

## Inverted Logic, High CMR Optocoupler for Intelligent Power Modules and IGBT/MOSFET Gate Drive

### Data Sheet

#### Description

The high-speed ACPL-P481/W481 optocoupler contains a GaAsP LED, a photo detector, and a Schmitt trigger that eliminates the requirement for external waveform conditioning circuits.

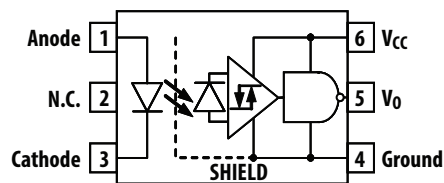
The totem pole output eliminates the requirement for a pull-up resistor. An Intelligent Power Module, Power MOSFET, or IGBT can be driven directly.

Propagation delay difference between devices has been minimized to maximize inverter efficiency through reduced switching dead time.

#### Applications

- IPM Interface Isolation
- Isolated IGBT/MOSFET Gate Drive
- AC and Brushless DC Motor Drives
- Industrial Inverters
- General Digital Isolation

#### Functional Diagram



Note: A 0.1  $\mu$ F bypass capacitor must be connected between pins 4 and 6.

#### Truth Table (Inverting Logic)

LED	V <sub>O</sub>
On	LOW
OFF	HIGH

#### Features

- Inverted output type (totem pole output)
- Performance Specified for Common IPM Applications Over Industrial Temperature Range
- Short Maximum Propagation Delays
- Minimized Pulse Width Distortion (PWD)
- Very High Common Mode Rejection (CMR)
- Hysteresis
- Available in Stretched SO-6 Package.
- Package Clearance/Creepage at 8 mm (ACPL-W481)
- Safety Approval: (pending)
  - UL Recognized with 3750V<sub>RMS</sub> (5000V<sub>RMS</sub> for ACPL-W481) for 1 minute per UL1577.
  - CSA Approved.
  - IEC/EN/DIN EN 60747-5-5 Approved with V<sub>IORM</sub> = 891V<sub>peak</sub> for ACPL-P481 and V<sub>IORM</sub> = 1140V<sub>peak</sub> for ACPL-W481, under option 060.

#### Specifications

- Wide Operating Temperature Range: -40°C to 100°C
- Maximum Propagation Delay t<sub>PHL</sub>/t<sub>PLH</sub> = 350 ns
- Maximum Pulse Width Distortion (PWD) = 250 ns
- Propagation Delay Difference: Min. -100 ns, Max. 250 ns
- Wide Operating V<sub>CC</sub> Range: 4.5V to 20V
- 20 kV/ $\mu$ s Minimum Common Mode Rejection (CMR) at V<sub>CM</sub> = 1000V

#### 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-P481/W481 is UL recognized with 3750/5000V<sub>RMS</sub> for 1 minute respectively per UL 1577. Both are approved under CSA Component Acceptance Notice #5, File CA 88324.

Part Number	Option	Package	Surface Mount	Tape and Reel	IEC/EN/DIN EN 60747-5-5	Quantity
	RoHS Compliant					
ACPL-P481 ACPL-W481	-000E	Stretched SO-6	X			100 per tube
	-500E		X	X		100 per tube
	-060E		X		X	100 per tube
	-560E		X	X	X	100 per tube

To order, choose a part number from the part number column and combine with the desired option from the option column to form an ordering part number.

Example 1:

ACPL-P481-560E: Stretched SO-6 Surface Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-5 Safety Approval and RoHS compliant.

Example 2:

ACPL-P481-000E: Stretched SO-6 Surface Mount package in tube packaging and RoHS compliant.

Option data sheets are available. Contact your Broadcom sales representative or authorized distributor for information.

## Recommended Pb-Free IR Profile

The recommended reflow profile is per JEDEC Standard, J-STD-020 (latest revision). Non-halide flux should be used.

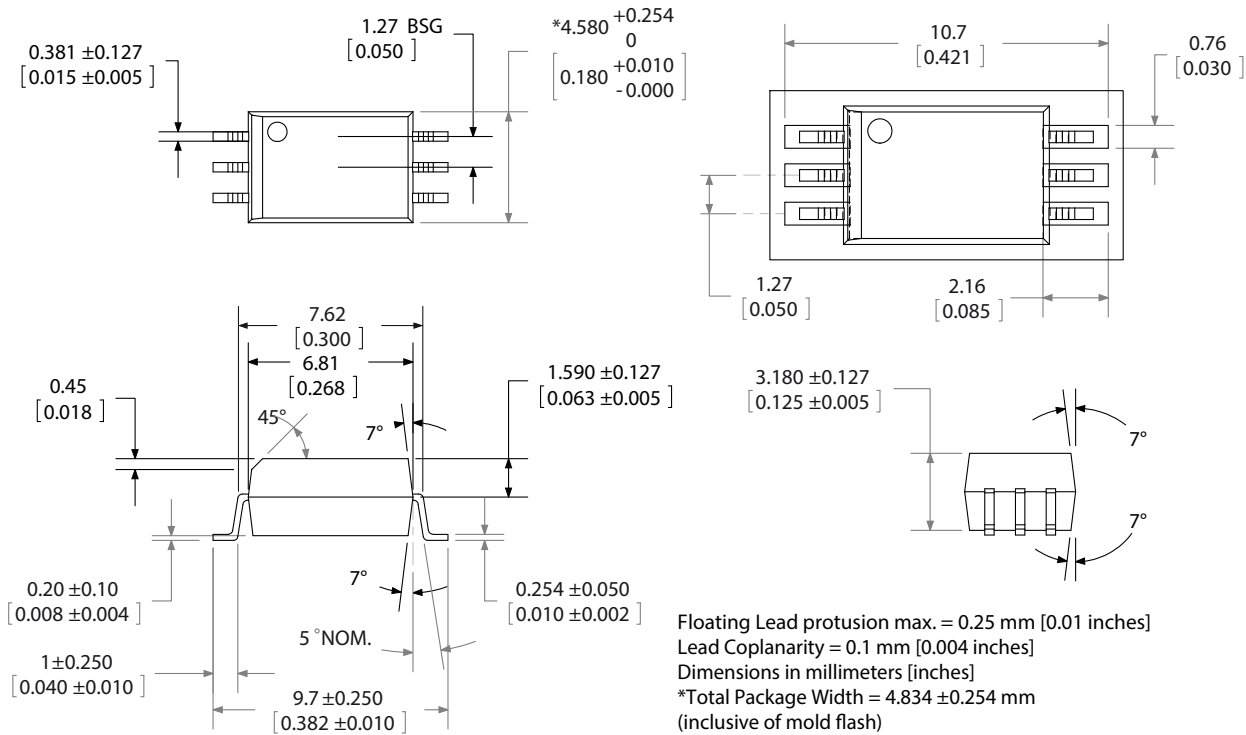
## Regulatory Information

The ACPL-P481/W481 is approved by the following organizations:

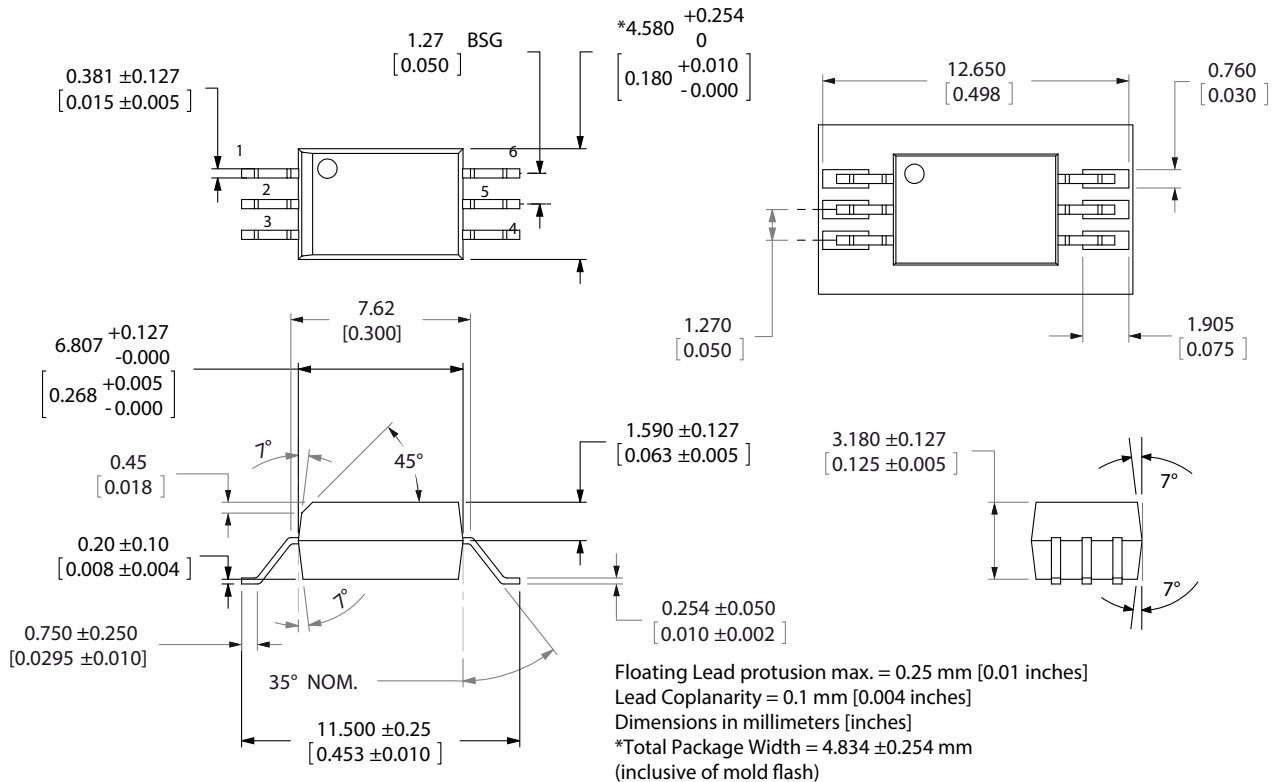
- IEC/EN/DIN EN 60747-5-5 (Option 060 only): Approved with Maximum Working Insulation Voltage  $V_{IORM} = 891V_{peak}$  for ACPL-P481 and  $V_{IORM} = 1140V_{peak}$  for ACPL-W481.
- UL: Approval under UL 1577, component recognition program up to  $V_{ISO} = 3750V_{RMS}$  (5000V<sub>RMS</sub> for ACPL-W481). File E55361.
- CSA: Approval under CSA Component Acceptance Notice #5, File CA 88324.

## Package Outline Drawings

### ACPL-P481 Stretched SO-6 Package (7 mm Clearance)



### ACPL-W481 Stretched SO-6 Package (8 mm Clearance)



## IEC/EN/DIN EN 60747-5-5 Insulation Characteristics (ACPL-P481/W481 Option 060)

Description	Symbol	ACPL-P481	ACPL-W481	Unit
Installation Classification per DIN VDE 0110/39, Table 1 for rated mains voltage $\leq 150V_{RMS}$ for rated mains voltage $\leq 300V_{RMS}$ for rated mains voltage $\leq 600V_{RMS}$		I – IV I – IV I – III	I – IV I – IV I – IV	
Climatic Classification		55/100/21	55/100/21	
Pollution Degree (DIN VDE 0110/39)		2	2	
Maximum Working Insulation Voltage	$V_{IORM}$	891	1140	$V_{peak}$
Input to Output Test Voltage, Method b <sup>a</sup> $V_{IORM} \times 1.875 = V_{PR}$ , 100% Production Test with $t_m = 1$ sec, Partial Discharge $< 5$ pC	$V_{PR}$	1670	2137	$V_{peak}$
Input to Output Test Voltage, Method a <sup>a</sup> $V_{IORM} \times 1.6 = V_{PR}$ , Type and Sample Test, $t_m = 10$ sec, Partial Discharge $< 5$ pC	$V_{PR}$	1426	1824	$V_{peak}$
Highest Allowable Overvoltage (Transient Overvoltage $t_{ini} = 60$ sec)	$V_{IOTM}$	6000	8000	$V_{peak}$
Safety-limiting Values – maximum values allowed in the event of a failure				
Case Temperature	$T_S$	175	175	$^{\circ}C$
Input Current	$I_{S, INPUT}$	230	230	mA
Output Power	$P_{S, OUTPUT}$	600	600	mW
Insulation Resistance at $T_S$ , $V_{IO} = 500V$	$R_S$	$>10^9$	$>10^9$	$\Omega$

- a. Refer to the optocoupler section of the Isolation and Control Components Designer's Catalog, under the Product Safety Regulations section, (IEC/EN/DIN EN 60747-5-5), for a detailed description of Method a and Method b partial discharge test profiles.

## Insulation and Safety Related Specifications

Parameter	Symbol	ACPL-P481	ACPL-W481	Unit	Condition
Minimum External Air Gap (External Clearance)	L(101)	7.0	8.0	mm	Measured from input terminals to output terminals, shortest distance through air.
Minimum External Tracking (External Creepage)	L(102)	8.0	8.0	mm	Measured from input terminals to output terminals, shortest distance path along body.
Minimum Internal Plastic Gap (Internal Clearance)		0.08	0.08	mm	Through insulation distance conductor to conductor, usually the straight line distance thickness between the emitter and detector.
Tracking Resistance (Comparative Tracking Index)	CTI	$>175$	$>175$	V	DIN IEC 112/VDE 0303 Part 1.
Isolation Group		IIIa	IIIa		Material Group (DIN VDE 0110, 1/89, Table 1).

## Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Note
Storage Temperature	$T_S$	-55	+125	°C	
Operating Temperature	$T_A$	-40	+100	°C	
Average Input Current	$I_{F(AVG)}$		10	mA	
Peak Transient Input Current ( $<1\ \mu\text{s}$ pulse width, 300 pps) ( $<200\ \mu\text{s}$ pulse width, $<1\%$ duty cycle)	$I_{F(TRAN)}$		1.0 40	A mA	
Reverse Input Voltage	$V_R$		5	V	
Average Output Current	$I_O$		25	mA	
Supply Voltage	$V_{CC}$	0	25	V	
Output Voltage	$V_O$	-0.5	+25	V	
Total Package Power Dissipation	$P_T$		210	mW	1

## Recommended Operating Conditions

Over recommended operating conditions  $T_A = -40^\circ\text{C}$  to  $+100^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $20\text{V}$ ,  $I_{F(ON)} = 6\text{ mA}$  to  $10\text{ mA}$ ,  $V_{F(OFF)} = 0\text{V}$  to  $0.8\text{V}$ , unless otherwise specified. All typicals at  $T_A = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Max.	Unit	Note
Power Supply Voltage	$V_{CC}$	4.5	20	V	2
Forward Input Current (OFF)	$I_{F(OFF)}$	6	10	mA	
Forward Input Voltage (ON)	$V_{F(ON)}$		0.8	V	
Operating Temperature	$T_A$	-40	+100	°C	

## Electrical Specifications

Over recommended operating conditions  $T_A = -40^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $20\text{V}$ ,  $I_{F(\text{ON})} = 6\text{ mA}$  to  $10\text{ mA}$ ,  $V_{F(\text{OFF})} = 0\text{V}$  to  $0.8\text{V}$ , unless otherwise specified. All typicals at  $T_A = 25^{\circ}\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Logic Low Output Voltage	$V_{OL}$			0.3	V	$I_{OL} = 3.5\text{ mA}$	1, 3	
				0.5		$I_{OL} = 6.5\text{ mA}$		
Logic High Output Voltage	$V_{OH}$	$V_{CC} - 1.8$	$V_{CC} - 0.9$		V	$I_{OH} = -3.5\text{ mA}$	2, 3, 7	
		$V_{CC} - 2.5$	$V_{CC} - 1.2$			$I_{OH} = -6.5\text{ mA}$		
Output Leakage Current ( $V_O = V_{CC} + 0.5\text{ V}$ )	$I_{OHH}$			100	$\mu\text{A}$	$V_{CC} = 5\text{V}$ , $V_F = 0\text{V}$		
				500	$\mu\text{A}$	$V_{CC} = 20\text{V}$ , $V_F = 0\text{V}$		
Logic Low Supply Current	$I_{CCL}$		1.9	3.0	mA	$V_{CC} = 5.5\text{V}$ , $I_F = 10\text{ mA}$ , $I_O = 0\text{ mA}$		
			2.0	3.0	mA	$V_{CC} = 20\text{V}$ , $I_F = 10\text{ mA}$ , $I_O = 0\text{ mA}$		
Logic High Supply Current	$I_{CCH}$		1.5	2.5	mA	$V_{CC} = 5.5\text{V}$ , $V_F = 0\text{V}$ , $I_O = 0\text{ mA}$		
			1.6	2.5	mA	$V_{CC} = 20\text{V}$ , $V_F = 0\text{V}$ , $I_O = 0\text{ mA}$		
Logic Low Short Circuit Output Current	$I_{OSL}$	25			mA	$V_O = V_{CC} = 5.5\text{V}$ , $I_F = 10\text{ mA}$		3
		50			mA	$V_O = V_{CC} = 20\text{V}$ , $I_F = 10\text{ mA}$		
Logic High Short Circuit Output Current	$I_{OSH}$			-25	mA	$V_{CC} = 5.5\text{V}$ , $V_F = 0\text{V}$ , $V_O = \text{GND}$		3
				-50	mA	$V_{CC} = 20\text{V}$ , $V_F = 0\text{V}$ , $V_O = \text{GND}$		
Input Forward Voltage	$V_F$		1.5	1.7	V	$T_A = 25^{\circ}\text{C}$ , $I_F = 6\text{ mA}$	4	
				1.85	V	$I_F = 6\text{ mA}$		
Input Reverse Breakdown Voltage	$BV_R$	5			V	$I_R = 10\text{ }\mu\text{A}$		
Input Diode Temperature Coefficient	$\Delta V_F / \Delta T_A$		1.7		mV/ $^{\circ}\text{C}$	$I_F = 6\text{ mA}$		
Input Capacitance	$C_{IN}$		60		pF	$f = 1\text{ MHz}$ , $V_F = 0\text{V}$		4

## Switching Specifications

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Propagation Delay Time to Logic Low Output Level	$t_{PHL}$		110	350	ns	with Peaking Capacitor	5, 6	6
Propagation Delay Time to Logic High Output Level	$t_{PLH}$		140	350	ns	with Peaking Capacitor	5, 6	6
Pulse Width Distortion	$ t_{PHL} - t_{PLH}  = PWD$			250	ns			9
Propagation Delay Difference Between Any Two Parts	PDD	-100		250	ns			11
Output Rise Time (10% to 90%)	$t_r$		16		ns		5, 8	
Output Fall Time (90% to 10%)	$t_f$		20		ns		5, 8	
Logic High Common Mode Transient Immunity	$ CM_H $	20			kV/ $\mu$ s	$ V_{CM}  = 1000V, V_F = 0V,$ $V_{CC} = 5V, T_A = 25^\circ C$	9	7
Logic Low Common Mode Transient Immunity	$ CM_L $	20			kV/ $\mu$ s	$ V_{CM}  = 1000V, I_F = 6.0\text{ mA},$ $V_{CC} = 5V, T_A = 25^\circ C$	9	7

## Package Characteristics

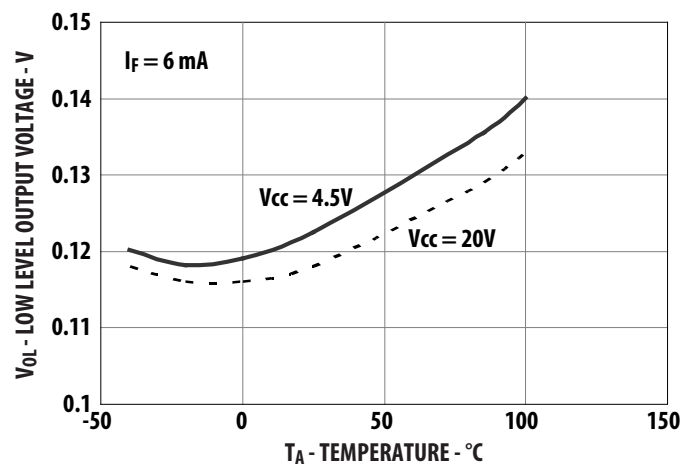
Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Input-Output Momentary Withstand Voltage <sup>a</sup>	$V_{ISO}$	3750 (ACPL-P481) 5000 (ACPL-W481)			$V_{RMS}$	RH < 50%, $t = 1\text{ min.}$ $T_A = 25^\circ C$		5, 8
Input-Output Resistance	$R_{I-O}$		$10^{12}$			$V_{I-O} = 500V_{DC}$		5
Input-Output Capacitance	$C_{I-O}$		0.6			$f = 1\text{ MHz}, V_{I-O} = 0V_{DC}$		5

- a. The Input-Output Momentary Withstand Voltage is a dielectric voltage rating that should not be interpreted as an input-output continuous voltage rating. For the continuous voltage rating refer to the IEC/EN/DIN EN 60747-5-5 Insulation Characteristics Table (if applicable).

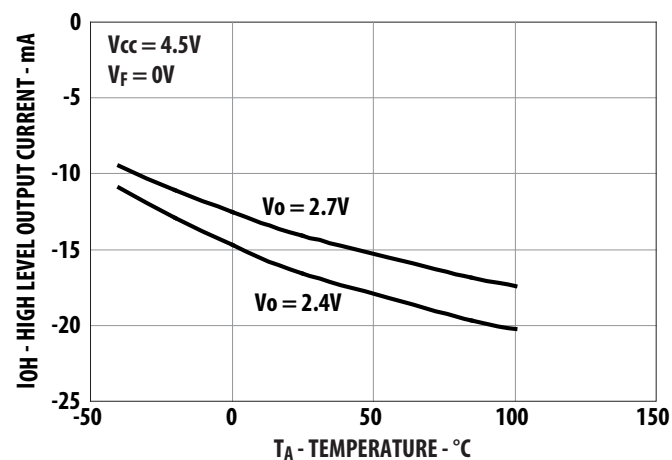
### Notes:

- Derate total package power dissipation,  $P_T$ , linearly above  $70^\circ C$  free-air temperature at a rate of  $4.5\text{ mW}/^\circ C$ .
- Detector requires a  $V_{CC}$  of  $4.5V$  or higher for stable operation as output might be unstable if  $V_{CC}$  is lower than  $4.5V$ . Be sure to check the power ON/OFF operation other than the supply current.
- Duration of output short circuit time should not exceed  $10\text{ ms}$ .
- Input capacitance is measured between pin 1 and pin 3.
- Device considered a two-terminal device: pins 1, 2, and 3 shorted together and pins 4, 5, and 6 shorted together.
- The  $t_{PLH}$  propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3V point on the trailing edge of the output pulse. The  $t_{PHL}$  propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.3V point on the leading edge of the output pulse.
- $CM_H$  is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic high state,  $V_O > 2.0V$ .  
 $CM_L$  is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic low state,  $V_O < 0.8V$ .
- In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage.  $4500V_{RMS}$  ( $6000V_{RMS}$  for ACPL-W481) for one second (leakage detection current limit,  $I_{L-O} \leq 5\text{ }\mu A$ ). This test is performed before the 100% production test for partial discharge (Method b) shown in the IEC/EN/DIN EN 60747-5-5 Insulation Characteristics Table, if applicable.
- Pulse Width Distortion (PWD) is defined as  $|t_{PHL} - t_{PLH}|$  for any given device.
- Use of a  $0.1\text{ }\mu F$  bypass capacitor connected between pins 4 and 6 is recommended.
- The difference between  $t_{PLH}$  and  $t_{PHL}$  between any two devices under the same test condition.

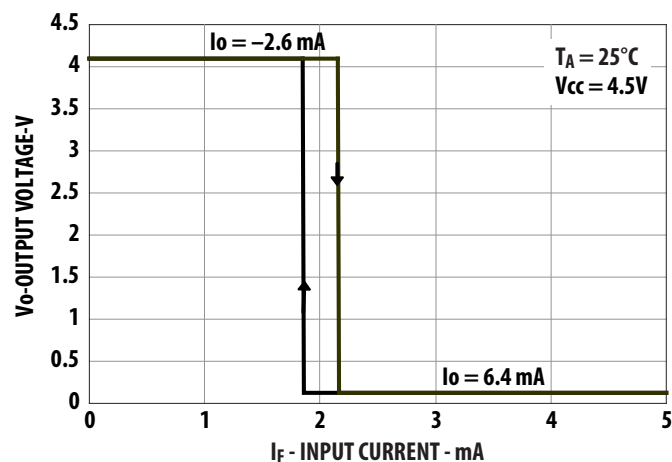
### Figure 1 Typical Logic Low Output Voltage vs. Temperature



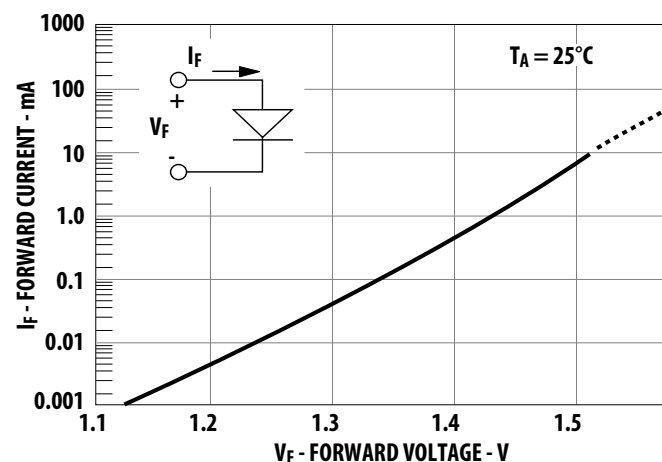
### Figure 2 Typical Logic High Output Current vs. Temperature



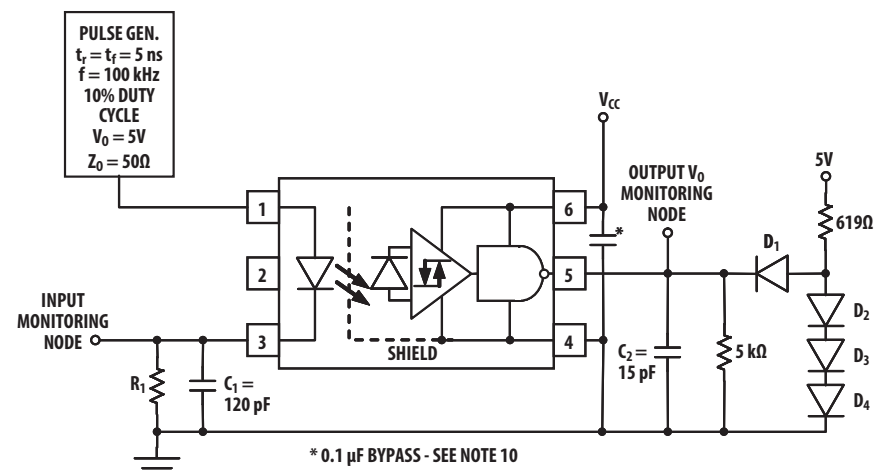
### Figure 3 Typical Output Voltage vs. Forward Input Current



#### Figure 4 Typical Input Diode Forward Characteristic



**Figure 5 Test Circuit for  $t_{PLH}$ ,  $t_{PHL}$ ,  $t_r$ , and  $t_f$**



THE PROBE AND JIG CAPACITANCES  
ARE INCLUDED IN  $C_1$  AND  $C_2$ .

$R_1$	660Ω	330Ω
$I_{F(ON)}$	6 mA	10 mA

ALL DIODES ARE EITHER 1N916 OR 1N3064

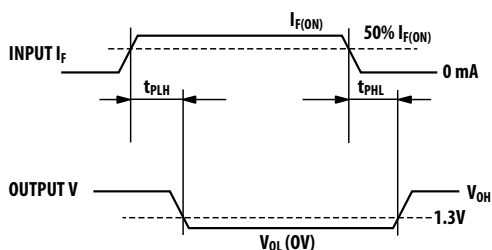




Figure 6 Typical Propagation Delays vs. Temperature

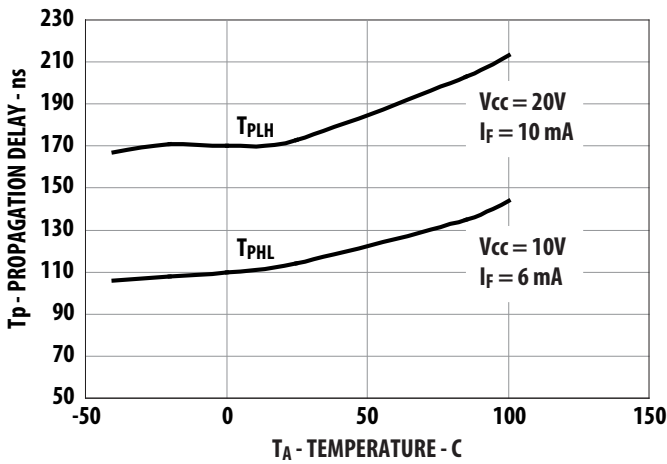


Figure 7 Typical Logic High Output Voltage vs. Supply Voltage

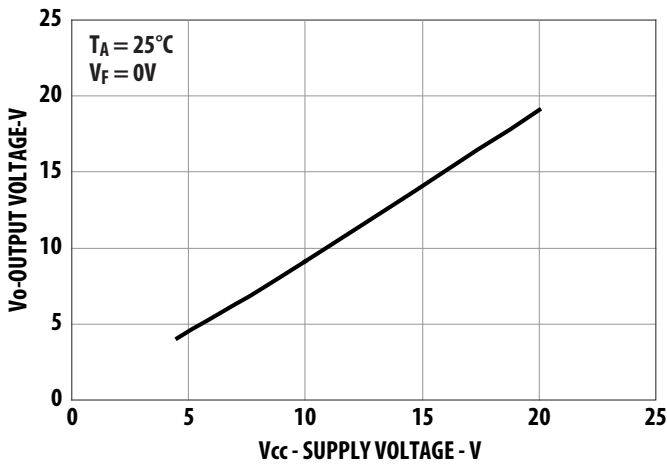


Figure 8 Typical Propagation Delay vs. Supply Voltage

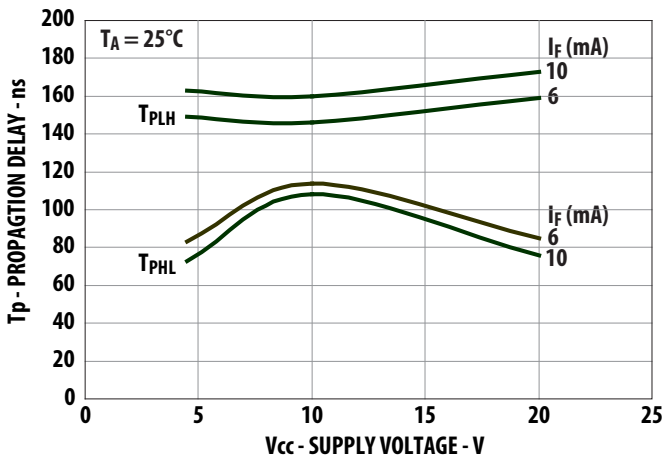
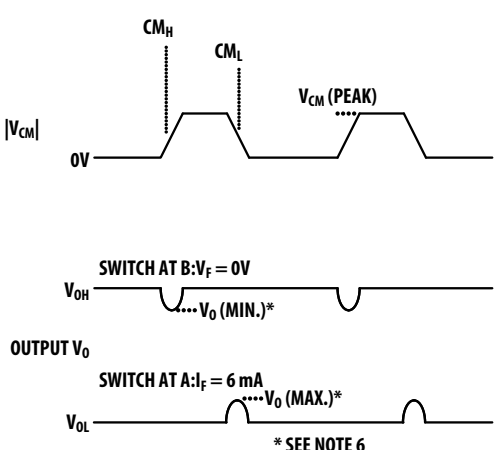
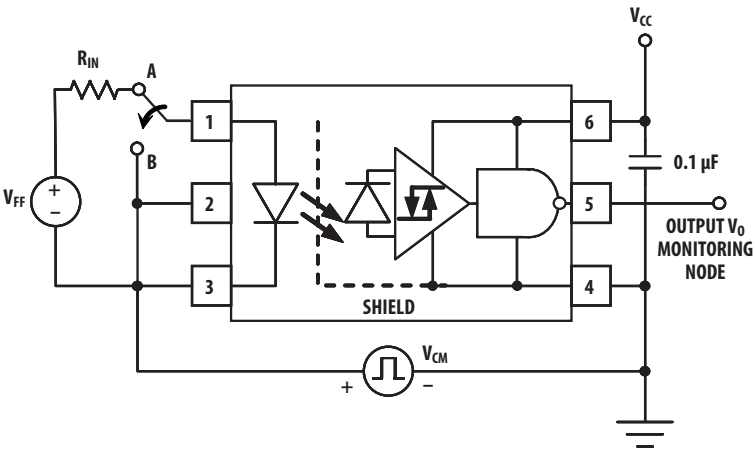


Figure 9 Test Circuit for Common Mode Transient Immunity and Typical Waveforms



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