BROADCOM®

Data Sheet

# ACPL-M61U-000E

## Wide Operating Temperature 10MBd Digital Optocoupler R²Coupler™ Isolation

## Description

The Broadcom® ACPL-M61U is a small outline wide operating temperature, high CMR, high speed, logic gate optocoupler. It is a single channel device in a five lead miniature footprint.

The ACPL-M61U optically coupled gates combine a AlGaAs light emitting diode and an integrated high gain photo detector. The output of the detector IC is an Open-collector Schottky-clamped transistor. The internal shield provides a guaranteed minimum common mode transient immunity specification of 10,000 V/µs at $V_{CM}$ = 1000V.

This optocoupler is suitable for use in industrial high speed communications logic interfacing with low propagation delays, input/output buffering and is recommended for use in high operating temperature environment.

This unique design provides maximum AC and DC circuit isolation while achieving TTL compatibility. The optocoupler AC and DC operational parameters are guaranteed from –40°C to 125°C.

Broadcom R²Coupler™ isolation products provide the reinforced insulation and reliability needed for critical in automotive and high temperature industrial applications

## Features

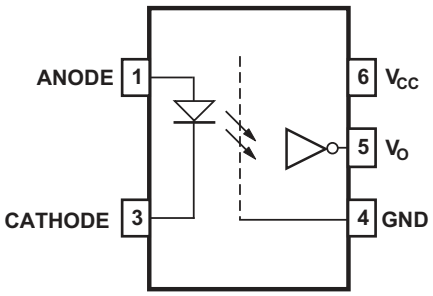
- High temperature and reliability CANBus communication interface for industrial application.
- Minimum 10 kV/µs high common-mode rejection at $V_{CM}$ = 1000 V
- Compact, auto-insertable SO-5 packages
- Wide temperature range: –40°C ~ 125°C
- High speed: 10 Mbaud (Typical)
- Low LED drive current: 6.5 mA (typ.)
- Low propagation delay: 100 ns (max.)
- Worldwide safety approval:
  - UL 1577, 3750 $V_{RMS}$ / 1 minute
  - CSA File CA88324, Notice #5
  - IEC/EN/DIN EN 60747-5-5 (for Option x60E)

## Applications

- CANBus communications interface
- High-temperature digital signal isolation
- Microcontroller interface
- Digital isolation for A/D and D/A conversion

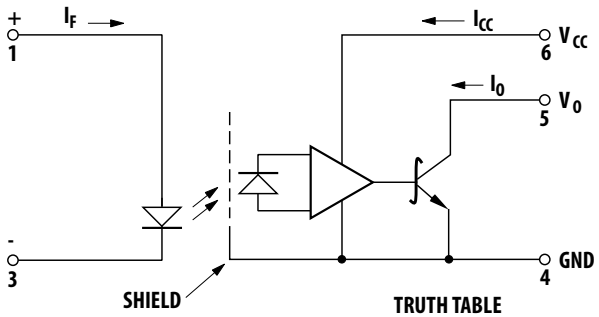
**CAUTION!** Take normal static precautions in handling and assembly of this component to prevent damage, degradation, or both that may be induced by ESD.

# Functional Block Diagram




**NOTE:** A 0.1-µF bypass capacitor must be connected between pins 4 and 6.

# Schematic




USE OF A 0.1 µF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 6 AND 4 (SEE NOTE 1).

TRUTH TABLE (POSITIVE LOGIC)

| LED | OUTPUT |
|---|---|
| ON | L |
| OFF | H |

# Ordering Information

| Part Number | Option (RoHS) Compliant | Package | Surface Mount | Tape and Reel | IEC/EN/DIN EN 60747-5-5 | Quantity |
|---|---|---|---|---|---|---|
| ACPL-M61U | -000E | SO-5 | X | | | 100 per tube |
| | -500E | | 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:

ACPL-M61U-500E describes a device with a surface mount SO-5 package; delivered in tape and reel with 1500 parts per reel; and full RoHS compliance.

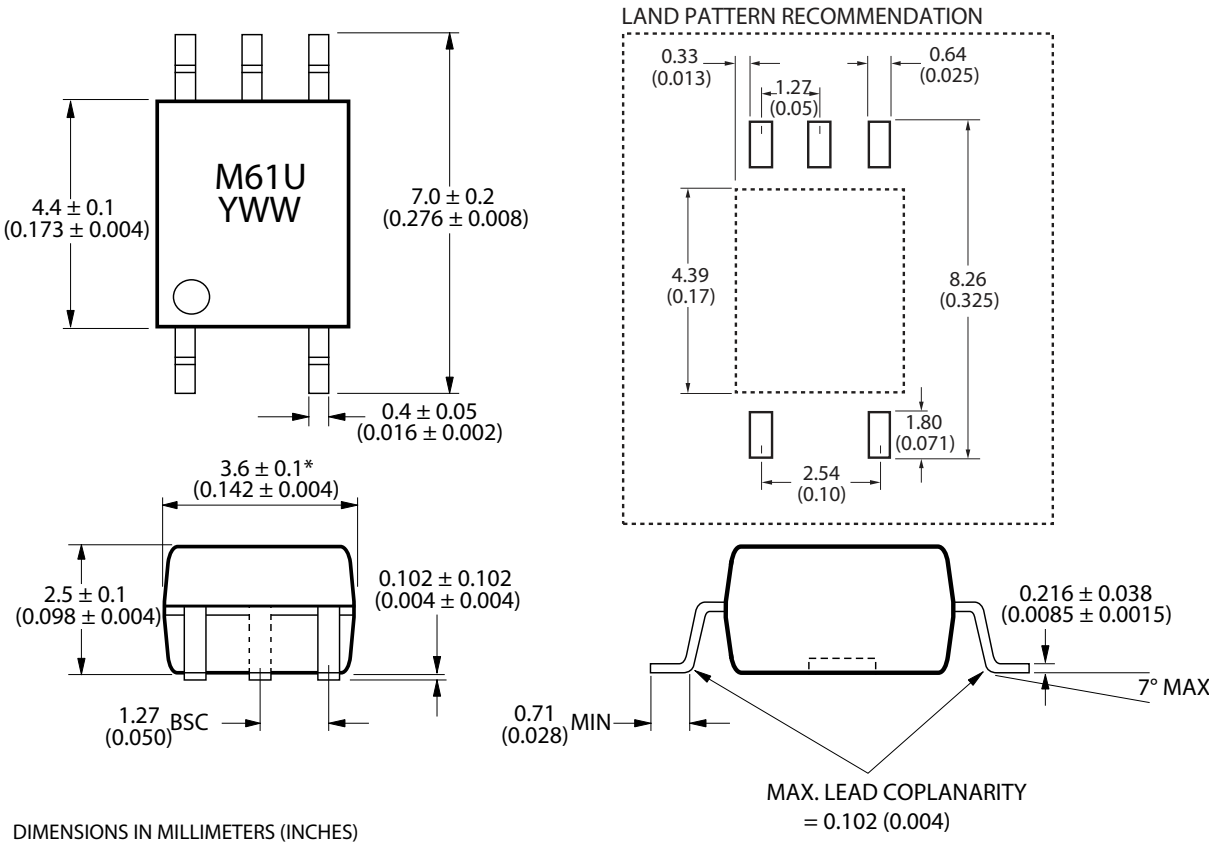
Example 2:

ACPL-M61U-000E describes a device with a surface mount SO-5 package; delivered in tube packaging; and full RoHS compliance.

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

# Package Outline Drawings

## ACPL-M61U-000E Small Outline SO-5 Package (JEDEC MO-155)




DIMENSIONS IN MILLIMETERS (INCHES)
* MAXIMUM MOLD FLASH ON EACH SIDE IS 0.15 mm (0.006)
NOTE: FLOATING LEAD PROTRUSION IS 0.15 mm (6 mils) MAX.

# Reflow Soldering Profile

The recommended reflow condition as per JEDEC Standard, J-STD-020 (latest revision). Use non-halide flux.

# Regulatory Information

The ACPL-M71U and ACPL-M72U are approved by the following organizations.

| | |
|---|---|
| **UL** | Approved under UL 1577, component recognition program up to $V_{ISO}$ = 3750 $V_{RMS}$. |
| **CSA** | Approved under CSA Component Acceptance Notice #5. |

# IEC/EN/DIN EN 60747-5-5 Insulation Characteristics (Option x60E)

| Description | Symbol | Characteristic | Units |
|---|---|---|---|
| Installation classification per DIN VDE 0110, Table 1 | | | |
| for rated mains voltage ≤ 150 Vrms | | I – IV | |
| for rated mains voltage ≤ 300 Vrms | | I – III | |
| for rated mains voltage ≤ 600 Vrms | | I – II | |
| Climatic Classification | | 40/125/21 | |
| Pollution Degree (DIN VDE 0110/39) | | 2 | |
| Maximum Working Insulation Voltage | $V_{IORM}$ | 567 | $V_{peak}$ |
| Input to Output Test Voltage, Method b[a]<br>$V_{IORM}$ × 1.875 = $V_{PR}$, 100% Production Test with $t_m$ = 1s, Partial Discharge < 5 pC | $V_{PR}$ | 1063 | $V_{peak}$ |
| Input to Output Test Voltage, Method a[a]<br>$V_{IORM}$ × 1.6 = $V_{PR}$, Type and Sample Test, $t_m$ = 10s, Partial Discharge < 5 pC | $V_{PR}$ | 907 | $V_{peak}$ |
| Highest Allowable Overvoltage (Transient Overvoltage, $t_{ini}$ = 60s) | $V_{IOTM}$ | 6000 | $V_{peak}$ |
| Safety Limiting Values (Maximum values allowed in the event of a failure) | | | |
| Case Temperature | $T_S$ | 175 | °C |
| Input Current | $I_{S, INPUT}$ | 150 | mA |
| Output Power | $P_{S,OUTPUT}$ | 600 | mW |
| Insulation Resistance at $T_S$, $V_{IO}$ = 500V | $R_S$ | $>10^9$ | Ω |

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

# Insulation and Safety Related Specifications

| Parameter | Symbol | ACPL-M61U | Units | Conditions |
|---|---|---|---|---|
| Minimum External Air Gap (Clearance) | L(I01) | ≥5 | mm | Measured from input terminals to output terminals, shortest distance through air. |
| Minimum External Tracking (Creepage) | L(I02) | ≥5 | mm | Measured from input terminals to output terminals, shortest distance path along body. |
| Minimum Internal Plastic Gap (Internal Clearance) | | 0.08 | mm | Insulation thickness between emitter and detector; also known as distance through insulation. |
| Tracking Resistance (Comparative Tracking Index) | CTI | 175 | Volts | DIN IEC 112/VDE 0303 Part 1 |
| Isolation Group (DIN VDE0109) | | IIIa | | Material Group (DIN VDE 0109) |

# Absolute Maximum Ratings

| Parameter | | Symbol | Min. | Max. | Units | Note |
|---|---|---|---|---|---|---|
| Storage Temperature | | $T_S$ | –55 | +125 | °C | |
| Ambient Operating Temperature | | $T_A$ | –40 | +125 | °C | |
| Lead Soldering Cycle | Temperature | | — | 260 | °C | |
| | Time | | — | 10 | s | |
| Input Current (50% duty cycle, 1 ms pulse width) (≤1 µs pulse width, 300 ps) | Average | $I_{F(avg)}$ | — | 20 | mA | 12 |
| | Peak | $I_{F(peak)}$ | — | 40 | mA | |
| | Transient | $I_{F(trans)}$ | — | 100 | mA | |
| Reverse Input Voltage | | $V_R$ | — | 5 | V | |
| Input Power Dissipation | | $P_I$ | — | 30 | mW | 13 |
| Output Power Dissipation | | $P_o$ | — | 85 | mW | 14 |
| Output Collector Current | | $I_O$ | — | 50 | mA | |
| Supply Voltage (pins 6, 4) | | $V_{CC}$ | –0.5 | 7 | V | |
| Output Voltage (pins 5, 4) | | $V_O$ | –0.5 | 7 | V | |

# Recommended Operating Conditions

| Parameter | Symbol | Min. | Max. | Units |
|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | 4.5 | 5.5 | V |
| Operating Temperature | $T_A$ | –40 | 125 | °C |
| Input Current, Low Level | $I_{FL}$[a] | 0 | 250 | µA |
| Input Current, High Level | $I_{FH}$ | 5 | 15 | mA |
| Fan Out ($R_L$ = 1 kΩ) | N | — | 5 | TTL Loads |
| Output Pull-Up Resistor | $R_L$ | 330 | 4000 | Ω |

a. The off condition can also be guaranteed by ensuring that $V_F$(off) ≤ 0.8V.

# Electrical Specifications (DC)

Over recommended operating temperature $T_A$ = –40°C to +125°C, unless otherwise specified.

| Parameter | Symbol | Min. | Typ.[a] | Max. | Units | Conditions | Figure | Note |
|---|---|---|---|---|---|---|---|---|
| Input Threshold Current | $I_{TH}$ | — | 2 | 5 | mA | $V_{CC}$ = 5.5V, $I_O$ ≥ 13 mA, $V_O$ = 0.6V | 4 | |
| High Level Output Current | $I_{OH}$ | — | 5.5 | 100 | µA | $V_{CC}$ = 5.5V, $V_O$ = 5.5V, $V_F$ = 0.5V | 1 | |
| Low Level Output Voltage | $V_{OL}$ | — | 0.4 | 0.6 | V | $V_{CC}$ = 5.5V, $I_F$ = 6.5 mA, $I_{OL}$ (sinking) = 13 mA | 2,4,5 | |
| High Level Supply Current | $I_{CCH}$ | — | 7.0 | 10.0 | mA | $V_{CC}$ = 5.5V, $I_F$ = 0 mA | | |
| Low Level Supply Current | $I_{CCL}$ | — | 9.0 | 13.0 | mA | $V_{CC}$ = 5.5V, $I_F$ = 10 mA | | |
| Input Forward Voltage | $V_F$ | 1.45 | 1.5 | 1.85 | V | $I_F$ = 10 mA, $T_A$ = 25°C | | |
| | | 1.35 | 1.5 | 1.95 | V | $I_F$ = 10 mA | | |
| Input Reversed Breakdown Voltage | $BV_R$ | 5 | — | — | V | $I_R$ = 10 µA | | |
| Temperature Coefficient of Forward Voltage | $\Delta V_F/\Delta T_A$ | — | –1.5 | — | mV/°C | $I_F$ = 10 mA | 3,12 | |

a. All typical specifications are at $T_A$ = 25°C, $V_{CC}$ = 5V.

# Package Characteristics

| Parameter | Symbol | Min. | Typ. | Max. | Units | Test Conditions | Figure | Note |
|---|---|---|---|---|---|---|---|---|
| Input-Output Momentary Withstand Voltage | $V_{ISO}$ | 3750 | — | — | $V_{rms}$ | RH ≤ 50%, t = 1 minute, $T_A$ = 25°C | | |
| Input-Output Resistance | $R_{I-O}$ | — | $10^{12}$ | — | Ω | $V_{I-O}$ = 500 Vdc | | |
| Input-Output Capacitance | $C_{I-O}$ | — | 0.6 | — | pF | f = 1 MHz, $V_{I-O}$ = 0 Vdc | | |

# Switching Specifications

Over recommended temperature $T_A$ = –40°C to +125°C, $V_{CC}$ = 5.0V, $I_F$ = 6.5 mA unless otherwise specified.

| Parameter | Symbol | Min. | Typ.[a] | Max. | Units | Test Conditions | | Figure | Note |
|---|---|---|---|---|---|---|---|---|---|
| Propagation Delay Time to Logic Low Output | $t_{PHL}$ | — | 46 | 75 | ns | $T_A$ = 25°C | $R_L$ = 350Ω, $C_L$ = 15 pF $I_F$ = 6.5 mA | 6,7,8 | 6 |
| | | | | 100 | ns | | | | |
| Propagation Delay Time to Logic High Output | $t_{PLH}$ | — | 50 | 75 | ns | $T_A$ = 25°C | | 6,7,8 | 5 |
| | | | | 100 | ns | | | | |
| Pulse Width Distortion | $\|t_{PHL} - t_{PLH}\|$ | — | 3.5 | 35 | ns | | | 9 | 10 |
| Propagation Delay Skew | $t_{PSK}$ | — | — | 40 | ns | | | 14,15 | 10,11 |
| Output Rise Time (10% - 90%) | $t_{rise}$ | — | 24 | — | ns | | | 10 | |
| Output Fall Time (90% - 10%) | $t_{fall}$ | — | 10 | — | ns | | | 10 | |
| Common Mode Transient Immunity at High Output Level | $\|CM_H\|$ | 15 | 30 | — | kV/µs | $V_{CM}$ = 1000Vp-p | $V_{O(min)}$ = 2V IF = 0 mA $T_A$ = 25°C $R_L$ = 350Ω | 11 | 7,9 |
| Common Mode Transient Immunity at Low Output Level | $\|CM_L\|$ | 15 | 30 | — | kV/µs | $V_{CM}$ = 1000Vp-p | $V_{O(max)}$ = 0.8V IF = 6.5 mA $T_A$ = 25°C $R_L$ = 350Ω | | 8,9 |

a. All typicals at $T_A$ = 25°C, $V_{CC}$ = 5V.

**NOTE:**

1. Bypassing of the power supply line is required with a 0.1 µF ceramic disc capacitor adjacent to each optocoupler. The total lead length between both ends of the capacitor and the isolator pins should not exceed 10 mm.
2. Peaking circuits may produce transient input currents up to 40 mA, 50 ns maximum pulse width, provided average current does not exceed 20 mA.
3. Device considered a two terminal device: pins 1 and 3 shorted together and pins 4, 5 and 6 shorted together.
4. In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage ≥ $4500V_{RMS}$ for 1 second (leakage detection current limit, $I_{I-O} \leq 5$ µA).
5. The $t_{PLH}$ propagation delay is measured from 3.25 mA point on the falling edge of the input pulse to the 1.5V point on the rising edge of the output pulse.
6. The $t_{PHL}$ propagation delay is measured from 3.25 mA point on the rising edge of the input pulse to the 1.5V point on the falling edge of the output pulse.
7. $CM_H$ is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (for example, $V_{OUT} > 2.0V$).
8. $CM_L$ is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (for example, $V_{OUT} < 0.8V$).
9. For sinusoidal voltages, $(|dV_{CM}|/dt)max = \pi f_{CM} V_{CM}(p\text{-}p)$.
10. See application section Propagation Delay, Pulse-Width Distortion, and Propagation Delay Skew for more information.
11. $t_{PSK}$ is equal to the worst case difference in $t_{PHL}$ and/or $t_{PLH}$ that will be seen between units at any given temperature within the worst case operating condition range.
12. Input current derates linearly above 85°C free-air temperature at a rate of 0.25 mA/°C.
13. Input power derates linearly above 85°C free-air temperature at a rate of 0.375 mW/°C.
14. Output power derates linearly above 85°C free-air temperature at a rate of 0.475 mW/°C.

**Figure 1: High Level Output Current vs. Temperature**

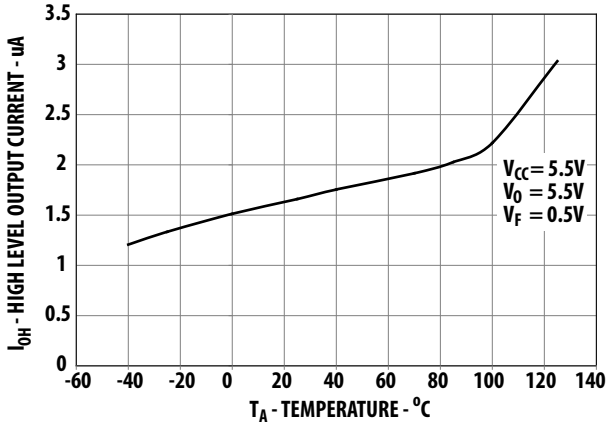



**Figure 2: Low Level Output Voltage vs. Temperature**

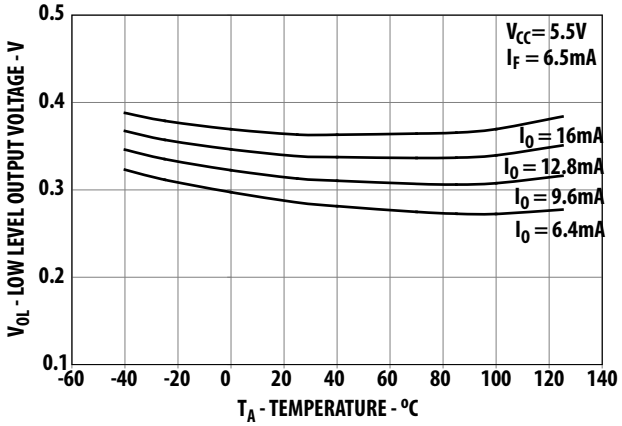



**Figure 3: Input Current vs. Forward Voltage**

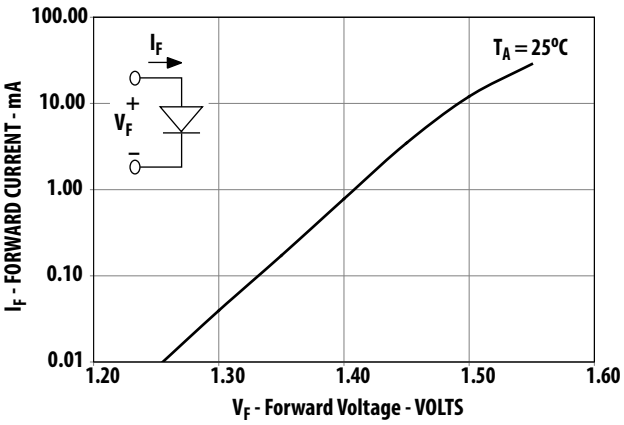



**Figure 4: Output Voltage vs. Forward Input Current**

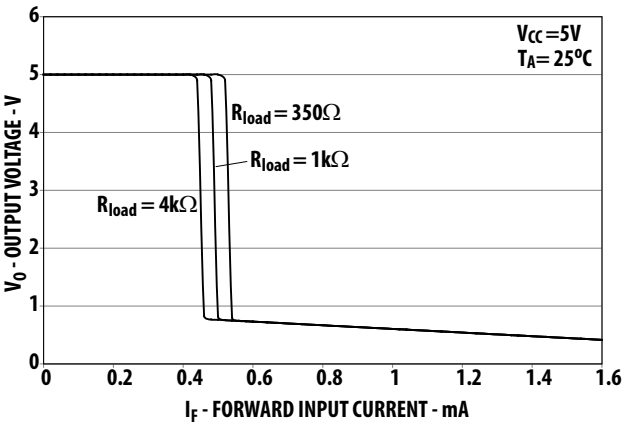



**Figure 5: Low Level Output Current vs. Temperature**

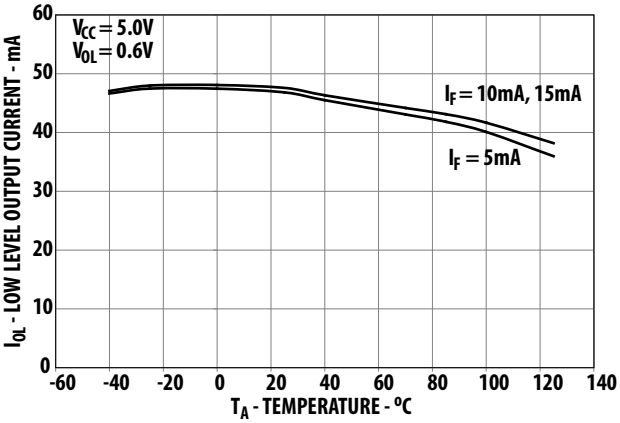


**Figure 6: Test Circuit for $t_{PHL}$ and $t_{PLH}$**

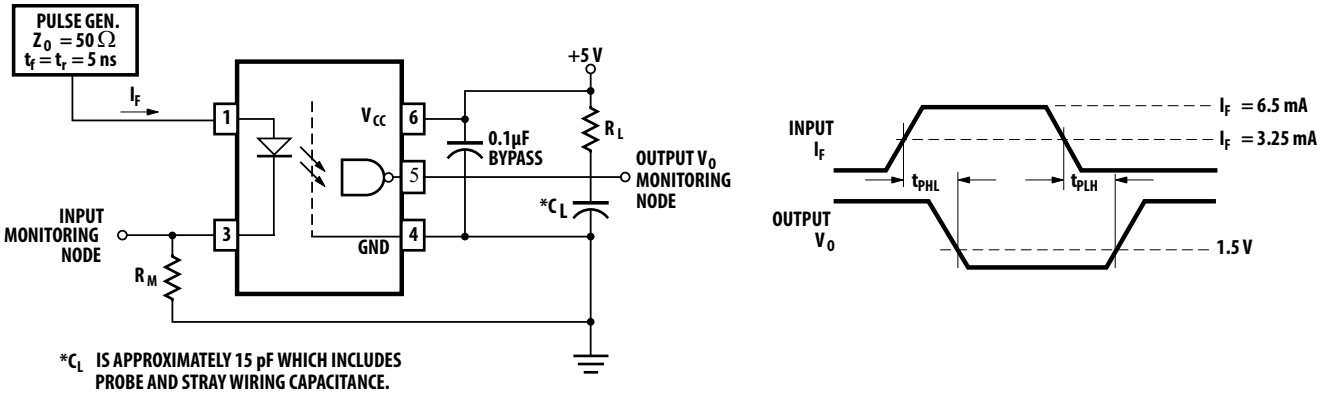



**Figure 7: Propagation Delay vs. Temperature**

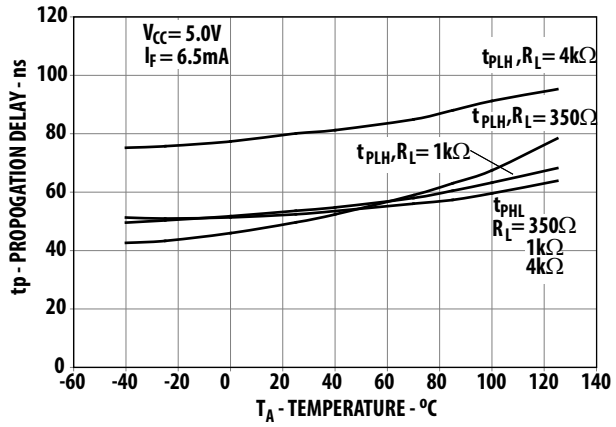



**Figure 8: Propagation Delay vs. Pulse Input Current**

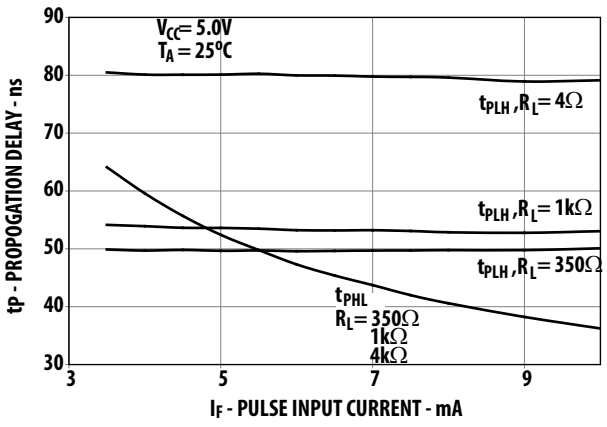



**Figure 9: Pulse Width Distortion vs. Temperature**

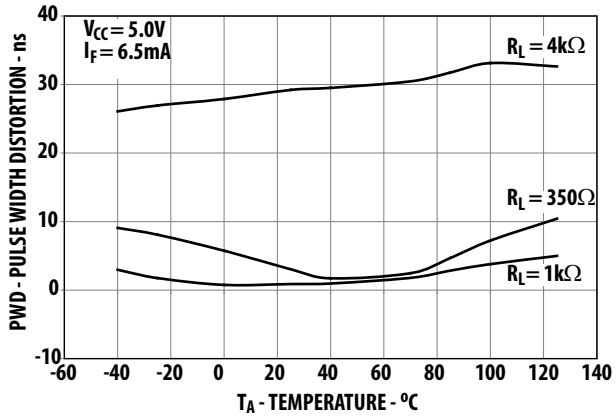



**Figure 10: Rise and Fall Time vs. Temperature**

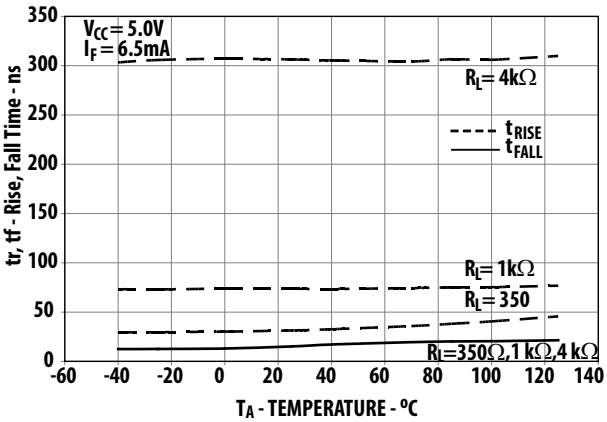


**Figure 11: Test Circuit for Common Mode Transient Immunity and Typical Waveforms**

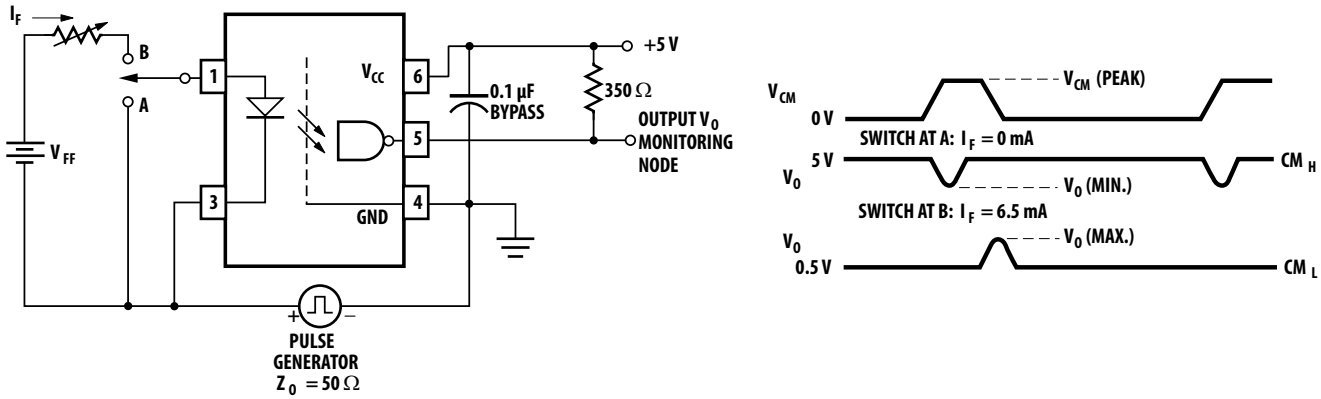



**Figure 12: Temperature Coefficient for Forward Voltage vs. Input Current**

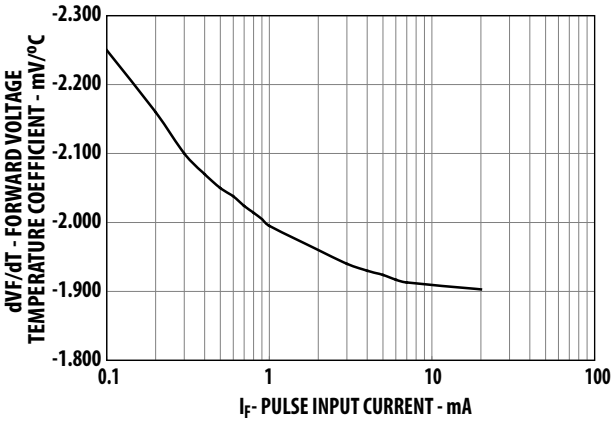
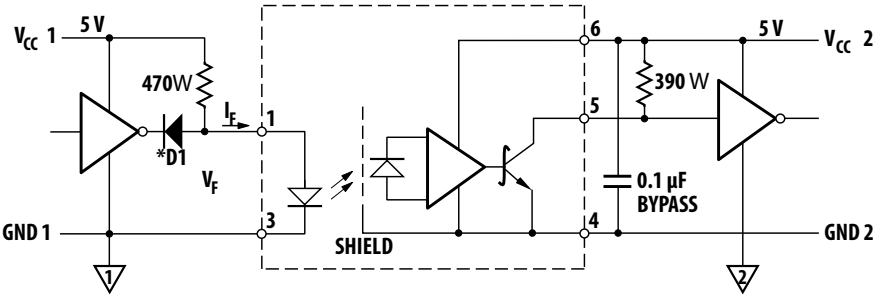



**Figure 13: Recommended TTL/LSTTL to TTL/LSTTL Interface Circuit**




* DIODE D1 (1N916 OR EQUIVALENT) IS NOT REQUIRED FOR UNITS WITH OPEN COLLECTOR OUTPUT.

# Propagation Delay, Pulse-Width Distortion, and Propagation Delay Skew

Propagation delay is a figure of merit which describes how quickly a logic signal propagates through a system. The propagation delay from low to high ($t_{PLH}$) is the amount of time required for an input signal to propagate to the output, causing the output to change from low to high. Similarly, the propagation delay from high to low ($t_{PHL}$) is the amount of time required for the input signal to propagate to the output, causing the output to change from high to low (see Figure 6).

Pulse-width distortion (PWD) results when $t_{PLH}$ and $t_{PHL}$ differ in value. PWD is defined as the difference between $t_{PLH}$ and $t_{PHL}$ and often determines the maximum data rate capability of a transmission system. PWD can be expressed in percent by dividing the PWD (in ns) by the minimum pulse width (in ns) being transmitted. Typically, PWD on the order of 20% to 30% of the minimum pulse width is tolerable; the exact figure depends on the particular application (RS232, RS422, T-1, and so forth).

Propagation delay skew, $t_{PSK}$, is an important parameter to consider in parallel data applications where synchronization of signals on parallel data lines is a concern. If the parallel data is being sent through a group of optocouplers, differences in propagation delays will cause the data to arrive at the outputs of the optocouplers at different times. If this difference in propagation delays is large enough, it will determine the maximum rate at which parallel data can be sent through the optocouplers.

Propagation delay skew is defined as the difference between the minimum and maximum propagation delays, either $t_{PLH}$ or $t_{PHL}$, for any given group of optocouplers which are operating under the same conditions (i.e., the same drive current, supply voltage, output load, and operating temperature). As illustrated in Figure 14, if the inputs of a group of optocouplers are switched either ON or OFF at the same time, $t_{PSK}$ is the difference between the shortest propagation delay, either $t_{PLH}$ or $t_{PHL}$, and the longest propagation delay, either $t_{PLH}$ or $t_{PHL}$.

As mentioned earlier, $t_{PSK}$ can determine the maximum parallel data transmission rate. Figure 15 shows the timing diagram of a typical parallel data application with both the clock and the data lines being sent through optocouplers. The figure shows data and clock signals at the inputs and outputs of the optocouplers. To obtain the maximum data transmission rate, both edges of the clock signal are being used to clock the data; if only one edge were used, the clock signal would need to be twice as fast.

Propagation delay skew represents the uncertainty of where an edge might be after being sent through an optocoupler. Figure 15 shows that there will be uncertainty in both the data and the clock lines. It is important that these two areas of uncertainty not overlap, otherwise the clock signal might arrive before all of the data outputs have settled, or some of the data outputs may start to change before the clock signal has arrived. From these considerations, the absolute minimum pulse width that can be sent through optocouplers in a parallel application is twice $t_{PSK}$. A cautious design should use a slightly longer pulse width to ensure that any additional uncertainty in the rest of the circuit does not cause a problem.

The $t_{PSK}$-specified optocouplers offer the advantages of guaranteed specifications for propagation delays, pulse-width distortion and propagation delay skew over the recommended temperature, and input current, and power supply ranges.

**Figure 14: Illustration of Propagation Delay Skew - $t_{PSK}$**

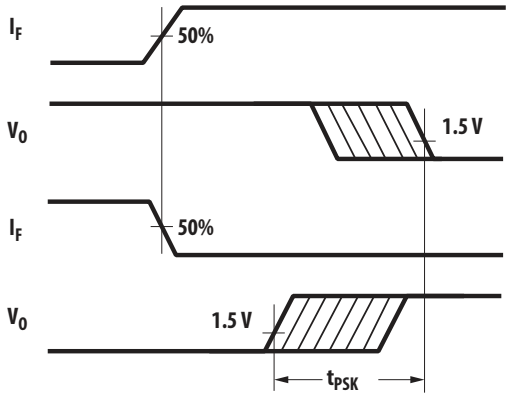
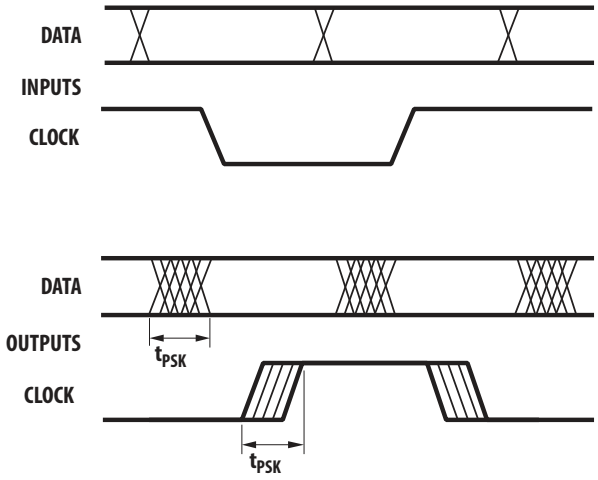


**Figure 15: Parallel Data Transmission Example**



BROADCOM®

Lead (Pb) Free
RoHS Compliant