

# Low Offset Voltage Dual Comparators

The LM393 series are dual independent precision voltage comparators capable of single or split supply operation. These devices are designed to permit a common mode range—to—ground level with single supply operation. Input offset voltage specifications as low as 2.0 mV make this device an excellent selection for many applications in consumer automotive, and industrial electronics.

• Wide Single-Supply Range: 2.0 Vdc to 36 Vdc

• Split–Supply Range: ±1.0 Vdc to ±18 Vdc

Very Low Current Drain Independent of Supply Voltage: 0.4 mA

Low Input Bias Current: 25 nALow Input Offset Current: 5.0 nA

• Low Input Offset Voltage: 2.0 mV (max) LM393A

5.0 mV (max) LM293/393

• Input Common Mode Range to Ground Level

• Differential Input Voltage Range Equal to Power Supply Voltage

 Output Voltage Compatible with DTL, ECL, TTL, MOS, and CMOS Logic Levels

 ESD Clamps on the Inputs Increase the Ruggedness of the Device without Affecting Performance

## LM393, LM393A, LM293, LM2903, LM2903V

# SINGLE SUPPLY, LOW POWER DUAL COMPARATORS

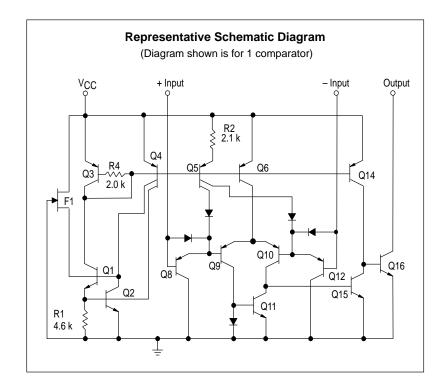
SEMICONDUCTOR TECHNICAL DATA

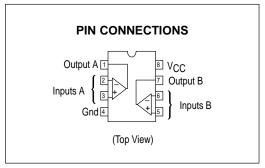


N SUFFIX PLASTIC PACKAGE CASE 626



D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO-8)





#### **ORDERING INFORMATION**

Device	Operating Temperature Range	Package
LM293D	$T_A = -25^{\circ} \text{ to } +85^{\circ}\text{C}$	SO-8
LM393D	T 0° to 170°C	SO–8
LM393AN,N	$T_A = 0^\circ \text{ to } +70^\circ \text{C}$	Plastic DIP
LM2903D	$T_A = -40^{\circ} \text{ to } +105^{\circ}\text{C}$	SO-8
LM2903N	1A = -40 to +103 C	Plastic DIP
LM2903VD	T. 40% to 1405%C	SO-8
LM2903VN	$T_A = -40^{\circ} \text{ to } +105^{\circ}\text{C}$	Plastic DIP

#### **MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Power Supply Voltage	Vcc	+36 or ±18	Vdc
Input Differential Voltage Range	V <sub>IDR</sub>	36	Vdc
Input Common Mode Voltage Range	VICR	-0.3 to +36	Vdc
Output Short Circuit–to–Ground Output Sink Current (Note 1)	I <sub>SC</sub> I <sub>Sink</sub>	Continuous 20	mA
Power Dissipation @ T <sub>A</sub> = 25°C Derate above 25°C	P <sub>D</sub> 1/R <sub>θ</sub> JA	570 5.7	mW mW/°C
Operating Ambient Temperature Range LM293 LM393, 393A LM2903 LM2903V	TA	-25 to +85 0 to +70 -40 to +105 -40 to +125	°C
Maximum Operating Junction Temperature LM393, 393A, 2903, LM2903V LM293	T <sub>J(max)</sub>	125 150	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C

 $\textbf{ELECTRICAL CHARACTERISTICS} \ \ (\text{V}_{CC} = 5.0 \ \text{Vdc}, \ \ T_{low} \leq T_{A} \leq T_{high}, \ \ ^{\star} \ \, \text{unless otherwise noted.})$ 

Characteristic	Symbol	Min	Тур	Max	Unit
Input Offset Voltage (Note 2)	VIO				mV
$T_A = 25$ °C		_	±1.0	±2.0	
$T_{low} \le T_A \le T_{high}$		_	-	4.0	
Input Offset Current	IIO				nA
$T_A = 25$ °C		_	±50	±50	
$T_{low} \le T_A \le T_{high}$		-	-	±150	
Input Bias Current (Note 3)	I <sub>IB</sub>				nA
$T_A = 25$ °C		_	25	250	
$T_{low} \le T_A \le T_{high}$		_	-	400	
Input Common Mode Voltage Range (Note 4)	VICR				V
$T_A = 25$ °C		0	-	V <sub>CC</sub> -1.5	
$T_{low} \le T_A \le T_{high}$		0	_	V <sub>CC</sub> -2.0	
Voltage Gain R <sub>L</sub> $\geq$ 15 k $\Omega$ , V <sub>CC</sub> = 15 Vdc, T <sub>A</sub> = 25°C	AVOL	50	200	_	V/mV
Large Signal Response Time	_	_	300	_	ns
V <sub>in</sub> = TTL Logic Swing, V <sub>ref</sub> = 1.4 Vdc					
$V_{RL} = 5.0 \text{ Vdc}, R_{L} = 5.1 \text{ k}\Omega, T_{A} = 25^{\circ}\text{C}$					
Response Time (Note 5) $V_{RL}$ = 5.0 Vdc, $R_L$ = 5.1 k $\Omega$ , $T_A$ = 25°C	tTLH	-	1.3	_	μs
Input Differential Voltage (Note 6)	V <sub>ID</sub>	_	-	Vcc	V
All $V_{in} \ge Gnd$ or $V-Supply$ (if used)					
Output Sink Current	I <sub>Sink</sub>	6.0	16	-	mA
$V_{in} \ge 1.0 \text{ Vdc}, V_{in+} = 0 \text{ Vdc}, V_O \le 1.5 \text{ Vdc}, T_A = 25^{\circ}\text{C}$					
Output Saturation Voltage	V <sub>OL</sub>				mV
$V_{in} \ge 1.0 \text{ Vdc}$ , $V_{in+} = 0 \text{ Vdc}$ , $I_{Sink} \le 4.0 \text{ mA}$ , $T_A = 25^{\circ}\text{C}$		-	150	400	
$T_{low} \le T_A \le T_{high}$			_	700	

 $<sup>^*</sup>T_{low} = 0^{\circ}C$ ,  $T_{high} = +70^{\circ}C$  for LM393/393A

NOTES: 1. The maximum output current may be as high as 20 mA, independent of the magnitude of V<sub>CC</sub>, output short circuits to V<sub>CC</sub> can cause excessive heating and eventual destruction.

- 2. At output switch point, V<sub>O</sub>=1.4 Vdc, R<sub>S</sub> = 0 Ω with V<sub>CC</sub> from 5.0 Vdc to 30 Vdc, and over the full input common mode range (0 V to V<sub>CC</sub> = -1.5 V).

  3. Due to the PNP transistor inputs, bias current will flow out of the inputs. This current is essentially constant, independent of the output state, there fore, no loading changes will exist on the input lines.
- 4. Input common mode of either input should not be permitted to go more than 0.3 V negative of ground or minus supply. The upper limit of common 5. Response time is specified with a 100 mV step and 5.0 mV of overdrive. With larger magnitudes of overdrive faster response times are obtainable.
- 6. The comparator will exhibit proper output state if one of the inputs becomes greater than V<sub>CC</sub>, the other input must remain within the common mode range. The low input state must not be less than -0.3 V of ground or minus supply.

 $\textbf{ELECTRICAL CHARACTERISTICS} \ \ (\text{V}_{CC} = 5.0 \ \text{Vdc}, \ \ \text{T}_{low} \leq \text{T}_{high}, \ \ ^{\star} \ \, \text{unless otherwise noted.})$ 

		LM393A			
Characteristic	Symbol	Min	Тур	Max	Unit
Output Leakage Current	lOL				μΑ
$V_{in-} = 0 \text{ V}, V_{in+} \ge 1.0 \text{ Vdc}, V_{O} = 5.0 \text{ Vdc}, T_{A} = 25^{\circ}\text{C}$		_	0.1	_	
$V_{in-} = 0 \text{ V}, V_{in+} \ge 1.0 \text{ Vdc}, V_{O} = 30 \text{ Vdc}, T_{low} \le T_{A} \le T_{high}$		_	_	1.0	
Supply Current	Icc				mA
R <sub>L</sub> = ∞ Both Comparators, T <sub>A</sub> = 25°C		_	0.4	1.0	
R <sub>L</sub> = ∞ Both Comparators, V <sub>CC</sub> = 30 V		_	1.0	2.5	

### $\textbf{ELECTRICAL CHARACTERISTICS} \quad (V_{CC} = 5.0 \text{ Vdc}, \text{ T}_{low} \leq \text{T}_{A} \leq \text{T}_{high}, \text{ unless otherwise noted.})$

		LM392, LM393		LM2903, LM2903V		M2903V		
Characteristic	Symbol	Min	Тур	Max	Min	Тур	Max	Unit
Input Offset Voltage (Note 2) $T_{A} = 25^{\circ}C$ $T_{low} \le T_{A} \le T_{high}$	V <sub>IO</sub>	_ _	±1.0 –	±5.0 9.0	_ _	±2.0 9.0	±7.0 15	mV
Input Offset Current $T_{A} = 25^{\circ}C$ $T_{low} \leq T_{A} \leq T_{high}$	I <sub>IO</sub>	_ _	±5.0 –	±50 ±150	-	±5.0 ±50	±50 ±200	nA
Input Bias Current (Note 3) $T_A = 25^{\circ}C$ $T_{low} \le T_A \le T_{high}$	I <sub>IB</sub>	_ _	25 -	250 400	1 1	25 200	250 500	nA
Input Common Mode Voltage Range (Note 3) $T_A = 25^{\circ}C$ $T_{low} \le T_A \le T_{high}$	VICR	0	1 1	V <sub>CC</sub> -1.5 V <sub>CC</sub> -2.0	0		V <sub>CC</sub> -1.5 V <sub>CC</sub> -2.0	V
Voltage Gain $R_L \ge 15 \text{ k}\Omega$ , $V_{CC} = 15 \text{ Vdc}$ , $T_A = 25^{\circ}\text{C}$	AVOL	50	200	_	25	200	_	V/mV
Large Signal Response Time $V_{in}$ = TTL Logic Swing, $V_{ref}$ = 1.4 Vdc $V_{RL}$ = 5.0 Vdc, $R_L$ = 5.1 k $\Omega$ , $T_A$ = 25°C	-	_	300	-	_	300	-	ns
Response Time (Note 5) $V_{RL} = 5.0 \text{ Vdc}, R_L = 5.1 \text{ k}\Omega, T_A = 25^{\circ}\text{C}$	tTLH	_	1.3	-	-	1.5	-	μs
Input Differential Voltage (Note 6)  All V <sub>in</sub> ≥ Gnd or V− Supply (if used)	VID	_	_	VCC	_	-	VCC	V
Output Sink Current $V_{in} \ge 1.0 \text{ Vdc}, V_{in+} = 0 \text{ Vdc}, V_O \le 1.5 \text{ Vdc } T_A = 25^{\circ}C$	l <sub>Sink</sub>	6.0	16	-	6.0	16	-	mA
Output Saturation Voltage $V_{in} \geq 1.0 \text{ Vdc, } V_{in+} = 0, \text{ I}_{Sink} \leq 4.0 \text{ mA, T}_{A} = 25^{\circ}\text{C}$ $T_{low} \leq T_{A} \leq T_{high}$	VOL	_ _	150 –	400 700	_	_ 200	400 700	mV
Output Leakage Current $V_{in-} = 0 \text{ V}, V_{in+} \ge 1.0 \text{ Vdc}, V_O = 5.0 \text{ Vdc}, T_A = 25^{\circ}\text{C}$ $V_{in-} = 0 \text{ V}, V_{in+} \ge 1.0 \text{ Vdc}, V_O = 30 \text{ Vdc},$	lOL	-	0.1	-	_	0.1	-	nA
$T_{low} \le T_A \le T_{high}$ Supply Current $R_L = \infty$ Both Comparators, $T_A = 25^{\circ}C$ $R_L = \infty$ Both Comparators, $V_{CC} = 30 \text{ V}$	Icc	_ _ _	0.4	1.0 2.5		0.4 –	1.0 2.5	mA

 $<sup>^*</sup>T_{low} = 0^{\circ}C, T_{high} = +70^{\circ}C \text{ for LM393/393A} \\ \text{LM293 T}_{low} = -25^{\circ}C, T_{high} = +85^{\circ}C \\ \text{LM2903 T}_{low} = -40^{\circ}C, T_{high} = +105^{\circ}C \\ \text{LM2903V T}_{low} = -40^{\circ}C, T_{high} = +125^{\circ}C \\ \text{LM2903V T}_{low} = -40^{\circ}C, T_{high} = -40^{\circ}C, T_{high} = +125^{\circ}C \\ \text{LM2903V T}_{low} = -40^{\circ}C, T_{high} = -40^{\circ}C, T_{hi$ 

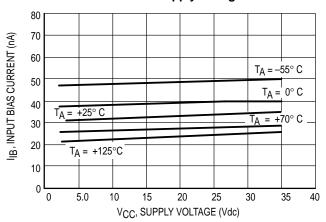
**NOTES:** 2. At output switch point,  $V_O \approx 1.4$  Vdc,  $R_S = 0$   $\Omega$  with  $V_{CC}$  from 5.0 Vdc to 30 Vdc, and over the full input common mode range (0 V to  $V_{CC} = -1.5$  V). 3. Due to the PNP transistor inputs, bias current will flow out of the inputs. This current is essentially constant, independent of the output state, there fore, no loading changes will exist on the input lines.

<sup>5.</sup> Response time is specified with a 100 mV step and 5.0 mV of overdrive. With larger magnitudes of overdrive faster response times are obtainable.

<sup>6.</sup> The comparator will exhibit proper output state if one of the inputs becomes greater than V<sub>CC</sub>, the other input must remain within the common mode range. The low input state must not be less than -0.3 V of ground or minus supply.

#### LM293/393,A

Figure 1. Input Bias Current versus Power Supply Voltage



LM2903

Figure 2. Input Bias Current versus Power Supply Voltage

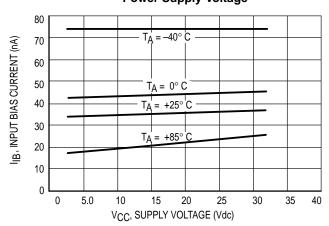


Figure 3. Output Saturation Voltage versus Output Sink Current

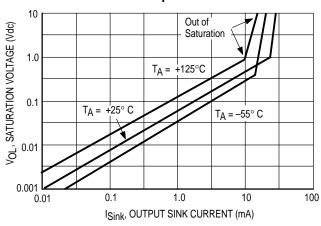


Figure 4. Output Saturation Voltage versus Output Sink Current

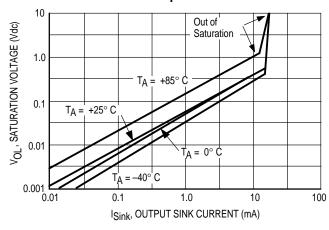


Figure 5. Power Supply Current versus
Power Supply Voltage

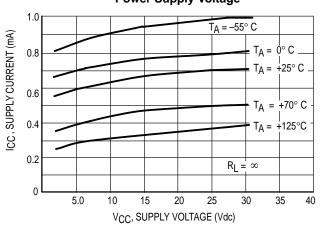
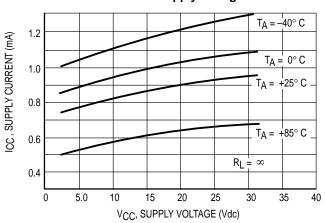


Figure 6. Power Supply Current versus
Power Supply Voltage



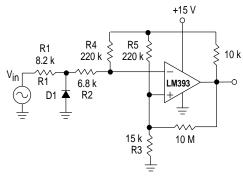
#### LM393, LM393A, LM293, LM2903, LM2903V APPLICATIONS INFORMATION

These dual comparators feature high gain, wide bandwidth characteristics. This gives the device oscillation tendencies if the outputs are capacitively coupled to the inputs via stray capacitance. This oscillation manifests itself during output transitions ( $V_{OL}$  to  $V_{OH}$ ). To alleviate this situation, input resistors <10 k $\Omega$  should be used.

The addition of positive feedback (<10 mV) is also recommended. It is good design practice to ground all unused pins.

Differential input voltages may be larger than supply voltage without damaging the comparator's inputs. Voltages more negative than -0.3 V should not be used.

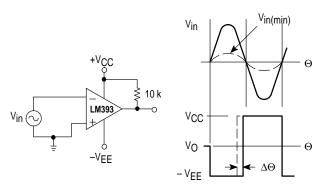
Figure 7. Zero Crossing Detector (Single Supply)



D1 prevents input from going negative by more than  $\,$  0.6 V.

$$R1 + R2 = R3$$
 
$$R3 \le \frac{R5}{10} \text{ for small error in zero crossing.}$$

Figure 8. Zero Crossing Detector (Split Supply)



 $V_{in(min)} \approx 0.4 \text{ V}$  peak for 1% phase distortion ( $\Delta\Theta$ ).

Figure 9. Free-Running Square-Wave Oscillator

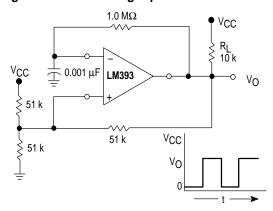


Figure 10. Time Delay Generator

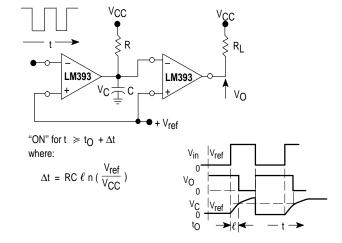
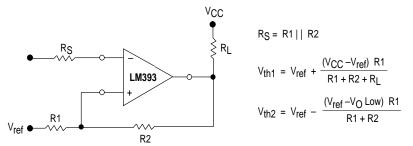
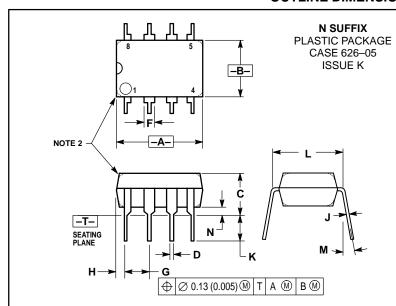


Figure 11. Comparator with Hysteresis

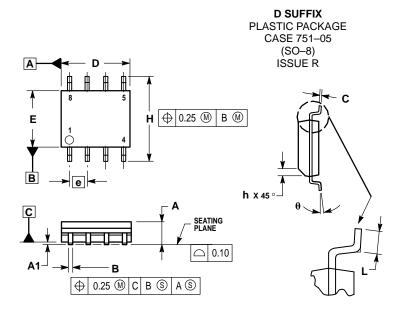


#### **OUTLINE DIMENSIONS**



- DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
   PACKAGE CONTOUR OPTIONAL (ROUND OR
- SQUARE CORNERS).
  3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

	MILLIN	METERS	INC	HES
DIM	MIN	MAX	MIN	MAX
Α	9.40	10.16	0.370	0.400
В	6.10	6.60	0.240	0.260
С	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100	BSC
Н	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300	BSC
М		10°		10°
N	0.76	1.01	0.030	0.040



#### NOTES

- 1. DIMENSIONING AND TOLERANCING PER ASME
- Y14.5M, 1994. DIMENSIONS ARE IN MILLIMETERS.
- DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
- MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
  DIMENSION B DOES NOT INCLUDE MOLD
- PROTRUSION. ALLOWABLE DAMBAR
  PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION

	MILLIMETERS			
DIM	MIN	MAX		
Α	1.35	1.75		
A1	0.10	0.25		
В	0.35	0.49		
С	0.18	0.25		
D	4.80	5.00		
Е	3.80	4.00		
е	1.27	1.27 BSC		
Н	5.80	6.20		
h	0.25	0.50		
Ĺ	0.40	1.25		
θ	0°	7 °		

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