

# ACPL-H312 and ACPL-K312

## 2.5 Amp Output Current IGBT Gate Driver Optocoupler with Low $I_{CC}$ & UVLO in Stretched S08



### Data Sheet



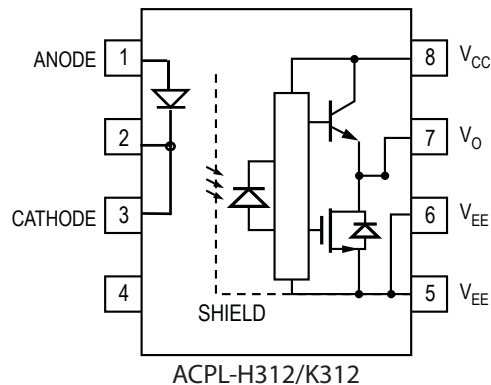
**Lead (Pb) Free**  
RoHS 6 fully compliant

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 insulation voltage of  $V_{IORM} = 1140 V_{peak}$  (Option 060).

#### Functional Diagram



Note: A 0.1  $\mu F$  bypass capacitor must be connected between pins  $V_{CC}$  and  $V_{EE}$ .

#### Truth Table

| LED | $V_{CC} - V_{EE}$<br>"POSITIVE GOING"<br>(i.e., TURN-ON) | $V_{CC} - V_{EE}$<br>"NEGATIVE GOING"<br>(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/ $\mu s$  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:  $-40^{\circ}C$  to  $100^{\circ}C$
- Safety Approval
  - UL1577 recognized
    - 3750  $V_{rms}$  for 1 minute for ACPL-H312
    - 5000  $V_{rms}$  for 1 minute for ACPL-K312
  - CSA Approved
  - IEC/EN/DIN EN 60747-5-2 Approved
    - $V_{IORM} = 891 V_{peak}$  for ACPL-H312
    - $V_{IORM} = 1140 V_{peak}$  for ACPL-K312

#### 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 UL1577 recognized (3750 V<sub>rms</sub> for 1 minute for ACPL-H312 and 5000 V<sub>rms</sub> for 1 minute for ACPL-K312)

| Part number | Option         | Package           | Surface Mount | Tape & Reel | UL 5000 V <sub>rms</sub> /<br>1 Minute rating | IEC/EN/DIN<br>EN 60747-5-2 | Quantity      |
|-------------|----------------|-------------------|---------------|-------------|-----------------------------------------------|----------------------------|---------------|
|             | RoHS Compliant |                   |               |             |                                               |                            |               |
| ACPL-H312   | -000E          | Stretched<br>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 |
| ACPL-K312   | -000E          | Stretched<br>SO-8 | X             |             | X                                             |                            | 80 per tube   |
|             | -500E          |                   | X             | X           | X                                             |                            | 1000 per reel |
|             | -060E          |                   | X             |             | X                                             | X                          | 80 per tube   |
|             | -560E          |                   | X             | 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:

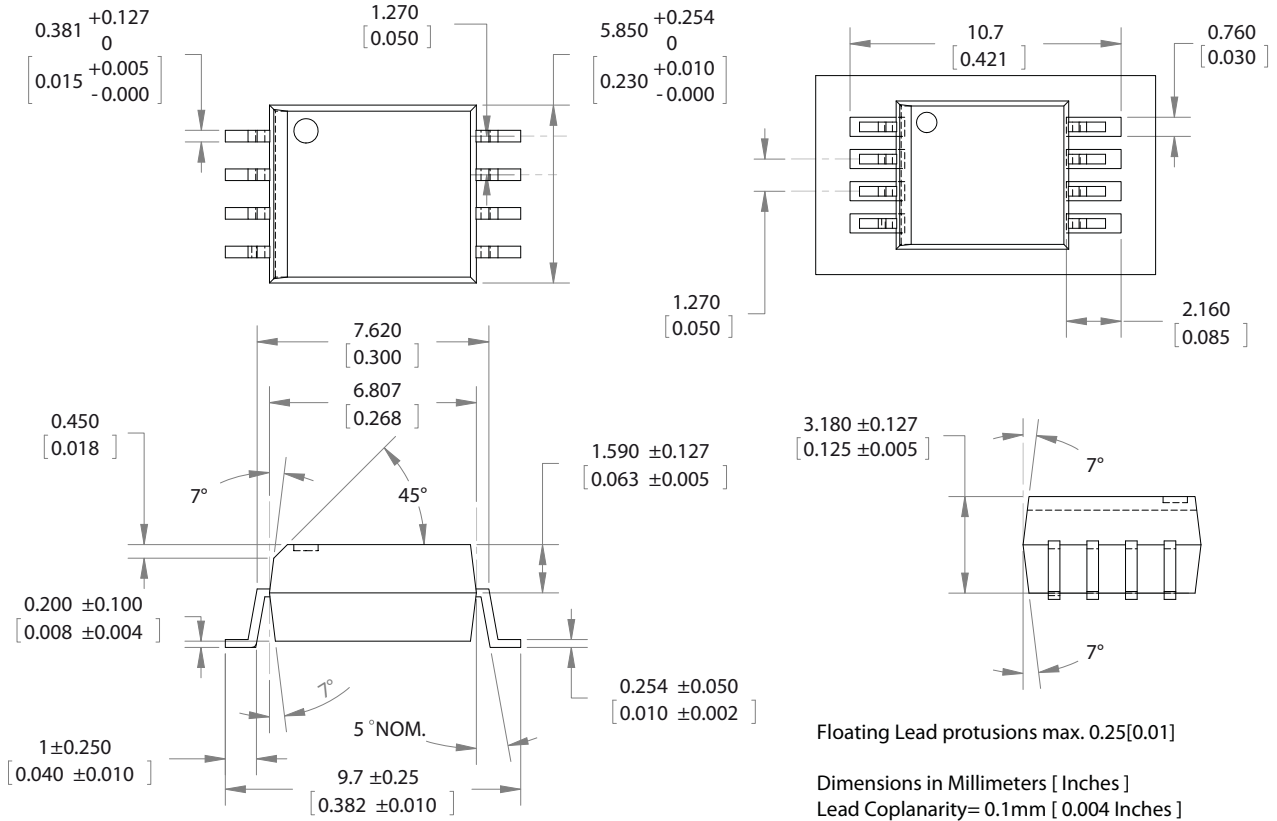
ACPL-H312-560E to order product of Stretched SO8 Surface Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-2 Safety Approval in RoHS compliant.

Example 2:

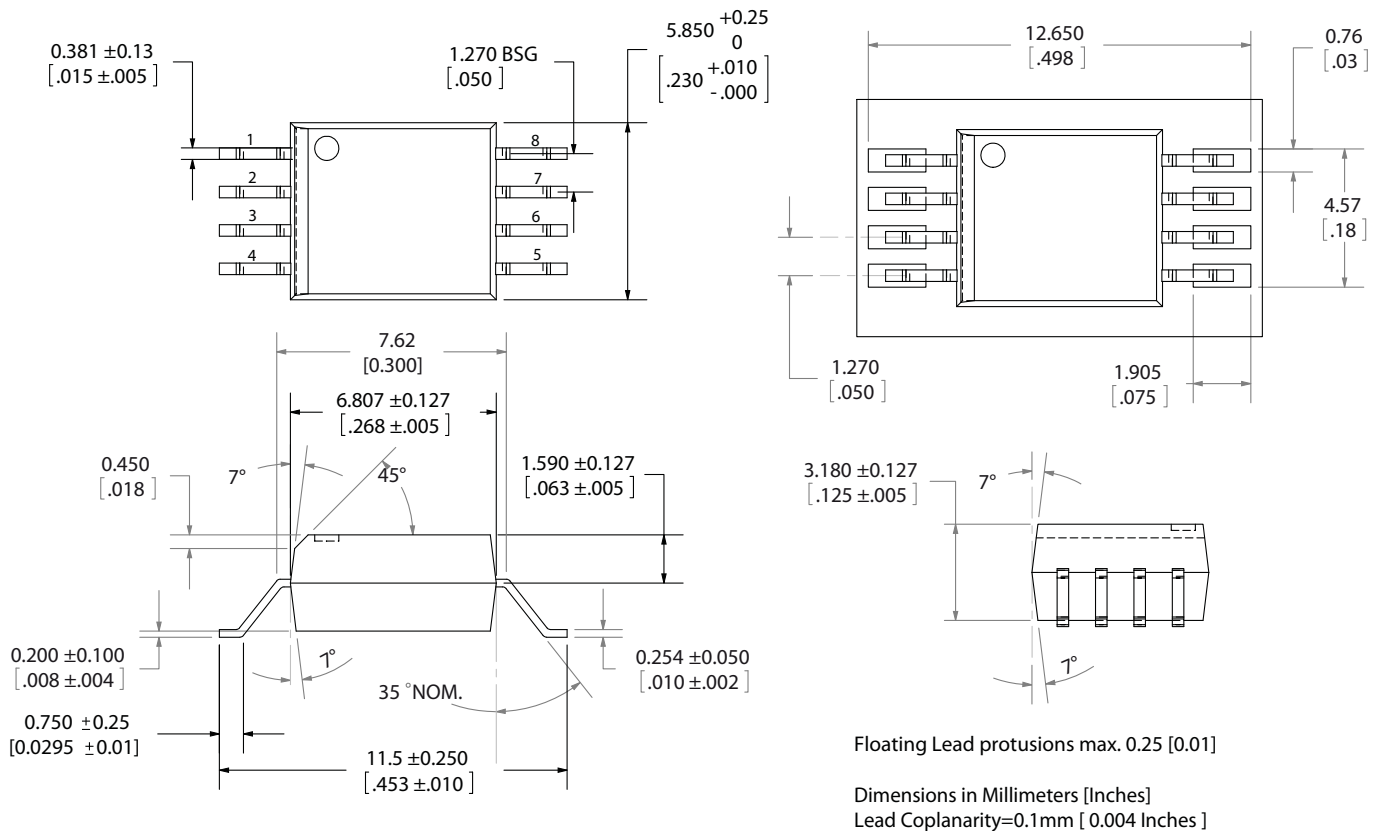
ACPL-H312-000E to order product of Stretched SO8 Surface Mount package in Tube Packaging and RoHS compliant. Option datasheets are available. Contact your Avago sales representative or authorized distributor for information.

## Package Outline Drawings

### ACPL-H312 Outline Drawing - Stretched S08



### ACPL-K312 Outline Drawing - Stretched S08



## Recommended Pb-Free IR Profile

Recommended reflow condition as per JEDEC Standard, J-STD-020 (latest revision). Non-Halide Flux should be used.

## Regulatory Information

The ACPL-H312/K312 is approved 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 up to  $V_{ISO} = 3750 V_{RMS}$  for the ACPL-H312 and  $V_{ISO} = 5000 V_{RMS}$  for the ACPL-K312, File E55361

### CSA

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

**Table 1. IEC/EN/DIN EN 60747-5-2 Insulation Characteristics <sup>[1]</sup> (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 $\leq 150 V_{rms}$                                                                                                                         |                 | I – IV    | I – IV    |            |
| for rated mains voltage $\leq 300 V_{rms}$                                                                                                                         |                 | I – IV    | I – IV    |            |
| for rated mains voltage $\leq 450 V_{rms}$                                                                                                                         |                 | I – III   | I – IV    |            |
| for rated mains voltage $\leq 600 V_{rms}$                                                                                                                         |                 | I – III   | I – IV    |            |
| for rated mains voltage $\leq 1000 V_{rms}$                                                                                                                        |                 |           | I – III   |            |
| 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 <sup>[1]</sup><br>$V_{IORM} \times 1.875 = V_{PR}$ , 100% Production Test with $t_m = 1$ sec,<br>Partial discharge $< 5$ pC | $V_{PR}$        | 1670      | 2137      | $V_{peak}$ |
| Input to Output Test Voltage, Method a <sup>[1]</sup><br>$V_{IORM} \times 1.5 = V_{PR}$ , Type and Sample Test, $t_m = 60$ sec,<br>Partial discharge $< 5$ pC      | $V_{PR}$        | 1336      | 1710      | $V_{peak}$ |
| Highest Allowable Overvoltage<br>(Transient Overvoltage $t_{ini} = 10$ sec)                                                                                        | $V_{IOTM}$      | 6000      | 8000      | $V_{peak}$ |
| Safety-limiting values<br>– 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                                                                                                                  | $R_S$           | $> 10^9$  | $> 10^9$  | $\Omega$   |

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<br>(Clearance)              | L(101) | 7.0       | 8.0       | mm    | Measured from input terminals to output terminals, shortest distance through air.                                                  |
| Minimum External Tracking<br>(Creepage)              | L(102) | 8.0       | 8.0       | mm    | Measured from input terminals to output terminals, shortest distance path along body.                                              |
| Minimum Internal Plastic Gap<br>(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<br>(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<br>( $<1\ \mu s$ 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  $100^\circ\text{C}$ ,  $I_{F(ON)} = 7$  to  $16$  mA,  $V_{F(OFF)} = -3.6$  to  $0.8$  V,  $V_{CC} = 15$  to  $30$  V,  $V_{EE} = \text{Ground}$ ) unless otherwise specified. All typical values at  $T_A = 25^\circ\text{C}$  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,<br>$I_F = 7$ to $16$ mA     | 7, 8      |      |
| Low Level Supply Current                            | $I_{CCL}$                 |            | 1.8        | 3.0  | mA                   | Output open,<br>$V_F = -3.6$ to $+0.8$ V | 7, 8      |      |
| Threshold Input Current<br>Low to High              | $I_{FLH}$                 |            | 2.3        | 5    | mA                   | $I_O = 0$ mA, $V_O > 5$ V                | 9, 15, 21 |      |
| Threshold Input Voltage<br>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<br>Input Forward Voltage | $\Delta V_F / \Delta T_A$ |            | -1.6       |      | mV/ $^\circ\text{C}$ | $I_F = 10$ mA                            |           |      |
| Input Reverse<br>Breakdown Voltage                  | $BV_R$                    | 5          |            |      | V                    | $I_R = 10$ $\mu$ A                       |           |      |
| 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  $100^\circ\text{C}$ ,  $I_{F(ON)} = 7$  to  $16$  mA,  $V_{F(OFF)} = -3.6$  to  $0.8$  V,  $V_{CC} = 15$  to  $30$  V,  $V_{EE} = \text{Ground}$ ) unless otherwise specified. All typical values at  $T_A = 25^\circ\text{C}$  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  | $\mu\text{s}$     | $R_g = 10\ \Omega$ ,<br>$C_g = 10\ \text{nF}$ ,<br>$f = 10\ \text{kHz}$ ,<br>Duty Cycle = 50% | 12, 13, 14, 23 | 8      |
| Propagation Delay Time to Low Output Level                     | $t_{PHL}$                      | 0.05  | 0.26 | 0.5  | $\mu\text{s}$     |                                                                                               |                |        |
| Pulse Width Distortion                                         | PWD                            |       |      | 0.3  | $\mu\text{s}$     |                                                                                               |                | 9      |
| Propagation Delay Difference Between Any Two Parts or Channels | PDD<br>( $t_{PHL} - t_{PLH}$ ) | -0.35 |      | 0.35 | $\mu\text{s}$     |                                                                                               |                | 10     |
| Rise Time                                                      | $t_R$                          |       | 0.05 |      | $\mu\text{s}$     |                                                                                               | 23             |        |
| Fall Time                                                      | $t_F$                          |       | 0.05 |      | $\mu\text{s}$     |                                                                                               |                |        |
| Output High Level Common Mode Transient Immunity               | $ CM_H $                       | 15    | 30   |      | kV/ $\mu\text{s}$ | $T_A = 25^\circ\text{C}$ ,<br>$I_F = 10$ to $16$ mA,<br>$V_{CM} = 1500$ V<br>$V_{CC} = 30$ V  | 24             | 11, 12 |
| Output Low Level Common Mode Transient Immunity                | $ CM_L $                       | 15    | 30   |      | kV/ $\mu\text{s}$ | $T_A = 25^\circ\text{C}$ ,<br>$V_F = 0$ V,<br>$V_{CM} = 1500$ V<br>$V_{CC} = 30$ V            | 24             | 11, 13 |

**Table 7. Package Characteristics**

Over recommended temperature ( $T_A = -40$  to  $100^\circ\text{C}$ ) unless otherwise specified. All typicals at  $T_A = 25^\circ\text{C}$ .

| Parameter                                  | Symbol    | Part Number | Min. | Typ.      | Max. | Units     | Test Conditions                                   | Fig. | Note   |
|--------------------------------------------|-----------|-------------|------|-----------|------|-----------|---------------------------------------------------|------|--------|
| Input-Output Momentary Withstand Voltage** | $V_{ISO}$ | ACPL-H312   | 3750 |           |      | $V_{rms}$ | RH < 50%, t = 1 min.,<br>$T_A = 25^\circ\text{C}$ |      | 14, 16 |
|                                            |           | ACPL-K312   | 5000 |           |      |           |                                                   |      | 15, 16 |
| Resistance (Input-Output)                  | $R_{I-O}$ |             |      | $10^{12}$ |      | $\Omega$  | $V_{I-O} = 500\text{ V}$                          |      | 16     |
| Capacitance (Input-Output)                 | $C_{I-O}$ |             |      | 0.6       |      | pF        | Freq = 1MHz                                       |      |        |

\*\* 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."

Notes:

- Derate linearly above  $70^\circ\text{C}$  free-air temperature at a rate of  $0.3\text{ mA}/^\circ\text{C}$ .
- Maximum pulse width =  $10\text{ }\mu\text{s}$ .
- Derate linearly above  $78^\circ\text{C}$  free-air temperature at a rate of  $5.7\text{ mW}/^\circ\text{C}$ .
- Derate linearly above  $78^\circ\text{C}$  free-air temperature at a rate of  $6.0\text{ mW}/^\circ\text{C}$ . The maximum LED junction temperature should not exceed  $125^\circ\text{C}$ .
- Maximum pulse width =  $50\text{ }\mu\text{s}$
- 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.
- Maximum pulse width =  $1\text{ ms}$
- This load condition approximates the gate load of a  $1200\text{ V}/100\text{ A}$  IGBT.
- Pulse Width Distortion (PWD) is defined as  $|t_{PHL} - t_{PLH}|$  for any given device.
- The difference between  $t_{PHL}$  and  $t_{PLH}$  between any two ACPL-H312/K312 parts under the same test condition.
- Pins 3 and 4 need to be connected to LED common.
- 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.,  $V_O > 15.0\text{ V}$ ).
- Common mode transient immunity in a low state is the maximum tolerable  $dV_{CM}/dt$  of the common mode pulse,  $V_{CM}$ , to assure that the output will remain in a low state (i.e.,  $V_O < 1.0\text{ V}$ ).
- In accordance with UL1577, each optocoupler is proof tested by applying an insulation test voltage  $\geq 4500\text{ Vrms}$  for 1 second (leakage detection current limit,  $I_{I-O} \leq 5\text{ }\mu\text{A}$ ).
- In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage  $> 6000\text{ Vrms}$  for 1 second (leakage detection current limit II-O  $< 5\text{ A}$ ).
- Device considered a two-terminal device: pins 1, 2, 3, and 4 shorted together and pins 5, 6, 7, and 8 shorted together.

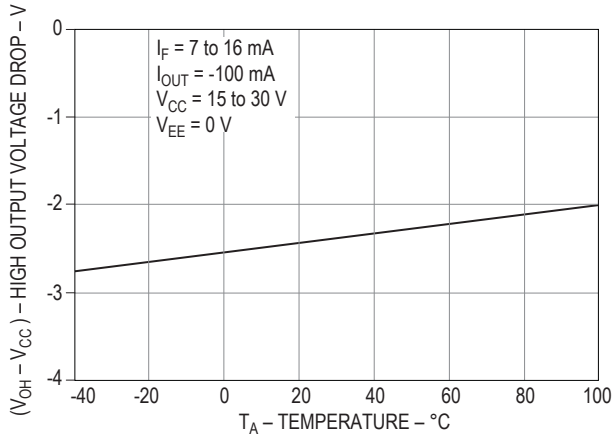


Figure 1.  $V_{OH}$  vs. Temperature

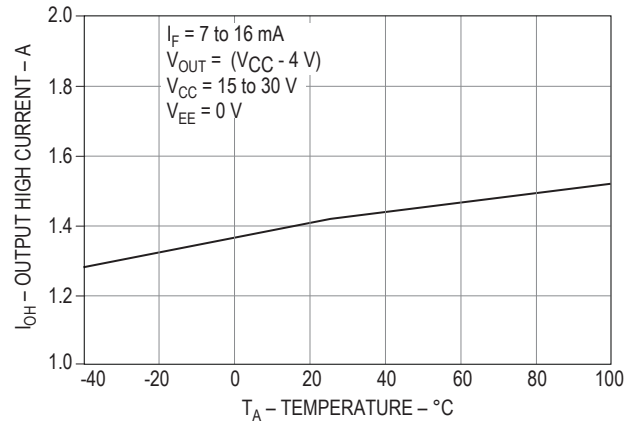


Figure 2.  $I_{OH}$  vs. Temperature

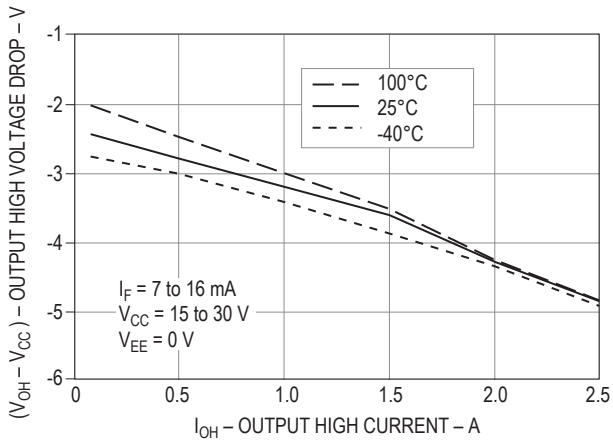


Figure 3.  $V_{OH}$  vs.  $I_{OH}$

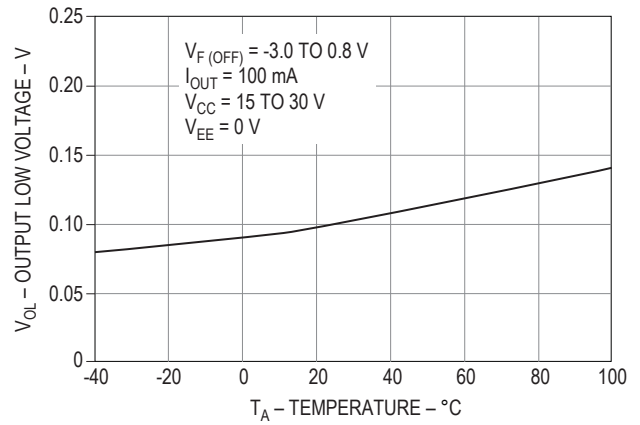


Figure 4.  $V_{OL}$  vs. Temperature

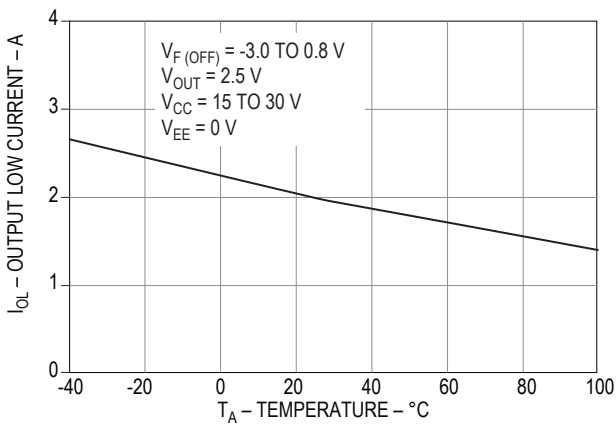


Figure 5.  $I_{OL}$  vs. Temperature

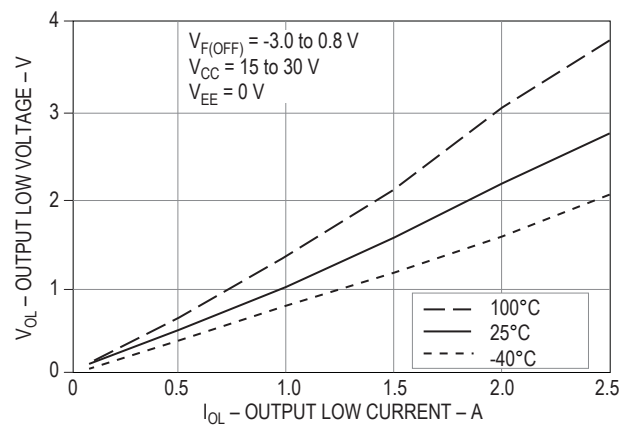


Figure 6.  $V_{OL}$  vs.  $I_{OL}$ .

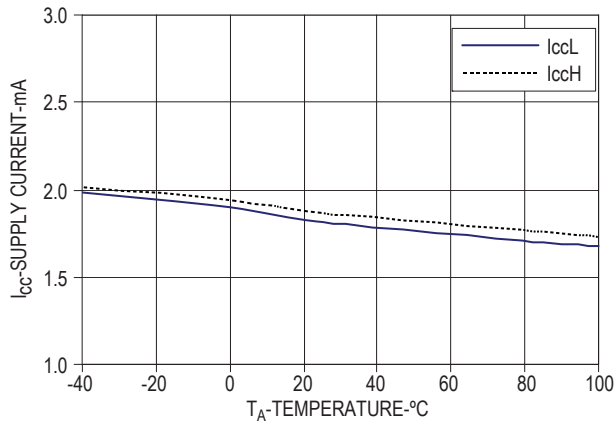


Figure 7.  $I_{CC}$  vs. Temperature

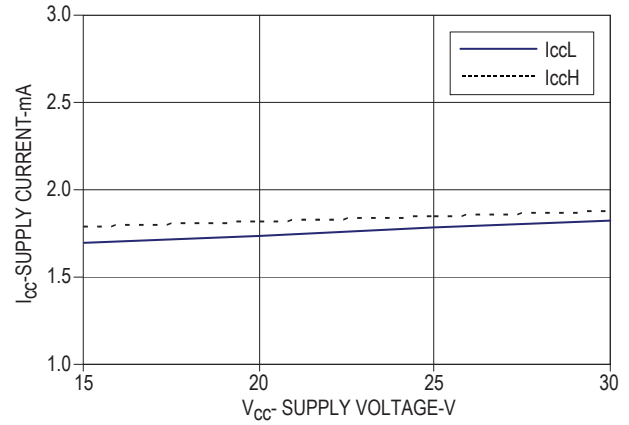


Figure 8.  $I_{CC}$  vs.  $V_{CC}$

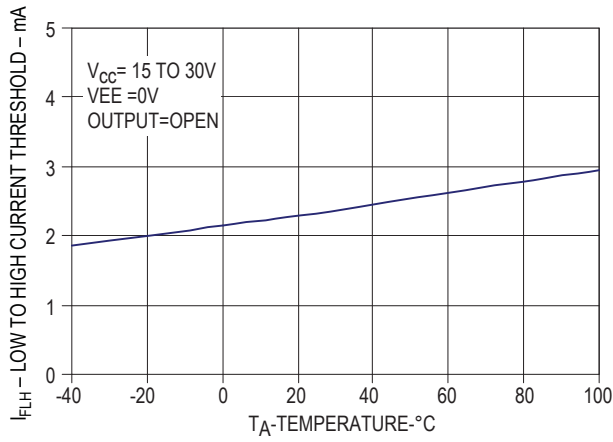


Figure 9.  $I_{FLH}$  vs. Temperature

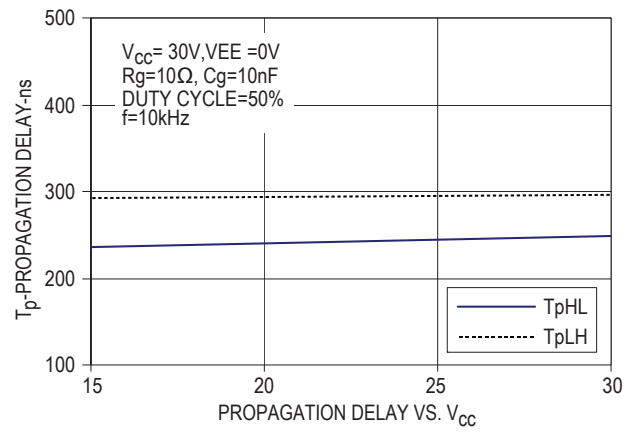


Figure 10. Propagation delay vs.  $V_{CC}$

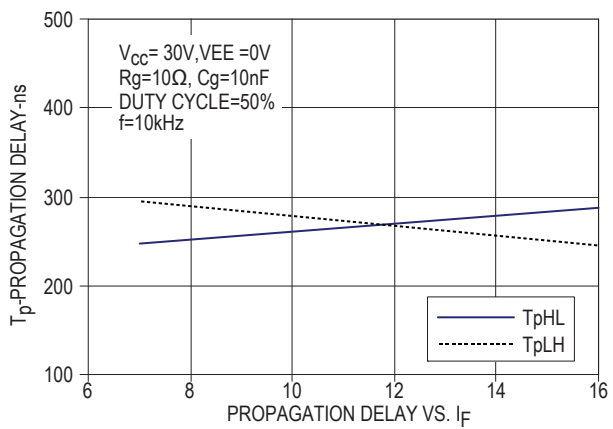


Figure 11. Propagation delay vs.  $I_F$

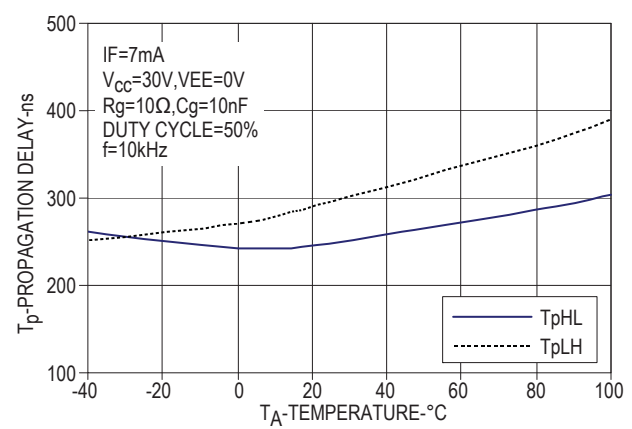


Figure 12. Propagation delay vs. Temperature

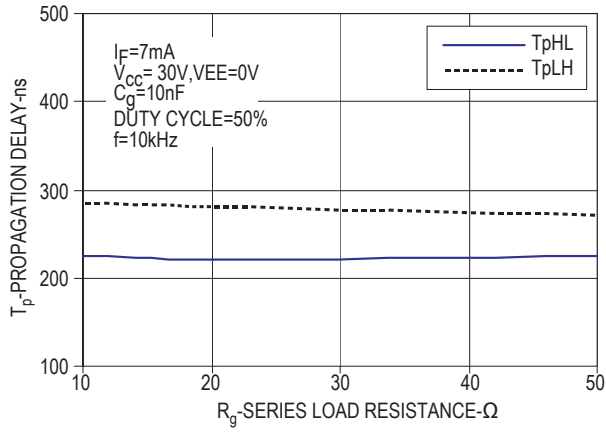


Figure 13. Propagation Delay vs.  $R_g$

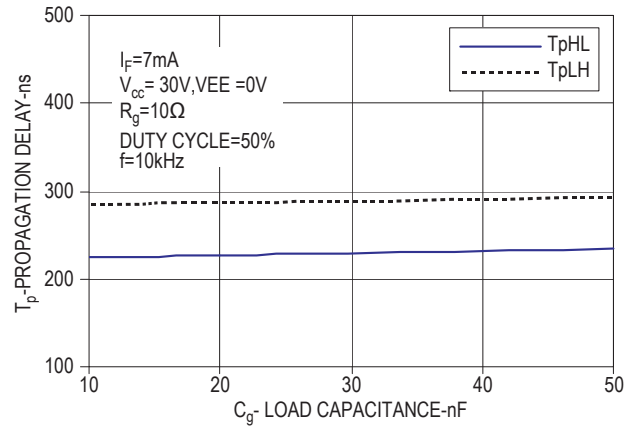


Figure 14. Propagation Delay vs.  $C_g$

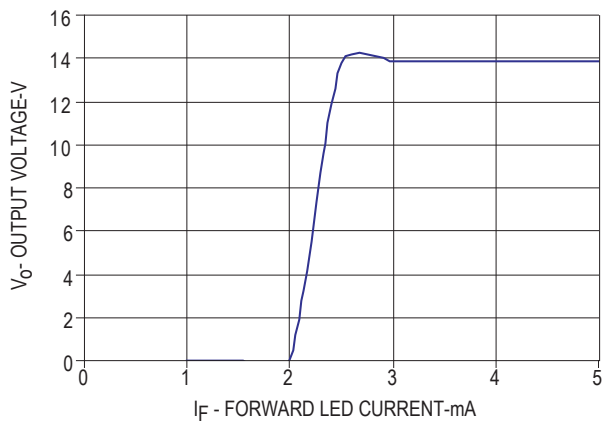


Figure 15. Transfer Characteristics

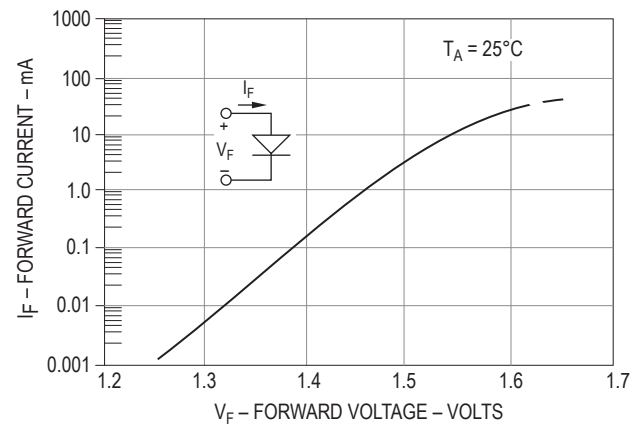


Figure 16. Input Current vs. Forward Voltage

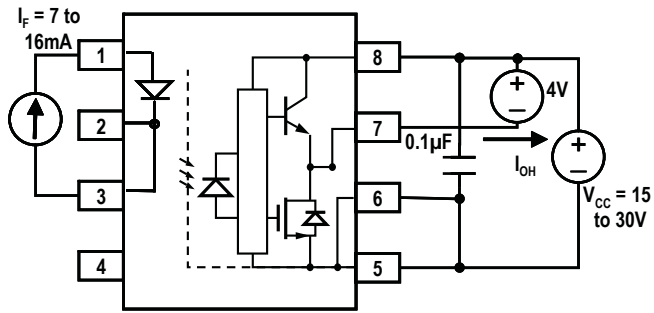


Figure 17.  $I_{OH}$  test circuit

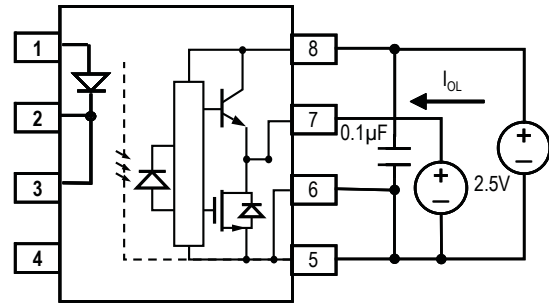


Figure 18.  $I_{OL}$  test circuit

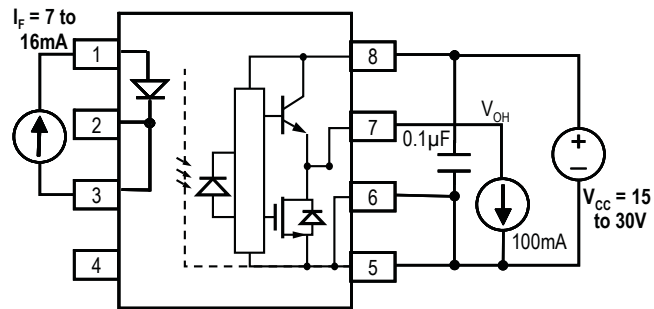


Figure 19.  $V_{OH}$  test circuit

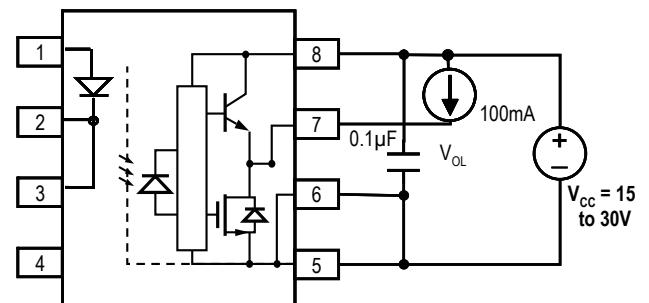


Figure 20.  $V_{OL}$  test circuit

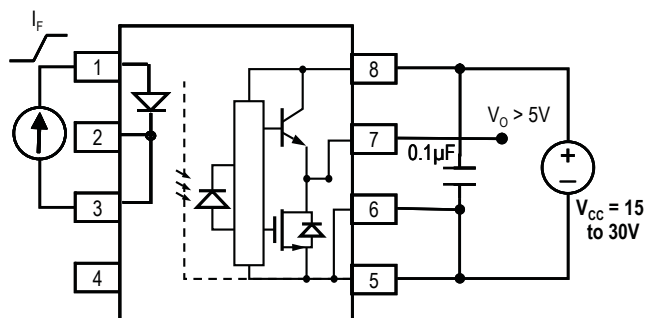


Figure 21.  $I_{FLH}$  test circuit

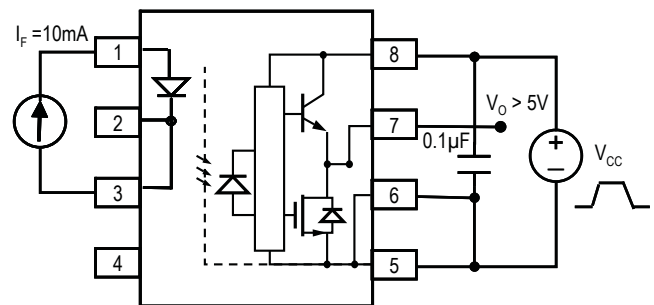


Figure 22. UVLO test circuit

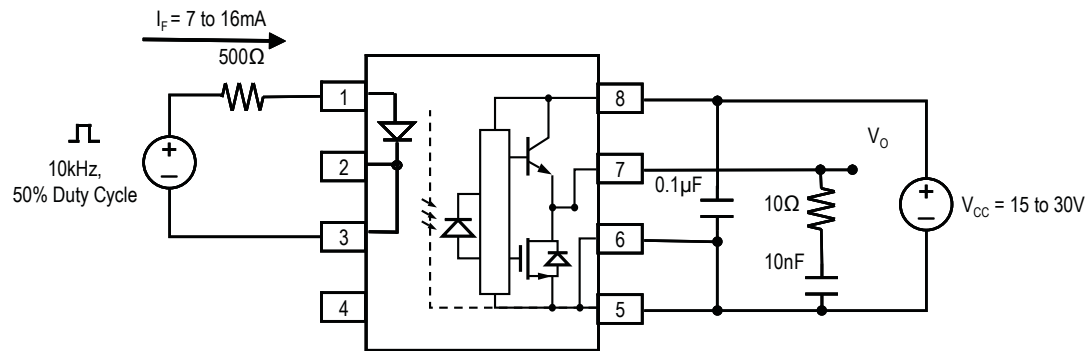


Figure 23.  $t_{PLH}$ ,  $t_{PHL}$ ,  $t_f$ ,  $t_r$  test circuit and waveforms

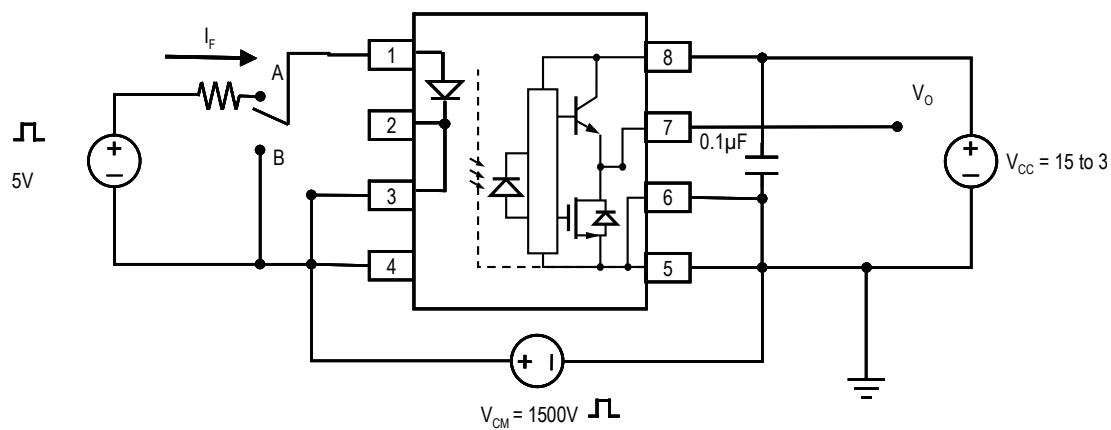


Figure 24. CMR test circuit and waveforms

## 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

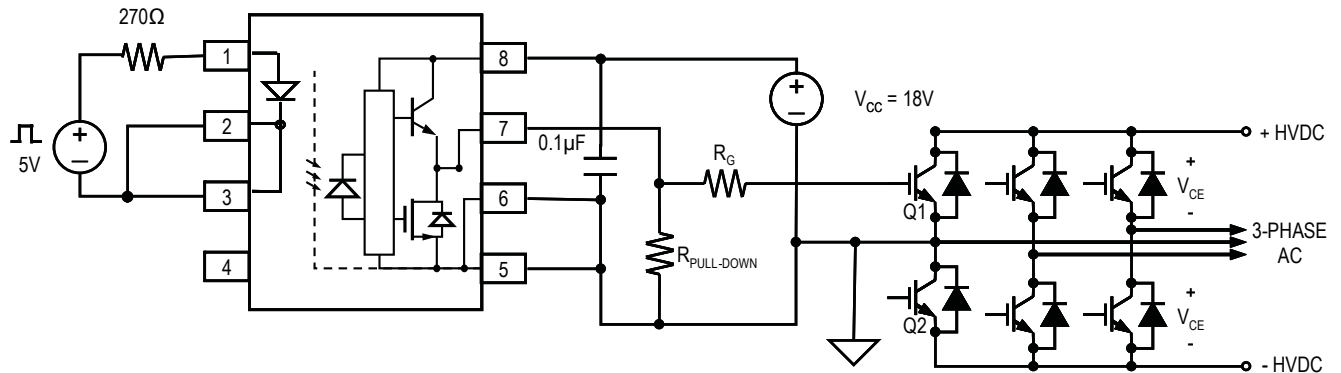


Figure 25. Recommended LED drive and application circuit

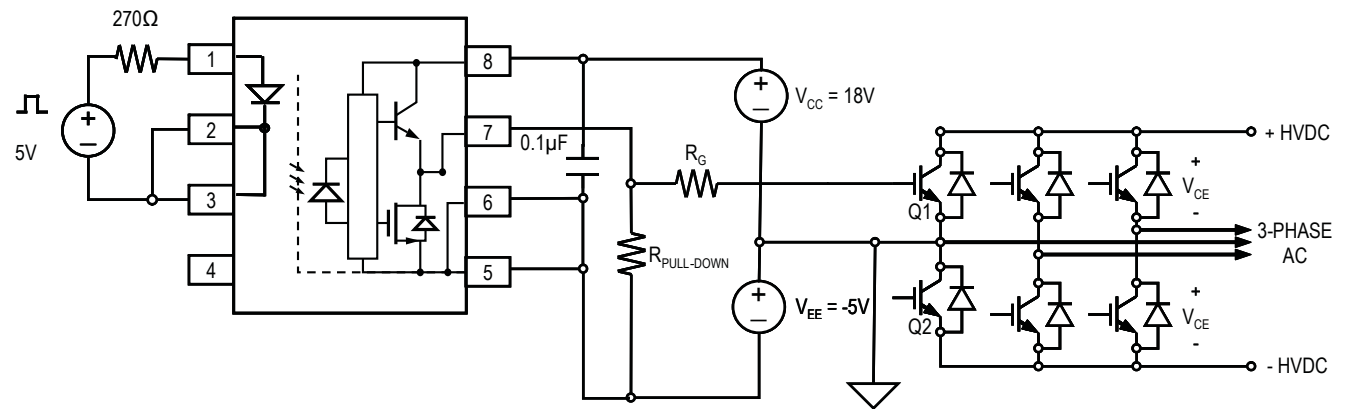


Figure 26. ACPL-H312/K312 typical application circuit with negative IGBT gate drive

## Thermal Model for ACPL-H312/K312 Stretched-S08 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 ( $^{\circ}\text{C}$ ).

$T_2$ : Junction temperature of Detector ( $^{\circ}\text{C}$ ).

$T_a$ : Ambient temperature.

$\Delta T_1$ : Temperature difference between LED junction and ambient ( $^{\circ}\text{C}$ ).

$\Delta T_2$ : Temperature difference between Detector junction and ambient.

Ambient Temperature: Junction to Ambient Thermal Resistances were measured approximately 1.25cm above optocoupler at  $\sim 23^{\circ}\text{C}$  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.

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

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

| Jedec Specifications | $R_{11}$ | $R_{12}, R_{21}$ | $R_{22}$ |
|----------------------|----------|------------------|----------|
| high K board         | 311      | 111              | 168      |

Notes:

1. Maximum junction temperature for above parts:  $125^{\circ}\text{C}$ .

## 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,

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

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

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

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 circuitry = 3.0mA (Table 5)

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

$Q_G$  = 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)

$$f_{\text{SWITCH}} = \text{switching frequency of application} = 10\text{kHz}$$

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

$$PI = 16\text{mA} * 1.8\text{V} = 28.8\text{mW}$$

$$PO = PO(\text{BIAS}) + PO(\text{SWITCH})$$

$$= 3.0\text{mA} * (18\text{V} - (-5\text{V})) + (18\text{V} + 5\text{V}) * 240\text{nC} * 10\text{kHz}$$

$$= 69\text{mW} + 55.2\text{mW}$$

$$= 124.2\text{mW}$$

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 78 °C and use the high conductivity thermal resistances.

LED junction temperature,

$$\begin{aligned} T1 &= (R_{11} * P_1 + R_{12} * P_2) + T_a \\ &= (311 * 28.8 + 111 * 124.2) + 78 \\ &= 22.7 + 78 = 100.7\text{ °C} \end{aligned}$$

Output IC junction temperature,

$$\begin{aligned} T2 &= (R_{21} * P_1 + R_{22} * P_2) + T_a \\ &= (111 * 28.8 + 168 * 124.2) + 78 \\ &= 24 + 78 = 102\text{ °C} \end{aligned}$$

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

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