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TCR Antenna For Small Satellite Application

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Abstract: The results of this study are interesting about antenna technology generation used in small satellite. A new design optimized of the TCR (tracking, command and ranging) antenna has been presented. It has a good impedance matching to the 50 Ohm coaxial line which has been radically enhanced with different geometric features. For the Ku band frequency band, the VSWR of 1.15 is not exceeded. In its optimized version, it is compact and aesthetic and this property reduces antenna distortions. Design considerations for this antenna performance in terms of coverage gain, side lobe isolation, and cross-polar isolation is discussed. The paper also discusses the possibilities of extending the frequency coverage of the antenna system into the Ku-band system can increase the capabilities and operational flexibility of existing earth stations as well as adapts with new current and future technology trends are presented.

Keywords: Tracking Command Ranging; small satellite; Ku-band, Omni Antenna.

1. INTRODUCTION

In the next few years, much interest has been shown in small satellite of the telecommunications, placing a small satellite into GEO orbital significantly cheaper than those larger satellites and enough to provide near national/regional coverage[1]. It also encourages research a fast development and establishment of a communications infrastructure, cost less, strengthening independence and prestige with the improvement of the technology base in this domain, especially interested in the topic of antennas where research is being carried out to design small antennas for communication [2].

Within the framework of the future project for the completion of small satellites by Algeria space agency, the aim of this mission has been undertaking communication with ground station especially during orbit raising maneuvers at Ku band frequency. We have chosen the omni coverage with the design of the tracking, command and range (TCR) antenna and a circular polarized that could be installed on the new ALCOMSAT-2 small satellite.

The spacecraft telemetry, tracking and command (TT&C) systems are in general provided with circularly polarized links having wide antenna coverage [3]. Most of the cases it is through omni or near-omni directional antenna system and it are possible to sustain the link with lower transmitted power from the satellite [4].

This paper focuses on antenna permitting operation of the earth terminal in large bands without requiring the replacement of the feed are a highly desirable capability here. The discône antenna was generally chosen due to its widely reported a good performance, but they are usually not suitable for applications requiring omnidirectional radiation patterns. One possible way to achieve omnidirectional radiation is the use of a biconical antenna[5][6].

The antenna presented are a new approach of the combines' advantages of both between designing of the two antennas in the same time. The first one with a circular waveguide choke antenna at Ku-band based on an advanced theoretical analysis of the classical biconical antenna's radiation modes [7], and gives a better coverage with good cross-polarization[8], and the mechanical dimensions are having better tolerance in Ku-band which makes this design attractive. The antenna design was carried out using simulation based CST-microwave studio software shown in Figure 1.

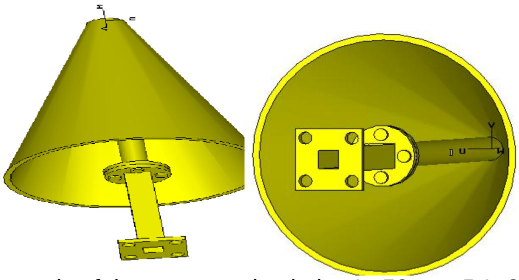


Fig. 1 Design schematic of the antenna simulation L=50mm, R1=20mm, R2=3mm.

2. RESULT AND DISCUSSION

The performance antenna simulated in domain time from the Computer Simulation Technology (CST) Microwave Studio tools based on the finite integration technique (FIT) method has been used for design and analyze this work. Overall channel in an indoor propagation antenna simulated has been computed a different angular direction with a transfer function of the transmitting and receiving, with the ranging channel on, ranging and telemetry are provided simultaneously on the same downlink carrier. As with commanding, ranging can be performed only with a phase-locked receiver.

All transitions are properly designed to eliminate even marginal reflections and provide a good antenna matching to 50Ω in the 10 GHz to 16 GHz frequency band are illustrated in Figure 2.

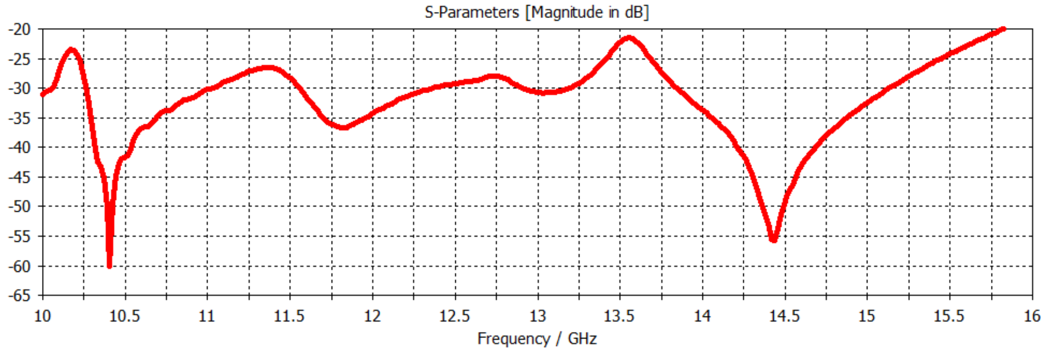


Fig. 2 Coefficients of reflection of the simulation on the antenna port and for the total system on the input port waveguide.

It is seen that the antenna has an omni-directional radiation pattern. Meanwhile, the energy reflection is below -20dB in all bandwidth is achievable over 6 GHz in both the downlink and uplink bands. It is with two a return loss from 10.75 GHz to 13.75 GHz and 15.75 GHz, which implies that the impedance of the polarizer can be matched in all of this two range free space and can be improved with knowledge of the input impedance.Otherwise, good agreement optimized between this work and others has been achieved[9][10].

Figure 3 shown a circular polarization simulated of the VSWR (Voltage Standing Wave Ratio).

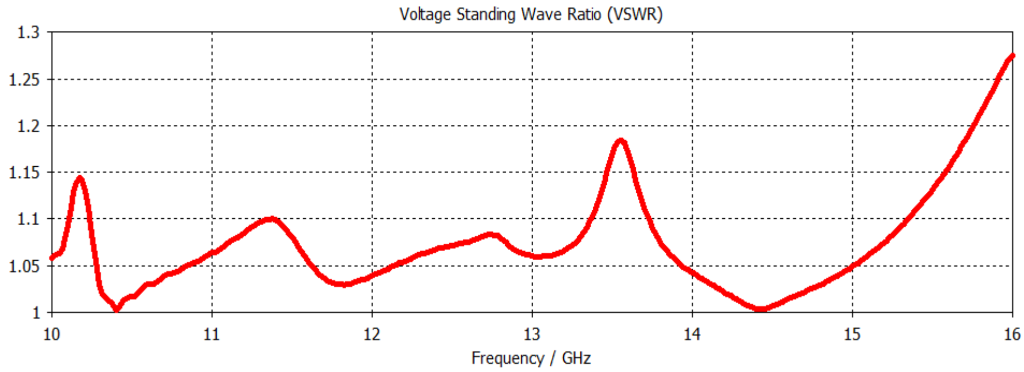
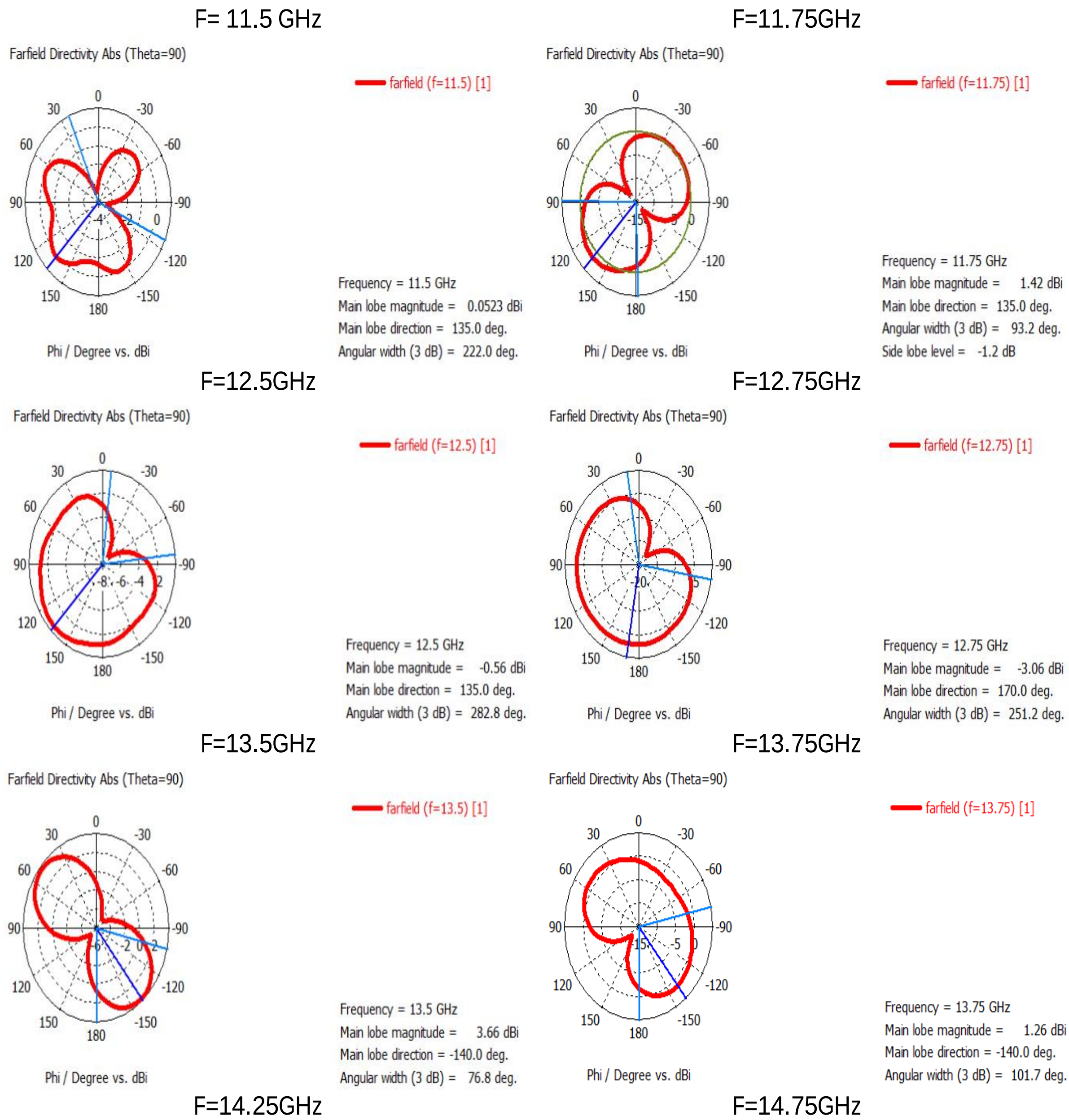


Figure 3VSWR simulated in CST studio.

The result is the peaks and valleys as seen. VSWR has been between 1.01 and 1.25 a maximum VSWR < 2 in frequency range from 10 to 15 GHz good more than other work [11], there would be no reflected power and the voltage would have a constant magnitude along the transmission line means the antenna is well-matched. Therefore, the bandwidth broadening of the proposed antenna comes from the optimization of the structure.
The radiation patterns directivity with theta 90° of antennas have been simulated with the downlink and uplink are represented in Figure 4 at different frequencies to give an idea about their frequency dependency.



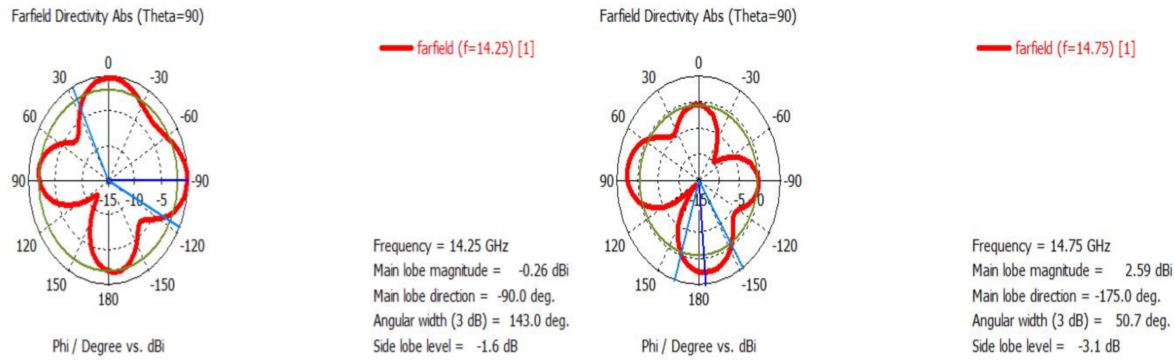


Fig. 4 Simulated radiation pattern of the TCR antenna with circular polarization at different frequency.

It is noted that good overall antenna efficiency and high power gains are observed at both resonance frequency bands, confirming that the proposed antenna works properly at both desired bands.The main differences are the slightly larger directivity at the downlink and the increase of the back lobe at 1.6° to 3.6°.
One of the reasons for this slight change at the higher frequencies is the waveguide nature of the TCR antenna with circular polarization were observed here to form results based on the field properties.
Figure.

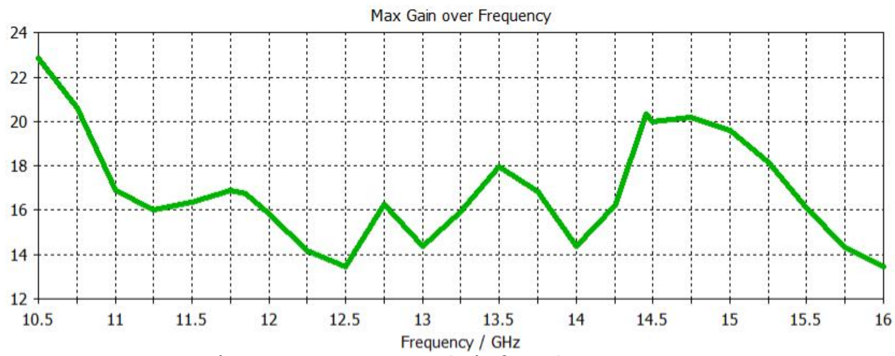


Fig. 5 Max Frequency Gain for TCR Antenna.

The gain of the antenna is simulated over 10 GHz to 16 GHz range shown in figure 5. We can notice that, the gain is above between 13.5 to 25 dB across the frequency band.Before 12.5 GHz, the antenna gain monotonically decreases from 23 to 13.5 dB, and then increases to 20 dB as the frequency increases further, it is acceptable as the gain of the parabolic reflector is increasing with the increase of frequency [12]. Consequently, the performance is degraded after 14.75 GHz frequency.
Radiation efficiency of the bottom fed TCR antenna is close to 5 dB, with a slight deterioration after to 13.5 GHz band frequency, as seen in Figure 6.

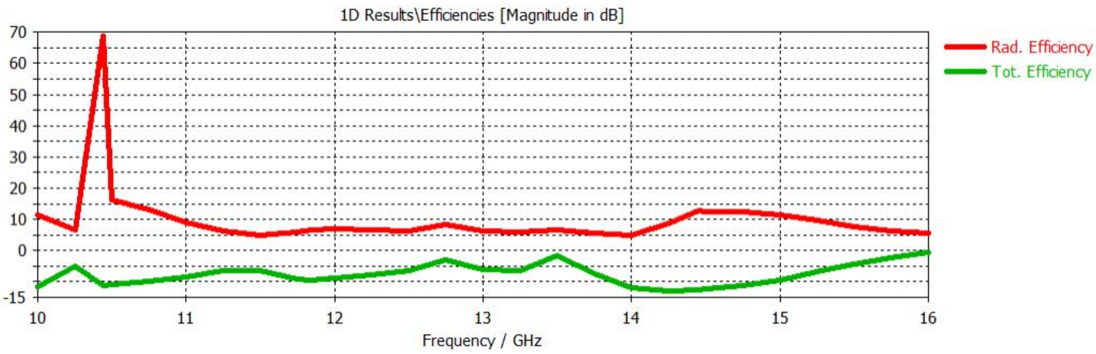


Fig. 6 Radiation and total efficiency for the bottom fed TCR antenna.

This antenna exhibits of a compact omnidirectional while keeping a high radiation efficiency. More accurately, the structure of a TCR antenna is modified to optimize its radiation efficiency with a constant global dimension on the optimal impedance presents the same radiation efficiency while having lower dimensions (compared to the free space operating wavelength).

3. CONCLUSION

The simulated response shows that it is possible to obtain a hemispherical coverage with a single antenna. Thus, by keeping two antennas of this type, we could obtain an almost spherical cover.

A new design of the TCR antenna has been presented. It has a good impedance matching to the 50 ohm coaxial line. In the frequency Ku band frequency, the VSWR is not exceeded more than 1.25.

The antenna of the proposed design has an almost constant radiation pattern across the entire given bandwidth. The changes in antenna design have reduced the size of the accepted antenna. The dimensions of the optimized prototype are suitable for its Ku-band application.

The advantages of the presented antenna are a wide bandwidth, which reduce any influence on GEO orbit. Consequently, all these properties make the antenna ideal for satellite communication systems.

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