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August 2016

Single-Channel: 6N138M, 6N139M Dual-Channel: HCPL2730M, HCPL2731M 8-Pin DIP Low Input Current High Gain Split Darlington Optocouplers

Features

- Low Current – 0.5 mA
- Superior CTR – 2000%
- Superior CMR – 10 kV/μs
- CTR Guaranteed 0 to 70°C
- Dual Channel – HCPL2730M, HCPL2731M
- Safety and Regulatory Approvals
 - UL1577, 5,000 VAC_{RMS} for 1 Minute
 - DIN EN/IEC60747-5-5

Applications

- Digital Logic Ground Isolation
- Telephone Ring Detector
- EIA-RS-232C Line Receiver
- High Common Mode Noise Line Receiver
- μP Bus Isolation
- Current Loop Receiver

Description

The single-channel, 6N138M, 6N139M and dual-channel HCPL2730M, HCPL2731M optocouplers consist of an AlGaAs LED optically coupled to a high gain split darlington photodetector.

The split darlington configuration separating the input photodiode and the first stage gain from the output transistor permits lower output saturation voltage and higher speed operation than possible with conventional darlington phototransistor optocoupler. In the dual channel devices, HCPL2730M and HCPL2731M, an integrated emitter-base resistor provides superior stability over temperature.

The combination of a very low input current of 0.5 mA and a high current transfer ratio of 2000% makes this family particularly useful for input interface to MOS, CMOS, LSTTL and EIA RS232C, while output compatibility is ensured to CMOS as well as high fan-out TTL requirements. An internal noise shield provides exceptional common mode rejection of 10 kV/μs.

Related Resources

- www.fairchildsemi.com/products/optoelectronics/
- www.fairchildsemi.com/pf/HC/HCPL0700.html
- www.fairchildsemi.com/pf/HC/HCPL0730.html
- www.fairchildsemi.com/pf/HC/HCPL0731.html

Schematics

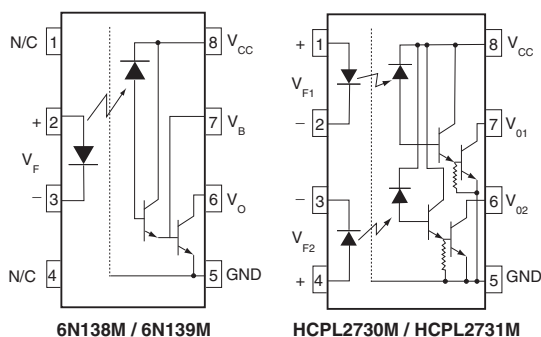


Figure 1. Schematics

Package Outlines



Figure 2. Package Options

Safety and Insulation Ratings

As per DIN EN/IEC 60747-5-5, this optocoupler is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings shall be ensured by means of protective circuits.

| Parameter | Characteristics | |
|---|---|-------|
| Installation Classifications per DIN VDE 0110/1.89 Table 1, For Rated Mains Voltage | < 150 V _{RMS} | I-IV |
| | < 300 V _{RMS} | I-IV |
| | < 450 V _{RMS} | I-III |
| | < 600 V _{RMS} | I-III |
| | < 1,000 V _{RMS} (Option T, TS) | I-III |
| Climatic Classification | 40/100/21 | |
| Pollution Degree (DIN VDE 0110/1.89) | 2 | |
| Comparative Tracking Index | 175 | |

| Symbol | Parameter | Value | Unit |
|-----------------------|--|-------------------|-------------------|
| V _{PR} | Input-to-Output Test Voltage, Method A, V _{IORM} × 1.6 = V _{PR} , Type and Sample Test with t _m = 10 s, Partial Discharge < 5 pC | 2,262 | V _{peak} |
| | Input-to-Output Test Voltage, Method B, V _{IORM} × 1.875 = V _{PR} , 100% Production Test with t _m = 1 s, Partial Discharge < 5 pC | 2,651 | V _{peak} |
| V _{IORM} | Maximum Working Insulation Voltage | 1,414 | V _{peak} |
| V _{IOTM} | Highest Allowable Over-Voltage | 6,000 | V _{peak} |
| | External Creepage | ≥ 8.0 | mm |
| | External Clearance | ≥ 7.4 | mm |
| | External Clearance (for Option TV, 0.4" Lead Spacing) | ≥ 10.16 | mm |
| DTI | Distance Through Insulation (Insulation Thickness) | ≥ 0.5 | mm |
| T _S | Case Temperature ⁽¹⁾ | 150 | °C |
| I _{S,INPUT} | Input Current ⁽¹⁾ | 200 | mA |
| P _{S,OUTPUT} | Output Power (Duty Factor ≤ 2.7%) ⁽¹⁾ | 300 | mW |
| R _{IO} | Insulation Resistance at T _S , V _{IO} = 500 V ⁽¹⁾ | > 10 ⁹ | Ω |

Note:

1. Safety limit value - maximum values allowed in the event of a failure.

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. $T_A = 25^\circ\text{C}$ unless otherwise specified.

| Symbol | Parameter | Value | Unit |
|-----------|-------------------------|----------------|------------------|
| T_{STG} | Storage Temperature | -40 to +125 | $^\circ\text{C}$ |
| T_{OPR} | Operating Temperature | -40 to +100 | $^\circ\text{C}$ |
| T_J | Junction Temperature | -40 to +125 | $^\circ\text{C}$ |
| T_{SOL} | Lead Solder Temperature | 260 for 10 sec | $^\circ\text{C}$ |

| Symbol | Parameter | Device | Value | Unit |
|-----------------|--|----------------------|--------------|------|
| EMITTER | | | | |
| I_F (avg) | DC/Average Forward Input Current Per Channel | All | 20 | mA |
| I_F (pk) | Peak Forward Input Current Per Channel (50% duty cycle, 1 ms P.W.) | All | 40 | mA |
| I_F (trans) | Peak Transient Input Current Per Channel ($\leq 1 \mu\text{s}$ P.W., 300 pps) | All | 1 | A |
| V_R | Reverse Input Voltage Per Channel | All | 5 | V |
| P_D | Input Power Dissipation Per Channel ⁽²⁾ | All | 35 | mW |
| DETECTOR | | | | |
| I_O (avg) | Average Output Current Per Channel | All | 60 | mA |
| V_{ER} | Emitter-Base Reverse Voltage | 6N138M, 6N139M | 0.5 | V |
| V_{CC}, V_O | Supply Voltage, Output Voltage | 6N138M, HCPL2730M | -0.5 to 7.0 | V |
| | | 6N139M, HCPL2731M | -0.5 to 18.0 | |
| P_O | Output Power Dissipation Per Channel | All | 100 | mW |

Note:

- No derating required for devices operated within the T_{OPR} specification (6N138M and 6N139M only).

Electrical Characteristics

Individual Component Characteristics

($V_{CC} = 5.0\text{ V}$, $T_A = 0^\circ\text{C}$ to 70°C unless otherwise specified. Typical value is measured at $T_A = 25^\circ\text{C}$.)

| Symbol | Parameter | Device | Test Conditions | Min. | Typ. | Max. | Unit |
|---------------------------|--|-------------------|---|--|--------|------|----------------------|
| EMITTER | | | | | | | |
| V_F | Input Forward Voltage | All | $I_F = 1.6\text{ mA}$, $T_A = 25^\circ\text{C}$ | | 1.30 | 1.70 | V |
| | | | $I_F = 1.6\text{ mA}$ | | | 1.75 | |
| BV_R | Input Reverse Breakdown Voltage | All | $I_R = 10\text{ }\mu\text{A}$, $T_A = 25^\circ\text{C}$ | 5.0 | 19.0 | | V |
| $\Delta V_F / \Delta T_A$ | Temperature Coefficient of Forward Voltage | All | $I_F = 1.6\text{ mA}$ | | -1.94 | | mV/ $^\circ\text{C}$ |
| DETECTOR | | | | | | | |
| I_{CCL} | Logic Low Supply Current | 6N138M, 6N139M | $I_F = 1.6\text{ mA}$, $V_O = \text{Open}$, $V_{CC} = 18\text{ V}$ | | 0.4 | 1.5 | mA |
| | | HCPL2730M | $V_{CC} = 7\text{ V}$ | $I_{F1} = I_{F2} = 1.6\text{ mA}$, $V_{O1} = V_{O2} = \text{Open}$ | 1.25 | 3 | |
| | | HCPL2731M | $V_{CC} = 18\text{ V}$ | | | | |
| I_{CCH} | Logic High Supply Current | 6N138M, 6N139M | $I_F = 0\text{ mA}$, $V_O = \text{Open}$, $V_{CC} = 18\text{ V}$ | | 0.0003 | 10 | μA |
| | | HCPL2730M | $V_{CC} = 7\text{ V}$ | $I_{F1} = I_{F2} = 0\text{ mA}$, $V_{O1} = V_{O2} = \text{Open}$ | 0.0003 | 20 | |
| | | HCPL2731M | $V_{CC} = 18\text{ V}$ | | | | |

Transfer Characteristics

| Symbol | Parameter | Device | Test Conditions | Min. | Typ. | Max. | Unit |
|----------------|--|-----------|--|------|--------|------|---------------|
| COUPLED | | | | | | | |
| CTR | Current Transfer Ratio ⁽³⁾⁽⁴⁾ | 6N138M | $I_F = 1.6\text{ mA}$, $V_O = 0.4\text{ V}$, $V_{CC} = 4.5\text{ V}$ | 300 | 1600 | | % |
| | | HCPL2730M | | | 2400 | | |
| | | 6N139M | $I_F = 0.5\text{ mA}$, $V_O = 0.4\text{ V}$, $V_{CC} = 4.5\text{ V}$ | 400 | 2000 | | |
| | | HCPL2731M | | | 3500 | | |
| | | 6N139M | $I_F = 1.6\text{ mA}$, $V_O = 0.4\text{ V}$, $V_{CC} = 4.5\text{ V}$ | 500 | 1600 | | |
| HCPL2731M | 2400 | | | | | | |
| I_{OH} | Logic High Output Current | 6N138M | $I_F = 0\text{ mA}$, $V_O = V_{CC} = 7\text{ V}$ | | 0.001 | 250 | μA |
| | | HCPL2730M | | | | | |
| | | 6N139M | $I_F = 0\text{ mA}$, $V_O = V_{CC} = 18\text{ V}$ | | 0.0036 | 100 | |
| | | HCPL2731M | | | | | |
| V_{OL} | Logic Low Output Voltage ⁽⁴⁾ | 6N138M | $I_F = 1.6\text{ mA}$, $I_O = 4.8\text{ mA}$, $V_{CC} = 4.5\text{ V}$ | | 0.06 | 0.4 | V |
| | | HCPL2730M | | | 0.05 | | |
| | | 6N139M | $I_F = 0.5\text{ mA}$, $I_O = 2\text{ mA}$, $V_{CC} = 4.5\text{ V}$ | | 0.05 | 0.4 | |
| | | 6N139M | | | | | |
| | | HCPL2731M | 0.08 | | | | |
| | | 6N139M | $I_F = 5\text{ mA}$, $I_O = 15\text{ mA}$, $V_{CC} = 4.5\text{ V}$ | | 0.13 | 0.4 | |
| | | HCPL2731M | | | | | |
| | | 6N139M | $I_F = 12\text{ mA}$, $I_O = 24\text{ mA}$, $V_{CC} = 4.5\text{ V}$ | | 0.18 | 0.4 | |
| HCPL2731M | 0.17 | | | | | | |

Notes:

- Current Transfer Ratio is defined as a ratio of output collector current, I_O , to the forward LED input current, I_F , times 100%.
- Pin 7 open. (6N138M and 6N139M only)

Electrical Characteristics (Continued)(V_{CC} = 5.0 V, T_A = 0°C to 70°C unless otherwise specified. Typical value is measured at T_A = 25°C.)**Switching Characteristics**

| Symbol | Parameter | Device | Test Conditions | Min. | Typ. | Max. | Unit |
|------------------|---|------------------------------|--|-------|--------|------|------|
| t _{PHL} | Propagation Delay Time to Logic LOW ⁽⁴⁾ (Fig. 15) | 6N139M | R _L = 270 Ω, I _F = 12 mA | | 0.2 | 2 | μs |
| | | HCPL2730M, HCPL2731M | R _L = 270 Ω, I _F = 12 mA | | 0.5 | 3 | |
| | | 6N138M | R _L = 2.2 kΩ, I _F = 1.6 mA | | 1.0 | 15 | |
| | | HCPL2730M, HCPL2731M | R _L = 2.2 kΩ, I _F = 1.6 mA | | 2.5 | 25 | |
| | | 6N139M | R _L = 4.7 kΩ, I _F = 0.5 mA | | 2.5 | 30 | |
| | | HCPL2731M | R _L = 4.7 kΩ, I _F = 0.5 mA | | 8.4 | 120 | |
| t _{PLH} | Propagation Delay Time to Logic HIGH ⁽⁴⁾ (Fig. 15) | 6N139M | R _L = 270 Ω, I _F = 12 mA | | 1.3 | 10 | μs |
| | | HCPL2730M, HCPL2731M | R _L = 270 Ω, I _F = 12 mA | | 1.0 | 15 | |
| | | 6N138M, HCPL2730M, HCPL2731M | R _L = 2.2 kΩ, I _F = 1.6 mA | | 7.3 | 50 | |
| | | 6N139M, HCPL2731M | R _L = 4.7 kΩ, I _F = 0.5 mA | | 13.6 | 90 | |
| CM _H | Common Mode Transient Immunity at Logic High ⁽⁵⁾ (Fig. 16) | All | I _F = 0 mA, V _{CM} = 10 V _{P-P} , R _L = 2.2 kΩ, T _A = 25°C | 1,000 | 10,000 | | V/μs |
| CM _L | Common Mode Transient Immunity at Logic Low ⁽⁵⁾ (Fig. 16) | All | I _F = 1.6 mA, V _{CM} = 10 V _{P-P} , R _L = 2.2 kΩ, T _A = 25°C | 1,000 | 10,000 | | V/μs |

Note:

5. Common mode transient immunity in logic HIGH level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse signal V_{CM}, to assure that the output will remain in a logic HIGH state (i.e., V_O > 2.0 V). Common mode transient immunity in logic LOW level is the maximum tolerable (negative) dV_{cm}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a logic LOW state (i.e., V_O < 0.8 V).

Electrical Characteristics (Continued)**Isolation Characteristics** ($T_A = 25^\circ\text{C}$ unless otherwise specified.)

| Symbol | Parameter | Device | Test Conditions | Min. | Typ. | Max. | Unit |
|------------------|---|-------------------------|--|-------|-----------|------|---------------------------|
| V_{ISO} | Withstand Insulation Test Voltage ⁽⁶⁾⁽⁷⁾ | All | $RH \leq 50\%$, $T_A = 25^\circ\text{C}$, $I_{\text{I-O}} \leq 10 \mu\text{A}$, $t = 1 \text{ min}$, $f = 50 \text{ Hz}$ | 5,000 | | | VAC_{RMS} |
| $R_{\text{I-O}}$ | Resistance (Input to Output) ⁽⁶⁾ | All | $V_{\text{I-O}} = 500 \text{ V}_{\text{DC}}$ | | 10^{11} | | Ω |
| $C_{\text{I-O}}$ | Capacitance (Input to Output) ⁽⁶⁾⁽⁸⁾ | All | $f = 1 \text{ MHz}$, $V_{\text{I-O}} = 0 \text{ V}$ | | 1 | | pF |
| $I_{\text{I-I}}$ | Input-Input Insulation Leakage Current ⁽⁹⁾ | HCPL2730M, HCPL2731M | $RH \leq 45\%$, $V_{\text{I-I}} = 500 \text{ V}_{\text{DC}}$, $t = 5 \text{ sec}$ | | 0.005 | | μA |
| $R_{\text{I-I}}$ | Input-Input Resistance ⁽⁹⁾ | HCPL2730M, HCPL2731M | $V_{\text{I-I}} = 500 \text{ V}_{\text{DC}}$ | | 10^{11} | | Ω |
| $C_{\text{I-I}}$ | Input-Input Capacitance ⁽⁹⁾ | HCPL2730M, HCPL2731M | $f = 1 \text{ MHz}$ | | 0.03 | | pF |

Notes:

- Device is considered a two terminal device: Pins 1, 2, 3 and 4 are shorted together and Pins 5, 6, 7 and 8 are shorted together.
- 5000 VAC_{RMS} for 1 minute duration is equivalent to 6000 VAC_{RMS} for 1 second duration.
- For dual channel devices, $C_{\text{I-O}}$ is measured by shorting pins 1 and 2 or pins 3 and 4 together and pins 5 through 8 shorted together.
- Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.

Electrical Characteristics (Continued)

T_A = 25°C unless otherwise specified

Current Limiting Resistor Calculations:

$$R_1 \text{ (Non-Invert)} = \frac{V_{CC1} - V_{DF} - V_{OL1}}{I_F}$$

$$R_1 \text{ (Invert)} = \frac{V_{CC1} - V_{OH1} - V_{DF}}{I_F}$$

$$R_2 = \frac{V_{CC2} - V_{OLX} (@ I_L - I_2)}{I_L}$$

Where:

- V_{CC1} = Input Supply Voltage
- V_{CC2} = Output Supply Voltage
- V_{DF} = Diode Forward Voltage
- V_{OL1} = Logic "0" Voltage of Driver
- V_{OH1} = Logic "1" Voltage of Driver
- I_F = Diode Forward Current
- V_{OLX} = Saturation Voltage of Output Transistor
- I_L = Load Current Through Resistor R₂
- I₂ = Input Current of Output Gate

| INPUT CONFIGURATION | | R ₁ (Ω) | R ₂ (Ω) @ OUTPUT CONFIGURATION | | | | | | |
|---------------------|----------|--------------------|---|-------------|------|-------|-------|--------|-------|
| | | | CMOS @ 5 V | CMOS @ 10 V | 74XX | 74LXX | 74SXX | 74LSXX | 74HXX |
| CMOS @ 5 V | NON-INV. | 2000 | 1000 | 2200 | 750 | 1000 | 1000 | 1000 | 560 |
| | INV. | 510 | | | | | | | |
| CMOS @ 10 V | NON-INV. | 5100 | | | | | | | |
| | INV. | 4700 | | | | | | | |
| 74XX | NON-INV. | 2200 | | | | | | | |
| | INV. | 180 | | | | | | | |
| 74LXX | NON-INV. | 1800 | | | | | | | |
| | INV. | 100 | | | | | | | |
| 74SXX | NON-INV. | 2000 | | | | | | | |
| | INV. | 360 | | | | | | | |
| 74LSXX | NON-INV. | 2000 | | | | | | | |
| | INV. | 180 | | | | | | | |
| 74HXX | NON-INV. | 2000 | | | | | | | |
| | INV. | 180 | | | | | | | |

Fig. 3 Resistor Values for Logic Interface



Fig. 4 Non-Inverting Logic Interface



Fig. 5 Inverting Logic Interface

Typical Performance Curves



Fig. 6 LED Forward Current vs. Forward Voltage



Fig. 7 LED Forward Voltage vs. Temperature

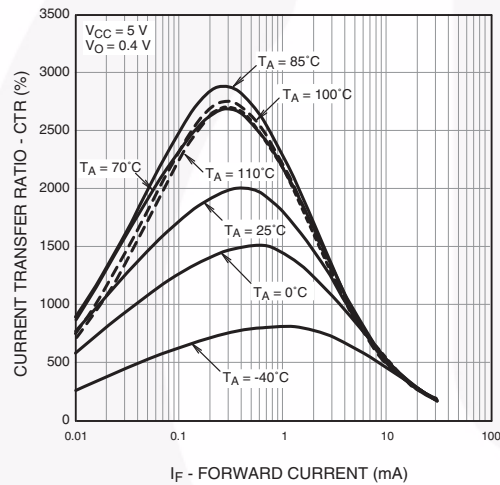


Fig. 8 Current Transfer Ratio vs. Forward Current (6N138M / 6N139M Only)

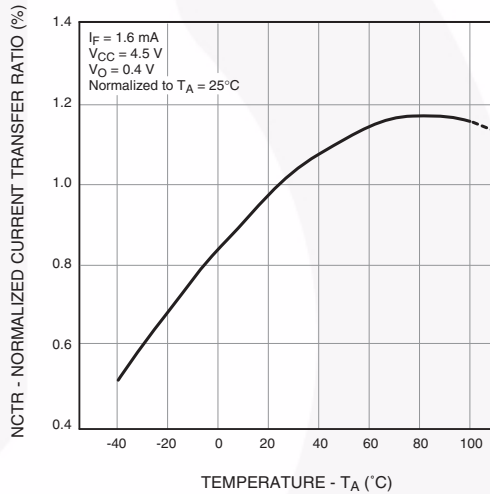


Fig. 9 Normalized Current Transfer Ratio vs. Ambient Temperature (6N138M / 6N139M Only)

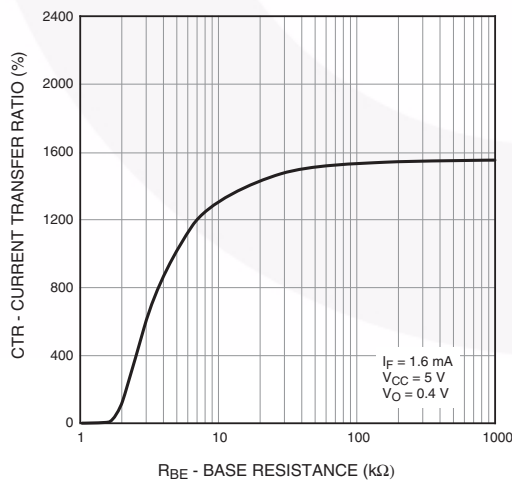


Fig. 10 Current Transfer Ratio vs. Base-Emitter Resistance (6N138M / 6N139M Only)

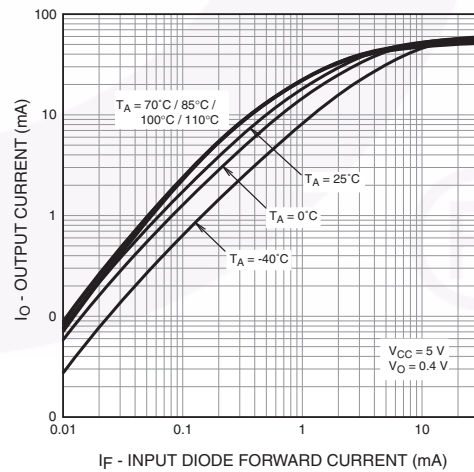


Fig. 11 Output Current vs. Input Diode Forward Current (6N138M / 6N139M Only)

Typical Performance Curves (Continued)



Fig. 12 Output Current vs Output Voltage (6N138M / 6N139M Only)

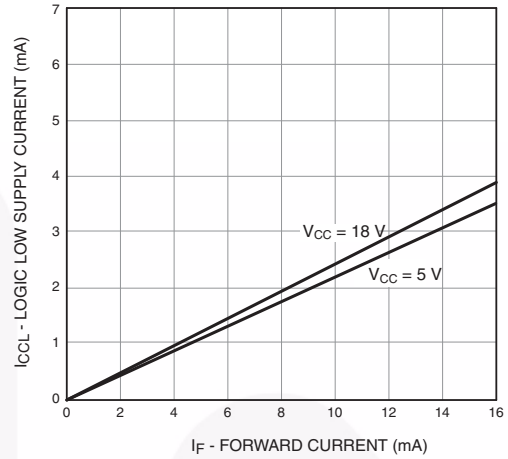


Fig. 13 Logic Low Supply Current vs. Input Diode Forward Current (6N138M / 6N139M Only)



Fig. 14 Propagation Delay vs. Temperature (6N138M / 6N139M Only)

Test Circuits



Test Circuit for 6N138M, 6N139M

Test Circuit for HCPL2730M and HCPL2731M



Fig. 15 Switching Time Test Circuit



Test Circuit for 6N138M and 6N139M

Test Circuit for HCPL2730M and HCPL2731M



Fig. 16 Common Mode Immunity Test Circuit

Reflow Profile



| Profile Feature | Pb-Free Assembly Profile |
|---|--------------------------|
| Temperature Min. (T _{min}) | 150°C |
| Temperature Max. (T _{max}) | 200°C |
| Time (t _s) from (T _{min} to T _{max}) | 60–120 seconds |
| Ramp-up Rate (t _L to t _p) | 3°C/second max. |
| Liquidous Temperature (T _L) | 217°C |
| Time (t _L) Maintained Above (T _L) | 60–150 seconds |
| Peak Body Package Temperature | 260°C +0°C / –5°C |
| Time (t _p) within 5°C of 260°C | 30 seconds |
| Ramp-down Rate (T _p to T _L) | 6°C/second max. |
| Time 25°C to Peak Temperature | 8 minutes max. |

Ordering Information

| Part Number | Package | Packing Method |
|-------------|---|--------------------------------------|
| 6N138M | DIP 8-Pin | Tube (50 units per tube) |
| 6N138SM | SMT 8-Pin (Lead Bend) | Tube (50 units per tube) |
| 6N138SDM | SMT 8-Pin (Lead Bend) | Tape and Reel (1,000 units per reel) |
| 6N138VM | DIP 8-Pin, DIN EN/IEC 60747-5-5 Option | Tube (50 units per tube) |
| 6N138SVM | SMT 8-Pin (Lead Bend), DIN EN/IEC 60747-5-5 Option | Tube (50 units per tube) |
| 6N138SDVM | SMT 8-Pin (Lead Bend), DIN EN/IEC 60747-5-5 Option | Tape and Reel (1,000 units per reel) |
| 6N138TVM | DIP 8-Pin, 0.4" Lead Spacing, DIN EN/IEC 60747-5-5 Option | Tube (50 units per tube) |
| 6N138TSVM | SMT 8-Pin, 0.4" Lead Spacing, DIN EN/IEC 60747-5-5 Option | Tube (50 units per tube) |
| 6N138TSR2VM | SMT 8-Pin, 0.4" Lead Spacing, DIN EN/IEC 60747-5-5 Option | Tape and Reel (1,000 units per reel) |

Note:

The product orderable part number system listed in this table also applies to the 6N139M, HCPL2730M and HCPL2731M product families.

Marking Information



Figure 17. Top Mark

| Definitions | |
|-------------|---|
| 1 | Fairchild Logo |
| 2 | Device Number |
| 3 | DIN EN/IEC60747-5-5 Option (only appears on component ordered with this option) |
| 4 | Two Digit Year Code, e.g., '16' |
| 5 | Two Digit Work Week Ranging from '01' to '53' |
| 6 | Assembly Package Code |

Carrier Tape Specifications (Option SD)



| Symbol | Description | Dimension in mm |
|--------|---------------------------------|------------------|
| W | Tape Width | 16.0 ± 0.3 |
| t | Tape Thickness | 0.30 ± 0.05 |
| P_0 | Sprocket Hole Pitch | 4.0 ± 0.1 |
| D_0 | Sprocket Hole Diameter | 1.55 ± 0.05 |
| E | Sprocket Hole Location | 1.75 ± 0.10 |
| F | Pocket Location | 7.5 ± 0.1 |
| P_2 | | 2.0 ± 0.1 |
| P | Pocket Pitch | 12.0 ± 0.1 |
| A_0 | Pocket Dimensions | 10.30 ± 0.20 |
| B_0 | | 10.30 ± 0.20 |
| K_0 | | 4.90 ± 0.20 |
| W_1 | Cover Tape Width | 13.2 ± 0.2 |
| d | Cover Tape Thickness | 0.1 max |
| | Max. Component Rotation or Tilt | 10° |
| R | Min. Bending Radius | 30 |



- NOTES:
- A) NO STANDARD APPLIES TO THIS PACKAGE
 - B) ALL DIMENSIONS ARE IN MILLIMETERS.
 - C) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSION
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PIN 1

15.0° (MAX)

10.16 (TYP)

0.20-0.40



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