Journal of Research in Engineering and Applied Sciences

DESIGN OF A UAV BLADE MONOPOLE WITH THE USE OF DIFFERENT RTADIATING ELEMENTS AND SIMULATION OF DRA ANTENNA

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Abstract

Because of its small size, light weight, and aerodynamic design that causes the least amount of drag blade monopole antennas are favored for usage in airborne applications.

Consequently, their radiation patterns are unipolar and produce deep nulls in the upward direction. Such patterns will cause severe blind spots for the aircraft above and below this plane, which is undesirable for avionics networks. [1] To solve this problem, a dielectric resonator antenna (DRA) is attached to the blade antenna and thus a different design is formed. In this paper a rectangular DRA is used to illustrate the main idea.

The antenna is housed inside the aerodynamically designed radome to reduce air drag (large dome-shaped structures which protect the radars from the bad weather conditions but at the same time allow the electromagnetic signals to be received by the radar without any distortion or attenuation). [11] An air core coil is also provided for DC grounding proposes. The antenna configuration is first optimized using HFSS based Ansys Electronics Desktop Student 2021 R2 simulation software and latter practically implemented. The comparison of simulated results is also presented in this paper.

Key Words - Blade antenna, Broadband, HFSS and simulation

1. Introduction

The purpose of this study is to simulate an antenna using the HFSS based Ansys Electronics Desktop Student 2021 R2 simulation software to show the differences and changes to which the model is subject if different processing methods are applied. This is achieved by applying a different medium and material to either the DRA or the blade, or both.

With in-flight sensing, communications, and data processing, UAVs are effective IoT instruments. The structure of bladed antennas is like that of planar monopole antennas. Especially, unmanned aerial vehicles (UAVs) work increasingly in the swarm form as exemplified in Fig. 1, in which the relative positions between those UAVs are random because the swarms are in high mobility.

In addition, the network of a UAV swarm is three-dimensional in nature and may include the connections for data transmission among themselves, but also between UAVs and satellites, UAVs, and aircraft, as well as UAVs and ground stations, as shown in the following Fig. 1 [9,10]. Therefore, installed hemispherical coverage antennas are more suitable for UAV swarms.

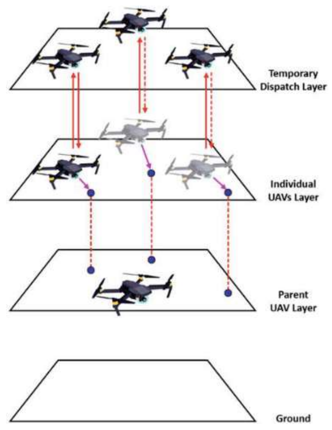


Fig. 1 Motion Planning of UAV Swarm: Recent Challenges and Approaches [12]

The wireless links established for the communication of UAV swarms are of utmost importance for wireless communications as well as their remote control. Characteristically, the so-called "extremely reliable data connection" of the groups in question requires particularly strong capabilities when engaging in either intentional or unintentional interference. [1]

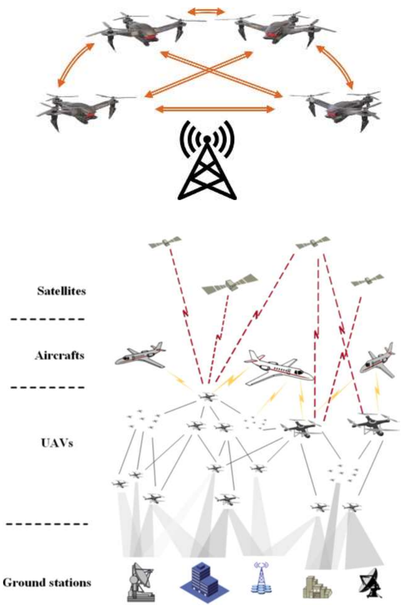


Fig. 2 (a) UAV swarm communication and control architectures [13]
(b) An example of wireless communication amongst swarms of UAVs. Any interactions between UAVs and other elements, such as ground stations, airplanes, satellites, and UAVs, are part of wireless communications. [10]

2. Description of Hypothesis and Simulation Process

Table 1. Description of Antenna components

DRA	The DRA (dielectric resonator antenna), which operates in the lowest TE111 mode and covers the high elevation angle region (i.e., is close to 0), is a crucial component.
Blade Monopole	The broadband blade antenna, which has a radiation pattern that is almost omni-directional in the low elevation angle zone (i.e., is close to 90), is another element.
Ground	As the ground is presumed to be properly parameterized and grounded, it is not represented in the process or involved in any way.

3. Hypothesis

H1: *DRA is made from copper and Blade Monopole is made from Isola Astra*
The S parameter is below zero and specifically between $-0.4*10^{-6}$ and $-0.2*10^{-5}$.
H2: *DRA is made from copper and Blade Monopole is made from glass.*
The S parameter is below zero and specifically between $-3*10^{-10}$and $-3*10^{-9}$.
H3: *DRA is made from polyflon copper and Blade Monopole is made from diamond.*
The S parameter is below zero and specifically between $-5.23*10^{-8}$ and $-7.5*10^{-8}$.
H4: *DRA is made out of teflon and Blade Monopole is made out of sapphire*
The S parameter is below zero and specifically between $-6.5*10^{-6}$ and $-1.06*10^{-5}$.
H5: *DRA and Blade Monopole are made from silicon dioxide.*
The S parameter is below zero and specifically between $-4*10^{-10}$ and $-1.4*10^{-9}$.
H6: *DRA is made from silicon and Blade Monopole is made from iron.*
The S parameter is below zero and specifically between $-0.4*10^{-6}$ and $-0.22*10^{-5}$.
H7: *DRA is made from copper and Blade Monopole is made from polyflon copper.*
The S parameter is below zero and specifically between $-0.4*10^{-5}$ and $-0.2*10^{-4}$.
H8: *DRA is made from copper and Blade Monopole is made from PVC plastic.*
The S parameter is below zero and specifically between -5-10^{-9} and $-1.6*10^{-8}$.

4. Methodology

The fundamental principle of this essay is shown using a rectangle DRA. The DRA operates at the lowest possible requirements i.e., at TE111, with the consequence that its corresponding radiation pattern covers the high-altitude angle region. At the low-altitude angle area, the radiation pattern of the blade antenna is omnidirectional. [1]

The goal of the current study is to demonstrate the differences and variations that the model of the antenna under discussion is subject to when the two components that make up the antenna are made of a different material.

In practice, this is reflected in the diagram with the S parameter as well as in the rest of the listed diagrams (gain plots a to h).

5. Antenna Design and Structures

Initially and since the parameters of the following Tables 2 & 3 have been applied to the model, the material for the construction of the DRA is copper and for the Blade Monopole the isola astra. Subsequently, the parameters for hypothesis H2 to H8 are applied.

Table 2. Material for Drone's Antenna parts

DRA material	Blade Monopole material
Copper	Isola astra
Copper	Glass
Polyflon copper	Diamond
Teflon	Sapphire
Silicon_dioxide	Silicon_dioxide
Silicon	Iron
Copper	Polyflon copper-clod

Copper	PVC Plastic

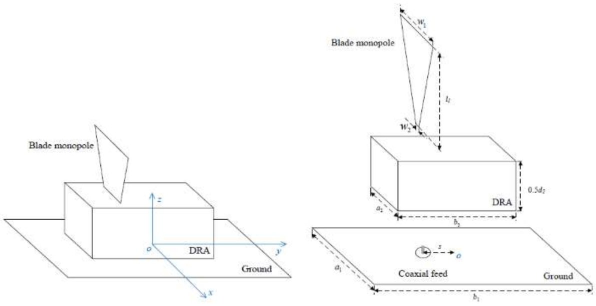


Fig. 3 Structure of the proposed blade-DRA antenna: (left) the whole structure and coordinate system and (right) assembly of the parts and the dimensions.[10]

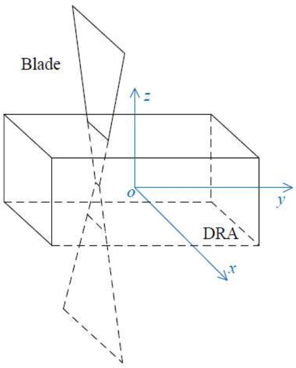


Fig. 4 Using the image theory, create a comparable model of the suggested blade-DRA antenna in Figure 2. [10]

After many tests of the model with various materials and considering that the HFSS based Ansys Electronics Desktop Student 2021 R2 application does not accept the combination of heterogeneous materials that are not amenable to combination and make the model non-functional, it is evident the different way of simulating the antenna from diagrams that follow.

Table 3. Structural parameters of the prototype antenna.

Bowtie Part	Value	DRA Part	Value
w1	45 mm	a2	40 mm
w2	1 mm	b2	48 mm
l1	50 mm	d2	45 mm
Thickness	0.5 mm	εr	9.5
s	12 mm	tanδ	0.003

6 Experimental Results

The prototype of the proposed antenna with optimal geometrical parameters as shown in Figures 2 & 3 was constructed and tested. The picture of a physically realized module is shown in Figures 4.

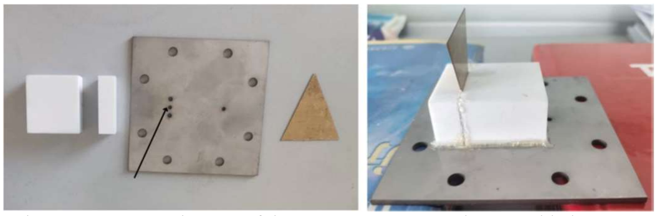


Fig. 5 Here are two images of the prototype antenna: the assembled antenna (b) and the discrete parts (a) before assembly. [10]

The design of the above model in combination with the use of hypothesis yields the following results:

a. Plots of the H1 Scenario

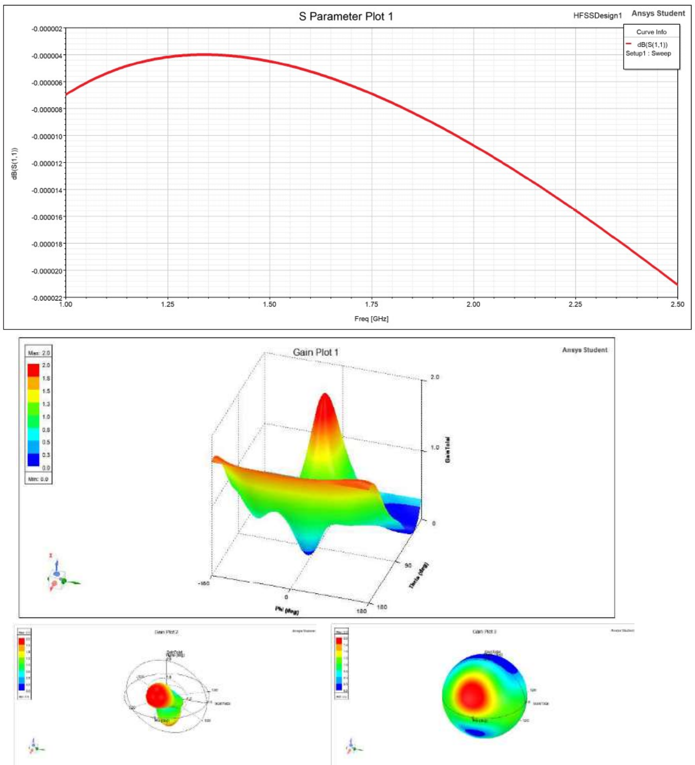
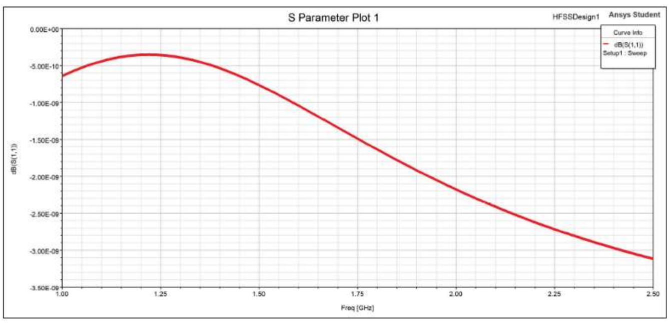


Fig. 6 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

b. Plots of the H2 Scenario



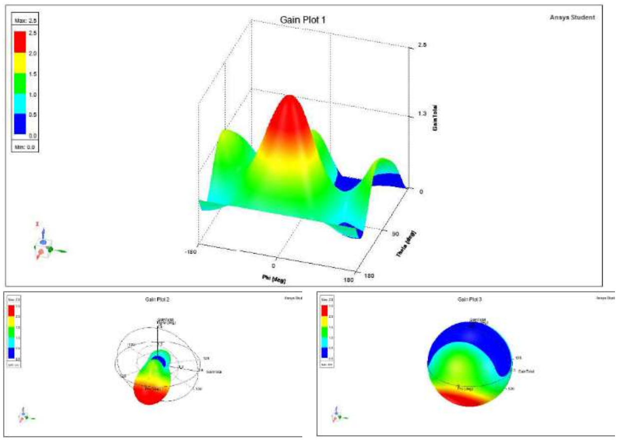


Fig. 7 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

c. Plots of the H3 Scenario

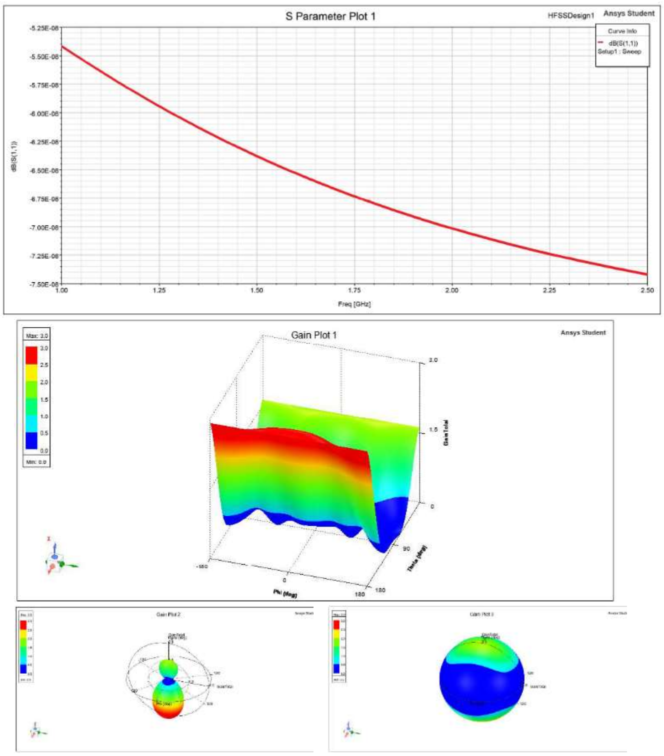


Fig. 8 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

d. Plots of the H4 Scenario

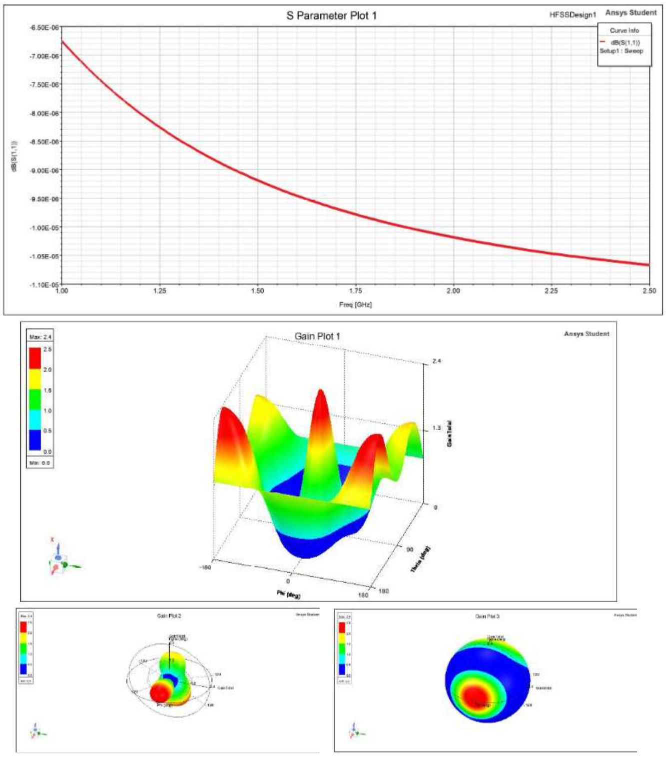


Fig. 9 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

e. Plots of the H5 Scenario

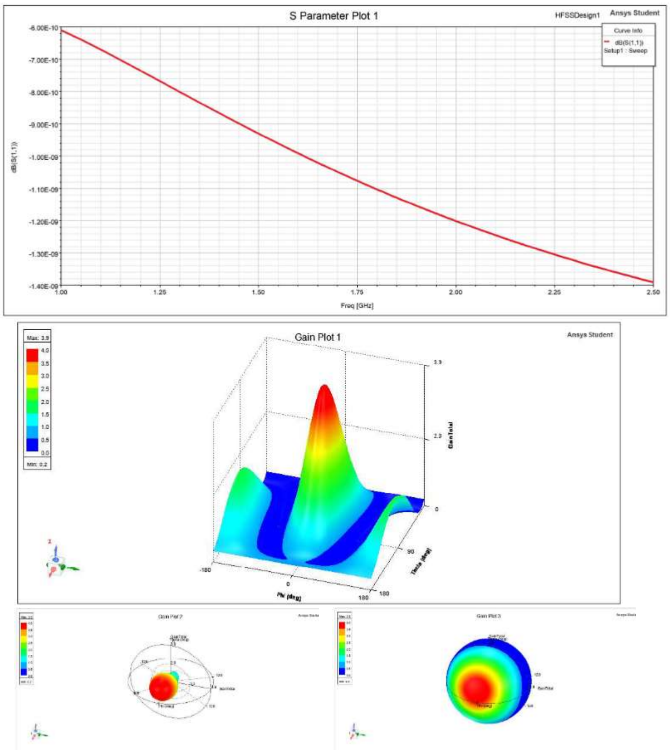


Fig. 10 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

f. Plots of the H6 Scenario

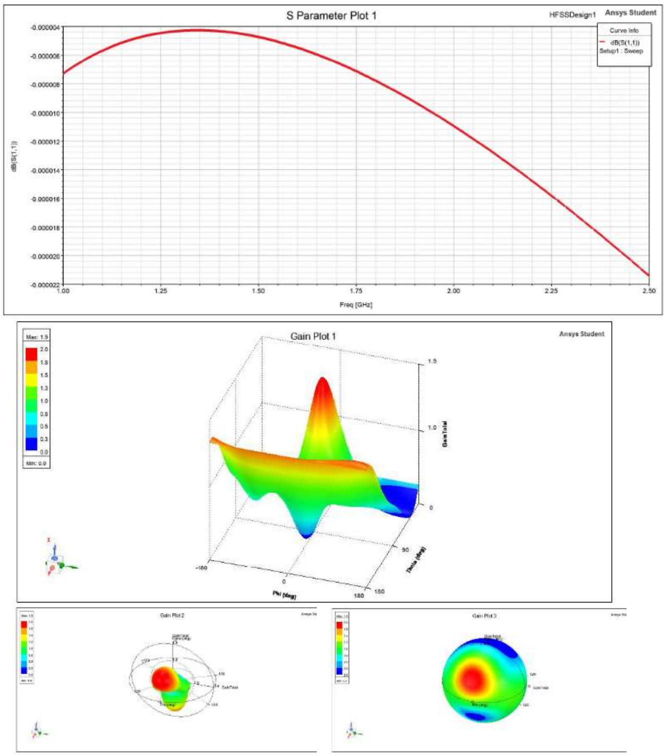


Fig. 11 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

g. Plots of the H7 Scenario

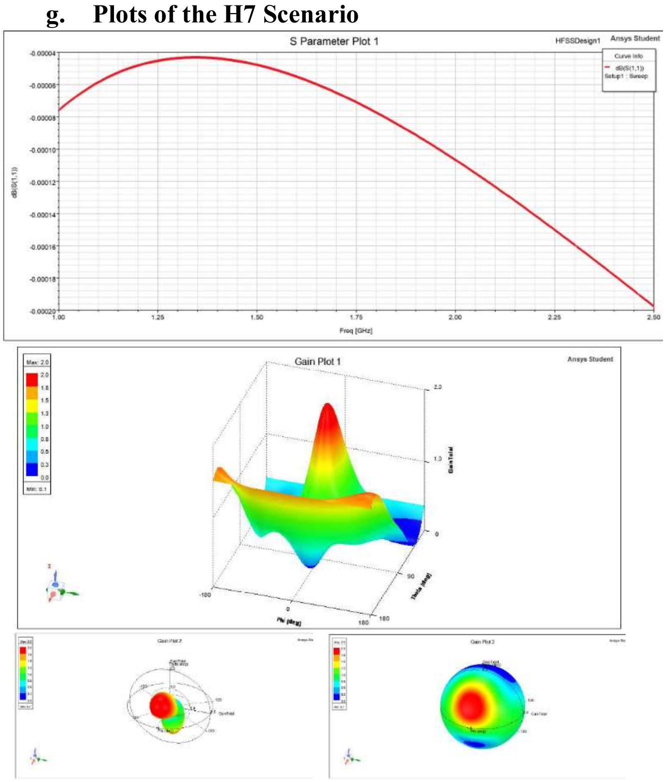


Fig. 12 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

h. Plots of the H8 Scenario

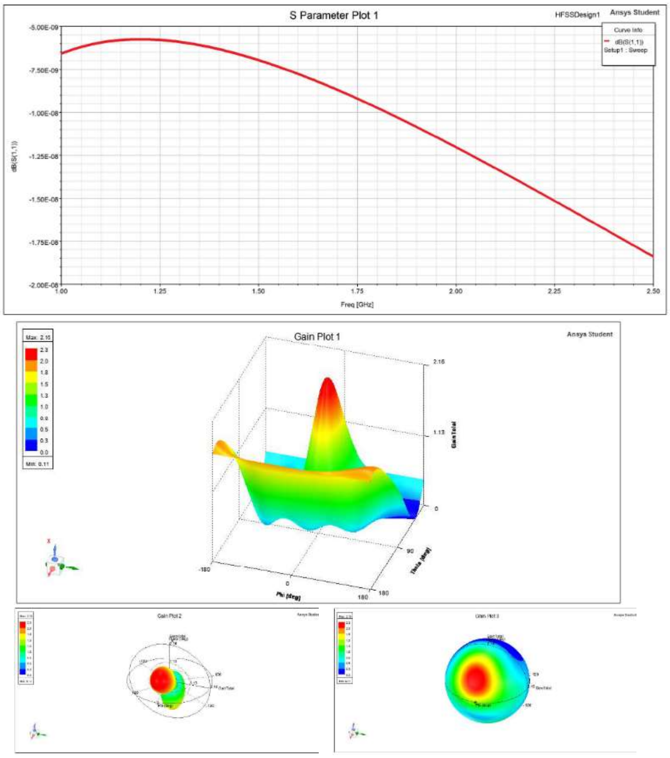


Fig. 13 (up) S parameter, (center) plot 3d, (down left) plot 3d polar, (down right) plot 3d sphere

The antenna consists of a blade section that acts as a main radiator and a DRA component that can provide good coverage towards the high-altitude angle region.

In the above diagrams the cases for the various materials of DRA and Blade Monopole have been investigated. The figures of cases a-h show the S parameter, the 3d plot, the 3d polar plot and the 3d sphere plot. Figure 8 shows that the rate of the S-parameter curve declines because of the materials employed.

6. Conclusion

This research is part of a research project looking at wireless communications for UAV swarms but also further design challenges of embedded antennas. In addition, it studies the effect of the differentiation of the materials that make up the "body" of an antenna as well as the mode of operation. In the present work using Ansys Electronics Desktop Student 2021 R2, the behavior of the antenna studied in [1] was examined with the design and differentiation of the medium in mind. Of course, there are other elements that must be considered, such as the area of examination and movement of the UAV as well as the operating bandwidth.

7. References

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