LM393, LM293, LM2903, LM2903V, NCV2903, NCV2903V

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.

Features

- 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: 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
- NCV Prefix for Automotive and Other Applications Requiring Site and Control Changes
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

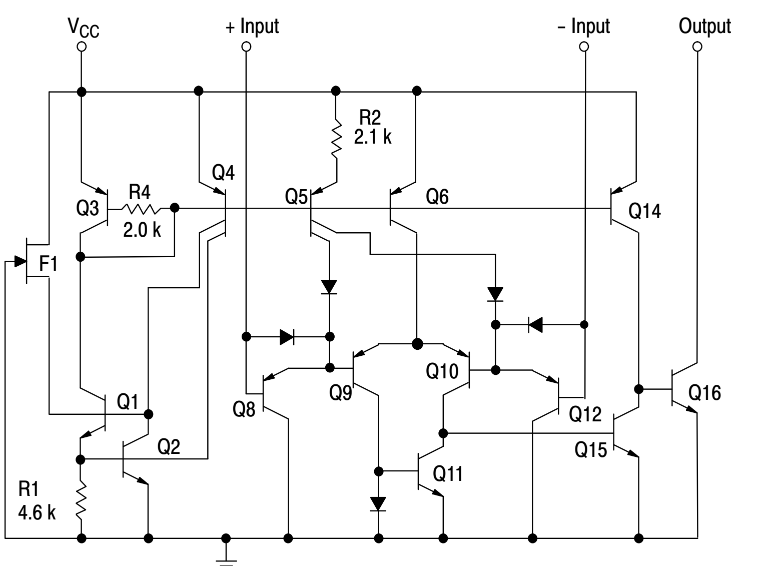
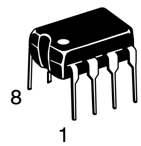


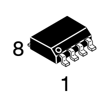
Figure 1. Representative Schematic Diagram
(Diagram shown is for 1 comparator)

ON Semiconductor®

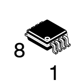
http://onsemi.com



PDIP−8
N SUFFIX
CASE 626

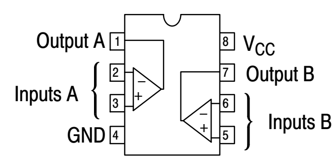


SOIC−8
D SUFFIX
CASE 751



Micro8™
DM SUFFIX
CASE 846A

PIN CONNECTIONS



(Top View)

DEVICE MARKING AND ORDERING INFORMATION

See detailed marking information and ordering and shipping information on pages 6 and 7 of this data sheet.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	+36 or ±18	V
Input Differential Voltage	V_{IDR}	36	V
Input Common Mode Voltage Range (Note 1)	V_{ICR}	−0.3 to +36	V
Output Voltage	V_O	36	V
Output Short Circuit−to−Ground Output Sink Current (Note 2)	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 LM2903 LM2903V, NCV2903 (Note 3) NCV2903V (Note 3)	T_A	 −25 to +85 0 to +70 −40 to +105 −40 to +125 −40 to +150	°C
Maximum Operating Junction Temperature LM393, 2903, LM2903V LM293, NCV2903	$T_{J(max)}$	 150 150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
ESD Protection at any Pin (Note 4) − Human Body Model − Machine Model	V_{ESD}	 1500 150	V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. For supply voltages less than 36 V, the absolute maximum input voltage is equal to the supply voltage.
2. 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.
3. *NCV2903 and NCV2903V are qualified for automotive use.*
4. V_{ESD} rating for NCV/SC devices is: Human Body Model − 2000 V; Machine Model − 200 V.

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

Characteristic	Symbol	LM293, LM393			LM2903, LM2903V, NCV2903, NCV2903V			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage (Note 6)	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 7)	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 7)	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 9) 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 10) 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 = ∞ Both Comparators, T_A = 25°C		–	0.4	1.0	–	0.4	1.0	
R_L = ∞ Both Comparators, V_{CC} = 30 V		–	–	2.5	–	–	2.5	

LM293 T_{low} = −25°C, T_{high} = +85°C
LM393 T_{low} = 0°C, T_{high} = +70°C
LM2903 T_{low} = −40°C, T_{high} = +105°C
LM2903V & NCV2903 T_{low} = −40°C, T_{high} = +125°C
NCV2903V T_{low} = −40°C, T_{high} = +150°C
NCV2903 and NCV2903V are qualified for automotive use.

5. 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.
6. 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).
7. Due to the PNP transistor inputs, bias current will flow out of the inputs. This current is essentially constant, independent of the output state, therefore, no loading changes will exist on the input lines.
8. 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.
9. 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.
10. 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

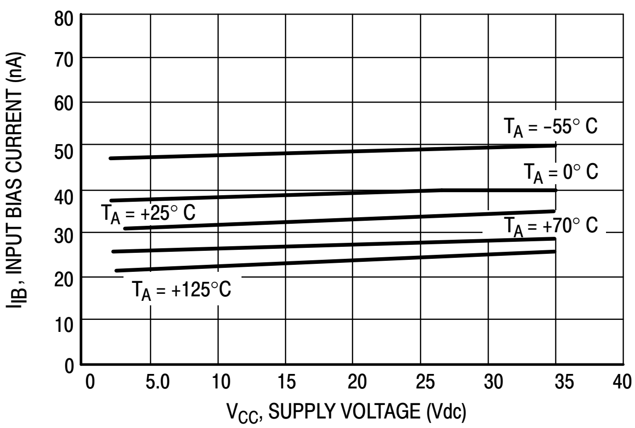


Figure 2. Input Bias Current versus Power Supply Voltage

LM2903

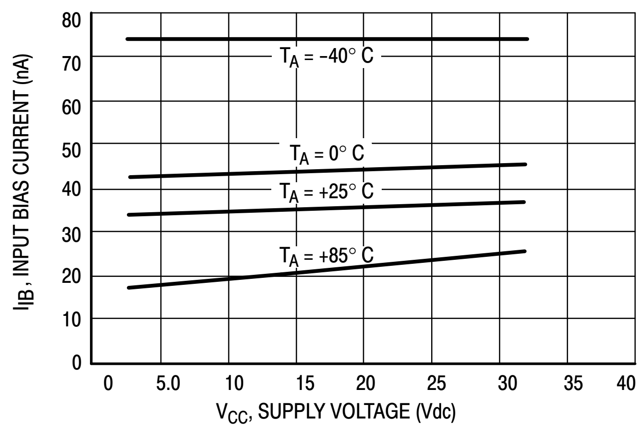


Figure 3. Input Bias Current versus Power Supply Voltage

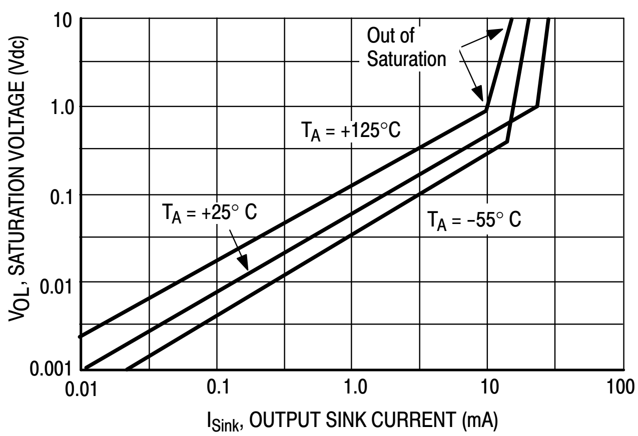


Figure 4. Output Saturation Voltage versus Output Sink Current

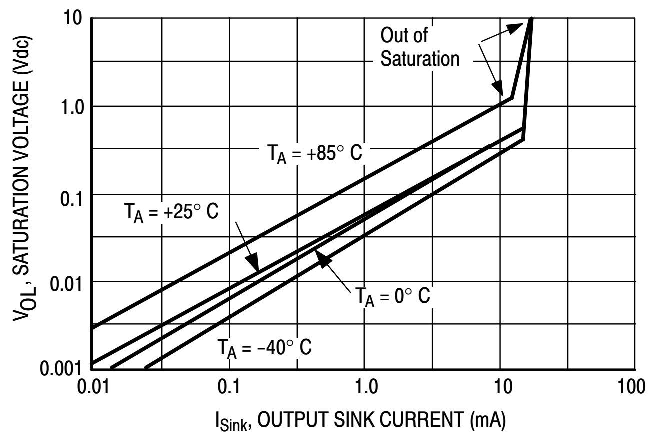


Figure 5. Output Saturation Voltage versus Output Sink Current

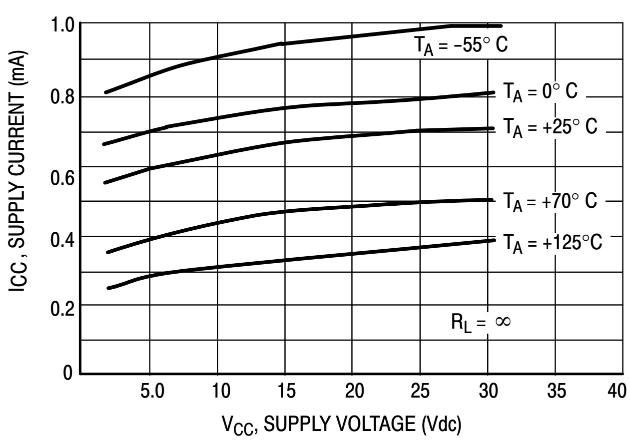


Figure 6. Power Supply Current versus Power Supply Voltage

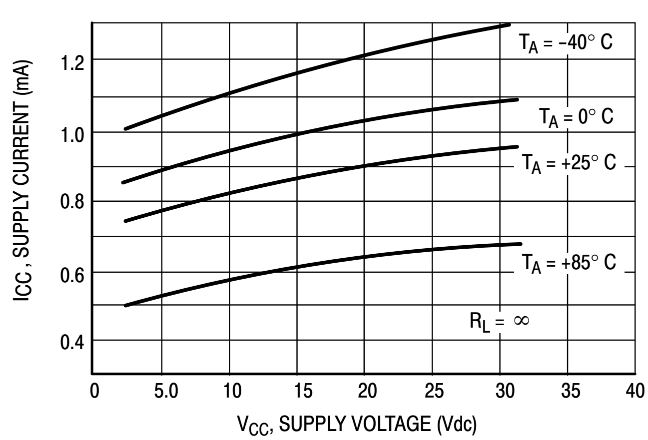


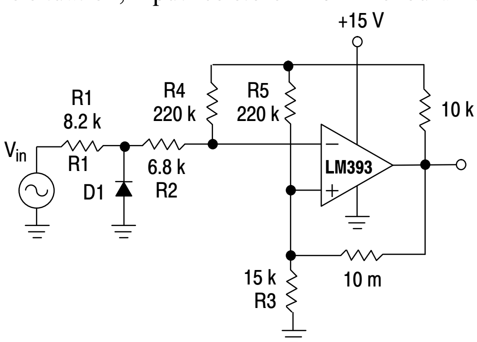
Figure 7. Power Supply Current versus Power Supply Voltage

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 kΩ 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.

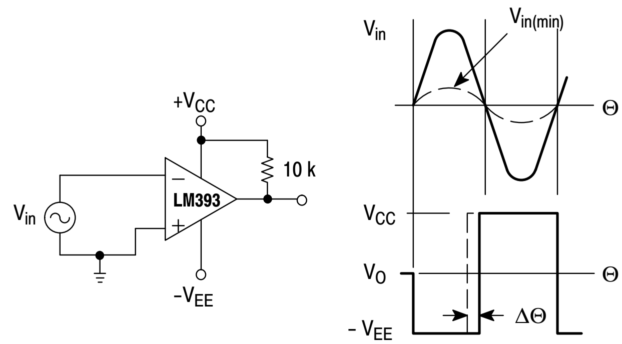


D1 prevents input from going negative by more than 0.6 V.

R1 + R2 = R3

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

Figure 8. Zero Crossing Detector (Single Supply)



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

Figure 9. Zero Crossing Detector (Split Supply)

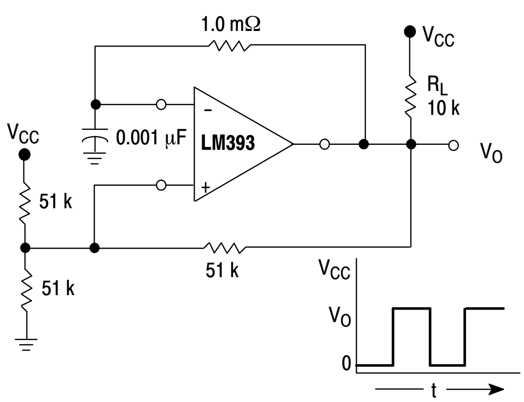


Figure 10. Free−Running Square−Wave Oscillator

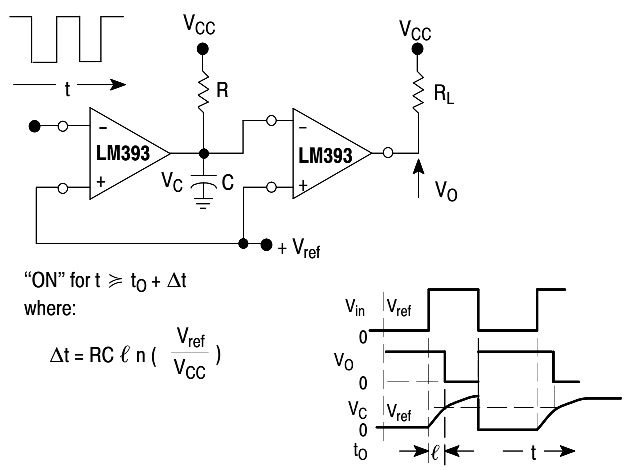
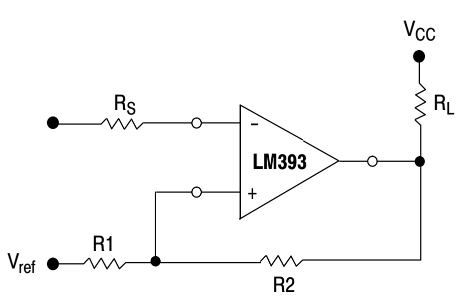


Figure 11. Time Delay Generator



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

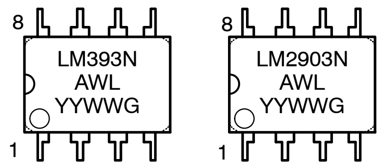
$V_{th1} = V_{ref} + \frac{(V_{CC} - V_{ref})\,R1}{R1 + R2 + R_L}$

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

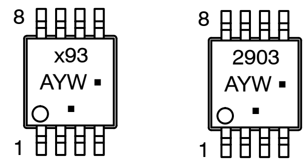
Figure 12. Comparator with Hysteresis

MARKING DIAGRAMS

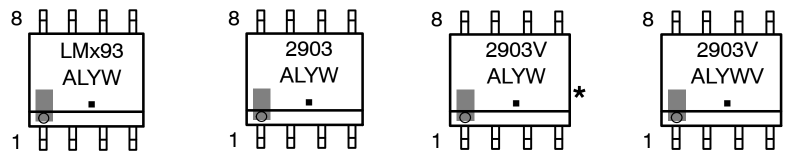
PDIP−8
CASE 626



Micro8
CASE 846A



SOIC−8
CASE 751



x	= 2 or 3
A	= Assembly Location
WL, L	= Wafer Lot
YY, Y	= Year
WW, W	= Work Week
▪, G	= Pb−Free Package

(Note: Microdot may be in either location)

*This marking diagram also applies to NCV2903DR2G

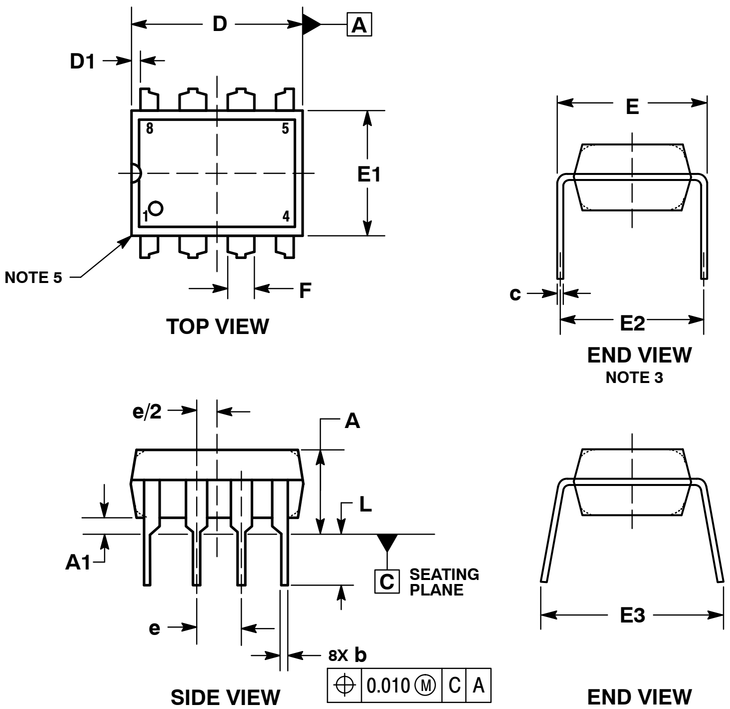
ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping†
LM293DG	−25°C to +85°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM293DR2G			2500 / Tape & Reel
LM293DMR2G		Micro8 (Pb−Free)	4000 / Tape and Reel
LM393DG	0°C to +70°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM393DR2G			2500 / Tape & Reel
LM393NG		PDIP−8 (Pb−Free)	50 Units / Rail
LM393DMR2G		Micro8 (Pb−Free)	4000 / Tape and Reel
LM2903DG	−40°C to +105°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM2903DR2G			2500 / Tape & Reel
LM2903DMR2G		Micro8 (Pb−Free)	4000 / Tape and Reel
LM2903NG		PDIP−8 (Pb−Free)	50 Units / Rail
LM2903VDG	−40°C to +125°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM2903VDR2G			2500 / Tape & Reel
LM2903VNG		PDIP−8 (Pb−Free)	50 Units / Rail
NCV2903DR2G		SOIC−8 (Pb−Free)	2500 / Tape & Reel
NCV2903DMR2G		Micro8 (Pb−Free)	4000 / Tape & Reel
NCV2903VDR2G	−40°C to +150°C	SOIC−8 (Pb−Free)	2500 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PACKAGE DIMENSIONS

PDIP−8
N SUFFIX
CASE 626−05
ISSUE M

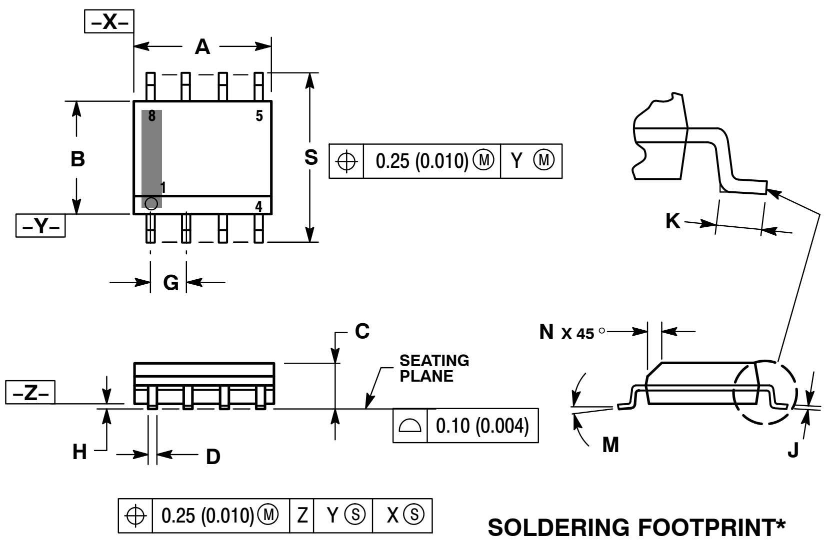


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSION E IS MEASURED WITH THE LEADS RESTRAINED PARALLEL AT WIDTH E2.
4. DIMENSION E1 DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

	INCHES			MILLIMETERS		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	----	----	0.210	----	----	5.33
A1	0.015	----	----	0.38	----	----
b	0.014	0.018	0.022	0.35	0.46	0.56
C	0.008	0.010	0.014	0.20	0.25	0.36
D	0.355	0.365	0.400	9.02	9.27	10.02
D1	0.005	----	----	0.13	----	----
E	0.300	0.310	0.325	7.62	7.87	8.26
E1	0.240	0.250	0.280	6.10	6.35	7.11
E2	0.300 BSC			7.62 BSC		
E3	----	----	0.430	----	----	10.92
e	0.100 BSC			2.54 BSC		
L	0.115	0.130	0.150	2.92	3.30	3.81

PACKAGE DIMENSIONS

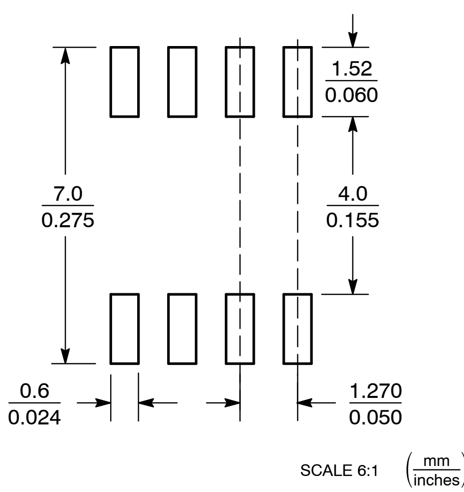
SOIC−8 NB
CASE 751−07
ISSUE AK



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

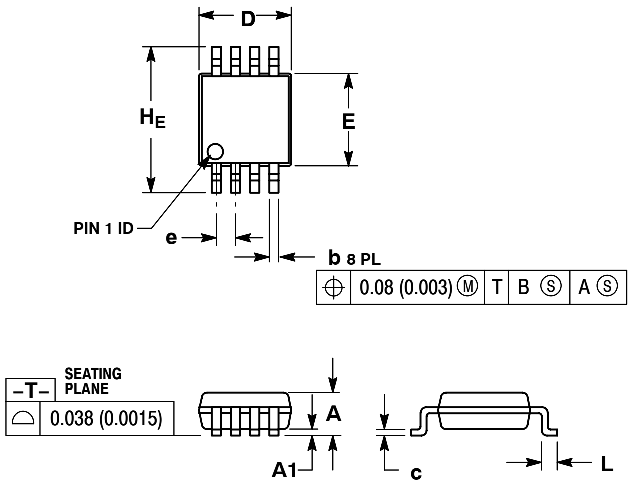
SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

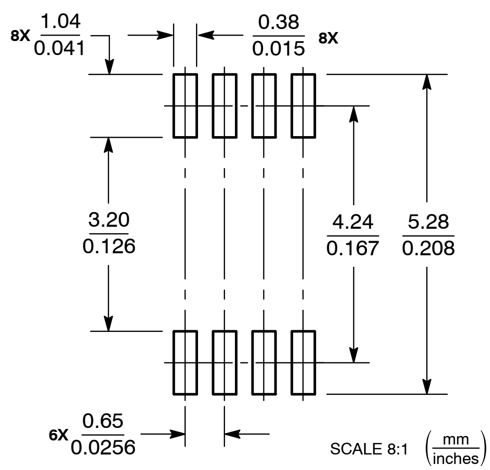
Micro8™
CASE 846A−02
ISSUE H



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. 846A−01 OBSOLETE, NEW STANDARD 846A−02.

	MILLIMETERS			INCHES		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	−−	−−	1.10	−−	−−	0.043
A1	0.05	0.08	0.15	0.002	0.003	0.006
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
e		0.65 BSC			0.026 BSC	
L	0.40	0.55	0.70	0.016	0.021	0.028
H_E	4.75	4.90	5.05	0.187	0.193	0.199

SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
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Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

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Phone: 81−3−5817−1050

ON Semiconductor Website: **www.onsemi.com**

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For additional information, please contact your local Sales Representative

Стандарт
Электрон
Связь

Мы молодая и активно развивающаяся компания в области поставок электронных компонентов. Мы поставляем электронные компоненты отечественного и импортного производства напрямую от производителей и с крупнейших складов мира.

Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

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