Abstract

This thesis presents the study, design, and analysis of some novel metamaterials, and application of those metamaterials to antennas. Three novel polarization and incident angle independent metamaterials are explored and applied to antennas. Applying metamaterials, low-profile high-gain antennas, compact MIMO antennas, frequency-reconfigurable MIMO antennas and low-RCS MIMO antennas are designed for application to IEEE designated WLAN and WiMAX frequency bands, and higher bands such as X-band.

Metamaterials are characterized with their effective permittivity and permeability in Chapter 2. Three novel metamaterials are crossed loop resonator (CLR), star-shaped (SS), and square-ring (SR). The effective parameters of those metamaterials are extracted and it is observed that they exhibit epsilon-very-large (EVL) – mu-near-zero (MNZ) or low-impedance properties irrespective of the polarization and incident angles. These properties are analyzed and verified with surface current distribution and measured results.

In Chapter 3, low-impedance metamaterials are applied to substrate integrated waveguide (SIW)-fed slot antennas as superstrate for radiation characteristics enhancement along with maintaining low-profile. The height of the superstrate is gradually decreased to zero with highest achieved gain.

In Chapter 4 and 5, metamaterials are also used to design compact MIMO antennas and reconfigurable MIMO antennas for WLAN and WiMAX applications. In Chapter 6, a metamaterial-based microwave absorber is designed and analyzed. The absorber, which is using lumped resistors has broadband absorption characteristics. The absorber using lumped resistors is more complex and costly to fabricate than planar metasurface, which is not using any lumped elements. Therefore, a metasurface (MS), which is the two-dimensional structure of metamaterial is studied and used for absorber design following scattering absorption method. A low-RCS low-profile MIMO antenna is realized by effectively using the metasurface-based absorber.

Keywords: High-gain, low-profile, metamaterials, metasurface, MIMO antenna, radar cross section, slot antenna, substrate integrated waveguide.