

# Dual 4-Bit Binary Ripple Counter

The MC74VHC393 is an advanced high speed CMOS dual 4-bit binary ripple counter fabricated with silicon gate CMOS technology. It achieves high speed operation similar to equivalent Bipolar Schottky TTL while maintaining CMOS low power dissipation.

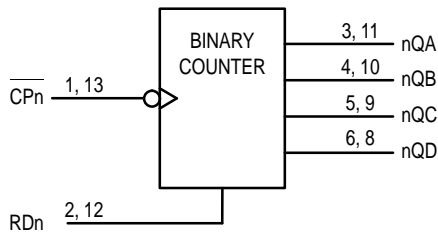
This device consists of two independent 4-bit binary ripple counters with parallel outputs from each counter stage. A  $\pm 256$  counter can be obtained by cascading the two binary counters.

Internal flip-flops are triggered by high-to-low transitions of the clock input. Reset for the counters is asynchronous and active-high. State changes of the Q outputs do not occur simultaneously because of internal ripple delays. Therefore, decoded output signals are subject to decoding spikes and should not be used as clocks or as strobes except when gated with the Clock of the VHC393.

The inputs tolerate voltages up to 7V, allowing the interface of 5V systems to 3V systems.

- High Speed:  $f_{max} = 170\text{MHz}$  (Typ) at  $V_{CC} = 5\text{V}$
- Low Power Dissipation:  $I_{CC} = 4\mu\text{A}$  (Max) at  $T_A = 25^\circ\text{C}$
- High Noise Immunity:  $V_{NIH} = V_{NIL} = 28\% V_{CC}$
- Power Down Protection Provided on Inputs
- Balanced Propagation Delays
- Designed for 2V to 5.5V Operating Range
- Low Noise:  $V_{OLP} = 0.8\text{V}$  (Max)
- Pin and Function Compatible with Other Standard Logic Families
- Latchup Performance Exceeds 300mA
- ESD Performance: HBM > 2000V; Machine Model > 200V
- Chip Complexity: 236 FETs or 59 Equivalent Gates

### LOGIC DIAGRAM



### FUNCTION TABLE

Inputs		Outputs
Clock	Reset	
X	H	L
H	L	No Change
L	L	No Change
↑	L	No Change
↓	L	Next State

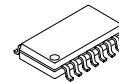
## MC74VHC393



**D SUFFIX**  
14-LEAD SOIC PACKAGE  
CASE 751A-03



**DT SUFFIX**  
14-LEAD TSSOP PACKAGE  
CASE 948G-01



**M SUFFIX**  
14-LEAD SOIC EIAJ PACKAGE  
CASE 965-01

### ORDERING INFORMATION

MC74VHCXXXD	SOIC
MC74VHCXXXDT	TSSOP
MC74VHCXXXM	SOIC EIAJ

### PIN ASSIGNMENT

CP1	1	14	V <sub>CC</sub>
RD1	2	13	CP2
1QA	3	12	RD2
1QB	4	11	2QA
1QC	5	10	2QB
1QD	6	9	2QC
GND	7	8	2QD



**MAXIMUM RATINGS\***

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	DC Supply Voltage	- 0.5 to + 7.0	V
V <sub>in</sub>	DC Input Voltage	- 0.5 to + 7.0	V
V <sub>out</sub>	DC Output Voltage	- 0.5 to V <sub>CC</sub> + 0.5	V
I <sub>IK</sub>	Input Diode Current	- 20	mA
I <sub>OK</sub>	Output Diode Current	± 20	mA
I <sub>out</sub>	DC Output Current, per Pin	± 25	mA
I <sub>CC</sub>	DC Supply Current, V <sub>CC</sub> and GND Pins	± 75	mA
P <sub>D</sub>	Power Dissipation in Still Air, SOIC Packages† TSSOP Package†	500 450	mW
T <sub>stg</sub>	Storage Temperature	- 65 to + 150	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range GND ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>CC</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or V<sub>CC</sub>). Unused outputs must be left open.

\* Absolute maximum continuous ratings are those values beyond which damage to the device may occur. Exposure to these conditions or conditions beyond those indicated may adversely affect device reliability. Functional operation under absolute-maximum-rated conditions is not implied.

†Derating — SOIC Packages: - 7 mW/°C from 65° to 125°C  
TSSOP Package: - 6.1 mW/°C from 65° to 125°C

**RECOMMENDED OPERATING CONDITIONS**

Symbol	Parameter	Min	Max	Unit
V <sub>CC</sub>	DC Supply Voltage	2.0	5.5	V
V <sub>in</sub>	DC Input Voltage	0	5.5	V
V <sub>out</sub>	DC Output Voltage	0	V <sub>CC</sub>	V
T <sub>A</sub>	Operating Temperature	- 40	+ 85	°C
t <sub>r</sub> , t <sub>f</sub>	Input Rise and Fall Time	V <sub>CC</sub> = 3.3V 0 V <sub>CC</sub> = 5.0V 0	100 20	ns/V

**DC ELECTRICAL CHARACTERISTICS**

Symbol	Parameter	Test Conditions	V <sub>CC</sub> V	T <sub>A</sub> = 25°C			T <sub>A</sub> = - 40 to 85°C		Unit
				Min	Typ	Max	Min	Max	
V <sub>IH</sub>	Minimum High-Level Input Voltage		2.0 3.0 to 5.5	1.50 V <sub>CC</sub> × 0.7			1.50 V <sub>CC</sub> × 0.7		V
V <sub>IL</sub>	Maximum Low-Level Input Voltage		2.0 3.0 to 5.5			0.50 V <sub>CC</sub> × 0.3		0.50 V <sub>CC</sub> × 0.3	V
V <sub>OH</sub>	Minimum High-Level Output Voltage	V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = - 50µA	2.0 3.0 4.5	1.9 2.9 4.4	2.0 3.0 4.5		1.9 2.9 4.4		V
		V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = - 4mA I <sub>OH</sub> = - 8mA	3.0 4.5	2.58 3.94		2.48 3.80			
V <sub>OL</sub>	Maximum Low-Level Output Voltage	V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OL</sub> = 50µA	2.0 3.0 4.5		0.0 0.0 0.0	0.1 0.1 0.1		0.1 0.1 0.1	V
		V <sub>in</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OL</sub> = 4mA I <sub>OL</sub> = 8mA	3.0 4.5			0.36 0.36	0.44 0.44		

## DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	V <sub>CC</sub> V	T <sub>A</sub> = 25°C			T <sub>A</sub> = -40 to 85°C		Unit
				Min	Typ	Max	Min	Max	
I <sub>in</sub>	Maximum Input Leakage Current	V <sub>in</sub> = 5.5V or GND	0 to 5.5			±0.1		±1.0	μA
I <sub>CC</sub>	Maximum Quiescent Supply Current	V <sub>in</sub> = V <sub>CC</sub> or GND	5.5			4.0		40.0	μA

AC ELECTRICAL CHARACTERISTICS (Input t<sub>r</sub> = t<sub>f</sub> = 3.0ns)

Symbol	Parameter	Test Conditions	T <sub>A</sub> = 25°C			T <sub>A</sub> = -40 to 85°C		Unit
			Min	Typ	Max	Min	Max	
f <sub>max</sub>	Maximum Clock Frequency (50% Duty Cycle)	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 15pF	75	120		65		ns
		C <sub>L</sub> = 50pF	45	65		35		
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, CP to QA	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 15pF		8.6	13.2	1.0	15.5	ns
		C <sub>L</sub> = 50pF		11.1	16.7	1.0	19.0	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, CP to QB	V <sub>CC</sub> = 5.0 ± 0.5V C <sub>L</sub> = 15pF	125	170		105	10.0	ns
		C <sub>L</sub> = 50pF	85	115		75	12.0	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, CP to QC	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 15pF		10.2	15.8	1.0	18.5	ns
		C <sub>L</sub> = 50pF		12.7	19.3	1.0	22.0	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, CP to QD	V <sub>CC</sub> = 5.0 ± 0.5V C <sub>L</sub> = 15pF		6.8	9.8	1.0	11.5	ns
		C <sub>L</sub> = 50pF		8.3	11.8	1.0	13.5	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, CP to Qn	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 15pF		11.7	18.0	1.0	21.0	ns
		C <sub>L</sub> = 50pF		14.2	21.5	1.0	24.5	
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay, RD to Qn	V <sub>CC</sub> = 5.0 ± 0.5V C <sub>L</sub> = 15pF		7.7	11.2	1.0	13.0	ns
		C <sub>L</sub> = 50pF		9.2	13.2	1.0	15.0	
t <sub>OSLH</sub> , t <sub>OSHL</sub>	Output to Output Skew	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 50pF		13.0	19.7	1.0	23.0	pF
		(Note NO TAG)		15.5	23.2	1.0	26.5	
C <sub>in</sub>	Maximum Input Capacitance	V <sub>CC</sub> = 5.0 ± 0.5V C <sub>L</sub> = 50pF		8.5	12.5	1.0	14.5	pF
		(Note NO TAG)		10.0	14.5	1.0	16.5	
C <sub>PD</sub>	Power Dissipation Capacitance (Note NO TAG)	V <sub>CC</sub> = 3.3 ± 0.3V C <sub>L</sub> = 50pF		7.9	12.3	1.0	14.5	pF
		C <sub>L</sub> = 50pF		10.4	15.8	1.0	18.0	
C <sub>PD</sub>	Power Dissipation Capacitance (Note NO TAG)	V <sub>CC</sub> = 5.0 ± 0.5V C <sub>L</sub> = 50pF		5.4	8.1	1.0	9.5	pF
		C <sub>L</sub> = 50pF		6.9	10.1	1.0	11.5	
						Typical @ 25°C, V <sub>CC</sub> = 5.0V		
						23		pF

1. Parameter guaranteed by design. t<sub>OSLH</sub> = |t<sub>PLHm</sub> - t<sub>PLHn</sub>|, t<sub>OSHL</sub> = |t<sub>PHLm</sub> - t<sub>PHLn</sub>|.

2. C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation: I<sub>CC(OPR)</sub> = C<sub>PD</sub> • V<sub>CC</sub> • f<sub>in</sub> + I<sub>CC</sub>/2 (per 4-bit counter). C<sub>PD</sub> is used to determine the no-load dynamic power consumption; P<sub>D</sub> = C<sub>PD</sub> • V<sub>CC</sub><sup>2</sup> • f<sub>in</sub> + I<sub>CC</sub> • V<sub>CC</sub>.

**NOISE CHARACTERISTICS** (Input  $t_r = t_f = 3.0\text{ns}$ ,  $C_L = 50\text{pF}$ ,  $V_{CC} = 5.0\text{V}$ )

Symbol	Parameter	$T_A = 25^\circ\text{C}$		Unit
		Typ	Max	
$V_{OLP}$	Quiet Output Maximum Dynamic $V_{OL}$	0.5	0.8	V
$V_{OLV}$	Quiet Output Minimum Dynamic $V_{OL}$	-0.5	-0.8	V
$V_{IHD}$	Minimum High Level Dynamic Input Voltage		3.5	V
$V_{ILD}$	Maximum Low Level Dynamic Input Voltage		1.5	V

**TIMING REQUIREMENTS** (Input  $t_r = t_f = 3.0\text{ns}$ )

Symbol	Parameter	Test Conditions	$T_A = 25^\circ\text{C}$		$T_A = -40$ to $85^\circ\text{C}$	Unit
			Typ	Limit	Limit	
$t_w$	Minimum Pulse Width, CP	$V_{CC} = 3.3 \pm 0.3\text{ V}$ $V_{CC} = 5.0 \pm 0.5\text{ V}$		5.0 5.0	5.0 5.0	ns
$t_w$	Minimum Pulse Width, RD	$V_{CC} = 3.3 \pm 0.3\text{ V}$ $V_{CC} = 5.0 \pm 0.5\text{ V}$		5.0 5.0	5.0 5.0	ns
$t_{rec}$	Minimum Recovery Time, RD to CP	$V_{CC} = 3.3 \pm 0.3\text{ V}$ $V_{CC} = 5.0 \pm 0.5\text{ V}$		5.0 4.0	5.0 4.0	ns
$t_r, t_f$	Minimum Input Rise and Fall Times	$V_{CC} = 3.3 \pm 0.3\text{ V}$ $V_{CC} = 5.0 \pm 0.5\text{ V}$		330 100	330 100	ns

**SWITCHING WAVEFORMS**

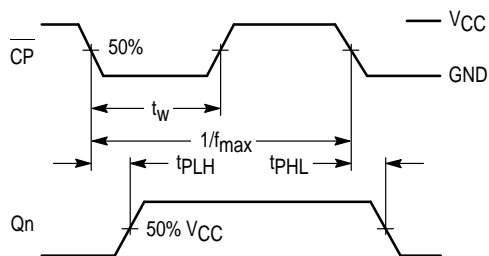


Figure 1.

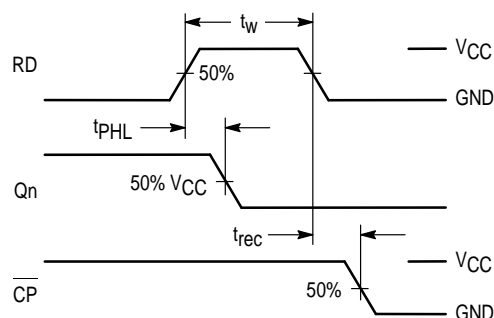
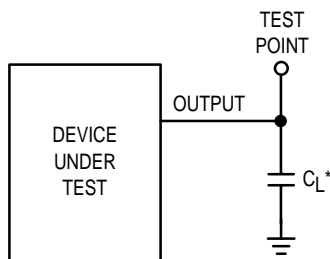


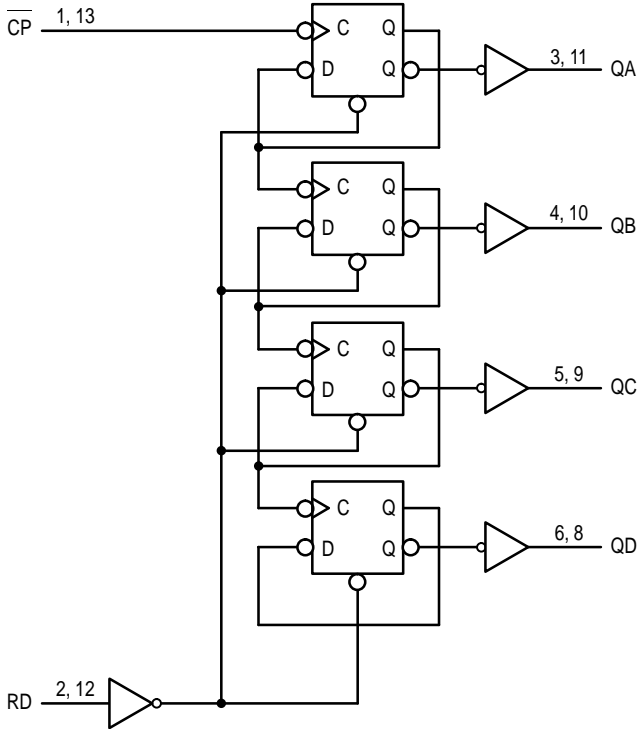
Figure 2.



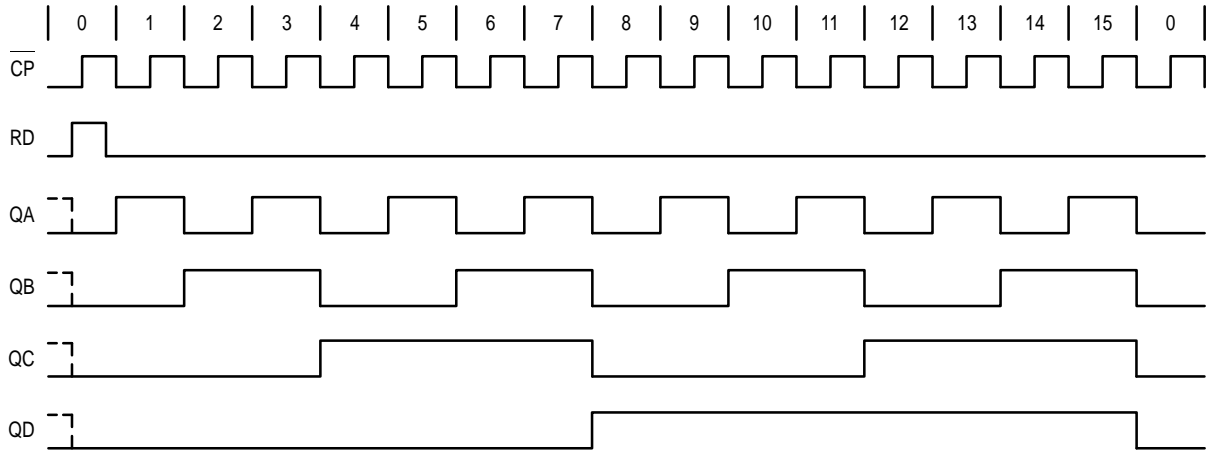
\* Includes all probe and jig capacitance

Figure 3. Test Circuit

EXPANDED LOGIC DIAGRAM



**TIMING DIAGRAM**

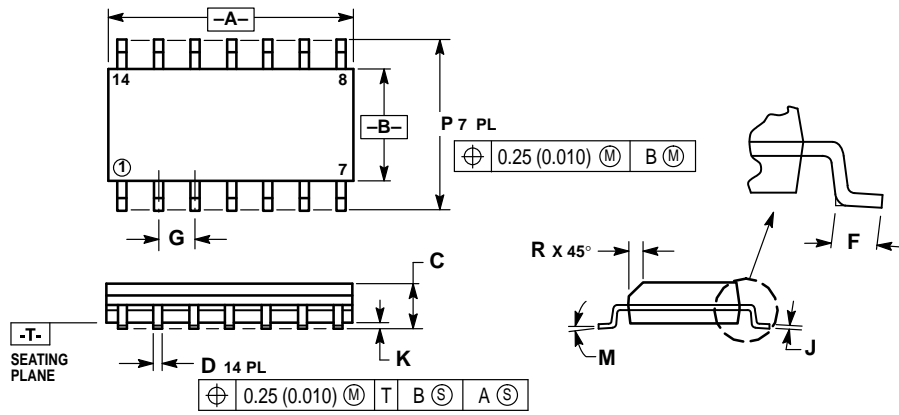


**COUNT SEQUENCE**

Count	Outputs			
	QD	QC	QB	QA
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H
10	H	L	H	L
11	H	L	H	H
12	H	H	L	L
13	H	H	L	H
14	H	H	H	L
15	H	H	H	H

OUTLINE DIMENSIONS

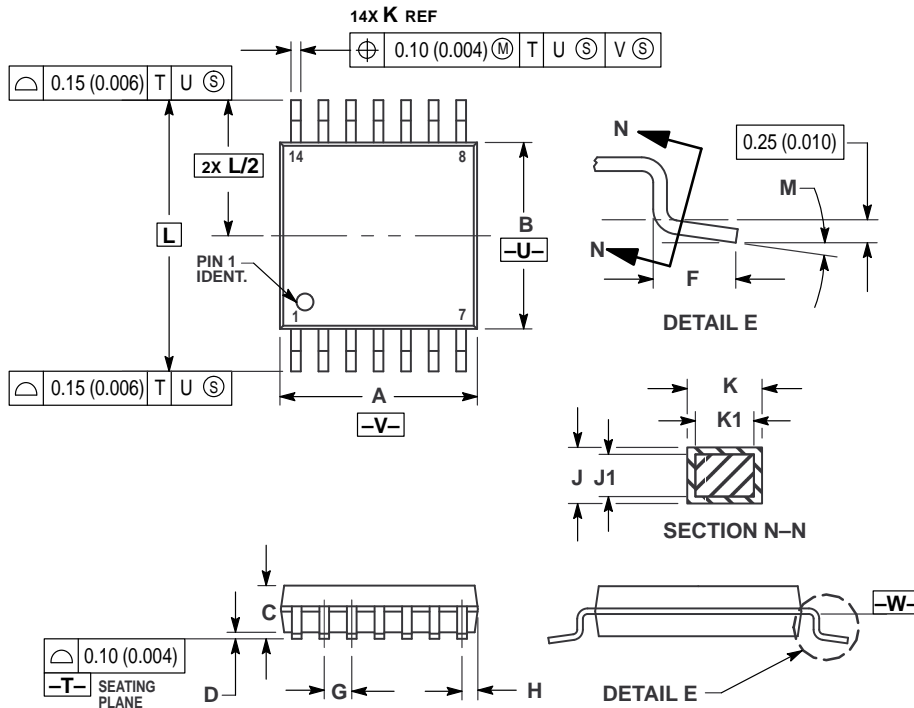
**D SUFFIX**  
 PLASTIC SOIC PACKAGE  
 CASE 751A-03  
 ISSUE F



- 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.

DIM	MILLIMETERS		INCHES	
	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

**DT SUFFIX**  
 PLASTIC TSSOP PACKAGE  
 CASE 948G-01  
 ISSUE O

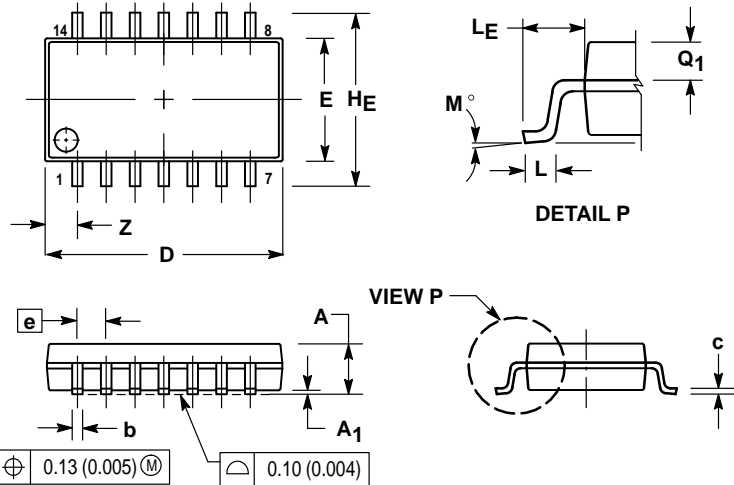


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
  4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.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

DIM	MILLIMETERS		INCHES	
	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°

OUTLINE DIMENSIONS

M SUFFIX  
PLASTIC SOIC EIAJ PACKAGE  
CASE 965-01  
ISSUE O



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS AND ARE MEASURED AT THE PARTING LINE. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
  4. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
  5. THE LEAD WIDTH DIMENSION (b) DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSIONS AND ADJACENT LEAD TO BE 0.46 (0.018).

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	2.05	—	0.081
A <sub>1</sub>	0.05	0.20	0.002	0.008
b	0.35	0.50	0.014	0.020
c	0.18	0.27	0.007	0.011
D	9.90	10.50	0.390	0.413
E	5.10	5.45	0.201	0.215
e	1.27 BSC		0.050 BSC	
HE	7.40	8.20	0.291	0.323
0.50	0.50	0.85	0.020	0.033
L <sub>E</sub>	1.10	1.50	0.043	0.059
M	0°	10°	0°	10°
Q <sub>1</sub>	0.70	0.90	0.028	0.035
Z	—	1.42	—	0.056

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