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A Survey on the Properties of Microstrip Antennas with Different Shapes

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Abstract: Microstrip antennas with different shapes have different properties. It can have many shapes, such as rectangular, circular or triangular. With the changing antenna geometry, very important properties for the antenna such as gain and directivity also change. In this study, a rectangular antenna and a triangular antenna will be compared with each other in terms of gain, directionality and reflection coefficient. In line with the information obtained from the literature review and the calculations made and the antennas were designed. Ansys HFSS program was used in the simulations.

Keywords: Microstrip antenna, Triangular patch antenna, Different antenna shapes

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1. INTRODUCTION

Developing technology has increased the use of mobile and wearable electronic devices. Smart watches, smartphones and smart wristbands are examples of these devices. Due to their compact structure, affordable cost and multi-band operating frequency, microstrip antennas are widely preferred to meet the communication needs in such application areas [1]. It is known that microstrip antennas with different geometries have different properties [2]. In order to examine the different properties of antennas with different geometries in more detail, the properties of a rectangular antenna and a triangular antenna will be compared.

2. LITERATURE REVIEW

The illustration of a rectangular microstrip antenna is given above. The actual length of the antenna (L), the actual width of the antenna (W), the width of the dielectric material (Wm), the length of the dielectric material (Lm); The depth of the dielectric material, h, and the dielectric constant ε_r, are calculated as follows. Due to the fringe effect, the antenna area appears slightly larger than its physical area [4]. In other words, the length of the antenna appears larger than its physical length. This length is denoted as ΔL. Example geometry is given in Figure 1.

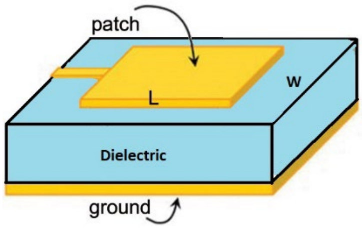

Figure 1. Rectangular antenna

The length of one side of the equilateral triangle is a; The width of the dielectric material is calculated as h and c being the speed of light. Example geometry is given in Figure 2.

Figure 1. Triangular antenna

2.1. Calculations

Equation 1 clearly shows the relationship between the width of a rectangular antenna and its resonant frequency. According to this equation, the width of the antenna and the dielectric constant of the insulator used directly affect the resonant frequency [5].

$$W = \left(\frac{c}{2f_r'}\right)\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

$$L = \left(\frac{c}{2f_r\sqrt{\varepsilon_{ff}}'}\right) - 2\Delta L \tag{2}$$

$$\varepsilon_{ff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left[1 + 12\frac{h}{W}\right]^{-1/2} \tag{3}$$

$$\Delta L = 0.412h\frac{(\varepsilon_{ff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{ff} - 0.258)(\frac{W}{h} + 0.8)} \tag{4}$$

Equation 2 shows the relationship between antenna length and resonance frequency. While determining the antenna length and resonance frequency, the effective dielectric coefficient derived from the dielectric coefficient of the used material. The equation of the effective dielectric coefficient is shown in Equation 3. The effective dielectric coefficient depends on the dielectric coefficient, the width of the antenna and the thickness of the insulating material used. Equation of ΔL is shown in Equation 4. While the microstrip antenna is operating, it emits a glow from its edges called fringing effect. This radiation causes the antenna size to be larger than its physical size. Therefore, this fringing effect should be taken into account when calculating the antenna length [6].

When it is desired to determine the resonance frequency of an antenna with equilateral triangle geometry; the length of one side of the equilateral triangle is calculated as a, the width of the dielectric material h, and the speed of light c. These calculations are made using the equations shown in 5 and 6. The effective dielectric constant used in Equation 5 is calculated by the Equation 3 given earlier.

$$\Delta L = \frac{2c}{3a_e\sqrt{\varepsilon_{ff}}} \quad (5)$$

$$a_e = a + \frac{h}{\sqrt{\varepsilon_r}} \quad (6)$$

3. SIMULATIONS

3.1. The physical properties of antennas

In line with the obtained information, an antenna with a triangular geometry was simulated. As a result of the calculations, an equilateral triangle antenna with a side of approximately 13mm is shown below. In the simulation, FR4 insulator material was used and its dielectric constant was taken as 4.4. The thickness of the dielectric material used is 1 mm. A rectangular antenna was designed using the same materials for comparison. The designed antenna geometries are shown in Figure 3 and Figure 4.

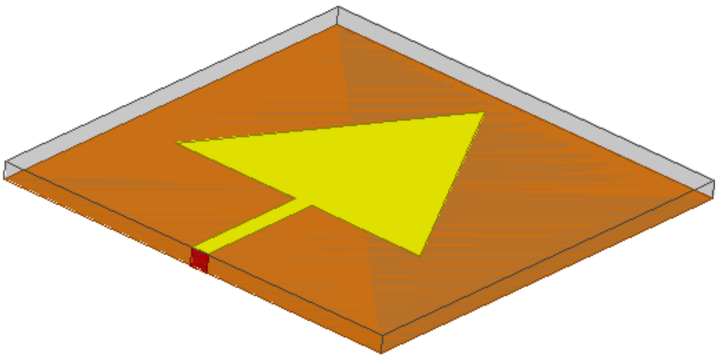

Figure 2. Designed triangular antenna

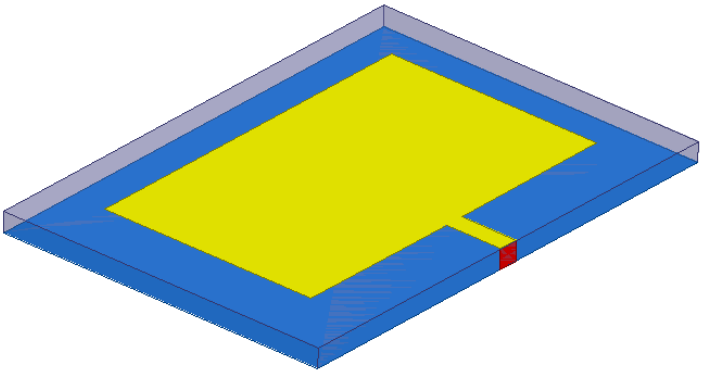

Figure 3. Designed rectangular antenna

3.2. Reflection coefficients

The reflection coefficients are similar when examined. Because both antennas are designed to operate at the same frequency. Both antennas are designed to have an initial resonance frequency of approximately 5.8 GHz. The reflection coefficients of both antennas at 5.8 GHz were simulated as approximately -20dB.

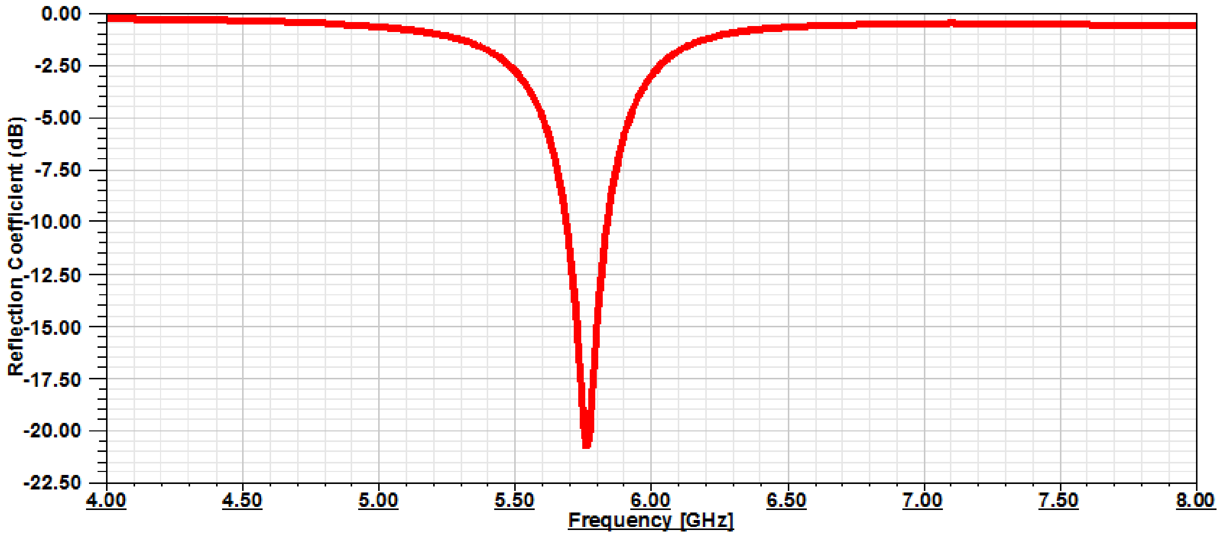

Figure 4. Triangular antenna's reflection coefficient graphic

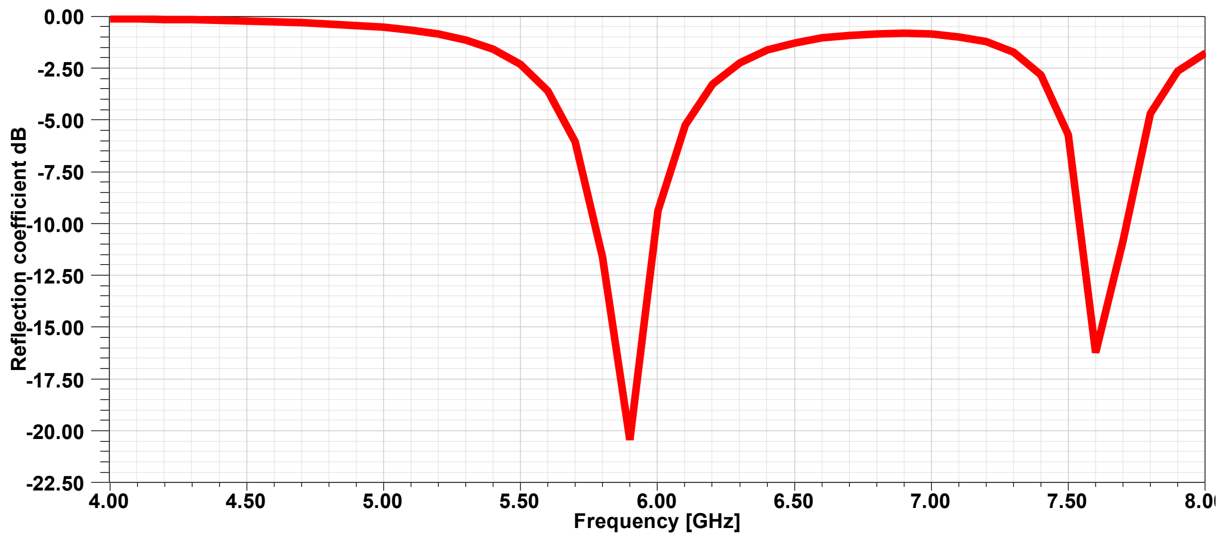

Figure 5. Rectangular antenna's reflection coefficient graphic

3.3. Gain and Radiation Patterns

When the gains of the two antennas are compared, the maximum gain simulated for the rectangular antenna is 2.75dB, while the maximum gain for the triangular antenna is 2.44dB. The results are quite close to each other.

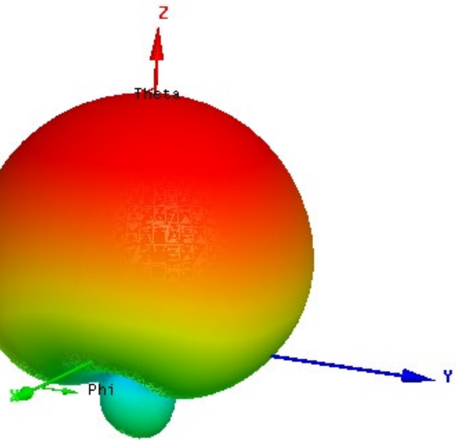

Figure 6. 3D Gain of rectangular antenna

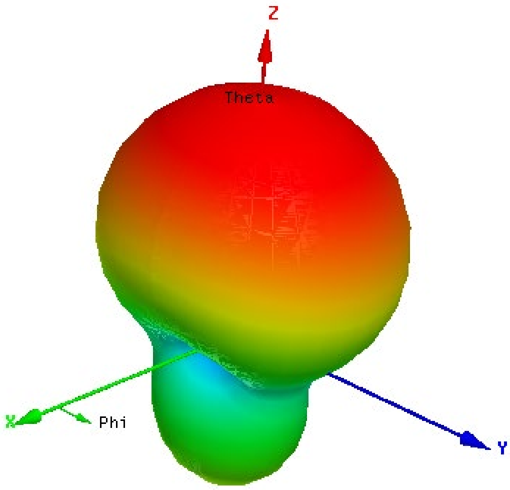

Figure 7. 3D Gain of triangular antenna

4. RESULTS

When the results are compared, it is clear that two antennas with different geometries designed for the same operating frequency have different properties. Let's start comparing these features with gains. The maximum gain measured for the rectangular antenna is 2.75dB, while the maximum gain for the triangular antenna is 2.44dB. The results are quite close to each other. When the radiation patterns are compared, quite different geometries emerge. This shows that the directivity of the antennas is also different. In addition, when the reflection coefficients are examined, it can be said that the triangular antenna works only one frequency band which is equal to 5.8 GHz. However, the rectangular antenna works on the double frequencies which are 5.8 GHz and 7.6 GHz. If you want to compare the physical properties, the areas covered by the patch parts of the antennas designed for the exact same frequency are also different. The area covered by the patch part of the rectangular antenna is approximately 211mm^2. The area occupied by the patch part of the triangular antenna is approximately 116mm^2. To compare in terms of the area covered by the ground surface, the area covered by the rectangular antenna is 422 mm^2, and the area covered by the triangular antenna is approximately 590mm^2. As can be seen, they have advantages over each other in terms of the area they cover according to the applications they will be used.

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