

# 4N45/4N46

## High Gain Darlington Output Optocouplers



### Data Sheet



#### Description

The 4N45/46 optocouplers contain a GaAsP light emitting diode optically coupled to a high gain photodetector IC.

The excellent performance over temperature results from the inclusion of an integrated emitter-base bypass resistor which shunts photodiode and first stage leakage currents as well as bleeding off excess base drive to ground. External access to the second stage base provides the capability for better noise rejection than a conventional photodarlington detector. An external resistor or capacitor at the base can be added to make a gain-bandwidth or input current threshold adjustment. The base lead can also be used for feedback.

The high current transfer ratio at very low input currents permits circuit designs in which adequate margin can be allowed for the effects of optical coupling variations.

The 4N46 has a 350% minimum CTR at an input current of only 0.5 mA making it ideal for use in low input current applications such as MOS, CMOS and low power logic interfacing. Compatibility with high voltage CMOS logic systems is assured by the 20 V minimum breakdown voltage of the output transistor and by the guaranteed maximum output leakage ( $I_{OH}$ ) at 18 V.

The 4N45 has a 250% minimum CTR at 1.0 mA input current and a 7 V minimum breakdown voltage rating.

Selection for lower input current down to 250  $\mu$ A is available upon request.

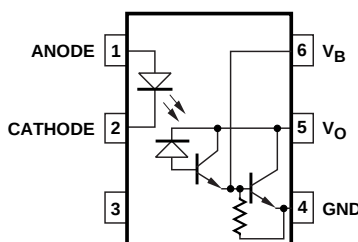
#### Features

- High current transfer ratio – 1500% typical
- Low input current requirement – 0.5 mA
- Performance guaranteed over 0°C to 70°C temperature range
- Internal base-emitter resistor minimizes output leakage
- Gain-bandwidth adjustment pin
- Safety approval  
UL Recognized -3750 V rms for 1 minute  
CSA Approved IEC/EN/DIN EN 60747-5-2

#### Applications

- Telephone ring detector
- Digital logic ground isolation
- Low input current line receiver
- Line voltage status indicator–low input power dissipation
- Logic to read relay interface
- Level shifting
- Interface between logic families

#### Functional Diagram



TRUTH TABLE  
(POSITIVE LOGIC)

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

\* JEDEC Registered Data  
\*\* JEDEC Registered up to 70°C.

**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

4N45/4N46 are UL Recognized with 3750 Vrms for 1 minute per UL1577 and is approved under CSA Component Acceptance Notice #5, File CA 88324.

| Part Number | Option         |                    | Package       | Surface Mount | Gull Wing | Tape & Reel | UL 5000 Vrms / 1 Minute rating | IEC / EN / DIN EN 60747-5-2 | Quantity      |
|-------------|----------------|--------------------|---------------|---------------|-----------|-------------|--------------------------------|-----------------------------|---------------|
|             | RoHS Compliant | non RoHS Compliant |               |               |           |             |                                |                             |               |
| 4N45        | -000E          | no option          | 300 mil DIP-6 |               |           |             |                                |                             | 50 per tube   |
|             | -300E          | -300               | 300 mil DIP-6 | X             | X         |             |                                |                             | 50 per tube   |
|             | -500E          | -500               | 300 mil DIP-6 | X             | X         | X           |                                |                             | 1500 per reel |
| 4N46        | -060E          | -060               | 300 mil DIP-6 |               |           |             | X                              |                             | 50 per tube   |
|             | -360E          | -360               | 300 mil DIP-6 | X             | X         |             | X                              |                             | 50 per tube   |
|             | -560E          | -560               | 300 mil DIP-6 | X             | 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:

4N45-560E to order product of 300 mil DIP Gull Wing Surface Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-2 Safety Approval and RoHS compliant.

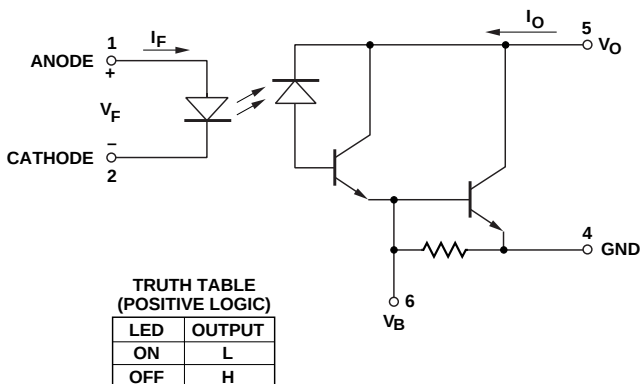
### Example 2:

4N45 to order product of 300 mil DIP package in Tube packaging and non RoHS compliant.

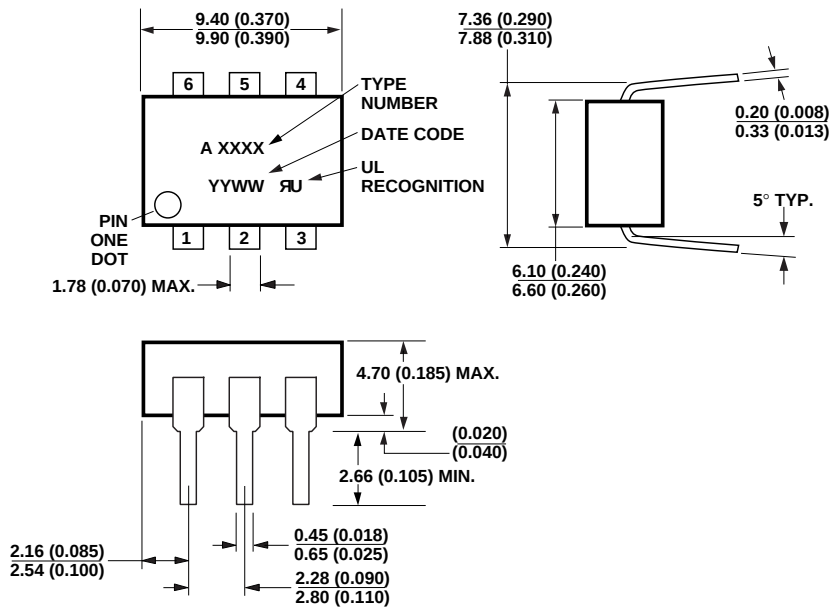
Option datasheets are available. Contact your Avago sales representative or authorized distributor for information.

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

## Schematic

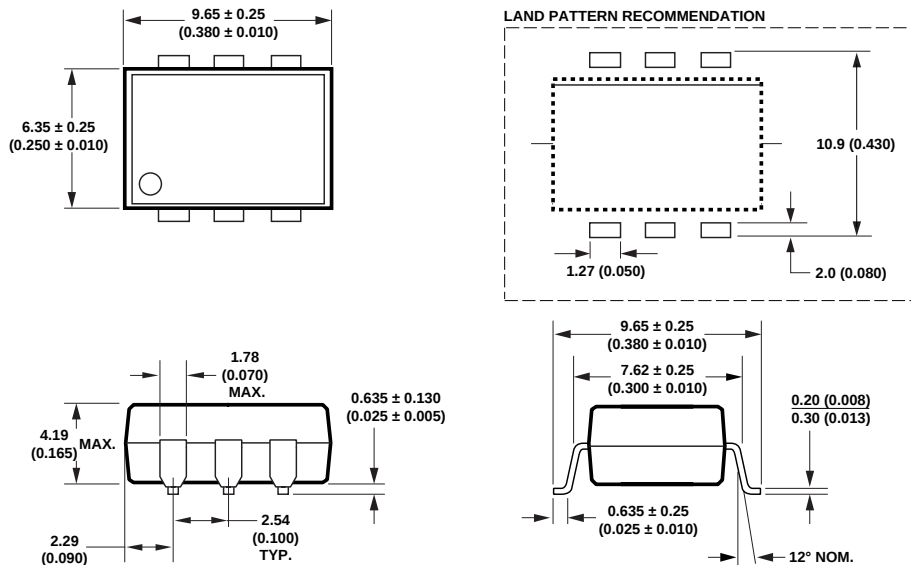


## Outline Drawing



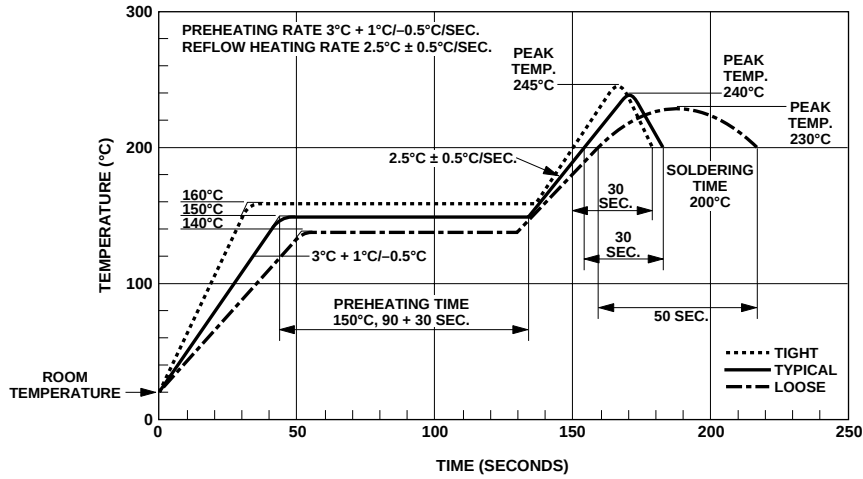
DIMENSIONS IN MILLIMETERS AND (INCHES).

## Outline Drawing – Option 300



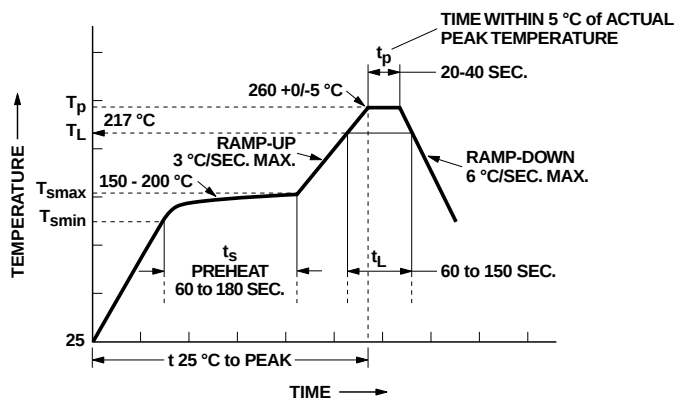
NOTE: FLOATING LEAD PROTRUSION IS 0.25 mm (10 mils) MAX.

## Solder Reflow Thermal Profile



Note: Non-halide flux should be used.

## Recommended Pb-Free IR Profile



### NOTES:

THE TIME FROM  $25^{\circ}\text{C}$  TO PEAK TEMPERATURE = 8 MINUTES MAX.

$T_{smax} = 200^{\circ}\text{C}$ ,  $T_{smin} = 150^{\circ}\text{C}$

Note: Non-halide flux should be used.

**Regulatory Information**

The 4N45 and 4N46 have been approved by the following regulatory organizations:

**UL**

Recognized under UL 1577, Component Recognition Program, File E55361.

**IEC/EN/DIN EN 60747-5-2**

Approved 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.  
(Option 060 only)

**CSA**

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

**Insulation and Safety Related Specifications**

| Parameter                                           | Symbol | Value | Units | Conditions                                                                                                                                                |
|-----------------------------------------------------|--------|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Min. External Air Gap<br>(External Clearance)       | L(I01) | 7.1   | mm    | Measured from input terminals to output terminals, shortest distance through air                                                                          |
| Min. External Tracking Path<br>(External Creepage)  | L(I02) | 7.4   | mm    | Measured from input terminals to output terminals, shortest distance path along body                                                                      |
| Min. Internal Plastic Gap<br>(Internal Clearance)   |        | 0.08  | mm    | Through insulation distance, conductor to conductor, usually the direct distance between the photoemitter and photodetector inside the optocoupler cavity |
| Tracking Resistance<br>(Comparative Tracking Index) | CTI    | 200   | Volts | DIN IEC 112/VDE 0303 PART 1                                                                                                                               |
| Isolation Group                                     |        | 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 60747-5-2 Insulation Related Characteristics

| Description                                                                                                                                                                                    | Symbol         | PDIP Option 060 | Units             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------|-------------------|
| Installation classification per DIN VDE 0110/1.89, Table 1<br>for rated mains voltage $\leq 150$ V rms<br>for rated mains voltage $\leq 300$ V rms<br>for rated mains voltage $\leq 600$ V rms |                | I-IV<br>I-III   |                   |
| Climatic Classification                                                                                                                                                                        |                | 55/85/21        |                   |
| Pollution Degree (DIN VDE 0110/1.89)                                                                                                                                                           |                | 2               |                   |
| Maximum Working Insulation Voltage                                                                                                                                                             | $V_{IORM}$     | 630             | V <sub>peak</sub> |
| Input to Output Test Voltage, Method b*<br>$V_{IORM} \times 1.875 = V_{PR}$ , 100% Production Test<br>with $t_m = 1$ sec, Partial Discharge $< 5$ pC                                           | $V_{PR}$       | 1181            | V <sub>peak</sub> |
| Input to Output Test Voltage, Method a*<br>$V_{IORM} \times 1.5 = V_{PR}$ , Type and Sample Test,<br>$t_m = 60$ sec, Partial Discharge $< 5$ pC                                                | $V_{PR}$       | 945             | V <sub>peak</sub> |
| Highest Allowable Overvoltage*<br>(Transient Overvoltage, $t_{ini} = 10$ sec)                                                                                                                  | $V_{IOTM}$     | 6000            | V <sub>peak</sub> |
| Safety Limiting Values<br>(See below for Thermal Derating Curve Figures)                                                                                                                       |                |                 |                   |
| Case Temperature                                                                                                                                                                               | $T_S$          | 175             | °C                |
| Input Current                                                                                                                                                                                  | $I_{S,INPUT}$  | 230             | mA                |
| Output Power                                                                                                                                                                                   | $P_{S,OUTPUT}$ | 600             | mW                |
| Insulation Resistance at $T_S$ , $V_{IO} = 500$ V                                                                                                                                              | $R_S$          | $\geq 10^9$     | $\Omega$          |

\*Refer to the front of the optocoupler section of the current catalog, under Product Safety Regulations section IEC/EN/DIN/ EN 60747-5-2, for a detailed description.

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

## Absolute Maximum Ratings

|                                                                    |                                                   |
|--------------------------------------------------------------------|---------------------------------------------------|
| Storage Temperature, $T_S$ .....                                   | -55° C to +125° C                                 |
| Operating Temperature, $T_A$ .....                                 | -40° C to +85° C                                  |
| Lead Solder Temperature, max .....                                 | 260° C for 10 s<br>(1.6 mm below seating plane)   |
| Average Input Current, $I_F$ .....                                 | 20 mA <sup>[1]</sup>                              |
| Peak Input Current, $I_F$ .....                                    | 40 mA<br>(50% duty cycle, 1 ms pulse width)       |
| Peak Transient Input Current, $I_F$ .....                          | 1.0 A<br>( $\leq 1$ $\mu$ s pulse width, 300 pps) |
| Reverse Input Voltage, $V_R$ .....                                 | 5 V                                               |
| Input Power Dissipation, $P_I$ .....                               | 35 mW <sup>[2]</sup>                              |
| Output Current, $I_O$ (Pin 5) .....                                | 60 mA <sup>[3]</sup>                              |
| Emitter-Base Reverse Voltage (Pins 4-6) .....                      | 0.5 V                                             |
| Output Voltage, $V_O$ (Pin 5-4)                                    |                                                   |
| 4N45 .....                                                         | -0.5 to 7 V                                       |
| 4N46 .....                                                         | -0.5 to 20 V                                      |
| Output Power Dissipation .....                                     | 100 mW <sup>[4]</sup>                             |
| Infrared and Vapor Phase Reflow Temperature<br>(Option #300) ..... | see Fig. 1, Thermal Profile                       |

## Recommended Operating Conditions

| Parameter             | Symbol       | Min. | Max. | Units |
|-----------------------|--------------|------|------|-------|
| Output Voltage (4N46) | $V_O$        | 4.5  | 20   | V     |
| Output Voltage (4N45) |              | 4.5  | 7    | V     |
| Input Current (High)  | $I_{F(ON)}$  | 0.5  | 10   | mA    |
| Input Voltage (Low)   | $V_{F(OFF)}$ | 0    | 0.8  | V     |
| Operating Temperature | $T_A$        | 0    | 70   | °C    |

## DC Electrical Specifications

Over recommended temperature ( $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ), unless otherwise specified.

| Parameter                                  | Device | Symbol                          | Min. | Typ.* | Max. | Units         | Test Conditions                                                                              | Fig.            | Note    |
|--------------------------------------------|--------|---------------------------------|------|-------|------|---------------|----------------------------------------------------------------------------------------------|-----------------|---------|
| Current Transfer Ratio                     | 4N46   | CTR                             | 350* | 1500  | 3200 | %             | $I_F = 0.5\text{ mA}, V_O = 1.0\text{ V}$                                                    | 3, 4, 5, 11, 12 | 5, 6, 8 |
|                                            |        |                                 | 500* | 1500  | 2000 |               | $I_F = 1.0\text{ mA}, V_O = 1.0\text{ V}$                                                    |                 |         |
|                                            |        |                                 | 200* | 600   | 1000 |               | $I_F = 10\text{ mA}, V_O = 1.2\text{ V}$                                                     |                 |         |
|                                            | 4N45   |                                 | 250* | 1200  | 2000 | %             | $I_F = 1.0\text{ mA}, V_O = 1.0\text{ V}$<br>$I_F = 10\text{ mA}, V_O = 1.2\text{ V}$        |                 |         |
| Logic Low Output Voltage                   | 4N46   | $V_{OL}$                        |      | 0.90  | 1.0  | V             | $I_F = 0.5\text{ mA}, I_{OL} = 1.75\text{ mA}$                                               | 3               | 6       |
|                                            |        |                                 |      | 0.92  | 1.0  |               | $I_F = 1.0\text{ mA}, I_{OL} = 5.0\text{ mA}$                                                |                 |         |
|                                            |        |                                 |      | 0.95  | 1.2  |               | $I_F = 10\text{ mA}, I_{OL} = 20\text{ mA}$                                                  |                 |         |
|                                            | 4N45   |                                 |      | 0.90  | 1.0  | V             | $I_F = 1.0\text{ mA}, I_{OL} = 2.5\text{ mA}$<br>$I_F = 10\text{ mA}, I_{OL} = 20\text{ mA}$ |                 |         |
| Logic High Output Current                  | 4N46   | $I_{OH}^*$                      |      | 0.001 | 100  | $\mu\text{A}$ | $I_F = 0\text{ mA}, V_O = 18\text{ V}$                                                       |                 | 6       |
|                                            | 4N45   |                                 |      | 0.001 | 250  | $\mu\text{A}$ | $I_F = 0\text{ mA}, V_O = 5\text{ V}$                                                        |                 |         |
| Input Forward Voltage                      |        | $V_F$                           |      | 1.4   | 1.7* | V             | $T_A = 25^\circ\text{C}$                                                                     | 2               |         |
|                                            |        |                                 |      |       | 1.75 |               | $I_F = 1.0\text{ mA}$                                                                        |                 |         |
| Temperature Coefficient of Forward Voltage |        | $\frac{\Delta V_F}{\Delta T_A}$ |      | -1.8  |      | mV/°C         | $I_F = 1.0\text{ mA}$                                                                        |                 |         |
| Input Reverse Breakdown Voltage            |        | $BV_R^*$                        | 5    |       |      | V             | $I_R = 10\text{ }\mu\text{A}$                                                                |                 |         |
| Input Capacitance                          |        | $C_{IN}$                        |      | 60    |      | pF            | $f = 1\text{ MHz}, V_F = 0$                                                                  |                 |         |

## Switching Specifications

(Over recommended temperature  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$  unless otherwise specified.  $V_{CC} = 5.0\text{ V}$ .)

| Parameter                                           | Symbol    | Min. | Typ.* | Max. | Units            | Test Conditions                                                                  | Fig.                                               | Note               |
|-----------------------------------------------------|-----------|------|-------|------|------------------|----------------------------------------------------------------------------------|----------------------------------------------------|--------------------|
| Propagation Delay Time to Logic Low at Output       | $t_{PHL}$ |      | 80    |      | $\mu\text{s}$    | $T_A = 25^\circ\text{C}$                                                         | $I_F = 0.5\text{ mA}$<br>$R_L = 10\text{ k}\Omega$ | 6, 7, 8, 9, 11, 13 |
|                                                     |           |      | 5     | 50*  |                  | $T_A = 25^\circ\text{C}$                                                         | $I_F = 10\text{ mA}$<br>$R_L = 2.2\text{ k}\Omega$ |                    |
|                                                     | $t_{PHL}$ |      |       | 60   |                  |                                                                                  |                                                    |                    |
|                                                     |           |      |       |      |                  |                                                                                  |                                                    |                    |
| Propagation Delay Time to Logic High at Output      | $t_{PLH}$ |      | 1500  |      | $\mu\text{s}$    | $T_A = 25^\circ\text{C}$                                                         | $I_F = 10\text{ mA}$<br>$R_L = 10\text{ k}\Omega$  | 6, 7, 8, 9, 11, 13 |
|                                                     |           |      | 150   | 500* |                  | $T_A = 25^\circ\text{C}$                                                         | $I_F = 10\text{ mA}$<br>$R_L = 220\text{ k}\Omega$ |                    |
|                                                     | $t_{PLH}$ |      |       | 600  |                  |                                                                                  |                                                    |                    |
|                                                     |           |      |       |      |                  |                                                                                  |                                                    |                    |
| Common Mode Transient Immunity at High Output Level | $ CM_H $  |      | 500   |      | V/ $\mu\text{s}$ | $I_F = 0\text{ mA}, R_L = 10\text{ k}\Omega$<br>$ V_{CM}  = 10\text{ }V_{P-P}$   | 10                                                 | 9                  |
| Common Mode Transient Immunity at Low Output Level  | $ CM_L $  |      | 500   |      | V/ $\mu\text{s}$ | $I_F = 1.0\text{ mA}, R_L = 10\text{ k}\Omega$<br>$ V_{CM}  = 10\text{ }V_{P-P}$ | 10                                                 | 9                  |

\*JEDEC Registered Data.

\*\*All typicals at  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

## Package Characteristics

For  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ , unless otherwise specified. All typicals at  $T_A = 25^{\circ}\text{C}$ .

| Parameter                                 | Symbol           | Min. | Typ.      | Max. | Units    | Test Conditions                                                      | Fig. | Notes |
|-------------------------------------------|------------------|------|-----------|------|----------|----------------------------------------------------------------------|------|-------|
| Input-Output Momentary Withstand Voltage* | $V_{\text{ISO}}$ | 3750 |           |      | V rms    | $RH \leq 50\%$ , $t = 1 \text{ min}$ ,<br>$T_A = 25^{\circ}\text{C}$ |      | 7, 10 |
| Resistance, Input-Output                  | $R_{\text{I-O}}$ |      | $10^{12}$ |      | $\Omega$ | $V_{\text{I-O}} = 500 \text{ Vdc}$                                   |      | 7     |
| Capacitance, Input-Output                 | $C_{\text{I-O}}$ |      | 0.6       |      | pF       | $f = 1 \text{ MHz}$                                                  |      | 7     |

\*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 VDE 0884 Insulation Characteristics Table (if applicable), your equipment level safety specification, or Avago Application Note 1074, "Optocoupler Input-Output Endurance Voltage."

### Notes:

- Derate linearly above  $50^{\circ}\text{C}$  free-air temperature at a rate of  $0.4 \text{ mA}/^{\circ}\text{C}$ .
- Derate linearly above  $50^{\circ}\text{C}$  free-air temperature at a rate of  $0.7 \text{ mW}/^{\circ}\text{C}$ .
- Derate linearly above  $25^{\circ}\text{C}$  free-air temperature at a rate of  $0.8 \text{ mA}/^{\circ}\text{C}$ .
- Derate linearly above  $25^{\circ}\text{C}$  free-air temperature at a rate of  $1.5 \text{ mW}/^{\circ}\text{C}$ .
- 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%.
- Pin 6 Open.
- Device considered a two-terminal device: Pins 1, 2, 3 shorted together and Pins 4, 5, and 6 shorted together.
- Use of a resistor between pin 4 and 6 will decrease gain and delay time. (See Figures 11, 12, and 13.)
- Common mode transient immunity in Logic High level is the maximum tolerable (positive)  $dV_{\text{CM}}/dt$  on the leading edge of the common mode pulse,  $V_{\text{CM}}$ , to assure that the output will remain in a Logic High state (i.e.,  $V_O > 2.5 \text{ V}$ ).
- Common mode transient immunity in Logic Low level is the maximum tolerable (negative)  $dV_{\text{CM}}/dt$  on the trailing edge of the common mode pulse signal,  $V_{\text{CM}}$ , to assure that the output will remain in a Logic Low state (i.e.,  $V_O < 2.5 \text{ V}$ ).
- In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage  $\geq 4500 \text{ V rms}$  for 1 second (leakage detection current limit,  $I_{\text{I-O}} \leq 5 \mu\text{A}$ ).

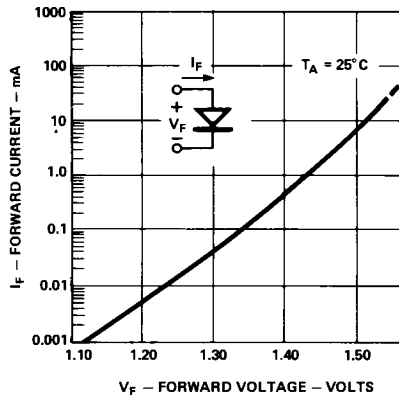


Figure 2. Input diode forward current vs. forward voltage.

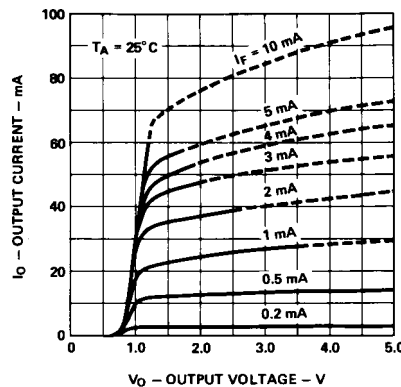


Figure 3. Typical DC transfer characteristics.

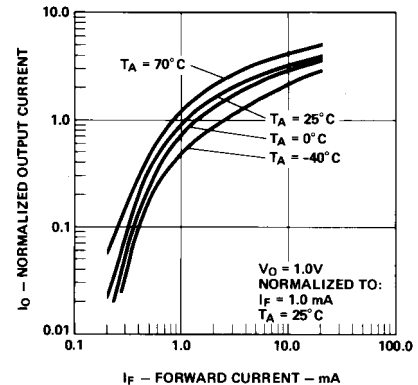


Figure 4. Output current vs. input current.

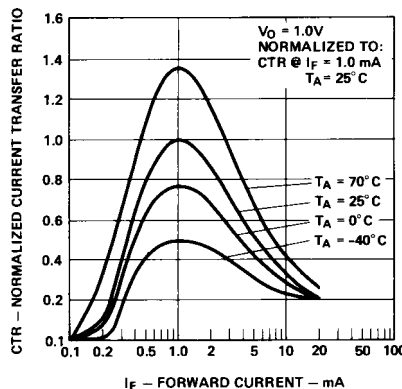


Figure 5. Current transfer ratio vs. input current.

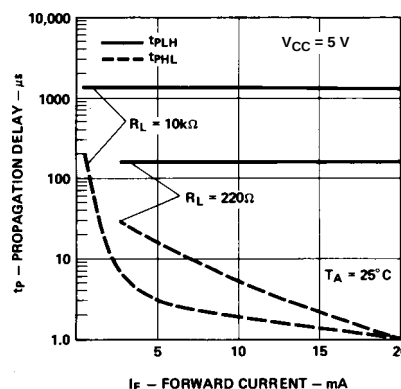


Figure 6. Propagation delay vs. forward current.

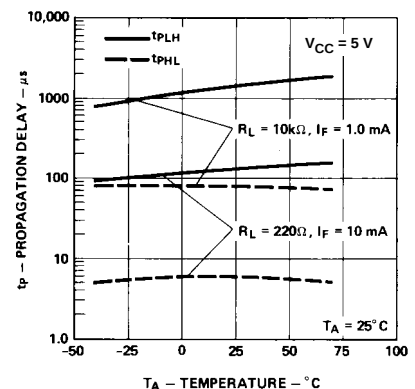


Figure 7. Propagation delay vs. temperature.

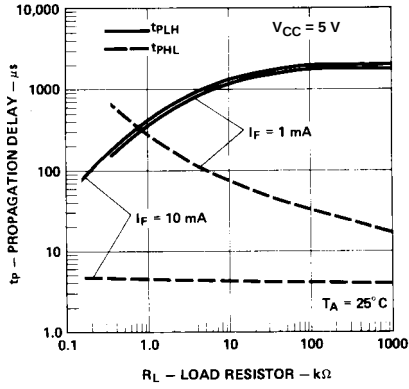


Figure 8. Propagation delay vs. load resistor.

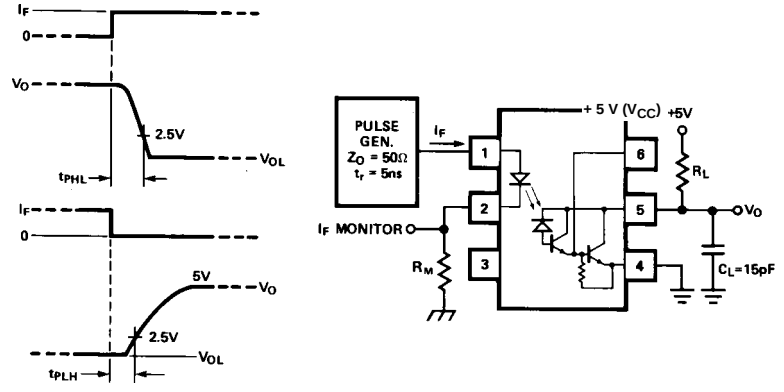


Figure 9. Switching test circuit.

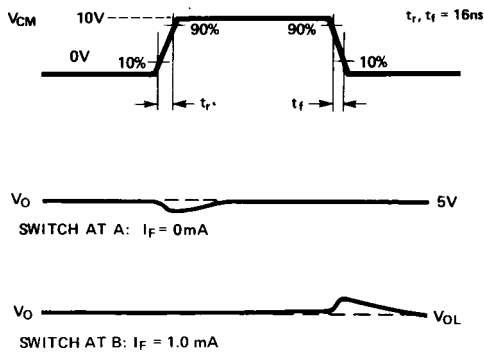


Figure 10. Test circuit for transient immunity and typical waveforms.

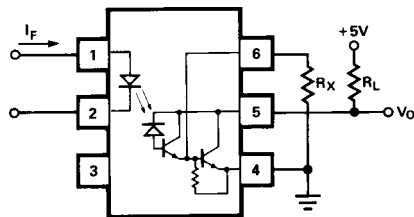


Figure 11. External base resistor,  $R_X$ .

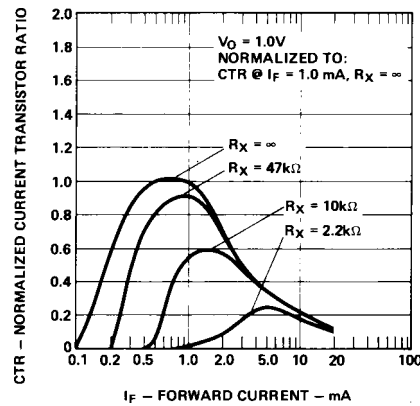


Figure 12. Effect of  $R_X$  on current transfer ratio.

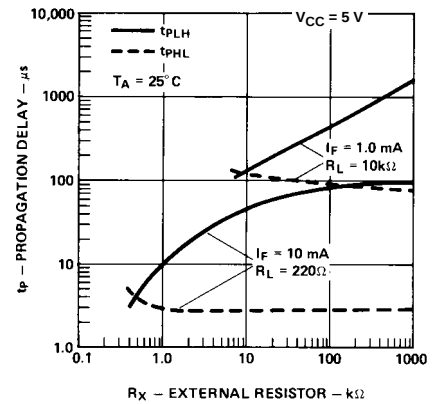
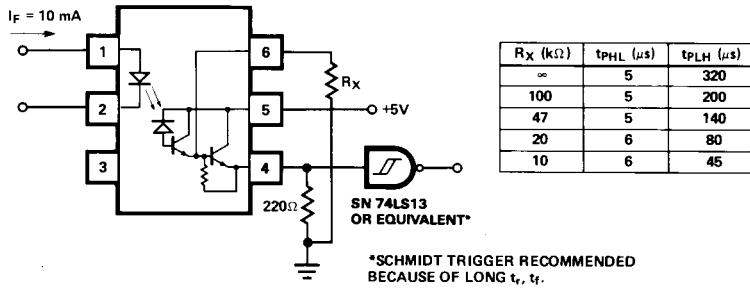
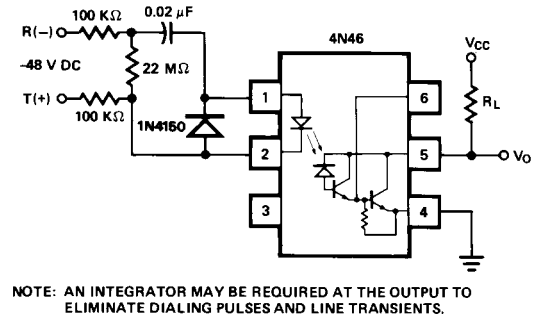


Figure 13. Effect of  $R_X$  on propagation delay.

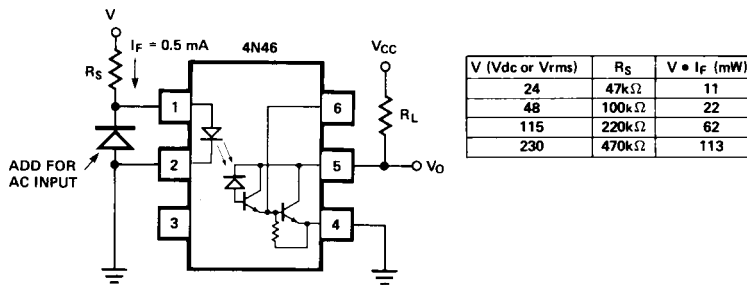
## Applications



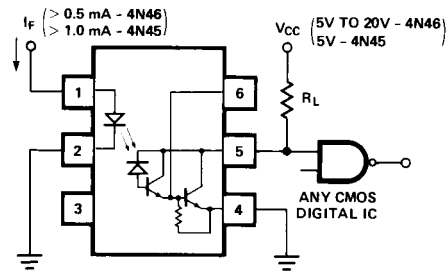
TTL Interface



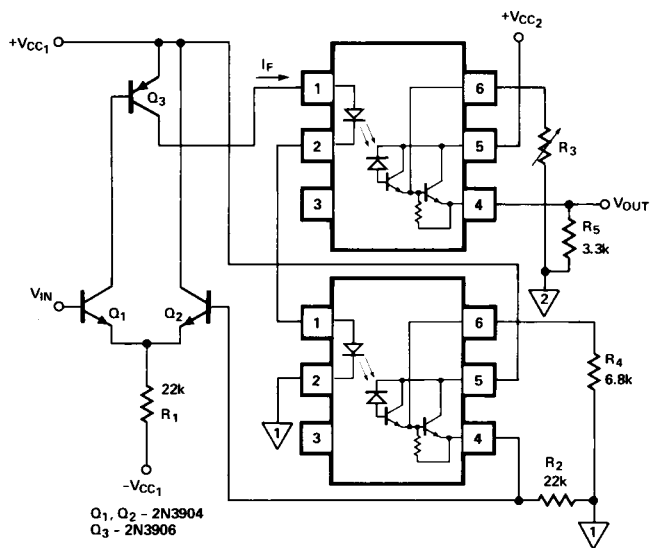
Telephone Ring Detector



Line Voltage Monitor



CMOS Interface



Analog Signal Isolation

### CHARACTERISTICS

$R_{IN} \approx 30M\Omega$ ,  $R_{OUT} \approx 50\Omega$   
 $V_{IN(MAX)} = V_{CC1} - 1V$ , LINEARITY BETTER THAN 5%

### DESIGN COMMENTS

$R_1$  - NOT CRITICAL ( $\ll \frac{V_{IN(MAX)} - (-V_{CC1}) - V_{BE}}{I_F(MAX)}$ )  $h_{FE} Q_3$   
 $R_2$  - NOT CRITICAL (OMIT IF 0.2 TO 0.3V OFFSET IS TOLERABLE)  
 $R_4 > \frac{V_{IN(MAX)} + V_{BE}}{1mA}$   
 $R_5 > \frac{V_{IN(MAX)}}{2.5mA}$

NOTE: ADJUST  $R_3$  SO  $V_{OUT} = V_{IN}$  AT  $V_{IN} = \frac{V_{IN(MAX)}}{2}$

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