DESIGN OF E-SHAPED MICROSTRIP PATCH ANTENNA WITH EDGE FEEDING ON DGS FOR WIRELESS COMMUNICATION

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Abstract -*The design and performance assessment of an E-shaped microstrip patch antenna with edge feeding and Defected Ground Structure (DGS) at a resonant frequency of 5.2 GHz are presented in this work. The antenna shows a stunning return loss of -30.6038 dB and an impressive gain of 5.58, indicating effective impedance matching and radiation characteristics. Edge feeding and DGS improve directivity and reduce undesired radiation, which improves antenna performance. For a variety of wireless communication applications requiring excellent performance in the 5.2 GHz frequency region, this small and effective antenna design shows promise.*

Key Words: **ANSYS HFSS, E-shaped, Edge Feed, FR4 epoxy, S-parameter, Gain, Directivity, VSWR.**

1.INTRODUCTION

The need for high-performance, small-sized antennas that operate at certain frequencies is constantly growing in today's wireless communication systems. Microstrip patch antennas are unique among antenna designs because of their small size, light weight, and simplicity of integration into electrical systems. In order to obtain a gain of 5.58 and a return loss of -30.6038 dB, this brief describes the design of an E-shaped microstrip patchantenna with edge feeding and Defected Ground Structure (DGS) operating at 5.2 GHz. Unique benefits of the E-shaped microstrip patch antenna arrangement include better impedance matching and increased tuning possibilities. This design modification improves control over the antenna's resonance frequency and radiation properties by adding a letter "E"-shaped protrusion to the rectangular patch. To reduce complexity and boost antenna performance, edge feeding—placing the feeding mechanism along the patch's edge—is used. This feeding method keeps the antenna footprint small while enabling effective stimulation of the radiating components.

1.1 Statement of the problem

The task at hand involves creating a microstrip patch antenna that can operate at 5.2 GHz and has two specified parameters: a return loss of -30.6038dB and a gain of 5.58. An E-shaped patch with edge feeding on a Defected Ground Structure (DGS) is part of the antenna layout. Optimizing the antenna's size and feed structure to meet the required performance standards within the available frequency range is the difficult part.

1.2 Objective

With a phenomenal return loss of -30.6038 dB and an operating frequency of 5.2 GHz, an E-shaped microstrip patch antenna edge-fed with defective ground structure (DGS) performs very well in small wireless communication systems.

1.3 Methodology

Design considerations and processes are used to create an antenna tailored to the desired frequency range.
• Use HFSS to model the antenna.
• Design parameter optimization and simulation.

2. Literature review

Due to its promising performance features, the E-shaped microstrip patch antenna with edge feeding on Defected Ground Structure (DGS) operating at 5.2 GHz has received a lot of attention in recent research. When compared to traditional patch antennas, the E-shaped arrangement has a number of benefits, such as small size, broad bandwidth, and improved radiation properties. The antenna's performance is further enhanced by the addition of Defective Ground Structure, which lowers radiation losses and suppresses surface wave excitation, improving gain and bandwidth. Several research concentrating on different facets of this antenna design have been published, according to a thorough study of the literature. To maximize performance metrics including gain, return loss, bandwidth, and radiation pattern, researchers have looked at various materials, substrate designs, and feeding methods. To assess and improve the antenna's performance, a number of design approaches have been used, including experimental validation and numerical simulations with electromagnetic simulation software. To comprehend how feeding methods, substrate characteristics, and geometrical aspects affect antenna performance, parametric studies have been carried out.Additionally, attempts have been made to improve the antenna's performance for certain uses, such satellite communications, radar systems, and wireless communication systems. Methods like as frequency tuning, polarization diversity, and met material loading have been investigated to customize the antenna properties to fit various applications

The literature, taken as a whole, highlights the potential uses of the E-shaped microstrip patch antenna with edge feeding on DGS at 5.2 GHz for a variety of wireless communication and sensing applications. To increase this antenna configuration's performance and adaptability, more investigation is necessary into novel design ideas, manufacturing processes, and integration opportunities.

3. Introduction to HFSS

High-performance full-wave electromagnetic (EM) field simulator HFSS leverages the graphical user interface of Microsoft Windows to enable arbitrary 3D volumetric passive device modeling. Solutions to your 3D EM challenges may be acquired fast and precisely because to its integration of solid modeling, automation, simulation, and visualization in an intuitive learning environment. To provide you with unmatched performance and insight into all of your 3D EM challenges, Ansoft HFSS uses adaptive meshing, the Finite Element Method (FEM), and stunning visualizations. Measurements like S-parameters, resonant frequency, and fields may be computed using ansoft HFSS.

4. MICROSTRIP PATCH ANTENNA

Planar antennas have drawn the attention of several academics and researchers throughout the past few decades. The need for a small, compact antenna that can be combined with MMIC design has grown since the early 1970s, when electronic circuit downsizing and large-scale integration underwent a revolution. Substrate-based planar antennas are simple to manufacture and integrate with MMICs and PCBs. These antennas have benefits including simplicity of construction, light weight, and low profile.

Designation	Frequency	Typical uses
L band	1 to 2 GHz	Military telemetry, GPS, mobile phones (GSM), amateur radio
S band	2 to 4 GHz	Weather radar, surface ship radar, some communications satellites, microwave ovens, microwave devices/ communications, radio astronomy, mobile phones, wireless LAN, Bluetooth, Zig-Bee, GPS, amateur radio
C band	4 to 8 GHz	Long-distance radio telecommunications
X band	8 to 12 GHz	Satellite communications, radar, terrestrial broadband, space communications, amateur radio, molecular rotational spectroscopy
Ku band	12 to 18 GHz	Satellite communications, molecular rotational spectroscopy
K band	18 to 26.5 GHz	Radar, satellite communications, astronomical observations, automotive radar, molecular rotational spectroscopy
Ka band	26.5 to 40 GHz	Satellite communications, molecular rotational spectroscopy
Q band	33 to 50 GHz	Satellite communications, terrestrial microwave communications, radio astronomy, automotive radar

Table -1: frequency spectrum

The electromagnetic spectrum's microwave band includes the S-band. It transcends the traditional 3.0 GHz line that separates UHF and SHF frequencies, and is specified by an IEEE standard for radio waves with frequencies that extend from 2 to 4 GHz. Radar used by surface ships and weather stations both operate in the S band. Certain regions of the electromagnetic spectrum, such as microwave wavelengths utilized for long-distance communications, are referred to as the C-band. The C-band (4 to 8 GHz) and its somewhat modified bands encompass frequency ranges utilized by certain Wi-Fi gadgets, certain cordless phones, and certain weather radar systems.

4.1 Method of microstrip antenna analysis

When scientists discovered that about half of the power in a microstrip radiator escapes as radiation, they understood the significance of microstrip radiators. Consequently, microstrip antennas were characterized as a microstrip emitting patch with a significant radiation loss. Subsequent research demonstrated that the discontinuities at each end of the microstrip transmission line were the source of this radiation process. A patch antenna's fundamental design consists of a flat plate placed over a ground plane and a dielectric substrate. Copper foil is often used to make the metal patch, however other forms of substrate material may be used instead, depending on the situation. As seen in Fig., the three layers are the bare minimum required to describe a patch antenna.

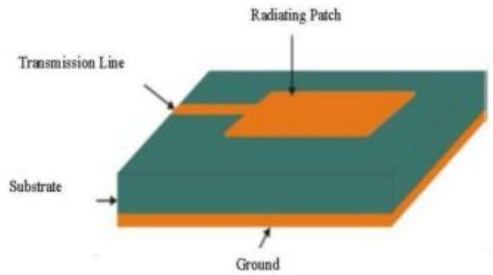

Fig -1: The fundamental geometry of a microstrip heater

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The majority of the analytical techniques for patch antennas take into account the 2D planar element. The transmission line model, cavity model, and full wave model are the three most used analytical techniques. The most basic model is the transmission line model, which provides a decent physical understanding but is not particularly precise. Although it is more difficult, the cavity model provides high accuracy and physical understanding. Lastly, compared to the other two models, the complete wave model is significantly more complicated to use and by far the most accurate and adaptable model. It also offers more alternatives. However, it provides less physical knowledge.

4.2 Model of Transmission Line

According to the transmission line concept, the rectangular patch antenna, as seen in Fig is a parallel plate transmission line connecting to radiating slots that are each of width W and height h. Charge is dispersed throughout the ground plane and the patch's bottom when it is stimulated by a feed line. The attractive forces between the ground plane and the patch's bottom tend to store a lot of charge at any given moment. Additionally, the charges are pushed to the patch's edge by the repulsive forces, which results in a high charge density on the edges.

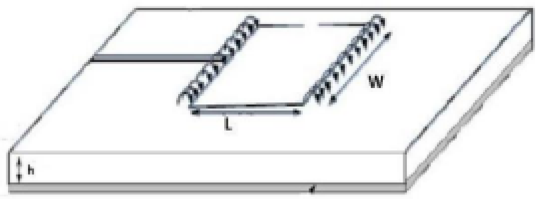

Fig -2: Curving Fields

5. E-SHAPED PATCH ANTENNA DESIGN

In wireless communication, a microstrip patch antenna is most frequently used to emit electromagnetic waves into space. A microstrip patch antenna's four basic parts are the ground, substrate, patch, and feed. It has a ground plane on one side and a dielectric constant on the other, and it can be square, elliptical, circular, rectangular, or ring-shaped. Microstrippatch antennas are used in many different applications, including as microwave communication, global positioning systems (GPS), automotive, and logistics tracking. A microstrip antenna is depicted in Figure 1 with W representing the width, L the length, and ε the effective dielectric constant of the rectangular patch.

5.2 Designing of E-Shaped patch antenna

To maximize its performance, an E-shaped patch antenna must be designed using a number of procedures and considerations. The main principles for creating an E-Shaped patch antenna are listed below:

1. Establish the frequency range or operational frequency of your antenna.
2. Selecting an appropriate dielectric substrate material is important. It's customary to utilize FR4.
3. Determine the permittivity (εr) of the substrate material.
4. Patch Dimensions: Find the E-Shaped patch's major and minor axes.

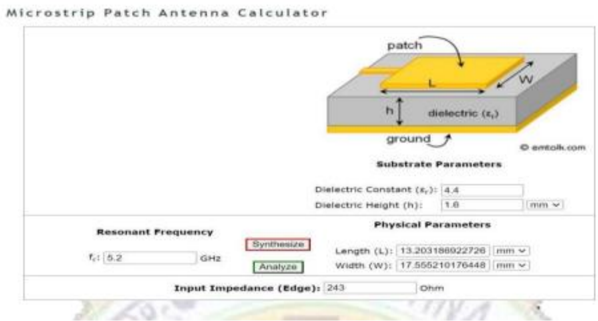

Fig -3: Patch calculator

PARAMETERS	EDGE FEED
Resonant Frequency (fr)	5.2GHz
Substrate	FR4 epoxy
Dielectric constant	4.4
Height of Substrate	1.6mm
Width of Patch	17.56mm
Length of Patch	12.56mm
Substrate Length	58.94mm
Substrate Width	35.9mm
Ground Plane Length	58.94mm
Ground Plane Width	35.9mm

Table -2: Antenna's measurements

6. Design of rectangular patch antenna in HFSS

- **Step 1:** creating a ground plane Material: copper Positions: 0,0,0 X size: length of the substrate Y size: width of the substrate Z size: height of the patch
- **Step 2:** creating a substrate Material: FR4-epoxy Positions :0,0,1.6 X size: length of the substrate Y size; width of the substrate Z size: height of the substrate
- **Step 3:** creating a patch Material: copper Positions: A,Ws/2-Wp/2,Hp+Hs
- **Step 4:** Edge feed

  Material: copper Position: A+Lp, Ws/2-Wf/2,Hp+Hs X size: Ls-A-Lp Y size: width of the feed Z size: height of the patch

- **Step5:** giving excitation Position: Ls,Ws/2-Wf/2,(Hp+Hs) Y size: width of the feed Z size: -(Hp+Hs)
- **Step6:**creating radiation boundary Operatingfrequency: 5.2GHz

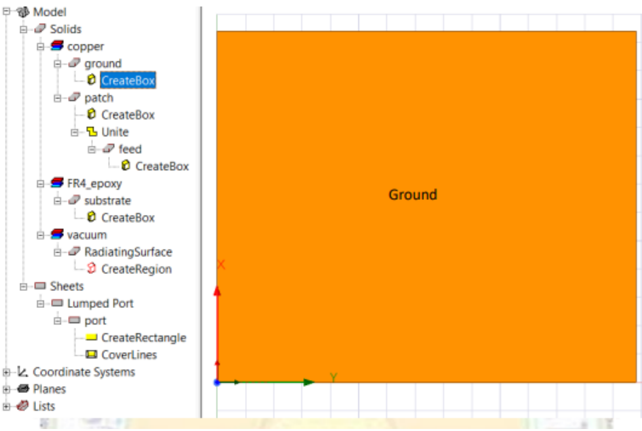

Fig -4: Utilizing ground

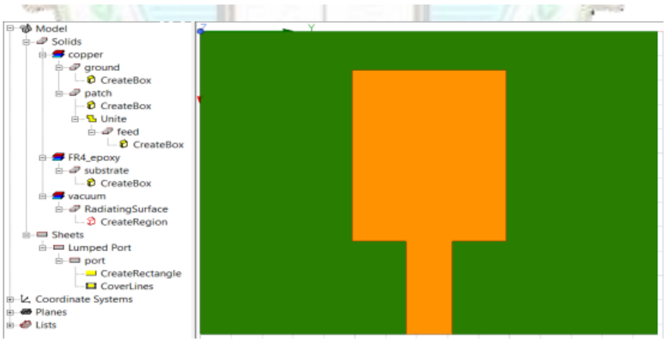

Fig -5: Putting on a substrate

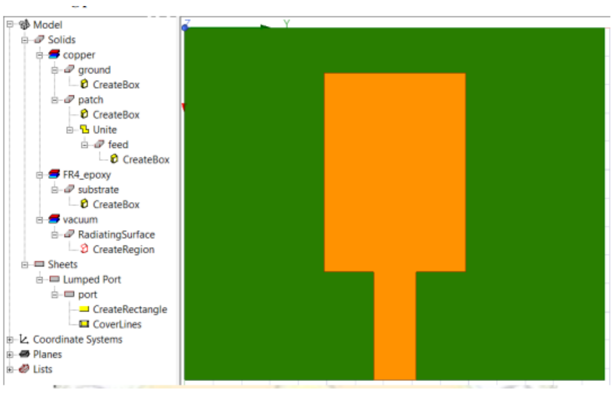

Fig -6: producing a patch

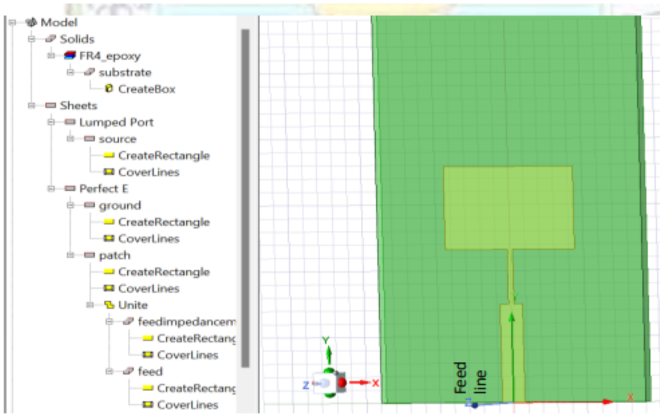

Fig -7: The edge feedline

7. RESULTS

A system's or antenna's ability to reflect power back to the source is measured by its return loss. It resembles the quantity of signal that is reflected back rather than sent forward. The aforementioned result suggests that the antenna exhibits perfect radiation since the return loss is relatively small at the radiated frequency of 5.2GHz.

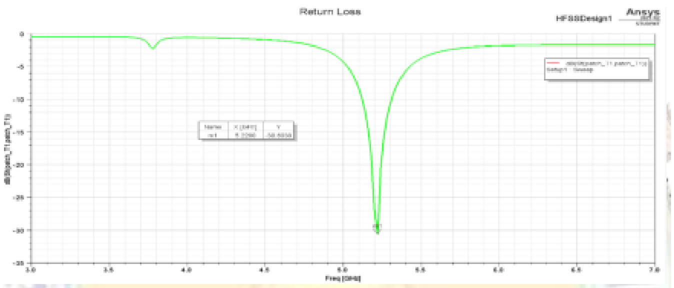

Fig -8: Return losses

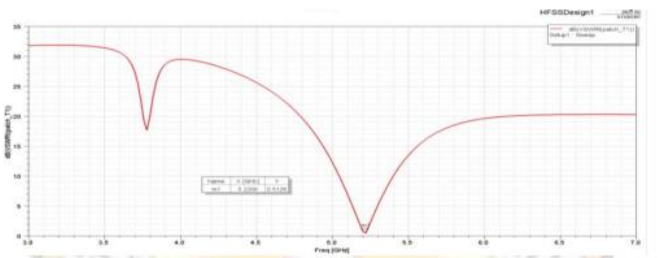

Fig -9: VSWR

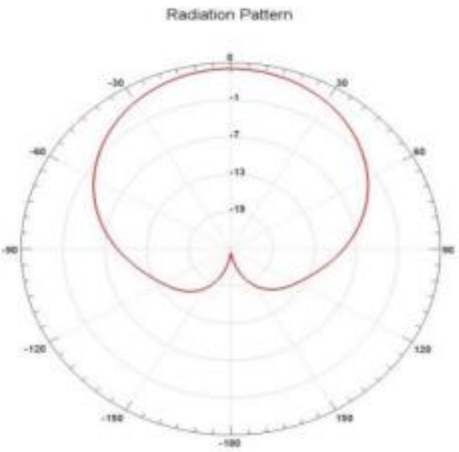

Fig -10: Radiation pattern

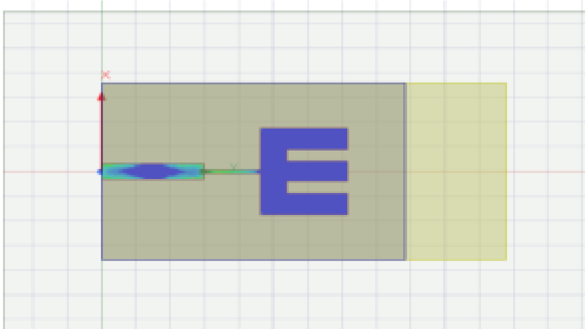

Fig -11: E-plane

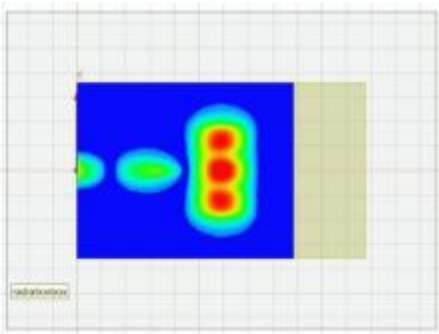

Fig -12: H-plane

8. CONCLUSIONS

In this study, a microstrip patch antenna with a resonance frequency of 5.2 GHz is constructed, simulated, and the results of the simulation are recorded using FR-4 epoxy as the substrate. The antenna design process uses the inset feeding approach. The E-Shaped patch antenna has a 5.2GHz bandwidth. Using HFSS software, an E-shaped patch antenna is simulated.

Parameters	Rectangular Microstrip Patch Antenna	E-Shaped Microstrip Patch Antenna on DGS
Return Loss	-30.3481	-30.6038
Gain	4.83	5.58
VSWR	0.52	0.51

Table-2: Results

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