1. General Description

The EM74HC138 and EM74HCT138 decode three binary weighted address inputs (A0, A1 and A2) to eight mutually exclusive outputs ($\overline{Y}0$ to $\overline{Y}7$). The device features three enable inputs ($\overline{E}1$, $\overline{E}2$ and E3). Every output will be HIGH unless $\overline{E}1$ and $\overline{E}2$ are LOW and E3 is HIGH. This multiple enable function allows easy parallel expansion to a 1-of-32 (5 to 32 lines) decoder with just four '138 ICs and one inverter. The '138 can be used as an eight output demultiplexer by using one of the active LOW enable inputs as the data input and the remaining enable inputs as strobes. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of V_{CC}.

2. Features and Benefits

- Wide operating voltage 2.0 V to 6.0 V
- High noise immunity
- CMOS low power dissipation
- Latch-up performance exceeds 250 mA
- Demultiplexing capability
- Multiple input enable for easy expansion
- Ideal for memory chip select decoding
- Active LOW mutually exclusive outputs
- Input levels:
  - For EM74HC138: CMOS level
  - For EM74HCT138: TTL level
- ESD protection:
  - ANSI/ESDA/JEDEC JS-001 class 2 exceeds 3500 V
  - CDM: ANSI/ESDA/JEDEC JS-002 class C3 exceeds 2000 V
- Multiple package options
- Specified from -40 °C to +85 °C and from -40 °C to +125 °C

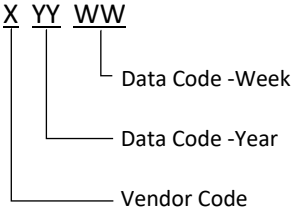
3.Ordering Information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Quantity
EM74HC138D	HC138 XYYWW	SOP-16L	plastic small outline package; 16 leads; body width 3.9 mm	3000
EM74HCT138D	HCT138 XYYWW			
EM74HC138PW	HC138 XYYWW	TSSOP-16L	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	3000
EM74HCT138PW	HCT138 XYYWW			

MARKING INFORMATION

NOTE: XYYWW = Vendor Code and Data Code.



4. Functional diagram

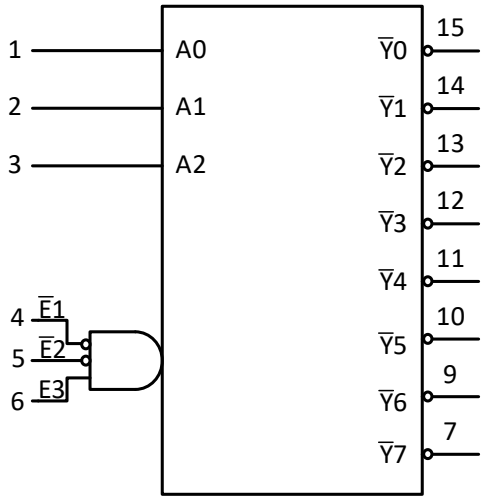


Fig. 1. Logic symbol

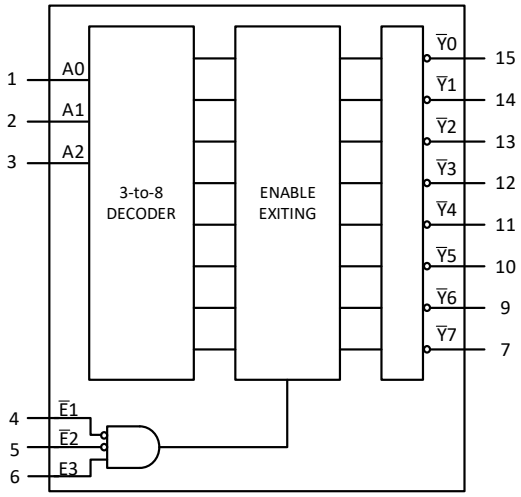


Fig. 2. Functional diagram

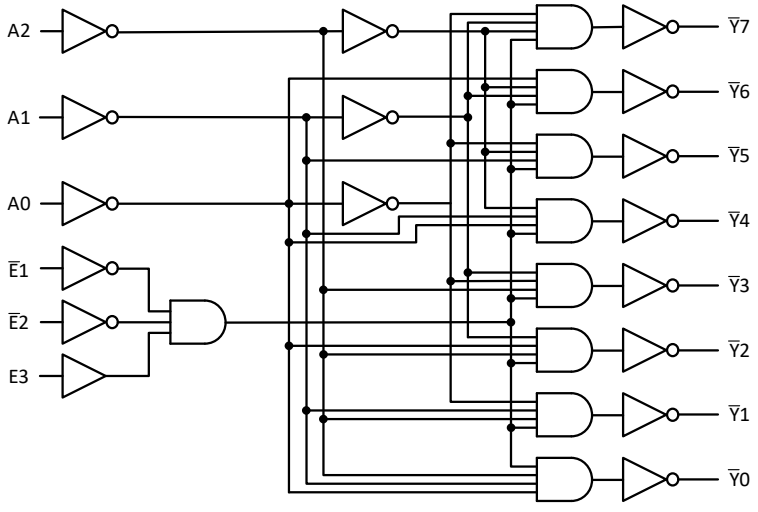


Fig. 3. Logic diagram

5. Pinning Information

5.1. Pinning

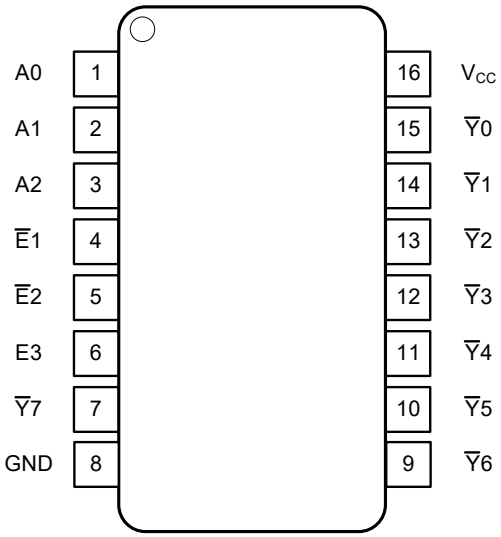


Fig. 4. Top view pin configuration SOP-20L and TSSOP-20L

5.2. Pin description

Table 2. Pin description

Symbol	Pin	Description
A0, A1, A2	1, 2, 3	address input
$\overline{E}1$, $\overline{E}2$	4, 5	enable input (active LOW)
E3	6	enable input (active HIGH)
$\overline{Y}0$, $\overline{Y}1$, $\overline{Y}2$, $\overline{Y}3$, $\overline{Y}4$, $\overline{Y}5$, $\overline{Y}6$, $\overline{Y}7$	15, 14, 13, 12, 11, 10, 9, 7	output
GND	8	ground (0 V)
V_{CC}	16	supply voltage

6.Functional Description

Table 3. Function table

H = HIGH voltage level; L = LOW voltage level; X = don't care.

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

7. Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Table 4. Absolute Maximum Ratings

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		-0.5	7	V
I_{IK}	input clamping current	$V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V		±20	mA
I_{OK}	output clamping current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V		±20	mA
I_O	output current	$-0.5V < V_O < V_{CC} + 0.5$ V		±25	mA
I_{CC}	supply current			50	mA
I_{GND}	ground current		-50		mA
P_{tot}	total power dissipation	Tamb = -40 °C to + 125 °C		500	mW
T_{stg}	storage temperature		-65	+150	°C

8. Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. EnergyMath does not recommend exceeding them or designing to Absolute Maximum Ratings.

Table 5. Recommended Operating Conditions

Symbol	Parameter	Conditions	EM74HC138			EM74HCT138			Unit
			Min	Min	Typ	Min	Min	Typ	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0		V_{CC}	0		V_{CC}	V
V_O	output voltage		0		V_{CC}	0		V_{CC}	V
T_{amb}	ambient temperature		-40	+25	+125	-40	+25	+125	°C
Δt/ΔV	input transition rise and fall rate	V_{CC} = 2.0 V			625				ns/V
		V_{CC} = 4.5 V		1.67	139		1.67	139	ns/V
		V_{CC} = 6.0 V			83				ns/V

9.Static Characteristics

Table 6. Static characteristics

At recommended operating conditions. Voltages are referenced to GND (ground = 0 V). Typical values measured at T_{amb} = 25°C (unless otherwise noted).

Symbol	Parameter	Conditions	-40 °C to +85 °C			-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	
EM74HC138								
V_{IH}	HIGH-level input voltage	V_{CC} = 2.0 V	1.5			1.5		V
		V_{CC} = 4.5 V	3.15			3.15		V
		V_{CC} = 6.0 V	4.2			4.2		V
V_{IL}	LOW-level input voltage	V_{CC} = 2.0 V			0.5		0.5	V
		V_{CC} = 4.5 V			1.35		1.35	V
		V_{CC} = 6.0 V			1.8		1.8	V
V_{OH}	HIGH-level output voltage	V_I = V_{IH} or V_{IL}						
		I_O = -20 µA; V_{CC} = 2.0 V	1.9			1.9		V
		I_O = -20 µA; V_{CC} = 4.5 V	4.4			4.4		V
		I_O = -20 µA; V_{CC} = 6.0 V	5.9			5.9		V
		I_O = -4.0 mA; V_{CC} = 4.5 V	3.84			3.7		V
		I_O = -5.2 mA; V_{CC} = 6.0 V	5.34			5.2		V
V_{OL}	LOW-level output voltage	V_I = V_{IH} or V_{IL}						
		I_O = 20 µA; V_{CC} = 2.0 V			0.1		0.1	V
		I_O = 20 µA; V_{CC} = 4.5 V			0.1		0.1	V
		I_O = 20 µA; V_{CC} = 6.0 V			0.1		0.1	V
		I_O = 4.0 mA; V_{CC} = 4.5 V			0.33		0.4	V
		I_O = 5.2 mA; V_{CC} = 6.0 V			0.33		0.4	V
I_I	input leakage current	V_I = V_{CC} or GND ; V_{CC} = 6.0 V			±1		±1	µA
I_{CC}	supply current	V_I = V_{CC} or GND ; I_O = 0 A ; V_{CC} = 6.0 V			20		40	µA
C_I	input capacitance			4.0				pF

Symbol	Parameter	Conditions	-40 °C to +85 °C			-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	
EM74HCT138								
V_{IH}	HIGH-level input voltage	V_{CC} = 4.5 V to 5.5 V	2.0			2.0		V
V_{IL}	LOW-level input voltage	V_{CC} = 4.5 V to 5.5 V			0.8		0.8	V
V_{OH}	HIGH-level output voltage	V_I = V_{IH} or V_{IL};						
		I_O = -20 µA; V_{CC} = 4.5 V	4.4			4.4		V
		I_O = -4.0 mA; V_{CC} = 4.5 V	3.84			3.7		V
V_{OL}	LOW-level output voltage	V_I = V_{IH} or V_{IL};						
		I_O = 20 µA; V_{CC} = 4.5 V			0.1		0.1	V
		I_O = 4.0 mA; V_{CC} = 4.5 V			0.33		0.4	V
I_I	input leakage current	V_I = V_{CC} or GND ; V_{CC} = 5.5 V			±1		±1	µA
I_{CC}	supply current	V_I = V_{CC} or GND; I_O = 0 A; V_{CC} = 5.5 V			20		40	µA
ΔI_{CC}	additional supply current	per pin ; V_I = V_{CC} - 2.1 V; I_O = 0 A; other inputs at V_{CC} or GND; V_{CC} = 4.5 V to 5.5 V			400		490	µA
C_I	input capacitance			4.0				pF

10. Dynamic Characteristics

Table 7. Dynamic characteristics

Voltages are referenced to GND (ground = 0 V); for test circuit see Fig. 7. Typical values measured at T_{amb} = 25°C (unless otherwise noted).

Symbol	Parameter	Conditions	-40 °C to +85 °C			-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	
EM74HC138								
t_{pd}	propagation delay	An to $\overline{Y}n$; see Fig. 5 [1]						
		V_{CC} = 2.0 V			35		40	ns
		V_{CC} = 4.5 V			20		25	ns
		V_{CC} = 6.0 V			15		20	ns
		E3 to $\overline{Y}n$; see Fig. 5 [1]						
		V_{CC} = 2.0 V			35		40	ns
		V_{CC} = 4.5 V			20		25	ns
		V_{CC} = 6.0 V			15		20	ns
		$\overline{E}n$ to $\overline{Y}n$; see Fig. 6 [1]						
		V_{CC} = 2.0 V			35		40	ns
		V_{CC} = 4.5 V			20		25	ns
		V_{CC} = 6.0 V			15		20	ns
t_t	transition time	$\overline{Y}n$; see Fig. 5 and Fig. 6 [2]						
		V_{CC} = 2.0 V			9		11	ns
		V_{CC} = 4.5 V			6		8	ns
		V_{CC} = 6.0 V			4		5	ns
C_{PD}	power dissipation capacitance	C_L = 50pF ; f = 1 MHz ; V_I = GND to V_{CC} [3]		67				pF

Symbol	Parameter	Conditions	-40 °C to +85 °C			-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	
EM74HCT138								
t_{pd}	propagation delay	An to $\overline{Y}n$; V_{CC} = 4.5V; see Fig. 5 [1]			20		25	ns
		E3 to $\overline{Y}n$; V_{CC} = 4.5V; see Fig. 5 [1]			20		25	ns
		$\overline{E}n$ to $\overline{Y}n$; V_{CC} = 4.5V see Fig. 6 [1]			20		25	ns
t_t	transition time	$\overline{Y}n$; V_{CC}=4.5V; see Fig. 5 and Fig. 6; [2]			6		8	ns
C_{PD}	power dissipation capacitance	C_L = 50pF ; f = 1 MHz ; V_I = GND to V_{CC} – 1.5 V [3]		67				pF

[1] t_{pd} is the same as t_{PHL} and t_{PLH}.

[2] t_t is the same as t_{THL} and t_{TLH}.

[3] C_{PD} is used to determine the dynamic power dissipation (P_D in µW).

$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:

f_i = input frequency in MHz;

f_o = output frequency in MHz;

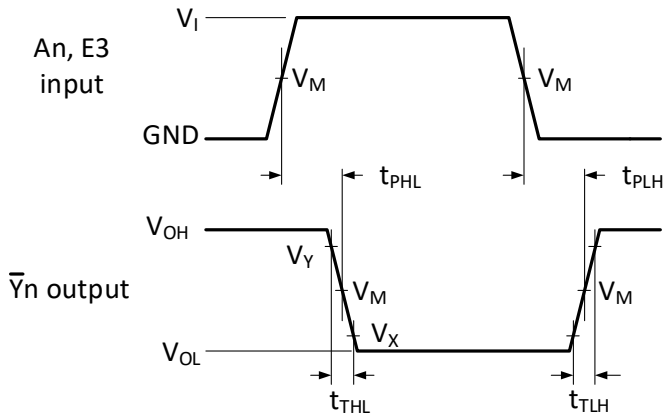
C_L = output load capacitance in pF;

V_{CC} = supply voltage in V;

N = number of inputs switching;

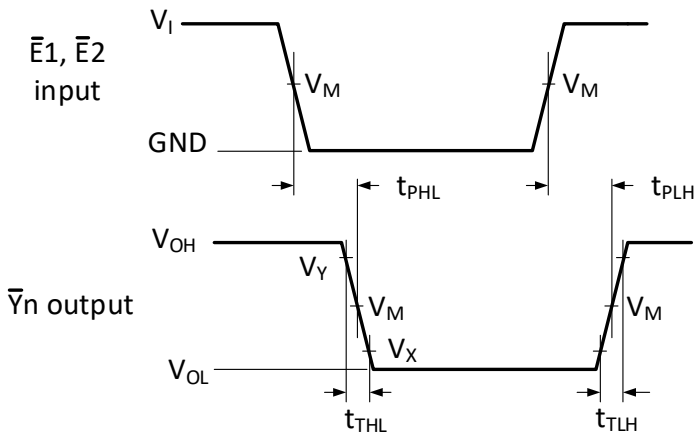
$\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of outputs.

10.1. Waveforms and test circuit



Measurement points are given in Table 8.
V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig. 5. Propagation delay input (An) and enable input (E3) to output ($\overline{Y}$n) and transition time output ($\overline{Y}$n)

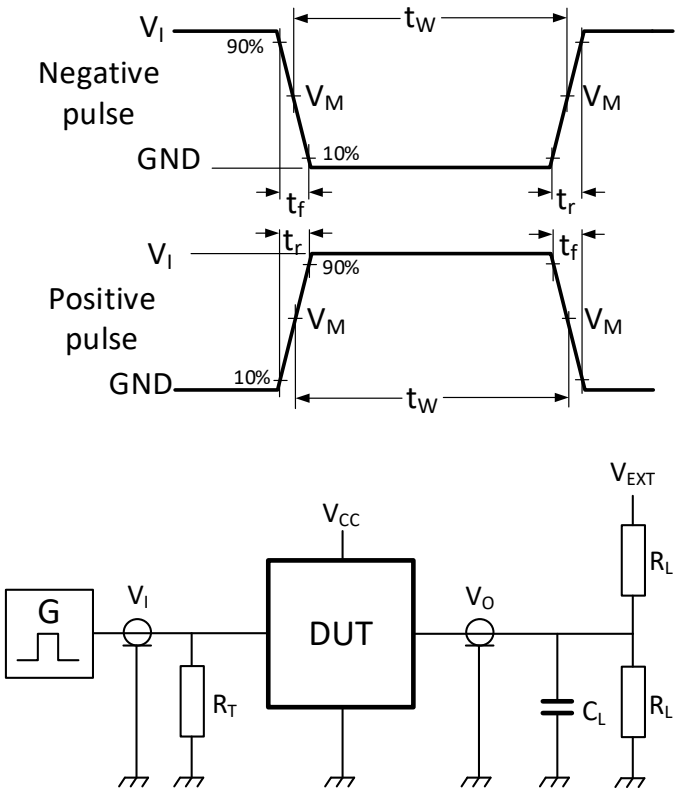


Measurement points are given in Table 8.
V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig. 6. Propagation delay enable input ($\overline{E}$n) to output ($\overline{Y}$n) and transition time output ($\overline{Y}$n)

Table 8. Measurement points

Type	Input	Output		
	V_M	V_M	V_X	V_Y
EM74HC245	0.5V_{CC}	0.5V_{CC}	0.1V_{CC}	0.9V_{CC}
EM74HCT245	1.3 V	1.3 V	0.1V_{CC}	0.9V_{CC}



Test data is given in Table 9.
Definitions for test circuit:
R_L = Load resistance.
C_L = Load capacitance including jig and probe capacitance.
R_T = Termination resistance should be equal to the output impedance Z_o of the pulse generator.
V_{EXT} = External voltage for measuring switching times.

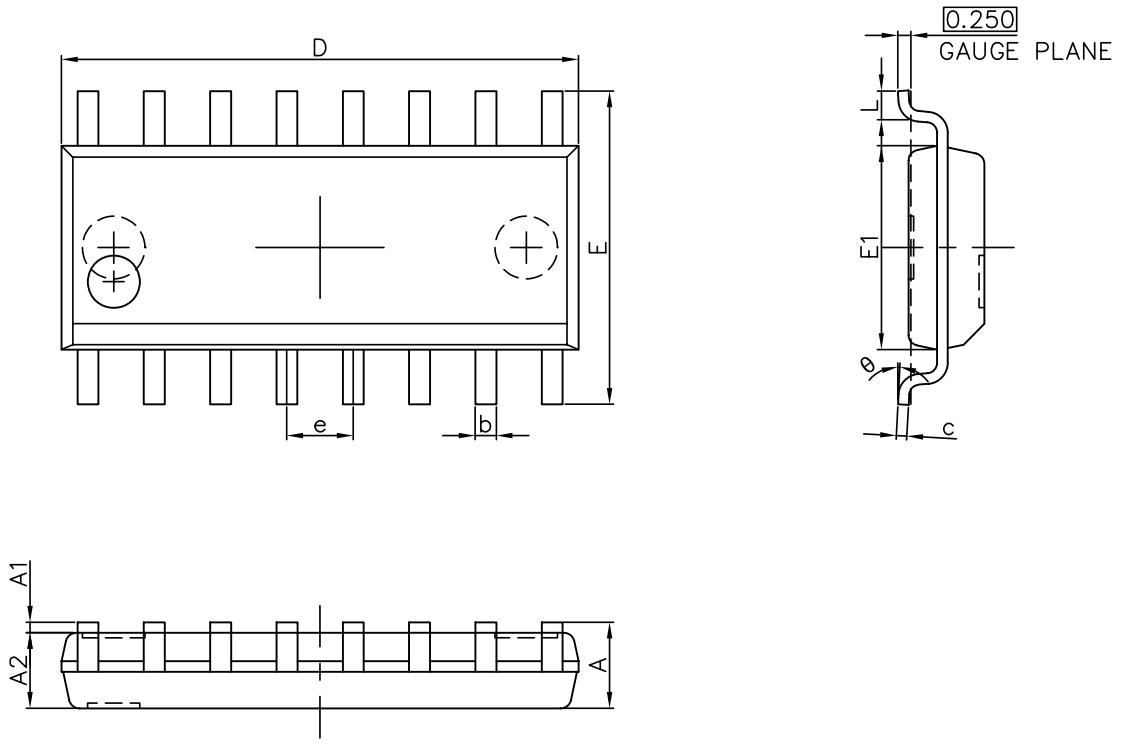
Fig. 7. Test circuit for measuring switching times

Table 9. Test data

Type	Input		Load		V_{EXT}		
	V_I	$t_r = t_f$	C_L	R_L	t_{PLH}, t_{PHL}	t_{PZH}, t_{PHZ}	t_{PZL}, t_{PLZ}
EM74HC245	V_{CC}	≤ 2.5 ns	50 pF	500Ω	open	GND	$2V_{CC}$
EM74HCT245	3 V	≤ 2.5 ns	50 pF	500Ω	open	GND	$2V_{CC}$

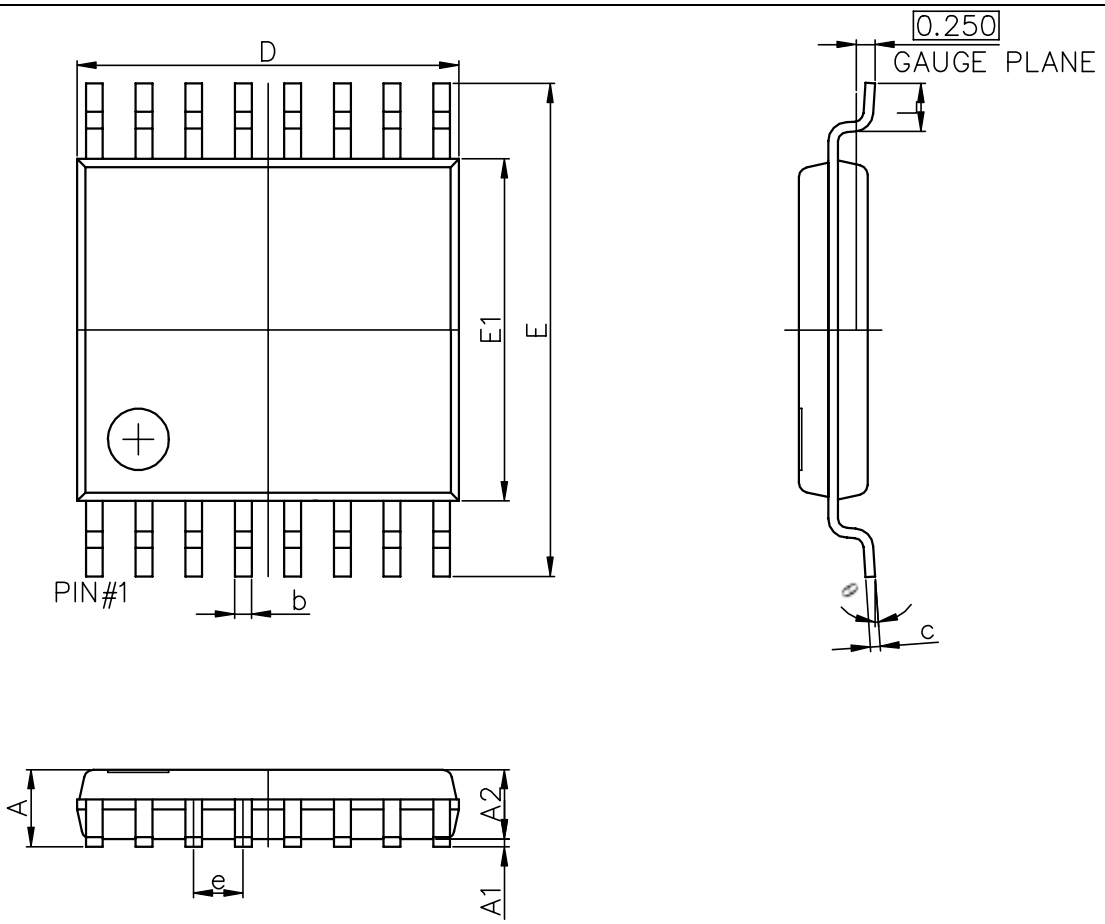
11. Package Outline

SOP-16L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	——	1.750	——	0.069
A1	0.150	0.250	0.006	0.010
A2	1.400	1.500	0.055	0.059
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.000	0.386	0.394
e	1.270(BSC)		0.050(BSC)	
E	5.900	6.100	0.232	0.240
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TSSOP-16L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	——	1.200	——	0.047
A1	0.020	0.100	0.001	0.004
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
e	0.650(BSC)		0.026(BSC)	
E	6.250	6.550	0.252(BSC)	
E1	4.300	4.500	0.169	0.177
L	0.500	0.700	0.020	0.028
θ	1°	7°	1°	7°

12. Abbreviations

Table 10. Abbreviations

Acronym	Description
CMOS	Complementary Metal-Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
CDM	Charged Device Model
TTL	Transistor-Transistor Logic

13. Revision History

Table 11. Revision history

Document ID	Release Date	Data sheet status	Change notice	Supersedes
EM74AHC_HCT138 Rev. 0.9	Apr 24, 2024	Draft datasheet		