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MOTOROLA

LM393, LM393A, LM293, LM2903, LM2903V

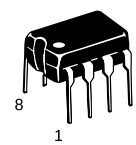
Low Offset Voltage Dual Comparators

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.

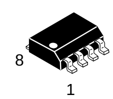
- Wide Single–Supply Range: 2.0 Vdc to 36 Vdc
- Split–Supply Range: ±1.0 Vdc to ±18 Vdc
- Very Low Current Drain Independent of Supply Voltage: 0.4 mA
- Low Input Bias Current: 25 nA
- Low Input Offset Current: 5.0 nA
- Low Input Offset Voltage: 2.0 mV (max) LM393A
5.0 mV (max) LM293/393
- Input Common 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

SINGLE SUPPLY, LOW POWER DUAL COMPARATORS

SEMICONDUCTOR TECHNICAL DATA



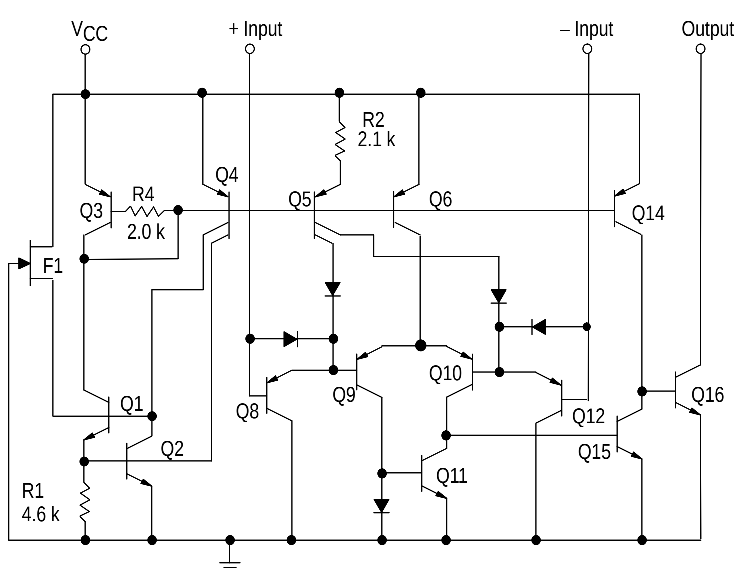
N SUFFIX
PLASTIC PACKAGE
CASE 626



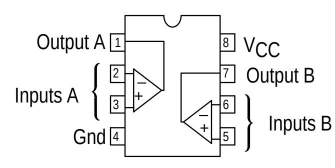
D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO–8)

Representative Schematic Diagram

(Diagram shown is for 1 comparator)



PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM293D	T_A = –25° to +85°C	SO–8
LM393D	T_A = 0° to +70°C	SO–8
LM393AN,N		Plastic DIP
LM2903D	T_A = –40° to +105°C	SO–8
LM2903N		Plastic DIP
LM2903VD	T_A = –40° to +125°C	SO–8
LM2903VN		Plastic DIP

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	+36 or ±18	Vdc
Input Differential Voltage Range	V_{IDR}	36	Vdc
Input Common Mode Voltage Range	V_{ICR}	–0.3 to +36	Vdc
Output Short Circuit–to–Ground Output Sink Current (Note 1)	I_{SC} I_{Sink}	Continuous 20	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D $1/R_{\theta JA}$	570 5.7	mW mW/°C
Operating Ambient Temperature Range LM293 LM393, 393A LM2903 LM2903V	T_A	 –25 to +85 0 to +70 –40 to +105 –40 to +125	°C
Maximum Operating Junction Temperature LM393, 393A, 2903, LM2903V LM293	$T_{J(max)}$	 125 150	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 Vdc, $T_{low} \le T_A \le T_{high}$,* unless otherwise noted.)

Characteristic	Symbol	LM393A			Unit
		Min	Typ	Max	
Input Offset Voltage (Note 2) T_A = 25°C $T_{low} \le T_A \le T_{high}$	V_{IO}	 – –	 ±1.0 –	 ±2.0 4.0	mV
Input Offset Current T_A = 25°C $T_{low} \le T_A \le T_{high}$	I_{IO}	 – –	 ±50 –	 ±50 ±150	nA
Input Bias Current (Note 3) T_A = 25°C $T_{low} \le T_A \le T_{high}$	I_{IB}	 – –	 25 –	 250 400	nA
Input Common Mode Voltage Range (Note 4) T_A = 25°C $T_{low} \le T_A \le T_{high}$	V_{ICR}	 0 0	 – –	 V_{CC} –1.5 V_{CC} –2.0	V
Voltage Gain $R_L \ge$ 15 kΩ, V_{CC} = 15 Vdc, T_A = 25°C	A_{VOL}	50	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 kΩ, T_A = 25°C	–	–	300	–	ns
Response Time (Note 5) V_{RL} = 5.0 Vdc, R_L = 5.1 kΩ, T_A = 25°C	t_{TLH}	–	1.3	–	µs
Input Differential Voltage (Note 6) All $V_{in} \ge$ Gnd or V– Supply (if used)	V_{ID}	–	–	V_{CC}	V
Output Sink Current $V_{in-} \ge$ 1.0 Vdc, V_{in+} = 0 Vdc, $V_O \le$ 1.5 Vdc, T_A = 25°C	I_{Sink}	6.0	16	–	mA
Output Saturation Voltage $V_{in} \ge$ 1.0 Vdc, V_{in+} = 0 Vdc, $I_{Sink} \le$ 4.0 mA, T_A = 25°C $T_{low} \le T_A \le T_{high}$	V_{OL}	 – –	 150 –	 400 700	mV

*T_{low} = 0°C, T_{high} = +70°C for LM393/393A

NOTES:
1. The maximum output current may be as high as 20 mA, independent of the magnitude of V_{CC}, output short circuits to V_{CC} can cause excessive heating and eventual destruction.
2. At output switch point, $V_O \simeq$ 1.4 Vdc, R_S = 0 Ω 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.
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 mode range is V_{CC} –1.5 V.
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_{CC}, 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.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 Vdc, $T_{low} \le T_A \le T_{high}$,* unless otherwise noted.)

Characteristic	Symbol	LM393A			Unit
		Min	Typ	Max	
Output Leakage Current	I_{OL}				μA
V_{in-} = 0 V, $V_{in+} \ge$ 1.0 Vdc, V_O = 5.0 Vdc, T_A= 25°C		–	0.1	–	
V_{in-} = 0 V, $V_{in+} \ge$ 1.0 Vdc, V_O = 30 Vdc, $T_{low} \le T_A \le T_{high}$		–	–	1.0	
Supply Current	I_{CC}				mA
$R_L = \infty$ Both Comparators, T_A = 25°C		–	0.4	1.0	
$R_L = \infty$ Both Comparators, V_{CC} = 30 V		–	1.0	2.5	

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 Vdc, $T_{low} \le T_A \le T_{high}$, unless otherwise noted.)

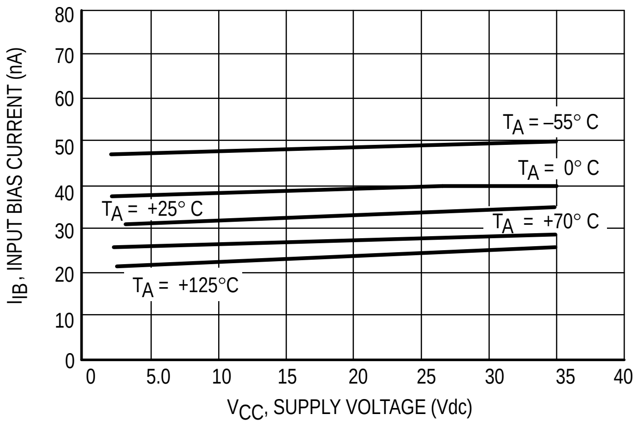
Characteristic	Symbol	LM392, LM393			LM2903, LM2903V			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage (Note 2)	V_{IO}							mV
T_A = 25°C		–	±1.0	±5.0	–	±2.0	±7.0	
$T_{low} \le T_A \le T_{high}$		–	–	9.0	–	9.0	15	
Input Offset Current	I_{IO}							nA
T_A = 25°C		–	±5.0	±50	–	±5.0	±50	
$T_{low} \le T_A \le T_{high}$		–	–	±150	–	±50	±200	
Input Bias Current (Note 3)	I_{IB}							nA
T_A = 25°C		–	25	250	–	25	250	
$T_{low} \le T_A \le T_{high}$		–	–	400	–	200	500	
Input Common Mode Voltage Range (Note 3)	V_{ICR}							V
T_A = 25°C		0	–	V_{CC} –1.5	0	–	V_{CC} –1.5	
$T_{low} \le T_A \le T_{high}$		0	–	V_{CC} –2.0	0	–	V_{CC} –2.0	
Voltage Gain $R_L \ge$ 15 kΩ, V_{CC} = 15 Vdc, T_A = 25°C	A_{VOL}	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 kΩ, T_A = 25°C	–	–	300	–	–	300	–	ns
Response Time (Note 5) V_{RL} = 5.0 Vdc, R_L = 5.1 kΩ, T_A = 25°C	t_{TLH}	–	1.3	–	–	1.5	–	μs
Input Differential Voltage (Note 6) All $V_{in} \ge$ Gnd or V– Supply (if used)	V_{ID}	–	–	V_{CC}	–	–	V_{CC}	V
Output Sink Current $V_{in} \ge$ 1.0 Vdc, V_{in+} = 0 Vdc, $V_O \le$ 1.5 Vdc T_A = 25°C	I_{Sink}	6.0	16	–	6.0	16	–	mA
Output Saturation Voltage	V_{OL}							mV
$V_{in} \ge$ 1.0 Vdc, V_{in+} = 0, $I_{Sink} \le$ 4.0 mA, T_A = 25°C		–	150	400	–	–	400	
$T_{low} \le T_A \le T_{high}$		–	–	700	–	200	700	
Output Leakage Current	I_{OL}							nA
V_{in-} = 0 V, $V_{in+} \ge$ 1.0 Vdc, V_O = 5.0 Vdc, T_A = 25°C		–	0.1	–	–	0.1	–	
V_{in-} = 0 V, $V_{in+} \ge$ 1.0 Vdc, V_O = 30 Vdc, $T_{low} \le T_A \le T_{high}$		–	–	1000	–	–	1000	
Supply Current	I_{CC}							mA
$R_L = \infty$ Both Comparators, T_A = 25°C		–	0.4	1.0	–	0.4	1.0	
$R_L = \infty$ Both Comparators, V_{CC} = 30 V		–	–	2.5	–	–	2.5	

*T_{low} = 0°C, T_{high} = +70°C for LM393/393A
LM293 T_{low} = –25°C, T_{high} = +85°C
LM2903 T_{low} = –40°C, T_{high} = +105°C
LM2903V T_{low} = –40°C, T_{high} = +125°C

NOTES: 2. At output switch point, $V_O \simeq$ 1.4 Vdc, R_S = 0 Ω 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.
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_{CC}, 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

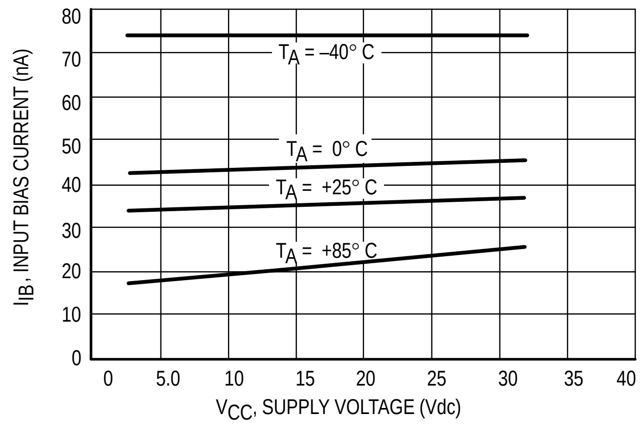


Figure 3. Output Saturation Voltage versus Output Sink Current

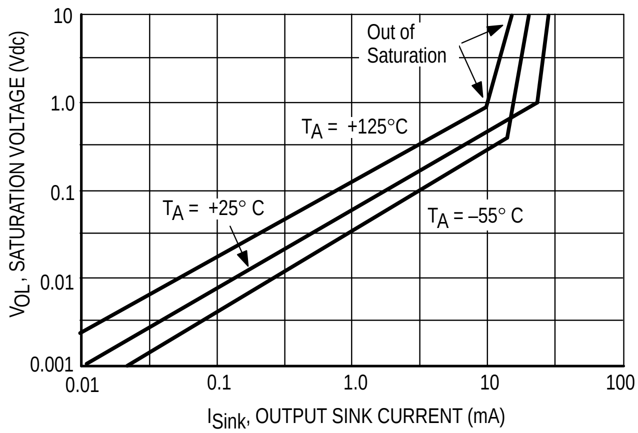


Figure 4. Output Saturation Voltage versus Output Sink Current

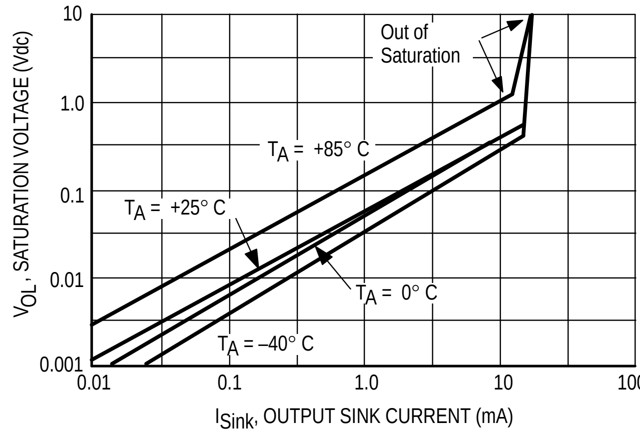


Figure 5. Power Supply Current versus Power Supply Voltage

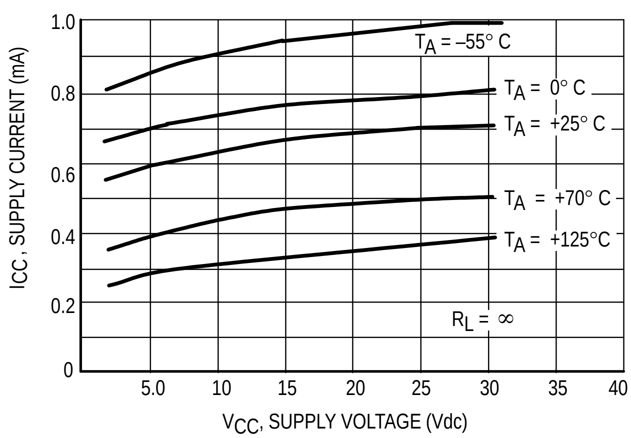
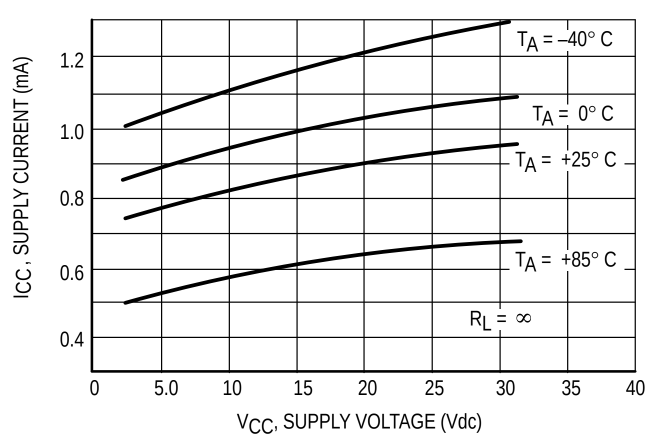


Figure 6. Power Supply Current versus Power Supply Voltage



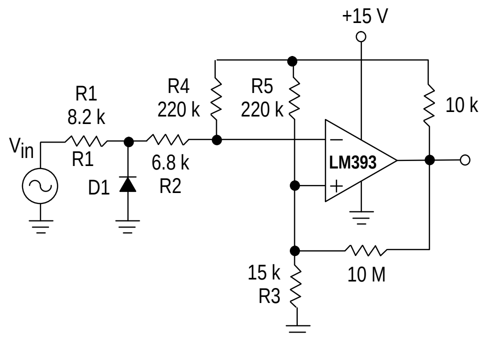
APPLICATIONS INFORMATION

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)

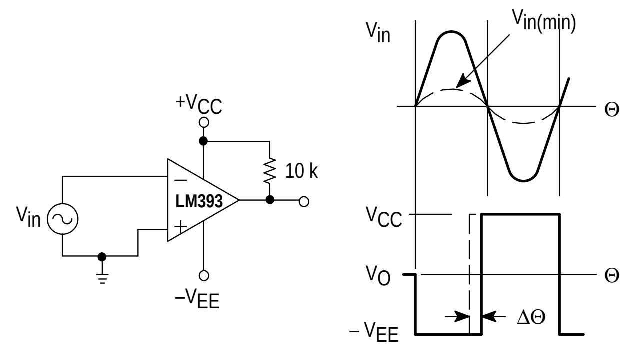


D1 prevents input from going negative by more than 0.6 V.

$$R1 + R2 = R3$$

$$R3 \leq \frac{R5}{10}$$ for small error in zero crossing.

Figure 8. Zero Crossing Detector (Split Supply)



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

Figure 9. Free–Running Square–Wave Oscillator

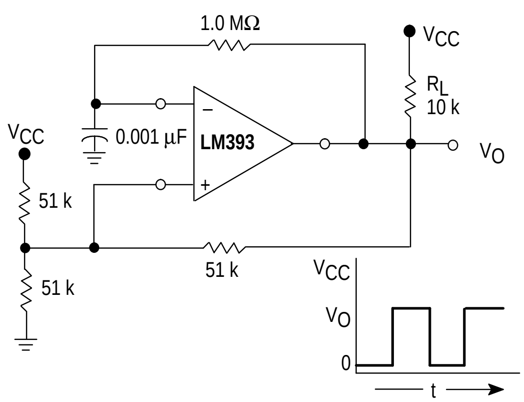
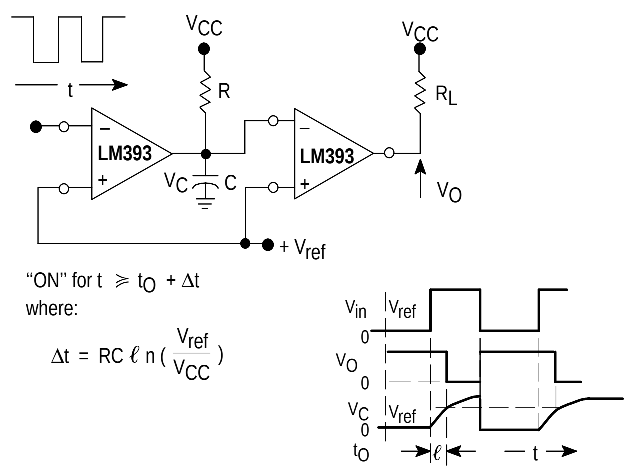


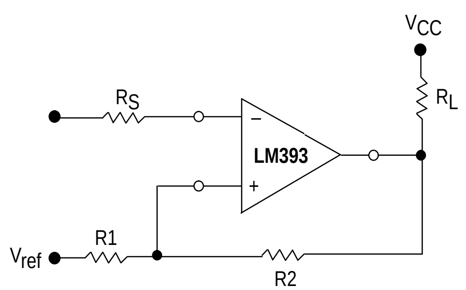
Figure 10. Time Delay Generator



"ON" for $t \geqslant t_O + \Delta t$
where:

$$\Delta t = RC\ \ell n \left(\frac{V_{ref}}{V_{CC}}\right)$$

Figure 11. Comparator with Hysteresis

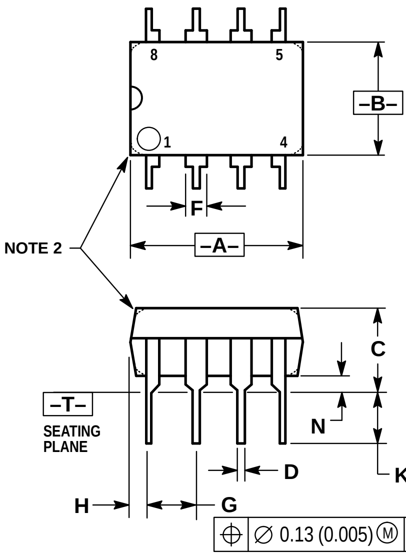


$$R_S = R1\ ||\ R2$$

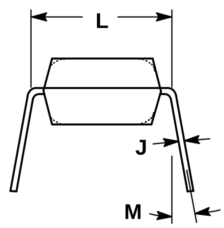
$$V_{th1} = V_{ref} + \frac{(V_{CC} - V_{ref})\ R1}{R1 + R2 + R_L}$$

$$V_{th2} = V_{ref} - \frac{(V_{ref} - V_{O\ Low})\ R1}{R1 + R2}$$

OUTLINE DIMENSIONS



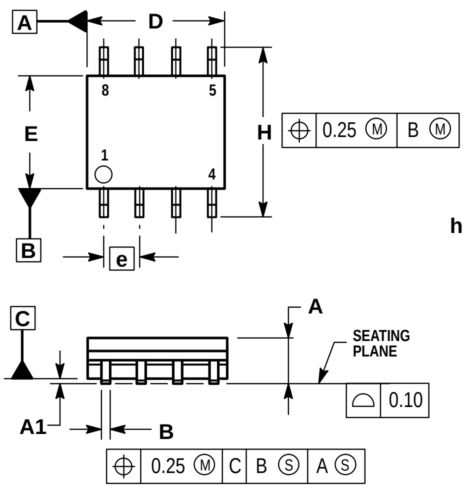
N SUFFIX
PLASTIC PACKAGE
CASE 626–05
ISSUE K

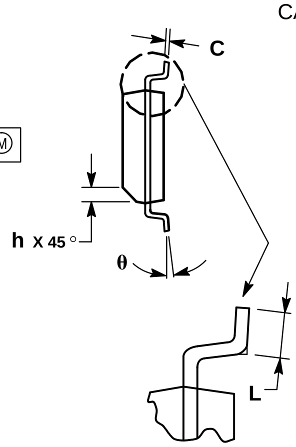


NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	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	
H	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	
M	—	10°	—	10°
N	0.76	1.01	0.030	0.040

D SUFFIX
PLASTIC PACKAGE
CASE 751–06
(SO–8)
ISSUE T





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

DIM	MILLIMETERS MIN	MILLIMETERS MAX
A	1.35	1.75
A1	0.10	0.25
B	0.35	0.49
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.25
θ	0°	7°

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