Miniaturization of Circular Microstrip Patch Antenna for ISM Band (5.8GHz) Application

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Abstract—In this paper a novel design of microstrip patch antenna we made an attempt to maximize the gain. To get a good result we used microstrip circular patch antenna at 5.8 GHz frequency ISM(Industrial, Scientific and Medical) Band Application. All the parameters are set accordingly and results of circular microstrip patch antenna and modified circular disc patch (MCDP) antenna later has been compared on the basis of return loss, directivity, radiation pattern and gain. HFSS (High Frequency Structured Simulator) software has been used for simulation of antenna and to find out the results. The antenna with dimension 40mm x 40mm is fabricated on Roggers /RT Duroid 5880(tm),with relative permittivity 2.2.The designed antenna has the capability to resonate at 5.8GHz frequency Thickness of substrate is kept 1.6mm minimized to reduce the spurious surface wave and width . Coaxial feeding technique has been used.

Keywords— Circular Microstrip patch antenna, ISM Band, MCDP (Modified Circular Disc Patch) antenna

I. INTRODUCTION

Microwave antenna is a major system component that allows a microwave system to transmit and receive data between microwave sites. Microwaves are radio waves with wavelengths ranging from as long as one metre to as short as one millimetre. Microwave antennas are widely used in various applications such as Television, Telephone communication system, wireless, Wi-Fi, WLAN, RADAR, and Bluetooth etc. Microstrip antennas can be divided into 4 different categories they are:

- Microstrip Patch antenna
- Microstrip dipoles
- Printed slot antennas
- Microstrip travelling wave antenna

Within few years microstrip patch antenna has gained lot of popularity and considered as most dynamic field in communication. There is increasing demand for compact and easy fabricated antenna with efficient results for use in various wireless communication systems. Microstrip antennas are mainly used in small portable devices, aircraft, spacecraft, satellite and missile application where small size, low cost, high performance and ease of installation are major constraint The major disadvantages of these antennas are narrow bandwidth and gain. Advantages of these Antennas are its low profile, conformability, robustness, inexpensive, light and compact design. It supports both linear as well as circular polarization.

Our design is applicable for ISM Band (5.8GHz).Its IEEE 802.11a utilises the 5GHz (5.180-8.825GHz) frequency band. Sometimes 2.4 GHz ISM Band gets overcrowded that time Wi-Fi network signal may be weak or not work at all, in this cases it is best to use 5GHz backhaul link to connect 2.4 GHz Wi-Fi network.

A feeding technique is a way to supply radio waves into the antenna structure. Number of feeding technique is in use in the technologies, it can be contacting and Non-contacting. The criteria of division are direct and indirect connectivity of RF (radio Frequency) power supply with the antenna. Microstrip line and coaxial are contacting feeding technique whereas aperture and proximity is non-contacting feeding.

II. RELATED WORK

Microstrip patch antennas have larger application due to its low profile, light weight, and ease to fabrication but with this there are few disadvantages as well i.e. low gain and narrow bandwidth. Many techniques have been applied to enhance the impedance bandwidth. Different feeding technique, use of FSS substrate, patch design they are the few ways that significantly reduces the losses[1]. DNG (Double Negative Slab), dielectric Slab and FSS are being used to achieve better efficiency using dielectric [3]. With the simulation, theoretical calculation is also done and being compared with simulation results. It shows nearby results as in [6] it achieved 3.3% bandwidth 4.2 dB gain.

Spacing between the substrates is filled with air and right decision of air gap has to be maintained to achieve best results. At the ISM band frequency 5.8GHz which achieved greater than 5 dB and showed conical radiation [7]. Similarly, another paper has demonstrated antenna at same frequency which achieved bandwidth 12.8% and gain of 5.7 dB [8].

Use of substrate is another way to get better results and even to reduce the size of antenna. Fractal shapes using Koch has reduced the size of antenna up to 80.3% [9].

A. Method of analysis

Wavelength in free space
$$\left(\lambda_o = \frac{c}{f_o}\right)$$

c is the velocity of light in air.
Therefore the resonant frequencies for the TMmn0 modes can be written as

$$(f_r)_{\mathrm{mn0}} = \frac{1}{2\pi a\sqrt{\mu\varepsilon}}\left(\frac{X'_{mn}}{a}\right)$$

Circular patch radius

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}}$$

Where
$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon_r}}$$

$$(f_r)_{110} = \frac{1.8412 v_o}{2\pi a\sqrt{\varepsilon_r}}$$

Effective radius of circular patch

$$a_e = a\left\{1 + \frac{2h}{\pi \varepsilon_r a}\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2}$$

Effective dielectric constant

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

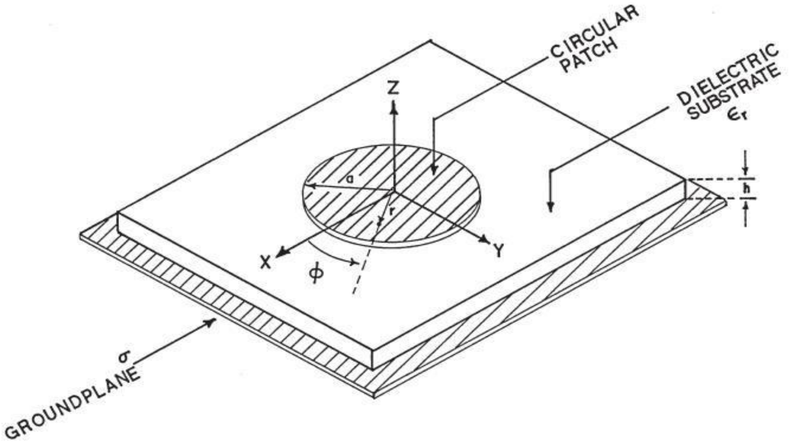

Fig-1:-The general structure of Circular Patch antenna

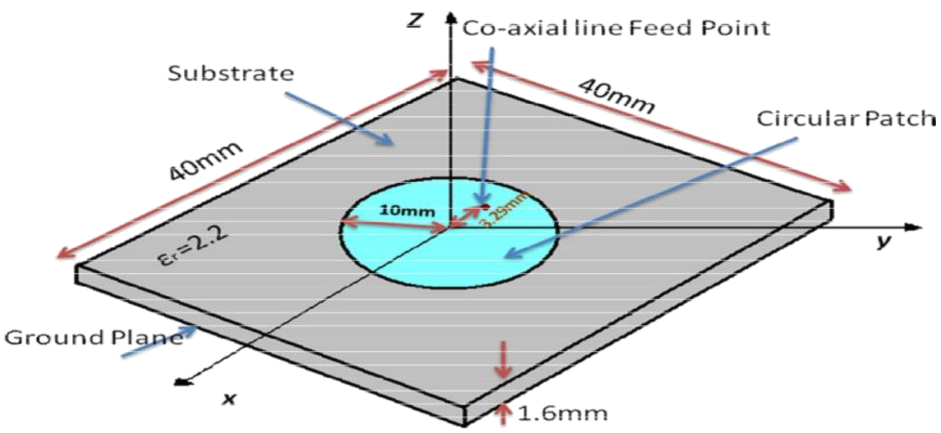

Fig-2:- Dimensions of designed Circular disc patch antenna(CDP)

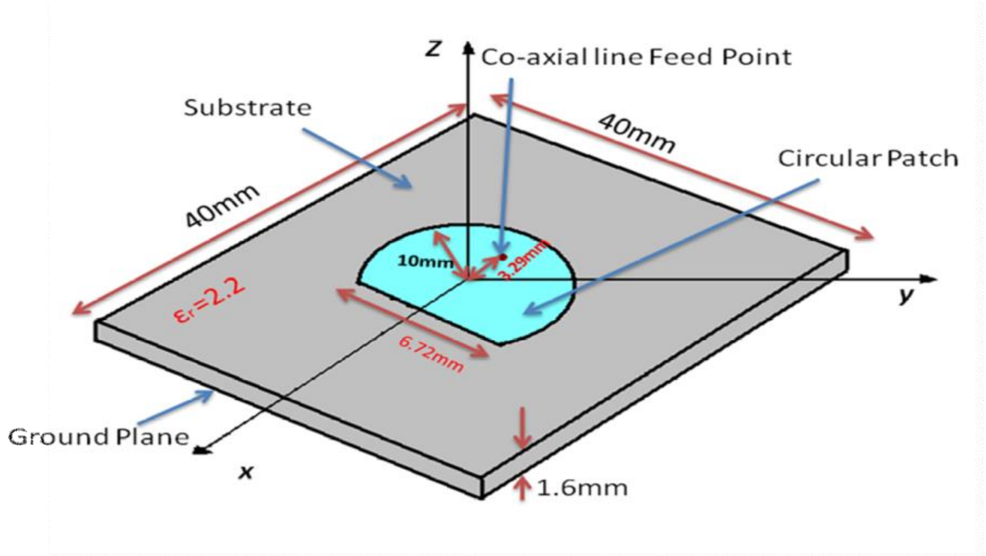

Fig:3:- Dimensions of Modified Circular Disc Patch (MCDP) antenna

Table 1- Design Parameter for circular Disc patch antenna

Parameters	**Parameters Value**
Operating frequency(*fr*)	5.8GHz
Substrate Material	Roggers / RT Duroid 5880
Substrate relative dielectric constant (*εr*)	2.2
Substrate height (*h*)	62 mil or 1.6 mm
Loss tangent (tanδ)	0.0009
Substrate length (*Ls*)	40mm×40 mm0
Calculated Disc radius (a)	*10mm*

III. SIMULATION RESULT AND DISCUSSION

A) Simulated Results for CDP antenna:

Return loss:-This mathematically designed circular patch antenna did not fulfil the Frequency requirement since operating frequency is 5.8GHz. From this curves it can observe that this CDP antenna design has a resonance point at 5.5GHz with 240MHz -10dB bandwidth. It also that minimum return loss obtained is -19.46 dB at 5.5 GHz.

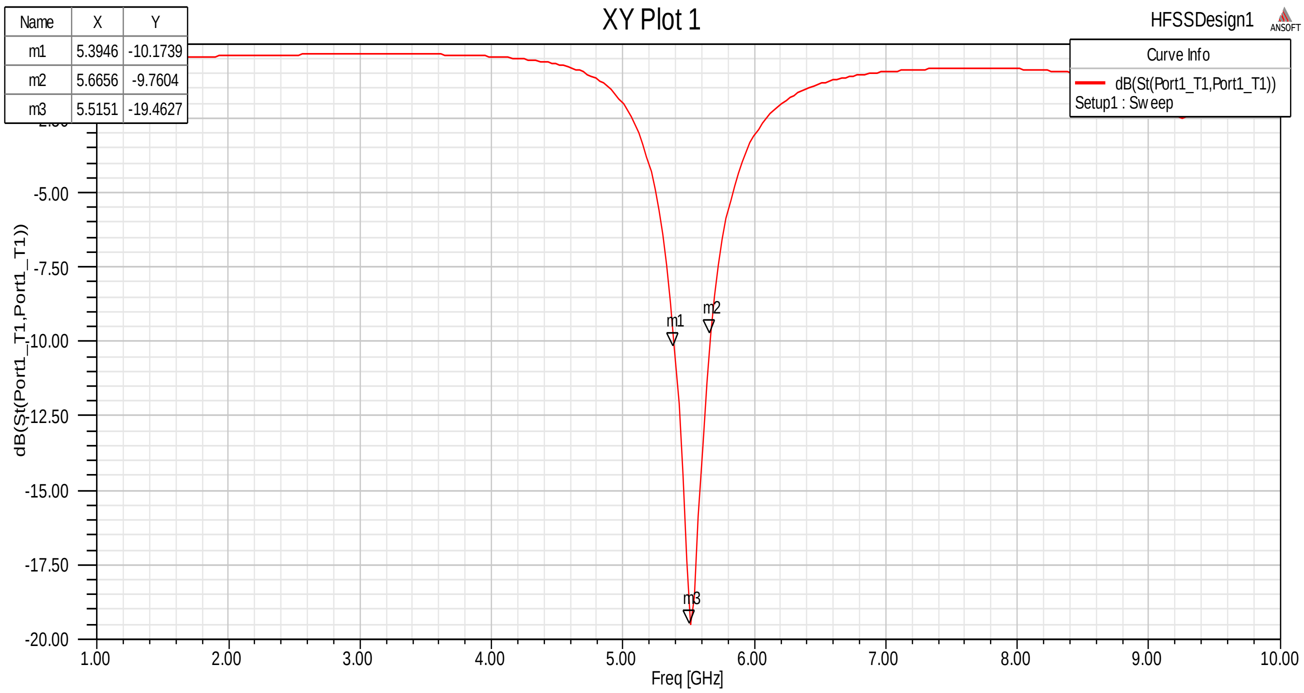

Fig:-4: The S_{11} (return Loss) response of CDP antenna

VSWR: - it is an important property of antenna to fulfil the requirement of matching. the VSWR of an antenna should be less than or equal to 2.the VSWR curve shows that CDP antenna is near to 1.2381 at frequency 5.5 GHz(fig:5).

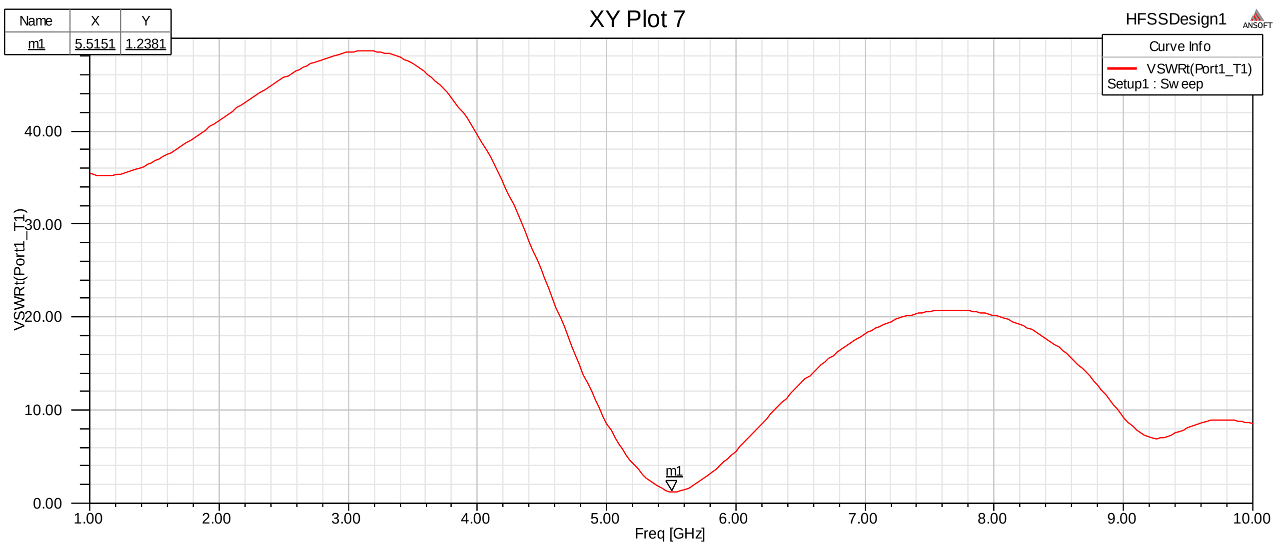

Fig-5: the VSWR response of CDP antenna

Radiation pattern Gain and Directivity: Another important parameter of antenna performance is its radiation pattern. These curves show the radiation pattern at $\theta=0^0$ and $\theta=90^0$. The maximum gain observed is 5.1866dB at frequency 5.8 GHz. It offers a maximum directivity near to 5.2251 at $\theta=0^0$ **&** $\theta=90^0$**.**

B) Simulated Results for MCDP antenna:

Return loss:-This modified design with truncated patch fulfilling the frequency requirement. From this curves it can observe that this MCDP antenna design has a resonance point at 5.8G Hz with 240MHz -10dB bandwidth. It also found, that minimum return loss obtained is -14.43dB at 5.8GHz. That is equivalent to reference paper [2].while this MCDP antenna generates many higher order harmonic

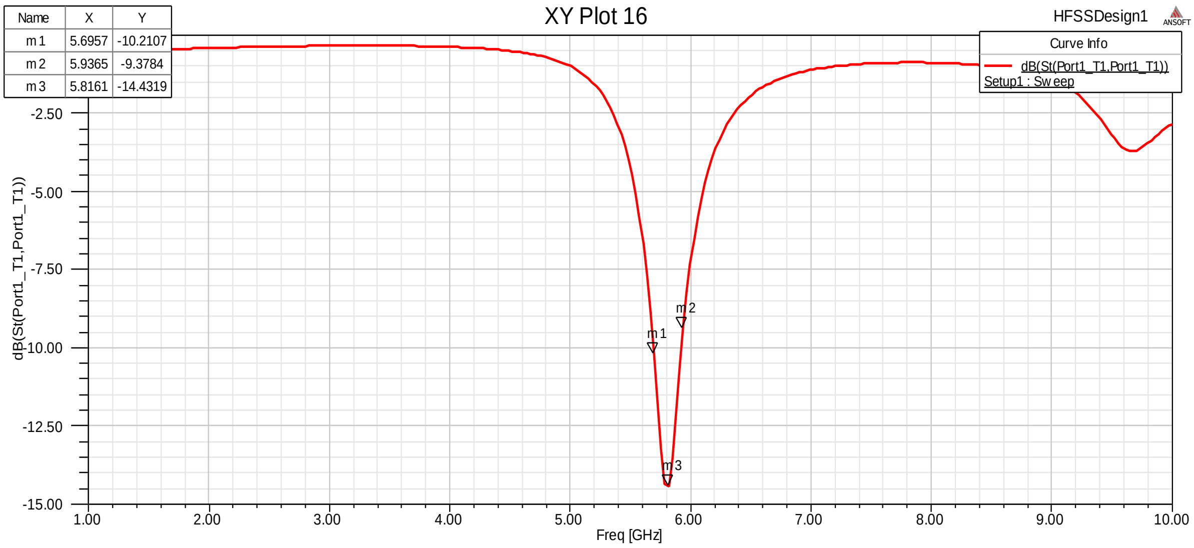

Fig:6:- the S11 (return loss) curve of MCDP antenna, resonating at 5.8 GHz

VSWR -this MCDP antenna better VSWR therefore this antenna is able to provide better matching than CDP antenna at 5.8GHz. the VSWR of an antenna should be less than or equal to 2. The VSWR curve shows that MCDP antenna is near to 1.4687 at frequency 5.8 GHz (fig-7)

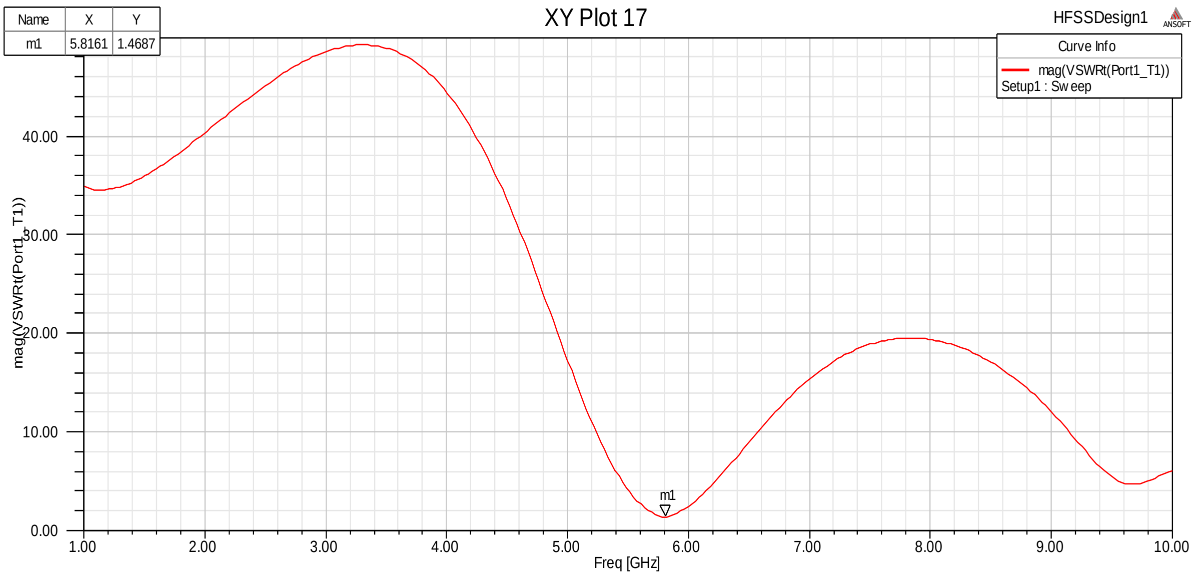

Fig-7:- VSWR curve of MCDP antenna, resonating at 5.8 GHz

Radiation pattern Gain and directivity: Another important parameter of antenna performance is its radiation pattern. The MCDP antenna design radiation pattern according to desired result. These curves show the radiation pattern at $\theta=0^0$ and $\theta=90^0$. The maximum gain observed is 5.3187 dB at frequency 5.8 GHz, this property is also better than the previous design. However, the maximum directivity reduces to 5.3693 at $\theta=0^0$ & $\theta=90^0$

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V. CONCLUSION

We designed antenna of two different patch(Circular Disc Patch Antenna & Modified Circular Disc Patch Antenna).We performed the analysis & simulation process at resonance frequency 5.8GHz.Finally it was found that the NCDP Antenna gave better performance at operating frequency in terms of Gain, Directivity, Frequency response, VSWR, Impedance etc. MCDP antenna can also be chosen for Rectenna application since the antenna is generating various higher order harmonics, then by designing low pass filter harmonics can be reduced. Thus by improving the design of Circular Patch Antenna the ISM Band frequency at 5.8GHz can be used without any congestion problem in WLAN, Wi-Fi etc

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