

# ACPL-M60L

Small Outline, 5 Leads, High CMR, High Speed,  
Logic Gate Optocouplers



## Data Sheet



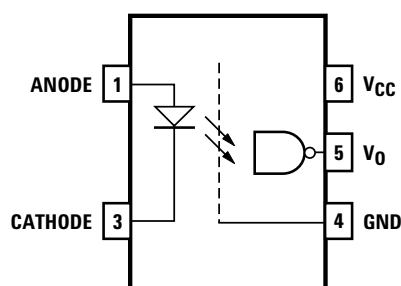
### Description

The ACPL-M60L is an optically coupled gate that combines a GaAsP light emitting diode and an integrated high gain photo detector. The output of the detector IC is an open collector Schottky-clamped transistor. The internal shield provides a guaranteed common mode transient immunity specification of 15 kV/ $\mu$ s at 3.3V operation.

This unique design provides maximum AC and DC circuit isolation while achieving LVTTTL/LVCMOS compatibility. The optocoupler AC and DC operational parameters are guaranteed from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , allowing trouble-free system performance.

These optocouplers are suitable for high speed logic interfacing, input/output buffering, as line receivers in environments that conventional line receivers cannot tolerate and are recommended for use in extremely high ground or induced noise environments.

### Functional Diagram



### Features

- Dual Voltage Operation (3.3V/5V)
- Low power consumption
- 15 kV/ $\mu$ s minimum Common Mode Rejection (CMR) at  $V_{CM} = 1000\text{ V}$  (3.3V operating voltage)
- High speed: 15 MBd typical
- LVTTTL/LVCMOS compatible
- Low input current capability: 5 mA
- Guaranteed AC and DC performance over temperature:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- Safety approvals; UL, CSA, IEC/EN/DIN EN 60747-5-2
- Surface mountable
- Very small, low profile JEDEC Registered package outline

### Applications

- Isolated line receiver
- Computer-peripheral interfaces
- Microprocessor system interfaces
- Digital isolation for A/D, D/A conversion
- Switching power supply
- Instrument input/output isolation
- Ground loop elimination
- Pulse transformer replacement
- Field buses

**CAUTION:** It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

## Ordering Information

ACPL-xxxx is UL Recognized with 3750 Vrms for 1 minute per UL1577 and is approved under CSA Component Acceptance Notice #5, File CA 88324.

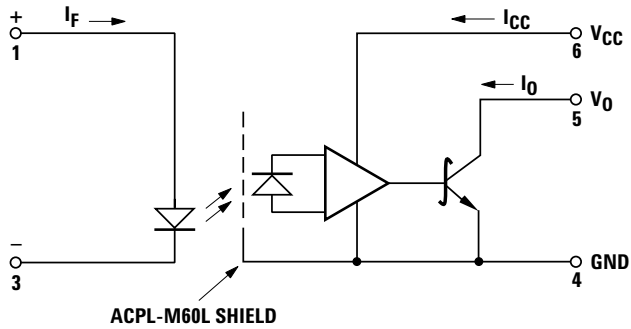
Part Number	Option		Surface Mount	Tape & Reel	IEC/EN/DIN EN 60747-5-2	Quantity
	RoHS Compliant	Package				
ACPL-M60L	-000E	SO-5	X			100 per tube
	-500E		X	X		1500 per reel

To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry. Combination of Option 020 and Option 060 is not available.

Example 1:

ACPL-M60L-500E to order product of Surface Mount SO-5 in Tape and Reel packaging with RoHS compliant. Option datasheets are available. Contact your Avago sales representative or authorized distributor for information.

## Schematic

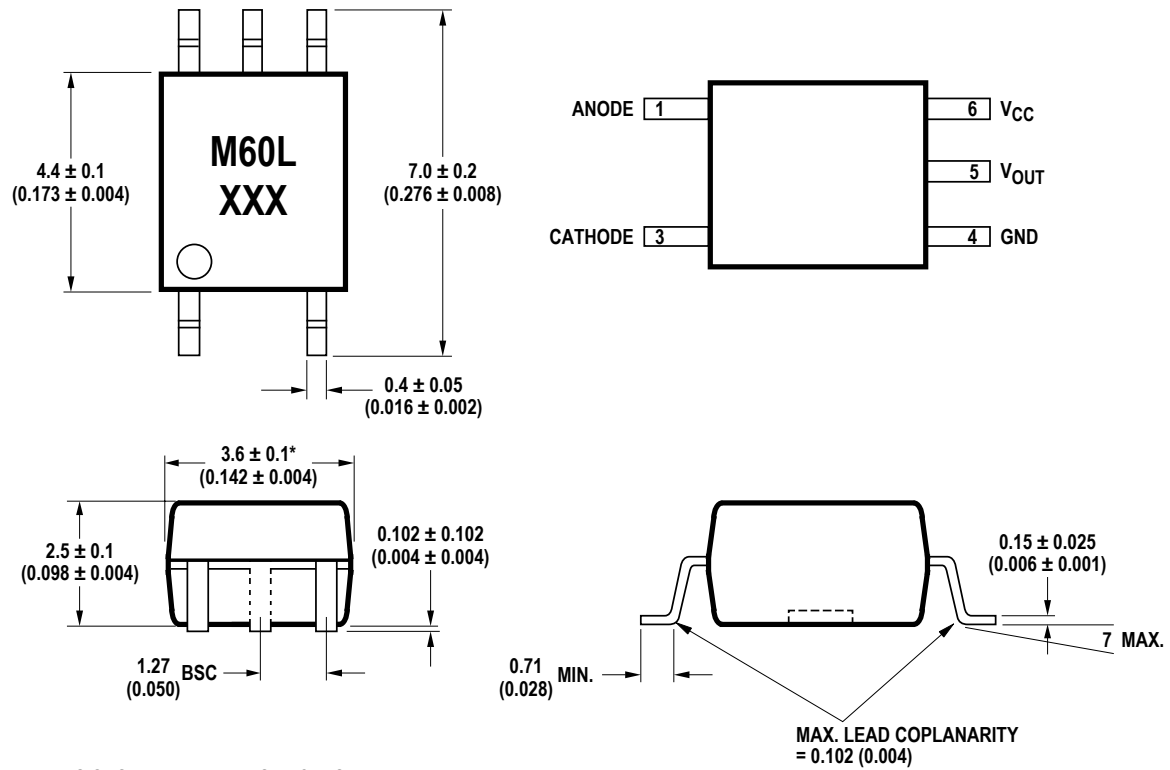


USE OF A 0.1  $\mu$ F BYPASS CAPACITOR  
MUST BE CONNECTED BETWEEN PINS  
6 AND 4 (SEE NOTE 1).

TRUTH TABLE  
(POSITIVE LOGIC)

LED	OUTPUT
ON	L
OFF	H

## Package Outline Drawing

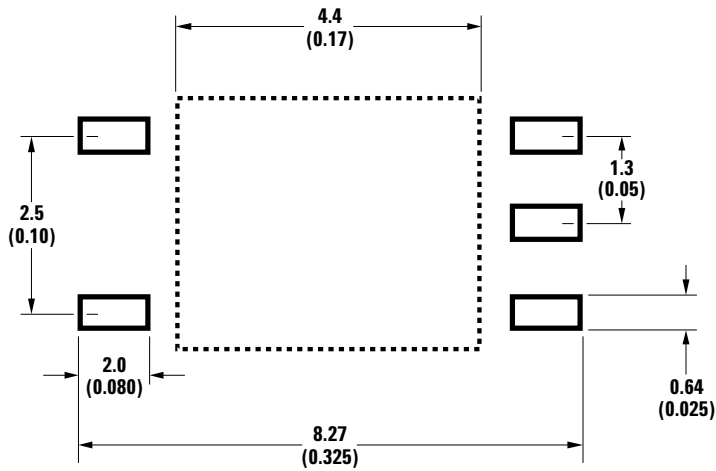


DIMENSIONS IN MILLIMETERS (INCHES)

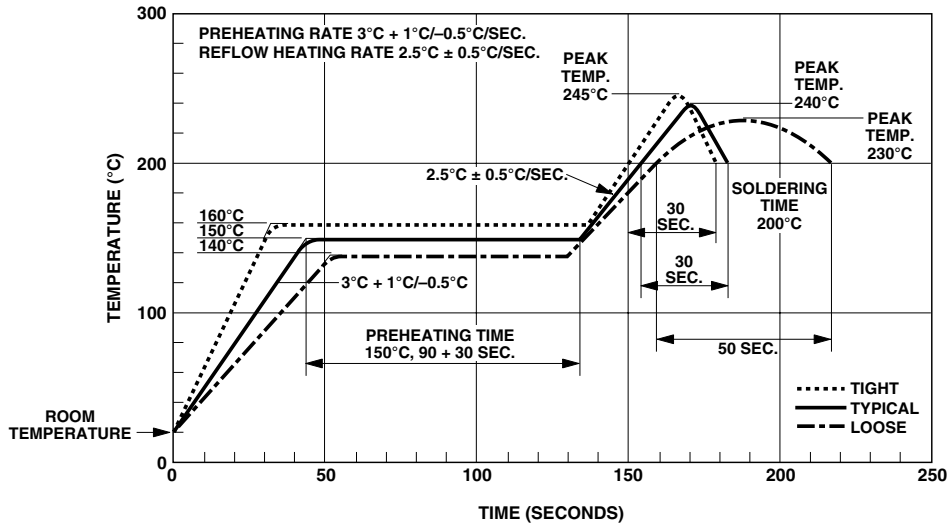
\* MAXIMUM MOLD FLASH ON EACH SIDE IS 0.15 mm (0.006)

NOTE: FLOATING LEAD PROTRUSION IS 0.15 mm (6 mils) MAX.

## Land Pattern

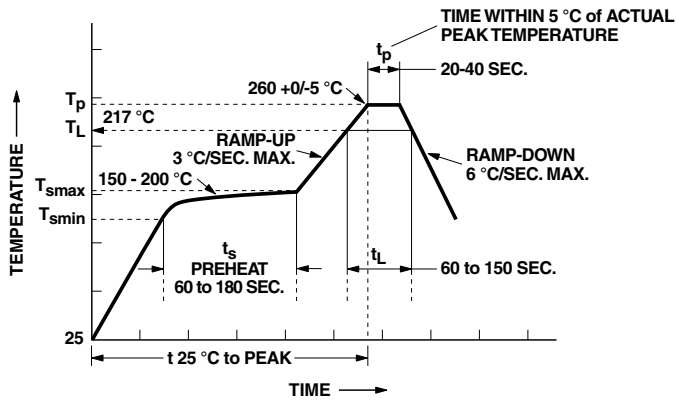


## Solder Reflow Temperature Profile



Note: Non-halide flux should be used

## Recommended PB-Free IR Profile



NOTES:  
 THE TIME FROM  $25^{\circ}\text{C}$  to PEAK TEMPERATURE = 8 MINUTES MAX.  
 $T_{smax} = 200^{\circ}\text{C}$ ,  $T_{smin} = 150^{\circ}\text{C}$

Note: Non-halide flux should be used

## Insulation and Safety Related Specifications

Parameter	Symbol	Value	Units	Conditions
Minimum External Air Gap (Clearance)	L (I01)	≥ 5	mm	Measured from input terminals to output terminals
Minimum External Tracking Path (Creepage)	L (I02)	≥ 5	mm	Measured from input terminals to output terminals
Minimum Internal Plastic Gap (Clearance)		0.08	mm	Through insulation distance, conductor to conductor
Tracking Resistance	CTI	175	V	DIN IEC 112/VDE 0303 Part 1
Isolation Group (per DIN VDE 0109)		IIIa		Material Group DIN VDE 0109

## Absolute Maximum Ratings (No Derating Required up to 85°C)

Parameter	Symbol	Min.	Max.	Units	Note
Storage Temperature	T <sub>S</sub>	-55	125	°C	
Operating Temperature†	T <sub>A</sub>	-40	85	°C	
Average Forward Input Current	I <sub>F</sub>		20	mA	1
Reverse Input Voltage	V <sub>R</sub>		5	V	
Input Power Dissipation	P <sub>I</sub>		40	mW	
Supply Voltage (1 minute maximum)	V <sub>CC</sub>		7	V	
Output Collector Current	I <sub>O</sub>		50	mA	
Output Collector Voltage	V <sub>O</sub>		7	V	
Output Collector Power Dissipation	P <sub>O</sub>		85	mW	
Solder Reflow Temperature Profile					See Package Outline Drawings section

## Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Input Current, Low Level	I <sub>FL</sub> *	0	250	μA
Input Current, High Level <sup>[1]</sup>	I <sub>FH</sub> **	5	15	mA
Power Supply Voltage	V <sub>CC</sub>	2.7	3.6	V
		4.5	5.5	V
Operating Temperature	T <sub>A</sub>	-40	85	°C
Fan Out (at R <sub>L</sub> = 1 kΩ) <sup>[1]</sup>	N		5	TTL Loads
Output Pull-up Resistor	R <sub>L</sub>	330	4 k	Ω

\*The off condition can also be guaranteed by ensuring that V<sub>FL</sub> ≤ 0.8 volts.

\*\*The initial switching threshold is 5 mA or less. It is recommended that 6.3 mA to 10 mA be used for best performance and to permit at least a 20% LED degradation guardband.

## Electrical Specifications

Over recommended Operating Condition ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $2.7\text{V} \leq V_{DD} \leq 3.6\text{V}$ ) unless otherwise specified.  
All Typical at  $V_{CC} = 3.3\text{V}$ ,  $T_A = 25^{\circ}\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	$I_{OH}^*$		4.5	50	$\mu\text{A}$	$V_{CC} = 3.3\text{V}$ , $V_O = 3.3\text{V}$ $I_F = 250\ \mu\text{A}$	1	
Input Threshold Current	$I_{TH}$		3.0	5.0	$\text{mA}$	$V_{CC} = 3.3\text{V}$ , $V_O = 0.6\text{V}$ , $I_{OL}$ (Sinking) = 13 $\text{mA}$		
Low Level Output Voltage	$V_{OL}^*$		0.35	0.6	$\text{V}$	$V_{CC} = 3.3\text{V}$ , $I_F = 5\ \text{mA}$ $I_{OL}$ (Sinking) = 13 $\text{mA}$	2	
High Level Supply Current	$I_{CCH}$		4.7	7.0	$\text{mA}$	$I_F = 0\ \text{mA}$ , $V_{CC} = 3.3\text{V}$		
Low Level Supply Current	$I_{CCL}$		7.0	10.0	$\text{mA}$	$I_F = 10\ \text{mA}$ , $V_{CC} = 3.3\text{V}$		
Input Forward Voltage	$V_F$	1.4	1.5	1.75*	$\text{V}$	$T_A = 25^{\circ}\text{C}$ , $I_F = 10\ \text{mA}$	5	
Input Reverse Breakdown Voltage	$BV_R^*$	5			$\text{V}$	$I_R = 10\ \mu\text{A}$		
Input Diode Temperature Coefficient	$\Delta V_F / \Delta T_A$		-1.6		$\text{mV}/^{\circ}\text{C}$	$I_F = 10\ \text{mA}$		
Input-Output Insulation	$V_{ISO}$	3750			$V_{RMS}$	$R_H \leq 50\%$ , $t = 1\ \text{min.}$		12, 13
Input Capacitance	$C_{IN}$		60		$\text{pF}$	$f = 1\ \text{MHz}$ , $V_F = 0\text{V}$		

\*The JEDEC Registration specifies  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . Avago specifies  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

## Electrical Specifications

Over recommended temperature ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $4.5\text{V} \leq V_{DD} \leq 5.5\text{V}$ ) unless otherwise specified.  
All Typical specification at  $V_{CC} = 5\text{V}$ ,  $T_A = 25^{\circ}\text{C}$

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	$I_{OH}$		5.5	100	$\mu\text{A}$	$V_{CC} = 5.5\text{V}$ , $V_O = 5.5\text{V}$ $I_F = 250\ \mu\text{A}$	1	
Input Threshold Current	$I_{TH}$		2	5	$\text{mA}$	$V_{CC} = 5.5\text{V}$ , $I_O \geq 13\ \text{mA}$ , $V_O = 0.6\text{V}$		
Low Level Output Voltage	$V_{OL}$		0.4	0.6	$\text{V}$	$V_{CC} = 5.5\text{V}$ , $I_F = 5\ \text{mA}$ , $I_{OL}$ (Sinking) = 13 $\text{mA}$	2	
High Level Supply Current	$I_{CCH}$		4	7.5	$\text{mA}$	$V_{CC} = 5.5\text{V}$ , $I_F = 0\ \text{mA}$ ,		
Low Level Supply Current	$I_{CCL}$		6	10.5		$V_{CC} = 5.5\text{V}$ , $I_F = 10\ \text{mA}$ ,		
Input Forward Voltage	$V_F$	1.4 1.3	1.5	1.75 1.85	$\text{V}$	$T_A = 25^{\circ}\text{C}$ , $I_F = 10\ \text{mA}$ $I_F = 10\ \text{mA}$	5	
Input Reverse Breakdown Voltage	$BV_R$	5				$I_R = 10\ \mu\text{A}$		
Input Diode Temperature Coefficient	$\Delta V_F / \Delta T_A$		-1.6		$\text{mV}/^{\circ}\text{C}$	$I_F = 10\ \text{mA}$		
Input-Output Insulation	$V_{ISO}$	3750			$V_{RMS}$	$R_H \leq 50\%$ , $t = 1\ \text{min.}$		12, 13
Input Capacitance	$C_{IN}$		60		$\text{pF}$	$V_F = 0\text{V}$ , $f = 1\ \text{MHz}$		

\*All typicals at  $T_A = 25^{\circ}\text{C}$ ,  $V_{CC} = 5\text{V}$ .

## Switching Specifications

Over recommended temperature ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ),  $V_{CC} = 3.3\text{ V}$ ,  $I_F = 7.5\text{ mA}$  unless otherwise specified.  
All Typical at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{ V}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to High Output Level	$t_{PLH}$			90	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$	6, 7, 8	5
Propagation Delay Time to Low Output Level	$t_{PHL}$			75	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$	6, 7, 8	6
Pulse Width Distortion	$ t_{PHL} - t_{PLH} $			25	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$	9	8
Propagation Delay Skew	$t_{PSK}$			40	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		
Output Rise Time (10-90%)	$t_r$		45		ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		
Output Fall Time (90-10%)	$t_f$		20		ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		

\*JEDEC registered data for the 6N137.

## Switching Specifications

Over recommended temperature ( $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ),  $V_{CC} = 5\text{ V}$ ,  $I_F = 7.5\text{ mA}$  unless otherwise specified.  
All Typical at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ .

Parameter	Symbol	Min.	Typ.*	Max.	Unit	Test Conditions	Fig.	Note
Propagation Delay Time to High Output Level	$t_{PLH}$	20	48	75 100	ns	$T_A = 25^\circ\text{C}$ , $R_L = 350\ \Omega$ $C_L = 15\text{ pF}$ $R_L = 350\ \Omega$ , $C_L = 15\text{ pF}$	6, 7, 8	5
Propagation Delay Time to Low Output Level	$t_{PHL}$	25	50	75 100	ns	$T_A = 25^\circ\text{C}$ , $R_L = 350\ \Omega$ $C_L = 15\text{ pF}$ $R_L = 350\ \Omega$ , $C_L = 15\text{ pF}$	6, 7, 8	6
Pulse Width Distortion	$ t_{PHL} - t_{PLH} $		3.5	35	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$	9	8
Propagation Delay Skew	$t_{PSK}$			40	ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		
Output Rise Time (10%-90%)	$t_{rise}$		24		ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		
Output Fall Time (10%-90%)	$t_{fall}$		10		ns	$R_L = 350\ \Omega$ $C_L = 15\text{ pF}$		

\*All typicals at  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ .

Parameter	Sym.	Device	Min.	Typ.	Units	Test Conditions	Fig.	Note	
Logic High Common Mode Transient Immunity	CM <sub>H</sub>	ACPL-M60L	15,000	25,000	V/μs	V <sub>CM</sub>   = 1000 V	V <sub>CC</sub> = 3.3 V, I <sub>F</sub> = 0 mA, V <sub>O(MIN)</sub> = 2 V, R <sub>L</sub> = 350 Ω, T <sub>A</sub> = 25°C	9	9, 11
			10,000	15,000				9	9, 11
Logic Low Common Mode Transient Immunity	CM <sub>L</sub>	ACPL-M60L	15,000	25,000	V/μs	V <sub>CM</sub>   = 1000 V	V <sub>CC</sub> = 3.3 V, I <sub>F</sub> = 7.5 mA, V <sub>O(MAX)</sub> = 0.8 V, R <sub>L</sub> = 350 Ω, T <sub>A</sub> = 25°C	9	10, 11
			10,000	15,000				9	10, 11

Notes:

1. Peaking circuits may produce transient input currents up to 50 mA, 50 ns maximum pulse width, provided average current does not exceed 20 mA.
2. Peaking circuits may produce transient input currents up to 50 mA, 50 ns maximum pulse width, provided average current does not exceed 15 mA.
3. Derate linearly above +80°C free-air temperature at a rate of 2.7 mW/°C for the SOIC-5 package.
4. Bypassing of the power supply line is required, with a 0.1 μF ceramic disc capacitor adjacent to each optocoupler as illustrated in Figure 11. Total lead length between both ends of the capacitor and the isolator pins should not exceed 20 mm.
5. The t<sub>PLH</sub> propagation delay is measured from the 3.75 mA point on the falling edge of the input pulse to the 1.5 V point on the rising edge of the output pulse.
6. The t<sub>PHL</sub> propagation delay is measured from the 3.75 mA point on the rising edge of the input pulse to the 1.5 V point on the falling edge of the output pulse.
7. t<sub>PSK</sub> is equal to the worst case difference in t<sub>PHL</sub> and/or t<sub>PLH</sub> that will be seen between units at any given temperature and specified test conditions.
8. See test circuit for measurement details.
9. CM<sub>H</sub> is the maximum tolerable rate of rise on the common mode voltage to assure that the output will remain in a high logic state (i.e., V<sub>O</sub> > 2.0 V).
10. CM<sub>L</sub> is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., V<sub>O</sub> < 0.8 V).
11. For sinusoidal voltages, (|dV<sub>CM</sub> / dt)<sub>max</sub> = πf<sub>CM</sub>V<sub>CM</sub> (p-p).
12. Device considered a two terminal device: pins 1 and 3 shorted together, and pins 4, 5 and 6 shorted together.
13. In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage ≥ 4500 V<sub>RMS</sub> for 1 second (Leakage detection current limit, I<sub>L-O</sub> ≤ 5 μA).

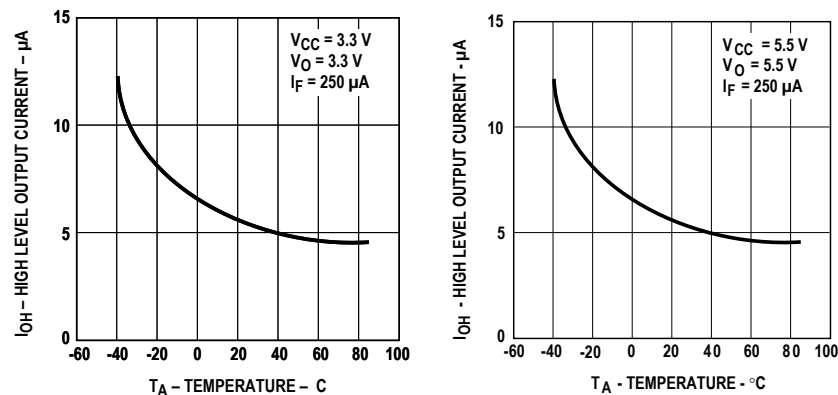


Figure 1. Typical high level output current vs. temperature.



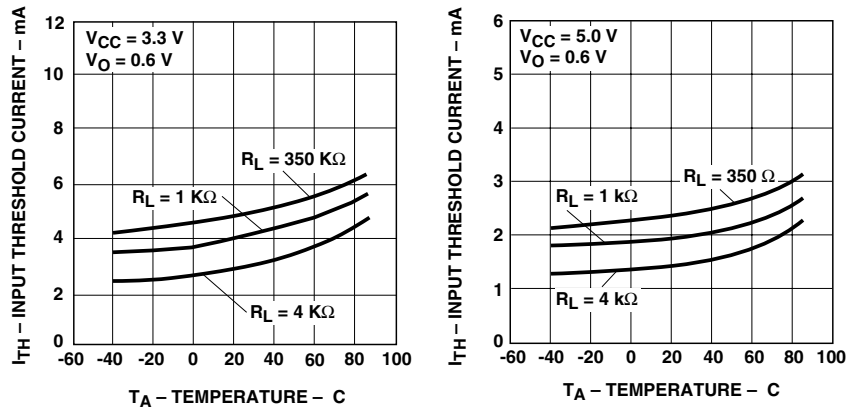


Figure 2. Typical input threshold current vs. Temperature

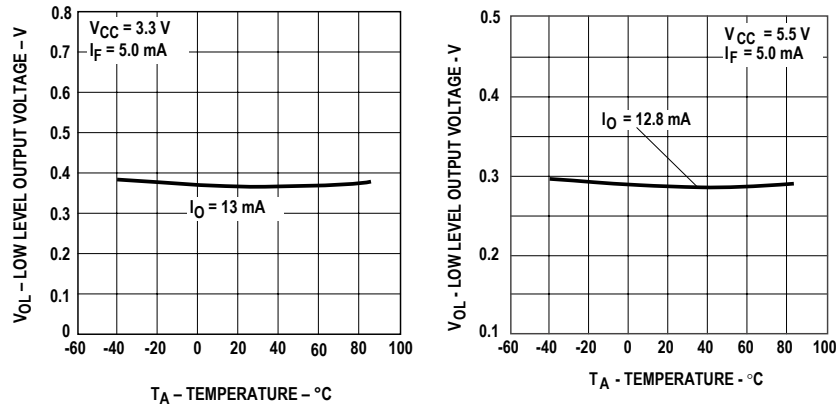


Figure 3. Typical low level output voltage vs. temperature.

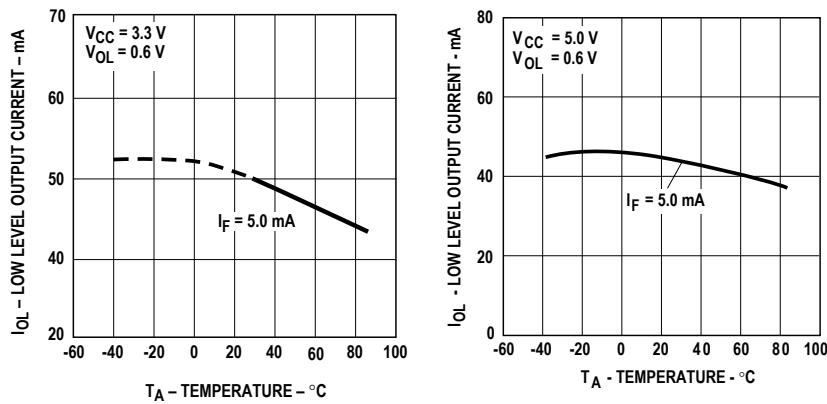


Figure 4. Typical low level output current vs. temperature.

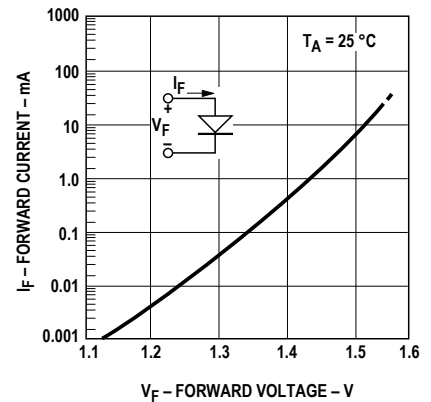


Figure 5. Typical input diode forward characteristic.

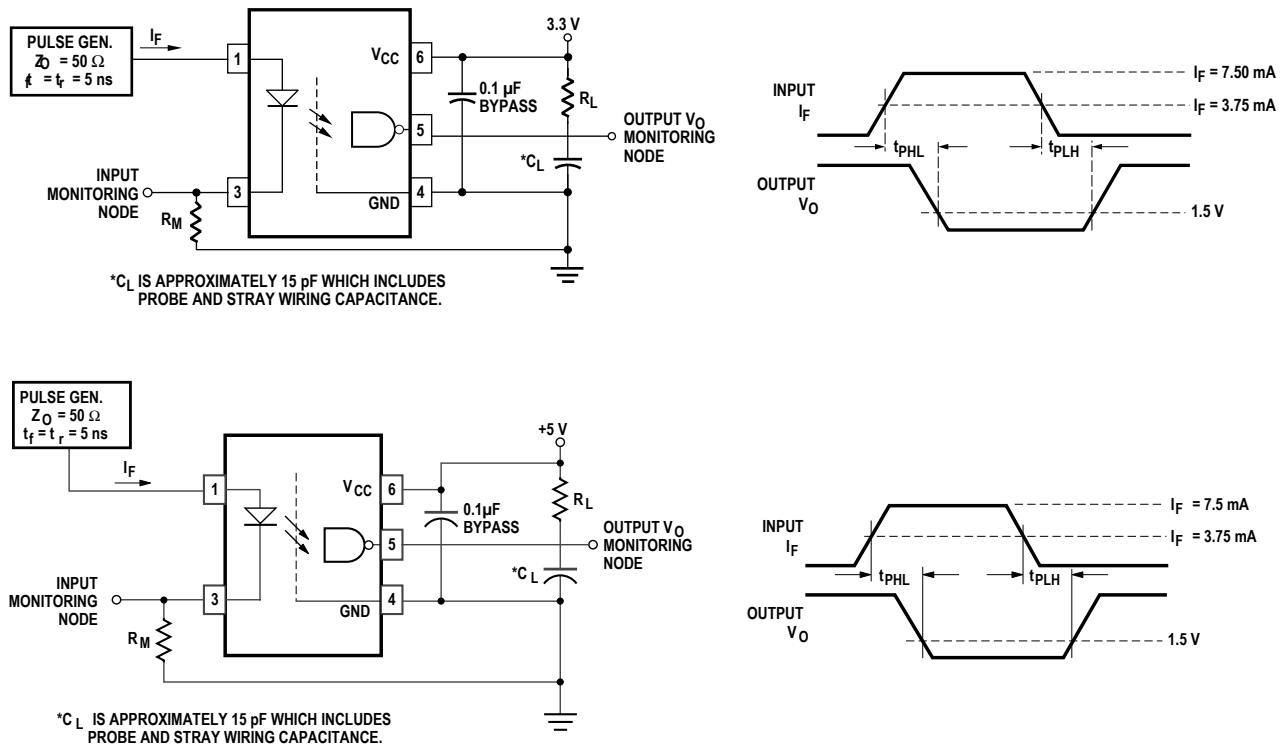


Figure 6. Test circuit for  $t_{pHL}$  and  $t_{pLH}$ .

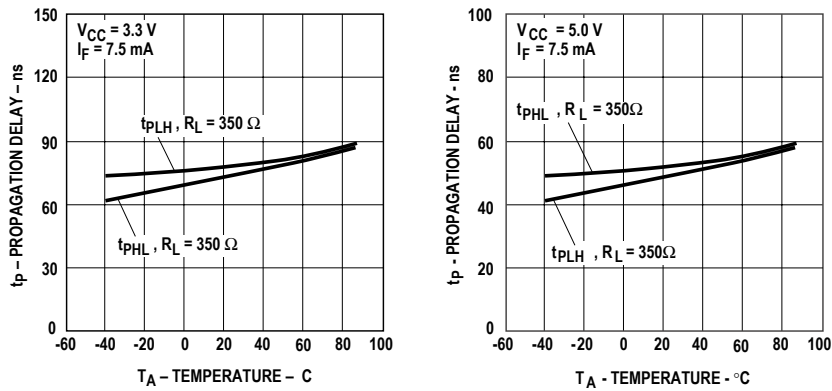


Figure 7. Typical propagation delay vs. temperature.

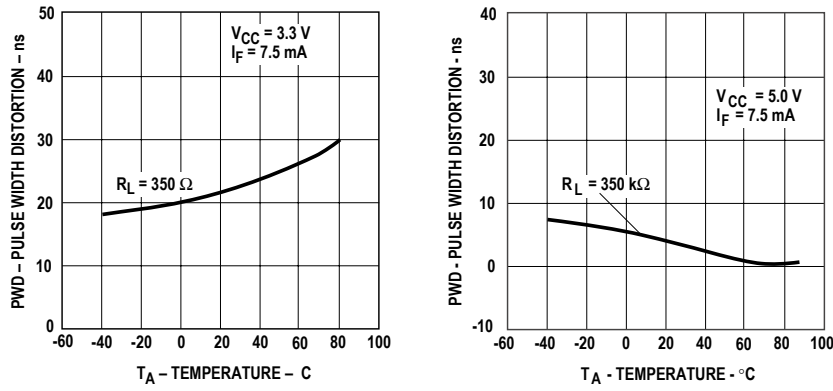


Figure 8. Typical pulse width distortion vs. temperature.

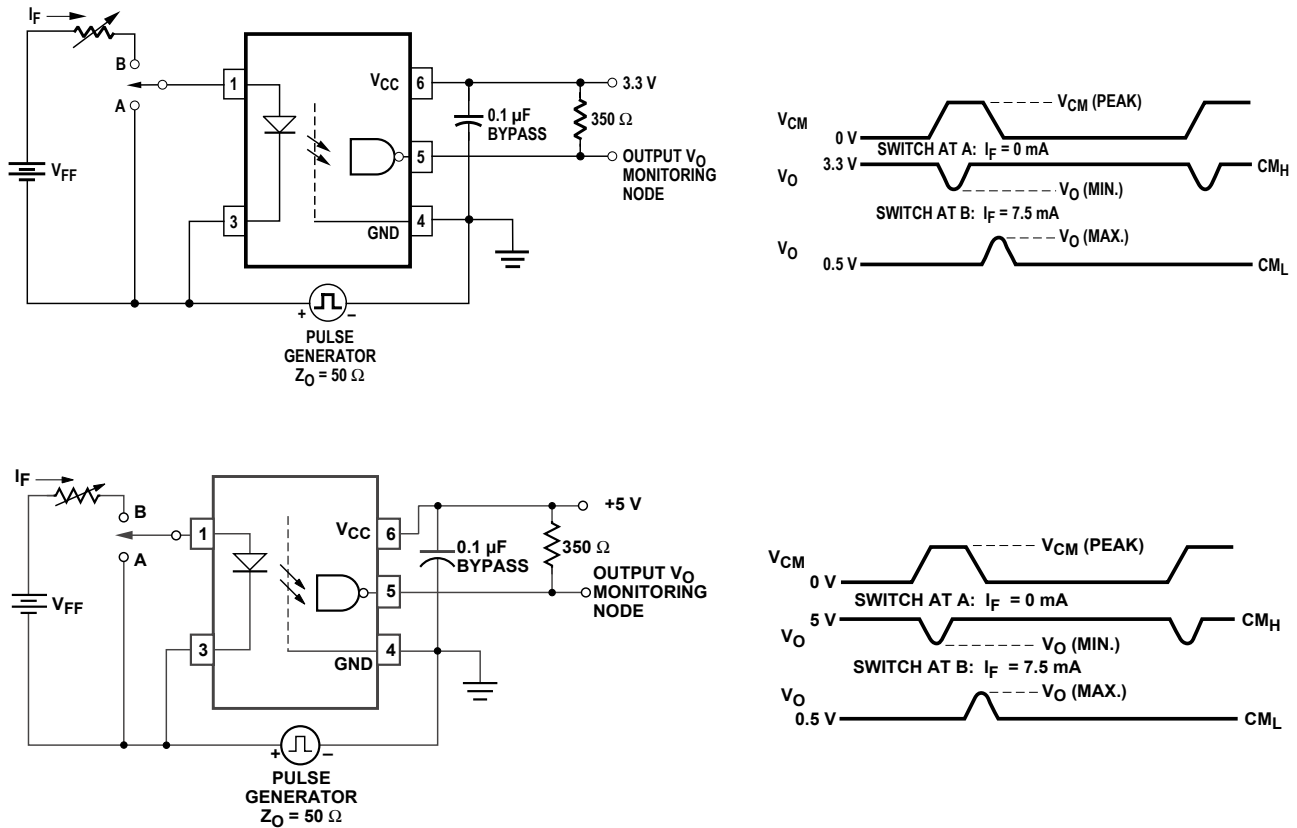


Figure 9. Test circuit for common mode transient immunity and typical waveforms.

For product information and a complete list of distributors, please go to our website: [www.avagotech.com](http://www.avagotech.com)

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