ABSTRACT

The research work presented in the thesis is primarily focussed on the design of millimeter wave 5G antennas. Based upon the requirements for the implementation of millimeter wave wireless communication systems, four antenna topologies are presented to counter the issues at millimeter wave 5G communication.

First, a three-element quasi Yagi-Uda antenna array with printed metamaterial surface generated from the array of uniplanar capacitively-loaded loop (CLL) unit-cells printed on the substrate operating in the band 25-30 GHz with 18dB isolation between the ports is presented. The measured peak gain of 11dBi is achieved for all the antenna elements. The three antenna elements radiate in three different directions and cover a radiation scan angle of 64^o. This wide angular coverage would be useful to maintain the communication link between the transmitter and receiver.

A four port mmWave multi-input-multi-output (MIMO) antenna with a small size of 11.3 mm $\times$ 31 mm is presented. Each antenna element has an end-fire gain of about 10dBi by employing an array of metamaterial unit cells. The isolation between the antenna elements with edge to edge separation $< \lambda_0/5.5$ at 28 GHz is enhanced by trimming the corners of the rectangular metamaterial region along with a ground stub between antennas. The prototype antenna covers 26-31 GHz band with return loss$> 10\ dB$ and isolation $> 21\ dB$. The second design is two port MIMO antenna for 28 GHz band which has dual-beam radiation for each port. The proposed antenna can cover a large radiation area owing to pattern diversity with radiation along $\phi = 60^{o}$ and $\phi = 120^{o}$ when port 1 is excited and along $\phi = 150^{o}$ and $\phi = 210^{o}$ when port 2 excited.

A new technique of electromagnetic wave routing using single-epsilon-high anisotropic media to generate dual-beam radiation at 28-GHz band. This technique is implemented using SIW

dipole antenna loaded with the single-epsilon-high anisotropic media realized using modified asymmetric electric-LC (ELC) metamaterial unit cell loaded vertically in front of the radiator. The effect of the media thickness loaded to the antenna is investigated and dual-beam radiation in the frequency band 26-31 GHz is obtained by choosing the appropriate number of ELC-slabs. The measured results confirm 26-31 GHz impedance bandwidth and dual-beam radiation directed along 50^o and 130^o with 8dBi beam peaks.

In the last part, mmWave lens antennas are presented for gain enhancement and multibeam MIMO applications. A simple technique of phase correction for gain enhancement using stacked dielectric slabs atop a microstrip patch antenna for 28-GHz application is presented. This arrangement of dielectric slabs enhances the gain of the patch antenna by 4.1dB when loaded to the antenna. Further, a novel technique employing high and low epsilon (HLE) biaxial anisotropic media to enhance the gain of any linearly polarized antenna is presented. The realization of the HLE media using metamaterials is presented which results in a flat 3D lens having $1.9\lambda_0^2$ physical area. The HLE lens has an aperture efficiency of 99% when loaded to a patch antenna with a broadside thickness of $0.6\lambda_0$ at 28 GHz. To further validate the performance, metamaterial lens is loaded to the SIW fed aperture coupled patch antenna, a realized peak gain of 13.6dBi is achieved with 6% 1-dB gain bandwidth which confirms the applicability of this gain enhancement technique for wider frequency range than the zero-index media/resonant cavity techniques. Lastly, a thin planar metasurface (MS) lens is presented for mmWave MIMO applications. The designed MS lens is polarization insensitive and has a peak aperture efficiency of 24.5% when loaded to a three-port antenna array. The MS lens loaded to three antenna array results in a peak gain of 20.2dBi and beam scanning from -15^o to $+15^o$ is achieved.