CHAPTER - VI

SUMMARY OF CONCLUSIONS

CHAPTER - VI

SUMMARY AND CONCLUSIONS

In this dissertation, discussion begins with brief view on filter. The filter is considered as frequency selective network such that it passes or suppresses a group of signals from mixture of signals. With this view a new biquadratic active R filter is developed and discussed in chapter iii, iv & V. Recent IC technology has drastically affected the design of linear network such as frequency selective network, wave shapping networks, delay lines etc. The absence of capacitors makes the design attractive for monolithic IC fabrication. Survey of literature of active filters shows, over the past few years, a number of papers published dealing with the design of a active R filter and switched capacitor active filter, which is the product of fully integrated active filter.

A more detailed discussion on basic filter circuits and classification is given in section (1.3). Electrical filters may be classified in number of ways such as analog filters, digital filters. Analog filter may further be divided into passive or active filters, depending on the type of element used in their realization.Filters are also classified according to functions they perform, as a low pass, high pass, band pass, band reject, amplitude equalizer and delay equalizers. There are some limitations of passive filter which are overcome by active filters. Most of the active filters are realized by using an op. amp. in RC network in feedback configuration, providing high Q networks. These inductorless filters give sharp filtering action. They are light in weight, compact, economical and free from loading effect. Among the drawbacks of these filters is the finite bandwidth of active devices. Recently, there has been a great interest in the active-R filters which are based upon the single pole model of the actual op.amps. They used only resistors and operational amplifiers without external capacitors. There is brief discussion on active-R filter in section (1.5). The advantages of an all resistive filters are extended frequency response, miniaturization in size, ease of design, ease of tunability and low sensitivity.

Before undertaking design of any active filter circuit, it is better to consider all theoretical aspects. With this view in mind, chapter - II discusses briefly the basic filter theory and approximations. The selection of an active filter configuration depends on the sensitivity of the transfer function to the variation in the passive elements and the active element parameters. In section (2.1), the discussion of the designing of higher order filter is given. A standered method of designing a higher order active -R filter is to realize it as cascade of second order filters. However, coupled biquad structures have lower sensitivity than cascade structures. The discussion on various type of sensitivities is given in section (2.2). Since the ideal response cannot be attained by any finite connection of elements, the determination of system functions which approximate the given curve within a specified tolerances is called "approximation problem". There are several types of low pass approximations which are discussed in section (2.3). They are Butterworth (maximally flat response), the Chebyshev (equiripple response), the inverse Chebyshev response and the Bessel (maximally flat delay response). The frequency transformation technique is then applied to design high pass and symmetric band pass and band reject filters.

A state variable technique is briefly discussed. A state variable representation is oneway of representing the effect of an energy storing element in any physical system. The state variable realization provides less Q sensitivity to element variation than a single- amplifier realization. Finally in this chapter, the filter topologies are discussed. The negative feedback and positive feedback topologies of biquads are the basic building blocks of active filters.

A new active - R biquadratic filter based on the single pole roll-off characteristics of operational amplifiers is described. In this circuit, two op. amps. and four resistance are used. The feedback resistance is tapped at center and resistance R is connected as shown fig. (3.1). The circuit is multiple feedback circuit which realizes four biquadratic functions namely low pass, high pass, bandpass and band stop at four different output terminals.

The resonant frequency Q of the poles and the location of the zeros can be controlled over a wide range by feedback and feedforward circuit. For practical realization, all values of resistances must be positive. Hence if f_o and R are assumed, an upper limit is set on the value of Q which is given by equation (3.12). The upper limit for Q, for f_o = 10 KHz and R = 1.7 ohms is given by 1.35 the response of circuit was studied for variation in Q = 0.2, 0.5 and 1 for f_o = 10 Khz and R_1 is topped at center point. The basic limitation is that none of the outputs should be either saturation limited or slew rate limited. From the response curves, an excellent agreement was observed between theoretical and experimental results. The response is extended from very low frequency region to 1 Mhz. It gives high gain in pass band but for band pass and high pass some degradation at very low frequencies is observed. The variation of R provide a controllable gain and resonant frequency. The center frequency was not disturbed for the different values of Q. Low pass response gives excellent response with higher gain . The high pass response is extended up to 200 Hz at lower frequencies. It is worth noting that various circuits discussed in literature give good response from 1 Khz onwards only. There is no overshot observed anywhere in the response. This is most probably due to lower Q values used in design.

Next, study of the response of the same circuit with variation of center frequency f_o is discussed in the chapter IV .The response of the circuit was studied for f_o = 10 Khz, 50 Khz and 100 Khz for Q= 1 and tapping at center. A new active-R filter discussed for different center frequencies show close agreement between the theoretical and experimental values. It is observed that, as the center frequency is increased, there is decrease in gain in pass band. The roll-off for the low-pass response is 35 dB/decade. For the high pass response, the flatness of curve in pass band decreases as center frequency increases. However, the curves are peaked for lower center frequency. For bandstop filter, there is sharp rejection point with decrease in the deep of rejection.

Finally, the study of the response of this new active-R filter circuit with change in tapping parameter A is discussed in chapter V . The response of the circuit was studied for different tapping point parameter A = 0.1, 0.3, 0.5,0.7 and 0.9 for Q = 0.2, f_o = 10 Khz . The circuit also shows excellent agreement between theoretical and experimental result. For low pass response, gain decreases as tapping point moves towards extreme points. However, for bandpass response, the response becomes peaked as tapping point moves towards either extremities. There is some degradation observed for band pass at low frequencies. The center frequency and gain bandwidth product gives excellent agreement with the designed value. Also it is observed that the gain roll off shows excellent agreement with theoretical values.

CONCLUSION :- This new biquad filter discussed in this dissertation provides a satisfactory response for all the four functions. The circuit is studied in detail with variation in Q, f_o and the tapping parameter. In all the cases the response is vary satisfactory. There is close agreement between the theoretical results and actual observations. However some degradations are observed in some cases at very low and very high frequencies .The variation of the feedback elements or the tapping parameter A provide control over the gain and design frequency. It is noted that for small values of R, the Q is low and therefore the circuit is free from overshoot in response curve. For large values of R, response shows peaks, The response for high pass filter is extended up to 200 hz at lower frequencies. However there are no other noticeable advantages. Hence the circuit is studied for low value of R only. The agreement of designed values of f_o is excellent in all the outputs except the band stop output.

The circuit uses three op. amps. for providing all the four outputs and uses four resistances. The resistance count is increased by one and a one more tapped resistance is required as compared to some circuits discussed in literature. This should not be considered as serious disadvantage as the tapped resistance provides a control over gain and frequency. Many circuits are designed with view of IC fabrication . In this case also there will not be serious difficulty by increase of one resistance, which may be provided by voltage controlled variable resistance device. Similarly the problem of tapping can be solved. Thus the biquad filter discussed in this dissertaion may prove quite useful.

FURTHER INVESTIGATION :- The biquad circuit discussed in this dissertation, although provides some advantages, it also has some degradations in response.

1. In study of response with variation of Q the low frequency gain is somewhat higher than the theoretical gain for high pass output. The same thing is observed for bandpass output. Similarly in bandstop response, the gain at higher frequencies are slightly low.

2. The study of response with variation of f_o also shows some degradation. The gain at low frequency side is slightly

higher than the expected value. For f_o = 100 Khz and for low Q there is no peaking, low gain and a flat response. Also noted is the fact that the high pass response is satisfactory above 1 Khz.

3. The variation of parameter A shows some disagreement with the expected results for high pass response. The gain at low frequency is quite high as compared to expected values .

All these deviations observed in the response curves are being further studied so as to find the exact cause of these deviations. This provide an interesting study for improving overall performance of the biquad circuit discussed in this dissertation.