A Novel Cassegrain Antenna with an FSS Sub-reflector and Cylinder Matcher

Hao Liu, Alexander Denisov, Jinghui Qiu, and Shu Lin
Department of Microwave Engineering
School of Electronics and Information Engineering
Harbin Institute of Technology
Harbin, Heilongjiang, China
hliu1988@163.com

Abstract – **Mobile communication between two moving objects is interesting because of its application in military and navigation. Cassegrain antenna, which is high gain and narrow beam, is the most common construction in mobile communication. To reduce the difficulty of position due to narrow beam, an FSS is proposed to obtain wide beam at some frequencies. The disk sub-reflector is used to decrease the axial size and a cylinder matcher is proposed to solve the mismatch resulting from the disk. The model is constructed and simulated by CST and the result is the same to theory.**

Index Terms — **Cassegrain antennas, image theory, FSS, cylinder matcher.**

1. Introduction

Mobile communication technology, which brings convenience to life and work, is currently undergoing a rapid development. To achieve a faster transmission rate, the operating frequency of mobile communication has been increased to Ku-band, and will be further arrived to Ka-band. Mobile phone communication, which connect a moving device and a base station, is a typical application of mobile communication technology, and 4G has been realized in many countries. Besides, the communication between two moving objects is also paid attention because of the application of military [1] and navigation.

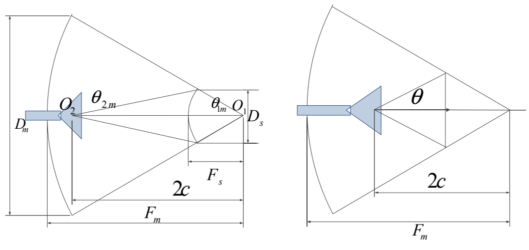
Mobile communication between moving devices [2] greatly arouse interest in recent years. The communication device, which is fixed on automobile, ship and aircraft, need to keep a real-time information exchange with the satellite. To ensure a smooth communication, the radial direction of antenna must point to the satellite all the time. The servo-system is employed to complete the task. However, the satellite antenna generally has a narrow beam width, which makes the servo-system to lose target. To solve the problem, a communication antenna with narrow and wide beam widths at different frequencies is proposed.

Cassegrain antenna is a common satellite communication antenna due to its narrow beam width, high gain and low side-lobe. To improve the positioning accuracy, a frequency selective surface (FSS) is proposed as sub-reflector. A wide beam is yielded at transmission band, and the other is narrow. The wide beam can be used as assistant position, and the narrow one can realize satellite communication. The dimension and weight are also important elements because of the demand of the flexibility. A matcher with the shape of cylinder is proposed to reduce the axial size and enhance bandwidth.

In this paper, the design of Cassegrain antenna with an FSS as sub-reflector is introduce in section 2, and the performance is simulated by CST software; in section 3, the cylinder matcher is propose the enhance the bandwidth of proposed antenna, the character is analyzed and verified.

2. Design of Cassegrain antenna

The design method of Cassegrain antenna generally employs geometrical optics. The design principle is shown in fig. 1(a). A paraboloid as main-reflector has the same focus with the hyperboloid as sub-reflector. According to the geometrical relationship, electromagnetic wave, which emits from one of focuses of the hyperboloid and reflects by the sub-reflector and main-reflector, will realize a plane wave transmission. The sub-reflector with the shape of disk further reduces the axial size according to image theory, shown in fig. 1(b).



(a) (b)

Fig.1 structure of Cassegrain antenna

To realize different beams, an FSS[3] is applied in the proposed Cassegrain antenna. The FSS has a three-layer structure as shown in fig. 2. The first and third layer has a dual rectangular frame, and the second one has a single rectangular frame. This structure can realize dual passband, and the equivalent circuit is shown in fig. 3.

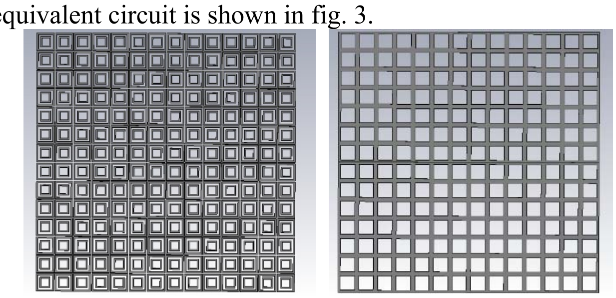


Fig.2 structure of FSS

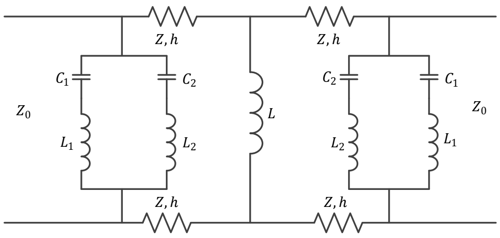


Fig. 3 equivalent circuit of the proposed FSS

According to the equivalent circuit, the operating band [4] can be obtained by equation (1) and (2).

$$f_1 = \frac{1}{2\pi\sqrt{\left(C_1 + \frac{\varepsilon_0\varepsilon_r h}{2}\right)(L_1 + L + 2\mu_0\mu_r h)}} \quad (1)$$

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{C_1 + C_2}{C_1 C_2 (L_1 + L_2)}} \quad (2)$$

The model of Cassegrain antenna with an FSS as sub-reflector is constructed and simulated by CST. The return loss is shown in fig. 4. A dual operating band is realized in Ku and Ka band. The pattern, which is shown in fig. 5, gets different beam bands at 10GHz, 12GHz, 29.5GHz and 30.5GHz. The FSS emitted by the electromagnetic wave at 10GHz and 30.5GHz has the performance of passband. The pattern of Cassegrain antenna is the same to feed horn. Oppositely, the FSS at 12GHz and 29.5GHz presents stopband, the pattern hence obtains a narrow beam band as traditional Cassegrain antenna.

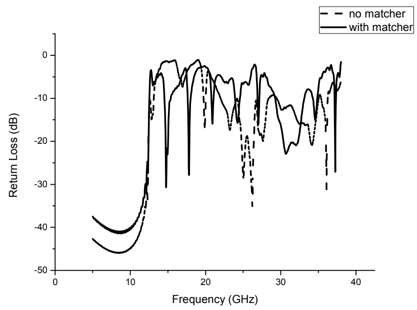


Fig. 4 return loss of the proposed antenna with and without matcher

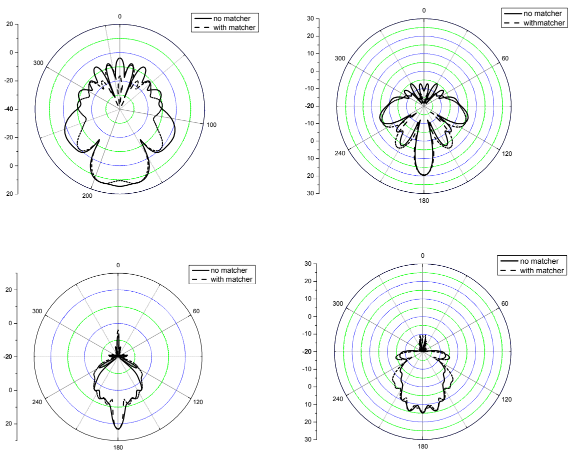
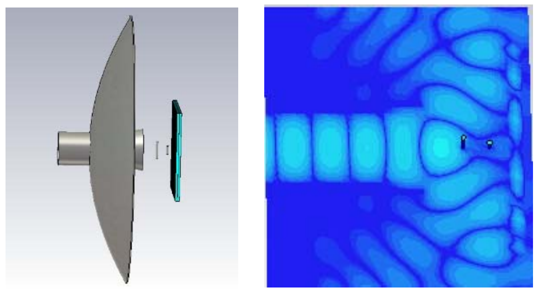


Fig. 5 pattern of the proposed antenna with and without matcher

3. Cylinder matcher for wide bandwidth

The Cassegrain antenna with an FSS sub-reflector can reduce the axial dimension, while the vertical reflection will lead to a bad return loss and limit the operating band. To solve the problem, a cylinder matcher is proposed. The cylinder matcher is located on the propagation path as shown in fig. 6(a). When the electromagnetic wave passes through the matcher, a diffraction takes place. The electric field transmission is depicted in fig. 6(b).

The model of the proposed antenna is constructed and simulated by CST. The return loss is improved in a wider operating band as shown in fig.4. The pattern, which is depicted in fig.5, has little influence except a mild depression in the middle.



(a) (b)

Fig. 6 (a) structure of matcher; (b) electric field transmission of the proposed antenna

4. Conclusion

Design of Cassegrain antenna with a FSS sub-reflector is introduced. The FSS has dual frequency band. When the passband is realized, the pattern is represented as a wide beam, on the other band, the pattern is narrow. The FSS is a plane structure which can decrease axial size. However, the return loss is deteriorated because of the vertical reflecting. To solve the problem, a cylinder matcher is proposed according to diffraction theory. The return loss is observably improved.

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