CHAPTER 6

General Conclusions and Suggestions for Further Investigations

6.1 Summary and Conclusions

A broad class of previously unknown networks has been introduced in this thesis. The networks have the important property of being able to discriminate between different types of polyphase input signal. This property can be used to advantage in single sideband modulation, N-path filtering and miscellaneous other applications requiring phase splitting or combining.

The networks fall into two main subdivisions: lossless and lossy. Lossless types require elements employing active devices and suffer from limitations regarding sensitivity to active element parameters, noise, linearity and the fact that a power supply is needed. Their main advantage is that there is no limitations on the type of frequency response that can be obtained and in consequence a given performance can be achieved in the most efficient manner. In contrast, lossy types can be made using only resistors and capacitors and so do not suffer significantly from noise, linearity and power constraints. The frequency response of lossy RC types is limited by the fact that the transmission poles all lie on the imaginary frequency axis. In general the obtainable response must be backed up by additional filtering such as low pass filtering in single sideband modulation applications.

Practical working models have been built of both types of filter. The five section lossless filter described in Chapter 3 used 1:j transformers constructed with discrete components. Although the model worked quite well it proved to be difficult to obtained the theoretical response. This was found to be largely due to imperfections in the 1:j transformers. It might well be possible to improve the performance by using operational amplifiers for the transformers. The passive 4-phase types described in Chapter 4 proved to be much easier to construct and it was found possible to approach much closer to the theoretical performance since this depended almost entirely on matching sets of four resistors or four capacitors. When used as a single sideband modulator the main limitation was found to be in the modulating devices. Even so sideband discriminations of up to 70dB have been achieved in practise at a carrier frequency of 100kHz.

Sensitivity studies, conducted in Chapter 4, on 4-phase lossy R-C single sideband modulator designs showed considerable advantages over previously known phase splitting methods. These advantages were found to reside principally in the easier component tolerances required and the more practical component values that are possible. A 50dB single sideband rejection for example would need 1% components with the polyphase method compared with a quadrature modulation scheme using R-C phase splitting networks which would have to be made with 0.1% components. These figures are approximate and would depend on the desired yield of networks meeting the specification.

Most sequence asymmetric polyphase filters can be designed using a complex single phase equivalent filter. A wide range of methods were developed for this purpose in Chapter 2. Such designs may be achieved either from first principles or through the transformation of existing symmetrical about zero frequeny filters.

Either transfer function or a complete filter structure can be produced with any of the methods described. Image filter designs were studied in some detail because of their usefulness in coming to an understanding of the many possible network structures and because of their flexibility when building practical models for investigation. Two different function synthesis techniques have been studied. The first method is generally applicable to band pass filters with equal ripple passband but arbitary stopband requirements. Filters designed using this technique would be of the lossless type employing constant reactances in the single phase equivalent network. The second synthesis method involving elliptic functions has a special case of particular interest for passive R-C type sequence asymmetric filters. Using this special case it is possible to design R-C filters with flat passbands and equiminima stopbands. Poles and Zeros for this type of filter are tabulated in an appendix.

Although the main result of this work has been improved single sideband modulators a number of other applications have been found for sequence asymmetric polyphase filters. By incorporating them into N-path filter systems tuneable low and high pass filters can be constructed. A practical polyphase oscillator has been constructed by including a sequence asymmetric filter in the feedback path of an 4 phase amplifier. The networks can also be used in any phase splitting or combining application requiring phase divisions of integer fractions of 360 degrees such as 120, 90, 72 60 etc., degrees.

6.2 Suggestions for Further Investigations

Because of the many possibilities inherent in the subject of sequence asymmetric polyphase filters it has not been possible in this thesis to cover every aspect in total detail. Many areas remain open to further investigation.

The subject of function synthesis of the single phase equivalent network has only been studied for the case of equiripple passbands. It should be possible to generate other function methods equivalent to Butterworth, Tchebychev, maximally flat delay and optimum pulse response types known in conventional network synthesis.

In the field of lossless networks it should prove worthwhile to investigate improved realiseations of 1:j impedance transformers using operational amplifiers. Since these transformers were found to be the limiting factor in the experimental models an improvement here would make it possible to achieve better stopband performance.

An interesting possibility of making low sensitivity conventional single phase filters arises with lossless filter structures. In a conventional filter the poles or zeros come in pairs making quadratic factors in the transfer function. By factorizing the quadratic factors into complex conjugate factors and realising each factor separately in a cascade of polyphase filter sections a low sensitivity filter should result. The filter would be driven on one input phase and the output taken out of one output phase. Although no work has been done on this it is believed that effort in this direction should prove fruitful.

Most of the work on lossy R-C filters has concentrated on the design and application of 4-phase types. Much work remains to be done in completing the pattern of overall knowledge of types with other than 4-phases. Their sensitivity to component variations may be better in some circumstances than that of 4-phase types. Sensitivity is a subject which would bear much deeper investigation as a whole to determine guide rules for what tolerances are necessary in a given application.

Finally it is, in the author's opinion, certain that many systems could benefit from the application of polyphase filtering techniques and the potential economies in cost and size offered by film circuit integration of the passive R-C types.