MC74VHC138

3-to-8 Line Decoder

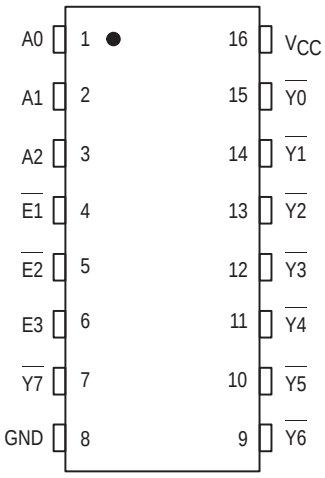
The MC74VHC138 is an advanced high speed CMOS 3–to–8 decoder fabricated with silicon gate CMOS technology. It achieves high speed operation similar to equivalent Bipolar Schottky TTL while maintaining CMOS low power dissipation.

When the device is enabled, three Binary Select inputs (A0 – A2) determine which one of the outputs ($\overline{Y0}$ – $\overline{Y7}$) will go Low. When enable input E3 is held Low or either $\overline{E2}$ or $\overline{E1}$ is held High, decoding function is inhibited and all outputs go high. E3, $\overline{E2}$, and $\overline{E1}$ inputs are provided to ease cascade connection and for use as an address decoder for memory systems.

The internal circuit is composed of three stages, including a buffer output which provides high noise immunity and stable output. The inputs tolerate voltages up to 7V, allowing the interface of 5V systems to 3V systems.

- High Speed: t_{PD} = 5.7ns (Typ) at V_{CC} = 5V
- Low Power Dissipation: I_{CC} = 4μA (Max) at T_A = 25°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 V (Max)
- Pin and Function Compatible with Other Standard Logic Families
- Latchup Performance Exceeds 300mA
- ESD Performance: HBM > 2000V; Machine Model > 200V
- Chip Complexity: 122 FETs or 30.5 Equivalent Gates

PIN ASSIGNMENT



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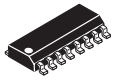
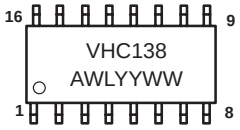
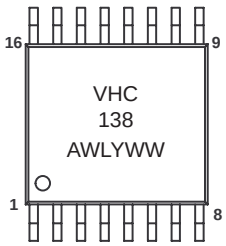
MARKING DIAGRAMS

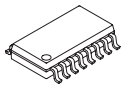


SOIC–16
D SUFFIX
CASE 751B

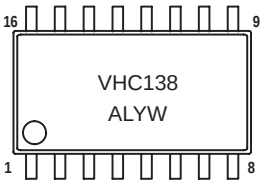


TSSOP–16
DT SUFFIX
CASE 948F





SOIC EIAJ–16
M SUFFIX
CASE 966



A = Assembly Location
WL = Wafer Lot
YY = Year
WW = Work Week

A = Assembly Location	A = Assembly Location
WL = Wafer Lot	L = Wafer Lot
Y = Year	Y = Year
WW = Work Week	W = Work Week

ORDERING INFORMATION

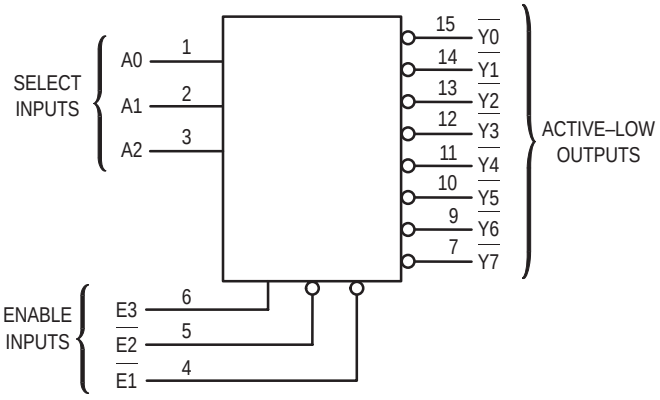
Device	Package	Shipping
MC74VHC138D	SOIC–16	48 Units/Rail
MC74VHC138DR2	SOIC–16	2500 Units/Reel
MC74VHC138DT	TSSOP–16	96 Units/Rail
MC74VHC138DTR2	TSSOP–16	2500 Units/Reel
MC74VHC138M	SOIC EIAJ–16	48 Units/Rail
MC74VHC138MEL	SOIC EIAJ–16	2000 Units/Reel

FUNCTION TABLE

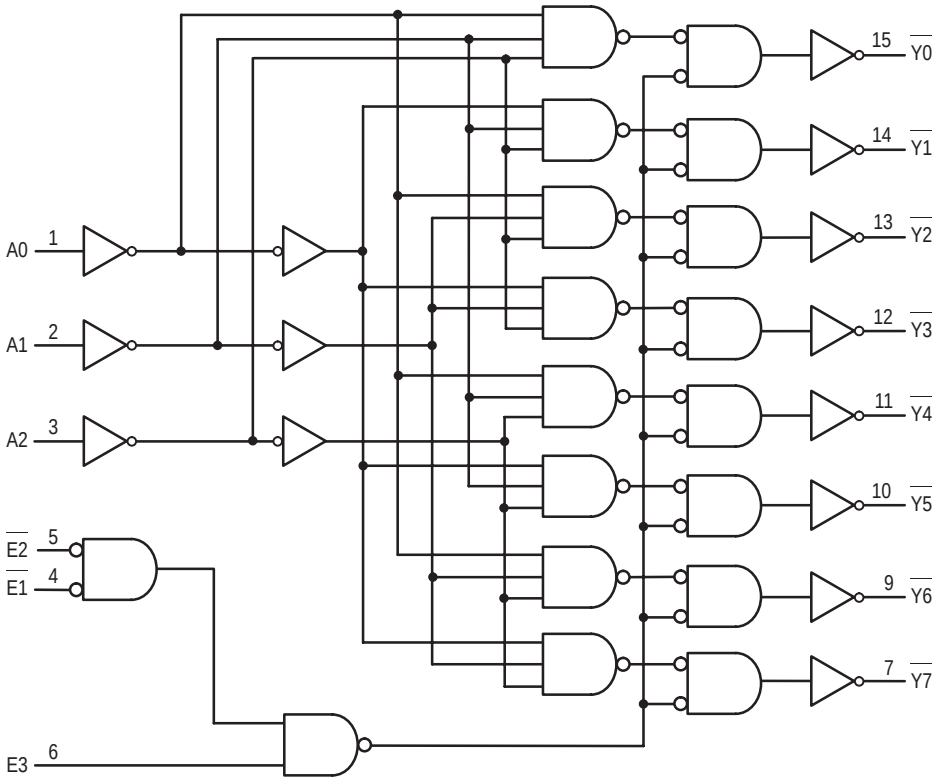
Inputs						Outputs							
E3	$\overline{E2}$	$\overline{E1}$	A2	A1	A0	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	L	L	H	H	H	H	L	H	H	H
H	L	L	H	L	H	H	H	H	H	H	L	H	H
H	L	L	H	H	L	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

H = high level (steady state); L = low level (steady state);
X = don't care

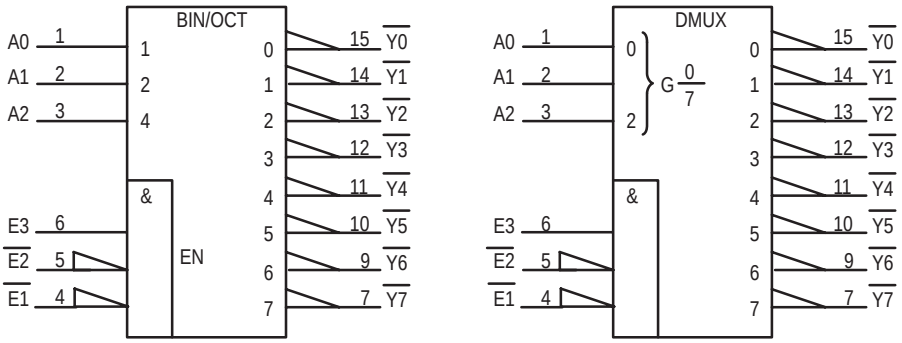
LOGIC DIAGRAM



EXPANDED LOGIC DIAGRAM



IEC LOGIC DIAGRAM



MAXIMUM RATINGS*

Symbol	Parameter	Value	Unit
V_{CC}	DC Supply Voltage	– 0.5 to + 7.0	V
V_{in}	DC Input Voltage	– 0.5 to + 7.0	V
V_{out}	DC Output Voltage	– 0.5 to V_{CC} + 0.5	V
I_{IK}	Input Diode Current	– 20	mA
I_{OK}	Output Diode Current	± 20	mA
I_{out}	DC Output Current, per Pin	± 25	mA
I_{CC}	DC Supply Current, V_{CC} and GND Pins	± 75	mA
P_D	Power Dissipation in Still Air, SOIC Packages†	500	mW
	TSSOP Package†	450	
T_{stg}	Storage Temperature	– 65 to + 150	°C

* 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

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_{in} and V_{out} should be constrained to the range GND ≤ (V_{in} or V_{out}) ≤ V_{CC}.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either GND or V_{CC}). Unused outputs must be left open.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter		Min	Max	Unit
V_{CC}	DC Supply Voltage		2.0	5.5	V
V_{in}	DC Input Voltage		0	5.5	V
V_{out}	DC Output Voltage		0	V_{CC}	V
T_A	Operating Temperature		– 55	+ 125	°C
t_r, t_f	Input Rise and Fall Time	V_{CC} = 3.3V ±0.3V	0	100	ns/V
		V_{CC} =5.0V ±0.5V	0	20	

The θ_{JA} of the package is equal to 1/Derating. Higher junction temperatures may affect the expected lifetime of the device per the table and figure below.

DEVICE JUNCTION TEMPERATURE VERSUS TIME TO 0.1% BOND FAILURES

Junction Temperature °C	Time, Hours	Time, Years
80	1,032,200	117.8
90	419,300	47.9
100	178,700	20.4
110	79,600	9.4
120	37,000	4.2
130	17,800	2.0
140	8,900	1.0

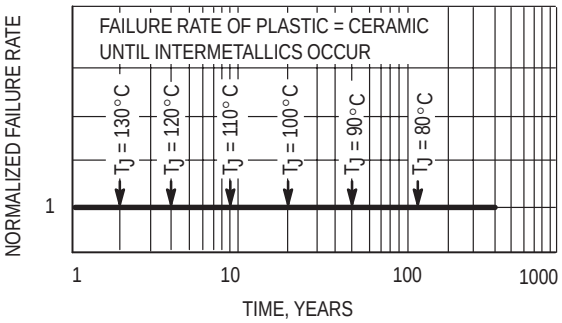


Figure 1. Failure Rate vs. Time Junction Temperature

DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	V_{CC} (V)	T_A = 25°C			T_A = ≤ 85°C		T_A = ≤ 125°C		Unit
				Min	Typ	Max	Min	Max	Min	Max	
V_{IH}	Minimum High–Level Input Voltage		2.0 3.0 4.5 5.5	1.5 2.1 3.15 3.85			1.5 2.1 3.15 3.85		1.5 2.1 3.15 3.85		V
V_{IL}	Maximum Low–Level Input Voltage		2.0 3.0 4.5 5.5			0.5 0.9 1.35 1.65		0.5 0.9 1.35 1.65		0.5 0.9 1.35 1.65	V
V_{OH}	Minimum High–Level Output Voltage V_{IN} = V_{IH} or V_{IL}	V_{IN} = V_{IH} or V_{IL} I_{OH} = – 50 μA	2.0 3.0 4.5	1.9 2.9 4.4	2.0 3.0 4.5		1.9 2.9 4.4		1.9 2.9 4.4		V
		V_{IN} = V_{IH} or V_{IL} I_{OH} = –4 mA I_{OH} = –8 mA	3.0 4.5	2.58 3.94			2.48 3.80		2.34 3.66		
V_{OL}	Maximum Low–Level Output Voltage V_{IN} = V_{IH} or V_{IL}	V_{IN} = V_{IH} or V_{IL} I_{OL} = 50 μA	2.0 3.0 4.5		0.0 0.0 0.0	0.1 0.1 0.1		0.1 0.1 0.1		0.1 0.1 0.1	V
		V_{IN} = V_{IH} or V_{IL} I_{OL} = 4 mA I_{OL} = 8 mA	3.0 4.5			0.36 0.36		0.44 0.44		0.52 0.52	
I_{IN}	Maximum Input Leakage Current	V_{IN} = 5.5 V or GND	0 to 5.5			± 0.1		± 1.0		± 1.0	μA
I_{CC}	Maximum Quiescent Supply Current	V_{IN} = V_{CC} or GND	5.5			4.0		40.0		40.0	μA

AC ELECTRICAL CHARACTERISTICS (Input t_r = t_f = 3.0ns)

Symbol	Parameter	Test Conditions	T_A = 25°C			T_A = – 40 to 85°C		T_A = – 55 to 125°C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
t_{PLH}, t_{PHL}	Maximum Propagation Delay, A to Y	V_{CC} = 3.3 ± 0.3V C_L = 15pF C_L = 50pF		8.2 10.0	11.4 15.8	1.0 1.0	13.5 18.0	1.0 1.0	13.5 18.0	ns
		V_{CC} = 5.0 ± 0.5V C_L = 15pF C_L = 50pF		5.7 7.2	8.1 10.1	1.0 1.0	9.5 11.5	1.0 1.0	9.5 11.5	
t_{PLH}, t_{PHL}	Maximum Propagation Delay, E3 to Y	V_{CC} = 3.3 ± 0.3V C_L = 15pF C_L = 50pF		8.1 10.6	12.8 16.3	1.0 1.0	15.0 18.5	1.0 1.0	15.0 18.5	ns
		V_{CC} = 5.0 ± 0.5V C_L = 15pF C_L = 50pF		5.6 7.1	8.1 10.1	1.0 1.0	9.5 11.5	1.0 1.0	9.5 11.5	
t_{PLH}, t_{PHL}	Maximum Propagation Delay, E2 or E1 to Y	V_{CC} = 3.3 ± 0.3V C_L = 15pF C_L = 50pF		8.2 10.7	11.4 14.9	1.0 1.0	13.5 17.0	1.0 1.0	13.5 17.0	ns
		V_{CC} = 5.0 ± 0.5V C_L = 15pF C_L = 50pF		5.8 7.3	8.1 10.1	1.0 1.0	9.5 11.5	1.0 1.0	9.5 11.5	
C_{IN}	Maximum Input Capacitance			4	10		10		10	pF

		Typical @ 25°C, V_{CC} = 5.0V	
C_{PD}	Power Dissipation Capacitance (Note 1.)	34	pF

1. C_{PD} 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: $I_{CC(OPR)} = C_{PD} \bullet V_{CC} \bullet f_{in} + I_{CC}$. C_{PD} is used to determine the no–load dynamic power consumption; $P_D = C_{PD} \bullet V_{CC}^2 \bullet f_{in} + I_{CC} \bullet V_{CC}$.

SWITCHING WAVEFORMS

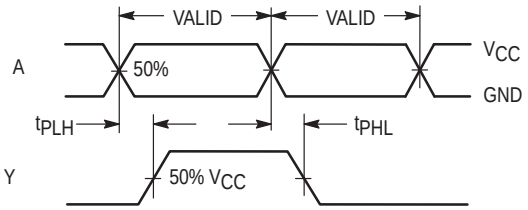


Figure 2.

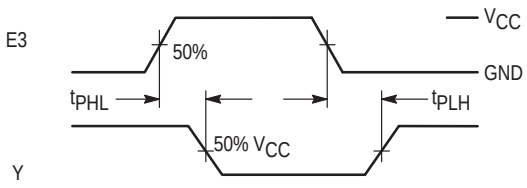


Figure 3.

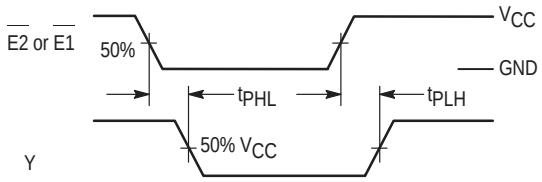
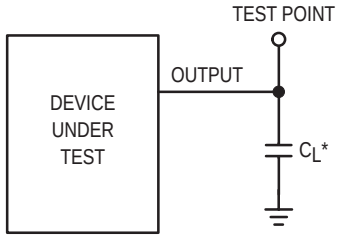


Figure 4.



*Includes all probe and jig capacitance

Figure 5. Test Circuit

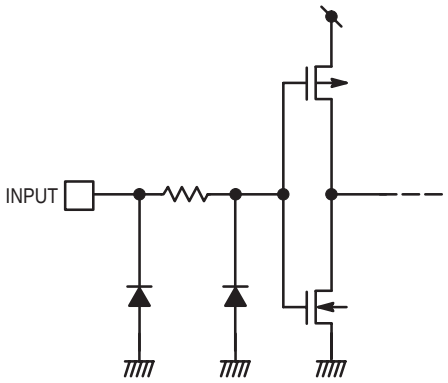
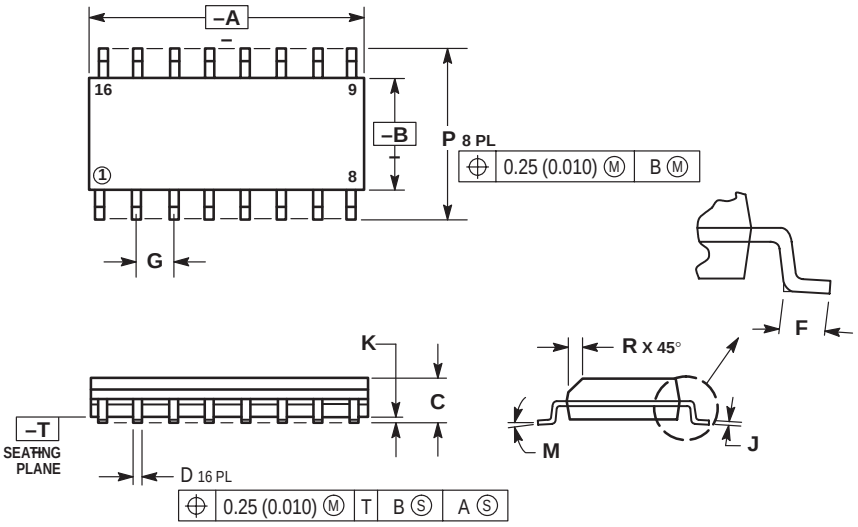


Figure 6. Input Equivalent Circuit

PACKAGE DIMENSIONS

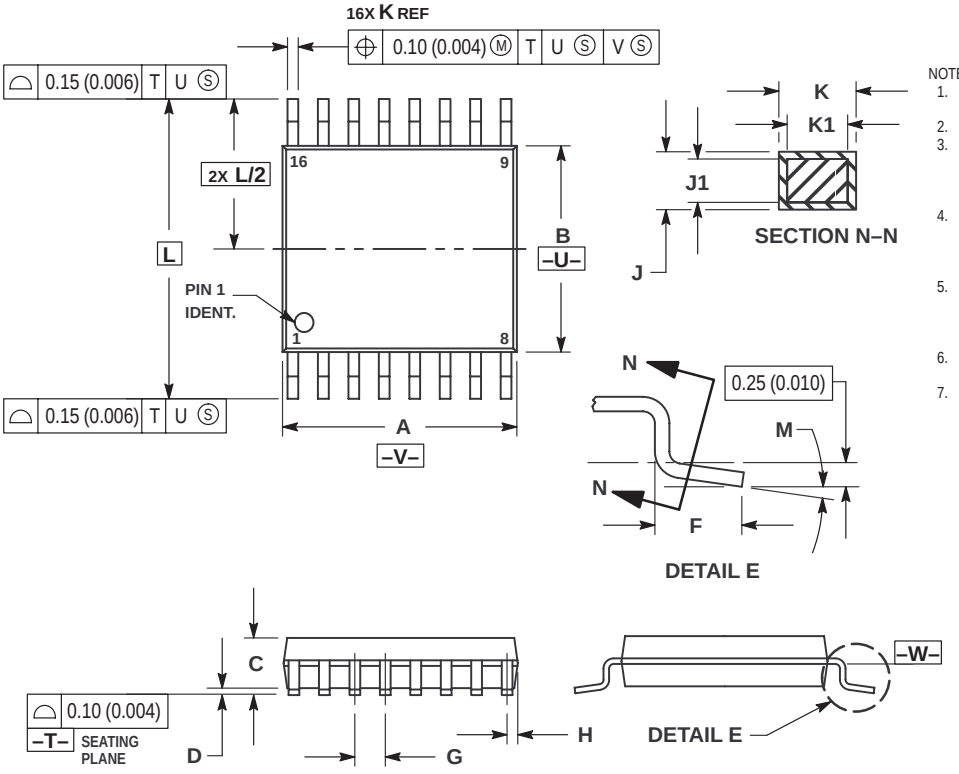
SOIC–16
D SUFFIX
CASE 751B–05
ISSUE J



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	9.80	10.00	0.386	0.393
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	0.229	0.244
R	0.25	0.50	0.010	0.019

TSSOP–16
DT SUFFIX
CASE 948F–01
ISSUE O

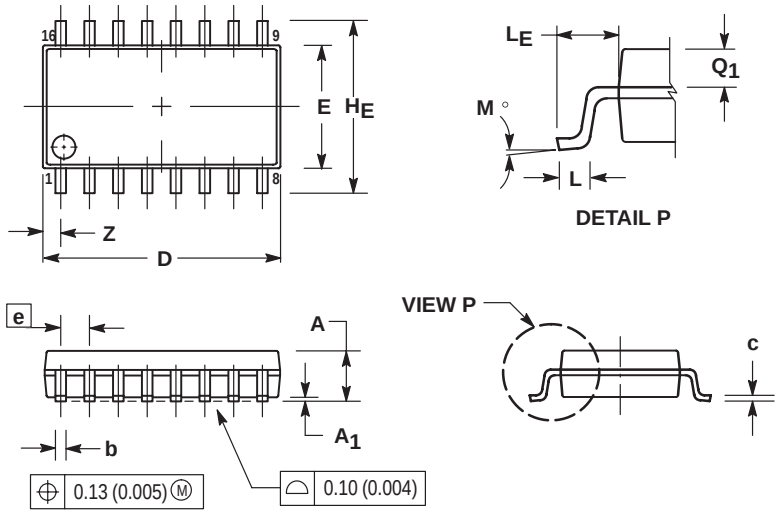


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD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

	MILLIMETERS		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	0.18	0.28	0.007	0.011
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 °

PACKAGE DIMENSIONS

SOIC EIAJ–16
M SUFFIX
CASE 966–01
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).

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	——	2.05	——	0.081
A_1	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	
H_E	7.40	8.20	0.291	0.323
L	0.50	0.85	0.020	0.033
L_E	1.10	1.50	0.043	0.059
M	0 °	10 °	0 °	10 °
Q_1	0.70	0.90	0.028	0.035
Z	——	0.78	——	0.031

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