iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VI **Month of publication:** June 2022

DOI: https://doi.org/10.22214/ijraset.2022.43746

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

Design and Simulation of Rectangular Microstrip Patch Antenna for 80 GHz

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Abstract— Wireless technology is one among the foremost significant topics to research within the world of communication systems and therefore the study of communication systems is incomplete without an understanding of the operation and fabrication of antennas. This was the main reason for choosing our mini-project specializing in this field of research. A BroadBand and High bandwidth Microstrip Patch Antenna is chosen for designing and simulation as they have low fabrication cost and hence are manufactured in large quantities. A Rectangular Microstrip Patch Antenna is designed using Rogers RT Duroid 5880 substrate with a 'tree' shape. The software used for designing and simulation purposes is Ansoft HFSS 15.0.

Keywords— Microstrip Patch Antenna, Rogers RT Duroid 5880, High Bandwidth, Ansoft HFSS 15.0

I. INTRODUCTION

Antennas are the essential components of wireless communication systems. The field of antennas[1] is vital and vibrant, and over the last 60 years antenna technology has been a necessary partner of the communications revolution. Many key developments that occurred during this period are in common use today. Mainly antennas are resonant devices, which radiate efficiently over a comparatively narrow frequency band. Antennas play a significant role in the field of wireless communication[2]. An antenna is a transducer or radiator or impedance matching device which is used for transmission and reception of electromagnetic signals in wireless communication. Thus, an antenna is a transitional structure between free space and a guided device. Antennas convert electric energy to RF waves in the case of transmitting antenna[3] and vice versa.

A. Microstrip Patch Antenna

Micro-strip patch antennas are a class of planar antennas which have been researched and developed extensively for decades. The idea was proposed by Deschamps first but little attention was paid to his idea until the 1970s. The idea arose from utilizing printed circuit technology as for radiating elements of an electronic system. This class of antennas has become much more attractive due to their light-weight and low cost. They are the backbone of wireless communication as it is crucial for both transmission and reception of signals and thus plays a vital role in wireless communication.

Microstrip patch antenna[4] consists of a very thin metallic strip supported by a ground plane with a dielectric substrate in-between. The radiating element and feed lines are placed during fabrication by the process of photo-etching on the dielectric material. Usually, the patch or microstrip[5] is chosen to be square, circular or rectangular in shape for the ease of analysis and fabrication. Microstrip patch antennas have many applications in the real world like in the military sector and commercial sector. They are used in mobile phones, space satellites, radars, radios, global positioning systems and many more.

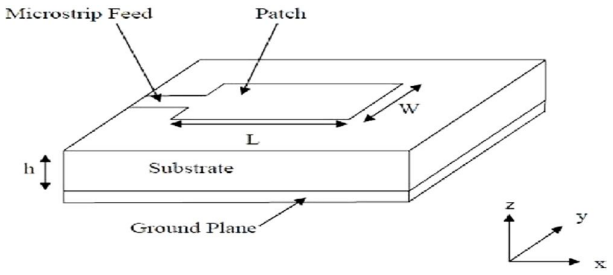

Fig. 1 Basic Microstrip Patch Antenna Configuration

II. PROPOSED ANTENNA DESIGN

In the rapidly increasing technology of wireless communication, there is a great demand for compact, low profile, low cost and light weight microstrip antennas. Here, we proposed to design an enhanced bandwidth and highly directive microstrip patch antenna using Rogers RT/duroid 5880(tm) substrate. We have designed the patch with a tree shape in order to get enhanced bandwidth. To carry out the design we used the simulation software i.e. HFSS (High Frequency Structural

Simulator). A rectangular microstrip patch (RMP) antenna is designed using a transmission line model. Three main parameters required for a design are a resonant frequency, dielectric constant and height of the dielectric substrate material. An inset feed of a rectangular patch antenna is designed to match the patch with a 50Ω microstrip transmission line.

The three essential parameters for the design of a rectangular Microstrip Patch Antenna:

A. Frequency of operation (fo)

The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for this design is 80 GHz.

B. Dielectric constant of the substrate (εr)

The dielectric material selected for our design is RT Duroid which has a dielectric constant of 2.2. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

C. Height of dielectric substrate (h)

For the microstrip patch antenna, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 3.5 mm.

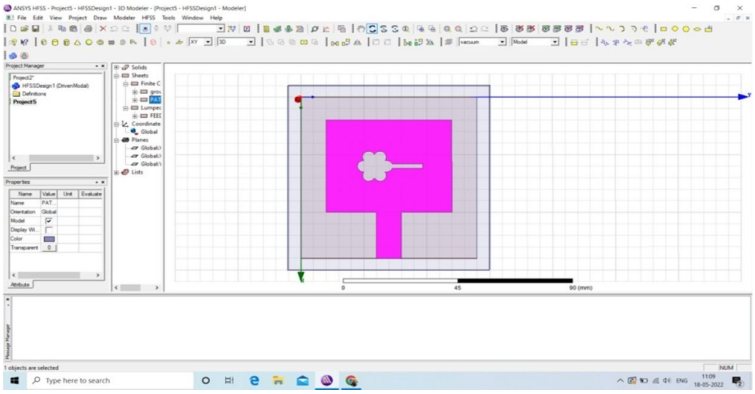

Fig. 2 Structural View of Patch of Proposed Antenna

TABLE I
PARAMETERS OF PROPOSED RECTANGULAR MICROSTRIP PATCH ANTENNA

Parameters	**Values**
Frequency(fo)	80GHz
Substrate used	Rogers RT/ duroid 5880(tm)
Dielectric Constant	2.2
Height (H) of substrate	3.5mm
Practical Length (L) of substrate	70mm
Practical width (W) of substrate	70mm
Practical width (w) of patch	40mm
Practical length (l) of patch	50mm
Feed length	10mm
Feed width	3.5mm

III. METHODOLOGY

Design of a Microstrip patch antenna requires the designer to first plan the substrate material to be used and the frequency of operation. For the present situation, a rectangular patch needs to be designed for greater than 40 GHz and the substrate material to be used is RT Duroid. Hence, we know the basic characteristics of the substrate material. The height and width of the rectangular patch is to be determined. For the length and width of the rectangular patch, there are numeral formulas and methodologies that have been defined in previous years. For calculating a rectangular patch antenna, parameters such as dielectric constant (er), resonant frequency (fo), and height of the substrate (h). For an efficient radiator, a practical width that leads to a good radiation efficiency.

A. Study on architecture & design equations for rectangular microstrip patch antenna.
B. Dimensions of rectangular microstrip patch antenna to be calculated for RT Duroid substrate.
C. Design and Simulation of rectangular antenna with tree shape patch.
D. Analysis and tabulation of results obtained (VSWR, S11, and directivity).

IV. RESULTS AND SIMULATION

The base of the proposed microstrip antenna is in the x-y plane and height of the antenna is in the z plane. The essential parameters for the design of a rectangular Microstrip Patch Antenna are:

A. Calculation of width (W) of patch:

$$W = \frac{c}{2fo\sqrt{\frac{(\varepsilon r+1)}{2}}}$$

Substituting c = 3x108 m/s, Ɛr =4.4 and fo = 6.3 GHz,We get: W = 38.04 mm

B. Calculation of effective Dielectric constant (Ɛreff):

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[\sqrt{\left(1+12\frac{h}{w}\right)}\right]$$

Substituting Ɛr = 4.4, W =38.04 mm and h = 1.6 mmWe get: Ɛreff = 4.08

C. Calculation extension Length: It is used for calculating resonant frequency of MicostripAntenna:

$$\Delta L = 0.412\frac{\left(\frac{W}{h}+0.264\right)(\varepsilon reff+0.3)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)}$$

Substituting Ɛreff = 4.08, W = 38.04 mm and h = 1.6 mm
We get: ΔL= 0.73mm

D. Calculation of Length (L) of patch:

Effective Length (Leff):

$$L_{eff} = \frac{c}{2fo\sqrt{\varepsilon reff}} \quad \text{and} \quad L = L_{eff} - 2\Delta L$$

Substituting Leff = 30.86 mm and ΔL = 0.73 mmWe get: L = 29.4 mm

V. RESULTS OF SIMULATION

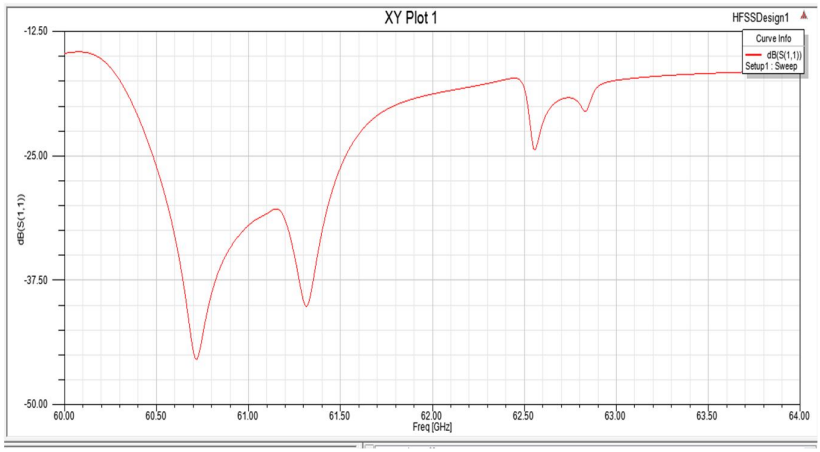

Fig.3 Simulation result of S11 of MSA

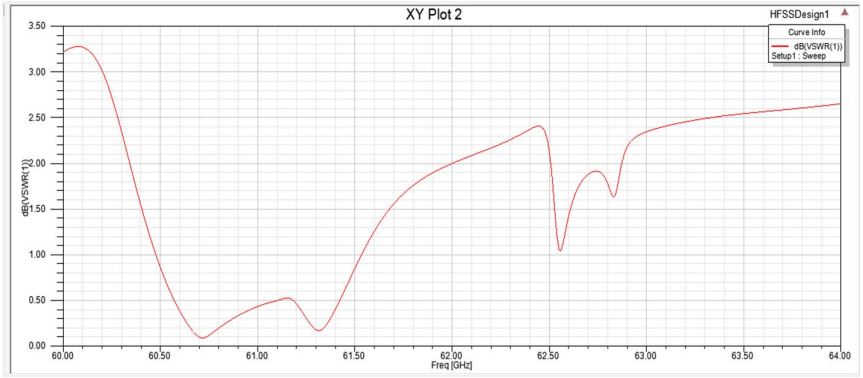

Fig. 4 Simulation result of VSWR

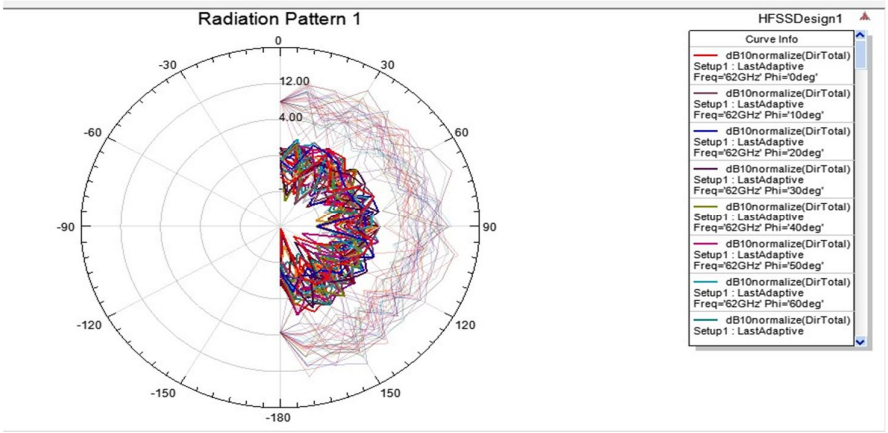

Fig. 5 Simulation result of Directivity

VI. CONCLUSION

The importance of the antenna in today's wireless communication system is briefly discussed here. A Broadband and highly directive microstrip patch antenna is designed using RT Duroid 5880 substrate and their simulation and results has been shown. The proposed design has a simple structure and can easily be constructed at low cost. For future enhancement, we will proceed for the comparative study of different substrates on our design This could be possible by changing material used for the design.

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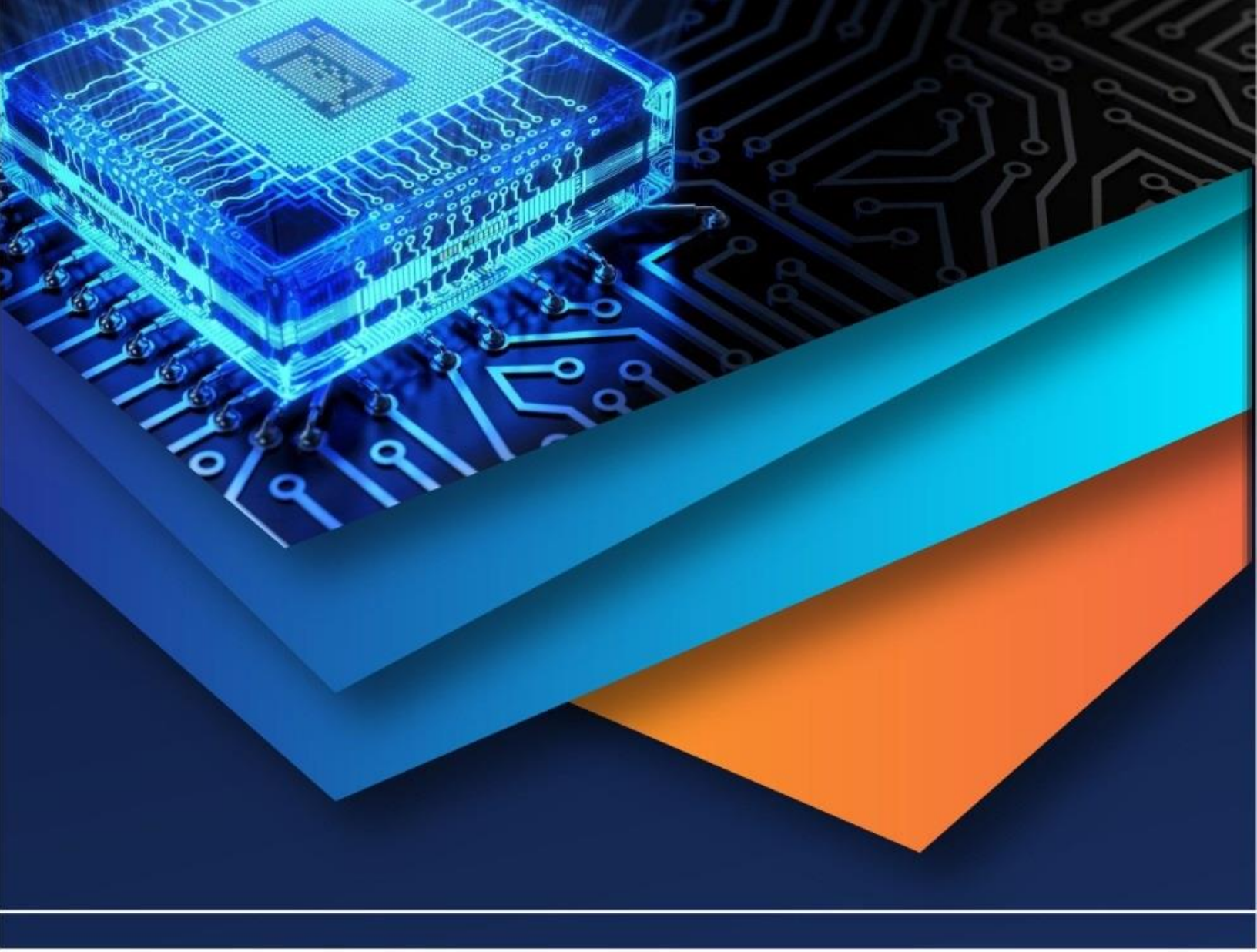

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