Microstrip antenna combining TM_{21} annular ring patch and TM_{11} circular patch for satellite communications

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1. Introduction

Microstrip antennas (MSAs) for satellite communications have a problem of poor directivity at low elevation angles [1]. To solve the problem, a configuration combining TM_{11} and TM_{21} MSAs with directivity in the zenith and elevation directions, respectively, are considered. Directivity is improved by using TM_{11} and TM_{21} in the elevation direction. This paper describes the results of evaluating the band characteristics and radiation pattern.

2. Antenna structure and results

Figure 1 shows the structure of the proposed MSA. The TM_{21} MSA uses an annular ring MSA for size reduction. This MSA is placed on a substrate with thickness t_2 of 0.6mm. The circular TM_{11} MSA is placed on a substrate with thickness of t_1 = 0.2 mm above the TM_{21} MSA. Dielectric constant ε_r of both the substrates is 2.3. These thicknesses and dielectric constant were optimized to achieve the bandwidth requirements (fractional bandwidth of 2.6 %) while maintaining small size. Two feed points of the differential feed are placed symmetrically for each polarization with respect to the center of the TM_{21} MSA. This configuration successfully eliminates pattern distortion caused by the TM_{11} MSA feed structure. Two ports are located per MSA to obtain circular polarization. A stub matching and a phase adjustment circuit are connected to the feed points of both MSAs. The design frequency is 29.6 GHz. The following results were calculated by Siemens HyperLynx [2].

Figure 2 shows the reflection characteristics of TM_{11} and TM_{21} MSAs in the matched state. S_{11} and S_{22} are for the TM_{11} MSA, and S_{33} and S_{44} are for the TM_{21} MSA. Fractional bandwidth of 9.6 and 8.8 % were obtained for TM_{11} MSA, and 2.7 and 3.3% for TM_{21} MSA, respectively.

Figure 3 shows the radiation patterns of the TM_{11} and TM_{21} MSAs at 29.6GHz. The maximum directivity of the TM_{11} MSA is 6.2 dB at $\theta = 0°$ and $\Phi = 0°$, and that of the TM_{21} MSA is 3 dB at $\theta = 45°$ and $\Phi = 0°$. The TM_{21} MSA achieves 0.4 dB higher directivity at $\theta = 45°$ than that of the TM_{11} MSA. Increasing the directivity of the TM_{21} MSA at all azimuth angles, θ of 45° is a future work.

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References

[1] X. Chen, X. Li, G. Fu and Y. -l. Yan, "CP higher-order mode annular-ring microstrip antenna for mobile satellite communication," 2012 International Conference on Microwave and Millimeter Wave Technology (ICMMT), 2012, pp. 1-4

[2] HyperLynx,Simens, https://www.macnica.co.jp/business/manufacturers/siemens/products/7018/

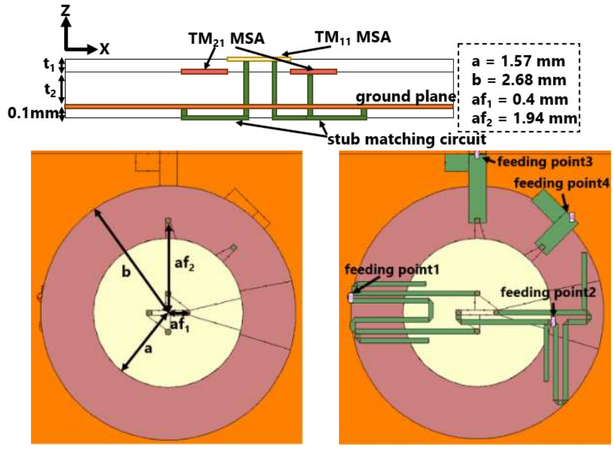


Fig.1 Structure of proposed MSA (yellow part is TM_{11} MSA, red part is TM_{21} MSA, green part is stub matching circuit and phase adjustment. circuit).

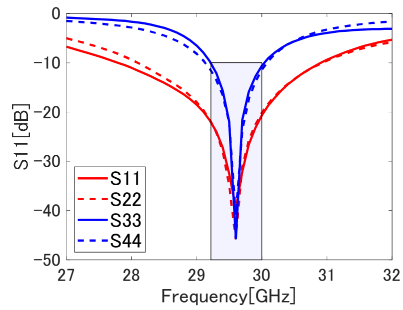
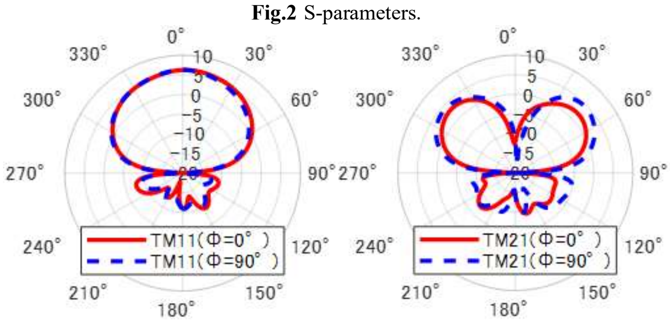


Fig.2 S-parameters.



(a) TM_{11} mode (b) TM_{21} mode

Fig.3 Radiation patterns.