EXPERIMENT #3 **PRECISION RECTIFIERS**

I OBJECTIVES

The primary objective of this experiment is to familiarize the student with half wave rectifier and precision full wave rectifier. We should all know that a diode can be used as a rectifier. We also know that a diode usually drops about 0.7 volts across it when conducting. When needed to rectify very small A.C. signals diodes and op-amps can be used to make the diode function more like an ideal diode.

II INTRODUCTION

The precision full-wave rectifier transmits one polarity of the input signal and inverts the other. Thus both half-cycles of an alternating voltage are transmitted but are converted to a single polarity of the circuit's output. The precision full wave rectifier can rectify input voltages with millivolt amplitudes. This type of circuit is useful to prepare signals for multi applications, averaging or demodulation. The precision rectifier is also called an *absolute-value* circuit.

III COMPONENTS AND INSTRUMENTATION

The focus is on the 741-type op amp provided one per IC, in an 8-pin dual-in-line (DIP) package whose schematic connection diagram and packaging are shown in fig. 3.1. For power, use two supplies. ±15 V for short. As well, you need a variety of resistors. For measurement, use a bench multimeter with ohms scale, a two channel oscilloscope and a function generator.

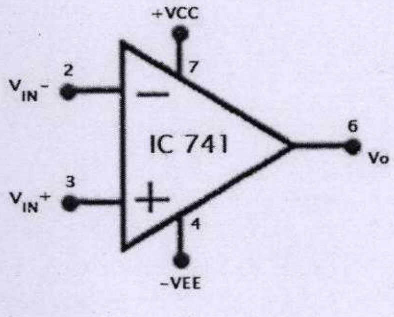

Fig 3.1(a) Symbol

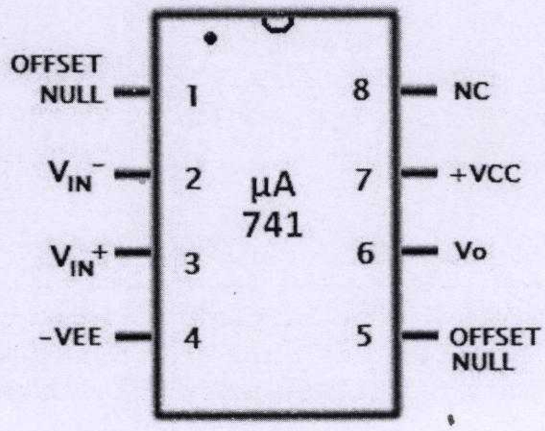

Fig 3.1(b) Pin diagram of µA741

IV PREPARATION

Q1 For the circuit given in Fig 3.2 use each of the diode models A and B (Fig.3.3) and determine the values of V_o and V_{ao}:

a) When V_{in} = 2 V dc model A V_O = 2V V_{ao} = 2V

model B V_O = 2V V_{ao} = 2.7V

b) When V_{in} = -3 V dc model A V_O = 0V V_{ao} = -13V (saturated)

model B V_O = 0V V_{ao} = -13V (saturated)

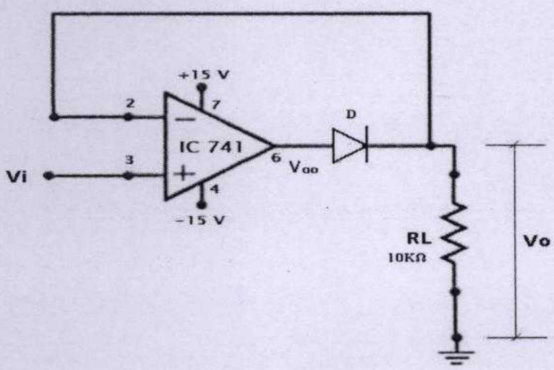

Fig. 3.2. Precision Half-Wave Rectifier

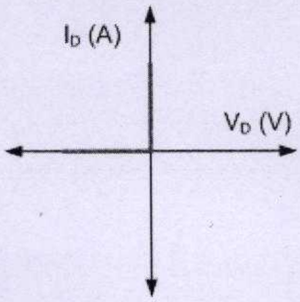

Fig. 3.3(a) . Model A

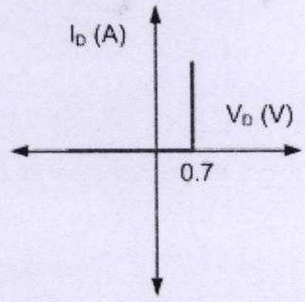

Fig. 3.3(b) . Model B

Q2 Compare diode models A and B by sketching V_o and V_{ao} with respect to time given $V_i = 5 \sin 2\pi ft$ for the rectifier circuit shown in Fig. 3.2 Assume f = 100 Hz.

Q 3 Sketch and label the Voltage Transfer Characteristics (VTC) of the circuit of Fig.3.4 if $R_2=2R_1$ and the non-inverting input of the op amp is connected to a -5V reference voltage (instead of to ground). Sketch and label V_o if V_I is a sinusoidal waveform with peak values of ±10V.

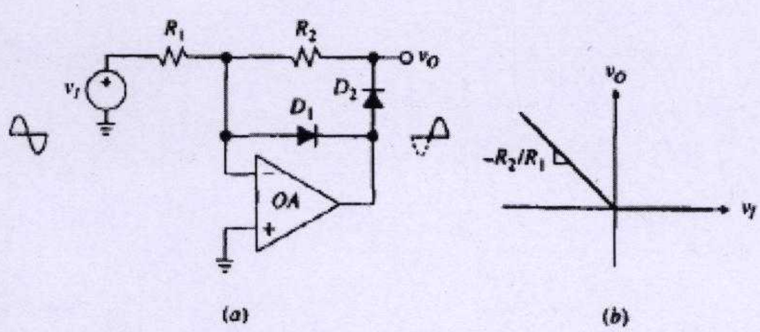

Fig. 3.4

V EXPERIMENTATION

5.1 – Precision Half wave Rectifier - A

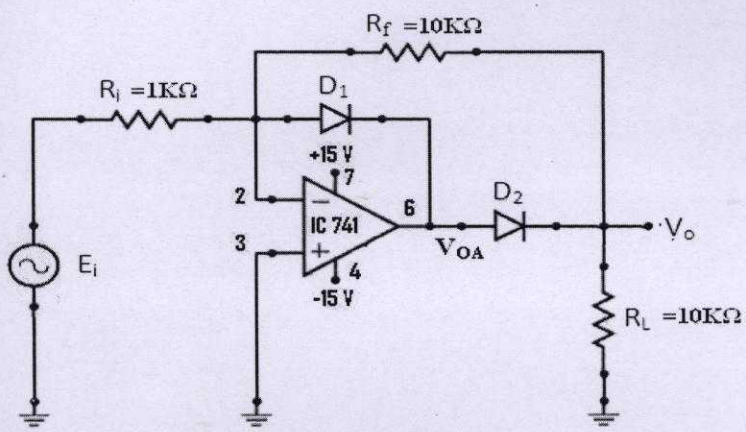

Fig 3.5. Precision Half-Wave Rectifier – A

1) Build the precision half wave rectifier circuit shown in fig. 3.5.

2) Use a square wave signal of 1V(peak to peak) and a period of 10 ms for V_{in}. Record V_o. V_o= 5V(peak)

3) Use a triangle wave signal of 1V(peak to peak) and a period of 10 ms for V_{in}. Record V_o. V_o= 5V(peak)

4) Capture V_o versus V_{in} in x-y mode and record the detail.

5) Increase the frequency from 500Hz to 1MHz in steps of one decade and note V_o(peak) in Table 3.1.

(The waveforms can be plotted on ordinary graph sheets, to be attached with report.)

Table 3.1

V_{in} (V) (Peak)	Frequency (kHz)	Square Waveform V_o (V) (Peak)	Triangle Waveform V_o (V) (Peak)
0.5	0.5	5	5
	5	5	5
	50	4	5
	500	0	0
	1000	0	0

E 5.2 – Precision Half wave Rectifier - B

Draw the circuit of Fig.3.5, with reversed polarities for the two diodes. This is the precion HWR – configuration B.

1) Build the precision rectifier circuit shown in Fig.3.6
2) Use a square wave of 1V(peak to peak) and a period of 10 ms. for V_{in}. Record V_O. $V_o = -5V$ (peak)
3) Use a triangle wave of 1V(peak to peak) and a period of 10 ms. for V_{in}. Record V_O. $V_o = -5V$(peak)
4) Capture V_O versus V_{in} in x-y mode and record the detail.
5) Increase the frequency from 500Hz to 1MHz in steps of one decade and note V_O(peak) in Table 3.2.

(The waveforms can be plotted on ordinary graph sheets, to be attached with report.)

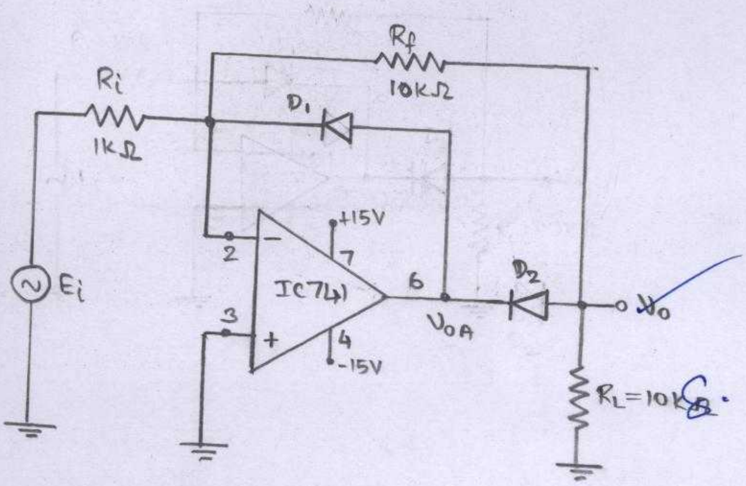

Fig 3.6. Precision Half-wave Rectifier - B

Table 3.2

V_{in} (V) (Peak)	Frequency (kHz)	Square Waveform V_o (V) (Peak)	Triangle Waveform V_o (V) (Peak)
0.5	0.5	-5	-5
	5	-5	-5
	50	-4	-2
	500	0	0
	1000	0	0

E 5.3 – Precision Full-wave Rectifier

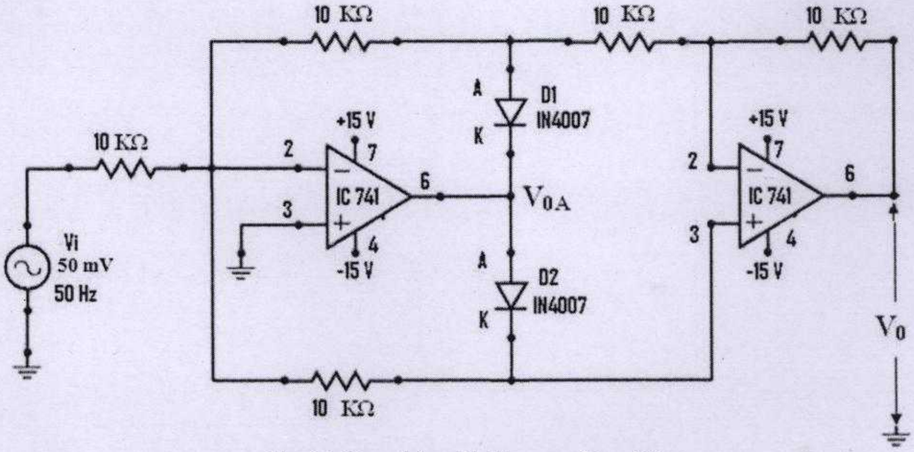

Fig 3.7 Precision Full-wave Rectifier

1) Connect the circuit as per Fig. 3.7
2) Give a sinusoidal input of 100 mV(peak to peak), 1 kHz from a signal generator.
3) Switch on the dual power supply and note down the output at nodes V_{OA} and V_O .
4) Increase the frequency of the sine wave until distortion occurs. Note the frequency. Record V_O .
   (The waveforms can be plotted on ordinary graph sheets, to be attached with report.)

V_o = 40mV (peak)

V_{OA} = 0.64V (peak-peak)

- At 5KHz, the output waveform is distorted, v_o = 40mV (peak)
- At 20KHz, the amplitude reduces, v_o = 35mV (peak)

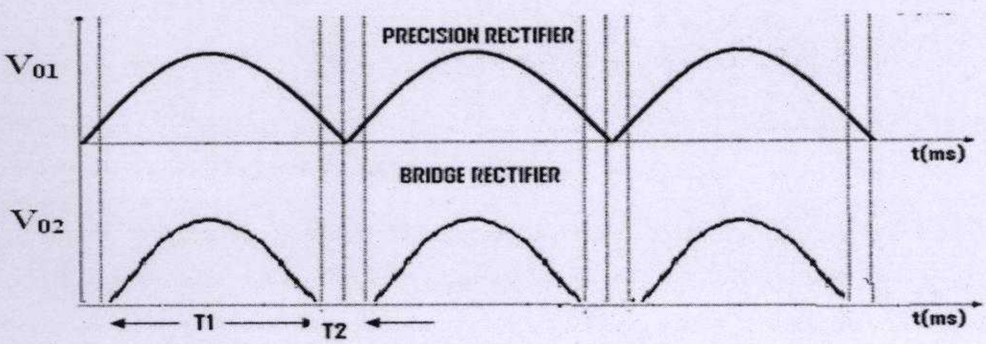

Fig 3.8. Comparison of waveforms

VI INFERENCE \ CONCLUSIONS

- A precision rectifier is more precise and accurate compared to the bridge rectifier, (general diode rectifier) since the diodes act as ideal diodes when ON, (ie) their drop being divided by a very high open loop gain of the op-amp.

- In the case of IC741, for high frequencies, the switching from closed loop operation to open loop operation takes longer than the switching of input signal.

- In such cases, high speed opamps should be used. ?

- Precision half wave rectifier A is used to rectify negative half of the input producing positive peak (inverting).
- Precision half wave rectifier B is used to rectify positive half of the input producing negative peak. (non-inverting).

Integrated Circuits Lab		
	Credit	Maximum Marks
Preparation	4 1/2	5
Experimentation	9 1/2	10
Reporting	5	5
Total Marks	19	20

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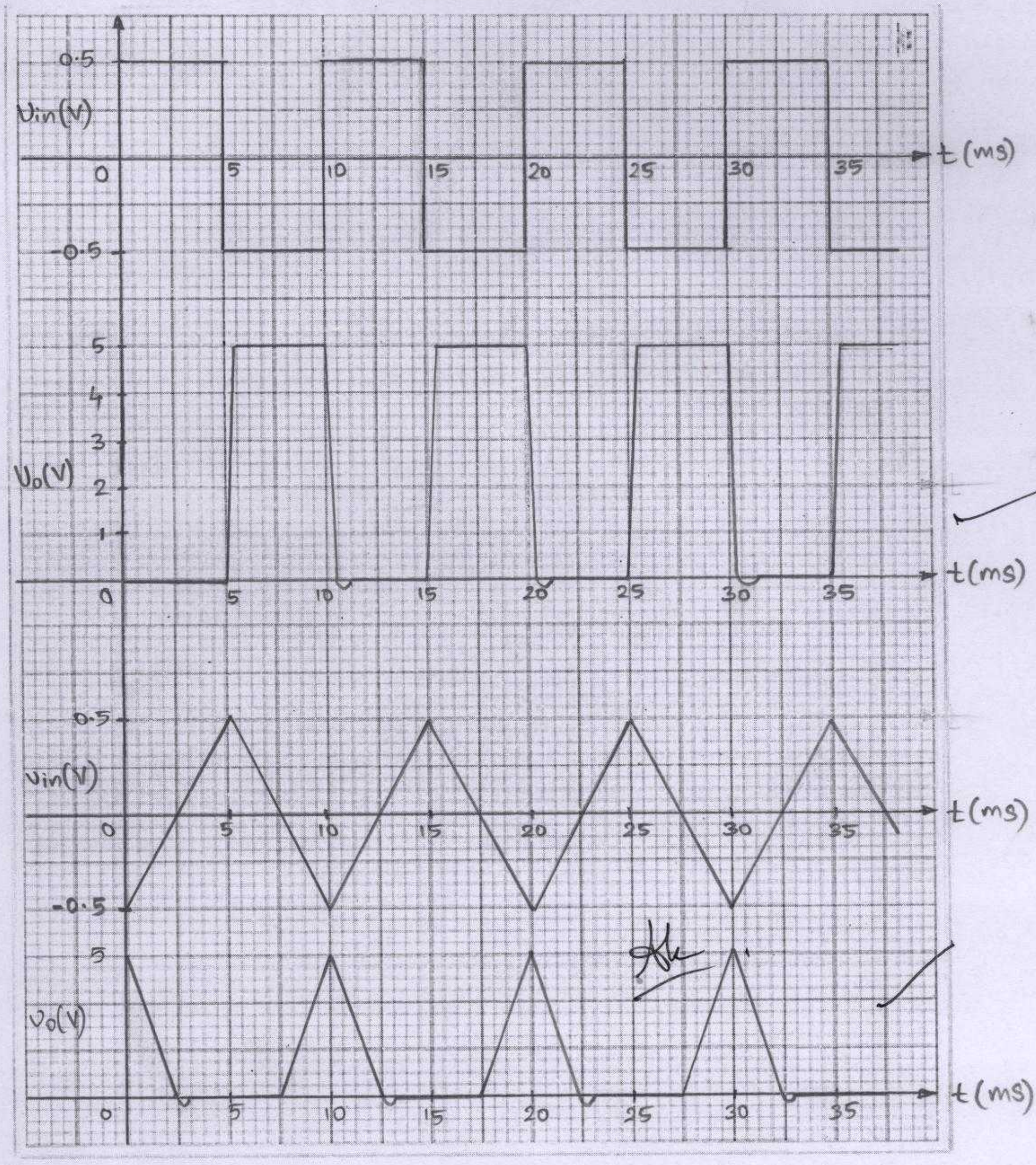
SCALE:

Along X axis, 1unit = 2.5ms

PRECISION HALFWAVE RECTIFIER-A (OUTPUTS)



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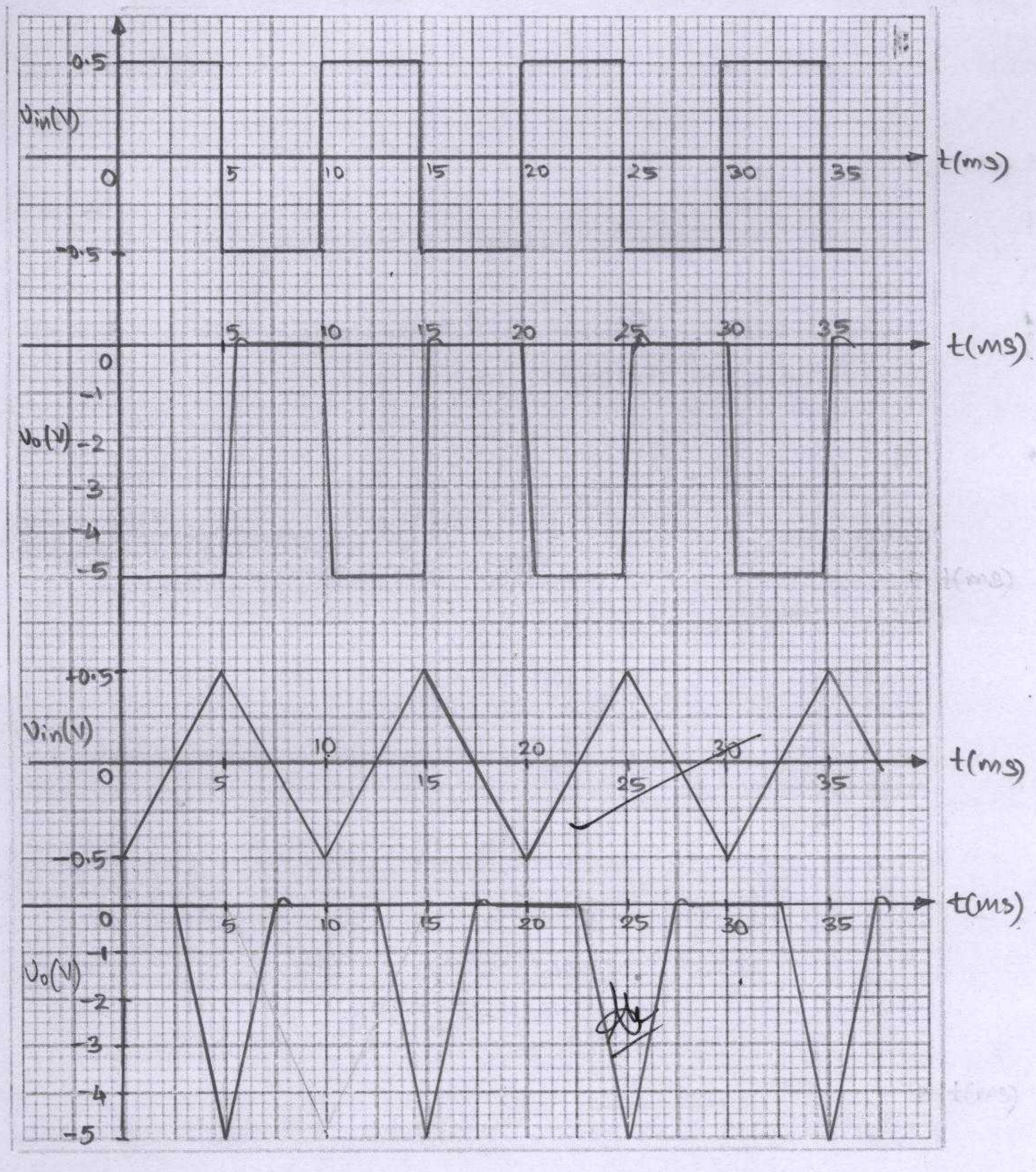
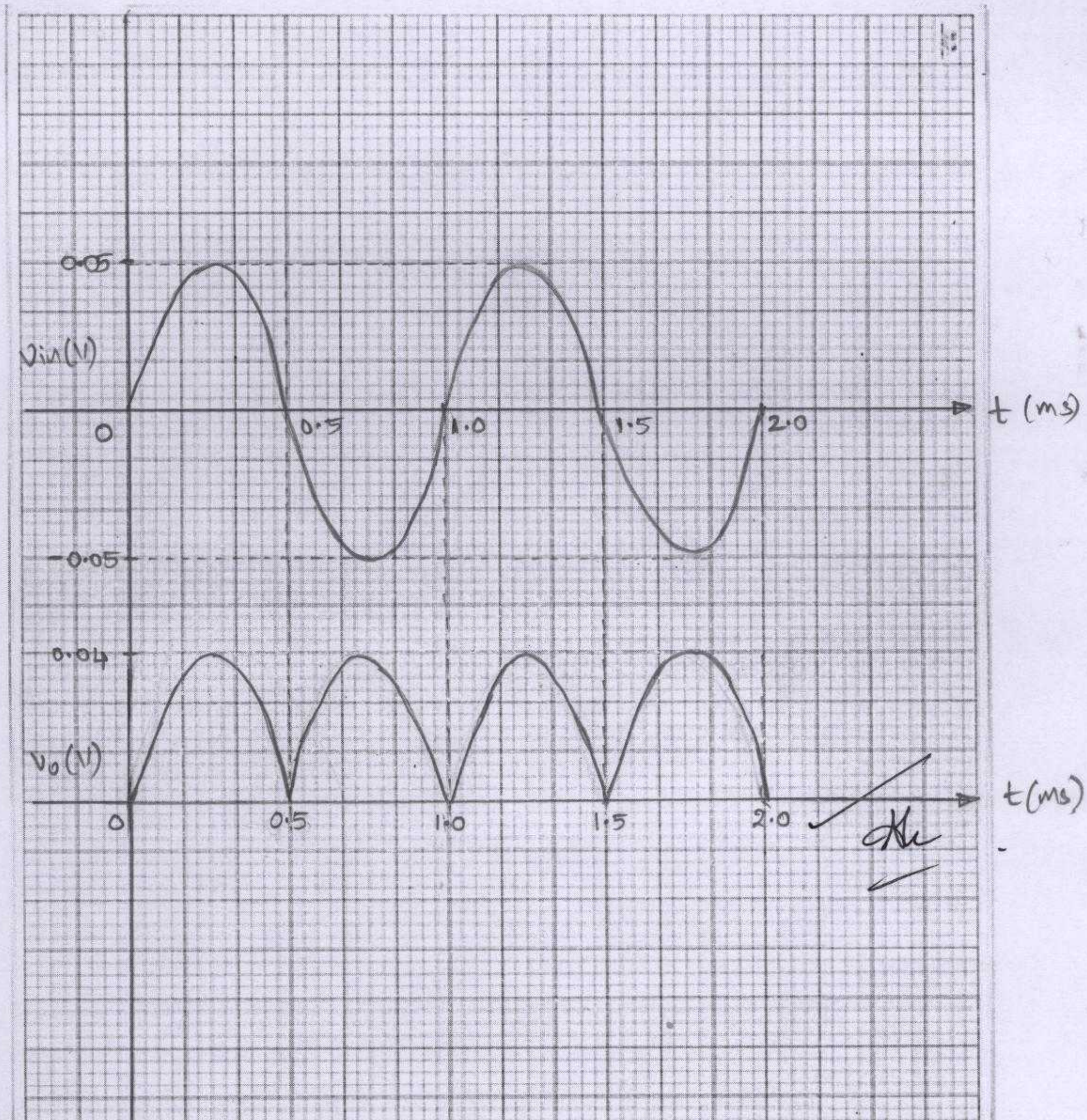
SCALE

Along X axis, 1unit = 2.5ms

PRECISION HALFWAVE RECTIFIER -B(OUTPUTS)



PRECISION FULL WAVE RECTIFIER - OUTPUT :



Question 3:

Sketch and label the voltage transfer characteristics (VTC) of the circuit in fig 3.4 if $R_2 = 2R_1$ and the non-inverting input of the op-amp is connected to a -5V reference voltage. Sketch and label V_o if V_i is a sinusoidal waveform with peak values of ±10V

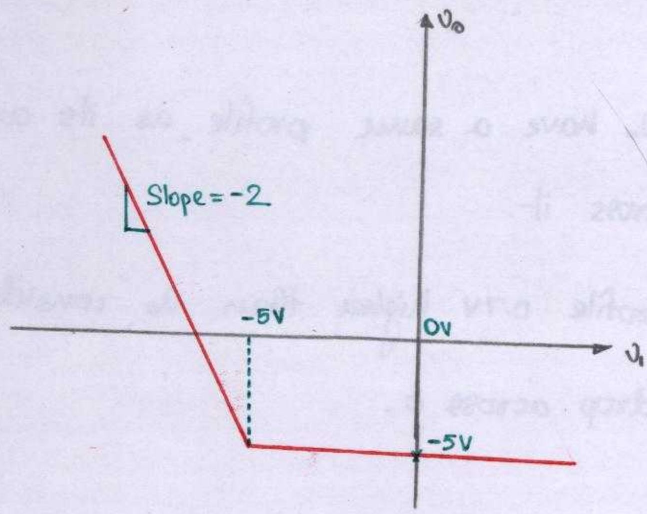
$$\frac{V_1 - (-5)}{R_1} = \frac{(-5) - V_o}{R_2} \quad \text{(when } D_2 \text{ ON} \ \& \ D_1 \text{ OFF)}$$

(ie) $$-\frac{R_2}{R_1} = \frac{V_o + 5}{V_1 + 5} \quad \ldots (1)$$

- when ($V_1 > -5V$), D_1 ON & D_2 OFF

∴ $V_o = -5V$.

- when ($V_1 < -5V$), V_o varies according to expression ①



Voltage Transfer Characteristics

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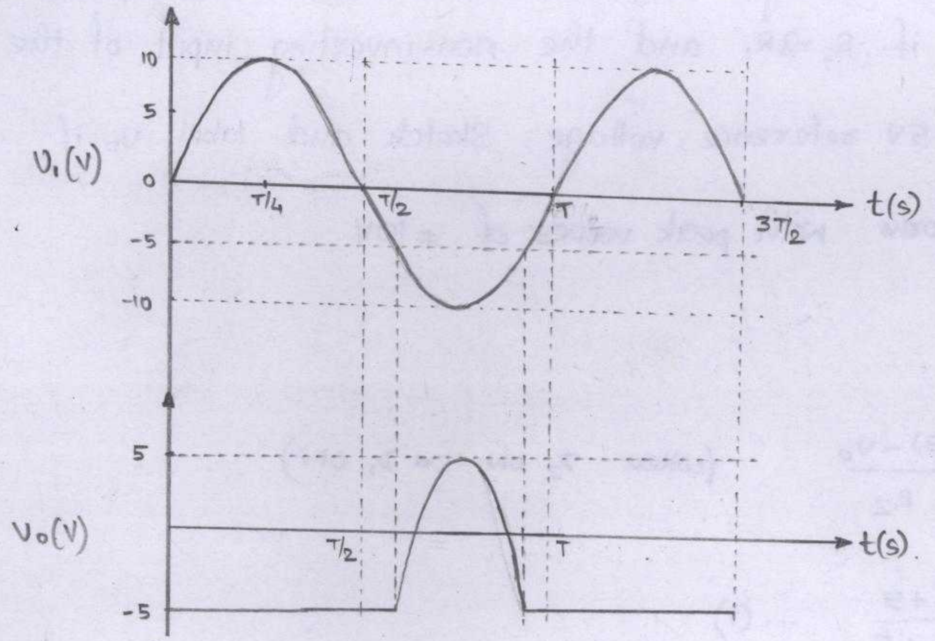
Output waveform :



Question 2 :

Compare diode models A and B by sketching v_o and v_{ao} with respect to time given $v_i = 5 \sin 2\pi f t$ for the rectifier circuit shown in fig 3.2. Assume $f = 100$ Hz.

- In mode A, both v_{ao} & v_o have a same profile as its an ideal diode without any drop across it.
- In mode B, v_{ao} has its profile 0.7V higher than v_o, considering a practical model with 0.7V drop across it.

Input and output waveforms: