Performance Analysis between MEMS Based Circular, Rectangular, Square and Triangular Microstrip Patch Antennas

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Abstract- The paper presents research work on compactness, Gain and Return Loss of a circular microstrip patch antenna. The pattern of Four different microstrip patch antennas are analysis and designed for 2.4GHz using Gold Substrate with 1.6nm thickness to maximize the Gain of antenna. The optimum Gain 19.53 db and return loss(S11) of -37.56db was observed. All the four microstrip antennas were analyzed and compared using HFSS simulation software.

Keywords- *Microstrip patch antenna, Gain, Return Loss(RL),Efficiency, Frequency 2.4Ghz.*

I. INTRODUCTION

The demand of wireless technology is varies rapidly in the market, with time and requirements. These devices are increasingly getting smaller in size, lightweight. This leads to an increasing demand for compactness property of the Microstrip antenna leading to the initiation of the integration of circuits and antennas on the same substrate resulting in antenna –circuit modules, which can also be met under the term active integrated antennas.Patch antennas are plays very significant role in the world of wireless system . The commonly used Microstrip patch antennas are rectangular and circular patch antennas. These patch antennas are used as simple and for the widest and most demanding wireless applications.The microstrip antennas are present day antenna designers choice due to the fact that low dielectric constant substrates are preferably used for maximum radiation, the conducting patch can take any shape but rectangular, circular configurations are the most widely used. The microstrip antenna consist of a single layer design which includes four parts (patch, ground plane, substrate and feeding part. These antennas are integrated with printed strip line feed networks and active devices. The patch is usually made of conducting material such as Copper or Gold and can take any possible shapes. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The thickness of substrate layer is 0.01–0.05 nm of free-space wavelength.

This provides proper spacing and mechanical support between the patch and its ground plane. It also often used with high dielectric constant material to load the patch and reduce its size. Several circular antennas have been developed over the past decade. The major disadvantages of these antennas are gain and narrow bandwidth.

After rectangular patch, the next configuration is the circular patch which has varying applications as a single patch element as well as in arrays. The modes that are supported primarily by circular patch element as well as in arrays. The modes that are supported primarily by a circular microstrip patch antenna whose substrate height is small (h<<λ) are taken to perpendicular to the patch. The circular patch has only one degree of freedom to control i.e. radius of the patch. Though this does not change the order of the modes, however it does change the value of the resonant frequency.

In MIMO system, it becomes a challenging for designers to placing the conventional antennas, it needs multiple factors like Gain, Impedance ,stable radiation, and mutual coupling effect. For an efficient MIMO system these factors need to be taken in to consideration.[1-3]. To reducing the mutual coupling effect and increasing system's channel capacity linearly with number of uncorrelated channels. Reconfigurable antenna become a solution for reduce the mutual coupling effect[.9].

The Circular microstrip patch antenna is more simple compared to triangular, rectangular, square and other antennas. Microstrip patch has one degree of freedom to control (radius) while microstrip has two (length and width)[1,5] . Therefore, such microstrip patch antenna is simpler to design and its radiation can be controlled easily.

II. OBJECTIVE

The main objective of this paper is to design a probe-fed Circular , Rectangular, square and triangular Microstrip antenna and study the effect of its dimensions, Length(L), Gain, efficiency, substrate parameters Dielectric constant ($\mathcal{E}_r$),substrate thickness(h) on the radiation parameters, Return loss(RL), VSWR and higher efficiency .

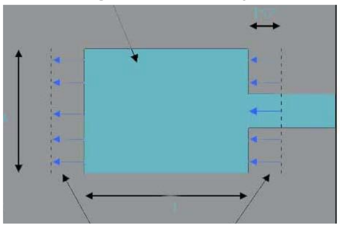

Fig.1: Constructional view of microstrip antenna

III. CONTRIBUTION

A programmable Gain control can be exist into the microstrip antenna array, as feature design to have better and adoptable solution. The system shows design of a microstrip patch antenna and comparing with other antennas like rectangular , triangular and square patch antennas using HFSS simulation software.

.Design and analysis :

Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by (Balanis, 1982)

$$a=\frac{F}{\left\{1+\frac{2h}{\pi \varepsilon r F}\left[\ln\left(\frac{F\pi}{2h}\right)+1.7726\right]\right\}^{1/2}} \qquad \ldots\ldots\ldots\ldots.. (1)$$

$$F=\frac{8.791x10^{9}}{f_r\sqrt{\varepsilon r}} \qquad \ldots\ldots\ldots\ldots.. (2)$$

The effective radius of the patch is given by (Balanis,1982)

$$a_e=a\left\{1+\frac{2h}{\pi \varepsilon r a}\left[\ln\left(\frac{a\pi}{2h}\right)+1.7726\right]\right\}^{1/2} \ldots\ldots\ldots\ldots.. (3)$$

ε_r -Dielectric constant of substrate
h- Height of a substrate
a_e- Radius of patch
f_r - Resonant frequency

By using above equations (1) and (2), radius of circular patch antenna(a), a=2.258 nm with Gold impurity, the substrate of dimension is 30mmx30mm.

The length of patch antenna, determines the resonate frequency The length is calculated by the formula

$L=L_{eff}-2\Delta L$ ------(3)

Where

$$L_{eff}=\frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

The Extension length(ΔL) = $0.412h\,\frac{[\varepsilon_{reff}+0.3][\frac{W}{h}+0.264]}{[\varepsilon_{reff}-0.258][\frac{W}{h}+0.8]}$

ε_{reff}= Effective dielectric constant
ε_r=Dielectric constant of substrate
h=Height of the dielectric substrate
W=Width of the patch

The width of the patch antenna is obtained by (W)

$$W=\frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}} \text{----- ------} \quad (4)$$

Using above equation 3and 4, find the width of the antenna is 4.63 µm , Length is 0.362nm.

IV. TABLES WITH SIMULATION RESULTS

TABLE I.

Frequency - 2.4GHz, Dielectric Constant- 2.63 for Circular microstrip antenna

S.No	Thickness (T)	Efficiency	Gain - db
1	1	99.894	19.53
2	3	9.684	19.52
3	5	99.474	19.51
4	10	98.955	19.49
5	20	97.935	19.44

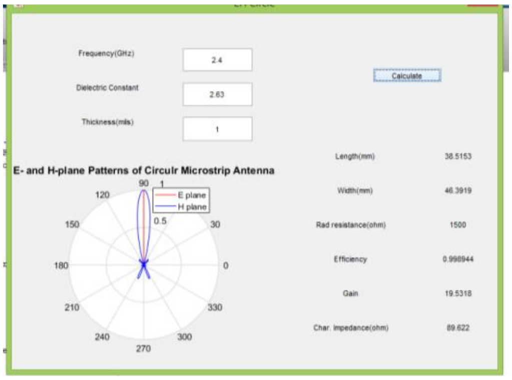

Fig.2: Frequency: 2.4GHz, Diele const. : 2.63 T: 01

The efficiency 99.894% with Gain 19.534dB.

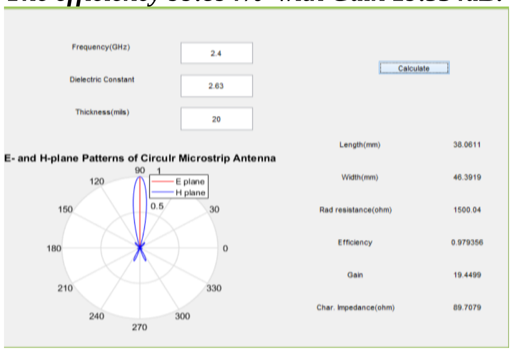

Fig.3: Frequency: 2.4GHz, Diele const. : 2.63 T: 20

The efficiency of 97.93% with Gain of 19.44dB..

TABLE II.

Frequency - 2.4GHz, Dielectric Constant- 2.63 for Rectangular microstrip antenna

S.No	Thickness(T)	Efficiency	Gain-db
1	1	99.99	18.56
2	3	99.75	18.55
3	5	99.58	18.55
4	10	99.17	18.53
5	20	98.36	18.49

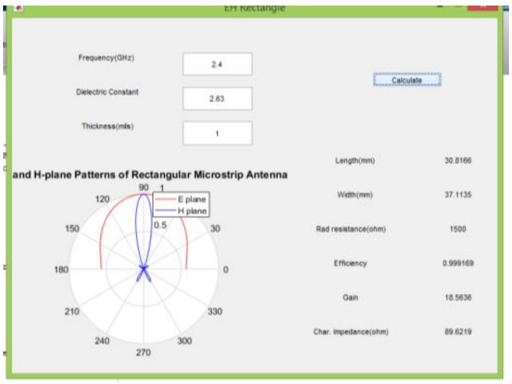

Fig.4: Frequency: 2.4GHz, Diele const. : 2.63 T: 01

The efficiency of 99.99% with Gain of 18.56dB.

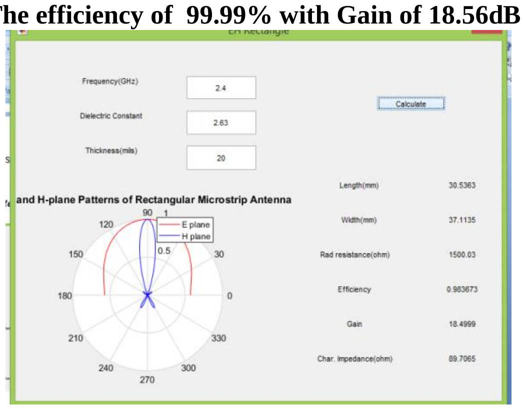

Fig.5: Frequency: 2.4GHz, Diele const. : 2.63 T: 20

The efficiency of 99.36% with Gain of 18.49dB..

.TABLE III.

Frequency - 2.4GHz, Dielectric Constant- 2.63 for Triangular microstrip antenna

S.No	Thickness(T)	Efficiency	Gain - db
1	1	99.95	18.57
2	3	99.87	18.56
3	5	99.79	18.55
4	10	99.58	18.55
5	20	99.17	18.53

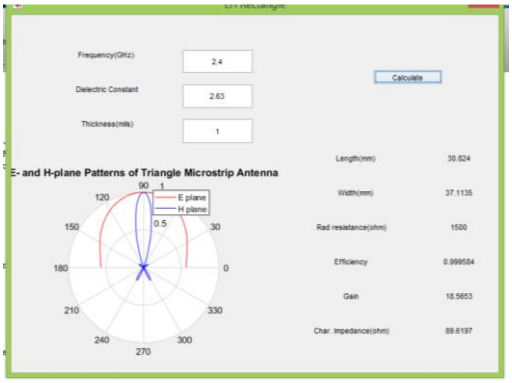

Fig. 6: Frequency: 2.4GHz, Diele const. : 2.63 T: 01

The efficiency of 99.95% with Gain of 18.57 dB

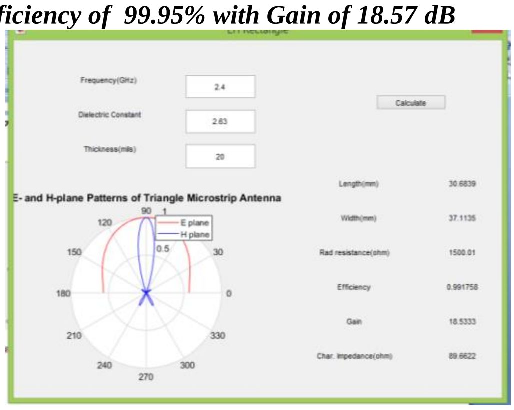

Fig.7: Frequency: 2.4GHz, Diele const. : 2.63 T: 20

The efficiency of 99.17% with Gain of 18.53dB

TABLE IV.

.Frequency - 2.4GHz, Dielectric Constant- 2.63 for Square microstrip antenna

S.No	Thickness(T)	Efficiency	Gain db
1	1	99.91	12.12
2	3	99.75	12.10
3	5	99.58	12.11
4	10	99.17	12.09
5	20	98.38	12.07

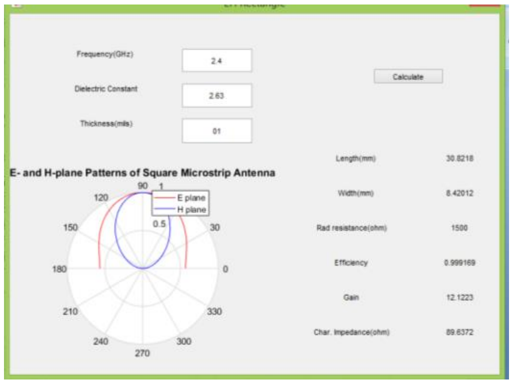

Fig.8: Frequency: 2.4GHz, Diele const. : 2.63 T: 01

The efficiency of 99.19% with Gain of 12.12dB

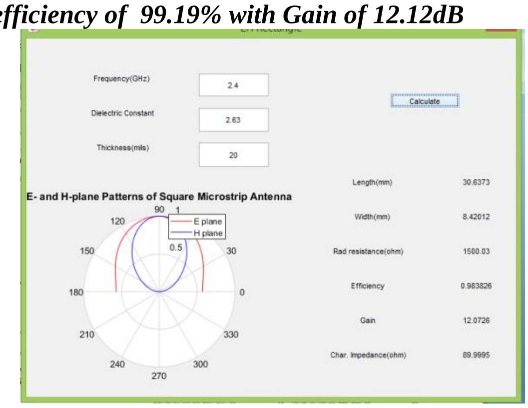

Fig.9: Frequency: 2.4GHz, Diele const. : 2.63 T: 20

The efficiency of 99.38% with Gain of 12.07dB

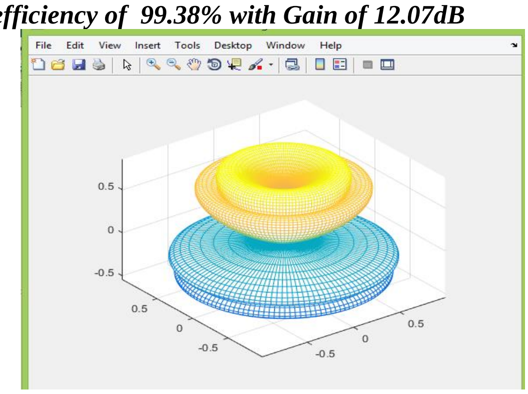

Fig.10: 3D-radiation plot for circular microstrip antenna

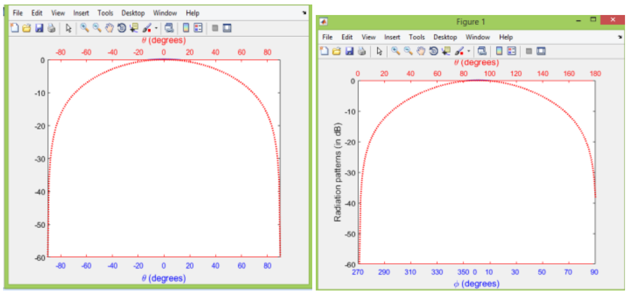

Fig.11: The Radiation Pattern of circular, rectangular microstrip antenna

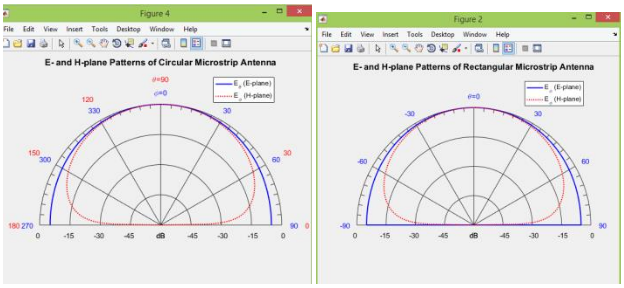

Fig.12: The E-plane and H-plane radiation pattern of circular, rectangular designed microstrip antenna

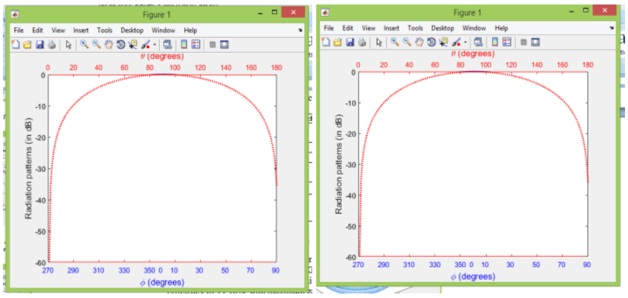

Fig.13: The radiation pattern of Square, Triangular designed microstrip antenna

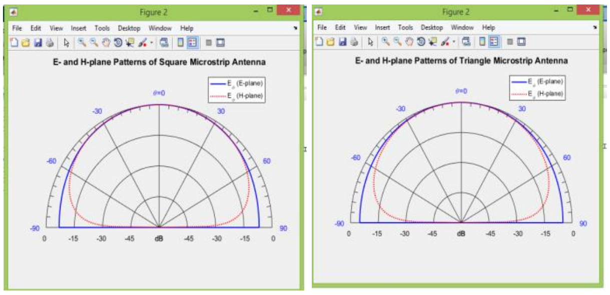

Fig.14: The E-plane and H-plane radiation pattern of Square, Triangular designed microstrip antenna

Output parameter	Circular patch antenna	Rectangular patch antenna	Square patch antenna	Triangular patch antenna
Physical parameters (in Nano)	2.2716	4.658	00	1.927
Effective parameter in nano	3.876	2.86	4.374	3.853
E-PLANE HPBW (degrees)	104.00	106.00	90.00	108.00
H-PLANE HPBW (degrees)	80.00	78.00	88.00	86.00
Directivity of patch	4.99	4.73	3.19	3.03
Directivity of patch in db	6.982	6.755	5.82	5.15
Return loss-db	-37.62	-34.03	-36.57	-30.00
VSWR	1.21	1.04	1.00	1.05

Table V: Comparison Table .

V. CONCLUSION

From the above theory and simulated results for MEMS based circular microstrip patch antenna has better efficiency of 99.98% with maximum Gain of 19.534dB compare with other antennas. We can conclude that the directivity of circular patch antenna is more than other patch antenna parameters.

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