Lab 7: Optocoupler

Objectives

1. To use an ohmmeter to determine the condition of the optoisolator.
2. To observe the operation of an optocoupler.
3. To determine the maximum frequency response of the optocoupler.
4. To use optocoupler as an isolated current transducer

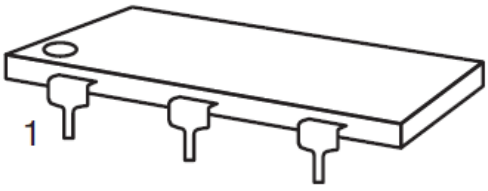
Introduction

An optoisolator is a hybrid integrated circuit that contains an LED on one side and a photodetector on the other. The entire IC is hermetically sealed and light-tight. It is called an optoisolator because it is used to electrically isolate a low-voltage circuit from a high-voltage circuit or one low-voltage circuit from another. A low-voltage control circuit is used to energize the LED. Light from the LED is then optically coupled to the detector, which is used to control a secondary circuit. For this reason, optoisolators are also called optocouplers or optical coupling devices. Optocouplers isolate sensitive circuits, such as computer chips, from the hazards associated with controlling high-voltage and high power circuits. They offer the advantages of separating high-voltage circuits from low voltage circuits, blocking power circuit voltage spikes from returning to the control circuit, and preventing ground-loop problems in data and control systems. They are capable of safely isolating 5V computer circuits from hundreds of volts in the output circuit. Optoisolators are also relatively inexpensive, take up little space, and greatly simplify control circuitry.

In this lab exercise, the operation of the optoisolator using a transistor as the detector will be observed.

Procedure

When light from the LED is off, the phototransistor will not be on, causing the resistance between the emitter and collector to be extremely high.



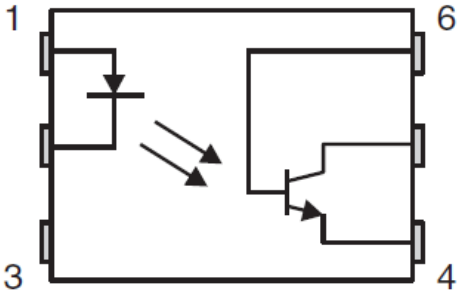


Figure 6-1

Step 1

Using Figure 6-2 as a reference, place an ohmmeter between the emitter and collector with the LED off. The negative lead should be on the emitter, the positive lead on the collector.

Rce (LED off) = ….....

When the light from the LED is on, the phototransistor will be on and create a low resistance between the emitter and collector.

Step 2

Use a DC voltage source and a resistor to forward bias the LED of the optocoupler as shown in figure 6-2. Change the DC voltage source and measure the resistance of the collector-emitter of the output transistor and fill in the following.

Rce(VDC=0.5V)=..... Rce(VDC=2V)=..... Rce(VDC=5V)=.....

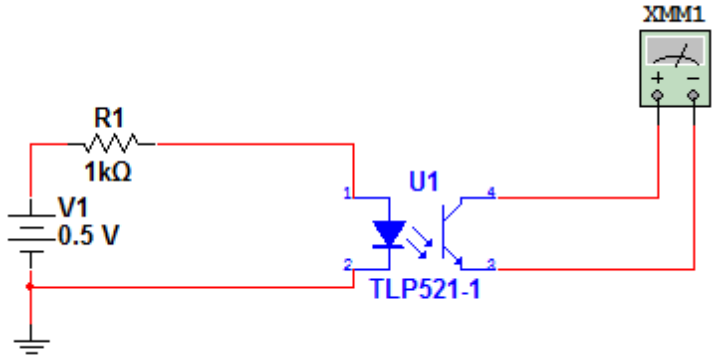


Figure 6-2

Step 3

Draw the circuit in Figure 6-3 in Multisim. Set the function generator for a 5V peak 1000-Hz square wave. This will provide a 5V forward-biased signal for the LED of the optoisolator.

Step 4

Connect channel 1 of the oscilloscope to the output of the function generator, and channel 2 of the oscilloscope to the output of the optoisolator. Turn on and adjust the power supply for 15V.

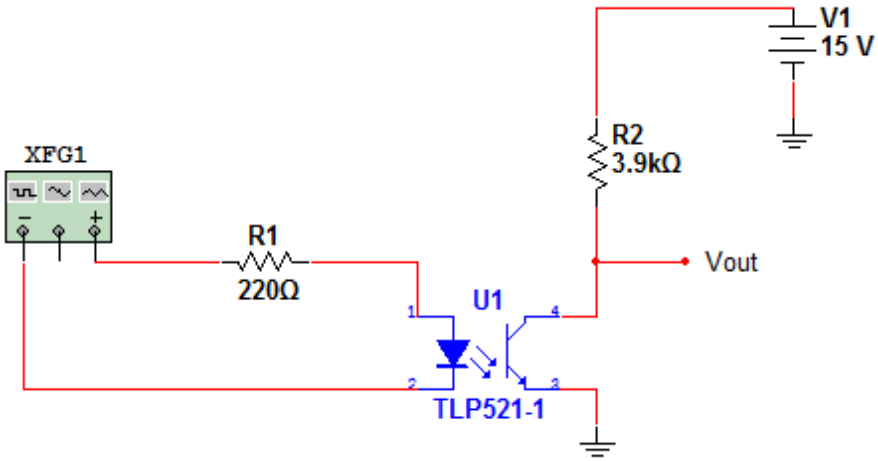


Figure 6-3

Adjust the oscilloscope to display the input and output signals of the optoisolator. In the space provided below, draw the two signals displayed on the oscilloscope. On the drawing, indicate the on or off condition of both the LED and the phototransistor of the optoisolator.

LED
On/Off
Condition

Optoisolator
(Transistor)
Output

Step 5

Increase the frequency of the function generator to up to 10kHz. Compare the input signal to the output signal. Does the phototransistor of the optoisolator react faster to the on-to-off or off -to-on transition of the LED?

A. on-to-off

B. off -to-on

Because there is a delayed reaction of the optoisolator, it has a maximum frequency rating when a square wave signal is applied to its input. Beyond the maximum frequency, the output signal cannot reach a good on or off level before the input signal is switched. Assume the input signal, which is a square wave, is applied. An acceptable output signal should reach at least 75 percent of its maximum signal.

Step 6

Increase the frequency of the square wave applied to the optoisolator until the output becomes unacceptable. Record this value.

Maximum operation frequency: …..... Hz

The ratio of the forward current flow in the LED and the collector current of the phototransistor is called the current transfer ratio (CTR). It is usually expressed as a percentage and can be calculated by using the formula:

CTR= (Ic/If) x 100

where If is the forward current through the diode and Ic is the collector current of the phototransistor.

Step 7

Using the circuit in Figure 6-4, turn on power and record:

Ic=

If=

Calculate the current transfer ratio for the circuit. CTR

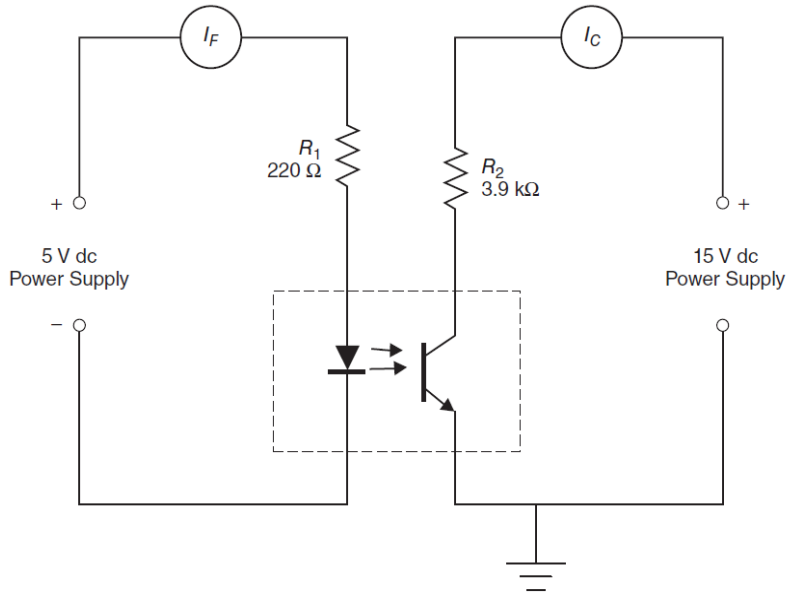


Figure 6-4

Step 8

Construct the circuit in Figure 6-4. Connect a voltmeter across the output and ground. Turn power on to the circuit.

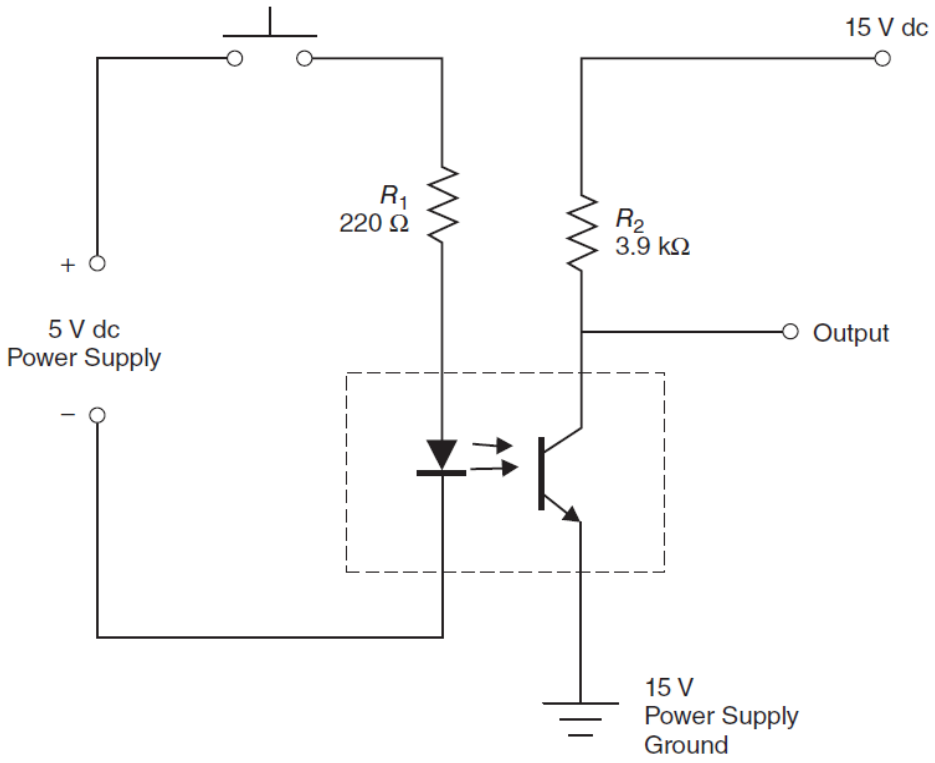


Figure 6-4

Press and release the push button. Note that the output of the optoisolator circuit is 15V when the push button is open and 0V when the push button is closed. (A closed push button will turn on the LED, which in turn turns on the phototransistor. The voltage across the phototransistor drops to 0V.)

Design Problem

How can the circuit be modified so that the output of the optoisolator circuit will be 0V when the push button is open and 15V when the push button is closed? Use the same components.

Step 9

Using optocoupler as an isolated current transducer to measure current in high voltage AC circuits and interface it to a low voltage electronic circuit is shown in figure 6-5. In this circuit the high voltage AC circuit is optically isolated from the low voltage electronic measurement circuit. Draw the circuit shown in figure 6-5 in Multisim and simulate it. Make lamps in parallel and connect to the AC source one by one and measure the output voltage of the optocoupler using a voltmeter. Fill out the following table:

Table 6-1

	AC circuit current	Optotransistor output voltage
No lamp connected		
One lamp connected		
Two lamps connected		
Three lamps connected		

What is the purpose of diode D1 in the circuit?

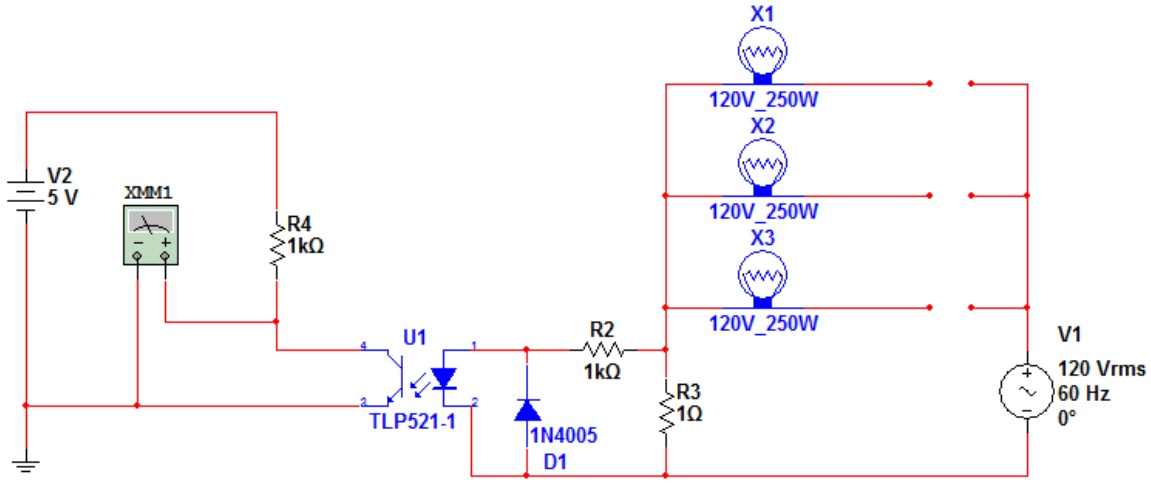


Figure 6-5

Step 10

Observe the input and output voltage of the optocoupler using oscilloscope and draw below.

Voltage across R3:

Voltage across collector-emitter of optotransistor:

Experiment Questions

1. T/F: An optocoupler is also referred to as an optoisolator.

2. When the LED in the optocoupler is turned on, the optodetector is turned.
A. on
B. off

3. When the optodetector is turned on, its resistance is.
A. low
B. high

4. If the current that turns on the LED of an optoisolator is 12 mA, and causes 3 mA to flow through the photodetector, the CTR is ….....

5. An acceptable square wave at the output of an optocoupler is …..... of its maximum signal.
A. 25%
B. 50%
C. 75%
D. 100%