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# Multi-Directional Patch Antenna Array

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***Abstract*— Here, an equilateral triangular shaped circular feed network is designed. This circular feed network can radiate in eight different directions. This radiation is depending on four input ports which are excited. It can cover wide area within upper hemisphere. This antenna is designed in such a way that it is useful for any applicable GHz ISM band frequency and utilizes a suspended FR4 substrate. For this antenna we used positive microstrip elements, so that it will make easy to manufacture.**

**Keywords- Circular structure, circular patch, multidirectional patch antenna, multi-beam antenna, circular feed network.**

## I. INTRODUCTION

In today's world the use of electronic devices is increasing in our day to day life. We are using various devices which work on the various frequencies and at various power levels. The use of these devices increases day by day which depend on higher power and frequencies People are attracting towards the usage of small and compact antennas in the present days. Small and moveable devices are having their importance in the communication techniques. Patch antennas are very important antennas for integrated RF front-end systems because of their compatibility with microwave integrated circuits. That's why we need to introduce such a antenna especially a microstrip antenna which can utilizes this power and can work at any desirable applicable frequency with more efficiency. We needed a directional beam with a wider beamwidth so here the modified structure is introduced.

## II. CIRCULAR FEED NETWORK DESIGN

Here, modified circular type network is designed. The feeding point is given at the center of the antenna. The feeding point is surrounded by equilateral triangular patches as shown in fig 1.

While most power dividers are designed to have minimum phase deviation between its two channels, the main purpose of introducing this design is to introduce a phase shift between different output terminals. This can be done by feeding the circle from an off- center position so that there is a difference in the distance travelled by the signal to reach each of the triangular patch elements.

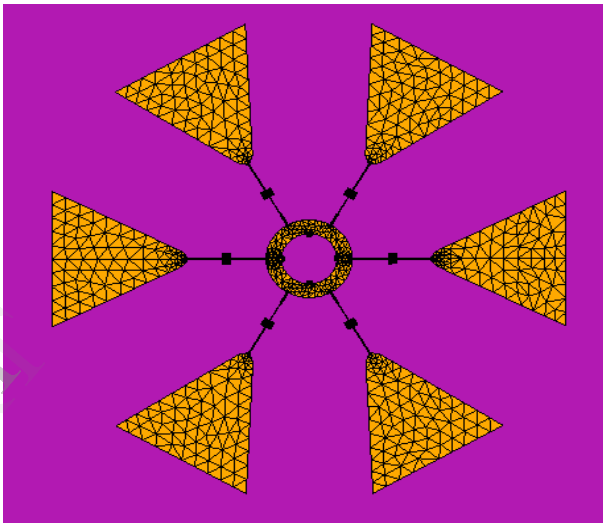

Fig 1. The proposed antenna geometry. The array contains circular feed network and equilateral triangular patches connected by impedance matching microstrip lines [1].

Here, we have designing this type of modified circular structure as shown in fig 2. Then, after simulating this type of structure in HFSS we got the results that are shown below,

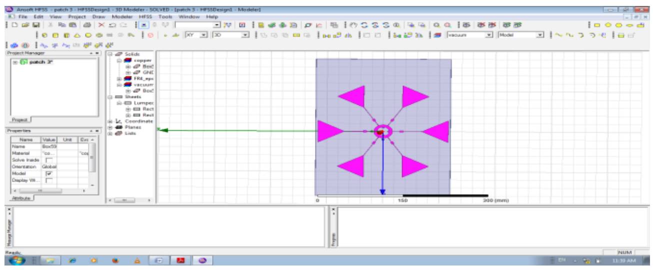

Fig 2. Modified structure of an microstrip patch antenna array at 2.45 GHz frequency

The center frequency is selected as the one at 2.45GHz which the return loss is minimum in the below Fig 3 the Return Loss is coming out to be -11.982179 db.

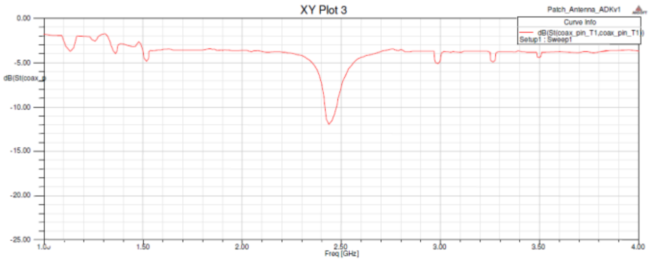


Fig 3. Return loss when Port B is simulated

Ideally, VSWR of Port B is coming out to be 1.823219 db. Ideally it must lie in the range of 1-2 which is achieved for the frequency 2.45 GHz, at the operating frequency value.

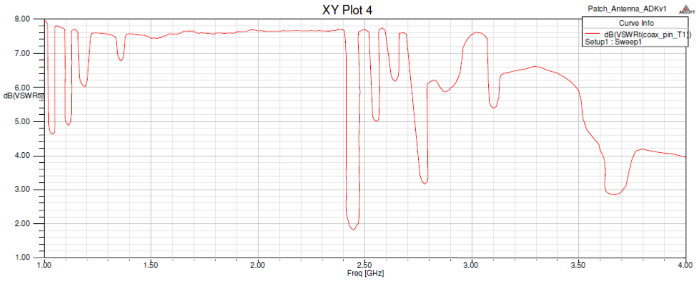


Fig 4. VSWR of Port B

Since a modified circular micro strip patch antenna radiates normal to its patch surface, the elevation pattern for phi = 0 degrees would be important. The maximum gain is obtained in the broadside direction and this is measured to be 7.843244 db.

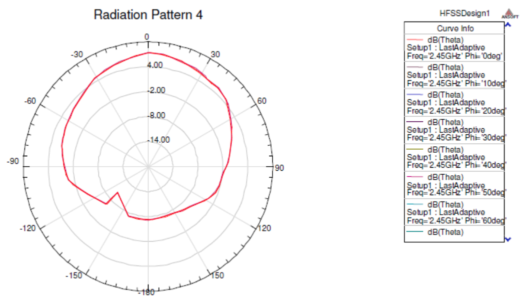


Fig 5. Gain obtained for Port B

## III. DESIGN PARAMETERS

The important parameters for the design of a Microstrip Patch Antenna are:
Frequency of operation ($f_o$): The resonant frequency of the antenna must be selected appropriately. The Mobile Communication System requires the frequency range from 2100-5600 MHz; hence the antenna designed must be able to operate in this frequency range.

Dielectric constant of the substrate ($€_r$): The dielectric material selected for our design is FR4 which has a dielectric constant of 4.4.
Height of dielectric substrate (h): For the micro strip patch antenna to be used in cell phones, it is necessary that the antenna is not bulky. So, the height of the dielectric substrate is selected as 1.5748 mm.

Step 1: Computation of the Width (W):

The width of the Micro strip patch antenna is,

$$W = \frac{c}{2 f_0 \sqrt{(\varepsilon_r + 1)/2}} \quad (1)$$

'C' is the speed of light in air and it is $3*10^8$ m/s.

Step 2: Computation of Effective dielectric constant ($\varepsilon_{reff}$):

The effective dielectric constant is:



$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{(-0.5)} \quad (2)$$

'h' is the height of substrate, 'w' is the width of the patch.

Step 3: Computation of Effective length ($L_{eff}$):

The effective length is:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{(\varepsilon_r e_{eff})}} \quad (3)$$

Step 4: Computation of Length extension ($\Delta$L) :

The length extension is:

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

Step 5: Computation of actual Length of patch:

The actual length is:

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

Step 6: Computation of the ground plane dimensions ($L_g$ and $W_g$):

The transmission line model is applicable only to infinite ground planes. However, for practical approximations, it is necessary to have a finite ground plane. The size of the ground plane must be greater than the patch dimensions by approximately six times the substrate thickness all around the peripheral surface. That's why, for this design, the ground plane dimensions will be given as:

$$L_g = 6h + L$$
$$W_g = 6h + W \quad (6)$$

Here, Length of each equilateral patch antenna is 54 mm and it is obtained by the calculation first and after that by using trial and error method the length obtained is 54 mm so that the resonance is at the desired frequency. It is almost impossible to get the exact value by calculations because of the complexity of the proposed architecture. The final inner and outer dimensions are 22 and 33 mm, respectively. Initial values are obtained using standard 50 Ohm line design equations.

## IV. IV.EQUILATERAL TRIANGULAR PATCH DESIGN

The proposed array contains six equilateral triangular patches. Their characteristics are explained in this section. The triangular shape is chosen because it is most suitable structure for creating a compact array. This circular array is used for the circular power divider while giving uniform element spacing along the length of the patches. The array elements should have uniform and wide beamwidth so that, they can allow steering in different directions without introducing losses. The reason for not selecting this plane circular structure is it is omni directional and we needed a directional beam with a wider bandwidth.

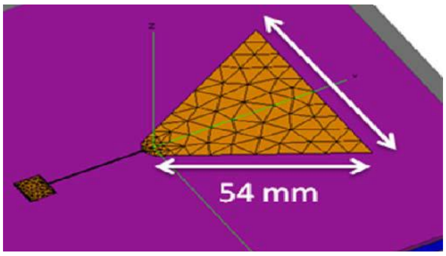


Fig 6. Equilateral triangular patch element geometry [1].

The each side length of equilateral triangle is selected 54 mm. This is because, 54 mm is than obtained by trial and error so that the resonance is at the desired frequency. It is almost impossible to get the exact value by calculations because of the complexity of the proposed architecture.

The antenna which we have designed here is rectangular microstrip antenna. The software tool used for designing this antenna is HFSS means high frequency simulating software.

## V CIRCULAR ARRAY

The six triangular patch elements and the central feeding network forms the final array structure as shown in Fig 1. Modifications can be made to the central feeding network after the array elements were added in the structure. The main purpose to add these elements is to fix the matching problems. These problems were occur due to mutual coupling between the elements.

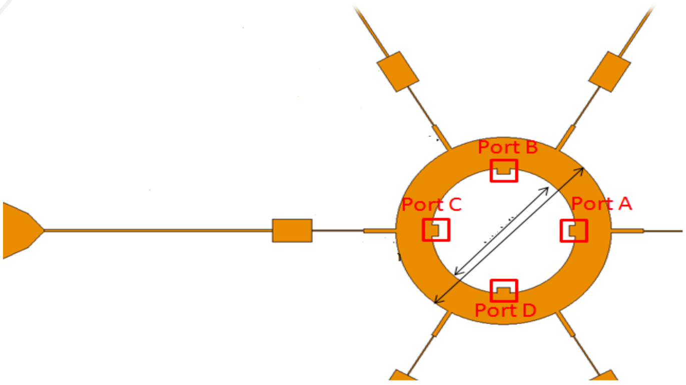


Fig 7. Dimensions of the circular feeding structure. The ports from A towards D are placed on the circular feed as labeled here [1].

At its center this circular patch contains four ports they are port A, port B, port C, and port D. as shown in figure 7. Different types of input are given to each port through feeding point. The inputs given to ports are such that they can achieve the desired outputs. The input given to the ports is with the help of VNA.

The feeding structure is shown in figure above. Here there are four ports that are placed inside this feeding structure. This antenna will radiate in eight different directions. The radiation direction is determined by excited ports that are placed inside that feeding network. when we give input to the feeding structure. This input is given to one port or two ports or three ports at a time so that it will radiate the pattern in any one direction but, here the radiation produced by this structure is more efficient and with more wider beamwidth. We can radiate this antenna in any direction with proper port selection and with proper angle of elevation and angle of rotation. When we use different port combinations of ports then similar patterns and gain were obtained. In this table, theta (θ) is the amount of elevation down the z-axis which it is perpendicular to the surface so theta is equal to zero degrees when the beam is ninety degree to the surface. Phi (Φ) is the amount of rotation in the x-y plane, in this example, phi equals to zero degrees in the direction where port A is located.

## VI CONCLUSION

In this paper an equilateral triangular patch antenna array is presented. This structure is having six equilateral triangular elements which radiate in only one direction or in two directions at a time depending on the combinations of ports which we are going to excite. In this paper a modified circular microstrip antenna is designed and simulated in HFSS.

In future firstly, in this project FR4 material is used, one can use different available dielectric materials such as Teflon, Rogers etc. Secondly, the air packaging is used for the antenna, different experiments carried out with other packaging types.

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