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# ACPL-M71U and ACPL-M72U

Wide Operating Temperature, High Speed, Low Power  
Digital Optocouplers with R<sup>2</sup>Coupler™ Isolation



## Data Sheet

### Description

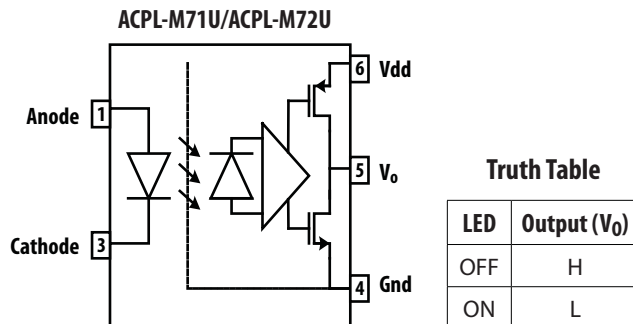
The Avago ACPL-M71U and ACPL-M72U are high temperature, digital CMOS optocouplers in SOIC-5 packages. These optocouplers use the latest CMOS IC technology to achieve outstanding performance and very low power consumption. All devices operate over the -40°C to 125 °C temperature range.

The ACPL-M71U uses a high speed LED, and the ACPL-M72U uses a low current LED for lower power dissipation. The high speed ACPL-M71U featuring a 35 ns maximum propagation delay ( $I_F = 10$  mA). The ACPL-M72U optocoupler features very low power. With a low 4 mA LED drive current, ACPL-M72U typical propagation delay is 60 ns.

Each digital optocoupler has a CMOS detector IC, an integrated photodiode, a high speed transimpedance amplifier, and a voltage comparator with an output driver.

Avago R<sup>2</sup>Coupler isolation products provide the reinforced insulation and reliability needed for critical in high temperature industrial applications

### Functional Block Diagram



Note: A 0.1  $\mu$ F bypass capacitor must be connected between pins 4 and 6.

### Features

- 5 V CMOS compatible
- Common-Mode Rejection 40kV/ $\mu$ s @  $V_{CM} = 1000$ V:
- Wide Industrial temperature range: -40°C to 125°C
- Low propagation delay :
  - High Speed ACPL-M71U: 26ns @  $I_F = 10$  mA (Typical)
  - Low Power ACPL-M72U: 60ns @  $I_F = 4$  mA (Typical)
- Worldwide safety approval:
  - UL 1577 recognized, 3750 Vrms / 1 min
  - CSA approved
  - IEC/EN/DIN EN 60747-5-5

### Applications

- Industrial CANBus communications interface
- Industrial isolated high speed gate drivers for IGBTs and Power MOSFETs
- High temperature digital signal isolation
- Microcontroller interface
- Digital isolation for A/D and D/A conversion

**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

| Part Number | Option           |  | Package | Surface Mount | Tape & Reel | Quantity      |
|-------------|------------------|--|---------|---------------|-------------|---------------|
|             | (RoHS) Compliant |  |         |               |             |               |
| ACPL-M71U   | -000E            |  | SO-5    | X             |             | 100 per tube  |
|             | -500E            |  |         | X             | X           | 1500 per reel |
| ACPL-M72U   | -000E            |  | SO-5    | X             |             | 100 per tube  |
|             | -500E            |  |         | X             | X           | 1500 per reel |

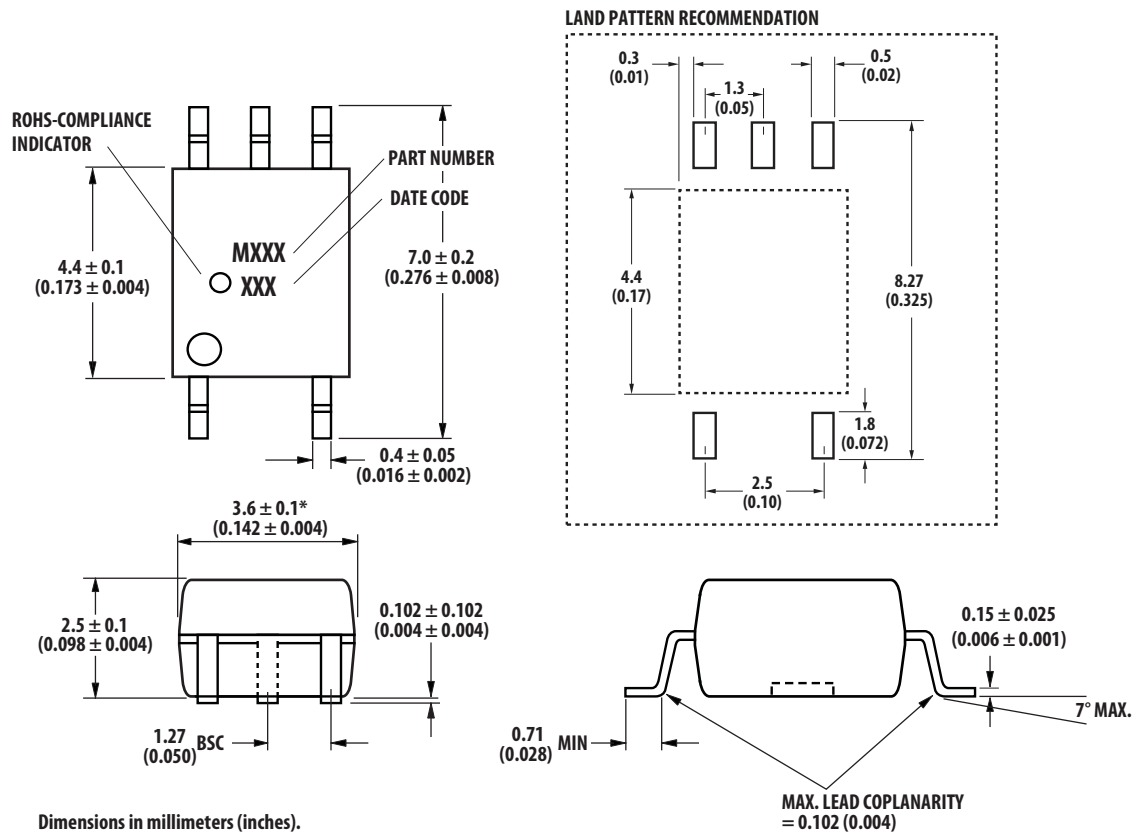
To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry.

For example, the part number ACPL-M71U-500E describes a device with a surface mount SOIC-5 package; delivered in Tape and Reel with 1500 parts per reel; and full RoHS compliance.

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

## Package Dimensions

### ACPL-M71U / ACPL-M72U (JEDEC MO-155 Package)



Dimensions in millimeters (inches).

Note: Floating Lead Protrusion is 0.15 mm (6 mils) max.

\* Maximum Mold flash on each side is 0.15 mm (0.006).

## Recommended Pb-Free IR Profile

Recommended reflow condition as per JEDEC Standard, J-STD-020 (latest revision).

Note: Non-halide flux should be used.

## Regulatory Information

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

### UL

Approved under UL 1577, component recognition program up to  $V_{ISO} = 3750 V_{RMS}$  expected prior to product release.

### CSA

Approved under CSA Component Acceptance Notice #5.

### IEC/EN/DIN EN 60747-5-5

## Insulation and Safety Related Specifications

| Parameter                                         | Symbol | Value | 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                                   |        | IIIa  |       | Material Group (DIN VDE 0109)                                                                 |

## IEC/EN/DIN EN 60747-5-5 Insulation Related Characteristics

| Description                                                                                                                                                    | Symbol          | ACPL-M71U/<br>ACPL-M72U | Units      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------------|------------|
| Maximum Working Insulation Voltage                                                                                                                             | $V_{IORM}$      | 567                     | $V_{PEAK}$ |
| Input to Output Test Voltage, Method b <sup>†</sup><br>$V_{IORM} \times 1.875 = V_{PR}$ , 100% Production<br>Test with $t_m = 1$ sec, Partial Discharge < 5 pC | $V_{PR}$        | 1063                    | $V_{PEAK}$ |
| Input to Output Test Voltage, Method a <sup>†</sup><br>$V_{IORM} \times 1.6 = V_{PR}$ , Type and Sample Test,<br>$t_m = 10$ sec, Partial Discharge < 5 pC      | $V_{PR}$        | 907                     | $V_{PEAK}$ |
| Highest Allowable Overvoltage <sup>†</sup><br>(Transient Overvoltage, $t_{ini} = 60$ sec)                                                                      | $V_{IOTM}$      | 6000                    | $V_{PEAK}$ |
| Safety Limiting Values<br>(Maximum values allowed in the event of a failure,<br>also see Thermal Derating curve, Figure 11.)                                   |                 |                         |            |
| Case Temperature                                                                                                                                               | $T_s$           | 175                     | °C         |
| Input Current                                                                                                                                                  | $I_{s, INPUT}$  | 150                     | mA         |
| Output Power                                                                                                                                                   | $P_{s, OUTPUT}$ | 600                     | mW         |
| Insulation Resistance at $T_s$ , $V_{IO} = 500$ V                                                                                                              | $R_{IO}$        | $\geq 10^9$             | $\Omega$   |

## Absolute Maximum Ratings

| Parameter                                                                          | Symbol        | Min. | Max.                                          | Units   | Condition                                                                   |
|------------------------------------------------------------------------------------|---------------|------|-----------------------------------------------|---------|-----------------------------------------------------------------------------|
| Storage Temperature                                                                | $T_S$         | -55  | +150                                          | °C      |                                                                             |
| Ambient Operating Temperature <sup>[1]</sup>                                       | $T_A$         | -40  | +125                                          | °C      |                                                                             |
| Supply Voltages                                                                    | $V_{DD}$      | 0    | 6.5                                           | Volts   |                                                                             |
| Output Voltage                                                                     | $V_O$         | -0.5 | $V_{DD} + 0.5$                                | Volts   |                                                                             |
| Average Forward Input Current                                                      | $I_F$         | -    | 20.0                                          | mA      |                                                                             |
| Peak Transient Input Current<br>( $I_F$ at 1 $\mu$ s pulse width, <10% duty cycle) | $I_{F(TRAN)}$ |      | 1<br>80                                       | A<br>mA | <1 $\mu$ s Pulse Width, 300pps<br><1 $\mu$ s Pulse Width,<br><10%Duty Cycle |
| Reverse Input Voltage                                                              | $V_R$         | -    | 5                                             | V       |                                                                             |
| Input Power Dissipation                                                            | $P_I$         |      | 40                                            | mW      |                                                                             |
| Output Power Dissipation                                                           | $P_O$         |      | 30                                            | mW      |                                                                             |
| Lead Solder Temperature                                                            |               |      | 260°C for 10 sec., 1.6 mm below seating plane |         |                                                                             |
| Solder Reflow Temperature Profile                                                  |               |      | See Solder Reflow Temperature Profile Section |         |                                                                             |

## Recommended Operating Conditions

| Parameter                     | Symbol       | Min. | Max. | Units |
|-------------------------------|--------------|------|------|-------|
| Ambient Operating Temperature | $T_A$        | -40  | +125 | °C    |
| Supply Voltages               | $V_{DD}$     | 3.0  | 5.5  | V     |
| Forward Input Current         | $I_{F(ON)}$  | 4.0  | 15   | mA    |
| Forward Off State Voltage     | $V_{F(OFF)}$ |      | 0.8  | V     |
| Input Threshold Current       | $I_{TH}$     |      | 3.5  | mA    |

## Electrical Specifications

Over recommended temperature ( $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $3.0\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ . All typical specifications are at  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = +5\text{V}$ .

| Parameter                        | Symbol    | Min.         | Typ. | Max. | Units                  | Test Conditions                                                            | Fig |
|----------------------------------|-----------|--------------|------|------|------------------------|----------------------------------------------------------------------------|-----|
| Input Capacitance                | $C_{IN}$  |              | 90   |      | pF                     |                                                                            |     |
| Input Reverse Breakdown Voltage  | $BV_R$    | 5.0          |      |      | V                      | $I_R = 10\ \mu\text{A}$                                                    |     |
| Logic High Output Voltage        | $V_{OH}$  | $V_{DD}-0.6$ |      |      | V                      | $I_{OH} = -4\text{mA}$                                                     | 4   |
| Logic Low Output Voltage         | $V_{OL}$  |              |      | 0.6  | V                      | $I_{OL} = 4\text{mA}$                                                      | 3   |
| Logic Low Output Supply Current  | $I_{DDL}$ |              | 0.9  | 1.5  | mA                     |                                                                            |     |
| Logic High Output Supply Current | $I_{DDH}$ |              | 0.9  | 1.5  | mA                     |                                                                            |     |
| LED Forward Voltage              | $V_f$     | 1.45         | 1.5  | 1.75 | V                      | $I_F = 10\text{mA}$ , $T_A = 25^{\circ}\text{C}$                           |     |
|                                  |           | 1.25         | 1.5  | 1.85 | V                      | $I_F = 10\text{mA}$ , $T_A = -40^{\circ}\text{C} \sim 125^{\circ}\text{C}$ |     |
| Vf Temperature Coefficient       |           |              | -1.5 |      | mV/ $^{\circ}\text{C}$ |                                                                            |     |

## ACPL-M71U High Speed Mode Switching Specifications

Over recommended temperature ( $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ),  $4.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ . All typical specifications are at  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = 5\text{V}$ .

| Parameter                                                          | Symbol    | Min. | Typ. | Max. | Units             | Test Conditions                                                                                                                                          | Fig    | Note  |
|--------------------------------------------------------------------|-----------|------|------|------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|
| Propagation Delay Time to Logic Low Output <sup>[1]</sup>          | $t_{PHL}$ |      | 26   | 35   | ns                | $V_{in} = 4.5\text{V}-5.5\text{V}$ ,<br>$R_{in} = 390\Omega \pm 5\%$ , $C_{in} = 100\text{pF}$ ,<br>$C_L = 15\text{pF}$                                  | 5,6,11 | 1,2,3 |
| Propagation Delay Time to Logic High Output <sup>[1]</sup>         | $t_{PLH}$ |      | 26   | 35   | ns                |                                                                                                                                                          |        |       |
| Pulse Width Distortion <sup>[2]</sup>                              | PWD       |      | 0    | 12   | ns                |                                                                                                                                                          |        |       |
| Propagation Delay Skew <sup>[3]</sup>                              | $t_{PSK}$ |      |      | 15   | ns                |                                                                                                                                                          |        |       |
| Output Rise Time (10% – 90%)                                       | $t_R$     |      | 10   |      | ns                |                                                                                                                                                          |        |       |
| Output Fall Time (90% - 10%)                                       | $t_F$     |      | 10   |      | ns                |                                                                                                                                                          |        |       |
| Common Mode Transient Immunity at Logic High Output <sup>[4]</sup> | $ CM_H $  | 15   | 25   |      | kV/ $\mu\text{s}$ | $V_{in} = 0\text{V}$ $R_{in} = 390\Omega \pm 5\%$ ,<br>$C_{in} = 100\text{pF}$ , $V_{cm} = 1000\text{V}$ ,<br>$T_A = 25^{\circ}\text{C}$                 | 12     | 4     |
| Common Mode Transient Immunity at Logic High Output <sup>[5]</sup> | $ CM_L $  | 15   | 25   |      | kV/ $\mu\text{s}$ | $V_{in} = 4.5\text{V}-5.5\text{V}$ ,<br>$R_{in} = 390\Omega \pm 5\%$ , $C_{in} = 100\text{pF}$ ,<br>$V_{cm} = 1000\text{V}$ , $T_A = 25^{\circ}\text{C}$ | 13     | 5     |

## ACPL-M72U Low Power Mode Switching Specifications

Over recommended temperature (-40°C to +125°C),  $3.0V \leq V_{DD} \leq 5.5V$ . All typical specifications at +25°C and  $V_{DD} = 5V$

| Parameter                                                          | Symbol    | Min. | Typ. | Max. | Units       | Test Conditions                                                                                                             | Fig                 | Note  |
|--------------------------------------------------------------------|-----------|------|------|------|-------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------|-------|
| Propagation Delay Time to Logic Low Output <sup>[1]</sup>          | $t_{PHL}$ |      | 60   | 100  | ns          | $I_F=4mA, C_L=15pF$                                                                                                         | 7,8,<br>9,10,<br>14 | 1,2,3 |
| Propagation Delay Time to Logic High Output <sup>[1]</sup>         | $t_{PLH}$ |      | 35   | 100  | ns          |                                                                                                                             |                     |       |
| Pulse Width Distortion <sup>[2]</sup>                              | PWD       |      | 25   | 50   | ns          |                                                                                                                             |                     |       |
| Propagation Delay Skew <sup>[3]</sup>                              | $t_{PSK}$ |      |      | 60   | ns          |                                                                                                                             |                     |       |
| Output Rise Time (10% – 90%)                                       | $t_R$     |      | 10   |      | ns          |                                                                                                                             |                     |       |
| Output Fall Time (90% - 10%)                                       | $t_F$     |      | 10   |      | ns          |                                                                                                                             |                     |       |
| Common Mode Transient Immunity at Logic High Output <sup>[4]</sup> | $ CM_H $  | 25   | 40   |      | kV/ $\mu s$ | Using Avago LED Driving Circuit,<br>$V_{IN}=0V, R_1=350\Omega \pm 5\%, R_2=350\Omega \pm 5\%, V_{CM}=1000V, T_A=25^\circ C$ | 15                  | 4     |
| Common Mode Transient Immunity at Logic High Output <sup>[5]</sup> | $ CM_L $  | 25   | 40   |      | kV/ $\mu s$ | Using Avago LED Driving Circuit,<br>$V_{IN}=4.5-5.5V, R_1=350\Omega \pm 5\%, R_2=350\Omega, V_{CM}=1000V, T_A=25^\circ C$   | 16                  | 5     |

## Package Characteristics

All Typical at  $T_A = 25^\circ C$ .

| Parameter                                | Symbol    | Min. | Typ.      | Max. | Units     | Test Conditions                                      |
|------------------------------------------|-----------|------|-----------|------|-----------|------------------------------------------------------|
| Input-Output Momentary Withstand Voltage | $V_{ISO}$ | 3750 |           |      | $V_{rms}$ | $RH \leq 50\%, t = 1 \text{ min.}, T_A = 25^\circ C$ |
| Input-Output Resistance                  | $R_{I-O}$ |      | $10^{14}$ |      | $\Omega$  | $V_{I-O} = 500 \text{ V dc}$                         |
| Input-Output Capacitance                 | $C_{I-O}$ |      | 0.6       |      | pF        | $f = 1 \text{ MHz}, T_A = 25^\circ C$                |

Notes:

- $t_{PHL}$  propagation delay is measured from the 50% ( $V_{in}$  or  $I_f$ ) on the rising edge of the input pulse to 0.8V on the falling edge of the  $V_O$  signal.  $t_{PLH}$  propagation delay is measured from the 50% ( $V_{in}$  or  $I_f$ ) on the falling edge of the input pulse to the 80% level of the rising edge of the  $V_O$  signal.
- PWD is defined as  $|t_{PHL} - t_{PLH}|$ .
- $t_{PSK}$  is equal to the magnitude of the worst case difference in  $t_{PHL}$  and/or  $t_{PLH}$  that will be seen between units at any given temperature within the recommended operating conditions.
- $CM_H$  is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state.
- $CM_L$  is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state.

## Performance Plots

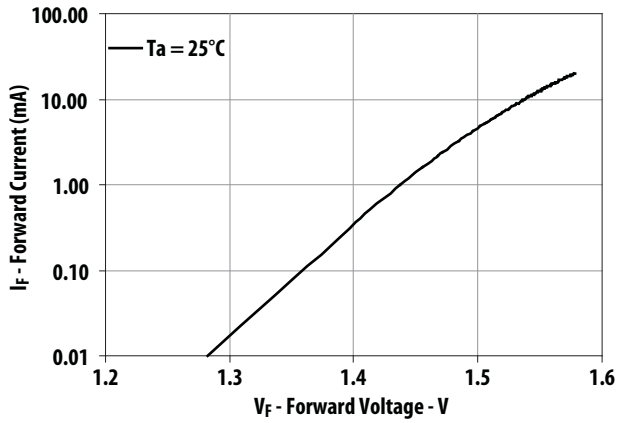


Figure 1. Typical Diode Input Forward Current Characteristic

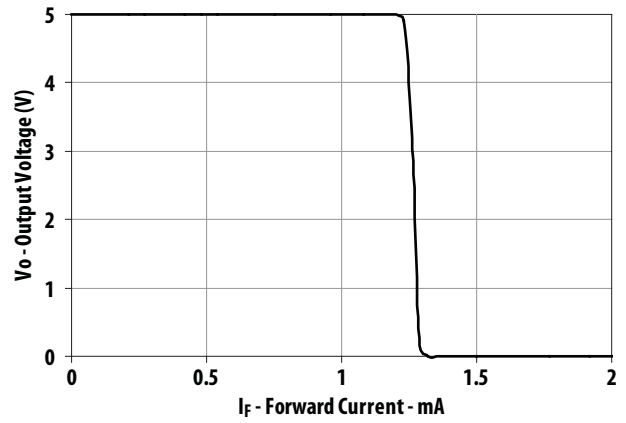


Figure 2. Typical Output Voltage vs Input Forward Current

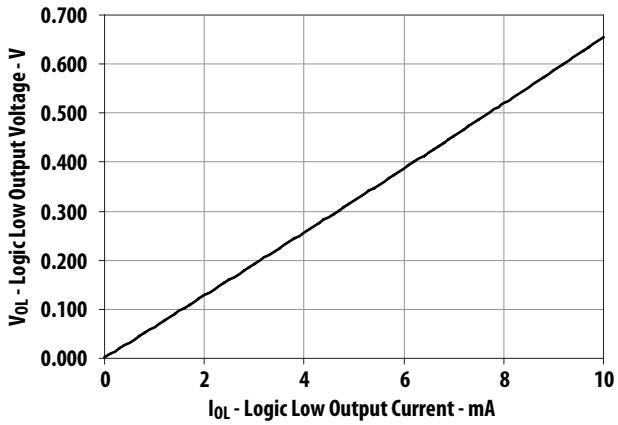


Figure 3. Typical Logic Low Output Voltage vs Logic Low Output Current

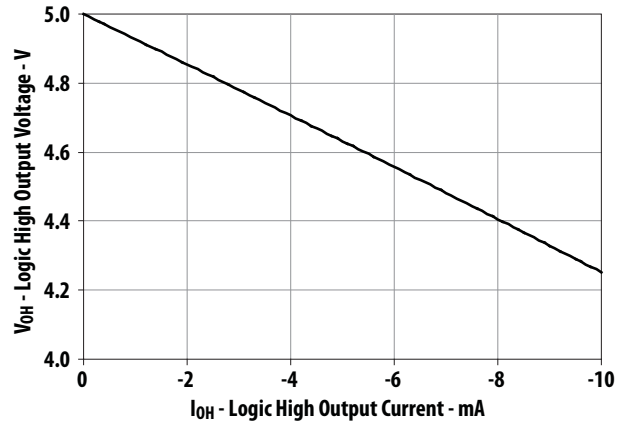


Figure 4. Typical Logic High Output Voltage vs Logic High Output Current

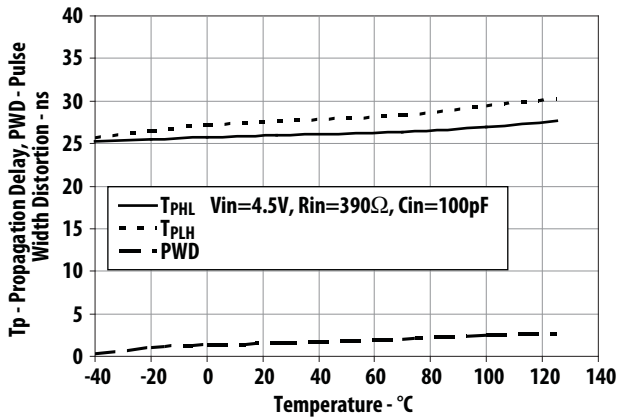


Figure 5. ACPL-M71U (High Speed) Typical Propagation Delay vs Temperature

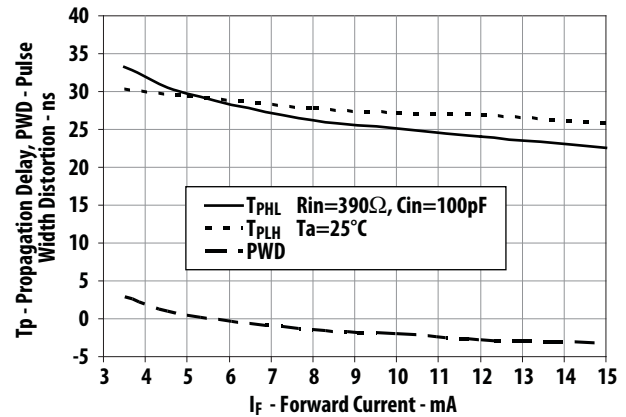


Figure 6. ACPL-M71U (High Speed) Typical Propagation Delay vs Forward Current -  $I_F$



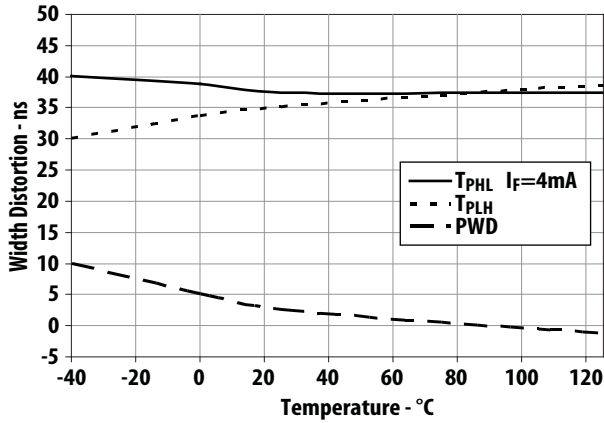


Figure 7. ACPL-M72U (5V) Typical Propagation Delay vs Temperature

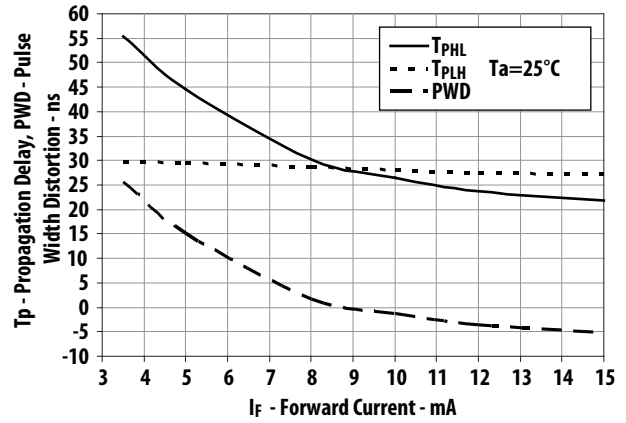


Figure 8. ACPL-M72U (5V) Typical Propagation Delay vs Forward Current -  $I_F$

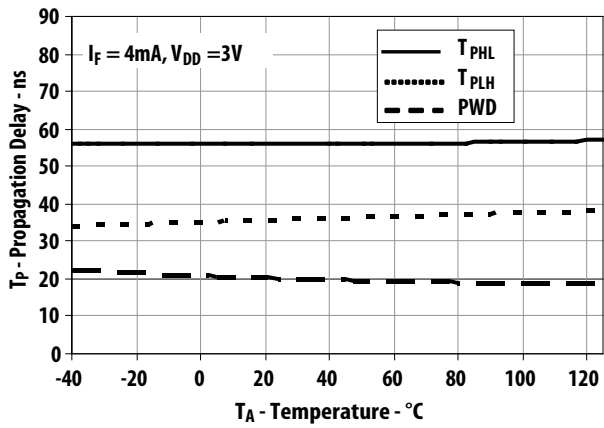


Figure 9. ACPL-M72U (3V) Typical Propagation Delay vs Temperature

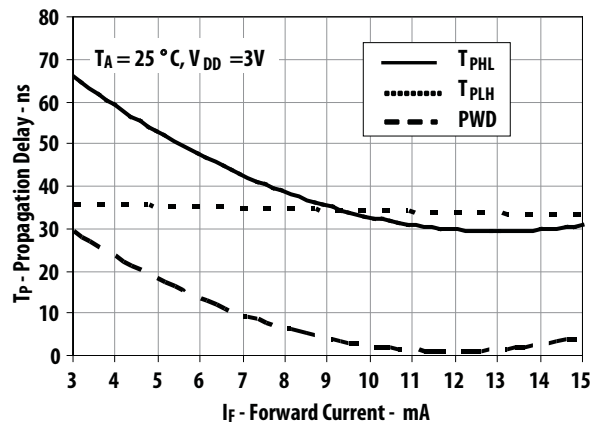


Figure 10. ACPL-M72U (3V) Typical Propagation Delay vs Input Forward Current

## Test Circuit Diagrams

### ACPL-M71U High Speed Mode:

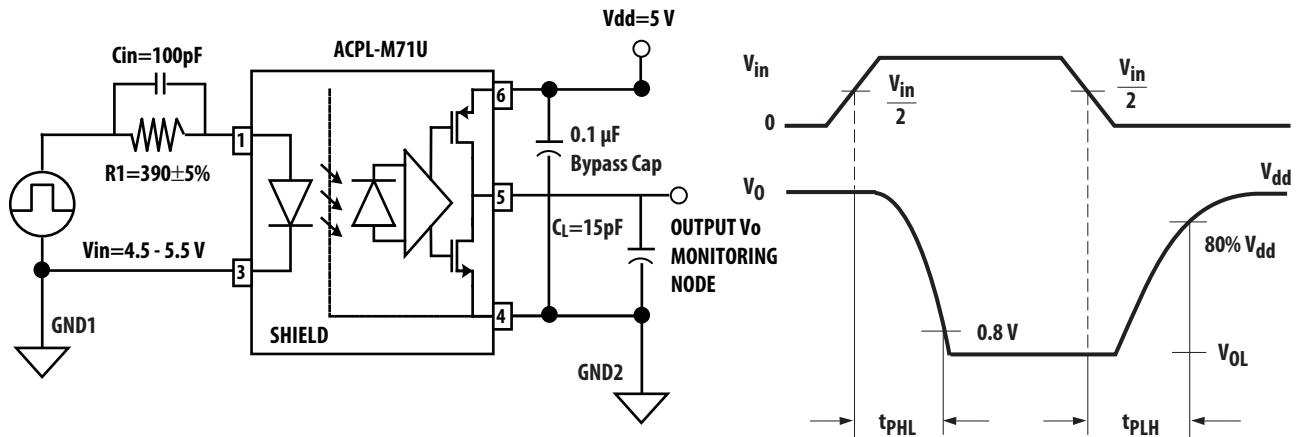


Figure 11. High Speed Mode Test Circuit and Typical Waveform

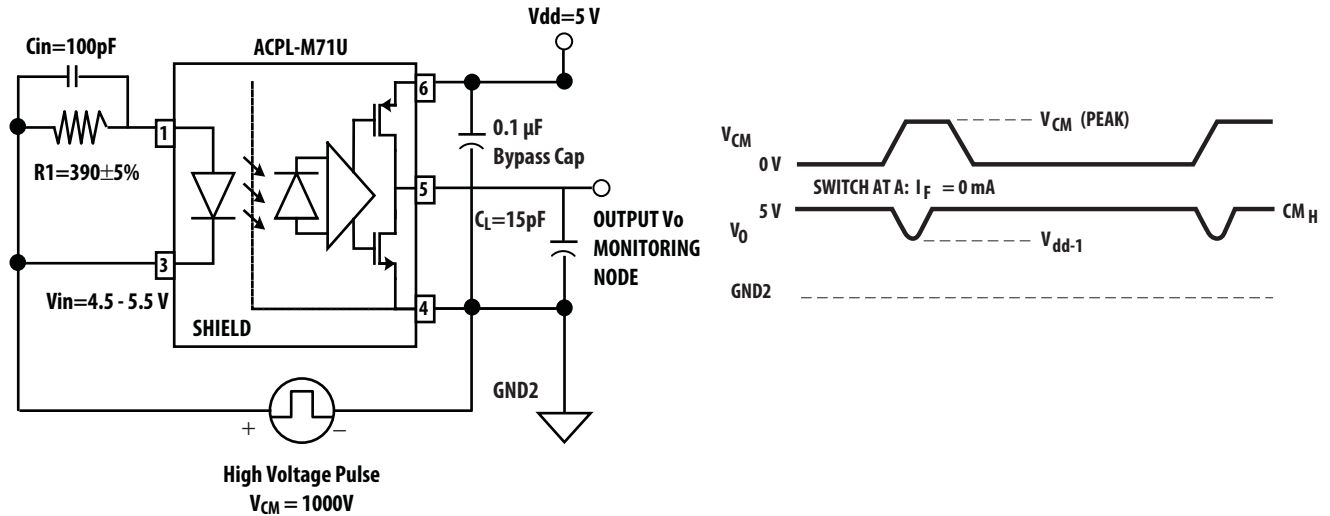


Figure 12. High Speed Mode CMH Test Circuit and Typical Waveform

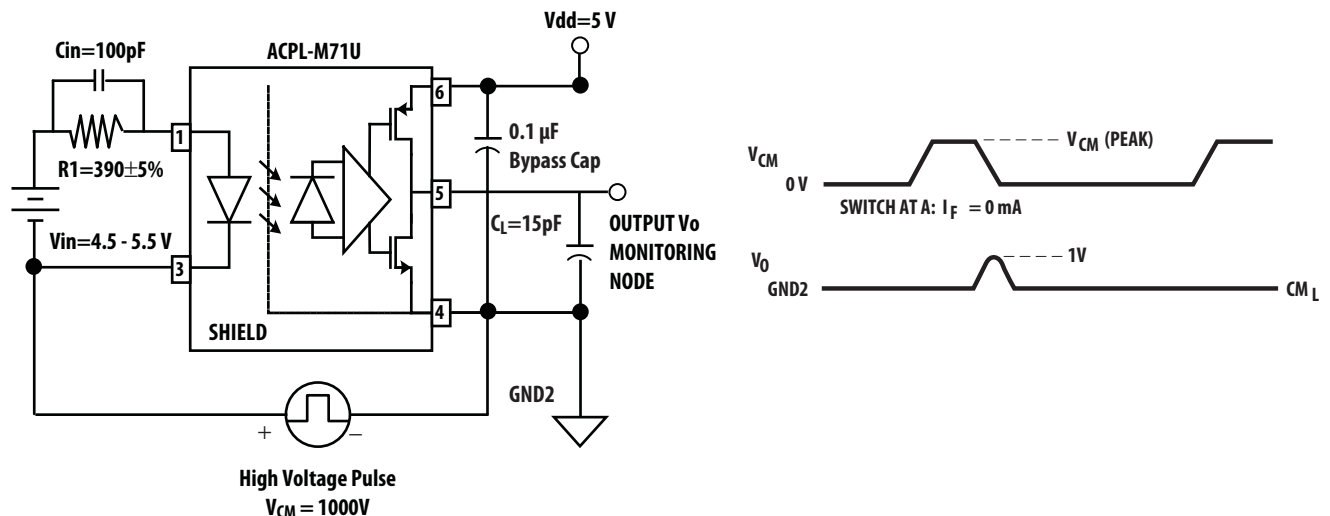


Figure 13. High Speed Mode CML Test Circuit and Typical Waveform

**ACPL-M72U Low Power Mode:**

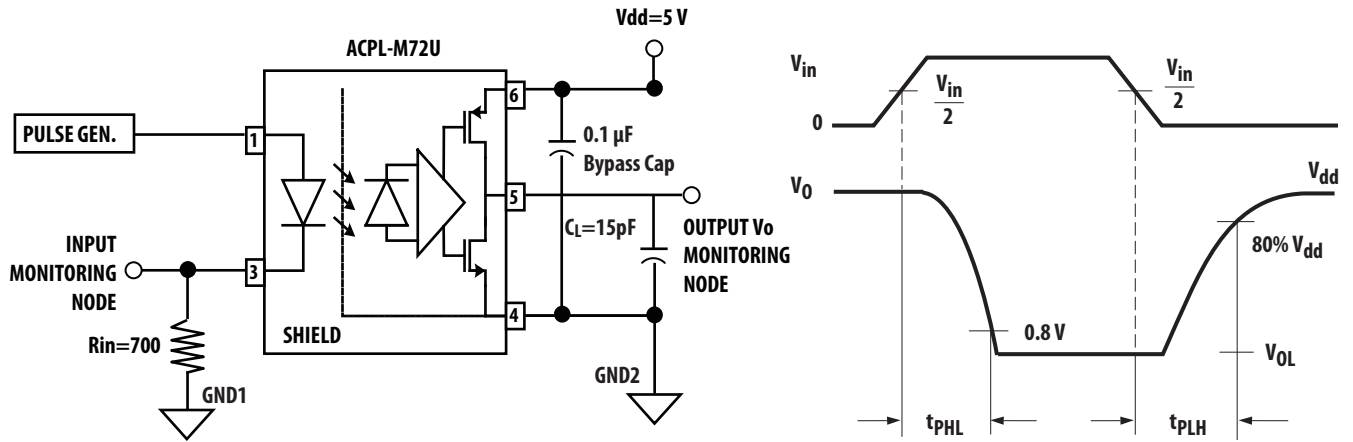


Figure 14. Low Power Mode Switching Test Circuit and Typical Waveform

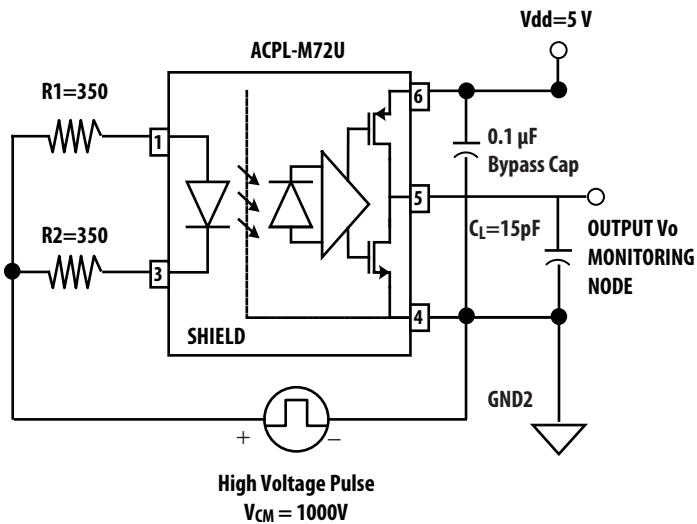


Figure 15. Low Power Mode High CMR, CMH Test Circuit

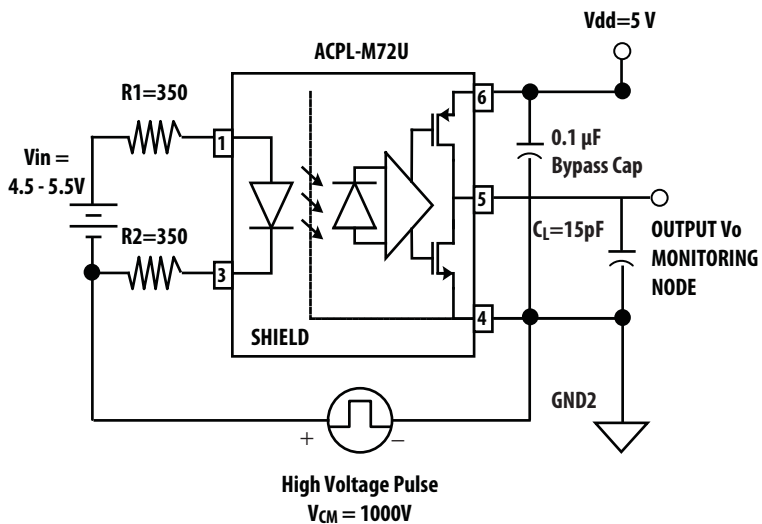
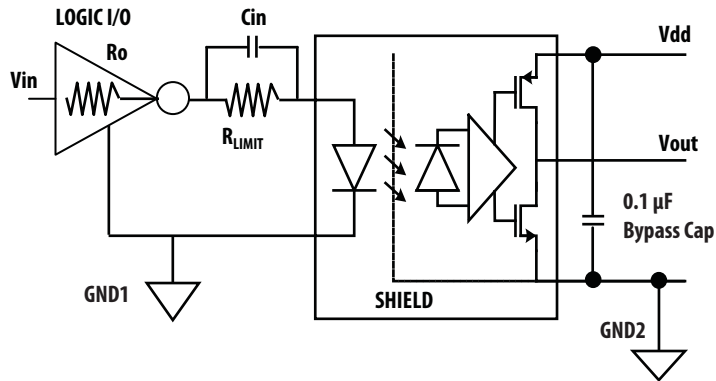


Figure 16. Low Power Mode High CMR, CML Test Circuit

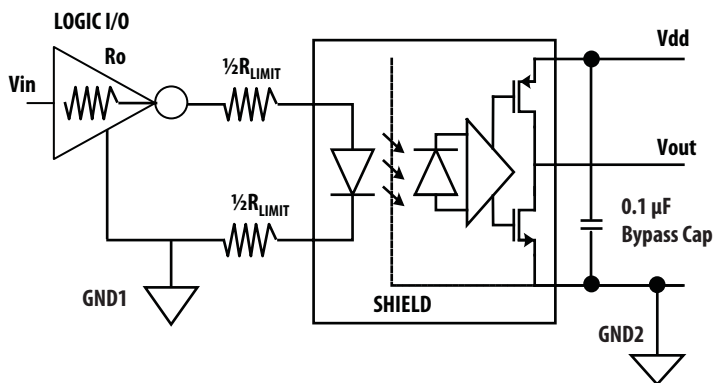
## Application Circuits



Truth Table

| Vin | LED | Vout |
|-----|-----|------|
| L   | ON  | L    |
| H   | OFF | H    |

Figure 17. Recommended Application Circuit for ACPL-M71U High Speed Performance



Truth Table

| Vin | LED | Vout |
|-----|-----|------|
| L   | ON  | L    |
| H   | OFF | H    |

Figure 18. Recommended Application Circuit for ACPL-M72U Low Power Performance

For product information and a complete list of distributors, please go to our web site: [www.avagotech.com](http://www.avagotech.com)

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