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Design and Analysis of 1x2 Circular Patch Antenna Array for 2.4 GHz Applications

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Abstract-- ***A 1x2 Circular micro strip patch antenna array operating at 2.4GHz using Ansys based HFSS simulator software is designed. It is useful for different WLAN (wireless local area network) applications, Bluetooth and IoT communications. The circular patch antenna is constructed on a FR4 substrate with dielectric constant = 4.4 and height of the substrate is 1.6mm and is fed using edge feeding technique. Several antenna characteristics such as return loss, radiation pattern, bandwidth, directivity, antenna gain, radiation efficiency etc. are studied.***

Keywords **: *circular patch microstrip antenna, HFSS, WLAN***

I.INTRODUCTION

Micro strip antennas have profound applications especially in the field of medical, military, mobile and satellite communications. Microstrip antennas are very versatile in terms of resonant frequency, polarization, pattern and impedance at the particular patch shape. Their utilization has become diverse because of their small size and light weight.[1] Rapid and cost effective fabrication is especially important when it comes to the prototyping of antennas for their performance evaluation. As wireless applications require more and more bandwidth, the demand for wideband antennas operating at higher frequencies becomes inevitable.[2] Inherently microstrip antennas have narrow bandwidth and low efficiency and their performance greatly depends on the substrate parameters i.e. its dielectric constant, uniformity and loss tangent. The microstrip antennas are mostly a broadside radiator.[3] The position of the feed has to be changed as before to control the input impedance.

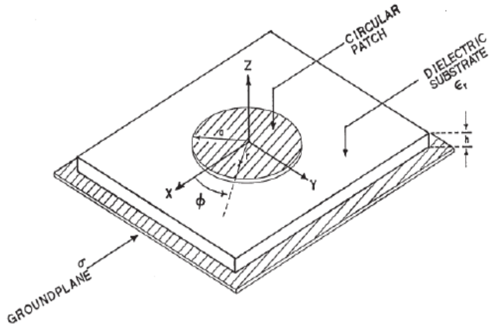

Fig Error! No text of specified style in document.. Circular microstrip patch

The patch, micro strip transmission line (or input, output pin of coaxial probe), and ground plane are made of high conductive material. The patch may be in a variety of shapes, but rectangular and circular are the most common because ease of analysis and fabrication, attractive radiation characteristics, especially low cross polarization. The patch is designed in such a way so that its pattern is maximum normal to it.[4] End-fire radiator can also be chosen by proper mode selection. The microstrip patch consists of a metallic "patch" on top of the dielectric substrate and below the dielectric material it has ground plane.

II.ANTENNA DESIGN

Microstrip antennas are very flexible and are used in an array to synthesize a desired pattern which cannot be obtained with a single element. We use an array to extend the performance of the antenna, scan the radiation pattern beam of an antenna system, enhance the directivity, and gain which would be better compared to that of a single element.[5] The elements can be fed by a single line or by multiple lines in a feed network arrangement. The important parameter for the design of a Microstrip patch antenna is the Frequency of operation (f_r). The resonant frequency of the antenna should be chosen appropriately. The Industrial, Scientific and Medical (ISM) Systems uses the frequency range from 2.4GHz - 2.5GHz. Hence the designed antenna must be competent to function in this frequency range.[6]
The resonant frequency chosen for our design is 2.4 GHz. The chosen value of the substrate (FR4) relative Dielectric constant (ε_r) is 4.4 and the substrate thickness (h) is 1.66 mm. Then, we evaluated the radius of the circular patch using the formula:

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

$$where F = \frac{8.791X10^9}{fr\sqrt{\varepsilon}}$$

Hence radius=17mm.

$$z_c = \begin{cases} \frac{60}{\sqrt{\varepsilon_{reff}}} ln\left[\frac{8h}{w_0} + \frac{w_0}{4h}\right], \frac{w_0}{h} \le 1 \\ \frac{120\pi}{\sqrt{\varepsilon_{reff}}\left[\frac{w_0}{h} + 1.393 + 0.667 ln\left(\frac{w_0}{h} + 1.444\right)\right]}, \frac{w_0}{h} > 1 \end{cases}$$

Permittivity of free space(ε_0) = 8.854 × 10-12 F/m

$\varepsilon = \varepsilon_r \times \varepsilon_0$

For a single circular patch optimal feed location is usually at one third distance from centre of the patch. The feed location is calculated using:

$$y = \frac{W}{2}$$

$$x = \frac{L}{2\sqrt{\varepsilon_{reff}}}$$

Generally, substrate length L and width W are:

L = 2 × Patch Diameter = 2 × (2a)
W = 2 × Patch Diameter = 2 × (2a)

The calculated dimensions are:

Radius:17mm
Feed location: (5.5,0)

Each of the patch is connected to 100Ω feedline. The equivalent at the junction of the two 100Ω lines is 50Ω. A 50Ω feedline is connected to edge feed.

Inter-element spacing = 62.5 mm
Width of 100Ω feedline =0.7mm
Width of 50Ω feedline =3mm

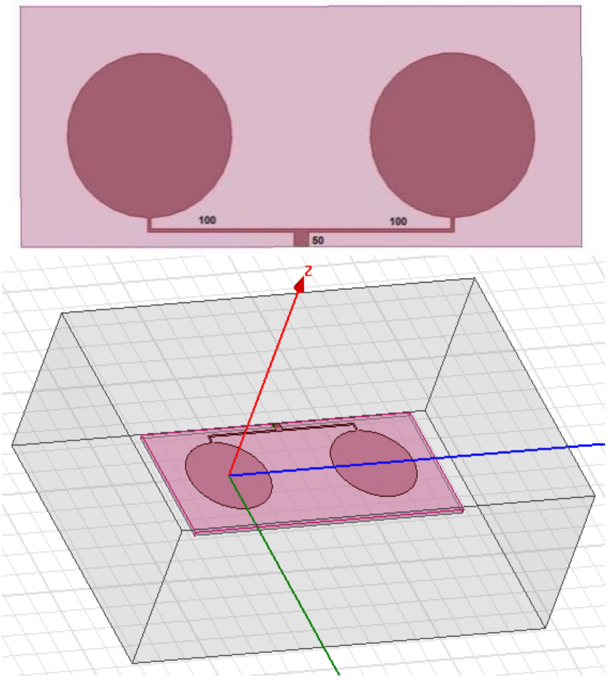

Fig 2. 1x2 array

III.SIMULATION RESULTS

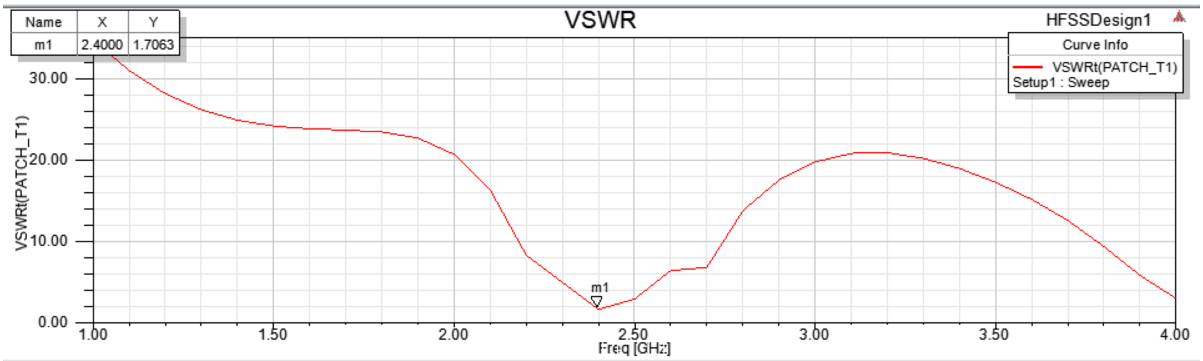

Fig 3. VSWR

Fig 4. Return Loss

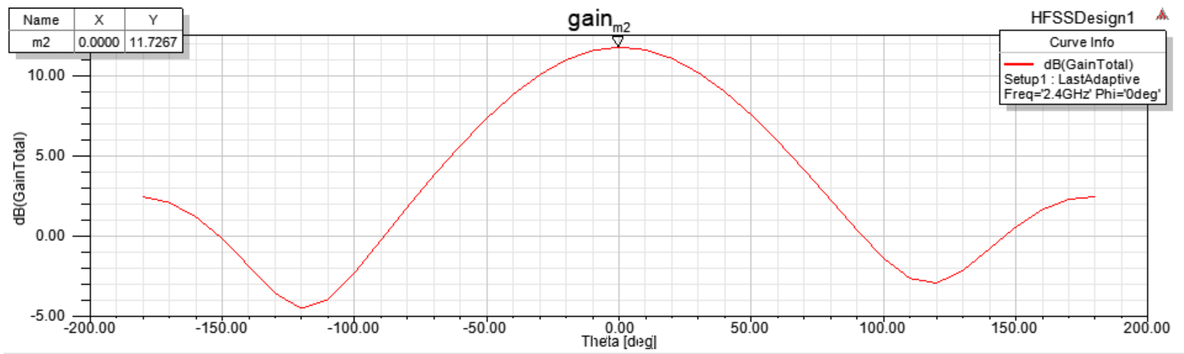

Fig 5. Gain

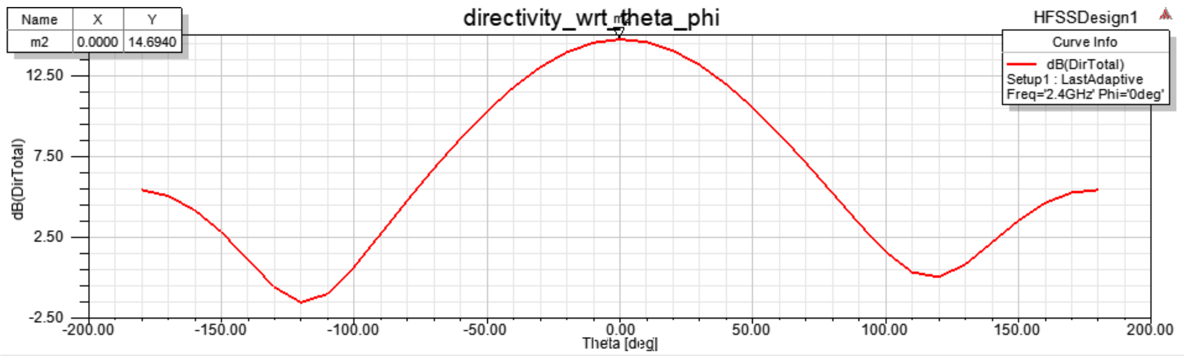

Fig 6. Directivity

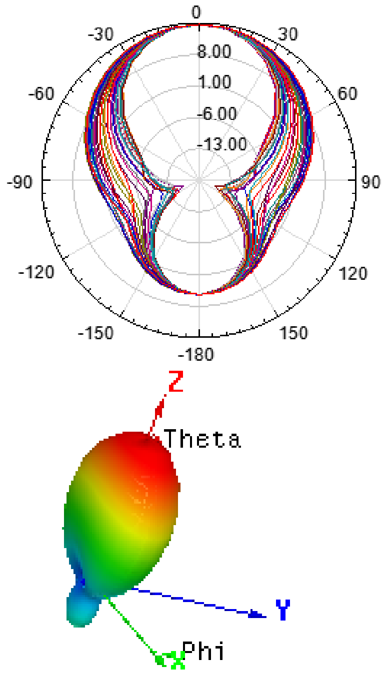

Fig 7. 3D Radiation Pattern

Table 1. Results

Parameter	Obtained value
Gain	11.7dB
Directivity	14.6dB
VSWR	1.7
Return Loss	-11.6dB
Radiation Efficiency	50%

IV.CONCLUSION

Microstrip patch antenna arrays of circular shaped radiating elements were successfully designed and implemented using the FR4 Epoxy Glass substrate. Through the Analysis of HFSS simulation software, it was observed that the antenna resonated at 2.4 GHz frequency. In this work, edge feed technique was used for the simulation of 2x1 Circular Patch Antenna. From the proposed simulation design, the maximum achieved gain was 11.7 dB for a 2x1 array. Return loss should be less than -10 dB for an acceptable operation. There are three solution types available in HFSS namely Discrete, Fast and Interpolating. [7] Discrete is the most accurate and takes the longest time to simulate out of the three types of solutions. Fast is the least accurate and takes the shortest time for simulation. Interpolating is moderately accurate and takes moderate time for simulation. Demand for wideband antennas is high. Microstrip antennas have narrow bandwidth and low efficiency and their performance greatly depends on the substrate parameters. [8] Advantage of circular patch over the rectangular patch is the need of lesser area. But they have high input impedance along the circumference as a disadvantage. Although antennas may be considered old technology, researchers are finding ways to innovate the antenna for the next generation of electronics.

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