Design, Implementation and Analysis of Cloverleaf Antenna

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***Abstract*—Antenna design is important for wireless communication technology. In this paper, the cloverleaf antenna [1] design is presented. The antenna design is evaluated in terms of various performance parameters and is also compared with some high performance antennas in literature.**

I. Introduction

Recently, there has been an explosive growth in wireless communications. The number of users leveraging various internet applications has gone up significantly. Further, the amount of data generated by these users has also exponentially increased. A lot of this data is transmitted over wireless links. In order to create a systematic development of wireless communication, various standard bodies have been developed (e.g., IEEE 802.11a/b/g/n/ac/ax [2], etc. as well as cellular standards such as 5G [3], 6G [4], etc.). Discussions led by these bodies has resulted in a huge innovation in the wireless domain. A number of additional use cases have been discussed. To satisfy the user needs in these use cases, a number of different wireless products have been developed. For instance, about two decades ago, there were very few wireless products (probably only cell phones) that were popular amongst users. However, today almost every product has some or the other wireless interface on it.

One of the important bands for communication is the C-band [5] of communication which covers the frequency in the range of 4 to 8 GHz. The C Band of operation has been leveraged for a number of applications ranging from satellite communication to Wi-Fi device transmissions. Consequently, studying antennas for C Band of operation is very crucial. Antenna is a key component of any wireless device [6]. An antenna has the capability to increase the signal strength from the intended receiver. Further, reducing the size of the antenna can also result in a reduction in the size of a wireless device [7].

II. C Band of Operation

C band is the term designated by the IEEE for radio waves propagating in the frequency range from 4 to 8 GHz. However, FCC designation for C band is in 3.7 GHz - 4 GHz. The typical wavelength of radio waves in this band vary from 3.8 cm to 7.5 cm. The C band lies between the S Band and the X Band of communication.

The C Band of operation provides several advantages. First, it does not suffer from significant interference due to heavy rain fading. Next, the bandwidth is cheaper compared to other bands. Due to is popularity, the equipment for C Band of operation has become quite easy to install and operate.

C Band of operation has a number of applications. It is used in satellite communication for transmission between the ground station and the satellite. It can be useful for weather monitoring system designs, radar designs as well as terrestrial microwave link design. Further, such types of antennas can also be used in 802.11 based Wi-Fi network. This band has also been used for amateur radio design, particle accelerator design, radio navigation service design, cellular system design, etc.

III. Antenna Design

The cloverleaf antenna [8], [9] is a closed loop antenna from design point of view. A closed loop antenna is an antenna whose signal and ground wires are attached to each other. Consequently, the voltage difference between them is zero. The design is best suited for transmitter antenna design.

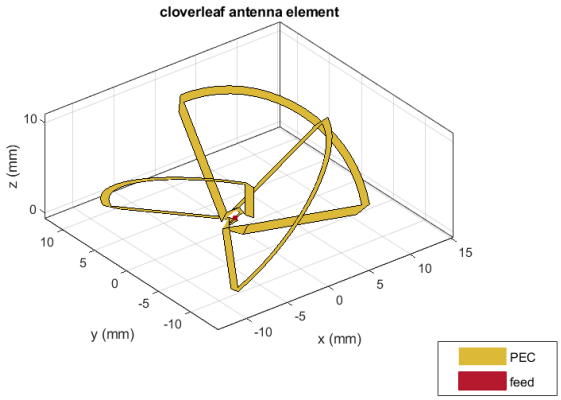

Fig. 1: Antenna Design.

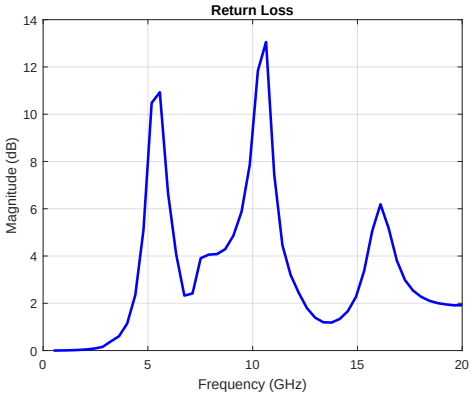

Fig. 2: Antenna Return Loss

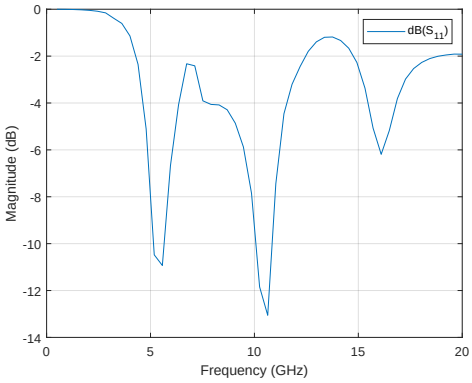

Fig. 3: Antenna S11

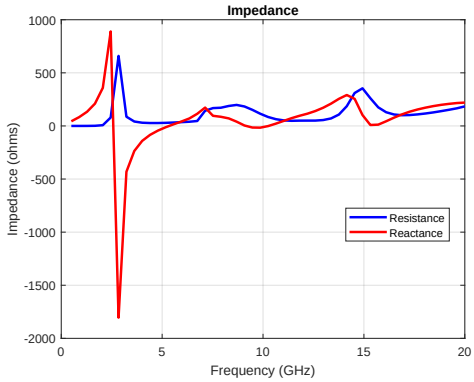

Fig. 4: Impedance of the proposed antenna.

However, cloverleaf antennas do not make good receiver antennas.

The design is a wideband antenna with circular polarization. Typically, the antenna generates three lobes which are 120 degrees apart in the horizontal plane and are at a 45 degree angle in the vertical plane. Consequently, the antenna has its peak radiation in the broadside and nulls in the axial direction. Such antennas are excellent for FPV video stream transmission as they can reduce impact of multipath interference. From practical usage perspective, the cloverleaf antennas are not very aerodynamic and can be quite fragile.

IV. Experimental Evaluation

Next, the cloverleaf antenna is thoroughly studied. The key parameters of the antenna that are studied are the impedance plots, the radiation pattern and the directivity plots.

A. Impedance

The ratio of voltage to current at the input port is defined as impedance. The impedance for the proposed antenna is as shown in fig. 4. The impedance has a real component which is resistance and an imaginary component which is the reactance. Both components for the antenna are frequency dependent. The plot shows the real and imaginary components of the proposed antenna design for the frequency range of 1 - 20 GHz.

B. Radiation Pattern

The radiation pattern for the proposed antenna augmented on the proposed antenna design is as

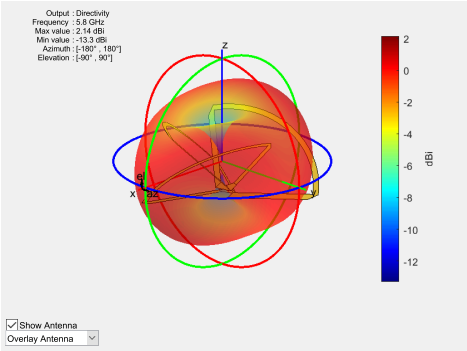

Fig. 5: 3 Dimensional radiation pattern of the proposed antenna augmented on the antenna design

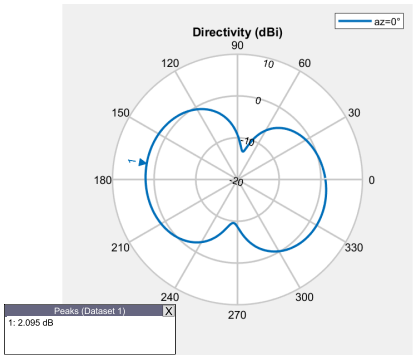

Fig. 6: Directivity of the proposed antenna.

shown in Fig. 5. As depicted in the figure, the maximum and the minimum values for the directivity are 2.4dBi and -13.3dBi respectively. The directivity of the antenna is as shown in fig. 6.

The radiation pattern results are as summarized in Table I.

C. Size Comparison

Next we compare the antenna with some of the high performance designs in literature. Specifically, four antenna designs are considered. The first three types are novel dual patch designs and the fourth one is a fractal antenna [7], [10]–[12]. All the antennas have resonant frequencies in the band in which the proposed antenna resonates.

Based on the table it can be seen that the proposed antenna works better than [7], [11], [12]. However,

Parameter	Value
Frequency	5.8 GHz
Max Value	2.14 dBi
Min Value	-13.3 dBi

TABLE I: Summary of radiation pattern results

Antenna	Length	Width	Area
[10]	19mm	17mm	323
[7]	40mm	30mm	1200
[11]	40mm	30mm	1200
Proposed design	20	20	400
[12]	51	75	3825

TABLE II: Comparison of various high performance antenna designs [7], [10]–[12]

[10] has a more compact design as it leverages a novel E shaped fractal design and is consequently extremely compact and provides high performance. In the future, we will improve our design to make our design more compact compared to the design in [10].

V. Conclusion

This paper presents the design and analysis of a cloverleaf. The antenna design is presented and it is analyzed in terms of numerous parameters such as resonant frequency and the radiation pattern. Further, comparison of the antenna with some high performance antenna designs in literature is also provided.

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