

Single-Channel: 6N138, 6N139 Dual-Channel: HCPL-2730, HCPL-2731 Low Input Current High Gain Split Darlington Optocouplers

Features

- Low current - 0.5 mA
- Superior CTR-2000%
- Superior CMR-10 kV/μs
- CTR guaranteed 0-70°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
- μP bus isolation
- Current loop receiver

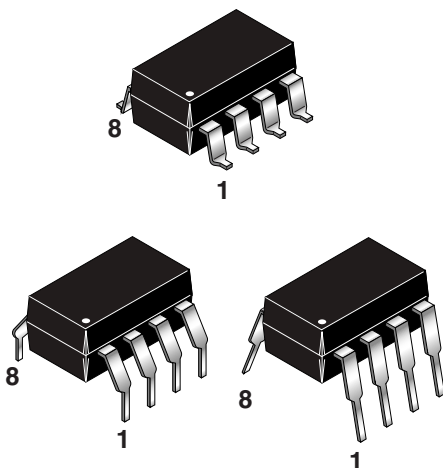
Description

The 6N138/9 and HCPL-2730/HCPL-2731 optocouplers consist of an AlGaAs LED optically coupled to a high gain split darlington photodetector.

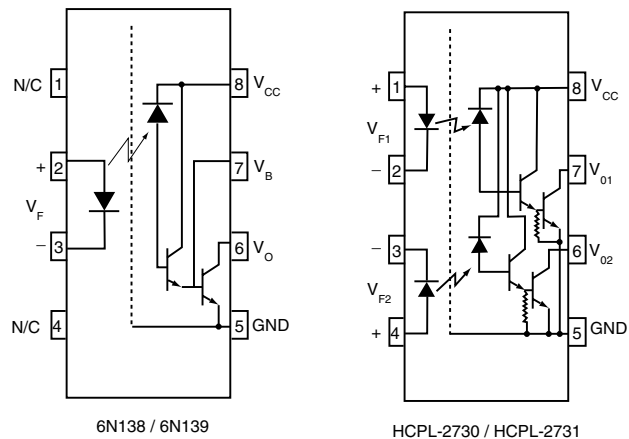
The split darlington configuration separating the input photodiode and the first stage gain from the output transistor permits lower output saturation voltage and higher speed operation than possible with conventional darlington phototransistor optocoupler. In the dual channel devices, HCPL-2730/HCPL2731, 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/μs.

Package



Schematic



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 SMD mounting)	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) (6N139, HCPL-2731)	V_{CC}, V_O	-0.5 to 7 V -0.5 to 18 V
Output Power Dissipation	Each Channel	P_O	100 mW

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

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

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)	$(I_F = 0.5 \text{ mA}, I_O = 2 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel	V_{OL}	6N139		0.08	0.4	V
			6N139		0.01	0.4	
	HCPL-2731		6N139		0.13	0.4	
			HCPL-2731				
	$(I_F = 0.5 \text{ mA}, I_O = 15 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel		6N139		0.20	0.4	
			HCPL-2731				
	$(I_F = 12 \text{ mA}, I_O = 24 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel		6N139		0.10	0.4	
			6N138				
$(I_F = 1.6 \text{ mA}, I_O = 4.8 \text{ mA}, V_{CC} = 4.5 \text{ V})$ Each Channel	6N138						
	HCPL-2730						

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

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)	$(R_L = 4.7\text{ k}\Omega, I_F = 0.5\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	6N139			30	μs
					4	25	
	$(R_L = 4.7\text{ k}\Omega, I_F = 0.5\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	HCPL-2731			120	μs
					3	100	
	$(R_L = 270\ \Omega, I_F = 12\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	6N139			2	μs
					0.2	1	
	$(R_L = 270\ \Omega, I_F = 12\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	HCPL-2730			3	μs
			HCPL-2731			0.3	
$(R_L = 2.2\text{ k}\Omega, I_F = 1.6\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	6N138			15	μs	
				1.5	10		
$(R_L = 2.2\text{ k}\Omega, I_F = 1.6\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PHL}	HCPL-2731			25	μs	
		HCPL-2730			1		20
Propagation delay time to logic high (Note 2) (Fig. 22)	$(R_L = 4.7\text{ k}\Omega, I_F = 0.5\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	6N139			90	μs
			HCPL-2731				
	$(R_L = 4.7\text{ k}\Omega, I_F = 0.5\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	6N139			12	μs
			HCPL-2731			22	
	$(R_L = 270\ \Omega, I_F = 12\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	6N139			10	μs
					1.3	7	
	$(R_L = 270\ \Omega, I_F = 12\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	HCPL-2730			15	μs
			HCPL-2731			5	
	$(R_L = 2.2\text{ k}\Omega, I_F = 1.6\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	6N138			50	μs
			HCPL-2730/1				
$(R_L = 2.2\text{ k}\Omega, I_F = 1.6\text{ mA})$ Each Channel $T_A = 25^\circ\text{C}$	T_{PLH}	6N138			7	μs	
		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) Each Channel	ICM_{HI}	6N138	1,000	10,000		$\text{V}/\mu\text{s}$
			6N139				
Common mode transient immunity at logic low	$(I_F = 1.6\text{ mA}, V_{CM} = 10\text{ V}_{P-P})$ $T_A = 25^\circ\text{C}, (R_L = 2.2\text{ k}\Omega)$ (Note 3) (Fig. 23) Each Channel	ICM_{LI}	6N138	1,000	10,000		$\text{V}/\mu\text{s}$
			6N139				
			HCPL-2730				
			HCPL-2731				

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

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	($RH \leq 50\%$, $T_A = 25^\circ\text{C}$, $I_{I-O} \leq 2 \mu\text{A}$) (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 Typical values at $T_A = 25^\circ\text{C}$

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. (6N138 and 6N139 only)
- 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).
- 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.
- 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.
- Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.

Electrical Characteristics (T_A = 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_{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

I₂ - Input Current of Output Gate

INPUT		R1 (V)	OUTPUT						
			CMOS @ 5 V	CMOS @ 10 V	74XX	74LXX	74SXX	74LSXX	74HXX
			R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)	R2 (V)
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. 1 Resistor Values for Logic Interface

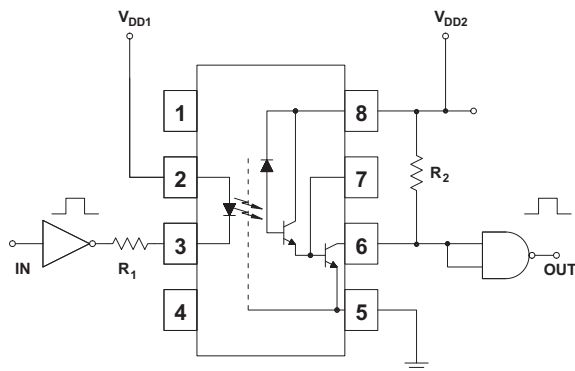


Fig. 2 Non-Inverting Logic Interface

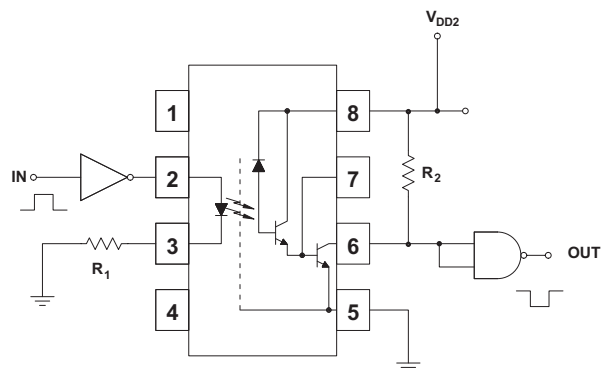


Fig. 3 Inverting Logic Interface

Fig. 4 LED Forward Current vs. Forward Voltage

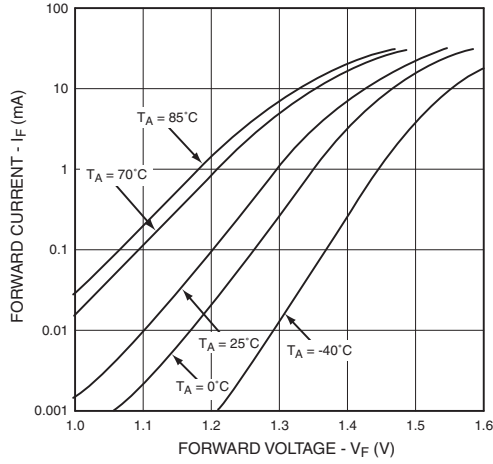


Fig. 5 LED Forward Voltage vs. Temperature

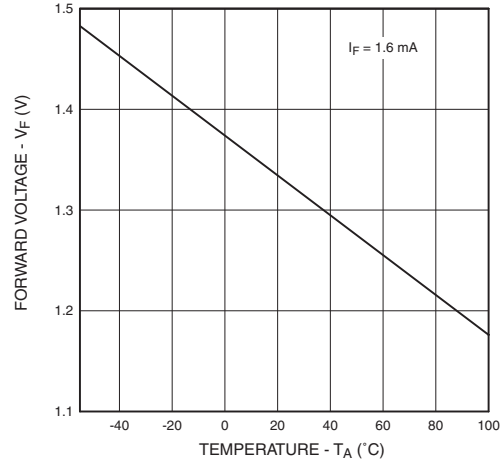


Fig. 6 Non-saturated Rise and Fall Times vs. Load Resistance (6N138 / 6N139 Only)

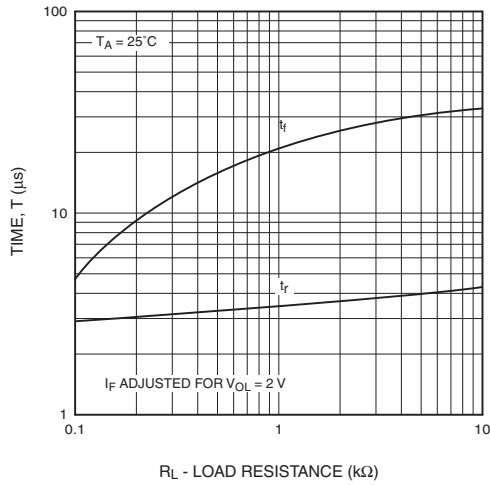


Fig. 7 Non-saturated Rise and Fall Times vs. Load Resistance (HCPL-2730 / HCPL-2731 Only)

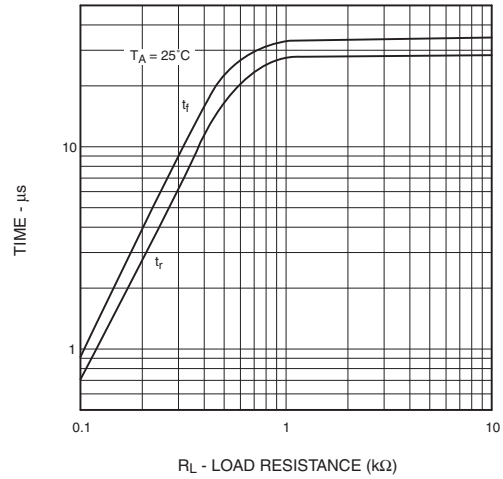


Fig. 8 Propagation Delay To Logic Low vs. Base-Emitter Resistance (HCPL-2730 / HCPL-2731 Only)

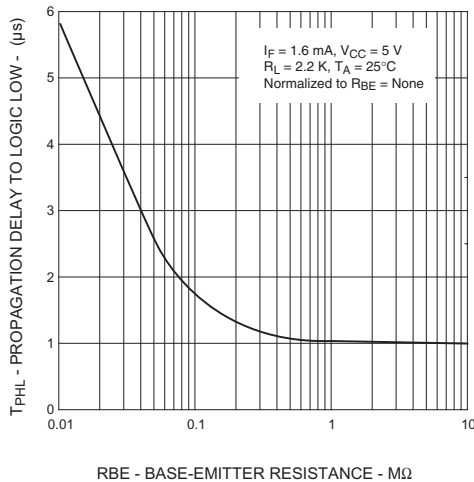


Fig. 9 Current Transfer Ratio vs. Forward Current (6N138 / 6N139 Only)

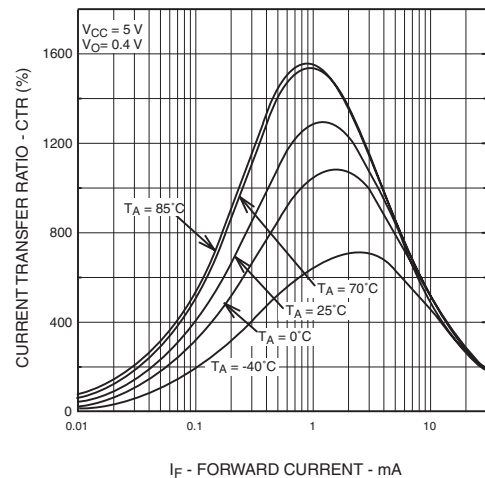


Fig. 10 Current Transfer Ratio vs. Base-Emitter Resistance (6N138 / 6N139 Only)

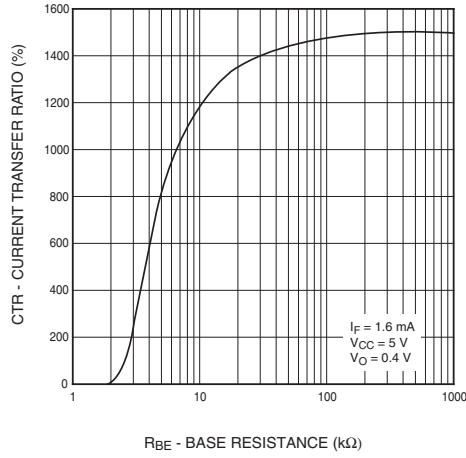


Fig. 11 Current Transfer Ratio vs. Forward Current (HCPL-2730 / HCPL-2731 Only)

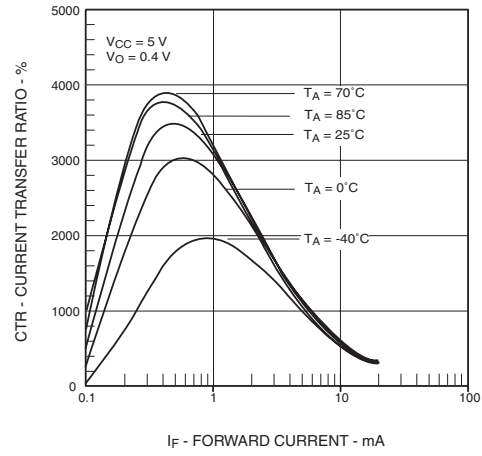


Fig. 12 Output Current vs Output Voltage (6N138 / 6N139 Only)

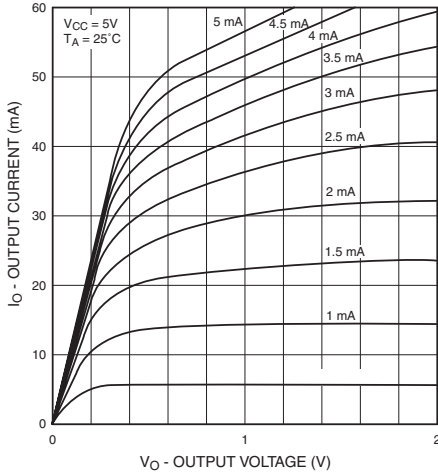


Fig. 13 Output Current vs Output Voltage (HCPL-2730 / HCPL-2731 Only)

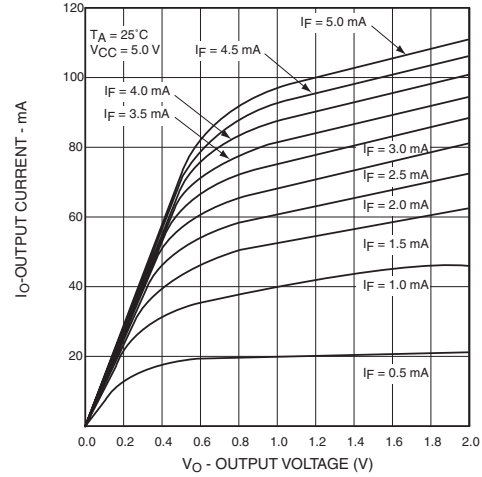


Fig. 14 Output Current vs. Input Diode Forward Current (6N138 / 6N139 Only)

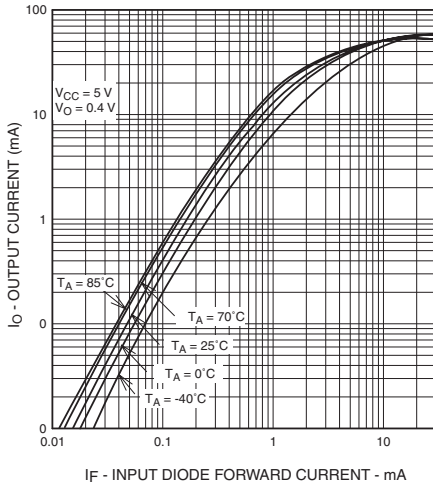


Fig. 15 Output Current vs Input Diode Forward Current (HCPL-2730 / HCPL-2731 Only)

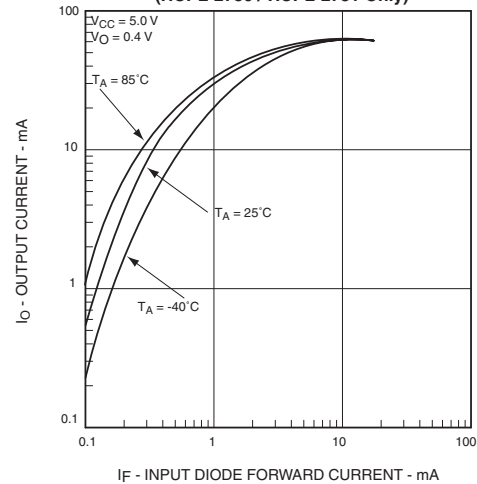


Fig. 16 Logic Low Supply Current vs. Input Diode Forward Current (6N138 / 6N139 Only)

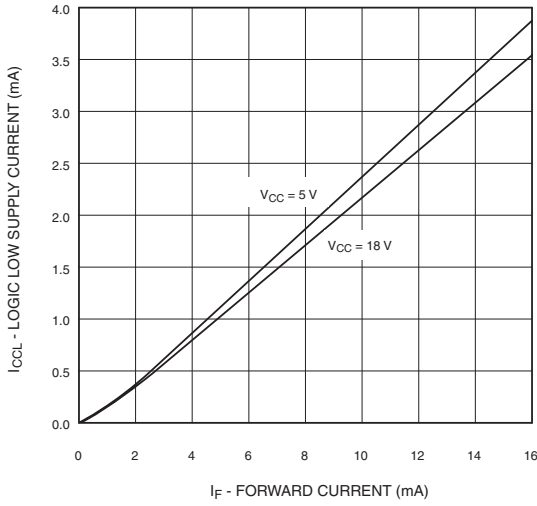


Fig. 17 Logic Low Supply Current vs. Input Diode Forward Current (HCPL-2730 / HCPL-2731 Only)

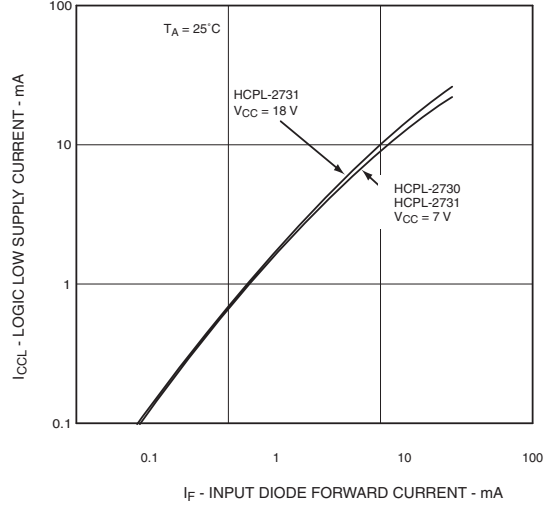


Fig. 18 Propagation Delay vs. Input Diode Forward Current (6N138 / 6N139 Only)

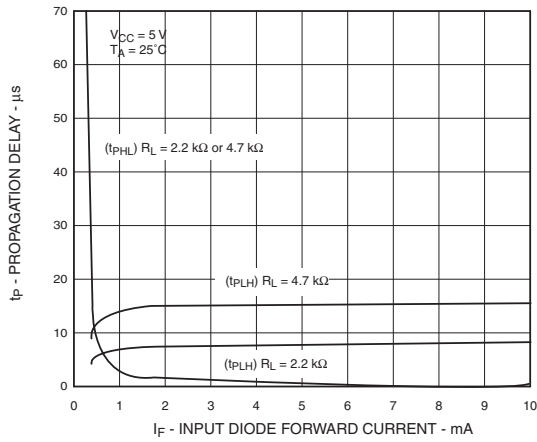


Fig. 19 Propagation Delay vs. Input Diode Forward Current (HCPL-2730 / HCPL-2731 Only)

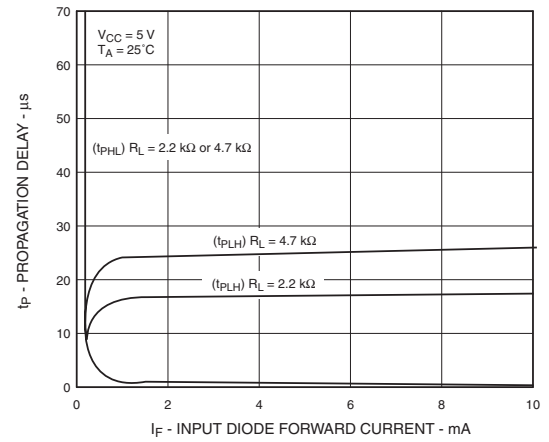


Fig. 20 Propagation Delay to Logic Low vs. Pulse Period (6N138 / 6N139 Only)

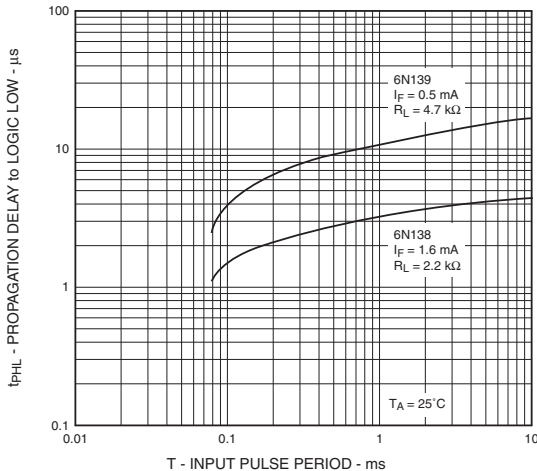


Fig. 21 Propagation Delay to Logic Low vs. Pulse Period (HCPL-2730 / HCPL-2731 Only)

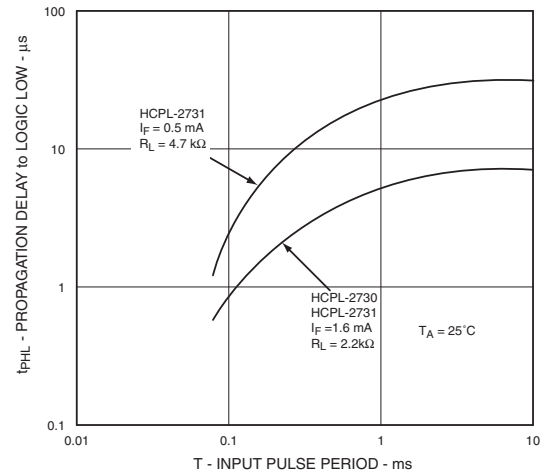


Fig. 22 Propagation Delay vs. Temperature (6N138 / 6N139 Only)

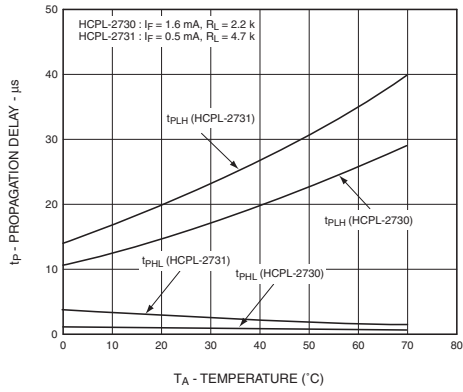
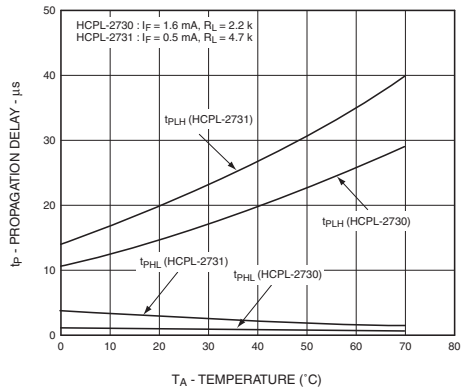
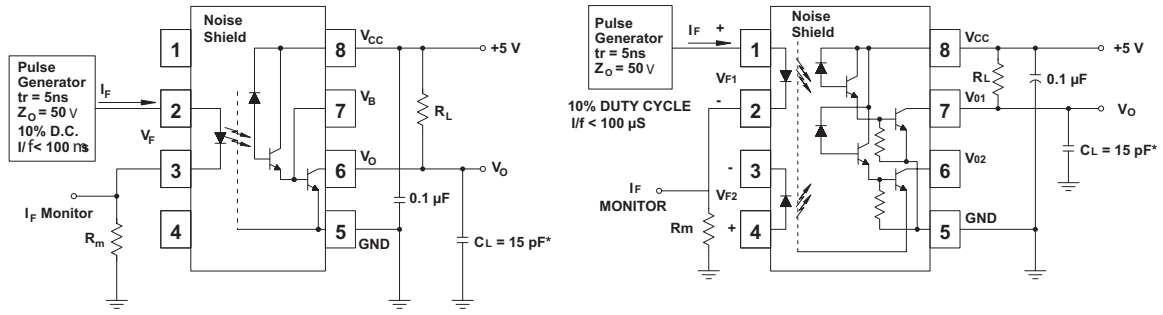


Fig. 23 Propagation Delay vs. Temperature (HCPL-2730 / HCPL-2731 Only)





Test Circuit for 6N138, 6N139

Test Circuit for HCPL-2730 and HCPL-2731

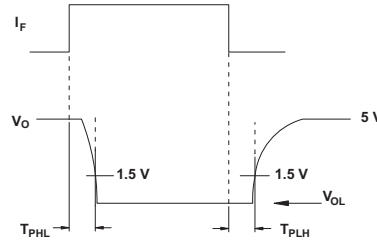
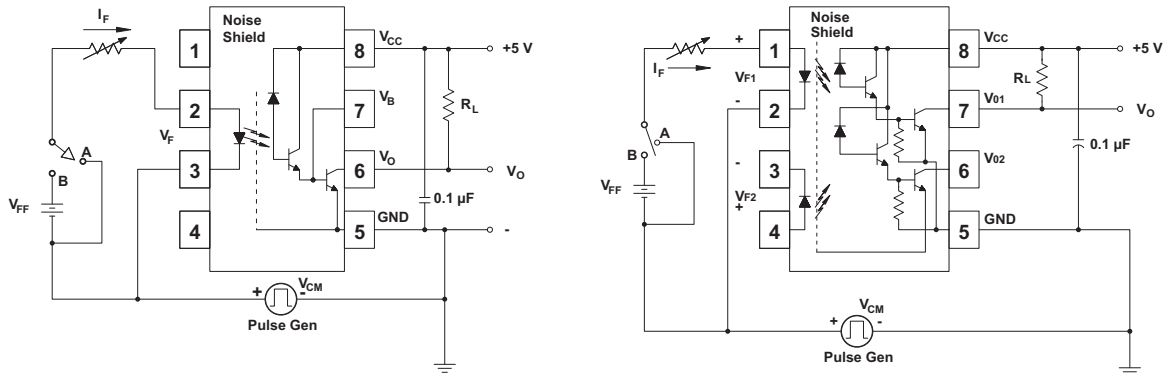


Fig. 22 Switching Time Test Circuit



Test Circuit for 6N138 and 6N139

Test Circuit for HCPL-2730 and HCPL-2731

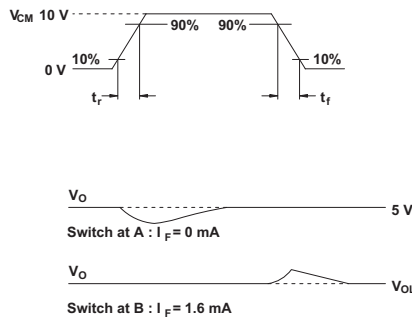
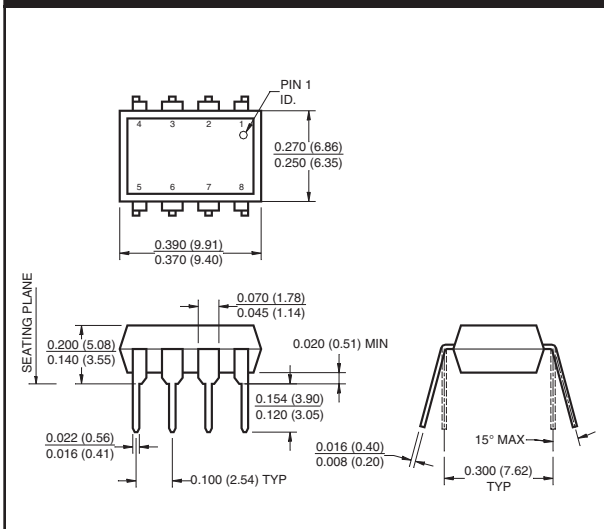
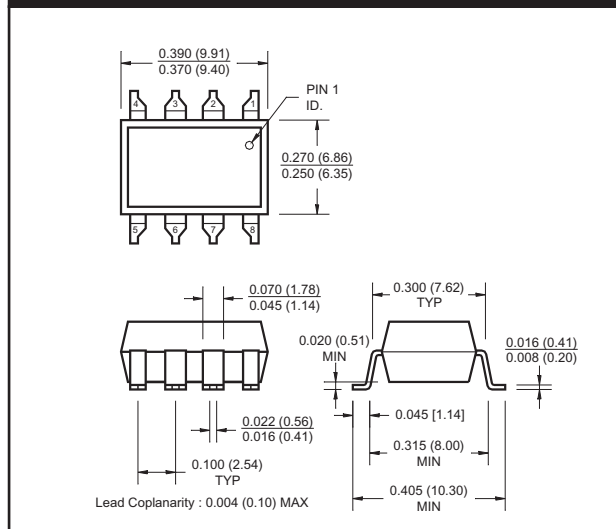


Fig. 23 Common Mode Immunity Test Circuit

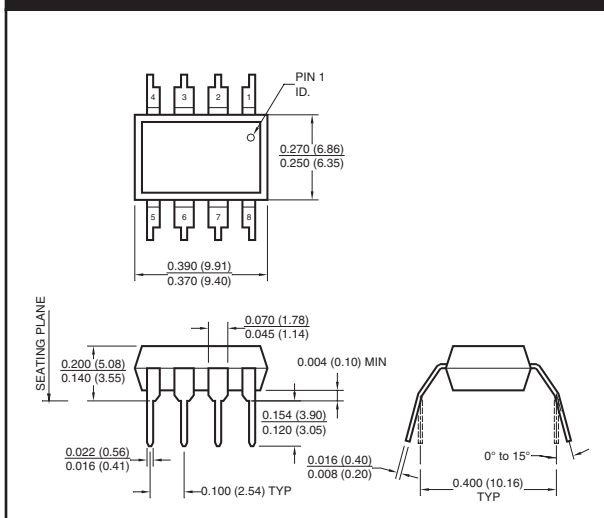
Package Dimensions (Through Hole)



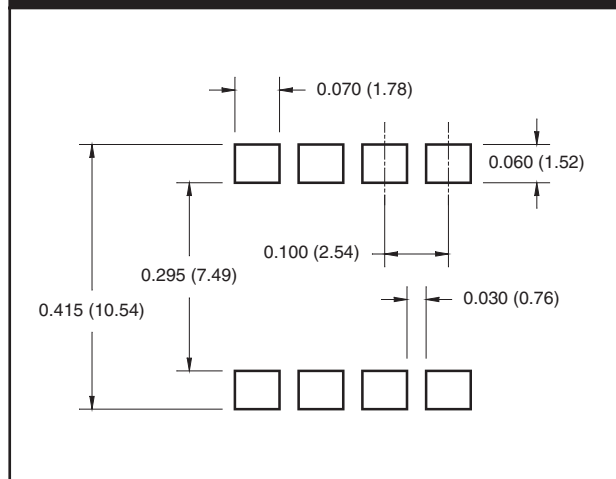
Package Dimensions (Surface Mount)



Package Dimensions (0.4" Lead Spacing)



Recommended Pad Layout for Surface Mount Leadform



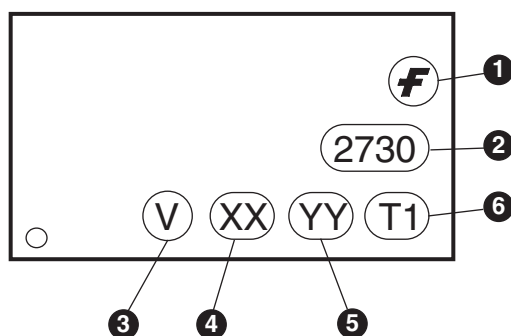
NOTE

All dimensions are in inches (millimeters)

Ordering Information

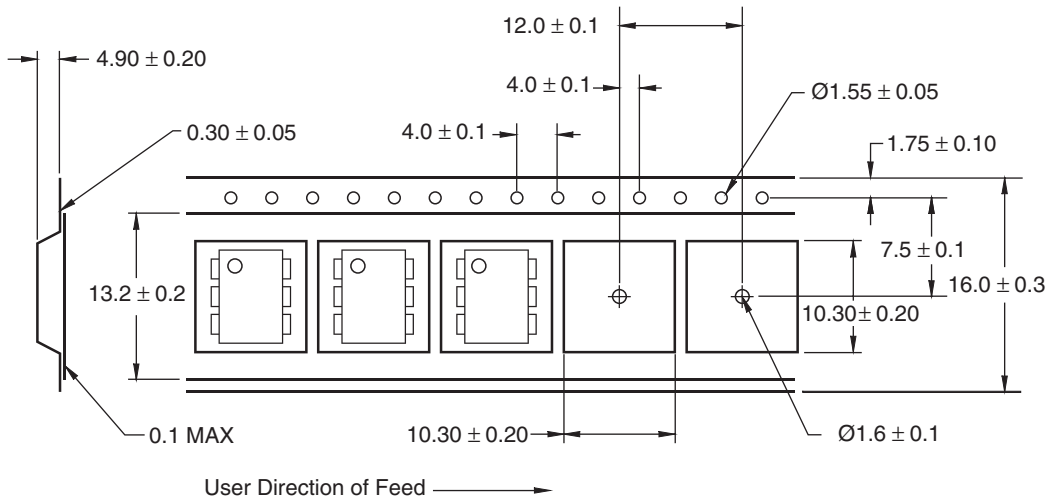
Option	Example Part Number	Description
S	6N138S	Surface Mount Lead Bend
SD	6N138SD	Surface Mount; Tape and reel
W	6N138W	0.4" Lead Spacing
V	6N138V	VDE0884
WV	6N138WV	VDE0884; 0.4" lead spacing
SV	6N138SV	VDE0884; surface mount
SDV	6N138SDV	VDE0884; surface mount; tape and reel

Marking Information

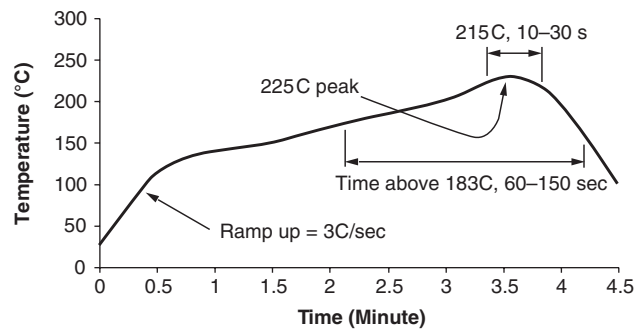


Definitions	
1	Fairchild logo
2	Device number
3	VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table)
4	Two digit year code, e.g., '03'
5	Two digit work week ranging from '01' to '53'
6	Assembly package code

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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Build it Now™	HiSeC™	OPTOPLANAR™	Stealth™	Wire™
CoolFET™	I ² C™	PACMAN™	SuperFET™	
CROSSVOLT™	i-Lo™	POP™	SuperSOT™-3	
DOME™	ImpliedDisconnect™	Power247™	SuperSOT™-6	
EcoSPARK™	IntelliMAX™	PowerEdge™	SuperSOT™-8	
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EnSigna™	LittleFET™	PowerTrench®	TCM™	
FACT™	MICROCOUPLER™	QFET®	TinyBoost™	
FAST®	MicroFET™	QS™	TinyBuck™	
FASTr™	MicroPak™	QT Optoelectronics™	TinyPWM™	
FPS™	MICROWIRE™	Quiet Series™	TinyPower™	
FRFET™	MSX™	RapidConfigure™	TinyLogic®	
	MSXPro™	RapidConnect™	TINYOPTO™	
Across the board. Around the world.™		µSerDes™	TruTranslation™	
The Power Franchise®		ScalarPump™	UHC™	
Programmable Active Droop™				

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- A critical component is 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.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

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