Chapter 6

Conclusions

A number of inadequacies in conventional array synthesis methods have been identified and addressed.

The transformation based synthesis method, prior to this thesis, could be used for the synthesis of rectangular planar arrays with quadrantal or centro symmetrical footprint patterns only. The transformation technique is extended to enable the synthesis of planar arrays with arbitrary contoured footprint patterns; planar arrays with non rectangular boundaries and planar arrays with triangular lattices. The transformation based synthesis technique utilises a transformation that divides the problem into two decoupled sub-problems. One sub-problem (the contour transformation problem) involves the determination of certain coefficients in order to achieve the required footprint contours. The number of contour transformation coefficients which must be used depends on the complexity of the desired contour, but is very small in comparison to the number of planar array elements. The other sub-problem consists of a prototype linear array synthesis, for which powerful methods for determining appropriate element excitations, already exist. The separation of the synthesis procedure into two sub-problems is not only good from a computational point of view, but aids understanding by highlighting which considerations will finally determine the required array size (viz. contour complexity; allowed coverage ripple; final planar array directivity). Simple recursive formulas then determine the final planar array excitations from the information forthcoming from the above two sub-problem solutions. The final planar array size is linked to the number of contour transformation coefficients and the prototype linear array size. The biggest advantage of the transformation based synthesis technique is its computational efficiency, making it feasible to conduct parametric studies of array performance design tradeoff studies even for very large arrays. However, the transformation based synthesis method does suffer some limitations, it can not be used to synthesise planar arrays with an arbitrary number of elements and it does not use all the degrees of freedom due to the very nature of the technique. Existing transformations were all shown to be special cases of the extended transformation based synthesis technique methods presented in the thesis.

No useful difference pattern synthesis method exists for planar arrays. A well ordered, step by step procedure for the synthesis of planar arrays with difference patterns is presented. The method utilises the convolution synthesis method and uses the extended transformation method as one of the steps. The technique in effect provides a structured procedure for spreading out the linear array excitations, thereby eliminating any guesswork that may otherwise be required. The result is near-optimum difference patterns for planar arrays with rectangular or hexagonal lattices. The difference pattern performance in the selected cut is identical to that of the archetypal linear array used, and will thus be optimum if the latter is optimum. In the other pattern cuts the sidelobes are below those of the archetypal linear array, but not unnecessarily low. The synthesis procedure is very rapid for even very large arrays, making it feasible to conduct design trade-off and parametric studies.

Synthesis of conformal arrays is an ill conditioned inverse problem with a multitude of local minima. Unlike linear and planar arrays, where the element pattern can be factored from the radiation pattern, no such simplification can be made to ease the conformal array synthesis problem. Due to the non linear nature of conformal array synthesis an effective conformal array synthesis method must have a rapid rate of convergence and some measure of confidence that the result will be close to the optimal solution. Previously no effective conformal array synthesis technique existed. The synthesis of arrays of arbitrary geometry and elements can be stated as the search for the intersection of properly defined sets. Proper sets were defined in both the radiation pattern space and excitation space; along with the necessary projector between these sets. From a practical engineering point of view the search for the intersection of sets in the excitation space will be best. Effective relaxation can be implemented in the excitation space as well. A proper selection of the starting point is needed to avoid falling into a trap. A number of possible ways of calculating starting points were investigated, and a novel method to obtain a set of initial values as close to the global minimum as possible is proposed for shaped and contoured beam synthesis. The phase variation in the shaped beam region is slow and may be written as a function of a few variables. The starting pattern is a summation of component beams, each weighted by the proper value of the shaping function and phase shifted by the proper value of the phase function. Genetic algorithm is used to optimise these phase function variables. Case studies were used to derive rules of thumb for obtaining the selection of various options available in the implementation of the method to obtain the best possible results. The importance of practical element patterns in the analysis and synthesis of conformal arrays was also shown. The intersection of sets method obtained better results than other existing methods.

A large number of representative examples were presented in each chapter to show the advantages of the proposed synthesis methods.