

3-to-8 Line Decoder

The MC74VHCT138A 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.

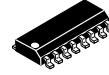
When the device is enabled, three Binary Select inputs (A0 – A2) determine which one of the outputs (Y0 – Y7) will go Low. When enable input E3 is held Low or either E2 or E1 is held High, decoding function is inhibited and all outputs go high. E3, E2, and E1 inputs are provided to ease cascade connection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

The VHCT inputs are compatible with TTL levels. This device can be used as a level converter for interfacing 3.3V to 5.0V, because they have full 5V CMOS level output swings.

The VHCT138A input structures provide protection when voltages between 0V and 5.5V are applied, regardless of the supply voltage. The output structures also provide protection when V_{CC} = 0V. These input and output structures help prevent device destruction caused by supply voltage – input/output voltage mismatch, battery backup, hot insertion, etc.

- High Speed: t_{PD} = 7.6ns (Typ) at V_{CC} = 5V
- Low Power Dissipation: I_{CC} = 4μA (Max) at T_A = 25°C
- TTL-Compatible Inputs: V_{IL} = 0.8V; V_{IH} = 2.0V
- Power Down Protection Provided on Inputs and Outputs
- Balanced Propagation Delays
- Designed for 4.5V to 5.5V Operating Range
- 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

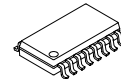
MC74VHCT138A



D SUFFIX
16-LEAD SOIC PACKAGE
CASE 751B-05



DT SUFFIX
16-LEAD TSSOP PACKAGE
CASE 948F-01

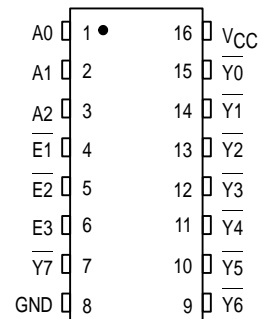


M SUFFIX
16-LEAD SOIC EIAJ PACKAGE
CASE 966-01

ORDERING INFORMATION

| | |
|----------------|-----------|
| MC74VHCTXXXAD | SOIC |
| MC74VHCTXXXADT | TSSOP |
| MC74VHCTXXXAM | SOIC EIAJ |

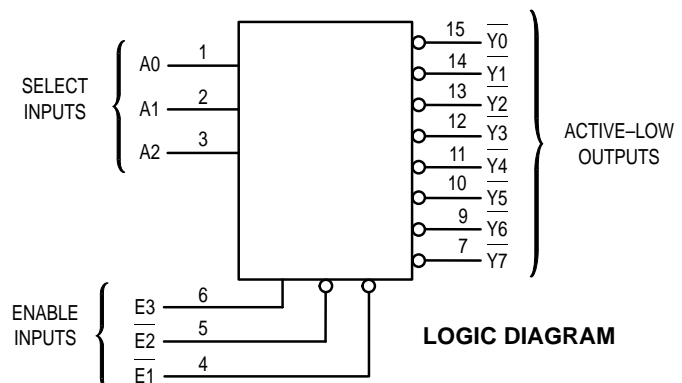
PIN ASSIGNMENT



FUNCTION TABLE

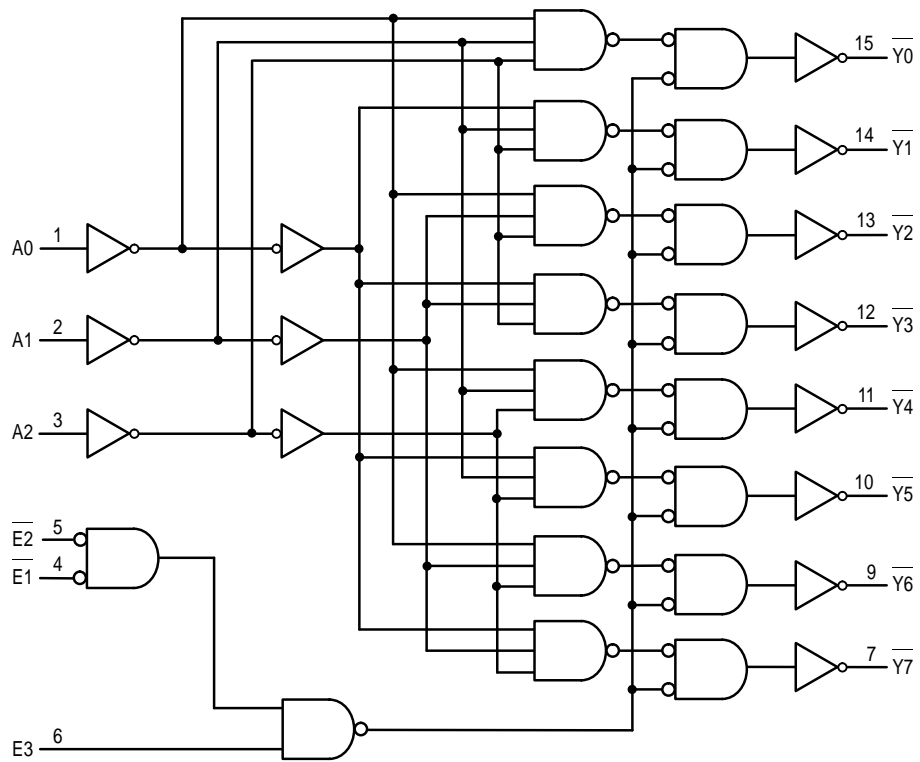
| Inputs | | | Outputs | | | | | | | | | | |
|--------|----|----|---------|----|----|----|----|----|----|----|----|----|----|
| E3 | E2 | E1 | A2 | A1 | A0 | Y0 | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 |
| X | X | H | X | X | X | H | H | H | H | H | H | H | H |
| X | H | X | X | X | X | H | H | H | H | H | 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 | L | 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



MC74VHCT138A

EXPANDED 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 V _{CC} = 0 High or Low State | - 0.5 to + 7.0 - 0.5 to V _{CC} + 0.5 | V |
| I _{IK} | Input Diode Current | - 20 | mA |
| I _{OK} | Output Diode Current (V _{OUT} < GND; V _{OUT} > V _{CC}) | ± 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† TSSOP Package† | 500 450 | mW |
| T _{stg} | 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_{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.

* 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 _{CC} | DC Supply Voltage | 4.5 | 5.5 | V |
| V _{in} | DC Input Voltage | 0 | 5.5 | V |
| V _{out} | DC Output Voltage V _{CC} = 0 High or Low State | 0 0 | 5.5 V _{CC} | V |
| T _A | Operating Temperature | - 40 | + 85 | °C |
| t _r , t _f | Input Rise and Fall Time V _{CC} = 5.0V ± 0.5V | 0 | 20 | ns/V |

DC ELECTRICAL CHARACTERISTICS

| Symbol | Parameter | Test Conditions | V _{CC} V | T _A = 25°C | | | T _A = - 40 to 85°C | | Unit |
|-------------------|---|--|----------------------|-----------------------|-----|-------|-------------------------------|-------|------|
| | | | | Min | Typ | Max | Min | Max | |
| V _{IH} | Minimum High-Level Input Voltage | | 4.5 to 5.5 | 2.0 | | | 2.0 | | V |
| V _{IL} | Maximum Low-Level Input Voltage | | 4.5 to 5.5 | | | 0.8 | | 0.8 | V |
| V _{OH} | Minimum High-Level Output Voltage V _{in} = V _{IH} or V _{IL} | I _{OH} = - 50µA | 4.5 | 4.4 | 4.5 | | 4.4 | | V |
| | | I _{OH} = - 8mA | 4.5 | 3.94 | | 3.80 | | | |
| V _{OL} | Maximum Low-Level Output Voltage V _{in} = V _{IH} or V _{IL} | I _{OL} = 50µA | 4.5 | | 0.0 | 0.1 | | 0.1 | V |
| | | I _{OL} = 8mA | 4.5 | | | 0.36 | | 0.44 | |
| I _{in} | Maximum Input Leakage Current | V _{in} = 5.5 V or GND | 0 to 5.5 | | | ± 0.1 | | ± 1.0 | µA |
| I _{CC} | Maximum Quiescent Supply Current | V _{in} = V _{CC} or GND | 5.5 | | | 4.0 | | 20.0 | µA |
| I _{CC} T | Quiescent Supply Current | Per Input: V _{IN} = 3.4V Other Input: V _{CC} or GND | 5.5 | | | 1.35 | | 1.50 | mA |
| I _{OPD} | Output Leakage Current | V _{OUT} = 5.5V | 0 | | | 0.5 | | 5.0 | µA |

MC74VHCT138A

AC ELECTRICAL CHARACTERISTICS (Input $t_r = t_f = 3.0\text{ns}$)

| Symbol | Parameter | Test Conditions | $T_A = 25^\circ\text{C}$ | | | $T_A = -40 \text{ to } 85^\circ\text{C}$ | | Unit |
|--------------------------|---|--|--------------------------|------------|--------------|--|--------------|------|
| | | | Min | Typ | Max | Min | Max | |
| t_{PLH} , t_{PHL} | Maximum Propagation Delay, A to Y | $V_{CC} = 5.0 \pm 0.5\text{V}$ $C_L = 15\text{pF}$ $C_L = 50\text{pF}$ | | 7.6 8.1 | 10.4 11.4 | 1.0 1.0 | 12.0 13.0 | ns |
| t_{PLH} , t_{PHL} | Maximum Propagation Delay, E3 to Y | $V_{CC} = 5.0 \pm 0.5\text{V}$ $C_L = 15\text{pF}$ $C_L = 50\text{pF}$ | | 6.6 7.1 | 9.1 10.1 | 1.0 1.0 | 10.5 11.5 | ns |
| t_{PLH} , t_{PHL} | Maximum Propagation Delay, E2 or E1 to Y | $V_{CC} = 5.0 \pm 0.5\text{V}$ $C_L = 15\text{pF}$ $C_L = 50\text{pF}$ | | 7.0 7.5 | 9.6 10.6 | 1.0 1.0 | 11.0 12.0 | ns |
| C_{in} | Maximum Input Capacitance | | | 4 | 10 | | 10 | pF |

| | | | | |
|----------|---|---|--|----|
| C_{PD} | Power Dissipation Capacitance (Note NO TAG) | Typical @ 25°C , $V_{CC} = 5.0\text{V}$ | | pF |
| | | 49 | | |

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

SWITCHING WAVEFORMS

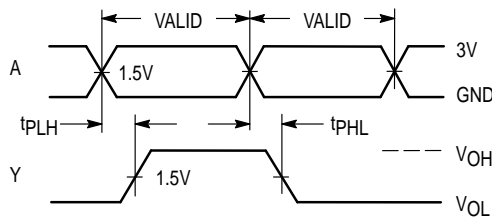


Figure 1.

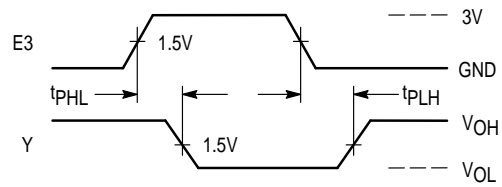


Figure 2.

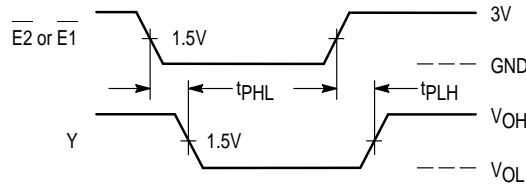
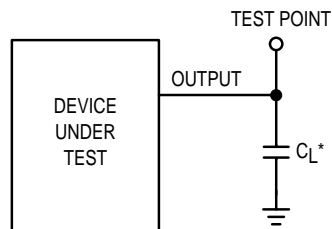


Figure 3.

TEST CIRCUIT

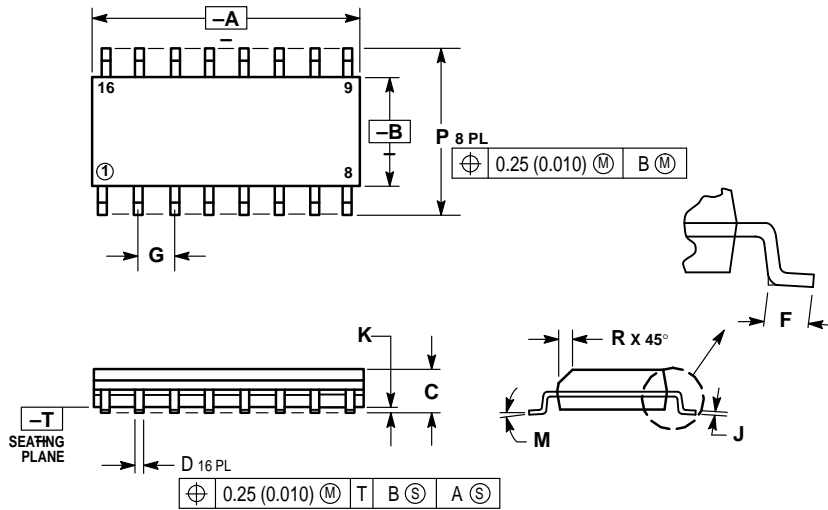


* Includes all probe and jig capacitance

Figure 4. Test Circuit

OUTLINE DIMENSIONS

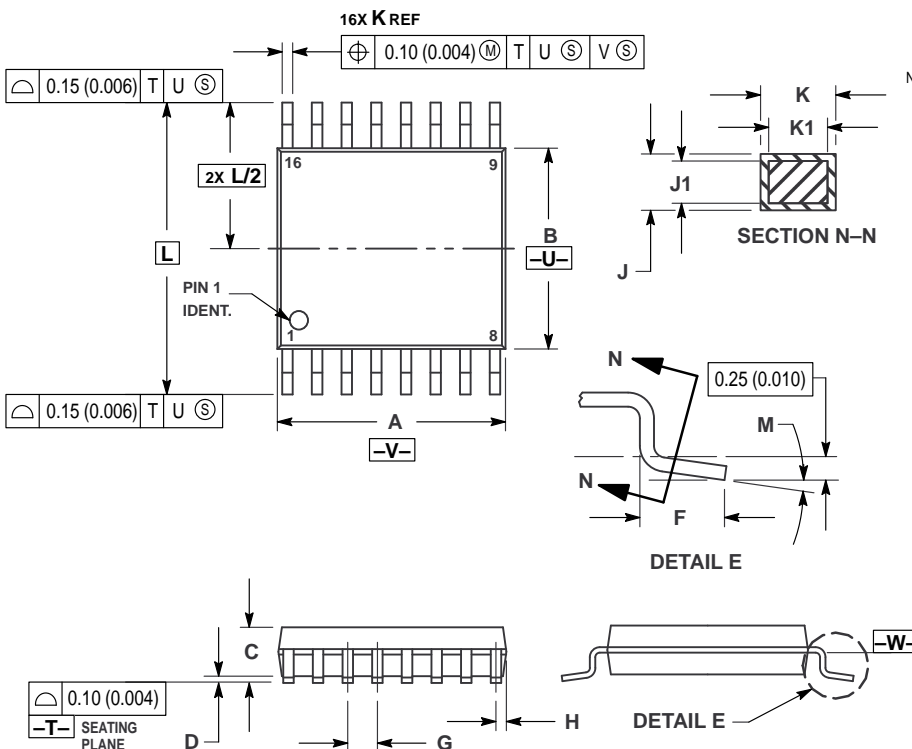
D SUFFIX
 PLASTIC SOIC PACKAGE
 CASE 751B-05
 ISSUE J



- 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.

| DIM | MILLIMETERS | | INCHES | |
|-----|-------------|-------|-----------|-------|
| | 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 |

DT SUFFIX
 PLASTIC TSSOP PACKAGE
 CASE 948F-01
 ISSUE O

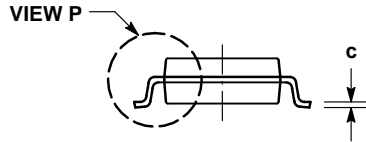
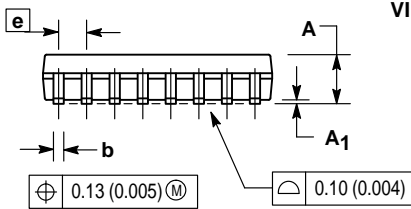
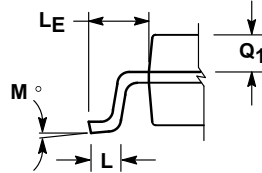
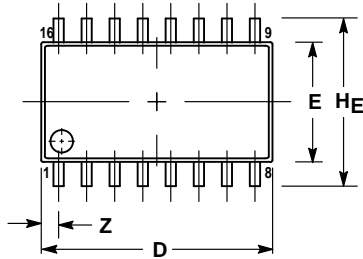


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.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

| 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 | 0.18 | 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° |

OUTLINE DIMENSIONS

M SUFFIX
PLASTIC SOIC EIAJ PACKAGE
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).

| DIM | MILLIMETERS | | INCHES | |
|----------------|-------------|-------|-----------|-------|
| | 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 | |
| HE | 7.40 | 8.20 | 0.291 | 0.323 |
| L | 0.50 | 0.85 | 0.020 | 0.033 |
| LE | 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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