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Design of UAV Antenna & Challenges: Review

***[1]Kapil Jain, [2]Vivek Singh Kushwah, [1]Vineet Shrivastava**

[1]ITM, Gwalior, 1NH-75 Jhansi Road, Gwalior, Madhya Pradesh, India.

[2]Amity University, Gwalior, Madhya Pradesh, India

*Corresponding Author Email: kapil.jain@itmgoi.in

Abstract. *In the last decade, researchers have been attracted by the drone and its antenna design. Few years back, drone was used only for surveillance but now drone is using in various filed i.e., weather forecasting, transportation, communication, search & rescue etc. Antennas are the most important part of drone or UAV. Designing of antennas for drone is the challenging task for the researchers without increasing the overall weight of drone. In this article, classification of drone as per their weight, altitude and applications, different types of antennas have been discussed with its challenge. Different antenna design has been discussed and compared with different parameters.*

Keywords: *drone, radiation pattern, gain, polarization, bandwidth.*

1. INTRODUCTION

UAV means unnamed aerial vehicle are also known as drones. It is widely used for civilian and military works. Now a days it is used in field of multimedia, exploration, surveillance and telemetry communication [2] [9]. In the era of wireless communication, drones are the current research topic of researchers due to their flexibility, autonomy and wide range of application. Drone also provides the on demand wireless communication where the communication infrastructure can't be installed or very costly. Due to tide, flood, natural disasters communication network has been destroyed, where drones work as aerial base station for temporary network establishment. Many companies are utilizing the drones for wireless communication for their project [9]. Main application of drones is to collect the information and send back to base station [1]. this task has been completed by single antenna or antenna array. Antenna of the drone is the important and research area of researchers. Researchers want to such types of antennae those provide the radiation in all direction or in specific direction. In the time of communication, antenna array is used because of [1]

1. High directivity
2. High gain
3. High SNR
4. Better throughput
5. Beam stearing

Drone antenna generally operates in L and C band or in HF, VHF and UHF bands [2]. There are Various types of antennae in drone application.

1. Compact narrowband antenna
2. Wideband monopole antenna
3. Wideband dipole antenna
4. Polarized antenna

The main contribution of this article is to provide the compressive and tutorial on the drone antenna requirements and their various applications in field of wireless communication. This antenna discussed the challenges of drone antenna design, classification of drone according to their weight, altitude & range and various applications. Moreover, this work also gives the knowledge of different types of antennae used in drone. Here, classification of antenna discussed as per polarization. At the end of this article is to gather the different antenna design for drone in sub-6 frequency range by different researchers.

2. CLASSIFICATION OF UAV

In today scenario, UAV can perform various activities in different fields i.e., shipping& delivery, geographic mapping, disaster management, weather forecast, search & rescue, law enforcement, ad-hoc network, temporary communication establishment. Our government is also focusing on the innovation of new technology in drone manufacturing in field of harvesting agriculture sector. The use of UAV in agriculture is helpful to farmers as it has some advantages i.e., high field capacity and efficiency, less turnaround time and other field operational delay, wastage reduction of pesticide and fertilizers due to high degree of atomization, water saving due to ultra-low volume spray technology. So according to various applications, UAV can be categorized in five segments as per their weight, height, range wings and application [10] [9]. In India, the directorate general of civil aviation (DGCA) governs the use of all types of drones.

TABLE 1. Classification of UAV

S.No.	Parameter	Types of Drones
1	Weight	Nano (>250 g)
		Micro (>250 g and <2 kg)
		Small (> 2 kg and < 150 kg)
		Medium (>25 kg and <150 kg)
		Large (> 150 kg)
2	Altitude & Range	HAP (Above 17 KM)
		LAP (Few mtr to Few KM)
3	Wings	Fixed Wings
		Rotary Wings
4	Application	Commercial
		Personal
		Government

3. CHALLENGES FOR UAV ANTENNA

In last few years, uses of drones in various field i.e. military, communication and in commercial market [18] [20], have attracted the researchers for innovation in designing of drone. The main object of the drone or UAV is to collect the information and send back to earth station. This task can be performed by antennas which are mounted on the wings of drone. The main purpose of mounted antenna is to receive and transmit the signal from or to earth station. So, it is mandatory to have reliable communication link between earth station and drone antenna [18], but there are some restrictions for drone antenna

1. Life of battery is limited which is installed on drone so over all fly time of UAV may be affected, if the antenna size is larger, so it will occupy the larger space on drone wings, so resulted the wider wind drag, so overall fly time will be less [18].
2. Ratio of flight distance and height is large for drone, which finds the radiation pattern of antenna.

Due to above mentioned limitation and drawback, microstrip antenna are the best choise of designer over onopole antenna. Microstrip patch antenna is small in size, weight, easy fabrication and compataibility with drones [20].it can be used for long distance transmission. Proper desired gain, bandwidth and directionality can be aceived by the optimization of microstrip patch antenna. According to above discussion drone antenna should be-

1. Less weight
2. Thin
3. Flexible
4. Compact in Size
5. Low Profile
6. Directional

So, it can be easily mounted on the wings of drone without increasing the overall weight of drone. In earlier days, dipole and bladed shapes microstrip patch antenna were used, which is not compatible for ultra-wideband application [19]. To increase the antenna, gain and directivity, antenna array is used. Directive antenna is used to reduce the co-channel interference and for long distance communication [11].

Types of Antennae Used in UAV: Various parameters can be used to classify the drone antenna, but mainly the drone antenna can be classified according to polarization [6]. Polarization reconfigurable antenna is useful for wireless application, where it can change their polarization state [23]. Polarization reconfigurable antenna can change the polarization plane of linear polarization (horizontal, vertical or slanted polarization) [23].
According to polarization, UAV antenna can be-

1. Linear Polarization Antenna
2. Circular Polarization Antenna

Linear Polarization: Linear polarization antenna is useful for point-to-point wireless communication applications i.e., satellite communication. To avoid the polarization mismatch and interference, alignment of the polarization is essential [23]. For this purpose, low weight and low profile microstrip patch antenna with reconfigurable plane is preferable. In linear polarization, field lines will be in one direction [6].

Circular Polarization: Linear polarization antenna have some limitations i.e., adjustment of polarization is required in each plane, problem of cross polarization, polarization changes as per latitude and longitude and are preferable for point-to-point communication. Circular polarization antenna has some advantage over the limitation of liner polarization i.e., polarization adjustment is not required, less chance of cross polarization. In circular polarization, the outgoing field lines would have rotated 360^0 within the time the signal has passed through the antenna [6]. In it, electric field radiates energy in all plane i.e., horizontal and circular planes both. Electric field is perpendicular to each other with same amplitude and phase difference. Circular polarization antenna can be classified into RHCP (right hand circular polarization) and LHCP (left hand circular polarization)

M.S. Sharawi et all [1] have discussed the L shape monopole antenna array for UAV. Which is operating at 2.4 GHz frequency. Designed antenna used FR-04 substrate with $\varepsilon_r = 4.8$ and **tan δ = 0.017.** Broadband dipole bladed antenna has been proposed by Mehrdad Nosrati et all [2] for UAV application. This antenna provides the wideband and stable radiation pattern by using two perpendicular slot and two vertical tails. Surface current path is excited by the two vertical tails. This antenna operates at 20 MHz to 1200 MHz with bandwidth of 1180 MHz.

Dual polarized microstip antenna has been presented for ultra-wideband application by P. Kumar et all [4].This antenna resonate at 5-6 GHz frequency with bandwidth of 3.1-10.6 GHz. Whereas improved broadband multilayer dual polaraized antenna for UAV radars is discussed in [5] with Rogers 5880 substrate. The feeding form is modified to the stripline, which introduced to solve the problem of loss and mutual coupling due to surface waves of the microstrip transmission line. The authors in [9] studied the different types of antenna used in FPV/WLAN applications. In this paper, classification of antenna was discussed according to their polarization, i.e. Linear and circular polarization. In [7], lightweight compact patch array antenna with a center frequency of 3.6 GHz for UAV application over 5G networks. Proposed antenna used the Rogers RO4350 and RT Duroid 5880 substrate.

In this paper [9], a comprehensive tutorial on uses of UAV and their various applications in wireless communication. Classification of UAV according to their altitude & range, weight and commercial application has been investigated. This paper also described the open problems and potential research directions pertaining to UAV communications. This paper provides key guidelines on how to analyze, optimize, and design UAV-based wireless communication systems.

E shaped microstrip patch antenna array 1 x 8 for synthetic aperture radar for UAV in C & X band has been investigated by Alfian Maulana Yusuf et all [12]. This is dual band antenna which resonates at the frequency 5.8 GHz (C Band) and 9.65 GHz (X Band) designed using FR-4 substrate. Bandwidth for both band is more than 50 MHz and the gain achieve 6.39 dBi at C-band and 3.825 dBi at X-band. Lightweight Microstrip Patch Array for Broadband UAV Applications over 5G networks has been proposed by the Maximilian James Arpaio et al. [14] for 3.4-3.8 GHz resonant frequency and the average gain is 8 dBi. Light weight structure achieved using the Rogers RO4350 and RT Duroid 5880. 2 x 2 array has been investigated to increase the overall gain.

In [18], authors have been design the miniaturized high-gain flexible antenna for UAV applications using asymmetric ground feeding structure for good impedance matching. In designed antenna three parts of printed patches are connected in cascade, etched on dielectric substrate. It has a low-profile compact size with omnidirectional antenna which operate in the 902 MHz–928 MHz with 4.5 dbi gain, which is high enough for the UAV application. Proposed antenna provide omnidirectional radiation pattern with linear polarization.

In [19], authors have been designed the U shaped MIMO compact and thin antenna for UAV application in C-Band. This antenna provides the omnidirectional radiation pattern with linear polarization and pattern diversity. Designed antenna resonates at 4.12 GHz to 5.45 GHz with bandwidth of 4.1-9.0 GHz.

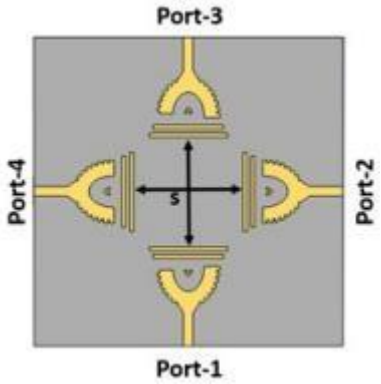

FIGURE 1. U Shaped 2 x 2 MIMO Antenna

Following table shows the comparison of different shapes of antenna for UAV by different researchers. Designed antenna have been compared with some parameters i.e., substrate, antenna gain, bandwidth, radiation patter and shape

TABLE 2. An Overview of different types and shape antenna for drone

Ref. No.	Operating Frequency	Substrate	Antenna Gain	Bandwidth	Radiation Pattern	Shape
1	2.4 GHz	FR-4	11 dbi		Monopole	E-Shape
2	50-1200 MHz		4 dbi	1180 MHz		Slotted Blade
4	3.1-5 GHz 6-10.6 GHz		6.038 dbi (at 10GHz)	3.1-5 GHz 6 -10.6 GHz	Omnidirectional	Dual Polarized
5	12-18 GHz	Rogers 5880		14.5-18.5 GHz		H-Shape Dual Polarazied Mutilayer
12	5.8 GHz 9.65 GHz	FR-4	6.39 dbi 3.825 dbi	189.8 MHz 545.8 MHz	Unidirectional	E-Shape
18	902 MHz	FR-4	4.56 dbi	902-948 MHz	Omnidirectional	Monopole
19	5.45-6.2 GHz	Rogers 5880	5.02 dbi (at 6 GHz)	4.1-9 GHz	Omnidirectional	U-Shape

4. CONCLUSION

Drone is not deployed only for wireless communication application. Drone has the various applications i.e. personal, military etc. In this paper, classification of drone has been discussed. Main objective of the drone is transmitting and receiving the signal from base station or drone. This essential task has been accomplished by antenna. Main objective of this article is to give the knowledge of drone antenna and their challenges to design it. In last of this article, discuss the various type of design and shape of antenna by researcher. This article is useful for initiating the work on antenna design of drone for beginner.

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