A NOVEL AIRCRAFT ANTENNA STRUCTURE USING COMPOSITE MATERIALS

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1 Introduction

Recently, according to development of antenna techniques, the aircraft antenna of new form has been researched. The electronics and the structure were combined, Conformal Load-bearing Antenna Structure (CLAS) technique is representative [1]. CLAS technique improves an electrical and structural efficiency of antenna. It will be possible to develop CLAS into aircraft from external antenna to internal antenna. This leads to aerodynamic efficiency of aircraft, shift periodic decrement and lightweight of antenna [2-7]. But, in order to apply CLAS to the aircraft antenna, a wideband and a miniaturization technique are essential.

In this paper, CLAS, a wideband and a miniaturization technique are combined, which will be applied in proposed antenna. Proposed antenna will be able to embedded into the skin of aircraft. The antenna implements spiral pattern to wideband characteristic, inductive loading and composite materials to a miniaturization. The antenna performance is confirmed by simulation and measurement.

2 Antenna Geometry and Properties

2.1 Antenna design structure

The aircraft antenna is usually used blade and spiral type of antenna. Blade antennas have narrowband, low radiation efficiency. On the other hand spiral antenna has wideband characteristic and high radiation efficiency. But, spiral antenna has high impedance characteristic and sensitive to a size. So, in order to embed into the skin of aircraft, spiral antenna solves these problems.

The antenna is affixed in the lower part of aircraft and the whole structure is presented in Fig.1. In order to improve the structural stability and electrical performance of antenna, radiating element, honeycomb and housing ordered.

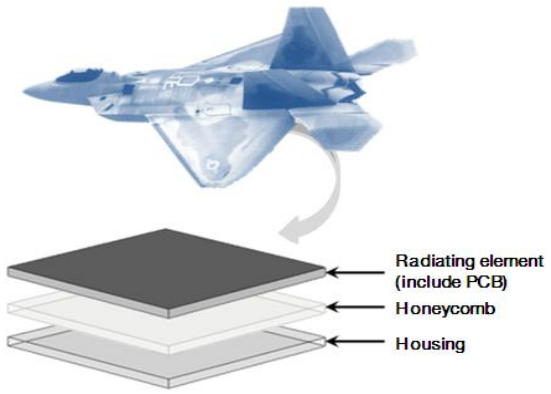


Fig.1. Antenna structure

2.2 The spiral antenna

In Fig.2 is general archimedean spiral antenna structure. The spiral consists of two identical arms which are shifted by 180˚ with respect to each other. The curve is described by the function (1). The function (2) is applied in self-complementary structures [8].

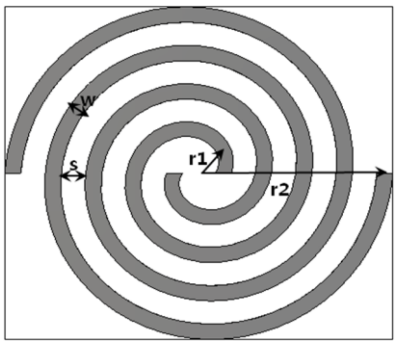


Fig.2. Arm pattern of archimedean spiral antenna

Design variable of spiral antenna is width of spiral arms (w), arm interval (s), arm radius (r1, r2). And according to design variable before the number of revolution (N) which is decided. Number of revolution (N) in compliance with the arm width and arm interval is decided.

$$(s + w)2N = r2 - r1 \quad (1)$$

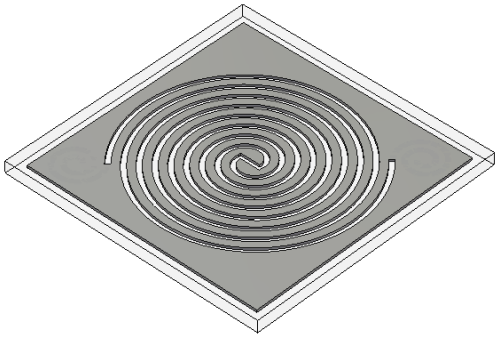
$$s = w = \frac{r2 - r1}{4N} \quad (2)$$

$$r1 \leq \frac{c}{2\pi f1}, \quad r2 \geq \frac{c}{2\pi f2} \quad (3)$$

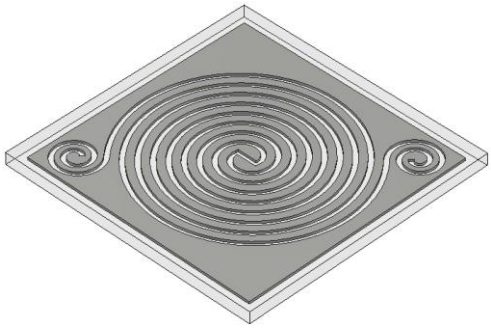
The radius r1 and r2 of the function (3) is decided in compliance with upper limit frequency and lower limit frequency [9]. The useable frequency of the spiral antenna is decided according to antenna size. So, to the case where the antenna size is restricted, additional antenna design technique is necessary.

3 Antenna Design

CLAS antenna is composed of radiating element, honeycomb and housing ordered as shown Fig.1. The housing prevents bad damage influences from the electric wave toward aircraft electronic equipment. And it supports the external infrastructure. The honeycomb absorbs shock of the radiating element. The radiating element protected the PCB from shock the outside and improves radiation efficiency. The spiral pattern is used to wideband characteristic of antenna. Resonance frequency of spiral antenna is affected by radius r1 and r2. So, in order to improve electric performance of the conventional spiral antenna, inductive loading is inserted at the end of spiral. Inductive loading improves the electric performance of antenna, because of the electric length extension effect and matched impedance characteristics. And PCB is covered with the composite materials, which comprises of mixture of ferrite powder and Acrylonitrile Butadiene Styrene (ABS). It improves the radiation efficiency and matched impedance characteristics more. Electric performance of antenna is confirmed by the CST_MWS [10]. The Fig.3 shows antenna shape of basic spiral structure and proposed spiral structure.



(a) Basic spiral structure



(b) Proposed spiral structure

Fig.3. Spiral antenna shape

3.1 M&S (Modeling & Simulation)

3.1.1 Inductive loading effect analysis

In order to confirm the efficiency improvement in compliance with an inductive loading compares the antenna from in Fig.3. The simulation results are shown Fig.4.

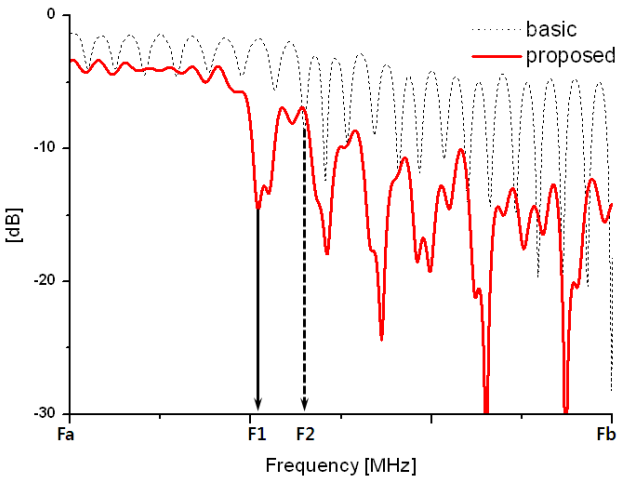


Fig.4. Return loss comparison followed in inductive loading use (simulation results)

The resonance of basic structure occurs from F2 MHz, proposed structure is from F1 MHz. The inductive loading effects are improved matched impedance characteristics and resonance frequency decreased of antenna.

3.1.2 Composite materials effects analysis

The next, in order to confirm the efficiency improvement in compliance with composite materials applied in two kind structures in Fig.3. The simulation results are shown Fig.5.

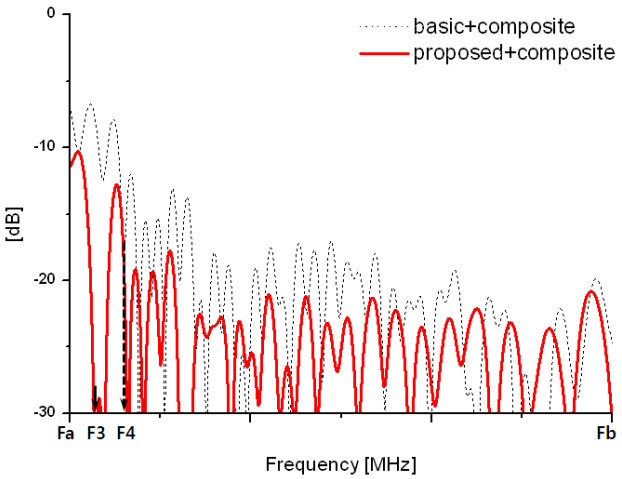


Fig.5. Return loss comparison followed in composite materials use (simulation results)

The composite materials applied in the antenna, which occurs resonance from F3 and F4 MHz. Composite materials caused resonance frequency decreased and matched impedance characteristics improved of antenna.

3.2 Measurement

The antenna is fabricated through the M&S results, the shape same as Fig.6. Return loss results of measured antenna are Fig.7. The frequency range Fa to Fb MHz is satisfied with below 5 dB. It means matched impedance characteristics go well. Radiation pattern of antenna has uniform characteristic in Fig.8. Like this radiation pattern is suitable applies in rear of the aircraft. The antenna gain is confirmed as the minimum value of -15 dBi for the whole frequency range.

Fig.6. Fabricated antenna shape

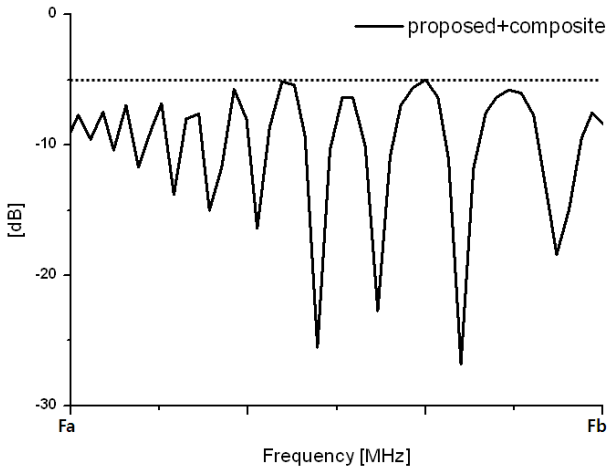


Fig.7. Return loss of proposed antenna (measured results)

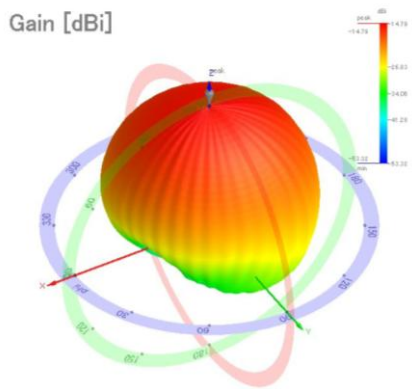


Fig.8. Radiation pattern at Fa

(measured results)

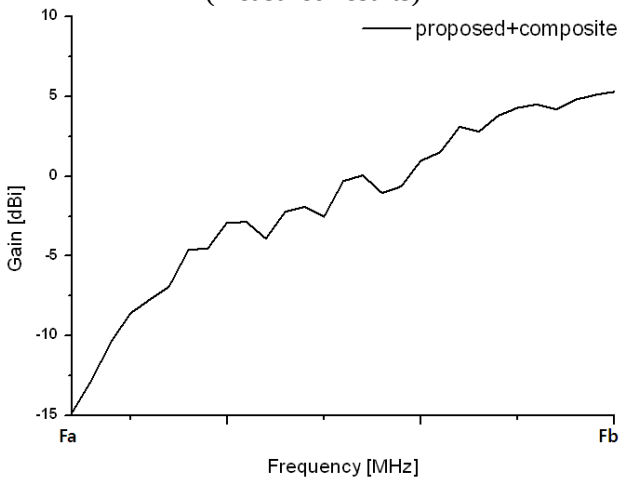


Fig.9. Gain as a function of frequency (measured results)

4 Conclusions

The aircraft CLAS antenna is designed, fabricated, and measured. In order to embed the antenna into the skin of aircraft, the antenna is consisted of radiating element, honeycomb and housing ordered. In order to wideband and a miniaturization inductive loading technique and composite materials are applied in the proposed antenna. Measured results, return loss of the proposed antenna satisfied below 5 dB from Fa MHz to Fb MHz. The antenna has a suitable radiation pattern applies in rear of the aircraft. And antenna gain is confirmed as the minimum value of -15 dBi for the whole frequency range.

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