Experiment - 5
Feedback Amplifier Circuits

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Experiment-5

Feedback Amplifier Circuit

Aim : The aim of the experiment is to study the effects of various feedback configurations on amplifier output.

Objective : To construct amplifier circuits with different feedback configuration and study the effect of feedback on mid-band gain, cutoff frequencies and gain bandwidth product

Formulae:

A_v (Voltage Gain) $= \frac{V_{out}(p\text{-}p)}{V_{in}(p\text{-}p)}$.

A_v (in dB) $= 20 \log_{10} A_v$

Bandwidth $= (f_H - f_L)$ Hz

f_H : higher cutoff frequency

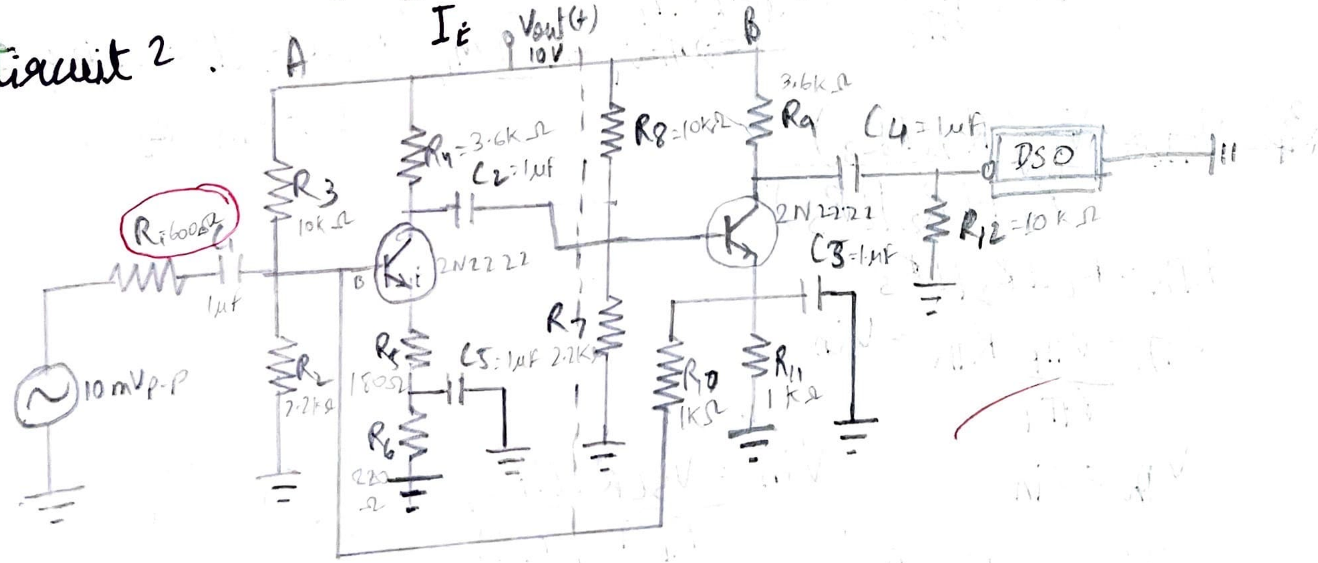
f_L : lower cutoff frequency

$I_E = I_C + I_B$

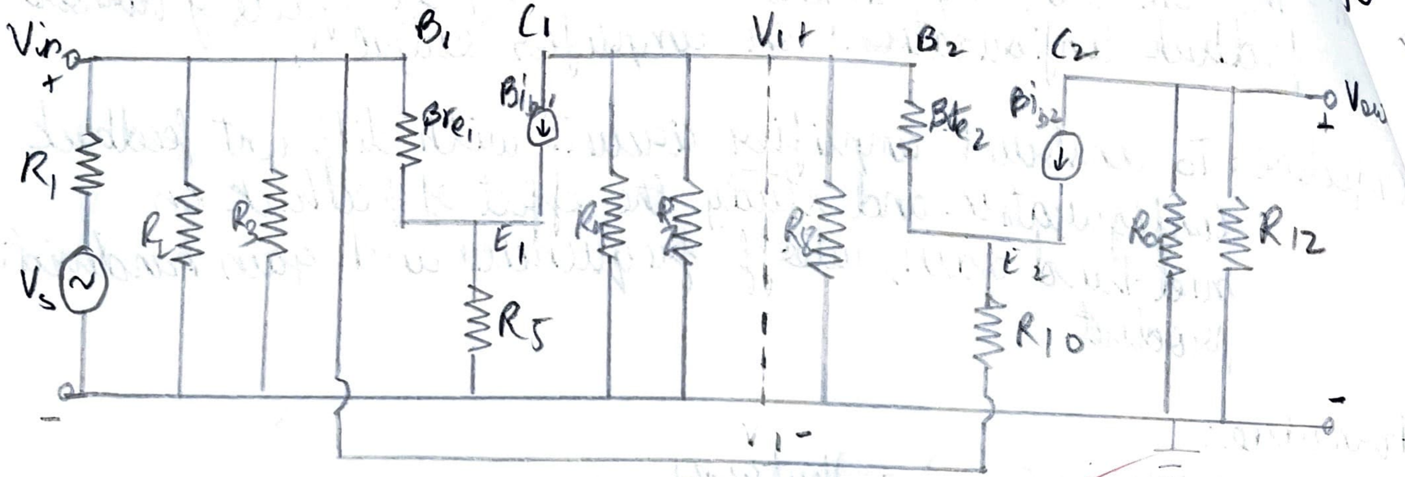
$I_C = I_{C\,majority} + I_{CO\,minority}$

$r_e = \frac{26\,mV\,(V_T)}{I_E}$

Circuit 2



A-C Equivalent Circuit



$$A_V = A_{V_2} A_{V_1} \left(\frac{V_{in}}{V_S}\right) = \frac{V_{out}}{V_1}\left(\frac{V_1}{V_{in}}\right)\frac{V_{in}}{V_S} = \frac{V_{out}}{V_S}$$

① $V_{out} = -g_{m_2} V_{\pi_2} (R_9 \parallel R_{12})$

$V_1 = V_{\pi_1}$

$$\frac{V_{out}}{V_1} = A_{V_2} = -g_{m_2}(R_C \parallel R_L)$$

$$g_{m_2} = \frac{I_C}{V_T} = \frac{I_C}{26mV}$$

② $V_1 = -g_{m_1} V_{\pi_1} (R_4 \parallel R_7 \parallel R_8 \parallel \beta r_e)$ $(\beta r_e = r_\pi)$

$$V_{in} = V_{\pi_1} + \left(\frac{V_{\pi_1}}{r_{\pi_1}} + g_{m_1} V_{\pi_1}\right) R_5$$

$$\frac{V_1}{V_{in}} = A_{V_1} = \frac{-g_{m_1}(R_4 \parallel R_7 \parallel R_8 \parallel \beta r_e)}{1 + \left(\frac{1}{r_{\pi_1}} + g_{m_1}\right) R_5}$$

since $i_{b_1} = \frac{V_{\pi_1}}{r_{\pi_1}} << g_{m_1} V_{\pi_1}$

$$\Rightarrow A_{V_1} = \frac{-g_{m_1}(R_4 \parallel R_7 \parallel R_8 \parallel \beta r_e)}{1 + g_{m_1} R_5}$$

③ $V_{Th} = \frac{V_S (R_2 \parallel R_3)}{R_1 + (R_2 \parallel R_3)}$

$R_{Th} = R_1 \parallel R_2 \parallel R_3$

$V_{Th} - \frac{V_{\pi_1}}{r_{\pi_1}} R_{Th} = V_{in}$

$V_{Th} = V_{in}$

$$V_{in} = \frac{V_S (R_2 \parallel R_3)}{R_1 + (R_2 \parallel R_3)}$$

$$\frac{V_{in}}{V_S} = \frac{R_2 \parallel R_3}{R_1 + (R_2 \parallel R_3)}$$

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Observation

$V_{in} = 90\,mV$. $V_{CC} = 10V$.

Frequency (KHz)	Vo (p-p) (V)	Av	Av in decibels.
0.5	1.55	17.22	24.72
1	1.84	20.44	26.21
2	1.9	21.11	26.44
5	2.0	22.22	26.84
10	2.3	25.55	28.13
20	2.6	28.88	29.18
30	2.9	32.22	30.16
40	3.3	36.67	31.29
50	3.3	36.67	31.29
60	3.3	36.67	31.29
70	3.3	36.67	31.29
80	3.2	35.55	31.02
90	3.1	34.44	30.73
100	3.0	33.33	30.44
200	2.8	31.11	29.86
300	2.5	27.77	28.85
400	2.3	25.55	28.13
500	2.2	24.44	27.75
600	~~128~~ 2.0	22.21	26.84
800	1.8	20.44	26.21
1000	1.6	17.22	24.72
2000	1.4	15.56	23.86.

~~Ensque~~ Circuit 2.

→ Ground R_{19} & connect R_{12} to base of transistor (Q_1) in first circuit.

Observation: $V_{in}(p\text{-}p) = 1.12V$ $V_{CC} = 10V$

Frequency (KHz)	Vo (p-p) (V)	$A_v = \left(\frac{V_o}{V_i}\right)$	A_v (in dB)
0.5	8.20	7.32	17.29
0.75	8.0	7.15	17.07
1	8.0	7.15	17.07
2	7.8	6.97	16.85
2.5	7.6	6.8	16.65
4	7.6	6.8	16.65

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Calculation:

$A_{v\,max} = \frac{V_o(max)}{V_i} = \frac{\cancel{2}\ 3.30\,V}{90\,mV} = 36.66$

$A_{v\,max}\ (dB) = \cancel{37}\ 20\log_{10}(36.66) = 31.29$

$A_o = \frac{A_{v\,max}}{\sqrt{2}} = 25.92$

$V_{out}\ (at\ A_o) = A_o \times V_{in} = 23.33$

- <u>3dB gain</u> F_L & F_H are at $A_{v\,max}$ - 3dB

$f_L = 5\,kHz \qquad f_H = 500\,kHz$

Bandwidth = $f_H - f_L = 995\,kHz$.

Midband frequency = $\frac{f_H - f_L}{2} = 247.5\,kHz$

Midband gain = $\frac{V_o\ (at\ f = 247.5)}{V_i} = 29.4$.

Result

Bandwidth = 995 kHz

Midband freq. 247.5 kHz

Midland gain = 29.4.

$A_{v\,max} = 36.66$

$A_{v\,max}\ (dB) = 31.29$

$A_o = \cancel{29}\ 25.92$

$V_{out}(max) = 3.3\,V$.

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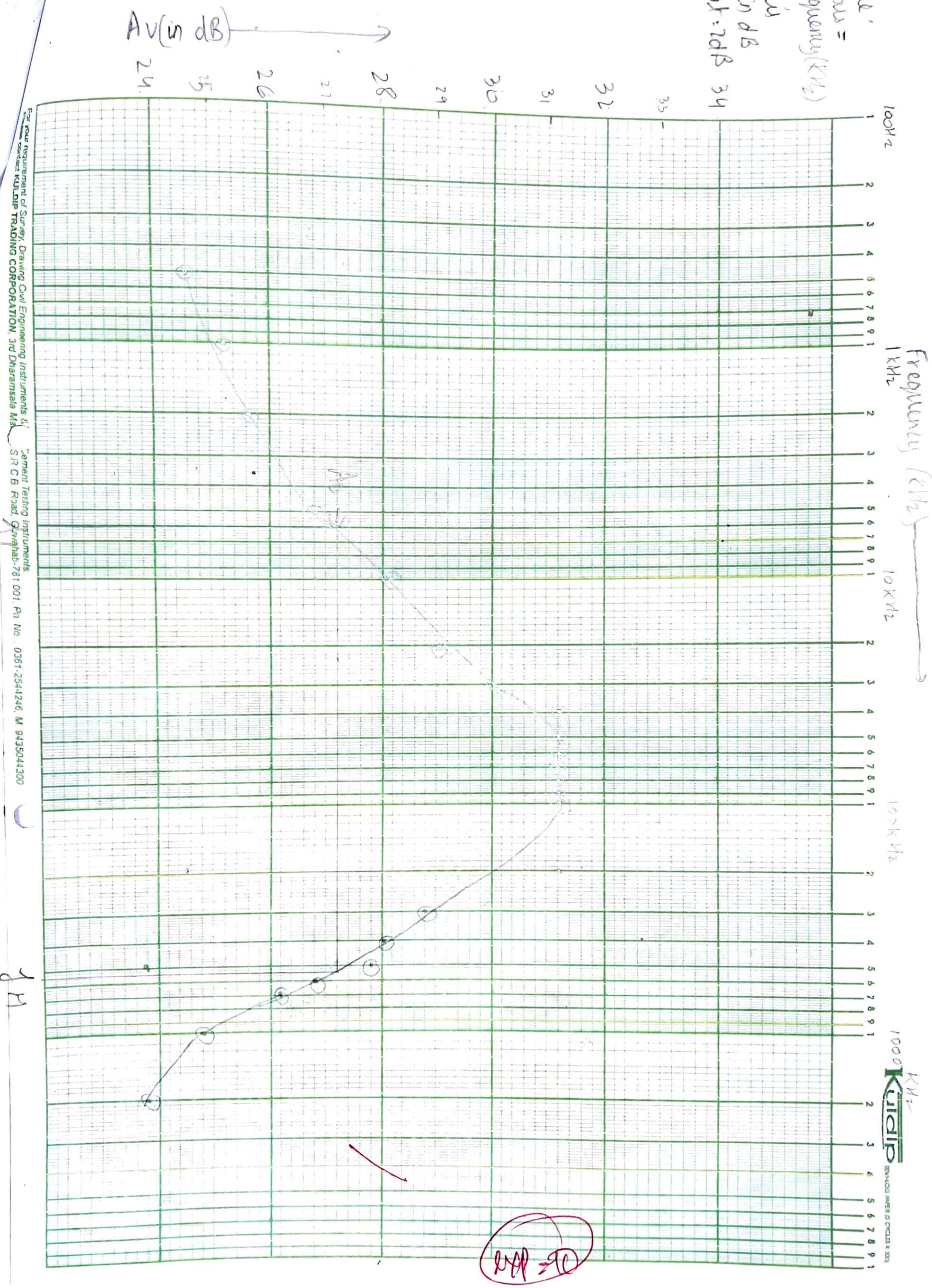
Av(in dB) v/s Frequency Graph



Discussions & Precautions

- Upon building Part A of the circuit we observed successfull amplification, hence we went ahead and built the Part B of the circuit as well

→ Amplification was observed and noted, upon increasing frequency, the voltage began to remain almost constant between 20 KHz to 300 KHz. From 500Hz to 20 KHz it was increasing and it was decreasing beyond 300 KHz.

→ Since we plotted the graph in dB for A_v, we have to perform "-3dB" from $A_{v\,max}$ in order to get full width half max of the graph. From this we got f_H & f_L to get Bandwidth.

→ In the modified circuit we gave input at high frequency and noted that the output was amplified and on increasing frequency the Vout decreased

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Precaution

- Avoid shorting ~~circuit~~ the circuit by checking ground of power supply
- All connections should be tight
- V_{in} should be less than 150mV to avoid clipping.

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