## 9. Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can affect the common-mode range of the comparator input and create an inaccurate comparison.

## 10. Layout

### 10.1. Layout Guidelines

To create an accurate comparator application without hysteresis, maintain a stable power supply with minimized noise and glitches, which can affect the high level input common-mode voltage range. To achieve this accuracy, add a bypass capacitor between the supply voltage and ground. Place a bypass capacitor on the positive power supply and negative supply (if available).

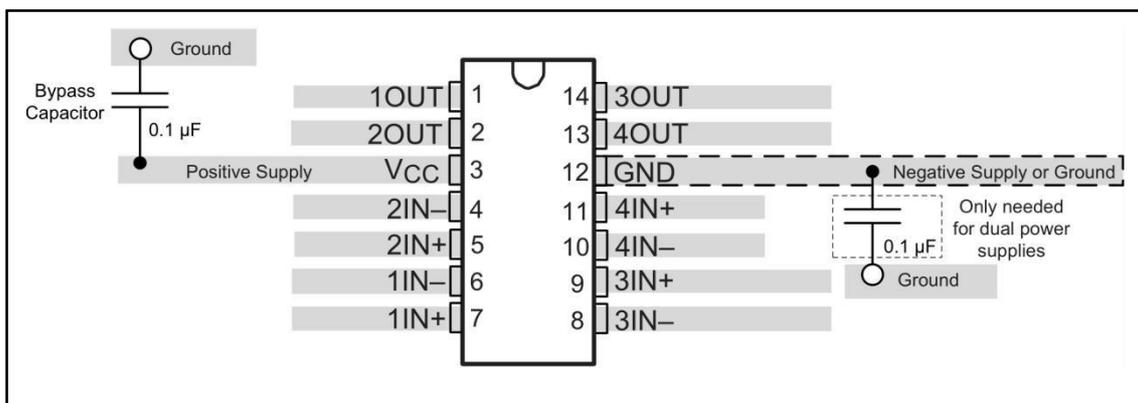


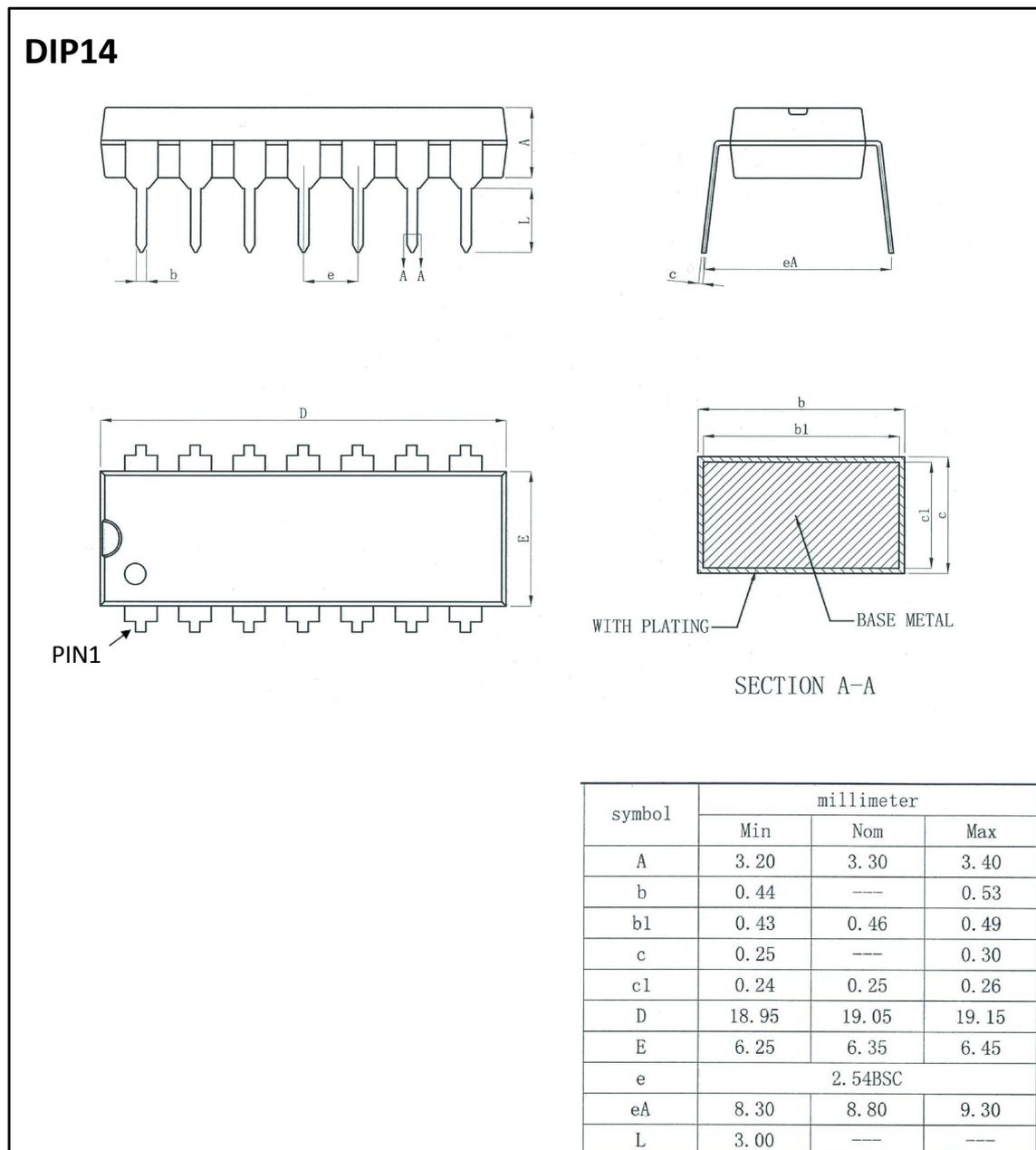
Figure 10-1. Layout Example

## 11. ORDERING INFORMATION

Ordering Information

Part Number	Device Marking	Package Type	Body size (mm)	Temperature (°C)	MSL	Transport Media	Package Quantity
XL339	XL339	SOP14	8.75 * 4.00	0 to +70	MSL3	T&R	2500
XD339	XD339	DIP14	19.05 * 6.35	0 to +70	MSL3	Tube 25	1000
XL239	XL239	SOP14	8.75 * 4.00	-25 to +85	MSL3	T&R	2500
XD239	XD239	DIP14	19.05 * 6.35	-25 to +85	MSL3	Tube 25	1000
XL2901	XL2901	SOP14	8.75 * 4.00	-40 to +85	MSL3	T&R	2500
XD2901	XD2901	DIP14	19.05 * 6.35	-40 to +85	MSL3	Tube 25	1000

## 12. DIMENSIONAL DRAWINGS



## SOP14

标注	尺寸	最小 (mm)	最大 (mm)	标注	Size	最小 (mm)	最大 (mm)
A		8.55	8.75	C4		0.193	0.213
A1		0.356	0.456	D		0.95	1.15
A2		1.27TYP		D1		0.40	0.70
A3		0.312TYP		D2		0.20TYP	
B		3.80	4.00	R1		0.20TYP	
B1		5.80	6.20	R2		0.20TYP	
C		1.40	1.60	θ1		8° ~ 12° TYP4	
C1		0.60	0.70	θ2		8° ~ 12° TYP4	
C2		0.55	0.65	θ3		0° ~ 8°	
C3		0.05	0.25	θ4		4° ~ 12°	

