**Abstract**

A mobile handset needs to transmit/receive data on multiple frequency bands to access a diverse range of services. This implies both an increase in real estate for mobile terminal antennas as well as ever escalating challenges for the antenna design and manufacturing departments. The pixel patch antenna has been proposed as a possible solution. The pixel patch antenna is made up of a large number of pixels which by themselves do not resonate at any frequency of practical interest. However, when a set of selected pixels are connected/switched together, antennas of different shapes are synthesized to deliver the required electrical characteristics. Ideally these properties are optimized for a given operating environment in real-time. Given the antenna hardware architecture, the problem of synthesizing the various shapes can be casted as a search among many configurations, which is not a trivial problem because of the large search space defined by the pixel array.

Early research has focused mostly on the physical construction and architecture of the pixel patch antenna and it is only recently that attention has increased on the search algorithm. A series of experiments using shorting ports, switches and varactor diodes are carried out as part of the literature review, to study tuning techniques. As a result of this study, novel architectures are proposed. The model based search algorithm is reviewed and its performance is compared to the Genetic Algorithm with and without pruning methods. This thesis builds upon the idea of making use of an antenna model in the search and optimization loop. To this end the known planar circuit model, augmented with segmentation and desegmentation methods, is further developed to yield an efficient model that is used to analyse a given arbitrary pixel antenna configuration. In the model's formulation, the Green's function approach is chosen to analyse the planar circuit. The Green's function is available for regular shapes only, and for arbitrary shaped structures, segmentation techniques are used to connect regular shapes together. The Generalized Cavity Model is used to model radiation and the fields beneath the patch.

In order to realize the model several studies and novel methods had to be developed. An analysis of the behaviour of the Green's function with respect to the number of modes needed for convergence was carried out. It was determined that that the number of modes needed is a function of frequency and the permittivity of the substrate $\varepsilon_r$, at which the Green's function is evaluated. It

was also found that the maximum number of modes is needed when the value of effective loss tangent is zero. These studies are used to dynamically estimate the number of modes needed per segment. A study is performed on the errors generated by multiple applications of the segmentation technique. The results from this study indicate that the number of segments used to represent the pixel patch antenna should be minimized. This is implemented in the Model Order Reduction algorithm.

The relationships between the pixels are represented in a tree and a graph. This tree is traversed in order to build the order of segmentation. The use of these data structures allows the analysis of any arbitrary pixel patch antenna. A novel method to calculate the current passing through a number of *n*-port networks is developed and described. This method is more computationally efficient than the method used in the original segmentation method. The graph is used to determine the edges of the segments that will be used in the segmentation algorithm.

A set of solvers are developed and their application in terms of efficiency are studied. In particular an algorithm that evaluates the input impedance of the antenna only in a set of intervals and interpolates between these points to find the minimum value of the input reflection coefficient is developed. The fields are only evaluated once the resonant frequency is found.

The results obtained from this model are compared to CST microwave studio simulations. A set of pixel patch antennas configured in regular shapes, and a set of arbitrary shaped pixel patch configurations are used in the evaluation. The planar circuit model yields accurate results for the resonant frequency while it gives a good estimate of the impedance matching. The different variants of the model are considered to study the trade-off between accuracy and computational efficiency. Finally, developments to the model that potentially improve computational efficiency are suggested and discussed.