Design of Triangular Patch Antenna with reduced RCS for Stealth Applications using Bionics

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ABSTRACT: In this paper Bionics principle is applied to the proposed triangular antenna to show the antenna radar cross section (RCS) reduction by the use of a model insect tentacle antenna . Bionics is the study of mechanical systems that function like living organisms or parts of living organisms. To authenticate this method, a novel triangular micro strip patch antenna with reduced RCS is proposed and simulated for stealth applications. Mono static RCS and Bi-static RCS of an insect tentacle antenna (ITA) of triangular shape is proposed and simulated.. In this paper we have taken the Flame retarded substrate (FR4) which is made up of epoxy resin component, which is a very smooth substrate and is very cheaper to manufacture and gives better return loss. The substrate FR4 Epoxy used in this have a dielectric constant of 4.4. The results shown that the performance of the proposed triangular antenna has lower RCS and favourable radiation performances.

KEYWORDS: Micro strip patch antenna, Mono static RCS, Bi-static RCS ,Return loss, Bionics, Stealth Technology.

I.   INTRODUCTION

The antenna is the transitional structure between free-space and a guiding device. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna, or from the antenna to the receiver. In the former case, we have a transmitting antenna and in the latter a receiving antenna which acts as a line of sight between the transmitting and reception for directional services. It is for radiating or receiving radio waves. These are used in systems such as radio, television broadcasting, radio communicators, radar and space communications. As a part of these systems, antennas are dominant scatters due to its nature of efficient electromagnetic radiation. Unless the antenna system has a less RCS(radar cross section), the whole stealth performance will be destroyed and its stealth systems will be worthless. Therefore, the designs of antennas with reduced RCS have a great importance in low observable platforms. So, we are using the micro strip patch antennas for this design. These are simple and compatible with printed-circuit technology and are widely used in the microwave frequency spectrum. Simply a micro strip patch antenna is a triangular or other shape, patch of metal on top of a grounded dielectric substrate. They are easy and cheap to manufacture, lightweight. We use radar cross section (RCS), which represents the ability of targets in capturing and scattering the power of the signal. Radar cross section is the measure of target's ability to reflect radar signals in the direction of the radar receiver. Especially, in stealth and military platform, radar cross section reduction is an important parameter. Antenna scattering is the main contribution to the total radar cross section. An antenna is a special scattered whose scattering is related with its feed termination impedance, which handicaps the design of antennas with low RCS

and good radiation characteristics. Design and manufacture of UWB antennas is among the most critical problems nowadays as it opens a promising door to the future of wireless communications and military applications such as ultra wide band (UWB) radars, military high-data-rate wireless communications, and so on. An UWB antenna should provide a gain and impedance bandwidth from 3.1 to 10.6 GHz. However, with the development of target identification technology, the design of UWB antennas with low RCS becomes crucial to the survivability of the antenna platforms, yet few publications on the RCS reduction of UWB antennas have been published. To solve this problem, an RCS reduction technique using bionics principle is first proposed in this letter.For this, we use a suitable UWB antenna which should be capable of operating over an ultra wide bandwidth as allocated by the Federal Communications Commission. They usually radiate different frequency components from different parts of the antenna, which distorts and stretches out the radiated waveform. And now, we apply this method to the Stealth technology, which aims to control the characteristic signal of the target to make it difficult to be detected and attacked in the low observable platform. Many military platforms are required to exhibit a low RCS in order to avoid detection by radar. The goal of stealth technology is to make an airplane invisible to radar. The two different ways to create invisibility is, the airplane can be shaped so that any radar signals it reflects that are reflected away from the radar equipment and also the airplane can be covered in materials that absorb radar signals. Such that a stealth aircraft is made up of completely flat surfaces and very sharp edges to reflect less signals to overcome the threat. For this process, we are using Bionics technology, it is the study of mechanical systems that functions like parts of the living organisms. In this project Bionics principle is applied to antenna radar cross section (RCS) reduction. Mono static RCS of an insect tentacle antenna (ITA) terminated with three different loads are studied and compared with that of a triangular patch antenna. So that the wings of an organism like insect, which is used to protect itself from threat. Therefore, by using this technique we can reduce the reflected signals away from the threat. This results shows that, compared to the reference antenna, the novel bionic antenna has lower RCS and favorable radiation performances. Hence, applying bionics principle to antenna for RCS reduction is feasible, which will serve as a good area for the future design of antennas with a requirement of RCS control.

II. RELATED WORK BASED ON RCS, STEALTH TECHNOLOGY AND BIONICS

Radar cross section (RCS) represents the ability of targets in capturing and scattering the power of the signal. Antenna scattering is the main contribution to the total radar cross section (RCS) of low observable platforms. An antenna is a special scattered whose scattering is related with its feed termination impedance, which handicaps the design of antennas with low RCS and good radiation characteristics

Stealth technology aims to control the characteristic signal of the target to make it difficult to be detected and attacked in the low observable platform. Many military platforms are required to exhibit a low RCS in order to avoid detection by radar. The radar cross section (RCS) of sensitive targets has been reduced considerably in the recent years. As to low observable platform, one of the major contributing sources of target RCS is the scattering due to onboard antennas, so the control of the RCS of the antenna gains more and more interest.

Bionics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. The word *bionic* was coined by Jack E. Steele in 1958, possibly originating from the technical term *bion* (pronounced *BEE-on*; from Ancient Greek: βίος), meaning 'unit of life' and the suffix *-ic*, meaning 'like' or 'in the manner of', hence 'like life'. It is a term which refers to the flow of concepts from biology to engineering and vice versa. Hence, there are two slightly different points of view regarding the meaning of the word. In medicine, bionics means the replacement or enhancement of organs or other body parts by mechanical versions.

III. ANTENNA GEOMETRY

The geometry of the reference antenna is shown in Fig.1 and that of proposed antenna are shown in Fig.2 The triangular patch of sides $a=b=c=34.5$ mm is introduced here in this design. The micro strip feed line of length *19* mm, width 3.2 mm and impedance of *50* ohm is printed on one side of substrate. On its other side is ground of length Lg=16 mm and width wg= 52 mm. The substrate of length and width $L=W=52$ mm is loaded with dielectric constant of ε=2.2 and has height of hr= 1.5 mm. At the opposite edges ground is blended to stop the gradually changes of radiating beam
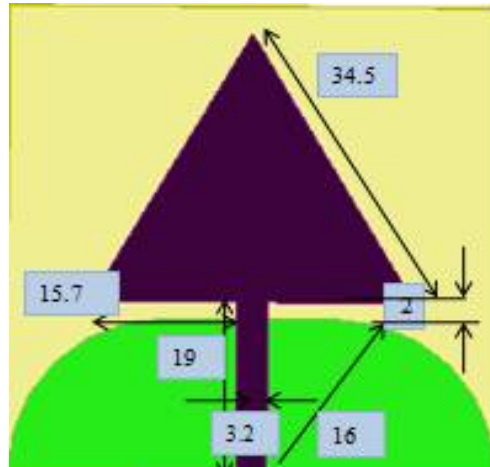
Fig1. Reference antenna

The triangular patch of the proposed antenna is designed totally different rather than rectangular or circular patches. In order to improve the RCS, a new triangular patch of small effective area is innovated in this design. By doing so, the maximum detection range of the target decreases, hence the RCS will become more efficient. In this paper we have taken the Flame retarded substrate (FR4) which is made up of epoxy resin component, which is a very smooth substrate and is very cheaper to manufacture and gives better return loss.

IV. PERFORMANCE AND CHARACTERISTICS

All the simulations in this work are obtained with the help of HFSS software. The measured value of proposed antenna return loss is -62.5 dB at 10GHz. The return loss in dB with respect to frequency at 10GHz for the proposed antenna proves that it can be used for stealth applications at 10GHz. Unlike calculating the return loss for patches differently, here the return loss is calculated for entire micro strip patch antenna. In order to get the efficient return loss, the substrate FR4 was used in this antenna design as it had dielectric constant of 4.4 with a tangent loss of 0.02. The major modification done in this antenna was applying bionics principle to the antenna in order to reduce the radar cross.

Table 1:

Parameters and their values

S.NO	PARAMETER	REFERENCE ANTENNA	PROPOSED ANTENNA
1.	Return loss	-25	-62.5
2.	Monostatic RCS	-6	-50
3.	Bi-static RCS	-6	-50

V.RESULTS AND ITS DISCUSSION

This section is about referring the calculation and parametric study of refereed and proposed antenna simulation. The proposed antenna has been analysed by simulation and it is compared with the reference antenna. The characteristics that are compared in this work are return loss and radiation pattern. Fig 2 shows the graph between the return loss and the frequency. In this figure we have a return loss -62.5dB at 10GHz frequency
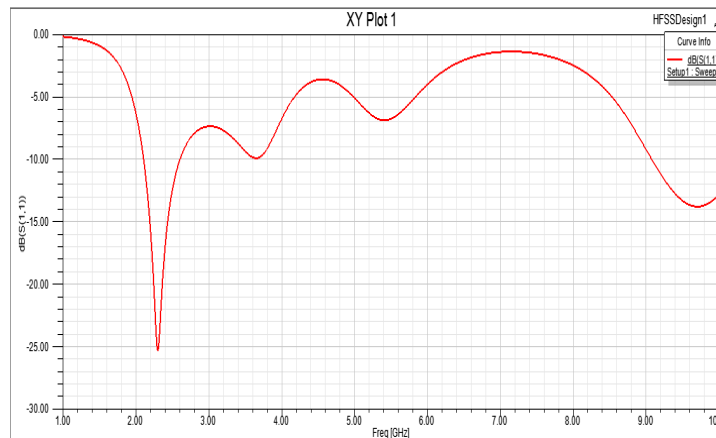
FREQUENCY VERSUS RETURN LOSS

Fig. 2. Graph of Return loss versus Frequency.

Fig 2. Shows graph between return loss and frequency. In this figure we have return loss -25dB at operating frequency 10GHz for reference antenna.
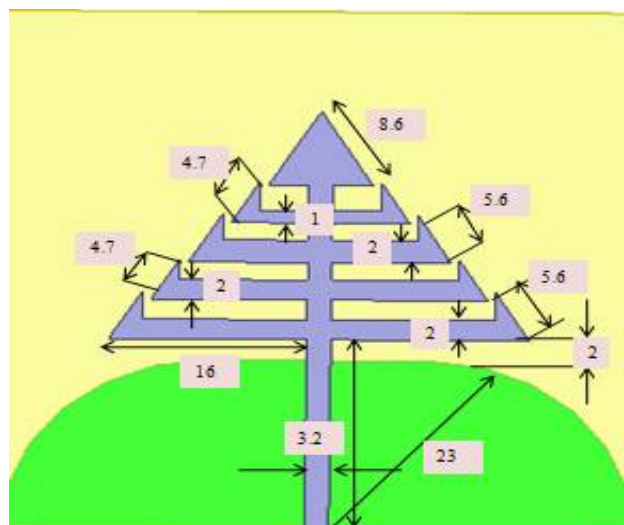
PROPOSED ANTENNA

Fig. 3. Proposed antenna.

This figure no.3 shows that proposed antenna where Bionics principle is applied.

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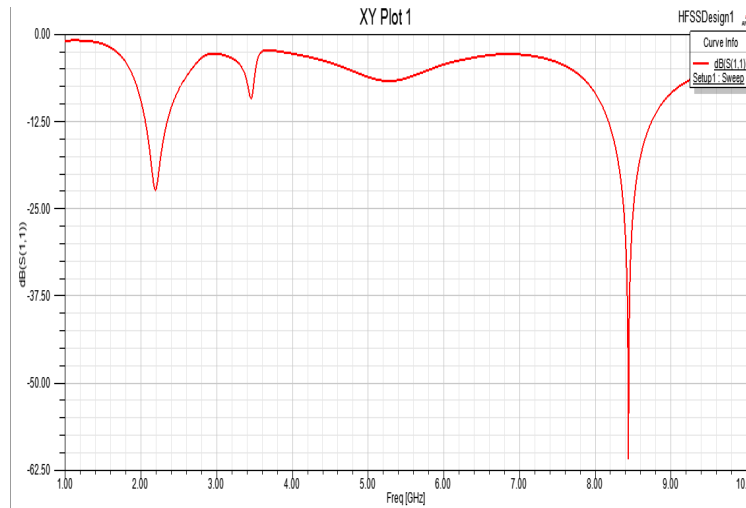### FREQUENCY VERSUS RETURN LOSS FOR PROPOSED ANTENNA

Fig.4 Frequency versus return loss graph for proposed antenna.

This figure shows that frequency versus impedance. For proposed antenna, we got impedance 50Ω operating frequency at 6 GHz in high frequency simulation software (HFSS).
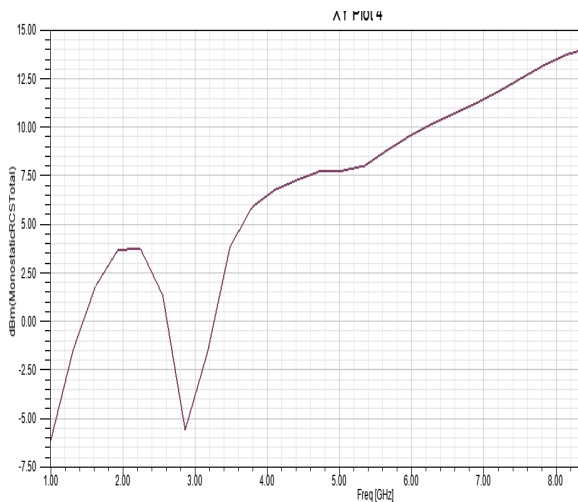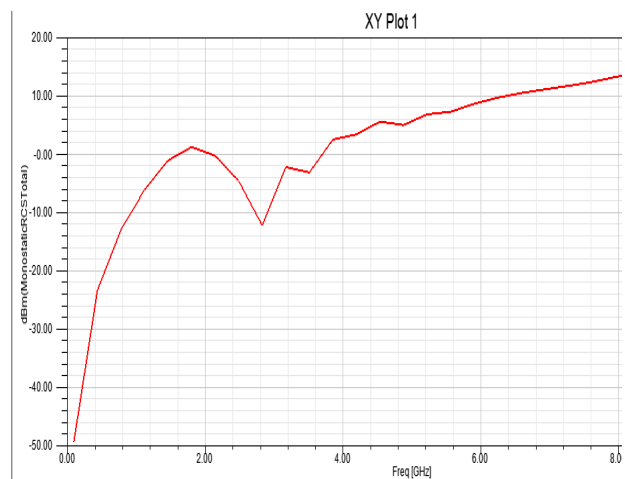

Fig.5 Monostatic RCS for reference antenna

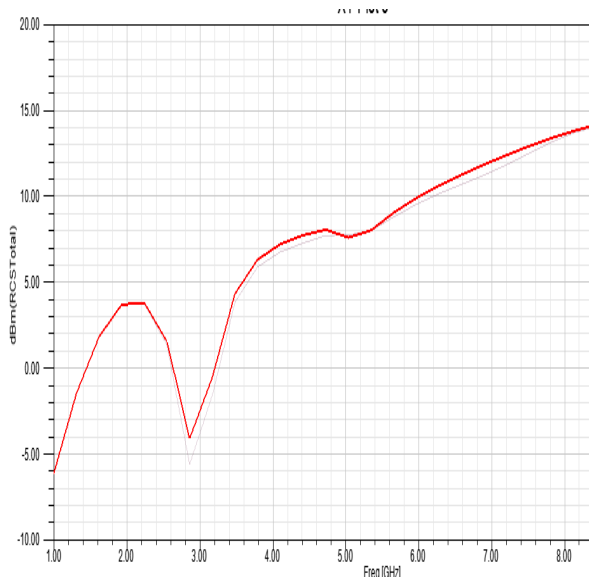

Fig.6Monostatic RCS for proposed antenna
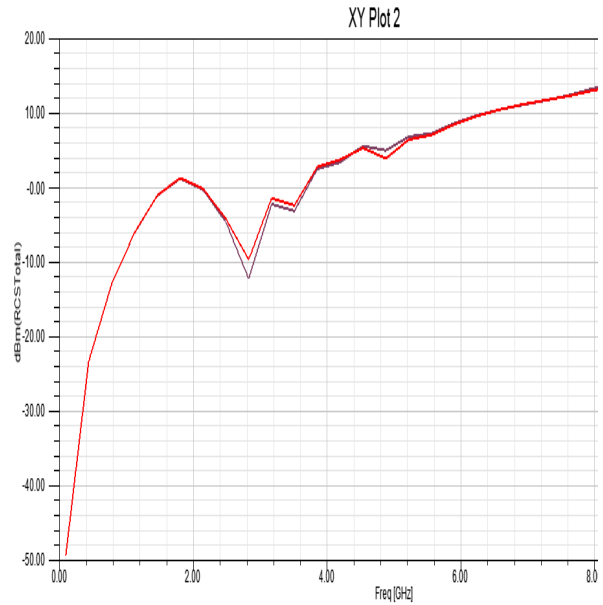
Fig.7 Bi-static RCS for reference antenna

Fig.8 Bi-static RCS for proposed antenna
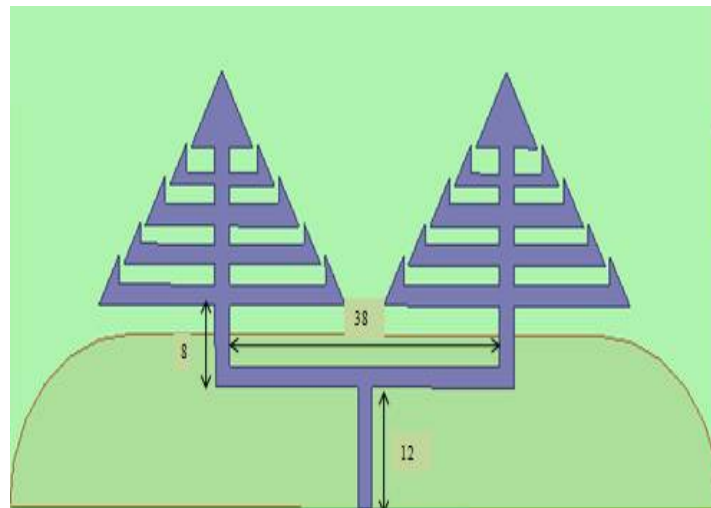
EXTENDED DESIGN

Fig.9 Extended design

We can design the proposed triangular design in the above manner also, where the return loss is expected to be lesser than the reference antenna and the monostatic RCS, bi-static RCS graphs will also have been observed

VI. CONCLUSION

Here the reference triangular antenna is compared with triangular antenna with more wings has higher return loss, this implies that as the spaces in patch antenna increases the number of reflections get decreased and the target

will be invisible to the radar. These are mostly used for military applications. The proposed antenna having radiation characteristics with a return loss of -19dB at 5GHz frequency. Its compactness, good frequency versus losses response will definitely help this designed antenna to be applicable for stealth applications

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