ABSTRACT

In recent years, a rapid growth in the number of mobile phone users and increasing demand for broadband services have thrown challenges to mobile communication networks in terms of user capacity, spectrum utilization, interference mitigation and power efficiency etc. Adaptive beamformers otherwise known as smart antennas, are considered to be an important solution to these problems. An adaptive beamformer customizes the radiation pattern to individual users and to their varying locations such that the main beam is directed towards the user and nulls towards interferers. The beamformer accomplishes this task by means of an array of antenna elements whose resultant radiation pattern may be manipulated by changing the amplitude and phase distribution in individual elements using a suitable adaptive beamforming algorithm.

Many existing beamforming algorithms such as Least Mean Square (LMS), Constant Modulus (CMA), Minimum Variance Distortion less Response (MVDR), Recursive Least Squares (RLS) are analyzed and compared. Though many of the algorithms are simple and less complex, the resultant main beamwidth is quite large and side lobe levels and null levels are not sufficiently low. As for the antenna array of the beamformer, microstrip antenna is usually selected for its various advantages like lightweight, small size and low fabrication cost. Commonly used rectangular

microstrip antenna array has serious limitation of narrow bandwidth which does not meet the requirement of emerging 4G broadband networks. Various methods are attempted to overcome these limitations by increasing the thickness of the dielectric substrate, decreasing dielectric constant, and the use of parasitic patches. But these solutions lead to the excitation of surface waves and increase in antenna size. To overcome the limitations of rectangular patch antenna array, a new straight 'E' shaped microstrip patch antenna has been designed for the frequency range 1.8GHz to 2.2GHz using Finite Difference Time Domain Method (FDTD) and Method of Moments (MoM).

In this thesis, two novel adaptive beamforming algorithms and suitable microstrip antenna array are designed to meet the requirement of mobile networks. One is Sample Matrix Inversion Data Reuse Normalized Least Mean Square(SMI-DRNLMS) algorithm and the other is Non Linear Variable Forgetting Factor Recursive Least Squares (NLVFF-RLS) algorithm. An antenna model of straight E shaped patch has been designed to obtain broad bandwidth and better directivity.

SMI-DRNLMS algorithm computes the amplitude and phase distributions based on the estimation of autocorrelation and cross correlation of block of incoming data. The individual good aspects of block adaptation approach and sample by sample basis approach is combined to model this novel adaptive beamforming algorithm. Current cellular mobile applications mostly use the 120° sector of cell as coverage region and hence the weight vector calculations are carried out for the scanning sector -60° to +60°. The

results of SMI-DRNLMS show 23% reduction in Half Power Beam Width (HPBW) of the main lobe, an average of 30% reduction in the power distribution in side lobes and the null level is deeper by 24% compared to conventional NLMS algorithm.

NLVFF-RLS algorithm consists in non linearly varying forgetting factor, based on the estimation of autocorrelation function of the error signal. When compared with conventional RLS, the NLVFF-RLS shows 29% reduction in HPBW of the main lobe, side lobe power is lower by 19%, the null level is deeper by 24% and the convergence rate is very fast.

The proposed straight ‘E’ shaped microstrip antenna array shows improvement of 12.5% in impedance bandwidth at a center frequency and the directivity is improved by 4dB compared to rectangular patch array. The implementation of SMI-DRNLMS using straight ‘E’ patch array is done in Matlab and Advanced Design System (ADS). The results reveal that the HPBW in the user direction has further reduces by 35%, the power in the unwanted side lobes is saved by 63%.