

## 1. DESCRIPTION

These devices consist of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Operation from dual supplies also is possible as long as the difference between the two supplies is 2 V to 36 V, and Vcc is at least 1.5 V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

The XL293D-8 and XD293 devices are characterized for operation from -25°C to 85°C. The XL393 and XD393 devices are characterized for operation from 0°C to 70°C. The XL2903 device is characterized for operation from -40°C to 125°C.

## 2. FEATURES

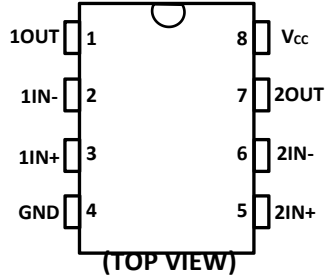
- Single-Supply or Dual Supplies
- Wide Range of Supply Voltage
- Maximum Rating: 2 V to 36 V
- Tested to 30 V: Non-V Devices
- Tested to 32 V: V-Suffix Devices
- Low Supply-Current Drain Independent of Supply Voltage: 0.4 mA (Typical) Per Comparator
- Low Input Bias Current: 25 nA (Typical)
- Low Input Offset Voltage: 2 mV (Typical)
- 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
- On Products Compliant to MIL-PRF-38535, All Parameters Are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testing of All Parameters.

## 3. APPLICATIONS

- Chemical or Gas Sensor
- Desktop PC
- Motor Control: AC Induction
- Weigh Scale

#### 4. PIN CONFIGURATIONS AND FUNCTIONS

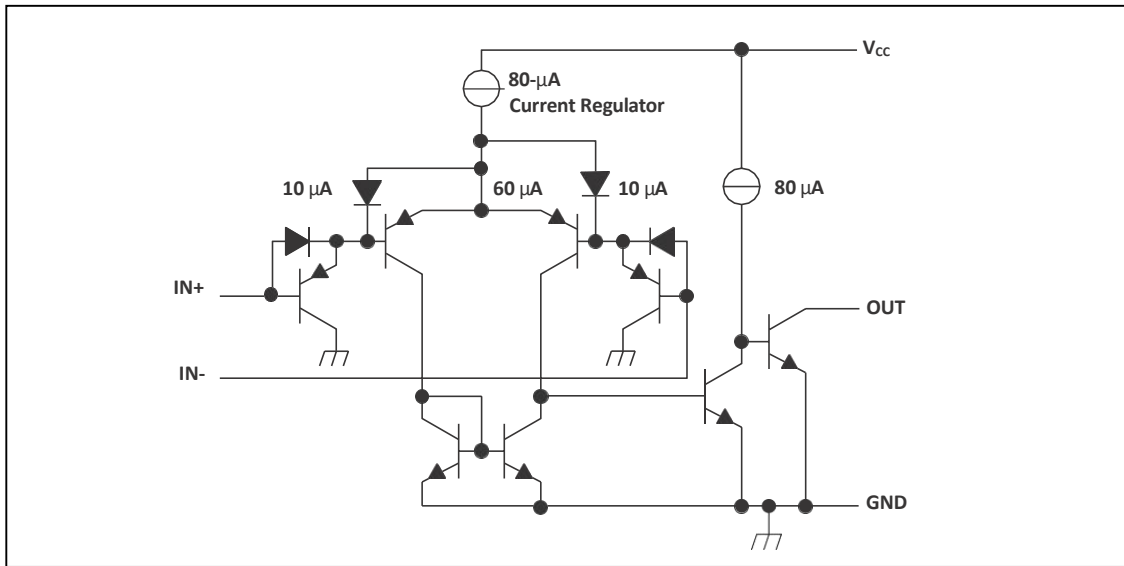
293, 393, 2903,



**Pin Functions**

PIN		I/O	DESCRIPTION
NAME	SOP,DIP		
1OUT	1	Output	Output pin of comparator 1
1IN-	2	Input	Negative input pin of comparator 1
1IN+	3	Input	Positive input pin of comparator 1
GND	4	Input	Ground
2IN+	5	Input	Positive input pin of comparator 2
2IN-	6	Input	Negative input pin of comparator 2
2OUT	7	Output	Output pin of comparator 2
Vcc	8	Input	Supply Pin

## 5. FUNCTIONAL BLOCK DIAGRAM



Block diagram

## 6. SPECIFICATIONS

### 6.1. Absolute Maximum Ratings

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

SYMBOL	PARAMETER	MIN	MAX	UNIT
VCC	Supply voltage range <sup>(2)</sup>	-	36	V
VID	Differential input voltage <sup>(3)</sup>		±36	V
VIN	Input pin voltage range	-0.3	36	V
VO	Output pin voltage range	-	36	V
I <sub>o</sub>	Output current		20	mA
	Duration of output short circuit to ground	Unlimited		
T <sub>j</sub>	Operating virtual-junction temperature		300	°C
T <sub>stg</sub>	Storage temperature range	-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 Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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

[3] Differential voltages are at IN+ with respect to IN-.

[4] Short circuits from outputs to Vcc can cause excessive heating and eventual destruction.

### 6.2. Thermal Resistance Characteristics

THERMAL METRIC <sup>(1)</sup>	XLx93, XL2903		UNIT	
	SOP	DIP		
	8 PINS	8 PINS		
R <sub>sJA</sub>	Junction-to-ambient thermal resistance	97	85	°C/W
R <sub>ejc(top)</sub>	Junction-to-case (top) thermal resistance	—	—	°C/W

### 6.3. ESD Ratings

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
VESD	Electrostatic Discharge	Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001	0	2000	V
		Charged Device Model (CDM), per JEDEC specification JESD22-C101	0	1000	V

[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> (non-V devices)	2	30	V
V <sub>CC</sub> (V devices)	2	32	V
T <sub>j</sub> Junction Temperature	-40	125	°C

## 6.5. Electrical Characteristics

At specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	XL293 XL393			UNIT
			MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V},$ $V_{IC} = V_{ICR\ min}, V_o = 1.4\text{ V}$	25°C	2	5	mV	
		Full range	9			
$I_{IO}$ Input offset current	$V_o = 1.4\text{ V}$	25°C	5	50	nA	
		Full range	250			
$I_{IB}$ Input bias current	$V_o = 1.4\text{ V}$	25°C	-25	-250	nA	
		Full range	-400			
$V_{ICR}$ Common-mode input-voltage range*		25°C	0 to $V_{CC} - 1.5$		v	
		Full range	0 to $V_{CC} - 2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}, V_o = 1.4\text{ V to }11.4\text{ V}, R_L \geq 15\text{ k}\Omega\text{ to }V_{CC}$	25°C	50	200	V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$	$V_{ID} = 1\text{ V}$	25°C	0.1	50	nA
	$V_{OH} = 30\text{ V}$	$V_{ID} = 1\text{ V}$	Full range	1		PA
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA},$	$V_{ID} = -1\text{ V}$	25°C	150	400	mV
			Full range	700		
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V},$	$V_{ID} = -1\text{ V}$	25°C	6		mA
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8	1	mA
		$V_{CC} = 30\text{ V}$	Full range	2.5		

[1] Full range (minimum or maximum) for XL293 is 25°C to 85°C, and for XL393 is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[2] The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the commonmode voltage range is  $V_{CC} + -1.5\text{ V}$  for the inverting input (-), and the non-inverting input (+) can exceed the  $V_{CC}$  level; the comparator provides a proper output state. Either or both inputs can go to 30 V without damage

## 6.6. Electrical Characteristics

At specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	XL293 XL393			UNIT
			MIN	TYP	MAX	
$V_{ID}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}, V_o = 1.4\text{ V}$ $V_{ic} = V_{ICR\ min}$	25°C	1	2	mV	
		Full range		4		
$I_{IO}$ Input offset current	$V_o = 1.4\text{ V}$	25°C	5	50	nA	
		Full range		150		
$I_{IB}$ Input bias current	$V_o = 1.4\text{ V}$	25°C	-25	-250	nA	
		Full range		-400		
$V_{ICR}$ Common-mode input-voltage range*		25°C	0 to $V_{CC} - 1.5$		v	
		Full range	0 to $V_{CC} - 2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}, V_o = 1.4\text{ V to } 11.4\text{ V},$ $R_L \geq 15\text{ k}\Omega\text{ to } V_{CC}$	25°C	50	200	V/mV	
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$	$V_{ID} = 1\text{ V}$	25°C	0.1	50	nA
	$V_{OH} = 30\text{ V}$	$V_{ID} = 1\text{ V}$	Full range		1	PA
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA},$	$V_{ID} = -1\text{ V}$	25°C	150	400	mV
			Full range		700	
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V},$	$V_{ID} = -1\text{ V}$	25°C	6		mA
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8	1	mA
		$V_{CC} = 30\text{ V}$	Full range		2.5	

[1] Full range (minimum or maximum) for XL293 is 25°C to 85°C, and for XL393 is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

[2] The voltage at either input or common-mode should not be allowed to go negative by more than 0.3 V. The upper end of the commonmode voltage range is  $V_{CC} + 1.5\text{ V}$ , but either or both inputs can go to 30 V without damage.

## 6.7. Electrical Characteristics

At specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_A^{(1)}$	XL2903			UNIT
			MIN	TYP	MAX	
$V_{ID}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}^{(2)}$ , $V_{ic} = V_{ICR\ min}$ , $V_o = 1.4\text{ V}$	25°C	2	7		mV
		Full range			15	
$I_{IO}$ Input offset current	$V_o = 1.4\text{ V}$	25°C	5	50		nA
		Full range			2000	
$I_{IB}$ Input bias current	$V_o = 1.4\text{ V}$	25°C	-25	-250		nA
		Full range			-400	
$V_{ICR}$ Common-mode input-voltage range*		25°C	0 to $V_{CC} - 1.5$			V
		Full range	0 to $V_{CC} - 2$			
$A_{VD}$ Large-signal differential-voltage amplification	$V_{CC} = 15\text{ V}$ , $V_o = 1.4\text{ V to } 11.4\text{ V}$ , $R_L \geq 15\text{ k}\Omega$ to $V_{CC}$	25°C	25	100		V/mV
$I_{OH}$ High-level output current	$V_{OH} = 5\text{ V}$	$V_{ID} = 1\text{ V}$	25°C	0.1	50	nA
	$V_{OH} = V_{CCMAX}^{(2)}$	$V_{ID} = 1\text{ V}$	Full range		1	PA
$V_{OL}$ Low-level output voltage	$I_{OL} = 4\text{ mA}$ , $V_{ID} = -1\text{ V}$	25°C	150	400		mV
		Full range			700	
$I_{OL}$ Low-level output current	$V_{OL} = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	6			mA
$I_{CC}$ Supply current	$R_L = \infty$	$V_{CC} = 5\text{ V}$	25°C	0.8	1	mA
		$V_{CC} = \text{MAX}$	Full range		2.5	

- [1] Full range (minimum or maximum) for XL2903 is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ . All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
- [2]  $V_{CC\ MAX} = 30\text{ V}$  for non-V devices and  $32\text{ V}$  for V-suffix devices.
- [3] The voltage at either input or common-mode should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_{CC} + 1.5\text{ V}$ , but either or both inputs can go to  $30\text{ V}$  ( $32\text{ V}$  for V-suffix devices) without damage.

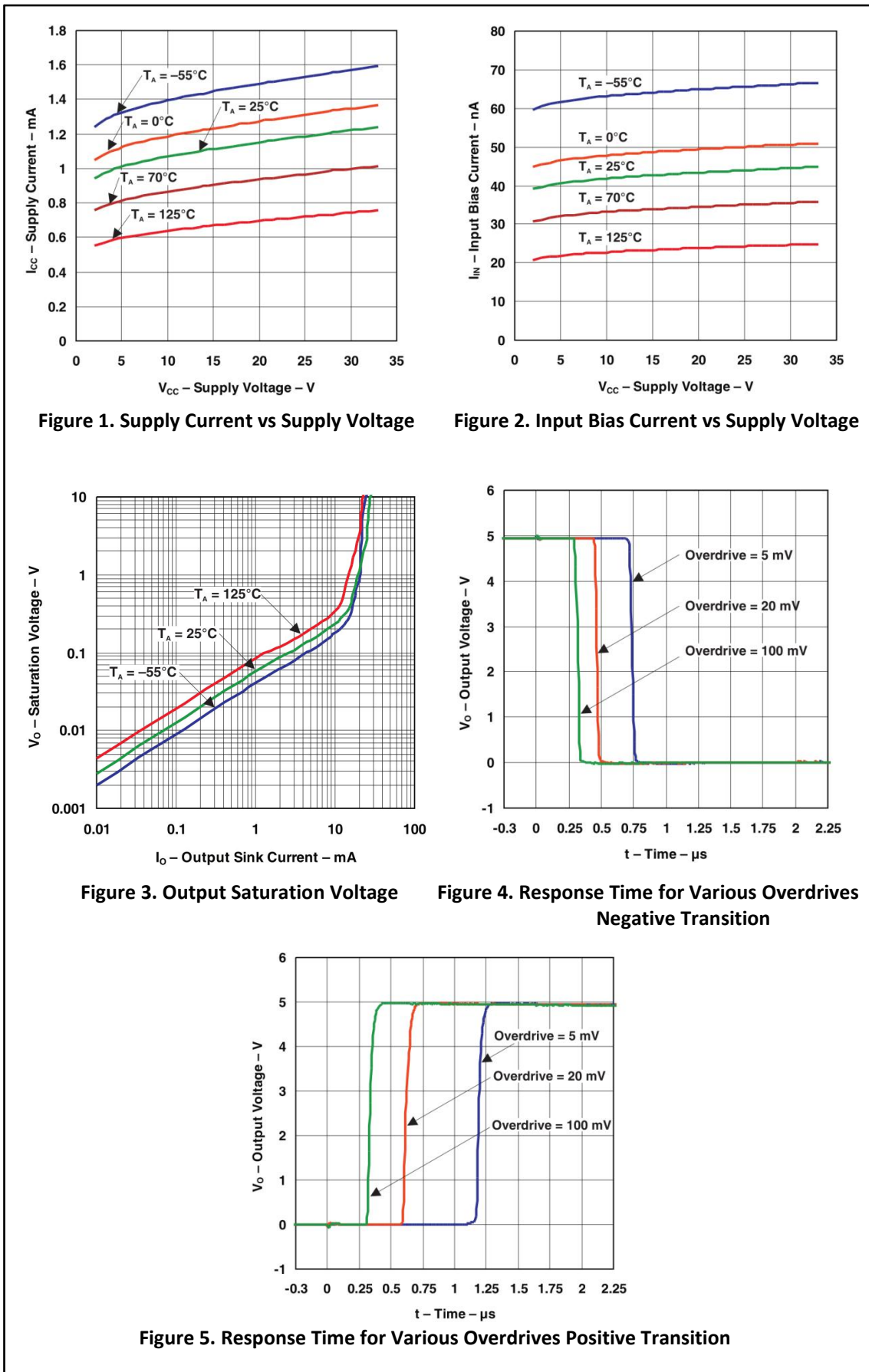
## 6.8. Switching Characteristics

$V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS		XL2903, XL293, XL393		UNIT
			TYP		
Response time	$R_i$ connected to $5\text{ V}$ through $5.1\text{ k}\Omega$ . $C_L = 15\text{ pF}^{(1)(2)}$	100-mV input step with 5-mV	1.3		$\mu\text{s}$
		TTL-level input step	0.3		

- [1]  $C_L$  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  $1.4\text{ V}$ .

### 6.9. Typical Characteristics





## 7. Detailed Description

### 7.1. Overview

The XL2903 is a dual comparator with the ability to operate up to 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 to 36 V), low Iq and fast response of the devices.

The open-drain output allows the user to configure the output's logic low voltage ( $V_{OL}$ ) and can be used to enable the comparator to be used in AND functionality.

XL2903 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 XL2903 to accurately function from ground to VCC-1.5V differential input. This enables much head room for modern day supplies of 3.3V and 5V.

The output consists of an open drain NPN (pull-down or low side) transistor. The output NPN will sink current when the positive input voltage is higher than the negative input voltage and the offset voltage. The  $V_{OL}$  is resistive and will scale with the output current. See Figure 3 for  $V_{OL}$  values with respect to the output current.

## 8. Device Functional Modes

### 8.1. Voltage Comparison

The XL2903 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 pull up) based on the input differential polarity.

## 9. Application and Implementation

### 9.1. Application Information

XL2903 will typically be used to compare a single signal to a reference or two signals against each other. 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 LM2903 optimal for level shifting to a higher or lower voltage.

### 9.2. Typical Application

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

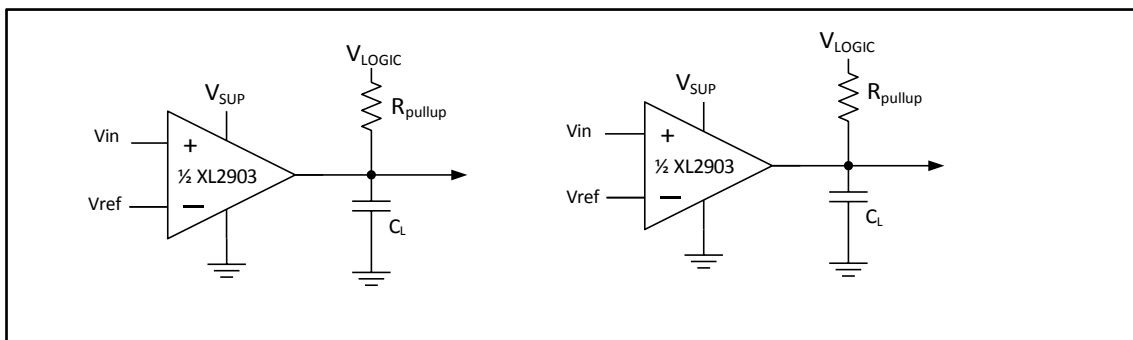


Figure 7. Single-Ended and Differential Comparator Configurations

### 9.2.1. Design Requirements

**Table 1. Design Parameters**

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0V to $V_{sup}-1.5\text{ V}$
Supply Voltage	2 V to 36 V
Logic Supply Voltage	2 V to 36 V
Output Current (R <sub>PULLUP</sub> )	1 $\mu\text{A}$ to 20 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance (C <sub>L</sub> )	15 pF

### 9.2.2. Detailed Design Procedure

When using XL2903 in a general comparator application, determine the following:

- Input Voltage Range
- Minimum Overdrive Voltage
- Output and Drive Current
- Response Time

### 9.2.3. 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  $V_{CC} \sim 2.0\text{ V}$ . This limits the input voltage range to as high as  $V_{CC} - 2.0\text{ V}$  and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

Below is a list of input voltage situation and their outcomes:

- (1) When both IN- and IN+ are both within the common-mode range:
  - a. If IN- is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current.
  - b. If IN- is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting.
- (2) When IN- is higher than common-mode and IN+ is within common-mode, the output is low and the output transistor is sinking current.
- (3) 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.
- (4) When IN- and IN+ are both higher than common-mode, the output is low and the output transistor is sinking current.

### 9.2.4. Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage ( $V_{IO}$ ). In order to make an accurate comparison the Overdrive Voltage ( $V_{OD}$ ) should 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 8 and Figure 9 show positive and negative response times with respect to overdrive voltage.

### 9.2.5. Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pullup voltage. The output current will produce a output low voltage ( $V_{OL}$ ) from the comparator. In which  $V_{OL}$  is proportional to the output current. Use Typical Characteristics to determine  $V_{OL}$  based on the output current.

The output current can also effect the transient response. See Response Time for more information.

### 9.2.6. Response Time

The transient response can be determined by the load capacitance ( $C_L$ ), load/pullup resistance ( $R_{pullup}$ ) and equivalent collector-emitter resistance ( $R_{CE}$ ).

- The positive response time ( $t_P$ ) is approximately  $t_P \sim R_{PULLUP} \times C_L$
- The negative response time ( $t_N$ ) is approximately  $t_N \sim R_{CE} \times C_L$

-Rce can be determine by taking the slope of Typical Characteristics in it's linear region at the desired temperature, or by dividing the  $V_{OL}$  by  $I_{out}$ .

## 9.3. Application Curves

The following curves were generated with 5V on  $V_{CC}$  and  $V_{Logic}$ ,  $R_{PULLUP} = 5.1 \text{ k}\Omega$ , and 50 pF scope probe.

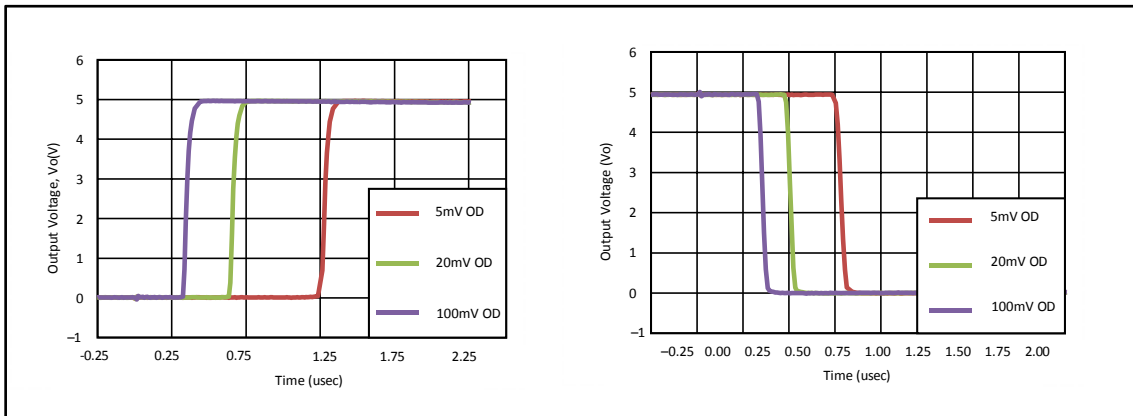


Figure 8. Response Time for Various Overdrives (Positive Transition)

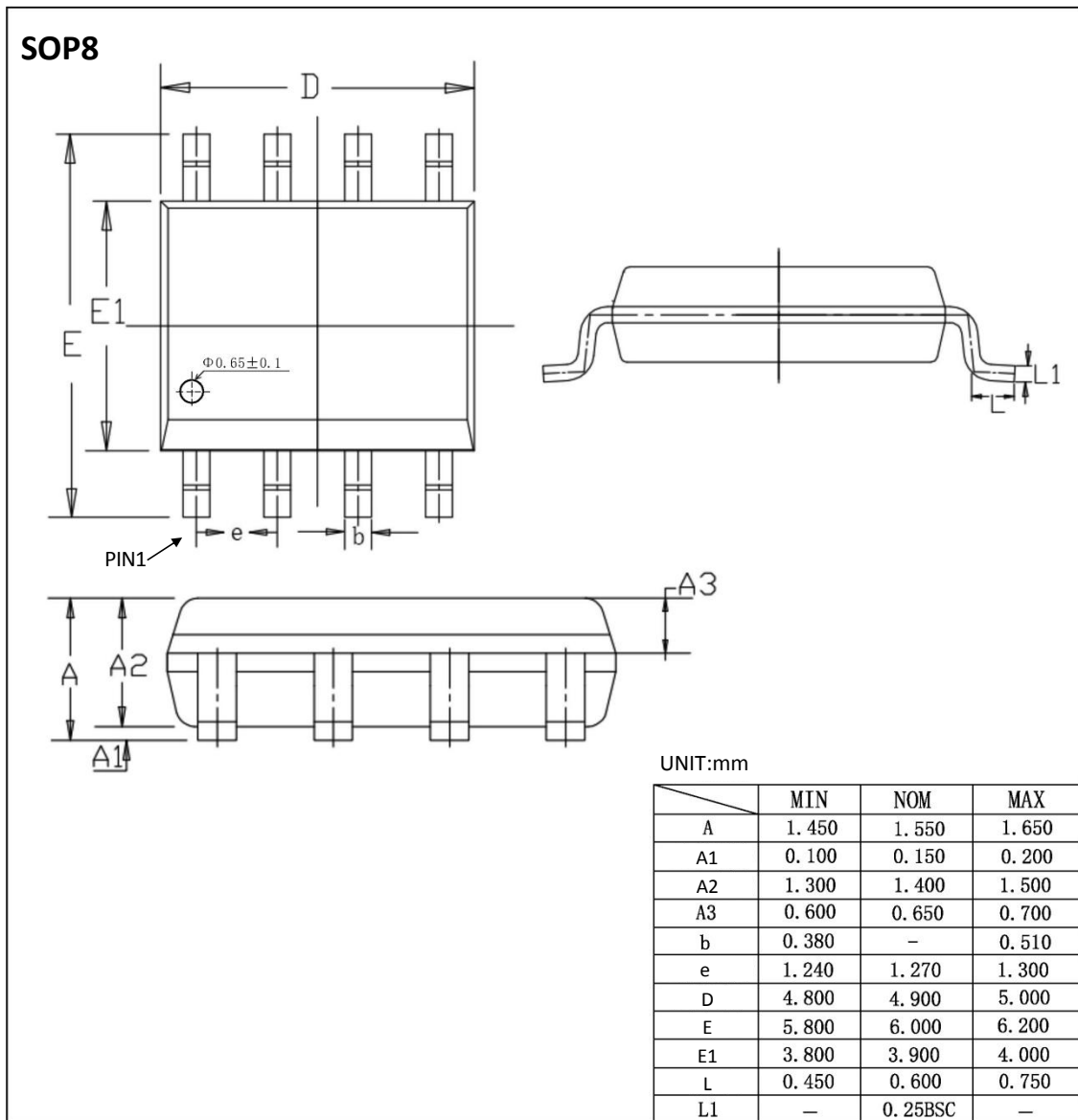
Figure 9. Response Time for Various Overdrives (Negative Transition)

## 10. ORDERING INFORMATION

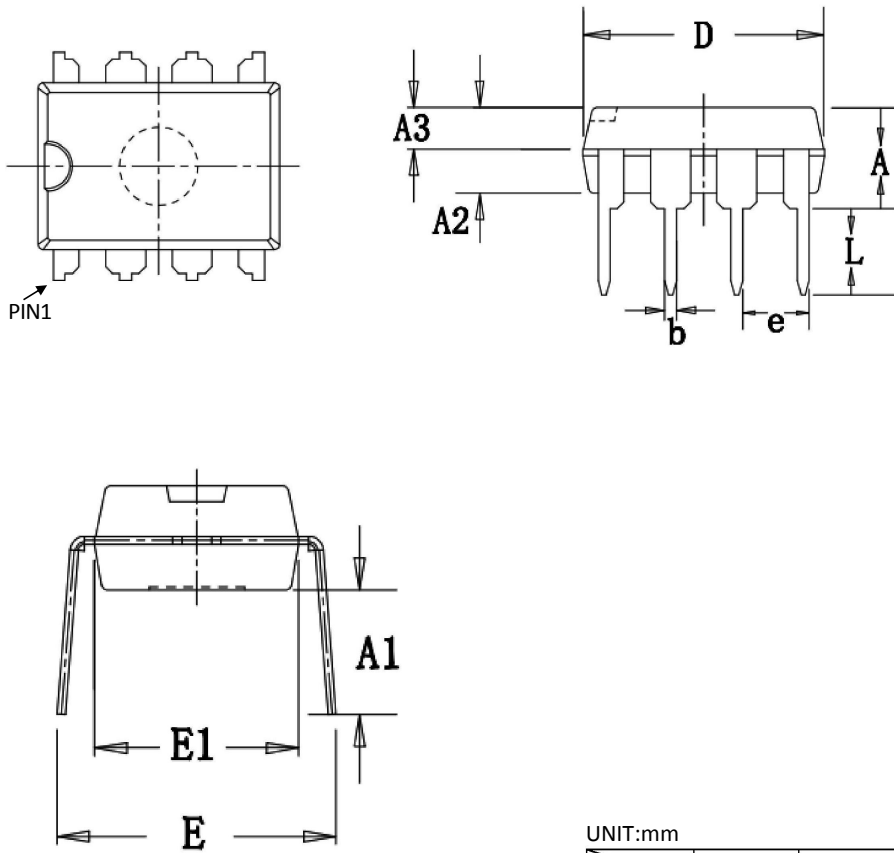
Ordering Information

Part Number	Device Marking	Package Type	Body size (mm)	Temperature (°C)	MSL	Transport Media	Package Quantity
XL293D-8	XL293D-8	SOP8	4.90 * 3.90	-25 to +85	MSL3	T&R	2500
XD293-KR	XD293-KR	VSSOP8	3.00 * 4.90	-25 to +85	MSL3	T&R	2500
XL293-TS	XL293-TS	TSSOP8	3.00 * 4.40	-25 to +85	MSL3	T&R	2500
XD293-8	XD293-8	DIP8	9.25 * 6.38	-25 to +85	MSL3	Tube 50	2000
XL393	XL393	SOP8	4.90 * 3.90	0 to +70	MSL3	T&R	2500
XL393-KR	XL393-KR	VSSOP8	3.00 * 4.90	0 to +70	MSL3	T&R	2500
XL393-TS	XL393-TS	TSSOP8	3.00 * 4.40	0 to +70	MSL3	T&R	2500
XD393	XD393	DIP8	9.25 * 6.38	0 to +70	MSL3	Tube 50	2000
XL2903	XL2903	SOP8	4.90 * 3.90	-40 to +125	MSL3	T&R	2500
XL2903-KR	XL2903-KR	VSSOP8	3.00 * 4.90	-40 to +125	MSL3	T&R	2500
XL2903-TS	XL2903-TS	TSSOP8	3.00 * 4.40	-40 to +125	MSL3	T&R	2500
XD2903	XD2903	DIP8	9.25 * 6.38	-40 to +125	MSL3	Tube 50	2000

### 11. DIMENSIONAL DRAWINGS



**DIP8**

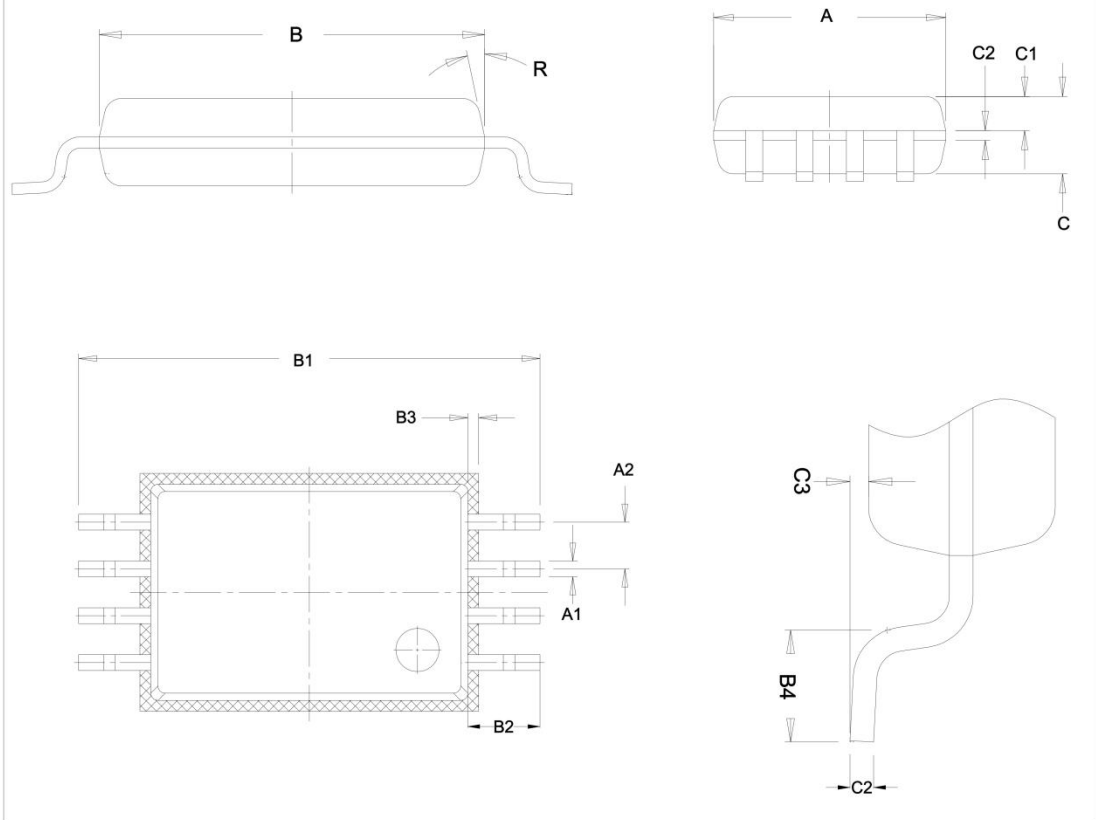


UNIT:mm

	MIN	NOM	MAX
A	3.600	3.800	4.000
A1	3.786	3.886	3.986
A2	3.200	3.300	3.400
A3	1.550	1.600	1.650
b	0.440	—	0.490
e	2.510	2.540	2.570
D	9.150	9.250	9.350
E	7.800	8.500	9.200
E1	6.280	6.380	6.480
L	3.000	—	—

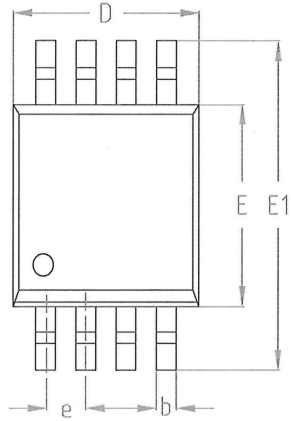
### TSSOP8

Size Mark	MIN (mm)	NOM (mm)	MAX (mm)	Size Mark	MIN (mm)	NOM (mm)	MAX (mm)
A	2.95	3.00	3.05	B4	0.50	0.60	0.70
A1		0.22		C	0.95	1.00	1.05
A2	0.63	0.65	0.68	C1	0.39	0.44	0.49
B	4.35	4.40	4.45	C2		0.127	
B1	6.30	6.40	6.50	C3	0.05	0.10	0.15
B2	0.90	1.00	1.10	R		12°	
B3			0.12				

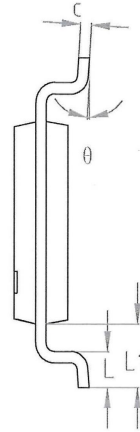


**VSSOP8**

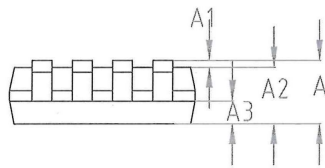
TOP VIEW



SIDE VIEW



SIDE VIEW



Dimensions			
SYMBOL	MIN	NOM	MAX
A	-	-	1.10
A1	0.05	-	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.28	-	0.36
c	0.15	-	0.19
D	2.90	3.00	3.10
E	2.90	3.00	3.10
E1	4.70	4.90	5.10
e	0.65 BSC		
L1	0.95 REF		
L	0.40	-	0.70
θ	0°	-	8°



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[E2-A](#) [UPC458G2-E1-A](#) [UPC824G2-E2-A](#) [UPC4574G2-E2-A](#) [UPC4558G2-E2-A](#) [UPC4560G2-E1-A](#) [UPC258G2-E1-A](#) [UPC4742GR-9LG-](#)  
[E1-A](#) [UPC4742G2-E1-A](#) [UPC832G2-E2-A](#) [UPC842G2-E1-A](#) [UPC802G2-E1-A](#) [UPC4741G2-E2-A](#) [UPC4572G2-E2-A](#) [UPC844GR-9LG-](#)  
[E2-A](#) [UPC259G2-E1-A](#) [UPC4741G2-E1-A](#) [UPC4558G2-E1-A](#) [UPC1251GR-9LG-E1-A](#) [UPC4744G2-E1-A](#) [UPC4092G2-E1-A](#)  
[UPC4574G2-E1-A](#) [UPC4062G2-E2-A](#) [UPC451G2-E2-A](#) [UPC832G2-E1-A](#) [UPC844GR-9LG-E1-A](#)