RESEAUX DU FUTUR : 5G ET AU-DELA

Antenne ultra-large bande avec polarisation circulaire pour des applications 5G

Ultra-Wideband Circularly Polarized Antenna for 5G Applications

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Résumé/Abstract

Cet article présente une antenne ultra-large bande pour des ondes millimétriques à polarisation circulaire qui fonctionne dans la bande de fréquences 26 - 37 GHz. Afin de valider l'antenne, des simulations dans CST Microwave Studio ont été réalisées. L'antenne a une bande passante de 11 GHz avec un gain maximum de 10 dB et un rapport axial inférieur à 3 dB dans la bande de fréquences 33,5-37,5 GHz. De plus, l'antenne proposée a un diagramme de rayonnement à polarisation circulaire droite et peut être utilisée pour du balayage de faisceau. Par la suite, l'antenne proposée peut être un bon candidat pour les communications des systèmes à ondes millimétriques.

This paper presents an ultra-wideband circularly polarized millimeter-wave antenna that operates in the 26 – 37 GHz frequency band. In order to validate the antenna, simulations in CST Microwave Studio have been realized. The antenna has a bandwidth of 11 GHz with an achieved maximum gain of 10 dB and an axial ratio lower than 3 dB in the 33.5-37.5 GHz frequency band. Moreover, the proposed antenna has a right-handed circular polarization (RHCP) radiation pattern and can be used for beam scanning. Subsequently, the proposed antenna can be a good candidate for millimeter wave system communications.

1 Introduction

Nowadays, people prefer wireless devices that are portable, operate on multiple frequency bands, have high speed data rates and are very small. This is why, over the years, designing antennas that operate at millimeter – wave (MM-wave) frequencies have attracted more and more attention among researchers. Furthermore, circularly polarized (CP) antennas offer more advantages than linearly polarized (LP) antennas, such as, lower susceptibility to multipath, more flexibility when orienting the antennas, lower atmospherically absorption and lower reflection effects [1]. Several methods can be used for designing CP antennas: single feeding [2], multi feeding techniques [3] or the usage of polarizers [4]. The single feeding technique has only one feeding port and a compact configuration. Therefore, in this paper, this method is used. The multi feeding technique has two to four feeding ports that are excited with equal amplitude and 90º phase difference and can achieve a wide band with minimum losses [5]-[8]. And finally, the technique that employs polarizers can obtain a wideband configuration, but the losses and the length of the antenna are increased because of the additional element.

In this paper, an ultra-wideband (UWB) circularly polarized antenna based on the use of a single-phase feeding is described. Furthermore, the performance of the proposed antenna with respect to the reflection coefficient, radiation pattern, axial ratio and realized gain in the 26-37 GHz frequency band is presented.

The article is structured as follows: in Section 2 the antenna design is studied, including the simulation results that validate the proposed antenna and Section 3 concludes that paper and gives an outlook for future works.

2 Antenna design and numerical results

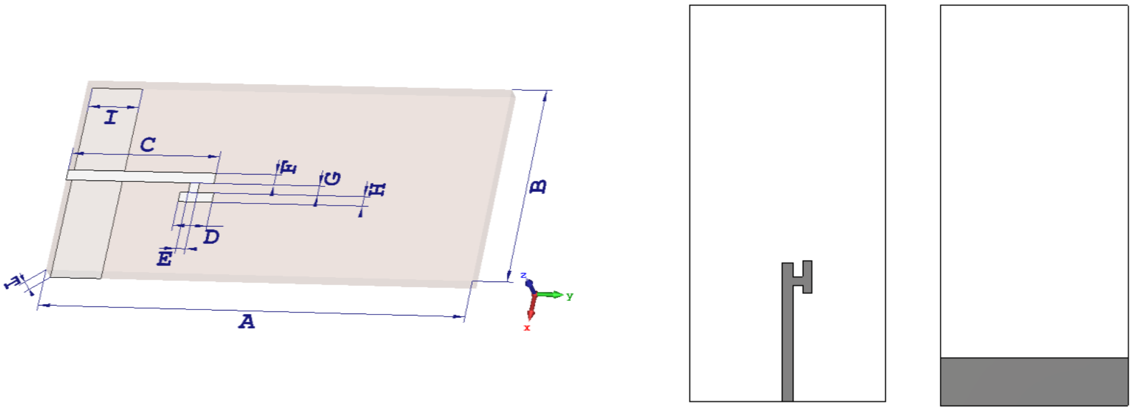
2.1 Antenna design

The geometry of the antenna used in this paper is shown in Figure 1 and the dimensions of the structure are described in Table 1. The length of the antenna is about 1.6λ in order to operate in the 26-37 GHz frequency band.

The evolution steps of the proposed antenna are shown in Figure 1(a). At first, the feeding line is designed followed by the strip (D × H). The length of the strip has been carefully optimized in order to obtain the best possible results in the frequency of interest.

The antenna is essentially made of a small line and a single-phase feeding. It has the dimensions of 15.625 mm length, 7.5 mm width and is printed on a Rogers TMM 10 lossy substrate with the permittivity of ε_r=9.2, tangent delta tanδ=0.0022 and thickness of 0.51 mm. The antenna can be translated to operate at other frequencies by changing its size. Simulations using CST Microwave Studio were carried out by including the MM-wave connector.

The antenna covers the impedance bandwidth (S11<-10dB) from 26 to 37 GHz with an achieved maximum gain of 10 dBi at 33.2 GHz and an axial ratio less than 3 dB from 33.5 to 37.5 GHz.



(a) *(b)* *(c)*

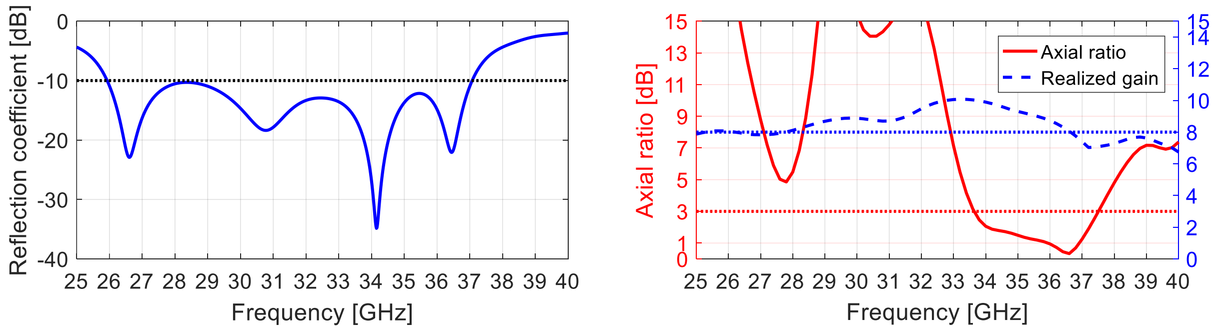
Figure 1 : Geometry of the proposed antenna: (a) 3D view, (b) Top view and (c) Bottom view

A	B	C	D	E	F	G	H	I	T
mm									
15.625	7.5	5.475	1.25	0.34	0.4	0.375	0.37	1.875	0.51

Table 1 : Dimensions of the antenna

2.2 Numerical results

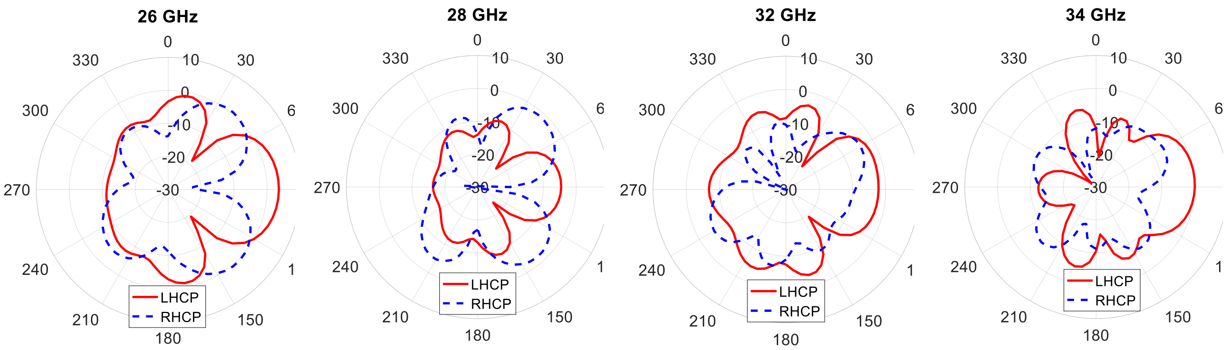
In order to determine the performance of the antenna, a full-wave analysis using CST Microwave Studio is realized. The antenna is excited using a 2.92 mm (K) connector, also designed in CST Microwave Studio, that ensures that the antenna operates as expected. Figure 2(a) presents the simulated reflection coefficient of the antenna which provides a matching bandwidth in the 26-37 GHz band with a fractional bandwidth of 34.92%.



(a) *(b)*

Figure 2 : Results : (a) Simulated reflection coefficient of the CP UWB antenna, (b) Realized gain and axial ratio of the CP UWB antenna

In Figure 2(b) the axial ratio and realized gain of the proposed antenna in the 25 – 40 GHz frequency band is shown. The antenna exhibits a 3-dB axial ratio bandwidth from 33.5 GHz to 37.5 GHz resulting in a fractional bandwidth of 11.26%. The calculated realized gain of the antenna (Figure 2(b)) experiences a 2 dB gain increase from 26 GHz to 37 GHz. The realized peak gain of 10 dBi is obtained at 33.2 GHz.



(a) (b) (c) (d)

Figure 3 : Radiation pattern of the CP antenna in the YoZ-plane at: (a) 26 GHz, (b) 28 GHz, (c) 32 GHz and (d) 34 GHz

The circular polarization radiation patterns (LHCP: left-hand circular polarization and RHCP : right-hand circular polarization) at 26 GHz, 28 GHz, 32 GHz and 34 GHz in the YoZ-plane are shown in Figure 3. As it can be observed, the proposed antenna possesses LHCP (left-hand circular polarization) characteristics as the line and the single feeding are designed in the clockwise direction.

3 Conclusion

In this paper, an ultra-wideband circular polarization MM-wave antenna has been presented. The proposed antenna has been designed to operate in the 26 – 37 GHz frequency band by combining a small line with a single-phase feeding system. The antenna provides a very high matching bandwidth of 11 GHz (34.92%), a 3-dB axial ratio bandwidth of 4 GHz (11.26%) and a maximum realized gain of 10 dBi at 33.2 GHz. The proposed antenna van be a good candidate for ultra-wideband circular polarization millimeter-wave applications.

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