Design and Development of Microstrip Antenna

Rajat Kuralkar
dept. of electronics and telecommunication engineering
Prof. Ram Meghe institute of technology and research
Amravati, India
rajatkuralkar2@gmail.com

Sanket Nirmal
Asst. Professor, dept. of electronics and telecommunication engineering
Prof. Ram Meghe institute of technology and research
Amravati, India
nirmal.sanket@gmail.com

Prashik Jarunde
dept. of electronics and telecommunication engineering
Prof. Ram Meghe institute of technology and research
Amravati, India
prashikjarunde29@gmail.com

Atharv Bhadange
dept. of electronics and telecommunication engineering
Prof. Ram Meghe institute of technology and research
Amravati, India
atharvbhadange@gmail.com

***Abstract*— This paper represents the design of a rectangular microstrip antenna for the working frequency range of 2.4 GHz which is developed on a substrate material and the simulation is done on HFSS software the supply to the micro strip antenna is provided by the feed line which has the impedance of 50ohm and the dielectric constant for the material is 4.4 for improving the bandwidth we have used this slotted rectangular patch antenna and the characteristics of the above antenna deliberated by using the HFSS (high-frequently structure simulator) software used for simulation of electromagnetism it is widely used in electromagnetic compatibility it provides the graphical interface for 3D models which also consist of various types of tools for the optimization of high-frequency device and component. The application for the microstrip antenna can be used in mobile communication such as mobile phones and tablets and many other devices. It can also be used in satellite communication because of its ability to provide low noise and high bandwidth, and it can also be used in medical applications and military aerospace.**

***Keywords*— *Microstrip Antenna, HFSS, wideband Frequency, Radiation,*Substrate, Optometric, Patch**

I. Introduction

Antenna is a transceiver used for transmitting and receiving radio frequency waves the first developed by Heinrich Rudolf Hertz in 1886 and the antenna is called a Hertz antenna also known as dipole antenna further development and commercialization is done by Gulielmo Giovanni Marconi

It was Deschamps who built the first microstrip antenna connected to its transmission line in 1953. Gutton and Bassinot then patented the first microstrip antenna design in 1955. Twenty years later, Muson and Howell conducted the first experiment on the microstrip antenna and made it public. The radiation of electromagnetic waves and applications related to electromagnetic induction have been in use since the early 1950s.

II. What is a Microstrip Antenna

Substrate ground and a conductive patch are identical. Gold and copper are the main components of conducting patch material. Gold is used in high-tech applications where accuracy is critical due to its superconductor properties. Yet, copper is also frequently used because it is more cost-effective. Modern metal patches come in a variety of shapes, including square, triangular, and round, depending on the working frequency. The patch is constructed using an insulating substrate like those that are typically used to construct microstrip antennas.

Substrate	Er	Loss Tangent	Resonant Frequency	Return frequency	Gain
Benzocyclobutance	2.6	0	2.04GHz	-18.124	5.5
Duroid 6010	10.7	.0060	2.455GHz	-9.449	4.02
Nylon fabric	3.6	.0083	989MHz	-35.42	6.11
Roger 4350	3.48	.004	2.586GHZ	-25.29	4.62
RT-Duroid	2.2	.0009	454MHz	-39.49	12.03
Foam	1.05	0	454MHz	-16.732	2.73
FR-4	4.4	.018	5.8GHz	-14.73	9.8

The third element of the microstrip antenna is the ground plane, which is made of the same material as the conducting patch and is joined to it by a connecting wire. As Fr4 is an economical and efficient material, we use it as our substrate material. The feed line supplies power to the microstrip antenna; as the power is supplied, electromagnetic waves begin to be created through the conducting patch. They gate terminate on the ground plane, which is located on the opposite side of the conducting patch.

III. STEP AND INSTRUCTION

For designing your microstrip patch antenna, we need three structures: a ground plane, a dielectric substrate, and a patch above the substrate

For antenna design, first, calculate the width and length of the microstrip antenna.

1. Dielectric constant: 4.4
2. Dielectric height: 1.6 mm
3. Resonant Frequency (Fr): 2.4GHz
4. Length(L): 29.44mm
5. Width(W): 38.03mm
6. Input Impedance: 50 ohms

Following table gives information about the positioning of the Microstrip antenna on HFSS software

Table 1. Position and dimensions of patch antenna

Sr. No.	Instance	Positions	X axis	Y axis	Z axis
1	Radiation	-40, -40, -20	80	80	40
2	Substrate	-30, -30, 0	60	60	1.6
3	Port	-30, -1.5, 1.6	X	3	-1.6
4	Ground	-30, -30, 0	60	60	Z
5	Patch	-29.4/2, -38/2, 1.6	29.4	38	Z
6	Cut	14.7, -2.5, 1.6	-9.5	5	Z
7	Feed	0, -1.5, 1.6	30	3	Z

1. First, we try to create the ground plane by using the rectangle, which is two-dimensional. Double-click on this rectangle name; it has ground. Click on create a rectangle to change the dimension. (Dimensions of the ground plane are as given above the table.)
2. Over this ground plane, place a dielectric substrate; for that, you can start at the same point where you started for the ground plane. Draw a box of the same size and extend it in the Z direction.

Click on the box so we can name this "substrate **Figure.1**

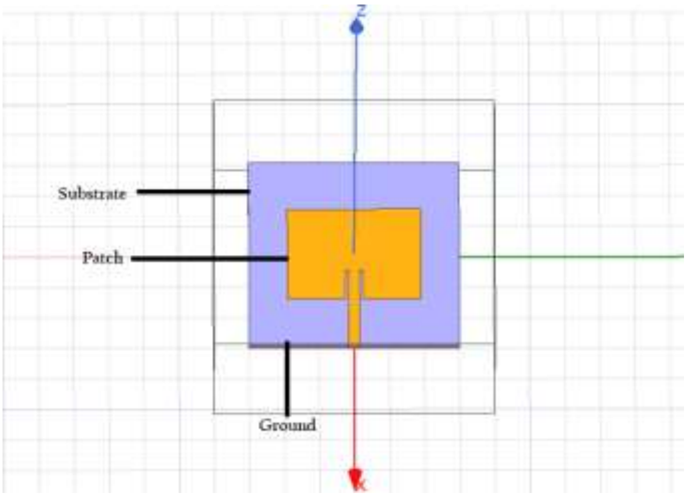

Fig 1 The structure of microstrip antenna

3. ". For a substrate, we are going to use FR4 as a dielectric substrate. Change the material from vacuum to FR4 epoxy.
4. Over the substrate, you need to place a patch. The patch's width and length have already been calculated. Click on the rectangle and name it a patch.
5. To make this patch, we need to provide a feed line and create a rectangle along the X-axis. So, this is acting as a feed. Click on the rectangle and name it "Feed"
6. But the impedance of these patches is 50 ohms. If you make a cut, the impedance of these patches will decrease or match the patch. We can design a rectangle over the feedline and call it a cut.
7. Select the patch and cut, then click on "subtract."
8. Now click "on patch," "feed," and "unite."
9. We have to create a port to give an input through an SMA connector.

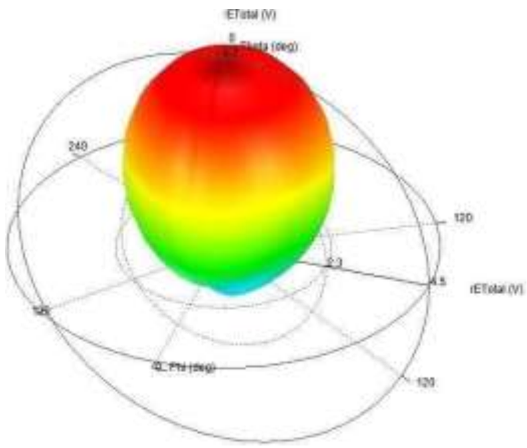

Figure.2 Radiation pattern of microstrip antenna.

- First, change the mode from XY to YZ, click on the rectangle, and name its port. Next, assign an excitationto the port.

- In a similar manner, these antenna designs must be radiated for this simulation environment to be created.
- For that, we use a draw box, create an environment, name this a radiation box, change the material to air, and change the transparency from 0 to 1.
- Substrate is provided with FR4 epoxy, but the ground and patch are not assigned any medical application.
- Select patch and ground then right-click on it andselect assign boundary-perfect E.
- Similarly, you have to assign radiation, for radiation select radiation-right click on it and select radiation.
- Next, we have to perform an analysis, so right-click onanalysis-add frequency sweep
- Take a frequency as 2.4GHz and the maximumnumber of passes as 20.
- When everything has been done validate the antenna, click on HFFS and validation check and analyze all

IV. Scattering Parameter results of Microstrip antenna

The S-parameter, also known as the scattering parameter, measures how effectively microstrip antennas, a type of printed antenna used for wireless communication, operate in the S-parameters characterize how the antenna scatters or reflects electromagnetic waves at its ports and are often represented as a matrix of complex integers. A useful component of HFSS is parametric analysis, which allows you to investigate how different design factors affect a microstrip antenna's performance.

With reference to the given fig. It showing the output for -10 db impedance bandwidth at two different consecutive points namely M1 and M2. The values are given below

M1= 2.3322 GHz

M2 = 2.4400 GHz

And the difference between M1 and M2 is exact bandwidth of our antenna in which it radiates

Bandwidth = M2 – M1 2.4400-2.3322 = 0.1078 GHz

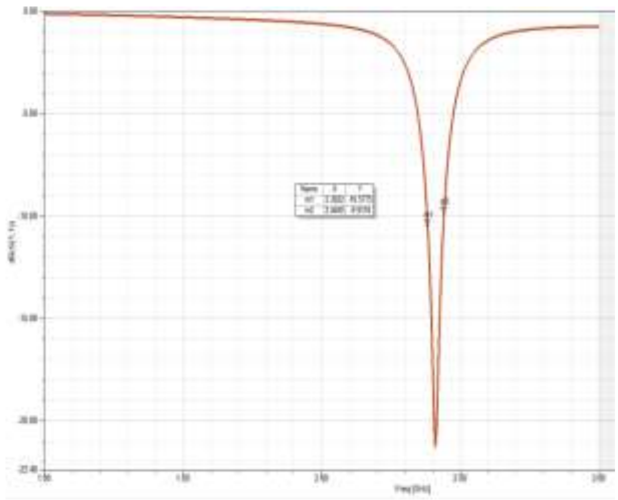

Figure 3. S11 parameter of microstrip antenna

Fig. 4 Optometric parameter simulation result

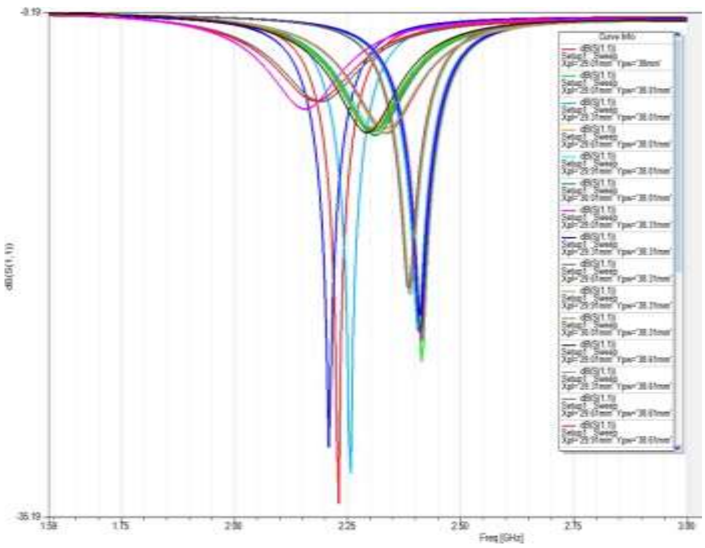

Fig. 4 Optometric parameter simulation result

V. Parametric optimization

The concept of "parametric" in the context of the HFSS (High- Frequency Structure Simulator) software refers to having the ability to construct and manipulate geometry using parameters that may be easily altered to change the parameters or characteristics of a model. Geometric parameters can be readily altered to examine the effects of various design decisions in parametric modelling, which enables effective and flexible design exploration. Parametric modelling is frequently used in HFSS to design intricate structures like antennas, waveguides, and microwave circuits. Dimensions, material characteristics, and excitation parameters are examples of design parameters that can be described as variables. Their values can be simply changed to examine how the design responds to various situations. Faster design iterations and electromagnetic structure optimization are made possible by parametric modelling in HFSS, which enables designers to swiftly change parameter values and iterate and optimize their designs.

- Start a new HFSS project and sketch the microstrip antenna's shape.
- Specify the factors you wish to alter in the parametric analysis, such as the size of the patch, the substrate's height, or the placement of the feed.
- Indicate the number of steps in the parametric sweep as well as the range of values for each variable. You have the option of using many variables or sweeping each one separately.
- Set the parameters for the excitation port as well as the frequency range, number of frequency points, and simulation settings.
- Pick "Parametric Analysis" under the "Solve" tab and pick the sort of analysis you wish to do, such as a "sweep" or "optimization."
- Carry out the simulation and provide the results for each parametric sweep step.

VI. ADVANTAGES

1. Low profile: Microstrip antennas tend to be lightweight and thin, making them ideal for applications with limited space

2. Broad frequency range: Microstrip antennas can work across an extensive spectrum of frequencies. enabling them to be used in various situations

3. Simple integration: they are a popular option for many wireless applications to combine with other components or within a larger system

4. Directional radiation pattern: It is possible to build a which enhances signal quality and lesson in some situations

VII. DISADVANTAGES

1. Low radiation efficiency: Microstrip antennas can have lower radiation efficiency compared to other types of antennas, which can result in lower signal strength.

2. Narrow bandwidth: While microstrip antennas can have wide bandwidth, they can also have narrow bandwidth depending on the specific design.

3. Limited power handling: microstrip antennas are not well suited for high power applications, as they have limited power handling capacity.

4. Susceptibility to the environmental factor: t can be affected by environmental factors such as temperature and humidity which can affect their performance.

VIII. APPLICATION

1. Mobile application: Microstrip antennas are frequently used to send and receive signals in mobile phones, tablets, and other portable devices.

2. Satellite communication: Because of their small size, light weight, and simplicity of merging with other parts, microstrip antennas are used in satellite communication systems.

3. Radar and sensing: Radar and sensing applications, such as weather monitoring,

surveillance, and navigation, use microstrip antennas.

4. Wireless local area network (WLAN): WLAN technologies like Wi-fi and Bluetooth frequently employ microstrip antennas to deliver wireless connectivity in structures and other indoor settings.

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