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# Design and Analysis of E and F shaped Microstrip Patch Antenna (MSPA) for 5G Applications

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**Abstract: In this paper, different shapes of an E and F shaped patch microstrip antenna designed and operating at x- and kubands is simulated by using High Frequency Structure Simulator (HFSS) software version 13. The finite element method is used to solve electromagnetic values. The dielectric substrate material is FR-4 Epoxy with dielectric constant (r = 3.2) and thickness h=1.79 mm is used in this design. The new designs including modifying and slotting E and F shaped-patch increased the gain of proposed antennas and provided a dual band frequency in 5G Applications. The return loss, voltage standing wave ratio (VSWR) and Gain, directivity are evaluated.**

## INTRODUCTION

Microstrip antennas (MSAs) have various unique properties which make them experienced increased popularity since the last decade. Distinctive physical features like low cost, light weight, conformability, low profile, relatively compact, mechanically robust and other desirable features have made MSAs an attractive source for the researchers. However, MSAs have narrow impedance bandwidth and low gain which represent the major weakness of these antennas. The significant study work has been presented till now many techniques for enhancing the bandwidth, increasing the gain and designing dualband antennas. Some of these techniques are employing a parasitic patches and stacked microstrip antennas to provide large bandwidth and high gain. Also, the experimental study has been designed a rectangular patch antenna which electromagnetically coupled with a two dielectric substrates. In 2007, Pedra et al. increased the bandwidth up to 32 percent using shorting pins and capacitive.

Feeding for E-shaped patch antenna. In particular, multifrequency or wideband operation obtained by using various slotted which allowed reactively loaded and modified MSA structures. Different shape and size of microstrip antennas with different feeding technique have been developed. These various feeding mechanisms include coaxial, aperture coupled, offset feedings and the coupling slot which represents the most popular feeding - technique. It is observed that the capacitive feeding technique that obtained by etching a small circular slot on the patch can reduce the probe inductance to achieve bandwidth. The experimental and simulation results have been studied the coaxially fed U-slot rectangular patch antenna on a foam substrate to increase the bandwidth up to 30 percent. Moreover, a novel equivalent circuit model has been analysed and designed for MSA with the defected ground structure for Ku band applications. The results indicate that a 56.67 percent impedance bandwidth is achieved. Previous researches have addressed different shape and size of slots incorporated into E-shaped MSAs for wideband applications. These various slots include two parallel slots and cutting a pair of tapered slots. Recently, researchers have been used a new E and F-shaped patch antenna to improve through-wall radio tomographic imaging. It was shown that the use of half structure techniques leads to extend the two U-slot patches to the edges and produce the E-shaped patch for wideband behaviour.

## II. DESIGN METHODOLOGY

We have proposed new designs of E and F-patch MSAs with FR-4 Epoxy as a dielectric substrate material. This substrate has dielectric constant (r = 3.2) and its dimensions are length (Ls=29mm), width (Ws=24mm) and thickness (h=1.79mm). The novelty of the antenna lies in its shape and the observed features. They have been made with the help of two different shapes of triangle, in addition to use circle and triangle slots. The version 13 of HFSS software was used to model these proposed antennas with an aim to achieve wideband and dual frequency operation in x- and Ku-bands.

This achievement can be use in the aircraft, spacecraft and satellite based communication system applications. In the design process, the parameters involved are dimensions of the triangles and circle slots, length and width of the patch and location of the feed point. The standard dimensions of rectangular MSA are design by

Calculating the width (W) and length (L) for a resonant frequency in GHz as shown in figure 1.1.

 

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$$W = \frac{c}{2f_0} \times \left(\frac{2}{\varepsilon_r+1}\right)^{-1} \quad (1)$$

$$L = \frac{c}{2f_0}\left(\varepsilon_{eff}\right)^{-1/2} - 2\Delta L \quad (2)$$

The values of effective dielectric constant ($\varepsilon_{eff}$) and length extension have been calculated using:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{(\varepsilon_r-1)\left(1+12\frac{h}{w}\right)^{-1/2}}{2} \quad (3)$$

$$\Delta L = 0.41h\left(\left(\varepsilon_{eff}+0.3\right)\left(\varepsilon_{eff}-0.258\right)^{-1}\right) * \left(\left(\frac{w}{h}+0.264\right)\left(\frac{w}{h}+0.8\right)^{-1}\right) \quad (4)$$

fig 1.1

## III. ANTENNA FEED AND FEEDING TECHNIQUES

The antenna feed system or antenna feed is the cable or conductor, and other associated equipment, which connects the transmitter or receiver with the antenna and makes the two devices compatible.

The available feeding techniques are variety of methods can feed microstrip Patch Antenna. These methods can be classified into two categories: contacting and non-contacting. In the contacting methods, the RF power is fed directly to the radiating patch using connecting elements such as a microstrip line. In a non-contacting scheme, the patch is not directly fed with the RF power, but instead, power is transferred to the path from the feed line through electromagnetic coupling. The most commonly used non-contacting feed methods are aperture and proximity coupled feed.

### A. Line Feed

In this type of feed technique, a conducting strip is connected directly to the microstrip patch's edge, as shown in figure. The conducting strip is smaller in width than the patch, and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it connected to Ground Plane Connector, as shown in figure. The purpose of the inset cut in the patch is to match the feed line's impedance to the patch without the need for any additional matching element.

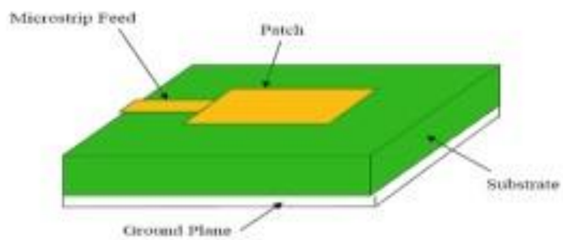


Figure 1.2 Microstrip Line Feed

### B. Coaxial Feed

The co-axial feed is a non-planar feeding technique in which z co-axial cable is used to feed the patch. The inner conductor of the co-axial connector extends through the dielectric, making a metal contact with the patch, and the outer conductor of the cable is connected to the ground plane, as shown in figure. The probe is in direct contact with the antenna, and it is located at the point where the antenna input is 50 ohms. This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it connected to Ground Plane Connector.

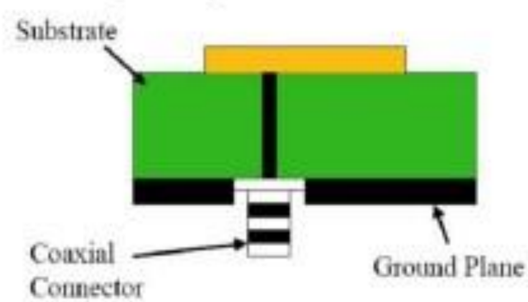


Figure 1.3 Coaxial feed

### C. Aperture Coupled Feed

The aperture feed technique consists of two dielectric substrates, namely antenna dielectric substrate, and feed dielectric substrate. These dielectric substrates are separated by a ground plane, which has a slot at its centre. The metal patch is placed on top of the antenna substrate is shown in figure. The ground plane is placed on the other side of the antenna dielectric. The feed dielectric and feed line are placed on the other side of the ground plane to provide isolation. Aperture feed provides excellent polarization purity, which is something unattainable with other feed techniques. Aperture fed antenna offers higher bandwidth. It is very useful in applications in which we don't want to use wires from one layer to another. The disadvantage with this feed is that it requires multilayer fabrication

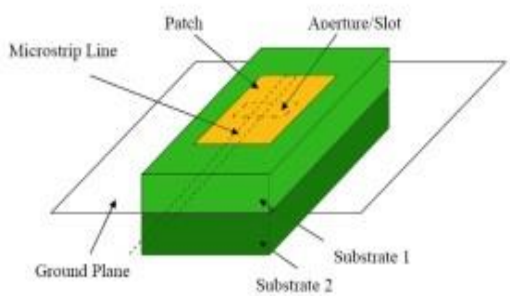


**Figure 1.4 Aperture coupled feed**

**D. Proximity Coupled Feed**

In proximity feed, the feed line is placed between two dielectric substrates. In the edge feed technique, it is impossible to choose a 50 ohms feed point since the impedance at the edges will be very high. To overcome this, the feed line is moved to a lower level below the patch. The edge of the feed line is located at a point where the antenna input impedance is 50 ohms. Here the power transfer from the feed to the patch takes place through electromagnetic field coupling. Since the feed line has been moved to a lower level, feed line radiation has been reduced to a great extent, and also, this technique allows planar feeding. Also, it has an improved bandwidth efficiency compared to the other techniques. The disadvantage with this method is that multilayer fabrication has to be done, and it offers poor polarization purity.

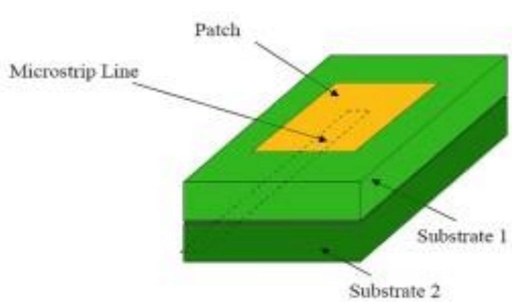


**Figure 1.5 Proximity coupled feed**

## IV. LIMITATIONS OF FEEDING TECHNIQUES

- The spurious radiation exists in various microstrip based antennas such as microstrip patch antenna, microstrip slot antenna and printed dipole antenna.
- It offers low efficiency due to dielectric losses and conductor losses.
- It offers lower gain.
- It has higher level of cross polarization radiation.
- It has lower power handling capability.
- It has inherently lower impedance bandwidth.
- The microstrip antenna structure radiates from feeds and other junction points.
- Extraneous radiation from feeds and junctions.
- Excitation of surface waves.
- Large ohmic losses in feed structure of arrays.
- Most of the microstrip antenna radiates into half-space.

## V. FR4 EPOXY AS A SUBSTRATE

- It is readily available and cheaper.
- It has a very good dielectric constant which adds a very good feature of electrical properties.
- The thickness of the substrate is also compatible.
- The loss tangent which accounts for the dielectric loss of the material is very low.
- It is also used as an electrical insulator.
- It possess good mechanical properties such as good Young's modulus, yield strength, etc.

## VI. RESULTS AND DISCUSSION

In the following context, we are going to discuss about the results obtained in our work. Results give an indication of how one parameter changes with respect to

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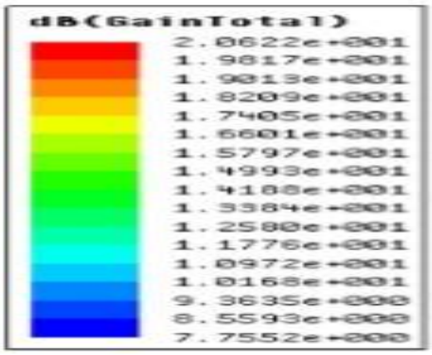
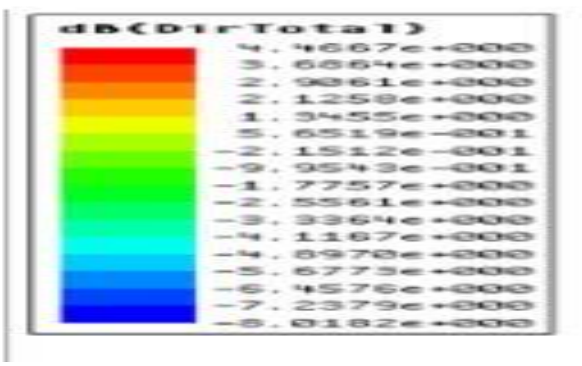
another parameter giving effectiveness and efficiency in



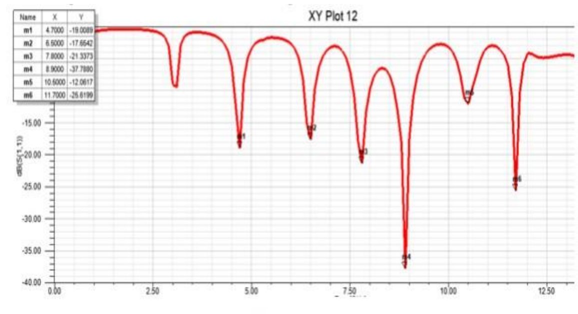

In the following figure shown, the gain of the antenna varies from 20.6 dB to 7.73 db. Red colour indicates where the gain is maximum and the value is 20.6 db. Blue colour indicates where the gain is minimum and the value is 7.73 dB with respect to the position of the antenna.




**Directivity Measurement**

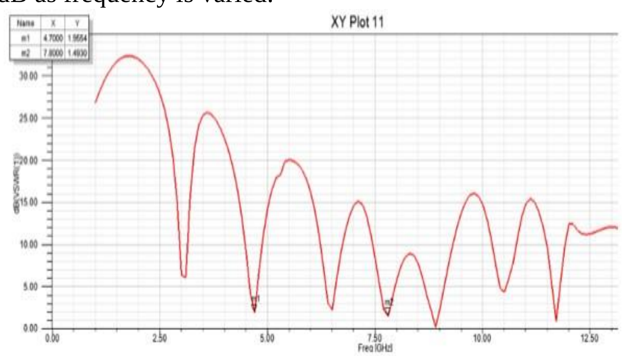
In the following figure shown, the Directivity of the antenna varies from 4.46 dB to -8.02 db. Red colour indicates where the directivity is maximum and the value is

4.46 db. Blue colour indicates where the Directivity is minimum and the value is -8.02 dB with respect to the position of the antenna.



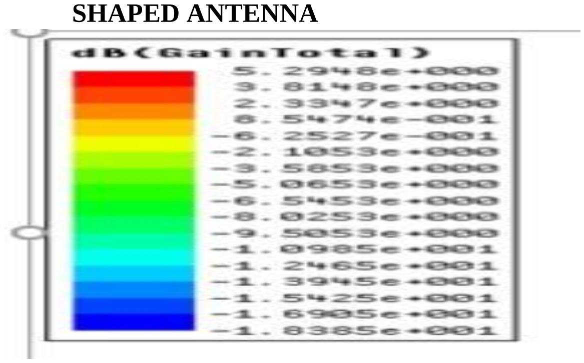

**s11 Measurement**

In the following figure shown, the s11 parameter varies as frequency is varied. It attains a maximum of -37.7880 dB as frequency is varied.




In the following figure shown, the VSWR parameter varies as frequency is varied. It attains a maximum of 1.03 dB as frequency is varied.

## VII. SIMULATED VALUES OF F SHAPED ANTENNA




**Gain Measurement**

In the following figure shown, the gain of the antenna

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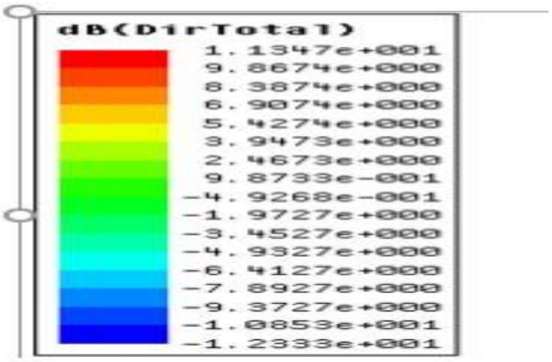
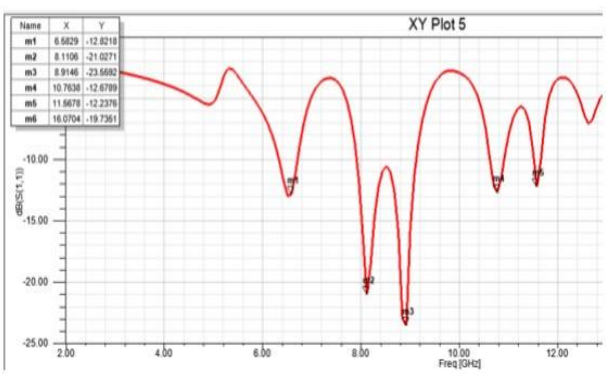
varies from 5.29 dB to -1.898 db. Red colour indicates where the gain is maximum and the value is 5.29 db. Blue colour indicates where the gain is minimum and the value is -1.898 dB with respect to the position of the antenna.



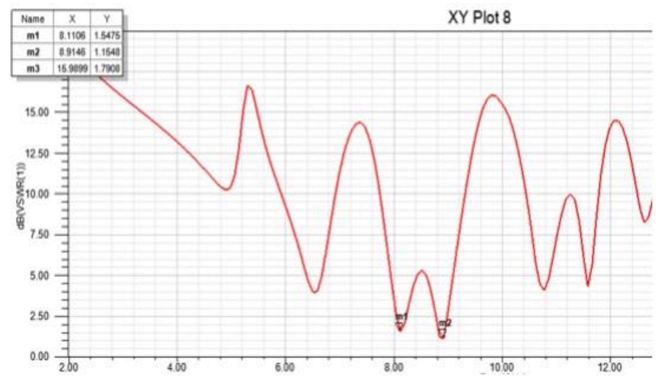

**Directivity measurement**

In the following figure shown, the Directivity of the antenna varies from 11.3 dB to -1.29 db. Red colour indicates where the directivity is maximum and the value is 11.3 db. Blue colour indicates where the Directivity is minimum and the value is -1.29 dB with respect to the position of the antenna.




**s11 measurement**

In the following figure shown, the s11 parameter varies as frequency is varied. It attains a maximum of -23.5 dB as frequency is varied.




**VSWR Measurement**

In the following figure shown,the VSWR parameter varies as frequency is varied.It attains a maximum of 1.15 dB as frequency is varied.

**ACKNOWLEDGMENT**

In this article, E and F-shaped MSAs were designed and simulated and their operating frequencies are in the X- and Ku-bands. The proposed antennas provide useful frequency, dual band and good radiation characteristics in terms of Gain,s11,VSWR and Directivity. .Therefore, these results make proposed antennas to be suitable for radar, satellite and wireless communication application and can be fabricated easily

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