

Lesson 1452, Optoelectronics



Experiment 7, Opto-isolator

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Objective


- To demonstrate the operating characteristics of a typical optical isolator





Introduction

- We have been concentrating on simple devices where only one electrical to optical or optical to electrical conversion was involved.
- This experiment will demonstrate how two such devices can be combined into one package to make a different type of device.

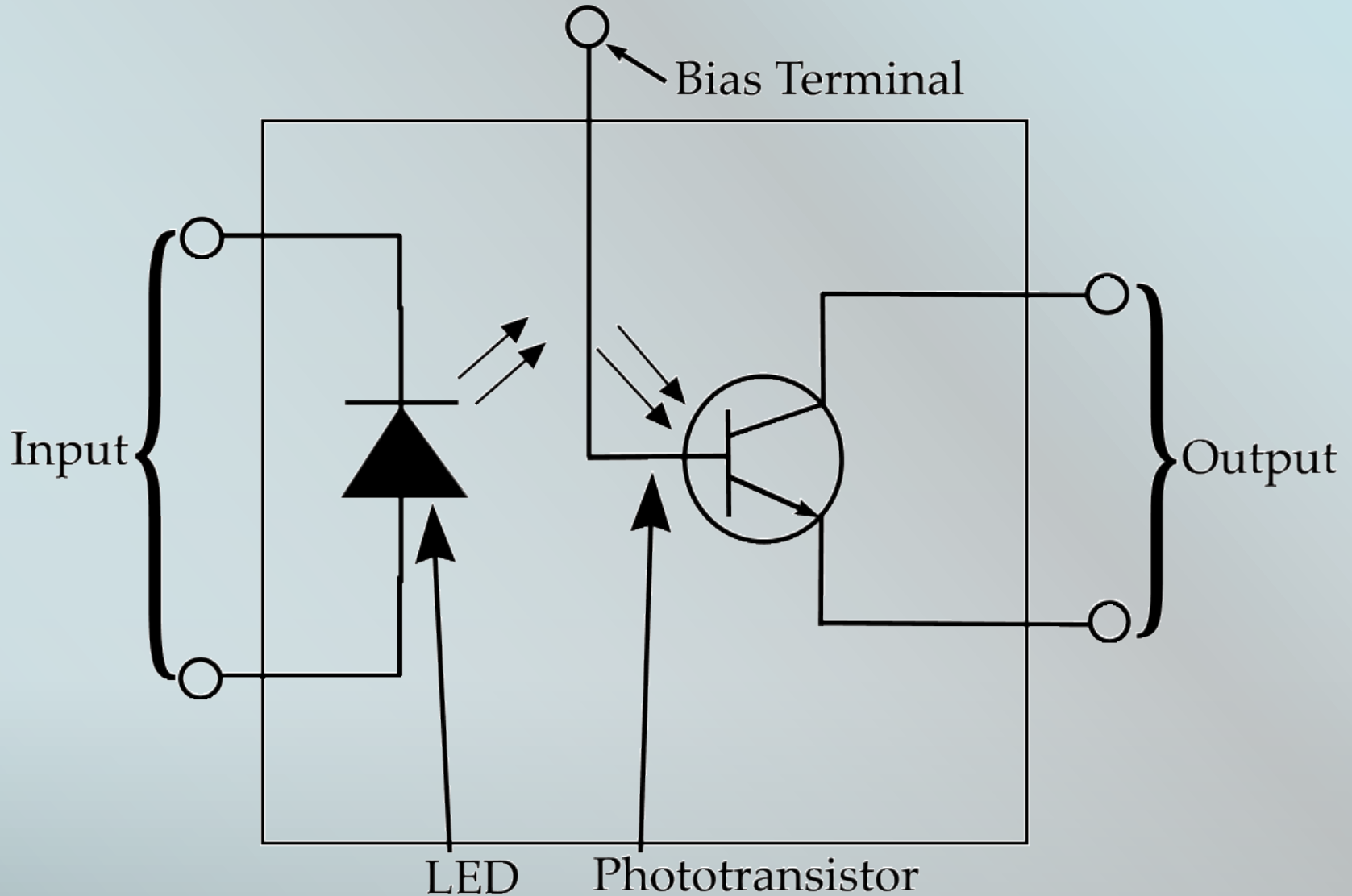
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- This device is called an opto-isolator; which is short for optical isolator
 - This device combines a LED with a phototransistor in one package
 - Opto-isolators are often used in digital circuits and have two important functions:
 - 1) The ability to electrically isolate two circuits from one another


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- a) For that reason, optical isolators are often used at the inputs and outputs of digital equipment where electrical isolation is important
 - 2) A second advantage of opto-isolators is they reduce the noise in the signal.
 - a) This noise reduction is especially important in applications where long signal paths occur


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- The schematic symbol for a typical opto=isolator is shown after we finish the component description.
 - There are two important parts to the device
 - 1) At the input, an LED turns an electrical into an optical equivalent
 - 2) The phototransistor at the output turns the optical signal back into an electrical signal


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- Ideally there should not be a change through this two-process conversion
 - Some signal degradation is inevitable at higher frequencies

Opto-isolator schematic symbol



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- It is easy to see there is not a direct electrical connection between the LED and the Phototransistor
 - Another way of saying the same this is; there is not a direct electrical connection between the input and output terminals
 - The electrical isolation of a typical optoisolator is rather high, generally greater than 1000V

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- This does not mean however, that a 1000V potential can be connected between the two input terminals or the two output terminals
 - Doing so would result in catastrophic failure!
 - However, you could hook up 1000V between one of the input terminals and ground or one of the output terminals and ground and no damage would occur since isolation is the purpose of the device

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- Practical isolators usually have a fifth terminal which was shown in the Opto-isolator symbol
 - This is the base connection to the phototransistor, which is used to bias it

This method of biasing the phototransistor allows the device to be used in a wide variety of circuits by simply adjusting the operating point of the phototransistor



Procedure

The schematic is shown following this introduction to the procedure

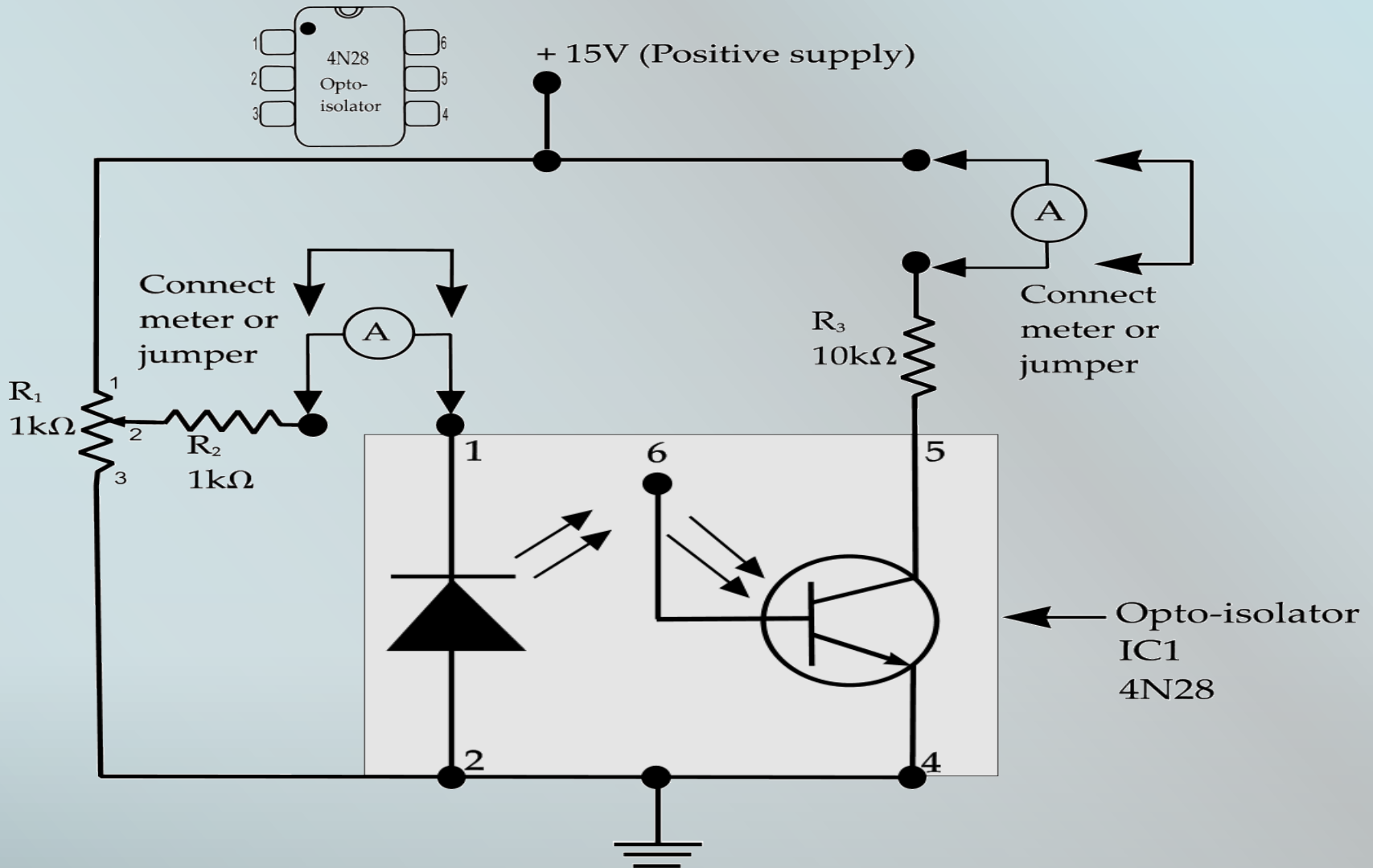
The opto-isolator we are using is typical of those found in many types of equipment

The following slide will illustrate the typical operating characteristics or specifications for this opto-isolator

Spec Info for the 4N28 Opto-isolator

- LED Max Input current (I_{in}) 80mA
- Phototransistor Max I_C 3mA
 - I_C = Collector current
- R_1 is used to adjust the input current
- R_2 limits the LED current to a safe value
- I_{out} measured at collector of transistor
 - I_{out} = Output current


Exp 7 Opto-isolator circuit



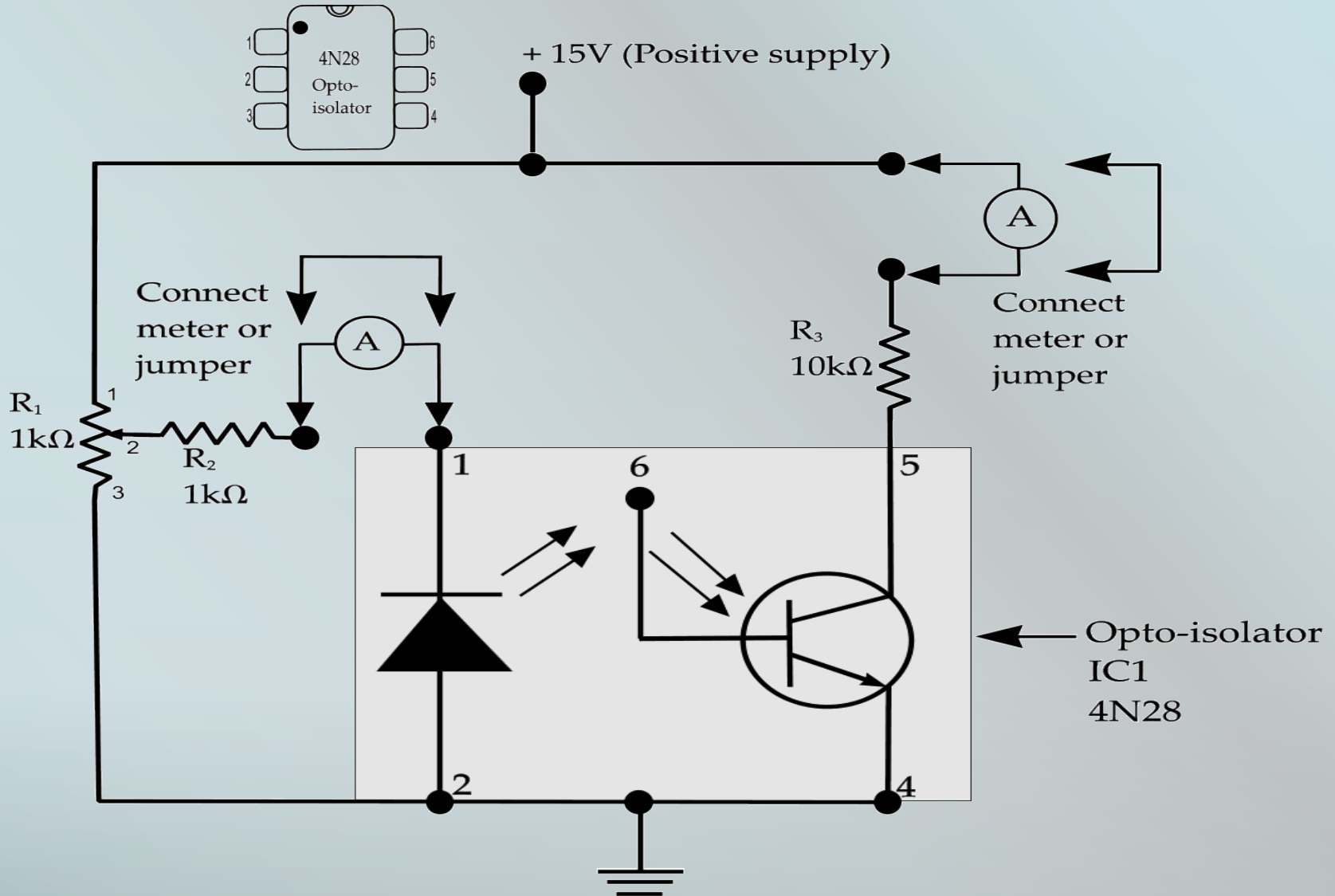


Procedure continued

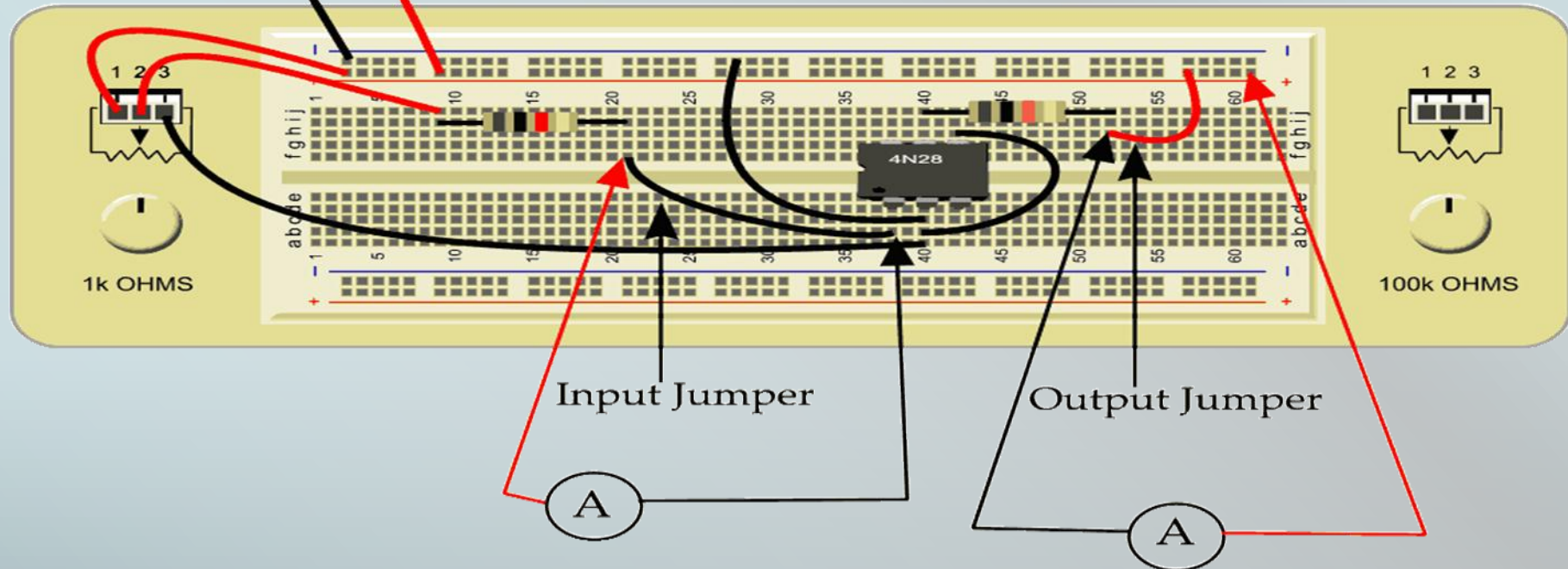
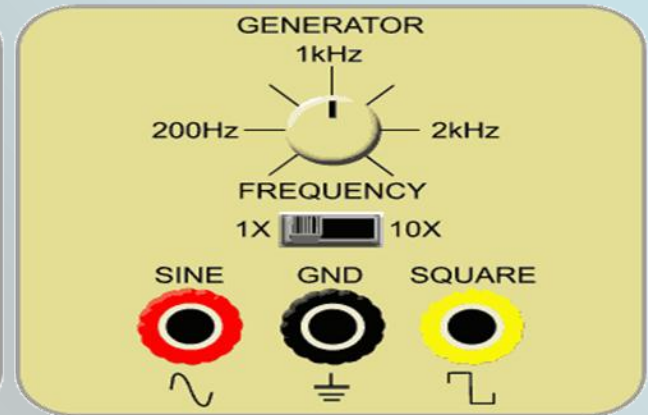
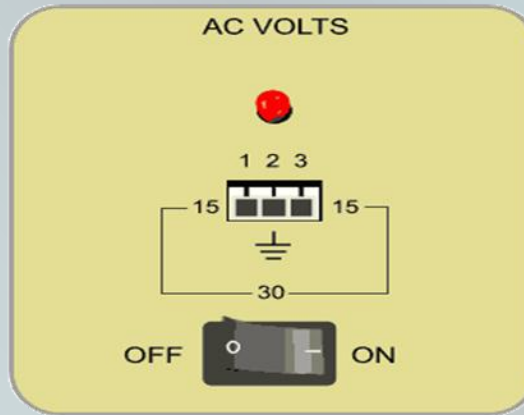
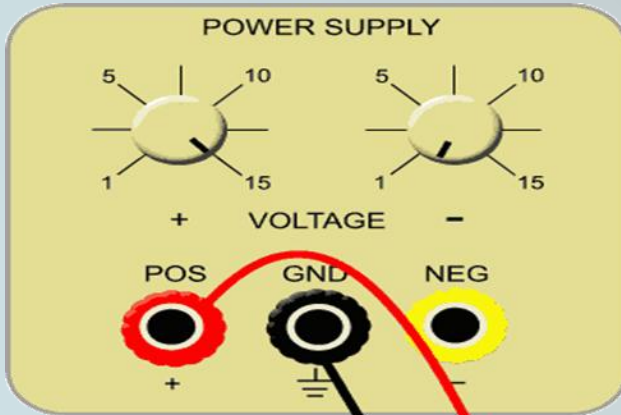
1. Turn on the trainer and set positive voltage to + 15V
 - a) Be sure not to disturb the setting throughout the remainder of experiment
2. With the power off, construct the circuit on the following slide
 - a) Be sure to choose the correct part since the 4N28 looks similar to the 741 Op Amp


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- b) Pay attention to the lead configuration of the opt-isolator as you build the circuit.
 1. The pinout of the IC is at the top of the diagram
 - c) Also note there are two places on the diagram where you are to insert your meter
 1. Make sure the jumper is installed, when the meter is removed from the circuit
 2. Obviously, the jumper is removed when the meter is in the circuit

Construct This Circuit



Experiment 7, Circuit Pictorial




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3. Switch the meter to the 25mA range and turn on the power
 - a) Adjust R_1 through its range, to verify that the LED current varies. (If not, turn power off and check the circuit connections)
 4. Set R_1 , for zero LED current and remove the meter from the circuit and connect the jumper in its place.
 - a) Turn off power when making all circuit changes




- b) Remove the jumper from the output circuit and connect the meter in its place
5. Switch the meter to the 2.5mA range and turn on the power
 - a) Note the reading and record its value in the Data table for this experiment
 6. Change the connections back so you can again read the input current
 - a) Remember to place the jumper back in the output circuit and remove the jumper in the input circuit

Data Table for Experiment 7

I_{IN}	I_{OUT}
0 mA	
1 mA	
2 mA	
3 mA	
4 mA	
5 mA	
6 mA	
7 mA	
8 mA	
9 mA	
10 mA	

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7. Adjust R_1 so that the input current is exactly 1 mA. Then change your connections so you can read the output current and record value in the data table
 8. Continue the process for all the input current values in the data table, until you have measured and recorded all the output current values
 - a) Remember to replace the jumper when removing the meter

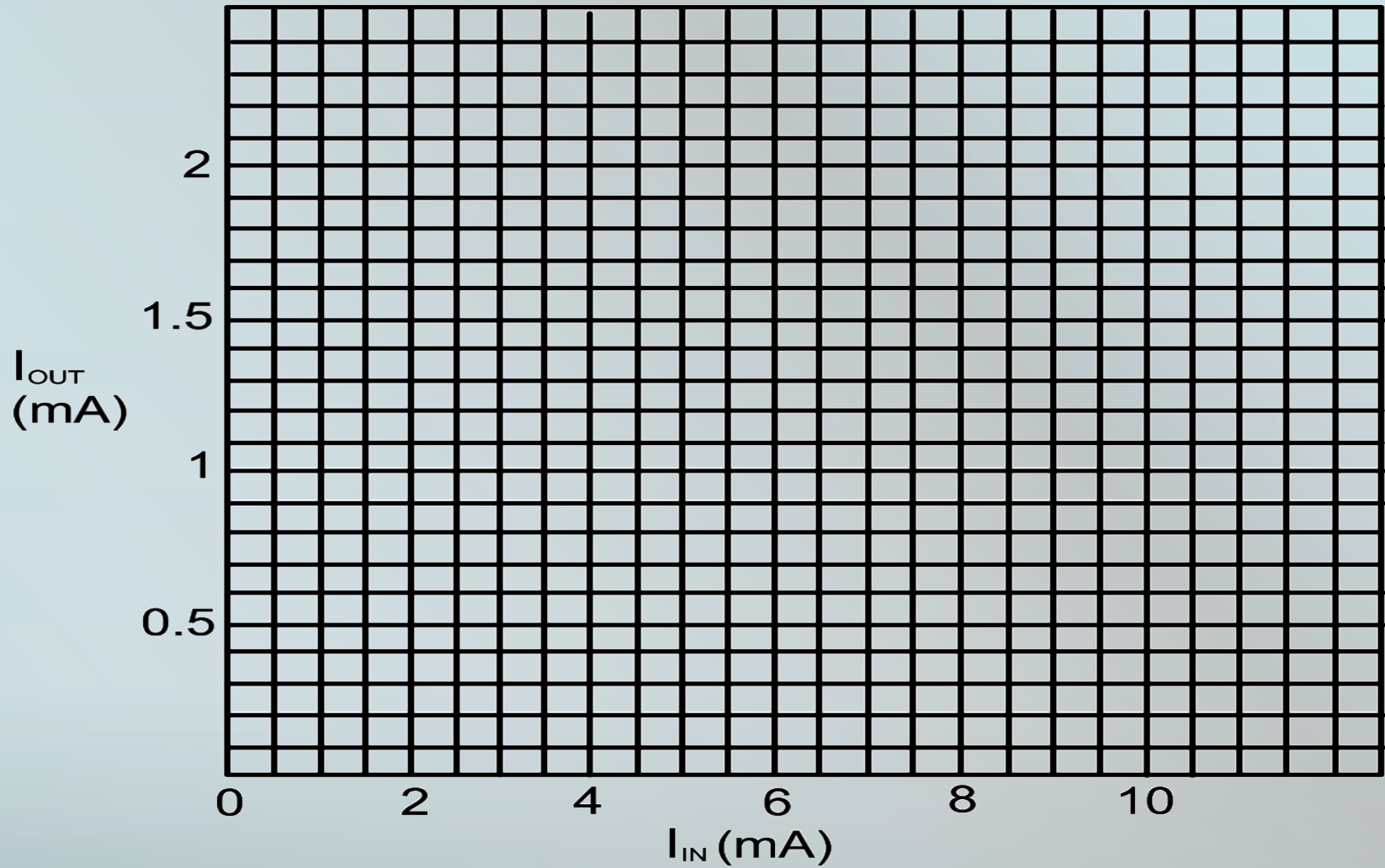


9. Turn off the power when all current measurements have been made.

a) Graph your results in the following
Experiment 7 Graph

1. The horizontal axis shows the various input current values
2. The vertical axis shows the various output current values
3. Use the data from the table to plot the points and connect them to form a smooth curve

Experiment Data Graph





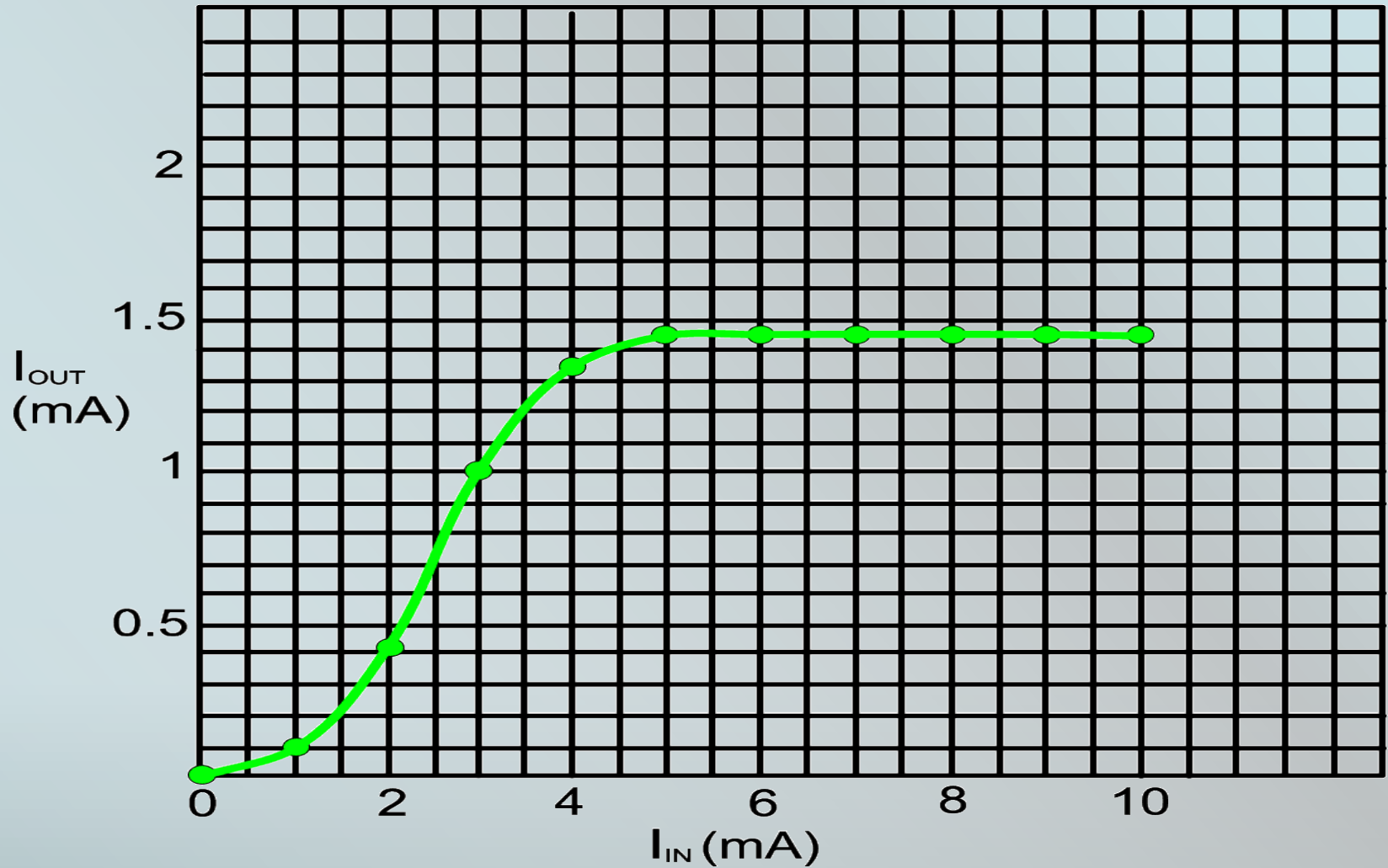
CIE Results

- While the following results are typical for a 4N28 Optical Isolator, your results could be somewhat different due to component variations
- You should note from the results, the output current increased up to a point
 - The maximum current is limited by the saturation point of the transistor

CIE Results

I_{IN}	I_{OUT}
0 mA	0 mA
1 mA	0.1 mA
2 mA	0.42 mA
3 mA	1 mA
4 mA	1.34 mA
5 mA	1.48mA
6 mA	1.48mA
7 mA	1.48mA
8 mA	1.48mA
9 mA	1.48mA
10 mA	1.48mA


Experiment Data Graph Plotted






Final Discussion


- An opto-isolator is a special device which contains a LED and a phototransistor
- It provides a high degree of electrical isolation due to its ability convert an electrical signal to optical and the optical signal back to an electrical signal
 - The particular opto-isolator we used is rated at 7000V isolation


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- The maximum or saturation current of a transistor is determined by the supply voltage, collector resistance and the transistor saturation voltage.

If we assume a saturation voltage of 0.2V, the maximum current for this experiment was;
 $14.8/10k = 1.48\text{mA}$.

The actual input current required to drive the phototransistor in to saturation depends on the gain of the particular phototransistor.

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- We did not use the additional terminal on the IC, which is often used to bias the base of the phototransistor.
 - A negative voltage can be applied to the base of the transistor to reduce/control the gain of the transistor
 - This would mean more LED current would be required to drive the transistor into saturation
 - Conversely, a positive base voltage could be applied to decrease the LED current required to drive the transistor into saturation

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- Your graph should show the opto-isolator was fairly linear up to a point.
 - This means the output current should have changed by a corresponding amount when the input current changed
 - Opto-isolators of this type are restricted to use in digital circuits, (circuits which have an on/off nature) since the conversion process is not perfectly linear.

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- The isolator you used has a rated isolation factor of 7000V; therefore, you should be able to measure an infinite resistance between the input and output terminals of the device.
 - While some leakage current may be present, it would be much too small for your meter to measure



Questions?



Resources

- Rosenow. (2001). *Lesson 1452: Optoelectronics*. Cleveland: Cleveland Institute of Electronics.



The End

**Developed and Produced by the Instructors
in the CIE Instruction Department.**

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