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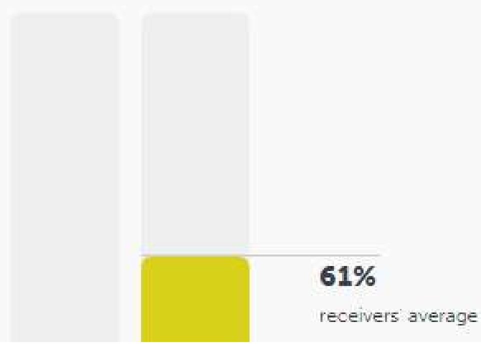

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An Integrated Complementary Array Antenna for Biomedical Applications

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Abstract

In this article describes an integrated invert U-shape Complementary array (IIUCA) with defected ground structure (DGS) antenna for biomedical applications. The proposed antenna is operated at a focus frequency of 2.45 GHz, at the bandwidth of 0.22 GHz. The achieved frequency spectrum provides the complete health care monitoring (HCM) applications. A flexible cotton dielectric material with a relative permittivity of 2.1 is used to build an integrated invert U-shaped complementary array antenna. The dimension of the proposed IIUCA antenna structure is 33x36x2.8mm3, as assessed by TL model derivatives. The overall gain of the proposed IIUCA antenna is 3.16 dB, also it is fabricated and verified the real-time performance by using VNA in various conditions. Based on this analysis, the measured values agree well with the simulated values.

Keywords – Cotton, HCM, IIUCA, TL-model, DGS

Introduction

In the modern era wireless communication the simulation of microstrip patch antenna is considered to be mandatory one because without this patch antenna [1] the wireless communication, biomedical applications in modern world is impossible [2]. In present scenarios the word biomedical getting more familiar and considered to be one of the emerging fields in this world so [5] most of the researchers in electromagnetic started to simulate the antenna to operate in ISM bands which covers biomedical applications [16]. This sudden drastic changes took place because one can able [4] to monitor patient through wirelessly all we know that in this pandemic this method of treating the patients one of the best preferred methods in most of the countries. This is happened in real time by two types of devices wearing device or implantable device [14] but this letter focuses on wearable devices because here the proposed antenna structure is simulated and fabricated [3] using cotton dielectric material with relative permittivity of 2.1. In Simulation of patch antenna the permittivity and tangent loss are considered to be critical parameters [7]. The appropriate selection of dielectric material for the patch antenna is important so the chosen dielectric material plays the prominent role [10]in proposed patch antenna structure to achieve desired frequency resonance [8] at biomedical applications. Therefore the proposed an integrated complementric split ring array antenna [19] can be wear by the humans by placing on the dress because of its flexibility nature and its compactness achieved in overall dimension [9, 13]. This proposed design is made successful in desired frequency is due to the combination of two techniques SRR (Split Ring Resonator), CSRR (Complementary Split Ring Resonators) [6] and implementing Array structure in ground plane, radiating patch of the proposed antenna respectively. In most of the microstrip patch antenna an array structure is preferred to be good one which can help to reduce the side lobes in patch antenna and also can achieve gain enhancement [15]. Another most important advantage is can able to avoid interference by steering the beam in signal transmission so can achieve improved overall performance rate of the patch antenna [18]. Due to the simple geometry & ease of fabrication SRR and CSRR structures are widely used in the microstrip patch antenna in recent days. By implementing these techniques in patch antenna, the miniaturization is achieved in overall dimension and able to achieve desired resonance frequency with less signal scattering. The miniaturization in overall dimension in microstrip antenna is happened by reducing the copper usage [19, 20], so can able to achieve some weight reduction in the antenna when compared to other antennas. The SRR and CSRR structures implemented in the proposed design can be termed it in single word as metamaterial technique. The term metamaterial is applicable where the resonators and capacitors are in parallel so here this metamaterial structure is loaded on radiating patch and also in ground plane [6]. The microstrip patch antenna with metamaterial structures has been proving that it is the one of the best structures by achieving enhanced frequency bandwidth, gain and radiation efficiency of the particular antenna via its reactive coupling [17]. The metamaterial technique is described in sixth paper by Surendar U in 2015 under the title "An UWB metamaterial antenna for WLAN applications" as title describes the author of the corresponding paper designed the microstrip patch antenna for WLAN applications by achieving the frequency resonance at 5.5 GHz with very less signal scattering in transmission of -28.5 dB by implementing the metamatrial structure in ground plane. Finally after fabrication and testing process author concluded that proposed antenna is suitable WLAN application in real time also and this is due to negative effect (metamaterial) of the antenna [6].

Design Analysis

An integrated invert U-shape Complementary array (IIUCA) with defected ground structure (DGS) antenna for biomedical applications with an overall dimension of 33x36x2.8mm3 is simulated using Cotton dielectric material of 2.1 relative permittivity with the help of ANSYS EM suite and the snap of simulated top and bottom view of the proposed antenna is represented in Figure 1. Strip line feed techniques were used in this work, along with a novel shape of CSRR loaded array patch structure. In proposed design 1x2 array patch is drawn on the radiating layer to improve the gain and to suppress the side lobes of the patch antenna. To achieve the desired frequency resonance at biomedical application and to make the proposed design a unique structure further optimization is carried out in patch layer by implementing CSRR structure in array of the proposed antenna, in other words the ring structure is drawn on the radiating layer and implemented the defected ground structure in the ground plane of the proposed antenna by drawing the split ring resonator in it. From the most of the antenna design in previous years the metamaterial structure is only implemented in ground structure, but in this design the metamaterial structure is implemented in ground plane as well as in patch to achieve the narrow bandwidth with less power consumption and structures proposed in IIUCA antenna is also called as double negative material. The proposed antenna structure is analyzed with all electromagnetic parameters in ANSYS EM suite version 21 and it is discussed.

Figure 1 Represents Snap of the proposed IIUCA antenna

Result Analysis

In this proposed research work, an integrated invert U-shape Complementary array (IIUCA) with defected ground structure (DGS) antenna is reported for biomedical applications. The simulation result of the proposed IIUCA antenna is analyzed using the ANSYS EM. This section discusses the obtained simulated electromagnetic results by plotting them in 2D and 3D plots.

Once entering into this part the most important electromagnetic parameter and first to be analyzed for the microstrip patch antenna is Return Loss because this electromagnetic parameter helps to prove that the simulated structure is suitable for the desired applications by giving information on frequency resonance. From the analysis the proposed IIUCA antenna structure

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resonates at center frequency of 2.47 GHz with the return loss of -26 dB			

so achieved minimal scattering of signal in transmission and the signal can reach the destination without any issues.

Figure 2 Represents S11 parameter of the proposed IIUCA antenna

Figure 3 represents the gain of the proposed IIUCA antenna in 3D plot. This electromagnetic parameter helps to describe how fast the patch antenna can able to convert the input power into electromagnetic waves. According to the analysis, the proposed simulated integrated invert U-shape Complementary array antenna has a gain of 3.16 dB, indicating that it is capable of efficiently converting input power to electromagnetic waves for signal transmission process.

Figure 3 represents the gain of the proposed IIUCA antenna

Figure 4 represents the directivity of the proposed IIUCA antenna in 3D plot. The importance of analyzing the directivity parameter in microstrip patch antenna can able to study the strength of the beam produced by the corresponding antenna. From the analysis obtained directivity value of proposed integrated invert U-shape Complementary array with defected ground structure (DGS) antenna for biomedical applications is 4.27 dB. From the obtained value it proves that the proposed IIUCA antenna is producing the strengthen signal beam which is capable to transmit the signal to its destination.

Figure 4 represents the directivity of the proposed IIUCA antenna

From the obtained values of gain and directivity the radiation efficiency of the patch antenna can be calculated from mathematical equation and it is represented below.

Efficiency (η) = Gain/Directivity x 100

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ŋ = 3.16/4.27 x 100

Efficiency = 74%

To check that the calculated value is correct proposed integrated invert U-shape Complementary array with defected ground structure (DGS) antenna structure is analyzed in the ANSYS Electromagnetic suite and place the 2D graph plot below. From the graphical representation the value of radiation efficiency at 2.45 GHz is 77 percent. Both the calculated value and simulated value of radiation efficiency of the proposed antenna tabulated in table 1, both the obtained values are similar. Radiation Efficiency (%) Calculated Simulated 74 77 Table 1 represents calculated and simulated radiation efficiency values of proposed IIUCA antenna

Figure 5 represents the radiation efficiency of the proposed IIUCA antenna

The analyzing of the radiation pattern in patch antenna is considered to be the mandatory because it describes the polarization by analyzing the elevation and azimuth angle of the patch antenna. The proposed integrated invert U-shape Complementary array with defected ground structure (DGS) antenna for biomedical applications is analyzed with the radiation pattern in zero and ninety degree at 2.45 GHz and it is represented in figure 6. At both the degree the proposed IIUCA antenna produces the circular polarization so can achieve minimal power consumption because it splits up the power equally.

Figure 6 represents the radiation pattern of the proposed IIUCA antenna

The proposed integrated invert U-shape Complementary array with defected ground structure (DGS) antenna is simulated for wearable biomedical applications by designing it in cotton substrate material so it is mandatory to analyze Specific Absorption Rate (SAR) for the proposed antenna. From the analysis obtained SAR value of the proposed IIUCA antenna is 0.14 which in acceptable range. This obtained SAR value of the proposed IIUCA antenna will not produce harmful radiation to the human beings.

Figure 7 represents the SAR for the proposed IIUCA antenna The proposed IIUCA patch antenna is undergone for Surface current analysis. Because this parameter analysis is important to find power wastage in patch antenna and can help to design patch antenna without the power wastage. From the analysis obtained surface current in patch and ground of the IIUCA antenna is represented in pictorial format. From the figure 8 the power from the feed line is spread with an equal amount throughout the patch and ground of the proposed antenna so the power wastage in the proposed design is not evident and also there will be minimal power consumption.

Figure 7 represents the Surface Current (J-surf) for the proposed IIUCA antenna

The power range of the proposed IIUCA antenna is analyzed and the obtained value is represented in 2D graph plot in figure 8. In the graph plot the obtained power values are represented in dBm so obtained values are converted to the watts and the converted values are tabulated. The obtained accepted power for the proposed IIUCA antenna at 2.45 GHz is 29.9 dBm and the radiated power obtained for the proposed antenna design is 28.8 dBm.

Frequency

2.45 GHz

Accepted Power

29.9 dBm

0.9772 Watts

Radiated Power

28.8 dBm

0.7586 Watts

Table 2 represents the power value of the proposed IIUCA antenna

From the tabulation the obtained values reported here are below range of 1 watts so the proposed antenna consumes minimal range of power.

Figure 8 represents the power of the proposed IIUCA antenna

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The proposed integrated invert U-shape Complementary array (IIUCA) with defected ground structure (DGS) antenna is fabricated in real time on flexible cotton dielectrics as per the values calculated during the simulation process so the overall dimension of the fabricated IIUCA antenna is also 33x36x2.8mm3.

Figure 9 represents the fabricated piece of the proposed IIUCA antenna

The MATLAB simulated results of permittivity proposed structure is plotted in figure 10, to prove that the metamaterial effect is produced in the proposed integrated invert U-shape Complementary array (IIUCA) antenna. From the simulated values the proposed IIUCA antenna structure achieve pure negative value in permittivity.

Figure 10 shows the metamaterial effect of permittivity

The fabricated IIUCA antenna is tested in real time using the Anritsu Vector Network Analyzer and placed the comparative 2D plot in figure 11. The fabricated piece of the proposed IIUCA antenna is measured two conditions initially it is measure without the 30 degree bend and secondly it is measured with 30 degree bend. From the analysis both the measured results shows the good agreement with the simulated result.

Figure 11 represents the comparative results of the proposed IIUCA antenna

IIUCA Frequency GHz RL dB VSWR Gain dB Directivity dB %

Simulated Measured

Normal 30deg Simulated Measured

2.47 2.49 2.38 -26.5 -23.1 -23 1.01 3.16 4.27 77

Table 3 represents the overall obtained values of the proposed IIUCA antenna

Conclusion

A novel integrated invert U-shape Complementary array (IIUCA) with defected ground structure (DGS) antenna was designed to operate at 2.45 GHz is reported in this article and discussed in detail by analyzing all the electromagnetic parameters. From the obtained values of all analyzed electromagnetic parameters proves that the proposed IIUCA antenna is suitable for the desired biomedical applications so it is also fabricated in real time using flexible cotton dielectric of thickness 2.8 mm. The fabricated IIUCA antenna SMA is connected to the Anritsu Vector Network Analyzed for the testing process in real time. In the testing the proposed IIUCA antenna is measured the values in two conditions (i,e) in 30 degree bend and in normal condition and found all the measured values are in similar to the simulated results. The testing process carried out by the fabricated IIUCA antenna can prove the flexible nature so this proposed and fabricated antenna is best suitable for wearable biomedical applications in modern wireless communication.

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