Basic Electrical Science Lab
Course Code: EE152

Laboratory Manual

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Section: B

Academic Session: April – August 2021

National Institute of Technology Goa

CERTIFICATE

This is to certify that Mr./ Ms. _____ of Class B.Tech 1st year (2nd Sem), Division Sec A/B, bearing Roll. No._____, has satisfactorily completed the course experiments in the Laboratory Course Basic Electrical Science Lab (EE152) in the academic year 2020-2021 in the Institution of National Institute of Technology Goa.

Course Instructor

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1	Verification of Ohms Law	04	20-05-2021	23-05-2021	
2	Verification of Kirchhoff's Laws – KVL and KCL	11	27-05-21	31-05-21	
3	Verification of Thevenin's and Norton's Theorem	04	03-06-21	17-06-21	
4	DC transient analysis of RC RL circuits	04	24-06-2021	02-07-21	
5	Power analysis in AC circuits	04	1-07-2021	9-07-2021	
6	Study of Diode Rectifier Circuits	05	8-7-2021	12-07-2021	
7	Clamping circuits and Voltage doubler circuits	05	15-07-2021	21-07-2021	
8	Study of Digital Logic gates	05	15-07-2021	18-07-2021	

Clamping & Voltage Doubler Circuit with Diodes

7. A. Introduction:

This session makes students to understand various applications of Diode (such as clamping circuit and voltage doubler circuit), and to verify their characteristics through a Simulation platform, MATLAB/Simulink.

7. B. Objectives:

a. Acquire a good knowledge on application of Diode in clamping and voltage doubler circuits.

b. Verification of the theoretical knowledge on these circuits through simulation in MATLAB/Simulink Platform.

7. C. Theory: Refer to the notes or necessary materials mentioned in EE151 course.

7. D. Statement of Experiments:

Fig. 7.1 represents clamping circuits with diode, where an ac sinusoidal voltage source ($v(t) = 230\sqrt{}\ 2\sin(100\pi t)$) gets clamped to a certain value decided by the doide's on-state voltage (**with 0.7 V as forward-bias voltage drop of the diode**). In Fig. 7.1(a), positive voltage gets clamped to diode on-sate voltage, while the negative voltage is clamped in the circuit shown in Fig. 7.1(b). Therefore, the former circuit is known as Positive Clamping circuit while the later one is a negative clamping circuit. The following task has to be done theoretically and those have to be verified by simulation in Matlab.

1. Derive the expression of $v_o(t)$ and $i_{in}(t)$.
2. Draw the waveforms of $v_o(t)$ and $i_{in}(t)$ for 5 cycles.

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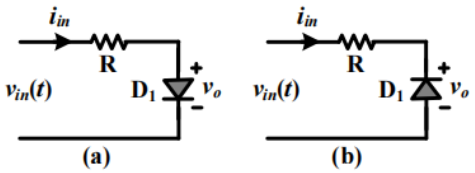


Fig. 7.1

7. E. Procedure:

Determine all the parameters asked in section- 7.D theoretically and draw corresponding experimental circuit (necessary measuring instruments are to be incorporated in the circuit) of the circuit shown in Fig. 7.1. Construct the Experimental circuits in Simulink domain, simulate it, and observe the output waveforms.

7. F. Assignments:

Part-1: Replace sinusoidal voltage source by a ramp voltage source (with slope 10) in Fig. 7.1, and do the simulation again.

Part-2: with the theoretical analysis, design a circuit with sinusoidal voltage source ($v(t) = 230\sqrt{}2\sin(100\pi t)$) and Ramp voltage source (with slope 10) to get both halves (positive and negative) clamping at 2.1 V of the output. With simulation, validate your design.

Part-3: Consider Fig.7.2 with $v(t) = 230\sqrt{}2\sin(100\pi t)$, C = 1 mF, do the same as mentioned in Section - 7.D.

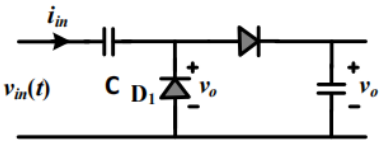


Fig. 7.2

Experiment 7

Clamping and Voltage Doubler circuits with diode

1. **Aim:** To verify the theoretical analysis of clamping and voltage doubler circuits using MATLAB simulation.

2. **Simulink Blockset used:** Diode, voltage measurement, current measurement, controlled voltage source, ramp, sinusoidal voltage source, rlc, powergui

3. **Theory:**

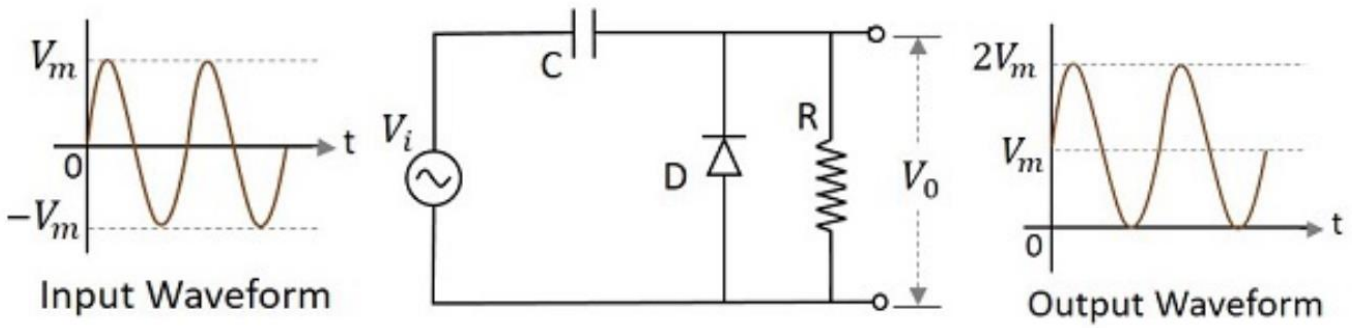
Clamper Circuit

A Clamper circuit can be defined as the circuit that consists of a diode, a resistor and a capacitor that shifts the waveform to a desired DC level without changing the actual appearance of the applied signal.

Positive Clamper Circuit

A Clamping circuit restores the DC level. When a negative peak of the signal is raised above to the zero level, then the signal is said to be **positively clamped**.

A Positive Clamper circuit is one that consists of a diode, a resistor and a capacitor and that shifts the output signal to the positive portion of the input signal. The figure below explains the construction of a positive clamper circuit.



Positive Clamper circuit

Initially when the input is given, the capacitor is not yet charged and the diode is reverse biased. The output is not considered at this point of time. During the negative half cycle, at the peak value, the capacitor gets charged with negative on one plate and positive on the other. The capacitor is now charged to its peak value V_m. The diode is forward biased and conducts heavily.

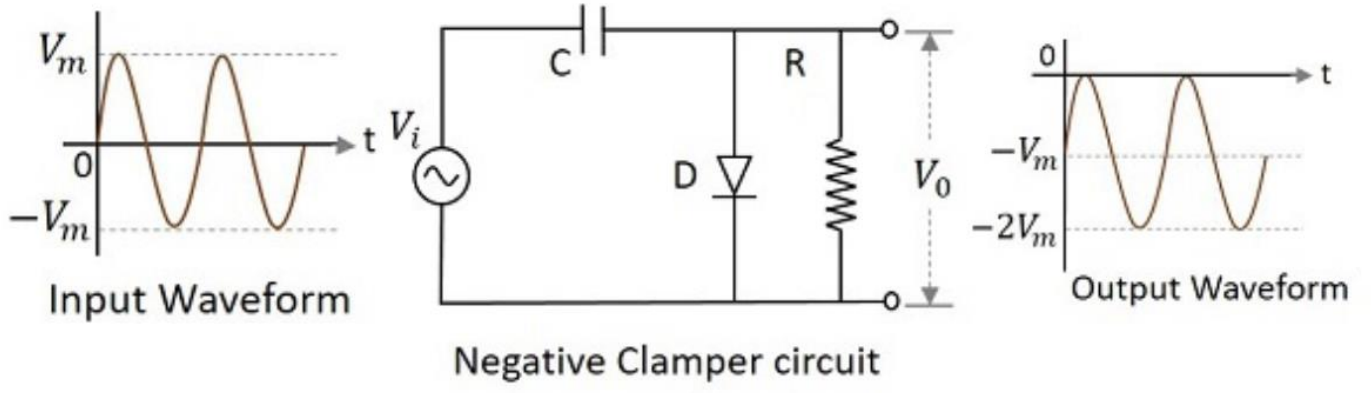
During the next positive half cycle, the capacitor is charged to positive Vm while the diode gets reverse biased and gets open circuited. The output of the circuit at this moment will be

$$V_0 = V_i + V_m$$

Hence the signal is positively clamped as shown in the above figure. The output signal changes according to the changes in the input, but shifts the level according to the charge on the capacitor, as it adds the input voltage.

Negative Clamper

A Negative Clamper circuit is one that consists of a diode, a resistor and a capacitor and that shifts the output signal to the negative portion of the input signal. The figure below explains the construction of a negative clamper circuit.



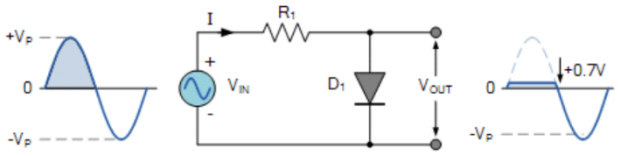
During the positive half cycle, the capacitor gets charged to its peak value vmvm. The diode is forward biased and conducts. During the negative half cycle, the diode gets reverse biased and gets open circuited. The output of the circuit at this moment will be

$$V_0 = V_i + V_m$$

Hence the signal is negatively clamped as shown in the above figure. The output signal changes according to the changes in the input, but shifts the level according to the charge on the capacitor, as it adds the input voltage.

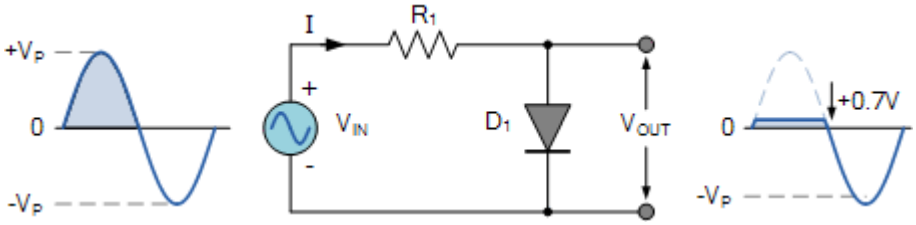
Diode Clipping Circuits

The Diode Clipper, also known as a Diode Limiter, is a wave shaping circuit that takes an input waveform and clips or cuts off its top half, bottom half or both halves together.



This clipping of the input signal produces an output waveform that resembles a flattened version of the input. For example, the half-wave rectifier is a clipper circuit, since all voltages below zero are eliminated.

Positive Diode Clipping Circuits

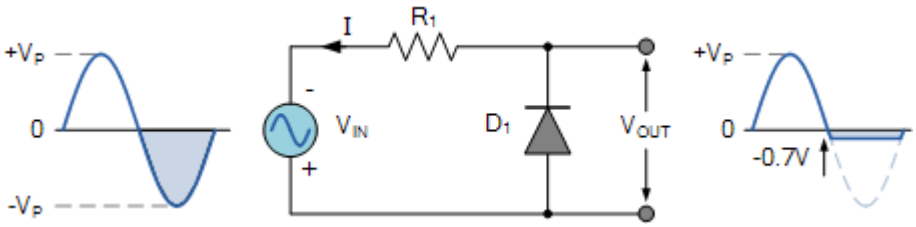


In this diode clipping circuit, the diode is forward biased (anode more positive than cathode) during the positive half cycle of the sinusoidal input waveform. For the diode to become forward biased, it must have the input voltage magnitude greater than +0.7 volts (0.3 volts for a germanium diode).

When this happens, the diodes begin to conduct and holds the voltage across itself constant at 0.7V until the sinusoidal waveform falls below this value. Thus, the output voltage which is taken across the diode can never exceed 0.7 volts during the positive half cycle.

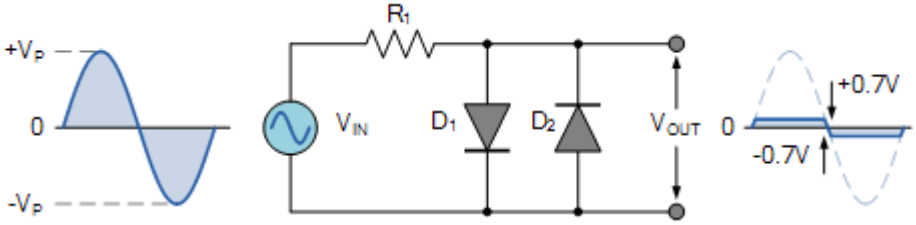
During the negative half cycle, the diode is reverse biased (cathode more positive than anode) blocking current flow through itself and as a result has no effect on the negative half of the sinusoidal voltage which passes to the load unaltered. Thus, the diode limits the positive half of the input waveform and is known as a positive clipper circuit.

Negative Diode Clipping Circuits



Here the reverse is true. The diode is forward biased during the negative half cycle of the sinusoidal waveform and limits or clips it to –0.7 volts while allowing the positive half cycle to pass unaltered when reverse biased. As the diode limits the negative half cycle of the input voltage it is therefore called a negative clipper circuit.

Clipping of Both Half Cycles



If we connected two diodes in inverse parallel as shown, then both the positive and negative half cycles would be clipped as diode D_1 clips the positive half cycle of the sinusoidal input waveform while diode D_2 clips the negative half cycle. Then diode clipping circuits can be used to clip the positive half cycle, the negative half cycle or both.

For ideal diodes the output waveform above would be zero. However, due to the forward bias voltage drop across the diodes the actual clipping point occurs at +0.7 volts and –0.7 volts respectively. But we can increase this ±0.7V threshold to any value we want up to the maximum value, (V_{PEAK}) of the sinusoidal waveform either by connecting together more diodes in series creating multiples of 0.7 volts, or by adding a voltage bias to the diodes.

4. Statement of Experiments:

Fig. 7.1 represents clipping circuits with diode, where an ac sinusoidal voltage source ($v(t) = 230V\ 2\sin(100\pi t)$) gets clamped to a certain value decided by the doide's on-state voltage (**with 0.7 V as forward-bias voltage drop of the diode**). In Fig. 7.1(a), positive voltage gets clipped to diode on-sate voltage, while the negative voltage is clipped in the circuit shown in Fig. 7.1(b). Therefore, the former circuit is known as Positive Clipping circuit while the later one is a negative clipping circuit. The following task has to be done theoretically and those have to be verified by simulation in MATLAB.

1. Derive the expression of $v_o(t)$ and $i_{in}(t)$.
2. Draw the waveforms of $v_o(t)$ and $i_{in}(t)$ for 5 cycles.

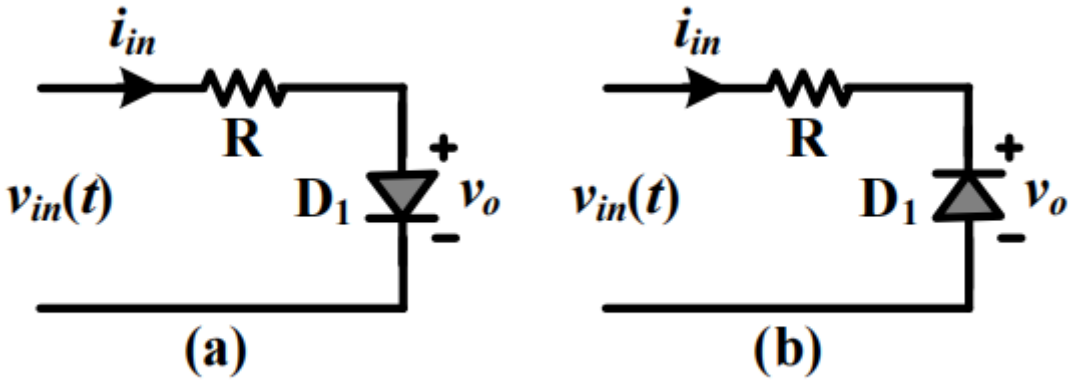


Fig. 7.1

5. Procedure:

Determine all the parameters asked in section- 7.D theoretically and draw corresponding experimental circuit (necessary measuring instruments are to be incorporated in the circuit) of the circuit shown in Fig. 7.1. Construct the Experimental circuits in Simulink domain, simulate it, and observe the output waveforms.

❖ Circuit Diagram:

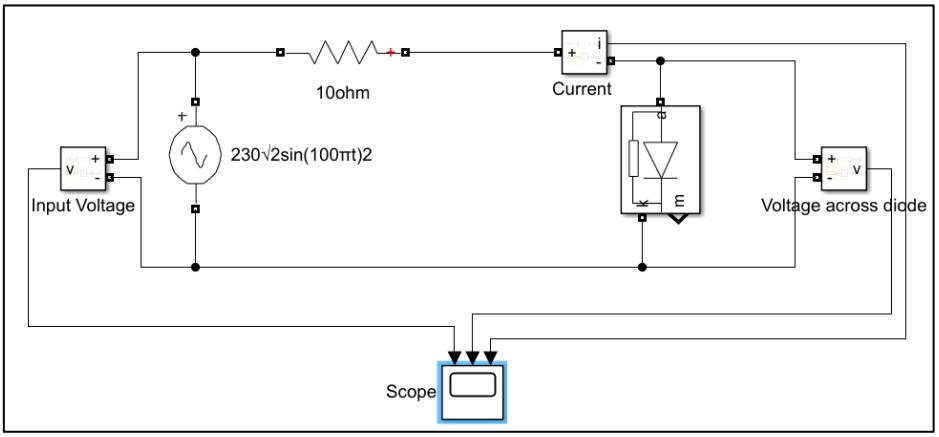
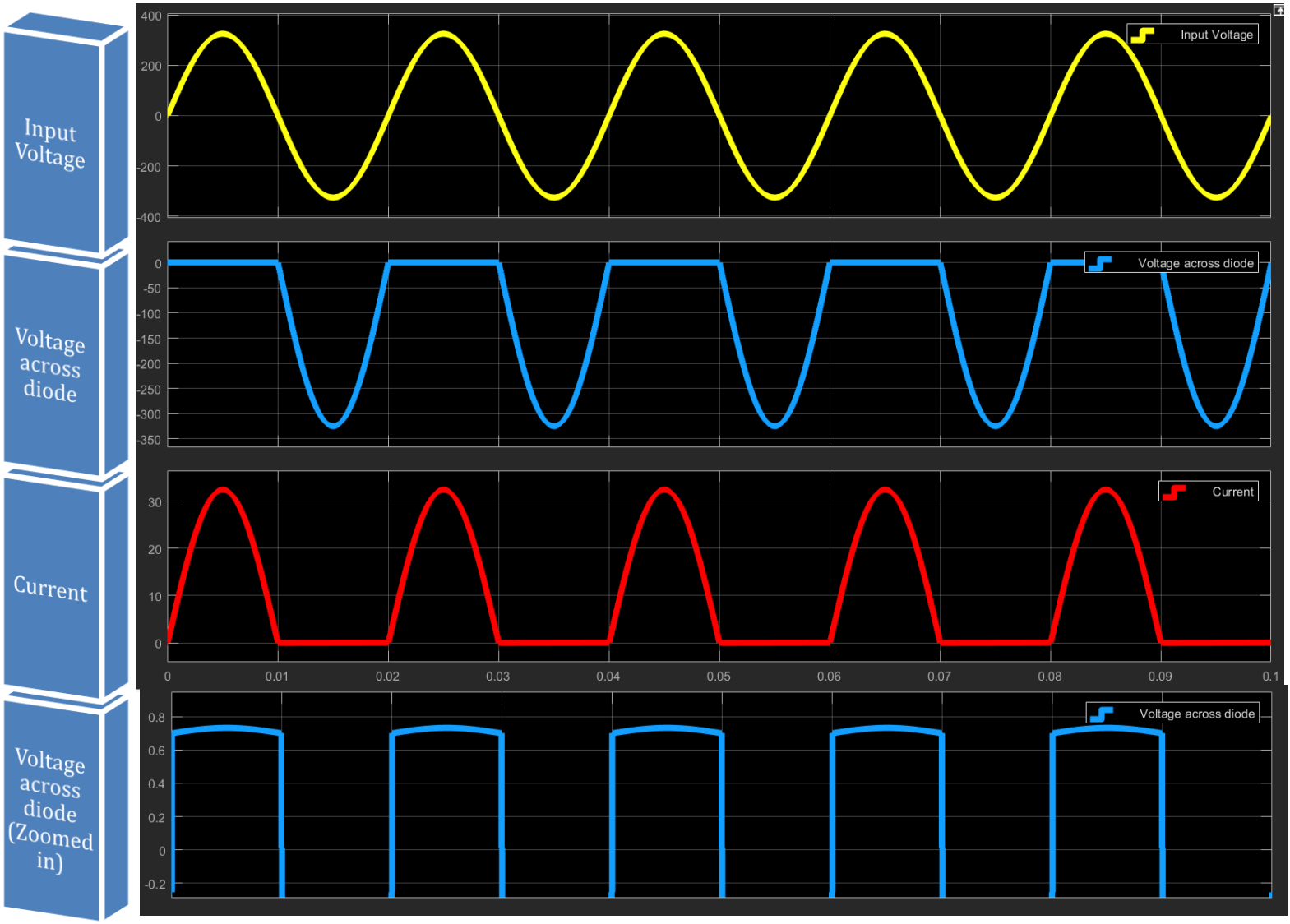
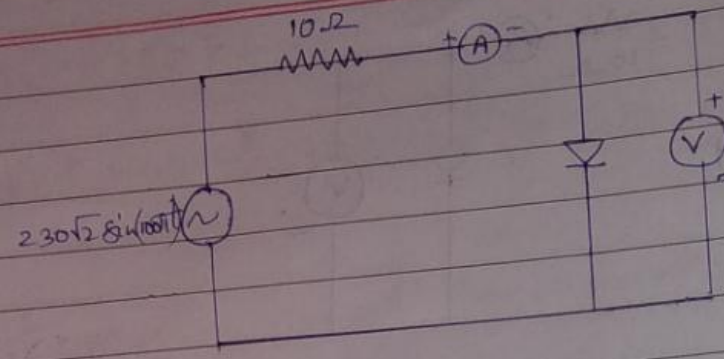


Fig7a: Circuit connections in Simulink for Positive Clipping



Graph7a: Graphical results of inputs and voltage current across diode



In positive cycle diode conducts
voltage across diode remains diode on state voltage
i.e. 0.7 V

$$i(t)R = V_{in} - 0.7$$

$$i(t) = \frac{230\sqrt{2}\sin(100\pi t)}{10} - \frac{0.7}{10}$$

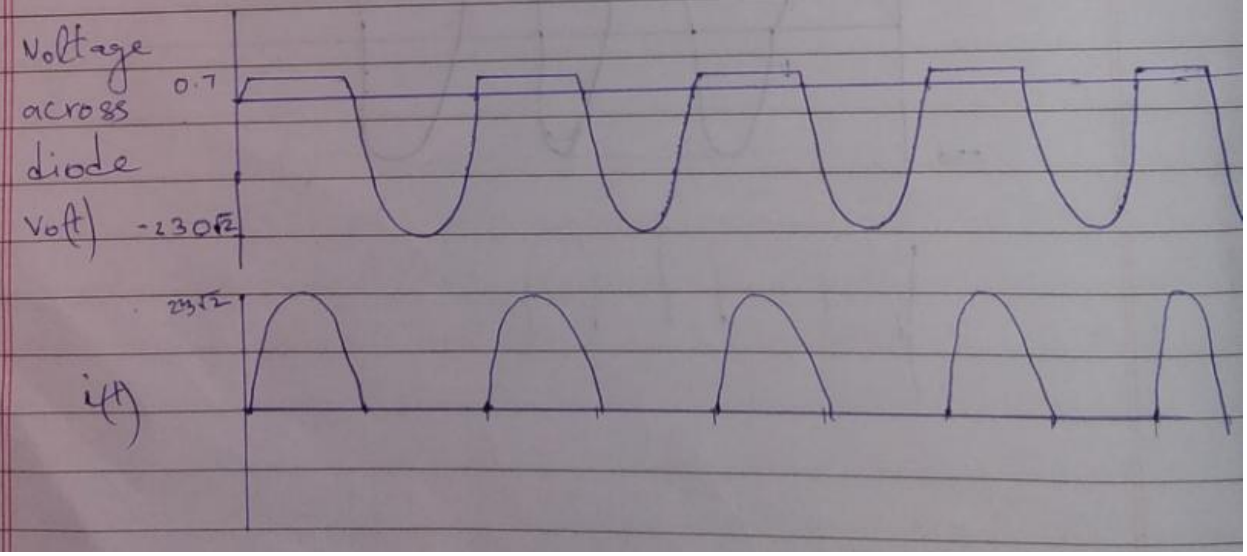
$$i(t) = 23\sqrt{2}\sin(100\pi t) - 0.07$$

In negative cycle diode do not conduct

$$i(t) = 0$$

voltage across diode = V_{in}

$$\therefore V = 230\sqrt{2}\sin(100\pi t)$$



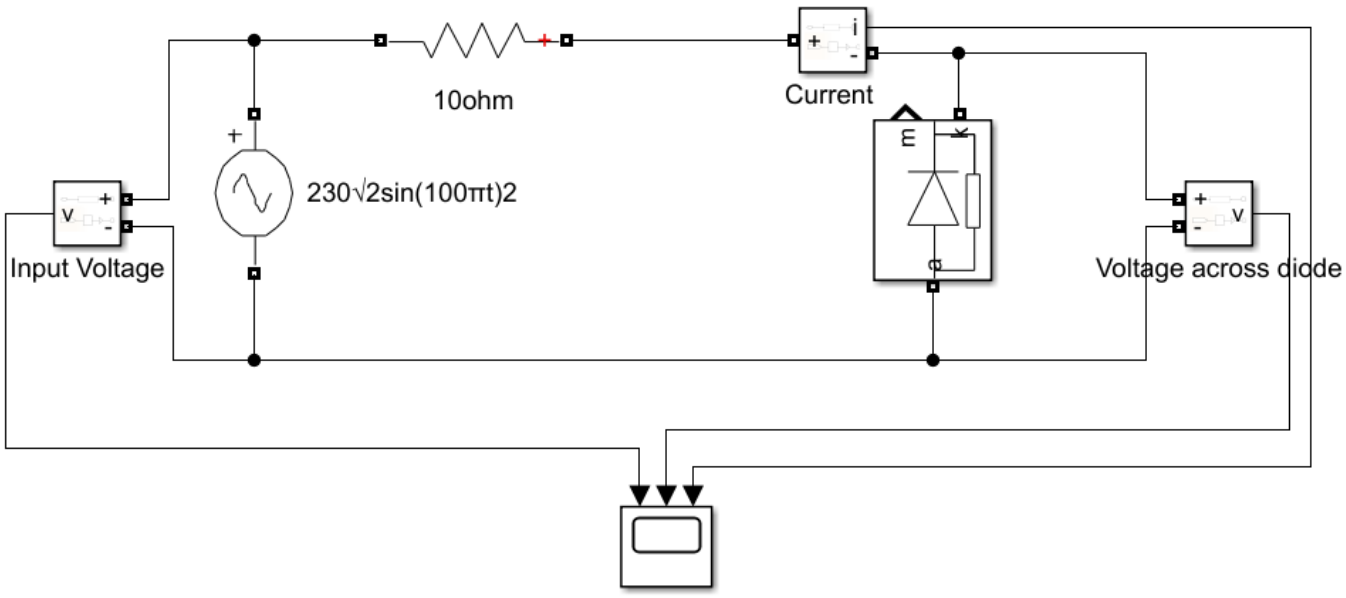
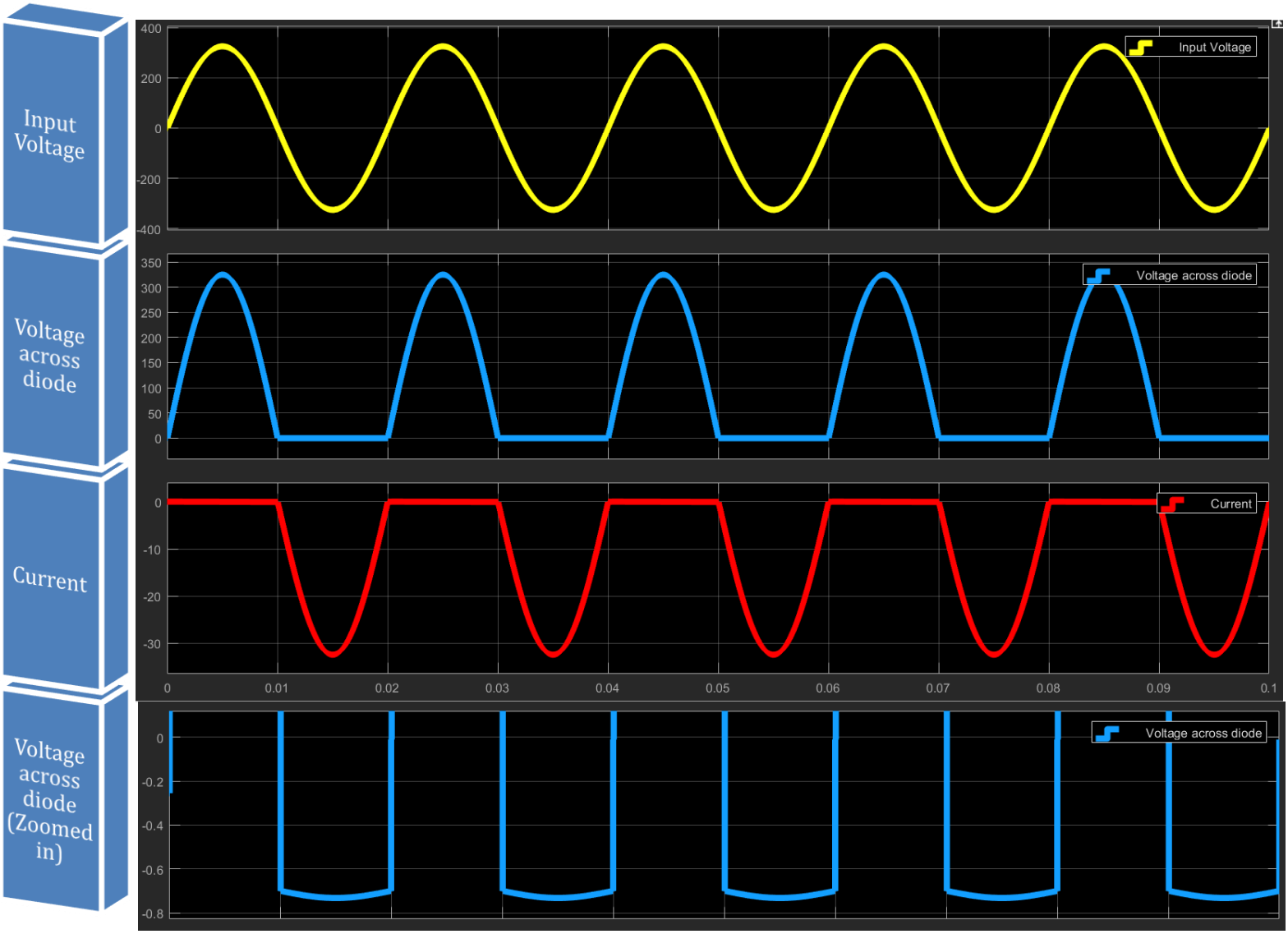
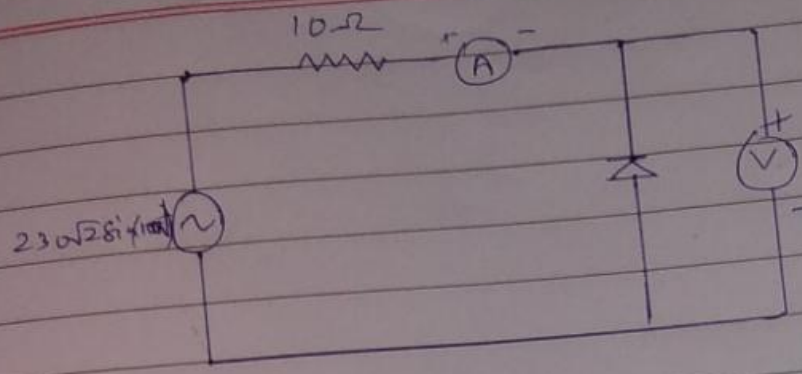


Fig7b: Circuit connections in Simulink for Negative Clipping



Graph7b: Graphical results of inputs and voltage current across diode



In positive cycles diode do not conduct
voltage across diode = voltage input

$i(t) = 0$

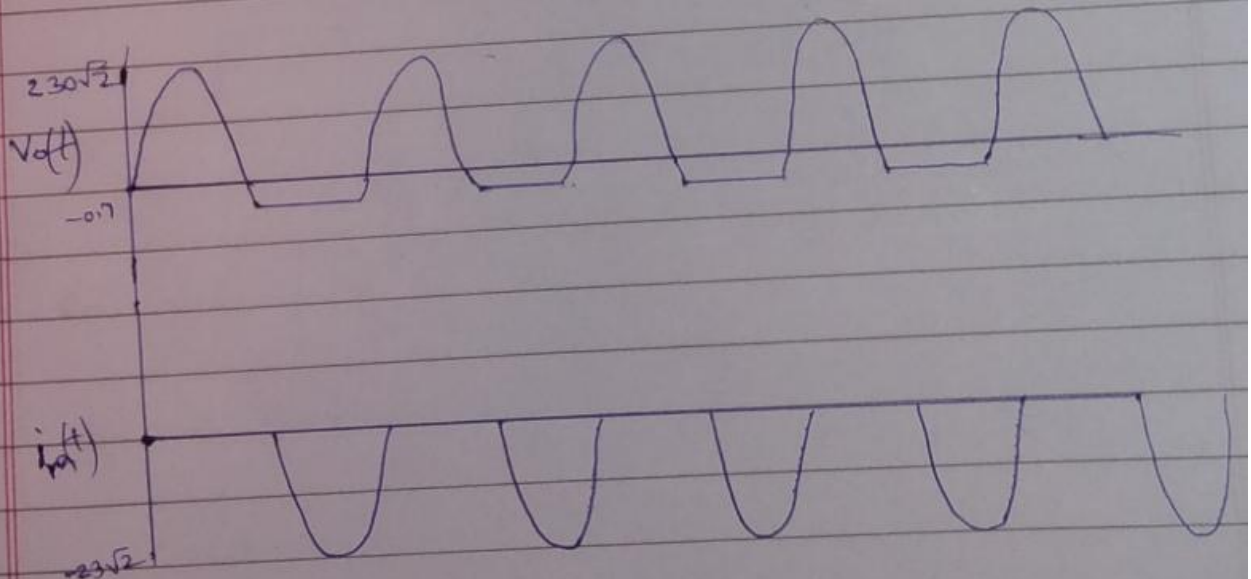
$v = 230\sqrt{2}\sin(100\pi t)$

In negative cycles diode conducts
voltage across diode remains on stat
voltage ie 0.7V

$i(t)\,R = V_{in} - 0.7$

$i(t) = \frac{230\sqrt{2}\sin(100\pi t)}{10} - \frac{0.7}{10}$

$i(t) = 23\sqrt{2}\sin(100\pi t) - 0.07$



Precautions:

a) Ensure that 'powergui' block set is included in the Simulink file.
b) Ensure that connections are properly made.
c) Ensure that the scale of the graphs should be adjusted to the range in which the readings vary.

7. **Inferences**: From the output, it can be inferred that diodes can be used to clip a part of the input voltage,

8. **Conclusion:** Theoretical Analysis on clamping and clipping circuits has been verified through simulation platform.

Assignments:

Part-1: Replace sinusoidal voltage source by a ramp voltage source (with slope 10) in Fig. 7.1, and do the simulation again.

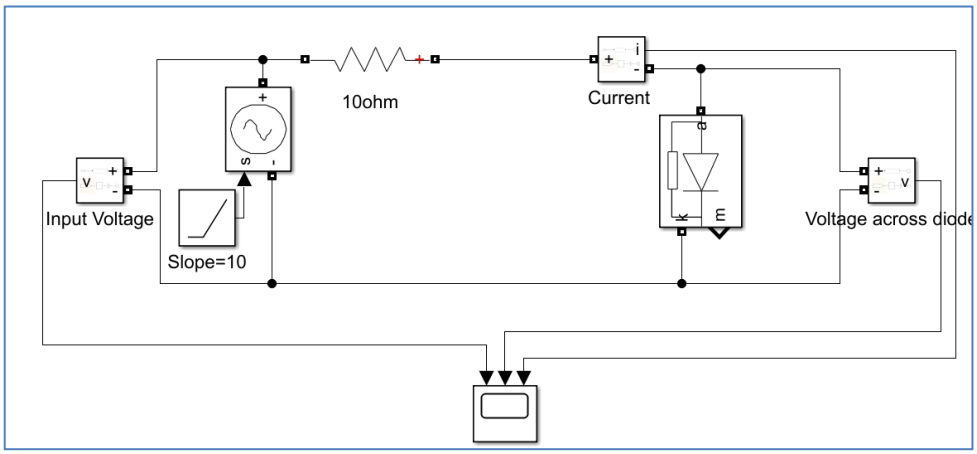
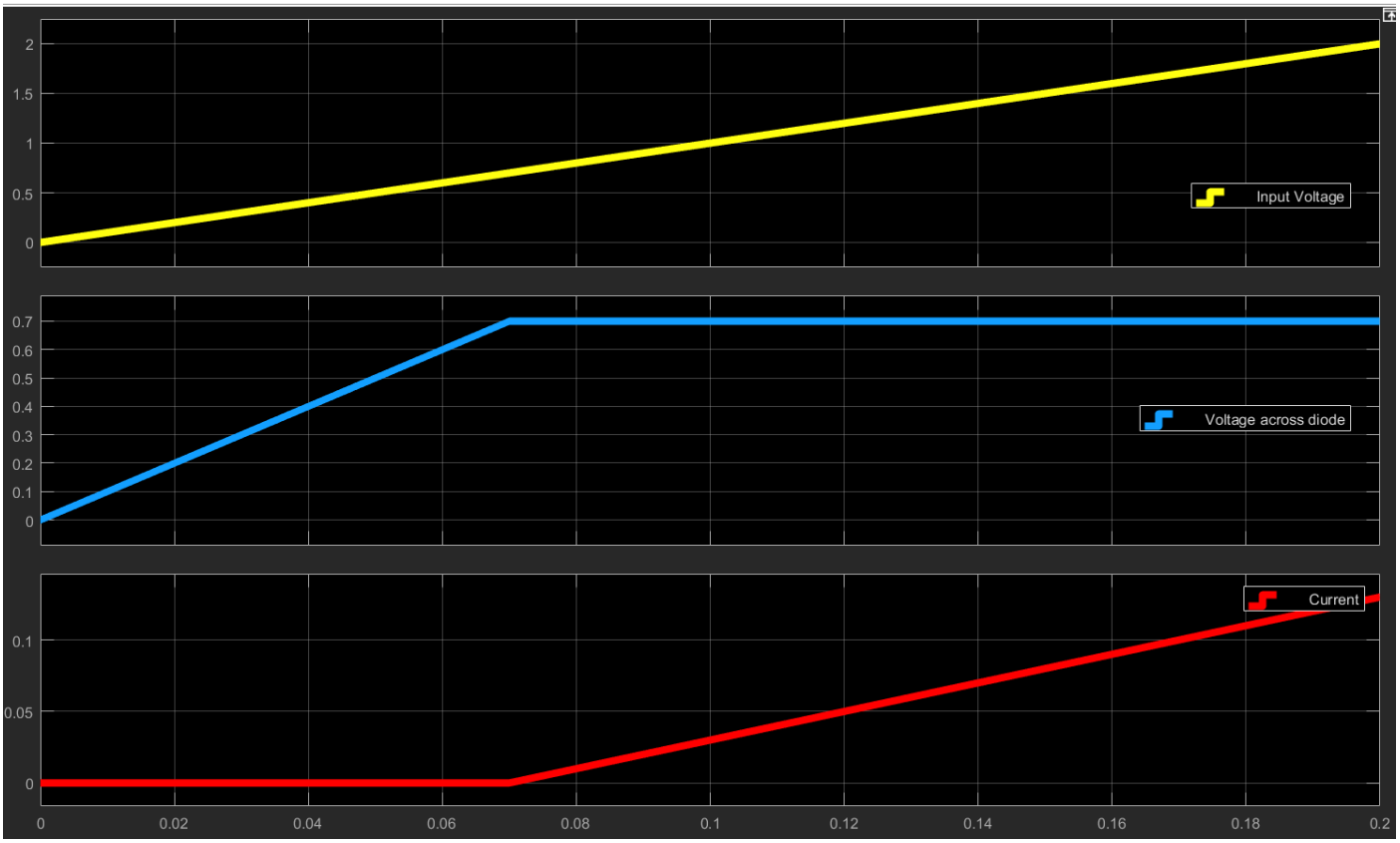


Fig7c: Circuit connections in Simulink for Positive Clipping using ramp



Graph7c: Graphical results of inputs and voltage current across diode

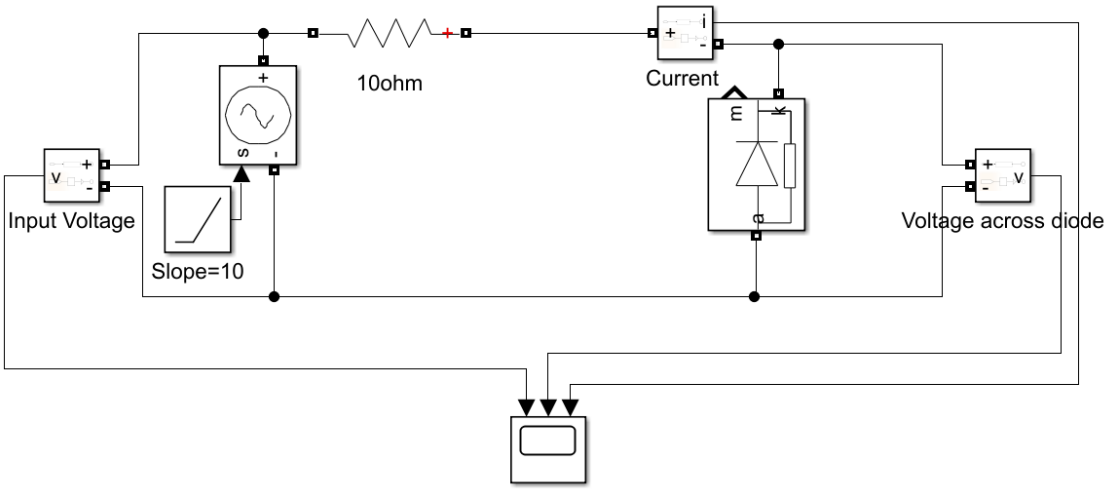
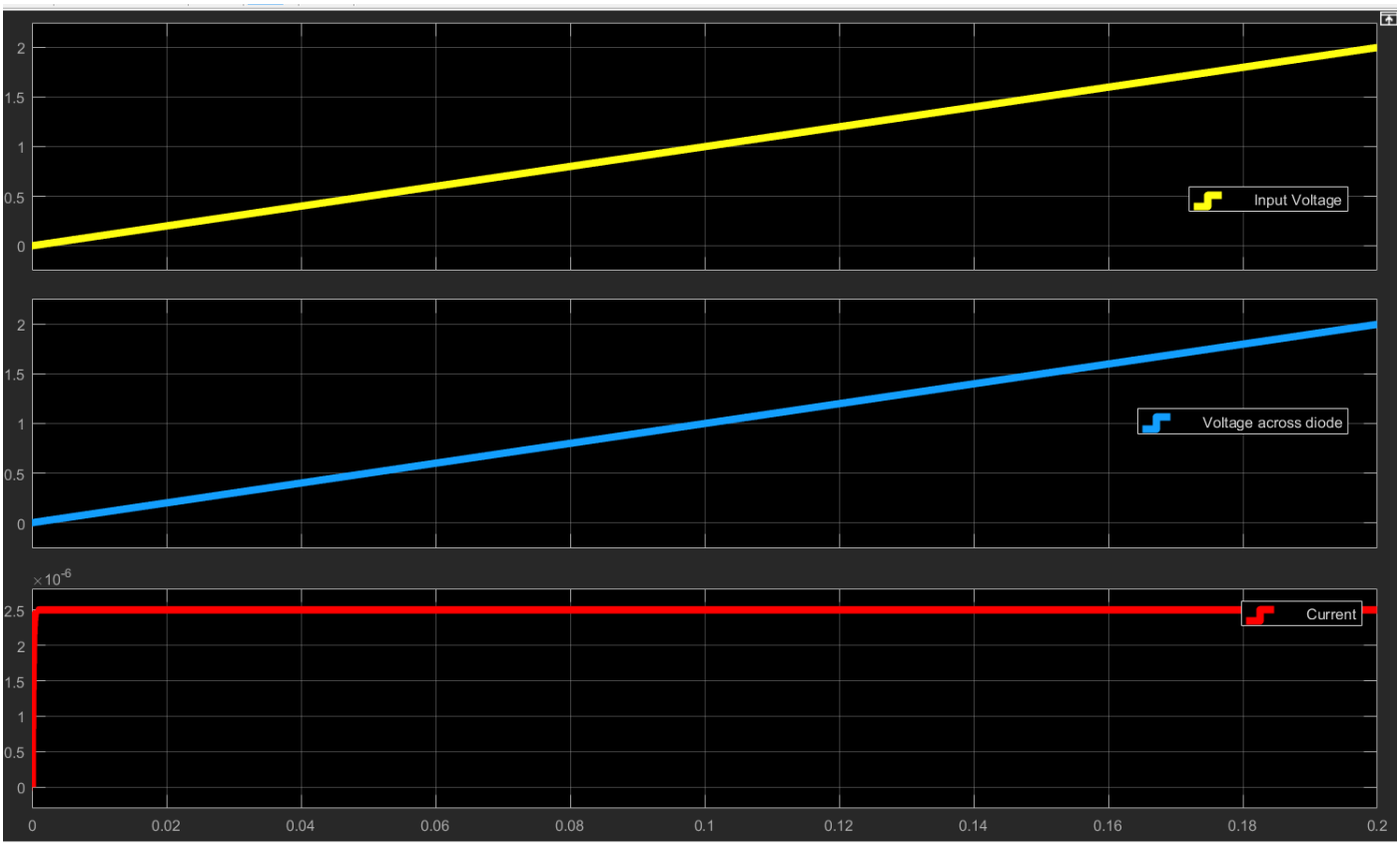
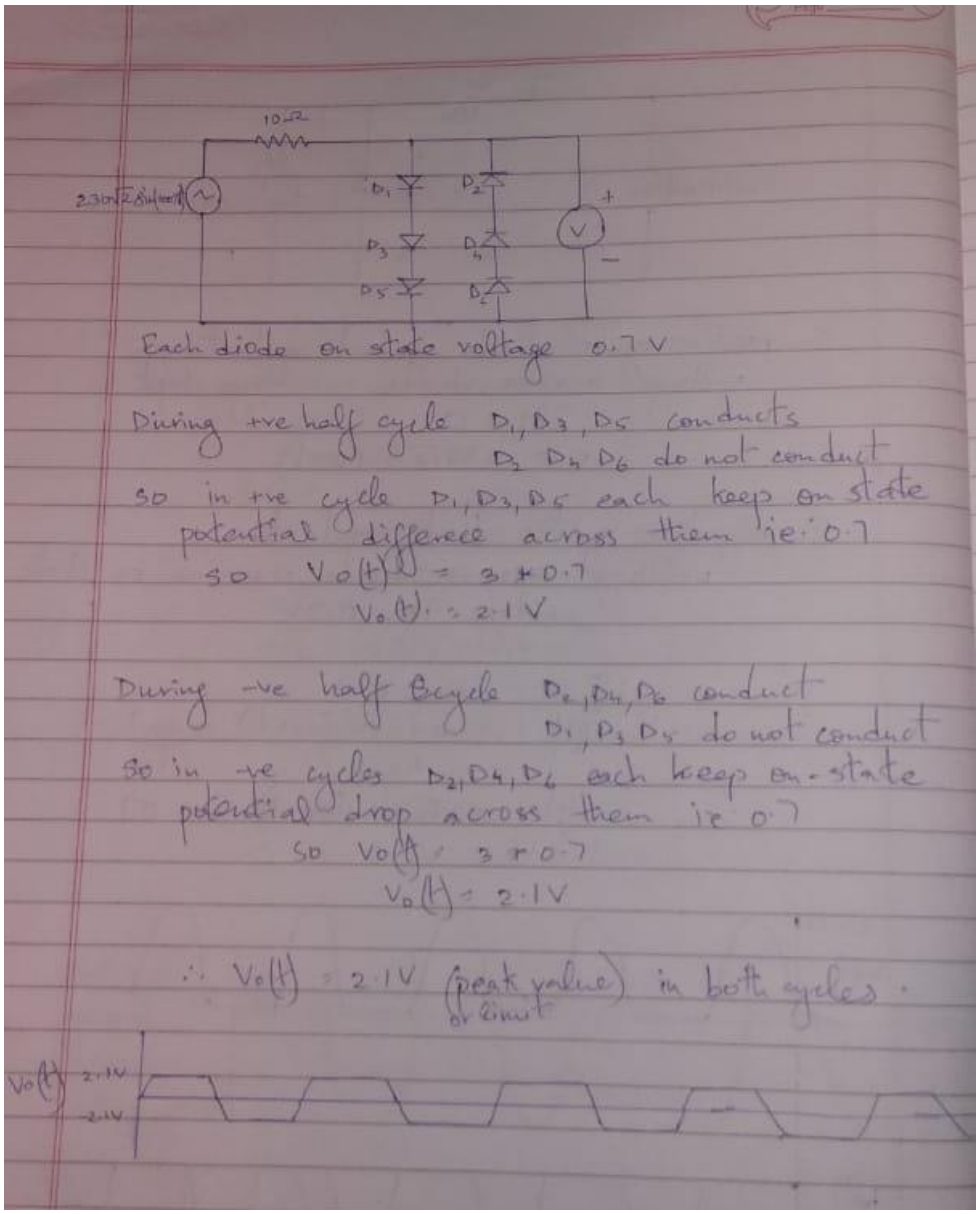


Fig7d: Circuit connections in Simulink using ramp



Graph7d: Graphical results of inputs and voltage current across diode

Part-2: with the theoretical analysis, design a circuit with sinusoidal voltage source ($v(t) = 230\sqrt{2}\sin(100\pi t)$) and Ramp voltage source (with slope 10) to get both halves (positive and negative) clamping at 2.1 V of the output. With simulation, validate your design.



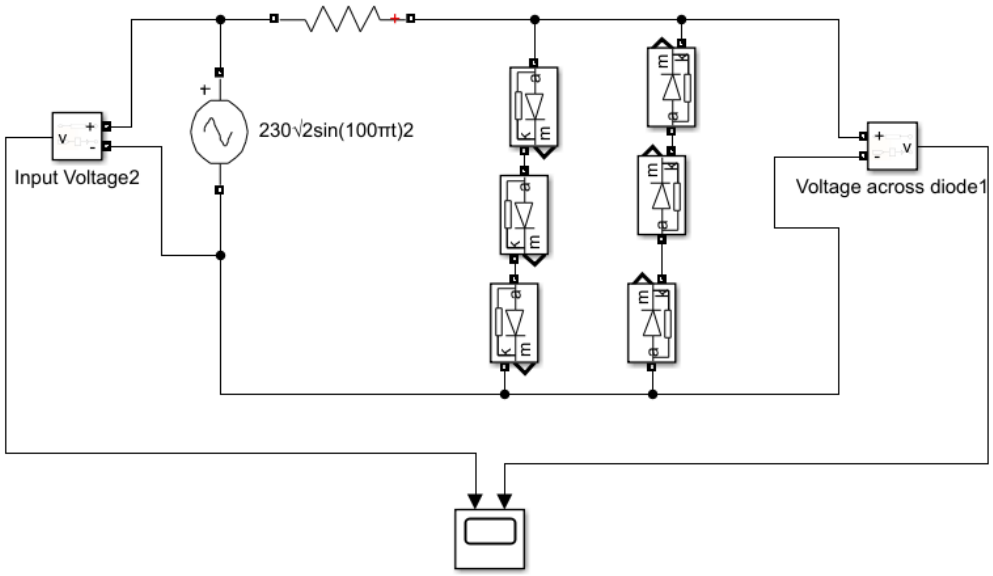
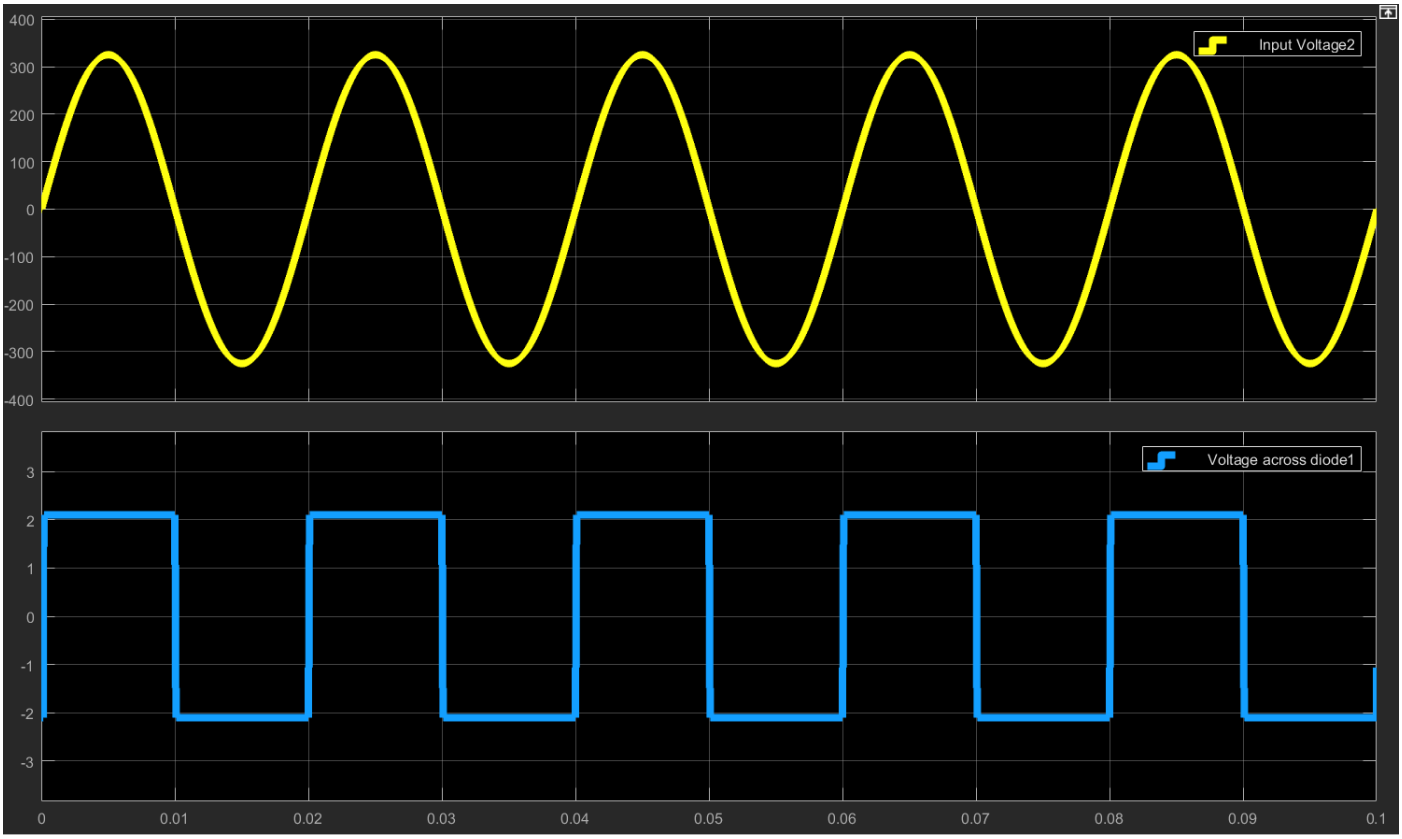


Fig7e: Circuit designed for 2.1V full wave clipping



Graph7a: Graphical results of inputs and voltage across diode

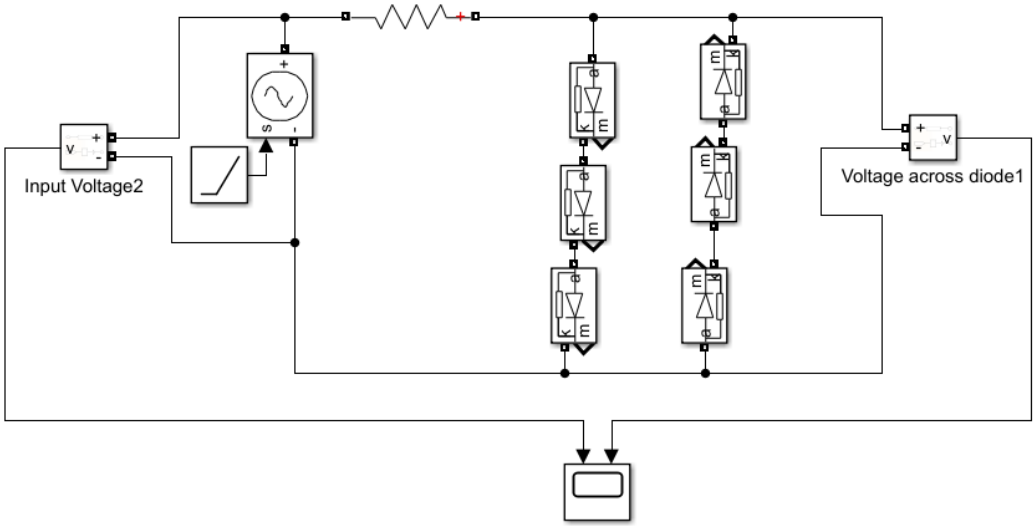
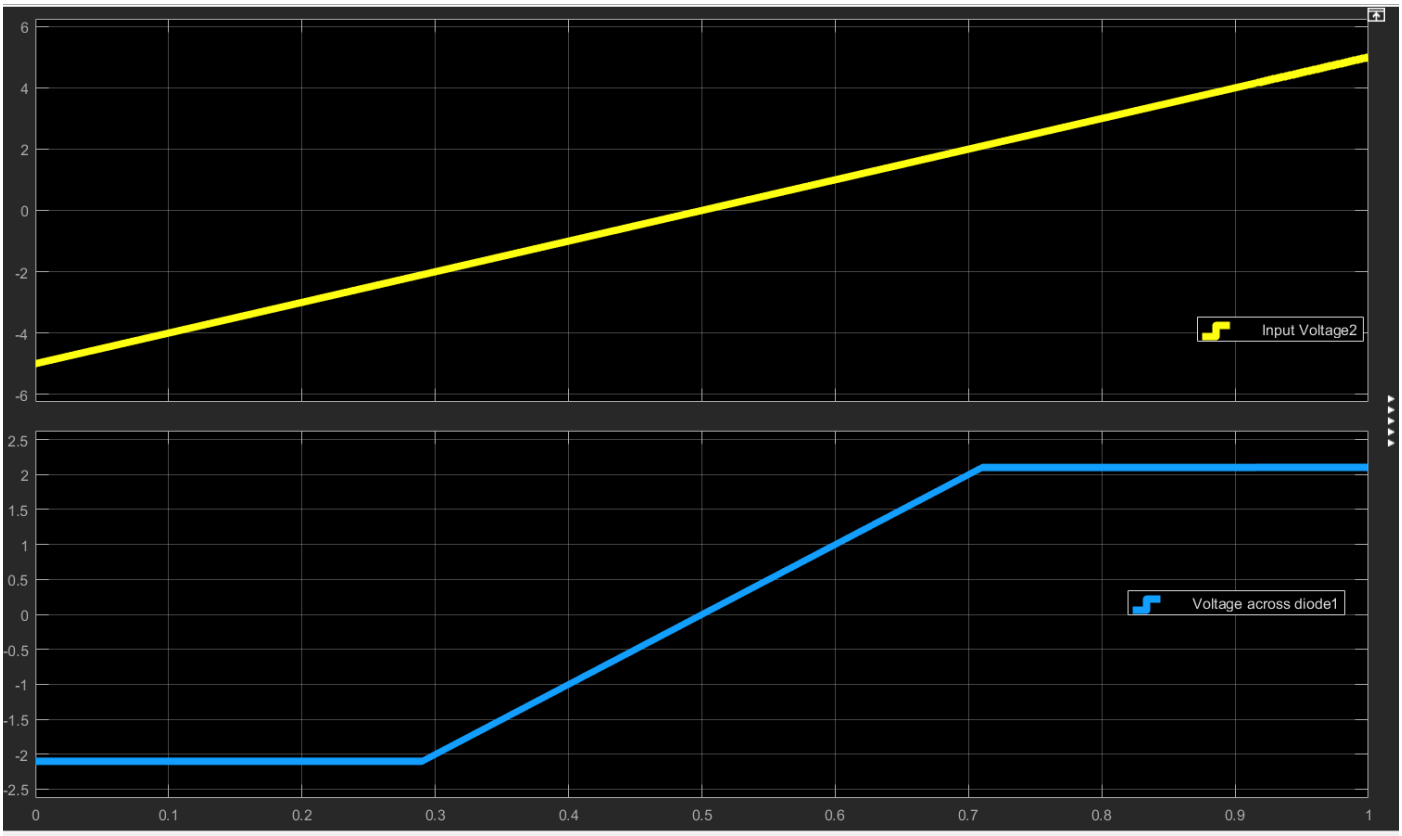


Fig7f: Circuit designed for 2.1V full wave clipping using ramp



Graph7a: Graphical results of inputs and voltage across diode

Part-3: Consider Fig.7.2 with $v(t) = 230\sqrt{2}\sin(100\pi t)$, C = 1 mF, do the same as mentioned in Section - 7.D.

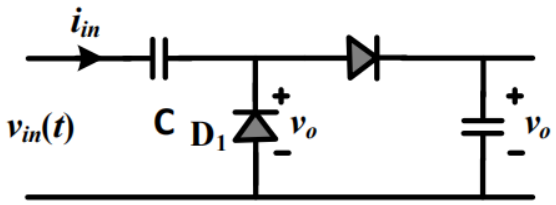


Fig. 7.2

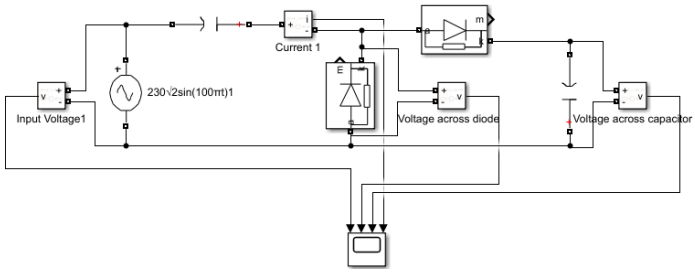
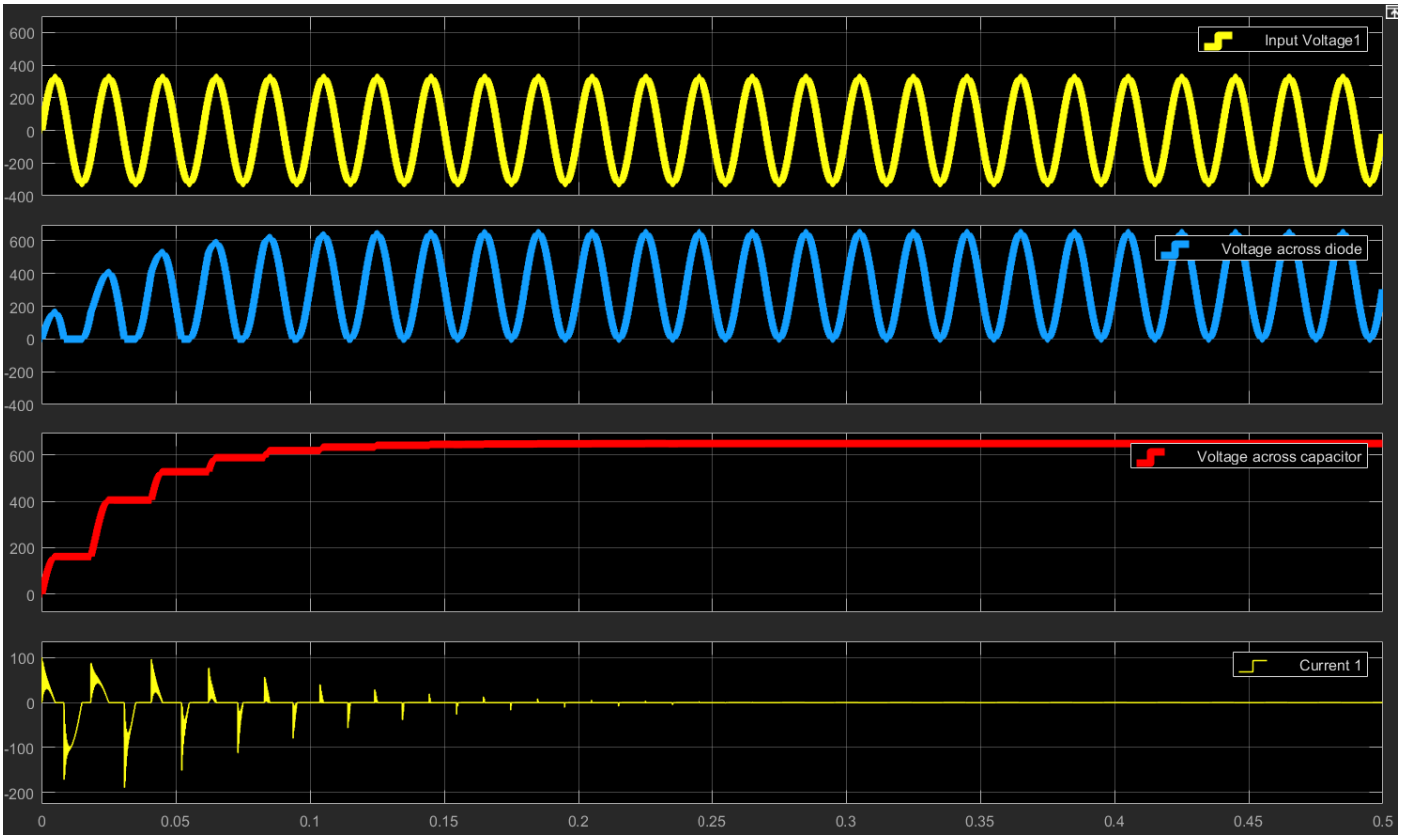
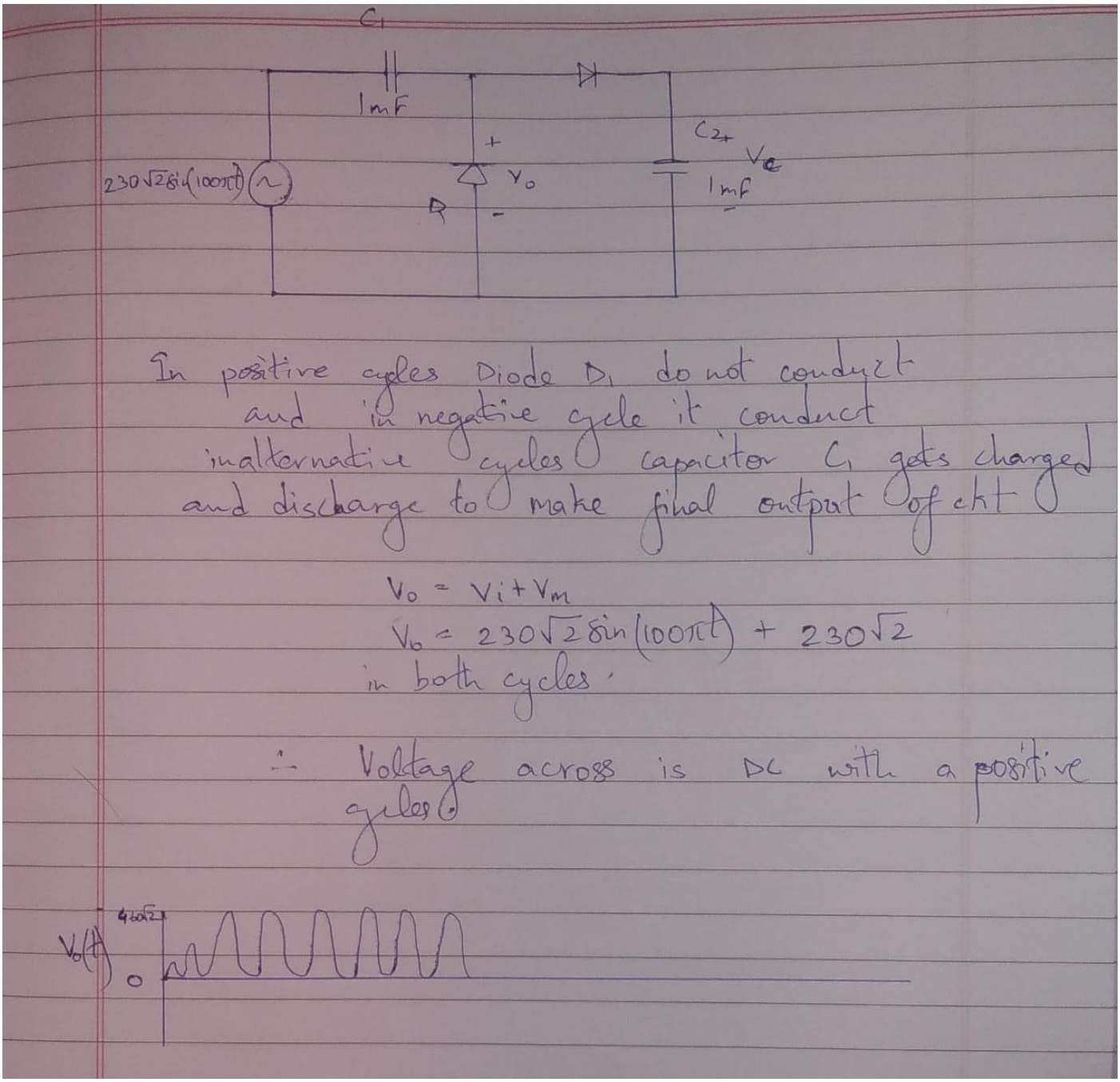


Fig7a: Simulation connections for given ckt in Fig 7.2



Graph7a: Graphical results of inputs and voltage current across diode



In positive cycles Diode D_1 do not conduct and in negative cycle it conduct inalternative cycles capacitor C_1 gets charged and discharge to make final output of ckt

$$V_o = V_i + V_m$$

$$V_o = 230\sqrt{2}\sin(100\pi t) + 230\sqrt{2}$$

in both cycles.

∴ Voltage across is DC with a positive cycles.