38+ 51 = 89

ENSC 225

LAB 2

Characterization of Diodes and simple diode Circuits

Lestley Gabo 301170055

Dana Sy 371137164

Joe Kuo 301175332

Anmol Bhullar 301172415

Written on March 2014

10

Experiment-1: P-N Diode I-V forward characteristics

We tested the forward characteristics of the signal diode using the SPA (Semiconductor Parameter Analyzer) from 0 to 0.8V to get the graph below:

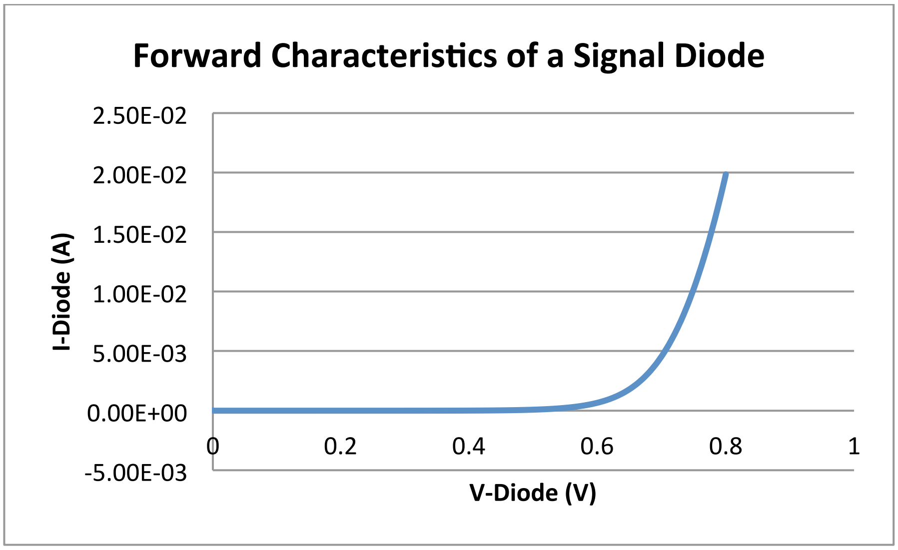


Figure 1: Characteristic of forward signal diode obtained from the SPA

Then, we tested the forward characteristics of the Zener diode from 0 to 0.8V to get the graph below:

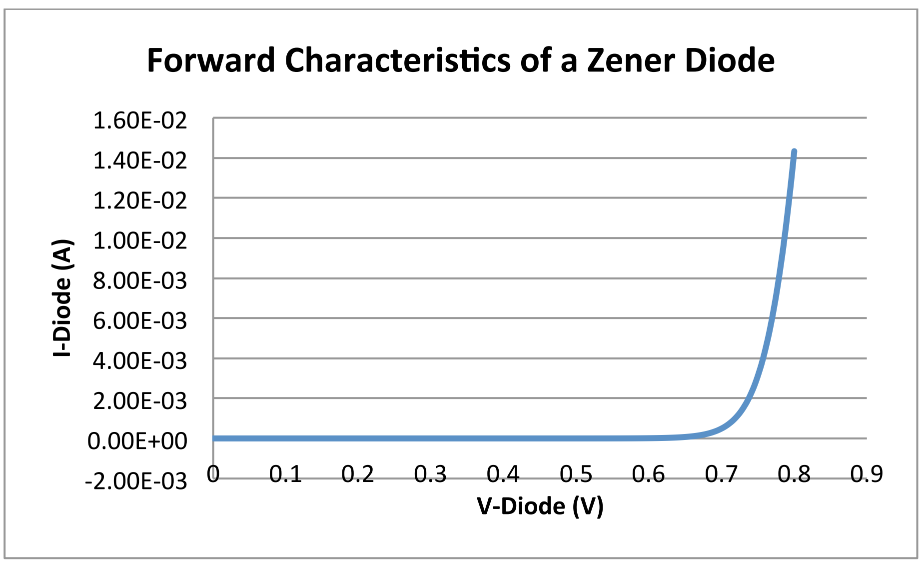


Figure 2: Characteristic of forward Zsener diode obtained from the SPA

Lastly, we tested the reverse characteristics of the Zener Diode from 0 to -7V to get the graph below:

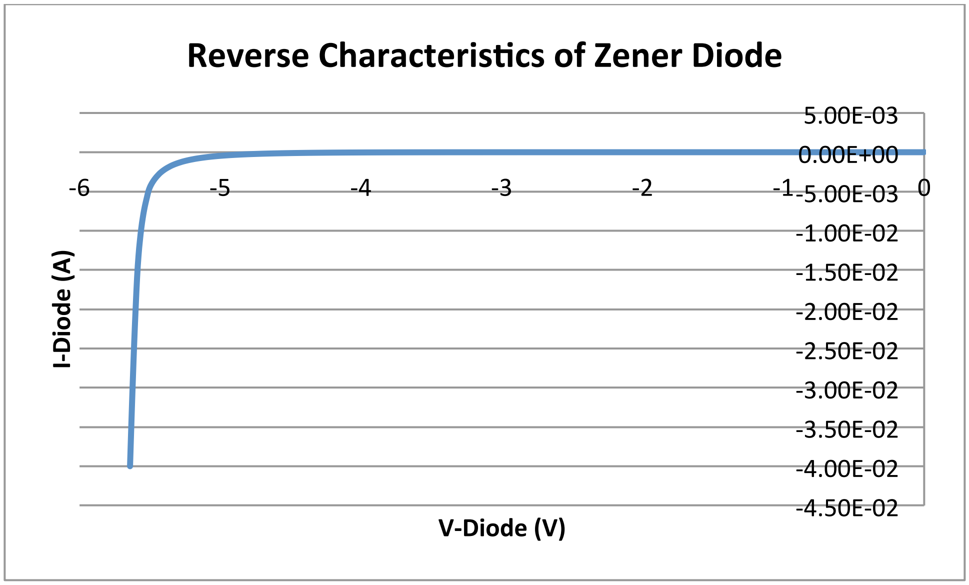


Figure 3: Characteristic of reverse Zener diode obtained from the SPA

Experiment-2: Determination of Scale Current and Technology factor (n): total 8

We plotted the signal diode with the characteristics of Ln(I_D) versus V_D (Fig. 4) and fitted a linear function using excel to find the technology factor of the diode.

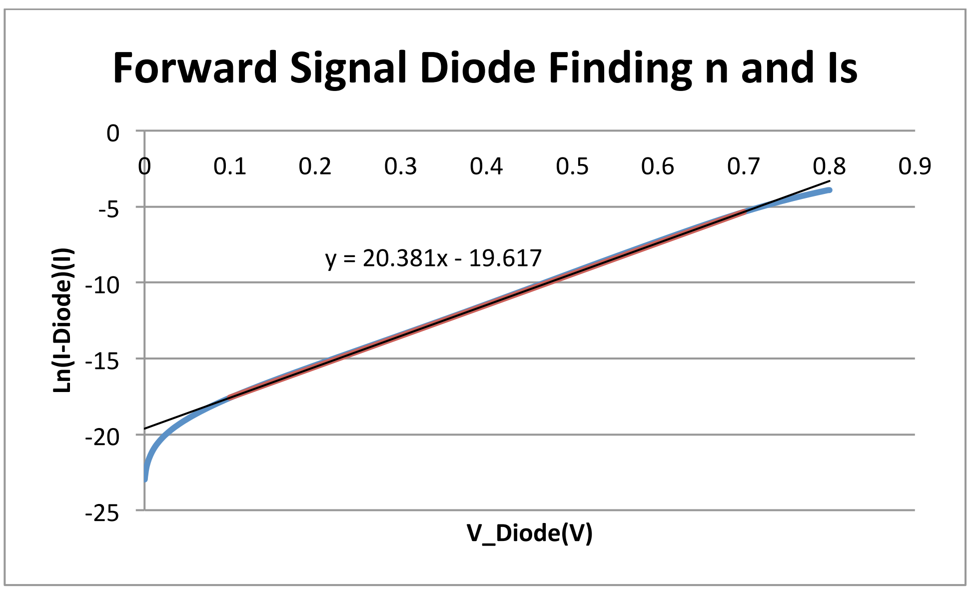


Figure 4: Plot of Ln(I-Diode) versus V-Diode

We know that $V_T = 25mV$ and the slope to be 20.381 from the graph in Fig. 4. Also, we can get I_s from the linear function intercept using the equation:

$$\text{Intercept} = \text{Ln(Is)}$$

Using the formula above we got that

$$I_S = 3.023 x 10^{-9} A$$

To find the technology factor (n) we used the equation below:

$$\frac{1}{nV_t} = slope$$

Using the formula above we found our technology factor (n)

20

$$n = 1.9627$$

Experiment-3: Determination of small signal resistance at various forward voltages for the signal diode:

We constructed a circuit exactly like Fig. 5 to measure the diode voltage.

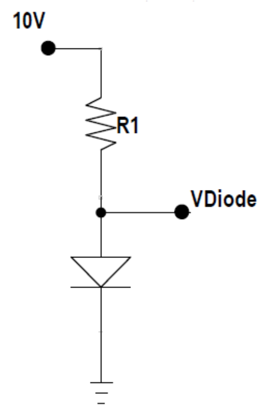


Figure 5: Circuit for finding small signal resistance

We then shunted the diode as seen in Fig. 6 and measured the diode voltage again.

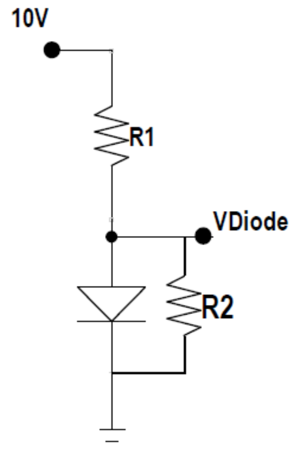


Figure 6: Shunted circuit of Fig. 5

We used three different pairs of resistors for the circuit. We recorded all our exact resistor values and diode voltage values in an orderly table shown below in Fig. 7.

R1(KΩ)	R2(KΩ)	V_{sup}(V)	V_{D1}(V)	V_{D2}(V)
0.9798	.9832	10.073	0.7327	0.7272
11.921	11.902	10.073	0.6063	0.6026
99.32	99.75	10.073	0.5033	0.5009

Figure 7: Calculation values of our rD determination experiment

Then we found the current through the diode before shunting (I_{D1}) for all three different resistance values using the equation:

$$I_{D1}=\frac{V_{sup}-V_{D1}}{R_1}$$

Then we found the current through the diode after shunting (I_{D2}) for all 3 different pair of resistance values using equation:

$$I_{D2}=\frac{V_{sup}-V_{D2}}{R_1}-\frac{\mathrm{V_{D2}}}{\mathrm{R_2}}$$

We found the experimental r_D using equation:

$$r_D=\frac{(V_{D1}-V_{D2})}{(I_{D1}-I_{D2})}$$

We then found the formula r_D from using equation:

$$\frac{nV_T}{I_{D1}}$$

Lastly we found the graphical r_D using excel by the equation:

$$r_{D=}\frac{1}{slope}$$

We found the slope using linear functions on the forward characteristics of the signal diode as seen clearly in Fig. 8.

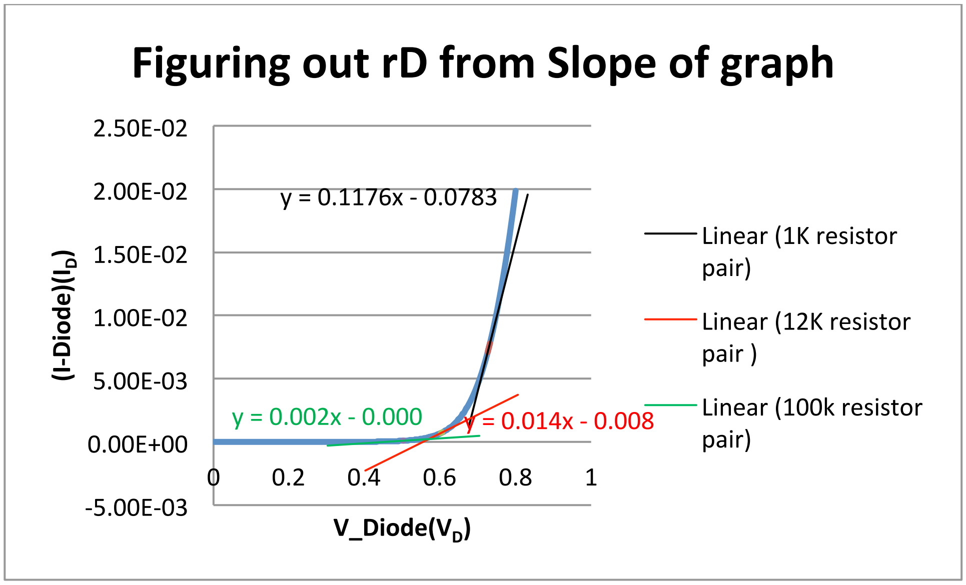


Figure 8: Finding rD using the tangent of each resistor pair

Using the given rD and rZ Calculation Helper our data is shown in Fig.9.

I_{D1}(A)	I_{D2}(A)	r_D (KΩ)	$\frac{nV_T}{I_{D1}}$ (KΩ)	r_D from slope of graph (KΩ)	Slope
9.53E-03	8.80E-03	7.493	5.147	8.55	0.17
7.94E-04	7.44E-04	73.530	61.789	71.4	0.014
9.64E-05	9.14E-05	480.251	509.252	500	.002

Figure 9: Calculated values of rD determination experiment

Comparing the three different small signal resistances, we found that the experimental and graphical small signal resistance to be very similar. Our calculated small signal resistance is the one that differs a lot compared to the other two small signal resistances. However, when the resistors were switched to the 100KΩ we found all three small signal resistances were very close to each other.

A reason why we do not get the same small signal resistance for all three is because of various errors. One of the possible errors is that we assumed that the room was in room temperature, therefore V_T is 25mV. This is because we do not know the exact temperature of the room or have control to the thermostat to properly conclude what the exact value of V_T. Another possible error could be from linear function of the graph. The points chosen might not have been the optimal points.

Experiment-4: Determination of Zener voltage and Zener Resistance 18/20

We constructed the circuit in Fig. 10 to measure the Zener diode voltage.

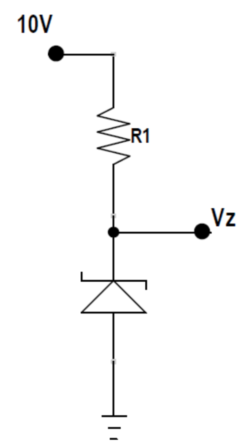


Figure 10: Circuit for finding Zener diode voltage

We then shunted the Zener diode and measured the Zener diode voltage again.

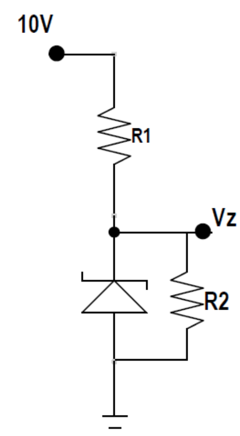


Figure 11: Shunted circuit of Fig. 10

We recorded our exact resistance values and the Zener diode voltage which are listed in Fig. 12.

R1(KΩ)	R2(KΩ)	V_{sup}(V)	V_{Z1}(V)	V_{Z2}(V)
9.759	0.981	10.073	5.539	5.525

1 Figure 12: Calculation values for Zener R_Z determination

We then found the Zener current, I_{Z1}, before shunting using the equation:

$$I_{Z1}=\frac{V_{sup}-V_{Z1}}{R_1}$$

$$I_{Z1}=4.62x10^{-4}A$$

Then found the Zener current, I_{Z2}, after shunting using the equation:

$$I_{Z2}=\frac{V_{sup}-V_{Z2}}{R_1}-\frac{V_{Z2}}{R_2}$$

$$I_{Z2}=-5.17x10^{-3}A$$ 2

With Vz and Iz we then found the experimental r_Z using the equation:

$$r_Z=\frac{(V_{Z1}-V_{Z2})}{(I_{Z1}-I_{Z2})}$$

$$r_Z=2.486\Omega$$ Vz=? 1/2

Lastly we found the graphical r_Z by using the equation:

$$r_{Z=\frac{1}{slope}}$$

The slope was found by using a linear function on the reverse characteristics of the Zener diode as seen clearly in Fig. 13.

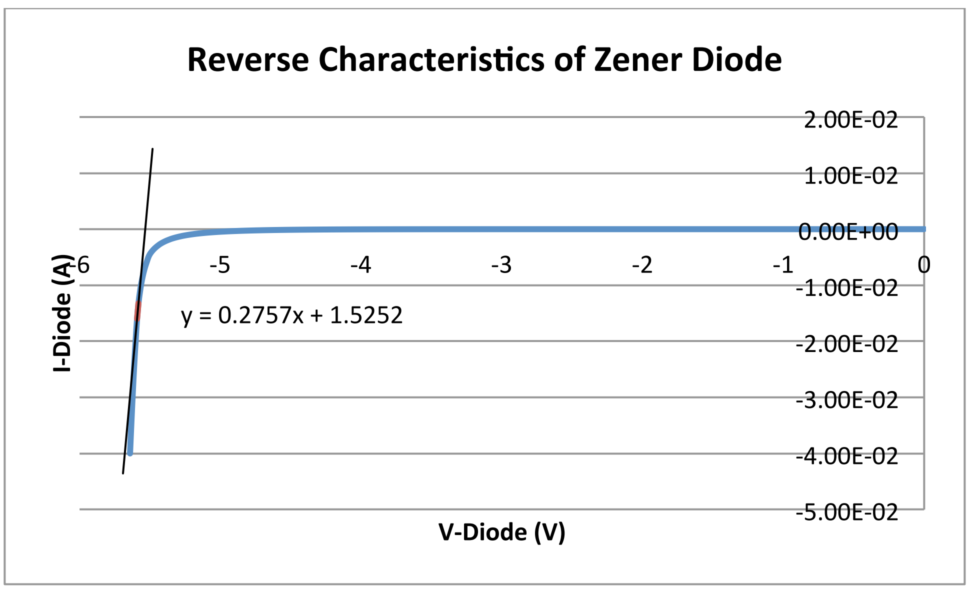


Figure 13: Finding rZ using the slope at I_{Z1}

Fig. 14 is a small table for the summary of the calculated values done in experiment 4.

I_{Z1}(A)	I_{Z2}(A)	rZ (KΩ)	rZ from slope of graph (KΩ)	Slope
4.65E-04	-5.17E-03	2.486	3.627 3	0.2757 3

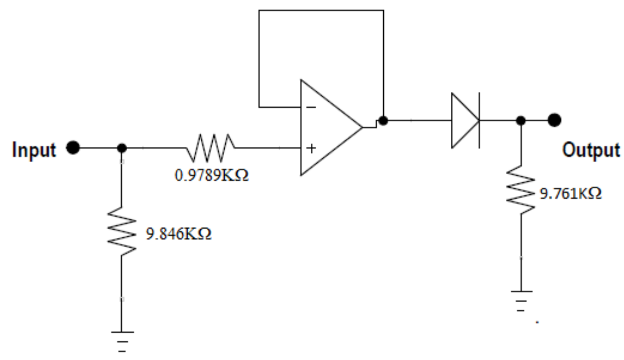
Figure 14: Calculated values of rZ determination experiment

too much discrepancy 3/4

Comparing the two Zener resistances there is only a difference of one thousand ohms. Though we found our graphical rZ a bit higher than the experimental value we were proud to see that the two values are quite close together. Obviously, the experimental rZ should be the more accurate Zener resistance. This is because the slope graphical approach is very punishing in terms of result when choosing the wrong co-ordinates. The small difference between the two resistances could be because of our error in choosing the co-ordinates.

Experiment-5: Simple half wave rectifier 17/20

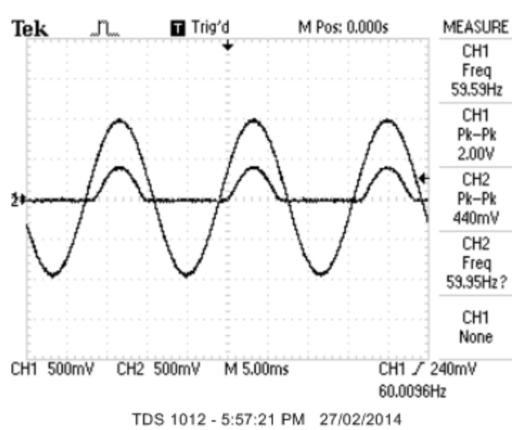
We constructed the circuit in Fig. 15 to create a simple half wave rectifier. The power supply was set to a current limit 50mA. The function generator was set to 60Hz, 1V peak, and sinusoidal signal.



2

Figure 15: Circuit for a simple half wave rectifier

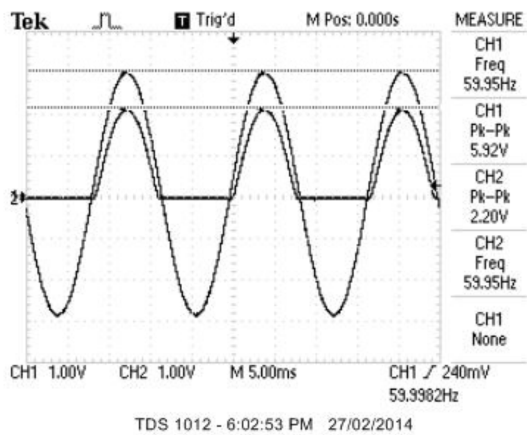
At 60 Hz and 1V peak we get the waveform shown in Fig. 16.



2

Figure 16: Simple half wave rectifier at 60Hz and 1V peak

Now after changing the 1V peak to a 3V peak we can see in Fig. 17 a difference in voltage drop



1

Figure 17: Simple half wave rectifier at 60Hz and 3V peak

Fig. 18 shows the values of the input and output amplitudes and also the diode drop.

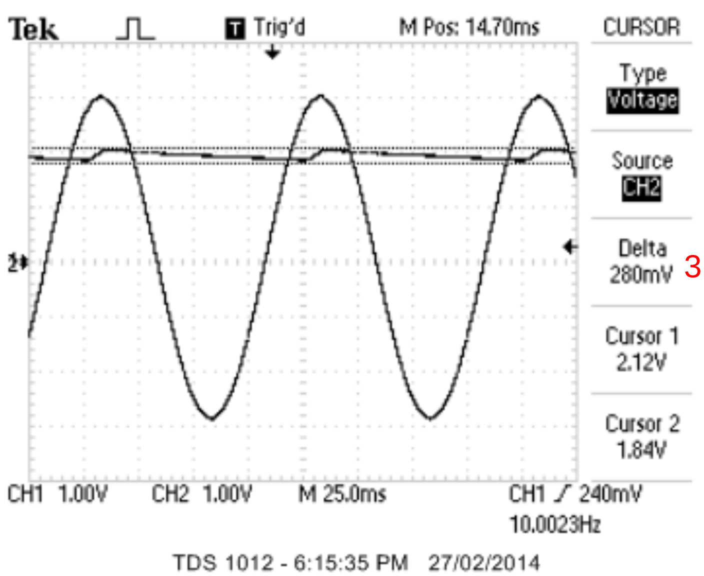
Amplitude V_{input}(V)	Amplitude V_{output}(V)	Diode Drop(V)
2.96	1.1	0.76

3

Figure 18: Calculated values of the simple half wave rectifier on 3V peak

Then we connected the 100 µFD electrolytic capacitor between the ground and what we got was a filtered clean DC output. We measured the rectified DC value output. Lastly we then lowered the frequency slowly down from 60Hz to 10Hz. We did this to clearly see (Fig.19) the ripple voltage on the scope trace. The cursors were then used to measure the Peak-to-Peak value of the ripple voltage.

how much? 0/3



1

3

Figure 19: Filtered simple half wave rectifier at 10Hz

Fig. 20 shows the values of the rectified filtered output and the rippled Peak-to-Peak values.

Rectified V_{output}(V)	Rippled Peak-to-Peak(V)
2.01	0.240

Figure 20: Cursor values of the filtered half wave rectifier at 10Hz

The conclusion for this experiment was tied with the conclusion of experiment six below. This is because the conclusion for both is just the comparison between the two experiments. Therefore this conclusion will be continued in the conclusion at part six.

Experiment-6: Precision half wave rectifier 16/20

We constructed the circuit in Fig. 21 to create a precision half wave rectifier. The power supply was set to a current limit 50mA. The function generator was set to 60Hz, 1V peak, and sinusoidal signal.

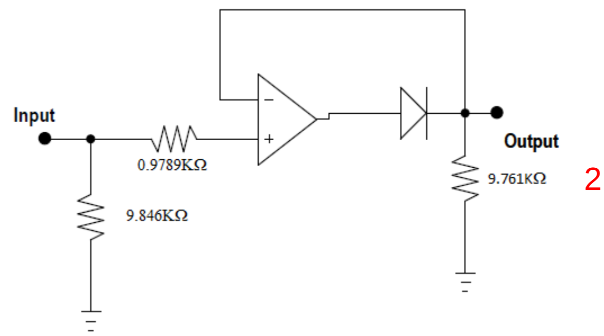


Figure 21: Circuit for a precision half wave rectifier

At 60 Hz and 1V peak we get the waveform shown in Fig. 22

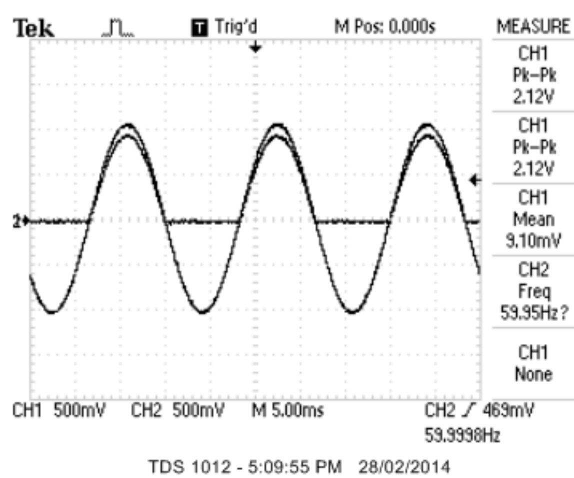
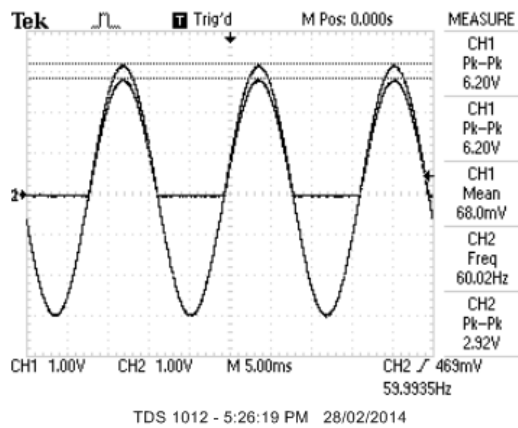


Figure 22: Precision half wave rectifier at 60Hz and 1V peak

Now after changing the 1V peak to a 3V peak we can see in Fig. 23 a difference in voltage drop



1

Figure 23: Precision half wave rectifier at 60Hz and 3V peak

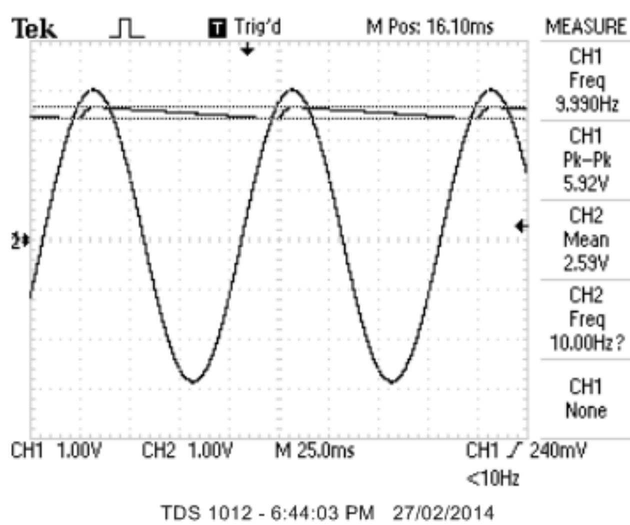
Fig. 24 shows the values of the input and output amplitudes and also the diode drop.

Amplitude V_{input}(V)	Amplitude V_{output}(V)	Diode Drop(V)
3.10	1.46	0.36 3

Figure 24: Calculated values of the precision half wave rectifier on 3V peak

Then we connected the 100 µFD electrolytic capacitor between the ground and what we got was a filtered clean DC output. We measured the rectified DC value output. Lastly we then lowered the frequency slowly down from 60Hz to 10Hz. We did this to clearly see (Fig.25) the ripple voltage on the scope trace. The cursors were then used to measure the Peak-to-Peak value of the ripple voltage.

how much? 0/2 comparison: 0/2



1

Figure 25: Filtered precision half wave rectifier at 10Hz

Fig. 26 shows the values of the rectified filtered output and the rippled Peak-to-Peak values.

Rectified V_{output}(V)	Rippled Peak-to-Peak(V)
2.69	0.240

Figure 26: Cursor values of the filtered precision wave rectifier at 10Hz

Comparing the DC and ripple values of both experiment five and experiment six we see quite a lot of differences. For the simple half wave rectifier the peak-to-peak voltage on both 1V and 3V was lower compared to the precision half wave rectifier. This also means the amplitude was lower for the simple half wave rectifier. The precision half wave rectifier on the other hand had a lower diode drop of only 0.36V, almost half of the simple half wave's 0.76V. 2/2 We can conclude that the precision half wave rectifier is better at retaining the voltage across its diode. Also, the measured rippled peak-to-peak voltages for both experiments were the same at 0.240V. We think this is because the same filtering capacitor, resistances, frequency, and voltages were used. Therefore nothing changed on the rippled peak-to-peak voltages between the simple and the half wave rectifier. 2/2