A High Gain Ultra Wideband Microstrip Antenna for EHF Medical Applications

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Abstract: A simple high gain ultra-wideband Microstrip patch antenna for extremely high frequency applications (EHF) is proposed in this paper. The antenna has simple shape and small size enable it to be inserted inside any medical gadget operating in EHF frequency band. The antenna overall dimensions are 57.3×4×1.6 mm. Simulation results show that the antenna has a bandwidth of 31.39 GHz which support a very high data rates and a maximum gain of 11.53dBi which represents such a high gain that the antenna can be considered to be with negligible losses.
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1. Introduction

The Microstrip antennas, the workhorse of the modern day communication systems, have significant advantages over other antennas types because of its small size, low cost, and easy fabrication techniques [1]. Unfortunately, the conventional designs of microstrip antennas have a noticeable shortcoming in the antenna gain and bandwidth. Consequently, many researchers have directed their interest toward improving these two parameters. Although, extremely high frequency (EHF) band, which covers the frequency range 30-300GHz, undergoes a very high atmospheric attenuation, it is preferred by many designers because it is less congested than other frequency bands that include many wireless applications [2].

Many researchers deal with improving the patch antenna gain and bandwidth for high data rate EHF applications. The band width improvement may be achieved either by utilizing the concept of multiband antennas [3] or by designing an ultra-wideband (UWB) antenna covering wide range of frequencies [4]. On the other hand, the gain improvement can be obtained by some special designs such as using metamaterial lens [5] and using artificial magnetic conductors [6]. Some special feeding techniques are also proposed for gain improvement purposes such as probe tangent feed [6] and waveguide feed [7].

In this paper, a simple patch antenna having wide bandwidth and very high gain is proposed for EHF medical applications. The proposed antenna is a UWB antenna with very low radiation losses due to its high gain properties. In spite of the antenna simple shape, the simulation results expose the antenna UWB behavior as well as its high radiation performance. The antenna bandwidth is determined by demonstrating the antenna reflection coefficient, while the antenna radiation performance is evaluated by studying the peak gain of the antenna at the center frequency of the operation bandwidth.

2. Antenna Structure

Like the conventional microstrip antennas, the proposed antenna has conducting patch etched on a dielectric substrate with metallic ground plane facing the antenna patch on the other side of the substrate as shown in Fig. 1. The antenna metallic parts are made of copper, whereas the substrate is an FR4 substrate with dielectric constant of 4.3. Fig. 2 shows the dimensions of each part of the antenna. The overall antenna dimensions are 57.3×4×1.6 mm. The patch of the proposed antenna consists of two overlapping rectangles, and the ground plane has circular shape printed on the other side of the ground plane. Therefore, it has very simple design compared to the counterpart antennas mentioned in Sections 1. Furthermore, the substrate is cheaper than the special substrates used in the designs pointed out in the literature review. It is worthwhile to mention that a coaxial feeding technique is used in this proposed design with feed point located at 2.5 mm away from the edge of the long rectangle that is covered by the ground plane.

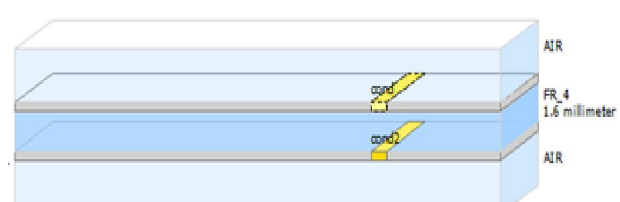

Figure 1. The overall structure of the proposed antenna

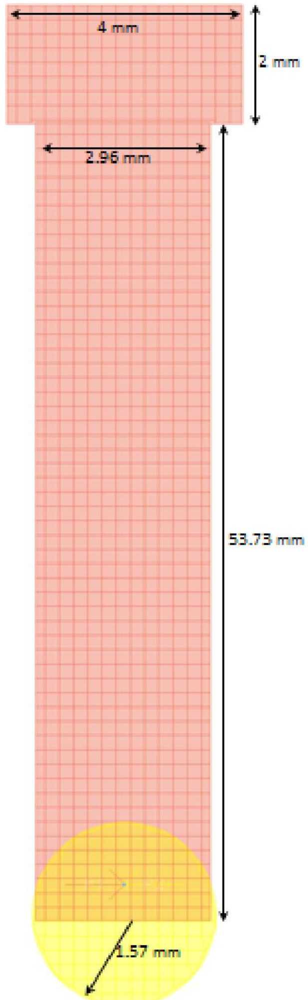

Figure 2. The geometry of the proposed patch antenna.

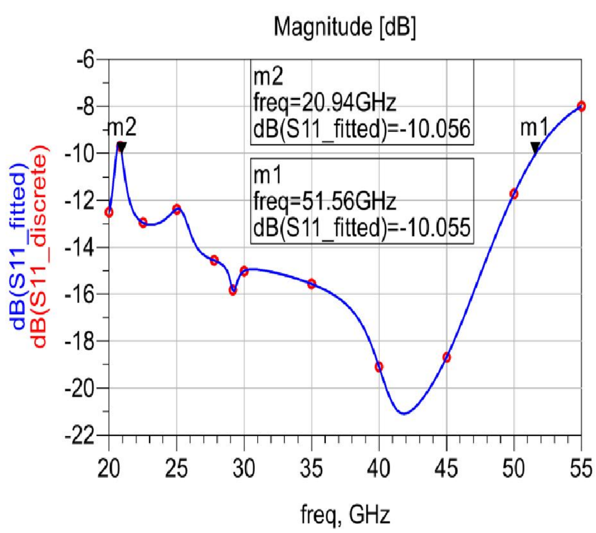

Figure 3. The simulated magnitude of the reflection coefficient of the proposed antenna.

3. Results and Discussion

The simulation results are obtained with aid of Advanced Design System (ADS) simulation suite. Fig. 3 illustrates the magnitude of the reflection coefficient of the proposed antenna. This figure expose that the antenna bandwidth is 31.39 GHz extended through frequency range of 20.94-51.56 GHz. It is clear that the proposed antenna operates within the EHF frequency band with very large bandwidth that qualifies the antenna to support very high data rate systems. The current distribution of the antenna at 40 GHz, which may be considered as the center resonant frequency of the operating band, is demonstrated in Fig. 4. The current is concentrated at four points along the antenna sides since this frequency represents the antenna fourth resonant frequency.

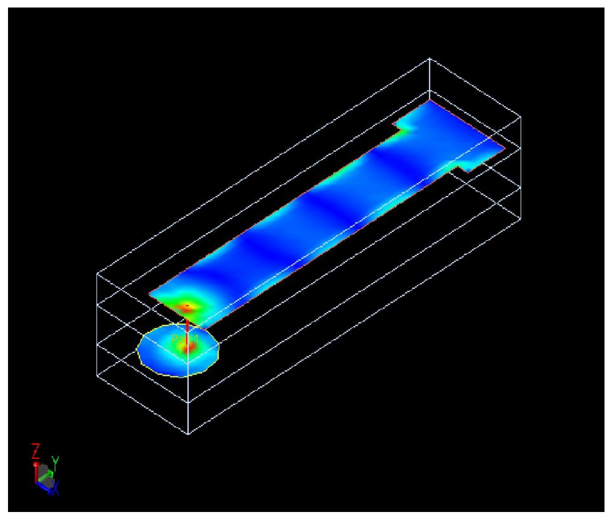

Figure 4. The current distribution of the proposed antenna at f=40GHz.

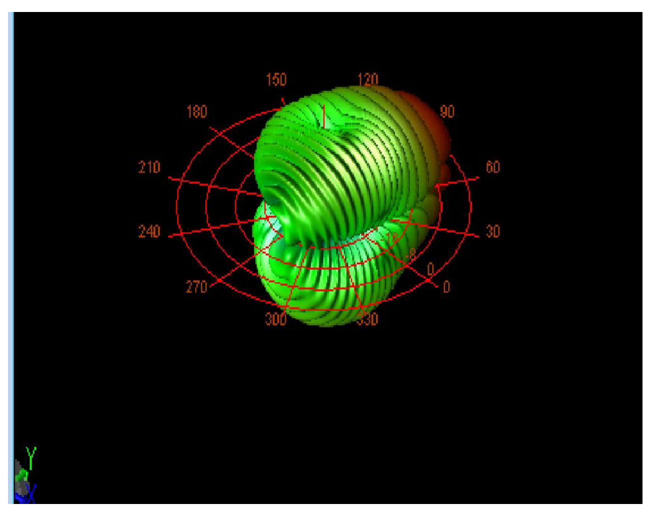

Figure 5. The simulated antenna gain at f=40GHz as a function of space coordinates.

To highlight the radiation characteristics of the proposed antenna, the gain as a function of coordinate system at 40 GHz is illustrated in Fig. 5. The antenna has bidirectional radiation pattern in E-plane (xz-plane) and almost omnidirectional pattern in H-plane (xy-plane). The maximum gain value is found to be 11.53 dBi at azimuth angle of 76^0 and elevation angle of 82^o, and this gain value is higher than that obtained in [3-8]. The antenna directivity is found to be 13.3 dBi at the same azimuth and elevation angle of the maximum gain. The antenna radiation intensity is 7.438 mW/steradian which results from dividing the radiated power by the effective steradian angle of the antenna [1].

The antenna gain value and bandwidth proves that the antenna operates as a high gain UWB antenna. This means that the antenna can be utilized for high data rate applications with very good radiation characteristics. Thus, this antenna is so suitable for high data rate medical devices which require low transmission losses.

4. Conclusion

A UWB microstrip antenna with high gain and simple shape is proposed in this work for EHF applications. Although the antenna has very simple shape, it covers very wide frequency range and provides very good radiation characteristics compared to the other more complex designs. The ADS simulation results show that the antenna has bandwidth of 31.39 GHz and maximum gain of 11.53 dBi at 40 GHz with bidirectional E-plane radiation pattern and omni-directional H-plane radiation pattern. These two values qualify the antenna to be inserted in high data rate gadgets that requires low loss transmission.

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