Design of Microstrip multiband Triangular patch antenna using DGS technique at 6.5 GHz

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Abstract

This work proposed the use of defective ground structure (DGS) in designing of a compact microstrip triangular patch multiband antenna for a diverse range of wireless applications. The methodology to minimize the structure and enhancing the design performance along with the return loss and defective ground structure. DGS is presented in proposed work, and the design incorporates copper to the ground and a patch that radiates of 0.035mm thickness, while the substrate with a permittivity of 4.4mm and a thickness of 1.6mm is utilized for the substrate and also for the suggested design measurements and simulation results at 6.5GHz with multiple bands at various frequencies are obtained. The suggested antenna performs better and is inexpensive lightweight, and simple to construct the antenna and is fed with 50Ω impedance using the microstrip feed line approach.

Key words: *DGS, CST, Microstrip, Multi-band antennas.*

I. INTRODUCTION

In today's global society, communication is a way of exchanging information between a person and a device or two persons or two devices. Communication is essential and can accomplish through wired or wireless systems. Wireless technology has advanced significantly, requiring smaller equipment to support multi-band communications. This technology offers a cost-effective and flexible way for communication. Antennas are a crucial component of wireless communication systems, and one kind of such is microstrip patch antenna, known for being lightweight, cost-effective, and easy to fabricate.

This is due to small size of patch antennas and the fact that they can easily be mounted directly on devices that has made them so widely applied in wireless communication. They are flat antennas used for wireless communication and other microwave applications. Due to its simple structure and efficiency in performance enhancement, DGS, which is considered a simplified version of the Electromagnetic Band Gap structure, has become popular. DGS involves creating defects on the ground plane of microstrip circuits, improving the performance of filters and various applications. Initially designed for filters, DGS is now in high demand for various applications. It has been commonly employed to enhance the effectiveness of microstrip antennas by improving bandwidth, gain, and radiation characteristics. A single example is a triangular patch antenna with a slot cut designed for 6.5GHz frequency using CST Microwave Studio software to observe the radiation pattern, return loss, bandwidth, and VSWR. Moreover, rectangular parasitic strip elements and slots cut at the side of feedline inserted to the patch can be added to achieve multi-band operation, which helps lower return loss.

II. Literature Review:

In recent years, new designs have been created to enhance the efficiency of patch antennas, allowing functioning across multiple frequency bands with increased bandwidth and a smaller size. The patch antenna consists a square shape that has U-shaped slots, while the ground plane is equipped with a rectangular shaped slot to produce a response across multiple bands. The proposed design yields a satisfactory level of gain with a desirable radiation pattern and offers a broad band response. The antenna described in this paper exhibits minimal cross-polarization for both the E and H fields across all resonant frequencies [1]. In this research work, designing and simulation of a dual-band triangular patch antenna with an equilateral shape also the technique of tapered feed is the prime objective. The simulation in CST MW 2016 has been done using the CST Microwave Studio Suite. Functioning at the frequency of 6.5 GHz, a triangular microstrip patch antenna possesses the frequency range of 300MHz with an additional attribute of compact size. On the other hand, another band works at a frequency of 10.3GHz with a frequency band of 10.05-10.55, having a bandwidth of 500MHz. It follows that it indicates effective impedance matching of this design since it is matched to 50Ω at antenna's resonant frequency. The antenna is applicable in many instances, specifically satellite communication and weather radar system applications [2]. DGS structures were proposed to increase the performances of microwave devices. The main applications of DGS relate to microwave filter design, couplers, oscillators, and amplifiers. In microstrip antenna design, DGS has applications in size reduction, reduction of cross-polarization, minimization of the inter-element coupling in antenna arrays, and harmonic attenuation. The concept of DGS evolved from the concept of Photonic/Electromagnetic Bandgap structures. This can also be done by etching Single or multiple PBG structures within the ground plane to create a defect. DGS can be modeled into an Equivalent circuit with inductors and capacitor wherein the values of L&C depend on size and area of defect. This makes it possible to achieve the required resonance frequency by varying the dimensions of the defect. [3-6]. This paper presents a grooved plus-shape DGS antenna for 5G Sub-6 GHz and WiMAX applications. The chip's rectangular aperture and terrestrial DGS improve its radiation in targeted communication systems. The designed PSPA has an outstanding reflection coefficient (−52.06 dB) at 3.12 GHz. It addresses the larger 2.56 GHz transmission capacity. PSPA VSWR value for time slot satisfies 1 < VSWR [11]. In this paper, two dual-band FR-4-based rectangular microstrip array antennas have been designed and fabricated for operating frequencies of 3.45 GHz belonging to the sub-6 GHz frequency band and 5.9 GHz belonging to the sub-7 GHz frequency band. Besides, measurements are done to validate the performance of the proposed compact, acting as a parasitic on the microstrip dual-band antenna of 36mm×37mm with a simple design. The proposed antenna bandwidth will be above 150 MHz below 6 GHz and 7 GHz; it will have gain values of 3.83 dBi at 3.45 GHz and 0.583 dBi at 5.9 GHz. All measurement and test values are verified by simulations based on CST- software. Besides, the study shows that the gain of antenna can further be increased by reducing the parasitic bandwidth. [10].

III. Antenna Design and simulation:

The structure of the proposed design is a triangular patch built on a grounded FR-4 substrate. The design consists of a ground layer with the thickness of 0.035 mm and dimensions of 21 mm× 23 mm.

The FR-4 substrate used was of 1.6 mm thickness and dimensioned of 21 × 23 mm on top of the base plate. Finally, a triangular patch is placed on the substrate as shown below.

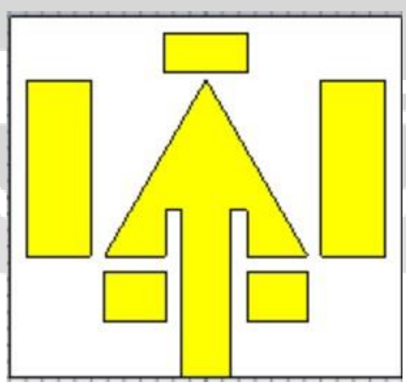


Fig 3(a):top view of the design

This figure below shows a microstrip triangular patch antenna with parasitic band elements responsible for resonating the antenna at different frequency bands. This proposed antenna uses a triangular chip and a power supply to the patch and the antenna section with a 50 ohms transmission line.

Below fig, shows the profile view of design

Fig 3(b): side view of designed antenna

The microstrip antenna is triangular in shape, and two slots are cut at the one side of patch to enhance S-parameters and impedance parameters, as illustrated in the figure above and optimized in the CST microwave simulator.

The patch antenna design with DGS is shown below.

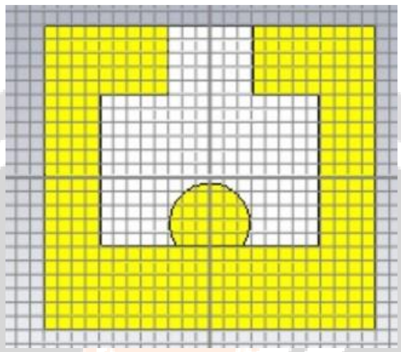


Fig 3(c): back view of antenna design

The above figure describes the construction of DGS patch antenna. The antenna model has the triangular patch at the top and an open square loop on the base plate.

IV. Results and Discussion:

S-Parameters:

Return loss of a multiband microstrip antenna is described. The S-parameters versus frequency curve is shown below. The return loss is shown to be -44.86 dBi at the frequency of 6.5 GHz, -23.54 dBi at the frequency of 10.37 GHz, -18.76 dBi at the frequency of 12.81 GHz, -11.69 dBi at the resonant frequency of 18.555 GHz at different frequencies.

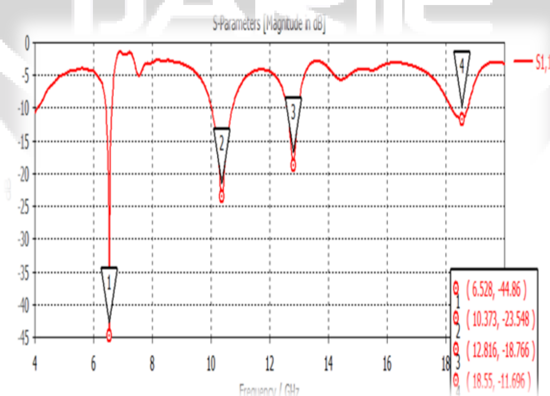


Fig 4(a): S11 Parameter of the proposed antenna

VSWR:

The figure below shows a plot of voltage standing wave ratio versus frequency. The graph clearly shows that the VSWR is 1.0115 at the required frequency.

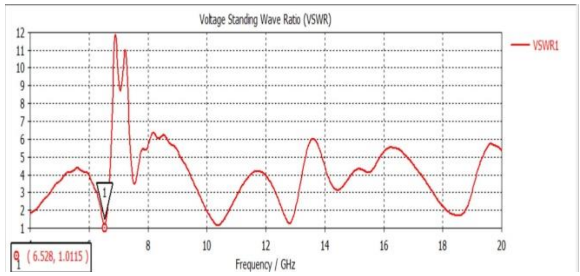


Fig 4(b): VSWR of the designed antenna

Input antenna Impedance:

The impedance versus frequency curve of Z-parameters is shown in figure below. The image clearly shows that the Z-parameters of real part of the impedance is almost 50 ohms, that means the characteristic resistance of the supply line matches the load resistance and the imaginary part is close to zero i.e., reactance is zero.

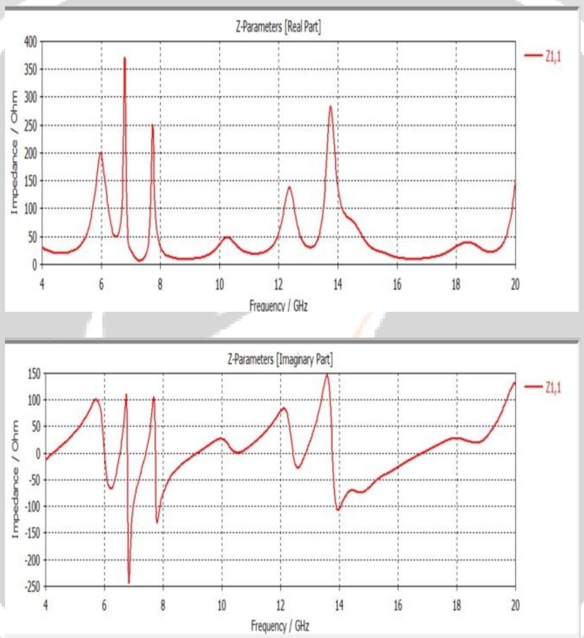


Fig 4(c): Reference Input Impedance of the antenna

Gain& Directivity:

A 3D view of antenna gain with DGS can also be seen in the image below. Gain of the designed ground is effective so that the antenna works well at 6.5 GHz.

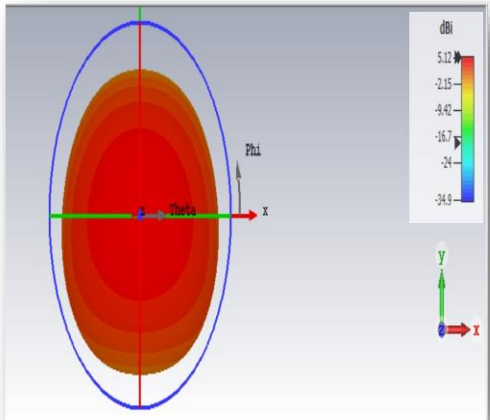
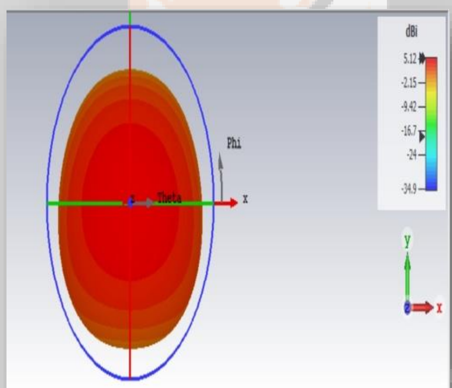
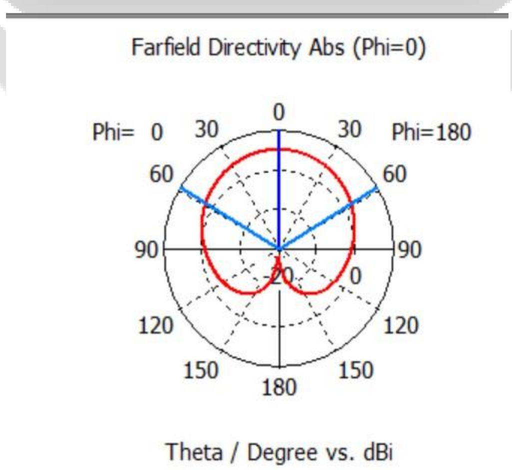


Fig 4(d): Gain &Directivity of antenna design

Radiation Pattern:

The figure below shows the field pattern of the antenna designed. The field pattern of the antenna is described as a graph of the distribution of the intensities of power radiated in space at any given frequency.





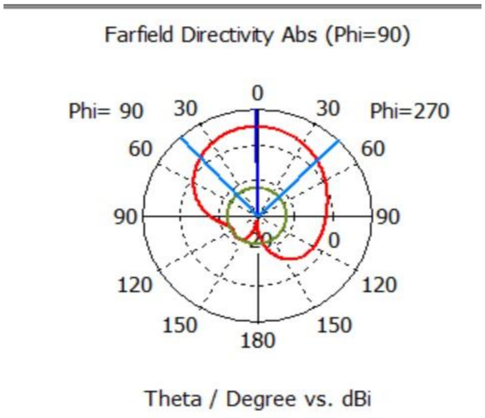


Fig 4(e): Field Pattern of antenna design

V. Conclusion:

This work is focused on designing and simulating a multiband triangular patch antenna with a Defective Ground Structure and a microstrip feed line using the CST Microwave Studio Suite Simulator. In this regard, a triangular microstrip patch antenna is designed to resonate at a frequency of 6.5 GHz. Further, the presence of the parasitic strips can considerably improve the performance of antenna design. Thereafter, the performance of the proposed multiband patch antenna with parasitic strips is validated. The antenna has a small size of 21 mm × 23 mm and is easy to design. The Bandwidth of the designed antenna is 200MHz which maintains the frequency bands occurred at different frequencies (i.e., -44.86dBi at 6.5GHz, -23.54dBi at 10.37GHz, -18.76dBi at 12.81GHz and -11.69dBi at the resonant frequency 18.55GHz). The impedance alignment is 50Ω at the resonance frequency of designed antenna, which further shows excellent impedance optimization. Application areas will include, but are not limited to, satellite communication and weather radar systems.

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