KLE TECHNOLOGICAL UNIVERSITY, Bhoomaraddi Campus, Hubballi

Experiment No :

Title of the experiment :

Linear applications - Inverting amplifier, Non-inverting amplifier and voltage follower.

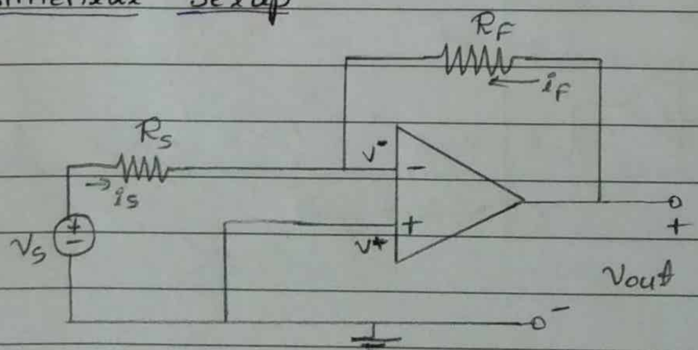
Objective of the experiment :

To design and test the performance of the inverting amplifier and attenuator, non-inverting amplifier and voltage follower.

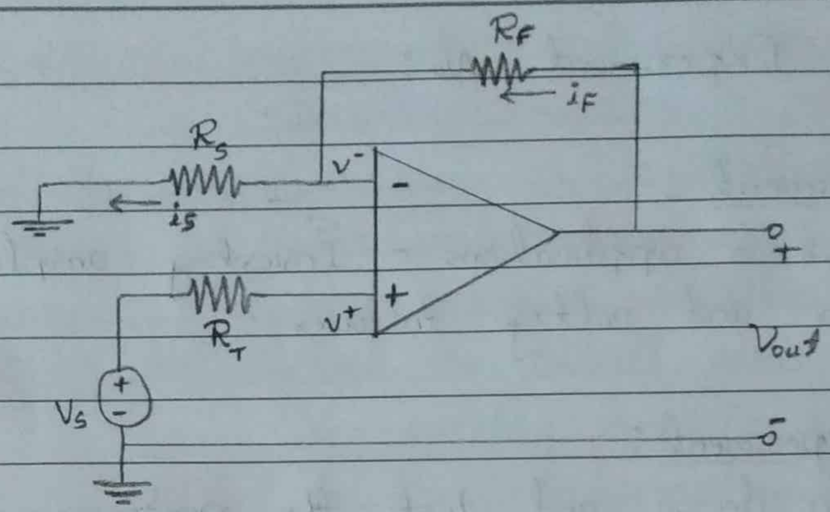
List of components/Equipments :

Sl. No.	Components	Specifications	Quantity
01	Regulated DC supply	0-30V, 2A	02
02	CRO	80 Vpp/20MHz	01
03	Ammeter	0-500nA	02
04	+12V and -12V power pack	—	01
05	Op-Amplifier	μA-741	01
06	Resistor	10k, 1k ½W CFR	02 each
07	Function generator	0-1MHz	01
08	BNC probes	—	02

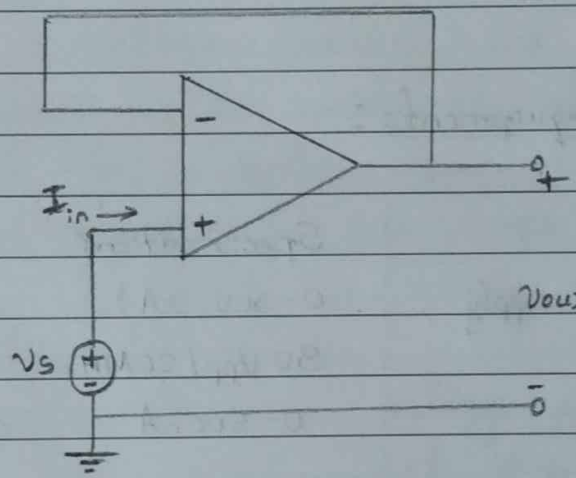
Experimental setup



Inverting amplifier

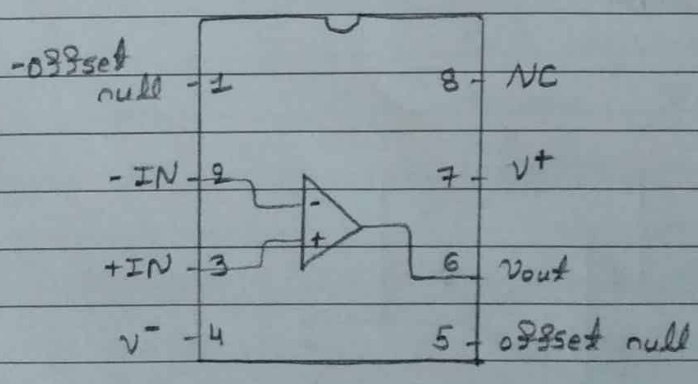


Non-inverting amplifier



Voltage follower

<u>Pin configuration of Op-Amp 741 IC:</u>



Theoretical background for the experiment:

Inverting Amplifier : It is a normal OP-AMP in which the output is given as a feedback to the inverted terminal of input by means of a feedback resistor. Now, the op-amp becomes closed loop inverting Amplifier which uses negative feedback to control the overall gain of amplifier.

Non-inverting Amplifier : The input voltage is directly applied to the non-inverting input terminal which means that the output gain of the amplifier becomes positive in value in contrast to the inverting Amplifier.

Voltage follower : It is also known as unity gain amplifier, a buffer and an isolation amplifier i.e, a op-amp circuit which has a voltage gain of 1. This means that the op-amp does not provide any amplification to the signal.

Formulae - required:

Inverting Amplifier : Voltage gain $\rightarrow -R_f/R_1$

Let required gain be 10

Assume $R_1 = 1k\Omega$

Therefore $R_f = 10k\Omega$

Non-inverting Amplifier: Voltage gain $= 1 + R_f/R_1$

Let required gain be 11

Assume $R_1 = 1k\Omega$

Therefore $R_f = 10k\Omega$

Voltage follower : Voltage gain $= \frac{v_o}{v_i} = 1$ (Unity)

Step by Step procedure to carry out experiment :

1] Connect the circuits as shown in figure
2] Select Input voltage (v_i) of 1KHz frequency and $v_m = 0.5\ V_{pp}$ is given from AFO.
3] Check ouput on CRO, Compare input and output
4] Note down the output voltage (v_o) and calculate the gain
5] Plot the graph for input and output voltage
6] Repeat the above steps for verifying other circuits.

Table of observation :

1] Inverting Amplifier

Sl.no	$V_{in(p-p)}$	$V_{o(p-p)}$	R_f	R_{in}	Gain (v_o/v_i)	Error

2] Non-inverting Amplifier

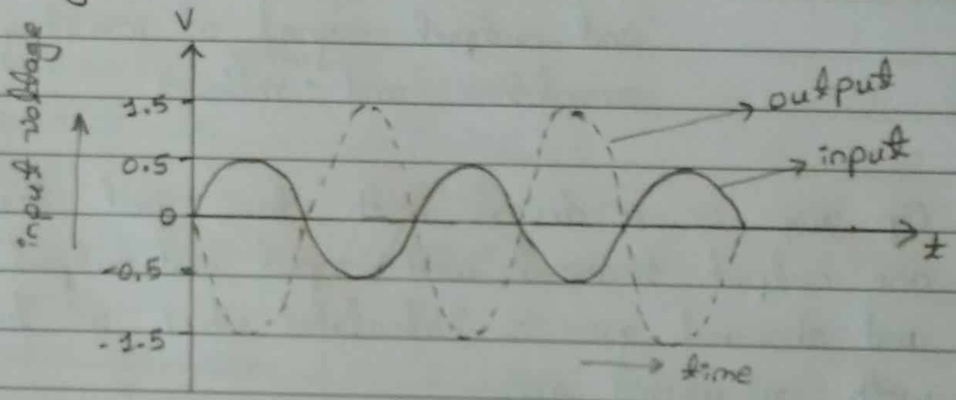
Sl.no	$V_{in(p-p)}$	$V_{out(p-p)}$	R_f	R_{in}	Gain (v_o/v_{in})	Error

3] Voltage follower

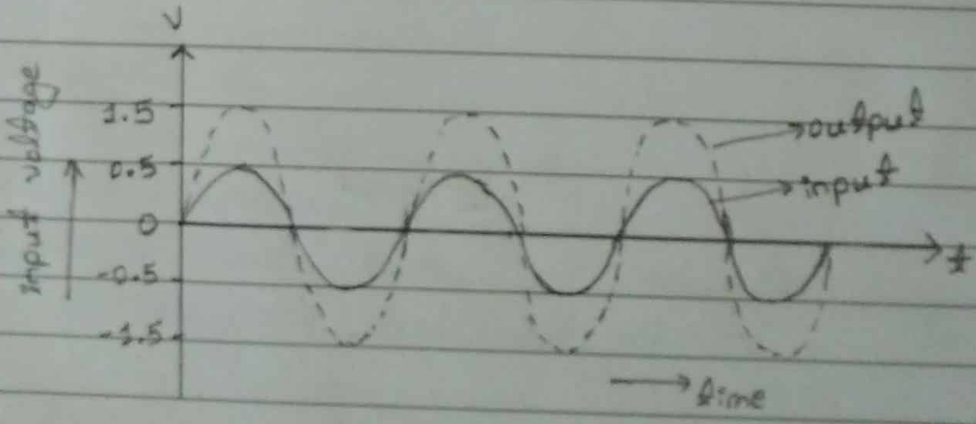
Sl.no	$V_{in(p-p)}$	$V_{out(p-p)}$	R_f	R_{in}	Gain (V_o/V_{in})	Error

Specifimen calculation : NA

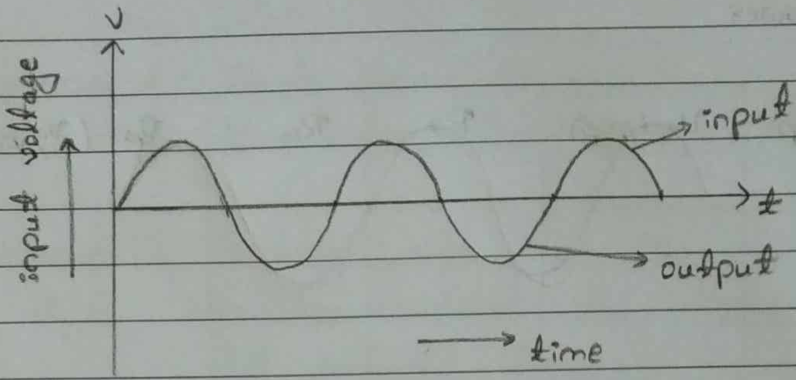
Nature of graph :



Inverting Amplifier



Non-inverting Amplifier



Conclusion of the Experiment :

Result and discussion : Experimental setup for measuring input and output signal of inverting, non-inverting amplifier and voltage follower

Conclusion : Op-amp is a device with two input terminals and one output terminal, with input and output plotted and observed gain is calculated which in turn is verified with calculated gain.

Experiment No. :

Title of experiment: Realization of non-linear applications - Zero crossing detector (ZCD) and schmitt trigger.

Problem statement: To design and test the performance of non-linear applications - Zero crossing detector and schmitt trigger.

List of components / Equipment :

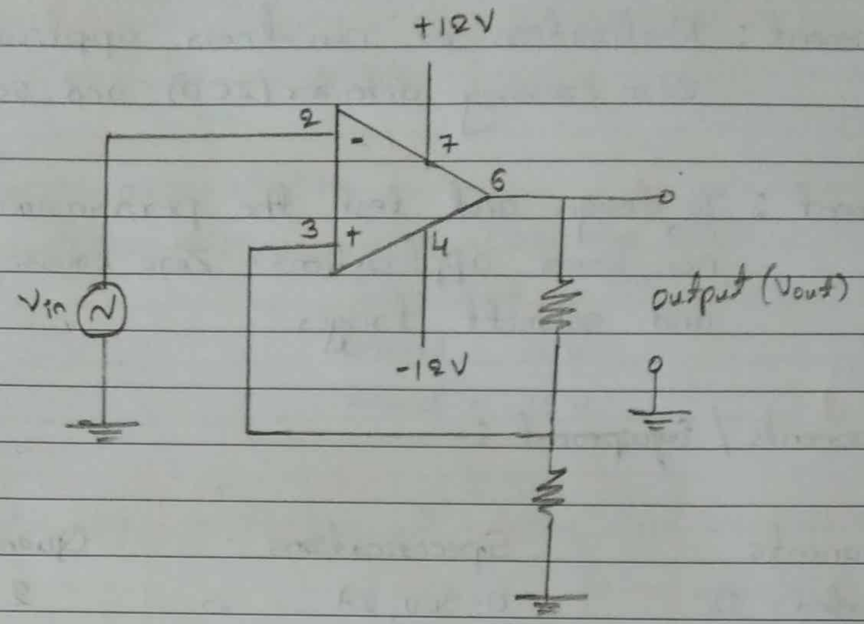
Sl.no	Components	Specifications	Quantity
1	Regulated DC	0-30V, 2A	2
2	CRO	80 V_{p-p} / 20MHz	1
3	Power Pack	+12V & -12V	1
4	Op-amp	μA-741	1
5	Function generator	0-1MHz	1
6	Resistor	10K ½ watt CFR	2
7	BNC Probes	—	2
8	Wires	—	assorted

(a) Schmitt trigger :

Objective of the experiment :

Design and testing of schmitt trigger for noise margin +/- 12V and dead band of 0V.

Experimental setup :



Theoretical background for the experiment :

Schmitt trigger converts an irregular shaped waveform to a square wave or pulse. The input voltage V_{in} triggers the output every time it exceeds certain voltage levels called the upperthreshold V_{UT} and lower threshold voltage V_{LT}.

When, $V_o = +V_{sat}$ the voltage across R_1 is called the upper threshold voltage across V_{UT} i.e, $V_{UT} = \frac{R_1}{(R_1+R_2)}(+V_{sat})$.

The input voltage must be slightly more +ve than V_{UT} in order to cause the output voltage V_o to switch from $+V_{sat}$ to $-V_{sat}$ when, $V_o = -V_{sat}$. The lower threshold voltage V_{LT} is given as $V_{LT} = \left(\frac{R_1}{R_1+R_2}\right)(-V_{sat})$ V_{in} must be slightly more -ve than V_{LT} in order to cause the output V_o to switch from $-V_{sat}$ to $+V_{sat}$, Thus if threshold voltage V_{UT} and V_{LT} are made larger than input noise margin the positive feedback will eliminate the focuse output transaction.

Formulae required :

1] $V_{UT} = \frac{R_1}{R_1 + R_2} (+V_{sat})$

2] $V_{LT} = \frac{R_1}{R_1 + R_2} (-V_{sat})$

3] Design calculation

Given data ; Noise margin = ±12 V

Deadband = 6V

+Vsat = 12 V

-Vsat = 12 V

Step by step procedure to carry out experiment :

1] Connections are made as per circuit diagram.

2] The input given in such a way that the output switches between +Vsat and -Vsat

3] From the output waveform and the input waveform, the dead band is calculated.

4] Feeding input to channel A and output to channel B, and connecting CRO to X Vin A mode through which hysteresis width is measured.

Table of observation :

Input voltage (V_{in})	Vout (p-p) (in V)		input frequency	output frequency	(Noise Margin) $V_H = V_{UTP} - V_{LTP}$	V_{UTP}	V_{LTP}
	+Vsat	-Vsat					

Specimen Calculation :

$$V_{UTP} = \frac{+V_{sat} \times R_1}{R_1 + R_2}$$

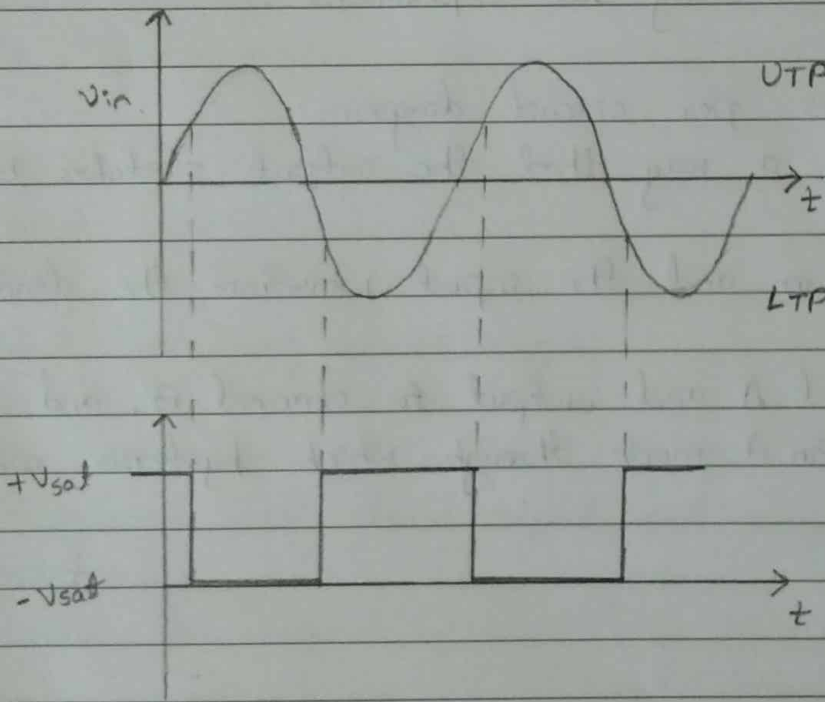
$$2 = \frac{10 \times R_1}{R_1 + R_2}$$

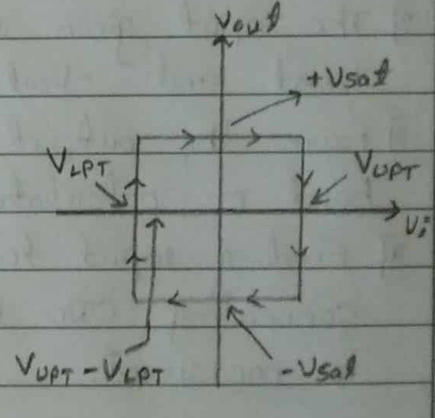
$$R_1 + R_2 = 5R_1$$

$$R_2 = 4R_1$$

Assume, $R_1 = 1K\Omega$ $R_2 = 4K\Omega$

Nature of graph :





(Transfer function)

Conclusion of the experiment :

After performing the experiment, we can conclude that the input voltage triggers the output every time, so that the irregular waveform gets converted into square wave or pulse.

(b) Zero crossing Detector :

Aim : To design and setup a zero crossing detector circuit with OP-AMP 741IC and plot the waveform

Theoretical Background :

It is the open loop / Saturation mode operation of OP-AMP. Here the signal is given to the non-inverting terminal so that the output signal is in phase with the input signal such a circuit is called non-inverting zero crossing detectors. In open loop configuration, the gain of the op-amp is very high, so when the input voltage is above zero voltage, output of the circuit goes high (+Vsat) which is approximately +10V. Similarly when the input voltage is below zero voltage, the output goes to -Vsat which is approximately -10V.

Step by step procedure :

1] Check the components.
2] Setup the circuit on the breadboard and check the connections.
3] Switch on the power supply.
4] Give $V_m = 2V_{p-p}$ / 1KHz Sine wave.
5] Observe input and output on the oscilloscope simultaneously.
6] Notedown and draw input and output waveform on the graph.
7] Verify the output.

Experimental setup :

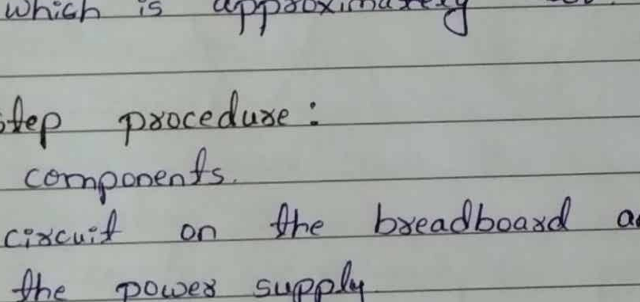
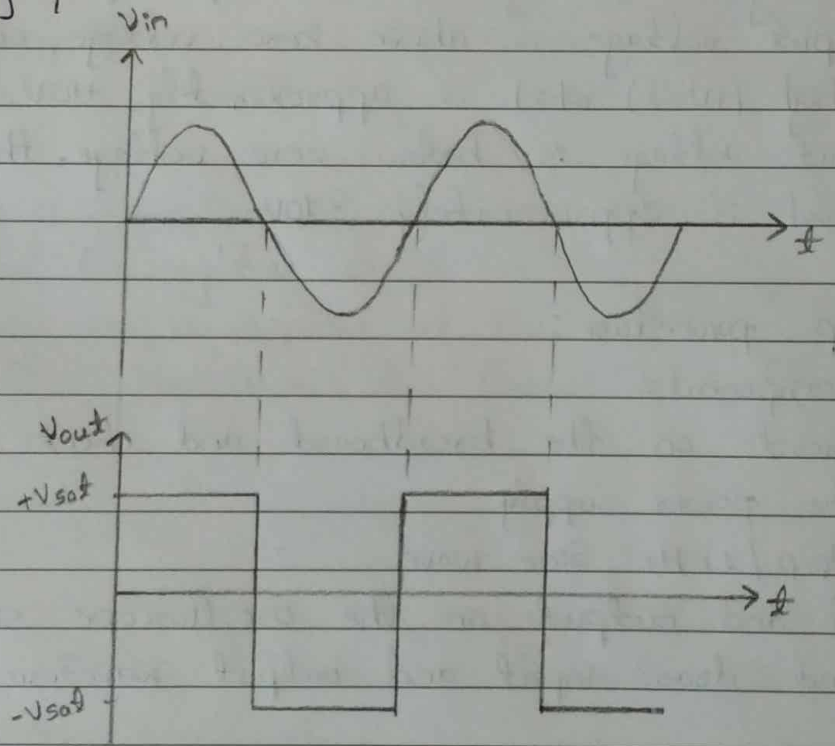


Table of observation :

Sl no.	Input voltage V_{in} in volts	Noise Margin in volts	Input frequency	+Vsat voltage in volts	-Vsat voltage in volts	Output frequency

Nature of graph :



Conclusion of Experiment :

After the completion of experiment we can conclude that for a small input, we are getting output to be saturated.

(c) Comparator :

Objectives :

1] To assemble the circuit of non-inverting comparator using op-amp IC 741

2] To observe and plot the output voltage waveform of non-Inverting comparator for sine wave input.

Theoretical Background :

A comparator is a circuit which compares signal on one input of op-amp with a reference voltage on the other input. In a simplest form it is nothing more than an open loop op-amp with two analog input and a digital output. Output of comparator may be (+) (or) (-) saturation voltage, depending upon which input is larger. Comparators are widely used in the circuits such as digital interfacing, Schmitt triggers, Oscillators

Above circuit shows the basic comparator in non-inverting configuration of op-amp. A fixed reference voltage (V_{ref}) is applied at the negative input of the op-amp and time varying signal voltage Vin is applied at the positive input of an op-amp. Because of this arrangement, this circuit is called as non-inverting comparator.

Procedure :

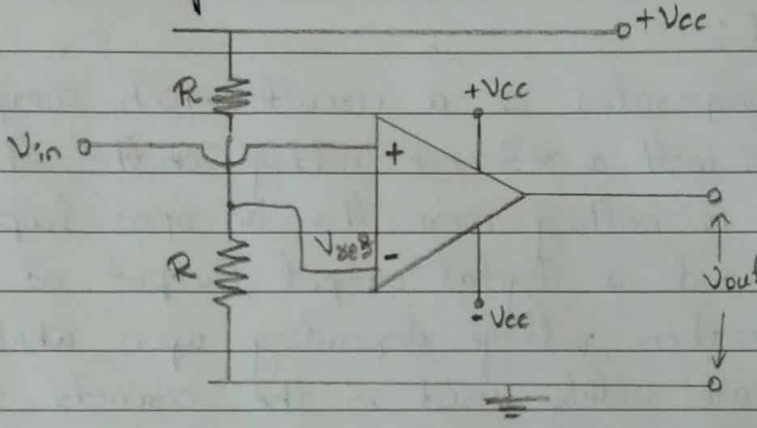
1] Refer the Pin Diagram of op-amp IC741 and assemble the basic comparator in inverting configuration circuit as per circuit diagram on the breadboard.

2] Set the DC power supply to provide +Vcc and -Vcc by making necessary adjustment and Apply Vcc and V_{EE} = ±15V at respective pins of op-amp IC 741

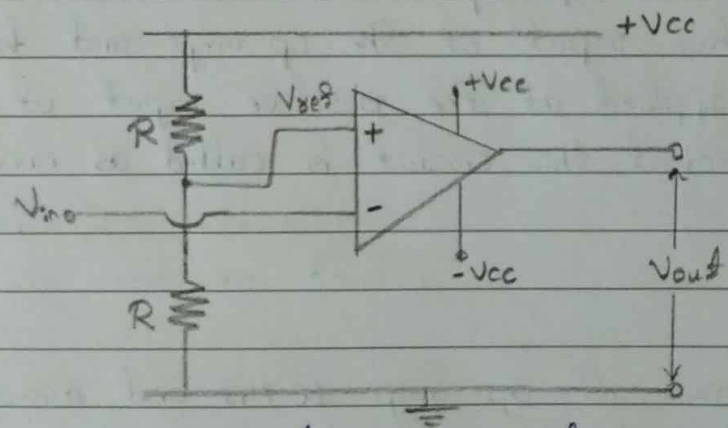
3] Set the function generator to provide 2V(p-p) sine wave at 500Hz and Apply this AC input at pin 2 and op-amp IC741

4] Set the DC power supply to provide 0.5V reference voltage by making necessary adjustment
5] Observe the output of this circuit on CRO
6] Measure the output voltage swing. Note the readings.
7] Plot the output voltage waveform for Vin and Vref.

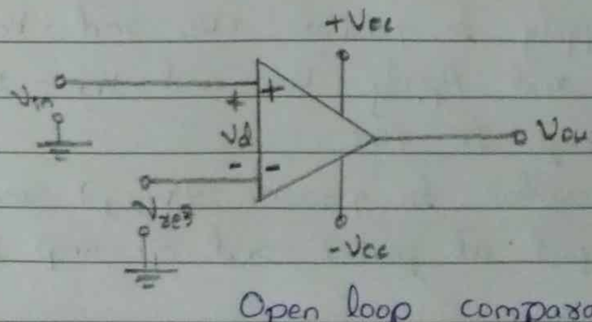
Experimental setup :



Non-inverting comparator circuit.



Inverting comparator circuit



Open loop comparator

Observation :

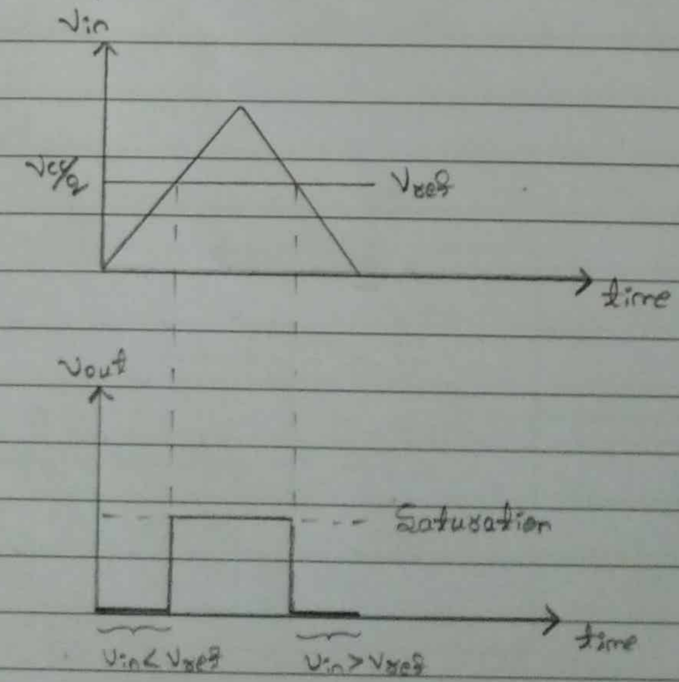
Non-inverting

Sl.no	input V_{p-p}	input f	Vref	Output (Vpp)

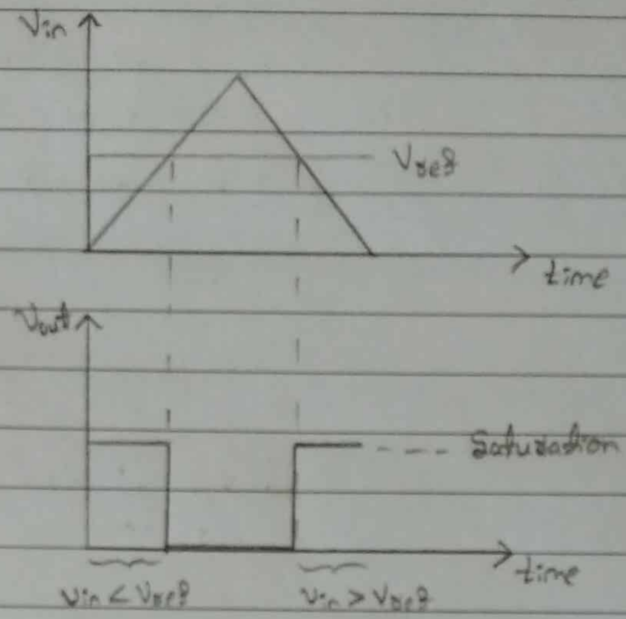
Inverting

Nature of graph :

1] Non-inverting comparator :



2] Inverting comparator



Conclusion :

Experiment No. :

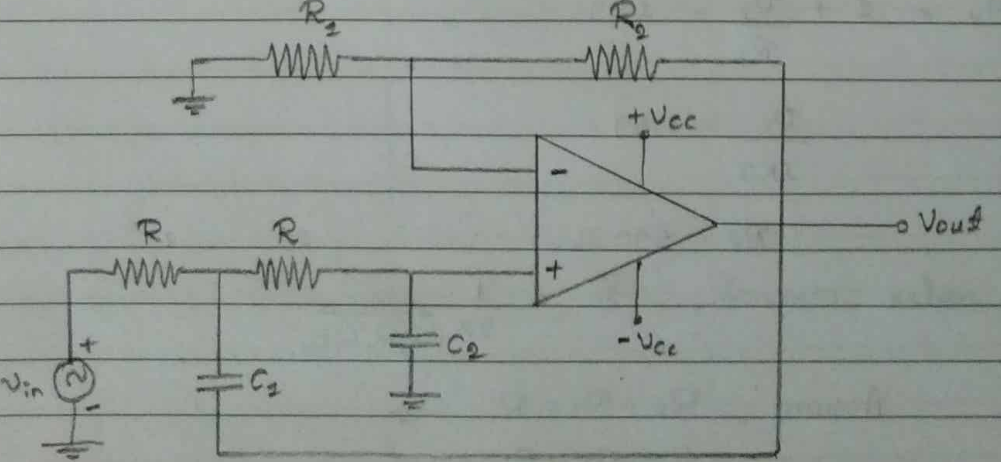
Title of the Experiment: Filters
Design a low pass filter and high pass filter of second order circuits

Objective of the experiment : To design a low pass filter and high pass filter and varify the response.

List of Components/ Equipments :

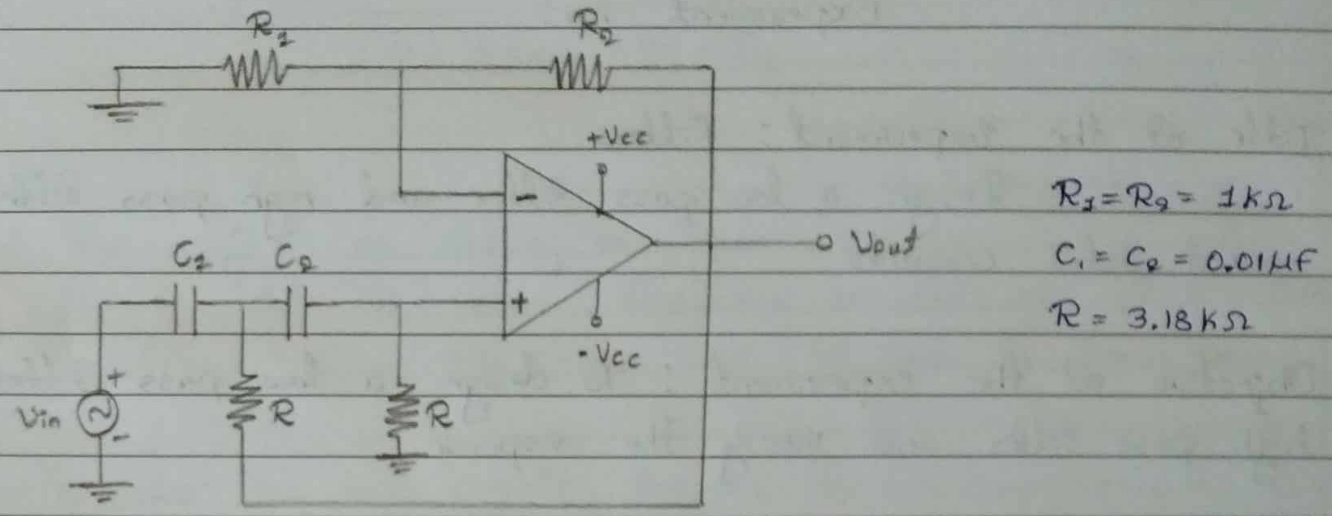
Sl.no.	Equipments	Specification	Quantity
01	Regulated DC	0-30V, 2A	01
02	CRO	80 Vp-p/ 20MHz	01
03	Crystal	32.168 KHz	01
04	BNC's	-	03
05	BJT	2N3904	01
	Resistors	21K, 0.25 W, CFR	04
		18K, 0.25 W, CFR	04
06	Capacitor	0.01 μF	01

Experimental setup :



$R_1 = 1 K\Omega$
$R_2 = 1 K\Omega$
$R = 3.18 K\Omega$
$C_1 = C_2 = 0.01 \mu F$

(Low pass filter)



(High Pass filter)

Theoretical Background for the experiment :

Set up the circuit as shown in the fig. with selected value of R and C. with a square wave at the filter input observe the output waveform. For, low pass filter apply a square wave of low enough frequency so that the output waveform becomes flat before the input waveform changes polarity. For high pass filter i.e, a differentiator exchange the position of the capacitor and the resistor in your circuit. The low pass filter acts as integrator.

Formulae required :

$$A_v = 1 + \frac{R_f}{R_i} = 1.59$$

$$\frac{R_f}{1k\Omega} = 0.59$$

$$\boxed{R_f = 590\,\Omega}$$

For second order circuit, $f_c = \dfrac{1}{2\pi\sqrt{R_3 R_2 C_1 C_2}}$

Assume, $R_2 = R_3 = R$

$C_1 = C_2 = C$

$$f_c = \frac{1}{2\pi RC} \Rightarrow 5\times10^3 = \frac{1}{2\pi\times R\times 0.01\times10^{-6}}$$

$$\boxed{R = 3.18\,k\Omega = R_2 = R_3}$$

Procedure :

1] Connect the circuit as shown in figure
2] Choose the R_1 and R_f values depending on the gain of the filter $A_f = 1 + (R_f/R_1)$ choose 590Ω for high R_f and R_1 then pass band gain 1.59.
3] Choose a value for high cutoff freqency f_H.
4] Calculate the R using $R = 1/2\pi f_H C$ where $C = 0.01\mu F$
5] Connecting the function generator to the input of the filter of fixed amplitude of 2V (p-p) for different values of input signal frequency F. Note the value of output voltage
6] Plot graph and Calculate band gain of the low pass filter.

Table of observation :

Low pass filter :

Sl no.	Input frequency (f_i) Hz	Output voltage (V_o) in V	gain $A_V = V_o/V_i$	Gain in dB = $20\log(V_o/V_i)$

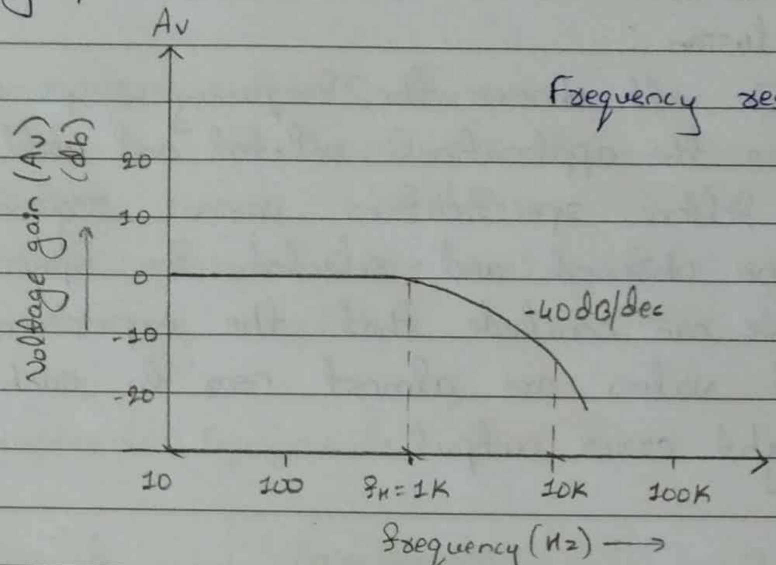
Sl.no.	Input frequency (f_i in Hz)	Output voltage (V_o in V)	Gain $A_v = V_o/V_i$	Gain in dB $= 20\log(V_o/V_i)$

High pass filter

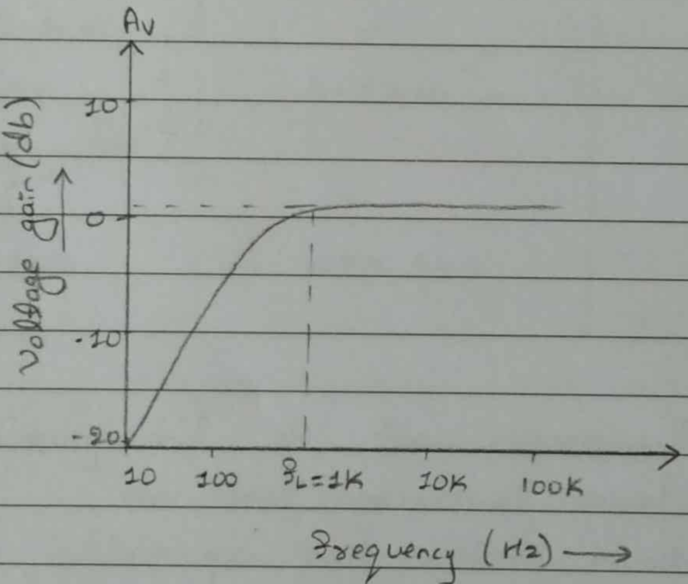
Sl.no.	Input frequency (f_i in Hz)	Output voltage (V_o in V)	Gain $A_v = V_o/V_i$	Gain in dB $= 20\log(V_o/V_i)$

Nature of graph :

Frequency response



(Low pass filter)



(High pass filter)

Result and conclusion :

We will observe the frequency response of various filters and discuss the applications related and will be able to comment on filters specifications various regional bands of filters can be observed and selected for specific filters.

We can conclude that the experiment values and the desired values are almost near to each other, with a very slight error output.

Experiment No. :

Title of the experiment : Summer
Realization of inverting and non-inverting summer

Objective of the experiment : To realize the application of op-amp 741 IC as summing amplifier.

List of components / Equipments :

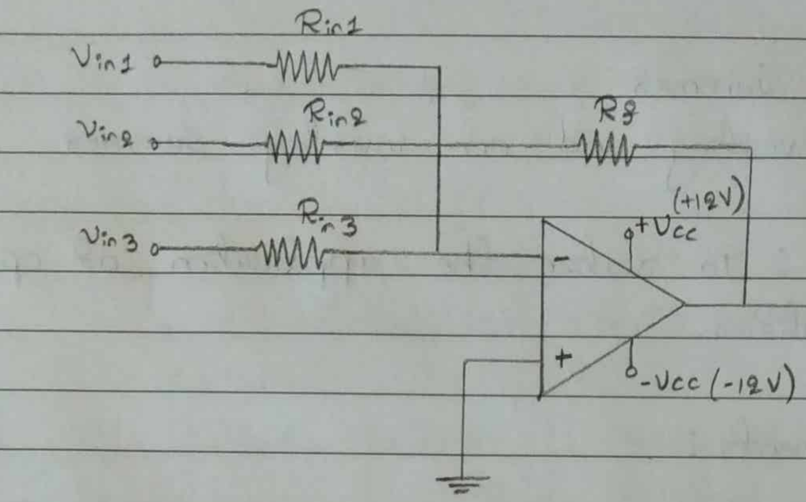
Sl no.	Equipments	Specification	Quantity
01	Regulated DC	0-30V, 2A	01
02	CRO	80 Vp-p / 20MHz	01
03	Oscilloscope	–	01
04	Function Generator	0-1MHz	01
05	DMM	–	01
06	Resistors	10KΩ, 5KΩ	each 1
07	BNC's	–	03

Theoretical Background of the experiment :

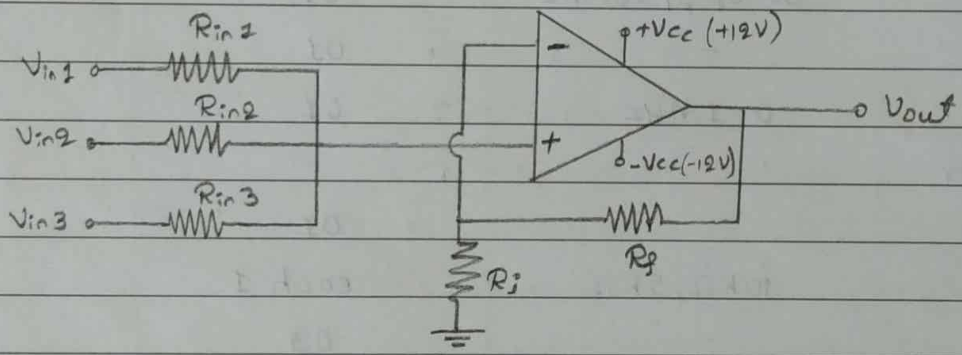
An ideal operational amplifier is an amplifier having infinite voltage gain and infinite bandwidth. It has infinite input impedance and zero output impedance. But practically op-amp has a very high Av and input impedance it has low output impedance. It's bandwidth is wide. It has two inputs, inverting and non-inverting. It operates on 2V DC supply voltages one positive and other negative.

The summing amplifier is an application of inverting op-amp it has two or more inputs and its output voltages are proportional to the negative of algebraic sum of its voltage

Experimental setup :



(Inverting summing amplifier)



(Non-inverting summing amplifier)

Procedure :

1] Connect circuit according to given circuit.
2] Connect V_1, V_2 and V_3 with potentiometer.
3] Set potentiometer 0.5 V and check V_{out} using DMM
4] Calculate output voltages by using

$$V_{out} = -(V_1 + V_2 + V_3)$$

5] Compare calculated value with DMM value
6] Set potentiometer 1 - 3V and Repeat the process.

Formulae required :

$$V_{out} = -(V_{in1} + V_{in2} + V_{in3} \ldots V_{inn})$$

if R_f is larger than input resistor,

$$V_{out} = -\frac{R_f}{R_A}(V_{in1} + V_{in2} + V_{in3} \ldots V_{inn})$$

For non-inverting summer,

$$V_{out} = V_{in}\left(1 + \frac{R_f}{R_i}\right)$$

$$V_{out} = \left[1 + \left(\frac{R_f}{R_i}\right)\right]\left(\frac{V_1 + V_2 + V_3}{3}\right)$$

Table of observation :

Conclusion :

If the input resistance of a summing amplifier are connected to potentiometers the individual signals can be mixed together by varying amountes.

The gain of the circuit is given below.

$$\text{gain}(A_v) = \frac{V_{out}}{V_{in}} = \frac{-R_f}{R_{in}}$$

Thus the output voltage is calculated and the circuit is implemented using the solid thinking activate load.

Experiment No. :

Title of the experiment : Integrator and differentiator using op-amp

Objective of the experiment : To design and set up an integrator and differentiator circuit using op-amp.

List of components / Equipments :

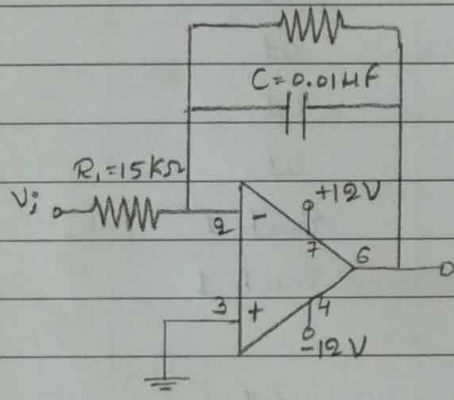
Sl.no	Equipments	Specification	Quantity
01	Oscilloscope	–	01
02	Dual power DC supply	0-30V, 2A	01
03	Function generator	0-1MHz	01
04	DMM	–	01
05	Resistors	100Ω, 1kΩ	Each 1
06	Capacitors	1μF, 10nF, 1.5nF	Each 1
07	741 IC	–	01

Theoretical Background :

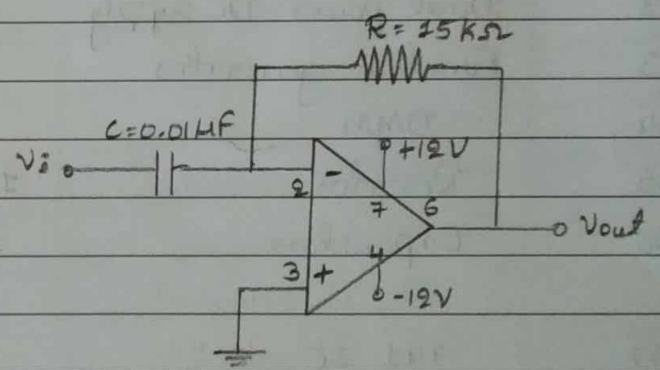
Integrator : This circuit performs the integration of the input waveform. The output voltage v_0 can be expressed as $v_0 = -\frac{1}{RC} \int v_i dt + K$ where k is the constant of integration which depends upon the value of v_0 at $t=0$. The peak of the output waveform v_T is given by the expression $v_T = V_T/4RC$, where T is the time period of the input square wave. Integrators are commonly used in analog computers and wave shaping networks

Differentiator : If the input resistor of the inverting amplifier is replaced by a capacitor, it forms an inverting differentiator. The output of the circuit is the derivative of the input. Gain of the differentiator increases with increasing frequency, which makes the circuit unstable. This is a drawback of the circuit. The output voltage v_0 can be expressed as $v_0 = -R_F C_i \, dv_i/dt$. Differentiator functions as high pass filter. At high frequency it becomes unstable and breaks into oscillations

Experimental setup :



Integrator



Differentiator

Formulae required :

Integrator : Let the input frequency be 1kHz

$$f_0 = \frac{1}{2\pi R_i C}$$

Let $C = 0.01\mu F$ then

$R_1 = 15.9\,k\Omega$ Use $15k\Omega$ std

Differentiator :

We have $f = \frac{1}{2\pi RC}$

Let $C = 0.01\mu F$ then $R = 15.9k\Omega \approx 15k\Omega$

Procedure :

Integrator :

1] Setup the integrator circuit as shown in figure. Give a rectangular wave of $\pm 5V$ and 1 KHz frequency at the input and observe the input and output simultaneously on CRO.

2] Vary the DC offset of the square wave input and observe the difference in the output waveform.

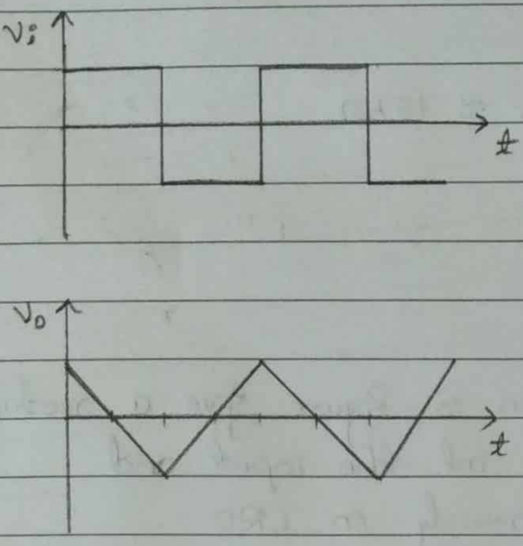
3] Repeat the experiment by feeding triangular wave and sine wave at the input and observe the output.

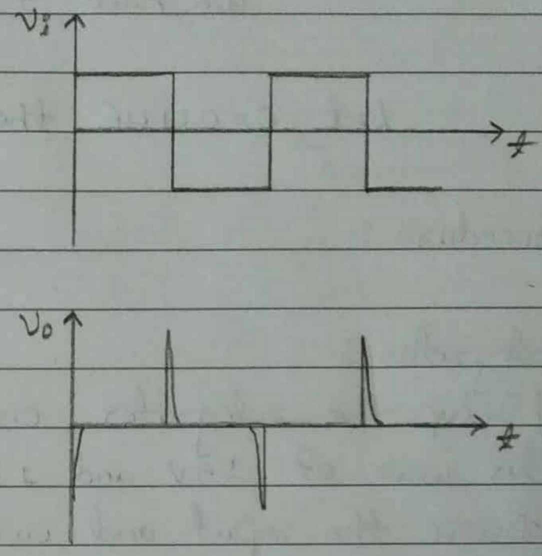
Differentiator :

1] Setup the differentiator circuit as shown in figure. Give a rectangular wave of $\pm 5V$ and 1KHz frequency at the input and observe the input & output simultaneously on CRO.

2] Repeat the experiment by feeding triangular wave and sine wave at the input and observe the output.

Nature of graph :





Integrator

Differentiator