Single, Dual, Quad General Purpose, Low Voltage Comparators

The HT331V is a CMOS single channel, general purpose, low voltage comparator. The HT393V and HT339V are dual and quad channel versions, respectively. The HT331V/393/339 are specified for 2.7 V to 5 V performance, have excellent input common−mode range, low quiescent current, and are available in several space saving

The HT331V is available in a 5−pin SC−70, a TSOP−5, and aULLGA8 package. The HT393V is available in a 8−pin Micro8 , SOIC−8, and a UDFN8 package, and the HT339V is available in a SOIC−14 and a TSSOP−14 package.

The HT331V/393/339 are cost effective solutions for applications where space saving, low voltage operation, and low power are the primary specifications in circuit design for portable applications.

Features

- Guaranteed 2.7 V and 5 V Performance
- Input Common−mode Voltage Range Extends to Ground
- Open Drain Output for Wired−OR Applications
- Low Quiescent Current: 60 μA/channel TYP @ 5 V
- Low Saturation Voltage 200 mV TYP @ 5 V
- Propagation Delay 200 ns TYP @ 5 V
- These are Pb−Free Devices

Typical Applications

- Battery Monitors
- Notebooks and PDA's
- General Purpose Portable Devices
- General Purpose Low Voltage Applications

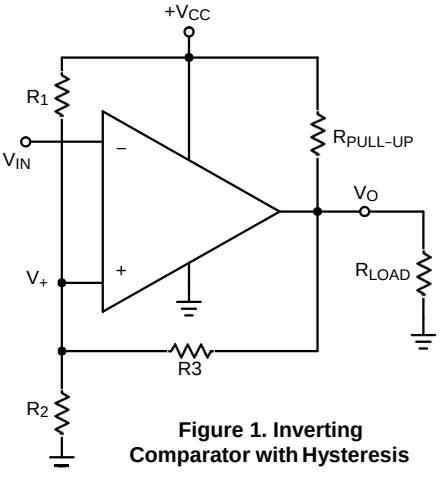
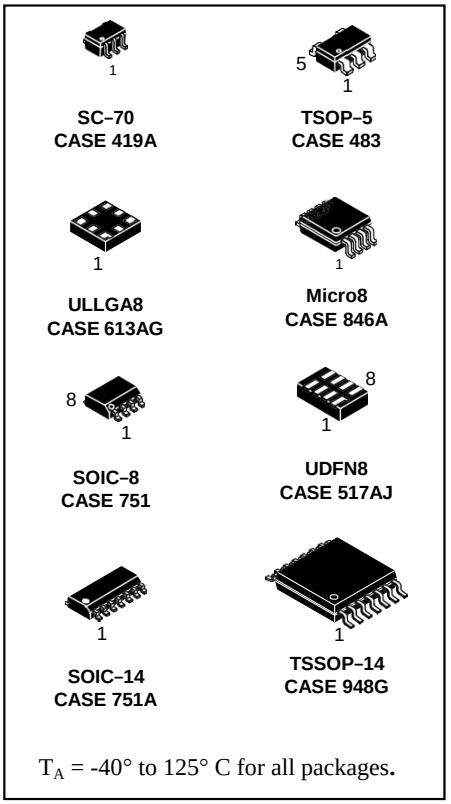


Figure 1. Inverting Comparator with Hysteresis



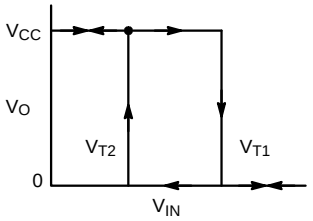
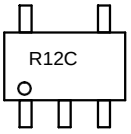


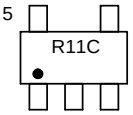
Figure 2. Hysteresis Curve

MARKING DIAGRAMS

SC−70
CASE 419A



TSOP−5
CASE 483

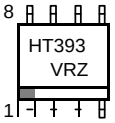


UDFN8
CASE 517AJ

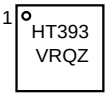
(Note: Microdot may be in either location)

Micro8
CASE 846A

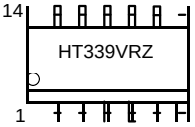
SOIC−8
CASE 751



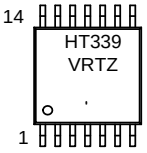
ULLGA8
CASE 613AG



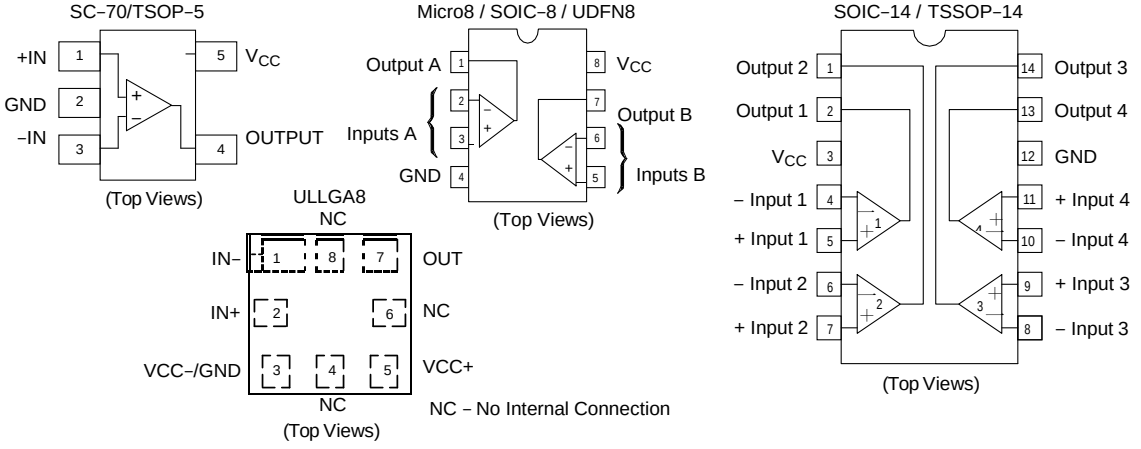
SOIC−14
CASE 751A



TSSOP−14
CASE 948G



PACKAGE PINOUTS



MAXIMUM RATINGS

Symbol	Rating	Value	Unit
V_S	Voltage on any Pin (referred to V⁻ pin)	5.5	V
V_{IDR}	Input Differential Voltage Range	±Supply Voltage	V
T_J	Maximum Junction Temperature	150	°C
T_{stg}	Storage Temperature Range	−65 to 150	°C
T_L	Mounting Temperature (Infrared or Convection (1/16″ From Case for 30 Seconds))	260	°C
V_{ESD}	ESD Tolerance (Note 1) Machine Model Human Body Model	 100 1000	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.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage Temperature Range (Note 2)	2.7 to 5.0	V
8_{JA}	Thermal Resistance SC−70 TSOP−5 ULLGA8 Micro8 SOIC−8 UDFN8 SOIC−14 TSSOP−14	 280 333 340 238 212 350 156 190	°C/W

2.7 V DC ELECTRICAL CHARACTERISTICS (All limits are guaranteed for T_A = 25°C, V^+ = 2.7 V, V^- = 0 V, V_{CM} = 1.35 V unless otherwise noted.)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}			1.7	9	mV
Input Offset Voltage Average Drift	T_C V_{IO}			5		µV/°C
Input Bias Current (Note 3)	I_B			< 1		nA
Input Offset Current (Note 3)	I_{IO}			< 1		nA
Input Voltage Range	V_{CM}			0 to 2		V
Saturation Voltage	V_{SAT}	$I_{SINK} \le 1$ mA		120		mV
Output Sink Current	I_O	$V_O \le 1.5$ V	5	23		mA
Supply Current HT331V HT393V HT339V	I_{CC}			40 70 140	100 140 200	µA

2.7 V AC ELECTRICAL CHARACTERISTICS (T_A = 25°C, V^+ = 2.7 V, R_L = 5.1 kΩ, V^- = 0 V unless otherwise noted.)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Propagation Delay – High to Low	t_{PHL}	Input Overdrive = 10 mV Input Overdrive = 100 mV		1000 500		ns
Propagation Delay – Low to High	t_{PLH}	Input Overdrive = 10 mV Input Overdrive = 100 mV		800 200		ns

3. Guaranteed by design and/or characterization.

5.0 V DC ELECTRICAL CHARACTERISTICS (All limits are guaranteed for T_A = 25°C, V^+ = 5 V, V^- = 0 V, V_{CM} = 2.5 V unless otherwise noted.)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	T_A = −40°C to +85°C		1.7	9	mV
Input Offset Voltage Average Drift		T_A = −40°C to +85°C		5		μV/°C
Input Bias Current (Note 4)	I_B	T_A = −40°C to +85°C		< 1		nA
Input Offset Current (Note 4)	I_{IO}	T_A = −40°C to +85°C		< 1		nA
Input Voltage Range	V_{CM}			0 to 4.2		V
Voltage Gain (Note 4)	A_V		20	50		V/mV
Saturation Voltage	V_{SAT}	$I_{SINK} \le 4$ mA T_A = −40°C to +85°C		200	400 700	mV
Output Sink Current	I_O	$V_O \le 1.5$ V	10	84		mA
Supply Current HT331V	I_{CC}	T_A = −40°C to +85°C		60	120 150	μA
Supply Current HT393V	I_{CC}	T_A = −40°C to +85°C		100	200 250	μA
Supply Current HT339V	I_{CC}	T_A = −40°C to +85°C		170	300 350	μA
Output Leakage Current (Note 4)		T_A = −40°C to +85°C		0.003	1	μA

5.0 V AC ELECTRICAL CHARACTERISTICS (T_A = 25°C, V^+ = 5 V, R_L = 5.1 kΩ, V^- = 0 V unless otherwise noted.)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Propagation Delay – High to Low	t_{PHL}	Input Overdrive = 10 mV Input Overdrive = 100 mV		1500 900		ns
Propagation Delay – Low to High	t_{PLH}	Input Overdrive = 10 mV Input Overdrive = 100 mV		800 200		ns

4. Guaranteed by design and/or characterization.

TYPICAL CHARACTERISTICS

(V_{CC} = 5.0 V, T_A = 25°C, R_L = 5 kQ unless otherwise specified)

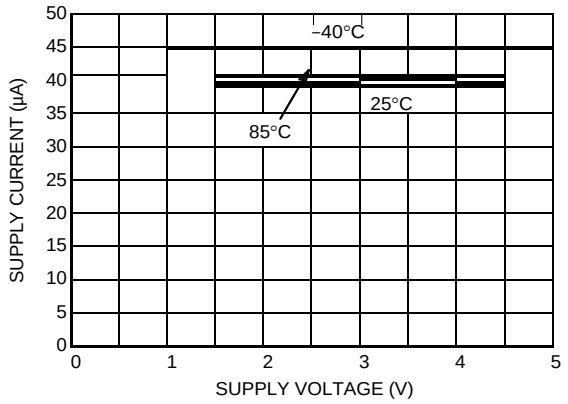


Figure 3. HT331VSupply Current vs. Supply Voltage (Output High)

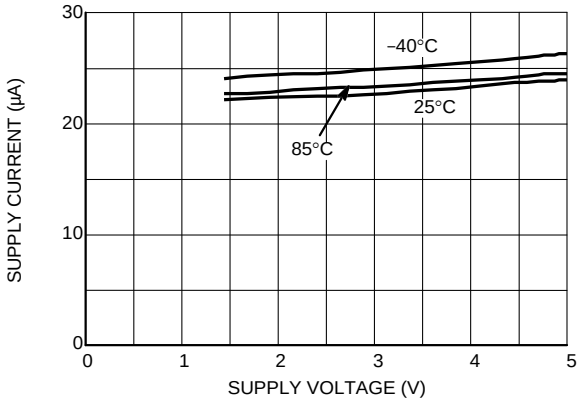


Figure 4. HT331VSupply Current vs. Supply Voltage (Output Low)

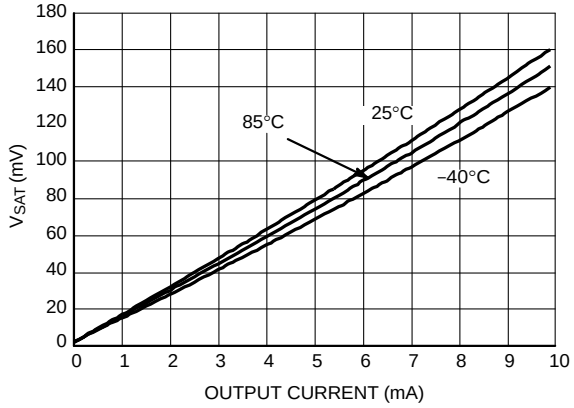


Figure 5. V_{SAT} vs. Output Current at V_{CC} = 2.7 V

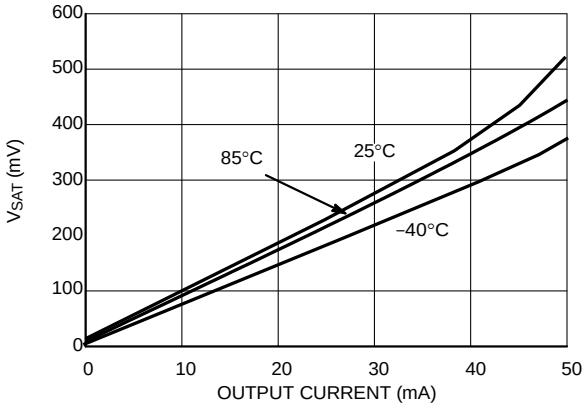


Figure 6. V_{SAT} vs. Output Current at V_{CC} = 5.0 V

NEGATIVE TRANSITION INPUT – V_{CC} = 2.7 V

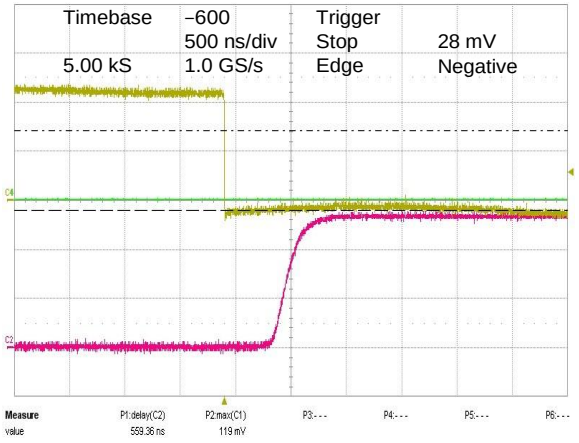


Figure 7. 10 mV Overdrive

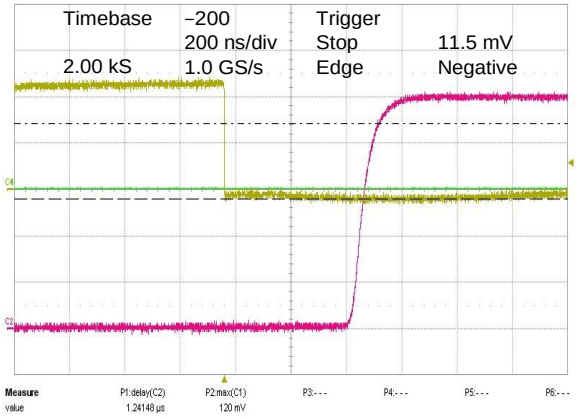


Figure 8. 20 mV Overdrive

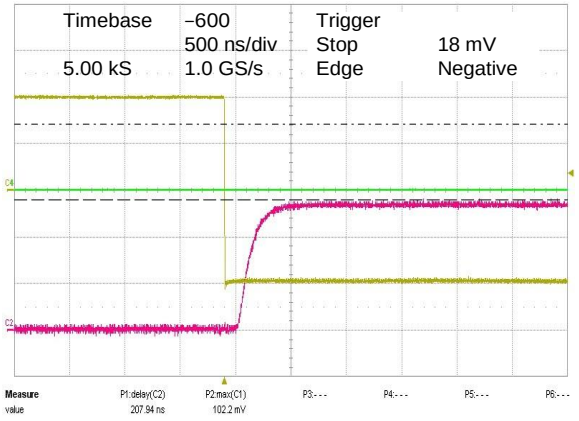


Figure 9. 100 mV Overdrive

POSITIVE TRANSITION INPUT – V_{CC} = 2.7 V

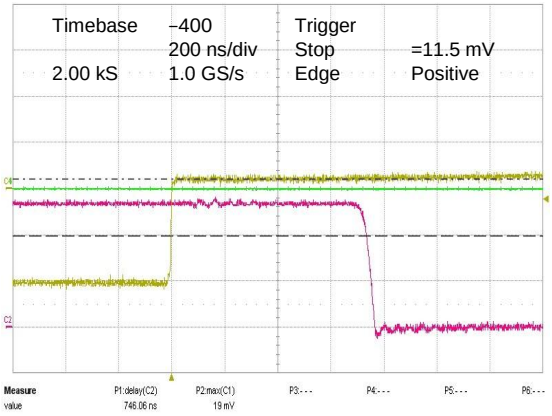


Figure 10. 10 mV Overdrive

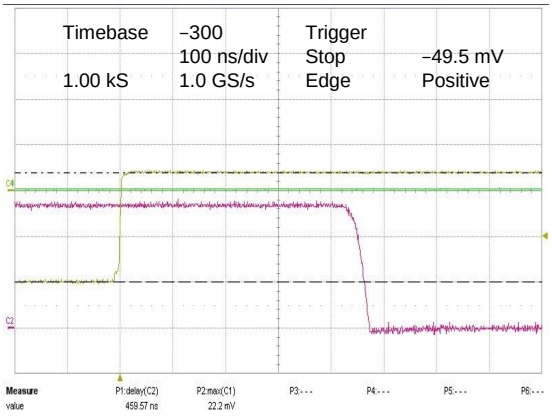


Figure 11. 20 mV Overdrive

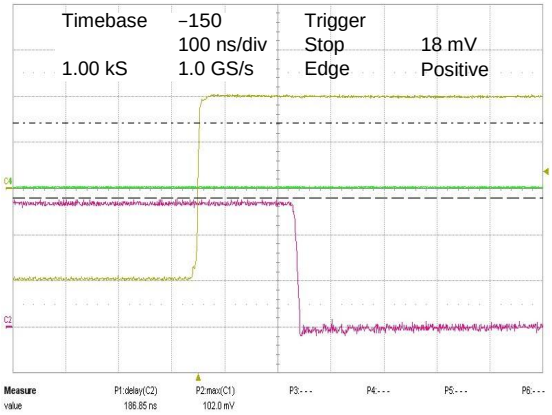


Figure 12. 100 mV Overdrive

NEGATIVE TRANSITION INPUT – V_{CC} = 5.0 V

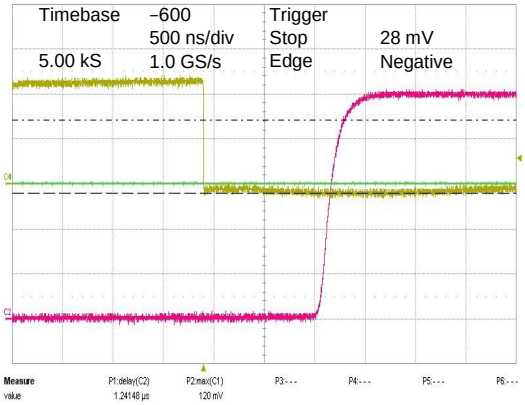


Figure 13. 10 mV Overdrive

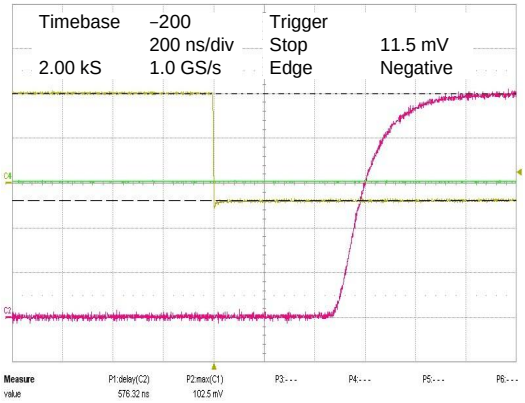


Figure 14. 20 mV Overdrive

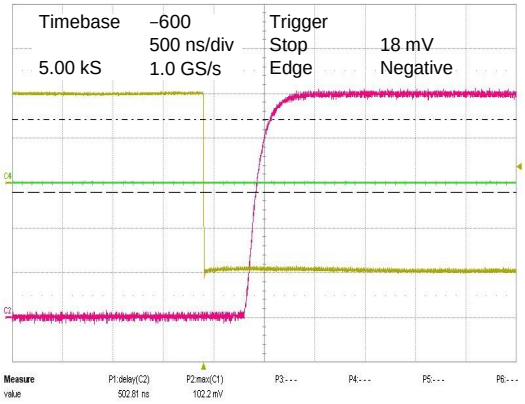


Figure 15. 100 mV Overdrive

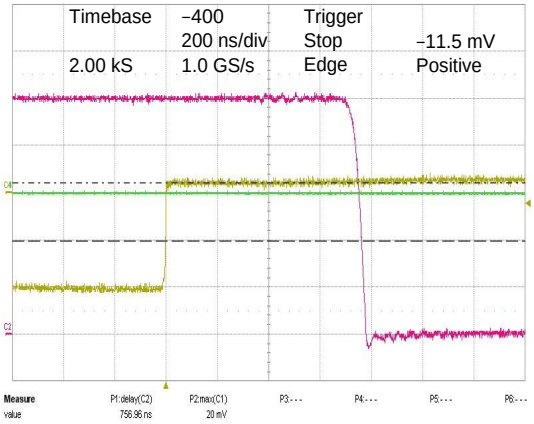


Figure 16. 10 mV Overdrive

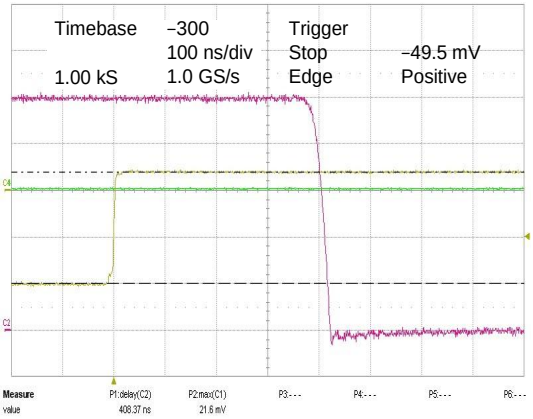


Figure 17. 20 mV Overdrive

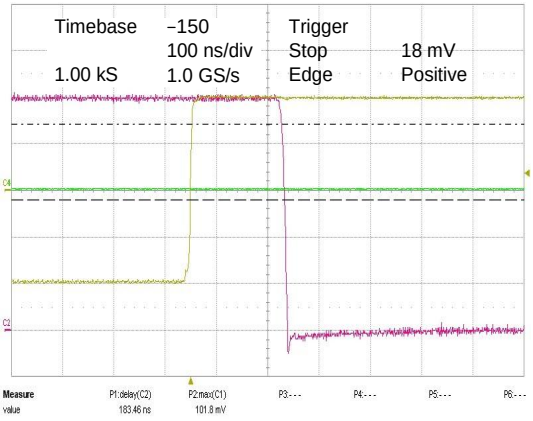


Figure 18. 100 mV Overdrive

APPLICATION CIRCUITS

Basic Comparator Operation

The basic operation of a comparator is to compare two input voltage signals, and produce a digital output signal by determining which input signal is higher. If the voltage on the non−inverting input is higher, then the internal output transistor is off and the output will be high. If the voltage on the inverting input is higher, then the output transistor will be on and the output will be low. The HT331V/393/339 has an open−drain output stage, so a pull−up resistor to a positive supply voltage is required for the output to switch properly.

The size of the pull−up resistor is recommended to be between 1 kΩ and 10 kΩ. This range of values will balance two key factors; i.e., power dissipation and drive capability for interface circuitry.

Figure 19 illustrates the basic operation of a comparator and assumes dual supplies. The comparator compares the input voltage (V_{IN}) on the non−inverting input to the reference voltage (V_{REF}) on the inverting input. If V_{IN} is less than V_{REF}, the output voltage (V_O) will be low. If V_{IN} is greater than V_{REF}, then V_O will be high.

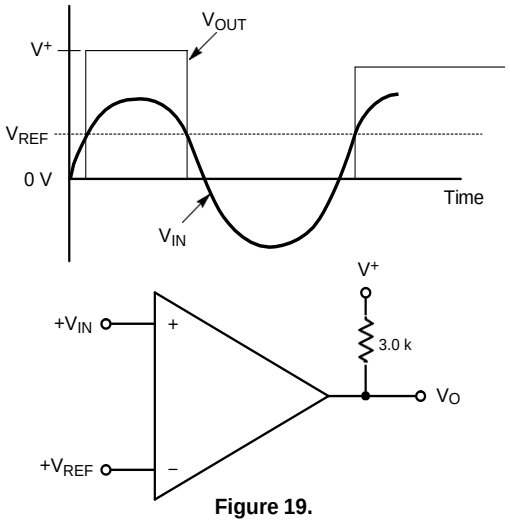


Figure 19.

Comparators and Stability

A common problem with comparators is oscillation due to their high gain. The basic comparator configuration in Figure 19 may oscillate if the differential voltage between the input pins is close to the device's offset voltage. This can happen if the input signal is moving slowly through the comparator's switching threshold or if unused channels are connected to the same potential for termination of unused channels. One way to eliminate output oscillations or 'chatter' is to include external hysteresis in the circuit design.

Inverting Configuration with Hysteresis

An inverting comparator with hysteresis is shown in Figure 20.

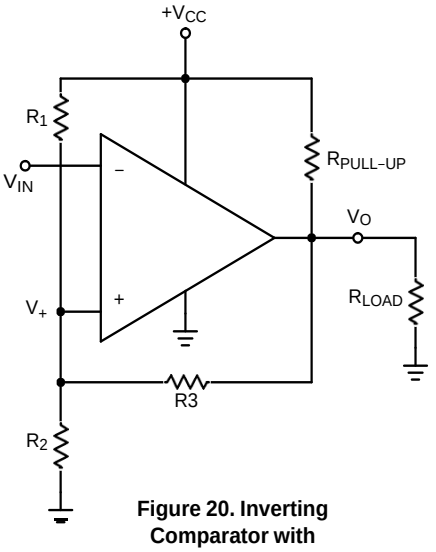


Figure 20. Inverting Comparator with Hysteresis

When V_{IN} is less than the voltage at the non−inverting node, V_+, the output voltage will be high. When V_{IN} is greater than the voltage at V_+, then the output will be low. The hysteresis band (Figure 21) created from the resistor network is defined as:

$$/JV_+ = V_{T1} — V_{T2}$$

where V_{T1} and V_{T2} are the lower and upper trip points, respectively.

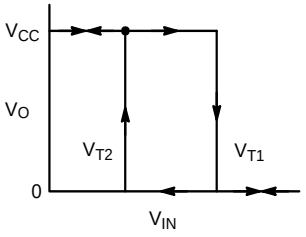


Figure 21.

V_{T1} is calculated by assuming that the output of the comparator is pulled up to supply when high. The resistances R_1 and R_3 can be viewed as being in parallel which is in series with R_2 (Figure 22). Therefore V_{T1} is:

$$V_{T1} = \frac{V_{CC} R_2}{R^{1} I R_3) + R_2}$$

V_{T2} is calculated by assuming that the output of the comparator is at ground potential when low. The resistances R_2 and R_3 can be viewed as being in parallel which is in series with R_1 (Figure 23). Therefore V_{T2} is:

$$V_{T2} = \frac{V_{CC} R_2 I R_3)}{R_1 + R_2 I R_3)}$$

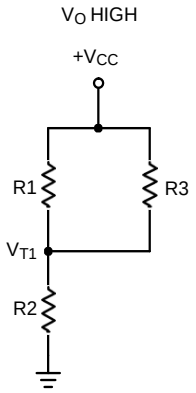


Figure 22.

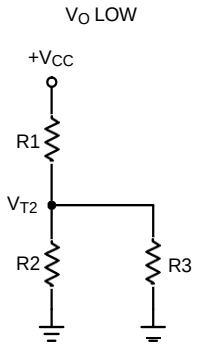


Figure 23.

Non−inverting Configuration with Hysteresis

A non−inverting comparator is shown in Figure 24.

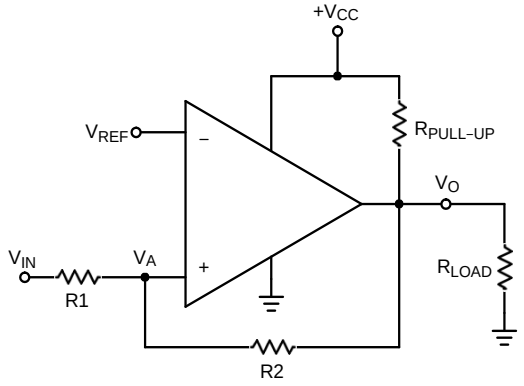


Figure 24.

The hysteresis band (Figure 25) of the non−inverting configuration is defined as follows:

$$/JV_{in} = V_{CC}R_1/R_2$$

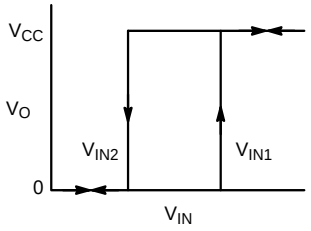


Figure 25.

When V_{IN} is much less than the voltage at the inverting input (V_{REF}), then the output is low. R_2 can then be viewed as being connected to ground (Figure 26). To calculate the voltage required at V_{IN} to trip the comparator high, the following equation is used:

$$V_{in1} = \frac{V_{ref}(R_1 + R_2)}{R_2}$$

When the output is high, V_{IN} must less than or equal to V_{REF} ($V_{IN} \le V_{REF}$) before the output will be low again (Figure 27). The following equation is used to calculate the voltage at V_{IN} to switch the output back to the low state:

$$V_{in2} = \frac{V_{ref}(R_1 + R_2) - V_{CC}R_1}{R_2}$$

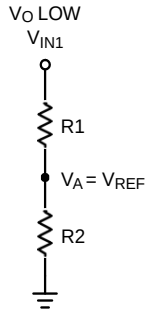


Figure 26.

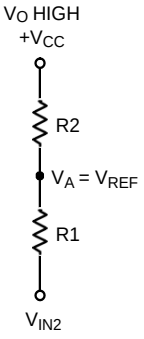


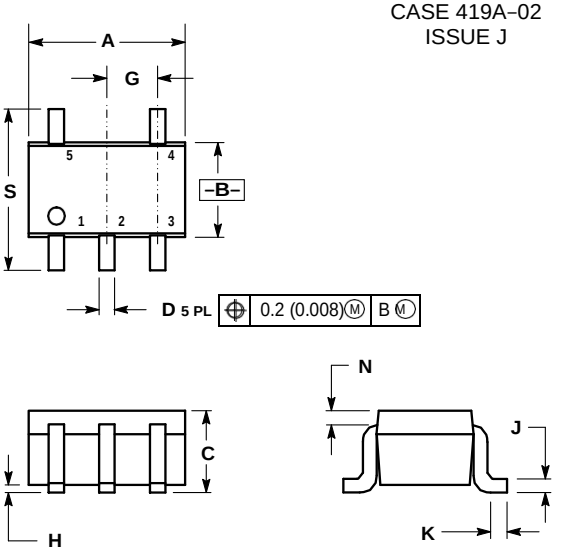
Figure 27.

Termination of Unused Inputs

Proper termination of unused inputs is a good practice to keep the output from ‘chattering.’ For example, if one channel of a dual or quad package is not being used, then the inputs must be connected to a defined state. The recommended connections would be to tie one input to V_{CC} and the other input to ground.

PACKAGE DIMENSIONS

SC−88A, SOT−353, SC−70
CASE 419A−02
ISSUE J

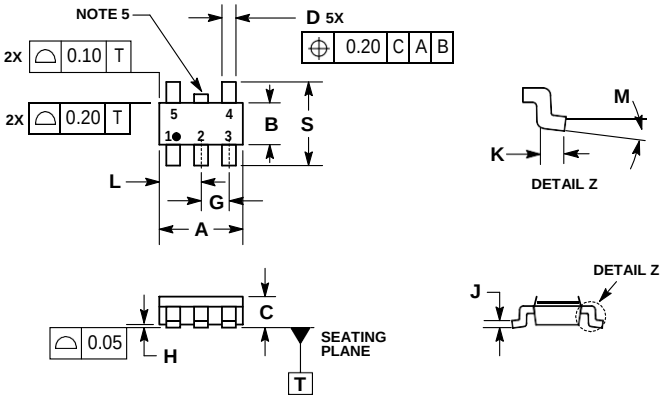


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A−01 OBSOLETE. NEW STANDARD 419A−02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.031	0.043	0.80	1.10
D	0.004	0.012	0.10	0.30
G	0.026 BSC		0.65 BSC	
H	---	0.004	---	0.10
J	0.004	0.010	0.10	0.25
K	0.004	0.012	0.10	0.30
N	0.008 REF		0.20 REF	
S	0.079	0.087	2.00	2.20

PACKAGE DIMENSIONS

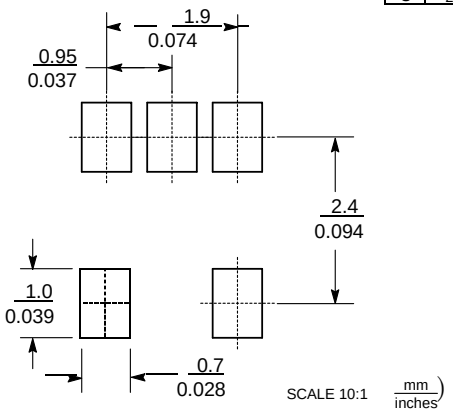
TSOP−5
CASE 483−02
ISSUE H



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

	MILLIMETERS	
DIM	MIN	MAX
A	3.00 BSC	
B	1.50 BSC	
C	0.90	1.10
D	0.25	0.50
G	0.95 BSC	
H	0.01	0.10
J	0.10	0.26
K	0.20	0.60
L	1.25	1.55
M	0 °	10 °
S	2.50	3.00

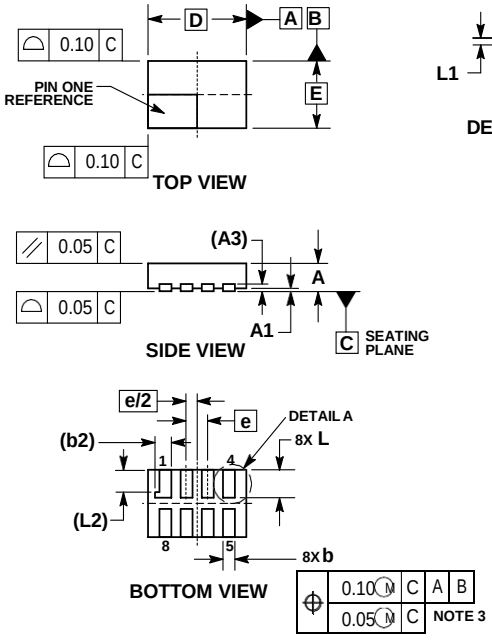
SOLDERING FOOTPRINT*



*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

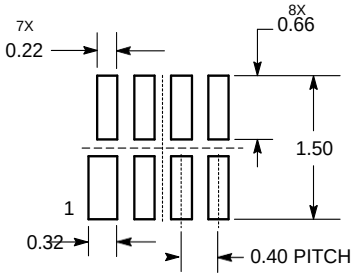
UDFN8 1.8x1.2, 0.4P
CASE 517AJ−01
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM TERMINAL TIP.
4. MOLD FLASH ALLOWED ON TERMINALS ALONG EDGE OF PACKAGE. FLASH MAY NOT EXCEED 0.03 ONTO BOTTOM SURFACE OF TERMINALS.
5. DETAIL A SHOWS OPTIONAL CONSTRUCTION FOR TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.127 REF	
b	0.15	0.25
b2	0.30 REF	
D	1.80 BSC	
E	1.20 BSC	
e	0.40 BSC	
L	0.45	0.55
L1	0.00	0.03
L2	0.40 REF	

MOUNTING FOOTPRINT*
SOLDERMASK DEFINED

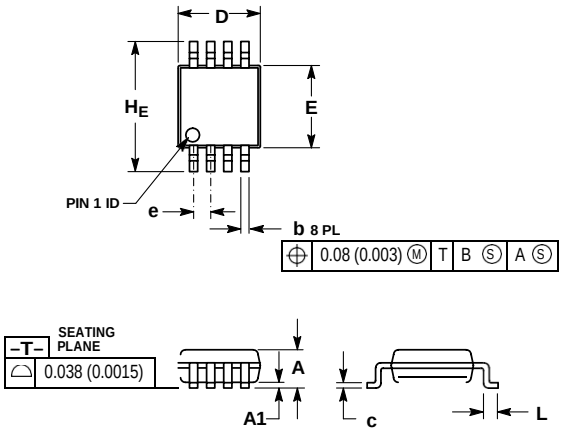


DIMENSIONS: MILLIMETERS

*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

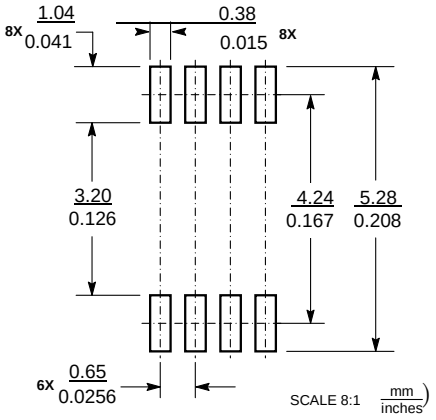
Micro8 刑
CASE 846A−02
ISSUE H



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

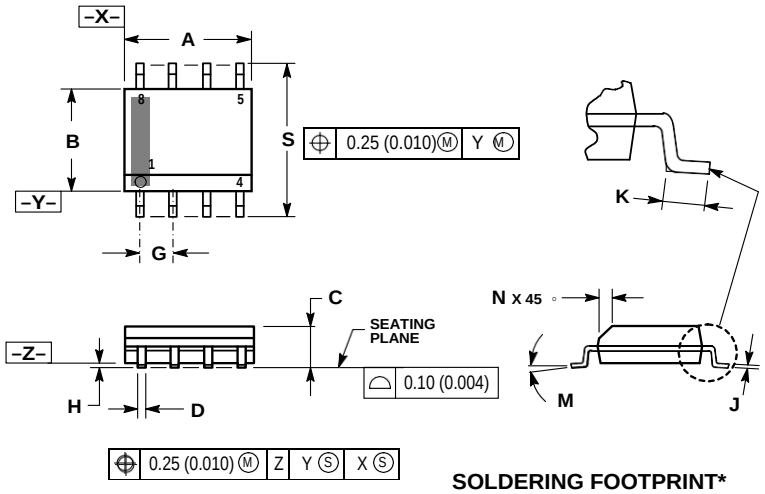
SOLDERING FOOTPRINT*



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

PACKAGE DIMENSIONS

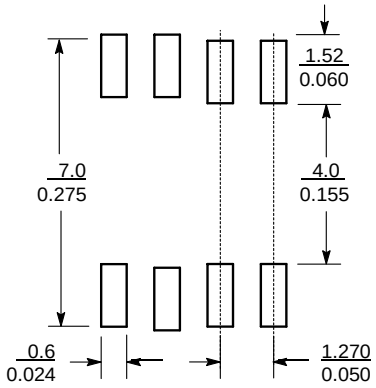
SOIC−8 NB
CASE 751−07
ISSUE AJ



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*

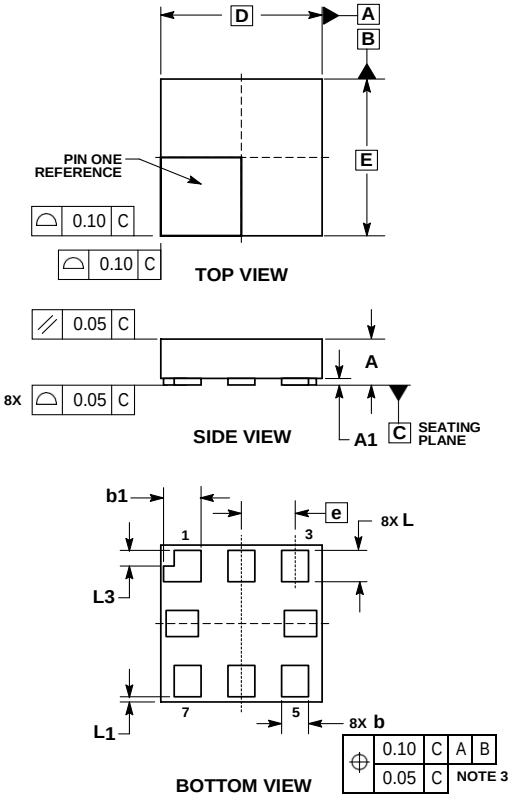


SCALE 6:1 (mm / inches)

*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

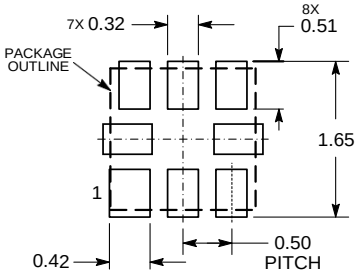
ULLGA8, 1.5x1.5, 0.5P
CASE 613AG−01
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM THE TERMINAL TIP.

	MILLIMETERS	
DIM	MIN	MAX
A	−−−	0.40
A1	0.00	0.05
b	0.20	0.30
b1	0.30	0.40
D	1.50 BSC	
E	1.50 BSC	
e	0.50 BSC	
L	0.25	0.35
L1	0.05 REF	
L3	0.15 REF	

MOUNTING FOOTPRINT*

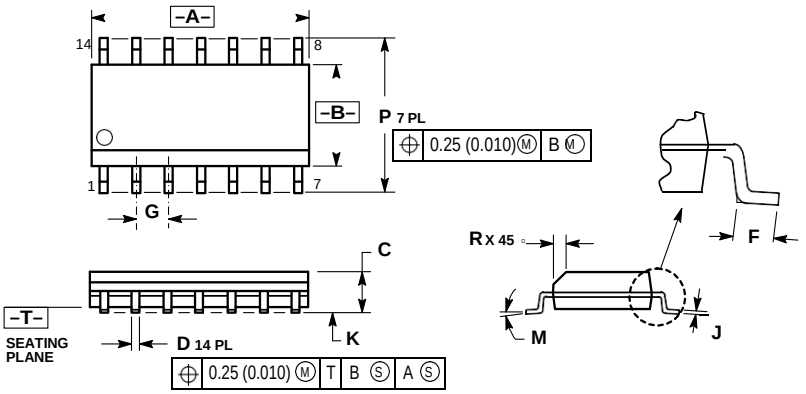


DIMENSIONS: MILLIMETERS

*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

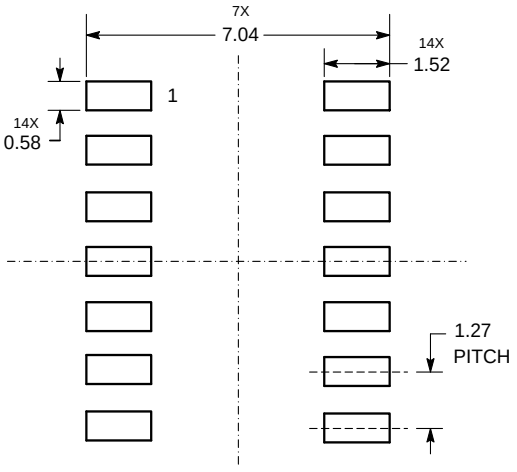
SOIC−14
CASE 751A−03
ISSUE H



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS 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.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0 °	7 °	0 °	7 °
P	5.80	6.20	0.228	0.244
R	0.25	0.50	0.010	0.019

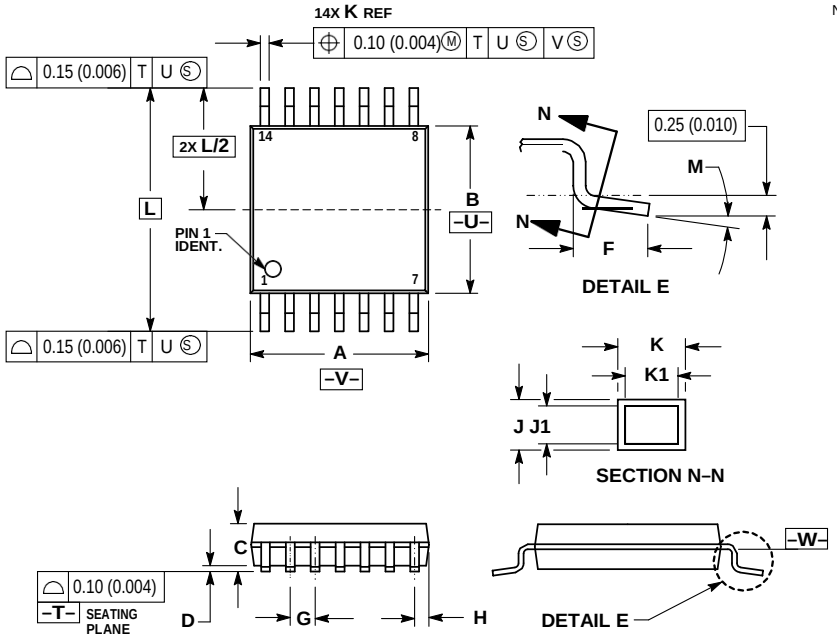
SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

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

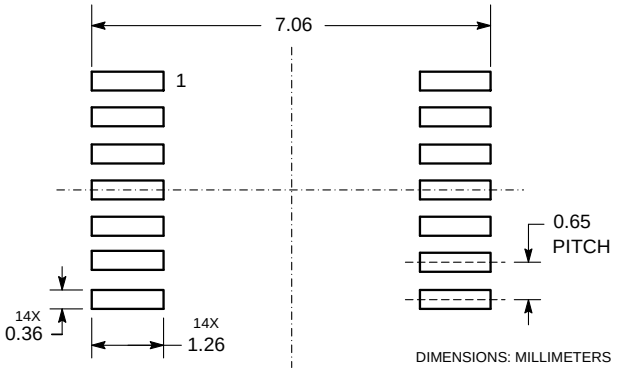
TSSOP–14
CASE 948G–01
ISSUE B



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 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. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE –W–.

	MILLIMETER		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	---	1.20	---	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0 °	8 °	0 °	8 °

SOLDERING FOOTPRINT



DIMENSIONS: MILLIMETERS

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