ABSTRACT

As the generation of communication technology is going higher, multiple antennas and components are being confined within a smaller real estate, leading to a higher amount of inter-element interaction. Apart from the coupling in multi-input-multi-output (MIMO) antenna arrays, the issue of mutual interaction between the incoming wave and object is also a matter of concern. The presence of intermediate object influences the propagation characteristics and the corresponding beam-pattern. Similarly, the electromagnetic exposure in biological tissues due to radiation from the cellular antenna poses a critical challenge for maintaining the specific absorption rate (SAR). This work addresses such coupling issues within the context of characteristic mode analysis (CMA). Initially, a modal computational framework has been designed where some existing implementation issues have been discussed with suitable alternates. The present thesis focusses on three interrelated topics of coupling analysis. Firstly, a theory of coupled characteristic modes (TCCM) has been formulated and verified with implemented results for the efficient modal solution of the coupled array. The proposed idea has been applied for two particular examples in wireless communication– the role of coupling in line-of-sight pathloss parameter and beam pattern analysis for spatial modulation. Secondly, it discusses the limitations of the existing literature on mutual coupling analysis. Then, some closed-form modal coupling parameters have been derived for analysing the coupled MIMO arrays. A new modal system has been proposed and validated using the matrix perturbation theory to study the mutual interaction between the antenna and the finite ground plane. Lastly, the proposed theoretical formulations have been applied for improving the performance of some practical coupling scenarios like for manipulating the coupling between two antenna elements, for controlling the undesired radiation exposure on biological tissue and for antenna positioning in the non-line-of-sight (NLOS) environment.

Keywords: Characteristic mode analysis (CMA), mutual coupling, antenna array, wireless propagation, MIMO, antenna positioning, SAR reduction, RF exposure.