1.1 TITLE OF THE EXPERIMENT.

Inverting amplifier, non inverting amplifier & Voltage follower

1.2 AIM OR OBJECTIVE

To design and implement a voltage series, shunt feedback amplifier and Voltage follower using op-amp µA 731.

1.3. LIST OF EQUIPMENTS

Sl no	component / device	Specifications	Quantity
1	Regulated DC	0-20V, 2A	02
2	CRO	80 Vpp/20MHz	01
3	Power Bank' Pack	+12V & -12V	01.
4	op-amp	µA-731	01
5	function generator	0-1 MHz	01.
6	Resistor	10k ½ watt CFR	02
		1k ½ watt CFR	02
7	BNC probes	–	02
8	Wires	–	assorted

1.4 THEORETICAL BACKGROUND

For Inverting amplifier.

This is most widely used of all the op-amp circuits. The output V_o is fed back to the input through the R_f - in network as shown in figure where R_f is the feedback resistor. The input signal V_i is applied to inverting input terminal through R_{in} and non-inverting input terminal of op-amp is grounded. The output V_o is given by

$$V_o = V_i\left(-R_f/R_{in}\right)$$

where, the gain of amplifier is $-R_f/R_{in}$

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The negative sign indicates a phase shift of 180° between Vi & V effective input impedance is Ri. An inverting amplifier uses negative feedback to invert and amplify a Voltage. The Rin, Rf resistor network allows some of the output signal to be returned to the in. Since output is 180° out of phase, This amount is effectively subtracted from the input.

For non Inverting amplifier.
In case of non-Inverting amplifier input is applied to non-In terminal of opamp, the gain is calculated by.

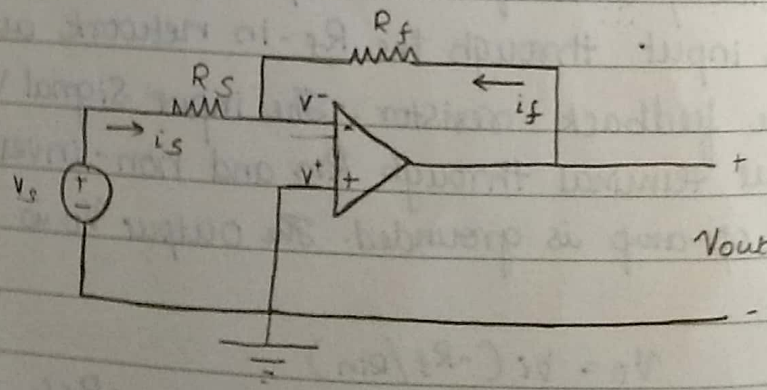
$$V_o/V_{in} = 1 + R_f/R_i$$

Voltage follower.
Voltage follower is one of the simplest uses of an operational amp where the output Voltage is exactly same as the input Voltage applied to the circuit. Gain is Unity.

1.5 DESIGN.

Inverting amplifier design.

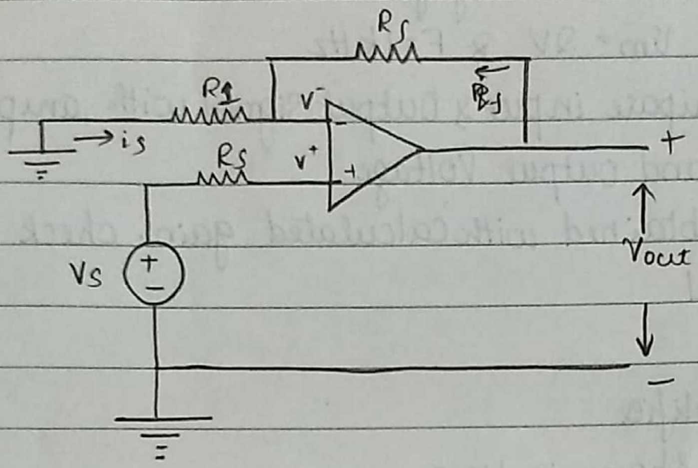
Voltage Gain = $-R_f/R_1$



INVERTING AMPLIFIER

Non Inverting Amplifier

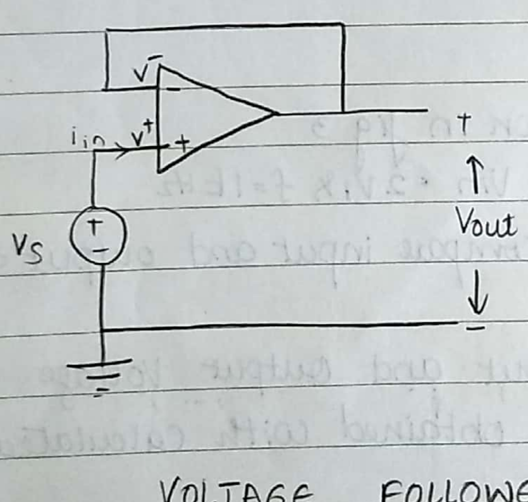
Voltage Gain = $(1 + R_f/R_1)$



NON INVERTING AMPLIFIER.

For Voltage follower

Gain = $V_o/v_{in} = 1$ (unity)



VOLTAGE FOLLOWER

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1.6. STEP BY STEP PROCEDURE

For inverting amplifier

- connect the circuit as shown in fig 1
- Supply Sinusoidal input Vm = 2V & F = 1kHz
- check Output on CRO, compare input & Output Signal with amplitude & freq
- Plot the graph for input and output Voltage
- compare practical gain obtained with calculated gain. check phase of input and output Signal

For non-Inverting amplifier

- connect the circuit as Shown in fig 2
- Supply sinusoidal input Vin - 2V & f = 1kHz
- Check Output on CRO, compare input and output signal with amplitude and frequency.
- Plot the graph for input and Output Voltage
- compare practical gain obtained with Calculated gain. Check phase of input and output Signal

For Voltage follower

- connect circuit as shown in fig 3
- Supply sinusoidal input Vin = 2V, & f = 1kHz
- check output on CRO, compare input and output Signal with amplitude & frequency.
- Plot the graph for input and output Voltage.
- compare practical gain obtained with Calculated gain.

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1.7 TABLE OF OBSERVATIONS

For inverting amplifier.

Sl no.	Vi	Vo	observed Gain	calculated Gain
1	0.9	8	- 8.88	- 10
2	1.9	18.5	- 9.73	- 10.

For non-Inverting amplifier

Slno	Vi	Vo	Observed Gain	Calculated Gain
1	1	9	9	11
2	2	19.6.	9.8	11

For voltage follower.

Slno	Vi	Vo	Observed Gain	Calculated Gain
1	1.7	1.8	1.05	1.
2	2.7	2.85	1.05	1

1.8 SPECIMEN CALCULATIONS.

For inverting

Gain = $-R_f/R_i$

Let required gain be 10

$R_1 = 1k\Omega$

$\therefore R_f = 10k\Omega$.

For non-inverting.

Gain = $1 + R_f/R_1$

Gain required = 11.

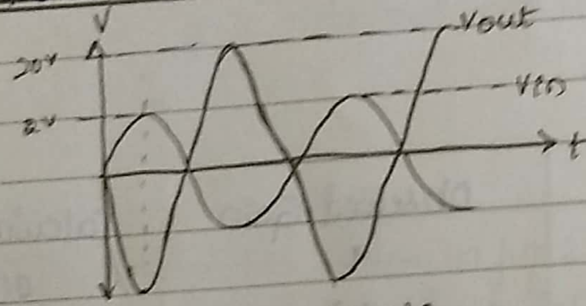
Assume $R_1 = 1k\Omega$

$\therefore R_f = 10k\Omega$

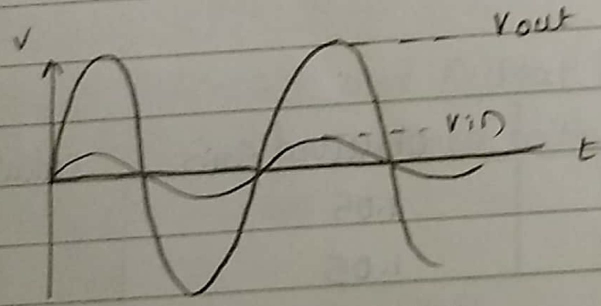
Voltage follower

Gain = 1.

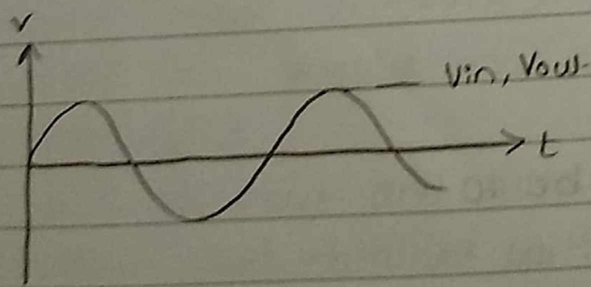
1.9 NATURE OF GRAPH.



INVERTING



NON INVERTING



VOLTAGE FOLLOWER.

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WC CONCLUSION OF THE EXPERIMENT.

Result & Discussion.

experimental Set up of inverting amplifier gives a Signal out of phase by 180° the Gain is nearly 10.

For non inverting, the Output is in phase Gain is nearly 10.

For Voltage follower.
the Gain is almost 1 and the output is in phase

CONCLUSION

Op-amp is a device with 2 input terminals and One Output terminal, with input and Output Signal is plotted and observed gain is calculated, which in turn is Verified with Calculated gain

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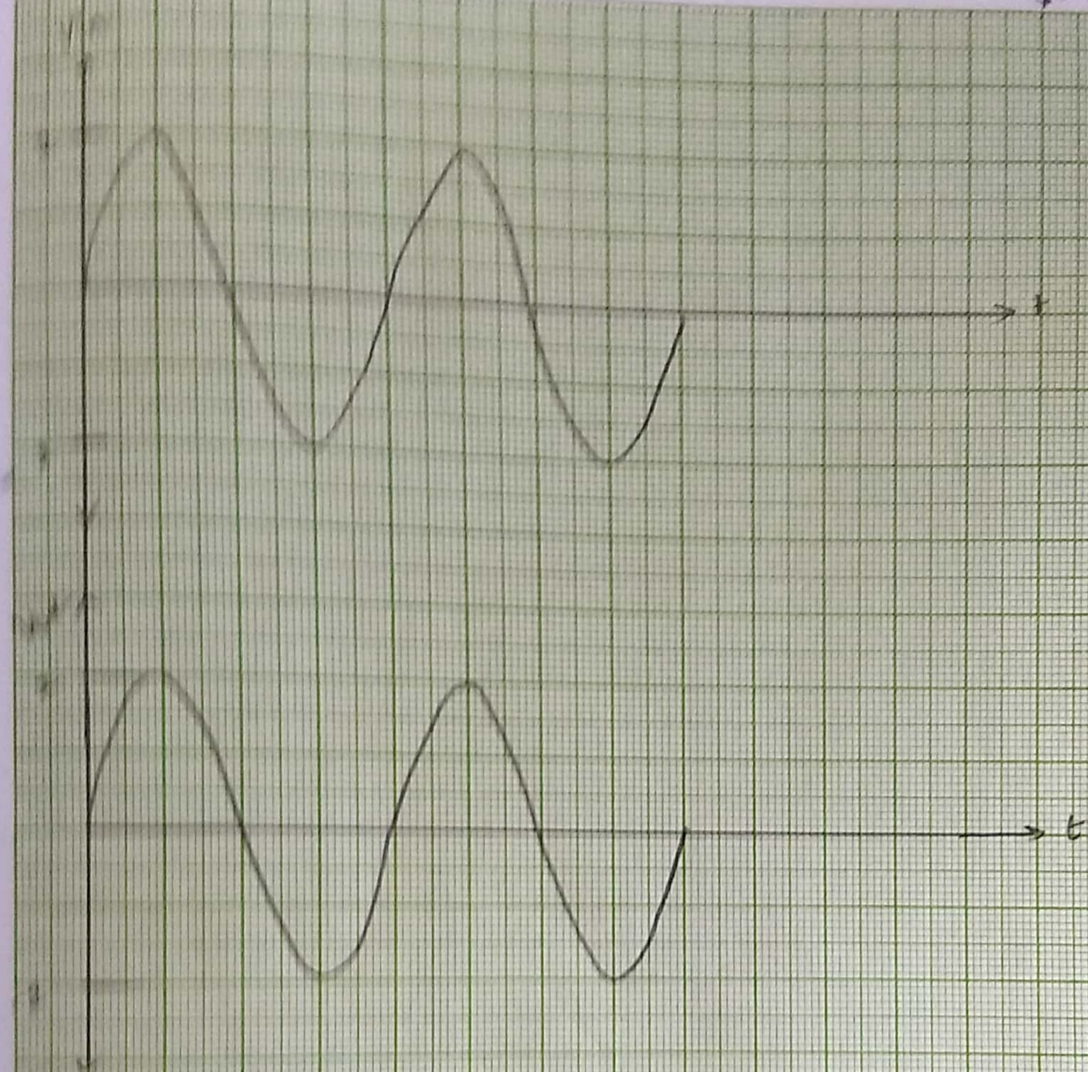
EXPERIMENT NO.:

DATE:

SCALE : X - axis : 4U = 1 ms
Y - axis : 1Um = 1V



VOLTAGE FOLLOWER

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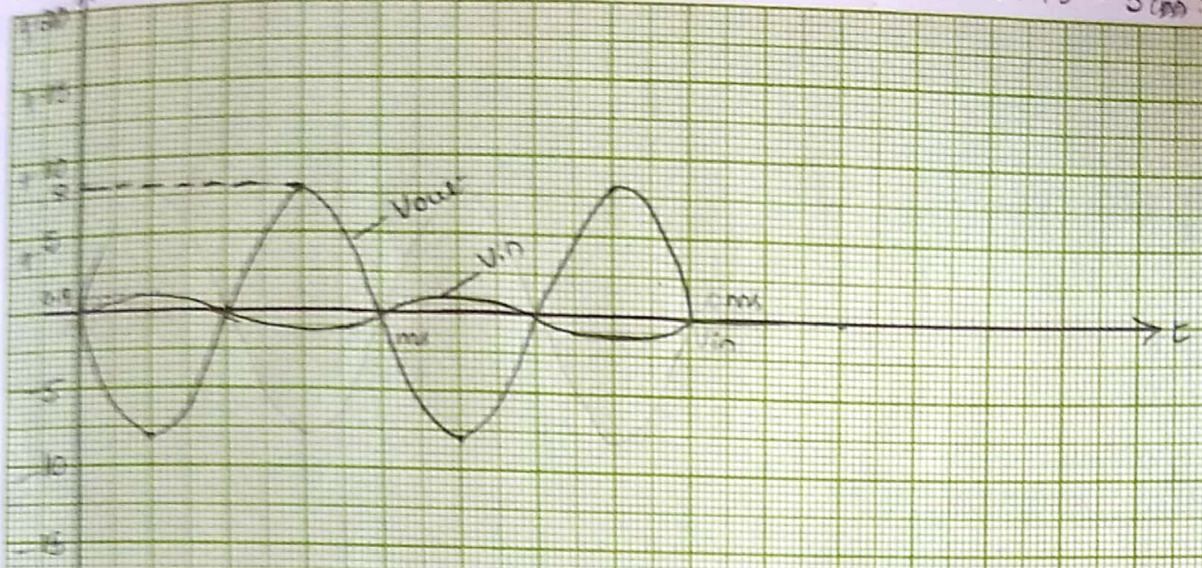
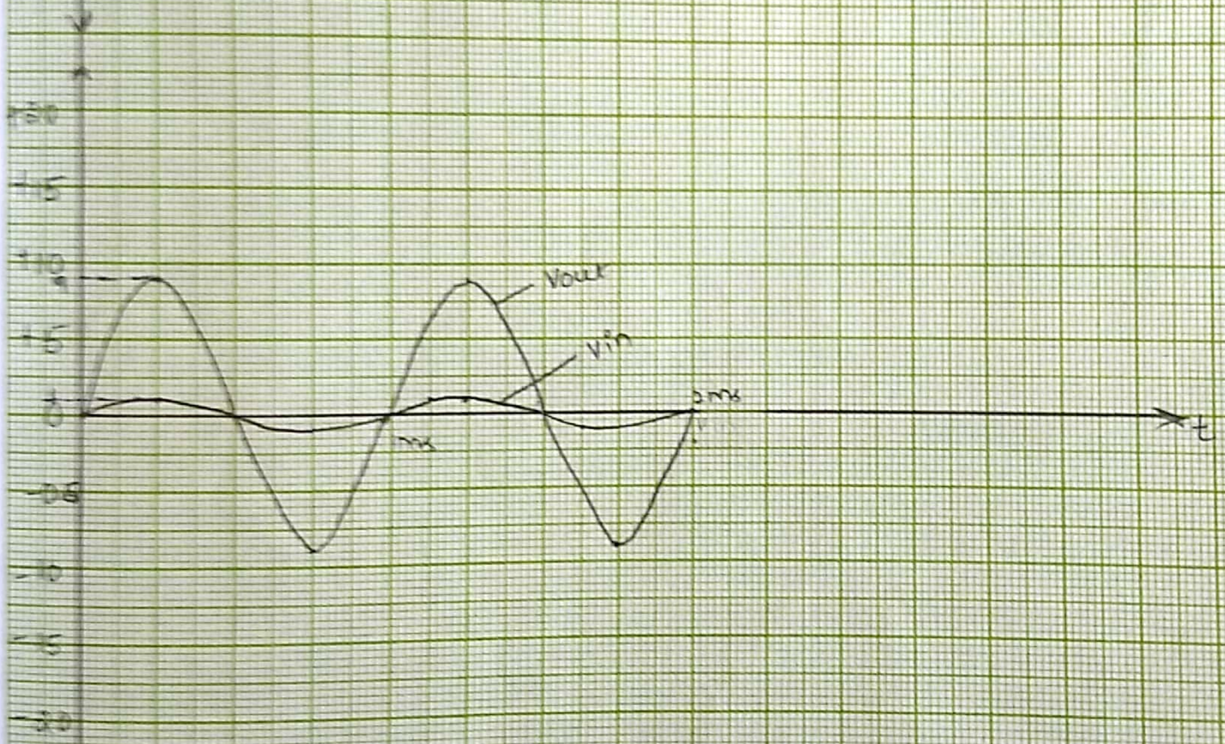
EXPERIMENT NO. :

DATE :

SCALE : X - axis : 4U = 1 ms
Y - axis : 1U = 5 V



INVERTING AMPLIFIER



NON INVERTING AMPLIFIER

2.1 TITLE OF THE EXPERIMENT

zero crossing detector, Schmitttrigger, precision rectifier.

2.2. AIM OF THE EXPERIMENT.

To design and implement ZCD, schmitt trigger and precision rectifier.

2.3. LIST OF EXPERIMENTS

Sl no.	components / Devices	specifications	Quantity.
1.	Regulated DC	0-20V, 2A	2
2.	CRO	80Vpp /20MHz	1
3.	Power Pack.	+12V & -12V.	1
4.	Op amplifier	μA-741	2
5.	Function generator	0-1MHz	1
6	Resistors	1k, ¼watt	4
7		5k, ¼ watt	3
7	BNC probes	-	3
8.	Single strand Wires.	-	assorted
9.	Diodes	IN4001	2.

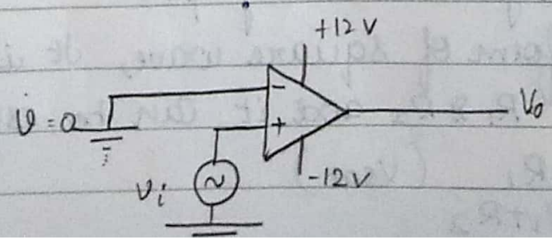
2.4. DESIGN.

a) Zero crossing Detector

Sine wave to square wave converter.

when $V_{in} = +V_i \Rightarrow V_o = -V_{sat}$

$V_{in} = -V_i \Rightarrow V_o = +V_{sat}$.



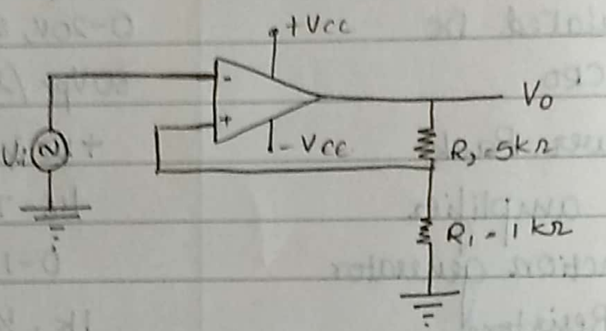
b) Schmitt trigger.

$$V_{utp} = \frac{R_1}{R_1 + R_2}(V_{sat}) \qquad V_{ltp} = \frac{R_1}{R_1 + R_2}(-V_{sat})$$

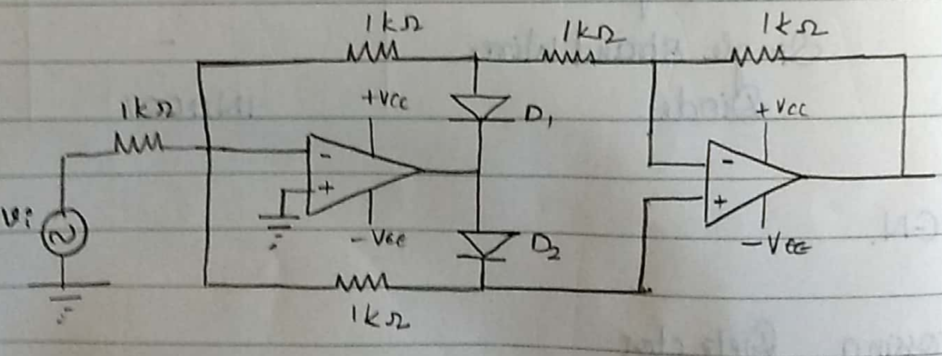
let us consider $R_1 = 1k\Omega$

Assume $V_{utp} = -V_{ltp} = 2V$ so w.k.t $V_{sat} = 12V$

∴ from the above equations we get $R_2 = 5k\Omega = 4.7k\Omega$



c) Precision Rectifier.



2.5. STEP BY STEP PROCEDURE

- connect the components as shown in the figure.
- Give the input Sine wave from inverting pin.
- Output should be in the form of square wave, It is magnitu depends on the resistors R_1 & R_2 and it can be estimated (usi the formula $V_{utp} = \frac{R_1}{R_1+R_2}(V_{sat})$

for Zero crossing Detector.

- Make connections as shown in fig.
- Give input Voltage (sine wave) and output will be square wave.
- Magnitude of output signal will be +Vcc & -Vee

for Precision Rectifier.

- Make connections as shown in fig.
- Give the input Sine wave (AC) from inverting pin
- Output will be half rectified

2.6. TABLE OF OBSERVATION.

Zero crossing Detector.

Sl no.	Vin	Vout	frequency (Hz)
1	1.4V	9V	1kHz
2	1.6V	9V.	1kHz

Schmitt trigger.

Sl no	Vin	frequency	V_{ip}	V_{op}
1	1V	1kHz	6V	+12V.
2				

Precision rectifier.

Sl no.	Vin	freq.	time period	output Voltage	o/p time
1	1.~~5~~	1kHz	1	1	1
2	1.5	1kHz	1	1.5	1

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2.7. SPECIMEN CALCULATION.

Schmitt trigger

$$V_{utp} = \frac{R_1}{R_1+R_2}(+V_{sat}) \qquad V_{ltp} = \frac{R_1}{R_1+R_2}(-V_{sat})$$

assume $V_{upp} = -V_{ltp} = 2V$ & $R_1 = 1k\Omega$

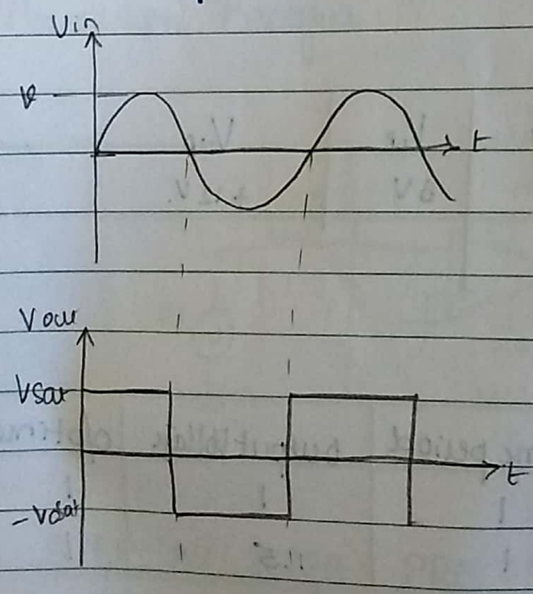
We know that $V_{cc} = -V_{EE} = 12V$

$\therefore$ from the eq^n. $= \frac{1k}{1k+R_2}(12)$

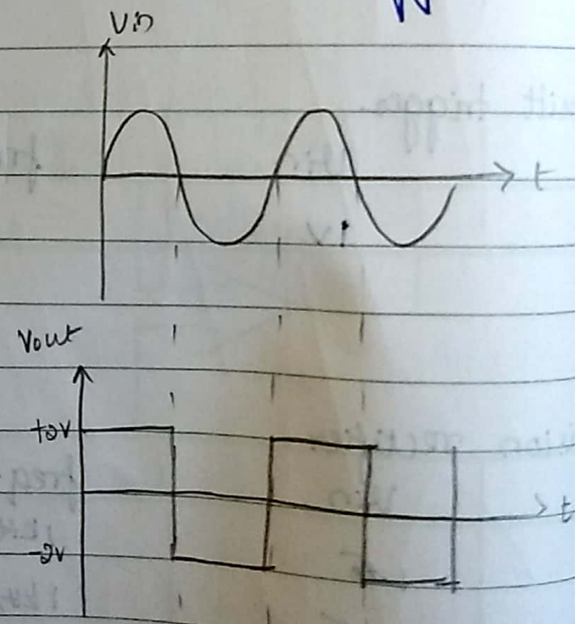
$R_2 = 5k\Omega$

2.8 NATURE OF GRAPH.

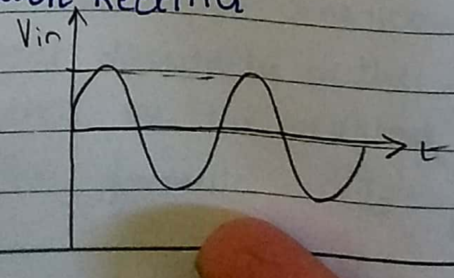
Zero crossing Detector

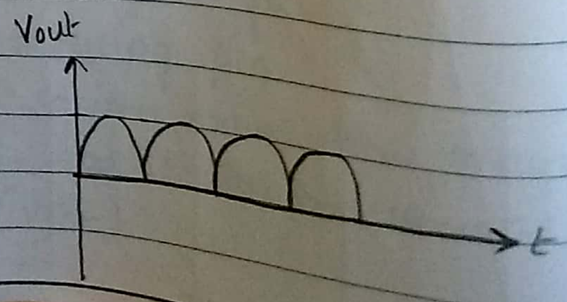


Schmitt trigger.



Precision Rectifier





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We have succesfully implemented the LCD, Schmitt trigger and precision rectifier and got the results similar to the expected ones

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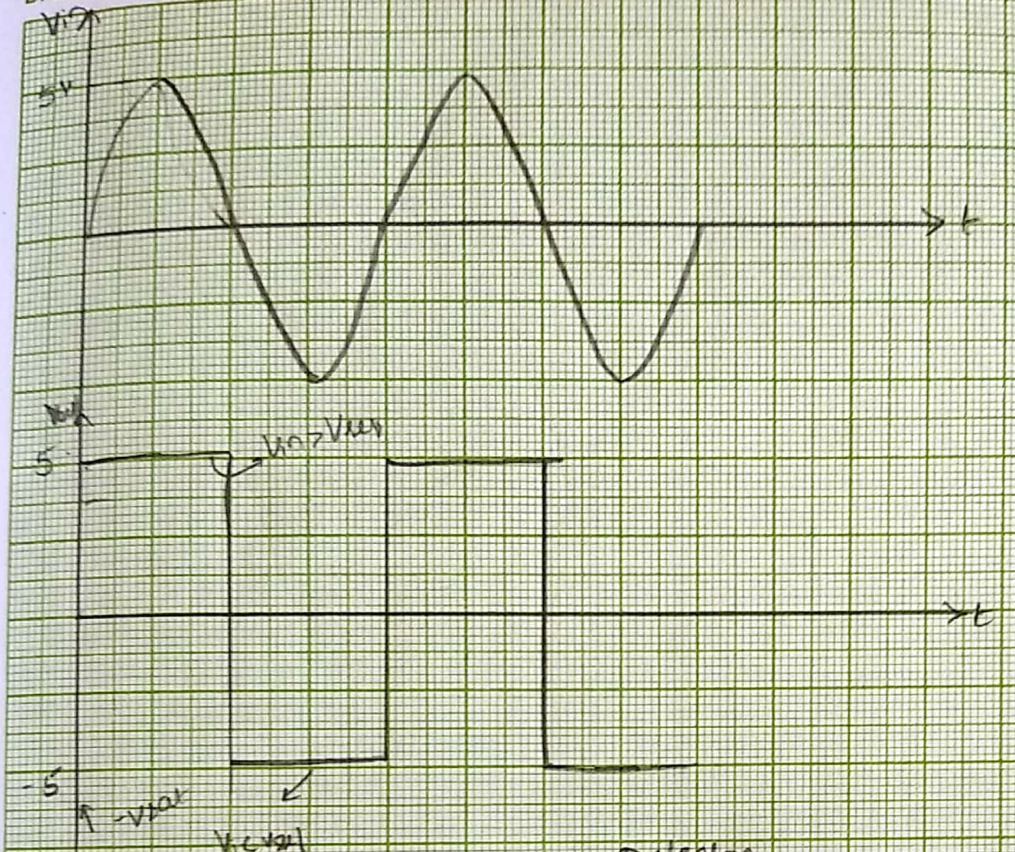
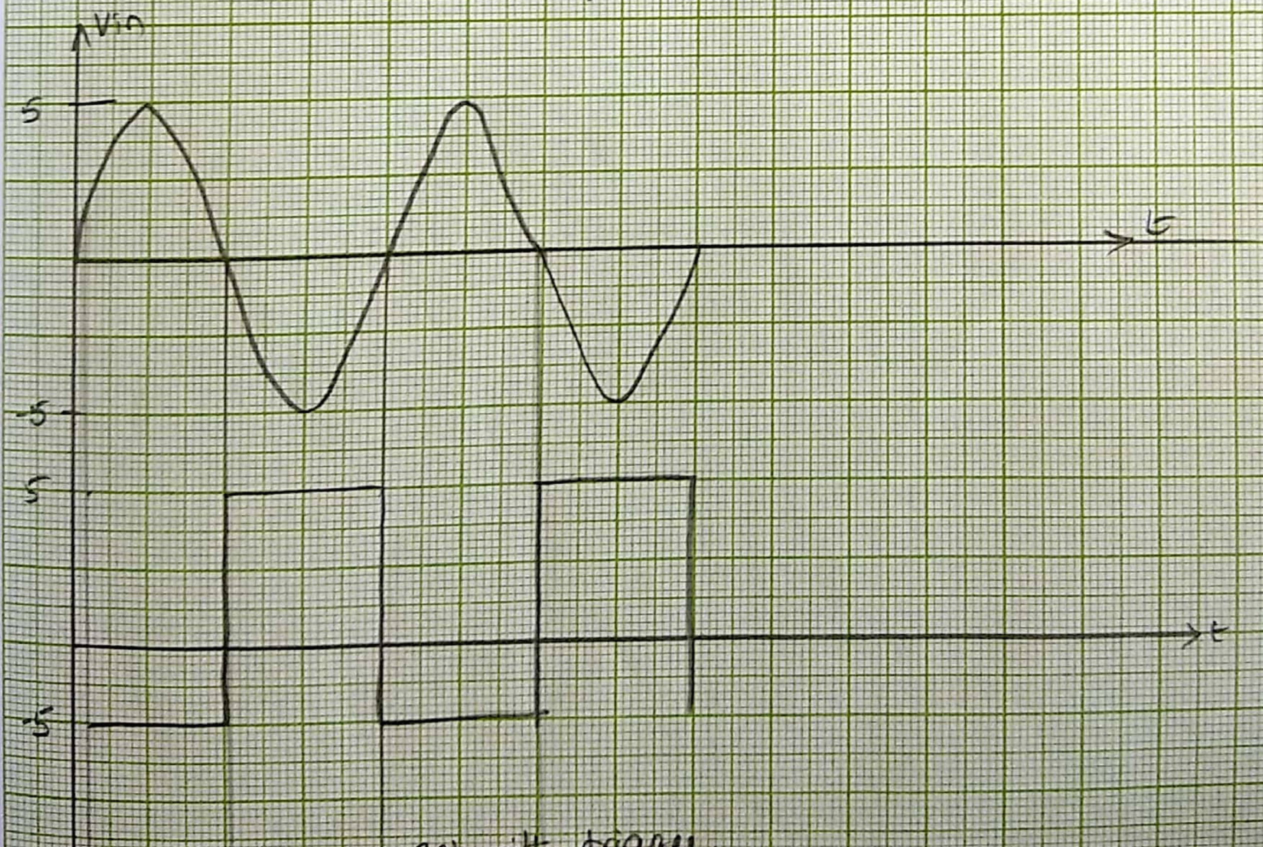
EXPERIMENT NO. :

DATE :

SCALE : X - axis : 1cm = 1msec.
Y - axis : 1cm = 2.5V



Zero crossing Detector



schmitt trigger

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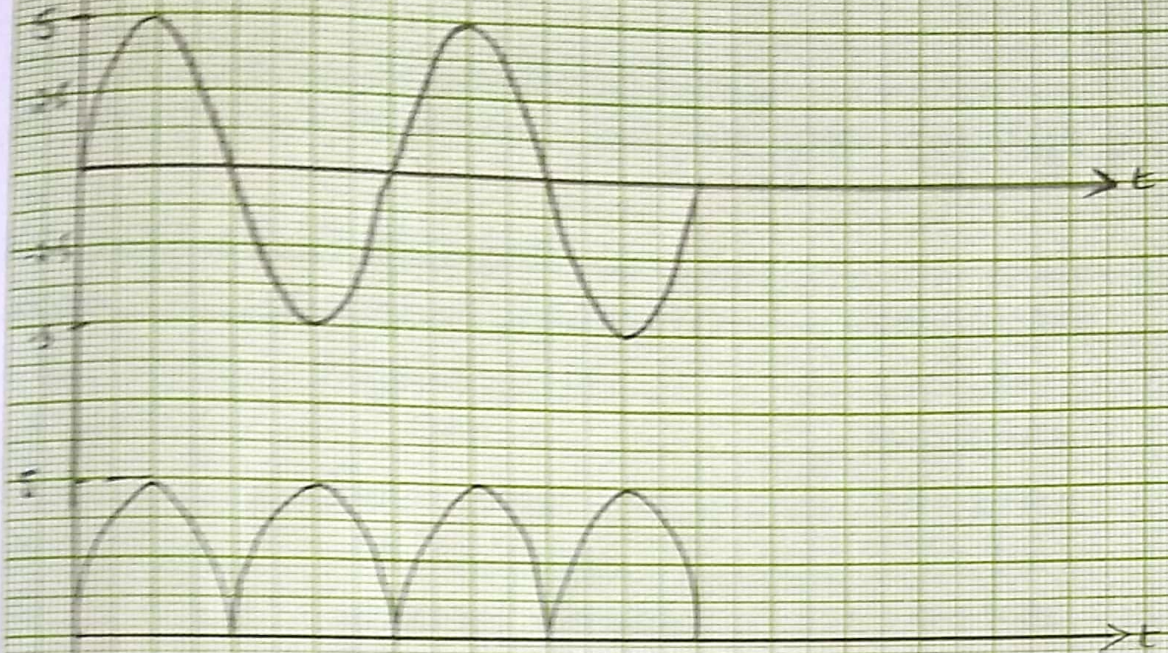
EXPERIMENT NO. :

DATE :

SCALE : X - axis : 2cm = 1ms

Y - axis : 2cm = 5V



Full wave precision rectifier

3.1 TITLE OF THE EXPERIMENT.

Second order filters.

3.2. AIM OF THE EXPERIMENT.

To design and implement low pass filter and high pass filter.

3.3. LIST OF COMPONENTS.

Sl no	components /equipments	specifications	Quantity
1	Regulated DC.	0-20V, 2A	2.
2.	CRO	80Vpp/20MHz	1
3	Power pack	+12V & -12V	1
4	Op. amplifier	µA-741	1
5.	function Generator	0-1 MHz	1
6.	Resistor.	1.5 kΩ	2
		2.2 kΩ	1
		1 kΩ	1
7	capacitors	0.01 µF	2.
8.	BNC probes	-	3
9	Wires	-	assorted.

3.4 DESIGN.

$A_f = 1 + R_f/R_1$. consider,

$$f_c = \frac{1}{2\pi\sqrt{R_2R_3C_2C_3}} \quad -① $$

assume $C_2 = C_3 = C$ and $R_2 = R_3 = R$

∴ ① becomes.

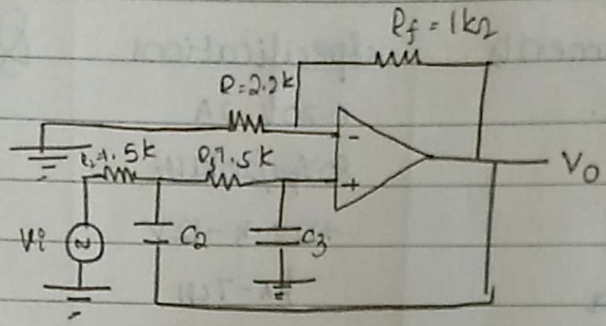
$$f_c = \frac{1}{2\pi RC} \quad (\text{consider } C = 0.01\,\mu F)$$

Let $f_c = 10\,kHz \Rightarrow 10\times10^3 = \dfrac{1}{2\pi R\times0.01\times10^{-6}}$

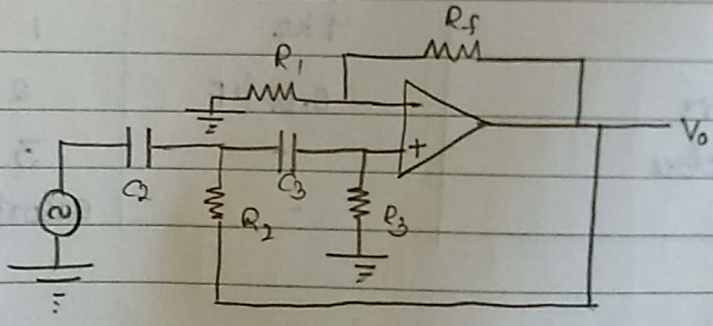
$$R = 1.59\ k\Omega$$

$$\text{Gain, } \frac{R_f}{R_1} + 1 = \frac{1}{2.2} + 1 = 1.45$$

a) Low Pass filters



b) High Pass filter



3.5. STEP BY STEP PROCEDURE

a) Low pass filter

- connect the circuit as shown in the fig.
- Increase the input frequency from 100Hz to 10kHz slowly and after the increase rapidly keep i/p Volt constant.
- Note down the output gain
- Draw gain Vs frequency graph

b) High pass filter

- Make connections as shown in the fig 2.
- Increase the input frequency rapidly till 10kHz afterwards increase slowly till 1MHz. Keep i/p volt constant
- Note down the output gain
- Draw gain Vs frequency graph.

3.6 TABLE OF OBSERVATIONS

a)

Sl no	frequency	Vo (P)(V)	Gain = Vo/Vin	Gain (dB)
1	100Hz	1.45	1.45	3.227
2	200Hz	1.45	1.45	3.227
3	300Hz	1.45	1.45	3.227
4	400Hz	1.45	1.45	3.227
5	500Hz	1.45	1.45	3.227
6	600Hz	1.45	1.45	3.227
7	700Hz	1.45	1.45	3.227
8	800Hz	1.45	1.45	3.227
9	900Hz	1.45	1.45	3.227
10	1kHz	1.45	1.45	3.227
11	2kHz	1.45	1.45	3.227
12	3kHz	1.45	1.45	3.227
13	4kHz	1.45	1.45	3.227
14	5kHz	1.4	1.4	2.92
15	6kHz	1.4	1.4	2.92
16	7kHz	1.25	1.25	1.938
17	8kHz	1.2	1.2	1.58
18	9kHz	1.1	1.1	0.828
19	10kHz	1	1.0	0
20	11kHz	0.9	0.9	-0.91

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Slno	frequency	Vo(p)(v)	Gain = Vo/Vin	Gain (dB)
21	12kHz	0.85	0.85	-1.412
22	13kHz	0.6	0.6	-4.437
23	14kHz	0.45	0.45	-6.9357
24	15kHz	0.45	0.45	-6.9352
25	16kHz	0.4	0.4	-7.959
26	17kHz	0.4	0.4	-7.959
27	18kHz	0.4	0.4	-7.959
28	19kHz	0.25	0.25	-12.041
29	20kHz	0.25	0.25	-12.041
30	25kHz	0.2	0.2	-13.979
31	30kHz	0.1	0.1	-20

b) HIGH PASS FILTER (Vin = 1Vp)

Slno	frequency	Vo(p)(v)	Gain = Vo/Vin	Gain(dB)
1	100Hz	0	0	
2	200Hz	0	0	
3	300Hz	0	0	
4	400Hz	0	0	
5	500Hz	0	0	
6	600Hz	0	0	
7	700Hz	0.1	0.1	-20
8	800Hz	0.1	0.1	-20
9	900Hz	0.1	0.1	-20
10	1kHz	0.1	0.1	-20
11	2kHz	0.15	0.15	-16.478
12	3kHz	0.2	0.2	-13.979
13	4kHz	0.22	0.22	-13.151
14	5kHz	0.25	0.25	-12.041
15	6kHz	0.4	0.4	-7.959
16	7kHz	0.55	0.55	-5.193

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sl.no	frequency	Vo (p)(v)	Gain Vo/Vin	Gain (db)
17	8kHz	0.6	0.6	-4.437
18	9kHz	0.8	0.8	-1.938
19	10kHz	0.9	0.9	-0.915
20	11kHz	0.95	0.95	-0.445
21	12kHz	1.0	1.0	0
22	13kHz	1.1	1.1	0.825
23	14kHz	1.15	1.15	1.214
24	15kHz	1.2	1.2	1.584
25	16kHz	1.2	1.2	1.584
26	17kHz	1.25	1.25	1.938
27	18kHz	1.3	1.3	2.279
28	19kHz	1.3	1.3	2.279
29	20kHz	1.35	1.35	2.606
30	25kHz	1.4	1.4	2.922
31	30kHz	1.4	1.4	2.922

3.7. SPECIMEN CALCULATION.

cut off frequency

$$f_c = \frac{1}{2\pi RC} \qquad R = 1.5k\Omega \qquad C = 0.01\mu F$$

$$= \frac{1}{2\pi \times 1.5\times10^{3}\times0.01\times10^{-6}}$$

$$\boxed{f_c = 10.61\,kHz}$$

Gain

$$A_v = 1 + \frac{R_f}{R_1} \qquad R_f = 1k\Omega \qquad R_1 = 2.2k\Omega$$

$$= 1 + \frac{1}{2.2}$$

$$\boxed{A_v = 1.45}$$

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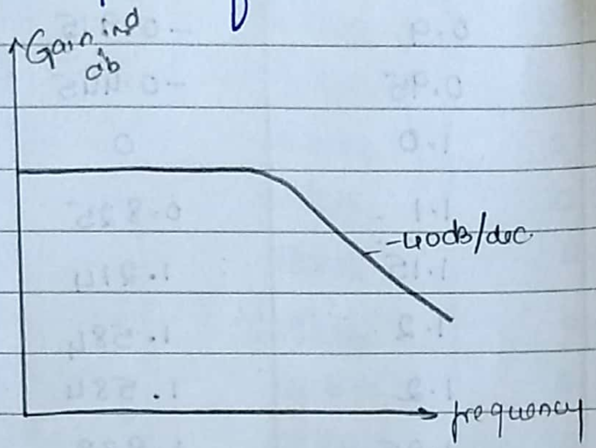
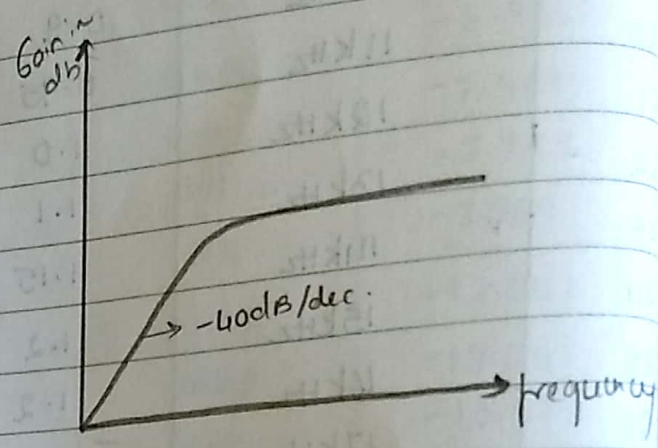
3.8. NATURE OF GRAPH

a) Low pass filter.



b) High pass filter



3.9. RESULTS AND CONCLUSION.

After the completion of experiment we have concluded that desired outputs are coming but there is a slight error in calculated and observed output. This is because of faulty connections.

We are getting cut off frequency as $f_c = 10.61 kHz$ when calculated but during observation we are getting as 12 kHz

4.1. TITLE OF THE EXPERIMENT

Sample and Hold circuit.

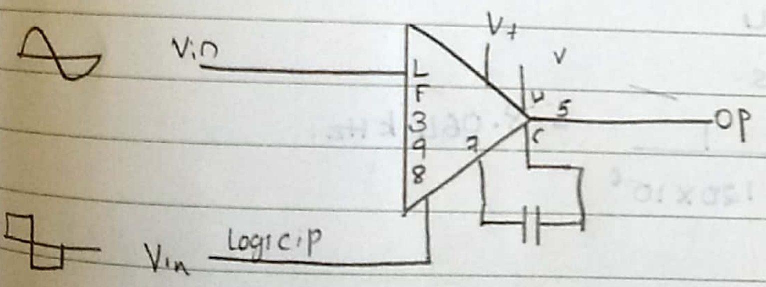
4.2. AIM OF THE EXPERIMENT

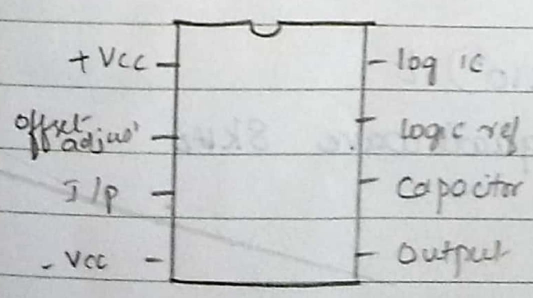
To design and implement sample and hold circuit using LF398

4.3 LIST OF COMPONENTS

Sl no	components/equipment	specification	Quantity
1	Regulated DC	0-20V, 2A	2
2	CRO	80 Vpp/20MHz	1
3	function generator	0-1 MHz	2
4	Sample & Hold IC.	LF398	1
5	capacitor	01 μF/0.1μF	1
6	BNC		1
7	Wires		3
			assorted

4.4. DESIGN





4.5. STEP BY STEP PROCEDURE

- connect as shown in the fig
- Give a Sine wave of 2Vp & 1kHz from 3rd pin
- Give a square wave of 2Vp & 5kHz from pin 5
- Check the Output from CRO.
- Calculate hold and sample time.

4.6. OBSERVATIONS

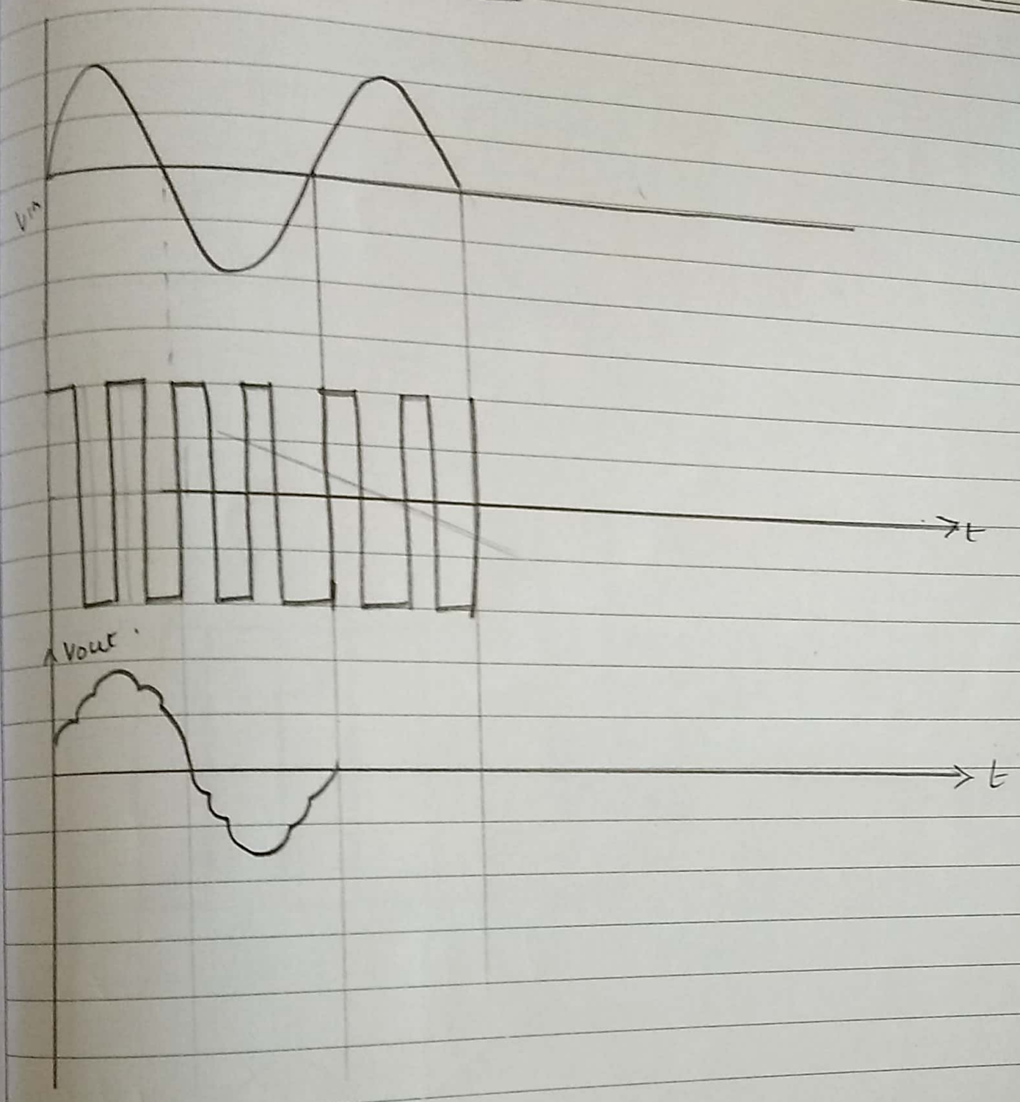
- Input signal amplitude : 4 V_{p-p}.
- I/p signal frequency : 1kHz
- Logic signal frequency = 8kHz
- Logic signal amplitude = 4 V_{p-p}.
- Amplitude of modulated signal : 4 V_{p-p}
- Hold time of the modulated Signal : 60 µs (T_H)
- Sample time of the modulated signal : 64 µs (T_s)
- $T_{inst} = T_s + T_H$, frequency $= f_s = \frac{1}{T_{inst}}$

$$T_{inst} = 60 + 64$$
$$= 124\,\mu s.$$
$$f_s = \frac{1}{120 \times 10^{-6}} = 8.064 \text{ kHz}.$$

4.7. SPECIMEN CALCULATION.

$$V_{in} = 2V_p \sin(2\pi \times 10^3)t$$
logic i/p = $2V_p$, Square wave 8kHz

4.8 NATURE OF GRAPH



4.9. RESULTS AND CALCULATION.

the circuit that we have designed is working according to our requirement. We are getting the Output as we coated and to improvise the Output just increase the frequency of logic Signal input.

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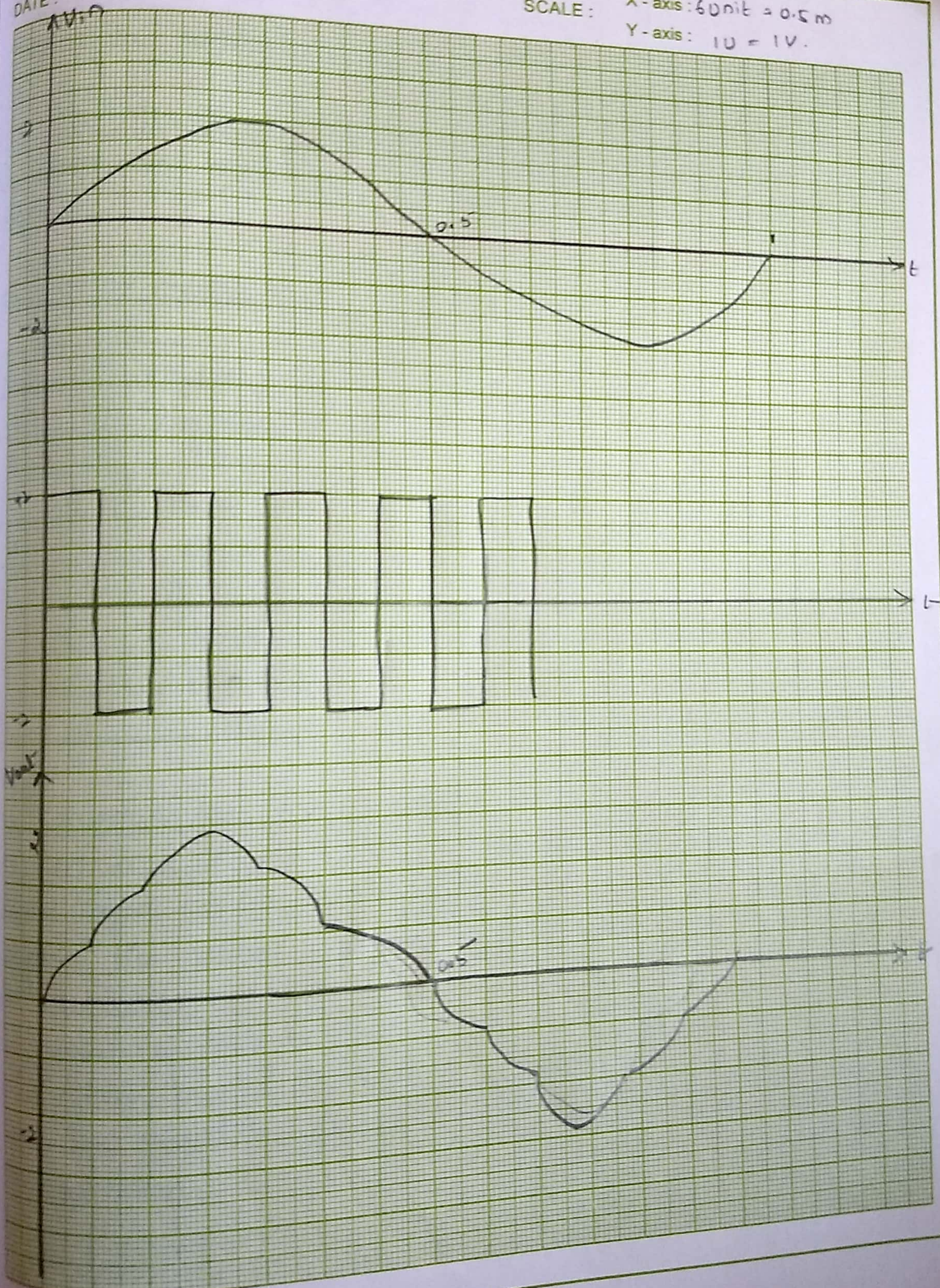
EXPERIMENT NO. :

Page No.:

DATE :

SCALE : X - axis : 6 unit = 0.5 m

Y - axis : 1U = 1V.



5.1 TITLE OF THE EXPERIMENT.

Digital to Analog converter.

5.2. ~~PO-1~~ AIM OR OBJECTIVE.

To design and implement a circuit which converts a digital to Analog signal.

5.3. LIST OF COMPONENTS.

Sl no.	components	specifications.	Quantity
1	Regulating DC	0-20V, 2A.	2
2	CRO	80 V_{pp} [20MHz]	1
3	Power pack	+12V, -12V.	1
4	op-amp	µA741	1
5	function generator	0-1MHz.	1
6	Resistors	10k, 1k, 1/2watt	2, 2
7	BNC Probes	-	2
8	Wires.	-	assorted

5.4. THEORETICAL BACKGROUND.

In electrons, a digital to analog converter is a system that converts a digital signal into an analog signal. An analog to digital converter performs the reverse function. There are several DAC architectures, the suitability of a DAC for a particular application is determined by figures of merit including resolution. Maximum sampling frequency and others. Digital to Analog conversion can degrade a signal so a DAC should be specified that HQs insignificant errors in terms of the application.

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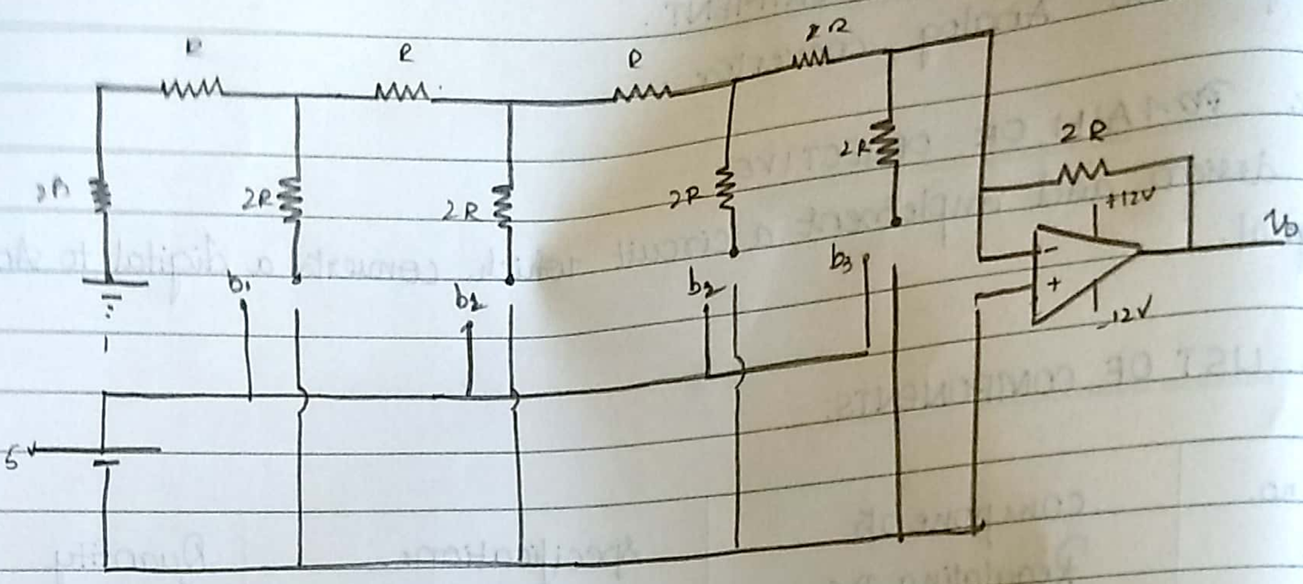
5.5 DESIGN



5.6. PROCEDURE.

- Connect the circuit as shown in the figure.
- Apply the Sinusoidal input of $V_{in} = 2V$ and $f = 1kHz$.
- Take V_{ref} as 5V, $R_f = 10k$ & assume $R = 34k\Omega$ and construct the resistors according to the circuit.
- Repeat the procedure for all possible 4 bit number combinations.
- Note down the corresponding Output Voltage

5.7. TABLE OF OBSERVATION

Binary Inputs				Vo(obs)	Vo(cal.)	Error
b_3	b_2	b_1	b_0			
0	0	0	0	0	0	0
0	0	0	1	0.552	0.625	0.073
0	0	1	0	1.2	1.25	0.05
0	0	1	1	1.75	1.875	0.125
0	1	0	0	2.5	2.5	0.
0	1	0	1	3	3.125	0.175
0	1	1	0	3.7	3.75	0.05
0	1	1	1	4.27	4.375	0.105

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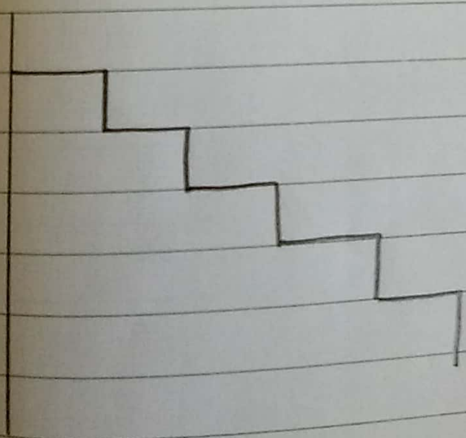
Binary Inputs				Vo (obs)	Vo (cal)	Error
b_3	b_2	b_1	b_0			
1	0	0	0	5.2	5	0.2
1	0	0	1	5.75	5.625	-0.125
1	0	1	0	6.4	6.25	-0.15
1	0	1	1	6.46	6.875	-0.085
1	1	0	0	7.72	7.5	-0.22
1	1	0	1	8.27	8.125	-0.145
1	1	1	0	8.57	8.750	0.18
1	1	1	1	8.9	9.375	0.47

5.8. SPECIMEN CALCULATION.

$$V_0 = -\frac{R_f}{R_1}(V_{ref})\left[\frac{b_3}{2} + \frac{b_2}{4} + \frac{b_1}{8} + \frac{b_0}{16}\right]$$

Here, $R = 3.9\,k\Omega$.

5.9. NATURE OF GRAPH.



5.10. RESULTS AND CONCLUSION

A digital to analog converter circuit converts a digital signal to an analog signal with resolution of -0.625 for next binary input & corresponding observed & calculated output voltage is rated down.

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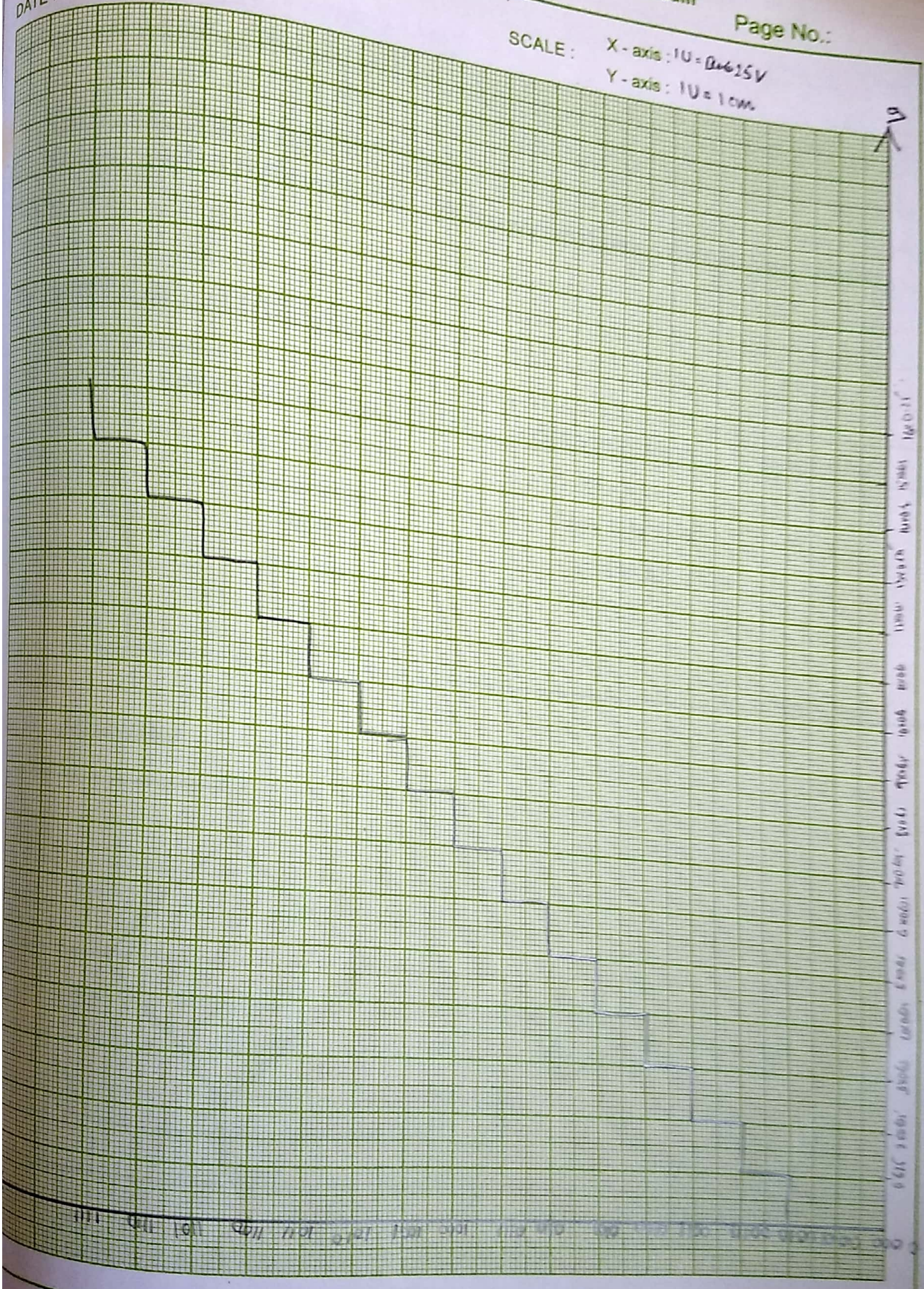
EXPERIMENT NO. :

DATE :

Page No.:

SCALE : X - axis : 1U = 0.625V
Y - axis : 1U = 1cm



6.1. TITLE OF THE EXPERIMENT

Instrumentation Amplifier.

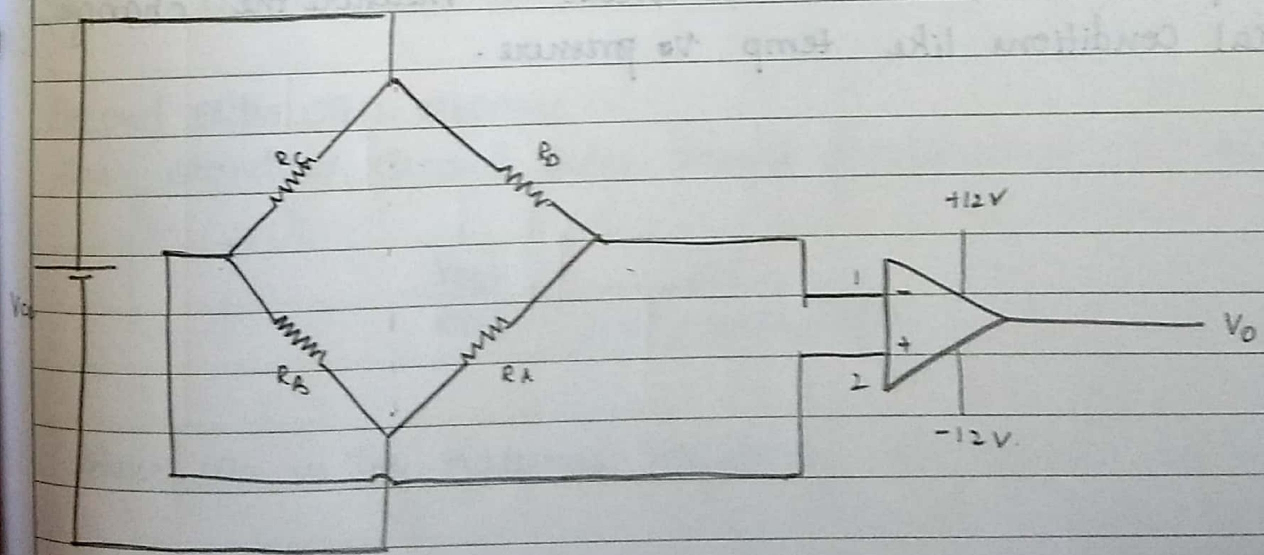
6.2. AIM OF THE EXPERIMENT.

to design and implement an instrumentation amplifier Using. INA114

6.3. LIST OF COMPONENTS.

Slno.	components/equipments	Specifications	Quantity
1	Regulated DC	0-20V, 2A	2
2	Resistors.	1kΩ, 10kΩ ½watt	2, 1
3	DAB	0.1MΩ	1
4	INA114	8 pin	1
5	DMM	-	1
6.	Wires	-	assorted

6.4 DESIGN



6.5. STEP BY STEP PROCEDURE.

- Make the connections as shown in figure
- Go on Varying R_D and measure V_A & V_B at pin 2 & 3
- Write down Voltages at Pin 6 using DMM.

6.6. TABLE OF OBSERVATIONS.

Sl no.	Resistance (Ω)	V_A	V_B	$V = V_A - V_B$	$V_o - V.G.$	V_o	Error
1	3.9k	2.5	2.5	0	0	0	0
2	4k	1.85	1.8	0.05	0.3	0.11	0.19
3	4.1k	1.84	1.8	0.04	0.24	0.18	0.06
4	4.2k	1.82	1.78	0.04	0.24	0.24	0.0
5	4.3k	1.81	1.75	0.06	0.36	0.31	0.05
6	4.4k	1.82	1.75	0.07	0.42	0.38	0.04
7	4.5k	1.78	1.7	0.08	0.48	0.44	0.04
8	4.6k	1.76	1.67	0.09	0.54	0.50	0.04
9	4.7k	1.75	1.65	0.1	0.6	0.55	0.05

6.7. RESULTS AND CONCLUSION.

In the experiment we can use this circuit to measure the change in physical conditions like temp v/s pressure.

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MATLAB EXPERIMENTS.

9A.1 TITLE OF THE EXPERIMENT

Second Order step response, peak time Over shoot and Unity feedback

9A.2. AIM/OBJECTIVE

To study and Understand about the Second Order Standard transfer function, the maximum Value of the given response to study about the Unity feedback control loops.

9A.3 LIST OF EQUIPMENTS

Sl no	components	specification	Quantity
1	Qube-Servo2closed	-	1
2	Quarc controller	-	1
3	Software Simulink	-	1
4	Desktop	-	1

9A.4 THEORETICAL BACKGROUND

Second order step response:
The standard Second Order transfer function has the form

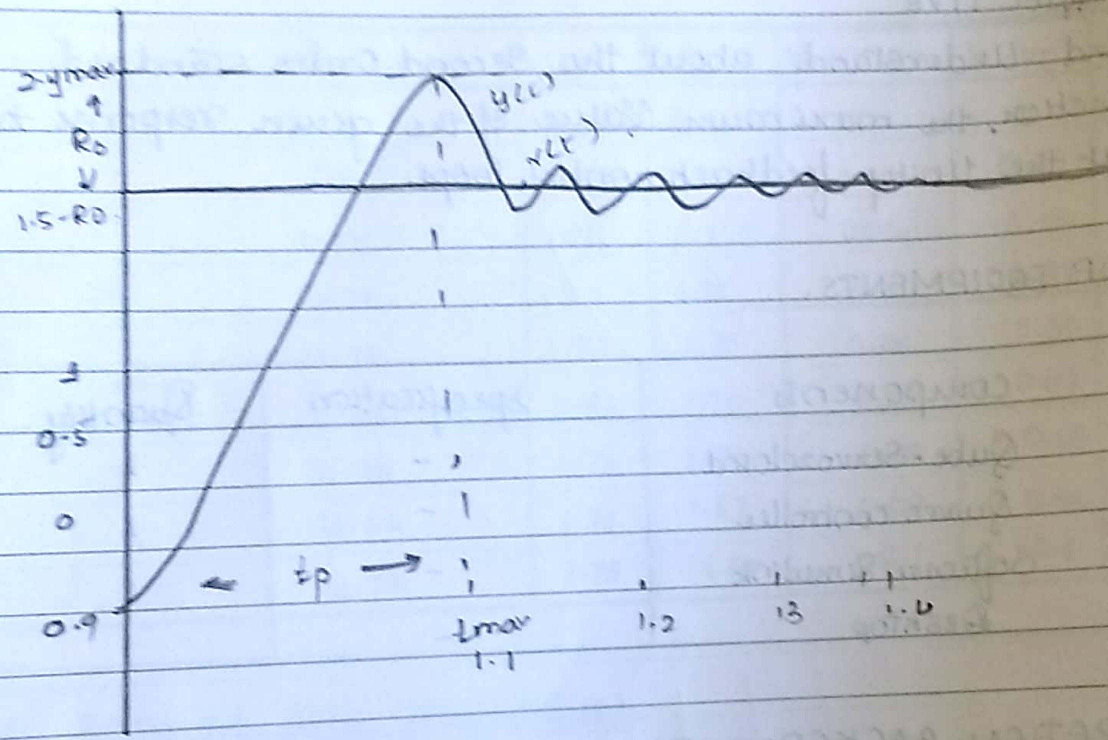
$$\frac{V(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

where ω_n is the natural frequency and ξ is damping factor.

consider Second-Order system shown in equation ① subjected to a Step input given by,

$$R(s) = \frac{R_0}{s}$$

where step modulation amplification of $R_0 = 1.5$. The system response to this input shown in fig. whether there is trace output response on y(t) & the dotted trace input is step input.



b) Peak time and Over shoot
the maximum Value of the is denoted by Variable y ~~mote~~ max & it occurs at time tmax. For a response similar to figure in previous, the percent Over shoot is found using

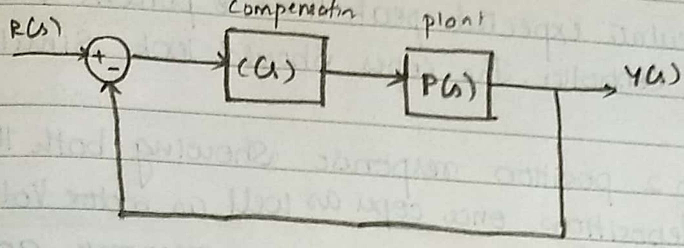
$$P_0 = \frac{100\,(V_{max} - R_0)}{R_0}$$

We also have $P_0 = 100e^{\frac{-\sqrt{\pi}\xi}{1-\xi^2}}$.

$$tp = \frac{\sqrt{\pi}}{\omega_n(1-\xi^2)}$$

c) Unity feedback.

The unity feedback controller loop in the figure will be used to control the position of QUBE-SERVO 2

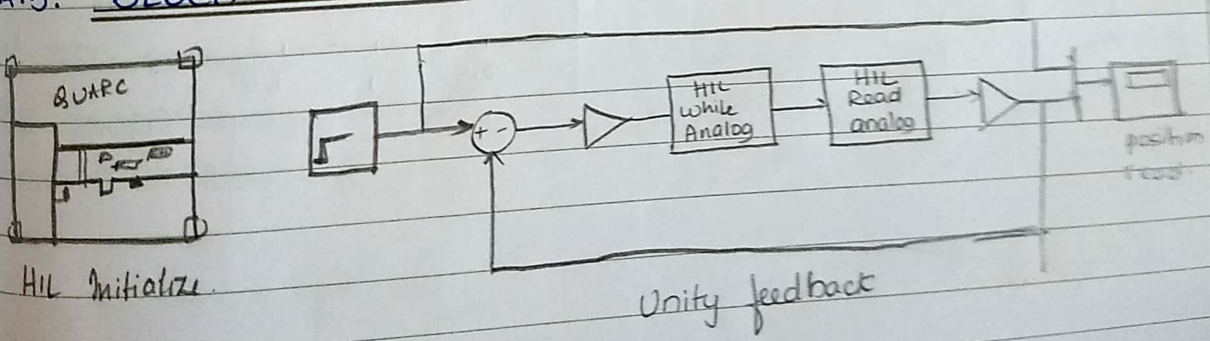


$$P(s) = \frac{\theta m(s)}{Vm(s)} = \frac{k}{s(Ts+1)}$$

The closed loop transfer function of position control from the reference point $R(s) = \theta(d(s))$ to output $y(s) = \theta m$ using the feedback.

$$\frac{\theta d(s)}{Vm(s)} = \frac{k}{s^2 + \frac{1s}{T} + \frac{k}{T}}$$

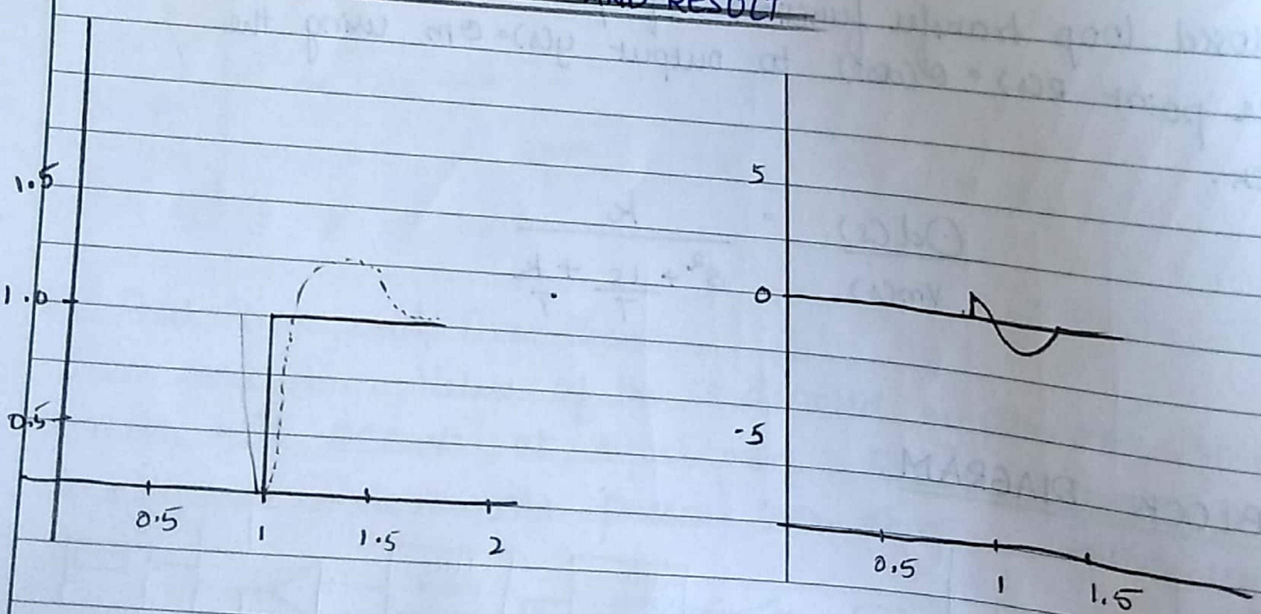
9A.5. BLOCK DIAGRAM.



9A.5 DESIGN STEPS.

- Given the QUBE - SERVO2 - closed loop equations, find natural frequen and damping ratio.
- Based on ω_n & ξ, calculate expected peak time & percent Overshoo
- Build & run the QUARC Controller. The copes should look Similar to figure before
- Attach the cube SERVO 2 position response showing both the Se point and measure depositions once copu as well as motor Voltage
- Measure the peak time & percent over shoot from response and compare that with expected results.
- Stop the QUARC controller.
- Power off the servo 2.

9A.7. OUTPUT WAVEFORM AND RESULT



1.1 TITLE OF THE EXPERIMENT

Study of Servo model, PID control & PV position control

1.2 AIM OF THE EXPERIMENT.

The aim is to learn about servo position control, proportional derivative compensation and designing control according to specifications.

1.3 LIST OF THE EXPERIMENTS.

Sl no.	components	Quantity
	QUBE - SERVO(2) closed.	1
	QUARC controller	1
	Simulink Software	1

1.4. THEORETICAL BACKGROUND.

Servo model.

The QUBE - Servo2 Voltage to position transformer function

$$P(s) = \frac{\theta_m(s)}{V_m(s)} = \frac{k}{s(s+1)}.$$

PID control

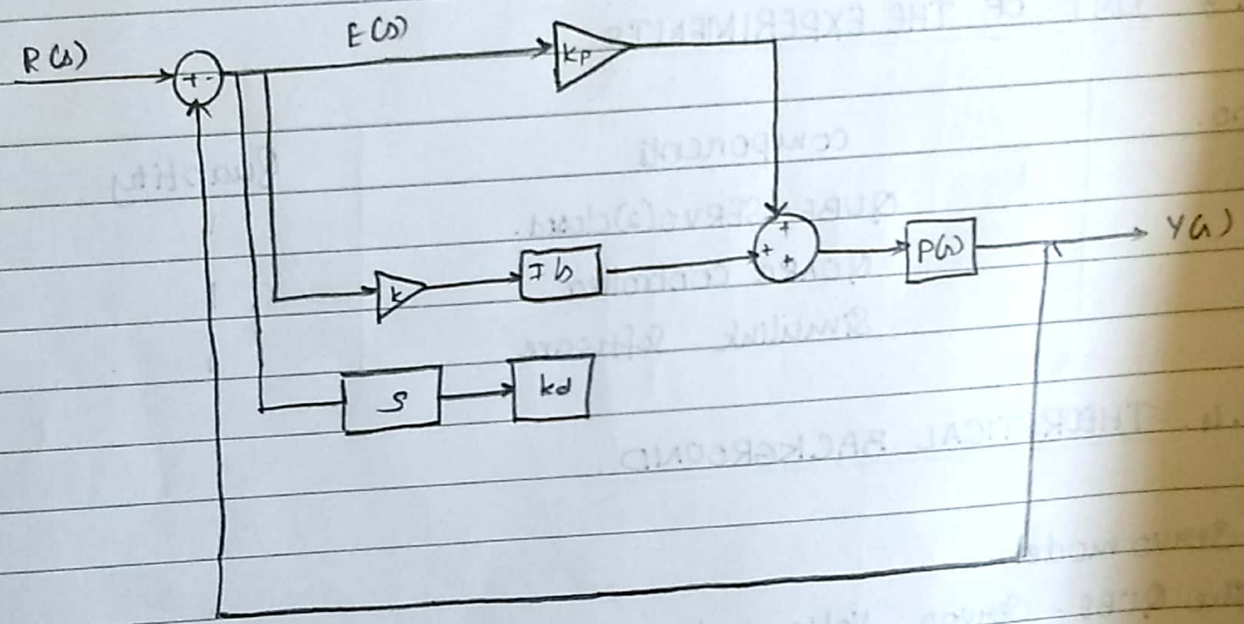
The proportional, integral & derivative control can be expressed mathematically as,

$$V(t) = k_p e(t) + k_i \int e(\tau)\, d\tau + k_d \frac{de(s)}{dt}.$$

The corresponding block diagram is given below.

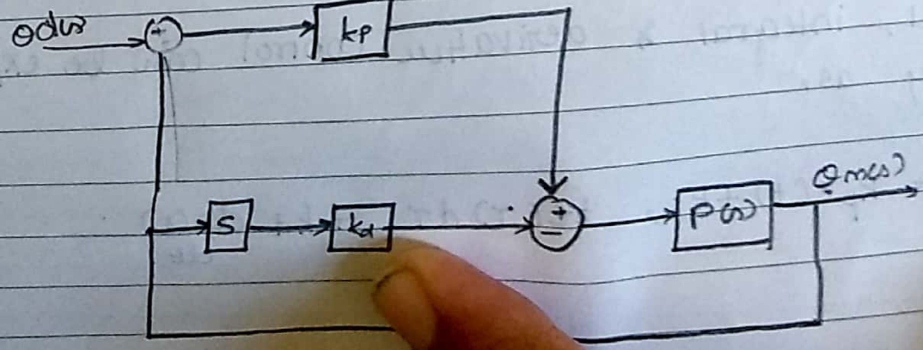
The controller equation can also be described as,

$$C(s) = kp + \frac{k_i}{s} + kS(v)$$



c) PV position control

The integral term will not be used to control these server positions. A variation of the classic PD control will be used.



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servo 2 is denoted by $y(s)/R(s) = \theta_m(s)/V_d(s)$. Assume initial $\theta_m(0^-)=0$ & $\dot{\theta}_m(0^-)=0$.

$$U(s) = K_p(R(s) - y(s)) - K_d s\, y(s)$$

Solving for $Y(s)/R(s)$ the obtained loop expression is,

$$\frac{Y(s)}{R(s)} = \frac{K k_p}{Ts^2 + (1+Kk_d)s + Kk_p}$$

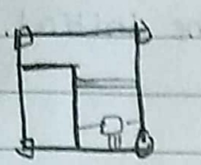
This is the form of 2nd order transfer equation function

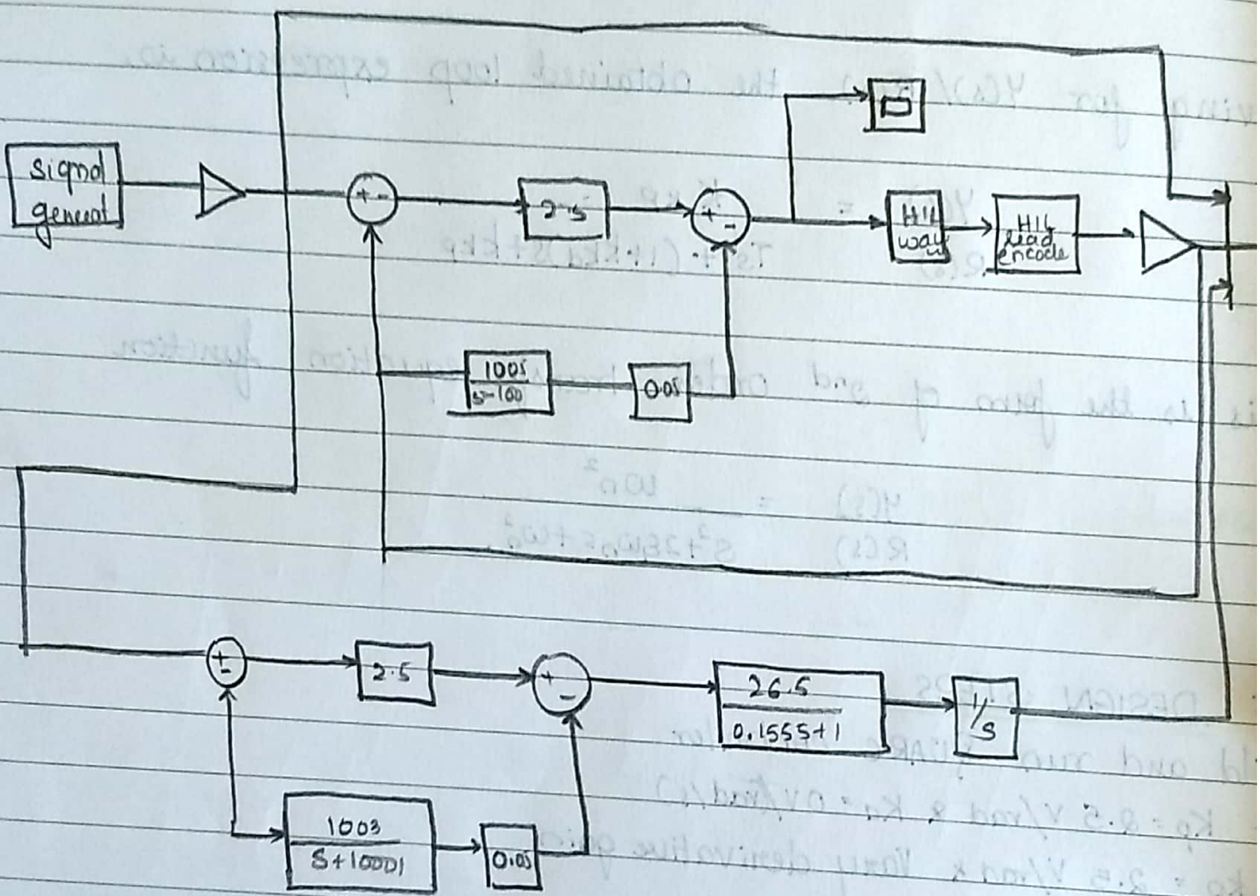
$$\frac{Y(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}.$$

9B.5 DESIGN STEPS

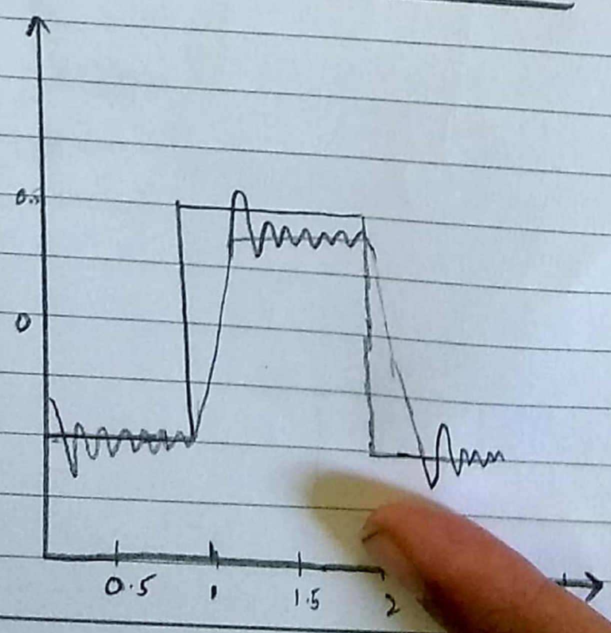
- Build and run QUARC controller
- Set $K_p = 2.5$ V/rad & $K_d = 0$ V/(rad/s)
- Set $k_p = 2.5$ V/rad & Vary derivative gain
- Stop the Quarc controller
- Power OFF QUBE SERVO-2

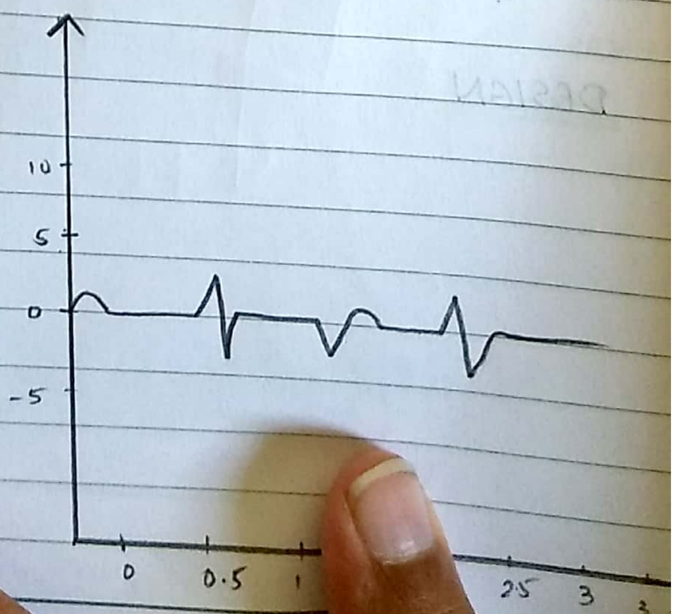
9B.6 DESIGN





98.7 RESULT & WAVEFORM





9C.1. TITLE OF THE EXPERIMENT

filtering

9C.2. AIM OF THE EXPERIMENT

To study about measuring speed using encoder and to Understand high frequency low pass filters blocking technique.

9C.3 LIST OF EQUIPMENTS.

Sl no.	components	specifications	Quantity
1	QUBE, SERVO 2 closed	-	1
2	QUARC controller	-	1
3	Software Simulink	-	1

9C.4. THEORETICAL BACKGROUND

all low pass filters can usually be used to block out the high frequency components of a signal.

A first order low pass filter transfer function is of the form

$$G(s) = \frac{\omega_f}{s+\omega_f}$$

where, ω_f is the cut off frequency of the filter in radian per second.

9C.5 DESIGN

Take the model and develop into the QUBE-SERVO 2 integration lab, change the encoder Calibration gains to measure the gear position in radians.

Build the simulation diagram.

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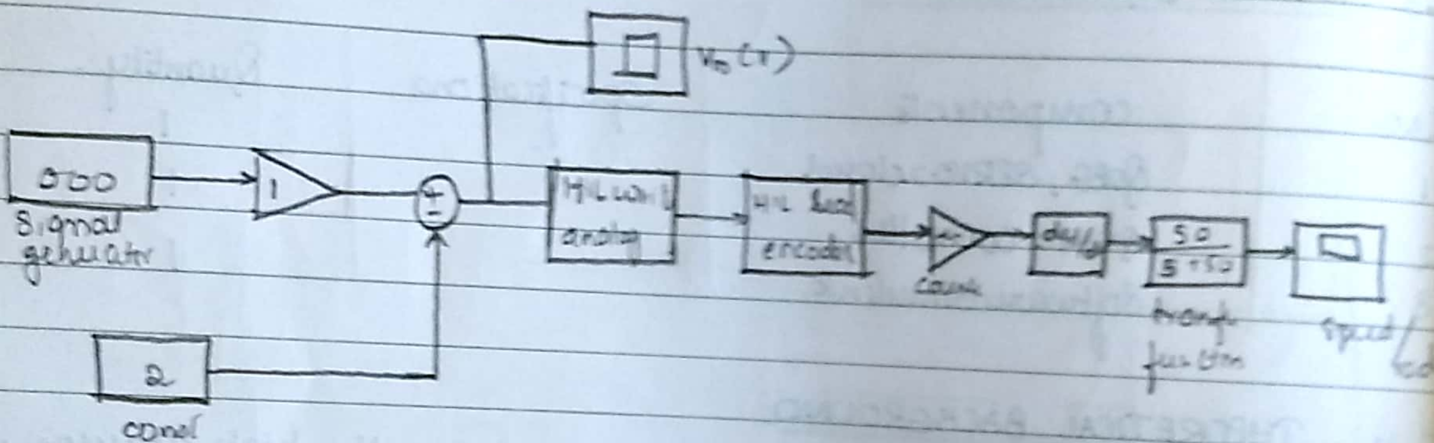
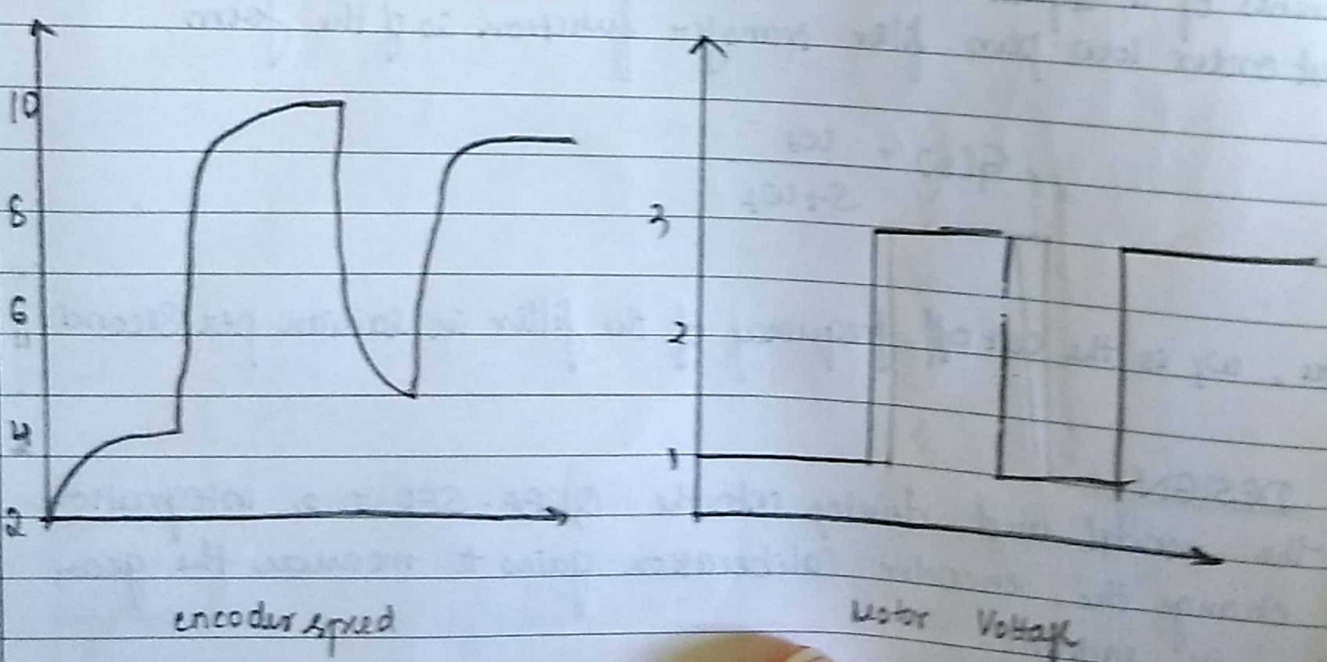
- Set up the Source blocks to output are Step Voltage that goes from 1V to 3V @ 0.4Hz.
- Build and run the Quarc controller. Examine the ecoder speed response.
- Attach Sample response
- Stop the Quarc controller
- Power off the QUBE SERVO-2

9c.6. BLOCK DIAGRAM



9c.7. OUTPUT WAVEFORM & RESULT



9D.1 TITLE OF THE EXPERIMENT

First principle modelling

9D.2. AIM OF THE EXPERIMENT.

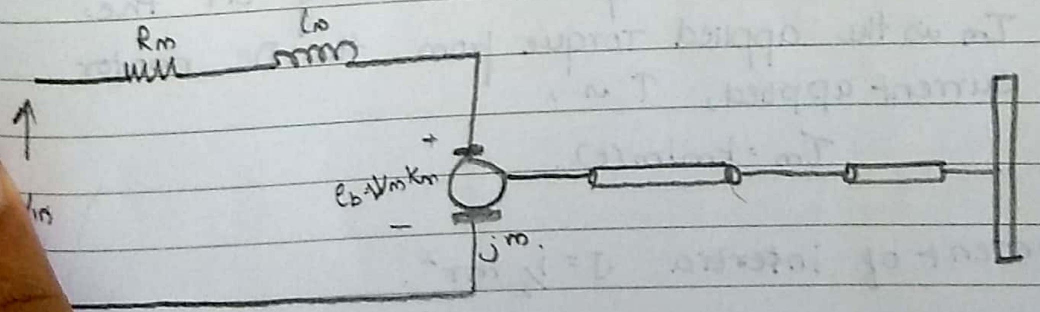
- To oblain the equation of a DC based rotary servo.
- To create & validate system model
- Model validation.

9D.3. COMPONENTS REQUIRED

Slno.	Components	Quantity.
1	QUBE - SERVO 2 [closed]	1
2	QUARC controller	1
3	Simulink Software	1

9D. 4. THEORETICAL BACKGROUND

The Quanser QUBE - SERVO 2 is direct Driver rotary servo system
This motor armature circuits schematic is shown in fig ⓐ below
The electrical & mechanical parameters are given the table
The hub is a metal disk used to mount the disk / rotary pendulum and has a moment of inertia of Jh. A disk load attaches to the Output shaft with a moment of inertia' Jd



The back-emf (electromotive) voltage $e_b(t)$ depends on the speed of the motor shaft, ω_m & the back-emf constant of the motor, K_m. It opposes the current flow. The back emf voltage is given by,

$$e_b(t) = K_m \omega_m(t).$$

Using Kirchoff's Voltage law, we can write the following equations.

$$V_m(t) - R_m i_m(t) - \frac{L_m d i_m(t)}{dt} - k_m \omega_m(t) = 0. \quad \text{—(a)}$$

L_m is much less than resistance, it can be ignored.

$$V_m(t) - R_m i_m(t) - k_m \omega_m(t) = 0$$

$$i_m(t) = \frac{V_m(t) - k_m \omega_m(t)}{R_m}.$$

The motor shaft equation is expressed as,

$$J_{eq} \dot{\omega}_m(t) = \tau_m(t).$$

where J_{eq} is total moment of inertia acting on the motor shift and τ_m is the applied Torque from the DC motor Based on current applied, τ is,

$$\tau_m = k_m i_m(t).$$

moment of interia $J = \frac{1}{2} mr^2.$

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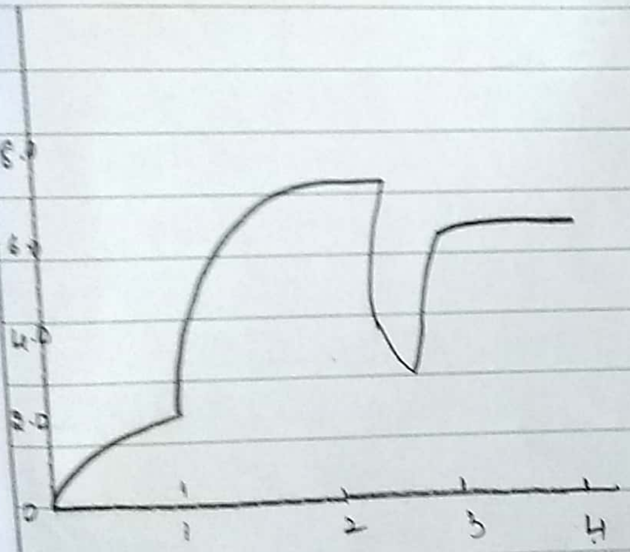
DESIGN STEPS.

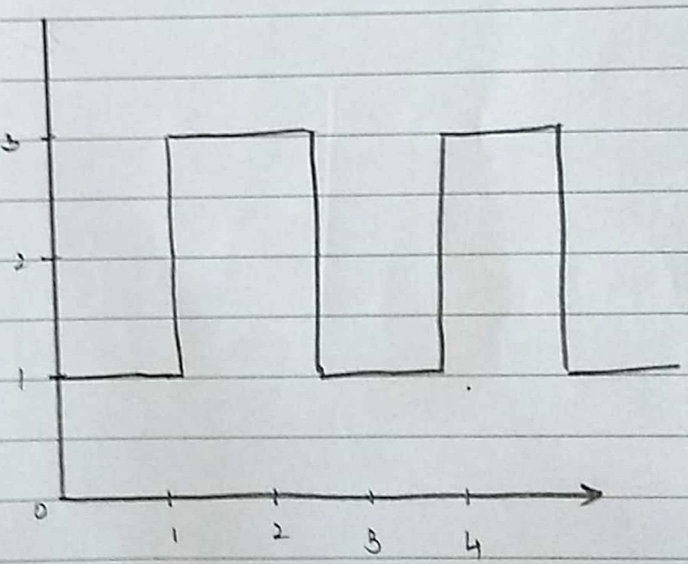
Motor shaft of QUBE-SERVO 2 is attached to lead hub and a disc load based on the parameters given table. Calculate the equivivalent moment of inertia that is acting on motor shaft.

Design of QUBE

SERVO-2 motor sub system described above, attached, server capture of the model & the matlab script.
Build and run the QUARC controller with your QUBE
Stop the QUARC controller
Power off the QUBE-SERVO-2.

9D.6 OUTPUT WAVEFORM AND DESIGN





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