CHAPTER 8

DISCUSSION AND CONCLUSION
This thesis has reported investigations into discrete coding techniques for improving range resolution and clutter performance of radar systems. The waveform considered in this work besides representing an interesting mathematical area, are also of practical significance in related fields such as sonar, navigation, and digital communications. The study is focused on the properties of the coded waveforms as modulating functions of a carrier signal. The design of hardware structures of radar processors has not been considered, since there are generally a number of ways available to implement near optimum receivers for a given waveform. Cost, complexity and reliability are usually the bounds set on processor design rather than physical realizability. These problems would have to be considered for each application individually.

The waveform design approach using discrete coding offers a degree of flexibility and has many advantages in terms of waveform shaping and processor implementation. The variations possible with such waveform is virtually unlimited in that the phase, amplitude, frequency and time of transmission of each sub-pulse can be varied. This is clearly in contrast to analogue waveforms which depend on one or possibly two parameters. The inherent multifunction capability of discrete coded waveforms is compatible with the requirements of modern phased array radars. In addition amplitude and phase modulated pulse trains are particularly well suited to digital implementation.

Throughout this work digital processing has been assumed. The application of digital processing techniques to radar becomes more practical as compactness, cheapness and operational speed of digital micro circuits continue to increase. Although modern optical processing techniques sometimes provide an attractive alternative, the use of digital method with its inherent flexibility and reliability offers many advantages. To mention but a few, it simplifies pulse compression and real time multi-dimensional analysis of input data in range, Doppler, bearing, etc. Furthermore, it also offers considerable
advantages in post detection and display processing. In addition the use of digital processor will in many cases reduce future system modifications to easy and inexpensive software changes, rather than requiring costly hardware replacements.

An attempt has been made in this work to present results of various design objectives. The assumption of a matched filter receiver underlying most of the work, is not a serious limitation on the applicability of the results, since in practice very little prior information about the target environment is usually available. Therefore, the investigations were concentrated on the auto-correlation function properties of the various types of pulse trains considered. The principal aim has been to design pulse trains whose auto-correlation side lobes are as low as possible. The design methods presented in this thesis have shown that phase coded pulse trains can improve the range, resolution and clutter ejection performance of a radar system. Self clutter interference introduced by inadequacies in the matched filter response impose rather fundamental limitations on weak target visibility. Moreover, the resolution problems caused by self clutter and undesired objects are in principle no different in that both impede resolution in the same manner. If processor complexity is not of utmost concern, the use of amplitude and phase modulated pulse trains may offer an improved performance. Alternatively, self clutter suppression may be achieved by side lobe reduction filters or methods proposed in this thesis. Although mismatching the receiver filter may be useful means of adopting the waveforms to a particular target environment, it should not be used as a primary method to improve resolution. Hence, the proper approach to clutter suppression, except in few special cases, is via waveform design and matched filtering.

In situations where the relative Doppler spread of the targets can not be neglected, the matched filter response has to be investigated in terms of the ambiguity function. In principle, the methods developed could be applied to the more general problem of designing pulse trains suitable for resolving targets in range and range rate. However, even with modern computers, the search for phase codes having good resolution properties in both range and range rate is so expensive that it would have to be
restricted to relatively short sequence and small areas of the range Doppler plan. For these reasons waveform synthesis for range and range rate resolution usually consists of a trial and error procedure and a judicious use of available information.

In summary, the signal problem has in general defied solution by all means other than exhaustion. In particular, no concise set of necessary and sufficient conditions has been formulated by which signals with specified properties can be synthesized. Signal theory, the basis for many technical advances is far from being complete and its further development is, therefore, of fundamental importance. As a final remark the design methods developed in this thesis are of general interest. With appropriate modifications they can be applied to a variety of signal and filtering problems.