Lab 8 - Applications of diodes

Purpose:

a) To demonstrate the operation of a diode clipper
b) To demonstrate the characteristics of a zener diode
c) To explore the application of zener diodes as a simple voltage regulator
d) To understand the important of current limiting resistor in LED circuit

To be submitted :

1. **Deadline** : At the end of the lab session, submit the softcopy of the result/report in LEA.
2. **No formal report required**.
    a. Answer all the questions in the lab in the blank space provided. If calculation is involved, clearly show all the working steps involved.
    b. Insert table/plot, screen shots, clearly labelled.

Theory

Diode clipper is wave-shaping circuits in that they are used to prevent signal voltages from going above or below certain levels. The clipping level may be either equal to the diode's barrier potential or made variable with a reference voltage source in series. Because of this limiting capability, the clipper is also called a *limiter*. A zener diode can be used in place of the rectifier diode.

Unlike rectifier diodes, **zener diodes** are normally reverse biased, so they maintain a constant voltage across their terminal over a specified range of current. When used as a regulator, the zener diode maintains a dc output voltage that is essentially constant even though the load current may vary.

A **light-emitting diode (LED)** is a semiconductor-based light source that is often used as a state indication light in all types of devices. Today, high-powered LEDs are being used in car lights, in back lights for televisions, and even in place of filament lights for general-purpose lighting (e.g., home lighting, traffic lights,etc.) mainly due to their longevity and extremely high efficiency in converting electrical power to light output. LEDs provide very useful status and debug information about your circuit, often used to indicate whether a state is true or false.

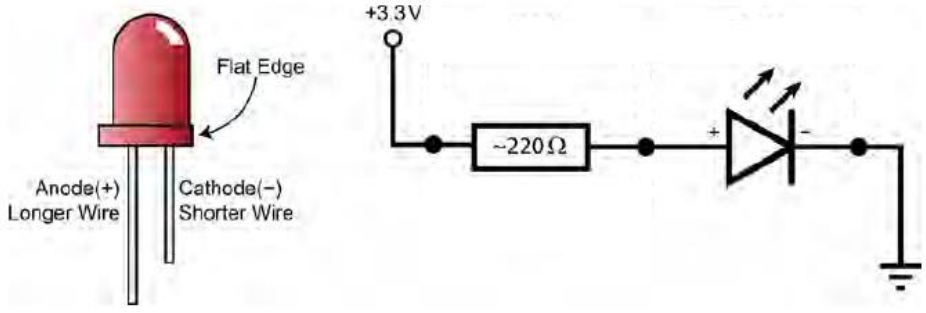


Figure 1 : red LED and simple circuit with current limiting resistor

Like diodes, LEDs are polarized. The symbol for an LED is illustrated above. To cause an LED to light, the diode needs to be forward biased by connecting the anode (+) to a more positive source than the cathode (–).

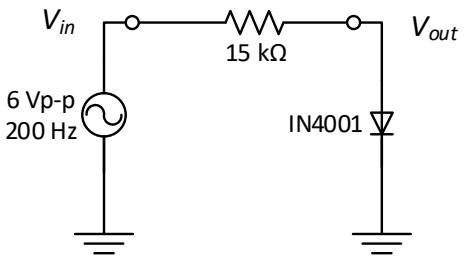
LEDs have certain operating requirements, defined by a *forward voltage* and a *forward current*. Every LED is different, and you need to reference the datasheet of the LED to determine these values. An LED does not have a significant resistance, so if you were to connect the LED directly across a 3.3 V supply, the LED would act like a short circuit, and you would drive a very large current through the LED, damaging it. Therefore, to operate an LED within its limits you need a series resistor, called a ***current-limiting resistor***. Choose this value carefully to maximize the light output of the LED and to protect the circuit.

Lab Work:

Part 1 : Diode Clipper

1. Wire the clipper circuit as shown in `Figure 2`. Use 2 channels of oscilloscope to view V_{in} and V_{out}. Set your oscilloscope to 1 V/division, DC coupling.

   Without any input signal connected to the breadboard, position the 2 lines on the oscilloscope's display so that they are at the same level (ground, or 0 V).



`Figure 2 : Positive clipper circuit`

2. Apply the ac signal to the circuit. Observe the waveforms and perform a screenshot.
   a. What is the positive peak voltage of the output?

      The positive peak voltage is 560mV on V_{out}.

      See screenshot below.

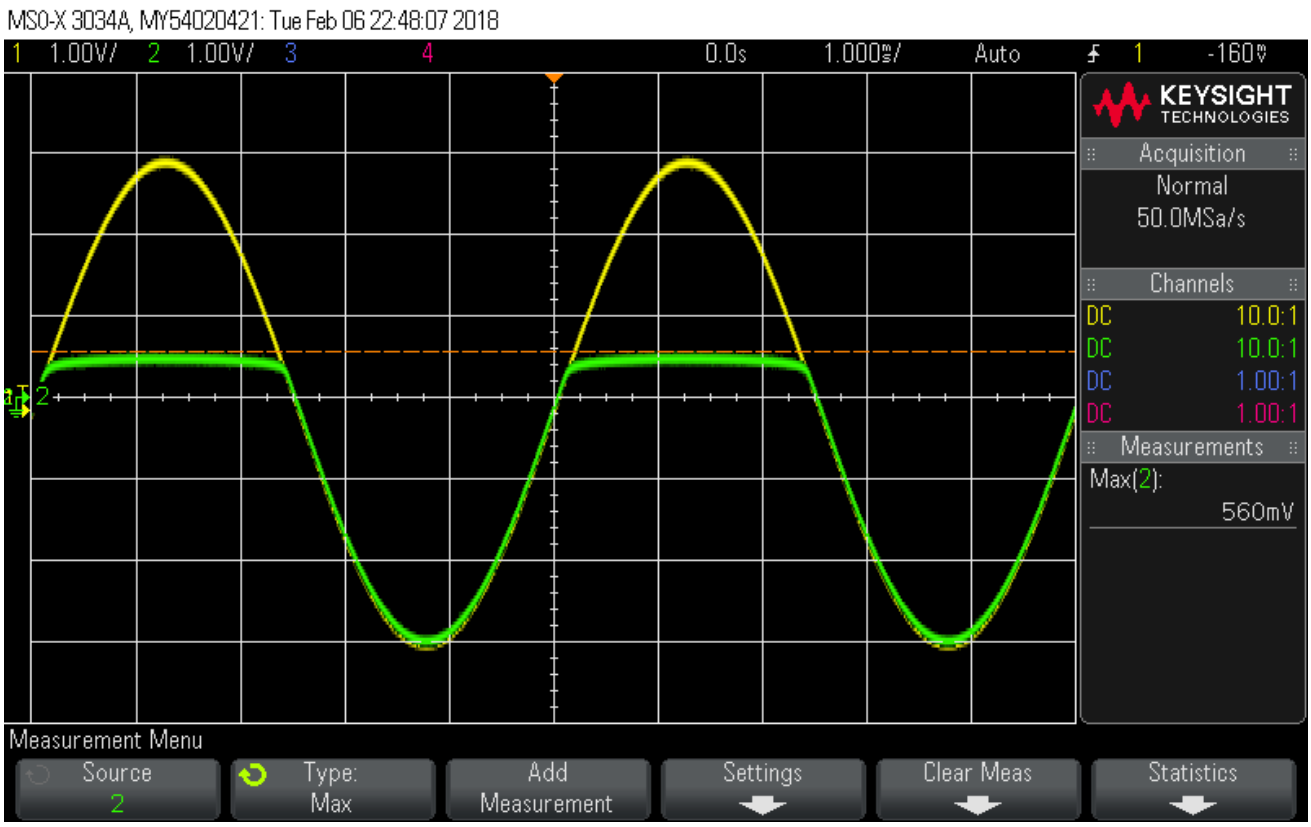
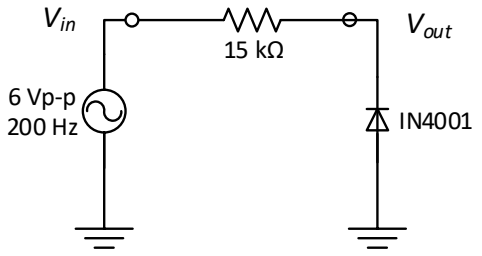


Figure 2 circuit waveform. Yellow: V_{IN} and Green: V_{OUT}.

b. Explain the functionality and operation of IN4001 rectifier diode in this clipper circuit.

Here, the 1N4001 acts like a clipper (similar to when two-diodes are used instead of one Zener diode). The clipper is designed to prevent a signal from exceeding a predetermined reference voltage level. The clipper here does not distort the remaining part of the applied waveform. It only "clips" part of the waveform (as seen above).

3. Now reverse the polarity of the diode in the circuit, as shown in `Figure 3`. How does this waveform compare with that of step 2?



`Figure 3: Negative clipper circuit`

This waveform is the reverse of the previous waveform in question 2b. In this waveform, only the positive cycles (and a minimal negative cycle) are produced. The previous waveform, only the negative cycles (and a minimal positive cycle) are produced. See screenshot below.

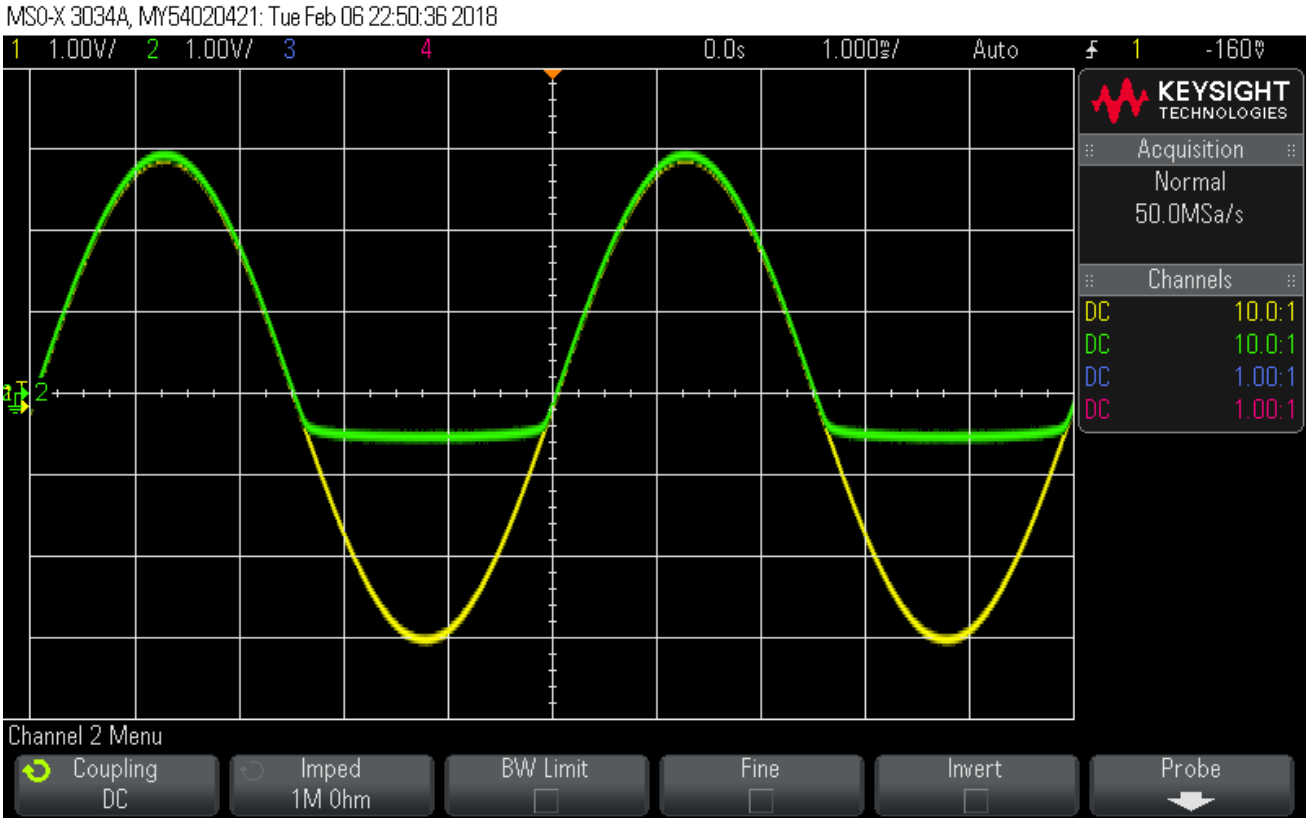
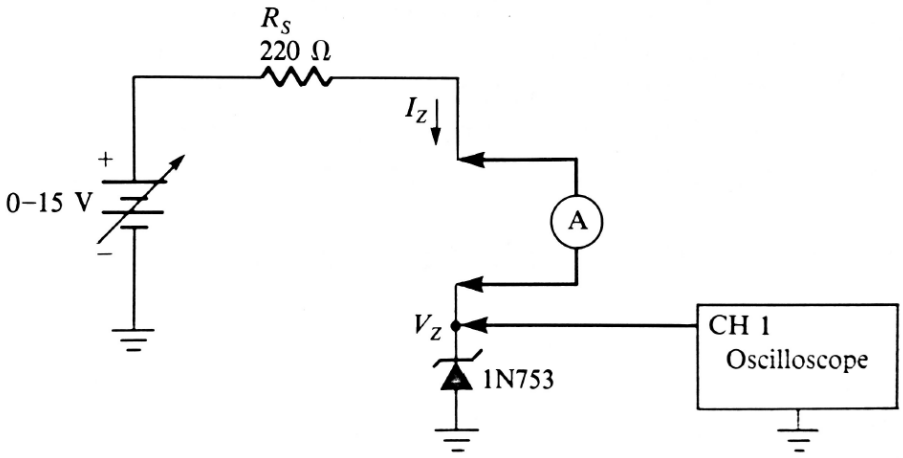


Figure 3 circuit waveform. Yellow: V_{IN} and Green: V_{OUT}.

Part 2: Zener diode and voltage regulation

4. Wire the circuit shown in `Figure 4`.



`Figure 4 AC series circuit measurements`

5. Increase the dc supply voltage in small steps while measuring the voltage across diode (V_Z) and the current through the circuit (I_Z). Record your data in a table, and plot your results for the corresponding Zener current and voltage values.

a. What do you observe about the current-voltage curve for the Zener diode?

This current-voltage curve for the Zener diode is similar to a regular diode. When the Zener voltage is around 6.2V, the Zener diode passes more current then at the other voltage values.

Demo: have me approve your graph *(Approved by Manijeh Khataie on March 12th)*

b. Based on your graph, determine the voltage across the Zener diode at a current of approximately 20 mA. Compare your result with nominal Zener Voltage as stated in IN753A datasheet.

Based on my graph that I created in excel, the voltage across the Zener diode at a current of 20mA is around 6.1V. Reading the 1N753A datasheet, it indicates that at around a Zener voltage of 6.2V, the Zener current will be 20 mA. As you can see, my results are close to what is specified. See picture below.

Device Type	V_Z@ I_{ZT} (Volts) Nominal	I_{ZT} (mA)
TC1N753A	6.2	20

A portion of the 1N753A Zener diode datasheet

Part 3: LED

6. Wire the circuit shown in `Figure 1` with a red LED. What is the voltage drop across LED?

   The voltage drop across the red LED is 1.8V.

7. Slowly increase the DC supply voltage to 4V. Does this affect the voltage drop across LED?

   The change in voltage across the LED is negligible. At 4V, the voltage drop across the LED is 1.9V as supposed to 1.8V when the output was set to 3.3V.

8. Assuming a supply DC voltage of 3.3V. What would be the minimum value of current limiting resistor for this LED circuit if maximum forward current is 20 mA?

   *The minimum value of current limiting would be 75Ω for this LED circuit if maximum forward current is 20 mA. *3.3V – 1.8V = 1.5V / 20 mA = R = 75Ω.*

9. Compare the different voltage drop LEDs across 5 different LED colors and models

Description	Color	Voltage drop
Light 1	Red	1.8V
Light 2	Yellow	1.9V
Light 3	Green	1.9V
Light 4	Ultra-bright Green	2.5V
Light 5	Ultra-bright Red	2.0V