

# Single-Channel: 6N138, 6N139 Dual-Channel: HCPL2730, HCPL2731 Low Input Current High Gain Split Darlington Optocouplers

## Features

- Low current – 0.5mA
- Superior CTR-2000%
- Superior CMR-10kV/μs
- CTR guaranteed 0–70°C
- U.L. recognized (File # E90700)
- VDE recognized (File # 120915) Ordering option V, e.g., 6N138V
- Dual Channel – HCPL2730, HCPL2731

## 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

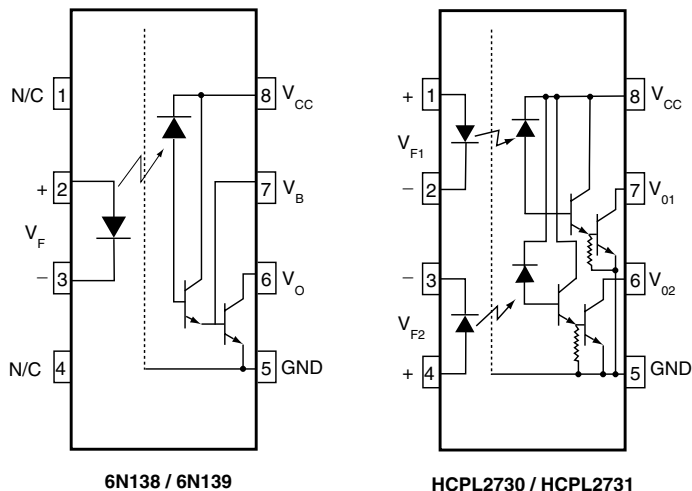
## Description

The 6N138/9 and HCPL2730/HCPL2731 optocouplers consist of an AlGaAs LED optically coupled to a high gain split darlington photodetector.

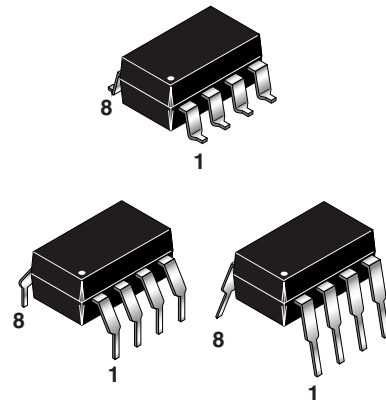
The split darlington configuration separating the input photodiode and the first stage gain from the output transistor permits lower output saturation voltage and higher speed operation than possible with conventional darlington phototransistor optocoupler. In the dual channel devices, HCPL2730/HCPL2731, an integrated emitter-base resistor provides superior stability over temperature.

The combination of a very low input current of 0.5mA 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.

## Schematic



## Package



**Absolute Maximum Ratings** ( $T_A = 25^\circ\text{C}$  unless otherwise specified)

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.

Symbol	Parameter	Value	Units
$T_{STG}$	Storage Temperature	-55 to +125	$^\circ\text{C}$
$T_{OPR}$	Operating Temperature	-40 to +85	$^\circ\text{C}$
$T_{SOL}$	Lead Solder Temperature (Wave solder only. See recommended reflow profile graph for SMD mounting)	260 for 10 sec	$^\circ\text{C}$
<b>EMITTER</b>			
$I_F$ (avg)	DC/Average Forward Input Current	Each Channel	20 mA
$I_F$ (pk)	Peak Forward Input Current (50% duty cycle, 1 ms P.W.)	Each Channel	40 mA
$I_F$ (trans)	Peak Transient Input Current ( $\leq 1\mu\text{s}$ P.W., 300 pps)		1.0 A
$V_R$	Reverse Input Voltage	Each Channel	5 V
$P_D$	Input Power Dissipation	Each Channel	35 mW
<b>DETECTOR</b>			
$I_O$ (avg)	Average Output Current	Each Channel	60 mA
$V_{ER}$	Emitter-Base Reverse Voltage	(6N138 and 6N139)	0.5 V
$V_{CC}, V_O$	Supply Voltage, Output Voltage	(6N138, HCPL2730)	-0.5 to 7 V
		(6N139, HCPL2731)	-0.5 to 18 V
$P_O$	Output Power Dissipation	Each Channel	100 mW

**Electrical Characteristics** ( $T_A = 0$  to  $70^\circ\text{C}$  unless otherwise specified)**Individual Component Characteristics**

Symbol	Parameter	Test Conditions	Device	Min.	Typ.*	Max.	Unit
<b>EMITTER</b>							
$V_F$	Input Forward Voltage	$T_A = 25^\circ\text{C}$ Each channel ( $I_F = 1.6\text{mA}$ )	All		1.30	1.7	V
						1.75	
$BV_R$	Input Reverse Breakdown Voltage	( $T_A = 25^\circ\text{C}$ , $I_R = 10\mu\text{A}$ ) Each Channel	All	5.0	20		V
$(\Delta V_F / \Delta T_A)$	Temperature coefficient of forward voltage ( $I_F = 1.6\text{mA}$ )		All		-1.8		mV/ $^\circ\text{C}$
<b>DETECTOR</b>							
$I_{OH}$	Logic HIGH output current	( $I_F = 0\text{mA}$ , $V_O = V_{CC} = 18\text{V}$ ) Each Channel	6N139 HCPL2731		0.01	100	$\mu\text{A}$
		( $I_F = 0\text{mA}$ , $V_O = V_{CC} = 7\text{V}$ ) Each Channel	6N138 HCPL2730		0.01	250	
$I_{CCL}$	Logic LOW supply	( $I_F = 1.6\text{mA}$ , $V_O = \text{Open}$ ) ( $V_{CC} = 18\text{V}$ ) ( $I_{F1} = I_{F2} = 1.6\text{mA}$ , $V_{CC} = 18\text{V}$ ) ( $V_{O1} - V_{O2} = \text{Open}$ , $V_{CC} = 7\text{V}$ )	6N138 6N139 HCPL2731 HCPL2730		0.4	1.5	mA
					1.3	3	
$I_{CCH}$	Logic HIGH supply	( $I_F = 0\text{mA}$ , $V_O = \text{Open}$ , $V_{CC} = 18\text{V}$ ) ( $I_{F1} = I_{F2} = 0\text{mA}$ , $V_{CC} = 18\text{V}$ ) ( $V_{O1} - V_{O2} = \text{Open}$ , $V_{CC} = 7\text{V}$ )	6N138 6N139 HCPL2731 HCPL2730		0.05	10	$\mu\text{A}$
					0.10	20	

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

**Transfer Characteristics** ( $T_A = 0$  to  $70^\circ\text{C}$  unless otherwise specified)

Symbol	Parameter	Test Conditions	Device	Min.	Typ.*	Max.	Unit
<b>COUPLED</b>							
CTR	Current transfer ratio (Note 1, 2)	$(I_F = 0.5\text{mA}, V_O = 0.4\text{V}, V_{CC} = 4.5\text{V})$	6N139	400	1100		%
			Each Channel HCPL2731		3500		
		$(I_F = 1.6\text{mA}, V_O = 0.4\text{V}, V_{CC} = 4.5\text{V})$	6N139	500	1300		
			Each Channel HCPL2731		2500		
		$(I_F = 1.6\text{mA}, V_O = 0.4\text{V}, V_{CC} = 4.5\text{V})$	6N138	300	1300		
			Each Channel HCPL2730		2500		
V <sub>OL</sub>	Logic LOW output voltage output voltage (Note 2)	$(I_F = 0.5\text{mA}, I_O = 2\text{mA}, V_{CC} = 4.5\text{V})$	6N139		0.08	0.4	V
			Each Channel HCPL2731		0.01	0.4	
		$(I_F = 0.5\text{mA}, I_O = 15\text{mA}, V_{CC} = 4.5\text{V})$	6N139		0.13	0.4	
			Each Channel HCPL2731				
		$(I_F = 12\text{mA}, I_O = 24\text{mA}, V_{CC} = 4.5\text{V})$	6N139		0.20	0.4	
			Each Channel HCPL2731				
		$(I_F = 1.6\text{mA}, I_O = 4.8\text{mA}, V_{CC} = 4.5\text{V})$	6N138		0.10	0.4	
			Each Channel HCPL2730				

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

**Switching Characteristics** ( $T_A = 0$  to  $70^\circ\text{C}$  unless otherwise specified.,  $V_{CC} = 5\text{V}$ )

Symbol	Parameter	Test Conditions	Device	Min.	Typ.*	Max.	Unit				
$T_{PHL}$	Propagation delay time to logic LOW (Note 2) (Fig. 24)	$(R_L = 4.7\Omega, I_F = 0.5\text{mA})$	6N139			30	$\mu\text{s}$				
		$T_A = 25^\circ\text{C}$			4	25					
		$(R_L = 4.7\Omega, I_F = 0.5\text{mA})$	HCPL2731			120					
		Each Channel $T_A = 25^\circ\text{C}$			3	100					
		$(R_L = 270\Omega, I_F = 12\text{mA})$	6N139			2					
		$T_A = 25^\circ\text{C}$			0.2	1					
		$(R_L = 270\Omega, I_F = 12\text{mA})$	HCPL2730			3					
		Each Channel $T_A = 25^\circ\text{C}$	HCPL2731		0.3	2					
$T_{PLH}$	Propagation delay time to logic HIGH (Note 2) (Fig. 24)	$(R_L = 4.7\Omega, I_F = 0.5\text{mA})$	6N139			90	$\mu\text{s}$				
		Each Channel	HCPL2731								
		$(R_L = 4.7\Omega, I_F = 0.5\text{mA}) T_A = 25^\circ\text{C}$	6N139		12	60					
		Each Channel	HCPL2731		22						
		$(R_L = 270\Omega, I_F = 12\text{mA})$	6N139			10					
		$T_A = 25^\circ\text{C}$			1.3	7					
		$(R_L = 270\Omega, I_F = 12\text{mA})$ Each Channel	HCPL2730			15					
		$T_A = 25^\circ\text{C}$	HCPL2731		5	10					
$ICM_{HI}$	Common mode transient immunity at logic HIGH (Note 3) (Fig. 25)	$(I_F = 0\text{mA},  V_{CM}  = 10V_{P-P})$	6N138	1,000	10,000		$\text{V}/\mu\text{s}$				
		$T_A = 25^\circ\text{C}, (R_L = 2.2\Omega)$	6N139								
		Each Channel	HCPL2730								
			HCPL2731								
		$(I_F = 1.6\text{mA},  V_{CM}  = 10V_{P-P})$	6N138					1,000	10,000		$\text{V}/\mu\text{s}$
			6N139								
Each Channel	HCPL2730										
	HCPL2731										

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

**Isolation Characteristics** ( $T_A = 0$  to  $70^\circ\text{C}$  unless otherwise specified)

Symbol	Characteristics	Test Conditions	Min.	Typ.*	Max.	Unit
$I_{I-O}$	Input-output insulation leakage current (Note 4)	(Relative humidity = 45%) ( $T_A = 25^\circ\text{C}$ , $t = 5$ s) ( $V_{I-O} = 3000\text{VDC}$ )			1.0	$\mu\text{A}$
$V_{ISO}$	Withstand insulation test voltage (Note 4)	(RH $\leq$ 50%, $T_A = 25^\circ\text{C}$ , $I_{I-O} \leq 2\mu\text{A}$ ) ( $t = 1$ min.)	2500			$V_{RMS}$
$R_{I-O}$	Resistance (input to output) (Note 4)	( $V_{I-O} = 500\text{VDC}$ )		$10^{12}$		$\Omega$
$C_{I-O}$	Capacitance (input to output) (Note 4, 5)	( $f = 1\text{MHz}$ )		0.6		pF
$I_{I-I}$	Input-Input Insulation leakage current (Note 6)	(RH $\leq$ 45%, $V_{I-I} = 500\text{VDC}$ ) $t = 5$ s, (HCPL2730/2731 only)		0.005		$\mu\text{A}$
$R_{I-I}$	Input-Input Resistance (Note 6)	( $V_{I-I} = 500\text{VDC}$ ) (HCPL2730/2731 only)		$10^{11}$		$\Omega$
$C_{I-I}$	Input-Input Capacitance (Note 6)	( $f = 1$ MHz) (HCPL2730/2731 only)		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.,  $V_O > 2.0\text{V}$ ). 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.,  $V_O < 0.8\text{V}$ ).
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.

### Electrical Characteristics (T<sub>A</sub> = 25°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<sub>DD1</sub> - Input Supply Voltage

V<sub>DD2</sub> - Output Supply Voltage

V<sub>DF</sub> - Diode Forward Voltage

V<sub>OL1</sub> - Logic "0" Voltage of Driver

V<sub>OH1</sub> - Logic "1" Voltage of Driver

I<sub>F</sub> - Diode Forward Current

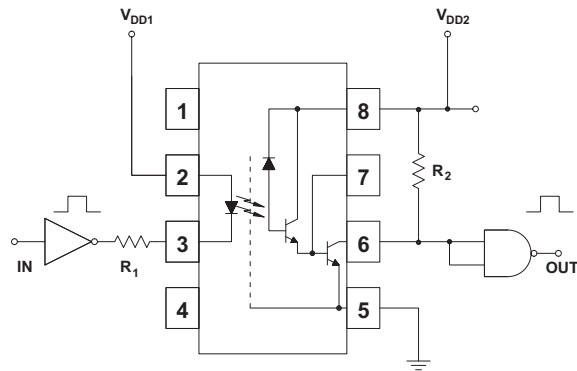
V<sub>OLX</sub> - Saturation Voltage of Output Transistor

I<sub>L</sub> - Load Current Through Resistor R<sub>2</sub>

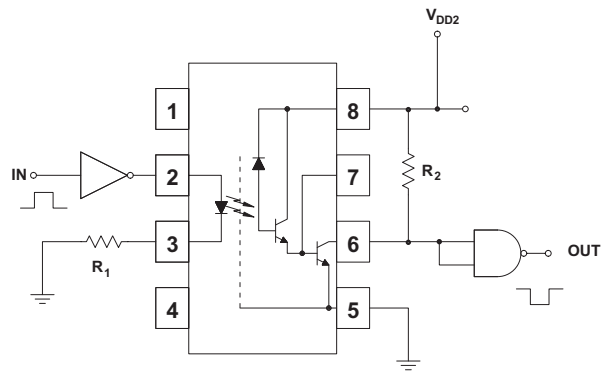
I<sub>2</sub> - Input Current of Output Gate

INPUT		R1 (V)	OUTPUT						
			CMOS @ 5V	CMOS @ 10V	74XX	74LXX	74SXX	74LSXX	74HXX
			R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)
CMOS @ 5V	NON-INV.	2000	1000	2200	750	1000	1000	1000	560
	INV.	510							
CMOS @ 10V	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**

Fig. 4 LED Forward Current vs. Forward Voltage

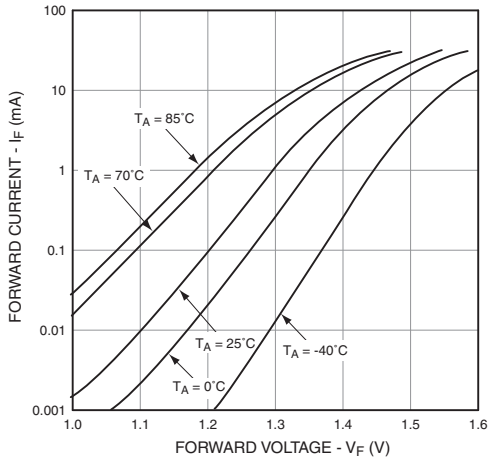


Fig. 5 LED Forward Voltage vs. Temperature

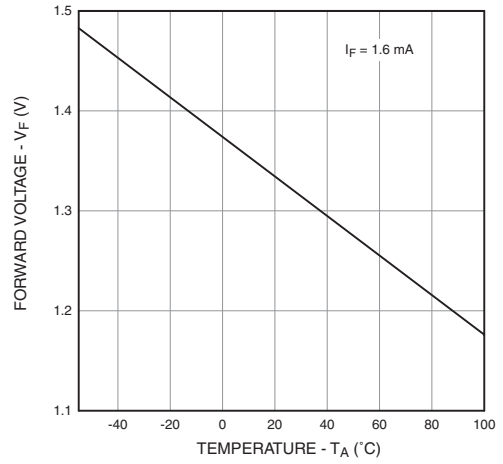


Fig. 6 Non-saturated Rise and Fall Times vs. Load Resistance (6N138 / 6N139 Only)

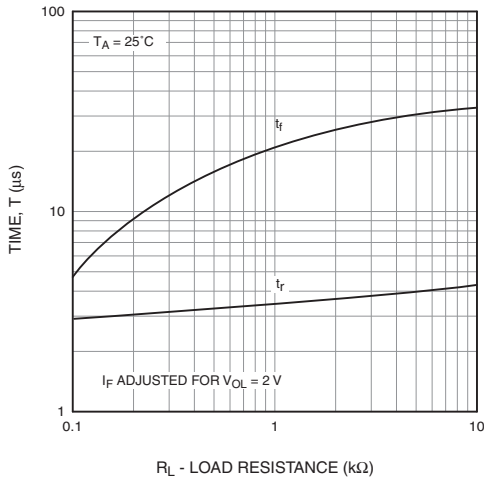


Fig. 7 Non-saturated Rise and Fall Times vs. Load Resistance (HCPL2730 / HCPL2731 Only)

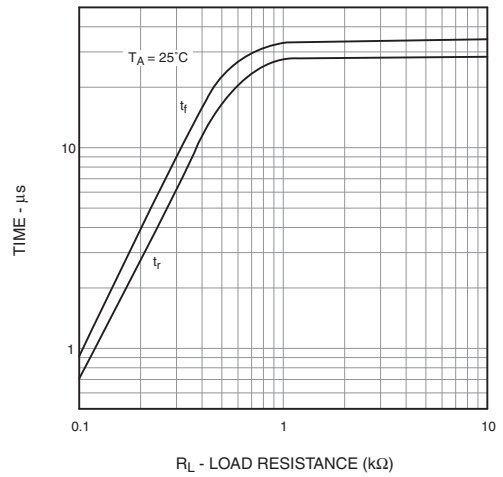


Fig. 8 Propagation Delay To Logic Low vs. Base-Emitter Resistance (HCPL2730 / HCPL2731 Only)

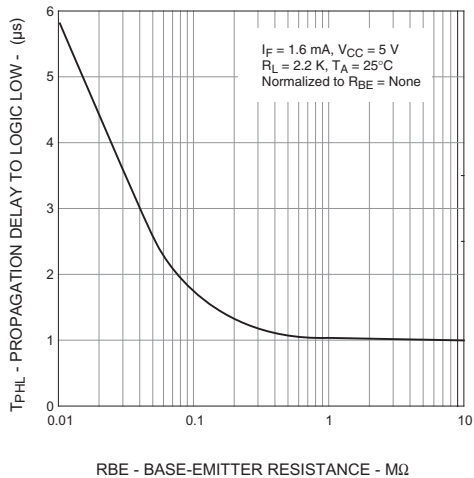
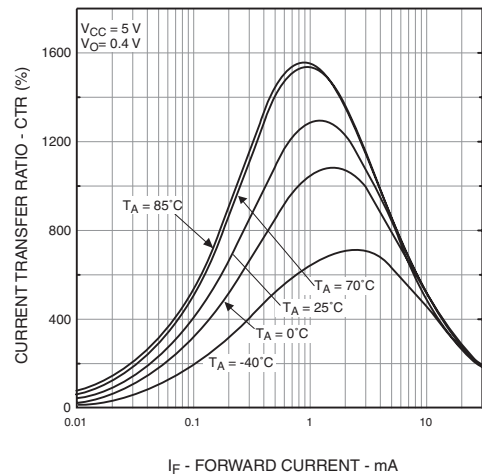
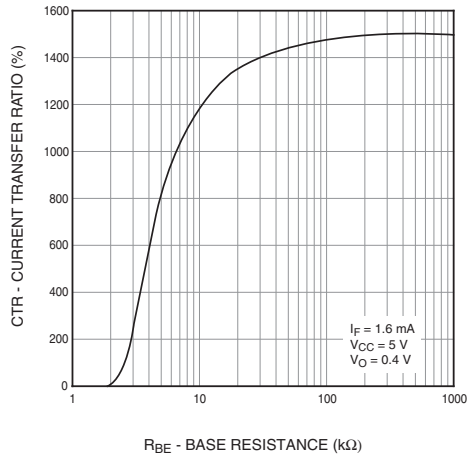


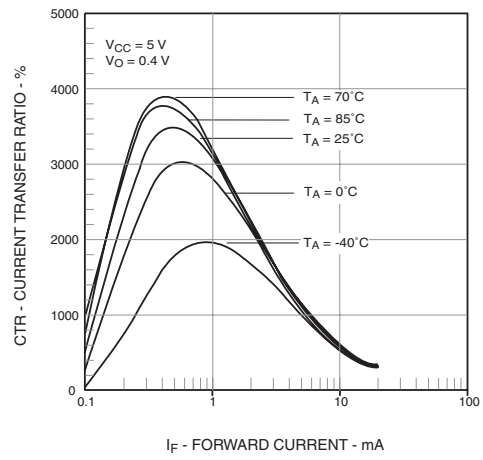
Fig. 9 Current Transfer Ratio vs. Forward Current (6N138 / 6N139 Only)



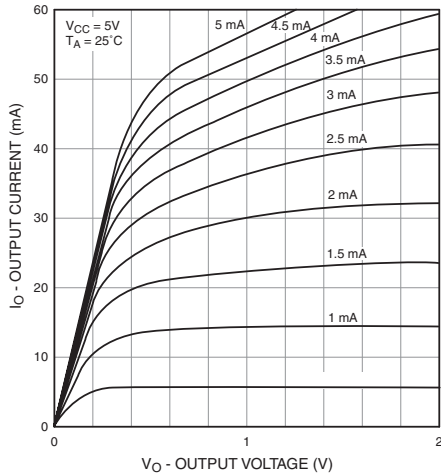
**Fig. 10 Current Transfer Ratio vs. Base-Emitter Resistance (6N138 / 6N139 Only)**



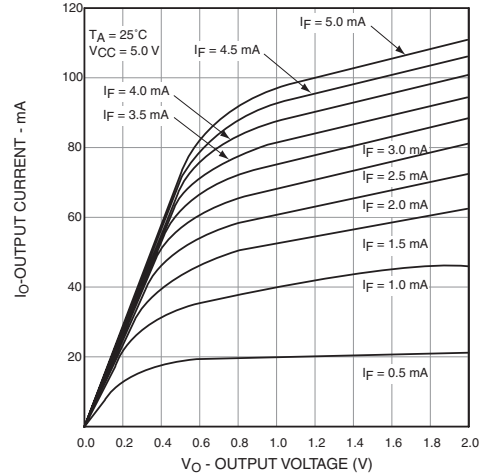
**Fig. 11 Current Transfer Ratio vs. Forward Current (HCPL2730 / HCPL2731 Only)**



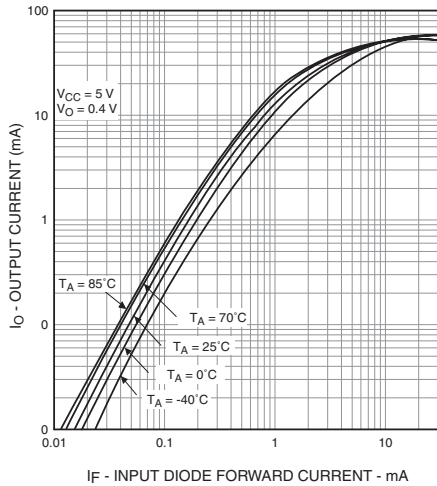
**Fig. 12 Output Current vs Output Voltage (6N138 / 6N139 Only)**



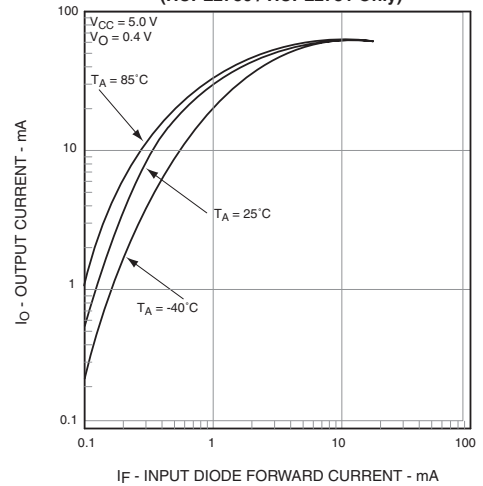
**Fig. 13 Output Current vs Output Voltage (HCPL2730 / HCPL2731 Only)**



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

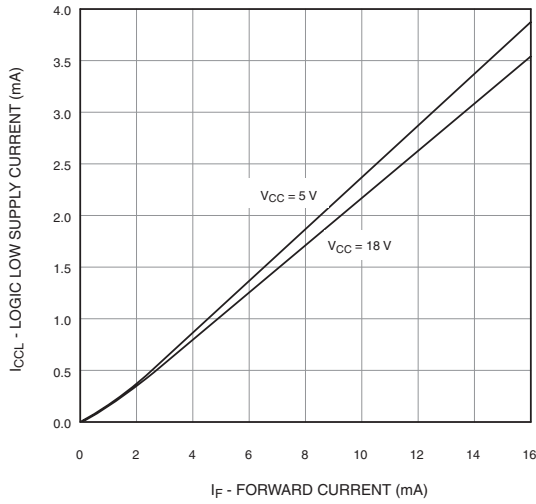


**Fig. 15 Output Current vs Input Diode Forward Current (HCPL2730 / HCPL2731 Only)**

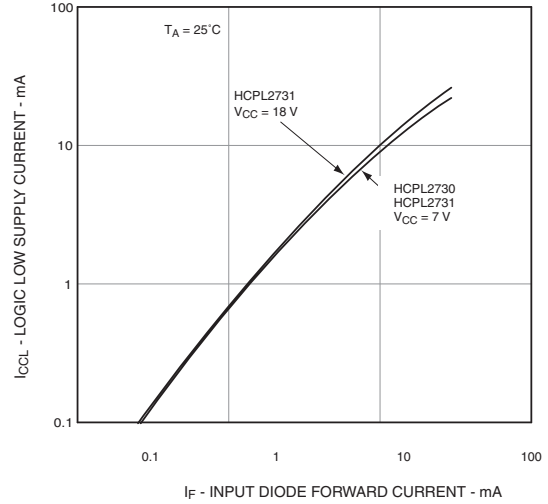




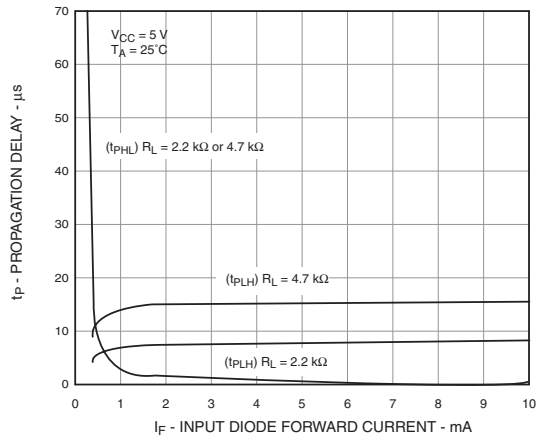
**Fig. 16 Logic Low Supply Current vs. Input Diode Forward Current (6N138 / 6N139 Only)**



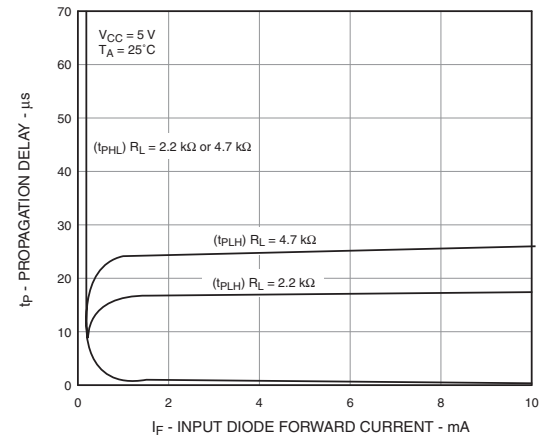
**Fig. 17 Logic Low Supply Current vs. Input Diode Forward Current (HCPL2730 / HCPL2731 Only)**



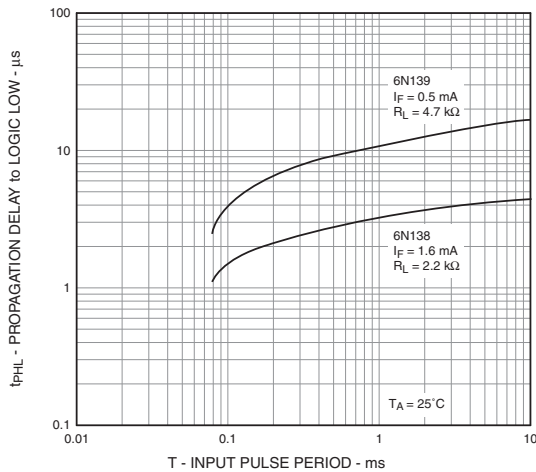
**Fig. 18 Propagation Delay vs. Input Diode Forward Current (6N138 / 6N139 Only)**



**Fig. 19 Propagation Delay vs. Input Diode Forward Current (HCPL2730 / HCPL2731 Only)**



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



**Fig. 21 Propagation Delay to Logic Low vs. Pulse Period (HCPL2730 / HCPL2731 Only)**

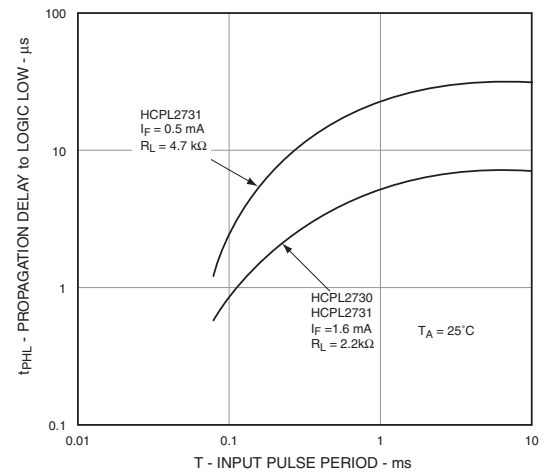


Fig. 22 Propagation Delay vs. Temperature  
(6N138 / 6N139 Only)

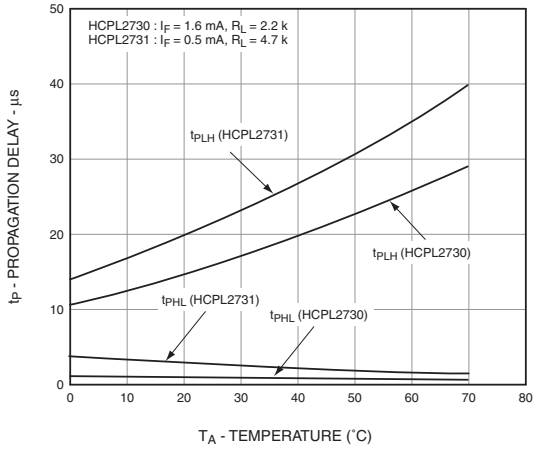
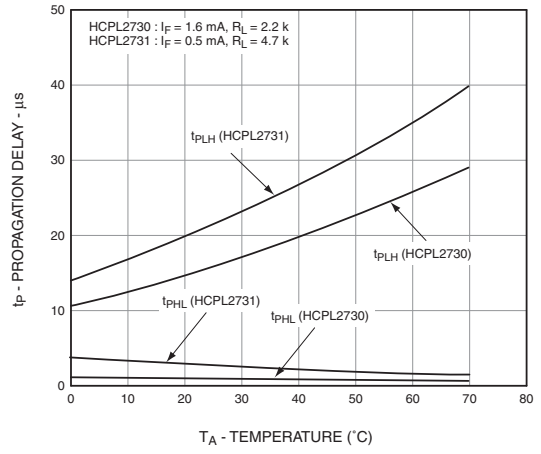


Fig. 23 Propagation Delay vs. Temperature  
(HCPL2730 / HCPL2731 Only)



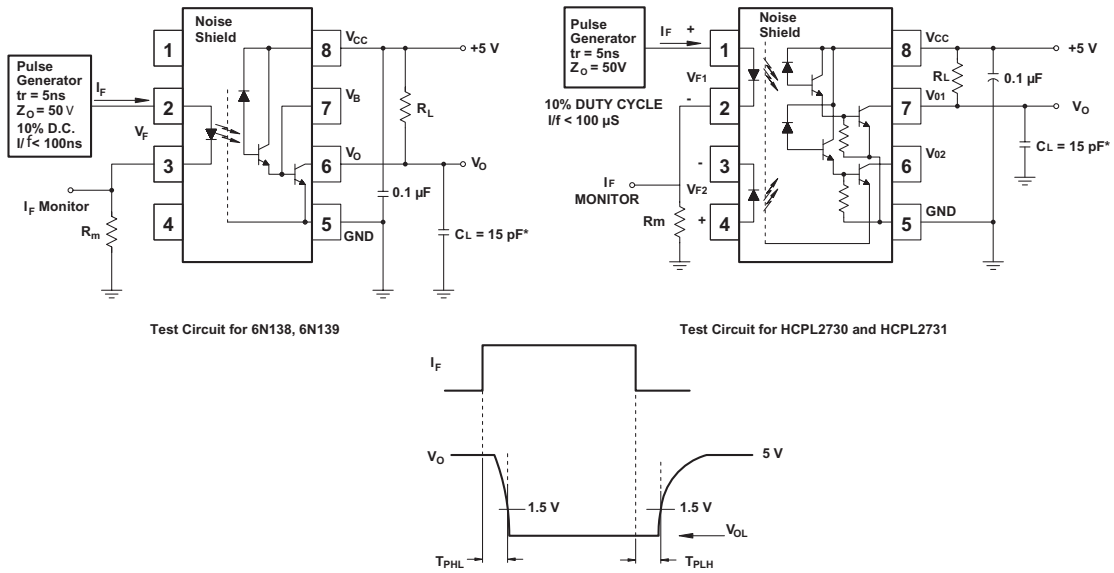


Fig. 24 Switching Time Test Circuit

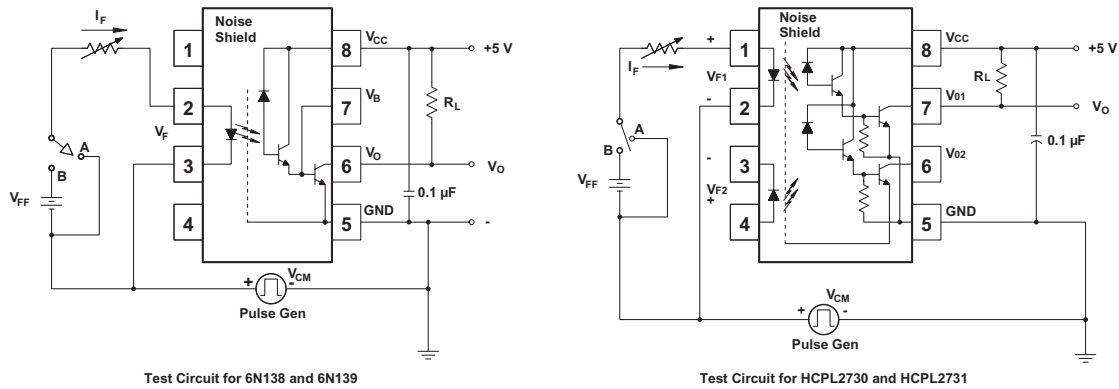
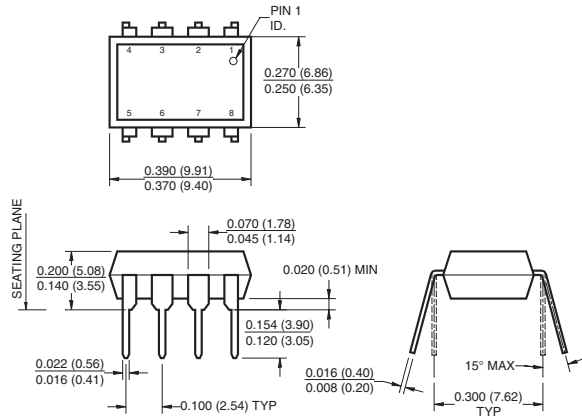


Fig. 25 Common Mode Immunity Test Circuit

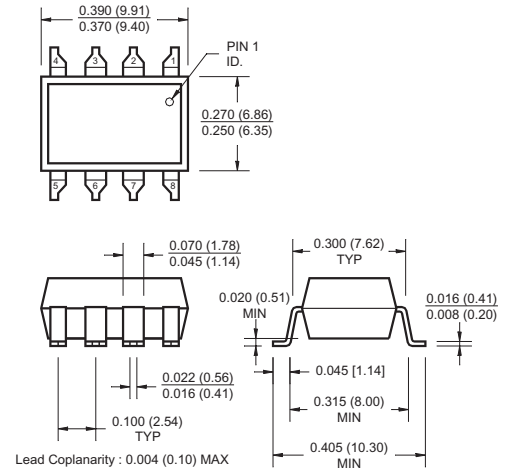
## Physical Dimensions

Dimensions are in inches (millimeters) unless otherwise noted.

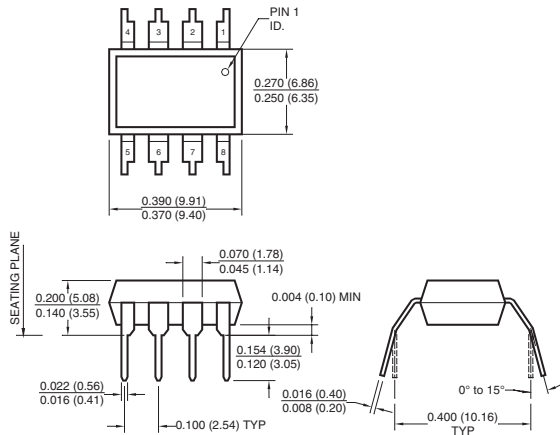
### Through Hole



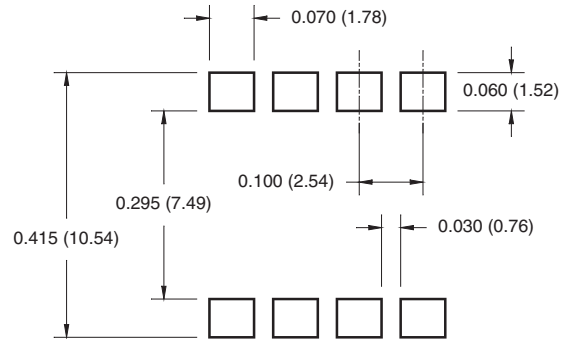
### Surface Mount



### 0.4" Lead Spacing



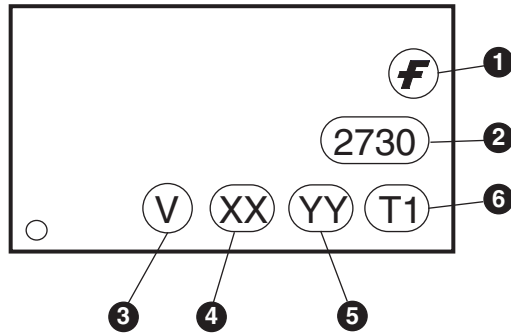
### Recommended Pad Layout for Surface Mount Leadform



### Ordering Information

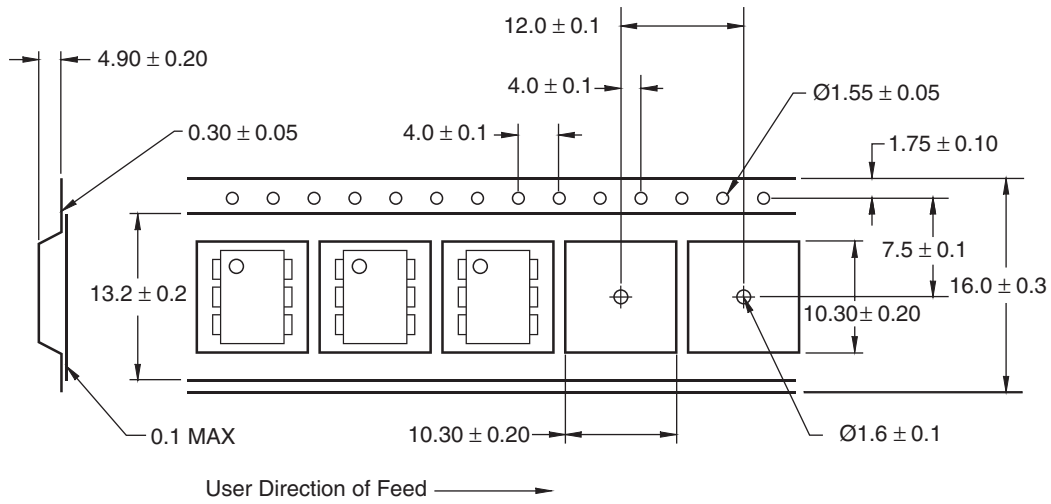
Option	Example Part Number	Description
No Suffix	6N138	Standard Through Hole Device, 50 pcs per tube
S	6N138S	Surface Mount Lead Bend
SD	6N138SD	Surface Mount; Tape and reel
W	6N138W	0.4" Lead Spacing
V	6N138V	VDE0884
WV	6N138WV	VDE0884; 0.4" lead spacing
SV	6N138SV	VDE0884; surface mount
SDV	6N138SDV	VDE0884; surface mount; tape and reel

### Marking Information

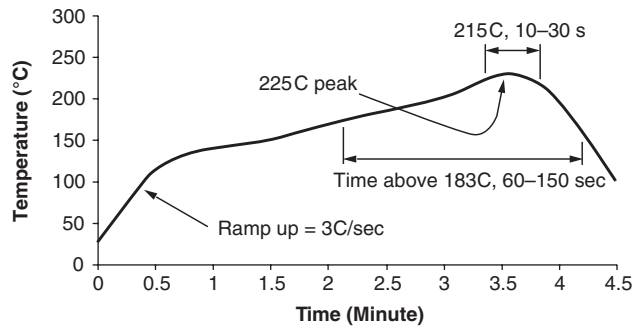


Definitions	
1	Fairchild logo
2	Device number
3	VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table)
4	Two digit year code, e.g., '07'
5	Two digit work week ranging from '01' to '53'
6	Assembly package code

### 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



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