ACPL-H312 and ACPL-K312

2.5 Amp Output Current IGBT Gate Driver Optocoupler with Low I_{CC} & UVLO in Stretched SO8

Data Sheet

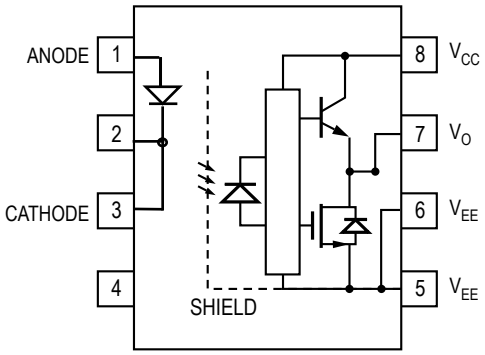
Lead (Pb) Free
RoHS 6 fully compliant

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

Description

The ACPL-H312/K312 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 1200 V/100 A. For IGBTs with higher ratings, the ACPL-H312 /K312 series can be used to drive a discrete power stage which drives the IGBT gate. The ACPL-H312 has an insulation voltage of V_{IORM} = 891 V_{peak} (Option 060). The ACPL-K312 has an isulation voltage of V_{IORM} = 1140Vpeak (Option 060).

Functional Diagram



ACPL-H312/K312

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

Truth Table

LED	$V_{CC} - V_{EE}$ "POSITIVE GOING" (i.e., TURN-ON)	$V_{CC} - V_{EE}$ "NEGATIVE GOING" (i.e., TURN-OFF)	V_O
OFF	0 – 30V	0 – 30V	LOW
ON	0 – 11V	0 – 9.5V	LOW
ON	11 – 13.5V	9.5 – 12V	TRANSITION
ON	13.5 – 30V	12 – 30V	HIGH

Features

- 2.5 A maximum peak output current
- 2.0 A minimum peak output current
- 15 kV/µs minimum Common Mode Rejection (CMR) at V_{CM} = 1500 V
- 0.5 V maximum low level output voltage (V_{OL})
- I_{CC} = 3 mA maximum supply current
- Under Voltage Lock-Out protection (UVLO) with hysteresis
- Package Clearance and Creepage at 8mm (ACPL-K312)
- Wide operating V_{CC} range: 15 to 30 Volts
- 500 ns maximum switching speeds
- Industrial temperature range: -40°C to 100°C
- Safety Approval (Pending)
  - UL Recognized 3750 Vrms for 1 min.
  - CSA Approval
  - IEC/EN/DIN EN 60747-5-2 Approved
    V_{IORM} = 891 Vpeak (Option 060)

Applications

- IGBT/MOSFET gate drive
- Inverter for Industrial Motor
- Inverter for Electrical Home Appliances
- Switching Power Supplies (SPS)

Application Note

- AN5336 – Gate Drive Optocoupler Basic Design

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-H312 /K312 is UL Recognized with 3750 Vrms for 1 minute per UL1577.

Part number	Option RoHS Compliant	Package	Surface Mount	Tape & Reel	IEC/EN/DIN EN 60747-5-2	Quantity
ACPL-H312 ACPL-K312	-000E	Stretched SO-8	X			80 per tube
	-500E		X	X		1000 per reel
	-060E		X		X	80 per tube
	-560E		X	X	X	1000 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.

Example 1:

ACPL-H312-560E to order product of Stretched SO8 Surface Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-2 Safety Approval in RoHS compliant.

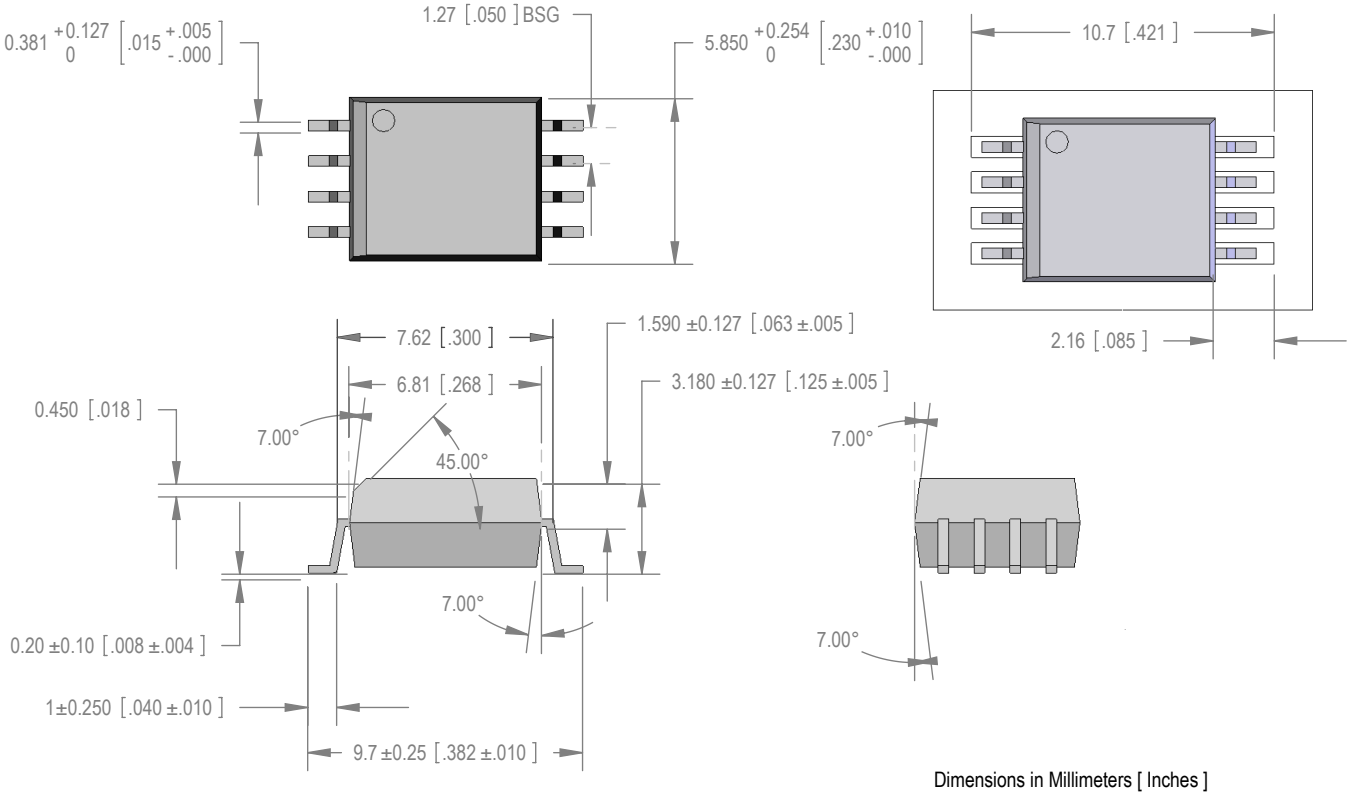
Example 2:

ACPL-H312-000E to order product of Stretched SO8 Surface Mount package in Tube Packaging and RoHS compliant.

Option datasheets are available. Contact your Avago sales representative or authorized distributor for information.

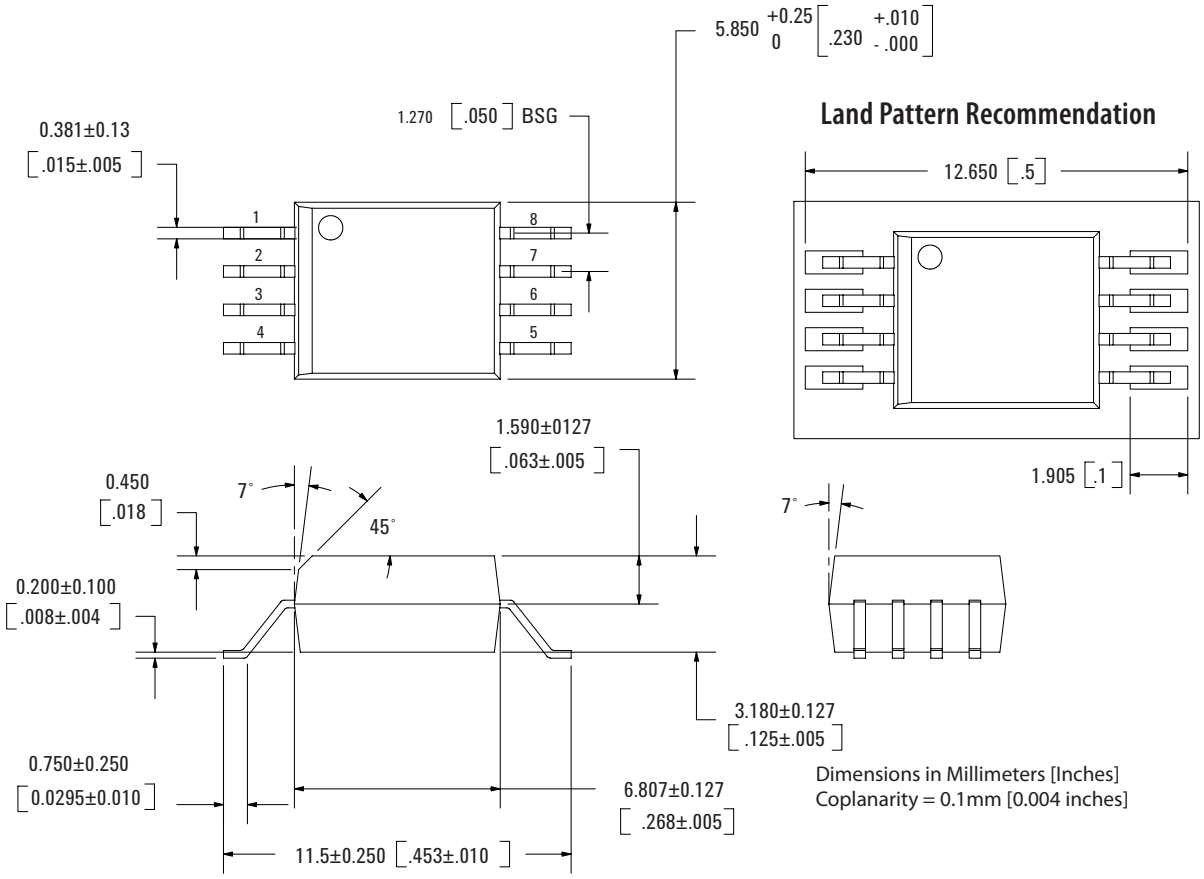
Package Outline Drawings

ACPL-H312 Outline Drawing - Stretched S08

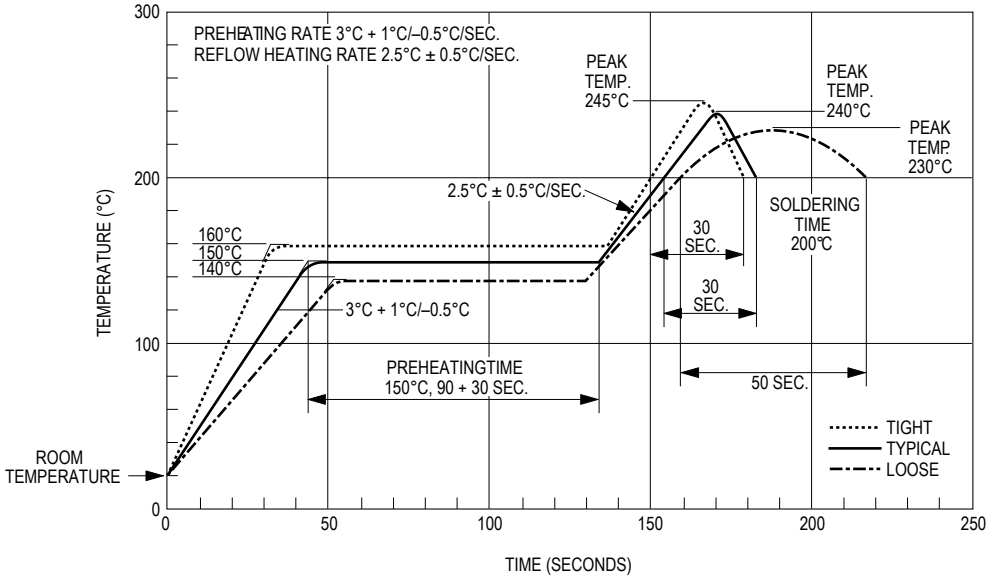


Dimensions in Millimeters [Inches]
Lead Coplanarity = 0.1mm [0.004 Inches]

ACPL-K312 Outline Drawing - Stretched S08

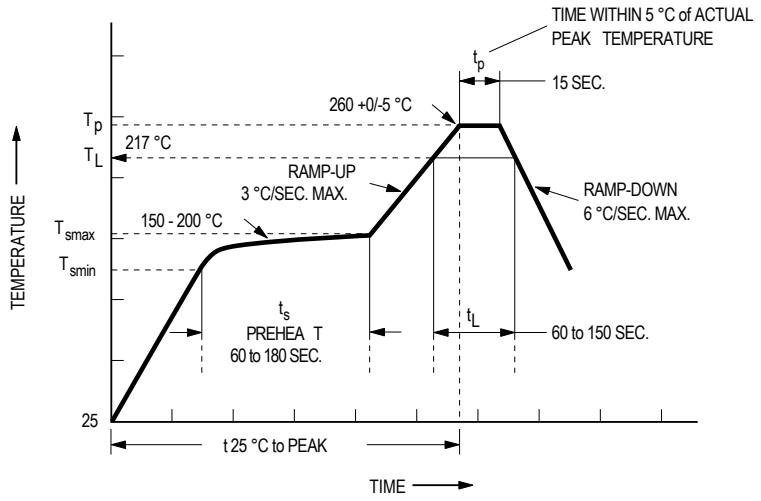


Recommended Solder Reflow Temperature Profile



Note: Non-halide flux should be used

Recommended Pb-Free IR Profile



Note:
The time from 25°C to PEAK TEMPERATURE = 8minutes max.
T_{smax}=200°C, T_{smin}=150°C

Non-halide flux should be used

Regulatory Information

The ACPL-H312/K312 is pending approval by the following organizations:

IEC/EN/DIN EN 60747-5-2 (ACPL-H312/K312 Option 060 only)

Approval under:
IEC 60747-5-2 :1997 + A1:2002
EN 60747-5-2:2001 + A1:2002
DIN EN 60747-5-2 (VDE 0884 Teil 2):2003-01

UL

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

CSA

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

Table 1. IEC/EN/DIN EN 60747-5-2 Insulation Characteristics [1] (ACPL-H312/K312 Option 060)

Description	Symbol	ACPL-H312	ACPL-K312	Unit
Installation classification per DIN VDE 0110/1.89, Table 1				
for rated mains voltage ≤ 150 V_{rms}		I – IV	I - IV	
for rated mains voltage ≤ 300 V_{rms}		I – IV	I - IV	
for rated mains voltage ≤ 450 V_{rms}		I – III	I - III	
for rated mains voltage ≤ 600 V_{rms}		I – III	I - III	
for rated mains voltage ≤ 1000 V_{rms}			I - II	
Climatic Classification		55/100/21	55/100/21	
Pollution Degree (DIN VDE 0110/1.89)		2	2	
Maximum Working Insulation Voltage	V_{IORM}	891	1140	V_{peak}
Input to Output Test Voltage, Method b[1] V_{IORM} x 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 [1] V_{IORM} x 1.5=V_{PR}, Type and Sample Test, t_m=60 sec, Partial discharge < 5 pC	V_{PR}	1336	1710	V_{peak}
Highest Allowable Overvoltage (Transient Overvoltage t_{ini} = 10 sec)	V_{IOTM}	6000	6000	V_{peak}
Safety-limiting values – maximum values allowed in the event of a failure.				
Case Temperature	T_S	175	175	°C
Input Current	$I_{S, INPUT}$	230	230	mA
Output Power	$P_{S, OUTPUT}$	600	600	mW
Insulation Resistance at T_S, V_{IO} = 500 V	R_S	$>10^9$	$>10^9$	Ω

Notes:
1. Refer to the optocoupler section of the Isolation and Control Components Designer's Catalog, under Product Safety Regulations section, (IEC/EN/DIN EN 60747-5-2) for a detailed description of Method a and Method b partial discharge test profiles.
2. 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 2. Insulation and Safety Related Specifications

Parameter	Symbol	ACPL-H312	ACPL-K312	Units	Conditions
Minimum External Air Gap (Clearance)	L(101)	7.0	8.0	mm	Measured from input terminals to output terminals, shortest distance through air.
Minimum External Tracking (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)

Notes:
1. All Avago 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, 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. There are recommended techniques such as grooves and ribs which may 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 pollution degree and insulation level.

Table 3. Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Note
Storage Temperature	T_S	-55	125	°C	
Operating Temperature	T_A	-40	100	°C	
Junction Temperature	T_J		125	°C	
Average Input Current	$I_{F(AVG)}$		25	mA	1
Peak Transient Input Current (<1 µs pulse width, 300pps)	$I_{F(TRAN)}$		1.0	A	
Reverse Input Voltage	V_R		5	V	
"High" Peak Output Current	$I_{OH(PEAK)}$		2.5	A	2
"Low" Peak Output Current	$I_{OL(PEAK)}$		2.5	A	2
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	3
Total Power Dissipation	P_T		295	mW	4
Lead Solder Temperature	260°C for 10 sec., 1.6 mm below seating plane				
Solder Reflow Temperature Profile	See Package Outline Drawings section				

Table 4. 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	
Operating Temperature	T_A	- 40	100	°C	

Table 5. Electrical Specifications (DC)

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

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
High Level Output Current	I_{OH}	0.5	1.5		A	$V_O = V_{CC} - 4$ V	2, 3, 17	5
		2			A	$V_O = V_{CC} - 15$ V		2
Low Level Output Current	I_{OL}	0.5	2.0		A	$V_O = V_{EE} + 2.5$ V	5, 6, 18	5
		2			A	$V_O = V_{EE} + 15$ V		2
High Level Output Voltage	V_{OH}	V_{CC}-4	V_{CC}-3		V	I_O = -100 mA	1, 3, 19	6, 7
Low Level Output Voltage	V_{OL}		0.1	0.5	V	I_O = 100 mA	4, 6, 20	
High Level Supply Current	I_{CCH}		1.8	3.0	mA	Output open, I_F = 7 to 16 mA	7, 8	
Low Level Supply Current	I_{CCL}		1.8	3.0	mA	Output open, V_F = -3.6 to +0.8 V	7, 8	
Threshold Input Current Low to High	I_{FLH}		2.3	5	mA	I_O = 0 mA, V_O > 5 V	9, 15, 21	
Threshold Input Voltage High to Low	V_{FHL}	0.8			V	I_O = 0 mA, V_O > 5 V		
Input Forward Voltage	V_F	1.2	1.5	1.8	V	I_F = 10 mA	16	
Temperature Coefficient of Input Forward Voltage	$\Delta V_F/\Delta T_A$		-1.6		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 = 0 V		
UVLO Threshold	V_{UVLO+}	11	12.3	13.5	V	I_F = 10 mA, V_O > 5 V	22	
	V_{UVLO-}	9.5	11.0	12	V	I_F = 10 mA, V_O > 5 V	22	
UVLO Hysteresis	$UVLO_{HYS}$		1.4		V	I_F = 10 mA, V_O > 5 V		

Table 6. Switching Specifications (AC)

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

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to High Output Level	t_{PLH}	0.05	0.28	0.5	µs	R_g = 10 Ω, C_g = 10 nF, f = 10 kHz, Duty Cycle = 50%	12, 13, 14, 23	8
Propagation Delay Time to Low Output Level	t_{PHL}	0.05	0.26	0.5	µs			
Pulse Width Distortion	PWD			0.3	µs			9
Propagation Delay Difference Between Any Two Parts or Channels	PDD (t_{PHL} – t_{PLH})	-0.35		0.35	µs			10
Rise Time	t_R		0.05		µs		23	
Fall Time	t_F		0.05		µs			
Output High Level Common Mode Transient Immunity	$\|CM_H\|$	15	30		kV/µs	T_A = 25°C, I_F = 10 to 16 mA, V_{CM} = 1500 V V_{CC} = 30 V	24	11, 12
Output Low Level Common Mode Transient Immunity	$\|CM_L\|$	15	30		kV/µs	T_A = 25°C, V_F = 0 V, V_{CM} = 1500 V V_{CC} = 30 V	24	11, 13

Table 7. Package Characteristics

Over recommended temperature (T_A = -40 to 100°C) unless otherwise specified. All typicals 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 min., T_A = 25°C		14, 15
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O} = 500 V		15
Capacitance (Input-Output)	C_{I-O}		0.6		pF	Freq= 1MHz		
LED-to-Case Thermal Resistance	θ_{LC}		***		°C/W	Thermal Model is located in the application section	27	
LED-to-Detector Thermal Resistance	θ_{LD}		***		°C/W		27	
Detector-to-Case Thermal Resistance	θ_{DC}		***		°C/W		27	

** 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 Avago Application Note 1074 entitled "Optocoupler Input-Output Endurance Voltage."

*** Refer to Thermal Model ACPL-H312/K312

Notes:

1. Derate linearly above 70° C free-air temperature at a rate of 0.3 mA/°C.
2. Maximum pulse width = 10 µs.
3. Derate linearly above 85° C free-air temperature at a rate of 4.1 mW/°C.
4. Derate linearly above 85° C free-air temperature at a rate of 3.4 mW/°C. The maximum LED junction temperature should not exceed 125°C.
5. Maximum pulse width = 50 µs
6. 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.
7. Maximum pulse width = 1 ms
8. This load condition approximates the gate load of a 1200 V/100A IGBT.
9. Pulse Width Distortion (PWD) is defined as $|t_{PHL} - t_{PLH}|$ for any given device.
10. The difference between tPHL and t_{PLH} between any two ACPL-H312/K312 parts under the same test condition.
11. Pins 3 and 4 need to be connected to LED common.
12. Common mode transient immunity in the high state is the maximum tolerable dV_{CM}/dt of the common mode pulse, V_{CM}, to assure that the output will remain in the high state (i.e., V_O > 15.0 V).
13. Common mode transient immunity in a low state is the maximum tolerable dV_{CM}/dt of the common mode pulse, VCM, to assure that the output will remain in a low state (i.e., V_O < 1.0 V).
14. In accordance with UL1577, each optocoupler is proof tested by applying an insulation test voltage ≥ 4500 Vrms for 1 second (leakage detection current limit, I_{I-O} ≤ 5 µA).
15. Device considered a two-terminal device: pins 1, 2, 3, and 4 shorted together and pins 5, 6, 7, and 8 shorted together.

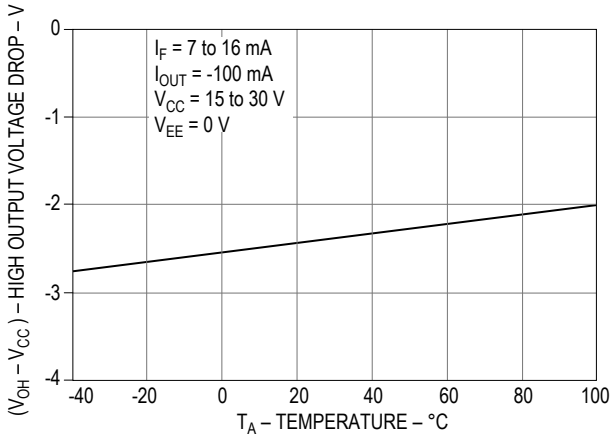


Figure 1. V_{OH} vs. Temperature

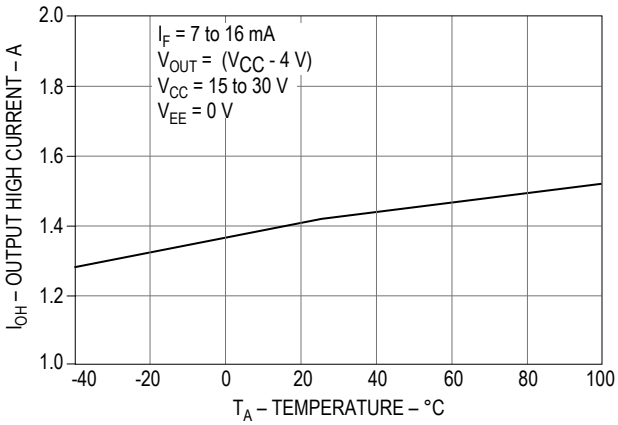


Figure 2. I_{OH} vs. Temperature

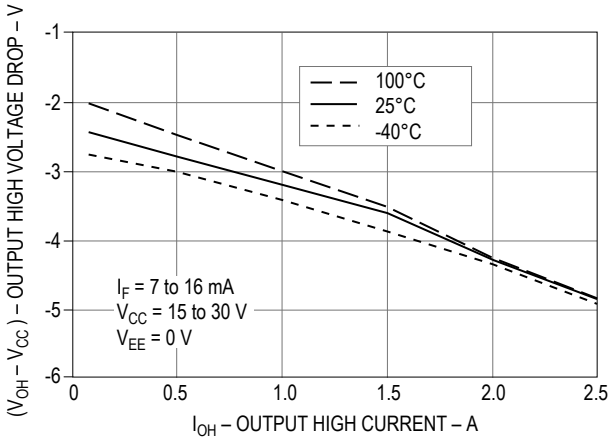


Figure 3. V_{OH} vs. I_{OH}

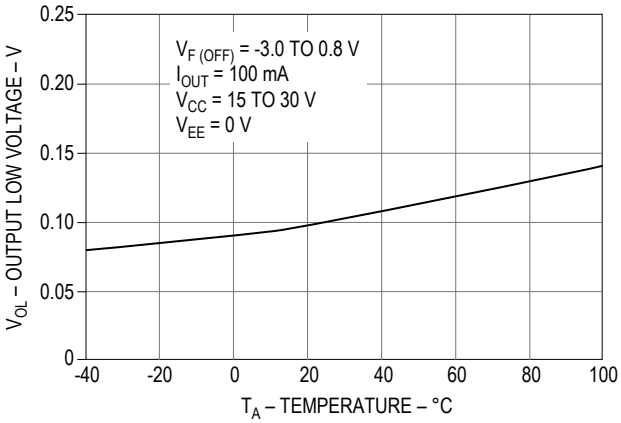


Figure 4. V_{OL} vs. Temperature

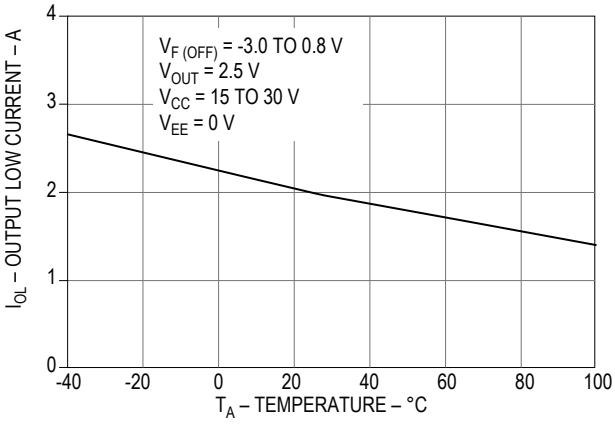


Figure 5. I_{OL} vs. Temperature

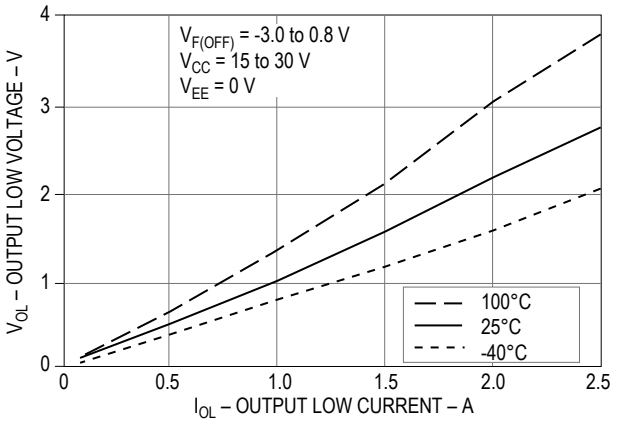


Figure 6. V_{OL} vs. I_{OL}.

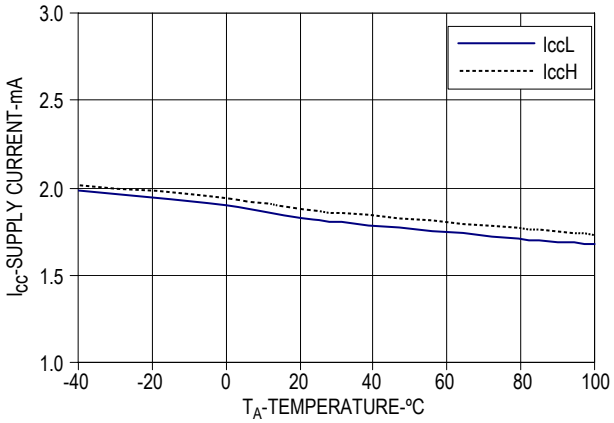


Figure 7. I_{CC} vs. Temperature

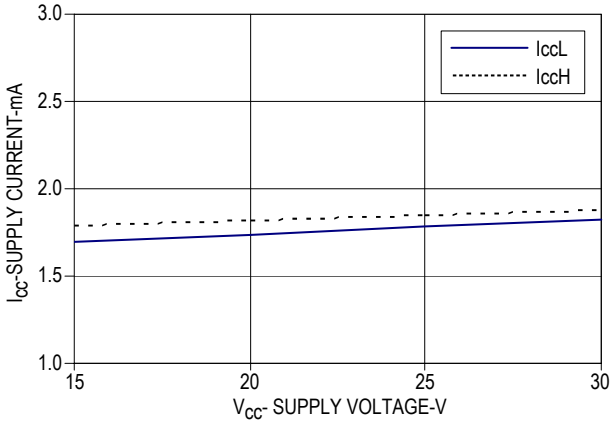


Figure 8. I_{CC} vs. V_{CC}

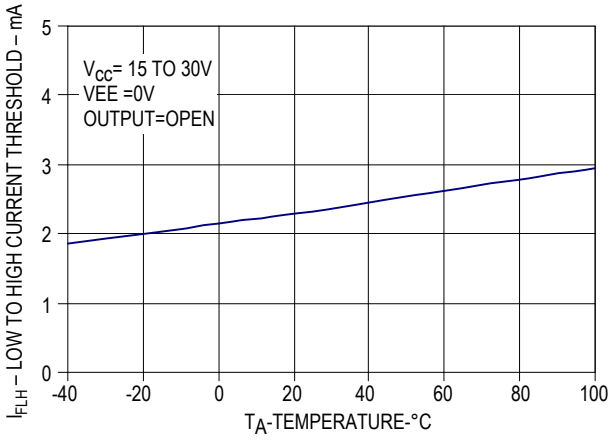


Figure 9. I_{FLH} vs. Temperature

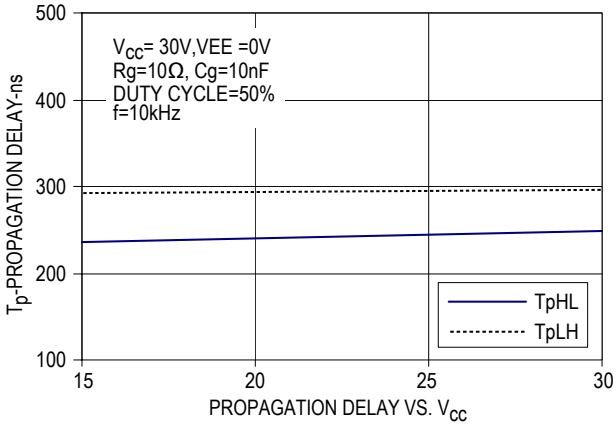


Figure 10. Propagation delay vs. V_{CC}

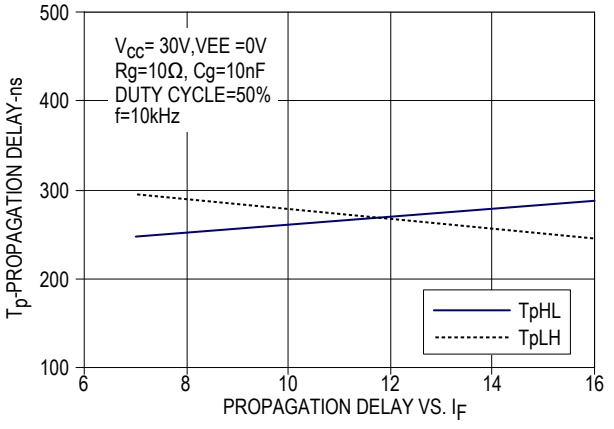


Figure 11. Propagation delay vs. I_F

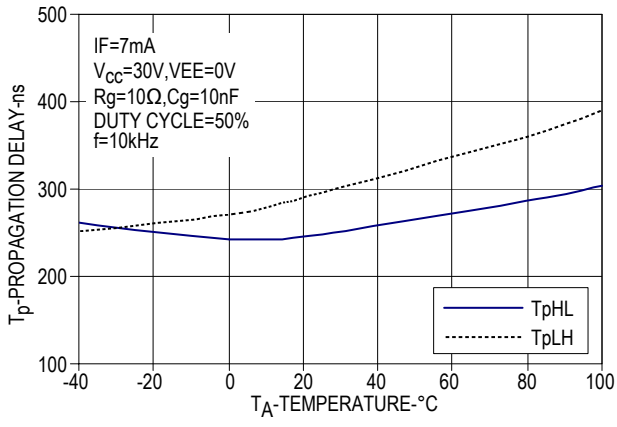


Figure 12. Propagation delay vs. Temperature

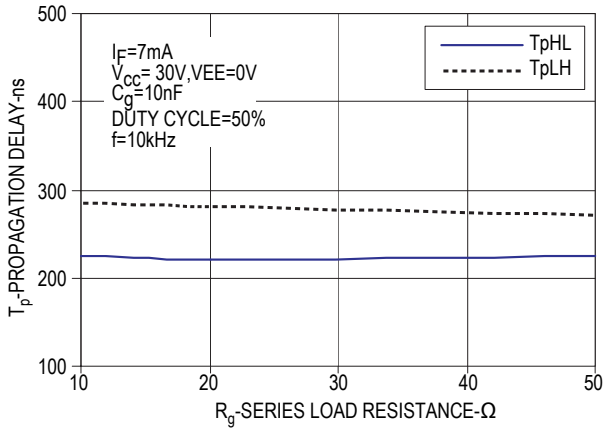


Figure 13. Propagation Delay vs. R_g

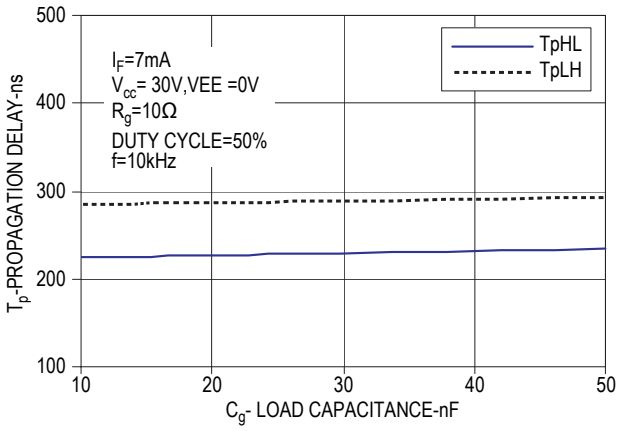


Figure 14. Propagation Delay vs. C_g

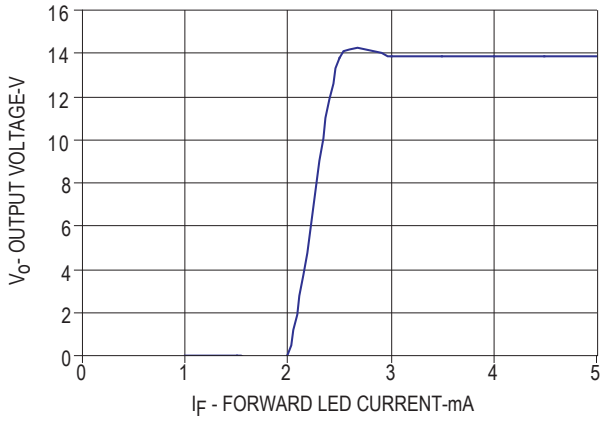


Figure 15. Transfer Characteristics

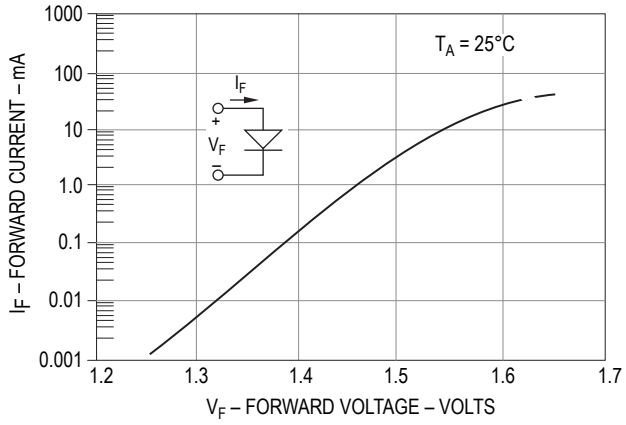


Figure 16. Input Current vs. Forward Voltage

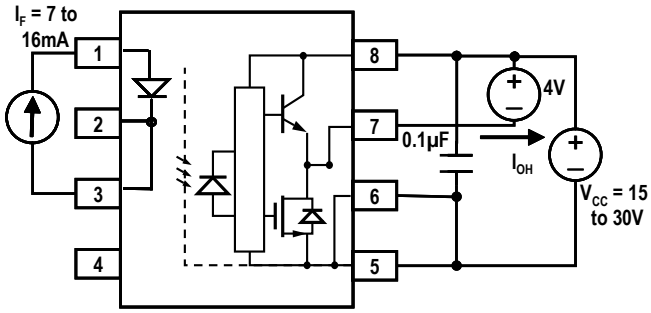


Figure 17. I_{OH} test circuit

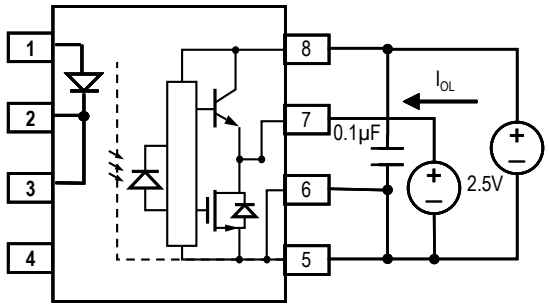


Figure 18. I_{OL} test circuit

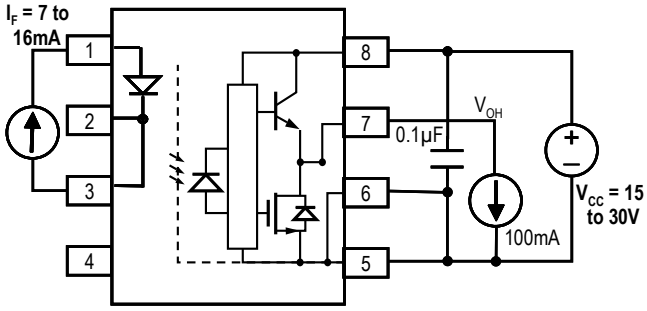


Figure 19. V_{OH} test circuit

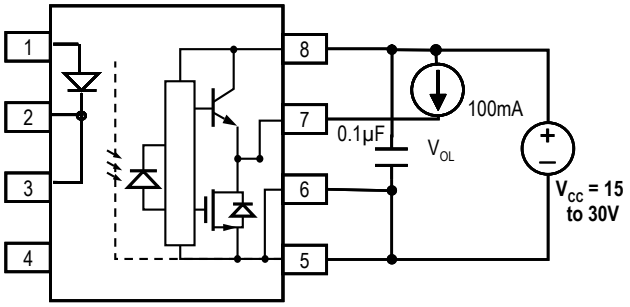


Figure 20. V_{OL} test circuit

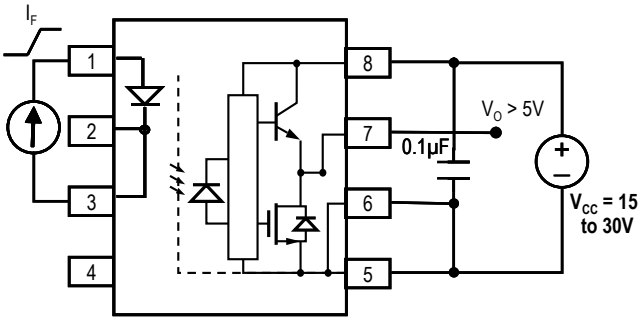


Figure 21. I_{FLH} test circuit

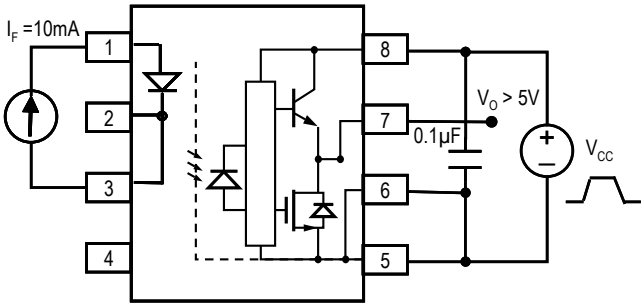


Figure 22. UVLO test circuit

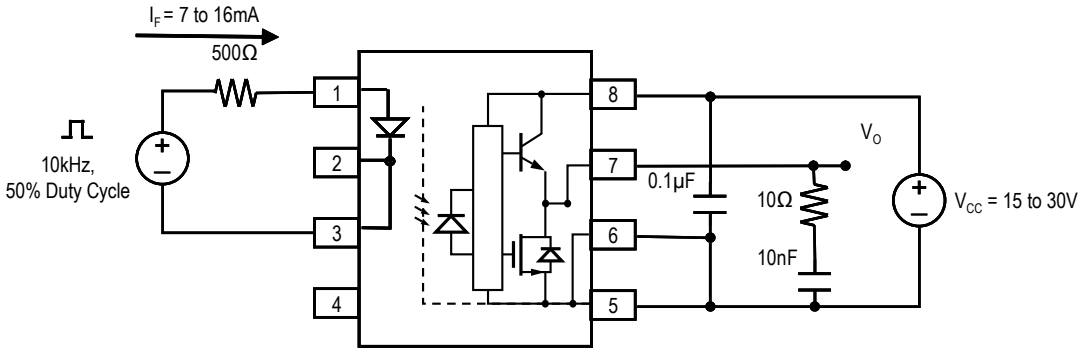


Figure 23. t_{PLH}, t_{PHL}, t_f, t_r, test circuit and waveforms

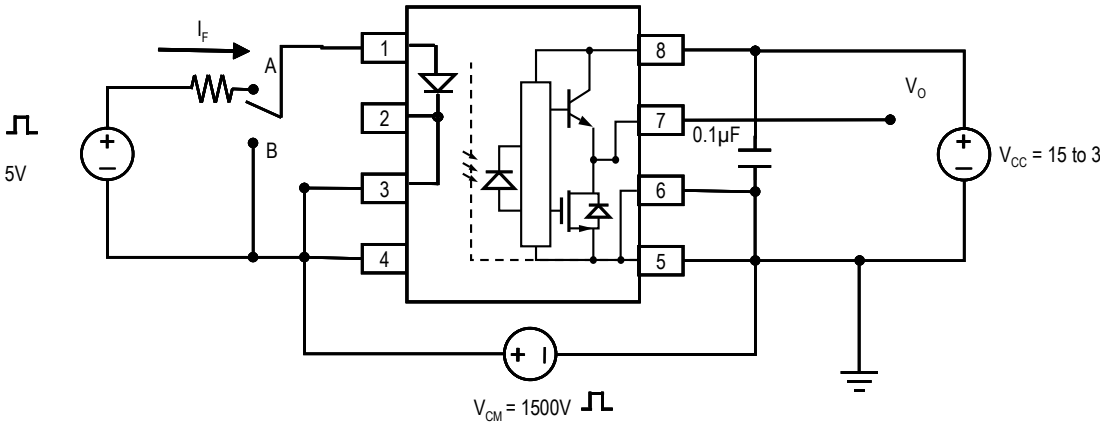


Figure 24. CMR test circuit and waveforms

Typical Application Circuit

Figure 25 and 26 show two gate driver application circuit using ACPL-H312/K312. AN5336 application note describes general method on gate drive optocoupler design

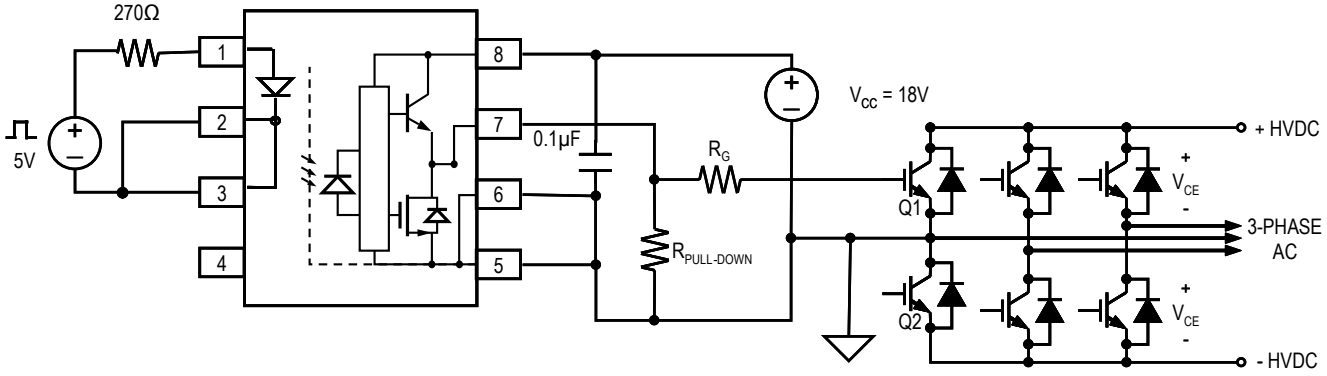


Figure 25. Recommended LED drive and application circuit

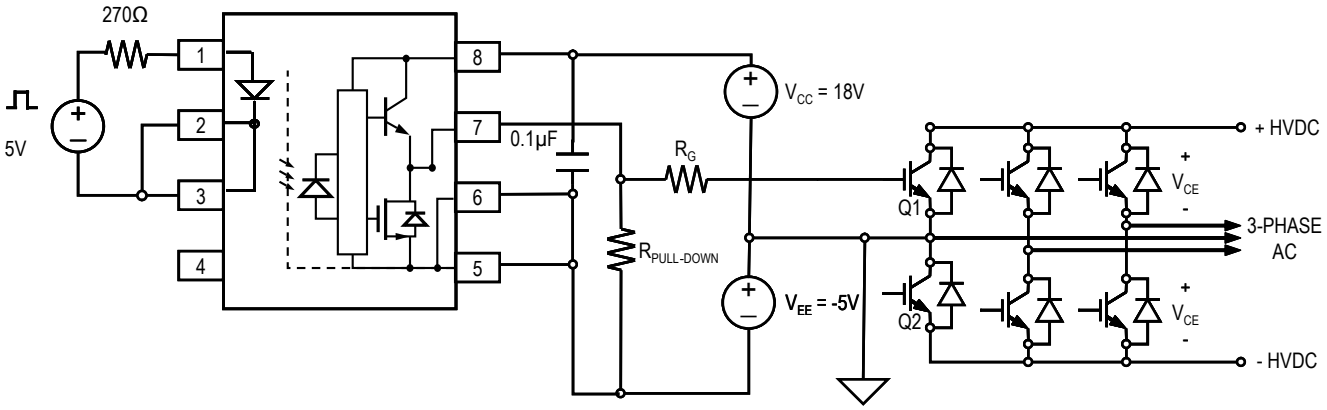


Figure 26. ACPL-H312/K312 typical application circuit with negative IGBT gate drive

Thermal Model for ACPL-H312/K312 Streched-SO8 Package Optocoupler

Definitions

R_{11}: Junction to Ambient Thermal Resistance of LED due to heating of LED

R_{12}: Junction to Ambient Thermal Resistance of LED due to heating of Detector (Output IC)

R_{21}: Junction to Ambient Thermal Resistance of Detector (Output IC) due to heating of LED.

R_{22}: Junction to Ambient Thermal Resistance of Detector (Output IC) due to heating of Detector (Output IC).

P_1: Power dissipation of LED (W).

P_2: Power dissipation of Detector / Output IC (W).

T_1: Junction temperature of LED (˚C).

T_2: Junction temperature of Detector (˚C).

T_a: Ambient temperature.

ΔT_1: Temperature difference between LED junction and ambient (˚C).

ΔT_2: Temperature deference between Detector junction and ambient.

Ambient Temperature: Junction to Ambient Thermal Resistances were measured approximately 1.25cm above optocoupler at ~23˚C in still air

Description

This thermal model assumes that an 8-pin single-channel plastic package optocoupler is soldered into a 7.62 cm x 7.62 cm printed circuit board (PCB). The temperature at the LED and Detector junctions of the optocoupler can be calculated using the equations below.

$T_1 = (R_{11} * P_1 + R_{12} * P_2) + T_a$ -- (1)

$T_2 = (R_{21} * P_1 + R_{22} * P_2) + T_a$ -- (2)

Jedec Specifications	R_{11}	R_{12}, R_{21}	R_{22}
low K board	468	253	341
high K board	399	169	256

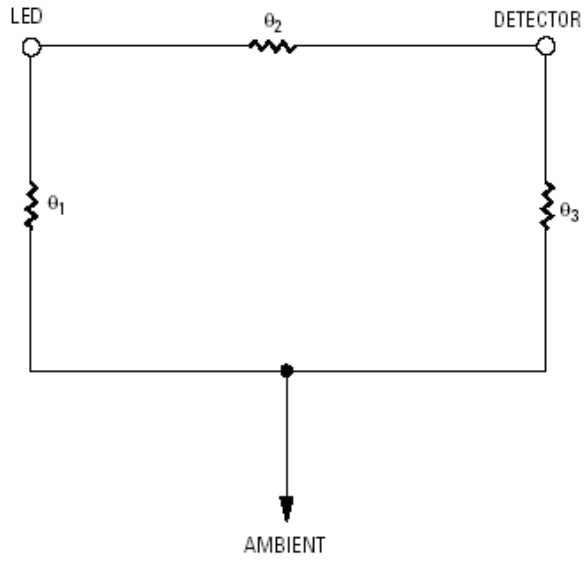


Figure 27. Thermal Model-B Diagram

Notes:
1. Maximum junction temperature for above parts: 125 °C.

Quick Gate Drive Design Example using ACPL-H312/K312

The total power dissipation (PT) is equal to the sum of the LED input-side power (PI) and detector output-side power (PO) dissipation:

$PT = PI + PO$

$PI = I_{F(ON),max} * V_{F,max}$

where,

$I_{F(ON),max}$ = 16mA (Table 4)

$V_{F,max}$ = 1.8V (Table 5)

$PO = PO(BIAS) + PO(SWTICH) = I_{CC2} * (V_{CC2} – V_{EE}) + \Delta V_{GE} * Q_G * f_{SWITCH}$

where,

PO(BIAS) = steady-state power dissipation in the driver due to biasing the device.

PO(SWITCH) = power dissipation in the driver due to charging and discharging of power device gate capacitances.

I_{CC2} = Supply Current to power internal circuity = 3.0mA (Table 5)

$\Delta V_{GE} = V_{CC2} + |V_{EE}| = 18 – (-5V) = 23V$ (Application example)

Q_G = Total gate charge of the IGBT or MOSFET as described in the manufacturer specification = 240nC (approximation of 100A IGBT which can be obtained from IGBT datasheet)

f_{SWITCH} = switching frequency of application = 10kHz

Similarly using the maximum supply current I_{CC2} = 3.0 mA.

PI = 16 mA * 1.8 V = 28.8mW

PO = PO(BIAS) + PO(SWITCH)

= 3.0 mA * (18 V – (–5 V)) + (18V + 5V) * 240nC * 10 kHz

= 69mW + 55.2mW

= 124.2 mW

Using the given thermal resistances and thermal model formula in this datasheet, we can calculate the junction temperature for both LED and the output detector. Both junction temperature should be within the absolute maximum rating. For this application example, we set the ambient temperature as 80 °C and use the high conductivity thermal resistances.

LED junction temperature,

$T1 = (R_{11} * P_1 + R_{12} * P_2) + T_a$

$= (399 * 28.8 + 164.1 * 124.2) + 80$

$= 31.9 + 80 = 111.9$ °C

Output IC junction temperature,

$T2 = (R_{21} \times P_1 + R_{22} \times P_2) + T_a$

$= (164.1 * 28.8 + 251 * 124.2) + 80$

$= 35.9 + 80 = 115.9$ °C

In this example, both temperature are within the maximum 125°C. If the juntion temperature is higher than the maximum junction temperature rating, the desired specification must be derated according.

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