Wideband of Microstrip Patch Antenna for 28 GHz 5G Applications

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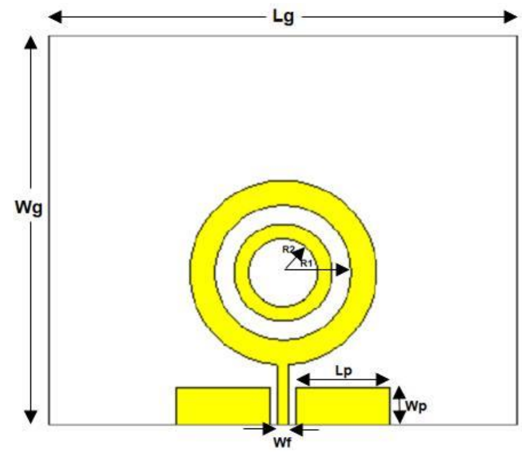
***Abstract*—In this article, the design of an annular ring patch antenna in the millimeter-wave range is presented. The antenna is placed on a 1.524 mm Rogers RO4003C substrate with a dielectric constant of 3.55. The antenna is designed to resonate at 28 GHz. The presented structure shows that the annular ring antenna in an uncomplicated structure can offer wider impedance bandwidth than the rectangular shape. The proposed antenna provides a wide impedance bandwidth of 71.4% and a realized gain of 5 dBi. The antenna results of this work provide to be suitable for automotive applications at the mm-wave band.**

Keywords— Annular ring patch antenna; Millimeter-wave; Wide bandwidth.

I. INTRODUCTION

Microstrip patch antennas have been used in a variety of wireless applications due to their lightweight, low cost, low profile, and ease of fabrication. However, narrow impedance bandwidth is one of the most significant drawbacks of these low-profile antennas, which limits their applications [1]. Several effective methods for increasing impedance bandwidth have been proposed over the years. First, increasing the thickness of the substrate is the simplest method to increase the impedance bandwidth [2]. A thick dielectric substrate can increase the patch antenna's typical narrow impedance bandwidth [3]. Furthermore, increasing the substrate thickness increases the impedance bandwidth at the cost of surface wave generation and spurious feed radiation. Other methods for increasing the impedance bandwidth include using stacked patch configurations [4-6], proximity coupling feed [7-8], or aperture coupling feed [9-10]. However, these solutions led to the use of multilayer substrate, which resulted in increased complexity and high fabrication cost.

Therefore, to address those limitations, an annular ring patch antenna has been designed to resonate at 28 GHz. Moreover, the annular ring patch antenna can provide a wider impedance bandwidth than a rectangular patch antenna. In [11], a simple structure rectangular patch antenna is designed to resonate at 28 GHz and offers 800 MHz impedance bandwidth. The proposed annular ring patch antenna in an uncomplicated structure offers a wide impedance bandwidth from 20 to 40 GHz. The gain of the proposed design has achieved 5 dBi. This paper is organized as follows. In section II, the antenna design is presented, followed by section III, which contains results and discussion. Then, the paper concludes in section IV.



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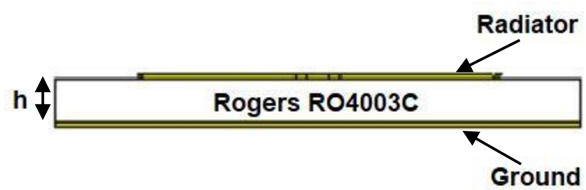

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Figure 1. Geometry of the proposed antenna: (a)Top view and (b) Cross-sectional view.

II. ANTENNA DESIGN

The antenna is designed and simulated in CST MWS studio 2020. An annular ring patch antenna at 28 GHz, with the radius presented as R1 in Fig. 1, connected by a transmission line is designed. An inner annular ring has been used, with a radius presented as R2 and without a direct electrical connection to avoid any significant increase in antenna structure size or complexity, to increase the impedance bandwidth. The radiator patch is located on the substrate which is located above the ground plane. The antenna is placed on a Rogers RO4003C substrate with a dielectric constant of 3.55 and a thickness of 1.524 mm. The dimensions of the substrate Lg and Wg are kept 9.2 mm and 7.75 mm, respectively. Fig. 1. shows the proposed antenna layout in CST, and the design parameters are summarized in Table I.

Table I. Antenna design parameters.

Parameter	Value (mm)
Length of the ground plane and substrate (Lg)	9.2
Width of the ground plane and substrate (Wg)	7.75
Outer annular ring radius (R1)	1.34
Inner annular ring radius (R2)	0.9
Length of the pads (Lp)	1.84
Width of the pads (Wp)	0.74
Thickness of substrate (h)	1.524
Width of the feed (Wf)	0.21

III. RESULTS AND DISCUSSION

The simulated results of the reflection coefficient (S_{11}) which shows the impedance bandwidth of the proposed annular ring patch antenna and a rectangular patch antenna from [11] are shown in Fig. 2. The results show that the rectangular patch antenna provides 800 MHz impedance bandwidth. Otherwise, the annular ring patch antenna can provide a wide impedance bandwidth from 20 to 40 GHz. Wide band is required for most of mm-wave applications. Moreover, V2X communications, for example, require a large impedance bandwidth to support a large number of sensors and communication chipsets for automated vehicles that can transmit and receive information with real applications [12].

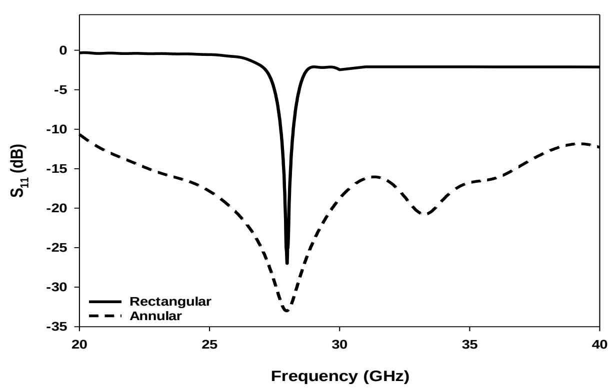
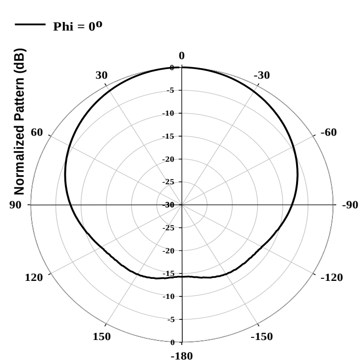


Figure 2. Simulated return losses for antenna designs (rectangular/annular).



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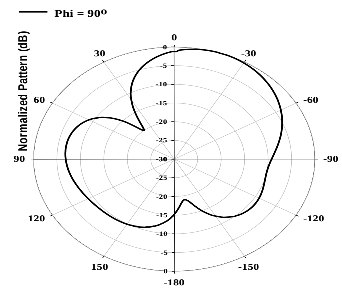

(b)

Figure 3. The radiation pattern in (a) E (b) H planes for the proposed antenna.

IV. CONCLUSION

In this paper, an annular ring patch antenna was presented. The design provides a wide impedance bandwidth in a simple antenna design. The simulation -10 dB impedance bandwidth is 71.4% and a realized gain of 5 dB. The proposed design is suitable for automotive applications operating at the V2X band that require a wide impedance bandwidth.

V. REFERENCES

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