③

Experiment no-7

Lab group- L8

Student-1 → Kumar Indramani (150107028)

student-2 → K.Y. Ashok (150107027)

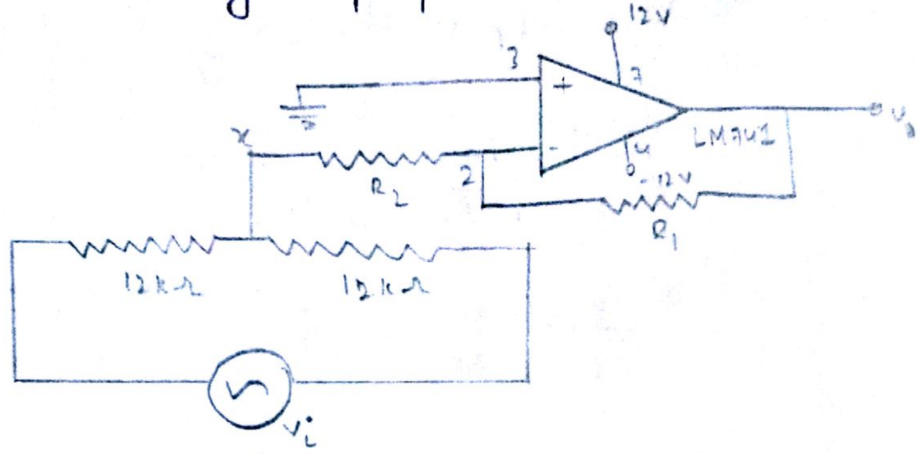
Table No → 14

Date → 16/03/2016

Experiment-7

PRE-EXPERIMENTAL ANALYSIS

PART-A Inverting Amplifier.



(i) $R_1 = 100 K\Omega$, $R_2 = 10 K\Omega$

Thevenin Resistance $= R_2 + \frac{12 \times 12}{12+12} K\Omega$

$= 10 k\Omega + 6 k\Omega$

$= 16 k\Omega$

$= R_{2Th}$

Voltage Input at x $= \frac{V_i}{2}$

$$\frac{V_o}{(V_i/2)} = \frac{-R_1}{R_{2Th}}$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{-R_1}{2R_{2Th}} = \frac{-100}{2 \times 16} k\Omega$$

$$= -3.125 k\Omega.$$

(ii) $R_1 = 10 k\Omega$, $R_2 = 1 k\Omega$

Thevenin Resistance $= R_2 + \frac{12 \times 12}{12+12} k\Omega$

$= (1+6)\ k\Omega$

$= \underline{\underline{7 k\Omega}}$

$= R_{2Th}$

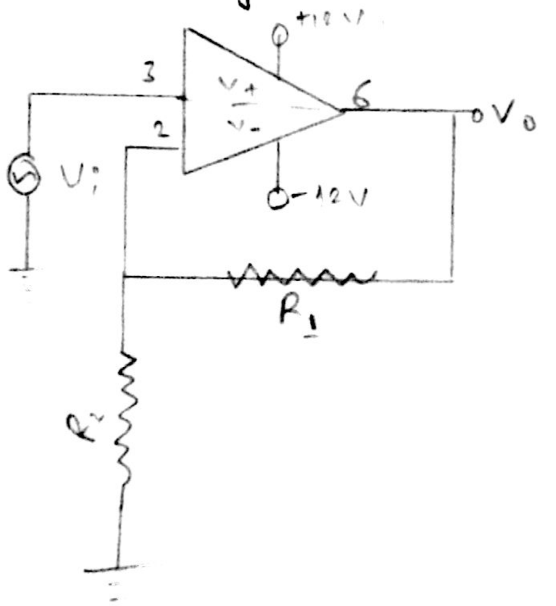
Voltage Input at $x = \frac{V_i}{2}$

$$\therefore \frac{V_o}{(V_i/2)} = \frac{-R_1}{R_2}$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{-R_1}{2R_2} = \frac{-10}{2\times 7}$$

$$= \underline{\underline{-0.714}}$$

PART B → Non- Inverting Amplifier.



voltage input at $c = \frac{V_i}{2}$ [Coming from voltage divider]

Applying Kirchoff's Law;

$$\frac{0 - V_i/2}{R_2} = \frac{V_i/2 - V_o}{R_1}$$

$$\Rightarrow \frac{-V_i}{2R_2} = \frac{V_i}{2R_1} - \frac{V_o}{R_1}$$

$$\Rightarrow \frac{V_o}{R_1} = \frac{V_i}{2}\left[\frac{1}{R_1}+\frac{1}{R_2}\right]$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{R_1}{2}\left[\frac{1}{R_1}+\frac{1}{R_2}\right]$$

$$\Rightarrow \left(\frac{V_o}{V_i}\right) = \frac{1}{2}\left[1+\frac{R_1}{R_2}\right]$$

(i) $R_1 = 100 k\Omega$, $R_2 = 10 k\Omega$

$$\left(\frac{V_o}{V_i}\right) = \frac{1}{2}\left(1+\frac{100}{10}\right) = \frac{11}{2} = \underline{\underline{5.5}}.$$

(ii) $R_1 = 10 k\Omega$, $R_2 = 1 k\Omega$

$$\left(\frac{V_o}{V_i}\right) = \frac{1}{2}\left(1+\frac{10}{1}\right) = \frac{11}{2} = \underline{\underline{5.5}}.$$

<u>PART C →</u>

Cut-off frequency; $f_c = \frac{1}{2\pi RC}$

$$= \frac{1}{2\times\pi\times 1k\Omega\times 0.1\mu F}$$

$$= \frac{1}{2\times\pi\times 0.1}$$

$$= \frac{1}{0.628}$$

$$= \underline{\underline{1.59\ KHz}}.$$

Objective : Realization of amplifier circuits with Op-amps.

Experimental observations:-

Part.A → Inverting Amplifier

$R_1 = 10 K\Omega$, $R_2 = 1 K\Omega$

At $v = 0.2v$,

$V_i = 200 mV_{(p-p)}$

$V_o = 4 \times 0.5 = 2V$ (180° out of phase)

$\therefore A = -\frac{V_o}{V_i} = \frac{2}{0.2} = -10$

At $v = 0.1 v$,

$V_i = 0.10 v$

$V_o = 0.2 \times 5 = 1V$

$\therefore A = -\frac{V_o}{V_i} = \frac{1}{0.1} = -100$

At $v = 0.3 v$,

$V_i = 0.26V$

$V_o = 2.5V$

$A = -\frac{V_o}{V_i} = \frac{2.5}{0.26} = -9.6$

CRO showing input 0.26V may be due to resistance of connecting wires of function generator and bread board.

$R_1 = 100 K\Omega$ & $R_2 = 10 K\Omega$

At $V = 0.10V$,

$V_i = 0.104V$

$V_o = 1.08V$

$\therefore A = -\frac{V_o}{V_i} = \frac{1.08}{0.104} = -10.3$

At $V = 0.2V$,

$V_i = 0.19V$

$V_o = 1.9V$

$\therefore A = -\frac{V_o}{V_i} = \frac{1.9}{0.19} = -10$

At $V = 0.3V$,

$V_i = 0.26V$

$V_o = 2.6V$

$\therefore A = -\frac{V_o}{V_i} = \frac{2.6}{0.26} = -10$

Through potential divider

(i) $\frac{R_1}{R_2} = \frac{100K\Omega}{10K\Omega}$, $\frac{V_o}{V_i} = \frac{0.68}{0.21} = -3.2$

(ii) $\frac{R_1}{R_2} = \frac{10K\Omega}{1K\Omega}$, $\frac{V_o}{V_i} = \frac{150mV}{210mV} = -0.71$.

Q1. For a source with high internal impedance, which configuration will be suitable for designing a good amplifier?

Ans - Non inverting Operational Amplifier will be suitable, because voltage gain of a non-inverting amplifier is not affected considerably. If the source impedance is high.

Part-B Non-Inverting Amplifier

$R_1 = 10K\Omega$ & $R_2 = 1K\Omega$

At $V = 200mV_{p-p}$

$V_i = 0.210V$

$V_o = 2.3V$

$\therefore A = \frac{V_o}{V_i} = 10.9$

At $V = 100mV_{p-p}$

$V_o = 1.12V$

$V_i = 108mV$

$\therefore A = \frac{V_o}{V_i} = \frac{1.12}{108} = 10.3V$

At $V = 300mV_{p-p}$;

$V_i = 270mV$

$V_o = 3V$

$\therefore A = \frac{V_o}{V_i} = \frac{3000}{270} = 11.1V$

For, $R_1 = 100K\Omega$ & $R_2 = 10K\Omega$,

At $V = 100mV_{p-p}$

$V_i = 112mV$

$V_o = 1.04V$

$A = \frac{1.04}{0.112} = 9.2$

At $V = 200mV_{p-p}$;

$V_i = 180mV$

$V_o = 1.8V$

$\therefore A = \frac{V_o}{V_i} = \frac{1.8}{0.18} = 10$

At $V = 300mV_{p-p}$;

$V_i = 270mV$

$V_o = 3V$

$\therefore A = \frac{V_o}{V_i} = \frac{3000}{270}$

$= 11.1$

Through potential divider

(i) $\frac{R_1}{R_2} = \frac{100K\Omega}{10K\Omega}$; $\frac{V_o}{V_i} = \frac{1160mV}{220mV} = 5.2$

(ii) $\frac{R_1}{R_2} = \frac{10K\Omega}{1K\Omega}$; $\frac{V_o}{V_i} = \frac{1.12}{0.210} = 5.3$

Part-C Non-Inverting High Pass filter,

$$\boxed{f_c = \frac{1}{2\pi RC}}$$

$\Rightarrow f_c$ (Theoritical) $= 1591.5 Hz$

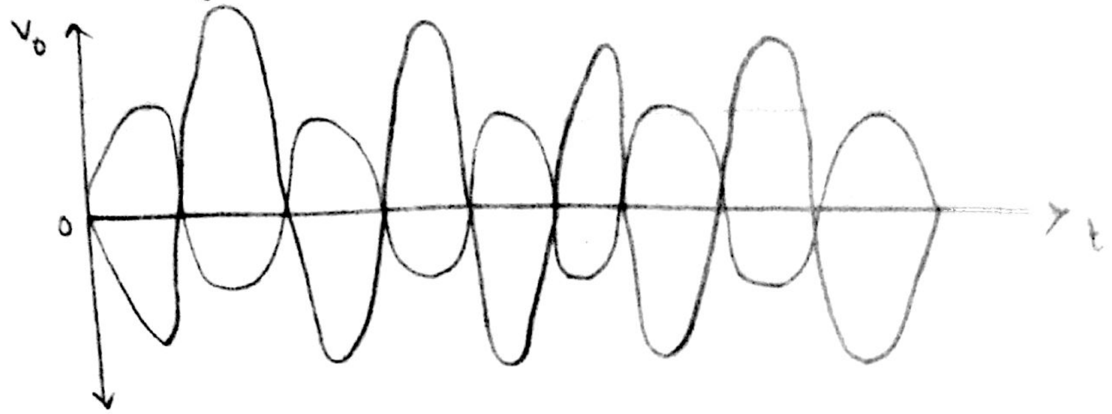
Frequency (kHz)	Vo (output)	Vi (input)	$A = \frac{V_o}{V_i}$
1.0	1.3V	210mV	6.19
1.2	1.42V	210mV	6.76
1.4	1.52V	210mV	7.28
1.6	1.65V	210mV	7.85
1.8	1.81V	210mV	8.57
2.0	1.85V	210mV	8.80
2.4	1.9V	210mV	9.04
2.6	1.95V	210mV	9.2[illegible]
2.8	1.95V	210mV	9.28
3.0	2V	210mV	9.52

$\therefore$ The cutoff frequency = between 1.2-1.4K

$$\boxed{f_c = 1.3KHz}$$

E-OBSERVATIONS:

PART A → Inverting Amplifier



$R_1 = 10\,k\Omega$ & $R_2 = 1\,k\Omega$

At $\vartheta = 0.2\,V$;

V_i = Peak to Peak

$20 \times 1 = 0.20\,V$.

V_0 = Peak to peak

$4 \times 0.5 = 2\,V$. (180° out of phase)

$\therefore A = \dfrac{-V_0}{V_i} = \dfrac{2}{0.2} = -10\,V$

At $\vartheta = 0.1\,V$;

$V_i = 0.10\,V$

$V_0 = 0.2 \times 5 = 1\,V$.

$\therefore A = \dfrac{-V_0}{V_i} = \dfrac{1}{0.1} = 10\,V$.

At $\vartheta = 0.26\,V$;

$V_i = 0.26\,V$

$V_0 = 2.5\,V$

$\therefore A = \dfrac{-V_0}{V_i} = \dfrac{2.5}{0.26} = 9.6\,V$.

$R_1 = 100k\Omega$ & $R_2 = 10k\Omega$

At $v = 0.104v$;

$V_i = 0.104V$

$V_0 = 1.08V$

$\therefore A = \frac{-V_0}{V_i} = \frac{1.08}{0.104} = -10.3v$

At $v = 0.2v$;

$V_i = 0.19V$

$V_0 = 1.9v$

$\therefore A = \frac{-V_0}{V_i} = \frac{1.9}{0.19} = -10v$.

At $v = 0.26v$;

$V_i = 0.26v$

$V_0 = 2.6v$

$\therefore A = \frac{-V_0}{V_i} = \frac{2.6}{0.26} = -10v$.

Through Potential divider;

(i) $\frac{R_1}{R_2} = \frac{100k\Omega}{10k\Omega}$; $\frac{V_0}{V_i} = \frac{0.68}{0.21} = 3.2$

(ii) $\frac{R_1}{R_2} = \frac{10k\Omega}{1k\Omega}$; $\frac{V_0}{V_i} = \frac{150\,mV}{200\,mV} = 0.71$.

B → Non-Inverting Amplifier

$R_1 = 10k\Omega$ & $R_2 = 1k\Omega$

At $V = 200\, mV_{p-p}$;

$V_i = 0.210\,V$.

$V_0 = 2.3\,V$

$\therefore A = \frac{V_0}{V_i} = 10.9\,V$.

At $V = 100\, mV_{p-p}$;

$V_0 = 1.12\,V$

$V_i = 108\,mV$

$\therefore A = \frac{V_0}{V_i} = \frac{1.12}{108} = 10.3\,V$.

At $V = 300\, mV_{p-p}$;

$V_i = 270\,mV$

$V_0 = 3\,V$

$\therefore A = \frac{V_0}{V_i} = \frac{3000}{270} = 11.1\,V$.

For; $R_1 = 100k\Omega$ & $R_2 = 10k\Omega$.

At $V = 100\, mV_{p-p}$;

$V_i = 112\,mV$

$V_0 = 1.04\,V$

$\therefore A = \frac{V_0}{V_i} = \frac{1.04}{0.112} = 9.2\,V$

At $V = 200\, mV_{p-p}$;

$V_i = 180\,mV$

$V_0 = 1.8\,V$

$\therefore A = \frac{V_0}{V_i} = \frac{1.8}{0.18} = 10\,V$

At $V = 300\, mV_{p-p}$;

$V_i = 270\,mV$

$V_0 = 3\,V$

$\therefore A = \frac{V_0}{V_i} = \frac{3000}{270} = 11.1\,V$

Through Potential divider;

(i) $\dfrac{R_1}{R_2} = \dfrac{100k\Omega}{10k\Omega}$; $\dfrac{V_o}{V_i} = \dfrac{1160mV}{220mV} = \underline{\underline{5.2}}$

(ii) $\dfrac{R_1}{R_2} = \dfrac{10k\Omega}{1k\Omega}$; $\dfrac{V_o}{V_i} = \dfrac{1.12}{0.210} = \underline{\underline{5.3}}$.

PART C → Non-Inverting High Pass filter;

$$\boxed{\therefore f_c = \frac{1}{2\pi RC}}$$

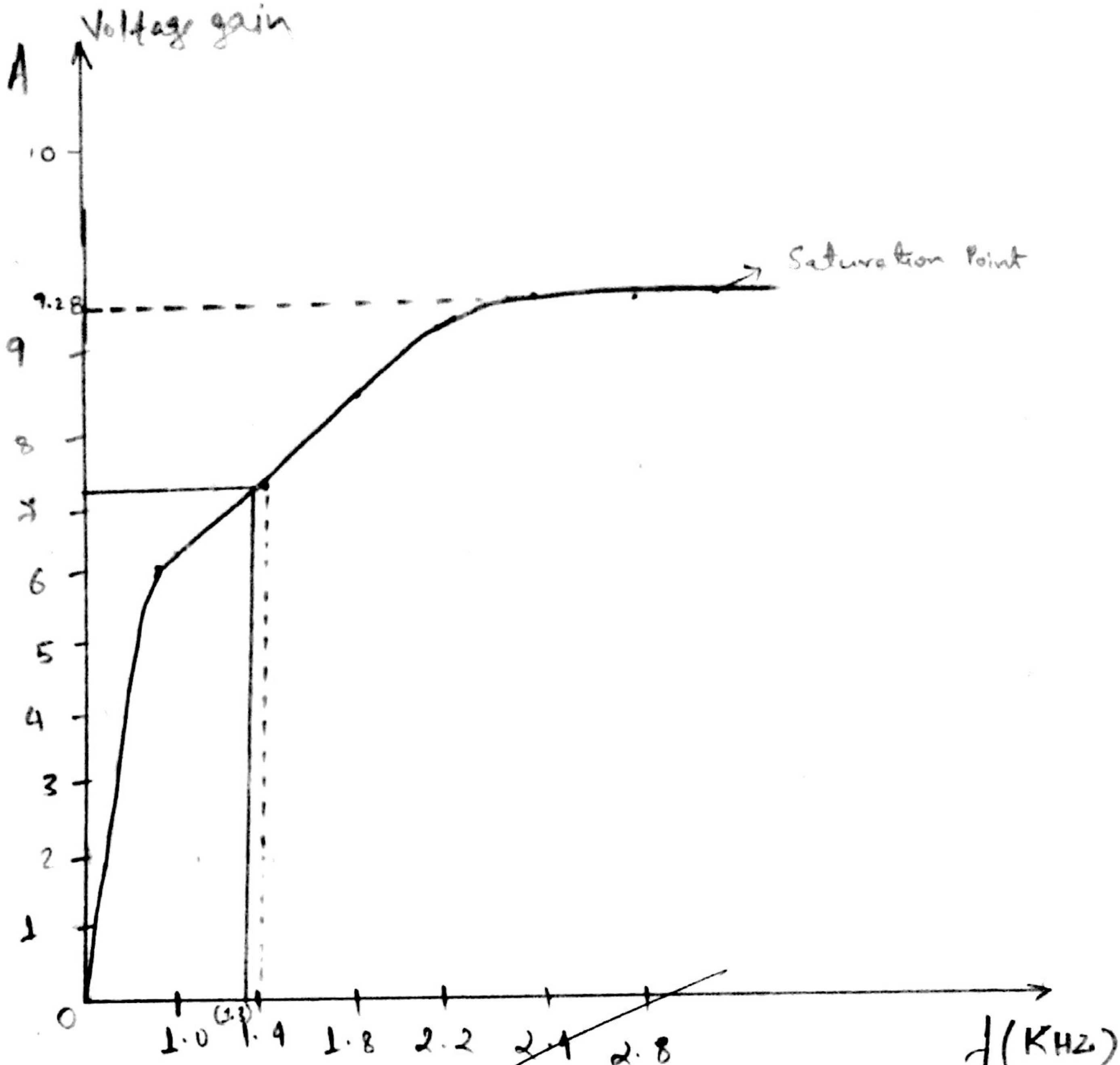
$\Rightarrow f_c$ (Theoretical) = 1591.5 Hz.

Frequency (Hz)	V_o (output)	V_i (Input)	$A = V_o/V_i$
1.0	1.3V	210 mV	6.19
1.1	1.36V	210 mV	6.47
1.2	1.42 V	210 mV	6.76
1.3	1.48 V	210 mV	7.04
1.4	1.52 V	210 mV	7.28
1.5	1.6 V	210 mV	7.61
1.6	1.65 V	210 mV	7.85
1.7	1.8 V	210 mV	8.57
1.8	1.8 V	210 mV	8.57
1.9	1.8 V	210 mV	8.57
2.0	1.85 V	210 mV	8.80
2.1	1.85 V	210 mV	8.80
2.4	1.9 V	210 mV	9.04
2.6	1.95 V	210 mV	9.28
2.8	1.95 V	210 mV	9.28
3.0	2 V	210 mV	9.52

∴ The Cutoff frequency = B/w 1.2 − 1.4

$$\boxed{f_c = 1.3\ kHz}$$

Gain (vs) frequency Graph →



f_c (cut off frequency) = 1.3 KHz.

16/03/2016

Precautions:-

1. Always connect the common terminal of the power supply to the ground on the bread board

2. for any integrated circuit; never, exceed the input voltage beyond the power supply limit

3. Never ever connect the only one side of power supply or interchange the positive & negative power supply as it damage the op-amps.

1. The op-amps works on split power supply so, both +ve & -ve power supply must be present, whenever op-amp is powered.

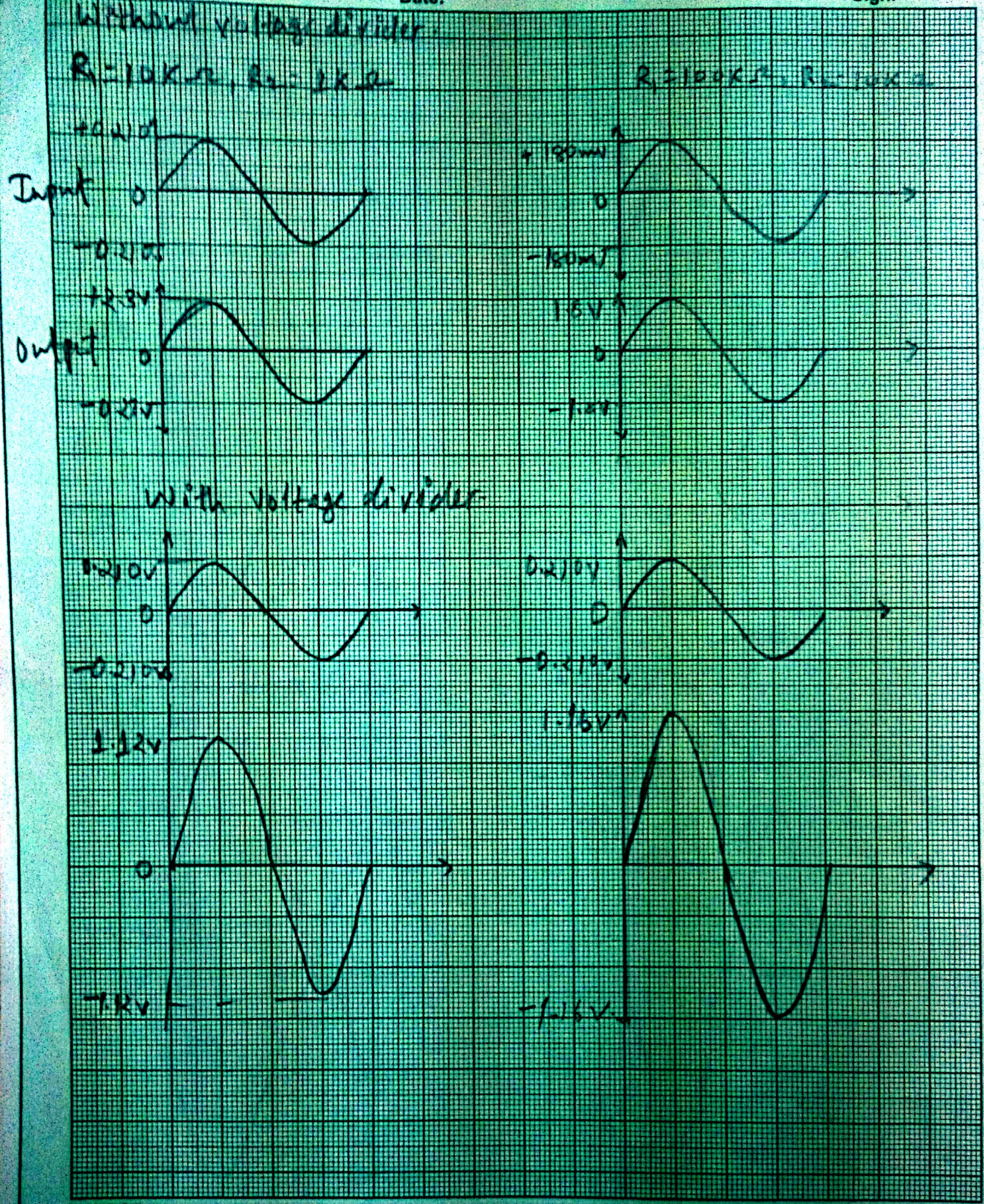
Result →

1) The cutoff frequency is b/w 1.2 - 1.3 KHz.

$$\boxed{\therefore f_c = 1.3\ \text{KHz}}$$

PART-B -

Roll No.: Date: Sign.



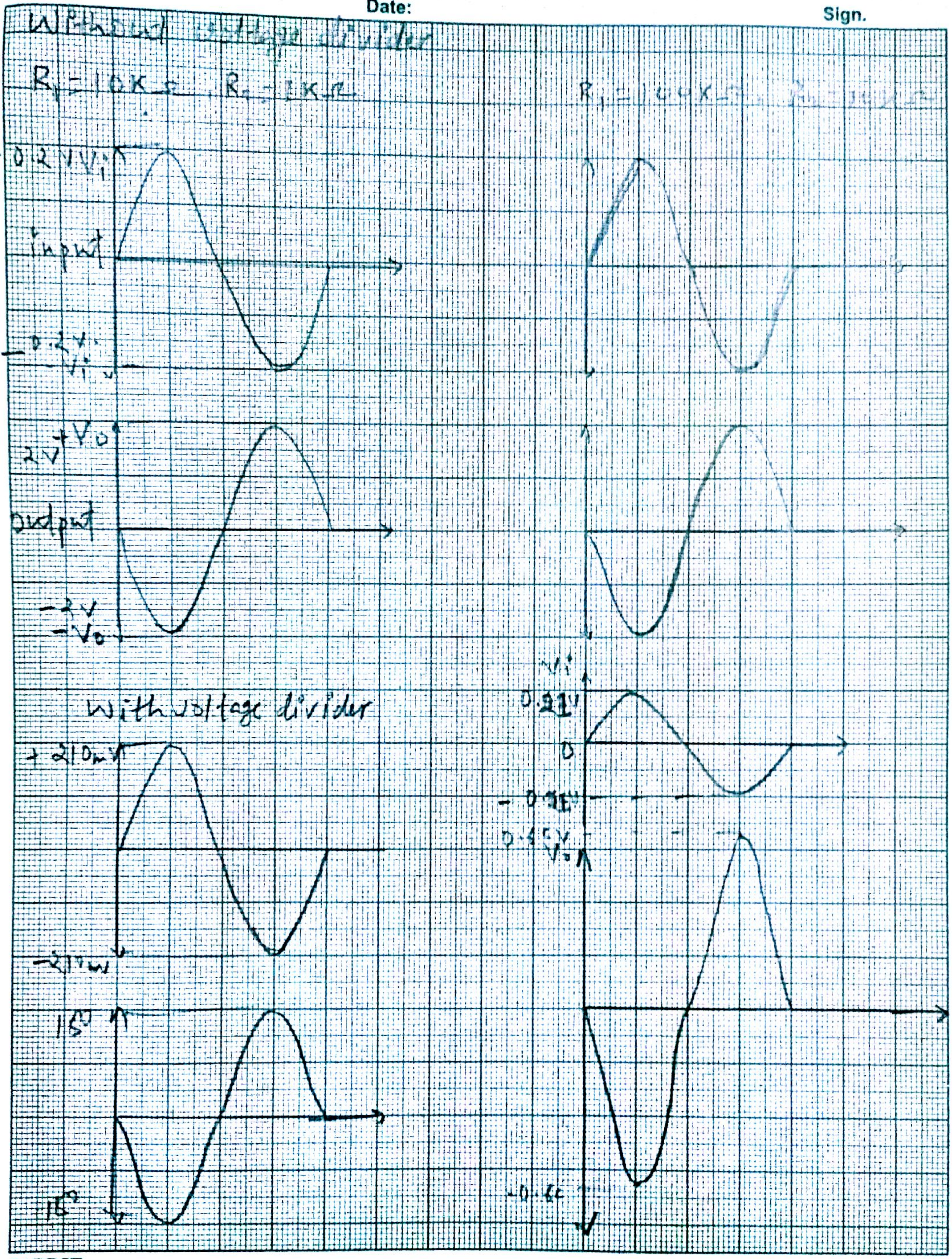
PARROT

PART-A

Roll No.:

Date:

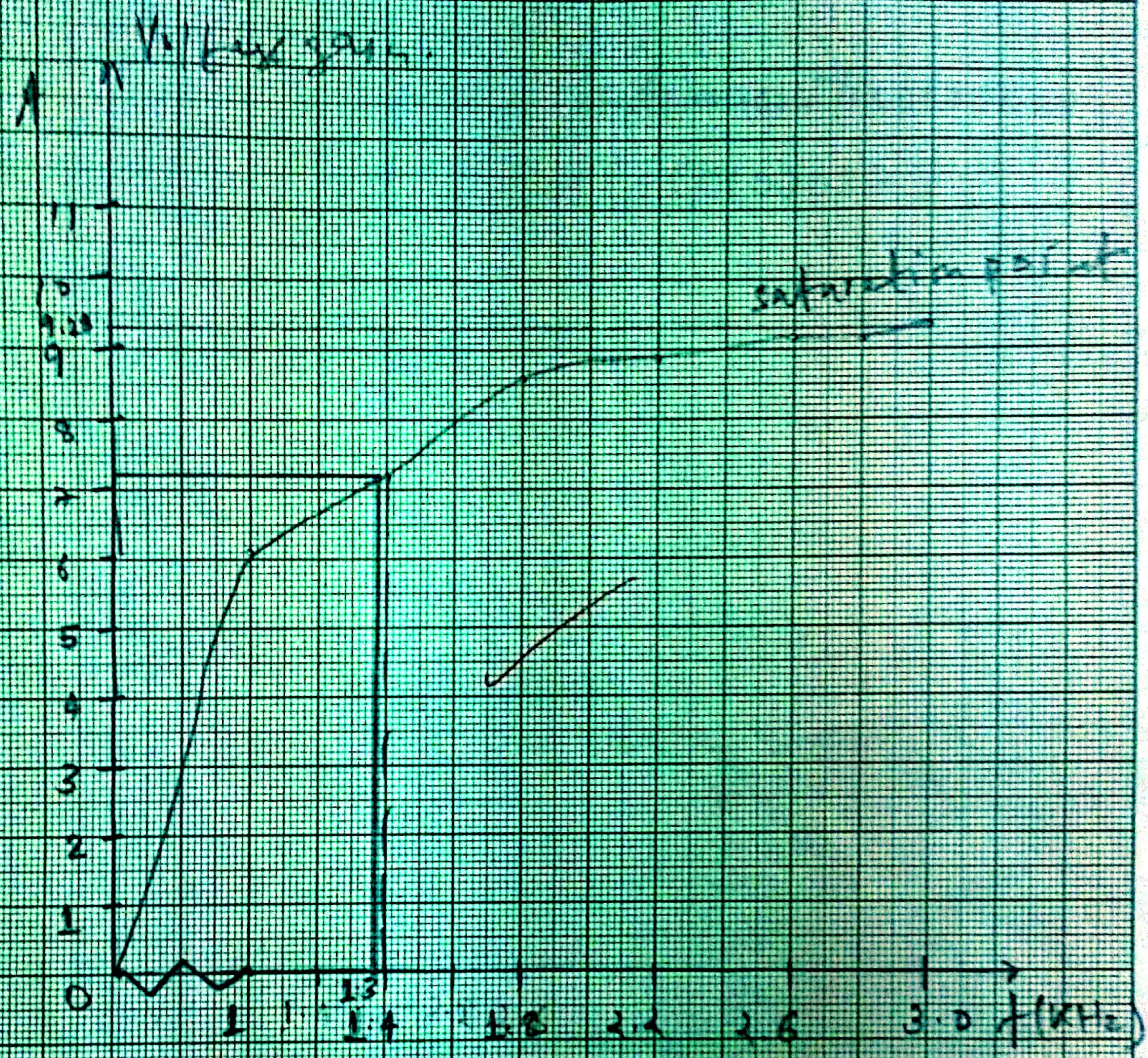
Sign.



PARROT

PART-C

Roll No.: Date: Sign.



fc (cutoff frequency) = 1.8 KHz

PARROT

GROUP NO: 4

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

Department of Electronics & Electrical Engineering

EE102: Basic Electronics Laboratory

EXPT. No. 7 : OPERATIONAL AMPLIFIER

OBJECTIVE : Realization of amplifier circuits with Op-Amp (Operational Amplifier).

MATERIALS REQUIRED

- Breadboard
- Equipment : Multioutput DC Power Supply, Function Generator, Oscilloscope.
- Components
  - Op-Amp : One: LM741.
  - Resistance : Five: 1 kΩ (1 no), 10 kΩ (1 no), 12 kΩ (2 nos), 100 kΩ (1 no).

PRECAUTIONS AND GUIDELINES

1. The op-amp generally works on split power supply (e.g. ±12 V). Both positive and negative power supplies must be present whenever op-amp is powered. The range of power supply is from ±5 V to ±15 V. Do not forget to connect the common terminal of the power supply to the *ground* on the breadboard.
2. Connecting only one side of power supply or interchanging positive and negative power supplies damages the op-amp.
3. For connecting power supply, you have to follow the procedure as given below.
   a. Disconnect the power supply to op-amps.
   b. Switch on the power supply.
   c. Set the output voltage as required (e.g. ±12 V).
   d. Switch off the power supply.
   e. Connect the power supply to op-amps.
   f. Switch on the power supply.
4. For any IC, never exceed the input voltage beyond the power supply limits.
5. Use the horizontal strips of the breadboard for power supply. Tap the power supply for each IC from these supply lines.
6. Keep ground terminals of the oscilloscope probes and function generator output, and power supply common connected together throughout the experiment.

<u>Pre-experiment Reading:</u>

Obtain theoretical values of V_o / V_i for step 5 of Part A. Do this for Part B also.

PART A : INVERTING AMPLIFIER

1. Assemble the circuit shown in Fig. 7.1 with R_1 = 10 kΩ and R_2 = 1 kΩ. Make sure the power supply ground is connected to the circuit ground.
2. Apply 200 mVp-p, 1 kHz sine wave at V_i from the function generator and see the output.
3. Observe V_o and V_i, and determine voltage gain $A = V_o / V_i$. Also obtain A for V_i = 100 mVp-p and 300 mVp-p.
4. Change R_1 & R_2 to 100 kΩ & 10 kΩ and determine A for V_i = 100 mVp-p, 200 mVp-p and 300 mVp-p.
5. Now apply a fraction of the voltage V_i (keeping V_i at 200 mVp-p) to the point 'X' through the potential divider circuit as shown in Fig. 7:2 and note the values of V_o for

(i) $R_1/R_2 = \dfrac{100\,\text{k}\Omega}{10\,\text{k}\Omega}$ and

(ii) $R_1/R_2 = \dfrac{10\,\text{k}\Omega}{1\,\text{k}\Omega}$

Compute V_o / V_i for (i) and (ii).

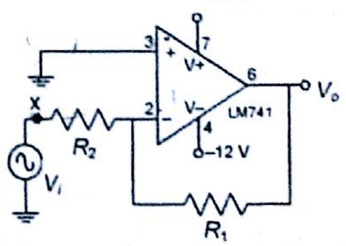


Fig. 7.1 Inverting amplifier

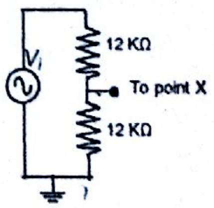


Fig. 7.2 Voltage Divider

PART B : NON-INVERTING AMPLIFIER

1) Assemble the circuit shown in Fig. 7.3 with R_1 = 10 kΩ and R_2 = 1 kΩ. Make sure the power supply ground is connected to the circuit ground.

2) Apply 200 mVp-p, 1 kHz sine wave at V_i from the function generator and see the output.

3) Observe V_o and V_i, and determine voltage gain $A = V_o / V_i$. Also obtain A for V_i = 100 mVp-p and 300 mVp-p.

4) Change R_1 & R_2 to 100 kΩ & 10 kΩ and determine A for V_i = 100 mVp-p, 200 mVp-p and 300 mVp-p.

5) Now apply a fraction of the voltage V_i (keeping V_i at 200 mVp-p) to the point 'X' through the potential divider circuit as shown in Fig. 7.2 and note the values of V_o for

(i) $R_1/R_2 = \dfrac{100\,k\Omega}{10\,k\Omega}$ and

(ii) $R_1/R_2 = \dfrac{10\,k\Omega}{1\,k\Omega}$

Compute V_o / V_i for (i) and (ii).

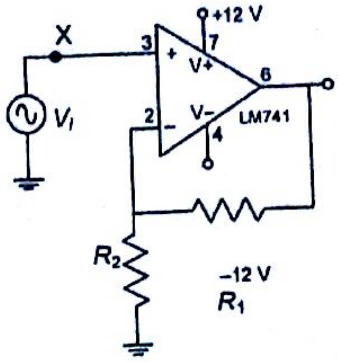


Fig. 7.3 Non-inverting amplifier

Q1. For a source with high internal impedance which configuration (inverting or non-inverting) will be suitable for designing a good amplifier?

PART C : NON-INVERTING HIGH PASS FILTER

The circuit given below is a non-inverting amplifier with the RC circuit at the non-inverting terminal of the OPAMP acting as a frequency dependent voltage divider. Cut-off frequency of this RC arrangement is given as

$$f_c = \frac{1}{2\pi RC}$$

Using this formula, find the theoretical value of cut-off frequency.

1) Assemble the circuit shown in Fig. 7.4 with R_1 = 10 kΩ, R_2 = 100kΩ, R=1 kΩ and C=0.1µF. Make sure the power supply ground is connected to the circuit ground.
2) Connect channel 1 of CRO to the input and channel 2 to the output of the circuit.
3) Apply 200 mVp-p at the input. Vary the frequency below and above the calculated cut-off frequency.
4) Observe corresponding V_o and V_i, and determine voltage gain $A = V_o / V_i$
5) Plot gain vs frequency graph and mark the cut-off frequency.

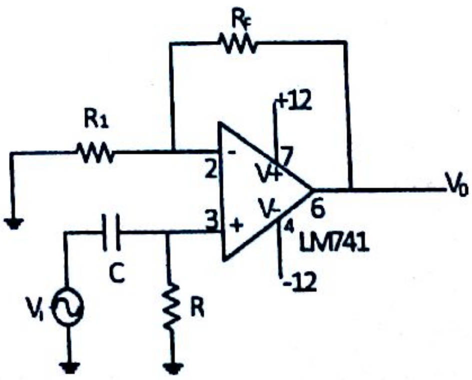


Fig. 7.4 Non-Inverting high pass filter

Note: Cut-off frequency is the frequency where gain falls below 70.7 % of the flat-band gain.

1 1.2 1.4 1.6 1.8 2.0.

.1