



## Multi-directional patch antenna array

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### ABSTRACT–

Here, a equilateral triangular shaped circular feed network is designed. This circular feed network can radiate in eight different directions. This radiation is depending on four inputs 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.

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### 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.

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.

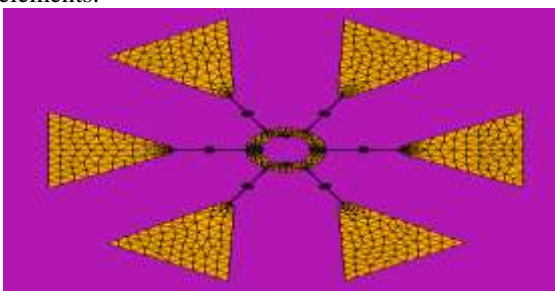


Fig 1. The proposed antenna geometry

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,

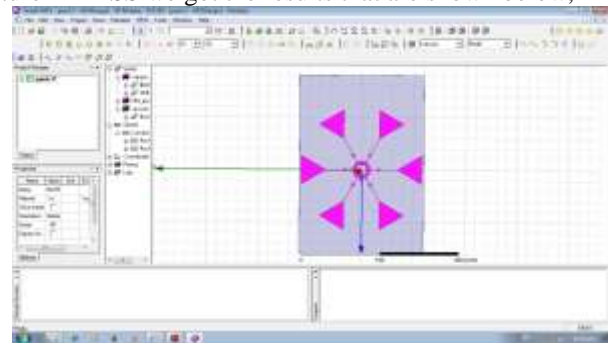


Fig 2. Modified structure of an microstrip patch antenna array at 2.45 GHz frequency

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.

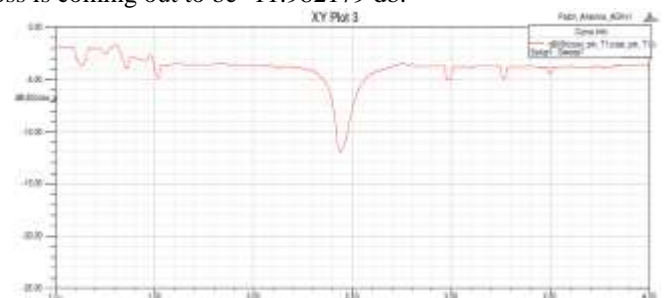


Fig 3. Return loss when Port B is simulated

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.

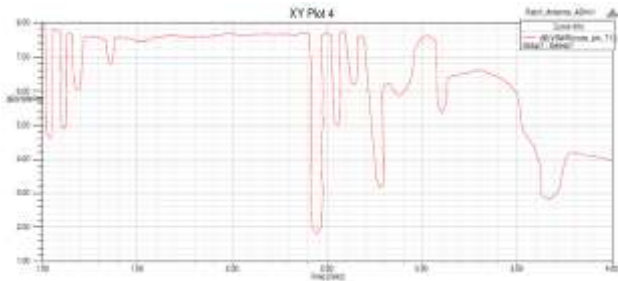


Fig 4. VSWR of Port B

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.

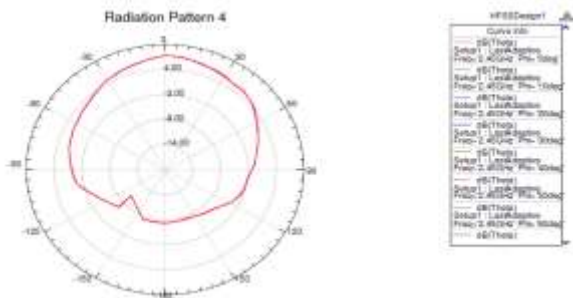


Fig 5. Gain obtained for Port B

Design parameters The important parameters for the design of a Microstrip Patch Antenna are:

Frequency of operation ( $f_0$ ): 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 ( $\epsilon_r$ ): 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,

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

#### Step 2: Computation of Effective dielectric constant ( $\epsilon_{\text{reff}}$ ):

The effective dielectric constant is:

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-0.5} \quad (2)$$

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

The effective length is:

$$L_{\text{eff}} = \frac{c}{2f_0 \sqrt{\epsilon_r \epsilon_{\text{reff}}}} \quad (3)$$

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

The length extension is:

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

#### Step 5: Computation of actual Length of patch:

The actual length is:

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

#### 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:

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

$$W_g = 6h + W$$

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.

#### 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.

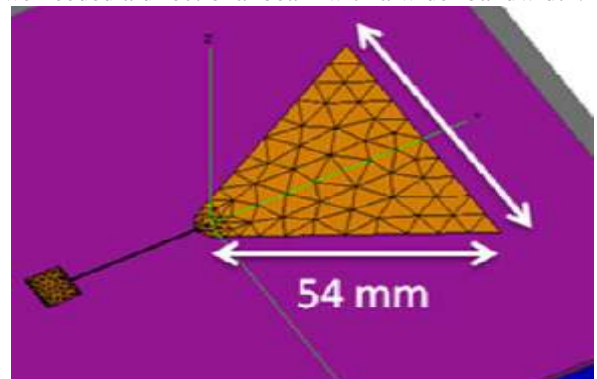


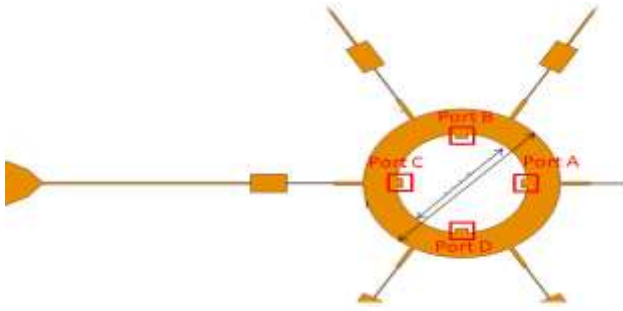
Fig 6. Equilateral triangular patch element geometry [1]

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

#### 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].

1] al Patch Antenna Array with Selectable Beams Using a Novel Feed Structure and Equilateral Triangular Patches” International Conference on communication Eastern Mediterranean University, Turkey.

2] Josaphat Tetuko Sri Sumantyo *Member, IEEE*, Koichi Ito, *Fellow, IEEE* and Masaharu Takahashi *Senior Member, IEEE* “Dual-Band Circularly Polarized Equilateral Triangular-Patch Array Antenna for Mobile Satellite Communications” *IEEE*

transactions on antennas and propagation, vol. 53, no. 11, November 2005.

3] Paolo De Vita, Francesca De Vita, *Member, IEEE*, Alberto Di Maria, and Angelo Freni, *Senior Member, IEEE*” An Efficient Technique for the Analysis of Large Multilayered Printed Arrays” *IEEE antennas and wireless propagation letters*, vol. 8, 2009.

4] Adnan Sondas, Mustafa H. B. Ucar, Yunus E. Erdemli “*Dual-Band Loop-Loaded printed Dipole Array*” 978-1-4244-7243-7/10/\$26.00 ©2010 IEEE

5] Ning Yuan,, Tat Soon Yeo, Xiao-Chun Nie “ Analysis of Probe-Fed Conformal Microstrip Antennas on Finite Grounded Substrate” *IEEE transactions on antennas and propagation*, vol. 54, no. 2, february 2006.

6] Ali Araghi and Gholamreza Dadashzadeh” Oriented Design of an Antenna for MIMO Applications Using Theory of Characteristic Modes” *IEEE antennas and wireless propagation letters*, vol. 11, 2012.

7] Megha Dadelland, Shweta Srivastava” Arrays of Patch Antenna using Log Periodic Property” 978-1-4577-1457-3/11/\$26.00 ©2011 IEEE