CHAPTER - V

STUDY OF RESPONSE OF THE CIRCUIT WITH VARIATION OF TAPPING POINT (A)

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5.1 INTRODUCTION

In order to investigate the effect of variation in the feedback by changing the tapping point parameter (A), the response of the circuit is studied by changing the tapping point. The circuit is redrawn to show the parameter 'A' in Fig.(5.1).

5.2 THEORY

To include the effect of tapping point parameter 'A', all the transfer functions are again obtained in terms of the parameter 'A'. They are given below,

(1) Voltage transfer function for Low Pass Filter

$$T_{LP}(S) = \frac{(-1/R_3)\ .\ GB_1 . GB_2}{S^2\left[\left(\frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{AR_1}\right) - \left(\frac{R}{AR_1}\right)\left(\frac{1-A}{R+A(1-A)R_1}\right)\right] + S\left[\frac{GB_1}{R+A(1-A)R_1}\right] + GB_1 . GB_2\left[\frac{1}{R_2} + \left(\frac{R}{R_1}\right)\left(\frac{1}{R+A(1-A)R_1}\right)\right]} \quad ..(5.1)$$

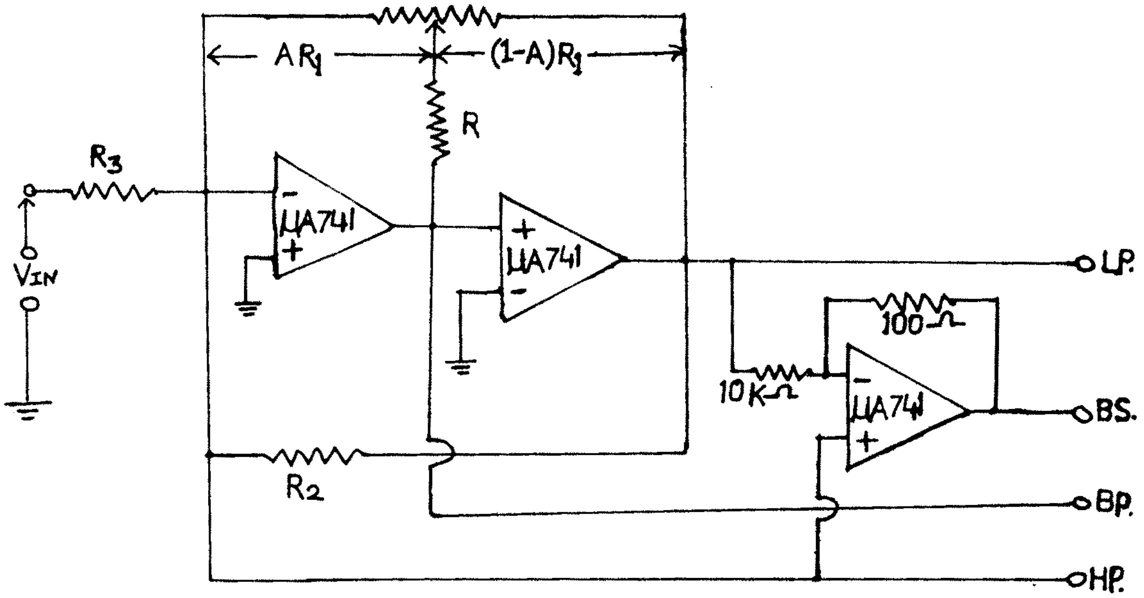


FIG.51: CIRCUIT DIAGRAM OF THE NEW ACTIVE-R BIAQUADRATIC FILTER.

(2) Voltage transfer function for High Pass filter

$$T_{HP}(S) = \frac{(1/R_3)\ S^2}{S^2\left[\left(\frac{1}{R_3}+\frac{1}{R_2}+\frac{1}{AR_1}\right)-\left(\frac{R}{AR_1}\right)\left(\frac{1-A}{R+A(1-A)R_1}\right)\right] + S\left[\frac{GB_1}{R+A(1-A)R_1}\right] + GB_1.GB_2\left[\frac{1}{R_2}+\left(\frac{R}{R_1}\right)\left(\frac{1}{R+A(1-A)R_1}\right)\right]} \quad ..(5.2)$$

(3) Voltage transfer function for Band Pass Filter :

$$T_{BP}(S) = \frac{(-1/R_3)\ .\ GB_1.S}{S^2\left[\left(\frac{1}{R_3}+\frac{1}{R_2}+\frac{1}{AR_1}\right)-\left(\frac{R}{AR_1}\right)\left(\frac{1-A}{R+A(1-A)R_1}\right)\right] + S\left[\frac{GB_1}{R+A(1-A)R_1}\right] + GB_1.GB_2\left[\frac{1}{R_2}+\left(\frac{R}{R_1}\right)\left(\frac{1}{R+A(1-A)R_1}\right)\right]} \quad ..(5.3)$$

5.3 DESIGN CONSIDERATION

As discussed in earlier chapters, the design equations were obtained by comparing the transfer functions with the general second order transfer function,

$$T(S) = \frac{\alpha_2 S^2 + \alpha_1 S + \alpha_o}{S^2 + (W_o/Q)\ S + W_o^2} \quad ....(5.4)$$

The result of comparison yields,

$$\left[\left(\frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{AR_1}\right) - \left(\frac{R}{R_1}\right)\left(\frac{1 - A}{R+A(1-A)R_1}\right)\right] = 1 \qquad \ldots.(5.5)$$

$$\left[\frac{GB_1}{R+A(1-A)R_1}\right] = \frac{W_o}{Q} \qquad \ldots.(5.6)$$

$$GB_1 . GB_2 \left[\frac{1}{R_2} + \left(\frac{R}{R_1}\right)\left(\frac{1}{R+A(1-A)R_1}\right)\right] = W_o^2 \qquad \ldots.(5.7)$$

The circuit is again assembled with the operational amplifiers used for earlier studies. Once again the value of 'R' was assumed to be 33 ohms and other components were calculated. The calculated and actually used component values are given in Table (5.1).

5.4 RESULTS AND DISCUSSION

The four filter outputs were observed over the frequency range from 50 Hz to 1 MHz. They are graphically shown in Fig.(5.2), (5.3), (5.4) and (5.5). From the observations following points are noted for various outputs.

(1) LOW PASS RESPONSE

The low pass response is shown in Fig.(5.2). A theoretical curve is also included for A = 0.5. It is seen that there is close agreement between the theoretical and observed results in passband. However, the theoretical

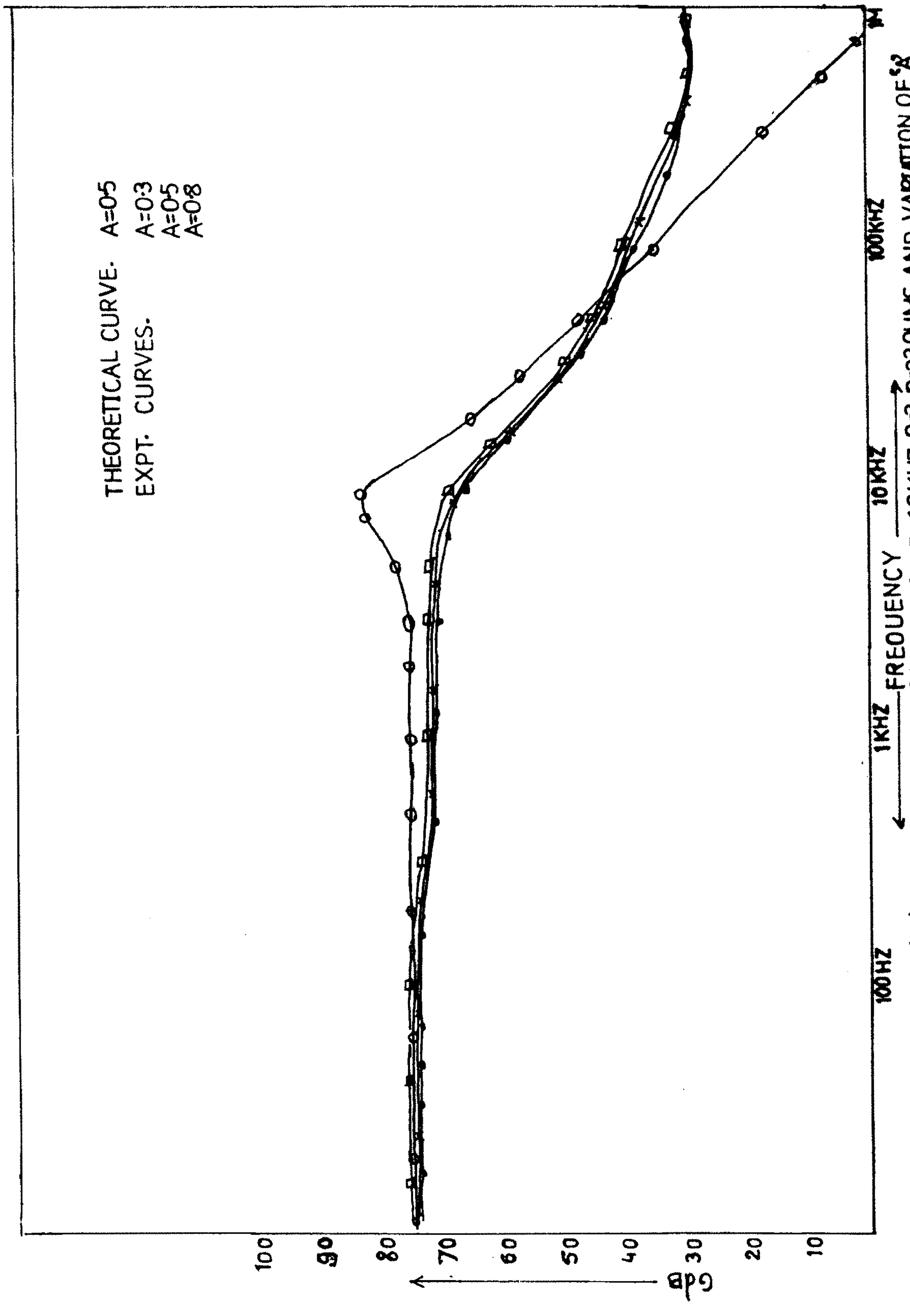
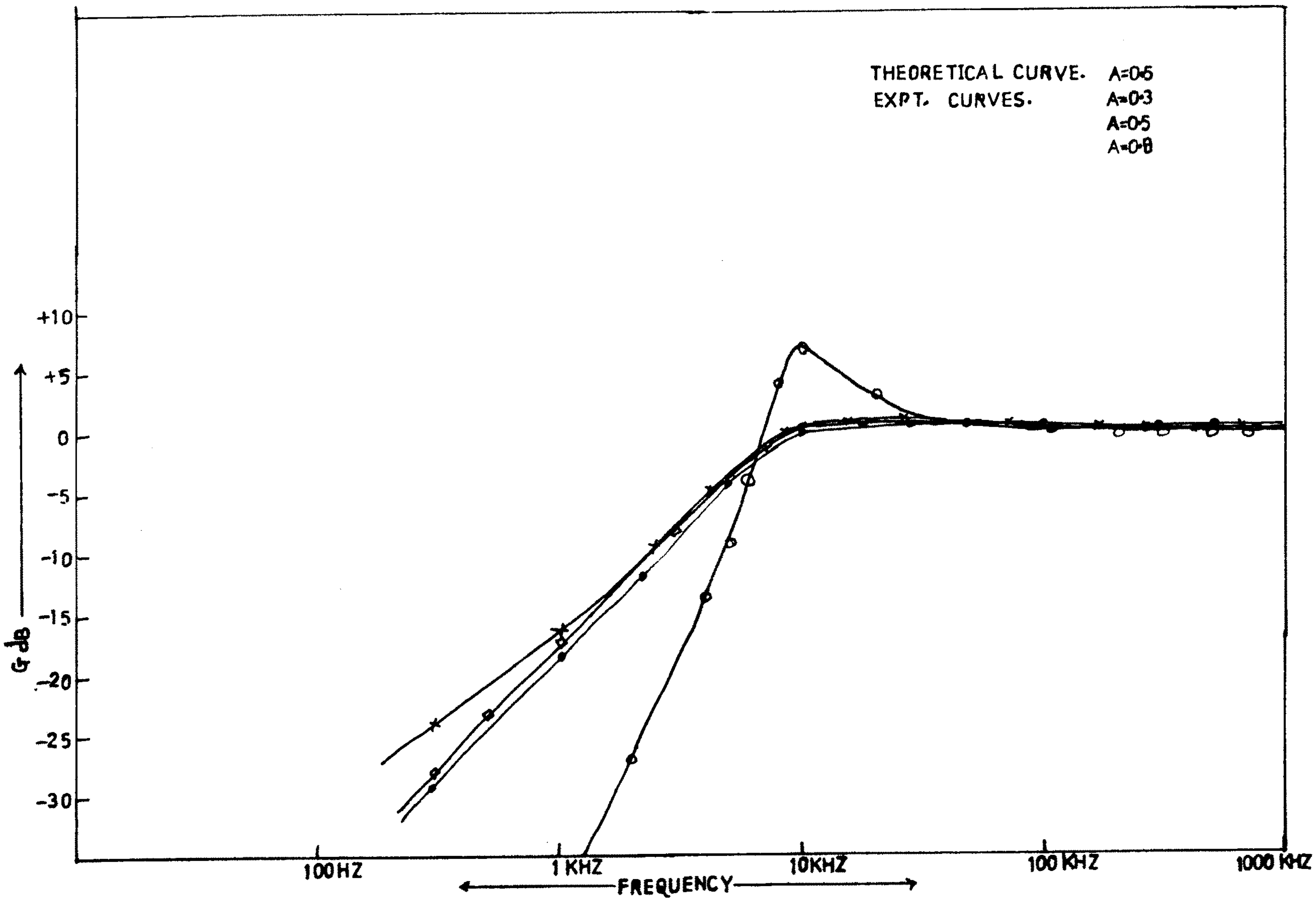


FIG.(52): LOW PASS RESPONSE FOR F_0=10KHZ, Q=3, R=33OHMS AND VARIATION OF 'A'



FIG(5·3) HIGH PASS RESPONSE FOR $F_0 = 10$ KHZ, $Q = 3$, $R = 33$ OHMS AND VARIATION OF 'A'.

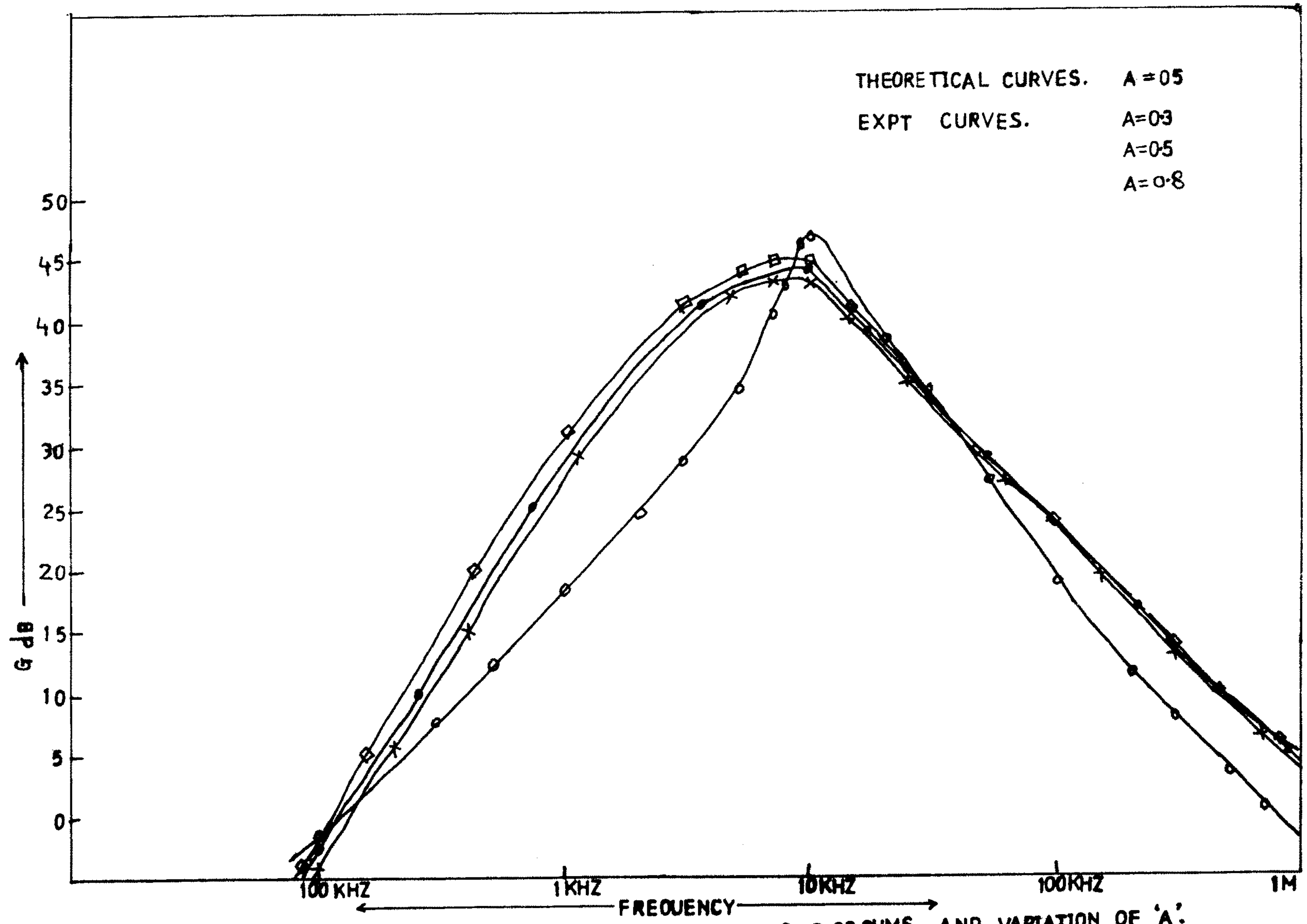
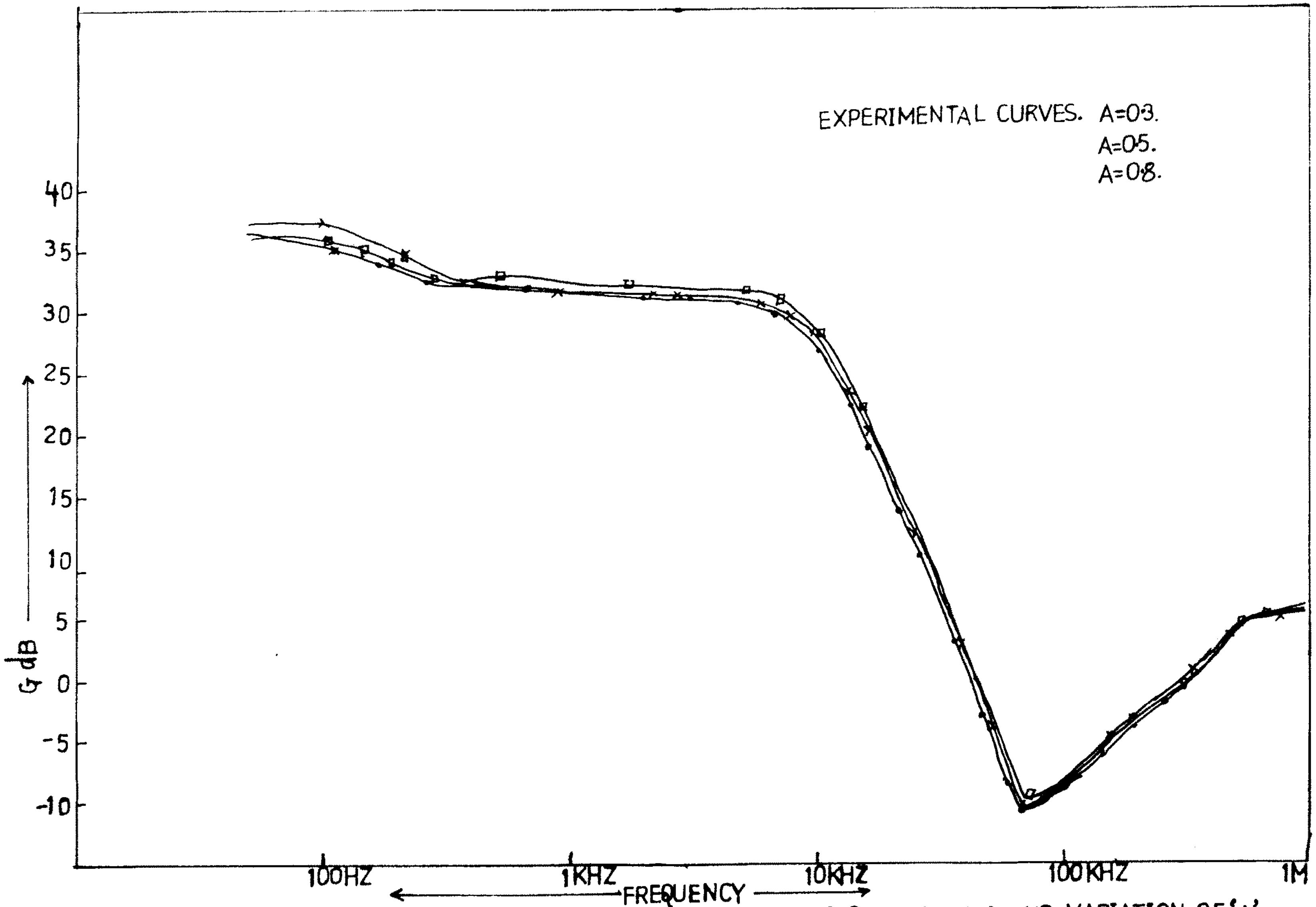


FIG.(54) BAND PASS RESPONSE FOR F0=10KHZ, Q=3, R=33 OHMS AND VARIATION OF 'A'.



FIG(5·5): BAND STOP RESPONSE FOR F_0=10KHZ, Q=3, R=33OHMS AND VARIATION OF 'A'.

curve shows a slight peaking at 10 KHz which is the design frequency F_o. A departure is also observed between theoretical curve and observed results above 100 KHz. This may be due to lower gain of the operational amplifier in the high frequency region. It is also noticed that the variation of tapping point parameter (A) has very little effect on the response. Further, there is a good agreement between the observed cut-off frequency and the design value of F_o. The circuit shows very high gain (74 dB) in the passband. The overall low pass response is satisfactory.

(2) HIGH PASS RESPONSE

The high pass response is shown in Fig.(5.3) along with the theoretical curve. It is noticed that the graphs merge together above 25 KHz. The theoretical curve shows a peak at F = 10 KHz which is the design value of F_o. The cut-off value is slightly lower as compared to design value F_o = 10 KHz. The variation of tapping point (A) has a small effect below the cut-off frequency but almost no effect in the passband. There is noticeable departure between the theoretical curve and the observed response below the cut-off frequency. This may be due to the higher gain of operational amplifier in the low frequency region. Secondly, the circuit being a multiple feedback circuit, the combined effect might have produced gradual increase in the gain in the low frequency region (20 dB/decade) while theoretical rate is approximately (40 dB/decade). The response is satisfactory otherwise.

(3) BAND PASS RESPONSE

The band pass response is shown in Fig.(5.4). The band pass response is similar to the response of a resonant circuit with low 'Q' values.

It is noticed that theoretical curve as well as observed curve show peaks at the design value of $F_o = 10$ KHz. The general nature of the response indicates a good agreement between the theoretical and observed results. On low frequency side, there is a slight departure making the observed graph somewhat broader as compared to the theoretical graph. Again, it is noticed that the variation of 'A' has very little effect on the performance.

(4) BAND STOP RESPONSE

The band stop response is shown in Fig.(5.5). From the graph, it is found that all the curves are identical showing there is no variation with respect to tapping point parameter (A). There is no correlation between design and observed value of F_o. The curves are similar to low pass response except the pronounced deep at about 70 KHz. The performance is not satisfactory in this case.

5.5 CONCLUSIONS

The response of the circuit over the entire range was studied for different values of A. It is noticed that the variation of A has practically no effect on the response. The behaviour of the circuit is satisfactory for L.P., H.P. and B.P. actions. However, the band stop response is very poor. This is also noticed for variation of F_o and variation 'Q'. Further, the theoretical curve shows peak at the frequency near about F_o while the observed responses show no peak at all. The departure at low and high frequencies might be due to high and low gains of the operational amplifiers in these regions respectively.

Table (5.1) : The designed and experimental values of resistances of a new Active-R biquadratic filter.

F_o (KHz)	Q	Tapping point (A)	Designed Values				Experimental Values			
			R_3	R_2	AR_1	$(1-A)R_1$	R_3	R_2	AR_1	$(1-A)R_1$
10	3	0.3	100 Ω	625.60 KΩ	23.40 KΩ	54.50 KΩ	100 Ω	625.60 KΩ	23.20 KΩ	55.00 KΩ
10	3	0.3	100 Ω	651.90 KΩ	22.40 KΩ	22.40 KΩ	100 Ω	651.40 KΩ	22.00 KΩ	22.00 KΩ
10	3	0.3	100 Ω	734.00 KΩ	23.40 KΩ	5.90 KΩ	100 Ω	735.00 KΩ	23.40 KΩ	5.60 KΩ