Printed U-slot Patch Antenna for 60GHz Applications

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Abstract

A high-gain and low-cost millimetre-wave patch antenna is presented. The designed antenna with a U-slot loaded on the patch is excited by a single mircostrip line. The impedance bandwidth of the prototype is ~11.6% from 57GHz to 60GHz. The gain of 8.2dBi is achieved at 60GHz. This single antenna element yields advantages of high gain, good directional radiation pattern and low fabrication cost. It is suitable for unlicensed millimeterwave ISM-band applications.

Index Terms- patch antenna, 60GHz, U-slot, high gain

1. Introduction

WiGig technology is the most promising technology to deliver multi-gigabit throughput wireless communication. Uncompressed digitized data, voice, and video contents can be transmitted over-the-air within a short distance at the rate of 8 Gb/s using 60 GHz transceivers [1]. FCC assigned an unlicensed frequency band from 57 to 64 GHz for this high-speed application [2]. Recently, antennas for high-speed indoor wireless communication in MMW bands have been interested by many researchers [2]-[8]. There are a lot of designs related to 60 GHz antennas such as stacked patch [2], grid array [3]-[4], helix [5], slot [6], ME-dipole [7], loop [8], etc.

Due to the high path loss of signal transmission at 60 GHz, array antennas are a common method to ensure a good wireless link quality. However, the most of array structures are complex which leads to high production costs [3]-[5]. For single antenna elements, their gains may not be sufficient for fulfilling the 60 GHz communication requirement. Some designs demonstrated that a loop antenna [8] has a gain of 1.43 dBi at 60 GHz and the capacitance-loaded antenna [9] has the maximum gain of -0.7 dBi at 60 GHz. Other design like as a magneto-electric (ME) dipole antenna [7] presents a better gain value of 7.5 dBi.

In this paper, we introduce a single printed patch design which employs a U-slot loaded on the patch to achieve a high gain and a wide impedance bandwidth for the 60 GHz short-range application. The proposed antenna has a simple architecture and yields advantages of desirable directional radiation pattern and low fabrication cost. The structure of the proposed antenna is show in Fig. 1.

2. ANTENNA GEOMETRY AND DESIGN

For millimetre-wave application, its wavelength is so small that antenna is made in high precision and expensive cost. To reduce the fabrication cost, we introduce microstrip antennas [10]-[11] to be the candidate for realizing a millimetre-wave antenna with low cost, wideband, high gain characteristics.

Conventional U-slot patch antenna has been demonstrated by many researchers [12]. All previous proposed employ the

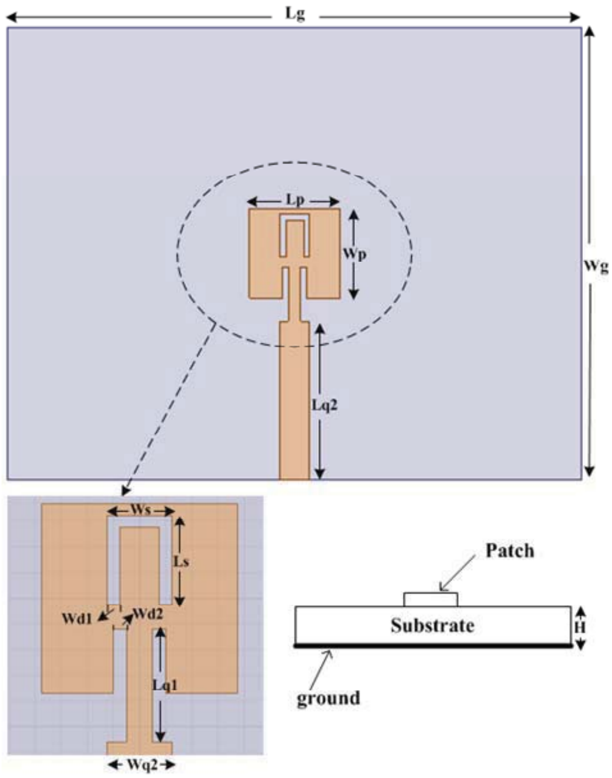


Fig. 1: The structure of the antenna.

U-slot loaded on the patch to increase the capacitance which suppresses the probe inductance resulting in widening the impedance bandwidth. However, there was no study to show the U-slot itself can also widen the bandwidth without the vertical probe. In this paper, a single-layer patch antenna in the form of a rectangular shape with loading the U-slot is investigated. The role of the U-slot is to provide double resonances on the patch so that the antenna can have a wideband feature.

Figure 1 shows the geometry of a U-slot patch antenna fed by a microstrip line. The antenna is fabricated on a thin ROGERS laminate (Rogers RT/duroid 5880, H=0.508 mm) with low permittivity (ε=2.2). The size of substrate is 7.5 mm× 9.5 mm. With the presence of the U-slot, two path currents operating at nearly 60 GHz can be generated. One path flows outwards around the U-slot, and other flows from the around the centre of the patch. Since the location of the U-slot is placed closer to the edge of patch, the two currents would operate nearly to each other. The distribution of the current is show in Fig. 2.

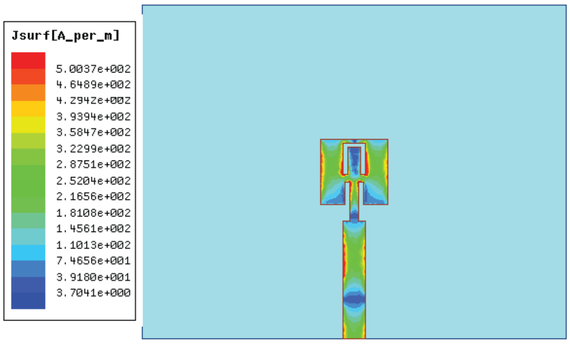


Fig. 2: Distribution of the current.

As a result, the impedance bandwidth of the antenna can be enhanced by the two resonances from the patch. Details of the antenna design parameters are listed in Table I.

Table I: ANTENNA PARAMETERS.

Name	Unit (mm)	Name	Unit (mm)
Wg	9.5	Ws	0.5
Lg	7.5	Ls	0.6
Wp	1.48	Wd1	0.1
Lp	1.5	Wq1	0.2
Lq1	0.88	Wq2	0.5
Lq2	2.63	Wd2	0.1
H	0.508		

3. SIMULATION RESULTS

A simulation study was carried out by Ansoft HFSS. Results are discussed in this section. Firstly, the reflection coefficient (dB) and realized gain are shown. Then, the radiation pattern is illustrated.

Figure 3 shows the result of reflection coefficient for the antenna. As shown, the antenna has an impedance bandwidth of 11.67% (S11≤-15 dB) from 57 to 64 GHz. It covers the unlicensed frequency of 60 GHz application. As shown in Fig. 4, the proposed antenna has a gain of 8.2 dBi at 60 GHz. And an average gain value of 7.73 dBi across the operating bandwidth from 57 to 64 GHz is obtained.

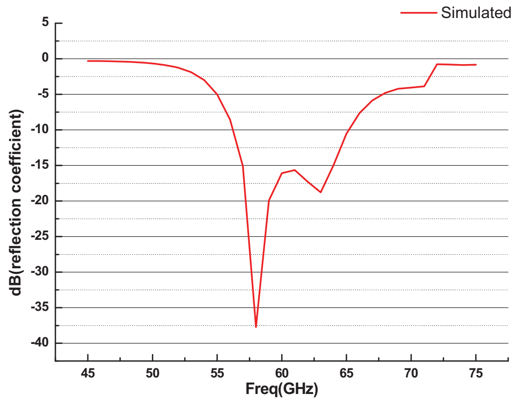


Fig. 3: Simulated reflection coefficient.

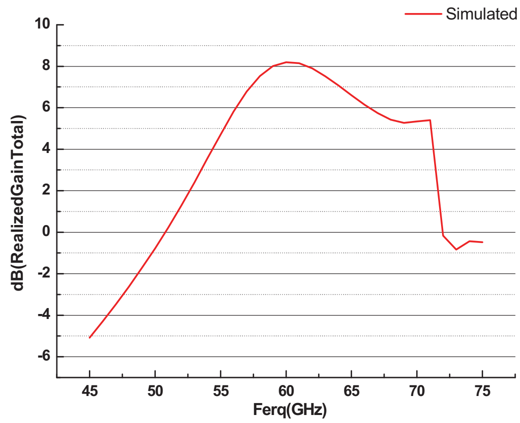
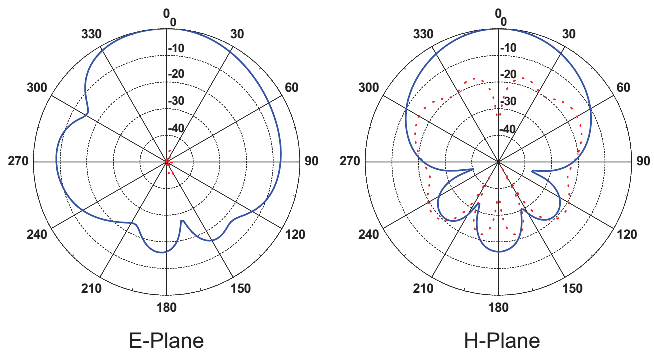


Fig. 4: Simulated realized gain total of the antenna.

Figure 5 shows the radiation patterns at frequencies of 57 GHz, 60 GHz and 64GHz for the E- and H- planes. As shown in the figure, broadside radiation patterns are stable across the operating bandwidth. In the E- plane, the radiation pattern is asymmetric due to the asymmetry of U-slot presented in the patch. However, the radiation pattern is symmetric in the H-plane. Figure 6 shows the simulated 3-D radiation pattern.



(a) 57 GHz

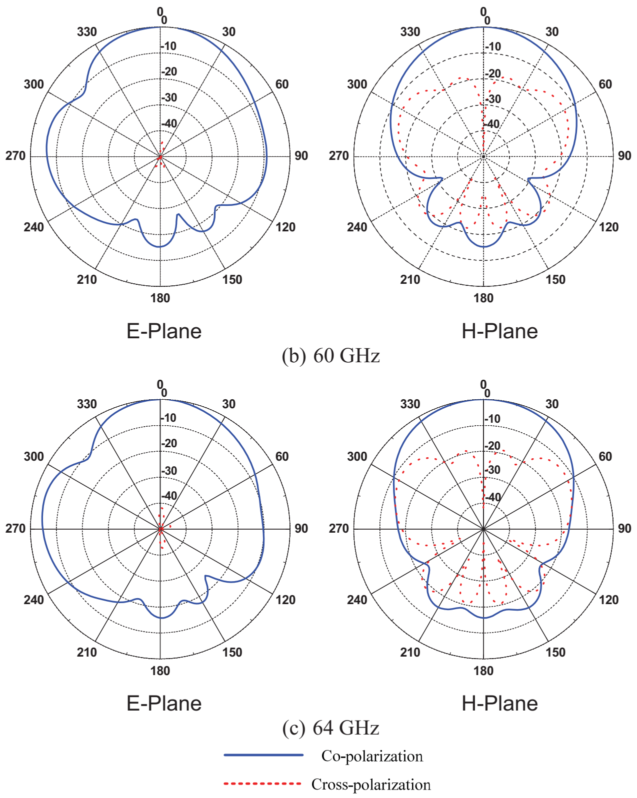


Fig. 5: Simulated antenna radiation pattern at 57 GHz, 60 GHz and 64 GHz.

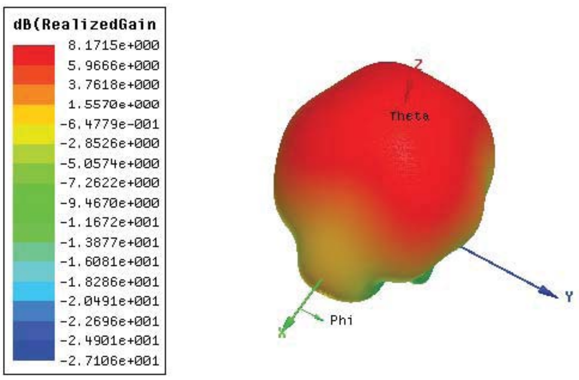


Fig. 6: 3-D radiation pattern at 60 GHz.

4. Conclusion

A wideband single-layered patch antenna composed of a U-slot for millimetre-wave applications was introduced. The proposed antenna is simple structure and low cost. The antenna achieves an impedance bandwidth of 11.6% (S11 ≤ -15 dB) covered the frequency band assigned by FCC for unlicensed WiGig communications. In addition, the antenna yields a gain of 8.2 dBi at 60 GHz. The antenna finds potential applications in millimetre-wave wireless communications.

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