Data Sheet

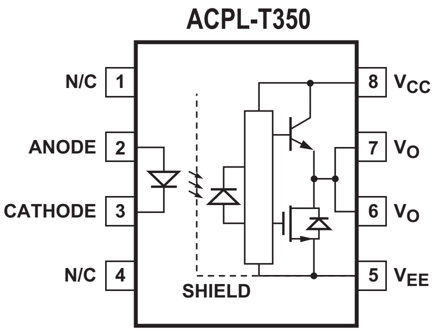
ACPL-T350

2.5-Amp Output Current IGBT Gate Driver Optocoupler with Low I_{CC}

Description

The ACPL-T350 contains a GaAsP LED. The LED is optically coupled to an integrated circuit with a power output stage. These optocouplers are ideally suited for driving power IGBTs and MOSFETs used in motor control inverter applications. The high operating voltage range of the output stage provides the drive voltages required by gate-controlled devices. The voltage and current supplied by these optocouplers make them ideally suited for directly driving IGBTs with ratings up to 1200V/100A. For IGBTs with higher ratings, the ACPL-T350 series can be used to drive a discrete power stage that drives the IGBT gate. The ACPL-T350 has an insulation voltage of V_{IORM} = 630V_{peak} (Option 060).

Figure 1: Functional Diagram



NOTE: A 0.1-µF bypass capacitor must be connected between pins V_{CC} and V_{EE}.

Table 1: UVLO Truth Table

LED	VCC – VEE “POSITIVE GOING” (TURN-ON)	VCC – VEE “NEGATIVE GOING” (TURN-OFF)	V_O
OFF	0V–30V	0V–30V	LOW
ON	0V–11V	0V–9.5V	LOW
ON	11V–13.5V	9.5V–12V	TRANSITION
ON	13.5V–30V	12V–30V	HIGH

Features

- 2.5A absolute maximum peak output current
- 15-kV/µs minimum Common Mode Rejection (CMR) at V_{CM} = 1500V
- 1.5V maximum low-level output voltage (V_{OL})
- I_{CC} = 4-mA maximum supply current
- Under-voltage lockout (UVLO) protection with hysteresis
- Wide operating V_{CC} range: 15V to 30V
- 500-ns maximum switching speeds
- Industrial temperature range: –40°C to 100°C
- Safety approval:
  - UL recognized 3750 V_{rms} for 1 minute
  - CSA approval
  - IEC/EN/DIN EN 60747-5-5 approved V_{IORM} = 630V_{peak} (Option 060)

Applications

- IGBT/MOSFET gate drive
- Inverter for home appliances
- Industrial inverters
- Switching power supplies (SPS)

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

Ordering Information

The ACPL-T350 is UL recognized with 3750 V_{rms} for 1 minute per UL1577.

Part Number	Option	Package	Surface Mount	Gull Wing	Tape & Reel	IEC/EN/DIN EN 60747-5-5	Quantity
	RoHS Compliant						
ACPL-T350	-000E	300-mil DIP-8					50 per tube
	-300E		X	X			50 per tube
	-500E/500ME		X	X	X		1000 per reel
	-060E					X	50 per tube
	-360E		X	X		X	50 per tube
	-560E/560ME		X	X	X	X	1000 per reel

To form an order entry, choose a part number from the Part Number column and combine it with the desired option from the Option column.

Example 1:

Use ACPL-T350-560E to order the product in a 300-mil DIP, gull-wing, surface-mount package in tape-and-reel packaging with IEC/EN/DIN EN 60747-5-5 safety approval and RoHS compliant.

Example 2:

Use ACPL-T350-000E to order the product in a 300-mil DIP package in tube packaging and RoHS compliant.

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

NOTE: The notation '#XXX' is used for existing products, whereas products launched since July15, 2001, with the RoHS compliant option use '-XXXE'.

Regulatory Information

The ACPL-T350 is approved by the following organizations:

IEC/EN/DIN EN 60747-5-5 (ACPL-T350 Option 060 only)

Approval under:
DIN EN 60747-5-5 (VDE 0884-5):2011-11
EN 60747-5-5:2011

UL

Approval under UL 1577, component recognition program, File E55361.

CSA

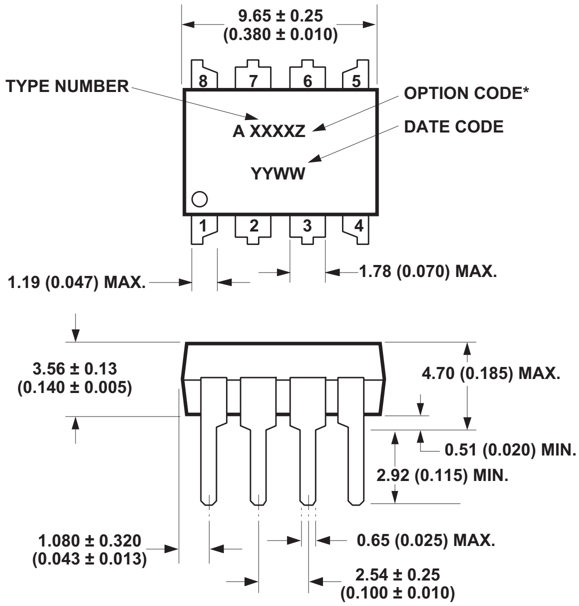
Approval under CSA Component Acceptance Notice #5, File CA 88324.

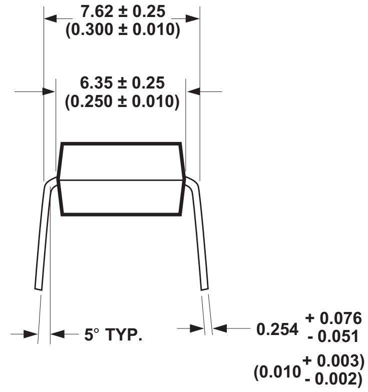
Recommended Pb-Free IR Profile

The recommended reflow condition is as per JEDEC standard J-STD-020 (latest revision). Non-halide flux should be used.

Package Outline Drawings

ACPL-T350 Outline Drawing (300-mil DIP)

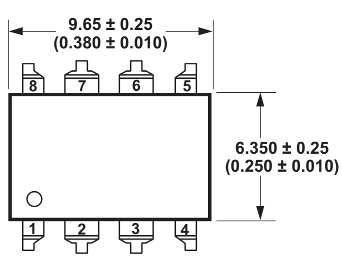


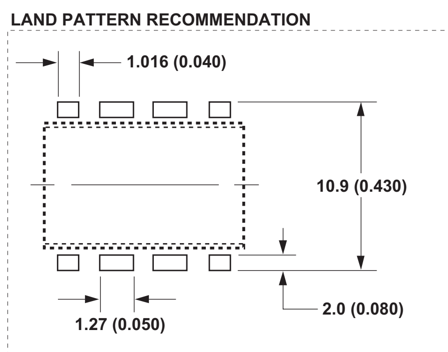


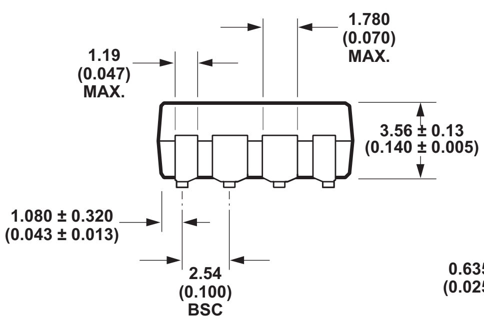
DIMENSIONS IN MILLIMETERS AND (INCHES).
* MARKING CODE LETTER FOR OPTION NUMBERS.
"V" = OPTION 060
OPTION NUMBERS 300 AND 500 NOT MARKED.

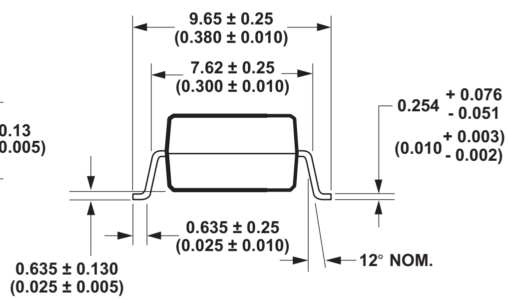
NOTE: FLOATING LEAD PROTRUSION IS 0.25 mm (10 mils) MAX.

ACPL-T350 Outline Drawing (300-mil Gull Wing)









DIMENSIONS IN MILLIMETERS (INCHES).
LEAD COPLANARITY = 0.10 mm (0.004 INCHES).

NOTE: FLOATING LEAD PROTRUSION IS 0.25 mm (10 mils) MAX.

Table 2: IEC/EN/DIN EN 60747-5-5 Insulation Characteristics[a] (ACPL-T350 Option 060)

Description	Symbol	ACPL-T350 Option 060	Unit
Installation Classification per DIN VDE 0110/39, Table 1 For rated mains voltage ≤ 150 V_{rms} For rated mains voltage ≤ 300 V_{rms} For rated mains voltage ≤ 450 V_{rms}	—	 I – IV I – IV I – III	—
Climatic Classification	—	55/100/21	—
Pollution Degree (DIN VDE 0110/39)	—	2	—
Maximum Working Insulation Voltage	V_{IORM}	630	V_{peak}
Input to Output Test Voltage, Method b[a] $V_{IORM} \times 1.875 = V_{PR}$, 100% Production Test with t_m = 1 second, Partial discharge < 5 pC	V_{PR}	1181	V_{peak}
Input to Output Test Voltage, Method a[a] $V_{IORM} \times 1.6 = V_{PR}$, Type and Sample Test, t_m = 10 seconds, Partial discharge < 5 pC	V_{PR}	1008	V_{peak}
Highest Allowable Overvoltage (Transient Overvoltage t_{ini} = 60 seconds)	V_{IOTM}	6000	V_{peak}
Safety-Limiting Values – maximum values allowed in the event of a failure	—		
Case Temperature	T_S	175	°C
Input Current	$I_{S,\ INPUT}$	230	mA
Output Power	$P_{S,\ OUTPUT}$	600	mW
Insulation Resistance at T_S, V_{IO} = 500V	R_S	$> 10^9$	Ω

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.

NOTE: These optocouplers are suitable for "safe electrical isolation" only within the safety limit data. Maintenance of the safety data shall be ensured by means of protective circuits. Surface-mount classification is Class A in accordance with CECC 00802.

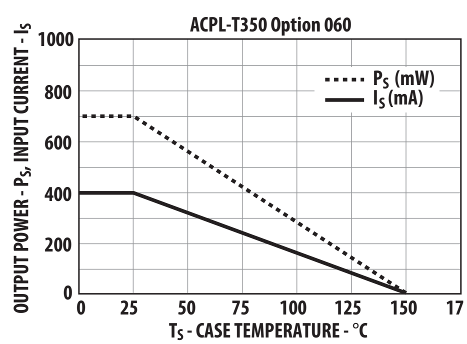


Table 3: Insulation- and Safety-Related Specifications

Parameter	Symbol	ACPL-T350	Units	Conditions
Minimum External Air Gap (Clearance)	L(101)	7.1	mm	Measured from input terminals to output terminals, shortest distance through air.
Minimum External Tracking (Creepage)	L(102)	7.4	mm	Measured from input terminals to output terminals, shortest distance path along body.
Minimum Internal Plastic Gap (Internal Clearance)	—	0.08	mm	Through insulation distance conductor to conductor, usually the straight line distance thickness between the emitter and the detector.
Tracking Resistance Comparative Tracking Index)	CTI	> 175	V	DIN IEC 112/VDE 0303 Part 1.
Isolation Group	—	IIIa	—	Material Group (DIN VDE 0110, 1/89, Table 1).

All Broadcom data sheets report the creepage and clearance inherent to the optocoupler component itself. These dimensions are needed as a starting point for the equipment designer when determining the circuit insulation requirements. However, once mounted on a printed circuit board, the minimum creepage and clearance requirements must be met as specified for individual equipment standards. For creepage, the shortest distance path along the surface of a printed circuit board between the solder fillets of the input and output leads must be considered (the recommended land pattern does not necessarily meet the minimum creepage of the device). There are recommended techniques, such as grooves and ribs, that can be used on a printed circuit board to achieve desired creepage and clearances. Creepage and clearance distances will also change depending on factors such as the pollution degree and insulation level.

Table 4: Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Note
Storage Temperature	T_S	–55	125	°C	
Operating Temperature	T_A	–40	100	°C	
Average Input Current	$I_{F(AVG)}$	—	25	mA	a
Peak Transient Input Current (<1 µs pulse width, 300 pps)	$I_{F(TRAN)}$	—	1.0	A	
Reverse Input Voltage	V_R	—	5	V	
“High” Peak Output Current	$I_{OH(PEAK)}$	—	2.5	A	b
“Low” Peak Output Current	$I_{OL(PEAK)}$	—	2.5	A	b
Supply Voltage	$V_{CC} – V_{EE}$	0	35	V	
Input Current (Rise/Fall Time)	$t_{r(IN)}$ / $t_{f(IN)}$	—	500	ns	
Output Voltage	$V_{O(PEAK)}$	0	V_{CC}	V	
Output Power Dissipation	P_O	—	250	mW	c
Total Power Dissipation	P_T	—	295	mW	d
Lead Solder Temperature	260°C for 10 seconds, 1.6 mm below seating plane				

a. Derate linearly above 70°C free-air temperature at a rate of 0.3 mA/°C.

b. Maximum pulse width = 10 µs.

c. Derate linearly above a 70°C free-air temperature at a rate of 4.8 mW/°C.

d. Derate linearly above a 70°C free-air temperature at a rate of 5.4 mW/°C. The maximum LED junction temperature should not exceed 125°C.

Table 5: Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Note
Power Supply	$V_{CC} – V_{EE}$	15	30	V	
Input Current (ON)	$I_{F(ON)}$	7	16	mA	
Input Voltage (OFF)	$V_{F(OFF)}$	–3.6	0.8	V	
$I_{OH(PEAK)}/I_{OL(PEAK)}$	T_A	–2.0	2.0	A	
Operating Temperature	T_A	–40	100	°C	

Table 6: Electrical Specifications (DC)

Over recommended operating conditions (T_A = –40°C to 100°C, $I_{F(ON)}$ = 7 mA to 16 mA, $V_{F(OFF)}$ = –3.6V to 0.8V, V_{CC} = 15V to 30V, V_{EE} = Ground) unless otherwise specified. All typical values at T_A = 25°C and $V_{CC} – V_{EE}$ = 30V, unless otherwise noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	I_{OH}	0.5	1.6	—	A	$V_O = V_{CC} – 4V$	3, 4, 16	a
		2.0	—	—	A	$V_O = V_{CC} – 15V$		b
Low Level Output Current	I_{OL}	0.5	1.6	—	A	$V_O = V_{EE} + 2.5V$	6, 7, 17	a
		2.0	—	—	A	$V_O = V_{EE} + 15V$		b
High Level Output Voltage	V_{OH}	$V_{CC} – 4$	$V_{CC} – 3$	—	V	I_O = –100 mA	2, 4, 18	c, d
Low Level Output Voltage	V_{OL}	—	V_{EE} + 0.5	1.5	V	I_O = 100 mA	5, 7, 19	
High Level Supply Current	I_{CCH}	—	2.0	4.0	mA	Output open, I_F = 7 mA to 16 mA	8, 9	
Low Level Supply Current	I_{CCL}	—	2.0	4.0	mA	Output open, V_F = –3.0V to +0.8V		
Threshold Input Current Low to High	I_{FLH}	—	2.0	5	mA	I_O = 0 mA, V_O > 5V	10, 20	
Threshold Input Voltage High to Low	V_{FHL}	0.8	—	—	V	I_O = 0 mA, V_O > 5V		
Input Forward Voltage	V_F	1.2	1.5	1.8	V	I_F = 10 mA		
Temperature Coefficient of Input Forward Voltage	$\Delta V_F/\Delta T_A$	—	–2.0	—	mV/°C	I_F = 10 mA		
Input Reverse Breakdown Voltage	BV_R	5	—	—	V	I_R = 10 µA		
Input Capacitance	C_{IN}	—	60	—	pF	f = 1 MHz, V_F = 0V		
UVLO Threshold	V_{UVLO+}	11.0	12.3	13.5	V	I_F = 10 mA, V_O > 5	15, 21	
	$V_{UVLO–}$	9.5	10.7	12.0	V	I_F = 10 mA, V_O > 5V		
UVLO Hysteresis	$UVLO_{HYS}$	—	1.6	—	V	I_F = 10 mA, V_O > 5V		

a. Maximum pulse width = 50 µs.

b. Maximum pulse width = 10 µs.

c. In this test, V_{OH} is measured with a DC load current. When driving capacitive loads, V_{OH} will approach V_{CC} as I_{OH} approaches zero amps.

d. Maximum pulse width = 1 ms.

Table 7: Switching Specifications (AC)

Over recommended operating conditions (T_A = –40°C to 100°C, $I_{F(ON)}$ = 7 mA to 16 mA, $V_{F(OFF)}$ = –3.6V to 0.8V, V_{CC} = 15V to 30V, V_{EE} = Ground) unless otherwise specified. All typical values at T_A = 25°C and $V_{CC} – V_{EE}$ = 30V, unless otherwise noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to High Output Level	t_{PLH}	0.05	0.25	0.5	µs	Rg = 10Ω, Cg = 10 nF, f = 10 kHz, Duty Cycle = 50%	11, 12, 13, 22	a
Propagation Delay Time to Low Output Level	t_{PHL}	0.05	0.25	0.5	µs			
Pulse Width Distortion	PWD	—	—	0.3	µs			b
Propagation Delay Difference Between Any Two Parts or Channels	PDD ($t_{PHL} – t_{PLH}$)	–0.35	—	0.35	µs			c
Rise Time	t_R	—	15	—	ns		22	
Fall Time	t_F	—	20	—	ns			
Output High Level Common Mode Transient Immunity	$\|CM_H\|$	15	20	—	kV/µs	T_A = 25°C, I_F = 10 mA to 16 mA, V_{CM} = 1500V, V_{CC} = 30V	23	d, e
Output Low Level Common Mode Transient Immunity	$\|CM_L\|$	15	20	—	kV/µs	T_A = 25°C, V_F = 0V, V_{CM} = 1500V, V_{CC} = 30V	23	d, f

a. This load condition approximates the gate load of a 1200V/100A IGBT.

b. Pulse width distortion (PWD) is defined as $|t_{PHL} – t_{PLH}|$ for any given device.

c. The difference between t_{PHL} and t_{PLH} between any two ACPL-T350 parts under the same test condition.

d. Pins 1 and 4 must be connected to LED common.

e. Common mode transient immunity in the high state is the maximum tolerable dV_{CM}/dt of the common mode pulse, V_{CM}, to ensure that the output will remain in the high state (that is, V_O > 15.0V).

f. Common mode transient immunity in a low state is the maximum tolerable dV_{CM}/dt of the common mode pulse, V_{CM}, to ensure that the output will remain in a low state (that is, V_O < 2.0V).

Table 8: Package Characteristics

Over the recommended temperature (T_A = –40°C to 100°C) unless otherwise specified. All typical values at T_A = 25°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Input-Output Momentary Withstand Voltage*	V_{ISO}	3750	—	—	V_{rms}	RH < 50%, t = 1 minute, T_A = 25°C		a, b
Resistance (Input-Output)	R_{I-O}	—	10^{12}	—	Ω	V_{I-O} = 500V		b
Capacitance (Input-Output)	C_{I-O}	—	0.6	—	pF	Freq = 1 MHz		
LED-to-Case Thermal Resistance	θ_{LC}	—	467	—	°C/W	Thermocouple located center underside of package		
LED-to-Detector Thermal Resistance	θ_{LD}	—	442	—	°C/W			
Detector-to-Case Thermal Resistance	θ_{DC}	—	126	—	°C/W			

* 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 refers to your equipment level safety specification or Application Note 1074 entitled *Optocoupler Input-Output Endurance Voltage*.

a. In accordance with UL1577, each optocoupler is proof-tested by applying an insulation test voltage ≥ 4500 V_{rms} for 1 second (leakage detection current limit, I_{I-O} ≤ 5 µA).

b. Device is considered a two-terminal device: pins 1, 2, 3, and 4 shorted together and pins 5, 6, 7, and 8 shorted together.

Figure 2: V_{OH} vs. Temperature

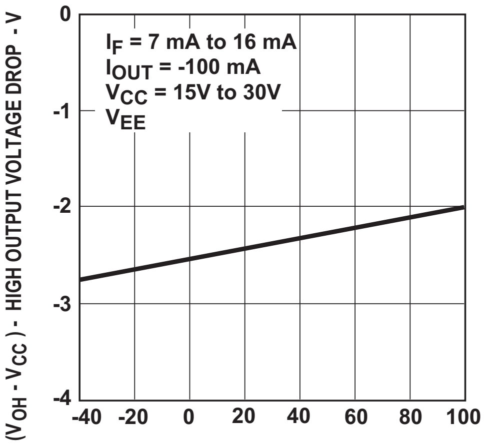


Figure 3: I_{OH} vs. Temperature

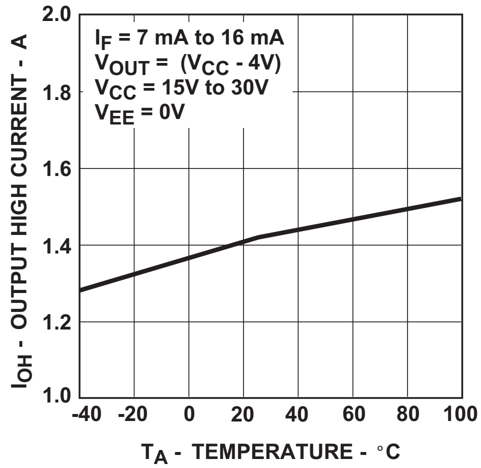


Figure 4: V_{OH} vs. I_{OH}

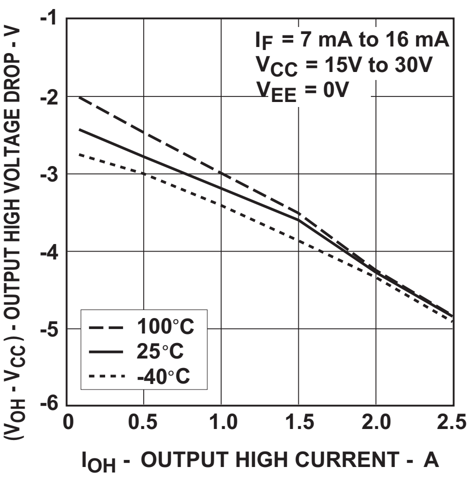


Figure 5: V_{OL} vs. Temperature

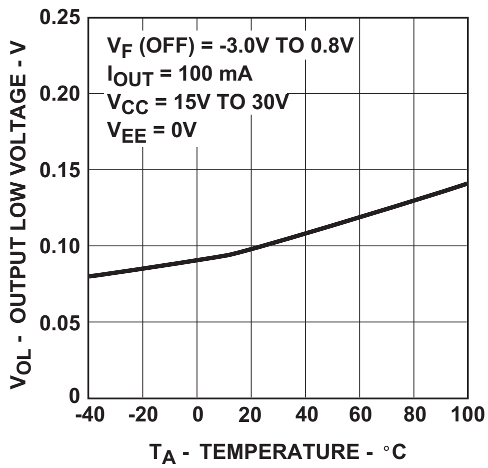


Figure 6: I_{OL} vs. Temperature

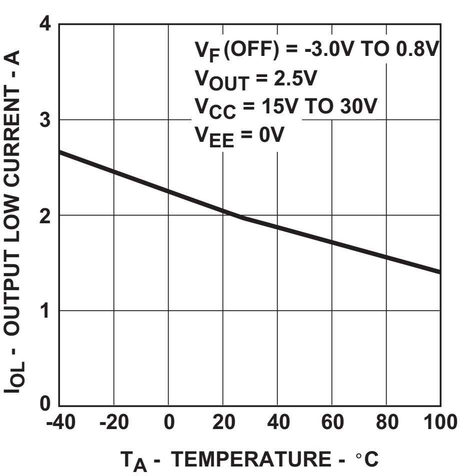


Figure 7: V_{OL} vs. I_{OL}

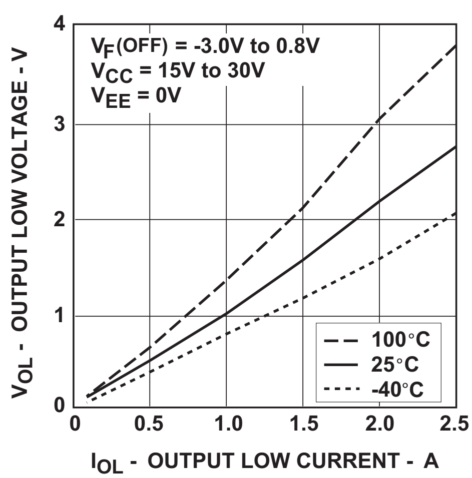


Figure 8: I_{CC} vs. Temperature

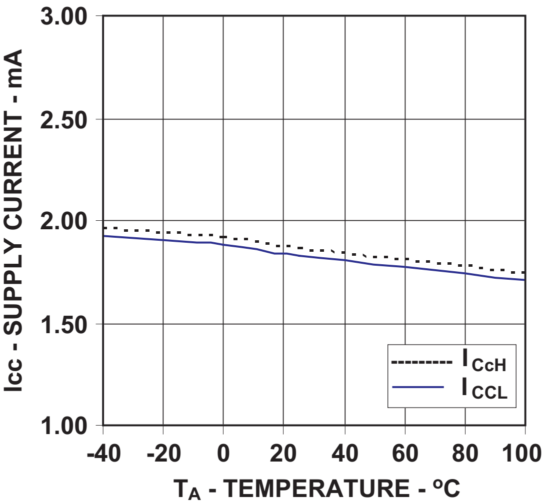


Figure 9: I_{CC} vs. V_{CC}

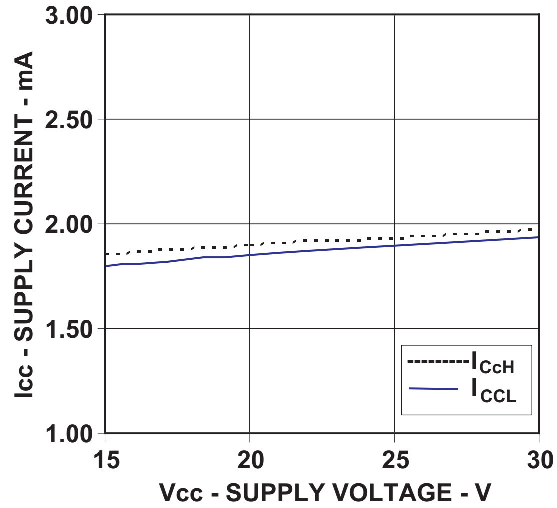


Figure 10: I_{FLH} vs. Temperature

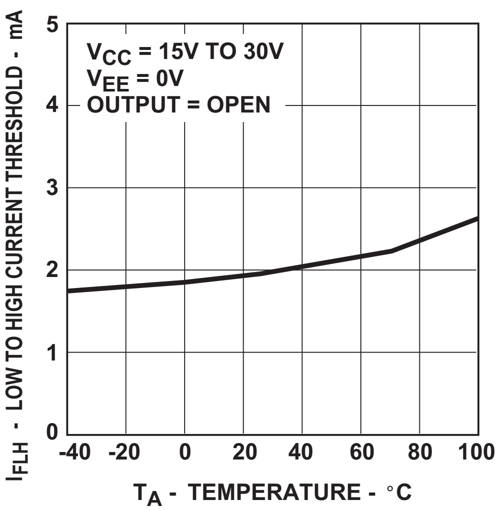


Figure 11: Propagation Delay vs. V_{CC}

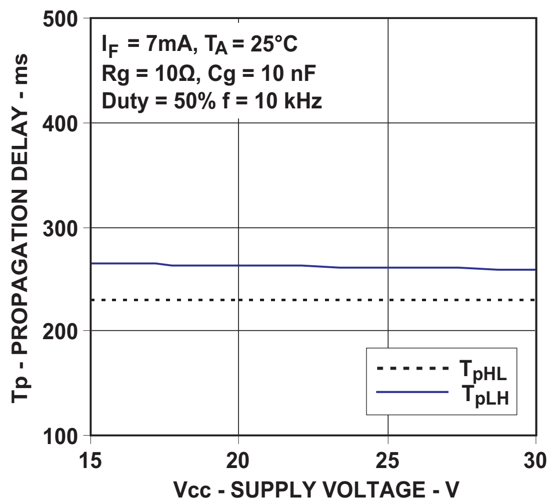


Figure 12: Propagation Delay vs. I_F

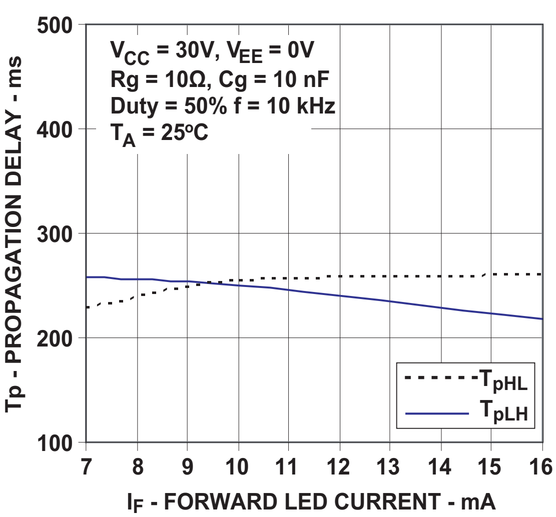


Figure 13: Propagation Delay vs. Temperature

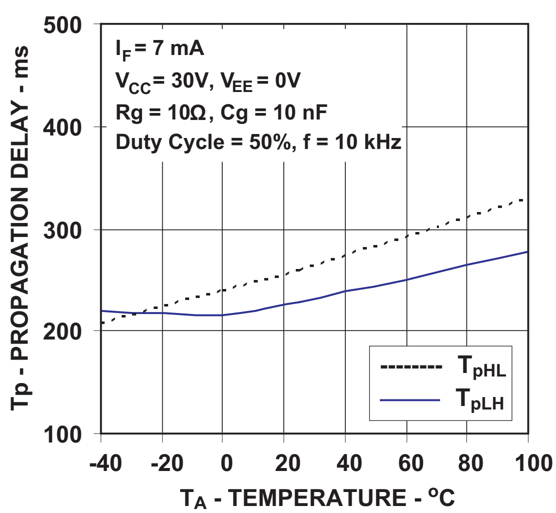


Figure 14: Input Current vs. Forward Voltage

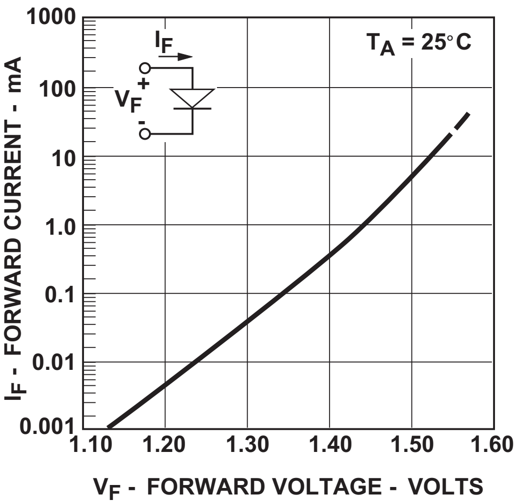


Figure 15: Undervoltage Lockout

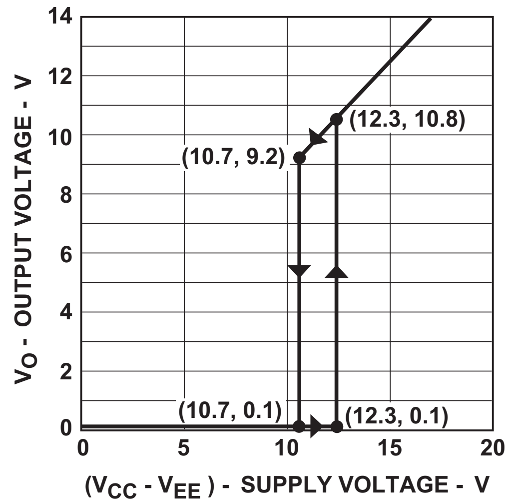


Figure 16: I_{OH} Test Circuit

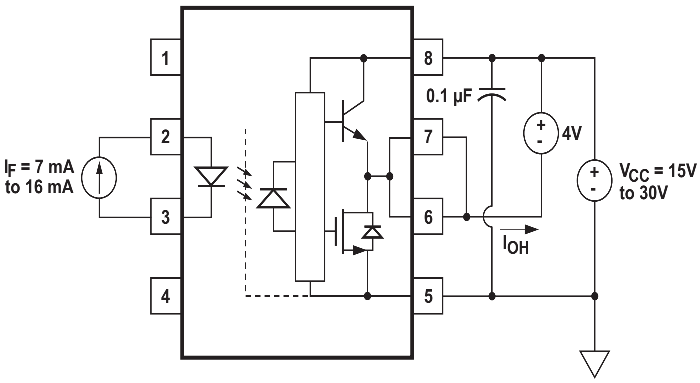


Figure 17: I_{OL} Test Circuit

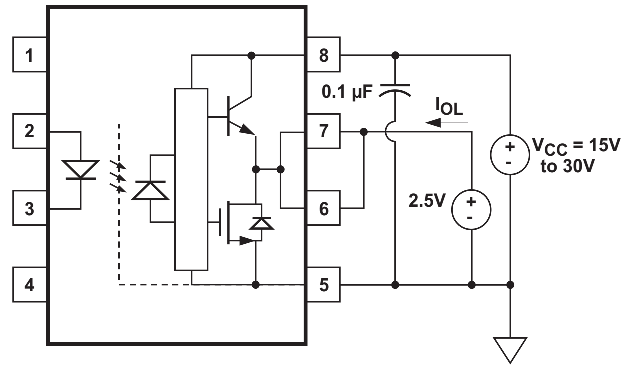


Figure 18: V_{OH} Test Circuit

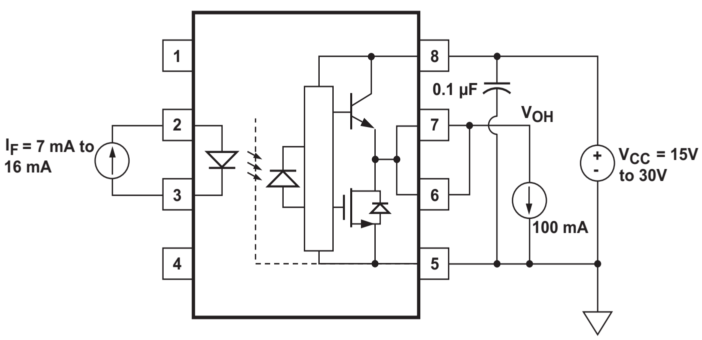


Figure 19: V_{OL} Test Circuit

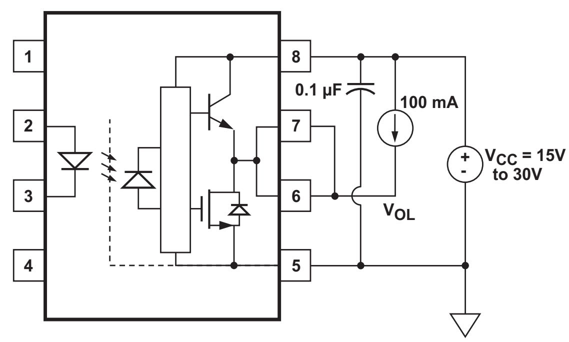


Figure 20: I_{FLH} Test Circuit

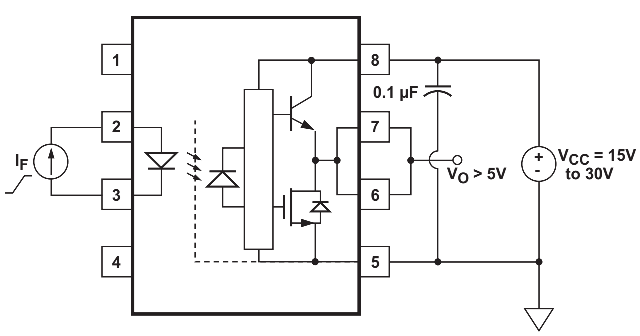


Figure 21: UVLO Test Circuit

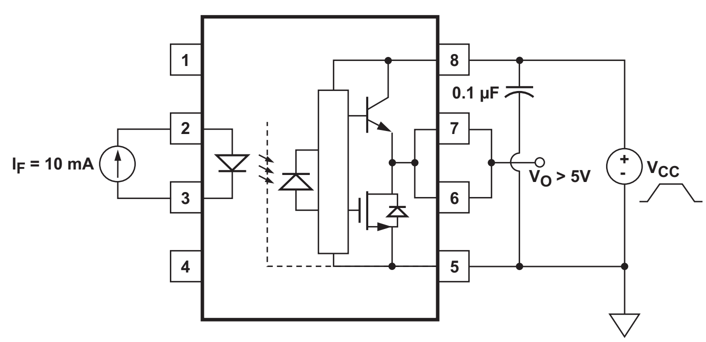


Figure 22: t_{PLH}, t_{PHL}, t_r, and t_f Test Circuit and Waveforms

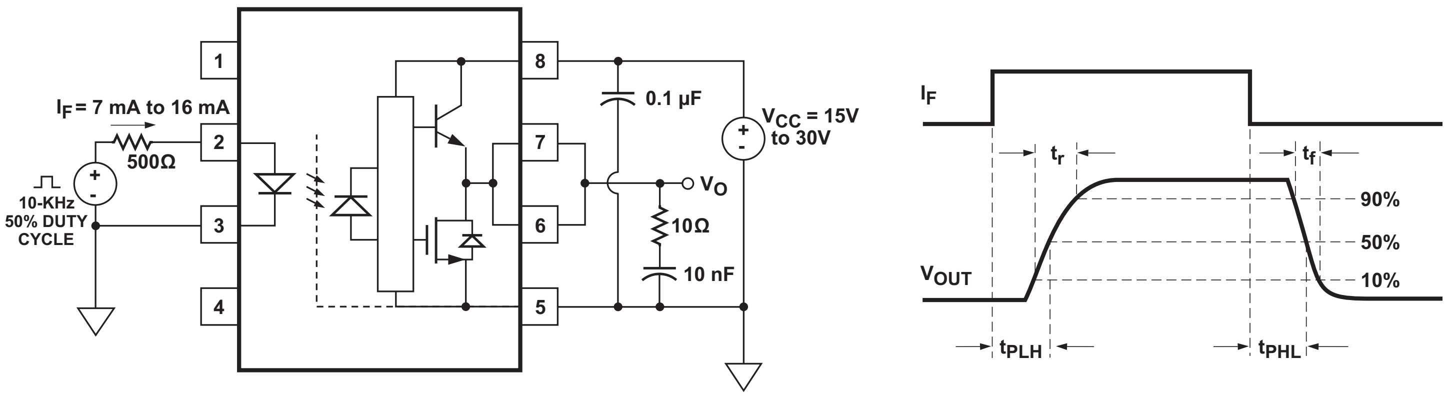


Figure 23: CMR Test Circuit and Waveforms

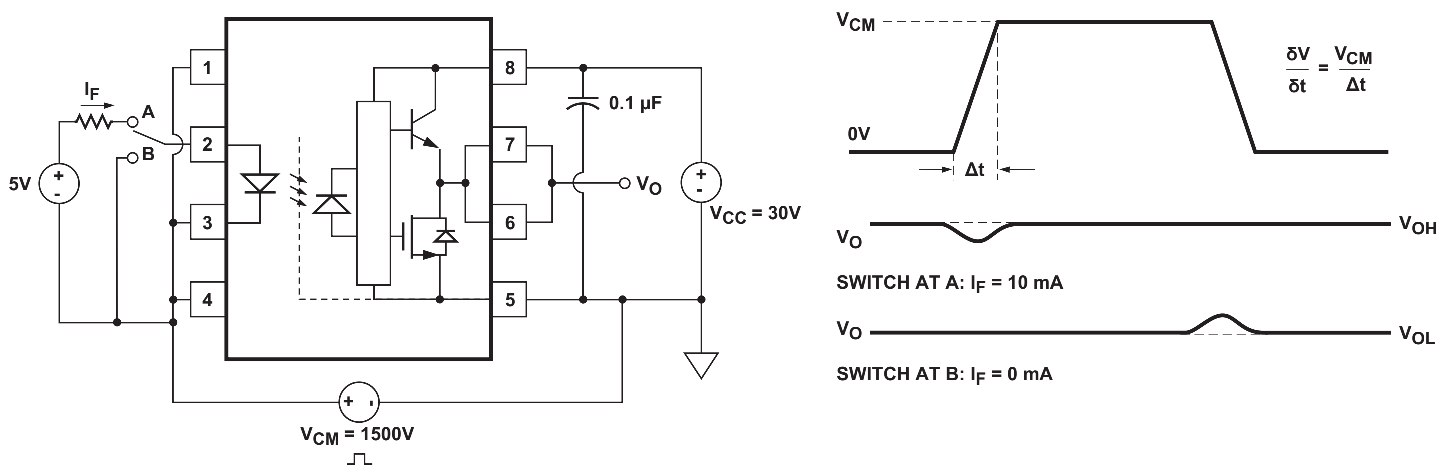


Figure 24: Typical Application Circuit

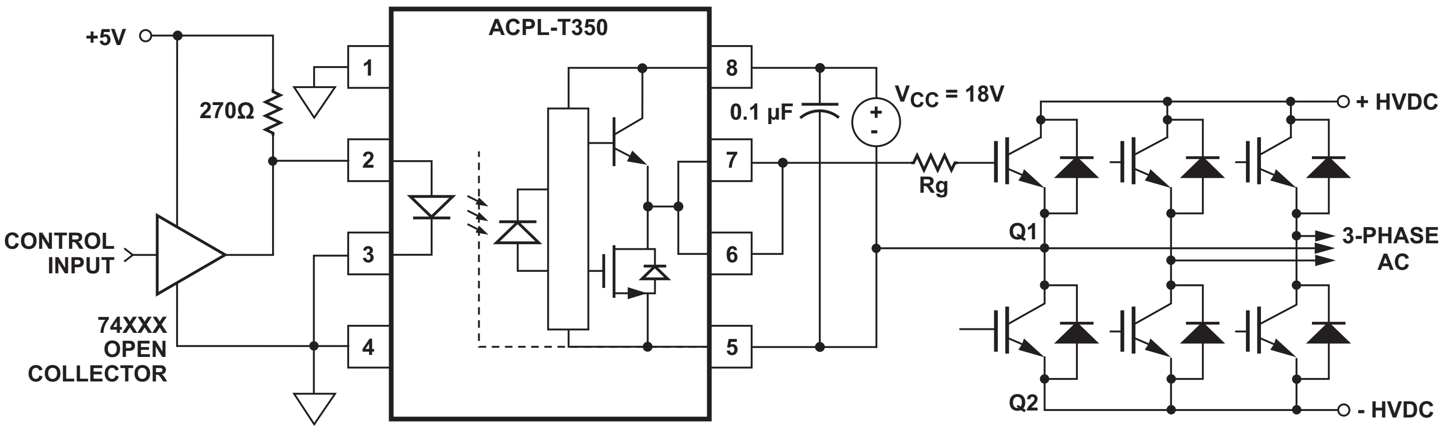
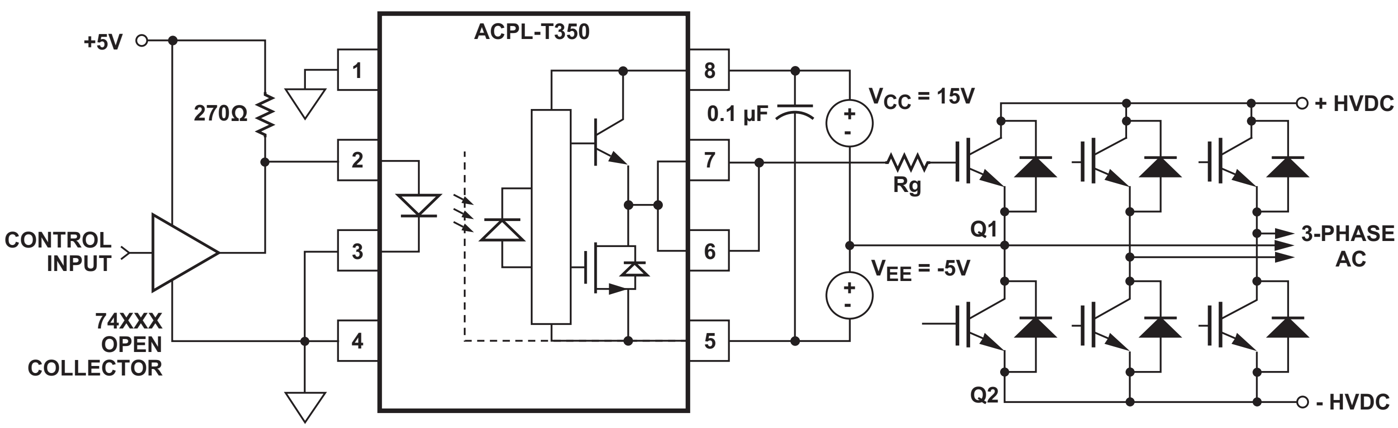


Figure 25: Typical Application Circuit with Negative IGBT Gate Drive



Lead (Pb) Free
RoHS 6 fully compliant

RoHS 6 fully compliant options available; -xxxE denotes a lead-free product