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# Rectangular Patch Antenna Array Slotted Design for Triple Band Using HFSS

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***Abstract: The proposed antenna can be suitably employed for satellite to earth communication. The proposed antenna covers the X-band satellite downlink as well as uplink frequency bands making it suitable to be employed for X band satellite communication applications. The specified frequency ranges of 13 GHz (Ku-band) can also be employed for military satellite, weather satellite and radio-determination purposes. Antenna also covers the K-Band as well as Ka-Band applications. The Results will show good impedance matching, good radiation patterns in the operating band. Thus, this antenna is a good applicant for wireless communication applications which includes long distance radio telecommunications like cordless telephones, some Wi-Fi devices, weather radar systems, direct broadcast satellite.***
***In this paper, a microstrip patch antennas for a dual frequency 10.55 and 14.59 GHz (that cover X-Band and Ku-Band) and triple frequency 11.54 GHz, 13.95 GHz, 23.48 GHz (that also cover X-Band, Ku-Band and K-Band) with only coaxial probe feeding technique is presented. The various parameters like return loss, radiation pattern, smith chart, electric field and VSWR are plotted for each antenna. The affect of various parameters like patch length, MSL length have been studied.***
***Keywords: Dual band, Triple Band.Slotted Patch Array Shape, Microstrip patch antenna,S-Parameters, smith chart, bandwidth, VSWR, resonant frequency,HFSS13.0.***

## I. INTRODUCTION

Antenna is the most fundamental block of the wireless communication. Recently, the growth of wireless systems leads to a lot of innovations in the Microstrip antenna designs. Microstrip patch antenna has become an integral part of these devices working in ultra to super high frequency ranges. The patch and slot are the two parameters which affect the overall antenna's performance [1].
Microstrip antenna technology began its rapid development in the late 1970s. By the early 1980s basic microstrip antenna elements and arrays were fairly well establish in term of design and modeling. In the last few years patch antennas have been largely studied due to their advantages over other radiating systems, which include light weightiness, reduced size, low cost, conformability and the ease of integration with active device [3].
Microstrip patch antenna is basically made of thin sheet of insulating material called dielectric substrate. It is back bone of circuit because it provides a support to strip and patch. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane.. One major drawback of microstrip patch antennas is their narrow bandwidth and low gain. It has been established that the slotted patch can significantly improve the bandwidth of the microstrip antenna. The slotted patch antenna can be designed not only for wideband applications, but also for dual-band and, triple-band application with small and wide frequency ratios.. The IEEE 802.16 WiMAX standard allows data transmission using multiple broadband frequency ranges. The original 802.16a standard specified transmissions in the range 10 - 66 GHz, but 802.16d allowed lower frequencies in the range 2 to 11 GHz. The lower frequencies used in the later specifications means that the signals suffer less from attenuation and therefore they provide improved range and better coverage within buildings[3].
Voice was the first means of communication between humans. For out of reach communications abounding methods and gadgets have been made current. Electromagnetic spectrum has been used very anew for communion, through the use of radio waves. This resource comes in the category of natural resource. It is available in abundant form of humankind. Antenna has to be used to a great amount to venture this resource. Wireless communication systems have been growing as the application of mobile phones and systems are booming in use. For such wireless systems the crucial component to emit and collect signals is the antenna. Antenna is not active device; they are passive that only guides the signal energy in a peculiar direction in connection with isotropic antenna. They act as bridging links between transmitter, free space and the receiver. Some of the alluring characteristics of antenna include low profile, radiation emitted from the antenna should be less, less bulkier, high gain, fabrication should be done in an

uncomplicated manner and its overall cost be less and it need to have certain amount of compatibility with looped surfaces. But, stability is still one of the important properties of coming up application [6]. Microstrip patch antenna is the most suitable and prevalent type of antenna in use today, their effective frequency range is in between 1GHz to 10 GHz. Since 1970s this antenna has been flourishing, where its size and performance were very effective as conversation entity was required at these frequencies. The architecture of the microstrip patch antenna consists of the substrate of which below is the ground plane and above is the patch. These antennas find applications in mobiles instruments, receivers using GPS technologies and other wireless and wired products reason being there high values of dielectric constant and additional size reduction. Since this antenna has flat profile and is light in weight also makes them suitable for applications like airborne and spacecraft [6].

## II. ANALYSIS OF ANTENNA

The length of the patch is denoted by L and width of the patch is denoted by W. Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. Since some of the waves travel in the substrate and some in air, an effective dielectric constant $\varepsilon reff$ is introduced to account for fringing and the wave propagation in the line.

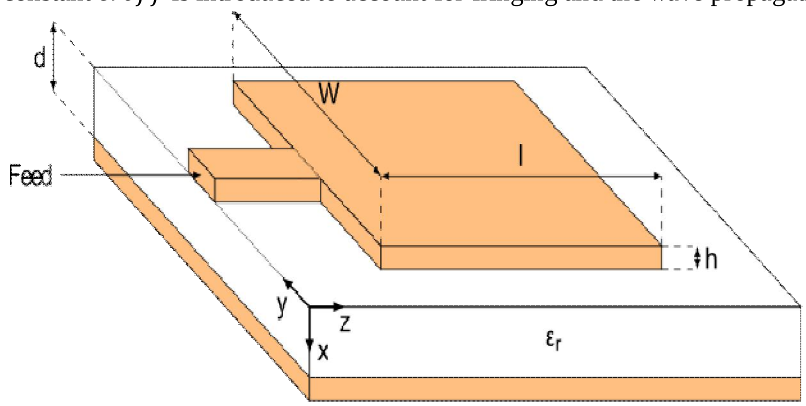


Figure 1 Basic Geometry of Microstrip Patch Antenna

### *A. Coaxial Feed*

A Coaxial Fed antenna consists of a microstrip patch fed by the center conductor of a coaxial line (see figure 2). The outer coaxial conductor is electrically connected to the ground plane. Due to the absence of a microstrip feed line, the substrate thickness and permittivity can be designed to maximize antenna radiation. However, the probe center conductor underneath the patch causes undesired distortion in the electric field between the patch and ground plane and produces undesired reactive loading effects at the antenna input port [1]. The undesired reactance can be compensated by adjusting the probe location on the patch. It suffers from the drawbacks of narrow bandwidth, difficult to model specially for thick substrate and possess inherent asymmetries which generate higher order modes which produce cross polarization radiation[1,2].

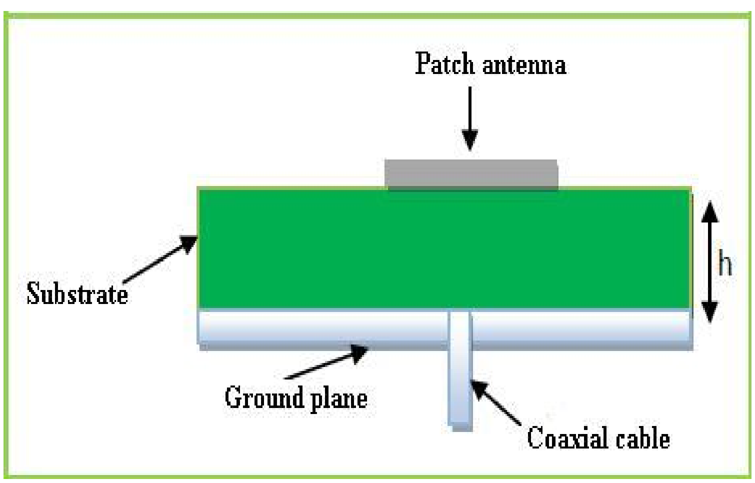


Figure 2 Coaxial Probe Feed

## III. DESIGNINGOF ANTENNA

### A. *Designing of proposed microstrip patch antenna*

The geometry of proposed antenna which is coaxial probe fed for wireless application is depicted in figure 3

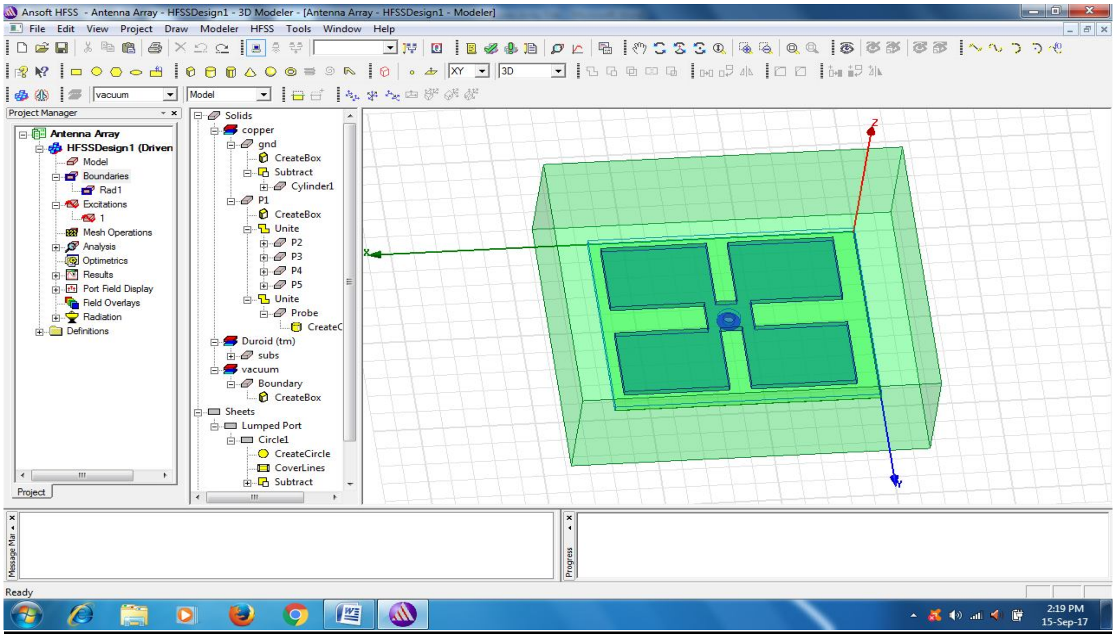

Figure 3 Designing with coaxial feed

### *B. Results*

*1) Observation from -10dB return loss*

*a)* Resonant frequency =19.95 GHz at -24.088 dB and 27.19 at -12.11dB

*b)* Band width at 19.95 GHz= $f_2$-$f_1$ = 20.12- 19.75 = 0.376 GHz = 376 MHz

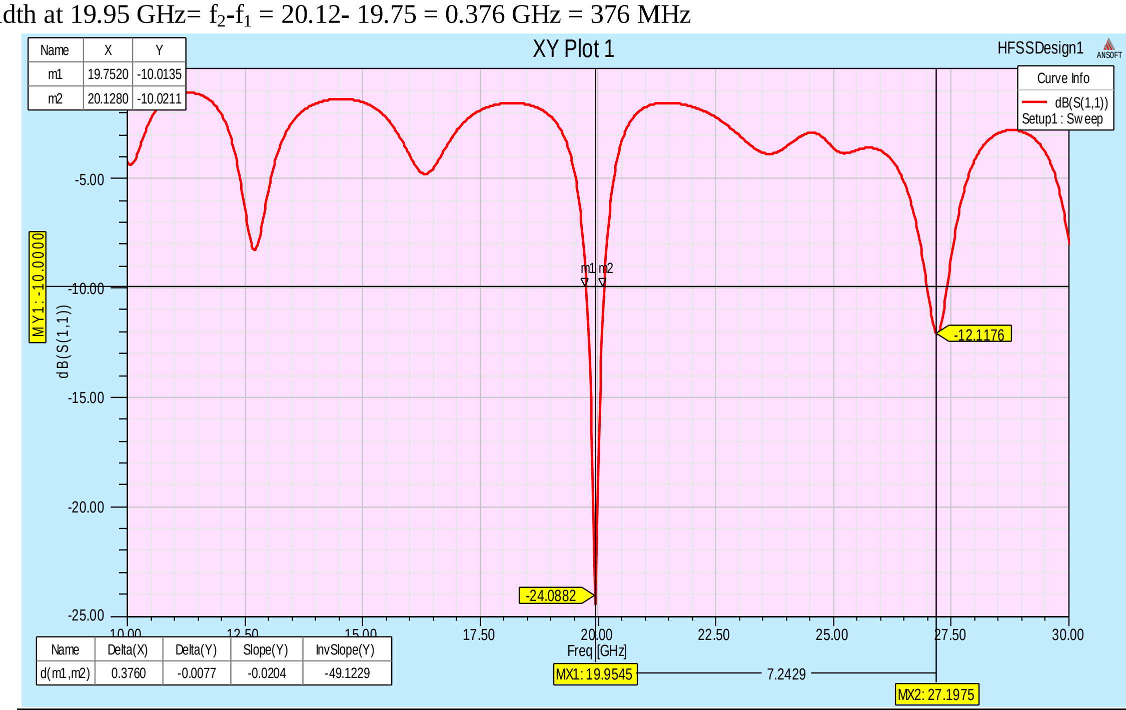


Figure 4 Return loss graph of coaxial feed

*2) Observation from VSWR*

*a)* VSWR at resonant frequency 19.95 GHz=1.13 which is good for practical antenna.

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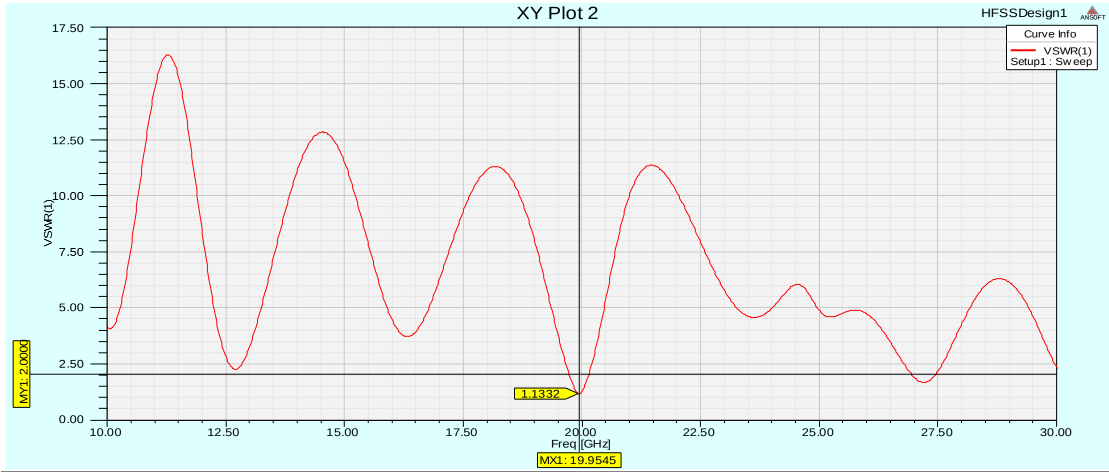


Figure 5 VSWR graph of coaxial feed

*3) Radiation Pattern*

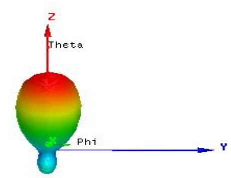


Figure 6 Radiation pattern graph of coaxial feed

*4) Smith Chart:* The smith chart gives 1.1076×50= 55.38 ohm impedance which is good as near to match the characteristic impedance of value of 50 ohm.

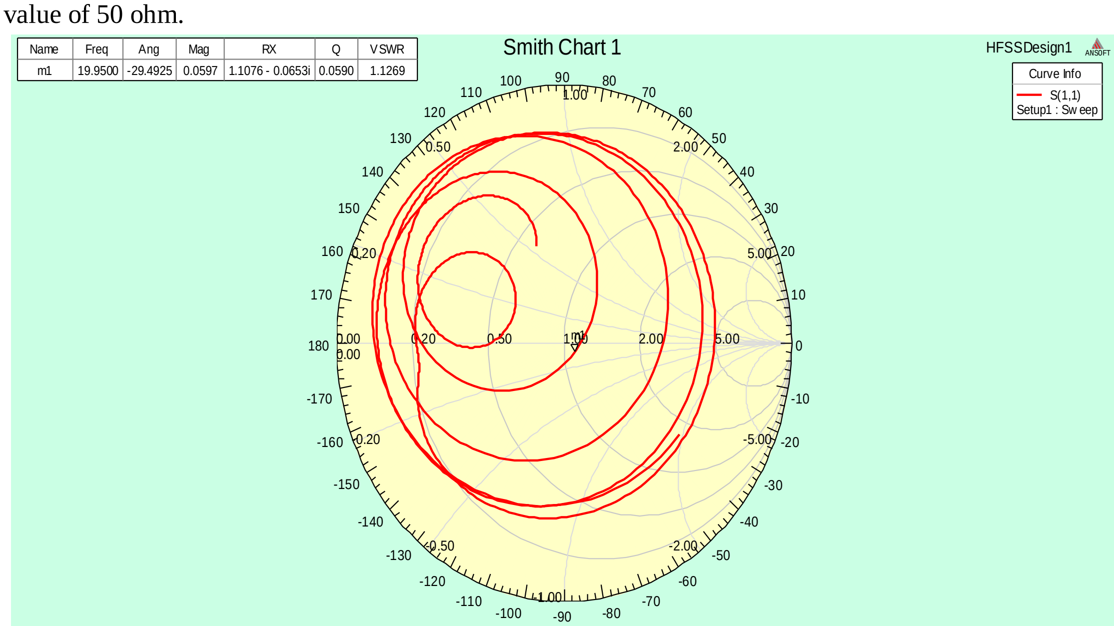


Figure 7 Smith chart graph of coaxial feed

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### *B. Design of Proposed Dual Band Antenna using DGS*

In this design we have reduced the size of ground dimension in X-direction to design a effective dual band antenna.In this technique, microstrip patch antenna is designed using coaxial probe feed and some changes in boundary conditions of above antenna to get desired results:

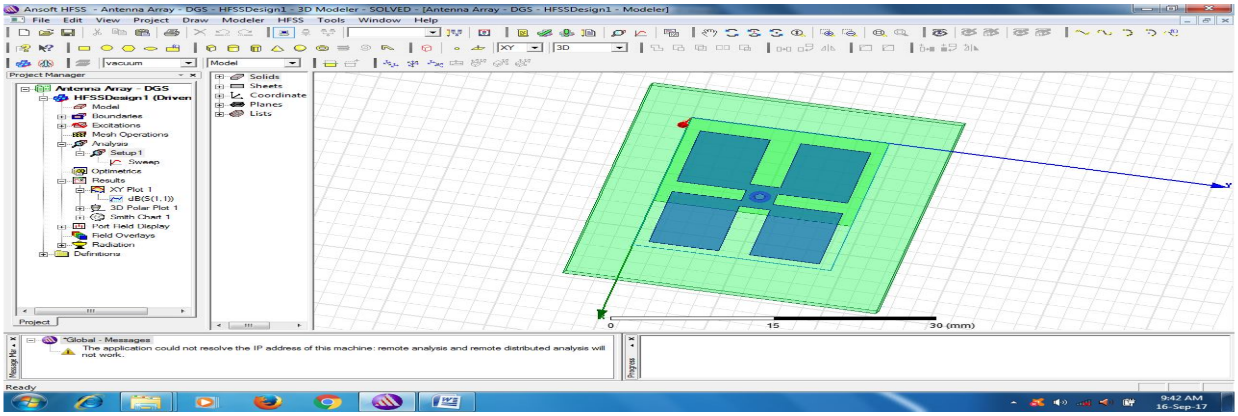


Figure 8 Designing of proposed dual band antenna

#### *1) Observation from -10dB return loss*

*a)* Resonant frequency =10.55 GHz at -21.52dB( S-parameter)

*b)* Resonant frequency =14.59 GHz at -37.97dB( S-parameter)

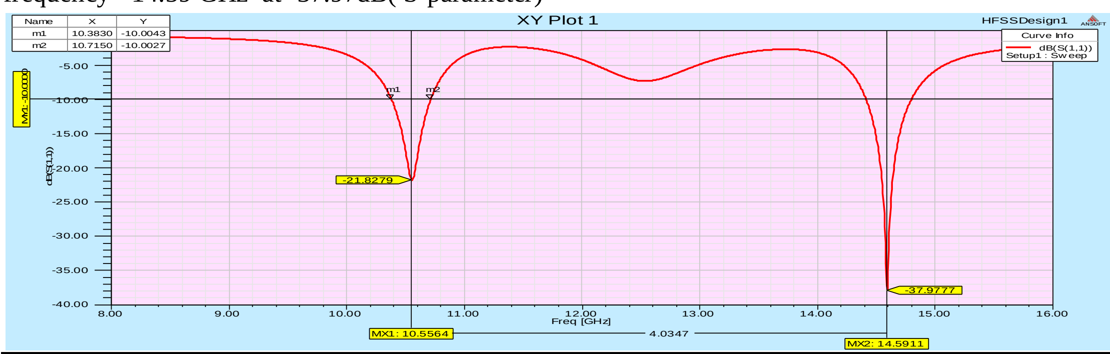


Figure 9 Return loss graph of Proposed dual antenna

#### *2) Observation from VSWR*

*a )*VSWR at resonant frequency 10.55 GHz=1.17

*b)*VSWR at resonant frequency 14.59 GHz=1.02

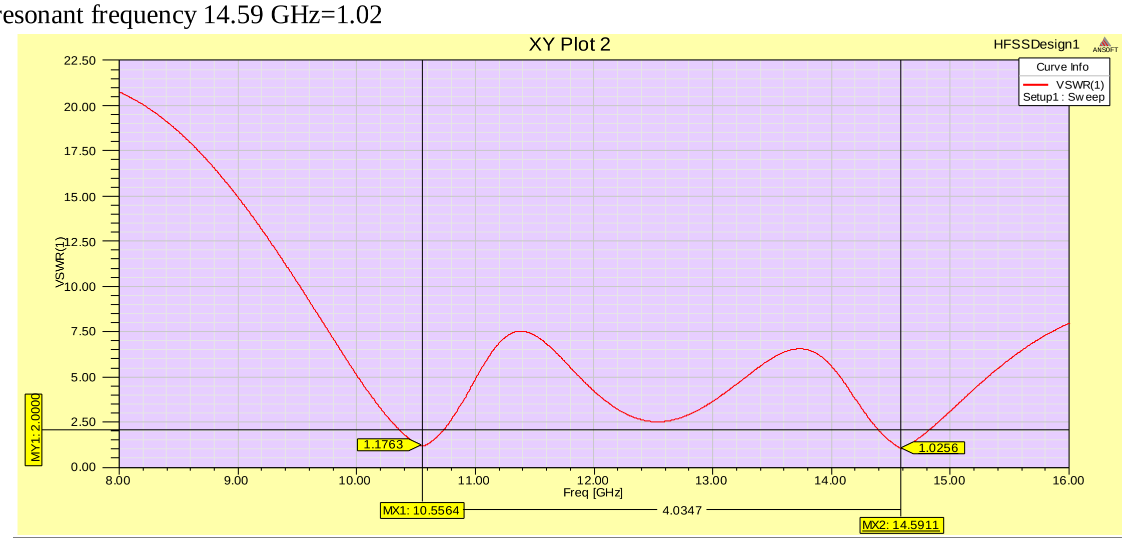


Figure 10 VSWR graph of Proposed dual Antenna

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*3) Radiation Pattern*


Figure 11 Radiation pattern curve of Proposed Dual Antenna

*4) Smith Chart*

The smith chart curve of Proposed Antenna is shown in Figure.

Impedance Matching = 0.9789 ×50= 48.95 ohm

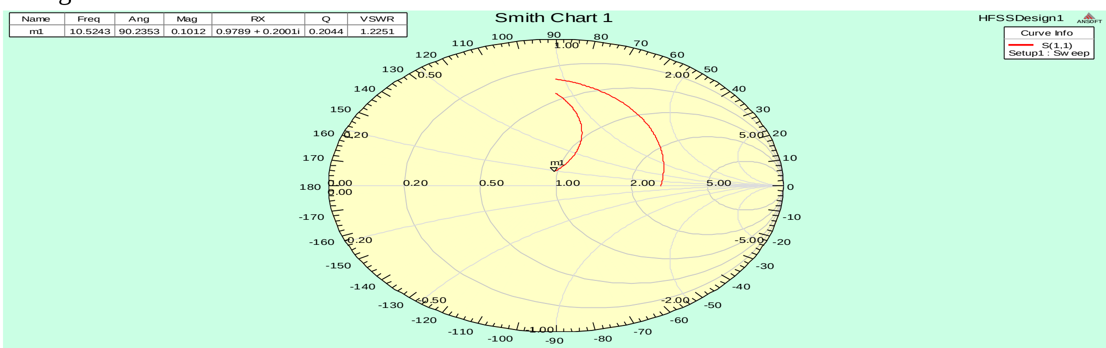


Figure 12 Smith chart curve of Proposed dual antenna

*C. Design of Proposed Triple Band Antenna using slotted patch and DGS:*

It is observed from the above model bands in designing microstrip patch antenna has been increased so we are using four slots with same size in patch plane that is single in each small rectangular patch (small patches which make array) and there is four array without any lot or DGS has been introduced in simple reference antenna design. The total three bands are achieved in this case.

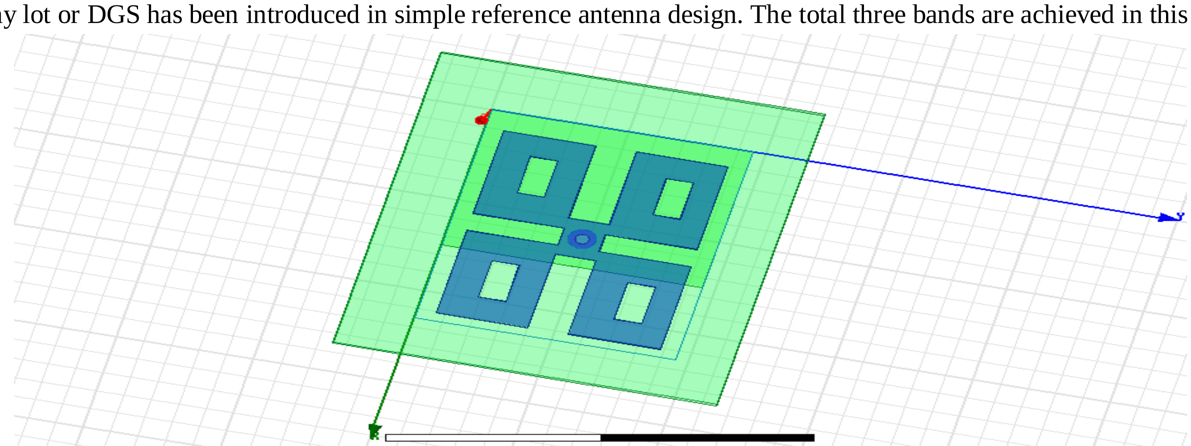


Figure 13 Designing for Triple band

*D. Results*

*1) Observation from -10dB return loss*

*a)* Resonant frequency = 11.54 GHz at -13.80dB( S-parameter)

*b)* Resonant frequency = 13.95 GHz at -17.49dB( S-parameter)

*c)* Resonant frequency = 23.48 GHz at -14.26dB( S-parameter)

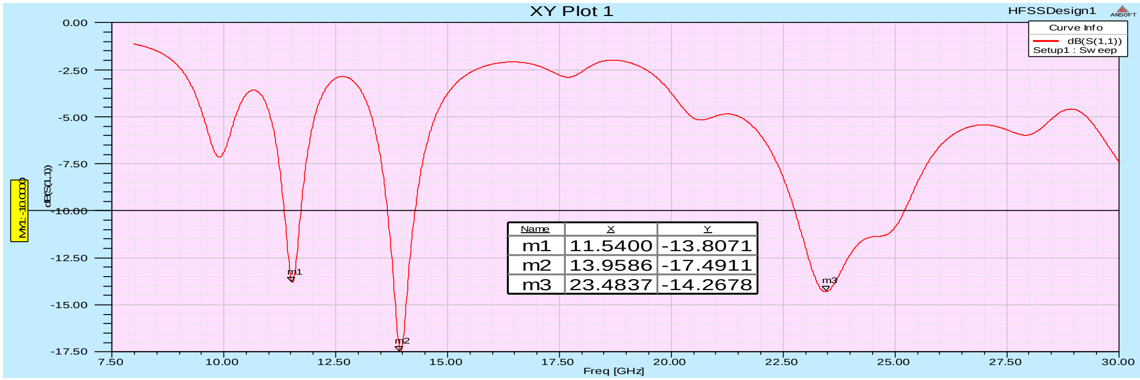


Figure 14 Return loss graph of proposed triple band antenna

*2) Observation from VSWR*

*a)* VSWR at resonant frequency 11.54 GHz =1.51

*b)* VSWR at resonant frequency 13.95 GHz =1.30

*c)* VSWR at resonant frequency 23.48 GHz =1.47

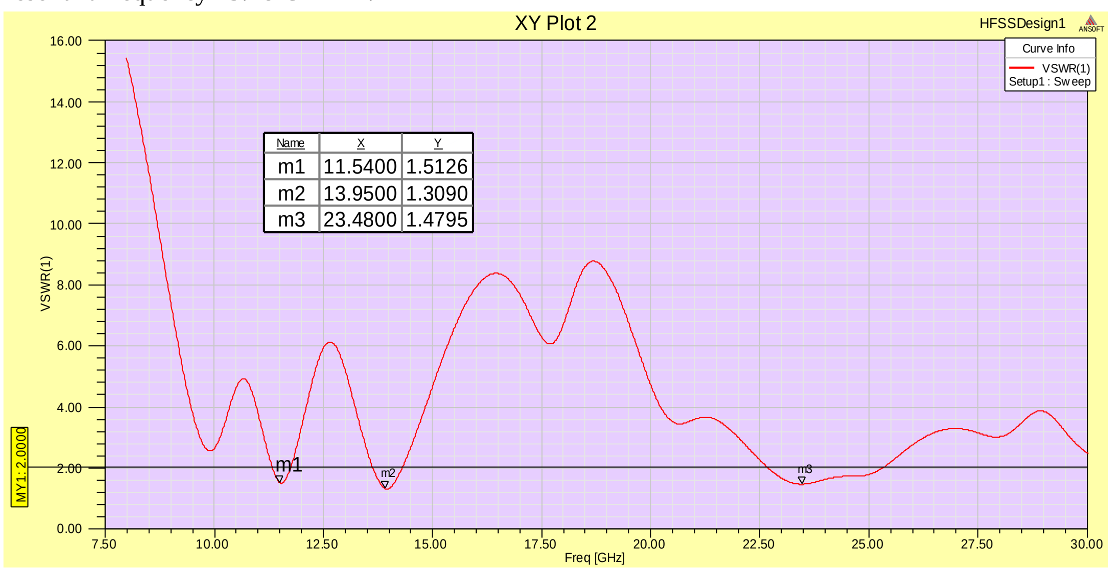


Figure 15 VSWR graph of Proposed triple band antenna

*3) Radiation Pattern*

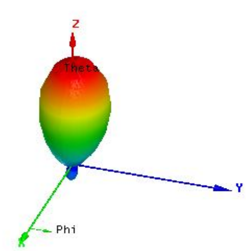


Figure 16 Radiation pattern curve of Proposed triple band antenna

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Table 1 Difference Table between Reference and Proposed antenna

| Antenna | Difference in Design | Resonant Frequency | VSWR |
|---|---|---|---|
| Reference Antenna (Single band) | Using antenna array in complete designing | 13.42 GHz | Less than 2 |
| Antenna Designing (as per reference) | Using patch array with only difference in patch | 19.95 GHz<br>27.19 GHz | 1.13<br>1.6 |
| Proposed Dual Band Antenna with DGS | Using DGS and some change in boundary dimension | 10.55 GHz<br>14.59 GHz | 1.17<br>1.02 |
| Proposed Triple Band Antenna with rectangular slots | Using 4 rectangular slot in all small patches (part of complete patch) | 11.54 GHz<br>13.95 GHz<br>23.48 GHz | 1.51<br>1.30<br>1.47 |

## IV. CONCLUSION

In this research paper, a microstrip patch antennas for a dual frequency 10.55 and 14.59 GHz (that cover X-Band and Ku-Band) and triple frequency 11.54 GHz, 13.95 GHz, 23.48 GHz (that also cover X-Band, Ku-Band and K-Band) with only coaxial probe feeding technique is presented. The various parameters like return loss, radiation pattern, smith chart, electric field and VSWR are plotted for each antenna.

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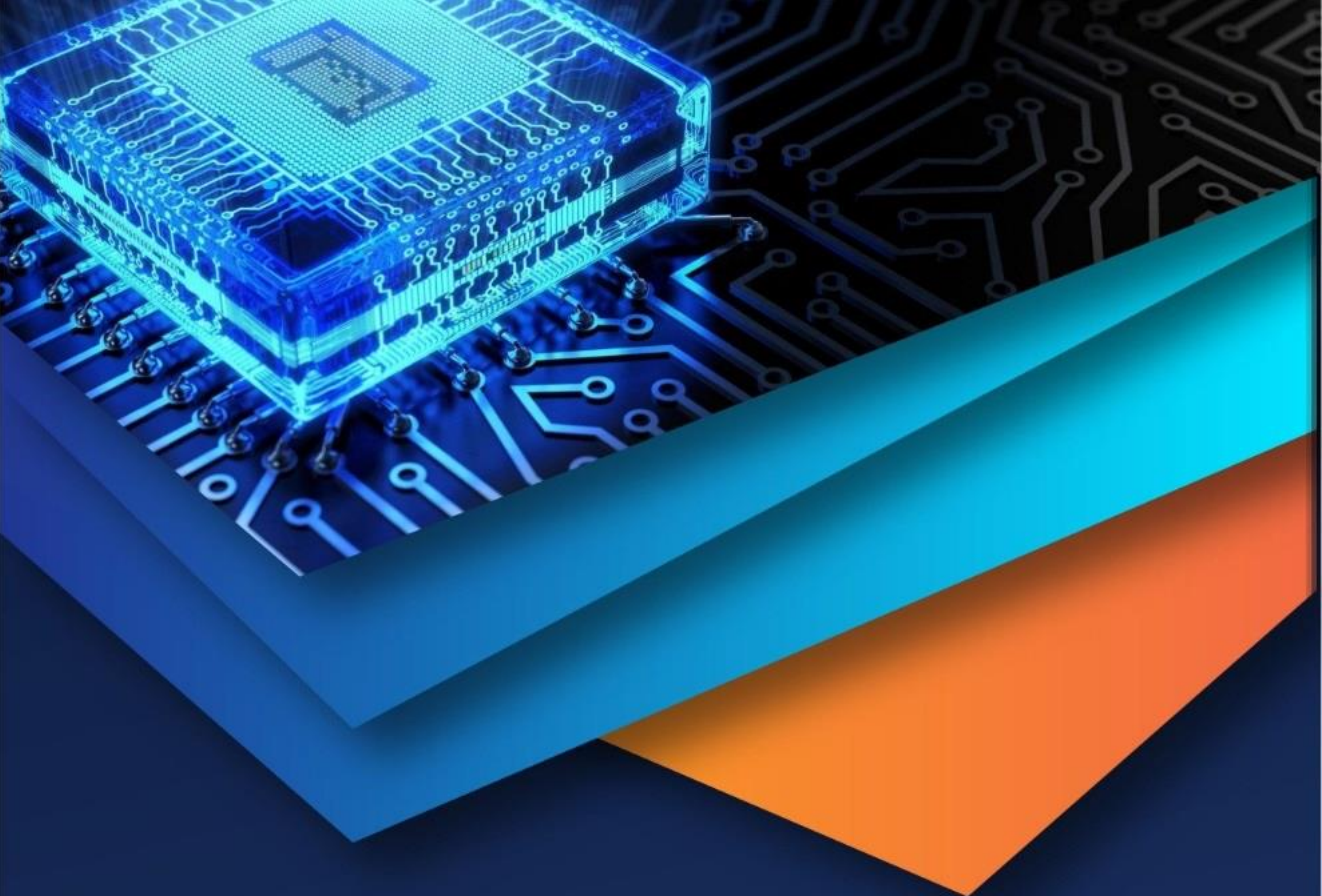


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