

HCPL-4701/-4731/-070A/-073A

Very Low Power Consumption High-Gain Optocouplers

Description

These Broadcom[®] devices are very low power consumption, high-gain, single- and dual-channel optocouplers. The HCPL-4701 represents the single-channel, 8-pin DIP configuration and is pin compatible with the industry-standard 6N139. The HCPL-4731 represents the dual-channel 8-pin DIP configuration and is pin compatible with the popular standard HCPL-2731. The HCPL-070A and HCPL-073A are the equivalent single- and dual-channel products in an SO-8 footprint. Each channel can be driven with an input current as low as 40 μA and has a typical current transfer ratio of 3500%.

These high-gain couplers use an AlGaAs LED and an integrated high-gain photodetector to provide an extremely high current transfer ratio between input and output. Separate pins for the photodiode and output stage results in TTL compatible saturation voltages and high-speed operation. Where desired, the V_{CC} and V_O terminals can be tied together to achieve conventional Darlington operation (single-channel package only).

These devices are designed for use in CMOS, LSTTL, or other low power applications. They are especially well suited for ISDN telephone interface and battery-operated applications due to the low power consumption. A 700% minimum current transfer ratio is guaranteed from 0°C to 70°C operating temperature range at 40 μA of LED current and $V_{CC} \geq 3\text{V}$.

The SO-8 does not require through holes in a PCB. This package occupies approximately one-third the footprint area of the standard dual-in-line package. The lead profile is designed to be compatible with standard surface-mount processes.

CAUTION! Take normal static precautions in the handling and assembly of this component to prevent damage, degradation, or both that might be induced by ESD. The components featured in this data sheet are not to be used in military or aerospace applications or environments.

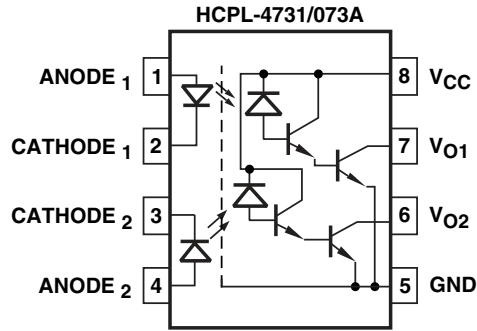
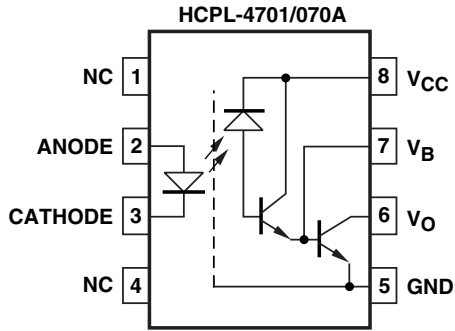
Features

- Ultra low input current capability: 40 μA
- Specified for 3V operation
 - Typical power consumption: <1 mW
 - Input power: <50 μW
 - Output power: <500 μW
- Will operate with V_{CC} as low as 1.6V
- High current transfer ratio: 3500% at $I_F = 40 \mu\text{A}$
- TTL and CMOS compatible output
- Specified ac and dc performance over temperature: 0°C to 70°C
- Safety approval
 - UL recognized: 3750 V_{rms} for 1 minute and 5000 V_{rms} for 1 minute per UL1577
 - CSA approved
 - IEC/EN/DIN EN 60747-5-5 approved with $V_{IORM} = 630\text{V peak}$ (Option 060) for HCPL-4701
- 8-pin product compatible with 6N138/6N139 and HCPL-2730/HCPL-2731
- Available in 8-pin DIP and SOIC-8 footprint
- Through-hole and surface-mount assembly available

Applications

- Battery-operated applications
- ISDN telephone interface
- Ground isolation between logic families – TTL, LSTTL, CMOS, HCMOS, HL-CMOS, LV-HCMOS
- Low input current line receiver
- EIA RS-232C line receiver
- Telephone ring detector
- AC line voltage status indicator – low input power dissipation
- Low power systems – ground isolation
- Portable system I/O interface

Functional Diagrams



NOTE: A 0.1- μ F bypass capacitor must be connected as close as possible between pins V_{DD} and GND.

Truth Table

| LED | V_o |
|-----|-------|
| ON | LOW |
| OFF | HIGH |

Selection Guide

| 8-Pin DIP (300 Mil) | | Small Outline SO-8 | | Wide Body Package (400 mil) | Minimum Input ON Current (I_F) | Minimum CTR | Absolute Maximum V_{CC} | Hermetic |
|------------------------|----------------------------|------------------------------|----------------------------|-----------------------------|------------------------------------|-------------|---------------------------|--|
| Single-Channel Package | Dual-Channel Package HCPL- | Single-Channel Package HCPL- | Dual-Channel Package HCPL- | Single-Channel Package | | | | Single- and Dual-Channel Packages HCPL- |
| 6N139 ^a | 2731 ^a | 0701 ^a | 0731 ^a | HCNW139 ^a | 0.5 mA | 400% | 18V | |
| 6N138 ^a | 2730 ^a | 0700 ^a | 0730 ^a | HCNW138 ^a | 1.6 mA | 300% | 7V | |
| HCPL-4701 | 4731 | 070A | 0730A | | 40 μ A | 800% | 18V | |
| | | | | | 0.5 mA | 300% | 20V | 5701 ^a 5700 ^a 5731 ^a 5730 ^a |

a. Technical data can be found in separate Broadcom publications.

Ordering Information

HCPL-4701, HCPL-4731, HCPL-070A and HCPL-073A are UL Recognized with 3750 V_{rms} for 1 minute per UL1577 and are approved under CAN/CSA-C22.2 No. 62368-1.

| Part Number | Option | | Package | Surface Mount | Gull Wing | Tape and Reel | UL5000 V _{rms} / 1 Minute Rating | IEC/EN/DIN EN60747-5-5 | Quantity |
|-------------|----------------|--------------------|---------------|---------------|-----------|---------------|---|------------------------|---------------|
| | RoHS Compliant | Non-RoHS Compliant | | | | | | | |
| HCPL-4701 | -000E | No option | 300-mil DIP-8 | | | | | | 50 per tube |
| HCPL-4731 | -300E | -300 | | X | X | | | | 50 per tube |
| | -500E | -500 | | X | X | X | | | 1000 per reel |
| | -020E | -020 | | | | | X | | 50 per tube |
| | -320E | -320 | | X | X | | X | | 50 per tube |
| | -520E | -520 | | X | X | X | X | | 1000 per reel |
| | -060E | -060 | | | | | | X | 50 per tube |
| | -360E | -360 | | X | X | | | X | 50 per tube |
| | -560E | -560 | | X | X | X | | X | 1000 per reel |
| HCPL-070A | -000E | No option | SO-8 | X | | | | | 100 per tube |
| HCPL-073A | -500E | -500 | | X | | X | | | 1500 per reel |
| | -060E | -060 | | X | | | | X | 100 per tube |
| | -560E | -560 | | X | | X | | X | 1500 per reel |

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

Example 1:

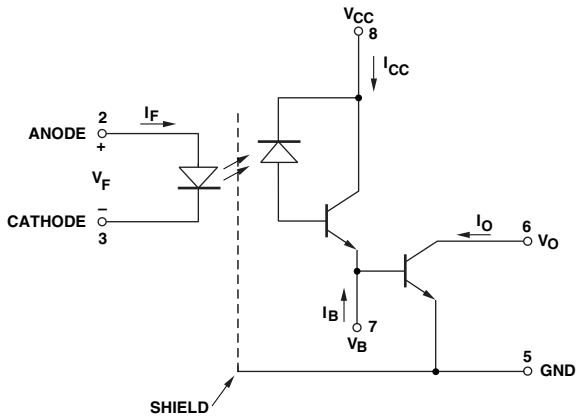
HCPL-4701-560E to order product of 300-mil DIP Gull Wing Surface-Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-5 Safety Approval and RoHS compliant.

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

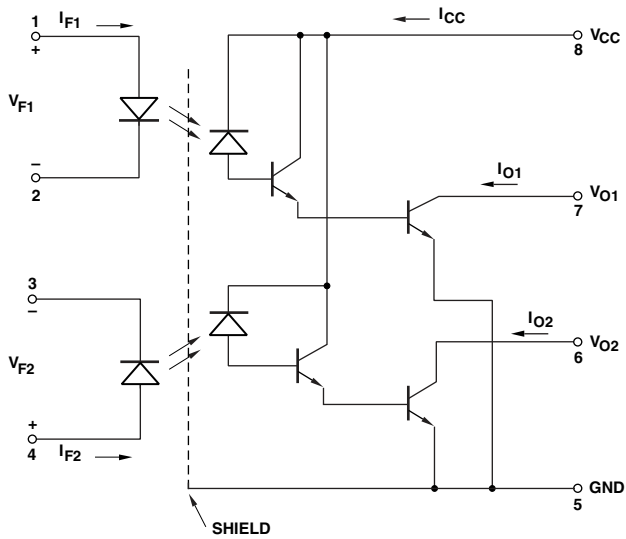
NOTE: The notation #XXX is used for existing products, while (new) products launched since July 15, 2001 and RoHS compliant will use -XXXE.

Schematics

HCPL-4701 and HCPL-070A



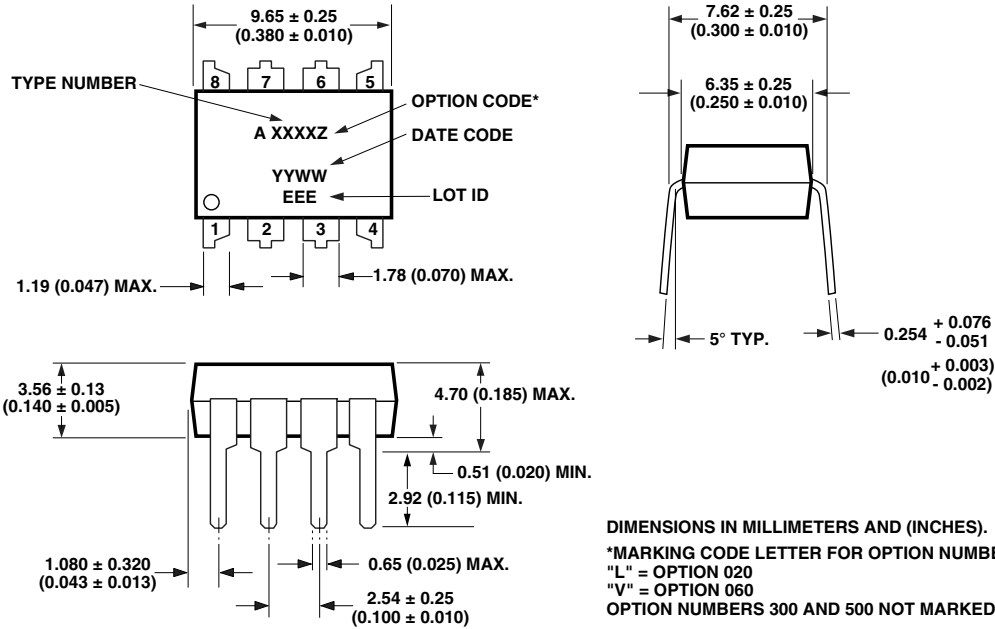
HCPL-4731 and HCPL-073A



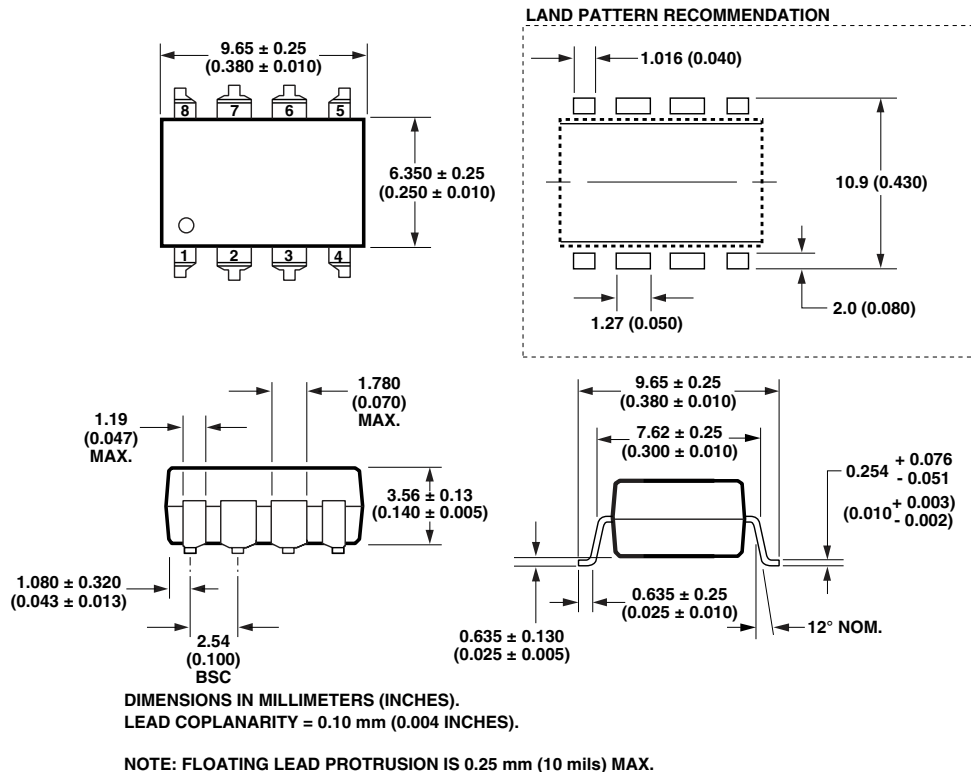
NOTE: Use of a 0.1- μ F bypass capacitor connected between pins 8 and 5 adjacent to the device is recommended.

Package Outline Drawings

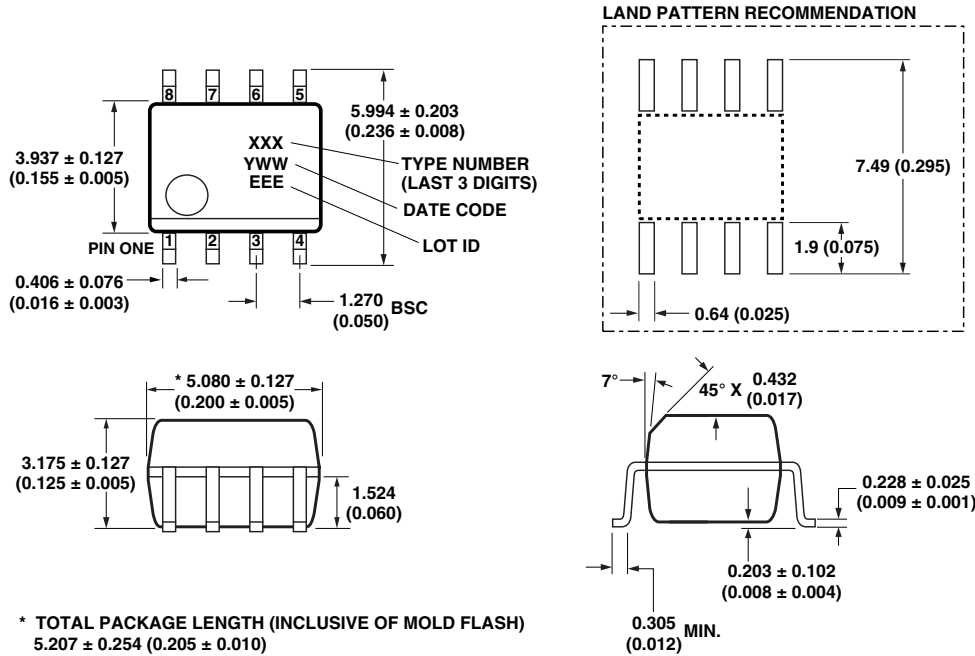
8-Pin DIP Package (HCPL-4701, HCPL-4731)



8-Pin DIP Package with Gull Wing Surface-Mount Option 300 (HCPL-4701, HCPL-4731)



Small-Outline SO-8 Package (HCPL-070A, HCPL-073A)



Reflow Soldering Profile

The recommended reflow soldering conditions are per JEDEC Standard J-STD-020 (latest revision). Non-halide flux should be used.

Regulatory Information

The HCPL-4701/4731 and HCPL-070A/073A have been approved by the following organizations:

- **IEC/EN 60747-5-5 (Option x60E only)**
- **UL** – Recognized under UL 1577, Component Recognition Program, File E55361.
- **CSA** – Approval under CAN/CSA-C22.2 No. 62368-1.

Insulation Related Specifications

| Parameter | Symbol | 8-Pin DIP (300 mil) Value | SO-8 Value | Unit | Conditions |
|---|--------|---------------------------|------------|------|---|
| Minimum External Air Gap (External Clearance) | L(101) | 7.1 | 4.9 | mm | Measured from input terminals to output terminals, shortest distance through air. |
| Minimum External Tracking (External Creepage) | L(102) | 7.4 | 4.8 | 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 direct distance between the photoemitter and photodetector inside the optocoupler cavity. |
| Tracking Resistance (Comparative Tracking Index) | CTI | 200 | 200 | V | DIN IEC 112/ VDE 0303 Part 1 |
| Isolation Group | | IIIa | IIIa | | Material Group (DIN VDE 0110, 1/89, Table 1) |

Option 300 – Surface-mount classification is Class A in accordance with CECC 00802.

IEC/EN/DIN EN 60747-5-5 Insulation Characteristics^a (Option x6xE)

| Description | Symbol | Characteristic | | Unit |
|--|-----------------|----------------------------|-----------------------------|-------------|
| | | HCPL-4701/ HCPL-4731 | HCPL-070A/ HCPL-073A | |
| Installation Classification per DIN VDE 0110/39, Table 1 For Rated Mains Voltage $\leq 150 V_{rms}$ For Rated Mains Voltage $\leq 300 V_{rms}$ For Rated Mains Voltage $\leq 600 V_{rms}$ | | I – IV I – IV I – IV | I – IV I – IV I – III | |
| Climatic Classification | | 55/85/21 | 55/85/21 | |
| Pollution Degree (DIN VDE 0110/39) | | 2 | 2 | |
| Maximum Working Insulation Voltage | V_{IORM} | 630 | 567 | V_{peak} |
| Input to Output Test Voltage, Method b ^a $V_{IORM} \times 1.875 = V_{PR}$, 100% Production Test with $t_m = 1s$, Partial Discharge $< 5 pC$ | V_{PR} | 1181 | 1063 | V_{peak} |
| Input to Output Test Voltage, Method a ^a $V_{IORM} \times 1.6 = V_{PR}$, Type and Sample Test, $t_m = 10s$, Partial Discharge $< 5 pC$ | V_{PR} | 1008 | 907 | V_{peak} |
| Highest Allowable Overvoltage (Transient Overvoltage $t_{ini} = 60s$) | V_{IOTM} | 8000 | 6000 | V_{peak} |
| Safety-Limiting Values | | | | |
| Case Temperature | T_S | 175 | 150 | $^{\circ}C$ |
| Input Current | $I_{S, INPUT}$ | 230 | 150 | mA |
| Output Power | $P_{S, OUTPUT}$ | 600 | 600 | mW |
| Insulation Resistance at T_S , $V_{IO} = 500V$ | R_S | $>10^9$ | $>10^9$ | Ω |

a. Refer to AV02-2041EN, *Avago Technologies Regulatory Guide for Isolation*, (IEC/EN/DIN EN 60747-5-5) for a detailed description of Method a and Method b partial discharge test profiles.

Note: Isolation characteristics are guaranteed only within the safety maximum ratings, which must be ensured by protective circuits in application.

Absolute Maximum Ratings

No derating required up to 70°C.

| Parameter | Symbol | Min. | Max. | Unit |
|---|--------------|------|----------|------|
| Storage Temperature | T_S | -55 | 125 | °C |
| Operating Temperature | T_A | -40 | 85 | °C |
| Average Forward Input Current HCPL-4701/4731 HCPL-070A/073A | $I_{F(AVG)}$ | — | 10 5 | mA |
| Peak Transient Input Current (50% duty cycle, 1-ms pulse width) HCPL-4701/4731 HCPL-070A/073A | I_{FPK} | — | 20 10 | mA |
| Reverse Input Voltage | V_R | — | 2.5 | V |
| Input Power Dissipation (Each Channel) | P_I | — | 15 | mW |
| Output Current (Each Channel) | I_O | — | 60 | mA |
| Emitter Base Reverse Voltage (HCPL-4701/070A) | V_{EB} | — | 0.5 | V |
| Output Transistor Base Current (HCPL-4701/070A) | I_B | — | 5 | mA |
| Supply Voltage | V_{CC} | -0.5 | 18 | V |
| Output Voltage | V_O | -0.5 | 18 | V |
| Output Power Dissipation (Each Channel) | P_O | — | 100 | mW |
| Total Power Dissipation (Each Channel) | P_T | — | 115 | mW |

Recommended Operating Conditions

| Parameter | Symbol | Min. | Max. | Unit |
|-----------------------------|--------------|------|------|------|
| Power Supply Voltage | V_{CC}^a | 1.6 | 18 | V |
| Forward Input Current (ON) | $I_{F(ON)}$ | 40 | 5000 | μA |
| Forward Input Voltage (OFF) | $V_{F(OFF)}$ | 0 | 0.8 | V |
| Operating Temperature | T_A | 0 | 70 | °C |

a. Specification information is available from the factory for 1.6V operation. Call your local field sales office for further information.

Electrical Specifications

$0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, $4.5\text{V} \leq V_{CC} \leq 20\text{V}$, $1.6\text{ mA} \leq I_{F(\text{ON})} \leq 5\text{ mA}$, $0\text{V} \leq V_{F(\text{OFF})} \leq 0.8\text{V}$, unless otherwise specified.

All typical specifications are at $T_A = 25^{\circ}\text{C}$.

NOTE: Use of a 0.1- μF bypass capacitor connected between pins 8 and 5 adjacent to the device is recommended.

| Parameter | Symbol | Device HCPL- | Min. | Typ. ^a | Max. | Unit | Test Conditions | Fig. | Note |
|--|---------------------------|--------------|------|-------------------|------|------------------------|---|---------------------|------|
| Current Transfer Ratio | CTR | | 800 | 3500 | 25k | % | $I_F = 40\ \mu\text{A}$, $V_{CC} = 4.5\text{V}$, $V_O = 0.4\text{V}$ | 3, 4 | b |
| | | | 600 | 3000 | 8k | | $I_F = 0.5\text{ mA}$, $V_{CC} = 4.5\text{V}$ | | |
| | | | 700 | 3200 | 25k | | $I_F = 40\ \mu\text{A}$ | | |
| | | | 500 | 2700 | 8k | | $I_F = 0.5\text{ mA}$ | | |
| Logic Low Output Voltage | V_{OL} | | — | 0.06 | 0.4 | V | $I_F = 40\ \mu\text{A}$, $I_O = 280\ \mu\text{A}$ | 1, 2 | |
| | | | — | 0.04 | 0.4 | | $I_F = 0.5\text{ mA}$, $I_O = 2.5\text{ mA}$ | | |
| Logic High Output Current | I_{OH} | | — | 0.01 | 5 | μA | $V_O = V_{CC} = 3\text{V to } 7\text{V}$, $I_F = 0\text{ mA}$ | | |
| | | | — | 0.02 | 80 | | $V_O = V_{CC} = 18\text{V}$, $I_F = 0\text{ mA}$ | | |
| Logic Low Supply Current | I_{CCL} | 4701/070A | — | 0.02 | 0.2 | mA | $I_F = 40\ \mu\text{A}$ | $V_O = \text{Open}$ | |
| | | | — | 0.1 | 1 | | $I_F = 0.5\text{ mA}$ | | |
| | | 4731/073A | — | 0.04 | 0.4 | | $I_F = 40\ \mu\text{A}$ | | |
| | | | — | 0.2 | 2.0 | | $I_F = 0.5\text{ mA}$ | | |
| Logic High Supply Current | I_{CCH} | 4701/070A | — | <0.01 | 10 | μA | $I_F = 0\text{ mA}$ | $V_O = \text{Open}$ | |
| | | 4731/073A | — | <0.01 | 20 | | $I_F = 0\text{ mA}$ | $V_O = \text{Open}$ | |
| Input Forward Voltage | V_F | | 1.1 | 1.25 | 1.4 | V | $I_F = 40\ \mu\text{A to } 500\ \mu\text{A}$, $T_A = 25^{\circ}\text{C}$ | 5 | |
| | | | 0.95 | 1.25 | 1.5 | | $I_F = 40\ \mu\text{A to } 500\ \mu\text{A}$ | | |
| Input Reverse Breakdown Voltage | BV_R | | 3.0 | 5.0 | — | V | $I_R = 100\ \mu\text{A}$, $T_A = 25^{\circ}\text{C}$ | | |
| | | | 2.5 | 5.0 | — | | $I_R = 100\ \mu\text{A}$ | | |
| Temperature Coefficient of Forward Voltage | $\Delta V_F / \Delta T_A$ | | — | -2.0 | — | mV/ $^{\circ}\text{C}$ | $I_F = 40\ \mu\text{A}$ | | |
| | | | — | -1.6 | — | | $I_F = 0.5\text{ mA}$ | | |
| Input Capacitance | C_{IN} | | — | 18 | — | pF | $f = 1\text{ MHz}$, $V_F = 0\text{V}$ | | |

a. All typical values at $T_A = 25^{\circ}\text{C}$ and $V_{CC} = 5\text{V}$, unless otherwise noted.

b. DC Current Transfer Ratio is defined as the ratio of output collector current, I_O , to the forward LED input current, I_F , times 100%.

Switching Specifications (AC)

Over the recommended operating conditions, $T_A = 0^\circ\text{C}$ to 70°C , $V_{CC} = 3\text{V}$ to 18V , unless otherwise specified.

| Parameter | Symbol | Device HCPL- | Min. | Typ. ^a | Max. | Unit | Test Conditions | Fig. | Note |
|---|-----------|--------------|-------|-------------------|------|------------------------|--|------|------|
| Propagation Delay Time to Logic Low at Output | t_{PHL} | | — | 65 | 500 | μs | $I_F = 40 \mu\text{A}$, $R_L = 11 \text{ k}\Omega$ to $16 \text{ k}\Omega$, $V_{CC} = 3.3\text{V}$ to 5V | 6, 8 | b, c |
| | | | — | 3 | 25 | | $T_A = 25^\circ\text{C}$, $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ | | |
| | | | — | 3 | 30 | | $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ | | |
| Propagation Delay Time to Logic High Output | t_{PLH} | | — | 70 | 500 | μs | $I_F = 40 \mu\text{A}$, $R_L = 11 \text{ k}\Omega$ to $16 \text{ k}\Omega$, $V_{CC} = 3.3\text{V}$ to 5V | 6, 8 | b, c |
| | | | — | 34 | 60 | | $T_A = 25^\circ\text{C}$, $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ | | |
| | | 4701/4731 | — | — | 90 | | $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ | | |
| | | 070A/073A | — | — | 130 | | $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ | | |
| Common Mode Transient Immunity at Logic High Output | $ CM_H $ | | 1,000 | 10,000 | — | $\text{V}/\mu\text{s}$ | $I_F = 0 \text{ mA}$, $R_L = 4.7$ to $11 \text{ k}\Omega$, $V_{CM} = 10 \text{ V}_{p-p}$, $T_A = 25^\circ\text{C}$ | 7 | d, e |
| Common Mode Transient Immunity at Logic Low Output | $ CM_L $ | | 1,000 | 10,000 | — | $\text{V}/\mu\text{s}$ | $I_F = 0.5 \text{ mA}$, $R_L = 4.7 \text{ k}\Omega$ to $11 \text{ k}\Omega$, $ V_{CM} = 10 \text{ V}_{p-p}$, $T_A = 25^\circ\text{C}$ | 7 | d, e |
| | | | — | 2,000 | — | | $I_F = 40 \mu\text{A}$, $R_L = 11 \text{ k}\Omega$ to $16 \text{ k}\Omega$, $ V_{CM} = 10 \text{ V}_{p-p}$ $V_{CC} = 3.3\text{V}$ to 5V , $T_A = 25^\circ\text{C}$ | | |

- a. All typical values at $T_A = 25^\circ\text{C}$ and $V_{CC} = 5\text{V}$, unless otherwise noted.
- b. Pin 7 open for single channel product.
- c. Use of a resistor between pins 5 and 7 will decrease gain and delay time. Significant reduction in overall gain can occur when using resistor values below $47 \text{ k}\Omega$ for single channel product.
- d. Common transient immunity in a Logic High level is the maximum tolerable (positive) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM} , to ensure that the output will remain in a Logic High state (i.e., $V_O > 2.0\text{V}$). Common transient immunity in a Logic Low level is the maximum tolerable (negative) dV_{CM}/dt on the trailing edge of the common mode pulse, V_{CM} , to ensure that the output will remain in a Logic Low state (i.e., $V_O < 0.8\text{V}$).
- e. In applications where dV/dt may exceed $50,000 \text{ V}/\mu\text{s}$ (such as static discharge) a series resistor, R_{CC} , should be included to protect the detector IC from destructively high surge currents. The recommended value is $R_{CC} = 220\Omega$.

Package Characteristics

| Parameter | Symbol | Device HCPL- | Min. | Typ. ^a | Max. | Unit | Test Conditions | Fig. | Note |
|---|------------------|--------------|------|-------------------|------|------------------|--|------|------|
| Input-Output Momentary Withstand Voltage ^b | V _{ISO} | | 3750 | — | — | V _{rms} | RH ≤ 50%, t = 1 min., T _A = 25°C | | c, d |
| Option 020 | | 4701, 4731 | 5000 | — | — | | | | c, e |
| Resistance (Input-Output) | R _{I-O} | | — | 10 ¹² | — | Ω | V _{I-O} = 500 VDC, RH ≤ 45% | | c |
| Capacitance (Input-Output) | C _{I-O} | | — | 0.6 | — | pF | f = 1 MHz | | c |
| Insulation Leakage Current (Input-Input) | I _{I-I} | 4731, 073A | — | 0.005 | — | μA | RH ≤ 45%, t = 5s, V _{I-I} = 500 VDC | | f |
| Resistance (Input-Input) | R _{I-I} | | — | 10 ¹¹ | — | Ω | | | |
| Capacitance (Input-Input) | C _{I-I} | 4731 | — | 0.03 | — | pF | f = 1 MHz | | f |
| | | 073A | — | 0.25 | — | | | | |

- a. All typical values at T_A = 25°C and V_{CC} = 5V, unless otherwise noted.
- b. 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), your equipment level safety specification.
- c. Device considered a two-terminal device: pins 1, 2, 3, and 4 shorted together, and pins 5, 6, 7, and 8 shorted together.
- d. In accordance with UL 1577, 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).
- e. In accordance with UL 1577, each optocoupler is proof-tested by applying an insulation test voltage ≥6000 V_{rms} for 1 second (leakage detection current limit, I_{I-O} ≤ 5 μA). 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.
- f. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.

Figure 1: DC Transfer Characteristics ($I_F = 0.5 \text{ mA to } 2.5 \text{ mA}$)

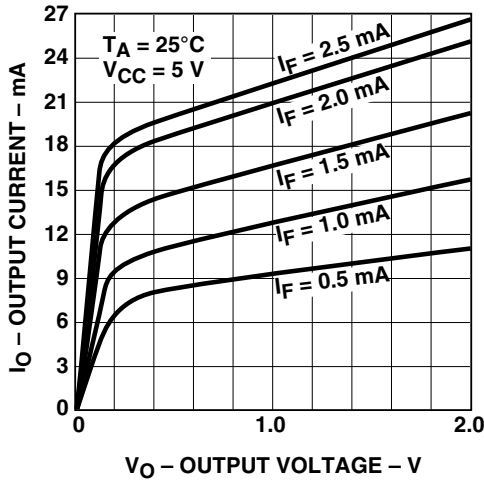


Figure 2: DC Transfer Characteristics ($I_F = 50 \mu\text{A to } 250 \mu\text{A}$)

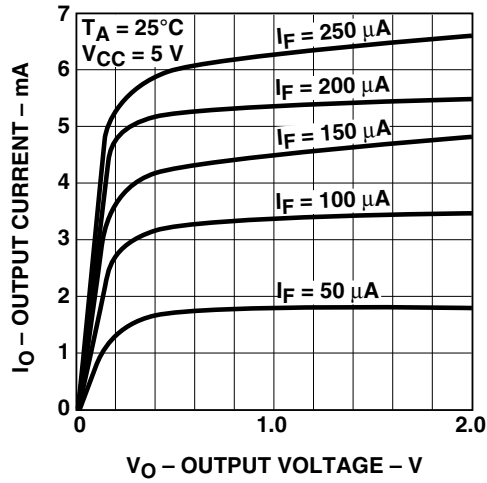


Figure 3: Current Transfer Ratio vs. Forward Current

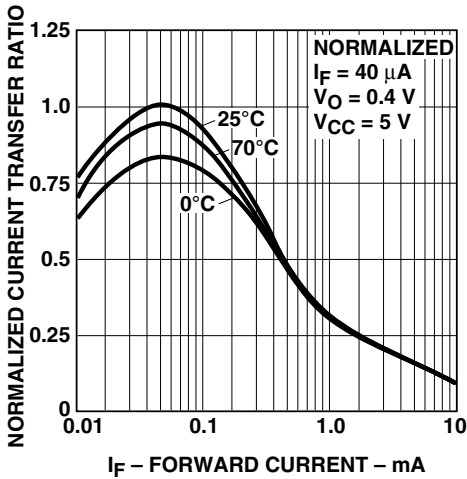


Figure 4: Output Current vs. Input Diode Forward Current

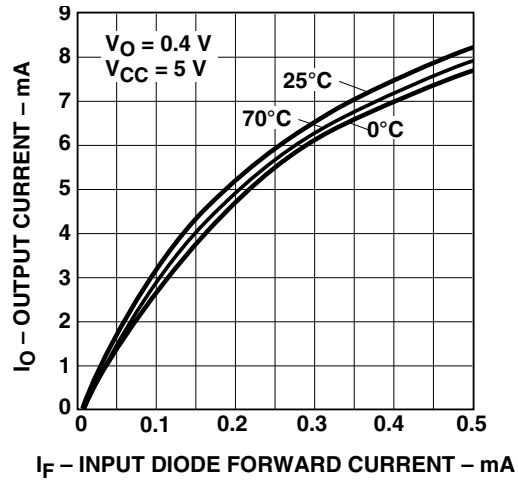


Figure 5: Input Diode Forward Current vs. Forward Voltage

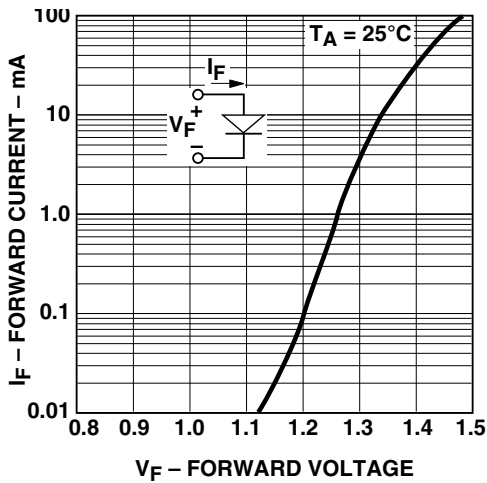


Figure 6: Propagation Delay vs. Temperature

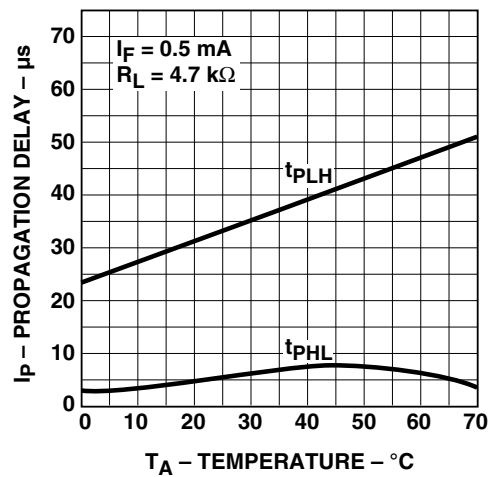
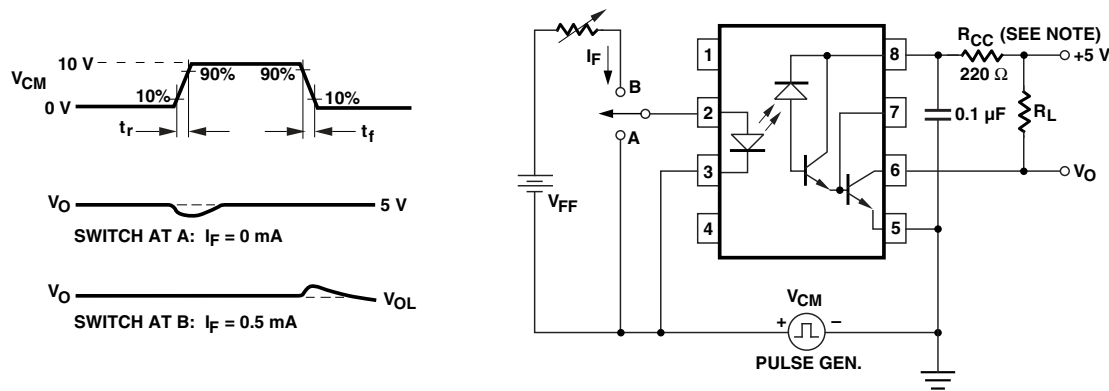
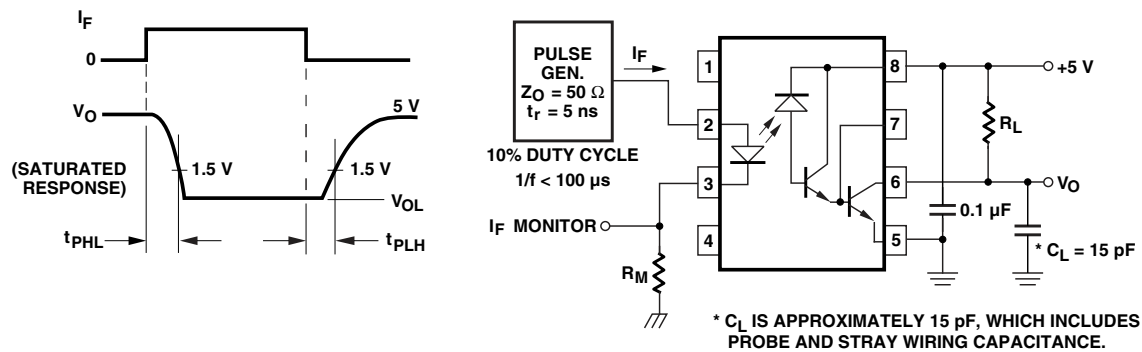


Figure 7: Test Circuit for Transient Immunity and Typical Waveforms



NOTE: In applications where dV/dt may exceed $50,000 \text{ V}/\mu\text{s}$ (such as static discharge), a series resistor, R_{CC} , should be included to protect the detector IC from destructively high surge currents. The recommended value is $R_{CC} = 220\Omega$.

Figure 8: Switching Test Circuit



Applications Information

Low-Power Operation Current Gain

There are many applications where low-power isolation is needed and can be provided by the single-channel HCPL-4701, or the dual-channel HCPL-4731 low-power optocouplers. Either or both of these two devices are referred to in this text as HCPL- 47XX product(s).

These optocouplers are Broadcom’s lowest input current, low-power optocouplers. Low-power isolation can be defined as less than a milliwatt of input power needed to operate the LED of an optocoupler (generally less than 500 μ A). This level of input forward current conducting through the LED can control a worst-case total output (I_{OL}) and power supply current (I_{CCL}) of two and a half milliamperes.

Typically, the HCPL-47XX can control a total output and supply current of 15 mA. The output current, I_O , is determined by the LED forward current multiplied by the current gain of the optocoupler, $I_O = I_F (CTR)/100\%$. In particular with the HCPL-47XX optocouplers, the LED can be driven with a very small I_F of 40 μ A to control a maximum I_O of 320 μ A with a worst-case design Current Transfer Ratio (CTR) of 800%. Typically, the CTR and the corresponding I_{OL} are four times larger.

For low-power operation, [Table 1](#) lists the typical power dissipations that occur for both the 3.3 Vdc and 5 Vdc HCPL-47XX optocoupler applications. These approximate power dissipation values are listed respectively for the LED, for the output V_{CC} and for the open-collector output transistor. Those values are summed together for a comparison of total power dissipation consumed in either the 3.3 Vdc or 5 Vdc applications.

Table 1: Typical HCPL-4701 Power Dissipation for 3V and 5V Applications

| Power Dissipation (μ W) | $V_{CC} = 3.3 \text{ Vdc}$ | | $V_{CC} = 5 \text{ Vdc}$ | |
|------------------------------|----------------------------|-------------------------|--------------------------|-------------------------|
| | $I_F = 40 \mu\text{A}$ | $I_F = 500 \mu\text{A}$ | $I_F = 40 \mu\text{A}$ | $I_F = 500 \mu\text{A}$ |
| P_{LED} | 50 | 625 | 50 | 625 |
| $P_{V_{CC}}$ | 65 | 330 | 100 | 500 |
| P_{O-C}^a | 20 | 10 | 25 | 20 |
| P_{TOTAL}^b | 135 μ W | 965 μ W | 175 μ W | 1,145 μ W |

- a. R_L of 11 k Ω open-collector (o-c) pull-up resistor was used for both 3.3 Vdc and 5 Vdc calculations.
- b. For typical total interface circuit power consumption in 3.3 Vdc application, add to P_{TOTAL} approximately 80 μ W for 40 μ A (1,025 μ W for 500 μ A) LED current-limiting resistor, and 960 μ W for the 11 k Ω pull-up resistor power dissipations. Similarly, for 5 Vdc applications, add to P_{TOTAL} approximately 150 μ W for 40 μ A (1,875 μ W for 500 μ A) LED current-limiting resistor and 2,230 μ W for the 11 k Ω pull-up resistor power dissipations.

Propagation Delay

When the HCPL-47XX optocoupler is operated under very low input and output current conditions, the propagation delay times will lengthen. When lower input drive current level is used to switch the high-efficiency AlGaAs LED, the slower the charge and discharge time will be for the LED. Correspondingly, the propagation delay times will become longer as a result. In addition, the split-Darlington (open-collector) output amplifier needs a larger, pull-up load resistance to ensure the output current is within a controllable range.

Applications that are not sensitive to longer propagation delay times and that are easily served by this HCPL-47XX optocoupler, typically 65 μ s or greater, are those of status monitoring of a telephone line, power line, battery condition of a portable unit, and so on. For faster HCPL-47XX propagation delay times, approximately 30 μ s, this optocoupler needs to operate at higher I_F (≥ 500 μ A) and I_O (≥ 1 mA) levels.

Battery-Operated Equipment

Common applications for the HCPL-47XX optocoupler are within battery-operated, portable equipment, such as test or medical instruments, computer peripherals, and accessories where energy conservation is required to maximize battery life. In these applications, the optocoupler would monitor the battery voltage and provide an isolated output to another electrical system to indicate battery status or the need to switch to a backup supply or begin a safe shutdown of the equipment via a communication port. In addition, the HCPL-47XX optocouplers are specified to operate with 3 Vdc CMOS logic family of devices to provide logic-signal isolation between similar or different logic circuit families.

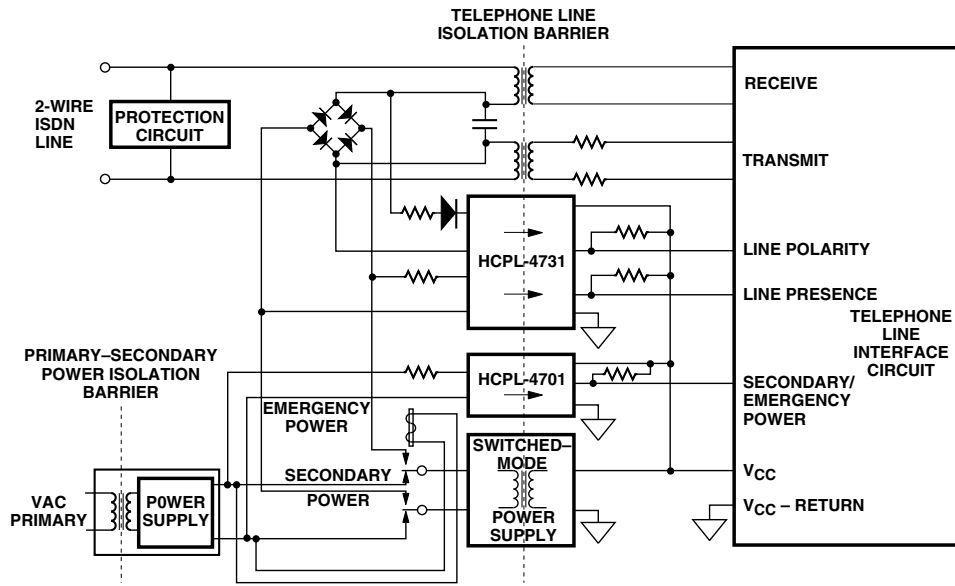
Telephone Line Interfaces

Applications where the HCPL-47XX optocoupler would be best used are in telephone line interface circuitry for functions of ring detection, on-off hook detection, line polarity, line presence and supplied-power sensing. In particular, Integrated Services Digital Network (ISDN) applications, as illustrated in [Figure 9](#), can severely restrict the input power that an optocoupler interface circuit can use (approximately 3 mW). [Figure 9](#) shows three isolated signals that can be served by the small input LED current of the HCPL-47XX dual- and single-channel optocouplers. Very low, total power dissipation occurs with these series of devices.

Switched-Mode Power Supplies

Within Switched-Mode Power Supplies (SMPS) the less power consumed the better. Isolation for monitoring line power, regulation status, for use within a feedback path between primary and secondary circuits or to external circuits are common applications for optocouplers. Low-power HCPL-47XX optocoupler can help keep higher energy conversion efficiency for the SMPS. [Figure 11](#) shows where low-power isolation can be used.

Figure 9: HCPL-47XX Isolated Monitoring Circuits for 2-Wire ISDN Telephone Line



NOTE: THE CIRCUITS SHOWN IN THIS FIGURE REPRESENT POSSIBLE, FUNCTIONAL APPLICATION OF THE HCPL-47XX OPTOCOUPLER TO AN ISDN LINE INTERFACE. THIS CIRCUIT ARRANGEMENT DOES NOT GUARANTEE COMPLIANCE, CONFORMITY, OR ACCEPTANCE TO AN ISDN, OR OTHER TELECOMMUNICATION STANDARD, OR TO FCC OR TO OTHER GOVERNMENTAL REGULATORY AGENCY REQUIREMENTS. THESE CIRCUITS ARE RECOMMENDATIONS THAT MAY MEET THE NEEDS OF THESE APPLICATIONS. Agilent DOES NOT IMPLY, REPRESENT, NOR GUARANTEE THAT THESE CIRCUIT ARRANGEMENTS ARE FREE FROM PATENT INFRINGEMENT.

Figure 10: Typical Optical Isolation Used for Power-Loss Indication and Regulation Signal Feedback

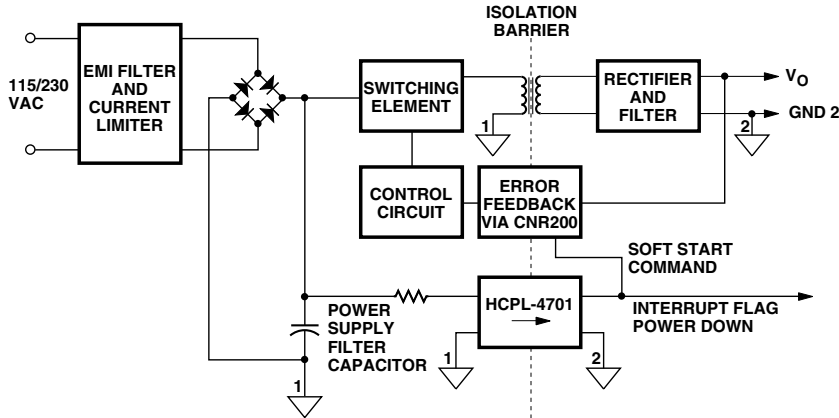
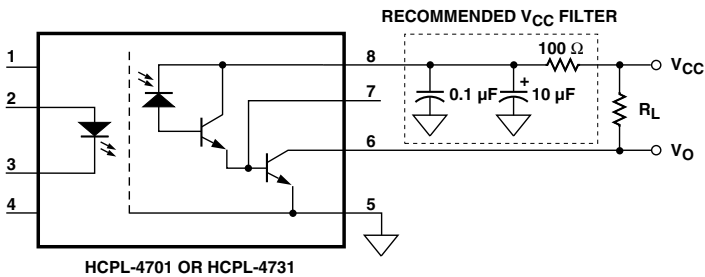


Figure 11: Recommended Power Supply Filter for HCPL-47XX Optocouplers



Data Communication and Input/Output Interfaces

In data communication, the HCPL-47XX can be used as a line receiver on a RS-232-C line or this optocoupler can be part of a proprietary data link with low input current, multi-drop stations along the data path. Also, this low-power optocoupler can be used within equipment that monitors the presence of high-voltage. For example, a benefit of the low input LED current (40 μ A) helps the input sections of a Programmable Logic Controller (PLC) monitor proximity and limit switches. The PLC I/O sections can benefit from low input current optocouplers because the total input power dissipation when monitoring the high voltage (120 Vac to 220 Vac) inputs is minimized at the I/O connections. This is especially important when many input channels are stacked together.

Circuit Design Issues

Power Supply Filtering

Since the HCPL-47XX is a high-gain, split-Darlington amplifier, any conducted electrical noise on the VCC power supply to this optocoupler should be minimized. A recommended V_{CC} filter circuit is shown in Figure 11 to improve the power supply rejection (psr) of the optocoupler. The filter should be located near the combination of pin 8 and pin 5 to provide best filtering action. This filter will drastically limit any sudden rate of change of V_{CC} with time to a slower rate that cannot interfere with the optocoupler.

Common-Mode Rejection and LED Driver Circuits

With the combination of a high-efficiency AlGaAs LED and a high-gain amplifier in the HCPL-47XX optocoupler, a few circuit techniques can enhance the common-mode rejection (CMR) of this optocoupler. First, use good high-frequency circuit layout practices to minimize coupling of common-mode signals between input and output circuits. Keep input traces away from output traces to minimize capacitive coupling of interference between input and output sections. If possible, parallel, or shunt switch the LED current as shown in Figure 12, rather than series switch the LED current as illustrated in Figure 14. Not only will CMR be enhanced with these circuits (Figure 12 and Figure 13), but the switching speed of the optocoupler will be improved as well. This is because in the parallel switched case the LED current is current-steered into or away from the LED, rather than being fully turned off as in the series switched case. Figure 12 illustrates this type of circuit. The Schottky diode helps quickly to discharge and pre-bias the LED in the off state. If a common-mode voltage across the optocoupler suddenly

attempts to inject a current into the off LED anode, the Schottky diode would divert the interfering current to ground. The combination of the Schottky diode forward voltage and the V_{ol} saturation voltage of the driver output stage (on-condition) will keep the LED voltage at or below 0.8V. This will prevent the LED (off-condition) from conducting any significant forward current that might cause the HCPL-47XX to turn on. Also, if the driver stage is an active totem-pole output, the Schottky diode allows the active output pull-up section to disconnect from the LED and pull high.

As shown in Figure 13, most active output driver integrated circuits can source directly the forward current needed to operate the LED of the HCPL-47XX optocoupler. The advantage of using the silicon diode in this circuit is to conduct charge out of the LED quickly when the LED is turned off. Upon turn-on of the LED, the silicon diode capacitance will provide a rapid charging path (peaking current) for the LED. In addition, this silicon diode prevents common-mode current from entering the LED anode when the driver IC is on and no operating LED current exists.

In general, series switching the low input current of the HCPL-47XX LED is not recommended. This is particularly valid when in a high common-mode interference environment. However, if series switching of the LED current must be done, use an additional pull-up resistor from the cathode of the LED to the input VCC as shown in Figure 15. This helps minimize any differential-mode current from conducting in the LED while the LED is off, due to a common-mode signal occurring on the input VCC (anode) of the LED. The common-mode signal coupling to the anode and cathode could be slightly different. This could potentially create a LED current to flow that would rival the normal, low input current needed to operate the optocoupler. This additional parallel resistor can help shunt any leakage current around the LED should the drive circuit, in the off state, have any significant leakage current on the order of 40 μ A.

With the use of this parallel resistor, the total drive current conducted when the LED is on is the sum of the parallel resistor and LED currents. In the series circuit of Figure 15 with the LED off, if a common-mode voltage were to couple to the LED cathode, there can be enough imbalance of common-mode voltage across the LED to cause a LED current to flow and, inadvertently, turn on the optocoupler. This series, switching circuit has no protection against a negative-transition, input common-mode signal.

Figure 12: Recommended Parallel LED Driver Circuit for HCPL-4701/-4731

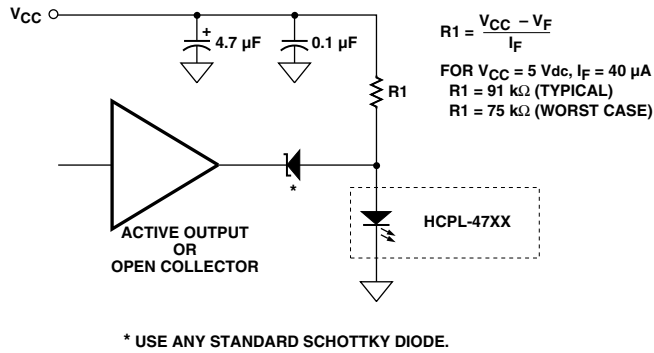


Figure 13: Recommended Alternative LED Driver Circuit for HCPL-4701/-4731L

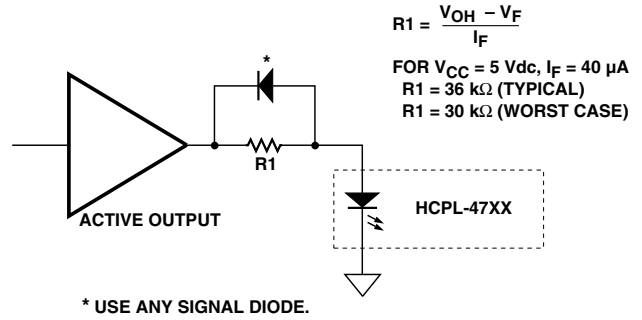


Figure 14: Series LED Driver Circuit for HCPL-4701/-4731

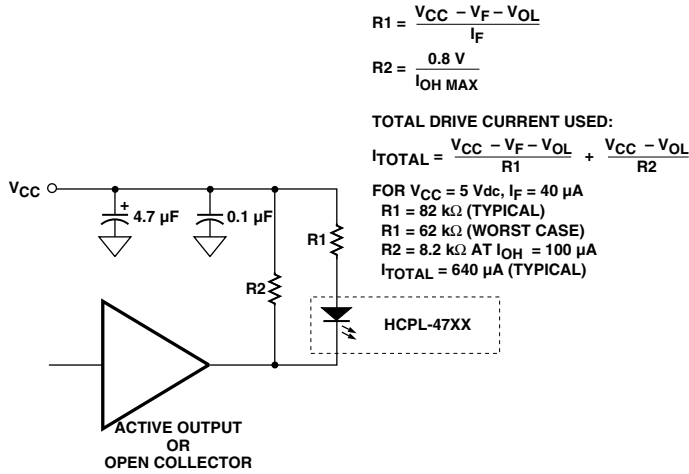
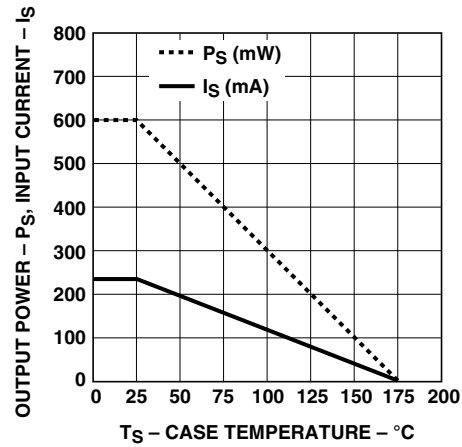


Figure 15: Thermal Derating Curve, Dependence of Safety Limiting Value with Case Temperature per VDE 0884



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