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Comparison Analysis of Microstrip Circular Patch Antenna for Symmetric and Asymmetric Feed

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Abstract:- ***This paper discusses the advantages of using either asymmetric feed over symmetric feed. We report a first-of-its-kind realization of directional transmission for smartphone-like mobile devices using multiple passive directional antennas, supported by only one RF chain. Patch was designed on Triolein dielectric substrate material with dielectric constant 3.2 and frequency range is 10-15 GHz. The simulation has been performed by using FEM based HFSS software to compute performance of microstrip patch antenna. By varying the values of coupling, the results obtained show the effects of dielectric constant on directivity and gain of microstrip antennas.***

Keywords: Circular patch, feed technique, HFSS, finite element method.

1. Introduction

The demand of small size electronic systems has been increasing for several decades. The physical size of systems is reduced due to advancement in integrated circuits. With eduction in size of electronic systems, there is also an increasing demand of small and low cost antennas. Patch antennas are one of the most attractive antennas for integrated RF front-end systems and cell phones due to their compatibility with microwave integrated circuits.

Making smartphone-like devices directional is a radical departure from existing and emerging wireless technologies. It provides an inexpensive and immediately deployable solution to improve network capacity and device efficiency. While we demonstrate the effectiveness of multi antenna system in improving link good put and device power efficiency, more network support is needed to fully realize its potential in improving network capacity. We are motivated by the commercial availability of miniature passive directional antennas that can be employed on mobile devices. Micro strip antennas are good examples. The key challenge to the use of directional antenna on mobile devices is that a mobile device can change its orientation through mobility and rotation. Since one directional antenna can only provide adequate gain for a limited range of orientations, multiple antennas should be placed around the device so that they collectively provide a much larger range of orientations in which at least one of them provide adequate gain.

Introduction to Symmetric Feed and Asymmetric Feed Techniques

Symmetric feed technique is the type of feed in which feed in induced in the center of patch.

Asymmetric feed is that in which energy is induced at one side of patch means not exactly in center of patch. There are various advantages of asymmetric feed over symmetric feed technique that are:

- Enhanced bandwidth.
- More gain.
- Less complexity and can be used in broadband applications.
- Possible to fabricate using PCB technique in array applications.
- Easy to tuning the resonance.

Design Requirements for Patch Antenna

The selection of appropriate design parameters is prerequisite for performance evaluation of the designed models. The radiation performance can be improved by using proper design structures. The use of high permittivity substrates can miniaturize microstrip antenna size. Thick substrates with lower range of dielectric offer better efficiency and wide bandwidth but it requires larger element size. Microstrip antenna with superconducting patch on uniaxial substrate gives high radiation efficiency and gain in millimeter wave length. The circular patch was designed on dielectric substrate material with dielectric constant 3.2. The single circular patch antenna was designed and simulated using FEM based HFSS. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface.

Circular Patch Element

The most popular configuration among the patches is the circular patch or disk because for the circular patch elements there is one degree of freedom to control. Thus it is more convenient to design as well as to control the radiation pattern of the circular patch element.

Table 1-Dimensions used to design patch antenna

Radius of patch	0.525 cm
Width of edge feed	0.11 cm
Length of edge feed	1.01 cm
Length of feed	0.58 cm
Width of feed	0.49 cm

In the Fig 1 shows the model of single patch antenna with edge feed line. The quarter wavelength transformer method is used to match the impedance of the patch element with the transmission line.

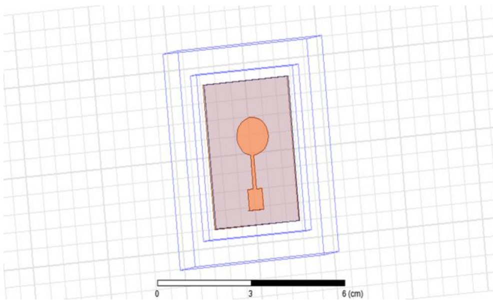

Fig 1-Design of single patch antenna with symmetric feed

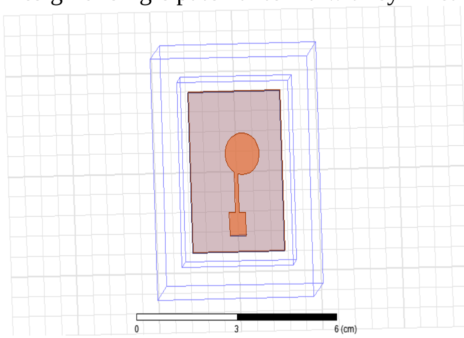

Fig 2-Design of single patch antenna with asymmetric feed

Adaptive Meshing

Meshing is the initial step in the pre-processing and the adaptive meshing is the enhanced advantage of HFSS. Adaptive meshing includes automatically refine, coarsen or relocate and adjust the basis to achieve a solution having a specified accuracy in an optimal fashion. Adaptive mesh refinement technique has been applied in both the models. After the adaptive refinement, number of mesh points and number of elements get increased as compared to standard meshing statistics. The meshing for element antenna is shown in fig 3.The total number of mesh elements are 46908.The simulations are performed using adaptive solver.13 number of passes are executed for convergence. The elapsed time to complete the processing is 00:05:45.

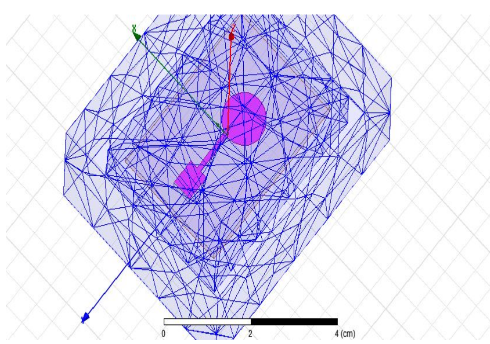

Fig 3-Mesh diagram of single patch antenna

Simulation Results

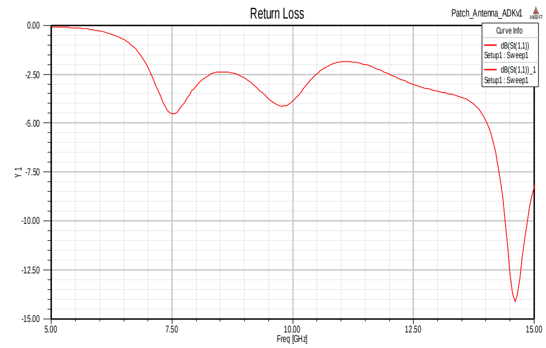

Fig 4-Return loss of patch antenna with symmetric feed

From the diagram it has been observed that value of return loss is -13dB. This parameter is used to determined that how well devices are matched. A match is good if return loss is high in negative value.

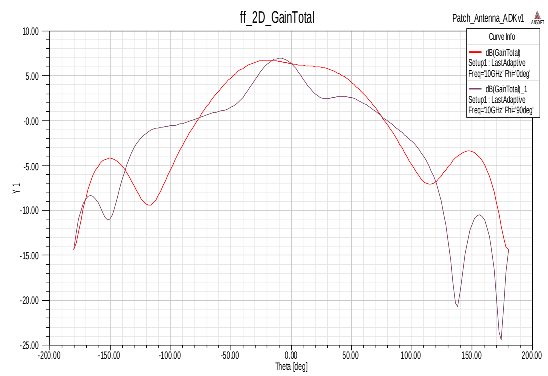

Fig 5 - 2D Gain of single patch antenna with symmetric feed

The gain of the antenna is the quantity which describes the performance of the antenna or the capability to concentrate energy through a direction to give a better picture of the radiation performance. The value of gain observed was 6.9 DB.

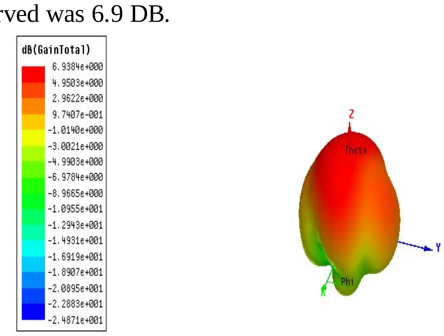

Fig 6- 3D radiation pattern of single patch antenna with symmetric feed.

This diagram demonstrates that the beam spread in all directions. The antenna with this radiation pattern was not suitable for use in mobile devices. To overcome this limitation we modeled antenna with asymmetric feed.

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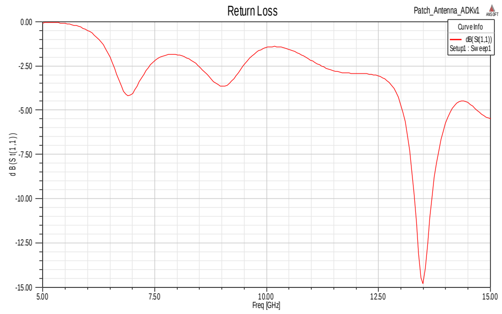

Fig 7- Return loss of patch antenna with asymmetric feed

From the diagram it is analyzed 15 dB of return loss is gained.

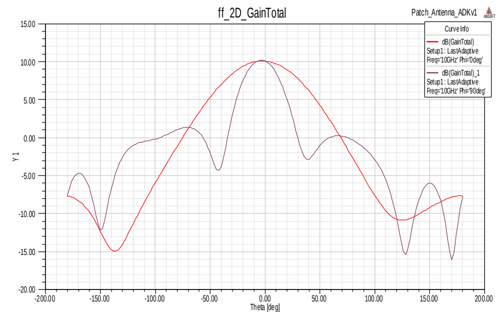

Fig 8- 2D total gain of patch antenna with asymmetric feed

This diagram shows the value of 10 dB

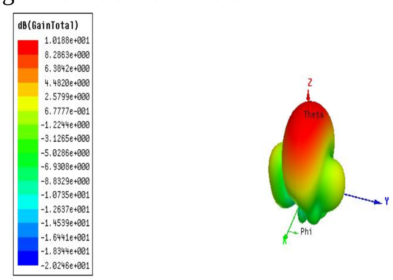

Fig 9 -3D radiation pattern of patch antenna with asymmetric feed.

The plots illustrate the directivity, which is a measure of the concentration of radiation in the direction of the maximum. It can be concluded from the figure that maximum directivity is obtained with asymmetric feed which completes the requirement of directive antenna used in mobile devices.

Table 2- Comparison of performance parameters with different feed techniques.

Feed Technique	Frequency (GHz)	Return loss (dB)	Total gain	Directivity
Symmetric feed	10-15	-13	8.02	Less directive
Asymmetric feed	10-15	-15	10.0	More directive

Conclusion

FEM based HFSS simulation software was used to design and simulate patch antenna with symmetric and asymmetric feed techniques. A gain rise of 4.2 dB per decade has been observed as the symmetric feed changes to asymmetric feed. It was also observed that directivity is best in one direction for the asymmetric feed. It is therefore concluded that selection of the feed technique is a key feature in achieving desired efficiency, gain, directivity and the antenna size. Therefore it can be used in mobile devices.

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