MIMO Antenna Systems for Wireless Handheld Devices

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ABSTRACT

Mobile communications have seen tremendous growths in the last decades in the form of smartphones, watches, wireless enabled Personal Digital Assistants (PDAs) and so on. The current and future wireless communication systems require high data-rate capabilities to support high speed needs of users in modern applications. Multiple-input multiple-output (MIMO) antenna systems have become the most promising candidate to support the increased data demand. Therefore, they have emerged as an integral part of the new 5G wireless standard. One key challenge regarding MIMO systems for the handheld is to be able to successfully accommodate multiple miniature platform integrated antennas within a small device. Associated with that challenge comes undesirable increased mutual coupling, efficiency and capacity degradation, human body effects etc. Innovative designs and techniques that can overcome these challenges for MIMO antennas for handheld devices are studied and developed in this dissertation.

First, due to the overarching importance of MIMO system performance, a detailed methodology to evaluate MIMO antennas is developed and presented. Second, new isolation improvement techniques between MIMO antenna elements using electromagnetic band gap (EBG) and defected ground structures is investigated and developed. High isolation between MIMO elements leads to decreased correlation resulting in significant enhancement of MIMO system performance which was the driving factor for the above effort. The efficacy of including these structures in improving MIMO performance is evaluated and demonstrated through simulations and experiments. Third, printed dipole MIMO antennas with pattern/polarization diversity within a handheld device are designed and analyzed for operation in free-space and next to head and hand phantoms. Pattern and polarization diversity have been found to be proven

techniques to enhance MIMO system capacity. Forth, various frequency and/or pattern reconfigurable MIMO antennas are investigated and developed. A novel frequency reconfigurable MIMO antenna array is designed, developed and tested that consists of four slot elements that are reconfigured using chip varactor diodes. The slots' resonance frequency can be electronically tuned by varying the effective length of the resonant slot by integrating varactor diodes on the slots. The antenna was optimized for 5-GHz Wi-Fi operation with a relative frequency tuning range of 15% extending from 5.1 GHz to 5.9 GHz. MIMO performance analysis and effect of mobile phone components were also investigated demonstrating performance.