GROUND EFFECTS ON RADIATION PATTERNS OF INVERTED-F ANTENNA ON A LARGE CYLINDRICAL CONDUCTING BODY

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1. Introduction

Recently, many studies on telemetry systems have been performed in fields of satellite launchers. The data collected by telemetry systems are used to evaluate flying performance in the satellite launcher and to investigate atmospheric temperature, pressure, and density and so on. As an important factor, the antenna gain has effects on the flying performance. Especially, according to the trajectory, the gain of antennas on a satellite launcher toward a ground system fluctuates considerably. Therefore, studies on antenna systems are indispensable to get a sufficient link budget for all flying trajectory.

Usually, inverted-F antenna (IFA) is used in satellite launchers like rockets for telemetering [1]. IFA has been a good candidate because it is extraordinarily aerodynamic and has omnidirectional characteristics in radiation pattern. Many researches on IFA have been performed and published in a field of a portable telephone. However, the study on IFA on a satellite launcher has almost been not published. Only a few studies on monopole on conducting body like a rocket and missile have been published [2-3]. IFAs on a satellite launcher are considered as electrically small antennas on an electrically large conducting body. So the antennas can be analyzed by full-wave analysis like method of moment (MoM) and FDTD (Finite Difference Time Domain) method if sufficient resources of computer are allowed. The large conducting body as a ground makes an analysis difficult. Recently, ground plane effects on planar inverted-F antenna (PIFA) performance are investigated [4]. According to the investigation, if a length of one side in a square ground is larger than 0.8λ, the resonant frequency, bandwidth, and gain are not significantly changed. However, the analysis of the ground effects on radiation patterns has not sufficiently performed in [4]. Also, simulations are performed only for flat ground in [4].

In this paper, ground effects on radiation patterns of IFAs on a large cylindrical conducting body like a satellite launcher at UHF, S, and C bands are simulated and analyzed. The electrical size of the satellite launcher is assumed to be sufficiently larger than that of the IFAs at S and C bands. Therefore, the surface current is limited to the vicinity of IFAs and the ground far away from IFAs can be ignored.

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2. Analysis model and IFA

Fig. 1a) shows the analysis model having a cylinder with two IFAs. A cylindrical conducting body indicates the simple model of the satellite launcher. The diameter of the cylinder is 850 mm which is about 1.22λ, 6.38λ, and 16.05λ at the specific center frequencies of UHF, S, and C bands, respectively. The length of the cylinder is 500 mm which is about 0.72λ, 3.75λ, and 9.44λ at the center frequencies of UHF, S, and C bands, respectively. Fig. 1b) shows the structure and the dimensions for IFA.

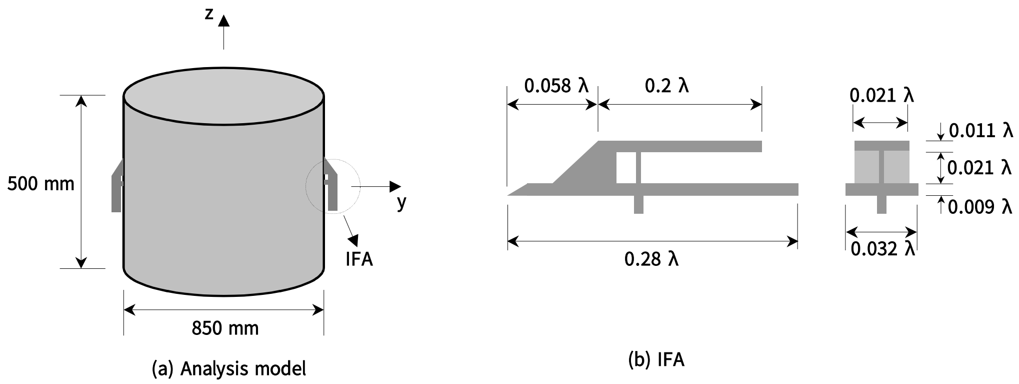

Fig. 1 Structure and dimensions of analysis model and IFA

3. Measured and simulated radiation patterns

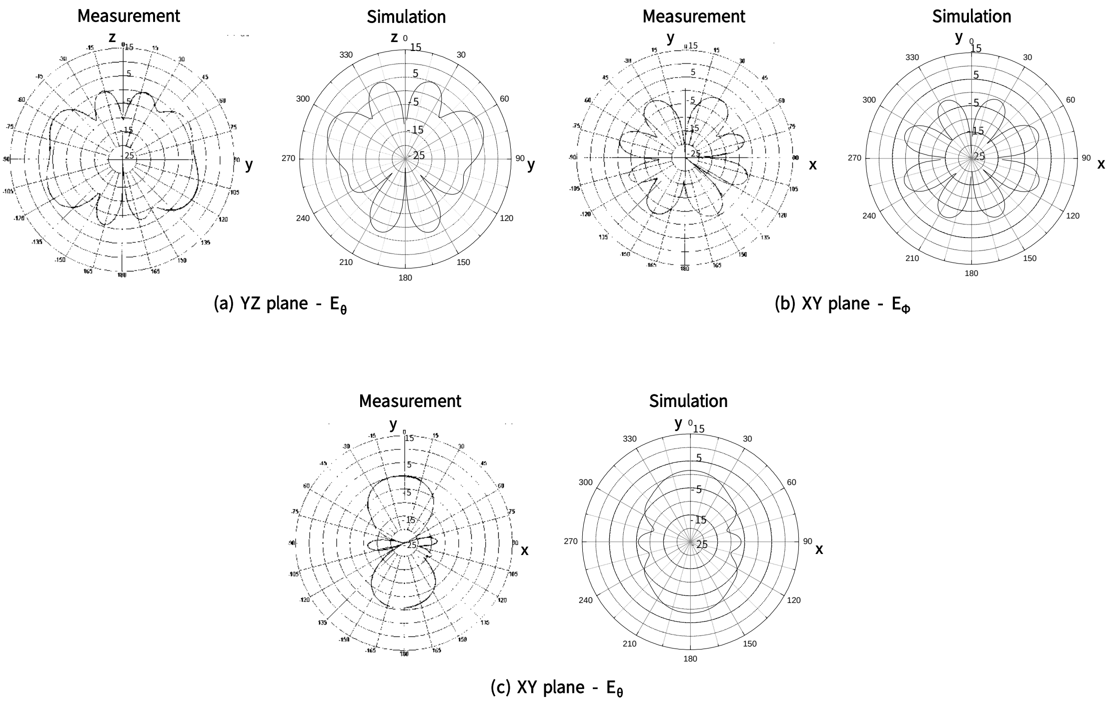

Fig. 2 Measured and simulated radiation patterns at UHF band (in dBi)

Fig. 2 shows the measured and simulated radiation patterns of the model in Fig. 1a) with IFAs for UHF band. Although some differences in null depth are observed, relatively good agreements are observed between the measured and simulated results. Because the model has small electrical volume of $0.84\lambda^3$ in the UHF band, the analysis for radiation patterns can be easily performed by Ansoft's HFSS (High Frequency Signal Simulator) [5].

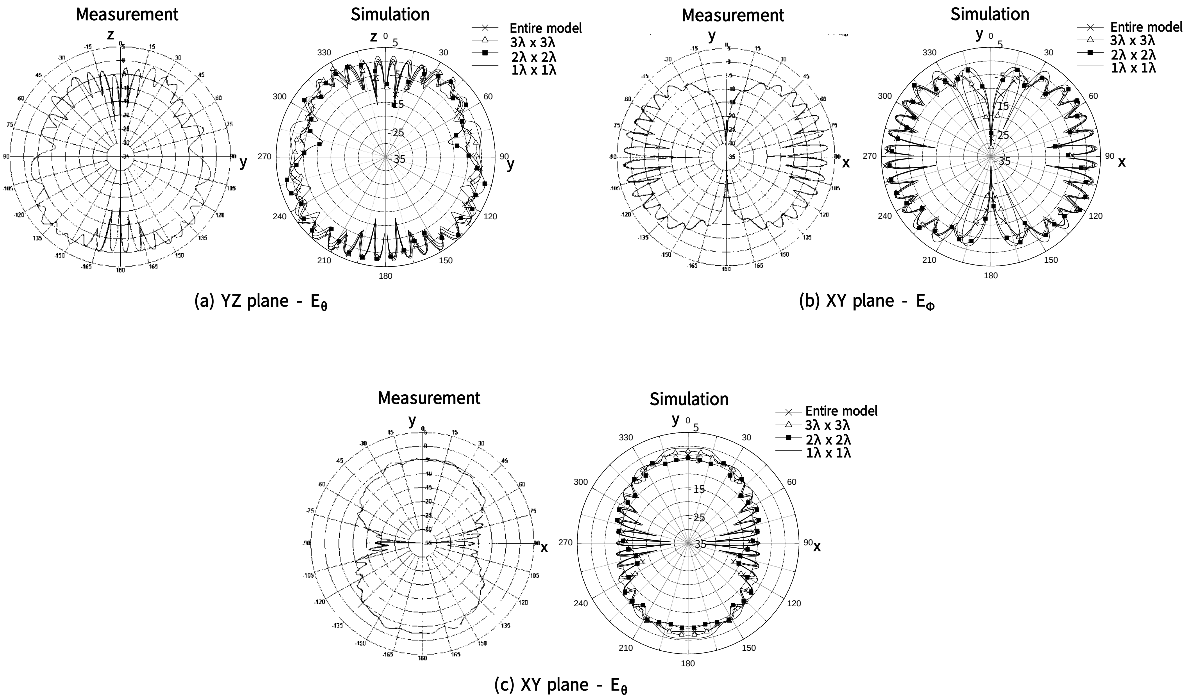

Fig. 3 Measured and simulated radiation patterns at S band (in dBi)

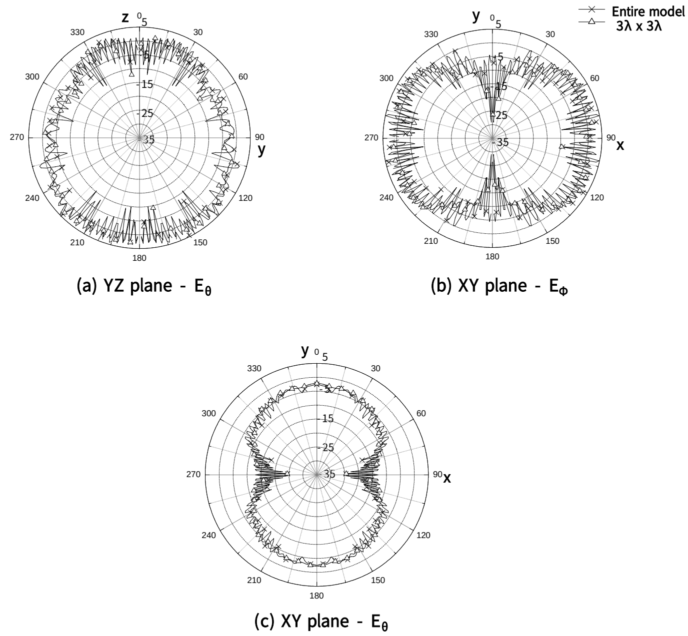

Fig. 4 Simulated radiation patterns at C band (in dBi)

Fig. 3 shows the measured and simulated radiation patterns of the model in Fig. 1a) with IFAs for S band. For comparison purpose, the simulated results with partial ground size of 1λ x 1λ, 2λ x 2λ, and 3λ x 3λ in vicinity of IFAs are also indicated. Good agreements are observed between the measured results and simulated ones of the entire model and the model with the ground size of 3λ x 3λ. It can be said that the rest of large ground far away from IFAs has slight effects on the radiation pattern. At S band, the given entire model has the electrical volume of $119.9\lambda^3$ which is larger than that of UHF band. It takes a number of hours and requires a lot of cost to compute and analyze the entire model although the utilization of the symmetry reduces the calculation time drastically. Instead of the entire model, the model with the ground size of 3λ x 3λ is very useful for saving time.

Fig. 4 shows the simulated radiation patterns with the model in Fig. 1a) with IFAs for C band. Like the S band, additional simulations are performed with partial ground in vicinity of IFAs. Relatively good agreements are observed between the entire model and that with the ground size of 3λ x 3λ. At C band, the given entire model has very large electrical volume of $1909.9\lambda^3$ which is much larger than that of S band. In this case, the analysis using full-wave method is difficult so that the model with the ground size of 3λ x 3λ is extremely useful to analyze the given model effectively.

4. Conclusions

Ground effects on radiation patterns of IFAs on a large cylindrical conducting body like a satellite launcher at UHF, S and C bands have been simulated and analyzed. Also the measurements have been performed and compared with the simulations. Good agreements have been observed between the measured and simulated results. In case of electrically large volume as in S and C bands, the model with the ground size of 3λ x 3λ in vicinity of IFAs gives efficient and accurate solutions.

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