Analysis And Design Of Circular Microstrip Patch Antenna At 5.8GHz

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Abstract— **Here we made an attempt to maximize the gain of microstrip patch antenna. To achieve this we used microstrip circular patch antenna at 5.8 GHz frequency ISM Band Application. Single FSS (frequency selective surface) substrate is used to increase efficiency. Parameters are set accordingly and results of microstrip patch antenna with FSS layer and microstrip patch antenna without substrate later compared on the basis of return loss, directivity, radiation pattern and gain. We used HFSS (high frequency structured simulator) software for simulation of antenna and to find out the results. We keep changing the design of antenna as our motive was to achieve miniature antenna with better results than conventional antenna's. Thickness of substrate has been minimized to achieve the same. Coaxial feeding technique has been used as it is easier to implement.**

Keywords— **Microstrip Antenna, Operating frequency 5.8GHz, Circular Microstrip patch antenna**

I. INTRODUCTION

Microstrip antennas are 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 and being used to realize millimeter wave monolithic integrated circuits for microwave, radar, GPS antennas and communication purposes. In response to their increasing demand for compact and easy fabricated antenna with efficient results for use in various wireless communication systems, several circular antennas have been developed over the past decade. The major disadvantages of these antennas are narrow bandwidth and gain. Advantages of these Antennas are its low profile, robustness, inexpensive, light and compact design. Photo etching technology is used to fabricate antenna together with microwave circuit. It supports both linear as well as circular polarization.

FSS (frequency selective surface) has a structure of periodically arranged array of special element in print on a substrate. As mentioned previously, FSS structures are periodic arrays of special elements in print on a substrate.

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 is direct and indirect connectivity of RF (radio Frequency) power supply with the antenna. Microstripline and coaxial are contacting feeding technique whereas aperture and proximity is non contacting feeding.

Here simulated result of circular patch antenna with single FSS layer compared with circular patch antenna without FSS layer. Details of both the antennas design and simulation result are presented and discussed.

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. DNG (Double Negative Slab), dielectric Slab and FSS are being used better efficiency is achieved using dielectric [2]. With the simulation theoretical calculation is also done and being compared with simulation results. It shows nearby results as in [4] 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 [8]. Similarly, another paper has demonstrated antenna at same frequency which achieved bandwidth 12.8% and gain of 5.7 dB [10].

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% [14].

III. ANTENNA DESIGN ANALYSIS

Microstrip patch antenna is used at 5.8GHz as resonance is achieved at this point. Coaxial feeding technique is used in the design because of its feature that it is easy to obtain input matching by adjusting feed position. Input impedance matching is critical requirement to achieve required bandwidth, if it doesn't occur than efficiency will be lower. "Line fed rectangular patches may be fed from the radiating or the non-radiating edge. To find an impedance match along the non-radiating edge we may use the Transmission Line Model. The input impedance along

the non-radiating edge is lowest at the centre since two equally high impedances at the two ends are transformed into a low value at the centre and connected in parallel with each other" [6].

The thickness of substrate tried to be kept minimum so that we can achieve maximum bandwidth with bin the

limit of .003λo <h <.05 λo. We chose FR4 epoxy material because it has Ɛr minimum as relative permittivity is inversely proportional to the bandwidth. RT-Duroid 5880 kept as a substrate layer above which a FSS superstrate is kept between them air gap of 28.96mm is adjusted to improve the bandwidth.
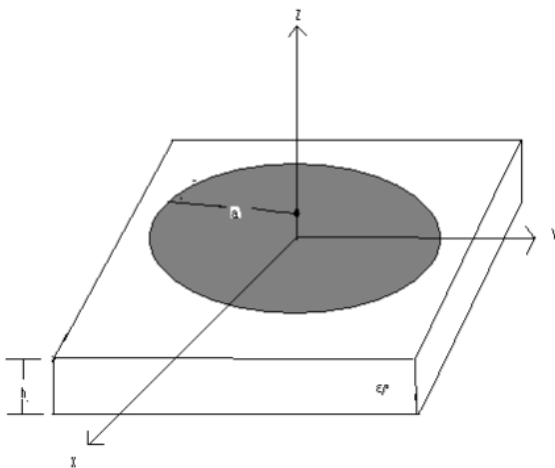
Fig.2.1.Geometry of Circular Patch Antenna

A. Method of Analysis

Wavelength in free space   λo: c/ fo
 c is the velocity of light in air.
Therefore the resonant frequencies for the TMmn0 modes can be written as (Richards, 1988; Gonca, 2005)

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

Circular patch radius:

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

$$(f_r)_{110} = \frac{1.8412\nu_0}{2\pi a_e\sqrt{\varepsilon_r}}$$

Effective radius of circular patch:

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

TABLE 1
ANTENNA DESIGN SPECIFICATION

PARAMETER	VALUES
Frequency band used	ISM band
Operating frequency :	5.8GHz
Wavelength in free space/ vacuum	51.72mm
Radius of circular patch	9.88mm
Substrate dielectric material	RT-duroid 5880
Substrate dielectric constant	2.2
Substrate thickness:	0.762mm
FSS surface used in superstrate layer above direction	FR-4 epoxy (4.4)(R= 2.5mm)
FSS surface used in below direction	RT duroid 5880
Feeding technique	probe feeding
Feed point location from center	3.1mm
Air gap	28.96(0.56 * 51.72mm)
Ground plane	l=75mm, W= 75mm

IV. SIMULATION RESULT AND DISCUSSION

A. Results of Microstrip Patch Antenna Without FSS Layer

1) Gain Total:
Operating Frequency: 5.8 GHz
Value of Gain Total (in db):7.1479 db
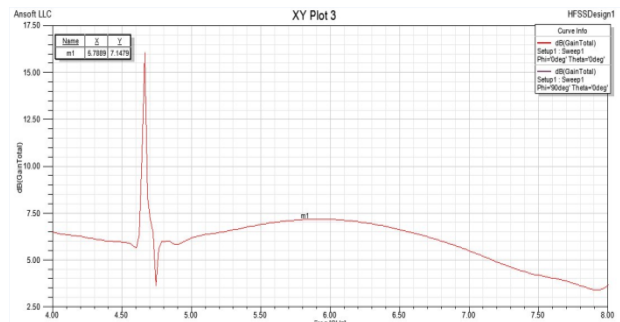Peak point (m1) of operating frequency: 5.7889GHz

Figure-5.1.1.Gain total (in db) without single FSS

2) Radiation Pattern:
Operating frequency: 5.8GHz
Setup1: sweep1
Peak point (m1) of operating frequency: 5.7889GHz
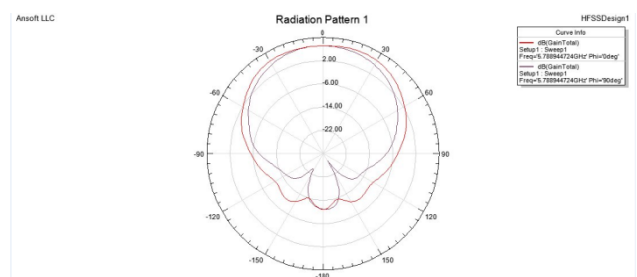Phi (in degree)-0 degree, phi(in degree)= 90 degree

Figure.5.1.2.Radiation pattern without single FSS

3) Return Loss:
Operating frequency: 5.8 GHz
Value of return loss (in db): -13.7496 db
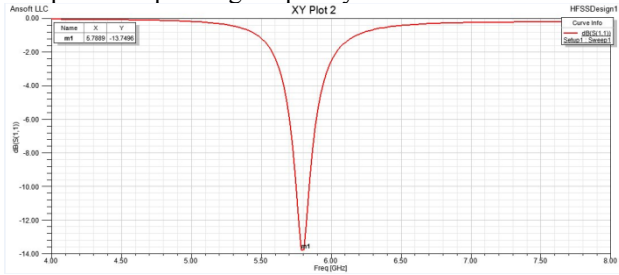Peak point of operating frequency: 5.7889

Figure.5.1.3.Return loss without single FSS

4) Directivity:

Operating frequency: 5.8GHz
Setup1:sweep1
Peak point (m1) of operating frequency: 5.7889GHz
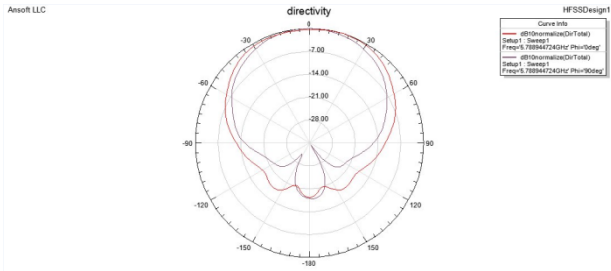Phi (in degree) = 0 degree, phi (in degree)= 90 degree

Figure.5.1.4.Directivity without single FSS

B. Result of Microstrip Patch Antenna with Single FSS Layer:

1) Total Gain:

Operating Frequency: 5.8GHz
Value of Gain Total (in db):9.8557
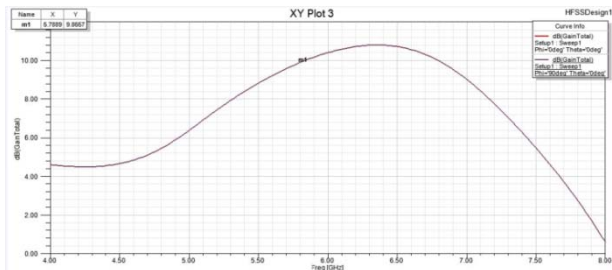Peak point (m1) of operating frequency: 5.7889GHz

Figure.5.2.1.Total gain (db) with single FSS

2) Radiation Pattern:

Operating frequency: 5.8GHz
Setup1: sweep1
Peak point (m1) of operating frequency: 5.7889GHz
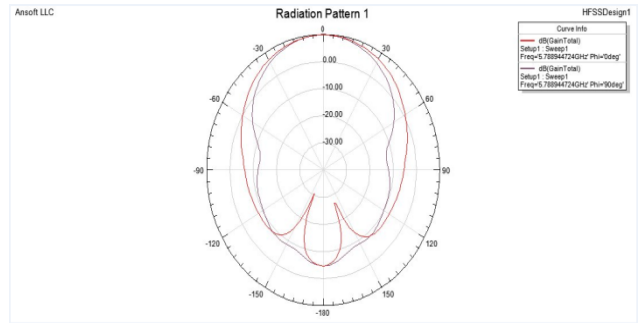Phi (in degree)-0 degree, phi (in degree) = 90 degree

Figure.5.2.2.Radiation pattern with single FSS

3) Return Loss:
Operating frequency: 5.8GHz
Value on return loss: -14.7357db
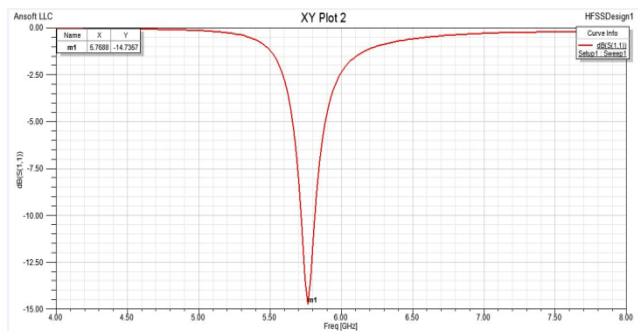Peak point of operating frequency: 5.7688GHz

Figure.5.2.3Return loss (db) with single FSS

4) Directivity:

Operating frequency: 5.8GHz
Setup1:Sweep1
Peak point (m1) of operating frequency: 5.7889GHz
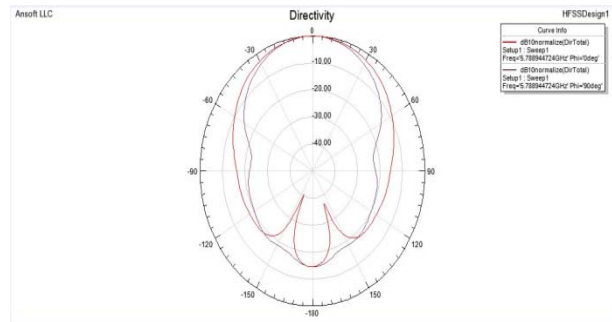Phi (in degree) = 0 degree, phi (in degree) = 90 degree

Figure.5.2.4.Directivity with single FSS

V.   CONCLUSION:

We made comparative analysis among conventional microstrip patch antenna and circular microstrip patch antenna which achieved resonance at 5.8GHz with FR-4 epoxy single layer with permittivity (εr =4.4) gives 38% increase in gain. The antenna radiation reflected lesser in antenna with FSS layer by 7.17% in reduction of return losses.

REFERENCES:

JOURNAL PAPER:

[1] Gohil, J.V.; Bhatia, D., "Design of 2×1 circularly polarized microstrip patch antenna array for 5.8 GHz ISM band applications," Engineering (NUiCONE), 2012 Nirma University International Conference in Ahmadabad, IEEE Publisher on, pp.1-4, 6-8 Dec. 2012.

[2] Mittra, R., Li, Y. and Yoo, K "A comparative study of directivity enhancement of microstrip patch antennas with using three different superstrates" Microwave Optical Technology Letter, volume 52, issue 2, 327–331, Feb 2010.

[3] Gupta, Samir Dev, and Amit Singh. "DESIGN AND ANALYSIS OF MULTIDIELECTRIC LAYER MICROSTRIP ANTENNA WITH VARYING SUPERSTRATE LAYER CHARACTERISTICS." International Journal of Advances in Engineering & Technology, Vol. 3 Issue 1, p55-68. 14p, Mar 2012.

[4] Guo, Y.J.; Paez, A.; Sadeghzadeh, R.A.; Barton, S.K., "A circular patch antenna for radio LAN's," Antennas and Propagation, IEEE Transactions on, vol.45, no.1, pp.177- 178, Jan 1997.

[5] T. F. Lai, Wan Nor Liza Mahadi, Norhayatision, "Circular Patch Microstrip Array Antenna for KU-band", World Academy of Science, Engineering and Technology, vol. 48, pp. 298-302, 2008.

[6] Carver, Keith R., and James Mink. "Microstrip antenna technology." Antennas and Propagation, IEEE Transactions , pp 2-24, Feb 1981.

[7] T. Samaras, A. Kouloglou, and J. N. Sahalos, "A Note on the Impedance Variation with Feed Position of a Rectangular Microstrip-Patch Antenna", IEEE Antennas and Propagation Magazine, Vol. 46, No. 2, pp. 90--92, April 2004.

[8] Liu, W. -C; Hu, Z.-K., "Broadband CPW-fed folded-slot monopole antenna for 5.8 GHz RFID application," Electronics Letters , in IET, vol.41, no.17, pp.937,939, 18 Aug. 2005.

[9] Singh, N.; Yadav, D.P.; Singh, S.; Sarin, R.K., "Compact corner truncated triangular patch antenna for WiMax application," in proceeding of conference Microwave Symposium (MMS) at Guzelyurt, 2010 Mediterranean , vol., no., pp.163,165, 25-27 Aug. 2010

[10] Al-Zoubi, Asem, Fan Yang, and Ahmed Kishk. "A broadband center-fed circular patch-ring antenna with a monopole like radiation pattern." Antennas and Propagation, IEEE Transactions on 57.3 (2009): 789-792, March 2009.

[11] A.Kotrashetti, J.Anthony, H. Crasto, N.Ram "Design and developemtn of microstrip patch antenna for ISM band transmitter-reciever system" in proceeding of international conference and Workshop on Emerging Trend in Technology, ACM New York, , Pages 458-461, Feb 2010.

[12] Balanis C.A (1982) Handbook of Microstrip Antennas. John Wiley and Sons New York.

[13] Burkholder, R and Lundin, T. (2006). Antenna and Radiation Pattern. IEEE. Transactions on Antennas and Propagation, 53(2):

[14] Z.-W. Yu, G.-M. Wang, X.-J. Gao, and K. Lu, "A novel small-size single patch microstrip antenna based on koch and sierpinski fractal-shapes," Progress In Electromagnetics Research Letters, Vol. 17, 95-103, 2010.