

Conclusion and Future Scope

In the thesis, comprehensive studies have been carried out on various types of beam steerable HF dipole antennas and printed dipole antennas. Many novel solutions in field of HF antennas and higher frequency antennas have been proposed to address various emerging issues.

HF propagation using the ionosphere is a widely used sky wave communications for various strategic fields of broadcasting, military and other short, medium & long distance communication. Also, HF propagation is widely used by radio amateurs to communicate across the globe. Hence, the importance of HF propagation using the ionosphere is likely to remain in use indefinitely as a form of radio communications technology. The ionosphere is an unstable medium which varies diurnally along with sky wave path length, solar cycle and the various seasons.

External environment strongly influences HF communication due to variation of ionosphere layers along with variation of time as well as environmental changes. Therefore, it is essential to provide standard guidelines for optimum HF propagation by selection of HF spot frequencies along with optimum deployment of antenna system for various ranges. In this thesis, practical solution for HF frequency prediction and optimum antenna deployment has been proposed. Novel methodology for prediction of HF frequency based on HF prediction tools has been proposed. Also, a novel solution for calculation of optimum HF antenna height for various communication ranges has also been proposed in the thesis. The proposed work can directly be implemented as standard guidelines for optimum HF communication within specified geographical region.

Further in the thesis, a novel frequency tunable Inverted-V HF dipole antenna has been proposed. With the implementation of feeding network modification technique most of range of HF spots has been covered without compromising actual characteristics of Inverted V HF dipole antenna along with minimum height variation. The research work proposed in the thesis will enhance the efficiency of HF communication for various time slots and provide novel platform for optimum operational performance of HF antenna specially in the field of police, maritime, Defence communication in order to enhance national security.

Due to HF frequency and path length variations, installation and changing height of long wire HF dipole antenna in short span of time is a complex process. In this thesis, a novel beam steerable Inverted V HF dipole antenna has been proposed to address the issue of the complex height variation of HF dipole antenna w.r.t. time and distance in order to achieve desired radiation take-off angle. Proposed beam steerable Inverted V HF Dipole Antenna is capable of continuous beam steering of 60 degree (± 30 degree) electronically by adjusting variable capacitor integrated at end of HF dipole keeping fixed parallel inductor. This beam steering technique will be highly useful to achieve desired radiation beam take-off angle of HF antenna to communicate at various ranges and time period without changing the height of antenna. Implementation of present work will enhance the operational efficiency of HF communication for various strategic and operational fields.

Due to complexity in open space measurement of radiation pattern of HF dipole antenna, a low cost small form factor model as beam steerable printed dipole antenna in ISM band has been proposed in thesis to verify radiation pattern performance of inverted V HF dipole antenna with similar design characteristics. Most of electrically tuned antennas requires more than one dipole and multiple tuning elements mounted on common platform for scanning between two angles / switching at different elevation angles. Proposed planar inverted V dipole antenna is capable of continuous beam steering (± 30 degree) electronically using single printed dipole and single varactor diode. Resistive and parasitic losses of proposed antenna is considerably low along with low design cost and the least space requirements. Proposed antenna to be utilised optimally in field of wireless communication, mobile/ vehicular communication, sensor applications.

Various pattern reconfigurable Antennas for pattern diversity have design complexity, high cost, more resistive/ parasitic losses and large external space requirements. In this thesis, proposed digitally controlled beam steerable printed dipole antenna has demonstrated capability of steering radiation pattern up to 45 degrees in first quadrant by switching PIN diode states using STM32 microcontroller. Resistive and parasitic losses of proposed antenna is considerably low along with low design cost and the less space requirement due to single dipole structure. Proposed antenna also possesses high portability and agility due to fast switching of PIN diodes through microcontroller. Proposed antenna may be used for its optimum performance in field of wireless communication, mobile/ vehicular communication, IOT applications, sensor applications and various industrial, scientific and medical applications of ISM band. The present concept can be rescaled to other frequency of interest including HF communication.

The various dipole antenna studies presented in thesis can be extended in future as Artificial Intelligence (AI) based beam steerable printed dipole antenna / HF dipole antenna. The STM-32 microcontroller input or varactor diode input can be regulated through AI controller to enable automatic switching of radiation pattern of digitally controlled beam steerable printed antennas. Similarly input for variable capacitor to control beam steering in HF dipole antenna can be fed through AI based controller to design an intelligent beam steerable HF antenna.