# OPTICAL ISOLATORS

The field of solid-state optoelectronics is providing today's designer with a wide range of extremely useful devices and design techniques. And nowhere is this more evident than in the area of opto-isolators. These versatile devices, which are also known as optical couplers, can provide convenient replacements for electromechanical components such as reed relays or pulse transformers in applications where the requirements of long life or severe environmental conditions are critical.

A breakthrough in LED technology was made in late 1971 with the introduction of green and yellow seven-compatibility with other solid state circuitry. Although the visible units (display and discrete devices) combine to take the lion's share of attention in LEDs, they are by no means the only tools available to the designer and any survey of solid state light would be incomplete without the mention of other devices. Infrared discrete LEDs are one area of considerable importance to some design areas. In general, these devices have made strong material advances and are available in many of the same configurations as the visible units.

Another important design unit is the opto-isolator, which combines an infrared LED and a photodevice in a single package, for solid state isolation of circuitry. These units are finding more and more applications each day and have also proved themselves as a highly reliable component with many advantages over conventional electro-optical isolation.

The basic opto-isolator (Fig. 1) consists of a gallium-arsenide (GaAs) infrared light-emitting diode (LED) optically coupled to a photo-sensitive silicon detector, which may be a diode, a transitor or an SCR. Both the light emitting diode and the detector are contained in the same package. Attractive characteristics of the opto-isolator include:

- The electrical isolation of a relay
- The speed of a semiconductor
- The reliability and long life of a semiconductor
- The noise rejection of a differential amplifier

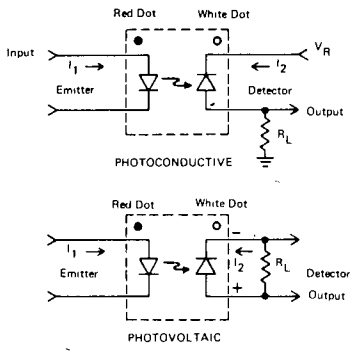



Figure 1: The basic opto-isolator consists of, within a single package, a GaAs light-emitting diode optically coupled to a photosensitive detector.

In addition, new packaging techniques and high-volume production are rapidly bringing the price of opto-isolators down to the point where they now compete with coupling devices like pulse transformers and reed relays.

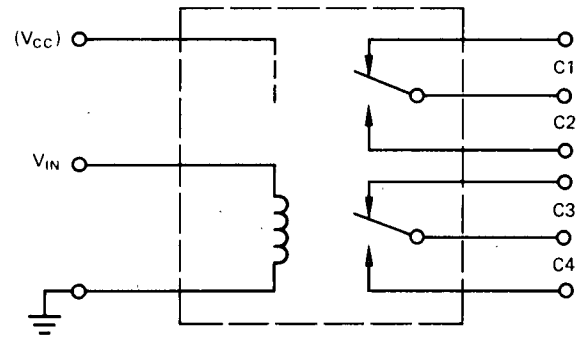
The following examples show some of the typical applications where opto-isolators are well suited because of their unique characteristics. A conceptual rather than a "cook book" approach is used in the examples, since the purpose is to show typical capability rather than detailed design.

## Digital Signal Isolation

The interference coupling problems within digital data processing systems are many. The coupling of noise and transients from data loggers, card punchers, input terminals and other peripheral equipment into computer systems generally creates EMI and compatibility problems. These problems appear as ground loops, spikes, and common mode impedance current. The electromechanical approach to solving these problems, such as the use of a standard DPDT relay or switch is shown in Figure 2. This particular approach has several disadvantages as follows:

- The transfer rate of information has been sharply reduced because of slow reed-relay speeds.
- Bouncing reeds can cause problems in the computer.
- Diodes must be added across each relay coil to prevent destruction of the drive gates and terminations.
- Resistors must be added across the coil to prevent the coaxial cable from ringing.
- Maintenance costs are high. One intermittent reed relay can keep the system down.

The solid state replacement for this circuit using iso-optics is shown in Figure 3. Here there is no use of coils, no reeds, no transformer; it is 100% semiconductor.




*Also could be SPDT

Figure 2: The standard Electro-mechanical DPDT*

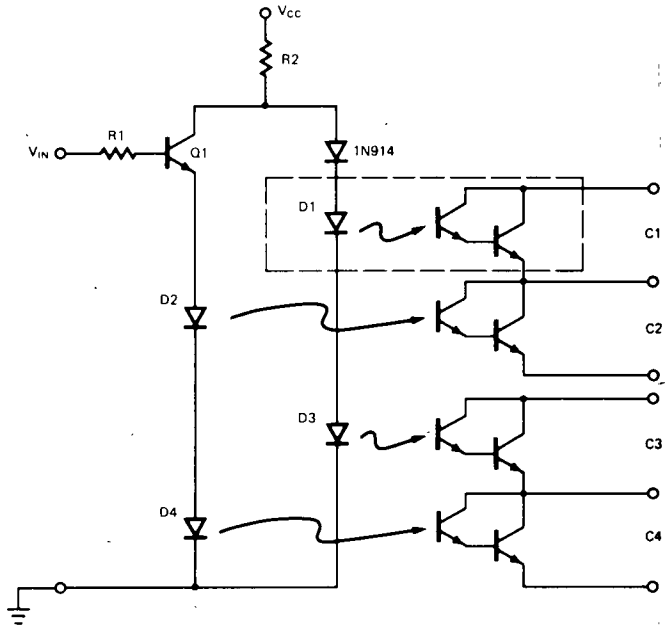



Figure 3: The semiconductor equivalent of figure 2.

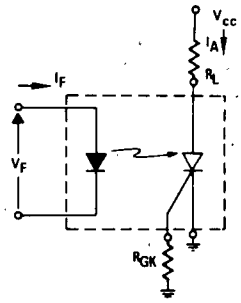



Figure 4: Operating Schematic

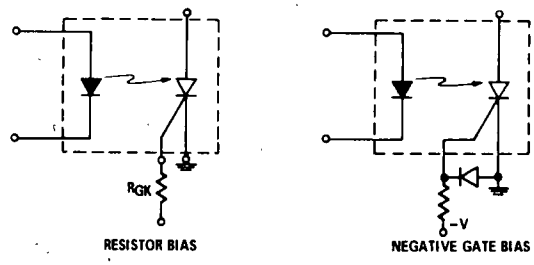



Figure 5: Gate Bias Considerations

## Photo SCR's

The Photo SCR coupled pair is intended for applications where complete electrical isolation is required between low power circuitry such as integrated circuits and AC line voltages providing high speed switching or relay functions. Its bistable characteristics lends itself for use as a latching relay in direct current circuits. (See Figures 4 & 5).

Here, the maximum peak current depends upon the duty cycle so as to stay within the maximum rated dissipation. The rise time of the SCR may be less then 500 nanoseconds.

## Triggering triacs

Using opto-isolators for triggering triacs is similar to triggering SCRs, in that isolation from the logic source is of absolute importance. One method of optically triggering triacs is shown in Figure 6. Using this method, it is possible to control 80A, 600V triacs with as little as 20 mA at 1.3V via the light-emitting diode! The diode bridge is used to convert the ac signal to dc for the photo-SCR. Whereas the ac would turn the SCR on and off, it is desired that the SCR be controlled only by the light-emitting diode, not the ac line.

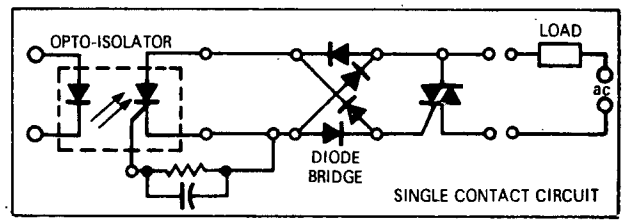



Figure 6: The triggering of triacs with opto-isolators is accomplished relatively easily. The diode bridge converts the ac to the dc required by the SCR.

## Phototransistor

The phototransistor opto-isolator has many applications, such as:

- AC line/digital logic isolator
- Digital logic/digital logic isolator
- Telephone/telegraph line receiver
- Twisted pair line receiver
- High frequency power supply feedback control
- Relay contact monitor
- Power supply monitor

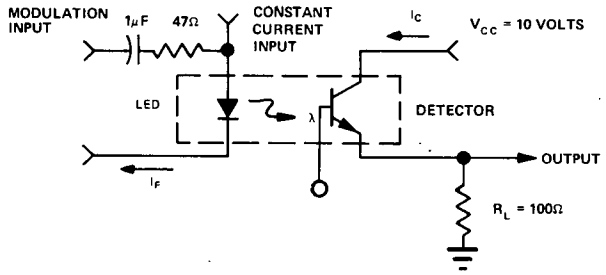
Figure 7 shows two operating circuits using the phototransistor as an isolation circuit. Here, the current transfer ratio ($I_C/I_F$) is the ratio of the detector collector current to the LED input current with Bce at the 10 volt level. Figure 8 shows the phototransistor in use in a line receiver application.

## Patient isolation in medical electronics

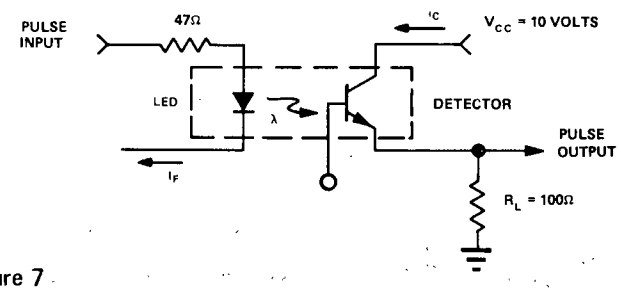
In the medical electronics and patient monitoring market, the interest in increased safety and reliability in equipment continues to grow. In some of these applications the patient is used as the signal generator. The signal produced must then be transmitted to monitoring equipment, which must be electrically isolated form the patient. Optical isolators can be used to perform this task. (See Figure 9);

## Sample Circuits

Figures 10 through 17 are sample circuits showing various different ways of using and implementing isooptics.




Modulation Circuit Used to Obtain Output vs Frequency Plot




Circuit Used to Obtain Switching Time vs Collector Current Plot

Figure 7

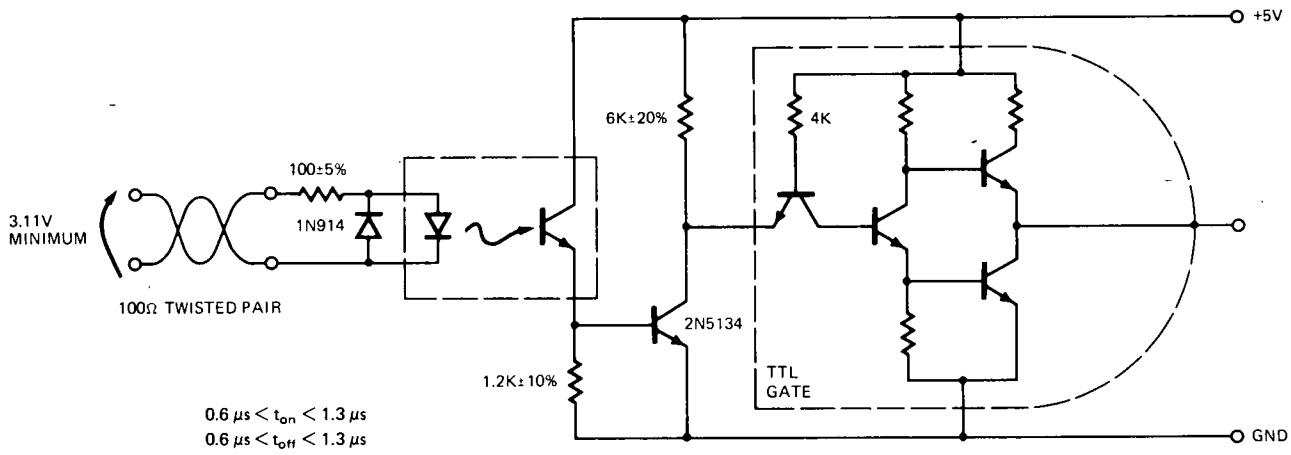



Figure 8: IBM 360 LINE RECEIVER APPLICATION

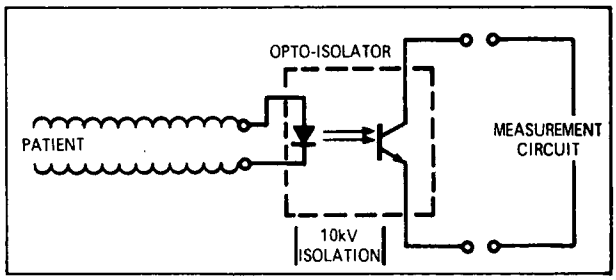



Figure 9: Excellent isolation between patient and monitoring equipment can be achieved by opto-isolators when used in medical electronic applications.

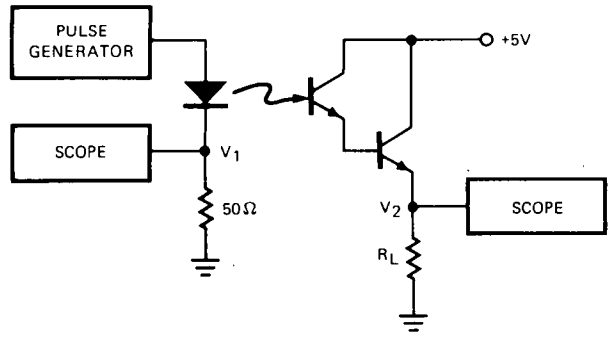
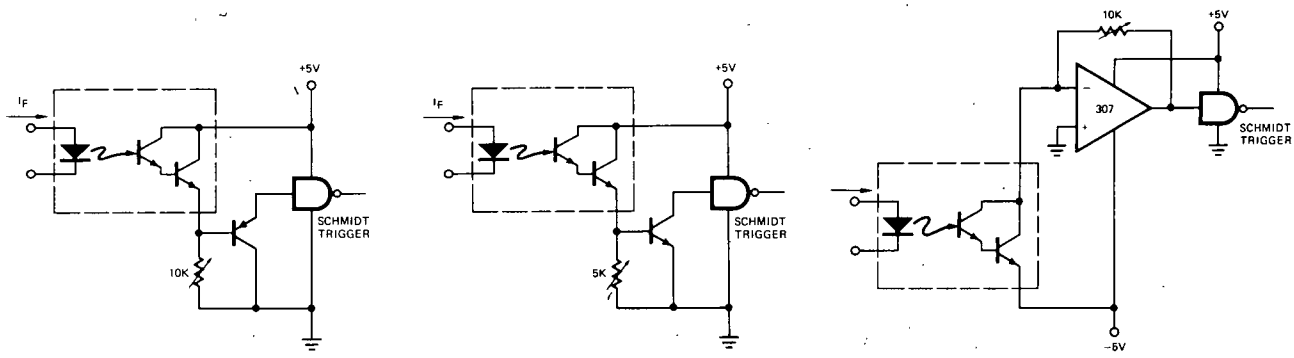



Figure 11: Circuit for Testing Switching Parameters




*Circuit 1* *Circuit 2* *Circuit 3*

Figure 10: Schmidt trigger configurations

Figure 12: Switching Time Test Circuit

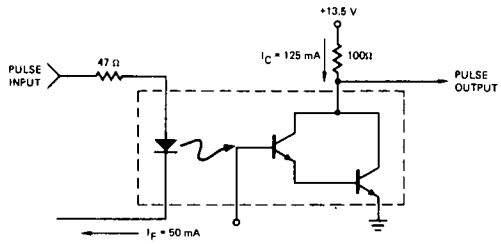
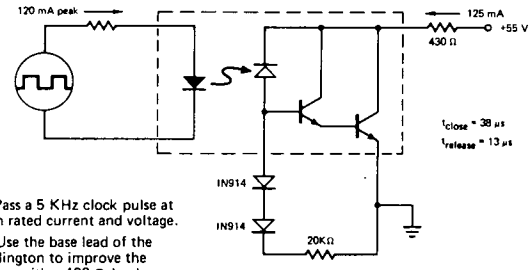



Figure 13: AC Coupling




NOTE:
Problem: Pass a 5 KHz clock pulse at maximum rated current and voltage.
Solution: Use the base lead of the photodarlington to improve the release time with a 400 Ω load.

Figure 14: Form C Contact using Two LED's

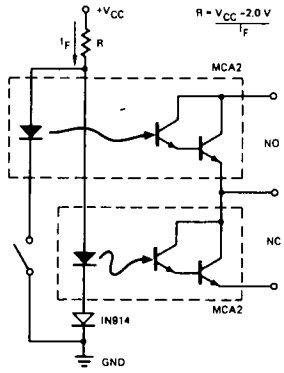



Figure 15: Triggering a triac

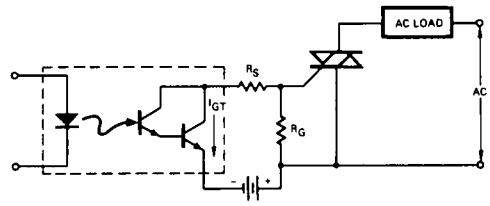



Figure 16: Isolated $T^2L$ LOGIC

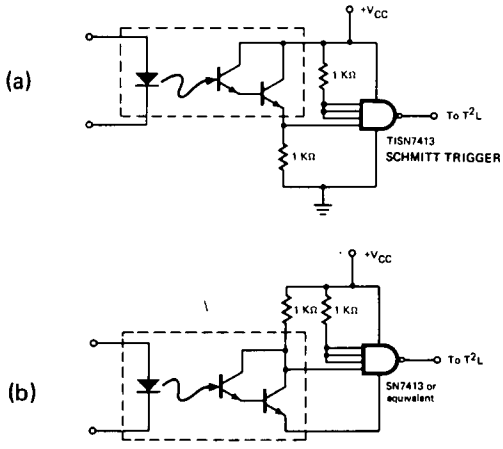



Figure 17: Operating a Relay Coil