CHAPTER VIII

CONCLUSIONS AND SCOPE FOR FUTURE WORK

8.1 Conclusions

In this study, antenna models are proposed and designed for 5G, millimeter-wave based future vehicular communications in IoV. High efficient antennas are required for the capability and reliability of high speed communications in 5G.

Four CPW fed antenna models are proposed that operate at different wireless frequencies. The proposed antenna models are designed and analyzed in CST electromagnetic tool. The plus shaped antenna model achieved better performance than the other three models. The proposed antenna is fabricated on FR4 substrate of thickness 0.16mm, dielectric constant of 4.4 and tan δ = 0.02. It operates at triple frequencies of 1.56GHz, 2.4GHz and 4.2GHz with considerable bandwidths. The VSWR value is between 2 and 1 at these resonating frequencies. The antenna with plus shaped patch has about 50ohm impedance at 2.4GHz. The impedance is about 40ohm at 1.56GHz and 4.2GHz. It achieved gain of 3.9db, 3.76dB and 4.9dB at the resonant frequencies 1.56GHz, 2.4GHz and 4.2GHz. The maximum efficiency of antenna is about 88%. Fabricated model is analyzed on VNA, measured and simulated results are in good agreement without affecting the antenna performance. The proposed plus shaped antenna maintains the minimum performance characteristics suitable for IoT devices applications.

For 5G and millimeter-wave based future vehicle communications in IoV, a DGS antenna is proposed and designed. On the top layer of the substrate, J-shaped balun is integrated with the staircase structured micro-strip line to achieve wide operating band and better impedance matching. The bottom layer consists of a printed dipole antenna as DGS which is the main radiating element. The micro-strip antenna dimensions are 13 x 10 x 0.254mm^3. The model is designed and simulated in ANSYS HFSS. It operates for a broad bandwidth of 17.65GHz from 24.3 to 41.95GHz and also from 49.91 to 52.15GHz with a bandwidth of 2.24GHz. The 5G and millimeter-wave frequencies as proposed by FCC for future connected vehicular communication applications are achieved by the proposed antenna. It also operates at an additional band resonating at 51GHz that is suitable for future satellite communications as released by ITU in the recent WRC.

The parametric analysis for feed width and dipole width is also done and the dimensions are selected for optimum results. The antenna performance in terms of VSWR is excellent for the required 5G frequencies. The impedance of the proposed dipole antenna is close to 50ohm throughout the operating bands. At 28GHz, the impedance is 59ohm, at 33GHz 62ohm, at 37GHz 75ohm, at 39GHz 85ohm and at 51GHz 47ohm. A peak gain of 6.81dB is obtained at 51GHz and the maximum efficiency obtained is 98.82% at 28GHz.

The conformal antenna models of proposed dipole antenna are developed for 20^0, 30^0, 45^0, 60^0, 75^0 and 90^0 central bending angles in ANSYS HFSS. The parameters; reflection coefficient, far-field radiation characteristics, VSWR, impedance and the surface current distributions are analyzed. The simulated results of developed conformal models are in good union with that of proposed planar antenna. The conformal models at 30^0 and 45^0 angles, resonate at 5G frequencies 28GHz, 33GHz, 37GHz, 39GHz and 51GHz where as other models operate at few frequencies only. 60^0 conformal model does not resonate at 28GHz and 75^0 model at 51GHz. The model at 20^0 central bending angle resonate at 28GHz, 33GHz and 37GHz while at 90^0, it resonate at 28GHz, 37GHz and 39GHz.

The proposed antenna is fabricated on LCP (liquid crystal polymer) flexible substrate of thickness 0.254mm, dielectric constant of 2.9 and tan $\delta = 0.002$. For validation of the proposed model, it is located on the vehicular body and analyzed using ANSYS-SAVANT tool. The performance is good enough with acceptable minor variations due to intrusion of the radiation with the metal and glass surfaces of the vehicular body. Hence, proposed printed dipole antenna is the best suitable for 5G based future vehicular communications in IoV.

A compact T-stub loaded two element collinear MIMO antenna is proposed that operates from 24.6 – 42.1GHz and 50.1-52.5GHz. It achieved the required 5G and millimeter-wave frequencies as proposed by FCC for future connected vehicular applications. The MIMO antenna model is also tested under vehicular environments and the results are validated. It has better MIMO performance metrics. The simulated and measured results are relatively in good agreement. Hence, the proposed MIMO antenna is best suitable for 5G and millimeter-wave based vehicular communication applications.

8.2 Scope for Future Work

The minimum gain requirement for better 5G based communications is 12dB. Further, the antenna arrays of the proposed printed dipole antenna can be developed and fabricated in future to meet the gain requirements for 5G and mm-wave frequencies.

The printed dipole antenna is tested in virtual environment of the vehicle body. In future, it may be placed on the vehicle in practical and can verify the measured values including array designs also. Further, the performance of the communication parameters like mobility, range, data rates can also be obtained. Further work can be continued in designing antennas with meta-materials for 5G frequencies, especially resonating at 60 GHz.