EE 3310L/5310L · Electronic Devices and Circuits Laboratory

Lab 2: LED/Phototransistor Optocoupler

Purpose

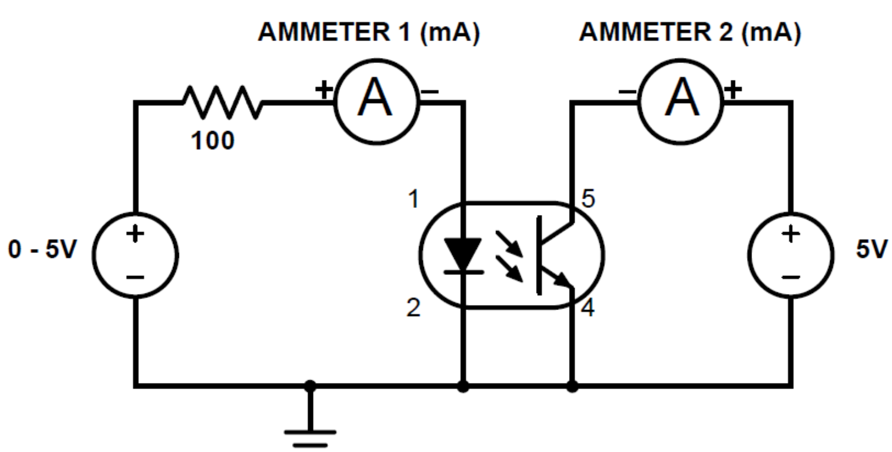
The purpose of this lab is to measure and plot the current transfer characteristics of a phototransistor-type optocoupler and examine its transient behavior.

Optocouplers

An *optocoupler* is a device that may be used to transfer signal using a *light source* such as an incandescent lamp, LED, or electroluminescent panel and a *light-sensitive sensor* such as a photoresistor, photodiode, or phototransistor, *with no direct electrical connection between source and sensor.* Rather, photons from the light source carry the desired signal to the sensor. This can offer huge advantages in applications where, for example, the source signal operates at a much different voltage or current level than is permissible by the load; or for cases where we need to *insulate* the load from the source for safety reasons, such as when patients are in contact with medical instrumentation powered by the 120 VAC line. This is called *galvanic isolation* and it prevents direct current flow between circuits, even if they are at potential differences of thousands of volts. In this lab, we will perform two experiments on a 4N25 optocoupler, which uses an infrared-wavelength LED for the light source and an NPN bipolar junction phototransistor for the sensor.

Experiment 1: 4N25 Static Characteristics

The 4N25 optocoupler is often used at logic-level voltages; thus, for this first experiment, we will take a series of measurements in order to determine the input-to-output current transfer characteristics at 5V. Build the following circuit, taking care to ensure that the correct pins of the DIP package are wired. Do not connect the 0-5V supply on the LED side without first ensuring that the initial voltage is set to <u>zero</u> (you will likely use the 0-20V bench supply for this purpose). Likewise, do not connect the 5V supply on the phototransistor side without first ensuring that it is preset to 5V.



Wright State University • 3640 Colonel Glenn Hwy. • Dayton, OH 45435 USA

With both power supplies energized, slowly increase the variable 0-5V voltage source in order to achieve an LED current of 0.020 mA or 20 µA, as indicated on ammeter #1. Observe and record the collector current indicated on ammeter #2. If either measurement fails to give an observable value, the ammeter may have a blown fuse; check with your TA for fuse replacement and verification. Repeat for all levels of LED current given in the table below. Then, reduce the transistor collector voltage to 3.3V and repeat the experiment.

LED Current I_{IN} (mA)	**I_{OUT} (mA) V_{CE} = 5V**	**I_{OUT} (mA) V_{CE} = 3.3V**
0.10	0	0
0.18	0	0
0.32	0	0.003
0.56	0.001	0.10
1.0	0.022	0.60
1.8	0.123	1.260
3.2	0.658	1.410
5.6	2.2	2.1
10.0	6.2	5.9
18.0	14.8	14.2
32.0	35.6	32.6

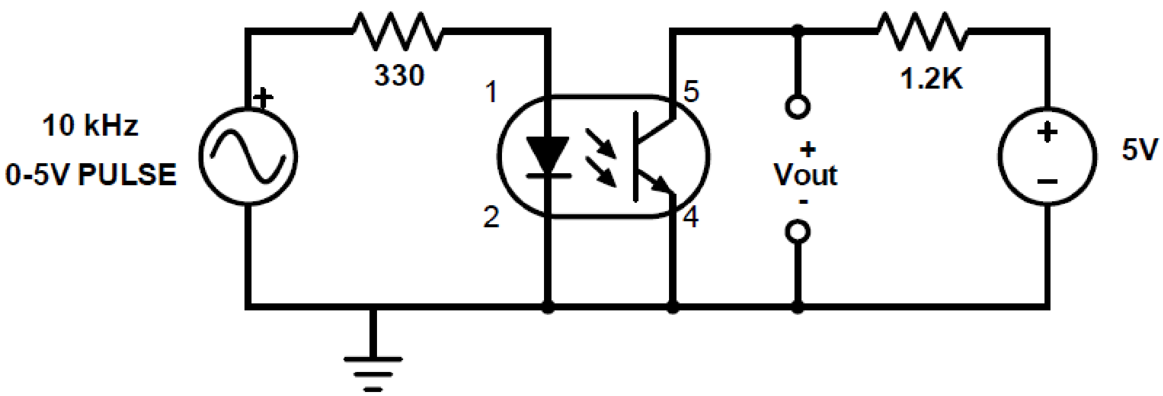
Experiment 1 Postlab

1) Plot I_{OUT} (y) vs. I_{IN} (x) at V_{CE} = 5V using a linear scale for both axes. Repeat, using a log scale for both axes. What do we conclude about the transfer characteristics of this device? Is it linear? Plot the same two responses at V_{CE} = 3.3V.

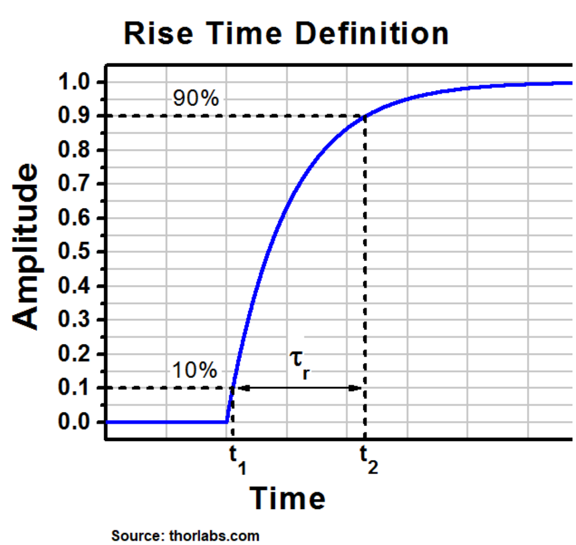
2) Visually determine the *saturation current level* of the optocoupler (that is, the output current above which further increases in LED current do not cause phototransistor current to increase) for each of the two phototransistor collector voltages; 5V and 3.3V.

Experiment 2: Rise Time

Phototransistor optocouplers are often with digital switching circuits. To test the pulse response of the 4N25 at 10 kHz, first generate a 0-5V pulse waveform by adding a +2.5VDC offset to a $5V_{p\text{-}p}$ square wave. Verify that you have achieved this waveform on the oscilloscope, and then build the following circuit, which creates an approximate LED pulse current magnitude of 10 mA:



Capture the output voltage V_{out} on the digital oscilloscope and include it in your lab report. The *rise time* of a digital signal is defined as the time required for a pulse to rise from 10 percent to 90 percent of its final value. Using the oscilloscope graticule in conjunction with the voltage and time axes, determine the rise time of the 4N25 optocoupler. Now replace the 1.2 kΩ resistor with 470 Ω, capture the waveform, and remeasure the rise time; repeat for 2.2 kΩ. Which value gives the quickest transient response?



Experiment 2 Postlab

Include all plots and computations in your final report and comment on your measured values of rise time; are they close to the published value of 2 μs for the 4N25?