A Systematic survey on Blade antennas for Airborne applications

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Abstract— This paper presents a comprehensive overview on Blade antenna, the very recent development in airborne applications. Blade antenna is well suited for airborne applications due to their compact size, light weight and aerodynamic shape leading to little drag. In this paper the different kinds of blade antennas, their applications, advantages, and comparisons are discussed chronologically.

Keywords— Blade antenna; airborne applications; blade monopole

1. INTRODUCTION

An antenna is one of the most significant components in wireless communications. An antenna is considered as a region of transition between a transmission line and free space. Antenna radiates or couple or concentrate or direct electromagnetic energy in the desired direction. In general the communication system performance can be improved with a suitable antenna design. An antenna is a metallic rod that converts radio-frequency fields into alternating currents or vice versa. Now days the wireless systems are expecting greater demands on antenna design [1]. The electric and magnetic field relations through a set of profound equations are expressively represented by James Clerk Maxwell [3]. Large number of books written on the antenna subject[4], [5], The different types of antenna classification is shown in the fig.1.

The quick growth in wireless communication has demanded broadband antennas to prop up wireless devices for instance aero plane, radar systems, and satellite communications. The Blade antenna is a monopole type antenna primarily for use on aircrafts. It has better state of affairs and advantages that build greater improvement in recent years. Monopole antenna is a quarter-wavelength long Omni directional antennas.

A monopole antenna is one half of a dipole antenna, approximately mounted above some sort of good ground plane. A slanted monopole antenna is blade antenna. Blade is a grouping of narrowed rectangle and elliptical antenna shapes.

Fig. 2. Blade Antenna

Fig. 1. Antenna Classification
BLADE ANTENNA BASICS

These days’ Blade antennas are used in various platforms such as mobile surveillance, aircraft, spacecraft, and ground supply. As compared with conventional aircraft antennas and monopole antennas, blade antennas add more advantages. They are lighter in weight, convenient in shape, low profile, and low volume. Blade can also provide linear and circular polarization with high gain. Blade antennas can be used in broadband frequency, C-band, and S-band. In designing the blade antenna the following factors such as the substrates to use, dielectric constant, feeding type, constant of the substrate and size of the antenna are likely to consider. Blade antenna can be able to withstand under adverse atmospheric conditions by using a radome to it and it also provides good insulation to the antenna. Most blade antennas are trapezoidal in shape.

III. BRIEF REVIEW OF EARLY WORK ON BLADE ANTENNAS

A. Baratta and C. B. Andrade presented a paper on Installed Performance Assessment of Blade Antenna by Means of the Infinitesimal Dipole in IEEE LATIN AMERICA TRANSACTIONS, VOL. 14, NO. 2, FEB 2016. They modeled an accurate and simple model to predict the radiation pattern of a blade antenna installed on an aircraft. They fabricated an equivalent infinitesimal dipole model (IDM) based on the far field radiation pattern of the blade antenna on a ground plane. A. Baratta and C. B. Andrade observed that by taking into consideration the basic geometry and some physical characteristics of the antenna to be modeled, their proposed approach has overcome one of the major problems of the classic IDM by reducing the number of parameters that to be optimized. They have chosen an aircraft in order to validate its application in electromagnetic large structures problems as a case study. They concluded that a good agreement with the radiation patterns is obtained between the proposed model and a blade antenna, where its accuracy and reduction in computational cost is verified.

Meliksah Yayan and Onurhan Duman presented a paper on Directional Blade Antenna with Increased Sectorial Gain, in 2015. They introduced and discussed the method for increasing the sectorial gain of a 3-notched directional blade antenna operating in C-band. Meliksah Yayan...
and Onurhan Duman expected that by inserting an additional 4th notch and using a cylindrical parasitic element all around the radiator, sectorial gain covering 70 degrees along the broadside radiation of the blade antenna is increased by approximately % 30. Their proposed antenna configuration is modeled and optimized by using CST Microwave Studio Suite, an EM simulation Software. Their observations revealed that, not only the return loss bandwidth is increased from % 10 to % 27 but also broadband minimum sectorial gain covering 70 degrees along the broadside radiation is also increased by % 30 after adding a 4th slot on the radiators proposed in [1] and placing a cylindrical parasitic all around the blade antenna.

Adra George and J. Geetha Ramani presented a paper on Survey on Various Designs of Monopole Blade Antenna in IFRSA’s International Journal Of Computing Vol. 5, issue 4, October 2015. In this paper they presented a survey on Blade monopole antenna and their historical perspectives. They discussed about the Blade monopole antenna, types, application and comparison of blade antenna over conventional monopole antenna.

In 2015 Hai Lu et al., presented a fast prototyping approach that combines accurate electromagnetic simulation and 3-D printing technology [14] in order to rally the necessities. The very unique feature of this type of approach is the specific transformation of coil model in electromagnetic simulations to mechanical design that can be man-made directly by 3-D printing and it is studied experimentally in this work.

Amna Ikram, Jean-Jacques Laurin presented a paper on “The Increase of the Directivity of a Low Profile Aircraft Antenna” in the 8th European Conference on Antennas and Propagation (EuCAP 2014). They alleged that their paper introduces a novel design to enhance the directivity of a low profile antenna for distance measuring equipment (DME) avionic system. A horizontal grooved ground plane is used by them to improve the antenna directivity. Their proposed design has a height of λ/10. Its radiation pattern is comparable with a monopole of λ/4 on the same ground plane size. Therefore they concluded that, with the use of a low profile antenna we can reduce the aircraft air drag without any significant change in its radiation characteristics. A new technique to increase the directivity of low-profile antennas at the horizon has been studied. Their proposed antenna was simulated in the High Frequency Structure Simulator (HFSS), fabricated and tested. The height of the proposed fabricated antenna from the top of the ground plane to the top plate of the antenna is 34.5mm, which also includes the thickness of middle plate. At the lowest frequency of DME band the electrical height of the antenna is 0.11λ. It has a radiation pattern similar to that of a monopole but it has the advantage of height reduction from 0.25λ to 0.11λ. Even with its reduced height, this antenna has more gain or directivity than the quarter-wave monopole (or blade antenna) at horizon. They concluded that based on simple calculations, its drag coefficient remains small and comparable to that of blade used for DME. The side view of the antenna placed on the grooved ground surface is shown in the figure.

Kaiyue Zhang presented a thesis on Modeling, Simulations, Measurements and Comparisons of Monopole-Type Blade Antenna in 2014. Kaiyue Zhang investigated two commercial blade antennas for aircraft applications. In his work the computed results are compared with measurements performed in the ASU Electro-Magnetic Anechoic Chamber (EMAC). The antennas are modeled as mounted on a 13-inch diameter circular ground plane, which corresponds to that of the measurements. Two electromagnetic modeling codes are used in his work to model the antennas and predicted their radiation and impedance characteristics by using FEKO and WIPL-D Pro. The classical wire monopole was also modeled using high-frequency methods, GO and GTD/UTD, mounted on both a rectangular and a circular ground plane. A good agreement between the patterns of this model and FEKO has been obtained. The final versions of the solvers used in this work are FEKO WIPL-D Pro v11 and WIPL-D Pro CAD 2013. Features of the simulation solvers are presented and compared. Simulation results of FEKO and WIPL-D Pro have good agreements with the measurements for radiation and impedance characteristics. WIPL-D Pro has a much higher computational efficiency than FEKO. The work concluded that by making reasonable modifications to the radome and coil, the Reasonable Approximation Model is obtained. The S-band Reasonable Approximation Model exhibits very good agreement with the measurements. The radiation patterns in the principal planes are almost identical to the measurements. Similarly, the predicted and measured return losses are in good agreement.

In 2011 Brendan D. Pell, [13], presented the concept of the modern vehicular antennas frequently configured in Blade or shark-fin housings, or as planar roof-mounted antennas. The work is focused to improve the appearance of the finished vehicle by painting these antennas on the or covering. In the work the narrow band and the wide band antennas are investigated and the effect of these coatings on impedance bandwidth and the radiation is observed [23].

In 2010, Emrah ONÇU, expressed [12] the concept of Single Stub Tuning Application via Semi-Rigid Coaxial Cables for
VHF and UHF Monopole Antennas on RASAT. The studies revealed that for maximum power transfer impedance matching is an important subject in communication systems. Besides, minimum complexity is another important concept in order to obtain cheaper, reliable and feasible matching networks. The work used a single stub matching implementation method applied while improving the return loss characteristic of blade antennas used in VHF/UHF communication system of RASAT is presented. RASAT is the first observation satellite designed and manufactured in Turkey.

The design and fabrication of a blade monopole antenna operating in 30 MHz – 600 MHz is presented by Bijan Abbasi Arand, Reza Shamsae and Behzad Yektakhhah in 2009. Bijan Abbasi and his team mates said that blade antennas are ideal antenna structures in airborne applications since they have light weight and are in aerodynamic shape. They studied and presented a special type of Blade antenna structure with an oblique edge which shows the improved impedance bandwidth in comparison to a normal blade antenna with the same total height and no oblique edge. Their proposed antenna is matched to a 50 Ω system with VSWR < 2 in the range 30 MHz – 600 MHz. Their experimental results revealed that the antenna pattern is Omni-directional with the maximum gain (G) of 5.6 dBi at 600 MHz and G > 0 dBi in the frequency range 150 MHz – 600 MHz.

Bijan Abbasi Arand, Reza Shamsae and Behzad Yektakkhah designed and fabricated a broadband monopole blade antenna with one oblique edge covering 30 MHz – 600 MHz. The final Blade antenna structure with an oblique edge with Teflon holders and impedance matching circuit is simulated by HFSS and also measured in anechoic chamber to obtain VSWR and gain pattern. Their simulation and measurement results for the antenna with the matching circuit show VSWR < 2 in the range 30 MHz – 600 MHz concluded that the oblique edge of the blade improves the impedance bandwidth for the antenna with no matching circuit.

In 2007, Marta Cabedo - Fabres, et al. presented a model to demonstrate that the Theory of Characteristic Modes can be used to perform a systematic design of different types of antennas. Characteristic modes are real current modes that can be computed numerically for conducting bodies of arbitrary shape. Since characteristic modes form a set of orthogonal functions, they can be used to expand the total current on the surface of the body. They discussed about what makes characteristic modes really attractive for antenna design in the physical insight they bring into the radiating phenomena taking place in the antenna. Their study confirmed that the resonance frequency of modes, as well as their radiating behavior, can be determined from the information provided by the Eigenvalues associated with the characteristic modes. Moreover, by studying the current distribution of modes, an optimum feeding arrangement can be found in order to obtain the desired radiating behavior is the noteworthy contribution from their study [9].

In 2006, L. Mattioni and G. Marrocco [8] presented a software tool for designing loaded antennas equipped with matching networks for broadband or multiband applications. The software implements a genetic algorithm to automatically optimize the large set of parameters involved in the design procedure. The graphical interface has been designed in MATLAB® to be used together with the popular NEC solver. However, the possibility of handling reduced-port models of the antenna permits the use of any kind of numerical solver for the electromagnetic analysis. Some examples of broadband and multi-band antenna designs in a complex environment demonstrate the potential of the tool [8].

In 2005, James E. Richie, presented the work on Antennas mounted to vehicles at VHF frequencies in comparison to whip and loop antennas. The antenna placement is the major concern in this work and it investigates the use of side-mounted loops on rectangular conducting platforms. From the experimentation he concluded that those tall thin platforms radiate similar to a dipole. In addition, as the thickness increases, the loop antennas can radiate in a nearly Omni directional fashion if the antenna-mounted sides of the platform are not too wide. In effect, a narrow platform width implies return currents for a loop antenna that remain mostly vertical [7].

In a research work carried in 2002, an application of physical optics and the methods of equivalent currents to the calculation of radar cross section of a helicopter rotor have been assessed in an experimental way. [6] The problem is treated using a quasi – stationary approach in this work. The calculation is parameterized as a function of locations of the radar transmitter and the receiver in relation to the rotor center. Blade geometry is taken into account using a triangular meshing generated by the I-DEAS meshing software. The far field and the near field of the antenna geometry are assessed in this work.

Makoto Ono and Yoshihiro Takeichi in 1990’s presented a paper on a one-eighth-wave blade antenna with metal leading edge. In the paper they very first investigated the change of the feed-point impedance of a reduced height monopole due to the grounded metal leading edge. Later they
presented a procedure to obtain wide band impedance matching on an antenna under the existence of a grounded metal leading edge. In the end they applied this theory to the VHF airborne antenna, producing wide band impedance matching on a one-eighth wave blade antenna. Makoto Ono and Yoshihiro Takeichi concluded that the Q of a reduced-height radiator is increased when a grounded conductor is located close by. They observed that a reduced-height radiator of low Q for wide band impedance matching can be obtained by means of a planar radiator with horizontal notches cut on it. Their proposed theory has been effectively practical to build up a one-eighth wave blade antenna that is used for aircraft. The effect of the impedance due to grounded parasitic element is shown in the figure.

![Impedance change due to grounded parasitic element](image)

**Fig.6. Impedance change due to grounded parasitic element**

## IV. CONCLUSIONS

A brief systematic survey on Blade antennas for airborne applications is presented in this paper. It is observed that the Blade antenna is well suited for airborne applications and with little modifications to the shape of the Blade antenna reasonable antenna performance can be obtained. It is noticed that the antenna pattern of the monopole antenna is Omni directional.

## REFERENCES


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Dr. Singh has been identified as Leading Scientist of the World-2011 by International Centre, Cambridge England, and recognized as Distinguished Honorary Member to Research Board of Advisers, American Biographical Institutes (ABI) in 2003. One of his research paper was awarded Sir Thomas Ward Memorial Prize by IE. He has written Carrier Counseling Colum for Eng Education in Hindustan Times. He has been Member Board of Governors, M.A.N.I.T. and CRISP Bhopal. He has been Key Note Speaker, Guest of Honor, and Chief Guest in Conferences/Seminars/Workshops/Social gatherings.