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Design and Analysis of Microstrip Patch Antenna

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ABSTRACT: The design of microstrip patch antennas has gained significant attention in recent years due to their compact size, light weight, compatibility with modern communication systems. These antennas find applications in various fields, including wireless communication, satellite communication and radar systems. This abstract provides an overview of the key aspects involved in the design of microstrip patch antennas. The fundamental structure of a microstrip patch antenna consists of a thin metallic patch mounted on a dielectric substrate, typically with a ground plane on the opposite side. The size and shape of the patch, along with the dielectric properties of the substrate, play crucial roles in determining the antenna's performance characteristics.

KEYWORDS: Micro strip patch antenna, analysis, thin metallic etc.

I. INTRODUCTION

Since technology is developing so that anyone may communicate or learn about anything with just a small mobile cellular device, people in our modern society need to be connected to the outside world. For users to access the Internet, make phone calls, participate in video conferencing, and use other services, this equipment must function across a broad frequency range. All of these technologies require extremely small, highly efficient multi-band antennas since they operate at distinct frequencies. This can be accomplished by presenting the idea of antenna geometry. A MIMO (multiple input multiple output) antenna in the shape of an octagon is proposed for WLAN and WiMAX services. The octagonal configuration of the decagon-shaped antenna allows for MIMO and WLAN antenna. The antenna displays a recently designed triangle decagon fractal antenna that can be used in wireless applications. The regular polygon with ten sides is called a decagon. The suggested design consists of three layers to provide varied operating frequencies with improved performance. The top layer features ten slots in a decagon layout. The bottom layers are the rectangle patch layers. The ground plane and the patch from the dielectric substrate are separated from one another. For antenna design, a substrate with a dielectric constant of 4.4 is utilized. The suggested antenna is provided together with its radiation pattern, gain, and simulated reflection properties.

II. RELATED WORK

A. "Design of Microstrip Patch Antennas for 5G Wireless Communication". Authors: S. K. Behera and S. K. Patra The paper reviews the design and performance parameters of 4G and 5G antennas, such as size, substrate material, polarization, gain, efficiency, and port isolation. It also reports various miniaturization techniques and multi-band parametric optimization for 5G microstrip antennas. It also analyses, designs, optimizes, and develops some examples of 5G microstrip antennas using HFSS software.

B. "5G wireless communication microstrip patch antenna array design with MIMO". Authors: The paper proposes a circular array microstrip patch antenna design for 5G wireless communication, using the millimeter wave band and the MIMO feeding technique. It shows the radiation pattern, directivity, and gain of the proposed antenna array using CST software. C. "Decagon Fractal Antenna for Antenna For Wireless Applications". Authors: S. Malathi, A. Sudheera, K. Lakshmi Durga

ANTENNA DESIGN

An antenna patch printed on a ground plane that radiates only within a designated frequency band is the fundamental form of a patch antenna. With a resonant frequency of 8GHz, the suggested antenna geometry is developed on an FR4 epoxy substrate with a thickness of 1.6mm and a relative permittivity of 4.4. Here, the antenna's top side is shaped like a decagon, while the bottom side is ground to produce ultra-wideband properties with a broad bandwidth. The total dimensions of a substrate are 42 mm in length, 40 mm in width, and 1.6 mm in height. The above Figure 1 depicts the suggested antenna design.

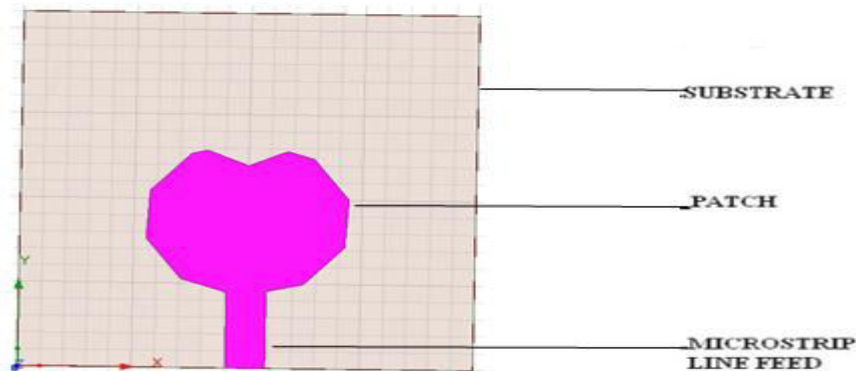


Figure1: Proposed antenna geometry

Different parameters of the antenna are calculated by using the below mathematical expressions:
The width of the microstrip patch antenna can be calculated by using following formula

$$W = \frac{c}{2f} \sqrt{\frac{2}{\epsilon_r + 1}} \dots\dots\dots(1)$$

The actual length of the microstrip patch antenna:

$$L = L_{eff} - 2\Delta L \dots\dots\dots(2)$$

Where

w-width of the patch

c-velocity of light(3×10⁸m/s)

L-length of the patch f-resonant frequency

ε_r- relative permittivity of the dielectric substrate Effective length of the patch is given by:(3)

ε_{eff}=dielectric constant

$$L_{eff} = \frac{c}{2f\sqrt{\epsilon_{reff}}} \dots\dots\dots(3)$$

Normalized extension in length is given by:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}} \dots\dots\dots(4)$$

Where
 ΔL - length extension

Effective dielectric constant:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}} \quad (5)$$

Table: Optimized parameter of the proposed antenna

Parameter	Length (mm)	Width (mm)	Height (mm)
Substrate	42	40	1.6
Ground	42	40	1.6
Feed	10	3.5	0
Radiation box	60	60	30

III. RESULT

The Each simulation is run through and observed using the Ansys High-Frequency structure simulator. From the HFSS program, all of the simulated results are extracted and loaded into the origin software, where each data plot is simultaneously plotted into a single figure.

Return loss:

Return loss is the ratio of the amount of radio waves that are rejected to the amount that arrives at the antenna input. The return loss of suggested antenna is -20.33Db

VSWR:

The voltage standing wave ratio quantifies the effectiveness of radiofrequency power transfer from a power source to a load via a transmission line. Most antenna applications are thought to benefit from a VSWR value of less than 2

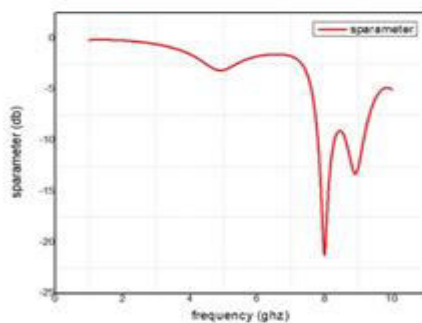


Figure.2 S-Parameter

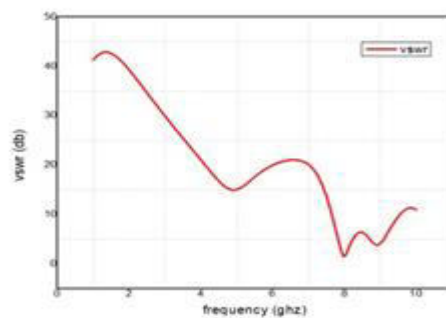


Figure.3: VSWR



GAIN:

When an antenna is compared to a theoretical antenna, the gain is its ability to emit more or less in any direction. If an antenna could be built into the shape of a perfect sphere, it would radiate equally in all directions. The gain of the suggested antenna is 5.03 dB.

RADIATION PATTERN:

It describes how the intensity of radio waves coming from an antenna or another source varies with direction. When an antenna radiates in the main lobe rather than the side lobe, it performs at its best.

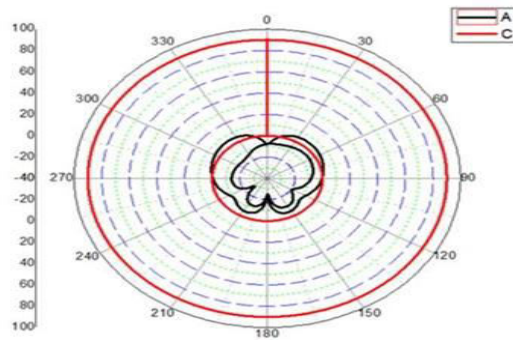


Fig. Radiation Pattern

References	Resonant Frequency (GHz)	Return Loss (dB)	Gain (dBi)
1	4.1	-8.44	2.3
2	2.4	-26	2.4
3	11.4	-25.33	8.02
4	25	-25.6	5.05

Table2: Comparison with Existing Work

Parameters	Results
Resonate frequency (GHz)	8
Return loss(dB)	-20.33
VSWR	1.51
Gain (dB)	5.03
Radiation efficiency	85%
Front to back ratio	21
Peak Directivity	5.28

Table3: performance parameters of decagon antenna results



IV. CONCLUSION

The features of a decagon fractal antenna, including radiation pattern, gain, VSWR, and return loss, are simulated and displayed. The antenna's gain increases when the fractal structure's iterations are increased. According to the report, the decagon microstrip antenna is one of the small, lightweight antennas with a wide range of applications. The designed antenna has a gain of 5.03dB, return loss of -20.33 dB, and a resonant frequency of 8GHz.

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