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Instructor:	Sandeep Kaler
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Assignment/Lab Number:	Lab 5
Assignment/Lab Title:	Wave Shaping Circuits

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## Introduction:

To capture the voltage-current characteristics of a diode, one can employ a diode to produce waveforms that meet the desired specifications. The diode achieves this by altering the input signals.

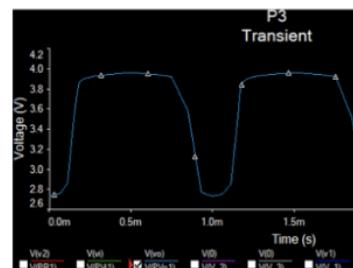
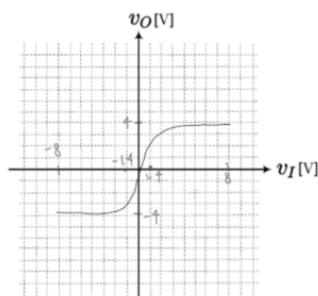
## Objectives:

The purpose of this laboratory experiment was to examine the impact of the quantity of resistors and capacitors connected to diodes on the waveform of the output voltage. Additionally, the objective was to gain insight into the voltage-current behavior of a diode within a non-linear circuit.

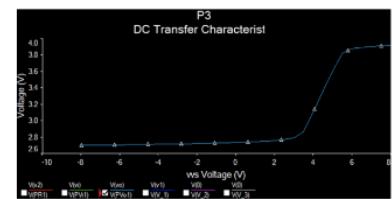
## Pre-lab:

Usba:

PART1:



OUTPUT VOLTAGE WAVEFORM



INPUT OUTPUT TRANSFER CHARACTERISTICS

PART 2  
a.) and b.)

$$R_1 \text{ & } R_2 = 3.4 \text{ k}\Omega$$

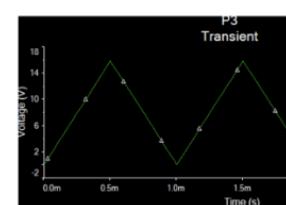
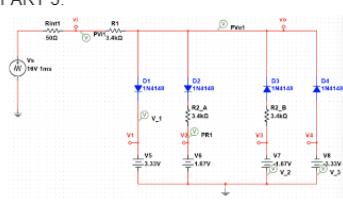
$$R_t = R_2 / (R_2 + R_1)$$

$$R_t = 3.4 / (3.4 + 3.4) \\ = 0.5 \text{ k}\Omega$$

Therefore the resistors are  $3.4 \text{ k}\Omega$

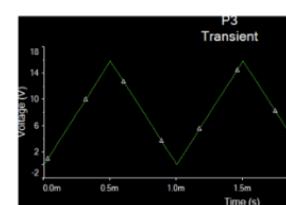
c.)  
 $I = V_{bias} / R$   
 $= 1.67 / 3.4$   
 $= 0.49 \text{ mA}$

PART 3:

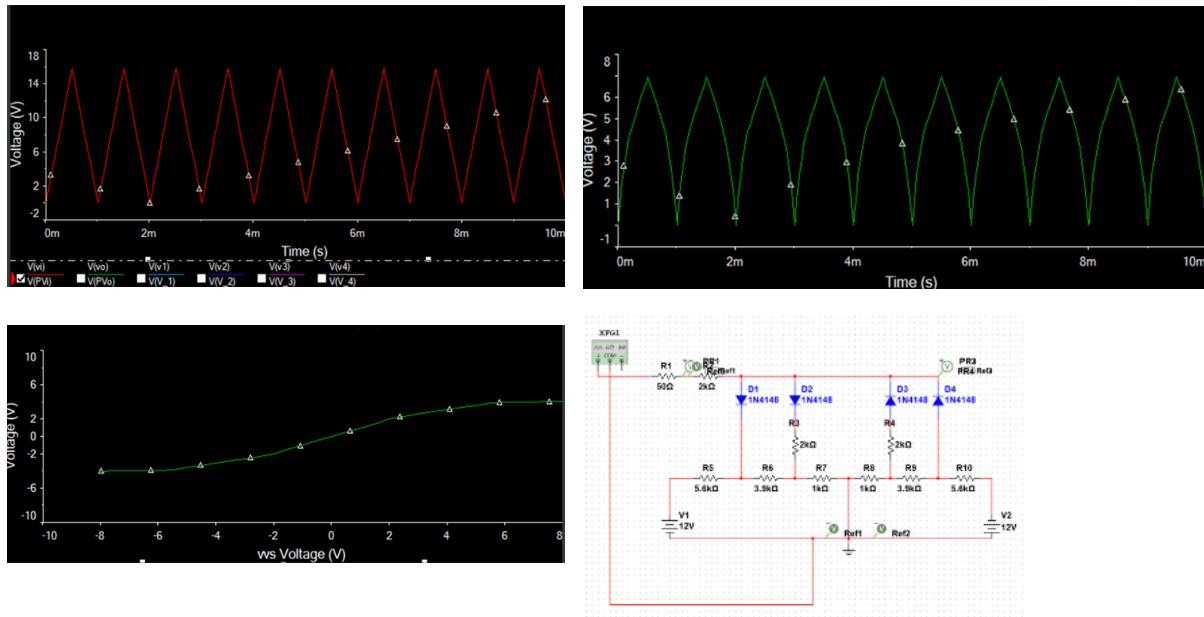


INPUT VOLTAGE WAVEFORM

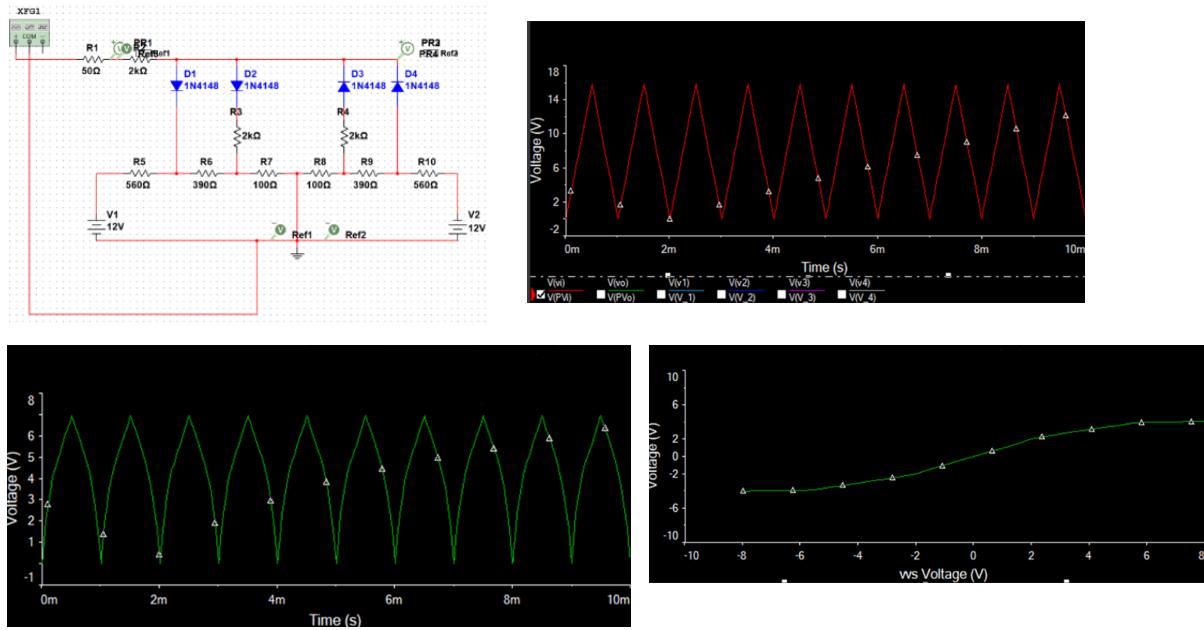
PART 4:



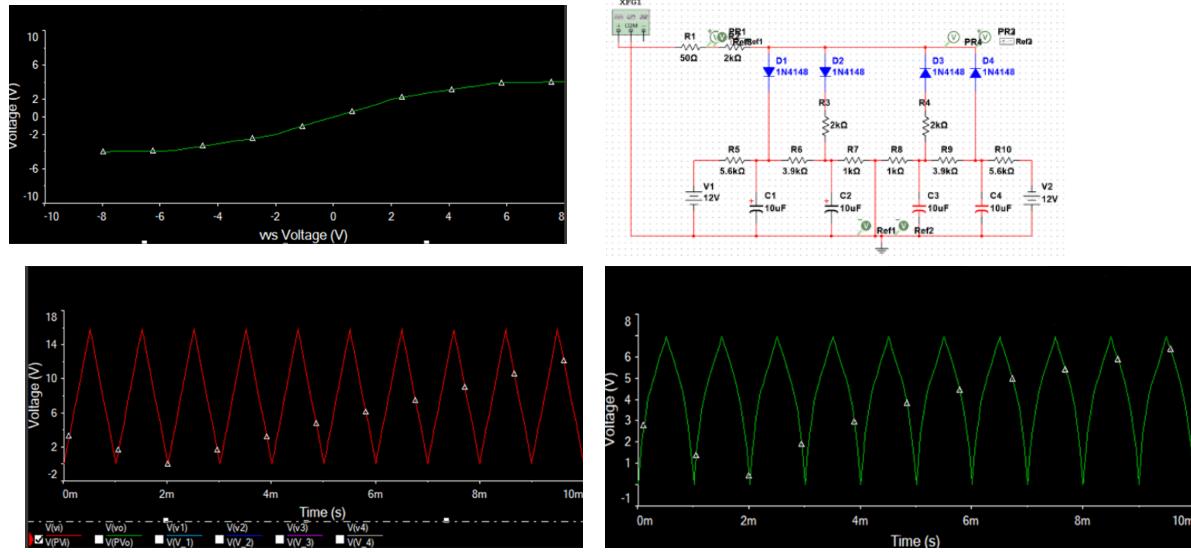
P5:



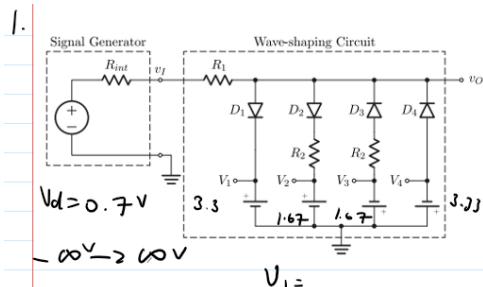
P6:



P7:



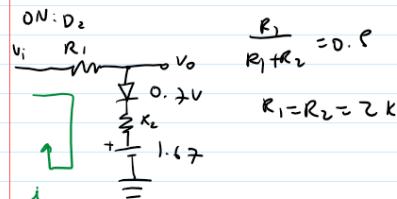
Nini:



$$-\infty < V_i < 1.67$$

$$\text{OFF: } D_1, D_2, D_3, D_4$$

$$1.67 < V_i < 5.3$$



$$-2.3 + 1.2k\Omega + 0.7V + 1.2k\Omega + 1.67 \approx 0$$

$$Y_{K1} = 2.5 - 1.67 - 0.7$$

$$i = 0.0475 \text{ mA}$$

$$V_o = 1.67 + 0.7 - 2k \cdot i$$

$$= 2.275$$

2

$$- R > 500 \quad \frac{R}{R_1 + R_2} = 0.5$$

$$- V_i = 8V$$

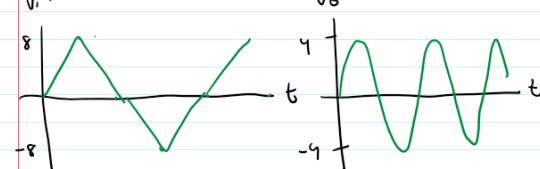
$$I_D > 0.5 \text{ mA} \quad R_1 = R_2$$

$$-V_{D1} + V_{D2} - 3.33 + 2(1.67) + I_{D2}R_2 = 0$$

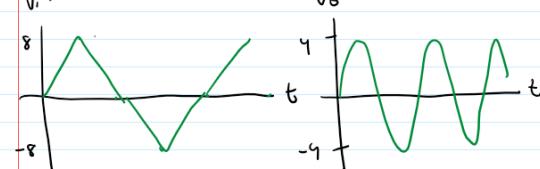
$$-3.3 + 1.67 - 3.33 + 3.34 + 0.5 \text{ mA} \cdot 2k = 0$$

$$R_2 = \frac{6.63 - 1.67 - 3.34}{0.5 \text{ mA}} = 6.63 \text{ k}\Omega \quad V_o = V_i \cdot \frac{R_1}{R_1 + R_2} = 8 \cdot 0.5 = 4$$

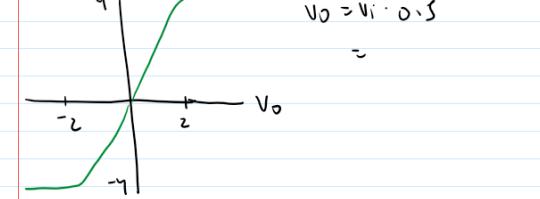
$V_i$ :



$V_o$ :



$V_i$ :



$$V_o = V_i \cdot 0.5$$

3.33 <  $V_i$ :

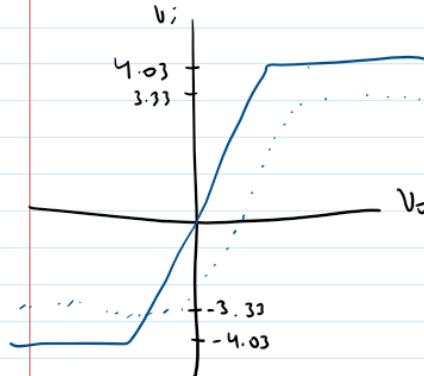
OFF:  $D_3 \& D_4$

ON:  $D_1 \& D_2$

$$-4.6 + 2k \cdot i_1 + 0.7 \cdot i_1 - 0.7 \cdot i_2 + 2 \cdot i_1 - 2 \cdot i_2 \approx 3.67$$

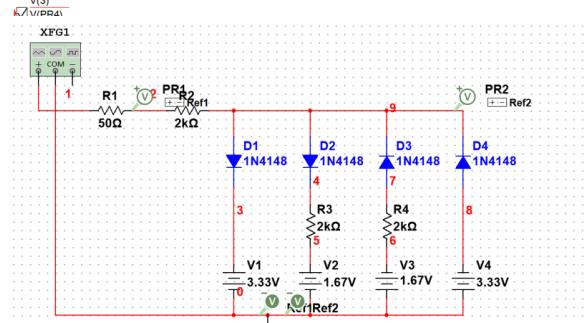
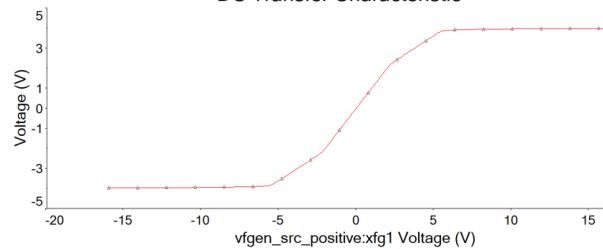
$$4.7i_1 - 2.7i_2 \approx 0.75$$

$$0.7V + 2i_1 - 2i_2 - 3.67 + 0.7$$

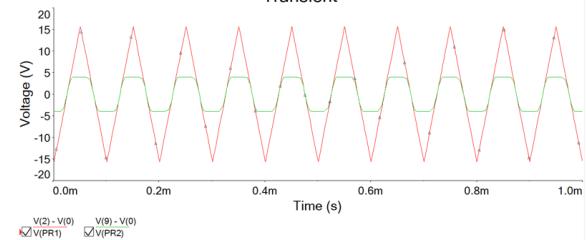


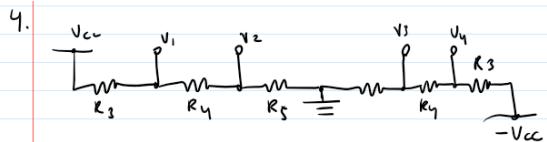
Pt 3

prelabpt3  
DC Transfer Characteristic



prelabpt3  
Transient



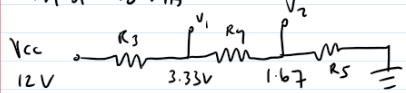


$$V_1 = -V_2 = 3.33 \text{ V}$$

$$V_2 = -V_1 = 1.67 \text{ V}$$

$$|V_{out}| = 12 \text{ V}$$

$$\text{Min } i = 15 \text{ mA}$$



$$V_{R3} = 12 \text{ V} - 3.33 = 8.67 \text{ V}$$

$$V_{Ry} = 8.67 - 1.67 = 7 \text{ V}$$

$$i = 15 \text{ mA}$$

$$i = 15 \text{ mA}$$

$$R_3 = \frac{8.67}{15 \text{ mA}}$$

$$R_y = \frac{7 \text{ V}}{15 \text{ mA}}$$

$$R_3 = 578 \Omega$$

$$= 466.67 \Omega$$

$$V_{Ry} = 7 \text{ V}$$

=

$$R_s = \frac{1.67}{15 \text{ mA}} = 111.33$$

=

$$R_1 = 3.33 \text{ k}\Omega$$

$$R_3 = 470 \text{ }\Omega$$

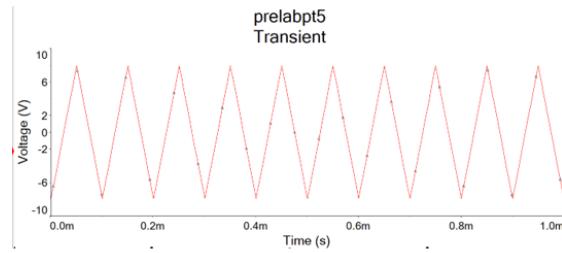
$$R_s = 91$$

$$R_2 = 3.33 \text{ k}\Omega$$

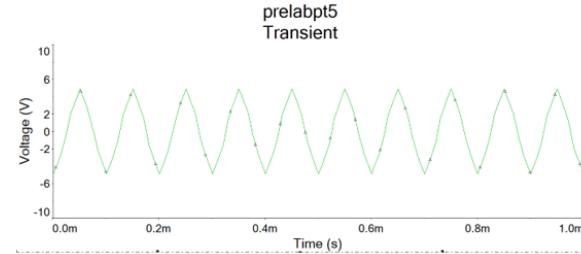
$$R_y = 91$$

Pt 5

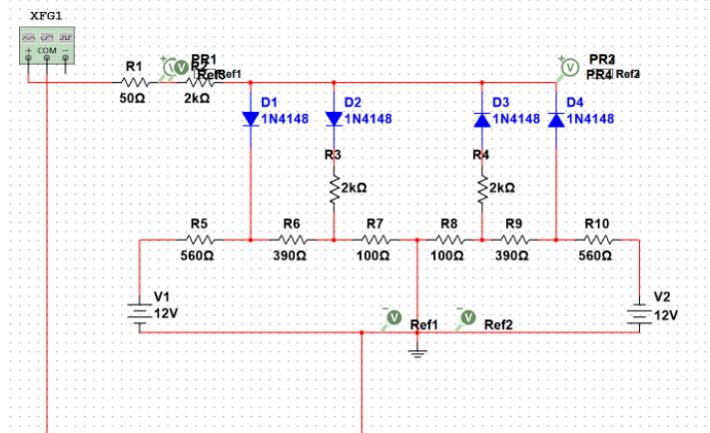
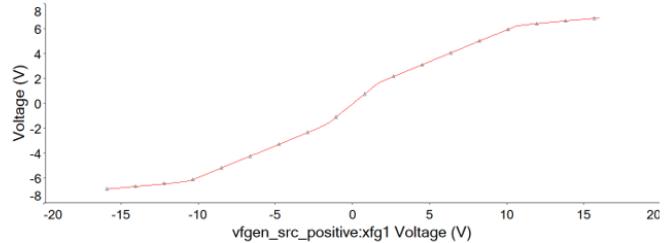
vi:



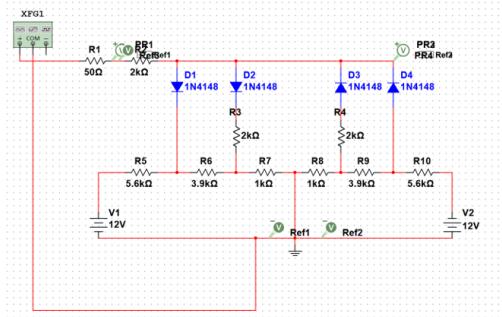
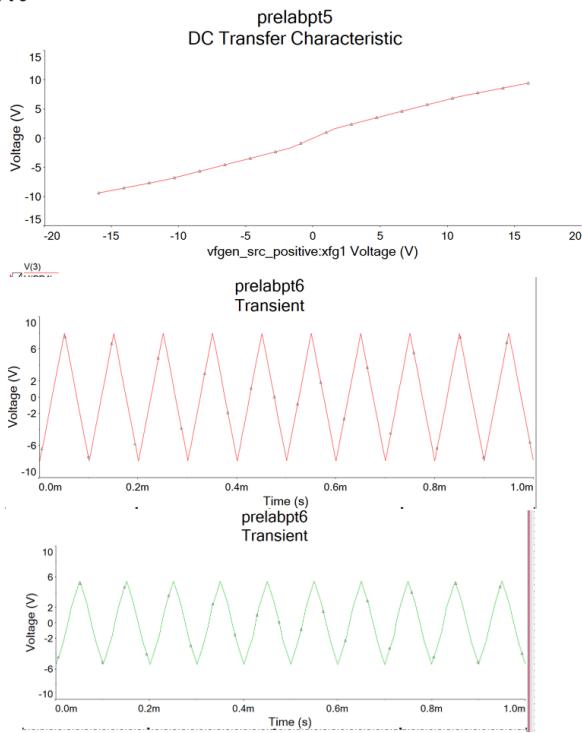
vO



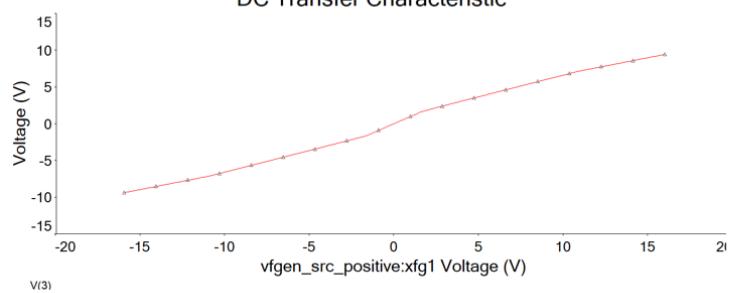
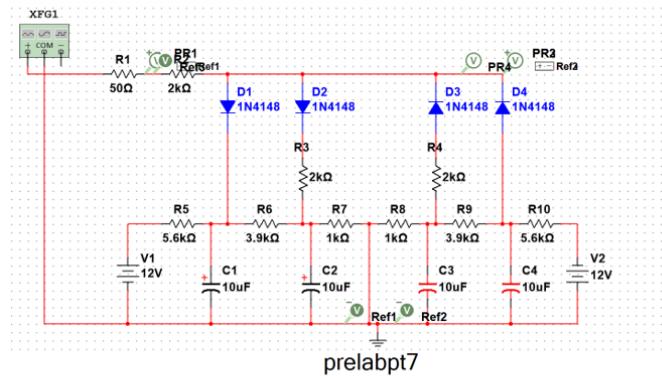
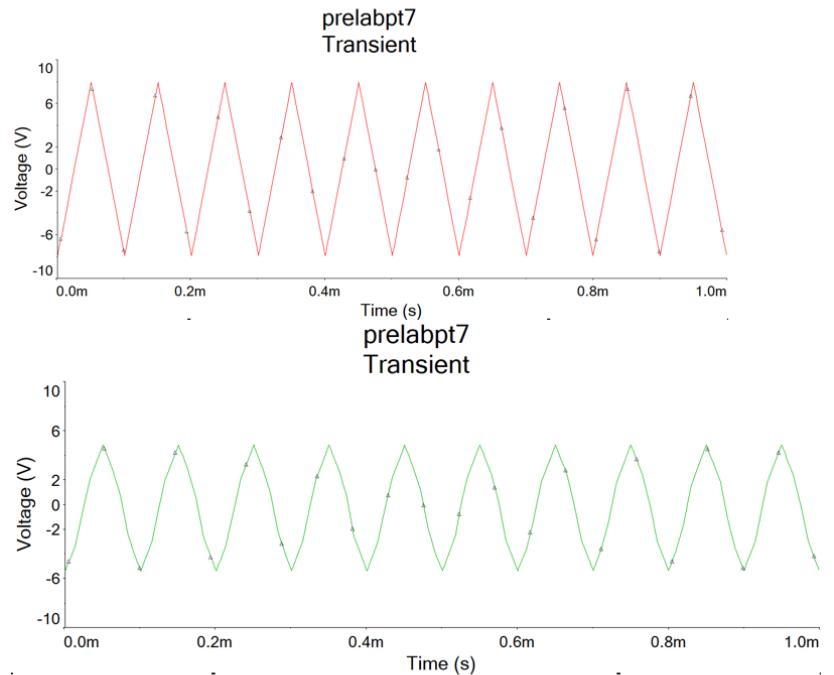
prelabpt5  
DC Transfer Characteristic



Pt 6



Pt 7



## Experiment:

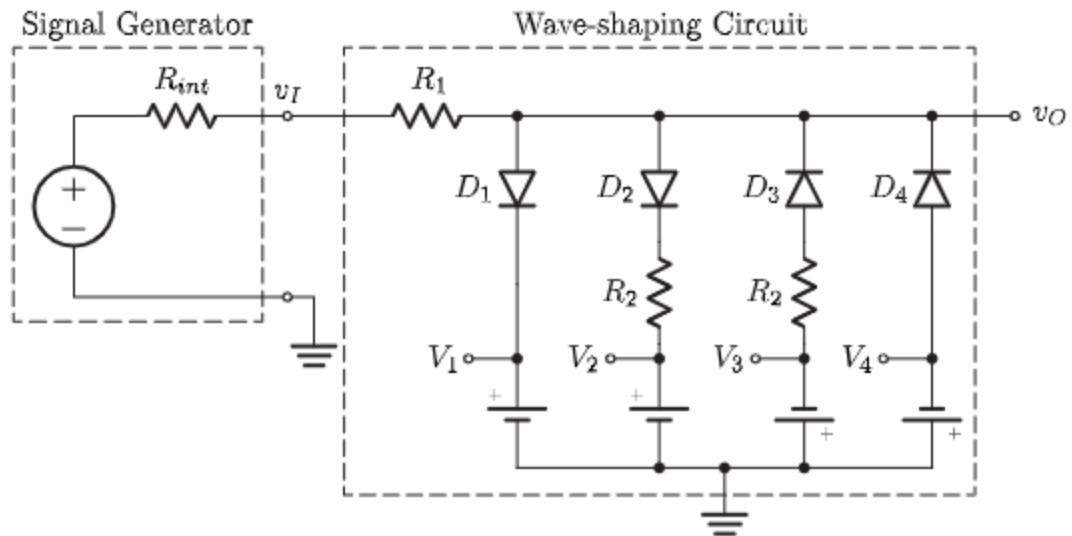


Figure 1. Wave-shaping circuit with multiple DC voltage sources (batteries).

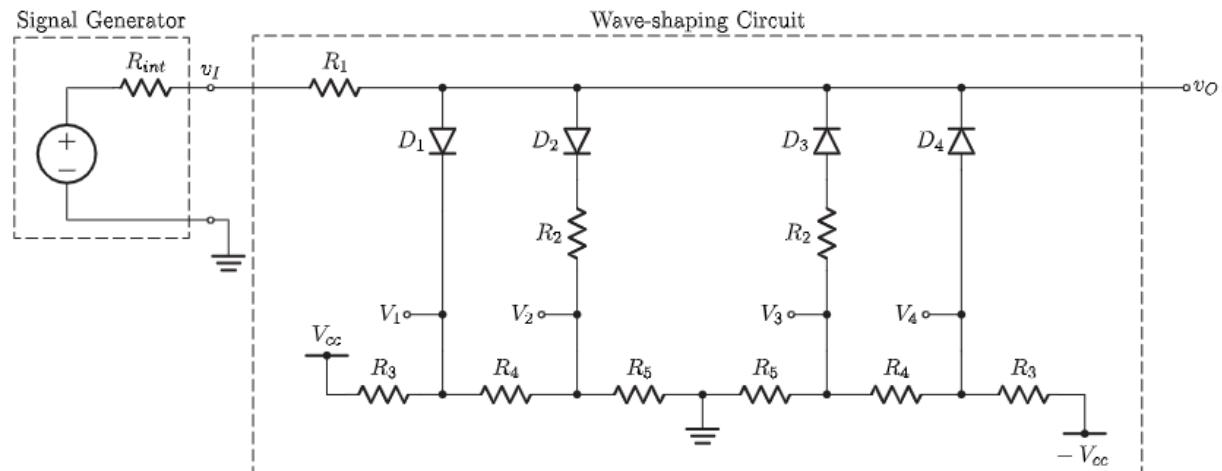


Figure 3. Wave-shaping circuit of Figure 1 in which the DC voltages are obtained from the voltage-dividing network of Figure 2.

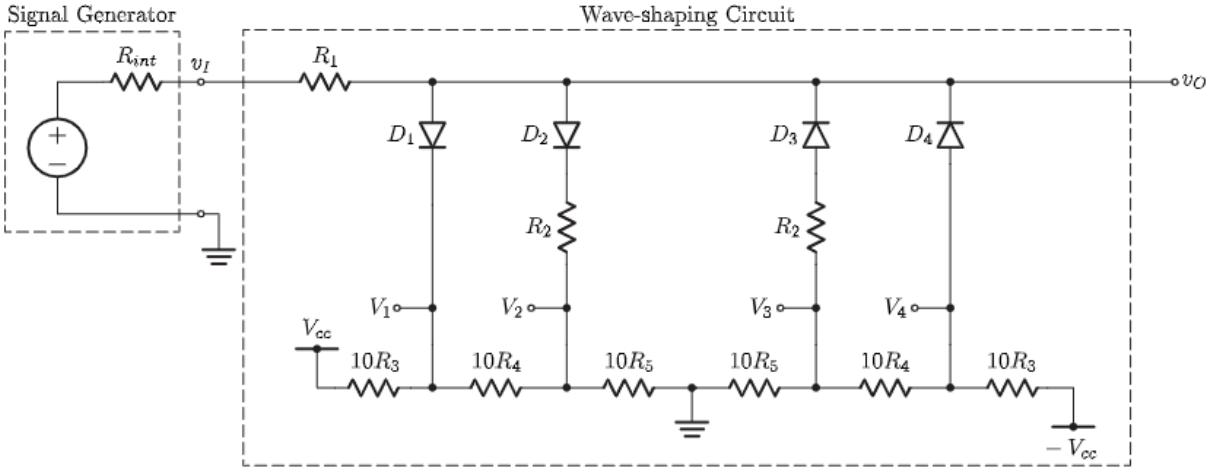


Figure 4. Wave-shaping circuit of Figure 3 in which **R3** through **R5** have been made 10 times larger.

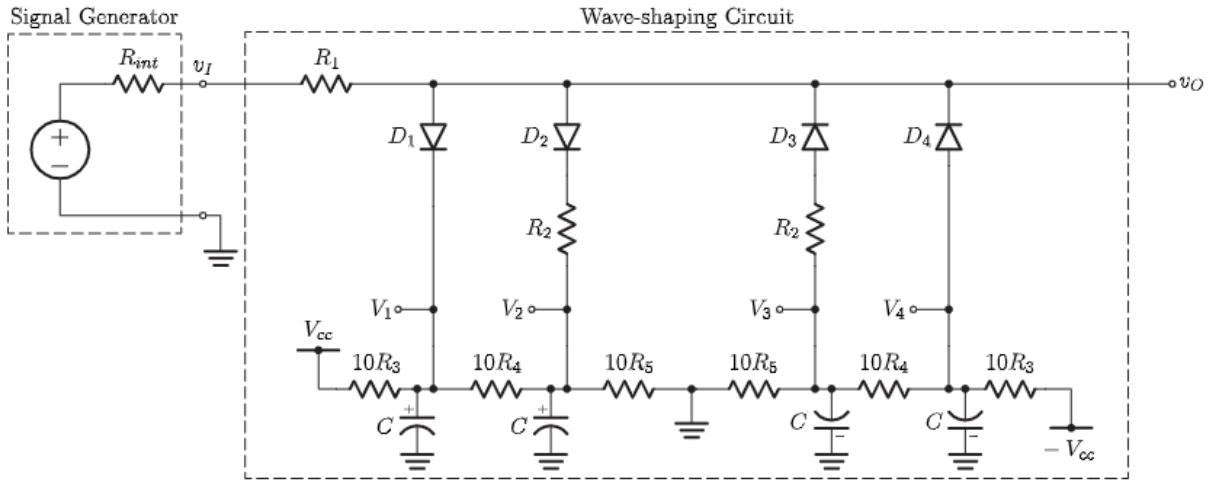
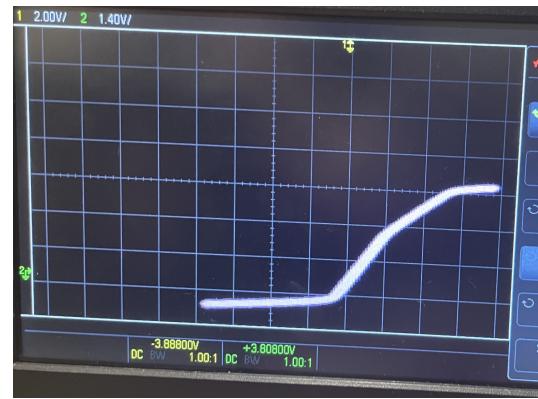
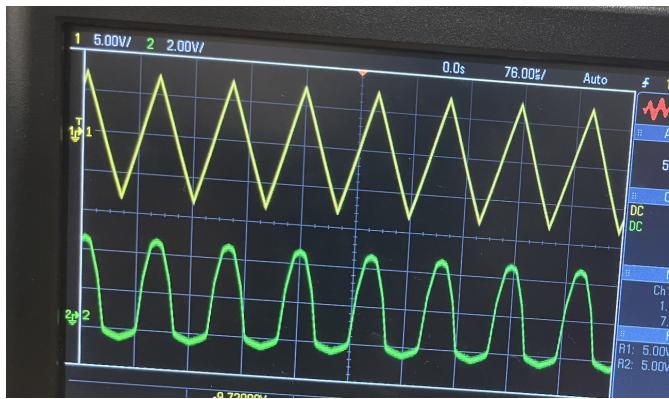


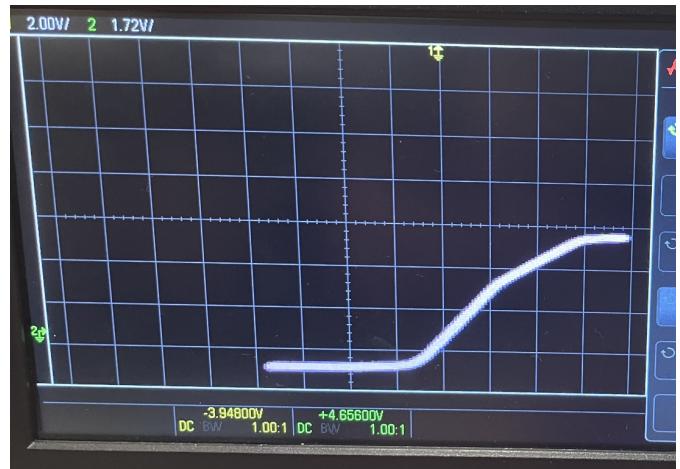
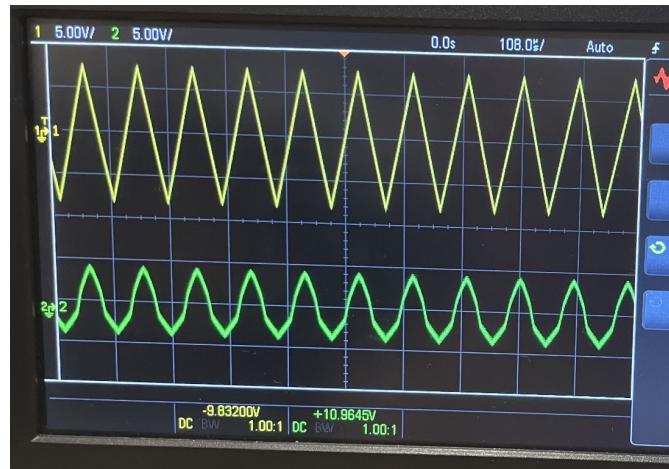
Figure 5. Modified wave-shaping circuit with resistances **R3** through **R5** made 10 times larger and bypassed by electrolytic capacitors

The initial configuration presented in Figure 2 utilizes 1N4148 diodes and a combination of 5 resistors, denoted as R1, R2, R3, R4, and R5. In this setup, the values of R1 and R2 are  $3.3\text{k}\Omega$ , R3 is  $4702\Omega$ , and R4 and R5 are  $91\Omega$ . The subsequent circuit depicted in Figure 2 employs the same set of resistors, but with their values increased tenfold for R1 through R5. Finally, the last circuit, illustrated in Figure 4, integrates the components from the previous setup and incorporates bypassed electrolytic capacitors.

## Results:



Graph's E1A and E1B are the results produced by the circuit constructed in fig.3.



Graph's E2A and E2B are the results produced by the circuit constructed in figure 4.



Lastly, Graph's E3A and E3B are the results produced by the circuit constructed in figure 5.

## **Conclusion:**

C1:

Based on the transfer characteristics displayed in Graph P3(b), when a symmetrical periodic triangular input voltage is applied to the circuit illustrated in Figure 1, the output voltage will exhibit a symmetrical sinusoidal waveform. However, this waveform is influenced by the presence of diodes configured as voltage clippers.

C2:

The transfer characteristics depicted in Graph P1 and Graph P3(b) can be considered comparable since they utilize a similar ratio of resistors and diodes in their respective circuits. The primary distinction between the two graphs stems from the voltage threshold necessary for the diodes to turn on. However, this discrepancy is insignificant as it does not lead to any contradiction or inconsistency between the two graphs.

C3:

Upon analyzing the transfer characteristics of Graph P1 in comparison to Graphs P5(b) and P6(b), several similarities become apparent. Firstly, all three graphs display a clipper voltage output waveform. Secondly, the slopes of the voltage output in these graphs are comparable. Lastly, in all three cases, the output voltage levels off once it reaches the cut-off point.

C4:

Upon comparing the transfer characteristics of Graph P1, P6(b), and P7(b), it is evident that Graph P7(b) exhibits a more consistent, linear, and higher output voltage in comparison to the other two graphs. This improved performance is attributed to the presence of capacitors in Graph P7(b), which effectively reduce ripple voltages by converting them into a smoother DC voltage flow. In contrast, the absence of capacitors in Graph P6(b) results in lower and less linear output voltage. It is important to note that all three graphs exhibit similar behavior to that of a voltage clipper circuit.

C5:

All of the graphs display a similar overall shape, but the discrepancies between them can be attributed to variations in their saturation points and slopes in the active region. Graphs E1 and P1 have comparable saturation points and slopes since E1 represents a basic and uncomplicated circuit. In contrast, Graphs P1 and E2 exhibit a steeper slope due to increased resistance, resulting in a reduction in oscilloscope noise. Finally, Graphs P1 and E3 differ significantly both in terms of the slope of the graph and the value of their saturation points. The circuit in E3 includes a bypass capacitor that enhances the gain, leading to a steeper slope and a less noisy reading. Additionally, the resistance in this circuit has been increased, resulting in a higher saturation point value.