

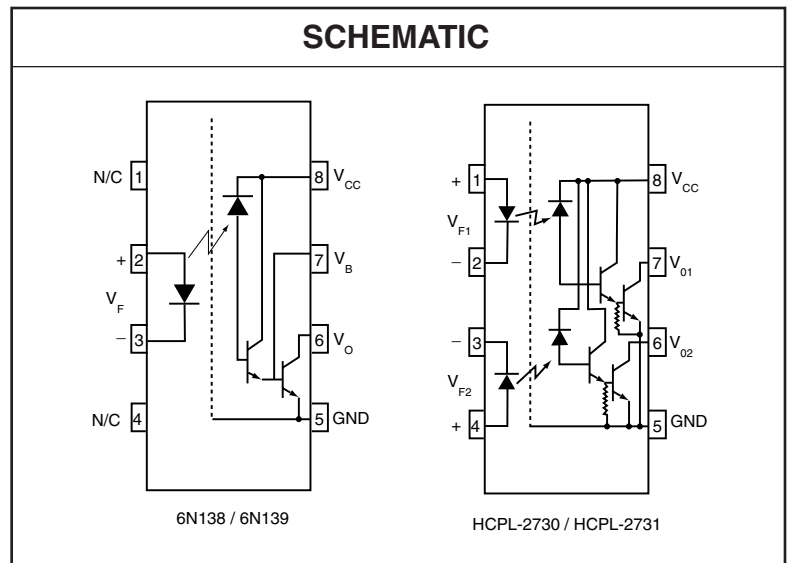
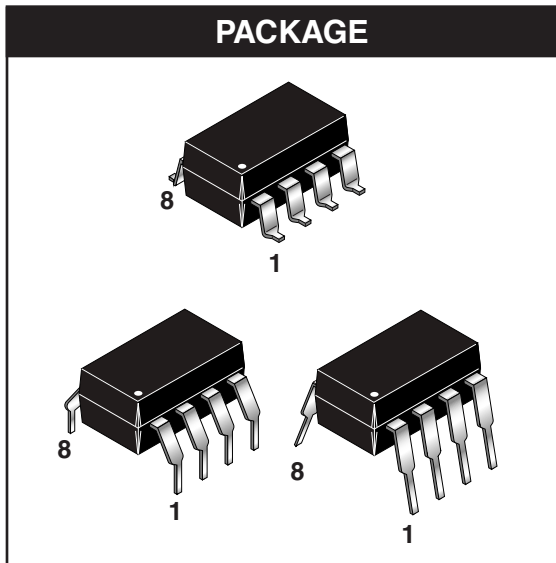


THE DATASHEET OF HCPL2731



SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730

6N139
HCPL-2731



DESCRIPTION

The 6N138/9 and HCPL-2730/HCPL-2731 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, HCPL-2730/HCPL2731, 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/ μ s.

FEATURES

- Low current - 0.5 mA
- Superior CTR-2000%
- Superior CMR-10 kV/ μ s
- CTR guaranteed 0-70°C
- U.L. recognized (File # E90700)
- VDE recognized (File # 120915) Ordering option V, e.g., 6N138V
- Dual Channel - HCPL-2730
- HCPL-2731

APPLICATIONS

- Digital logic ground isolation
- Telephone ring detector
- EIA-RS-232C line receiver
- High common mode noise line receiver
- μ P bus isolation
- Current loop receiver

**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

ABSOLUTE MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise specified)

| Parameter | Symbol | Value | Units |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------|------------------|
| Storage Temperature | T_{STG} | -55 to +125 | $^\circ\text{C}$ |
| Operating Temperature | T_{OPR} | -40 to +85 | $^\circ\text{C}$ |
| Lead Solder Temperature (Wave solder only. See recommended reflow profile graph for convection or infrared reflow soldering process limits) | T_{SOL} | 260 for 10 sec | $^\circ\text{C}$ |
| EMITTER | | | |
| DC/Average Forward Input Current | Each Channel | I_F (avg) | 20 mA |
| Peak Forward Input Current (50% duty cycle, 1 ms P.W.) | Each Channel | I_F (pk) | 40 mA |
| Peak Transient Input Current - ($\leq 1 \mu\text{s}$ P.W., 300 pps) | | I_F (trans) | 1.0 A |
| Reverse Input Voltage | Each Channel | V_R | 5 V |
| Input Power Dissipation | Each Channel | P_D | 35 mW |
| DETECTOR | | | |
| Average Output Current | Each Channel | I_O (avg) | 60 mA |
| Emitter-Base Reverse Voltage | (6N138 and 6N139) | V_{ER} | 0.5 V |
| Supply Voltage, Output Voltage | (6N138, HCPL-2730) | V_{CC}, V_O | -0.5 to 7 |
| | (6N139, HCPL-2731) | | -0.5 to 18 |
| Output Power Dissipation | Each Channel | P_O | 100 mW |

SINGLE-CHANNEL: 6N138

6N139

DUAL-CHANNEL: HCPL-2730

HCPL-2731

ELECTRICAL CHARACTERISTICS ($T_A = 0$ to 70°C Unless otherwise specified)

INDIVIDUAL COMPONENT CHARACTERISTICS

| Parameter | Test Conditions | Symbol | Device | Min | Typ** | Max | Unit |
|----------------------------------------------|-------------------------------------------------------------------------|-----------------------------|----------------|-----|-------|-----|----------------------|
| EMITTER Input Forward Voltage | $T_A = 25^\circ\text{C}$ Each channel ($I_F = 1.6$ mA) | V_F | All | | 1.30 | 1.7 | V |
| | | | | | 1.75 | | |
| Input Reverse Breakdown Voltage | ($T_A = 25^\circ\text{C}$, $I_R = 10$ μA) Each Channel | BV_R | All | 5.0 | 20 | | V |
| Temperature coefficient of forward voltage | ($I_F = 1.6$ mA) | $(\Delta V_F / \Delta T_A)$ | All | | -1.8 | | mV/ $^\circ\text{C}$ |
| DETECTOR Logic high output current | ($I_F = 0$ mA, $V_O = V_{CC} = 18$ V) Each Channel | I_{OH} | 6N139 | | 0.01 | 100 | μA |
| | | | HCPL-2731 | | | | |
| | ($I_F = 0$ mA, $V_O = V_{CC} = 7$ V) Each Channel | | 6N138 | | 0.01 | 250 | |
| | | | HCPL-2730 | | | | |
| Logic low supply | ($I_F = 1.6$ mA, $V_O = \text{Open}$) ($V_{CC} = 18$ V) | I_{CCL} | 6N138 6N139 | | 0.4 | 1.5 | mA |
| | ($I_{F1} = I_{F2} = 1.6$ mA, $V_{CC} = 18$ V) | | HCPL-2731 | | 1.3 | 3 | |
| | ($V_{O1} - V_{O2} = \text{Open}$, $V_{CC} = 7$ V) | | HCPL-2730 | | | | |
| Logic high supply | ($I_F = 0$ mA, $V_O = \text{Open}$, $V_{CC} = 18$ V) | I_{CCH} | 6N135 6N136 | | 0.05 | 10 | μA |
| | ($I_{F1} = I_{F2} = 0$ mA, $V_{CC} = 18$ V) | | HCPL-2731 | | 0.10 | 20 | |
| | ($V_{O1} - V_{O2} = \text{Open}$, $V_{CC} = 7$ V) | | HCPL-2730 | | | | |

** All Typical at $T_A = 25^\circ\text{C}$

SINGLE-CHANNEL: 6N138

6N139

DUAL-CHANNEL: HCPL-2730

HCPL-2731

TRANSFER CHARACTERISTICS ($T_A = 0$ to 70°C Unless otherwise specified)

| Parameter | Test Conditions | Symbol | Device | Min | Typ** | Max | Unit |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------|-----------|-----|-------|-----|------|
| COUPLED Current transfer ratio (Note 1, 2) | $(I_F = 0.5 \text{ mA}, V_O = 0.4 \text{ V}, V_{CC} = 4.5 \text{ V})$ Each Channel | CTR | 6N139 | 400 | 1100 | | % |
| | | | HCPL-2731 | | 3500 | | |
| | $(I_F = 1.6 \text{ mA}, V_O = 0.4 \text{ V}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N139 | 500 | 1300 | | % |
| | | | HCPL-2731 | | 2500 | | |
| | $(I_F = 1.6 \text{ mA}, V_O = 0.4 \text{ V}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N138 | 300 | 1300 | | % |
| | | | HCPL-2730 | | 2500 | | |
| Logic low output voltage output voltage (Note 2) | $(I_F = 0.5 \text{ mA}, I_O = 2 \text{ mA}, V_{CC} = 4.5 \text{ V})$ | V _{OL} | 6N139 | | 0.08 | 0.4 | V |
| | $(I_F = 1.6 \text{ mA}, I_O = 8 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N139 | | 0.01 | 0.4 | |
| | | | HCPL-2731 | | | | |
| | $(I_F = 0.5 \text{ mA}, I_O = 15 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N139 | | 0.13 | 0.4 | |
| | | | HCPL-2731 | | | | |
| | $(I_F = 12 \text{ mA}, I_O = 24 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N139 | | 0.20 | 0.4 | |
| | | | HCPL-2731 | | | | |
| | $(I_F = 1.6 \text{ mA}, I_O = 4.8 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel | | 6N138 | | 0.10 | 0.4 | |
| | HCPL-2730 | | | | | | |

** All Typicals at $T_A = 25^\circ\text{C}$

SINGLE-CHANNEL: 6N138

6N139

DUAL-CHANNEL: HCPL-2730

HCPL-2731

| SWITCHING CHARACTERISTICS ($T_A = 0$ to 70°C unless otherwise specified., $V_{CC} = 5\text{ V}$) | | | | | | | | |
|-------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------|------------------------|-------|--------|-----|------------------------|----|
| Parameter | Test Conditions | Symbol | Device | Min | Typ** | Max | Unit | |
| Propagation delay time to logic low (Note 2) (Fig. 22) | ($R_L = 4.7\text{ k}\Omega$, $I_F = 0.5\text{ mA}$) $T_A = 25^\circ\text{C}$ | T_{PHL} | 6N139 | | | 30 | μs | |
| | | | | 4 | 25 | | | |
| | ($R_L = 4.7\text{ k}\Omega$, $I_F = 0.5\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | HCPL-2731 | | | 120 | | |
| | | | | 3 | 100 | | | |
| | ($R_L = 270\ \Omega$, $I_F = 12\text{ mA}$) $T_A = 25^\circ\text{C}$ | | 6N139 | | | 2 | | |
| | | | | 0.2 | 1 | | | |
| | ($R_L = 270\ \Omega$, $I_F = 12\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | HCPL-2730 | | | 3 | | |
| | | | HCPL-2731 | | | 0.3 | | 2 |
| Propagation delay time to logic high (Note 2) (Fig. 22) | ($R_L = 2.2\text{ k}\Omega$, $I_F = 1.6\text{ mA}$) $T_A = 25^\circ\text{C}$ | T_{PLH} | 6N138 | | | 15 | μs | |
| | | | | 1.5 | 10 | | | |
| | ($R_L = 2.2\text{ k}\Omega$, $I_F = 1.6\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | HCPL-2731 | | | 25 | | |
| | | | HCPL-2730 | | | 1 | | 20 |
| | ($R_L = 4.7\text{ k}\Omega$, $I_F = 0.5\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | 6N139 | | | 90 | | |
| | | | HCPL-2731 | | | | | |
| | ($R_L = 4.7\text{ k}\Omega$, $I_F = 0.5\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | 6N139 | | | 12 | | 60 |
| | | | HCPL-2731 | | | 22 | | |
| Common mode transient immunity at logic high | ($R_L = 270\ \Omega$, $I_F = 12\text{ mA}$) $T_A = 25^\circ\text{C}$ | T_{PLH} | 6N139 | | | 10 | μs | |
| | | | | 1.3 | 7 | | | |
| | ($R_L = 270\ \Omega$, $I_F = 12\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | HCPL-2730 | | | 15 | | |
| | | | HCPL-2731 | | | 5 | | 10 |
| | ($R_L = 2.2\text{ k}\Omega$, $I_F = 1.6\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | 6N138 | | | 50 | | |
| | | | HCPL-2730/1 | | | | | |
| | ($R_L = 2.2\text{ k}\Omega$, $I_F = 1.6\text{ mA}$) Each Channel $T_A = 25^\circ\text{C}$ | | 6N138 | | | 7 | | 35 |
| | | | HCPL-2730/1 | | | 16 | | |
| Common mode transient immunity at logic high | ($I_F = 0\text{ mA}$, $ V_{CM} = 10\text{ V}_{P-P}$) $T_A = 25^\circ\text{C}$, ($R_L = 2.2\text{ k}\Omega$) (Note 3) (Fig. 23) | ICM_{HI} | 6N138 6N139 | 1,000 | 10,000 | | $\text{V}/\mu\text{s}$ | |
| | Each Channel | | HCPL-2730 HCPL-2731 | | | | | |
| Common mode transient immunity at logic low | ($I_F = 1.6\text{ mA}$, $ V_{CM} = 10\text{ V}_{P-P}$, $R_L = 2.2\text{ k}\Omega$) $T_A = 25^\circ\text{C}$, (Note 3) (Fig. 23) | ICM_{LI} | 6N138 6N139 | 1,000 | 10,000 | | $\text{V}/\mu\text{s}$ | |
| | Each Channel | | HCPL-2730 HCPL-2731 | | | | | |

** All Typicals at $T_A = 25^\circ\text{C}$

**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

| ISOLATION CHARACTERISTICS ($T_A = 0$ to 70°C Unless otherwise specified) | | | | | | |
|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|---------------|------------|--------------|------------|---------------|
| Characteristics | Test Conditions | Symbol | Min | Typ** | Max | Unit |
| Input-output insulation leakage current | (Relative humidity = 45%) ($T_A = 25^\circ\text{C}$, $t = 5$ s) ($V_{I-O} = 3000$ VDC) (Note 8) | I_{I-O} | | | 1.0 | μA |
| Withstand insulation test voltage | ($RH \leq 50\%$, $T_A = 25^\circ\text{C}$) (Note 4) ($t = 1$ min.) | V_{ISO} | 2500 | | | V_{RMS} |
| Resistance (input to output) | (Note 4) ($V_{I-O} = 500$ VDC) | R_{I-O} | | 10^{12} | | Ω |
| Capacitance (input to output) | (Note 4, 5) ($f = 1$ MHz) | C_{I-O} | | 0.6 | | pF |
| Input-Input Insulation leakage current | ($RH \leq 45\%$, $V_{I-I} = 500$ VDC) (Note 6) $t = 5$ s, (HCPL-2730/2731 only) | I_{I-I} | | 0.005 | | μA |
| Input-Input Resistance | ($V_{I-I} = 500$ VDC) (Note 6) (HCPL-2730/2731 only) | R_{I-I} | | 10^{11} | | Ω |
| Input-Input Capacitance | ($f = 1$ MHz) (Note 6) (HCPL-2730/2731 only) | C_{I-I} | | 0.03 | | pF |

** All Typicals at $T_A = 25^\circ\text{C}$

Notes

1. Current Transfer Ratio is defined as a ratio of output collector current, I_O , to the forward LED input current, I_F , times 100%.
2. Pin 7 open. (6N138 and 6N139 only)
3. 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).
4. 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.
5. For dual channel devices, C_{I-O} is measured by shorting pins 1 and 2 or pins 3 and 4 together and pins 5 through 8 shorted together.
6. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.

**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise specified)

Current Limiting Resistor Calculations

$$R_1 \text{ (Non-Invert)} = \frac{V_{DD1} - V_{DF} - V_{OL1}}{I_F}$$

$$R_1 \text{ (Invert)} = \frac{V_{DD1} - V_{OH1} - V_{DF}}{I_F}$$

$$R_2 = \frac{V_{DD2} - V_{OLX} (@ I_L - I_2)}{I_L}$$

Where:

V_{DD1} - Input Supply Voltage

V_{DD2} - 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

I_2 - Input Current of Output Gate

| INPUT | | R1 (V) | OUTPUT | | | | | |
|-------------|----------|--------|------------|-------------|--------|--------|--------|--------|
| | | | CMOS @ 5 V | CMOS @ 10 V | 74XX | 74LXX | 74SXX | 74LSXX |
| | | | R2 (V) | R2 (V) | R2 (V) | R2 (V) | R2 (V) | R2 (V) |
| CMOS @ 5 V | NON-INV. | 2000 | 1000 | 2200 | 750 | 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. 1 Resistor Values for Logic Interface

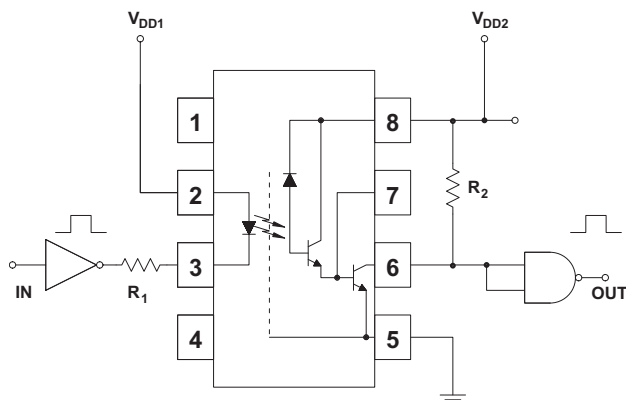


Fig. 2 Non-Inverting Logic Interface

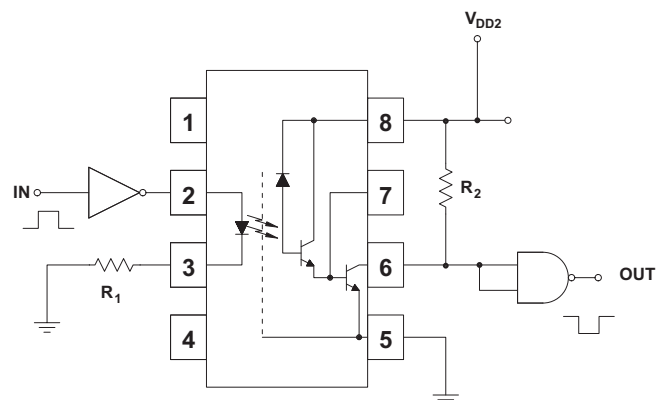


Fig. 3 Inverting Logic Interface

**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

Fig. 4 LED Forward Current vs. Forward Voltage

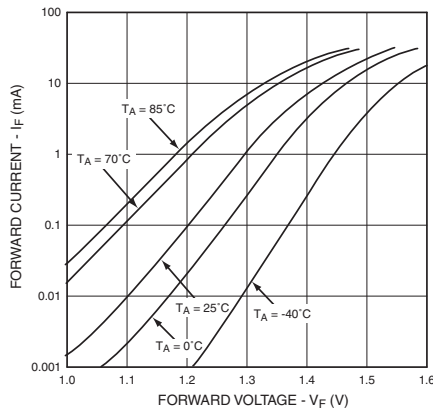


Fig. 5 LED Forward Voltage vs. Temperature

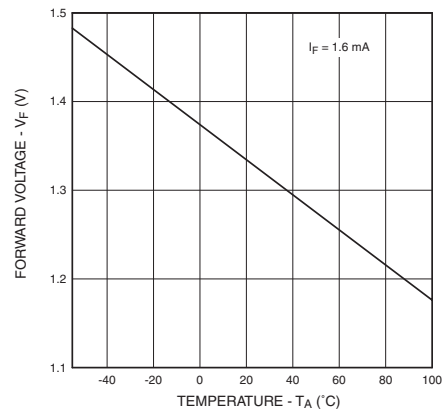


Fig. 6 Non-saturated Rise and Fall Times vs. Load Resistance (6N138 / 6N139 Only)

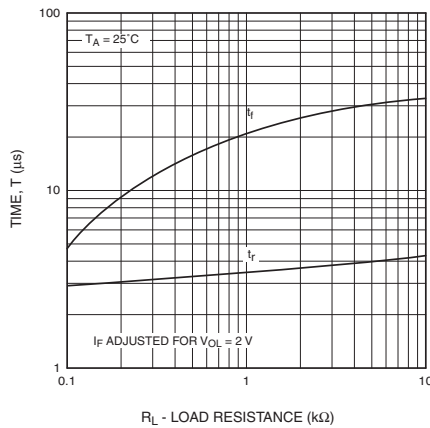


Fig. 7 Non-saturated Rise and Fall Times vs. Load Resistance (HCPL-2730 / HCPL-2731 Only)

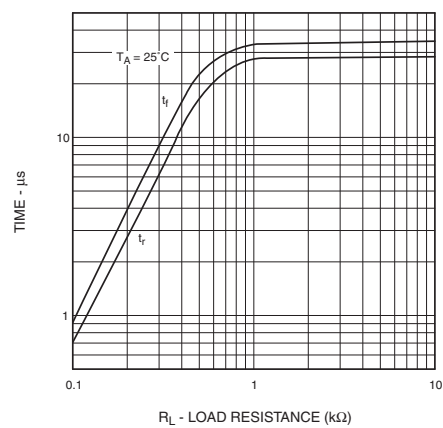


Fig. 8 Propagation Delay To Logic Low vs. Base-Emitter Resistance (HCPL-2730 / HCPL-2731 Only)

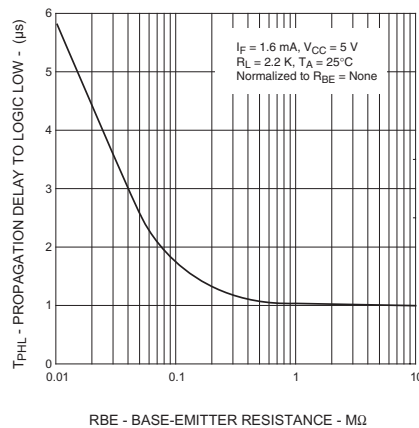
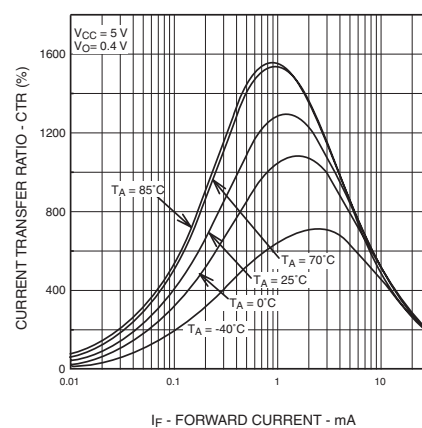


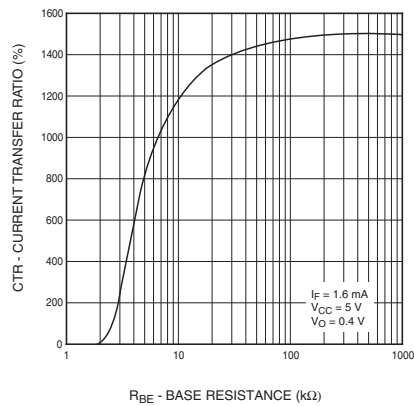
Fig. 9 Current Transfer Ratio vs. Forward Current (6N138 / 6N139 Only)



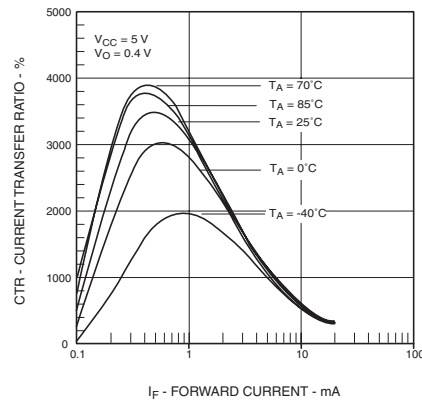
**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

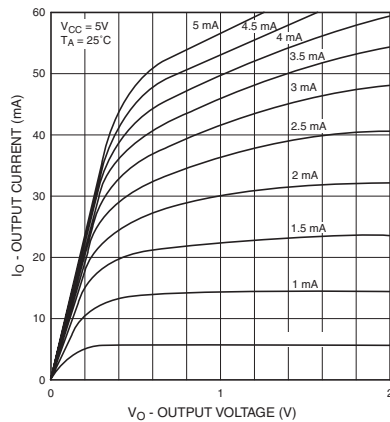
**Fig. 10 Current Transfer Ratio vs. Base-Emitter Resistance
(6N138 / 6N139 Only)**



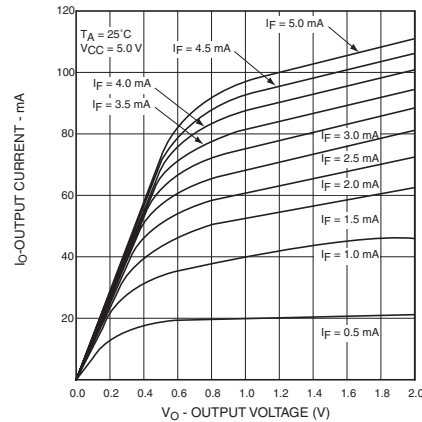
**Fig. 11 Current Transfer Ratio vs. Forward Current
(HCPL-2730 / HCPL-2731 Only)**



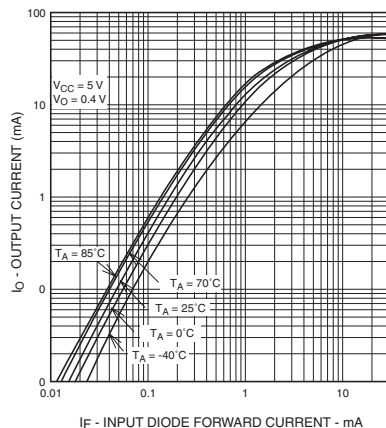
**Fig. 12 Output Current vs Output Voltage
(6N138 / 6N139 Only)**



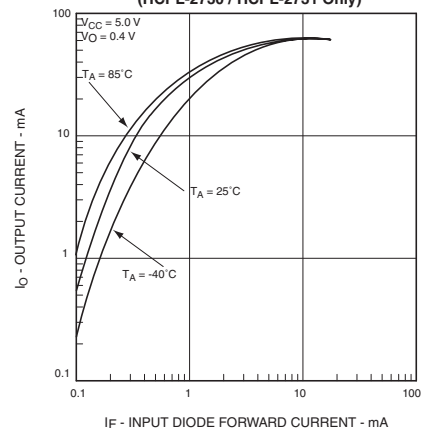
**Fig. 13 Output Current vs Output Voltage
(HCPL-2730 / HCPL-2731 Only)**



**Fig. 14 Output Current vs. Input Diode Forward Current
(6N138 / 6N139 Only)**



**Fig. 15 Output Current vs Input Diode Forward Current
(HCPL-2730 / HCPL-2731 Only)**



SINGLE-CHANNEL: 6N138

6N139

DUAL-CHANNEL: HCPL-2730

HCPL-2731

Fig. 16 Logic Low Supply Current vs. Input Diode Forward Current (6N138 / 6N139 Only)

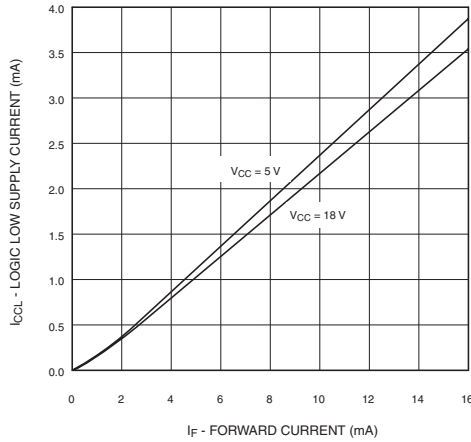


Fig. 17 Logic Low Supply Current vs. Input Diode Forward Current (HCPL-2730 / HCPL-2731 Only)

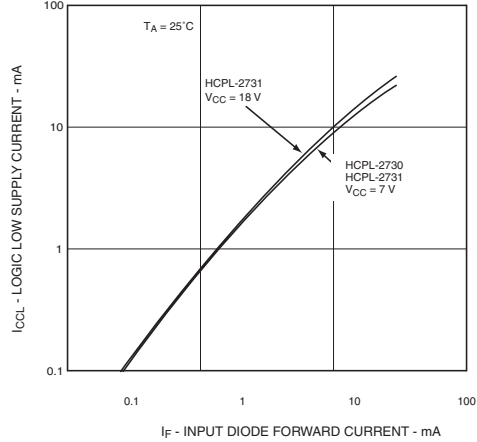


Fig. 18 Propagation Delay vs. Input Diode Forward Current (6N138 / 6N139 Only)

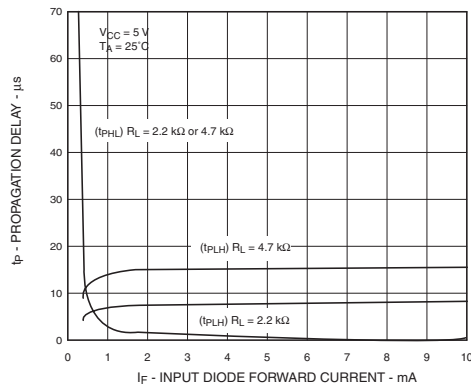


Fig. 19 Propagation Delay vs. Input Diode Forward Current (HCPL-2730 / HCPL-2731 Only)

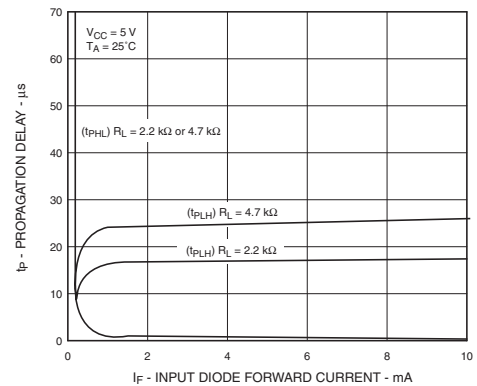


Fig. 20 Propagation Delay to Logic Low vs. Pulse Period (6N138 / 6N139 Only)

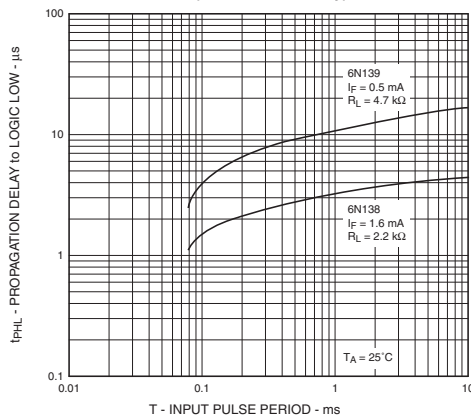
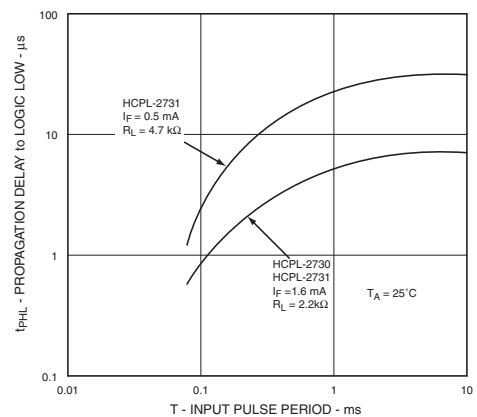


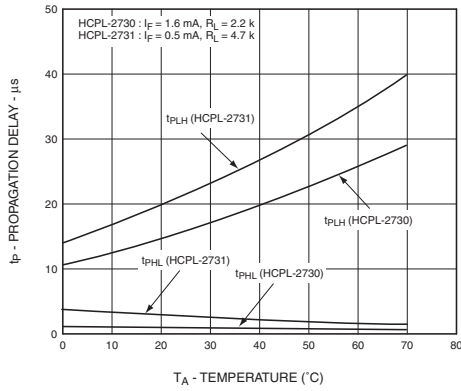
Fig. 21 Propagation Delay to Logic Low vs. Pulse Period (HCPL-2730 / HCPL-2731 Only)



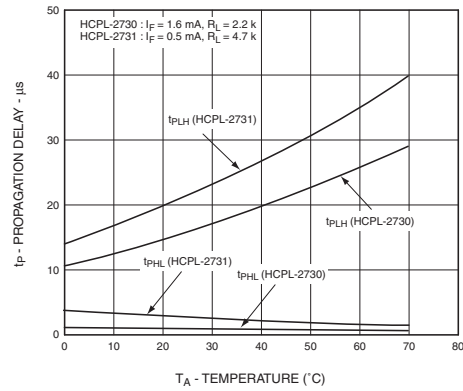
**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

**Fig. 22 Propagation Delay vs. Temperature
(6N138 / 6N139 Only)**

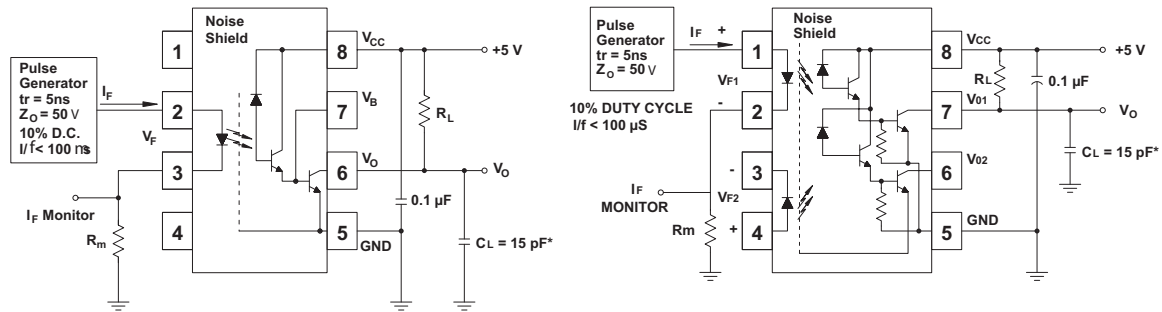


**Fig. 23 Propagation Delay vs. Temperature
(HCPL-2730 / HCPL-2731 Only)**



**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**



Test Circuit for 6N138, 6N139

Test Circuit for HCPL-2730 and HCPL-2731

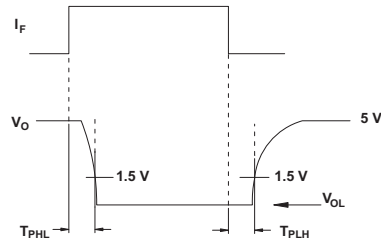
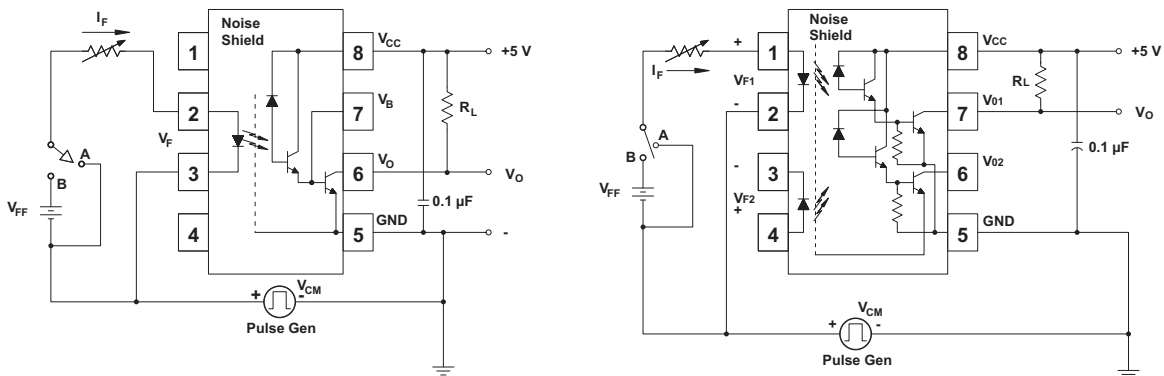


Fig. 22 Switching Time Test Circuit



Test Circuit for 6N138 and 6N139

Test Circuit for HCPL-2730 and HCPL-2731

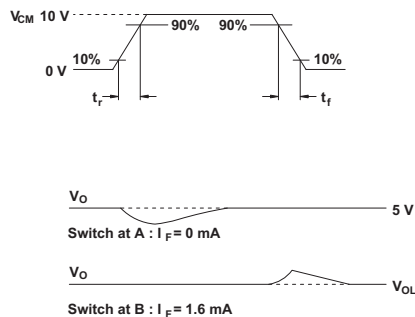


Fig. 23 Common Mode Immunity Test Circuit

SINGLE-CHANNEL: 6N138

6N139

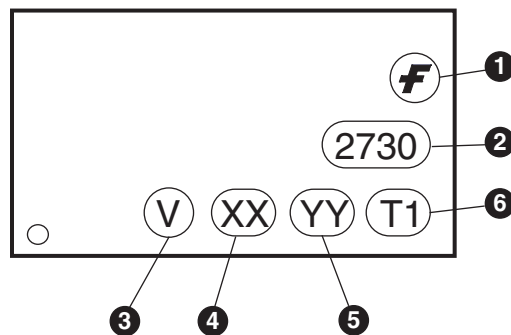
DUAL-CHANNEL: HCPL-2730

HCPL-2731

ORDERING INFORMATION

| Option | Example Part Number | Description |
|--------|---------------------|---------------------------------------|
| S | 6N138S | Surface Mount Lead Bend |
| SD | 6N138SD | Surface Mount; Tape and reel |
| T | 6N138T | 0.4" Lead Spacing |
| V | 6N138V | VDE0884 |
| TV | 6N138TV | VDE0884; 0.4" lead spacing |
| SV | 6N138SV | VDE0884; surface mount |
| SDV | 6N138SDV | VDE0884; surface mount; tape and reel |

MARKING INFORMATION

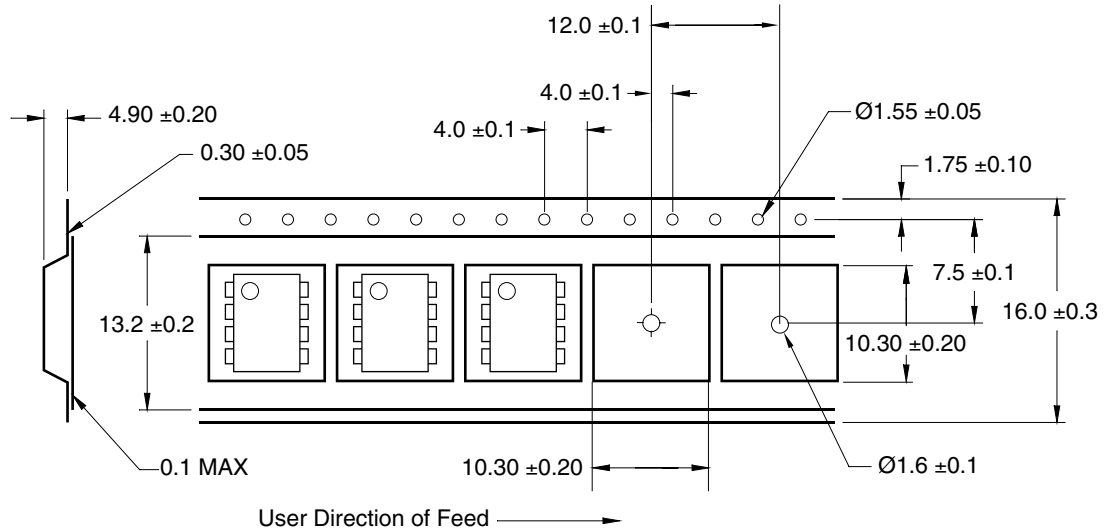


| Definitions | |
|-------------|----------------------------------------------------------------------------------------|
| 1 | Fairchild logo |
| 2 | Device number |
| 3 | VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table) |
| 4 | Two digit year code, e.g., '03' |
| 5 | Two digit work week ranging from '01' to '53' |
| 6 | Assembly package code |

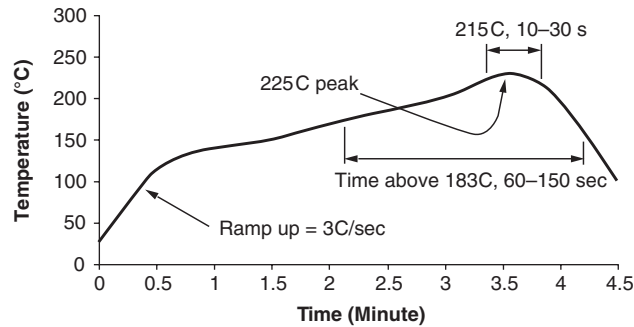
**SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730**

**6N139
HCPL-2731**

Carrier Tape Specifications



Reflow Profile



- Peak reflow temperature: 225C (package surface temperature)
- Time of temperature higher than 183C for 60-150 seconds
- One time soldering reflow is recommended

SINGLE-CHANNEL: 6N138
DUAL-CHANNEL: HCPL-2730

6N139
HCPL-2731

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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