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DESIGN OF TRIPLE BAND RECTANGULAR PATCH MICRO STRIP ANTENNA

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ABSTRACT

Antenna which is said to be a metallic device is used to radiate the radio wavesor to receive radio waves.Theantennas that provides high performance forvast frequency rangewith high gain and antennas which provides large bandwidth and smaller size is required.Due to the advantage of ease and low cost fabrication and integration. Microstrip antenna has extensive utility in wi-fi communication.The antenna has resonant frequencies at C and X band are to be used for C band(4GHz-8GHz)and X band(8GHz-12GHz) applications. Proposed antenna have substrate length of 20.8mm and substrate width is 24.7mm. The patch length of the proposed antenna is 11.8mm and patch width is 15.7mm.

I. INTRODUCTION

Antenna is intended to transmit or receive electromagnetic waves.Definition of antenna given by IEEE as "antenna is a part of transmitter or receiver which is used to transmit or receive EM waves".The antennas can be divided as omni directional and unidirectional antennas. Omni directional antennas are the one which radiates energy not only in one direction but also in all directions whereas unidirectional antennas radiate energy in one specified direction.The important characteristics of antenna are bandwidth, gain, effective aperture, radiation pattern, field regions, efficiency, polarization and impedance matching.The above characteristics should be carefully monitored during the design of any antenna structure. In antennas electrical conductors radiate and receive EM waves. Between a transmission lineused and free space antenna is the interface and guiding structure. The antenna also acts as matching system between source of EM energy and space.Every communications systems contains of a transmitter to transmit the signals to the desired directions, a receiver to receive the signal in the desired direction, and a communications medium through which the signal travels.

Printed antennas is the other name of Microstrip antenna. Microstrip antennas are widely used as they can be printed easily and directly onto a circuit board. It is introduced first in 1950s. Microstrip antennas is commonly used as they have lower cost and has low profile and can be easily fabricated.The mutualkind of microstrip antenna is patch antenna.Inventor of Microstrip patch antenna is Robert E.Munson. The patch antenna can be easily mounted on a flat surface.

Microstrip patch antenna because of the advantages like ease of integration and low cost of fabrication it is wide application in wireless communication.

For maintaining high frequency performance there is in need for low cost,low profile antenna and microstrip antenna fulfils the above requirements. Microstrip patch antenna is divided into four categories a)Microstrip patch antennas, b)Microstrip dipoles, c)Printed slot antennas, d)Microstrip travelling wave antennas.

Microstrip patch antenna has four basic parts:

The patch

Dielectric Substrate

Ground Plane

Feed Line

In the upper side of microtsrip patch antenna of dielectric substrate contains radiating patch and in the bottom side it contains ground plane.Copper or gold is often used for making the patch that is used in antennas. Microstrip patch antennas are frequently designed to possess various dimensions and it can have various geometrical shapes but in many applications circular and rectangular resonant patch were used. Common shapes of patch antenna were square, rectangular, elliptical and circular. Defected Ground Structure (DGS)-integrated patch isfamiliar for numerouspurpose. Major design considerations were in decreasing the size of the antenna and to improve the bandwidth.Many research work is going on microstrip antenna to improve some of the characteristics of the antenna for its better utilization in future.

In proposed antenna design is rectangular microstrip inset feed patch antenna without slot structure and the gain of the antenna was noted. After that a slot is introduced in the microstrip lineit is observed that the gain was improved. The comparative study was made between the microstripantenna without introducing the slot structure and after the introduction of slot structure.

II. LITERATURE RIVIEW

Yang Yun- Xing, Zhao Hui-Chang, Chen Si, Zhang Shu-Ning (2018) designed a proximity fuse antenna. This antenna is designed for high order mode. The main advantage is simple construction. It had a side radiation pattern. Ordinary circuit antenna added a two tiny sector. In this method variation theory separated two frequency and both frequency working on TM21 higher order mode. Gain will increase with the help of proximity fuse. The simulation permitted the reliability of the investigation.

Sonal Mishra, PrateekWankhade, ArvindSahu (2017) performed the operation of single feed and dual band. Resonant frequency of antenna is 3.105GHz which includes the S-band operation. In this project return loss improved by cutting the slots within the patch. The technique introduced here is increases the height concerning the substrate and ground plane which increase the bandwidth.

The microstrip patch antenna had a rectangular radiating patch and used in the slots T and U. Truncation of the corner with meshed finite ground plane is done. The antenna proposed uses IE3D simulation software and it got the maximum return loss value of -42.57. They achieved a 92 % of good radiation pattern and efficiency. Bandwidth also increase till 21 % into s band operations.

Imad Ali, Ronald Y. Chang (2015) designed dual band rectangular microstrip patch antenna for 2.5 GHz and 3.5 GHz communications. The proposed antenna has two slots one is in the ground plane of the antenna. Parametric analysis used to improve the bandwidth and gain. This antenna provides the bandwidth of 13.56 % and 10.36 % at centerfrequencies of 2.5 GHz and 3.5 GHz. The gain in E-plane are 6.7 dB and 5.1 dB and H-plane are 6.5 dB and 4.88 dB for the dual frequencies. The antenna proposed gives monopole radiation pattern[24].

P. A. Ambresh and P. M. Hadalgi, P.V. Hunagund (2011) designed a patch antenna and the antenna is used for wide band operation with the help of single feed. The proposed antenna consists of conducting slotted elements with air filled dielectric medium. This antenna has low VSWR and high gain, and also reduce the dimension of the antenna. The application of the design is Wi-max, RADAR between the frequency range of 3-4 GHz. The main advantage of the antenna is low profile, smaller size and light weight.

A. Bekasiewicz, S. Koziela (2016) designed a novel structure of compact ultra wideband monopole antenna. The antenna had rectangular fed radiator with a ground plane and L-shaped slot. They designed a small size antenna with complex structure. The size of the antenna is 9.45x18.5 mm and footprint of 175 mm^2.

Paula Reis, Dr H. G. Virani proposed a compacted microstrip antenna meant for wireless applications. The main applications are WiFi, WLAN, WiMax and satellite communication. The software used in this antenna was IE3D Zeland software. The substrate used in this antenna was FR4 and the thickness is 0.162 mm. This antenna has four resonating frequency 3.1 GHz, 4.8 GHz, 6.3 GHz, 7.7 GHz. This antenna has a variable patches in the ground plane and the shapes are I, L, F and E. It works on the S, C and X band operations. VSWR, gain, directivity and return loss were analysed [25][26][27][28].

Prashant Sharma, Devendra Kumar (2019) designed a microstrip antenna to work on 2.4GHz. The main applications are industrial, science and medical and used in IOT. Advantage of this antenna is smaller size, low profile and low cost so it was used in a medical field. Software used to design this antenna is CST microwave studio suite.

AnjuSatheesh, RithikaChandraBabu, I.Srinivasa Rao (2017) designed a compressed microstrip rectangular patch antenna with dissimilar slots. The main applications are IOT and real time weather monitoring in aircrafts. In this antenna slots are introduced which reduces the size of the antenna. It used in the S band operations. Various shape slots are introduced to change the S band operation to L band operations. Main advantage of the antenna is reduction in size of the antenna. FR4 substrate and this antenna is simulated by HFSS.

Chenghui Wang, Yikai Chen, Shiwen Yang (2019) designed In band scattering reduction for U-slot patch antenna with systematic with in band scattering cross section. U –slot is used in this antenna. In this antenna analyse and visualize the resonant behaviour of the radiating patch. Reduced SCS and reference antennas are fabricated in this paper.

III. ANTENNA DESIGN

Schemeof the proposed patch antenna,simulation of proposed antenna are done through usingHigh Frequency Structural Stimulator(HFSS).

Formula for designing microstrip patch antenna,

Patch width,

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

Where,

c=speed of the light

f_0=resonant frequency

ε_r= substrate dielectric constant

Effective dielectric constant,

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

Where, h=substrate height

The effective length,

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (3)$$

The length extension,

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

The length of the patch,

$$L = L_{eff} - 2\Delta L \quad (5)$$

By using the above formula for the resonant frequency (f_0) of 5.8GHz and for ε_r= 4.4 of the FR-4 substrate of the proposed rectangular microstrip patch antenna substrate length of 20.8mm and substrate width is 24.7mm and the patch length of the proposed antenna is 11.8mm and patch width is 15.7mm were obtained.

The rectangular patch antenna is cost wise good choice as it has low cost, it has better performance and easily manufactured as microstrip antennas and hence it used in our design.FR4 substrate was used because the material is cost efficient compared to other material and has wide range of applications.The solid ground is used which has dimension same as that of substrate.The solid ground is preferred for its better efficiency.We used contact inset feeding technique for design of microstrip patch antenna.In inset feed width of conducting strip is small as compared to the patchso that it can be easily fabricated andeasy to modeland have easier impedance matching.The main advantage of inset feed for microstrip patch antenna is that it matches the feed line impedance withthe patch input impedance without necessity forother matching element and it can be achieved by adjusting the inset cut position and dimensions.

The following section (III) and (IV) shows comparison between the rectangular microstrip patch antenna without slot and with the presence of slot.The results are shown below.

IV. MICROSTRIP ANTENNA WITHOUT SLOT

The table 1 below shows the dimensions of rectangular microstrip patch antenna without any slot structure,

Table 1

Parameter	Dimension(mm)
Inset Length	4.6
Pitch Gap	0.25
Microstrip feed length	6.6
Microstrip feed width	2.88

The proposed microstrip antenna has 3 resonant frequencies at 5.6GHz, 8.7GHz,10.2GHz and it can be used for Bluetooth/WLAN applications and satellite applications.

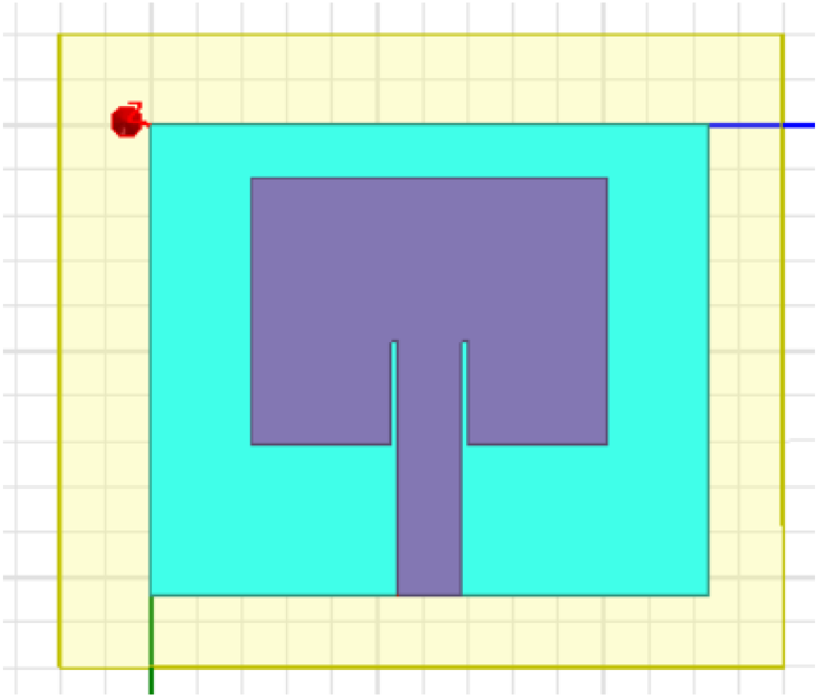

Fig:1 Proposed design without slot structure

The simulation result in HFSS such as gain, VSWR, S-parameter and radiation pattern is shown below,

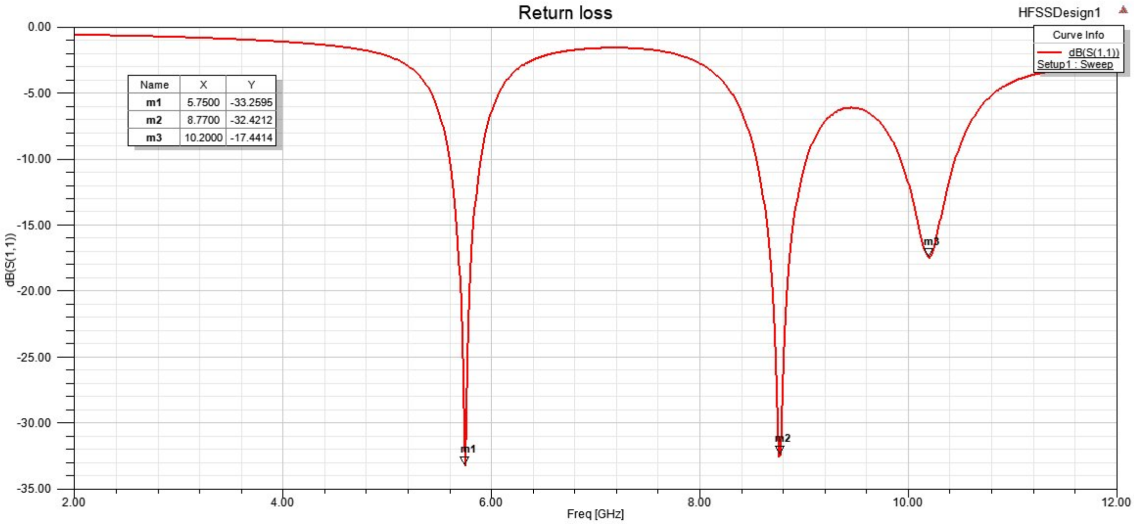

Fig:2 S parameter of the antenna without slot structure

The s-parameter or return loss or reflection co-efficient should always less than -10dB for the good antenna performance. The proposed antenna has s-parameter less than -10dB for all the resonant frequencies.

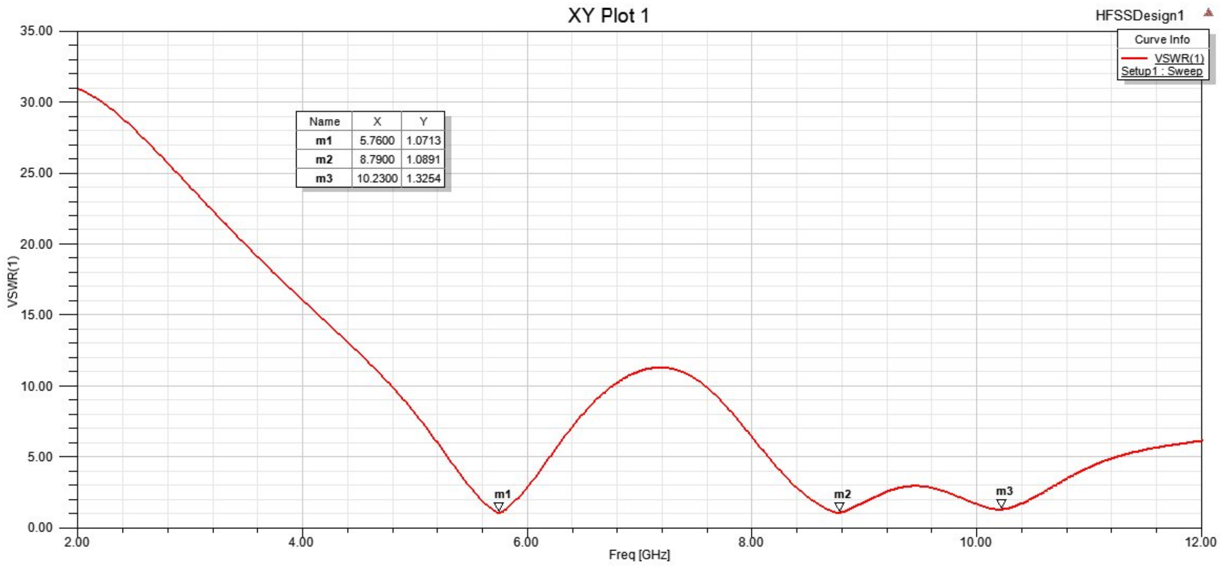

Fig:3 VSWR of the antenna without slot structure

If the VSWR of the antenna should less than 2 then the antenna has good impedance matching. The proposed antenna has VSWR less than 2 for all the resonant frequencies as shown in figure 3.

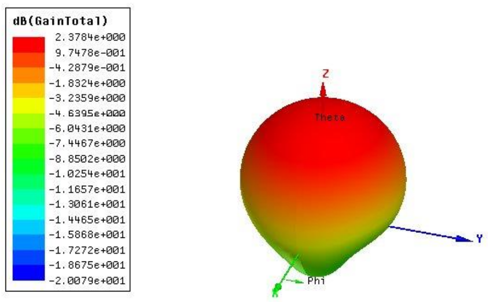

Fig:4 Gain of the antenna without slot structure

V. MICROSTRIP ANTENNA WITH SLOT

A slot of size 4mmx0.25mm is introduced in the microstrip line of the antenna as shown in figure 6 and the corresponding gain, VSWR, s-parameter and radiation pattern is obtained.

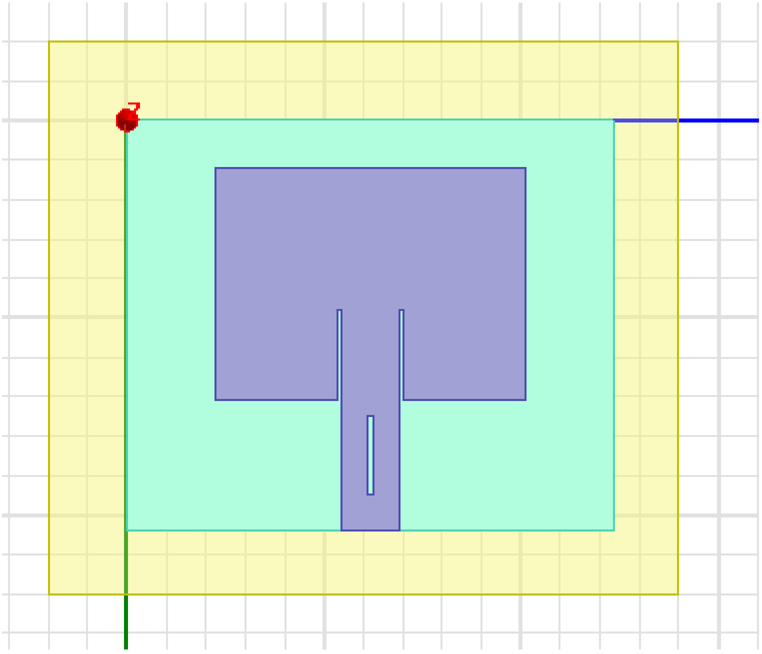

Fig:6 Proposed design with slot structure

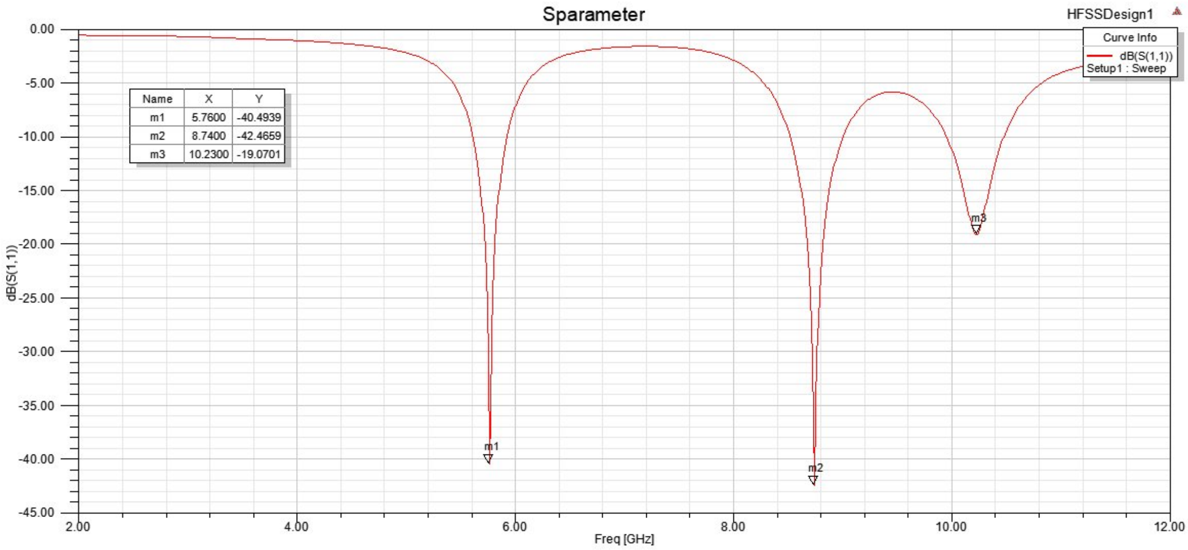

Fig:7 S-parameter with slot structure

After the slot is introduced in the microstrip line of the antenna the S-parameter value -40.4dB at 5.7GHz,-42.46dB at 8.7GHz and -19dB at 10.2GHz which is less than -10dB for all the resonant frequencies as shown in figure 7.

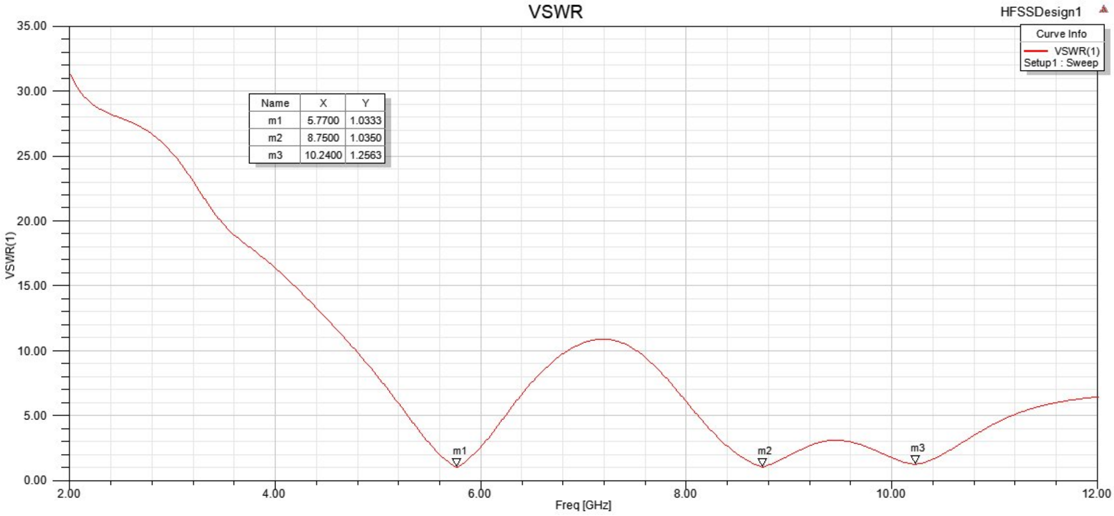

Fig:8 VSWR of the antenna with slot structure

After the slot is introduced in the microstrip line of the antenna the VSWR value is 1 at 5.7GHz,1 at 8.7GHz and 1.25 at 10.2GHz which is less than 2 for all the resonant frequencies as shown in figure 8.

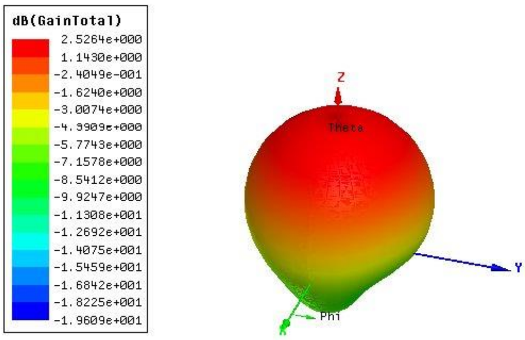

Fig:9: Gain with slot in microstrip line

After slot is introduced the gain is improved to 2.5Db as shown in figure 9.

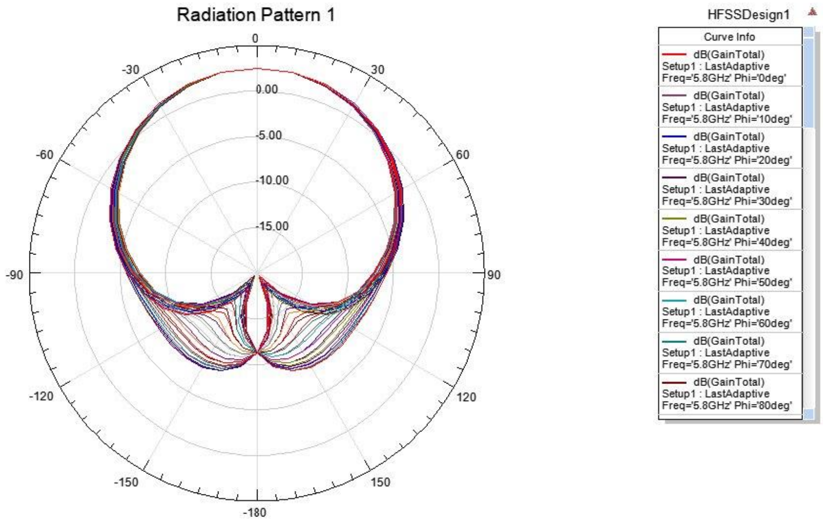

Fig:10 Radiation pattern with slot in microstrip line

VI. CONCLUSION:

The proposed antenna has good gain,S parameter,VSWR compared to exisiting works.It has three resonant frequencies at 5.7GHz, 8.7GHz and 10.2GHz so it has triple band characteristic. The proposed antenna able to be used for C band(4GHz-8GHz) and X band applications(8GHz-12GHz) such as Bluetooth/WLAN, radar and satellite communication

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