DESIGN OF COMPACT, LIGHT WEIGHTED, MULTI-BAND CONFORMAL LOAD-BEARING ANTENNA WITH MAGNETO-DIELECTRIC MATERIAL

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1 Introduction

In this paper, the novel antenna technology is proposed for the conformal load-bearing antenna. For fabricating a compact, light weighted and multi-band antenna, magneto-dielectric concept is developed to the Conformal Load-bearing Antenna Structure (CLAS) in this study.

In generally, the present CLAS is composed of composite material, honeycomb, PCB micro-strip antenna and absorber etc. However the antenna radiator doesn't have enough mechanical strength and electrical performance like as compact and multi-band.

We propose magneto-dielectric material and slotted log-periodic element to acquire higher mechanical and electrical performance than the present structure. Radiator is manufactured in one piece with slotted log-periodic element in magneto-dielectric, M&S model is shown Fig.2.

Magneto-dielectric for the last development product will be made of plastic material (ABS, PET etc.) and ferrite powder by the injection molding. We have designed, manufactured, and tested in pre-stage of the injection molding in this work.

Because of the element inside magneto-dielectric, radiator showed higher mechanical strength than PCB micro-strip antenna. The compact and light weighted antenna was designed by plastic's dielectric constant and ferrite's magnetism.

Slotted log-periodic element inside Magneto-dielectric is composed of slot element, parasitic slot and transmission line. Fig.3. shows the slotted log-periodic element inside magneto-dielectric [1-5].

Each Slot element is charged of the function of a radiator and parasitic slot makes long of electrical length and is operated as a matching unit [6-10]. The proposed radiator was manufactured with the size of $300 \times 300 \times 30$ mm^3 for UHF-band.

So the size of conformal load-bearing antenna is smaller 50 % over than airborne antenna in previous work and electrical properties are equal or high.

2 Design Simulation

2.1 Simulation Model

Total design model of antenna is composed of housing, honeycomb, radiator, face sheet, and so on. It is shown in Fig.1.

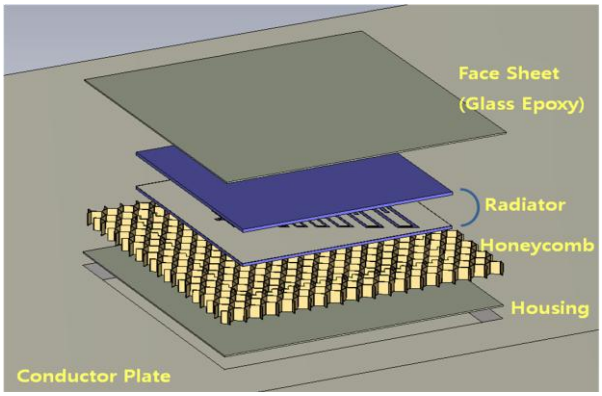


Fig.1. Antenna design model

To design the antenna, simulation tool is used CST_MWS. The important parameters are size and shape of housing, honeycomb, radiator, and face sheet, electrical performance values (permittivity, permeability, conductivity) in the design.

For condition of equipment airplane, skin of airplane was considered in the design like the Fig.1. When the antenna is equipped airplane, face sheet of antenna and skin of airplane are located on the same surface and face sheet play a role of airplane skin. Conductor plate around the antenna was used in

antenna design to analysis effect of the skin on electrical performance.

2.2 Radiator Design

In Fig.1, housing, face sheet are charge of major role of mechanical performance (protecting and supporting antenna from outer circumstance), radiator is charge of transmission and reception and honeycomb is charge of keeping gap and road bearing between housing and radiator.

In this part, we deal with a change of electrical properties according to a shape of antenna. A shape of radiator is shown in Fig.2.

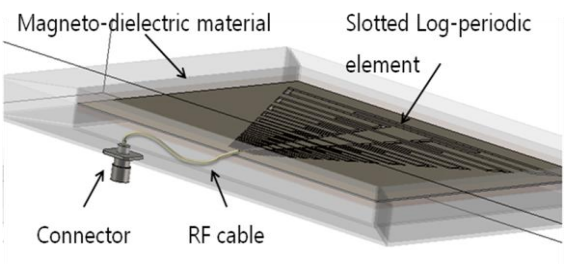


Fig.2. Radiator M&S model, Slotted log-periodic antenna with magneto-dielectric material

The radiator is composed of slotted log-periodic element, RF cable, connector and magneto-dielectric material. The magneto-dielectric is mixture of plastic (dielectric material) and ferrite, magneto-dielectric and slotted log-periodic are manufactured in one-piece. As doing that, the mechanical stability of slotted log-periodic element and improvement of electrical performance of antenna by ferrite can be acquired. Fig.8 and Fig.9 show improvement of electrical performance of antenna by ferrite.

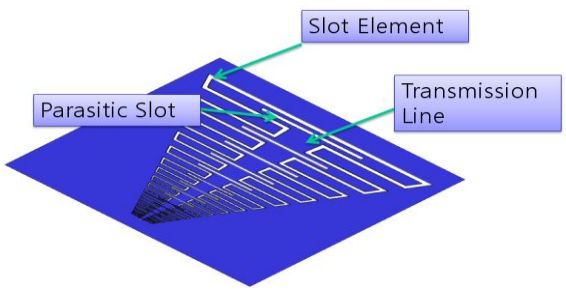


Fig.3. Slotted log-periodic element

Slotted log-periodic element is composed of slot element, transmission line and parasitic slot like the Fig.3. There are major three points in the design of slotted log-periodic element.

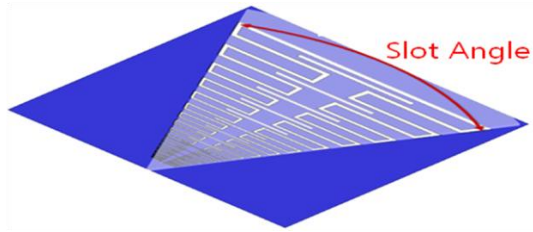


Fig.4. Slot angle

First is angle of slot which determines bandwidth. Bandwidth is as wide as slot angle but gain deviation is wide. So the selection of slot angle is needed to optimize gain and bandwidth.

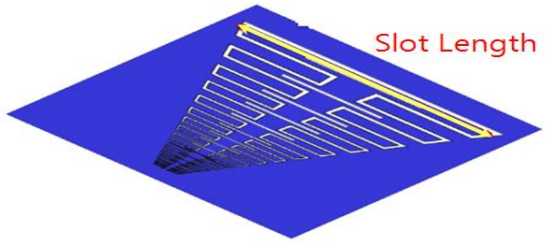


Fig.5. Slot length

Second is length of slot which determines frequency band by resonance of each slot. Numbers and length are selected by used frequency band.

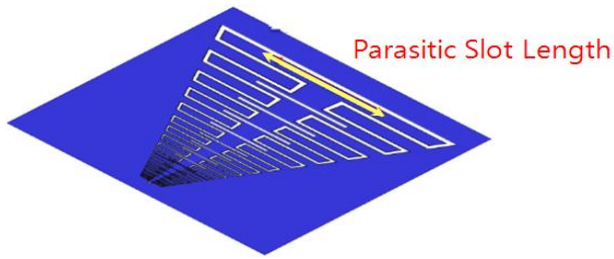


Fig.6. Parasitic slot length

Third is length of parasitic slot which makes impedance matching with the function controlling input-phase of each slot. Fig.7. shows reflected loss before and after parasitic slot.

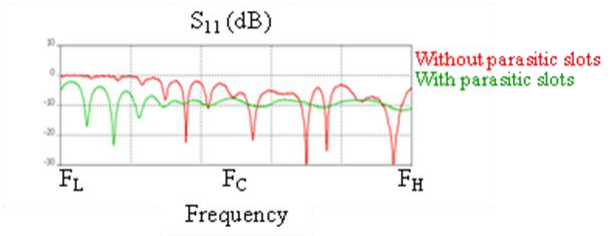


Fig.7. Effect of the magneto-dielectric on the reflected loss

2.3 Simulation Results

We verified that small size (inner 300 × 300 mm^2) of CLAS can be realized in UHF bandwidth. Mechanical design result of antenna includes slotted log-periodic element with 16 slots, radiator size with 300 × 300 mm^2 through M&S design process.

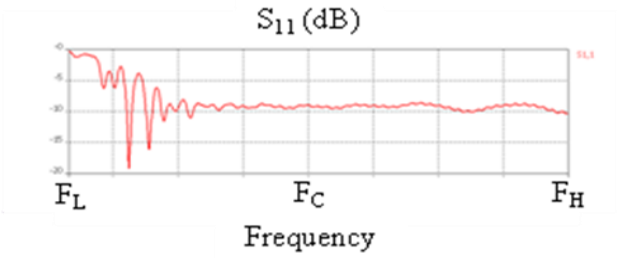


Fig.8. Reflected loss
(Simulation results, without magneto-dielectric)

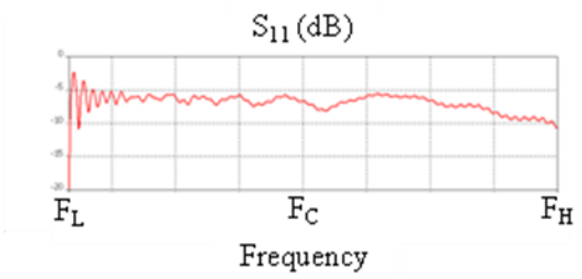
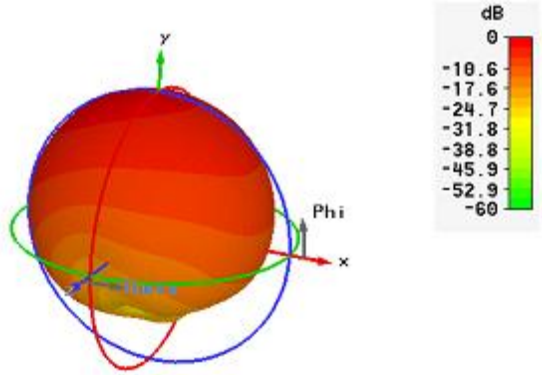
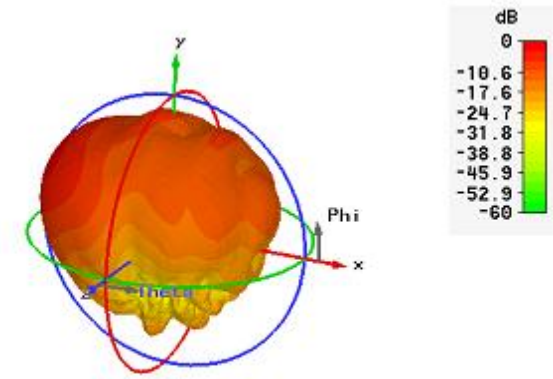


Fig.9. Reflected loss
(Simulation results, with magneto-dielectric)

Fig.8 and Fig.9 show electrical performance, and verification of improvement of reflected loss in case of magneto dielectric under UHF low frequency band.



(a) F_L



(b) F_H

Fig.10. Radiation pattern (Simulation results)

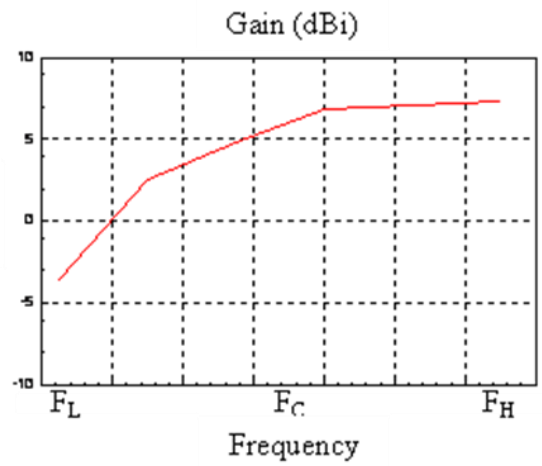


Fig.11. Gain (Simulation results)

3 Experimental Results

3.1 Photographs of fabricated antenna

Fig.12 and Fig.13 show pictures of slotted log-periodic element and manufactured antenna each other. Air plate is used instead of honeycomb for similar permittivity. Skin of airplane and housing was made with aluminum. Radiator was used fabricated thing instead of injection molding. Black part is antenna and outer part is conductor plate (skin of airplane).

Fig.12. Photograph of Slotted Log-periodic element

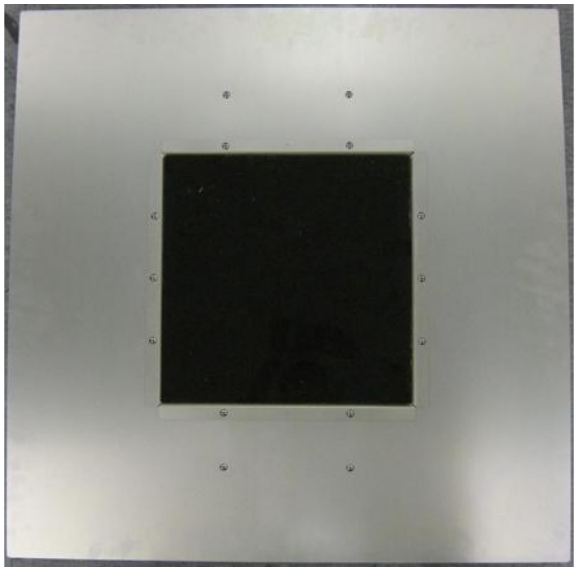


Fig.13. Photograph of fabricated antenna

3.2 Measurement Results

Fig.14, Fig.15 and Fig.16 show reflected loss, radiation pattern and gain of measurement. We can verify to minimize size of CLAS under 300 × 300 mm^2 in UHF bandwidth. At the lowest resonant frequency of UHF-band, antenna gain has higher over -4.35dB and reflected loss is under -5dB. Radiation pattern is also particular directional.

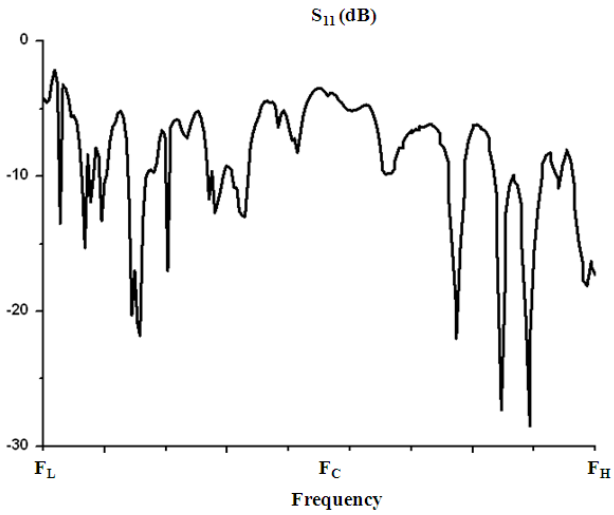
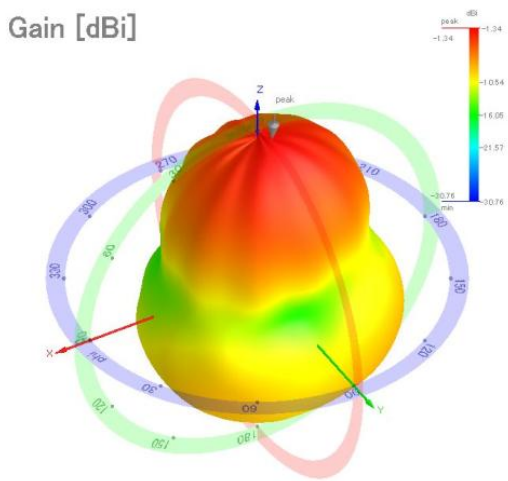
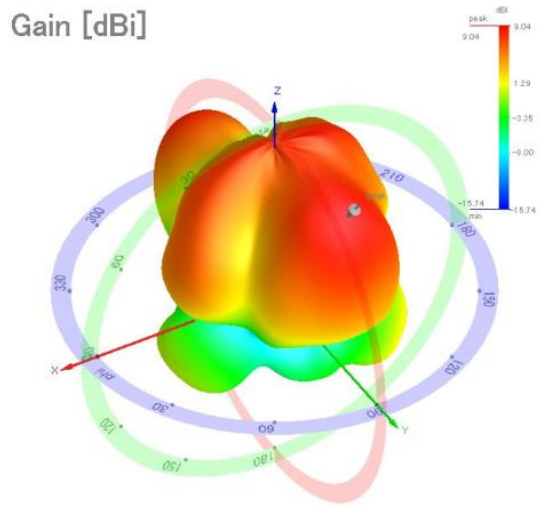


Fig.14. Reflected loss versus the frequency of the fabricated antenna (Measured results)



(a) 3D gain pattern at F_L



(b) 3D gain pattern at F_H

Fig.15. 3D radiation pattern of fabricated antenna

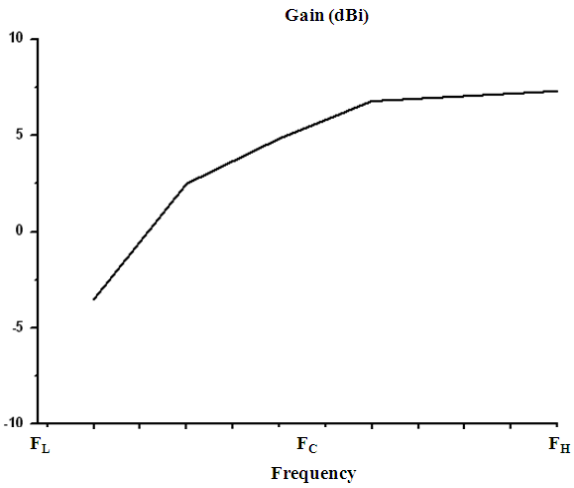


Fig.16. 3D peak gain of fabricated antenna versus the frequency

4 Conclusions

The novel antenna technology is designed, fabricated and tested for adapting to CLAS system. It is verified as a CLAS antenna by one piece of magneto-dielectric and slotted Log-periodic element.

CLAS antenna of UHF band can be manufactured 300 × 300 mm^2 size and be smaller 50% over than the previous type of antenna.

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