

# Single-Channel: 6N138M, 6N139M Dual-Channel: HCPL2730M, HCPL2731M (Preliminary) 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, Vol. 2)
- VDE recognition (pending)
  - Ordering option V, e.g., 6N138VM
- Dual Channel – HCPL2730M, HCPL2731M (coming soon)

## 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 6N138M/9M and HCPL2730M/31M optocouplers consist of an AlGaAs LED optically coupled to a high gain split darlington photodetector.

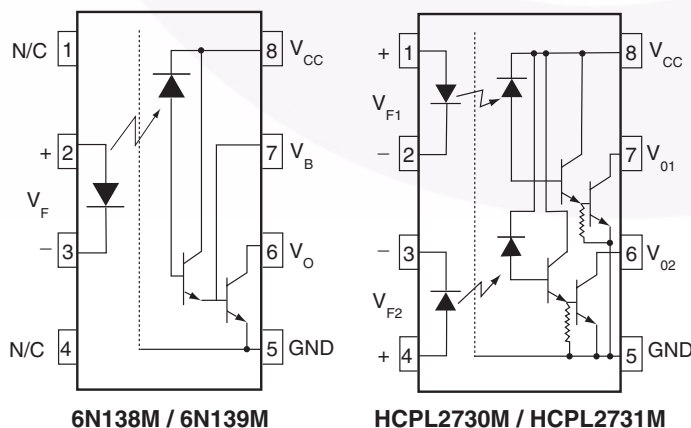
The split darlington configuration separating the input photodiode and the first stage gain from the output transistor permits lower output saturation voltage and higher speed operation than possible with conventional darlington phototransistor optocoupler. In the dual channel devices, HCPL2730M/HCPL2731M, 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.

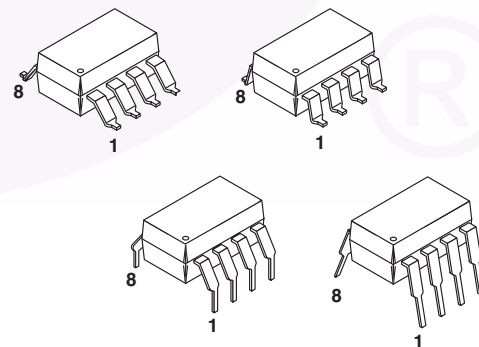
## Related Resources

- [www.fairchildsemi.com/products/opto/](http://www.fairchildsemi.com/products/opto/)
- [www.fairchildsemi.com/pf/HC/HCPL0700.html](http://www.fairchildsemi.com/pf/HC/HCPL0700.html)
- [www.fairchildsemi.com/pf/HC/HCPL0730.html](http://www.fairchildsemi.com/pf/HC/HCPL0730.html)
- [www.fairchildsemi.com/pf/HC/HCPL0731.html](http://www.fairchildsemi.com/pf/HC/HCPL0731.html)

## Schematic



## Package Outlines



**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		-40 to +125	$^\circ\text{C}$
$T_{OPR}$	Operating Temperature		-40 to +100	$^\circ\text{C}$
$T_{SOL}$	Lead Solder Temperature (Wave solder only. See recommended reflow profile graph on page 13 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 <sup>(1)</sup>	Each Channel	35	mW
<b>DETECTOR</b>				
$I_O$ (avg)	Average Output Current	Each Channel	60	mA
$V_{ER}$	Emitter-Base Reverse Voltage	6N138M and 6N139M	0.5	V
$V_{CC}, V_O$	Supply Voltage, Output Voltage	6N138M and HCPL2730M	-0.5 to 7	V
		6N139M and HCPL2731M	-0.5 to 18	
$P_O$	Output Power Dissipation <sup>(1)</sup>	Each Channel	100	mW

**Note:**

1. No derating required for devices operated within the  $T_{OPR}$  specification (6N138 and 6N139 only). HCPL2730 and HCPL2731 derating TBD.

## Electrical Characteristics

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

### 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	$T_A = 25^\circ\text{C}$ , $I_R = 10\mu\text{A}$	All	5.0	19		V
$\Delta V_F / \Delta T_A$	Temperature Coefficient of Forward Voltage	$I_F = 1.6\text{mA}$	All		-1.94		mV/ $^\circ\text{C}$
<b>DETECTOR</b>							
$I_{OH}$	Logic HIGH Output Current	$I_F = 0\text{mA}$ , $V_O = V_{CC} = 18\text{V}$	6N139M		0.0036	100	$\mu\text{A}$
		Each Channel	HCPL2731M				
		$I_F = 0\text{mA}$ , $V_O = V_{CC} = 7\text{V}$	6N138M		0.001	250	
		Each Channel	HCPL2730M				
$I_{CCL}$	Logic LOW supply	$I_F = 1.6\text{mA}$ , $V_O = \text{Open}$ , $V_{CC} = 18\text{V}$	6N138M, 6N139M		0.4	1.5	mA
		$I_{F1} = I_{F2} = 1.6\text{mA}$ , $V_{O1} = V_{O2} = \text{Open}$	$V_{CC} = 18\text{V}$ HCPL2731M			3	
			$V_{CC} = 7\text{V}$ HCPL2730M				
$I_{CCH}$	Logic HIGH Supply	$I_F = 0\text{mA}$ , $V_O = \text{Open}$ , $V_{CC} = 18\text{V}$	6N138M, 6N139M		0.0003	10	$\mu\text{A}$
		$I_{F1} = I_{F2} = 0\text{mA}$ , $V_{O1} = V_{O2} = \text{Open}$	$V_{CC} = 18\text{V}$ HCPL2731M			20	
			$V_{CC} = 7\text{V}$ HCPL2730M				

### Transfer Characteristics

Symbol	Parameter	Test Conditions	Device	Min.	Typ.	Max.	Unit
<b>COUPLED</b>							
CTR	Current Transfer Ratio <sup>(2)(3)</sup>	$I_F = 0.5\text{mA}$ , $V_O = 0.4\text{V}$ , $V_{CC} = 4.5\text{V}$	6N139M	400	2000		%
		Each Channel	HCPL2731M				
		$I_F = 1.6\text{mA}$ , $V_O = 0.4\text{V}$ , $V_{CC} = 4.5\text{V}$	6N139M	500	1600		
		Each Channel	HCPL2731M				
		$I_F = 1.6\text{mA}$ , $V_O = 0.4\text{V}$ , $V_{CC} = 4.5\text{V}$	6N138M	300	1600		
		Each Channel	HCPL2730M				
$V_{OL}$	Logic LOW Output Voltage <sup>(3)</sup>	$I_F = 0.5\text{mA}$ , $I_O = 2\text{mA}$ , $V_{CC} = 4.5\text{V}$	6N139M		0.05	0.4	V
		$I_F = 1.6\text{mA}$ , $I_O = 8\text{mA}$ , $V_{CC} = 4.5\text{V}$	6N139M		0.093	0.4	
		Each Channel	HCPL2731M				
		$I_F = 5\text{mA}$ , $I_O = 15\text{mA}$ , $V_{CC} = 4.5\text{V}$	6N139M		0.13	0.4	
		Each Channel	HCPL2731M				
		$I_F = 12\text{mA}$ , $I_O = 24\text{mA}$ , $V_{CC} = 4.5\text{V}$	6N139M		0.18	0.4	
		Each Channel	HCPL2731M				
		$I_F = 1.6\text{mA}$ , $I_O = 4.8\text{mA}$ , $V_{CC} = 4.5\text{V}$	6N138M		0.06	0.4	
Each Channel	HCPL2730M						

### Electrical Characteristics (Continued)

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

#### Switching Characteristics ( $V_{CC} = 5\text{V}$ )

Symbol	Parameter	Test Conditions	Device	Min.	Typ.	Max.	Unit			
$t_{PHL}$	Propagation Delay Time to Logic LOW <sup>(3)</sup> (Fig. 12)	$R_L = 4.7\text{k}\Omega$ , $I_F = 0.5\text{mA}$ $T_A = 25^\circ\text{C}$	6N139M		2.5	30	$\mu\text{s}$			
		$R_L = 4.7\text{k}\Omega$ , $I_F = 0.5\text{mA}$ Each Channel $T_A = 25^\circ\text{C}$	HCPL2731M			120				
		$R_L = 270\Omega$ , $I_F = 12\text{mA}$ $T_A = 25^\circ\text{C}$	6N139M		0.24	2				
		$R_L = 270\Omega$ , $I_F = 12\text{mA}$ , Each Channel $T_A = 25^\circ\text{C}$	HCPL2730M HCPL2731M			3 2				
		$R_L = 2.2\text{k}\Omega$ , $I_F = 1.6\text{mA}$ $T_A = 25^\circ\text{C}$	6N138M		1	15 10				
		$R_L = 2.2\text{k}\Omega$ , $I_F = 1.6\text{mA}$ , Each Channel $T_A = 25^\circ\text{C}$	HCPL2731M HCPL2730M			25 20				
		$t_{PLH}$	Propagation Delay Time to Logic HIGH <sup>(3)</sup> (Fig. 12)	$R_L = 4.7\text{k}\Omega$ , $I_F = 0.5\text{mA}$ Each Channel $T_A = 25^\circ\text{C}$	6N139M HCPL2731M				90	$\mu\text{s}$
				$R_L = 4.7\text{k}\Omega$ , $I_F = 0.5\text{mA}$ , $T_A = 25^\circ\text{C}$ Each Channel	6N139M HCPL2731M			13.6	60	
$R_L = 270\Omega$ , $I_F = 12\text{mA}$ $T_A = 25^\circ\text{C}$	6N139M				1.3	10 7				
$R_L = 270\Omega$ , $I_F = 12\text{mA}$ , Each Channel $T_A = 25^\circ\text{C}$	HCPL2730M HCPL2731M					15 10				
$R_L = 2.2\text{k}\Omega$ , $I_F = 1.6\text{mA}$ Each Channel	6N138M HCPL2730M HCPL2731M					50				
$R_L = 2.2\text{k}\Omega$ , $I_F = 1.6\text{mA}$ , $T_A = 25^\circ\text{C}$ Each Channel	6N138M HCPL2730M HCPL2731M				7.3	35				
$ICM_{HI}$	Common Mode Transient Immunity at Logic HIGH <sup>(4)</sup> (Fig. 13)			$I_F = 0\text{mA}$ , $ V_{CM}  = 10V_{P-P}$ , $T_A = 25^\circ\text{C}$ , $R_L = 2.2\text{k}\Omega$	6N138M 6N139M	1,000	10,000		$V/\mu\text{s}$	
				Each Channel	HCPL2730M HCPL2731M					
$ICM_{LI}$	Common Mode Transient Immunity at Logic LOW <sup>(4)</sup> (Fig. 13)	$(I_F = 1.6\text{mA},  V_{CM}  = 10V_{P-P}, R_L = 2.2\text{k}\Omega)$ $T_A = 25^\circ\text{C}$	6N138M 6N139M	1,000	10,000		$V/\mu\text{s}$			
		Each Channel	HCPL2730M HCPL2731M							

**Electrical Characteristics** (Continued)(T<sub>A</sub> = 0 to 70°C unless otherwise specified. Typical value is measured at T<sub>A</sub> = 25°C and V<sub>CC</sub> = 5.0V.)**Isolation Characteristics**

Symbol	Characteristics	Test Conditions	Min.	Typ.	Max.	Unit
V <sub>ISO</sub>	Withstand Insulation Test Voltage <sup>(5)</sup>	RH ≤ 50%, T <sub>A</sub> = 25°C, I <sub>I-O</sub> ≤ 10μA, 50Hz, t = 1 min.	5000			V <sub>RMS</sub>
R <sub>I-O</sub>	Resistance (Input to Output) <sup>(5)</sup>	V <sub>I-O</sub> = 500VDC		10 <sup>11</sup>		Ω
C <sub>I-O</sub>	Capacitance (Input to Output) <sup>(5)(6)</sup>	f = 1MHz, V <sub>I-O</sub> = 500V		1		pF
I <sub>I-I</sub>	Input-Input Insulation Leakage Current <sup>(7)</sup>	RH ≤ 45%, V <sub>I-I</sub> = 500VDC, t = 5s, HCPL2730M/2731M only		0.005		μA
R <sub>I-I</sub>	Input-Input Resistance <sup>(7)</sup>	V <sub>I-I</sub> = 500VDC, HCPL2730M/2731M only		10 <sup>11</sup>		Ω
C <sub>I-I</sub>	Input-Input Capacitance <sup>(7)</sup>	f = 1MHz, HCPL2730M/2731M only		0.03		pF

**Notes:**

- Current Transfer Ratio is defined as a ratio of output collector current, I<sub>O</sub>, to the forward LED input current, I<sub>F</sub>, times 100%.
- Pin 7 open. (6N138M and 6N139M only)
- Common mode transient immunity in logic HIGH level is the maximum tolerable (positive) dV<sub>cm</sub>/dt on the leading edge of the common mode pulse signal V<sub>CM</sub>, to assure that the output will remain in a logic HIGH state (i.e., V<sub>O</sub> > 2.0V). Common mode transient immunity in logic LOW level is the maximum tolerable (negative) dV<sub>cm</sub>/dt on the trailing edge of the common mode pulse signal, V<sub>CM</sub>, to assure that the output will remain in a logic LOW state (i.e., V<sub>O</sub> < 0.8V).
- 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<sub>I-O</sub> 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)  $T_A = 25^\circ\text{C}$  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

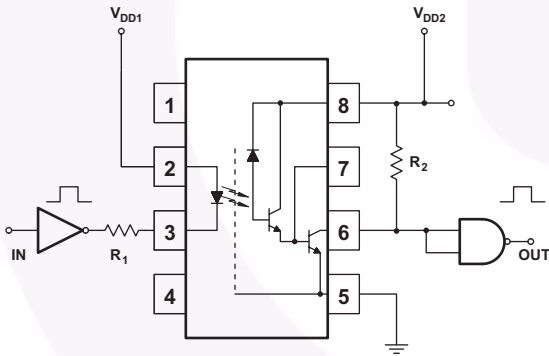
$V_{OLX}$  = Saturation Voltage of Output Transistor

$I_L$  = Load Current Through Resistor R2

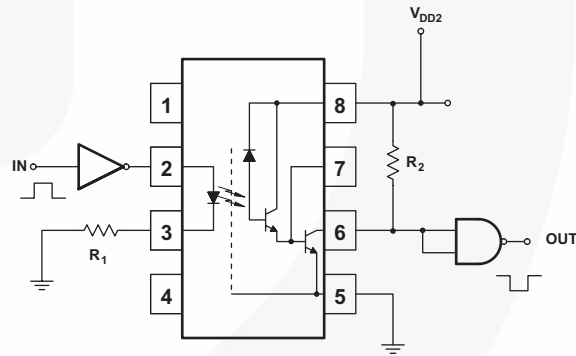
$I_2$  = Input Current of Output Gate

INPUT		R1 (V)	OUTPUT						
			CMOS @ 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**



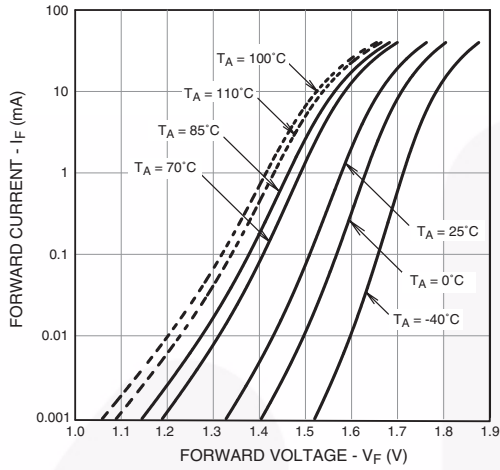
**Fig. 2 Non-Inverting Logic Interface**



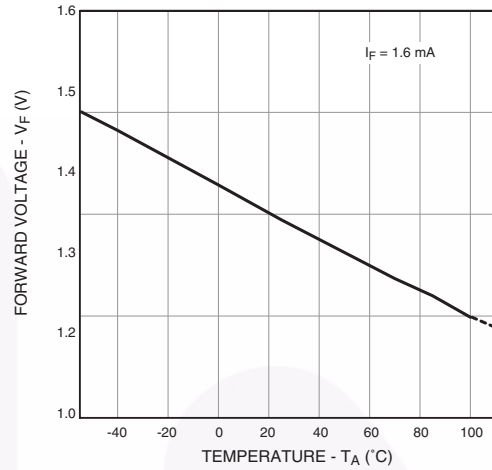
**Fig. 3 Inverting Logic Interface**

## Typical Performance Curves

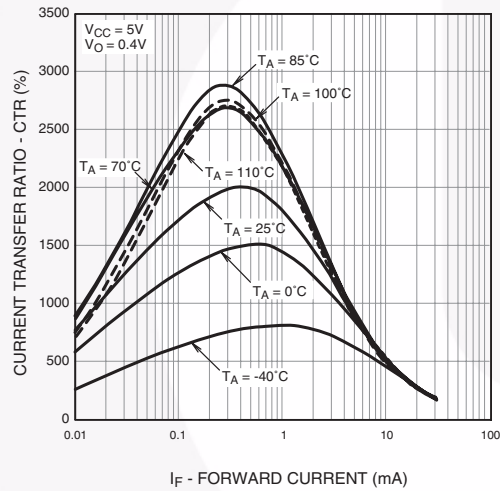
**Fig. 4 LED Forward Current vs. Forward Voltage**



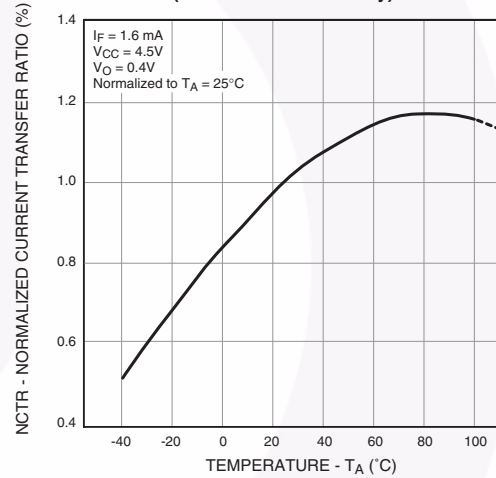
**Fig. 5 LED Forward Voltage vs. Temperature**



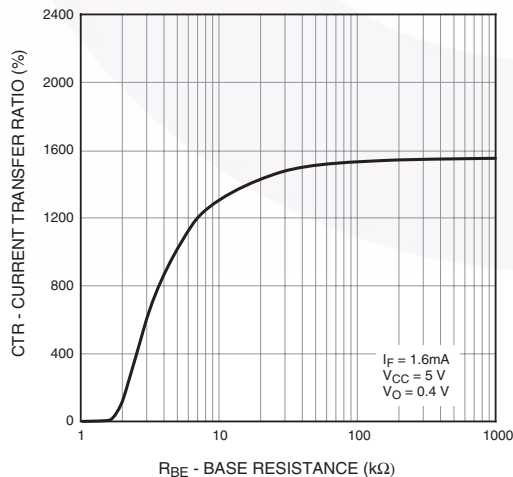
**Fig. 6 Current Transfer Ratio vs. Forward Current (6N138M / 6N139M Only)**



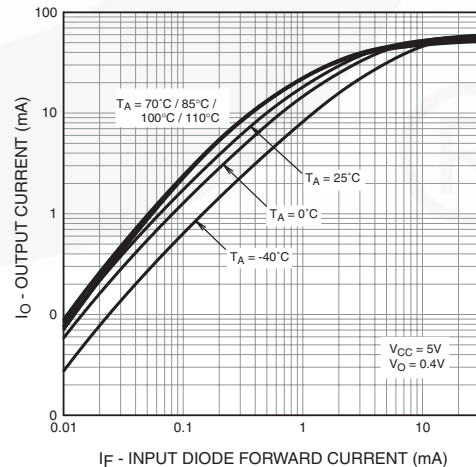
**Fig. 7 Normalized Current Transfer Ratio vs. Ambient Temperature (6N138M / 6N139M Only)**



**Fig. 8 Current Transfer Ratio vs. Base-Emitter Resistance (6N138M / 6N139M Only)**



**Fig. 9 Output Current vs. Input Diode Forward Current (6N138M / 6N139M Only)**



Typical Performance Curves (Continued)

Fig. 10 Output Current vs Output Voltage (6N138M / 6N139M Only)

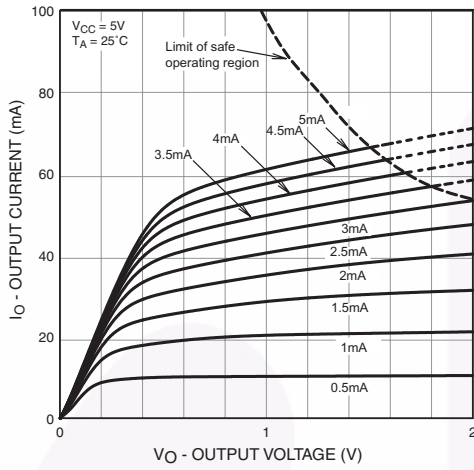


Fig. 11 Logic Low Supply Current vs. Input Diode Forward Current (6N138M / 6N139M Only)

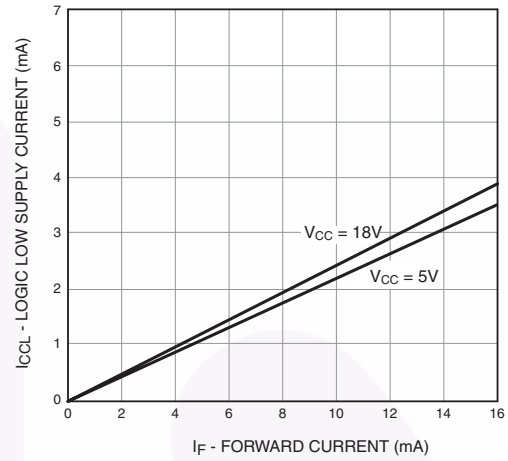
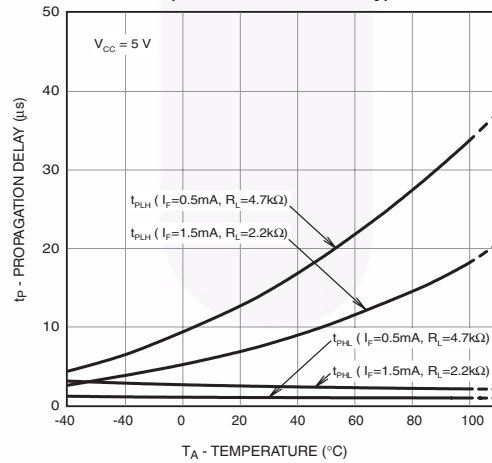
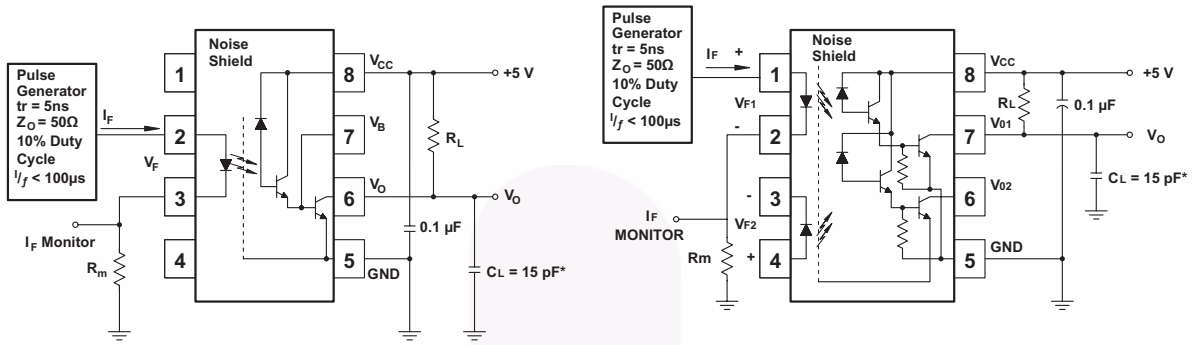


Fig. 12 Propagation Delay vs. Temperature (6N138M / 6N139M Only)





### Test Circuits



Test Circuit for 6N138M, 6N139M

Test Circuit for HCPL2730M and HCPL2731M

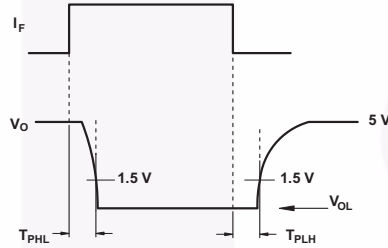
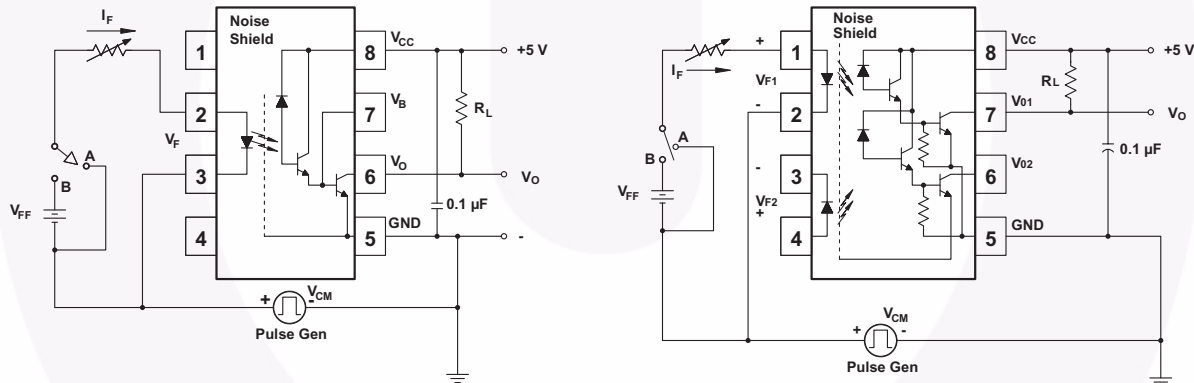


Fig. 13 Switching Time Test Circuit



Test Circuit for 6N138M and 6N139M

Test Circuit for HCPL2730M and HCPL2731M

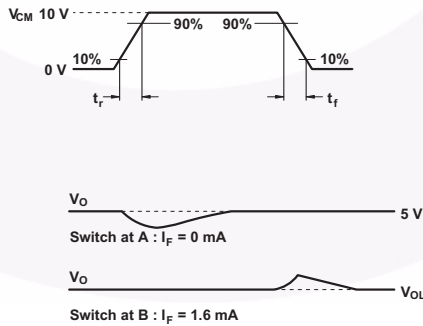
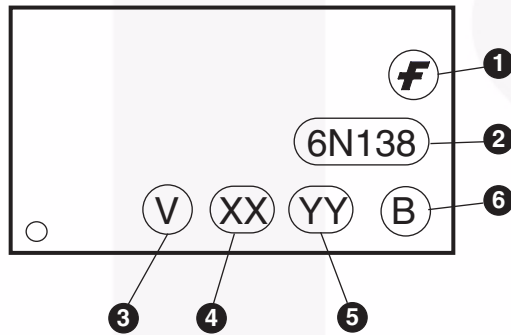


Fig. 14 Common Mode Immunity Test Circuit

### Ordering Information

Option	Example Part Number	Description
No Suffix	6N138M	Standard Through Hole Device, 50 pcs per tube
S	6N138SM	Surface Mount Lead Bend
SD	6N138SDM	Surface Mount; Tape and reel
V	6N138VM	IEC60747-5-2 approval pending (VDE)
TV	6N138TVM	IEC60747-5-2 approval pending (VDE); 0.4" lead spacing
SV	6N138SVM	IEC60747-5-2 approval pending (VDE); surface mount
SDV	6N138SDVM	IEC60747-5-2 approval pending (VDE); surface mount; tape and reel

### Marking Information



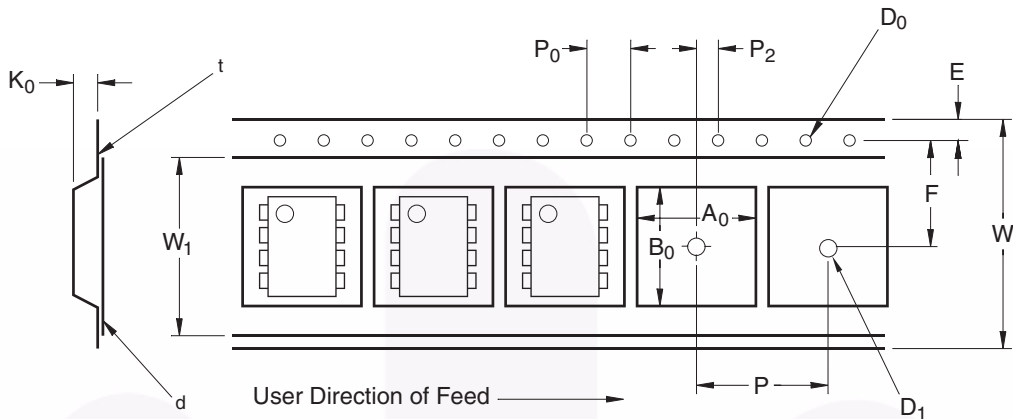
Definitions	
1	Fairchild logo
2	Device number
3	VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table) (pending approval)
4	Two digit year code, e.g., '07'
5	Two digit work week ranging from '01' to '53'
6	Assembly package code

**Note:**

'HCPL' devices are marked only with the numerical characters (for example, HCPL2730 is marked as '2730').

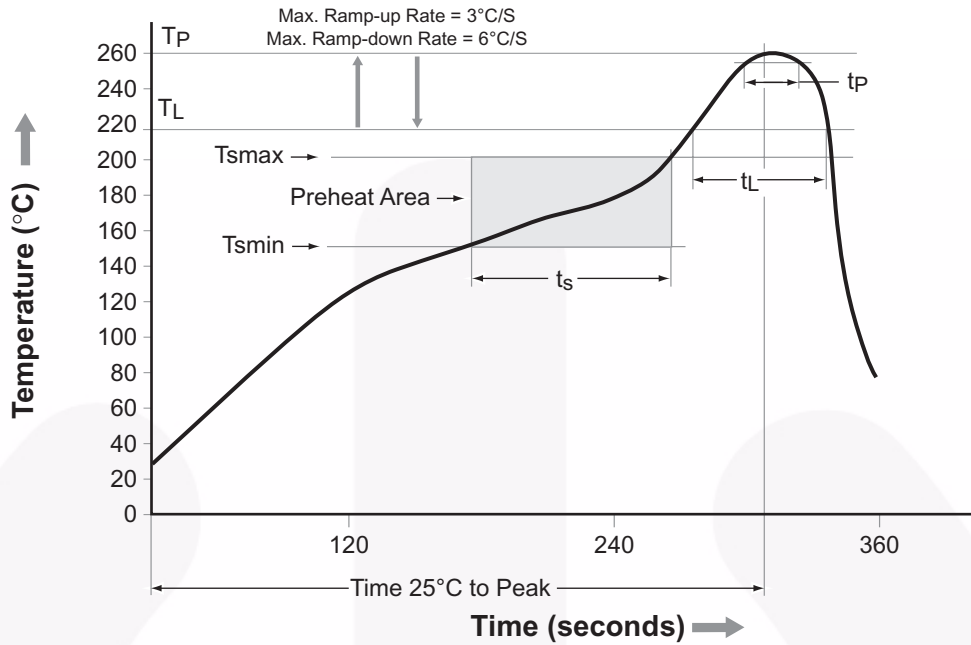
The 'M' suffix on the part number is an order identifier only. It is used to identify orders for the white package version. The 'M' does not appear on the device's top mark.

### Carrier Tape Specifications (Option SD)

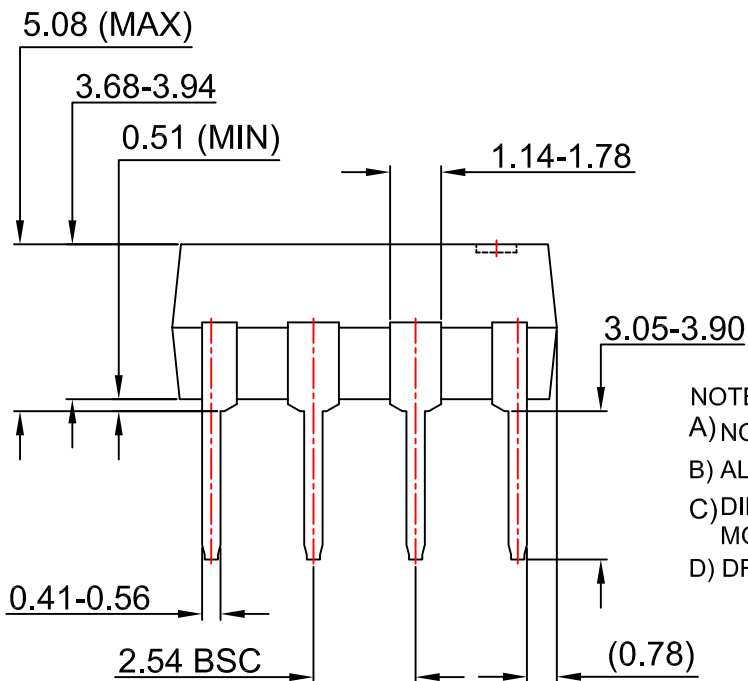
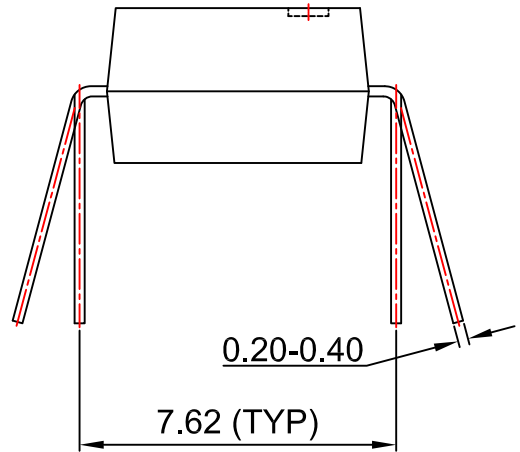
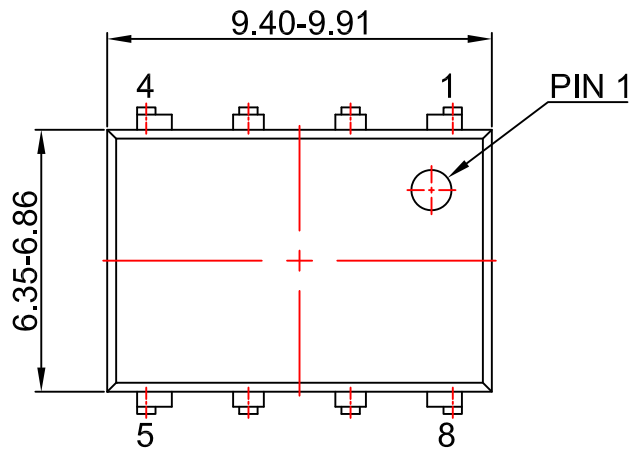


Symbol	Description	Dimension in mm
W	Tape Width	16.0 ± 0.3
t	Tape Thickness	0.30 ± 0.05
P <sub>0</sub>	Sprocket Hole Pitch	4.0 ± 0.1
D <sub>0</sub>	Sprocket Hole Diameter	1.55 ± 0.05
E	Sprocket Hole Location	1.75 ± 0.10
F	Pocket Location	7.5 ± 0.1
P <sub>2</sub>		2.0 ± 0.1
P	Pocket Pitch	12.0 ± 0.1
A <sub>0</sub>	Pocket Dimensions	10.30 ± 0.20
B <sub>0</sub>		10.30 ± 0.20
K <sub>0</sub>		4.90 ± 0.20
W <sub>1</sub>	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

## Reflow Profile

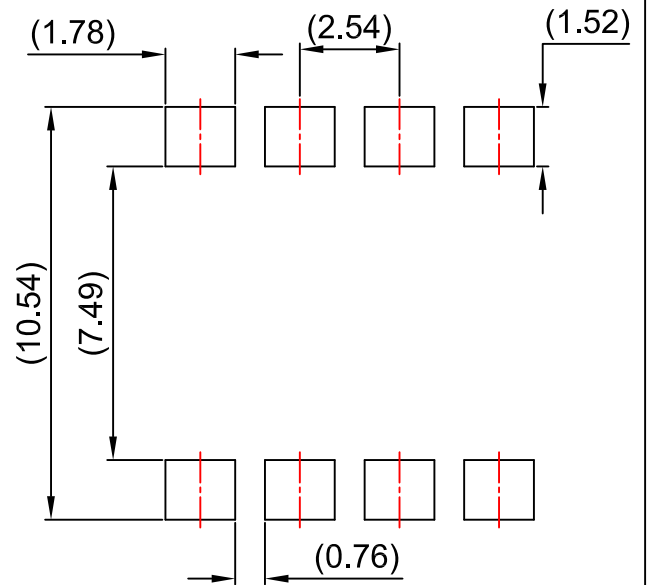
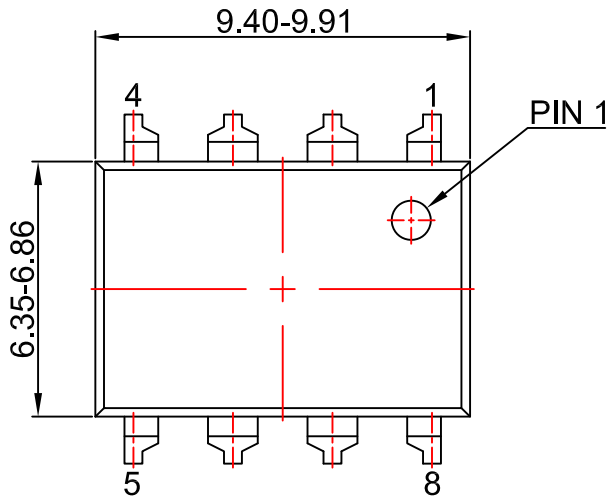


Profile Feature	Pb-Free Assembly Profile
Temperature Min. (T <sub>smin</sub> )	150°C
Temperature Max. (T <sub>smax</sub> )	200°C
Time (t <sub>s</sub> ) from (T <sub>smin</sub> to T <sub>smax</sub> )	60–120 seconds
Ramp-up Rate (t <sub>L</sub> to t <sub>p</sub> )	3°C/second max.
Liquidous Temperature (T <sub>L</sub> )	217°C
Time (t <sub>L</sub> ) Maintained Above (T <sub>L</sub> )	60–150 seconds
Peak Body Package Temperature	260°C +0°C / -5°C
Time (t <sub>p</sub> ) within 5°C of 260°C	30 seconds
Ramp-down Rate (T <sub>P</sub> to T <sub>L</sub> )	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

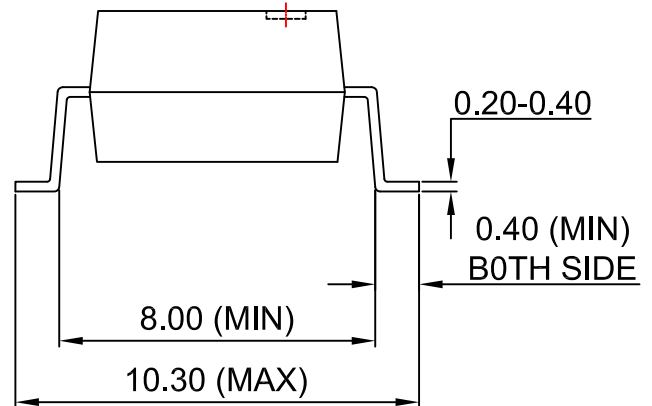
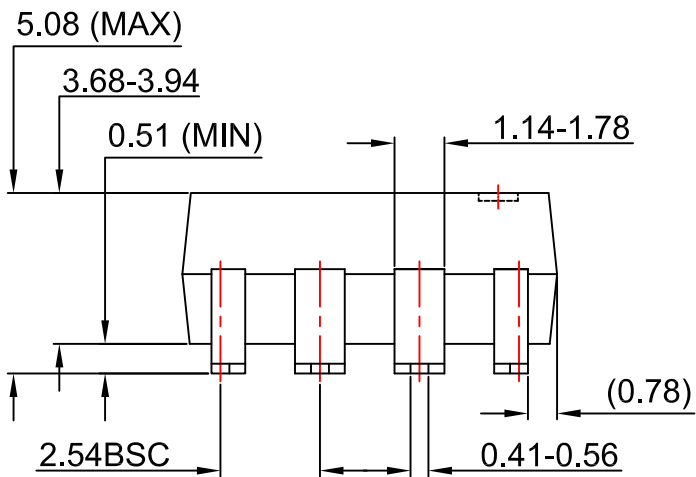


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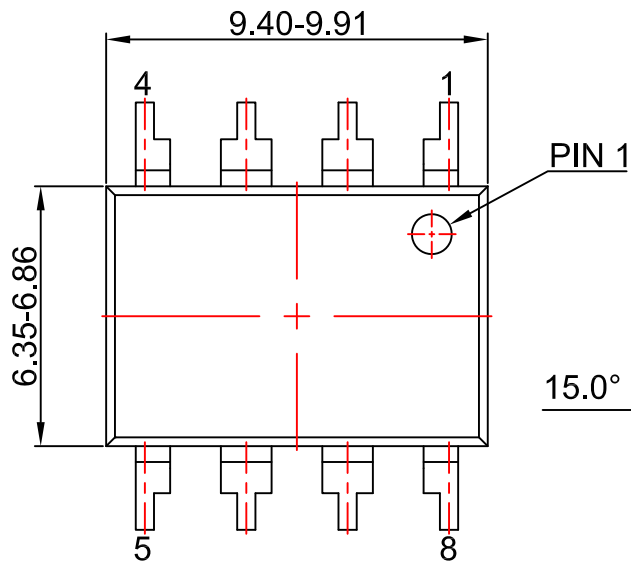
LAND PATTERN RECOMMENDATION



NOTES:

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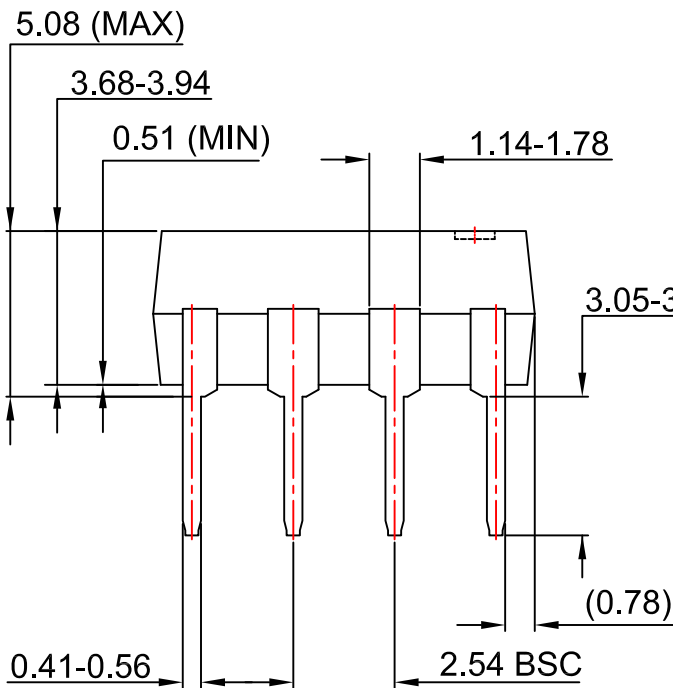


PIN 1

15.0° (MAX)

10.16 (TYP)

0.20-0.40



NOTES:






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