1.62GHz Circularly Polarized Pin-Fed Notched Circular Patch Antenna

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Abstract

This paper studies a circular patch antenna which is fed by using a coaxial pin, which is a suitable antenna design for applications where small size is of importance. Such applications are wearable antenna designs. The main purpose of this paper is to design an antenna with wearable capabilities and adequate radiation characteristics for satellite communications and more specifically for the Iridium satellite constellation. The goals for the radiation characteristics of the antenna are the tuning of the antenna to 1.62GHz which is the Iridium's frequency, maximum boresight gain for this frequency, as well as circular polarization.

1. Introduction

The Iridium satellite constellation is one of the very well-known global satellite systems that provide voice and data services over the entire surface of the planet. In particular, their services are used in military, sea and air transport, emergency services as well as in many other industries, which suggests that it is used in areas where reliable communication is of importance, and thus, for antennas used for this purpose, it is significant to demonstrate solid radiation characteristics.

Polarization is one of the fundamental characteristics of any antenna and the types of polarization which are considered in electromagnetics are the: 1) linear, 2) circular, and 3) elliptical. The fundamental advantage of circular polarization (CP) is that all reflections change the direction of polarization, precluding the usual addition or subtraction of main and reflected signals. Therefore, there is far less fading and flutter when circular polarization is used at each end of the link. The circularly polarized wave will radiate energy in the horizontal and vertical plane, as well as every plane in between [2].

There are two directions of propagation that come with circular polarization: Right-Hand-Circular-Polarization (RHCP) which follows a clockwise pattern, and Left-Hand-Circular-Polarization (LHCP) which follows a counterclockwise pattern. Due to the advantages of circular polarization, it makes it ideal for use in satellite communications. Figure 1 clearly depicts the components of circular polarization. The horizontal component (green) in conjunction with the vertical component (blue), generate the circular polarization.

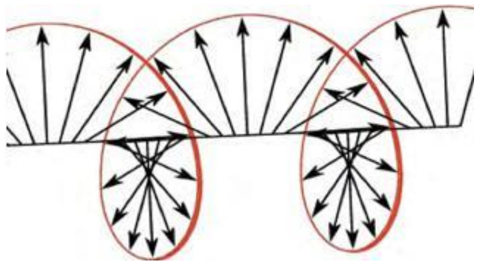

Figure 1. Analysis of circular polarization [3].

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. They are low cost, have a low profile and are easily fabricated and for that reason they are becoming very widespread throughout the whole antenna industry [4, 5]. In this paper, a model of a pin-fed notched circular patch antenna [6, 7] which was designed in CST Microwave Studio is studied, which is designed for circular polarization, maximum boresight gain and minimum VSWR for the frequency of 1.62GHz (Iridium).

2. Implementation and Results

For the purpose of this paper a model of a pin-fed notched circular patch antenna was designed in CST Microwave Studio as demonstrated in Figure 2. The patch antenna consists of four main components, 1) a dielectric material with the same characteristics as FR4 (relative permittivity etc.), 2) a ground plane layer, 3) a coaxial feed pin on the rear, 4) and a notched circular patch on the front of the antenna. By implementing some powerful tools which are provided by CST MWS an optimal geometry for the patch antenna was developed and Table 1 describes all the geometrical elements of the patch antenna.

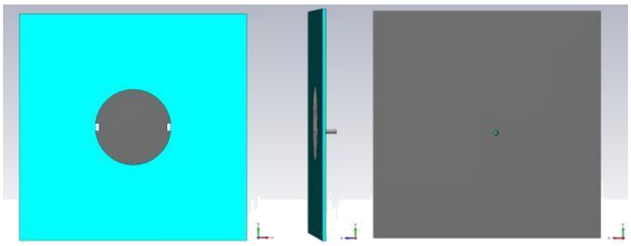

Figure 2. CST MWS model of a pin-fed notched circular patch antenna.

Geometrical Element	Value
Notch Length	4.59 mm
Notch Width	9.19 mm
Patch Diameter (Ø)	70.79 mm
Dielectric Length	Ø * 3 mm
Dielectric Width	Ø * 3 mm
Coaxial Pin Diameter Inner (Outer)	1.80 mm (Inner/0.43)mm
Coaxial Pin Offset	11.04 mm
Coaxial Pin Angular Position	-45°
Coaxial Pin Length	$\lambda_{1.62GHz}$/10 mm

Table 1. The geometry of the patch antenna.

The results of the designed geometry of the antenna as it is observed in the following figures generates satisfactory radiation characteristics for the purpose of satellite communication, taking into consideration that it is a small form factor patch antenna. As it is observed in Figure 3, the antenna is finely tuned for the Iridium frequency range.

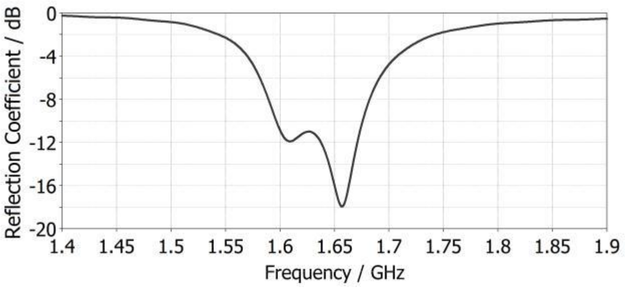

Figure 3. Simulated reflection coefficient.

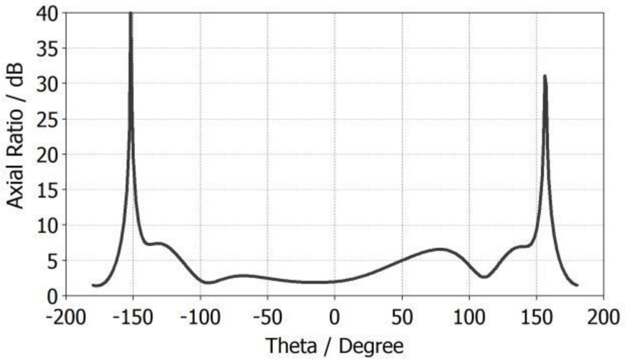

Figure 4. Simulated Axial Ratio vs Theta (Phi = 0) for the frequency of 1.62 GHz.

The axial ratio which is shown in Figure 4 demonstrates a qualitative circular polarization with values below the limit of 3dB across most of the angles, especially at the front of the antenna (Phi=0, Theta =0) which implies a small cross polarization level. The antenna excites left-hand CP (LHCP), and the cross polarization is right-hand CP (RHCP) as it can be observed in Figure 5 and it attains reasonable boresight realized gain for the desired frequency of 1.62GHz.

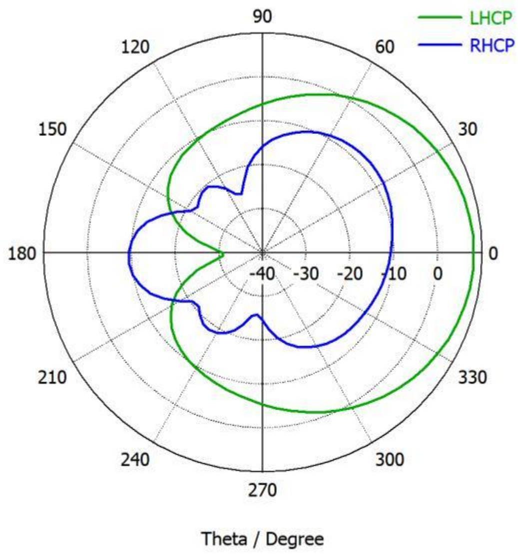

Figure 5. Simulated LHCP and RCHP.

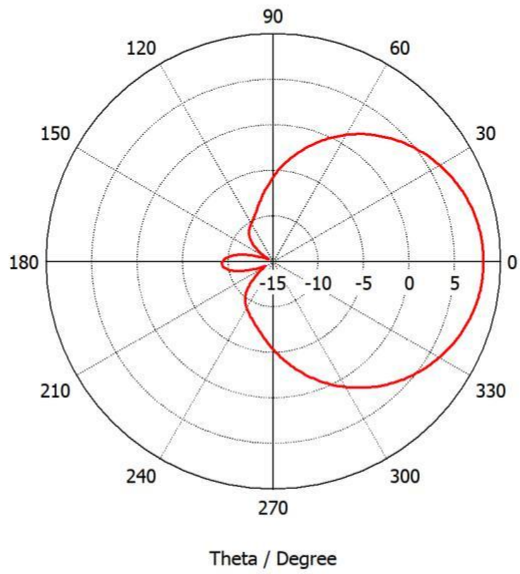

Figure 6. Simulated realized gain.

In Figure 7 a very narrow axial ratio is observed, nonetheless, by further optimizing the geometry of the designed antenna it is possible to widen the bandwidth of the antenna axial ratio as well as all the rest of the antenna radiation characteristics.

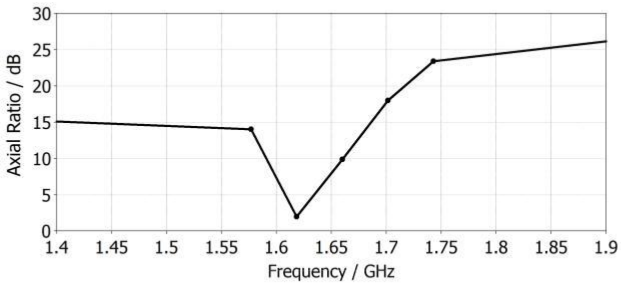

Figure 7. Axial Ratio vs Frequency (Theta = 0, Phi = 0).

3. Conclusion

A pin-fed notched circular patch antenna was studied for satellite communications and small form factor in mind. The design demonstrates solid radiation characteristics, such as low cross polarization, adequate gain and fine tuning for the Iridium central frequency (1.62GHz). However, this initial design can be further optimized, and performance, such as axial ratio and gain, can be improved.

4. References

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