Antennas in Airborne Applications

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***Abstract*—This paper gives an overview of various types of antennas used in airborne applications such as delivery using UAVs, defence, disaster management. Antenna characteristics are very sensitive and must be used before implementing in airborne applications. Because of different nature of aerial body on which antennas are mounted, different antenna positions will result in variations in the radiation pattern. In recent studies, researcher considers antenna positioning with respect to azimuth and elevation angles. Effect of aerial body on antenna, its signal strength and radiation pattern is observable. Cross polarization discrimination occurs due to polarization mixing of communicating channels.**

Keywords: XPD, Disaster, Array, Unmanned Aerial Vehicle

I. Introduction

This paper aims for usage of antenna in Unmanned Aerial Vehicle. First phase of paper aims dynamics and concepts of Unmanned Aerial Vehicle. Second phase covers types of antenna usage with problem faced in implementation and testing in real time application. Last phase explains importance of antennas in Unmanned Aerial Vehicle for various applications [1].

II. DYNAMICS OF UAV

UAVs are of different types based on construction, weight, size, range etc. Four arm is called quadcopter and six arm is called hexacopter. As per load carrying capacity and increased flight time, maximum arm UAVs are preferred. Main parameters to be considered for airborne application is elevation angle and azimuth angle as shown in Fig 1. Height of flight and privacy of citizens are taken care by following guidelines of Directorate General of Civil Aviation [14].

Hexacopter proves to be more efficient than quadcopter as it aims for real time application. Hexacopter is six arm on which antenna can be implemented for data collection and survey. It contains motors, propeller, chasis and electronic speed controller. Hexacopter can be used in disaster scenarios and earthquake to rescue human lifes. Temperature of environment, humidity, direction of wind, mechanical shock vibration needs to be considered for antenna implant on UAVs.

III. ANTENNAS

Antenna is a device which is used to transmit and receive radio signals. We consider free band ISM Industrial Scientific and Medical. There are various types of antenna but we consider micro strip patch antenna due to its compact, lightweight, size and parameters.

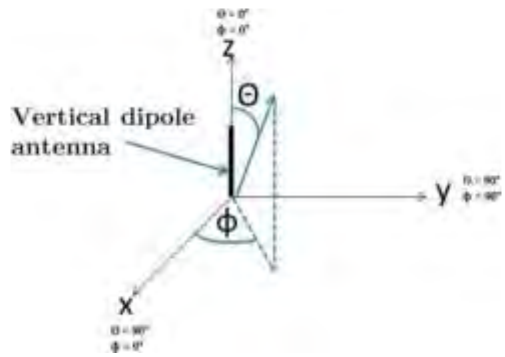

Fig. 1: Elevation and Azimuth Angle

Fig. 2: Quadcopter Assembling

In airborne applications especially in Unmanned Aerial Vehicles such as hexacopter, various parameters of antenna need to be considered. We consider array antenna as its performance is better than other antennas in terms of directivity and gain which is the need of airborne applications. Different types of shape has been reviewed in many papers for implementing on Unmanned Aerial Vehicle.[1][2][13]

The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are gen-

Fig. 3: Hexacopter Assembling

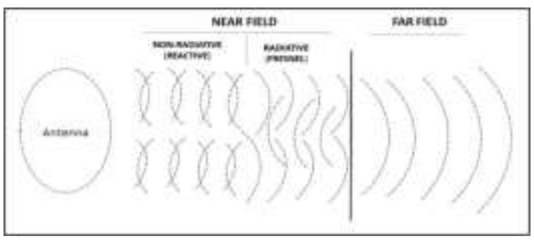

Fig. 4: Near Field and Far Field

erally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyse and require heavy numerical computation. Near field and far field effect is to be considered before testing the antenna on the body of UAV. [6][7][15].

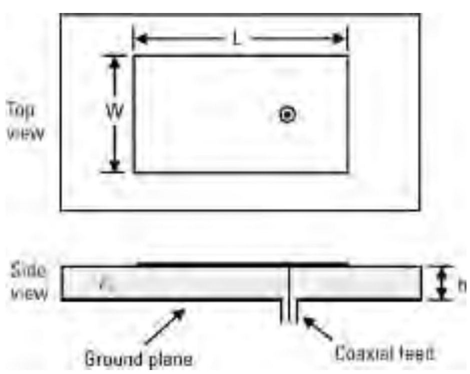

Fig. 5: Broadband Micro strip Antenna

From simulation results we get an idea and accordingly we fabricate for testing results on network analyser. We can observe small change in readings due to loss in fabrication. Similarly for 1 by 4 array is designed and fabricated

Main problems faced during implementation are as follows:

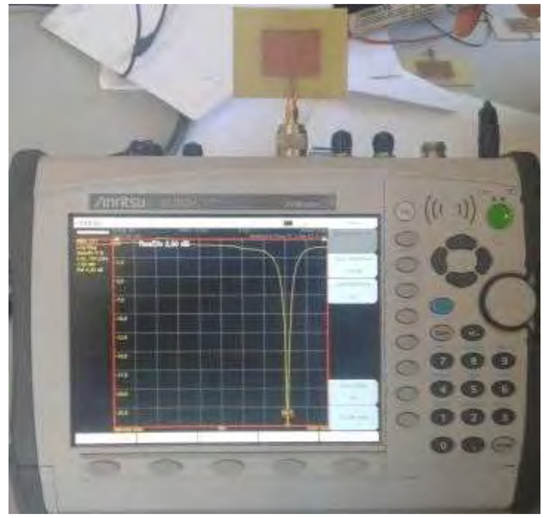

Fig. 6: Testing of Single Patch Antenna

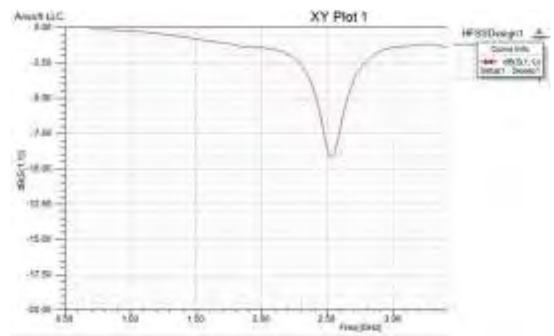

Fig. 7: Simulation of Single Patch Antenna

a) Position of placement b) Orientation of antenna c) Cross polarization discrimination

As the space at drone is very less, placement at ideal location is major concern of worry and after that cross polarization effects due to aerial movement.

To analyse radiation pattern and cross polarization discrimination, the impact of the Unmanned Aerial Vehicle body and placing of antenna is to be given priority which can be tested in anechoic chamber and mainly in-field experiments. Some review papers have published results which are as follows:

From the table 2 & 3 we can observe that cross polarization

TABLE I: Results Comparison

Single Patch Antenna	Simulated Results (HFSS)	Tested Results
S11	-8.5	-7.75

TABLE II: Loss at various positions

Experiment	**Average Loss**	**Maximum Loss**
Antenna on West Position	2.57 dB	8.34 dB
Antenna on North Position	3.27 dB	10.25 dB

TABLE III: XPD at various distances

Direction	20 m	40 m	60 m	80 m	100 m	Avg
XPD North	1.29	1.55	2.64	2.1	3.53	2.22
XPD South	5.67	3.45	7.61	6.01	5.2	5.58
XPD East	4.56	10.17	11.61	8.0	8.32	8.51
XPD West	4.2	9.83	11.24	10.6	8.43	8.86

TABLE IV: Design Parameters

Sr. No.	Parameters of Array	Measured value in millimetres
1	Width of the Patch	38.03
2	Length of the Patch	29.54
3	Inter-element spacing	62.5
4	Width of 100 ohm feed line	0.7
5	Width of 50 ohm feed line	3

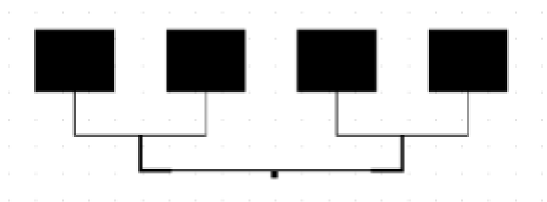

Fig. 8: Rectangular Patch Antenna Array

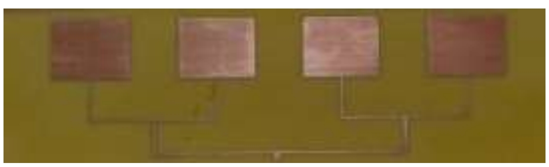

Fig. 9: Fabrication of Rectangular Patch Antenna Array

Fig. 10: Future UAV Communication Network

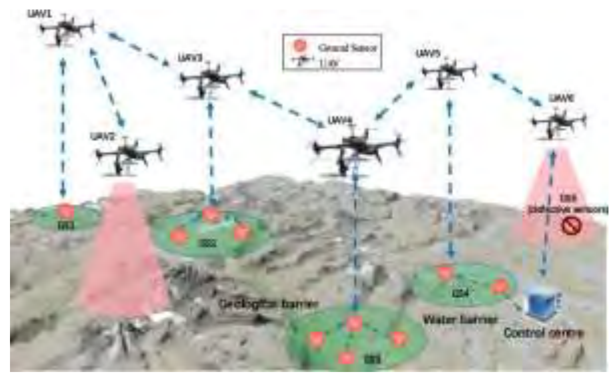

Fig. 11: UAV based network for disaster scenario

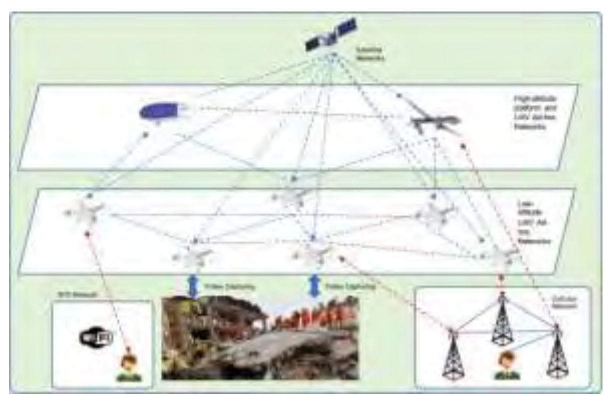

Fig. 12: A Universal Network Architecture for Airborne Applications

discrimination changes as the UAV take different directions and elevation with respect to base control station. Strong XPD is observed at East and West Direction whereas lowest is at North direction. We can see the drastic change in loss as well as XPD as we change the direction and flight of UAVs. [10][11]

IV. AIRBORNE APPLICATIONS

Airborne applications are as shown in Fig 10 & Fig 11 There are various types of natural disaster, such as climate based i.e. extreme temperature, drought, and wildfire , meteorological like tropical storm, hurricane, sandstorm, and heavy rain-fall, hydrological related like flash-floods, debris flow, and floods, geophysical such as earthquake, tsunami, volcano, landslide, and avalanche etc. These disasters are very huge and hence for rescue team to reach physically at the location becomes difficult. In such scenario best alternative option is to use airborne communication for aid of rescue team and survivors.[11][12]

V. CONCLUSION

This paper gives a clear understanding of best antenna to be used, and how it can be utilized for Unmanned Aerial Vehicle for all possible airborne applications. We understand all possible problems faced by researcher to implement antenna in real time as various factors affect the performance. It is surely one of the best researches to work due to need of an hour. There is scope in improvement of antenna gain and directivity by design changes so that losses can be reduced and factors affecting the performance can be nullified in airborne applications. This paper gives an idea of antenna importance in airborne applications. In future research can be enhanced in this field as need of an hour.

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