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A DESIGN AND ANALYSIS OF T-SHAPE PATCH ANTENNA FOR 5G APPLICATIONS USING HFSS SOFTWARE

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ABSTRACT

As technologies are advancing day by day after the successful implementation of 4G network. Now, the technology is footed into 5G communications. The prime need for the communication system is to provide high gain antennas which are capable of delivering 5G frequencies. A structure of antenna is integrated with lumped radiator and T-shaped patch on the radiating element. To provide antenna solution for 5G, a T-shaped antenna has been proposed. The T-shaped micro-patch antenna is designed to operate on 34GHz frequency. The proposed configuration has the antenna has S11 <-10dB bandwidth of 4.39GHz at 28GHz and 2.36GHz at 34GHz. The obtained bandwidth can easily satisfy the requirement of 5G and higher satellite band. Which is highly compact size, overall radiation efficiency, good gain, table radiation pattern obtained at targeted 5G applications by DGS technology?

Keywords: *T-Shaped antenna, HFSS Software, DGS technology*.

1. INTRODUCTION

"An Antenna is an electromagnetic radiator, a sensor, a transducer and an impedance matching device with extensive applications in all communications, Radar and in Bio-Medical systems". An antenna is basically a transducer. It converts radio frequency (RF) electrical current in to an electromagnetic (EM) wave of same frequency. It produces electric and magnetic fields, an electromagnetic field. The tar and reception of EM energy is obtained by this field. It forms a part of transmitter as well as receiver circuits. Its equivalent circuit is characterized by the presence of distributed elements, namely, resistance, inductance and capacitance. The current produces magnetic field and the charge produces electrostatic field. These two in turn create an induction field. When RF signal is applied to an antenna, electric and magnetic fields are produced. These two fields constitute the EM wave. As a result, antenna is known as a generator / radiator of EM waves and it is also a sensor of EM waves. The electric and magnetic fields of EM wave are perpendicular to each other and hence E.H=0. EM waves carry information signals from transmitter to receiver. There is no communication system without one type of antenna or the other. The antennas are characterized by several parameters.

2. LITERATURE SURVEY

An antenna is generally a bidirectional device, that is, the power through the antenna can flow in both directions, coupling electromagnetic energy from the transmitter to free space and from free space to the receiver, and hence it works as a transmitting as well as a receiving device. Transmission lines are used to transfer electromagnetic energy from one point to another within a circuit and this mode of energy transfer is generally known as guided wave propagation. An antenna can be thought of as a mode transformer which transforms a guided-wave field distribution into a radiated-wave field distribution. It can also be thought of as a mode transformer which transforms a radiated-wave field distribution into a guided-wave field distribution (since the two waves may have different impedances, it may also be thought of as an impedance transformer).

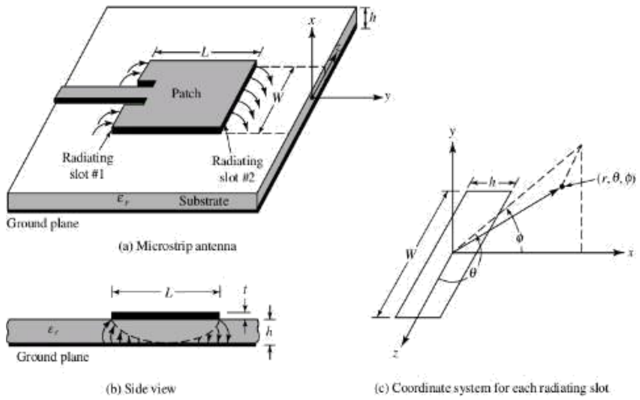
3. BASIC CHARACTERISTICS

Microstrip antennas, as shown in Figure 3.2, consist of a very thin ($t \ll \lambda 0$, where$\lambda 0$ is the free-space wavelength) metallic strip (patch) placed a small fraction of a wavelength ($h \ll \lambda 0$, usually $0.003\lambda 0 \leq h \leq 0.05\lambda 0$) above a ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch. End-fire radiation can also be accomplished by judicious mode selection. For a rectangular patch, the length L of the element is usually $\lambda 0/3 < L < \lambda 0/2$. The strip (patch) and the ground plane are separated by a dielectric sheet (referred to as the substrate). There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq \ \leq 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. The radiating elements and the feed lines are usually photo-etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other configuration. Square, rectangular, dipole (strip), and circular are the most

common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. There are various methods of analysis for microstrip antennas with the most popular models being the transmission-line, cavity, and full wave models (which include primarily integral equations/Moment Method).The transmission-line model is the easiest of all, it gives good physical insight, but is less accurate and it is more difficult to model coupling.

4. WORKING OF MICRO PATCHES ANTENNA

Patch Antenna or Microstrip Antenna Some patch antennas do not use a dielectric substrate and instead made of a metal patch mounted above a ground plane using dielectric spacers. The resulting structure is less rugged but has a wider bandwidth. Patch antennas can be designed rom the UHF band to as high as 100 GHz. The basic working principles of microstrip patch antennas are: The patch acts approximately as a resonant cavity (with short-circuit (PEC) walls on top and bottom, open-circuit (PMC) walls on the edges). Radiation is accounted for by using an effective loss tangent for the substrate. In a cavity, only certain modes are allowed to exist, at different resonance frequencies. If the antenna is excited at a resonance frequency, a strong field is set up inside the cavity, and a strong current on the (bottom) surface of the patch. This produces significant radiation (a good antenna). A microstrip antenna can radiate well, even with a thin substrate, because of resonance. As the substrate gets thinner the patch current radiates less, due to image cancellation (current and image are separated by 2h). However, the Q of the resonant cavity mode also increases, making the patch currents stronger at resonance. These two effects cancel, allowing the patch to radiate well even for thin substrates (though the bandwidth decreases).



5. DEFECTED GROUND STRUCTURE

The compact geometrical slots on the ground plane of microwave circuits are referred to as Defected Ground Structure (DGS). A single defect (unit cell) or a number of periodic and aperiodic defects configurations may be comprised in DGS. Thus, periodic and/or aperiodic defects etched on the ground plane of planar microwave circuits are referred to as DGS. Earlier Photonic Band Gap (PBG) and Electromagnetic Band Gap (EBG) have been reported with irregular ground planes. Defected ground structure (DGS), increases the performance of the system by deliberately altering the ground plane metal of micro strip circuit. DGS is analyzed by intentionally etching off a normal shape (slot or defect) in the ground surface plane which is called as “defect or fault”. Several forms and sizes of the defect, interrupts the shielded distribution of the micro strip current in the plane of ground, that results in propagation of the electromagnetic (EM) waves through the layers of substrate. This disturbance also changes the line inductance and capacitance of a transmission line. In fact, any slightly defect etched in the micro strip’s ground plane can enhance the effective capacitance and inductance. For better performance the shape of defect may be changed from the simple shape to the complex shape. Depending on the shape and configuration of the defects, the performance of micro strip system may be varied. The defects can be single or multiple in the ground plane. The defects can be used to suppress the coupling (mutual) between the elements and to decrease the harmonics. Defected Ground Structure has become very popular in the area of microwave engineering which is used in many applications and developments. Nowadays many researchers are working on the defected ground structures for antenna applications also for improving, bandwidth, size reduction, polarization and multiband applications. These structures are capable in improving the impedance bandwidth, resonant frequency and minimize the mutual coupling between the antenna arrays elements. In addition, it has presented that the DGS is also capable of eliminating and improving the return loss level. Defected Ground Structure has various other advantages for micro strip patch antennas. This is a good field for the research work and this technology has been deployed in various micro strip antennas for various applications.

6. DESIGN OF PATCH ANTENNA

1. Dielectric constant of the substrate: The dielectric material that is used in my design of the patch antenna is “RT DURIOD 5880” with relative permittivity, as this is one of the maximum values of the dielectric substrate has been taken to reduce the size of the antenna. The value of dielectric constant is taken as 2.2 whereas the substrate dimensions are taken as 12x12 mm^2.

2. Frequency of the operation (fr): The frequency of operation for this patch antenna design has been selected as 28 GHz.The T- antenna is used to operate at a frequency range of 24-38 GHz.

3. Height of the dielectric substrate (h): Micro strip patch antenna has been designed to overcome the drawbacks of the conventional antennas as the patch antennas are used in most of the compact devices. Therefore, the height of the antenna has been taken as 0.8 mm respectively. And, on the top of the substrate, a feed line is designed an characteristic impedance of 50 ohms. it allows it to be utilized on a breadboard, a Perf Board, or even a PCB, making it a common component in most electrical applications. There are two sorts of buzzers on the market now. The one pictured here is a simple buzzer that, when powered, produces a Continuous Beeeeeepp Beep. Beep. It produces sound owing to an inbuilt oscillating circuit. However, the one illustrated here is the most popular because it can be altered with the help of other circuits to meet specific needs.

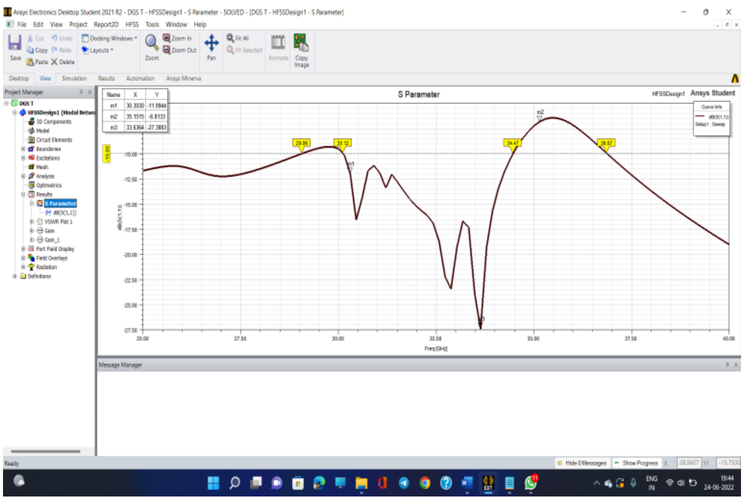
7. HFSS SOFTWARE

HFSS is a commercial finite element method solver for electromagnetic structures from Ansys. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines. HFSS is high frequency structure simulator it is high performance full wave electromagnetic field simulator 3D volumetric passive device modeling that takes advantages of familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling and automaton in easy to learn environment. ANSYS HFSS software is the industry standard for simulating high-frequency electromagnetic fields. Its gold-standard accuracy, advanced solvers and high-performance computing technologies make it an essential tool for engineers tasked with executing accurate and rapid design in high-frequency and high-speed electronic devices and platforms. HFSS offers state-of-the-art solver technologies based on finite element, integral equation, asymptotic and advanced hybrid methods to solve a wide range of microwave, RF and high-speed digital applications. HFSS delivers 3-D full-wave accuracy for components to enable RF and high- speed design. By leveraging advanced electromagnetic field simulators dynamically linked to powerful harmonic balance and transient circuit simulation, HFSS breaks the cycle of repeated design iterations and lengthy physical prototyping. With HFSS, engineering teams consistently achieve best-in-class design in a broad range of applications including antennas, phased arrays, passive RF/mW components, high-speed interconnects, connectors, IC packaging and PCB's. When combined with Ansys HPC technologies, like domain decomposition or distributed frequencies, HFSS can simulate at a speed and scale never before thought possible, further allowing you to more fully explore and optimize your device's performance. With HFSS you know your designs will deliver on their product promise.

8. RESULTS

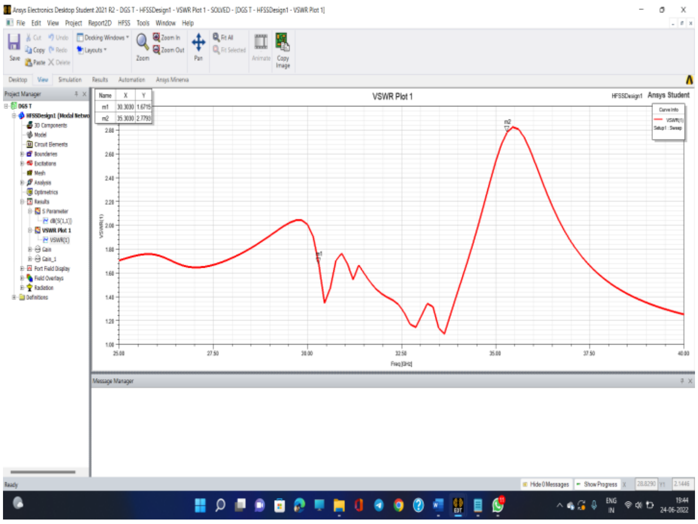
Return Loss Characteristics:

The return loss characteristics for DGS T patch shows that the antenna resonating at 25.5 GHz. By using defected ground structures, the resonating frequency can be improved. The return characteristics show that the DGS T antenna is resonating for multiple frequencies at 30.30GHz and 35.15GHz at the gains of -11.99dB and -6.813dB.



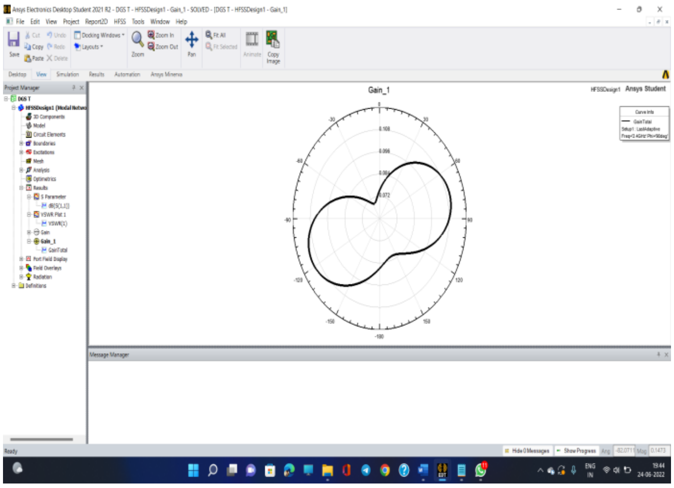
VSWR plot:

The VSWR response for DGS T- antenna is shown in figure. Ideally, the VSWR value should be 1. Practically, the value of VSWR should be < 2 which offers the best performance. The plot as shown in the figure.



Gain:

The T patch antenna has a gain of -10dB at a frequency range of 30GHz. The gain of DGS T antenna is as shown in the figure.



9. CONCLUSIONS

In this proposed, compact T-shape microstrip antenna is proposed for 5G wireless communication system. The proposed microstrip patch antenna was simulated and printed by using R/Duriod 5880 LZ, with an overall size of the microstrip patch antenna was 22×24×0.25mm3. Designing T-shape microstrip patch is done to overcome the narrow bandwidth limitation of the conventional microstrip patch antenna. This structure provides the best impedance matching at different frequencies and thus has stable radiation characteristics at different frequencies. Introducing a rectangular T-shaped aperture at ground level can improve the bandwidth of the low-frequency band. The optimize antenna's fractional bandwidth is 42.81% (2.90 GHz to 4.48 GHz) with a resonant frequency of 3.6 GHz and return loss -28.76 dB. The proposed antenna gain is 2.52 dB and the antenna efficiency is 98.474% at 3.6 GHz resonant frequency. This type of structure is more suitable for a long-term information technology due to the direction of their development. This feature has improved the proposed architecture making it suitable for various wireless communications such as 5G mobile applications. module which helps to send the location to their member in case the blind person gets lost or if they are in the danger. And the rain sensor is used to detect the water. This project is to people with disabilities that are blind to facilitate the movement and increase their safety.

10. FUTURE SCOPE

This T- patch MIMO antenna have a tremendous application potential. These type of array antennas are actively considered for application, such as satellite communication systems, where thin profile and light weight are important, consideration. The present model can be extended for array of patch antenna. For this development some additional models will have to be developed. Many applications in communications and radar required dual frequency.

The present work can be extended also for designing of triple band frequency patch antenna. This Antenna design can be continuously improved to achieve better performance and also new designs will be required for high bandwidth applications. These antennas are used to provide high gain with good band width. By using DGS technique, it is used to give small size antennas with compact size, low profile and planar geometry. In future communication applications, it is vastly used for greater reliability and provides solutions for 5G communications.

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