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Performance Analysis of X-Band Hexagonal Patch Antenna Array

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Abstract: In this paper, we analyse the performance of Hexagonal patch antenna array using microstrip and coaxial feed techniques. Here antenna array is mainly designed for X-Band applications. Antenna is simulated using HFSS 14.0 and performance measures of hexagonal patch antenna array such as return loss, gain, radiation pattern and VSWR are measured and compared for both microstrip and coaxial feeding techniques.

Keywords: Hexagonal patch, X-Band, Antenna array, Microstrip line feed, coaxial feed, gain, return loss, VSWR.

I. INTRODUCTION

Antenna is a metallic device used for radiating or receiving radio waves. There are various type of antennas such as wire antenna, array, reflector, aperture, lens, Microstrip. Among all antennas microstrip have several advantages. Microstrip antennas also called as patch antennas consist of a metallic patch on a grounded substrate. These are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to fabricate using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and very versatile in terms of resonant frequency, polarization, pattern, and impedance.

Antenna array is a set of two or more antennas and the signals are combined or processed to achieve improved performance over single element. These antenna arrays are mainly used to enhance the gain, to provide diversity gain for multipath signal reception and to enable signal processing of an antenna array.

X-Band:
Here we are analysing the performance of array of hexagonal patch using X-band. X-band frequency ranges from 8-12 GHz.X-Band is used in military and in radar applications including continuous-wave, pulsed, single-polarisation, dual-polarisation, synthetic aperture radar and phased arrays. And the radar frequency sub-bands of X-Band are used in civil, military and government institutions for weather monitoring, air traffic control, maritime vessel traffic control, defence tracking and vehicle speed detection for law enforcement.

Hexagon patch:
Aregular hexagon patch antenna is nothing but a variation of the circular patch antenna in which the resonant frequency for the lowest order mode can be approximated as KS=2.01, Where S is the side of the hexagon patch antenna, K is constant depends on either TM or TE mode. Resonance frequency of hexagonal patch depends on the feed position.

II.ANTENNA DESIGN

The patch used in the antenna can be of any shape like rectangular, circular, triangular, elliptical, hexagon etc., Here we are using the hexagonal patch for the antenna array designing. And patch is designed in such a way that it should operate at the resonant frequency.

Table-1 Design specifications for hexagonal patch antenna using microstrip and coaxial feed

Type of antenna	Hexagonal patch antenna array with microstrip feed	Hexagonal patch antenna array with coaxial feed
Dielectric constant of substrate	FR4-Epoxy(4.4)	FR4-Epoxy(4.4)
Operating frequency	9 GHz	9 GHz
Height of the substrate	0.76 mm	0.76 mm
Side of the patch	4.608mm	4.608mm

Design parameters:
The important parameters for the design of a Hexagonal microstrip patch antenna are resonant frequency (f_r), dielectric constant of the substrate (ϵ_r),height of the dielectric substrate(h).

For hexagonal patch, height of the dielectric substrate is given as,

$$h \leq \frac{0.3 * c}{2\pi f_r \sqrt{\epsilon_r}}$$

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Side of the hexagonal patch is given as,

$$S = \frac{c}{3.1033\, f_r \sqrt{\epsilon_r}}$$

Radius of hexagonal patch antenna is given as,

$$r = S\sqrt{\frac{2.598}{\pi}}$$

where, h=height of the substrate
c=velocity of light=$3*10^8 m/sec$
S=side of the patch
f_r=resonant frequency
ϵ_r=dielectric constant of the substrate
r =radius of the patch

Antenna parameters:
Return loss (RL):It is the loss of signal returned or reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the transmitting load or with a device inserted in the line.

VSWR: It is a measure of impedance matching of loads to the characteristic impedance of a transmission line or waveguide. It is the ratio of standing wave amplitude at antinode to the amplitude at node.

Gain:It is defined as the ratio of the intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna radiated isotropically.

Radiation pattern: It is defined as the mathematical function or graphical representation of radiation properties of antenna as a function of space coordinates.
It is determined in the far field region and represented as directional coordinates. Radiation properties include power flux density, field strength, polarisation.

Antenna designs for single element and array:
The following figure 1, shows the hexagonal patch antenna design using coaxial feed for single element, achieved a gain of 3.4976 dB, return loss of -30.8505 dB and VSWR of 1.059.

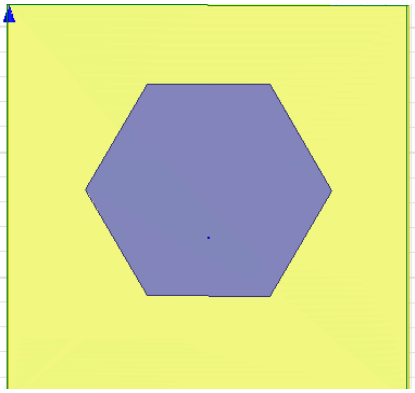

Fig.1. Hexagonal patch antenna using coaxial feed for single element

The following figure 2, shows the hexagonal patch antenna design using microstrip feed for single element, achieved a gain of 4.097 dB, return loss of -25.549 dB and VSWR of 1.1115.

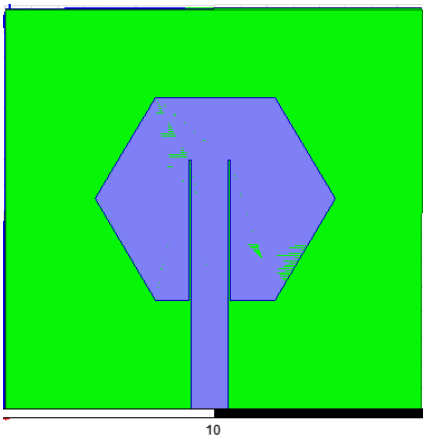

Fig.2. Hexagonal patch antenna using microstrip feed for single element

In order to enhance the gain,bandwidth and also to improve the performance measures such as return loss,directivity, VSWR we will go for the array pattern.So,after designing patch antenna for single element we will extend it to the design of four element hexagonal patch antenna arrayusing both coaxial and microstrip feeds.

The following figure shows the hexagonal patch antenna array design using microstrip feed,

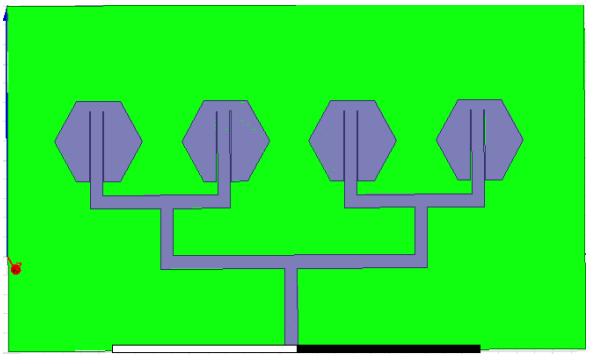

Fig.3.Hexagonal patch antenna array design using microstrip feed

The following figure 4, shows the hexagonal patch antenna array design using coaxial feed,

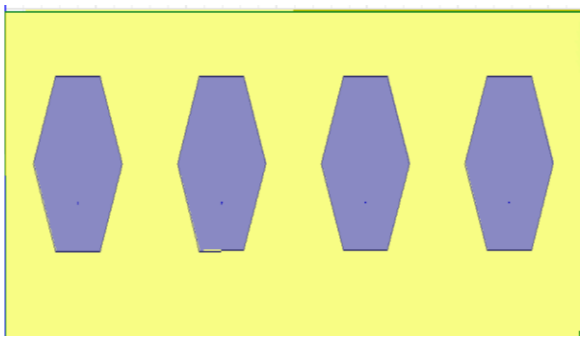

Fig.4.Hexagonal patch antenna arraydesign using coaxial feed

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III. SIMULATION

The simulation of this antenna array is done using HFSS 14.0.High Frequency Simulation Software (HFSS) is used for the design and simulation of the antennawhich uses finite element method for solving electromagnetic structures and design of antennas,RF electronic circuit elements such as filters and transmission lines.HFSS is high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modelling that takes the advantage of the familiar Microsoft Windows user interface. It is an interactive software package for calculating the electromagnetic behaviour of a structure. Ansoft HFSS can be used to compute basic electromagnetic field quantities, Characteristic port impedances and propagation constants.

IV. RESULTS

1.Return loss:
The following figure 5, shows the return loss plot for microstrip feed hexagonal patch antenna array achieved a return loss of -18.81 dB at 9 GHz,

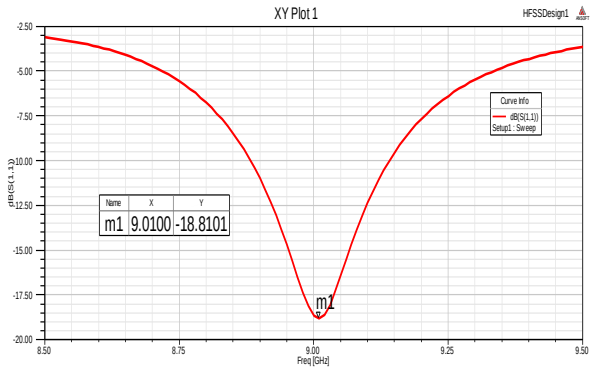

Fig.5. Return loss plot for microstrip feed

The following figure 6, shows the return loss plot for coaxial feed hexagonal patch antenna array which achieved a return loss of -22.644 dB at 9 GHz,

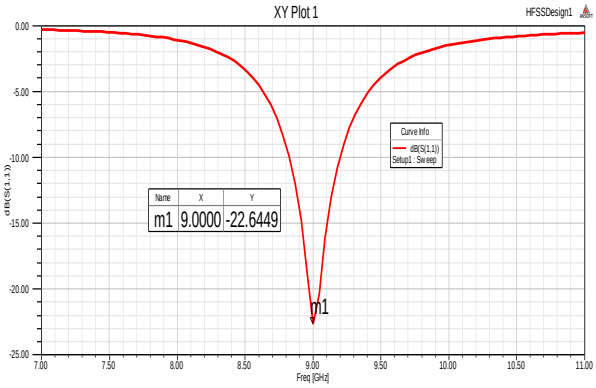

Fig.6.Return loss plot for coaxial feed

2.VSWR:

The following figure 7, shows the VSWR plot for microstrip feed hexagonal patch antenna array achieved a VSWR of 1.2648 at 9 GHz,

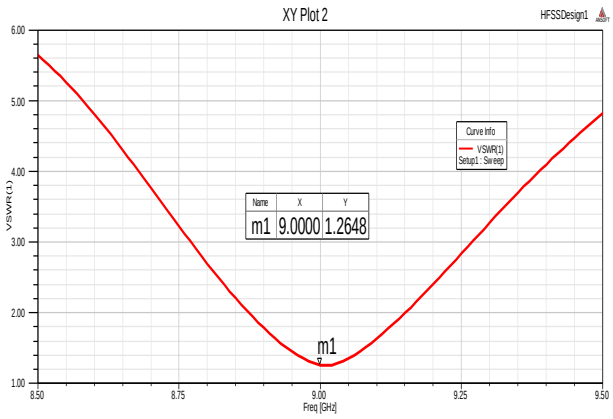

Fig.7. VSWR plot for microstrip feed

The following figure 8, shows the VSWR plot for coaxial feedhexagonal patch antenna arrayachieved a VSWR of 1.1592 at 9 GHz,

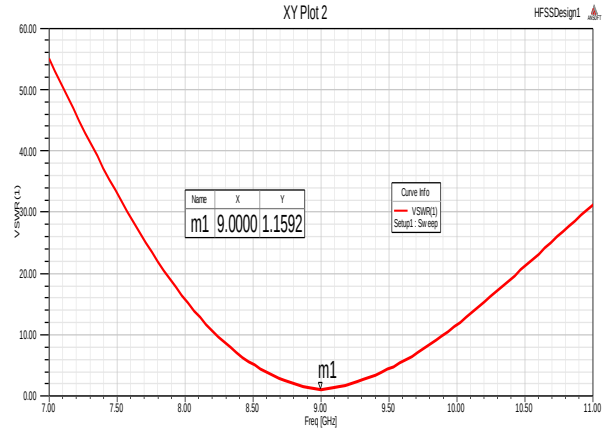

Fig.8.VSWR plot for coaxial feed

3. Gain:
The following figure 9, shows the gain plot for microstrip feed hexagonal patch antenna array achieved a gain of 9.0616 dB at 9 GHz,

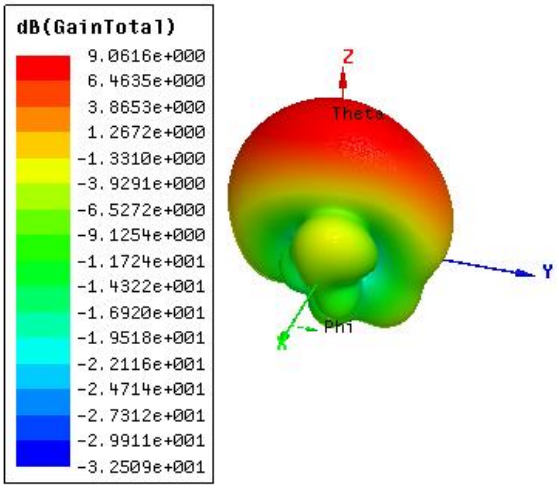

Fig.9. Gain plot for microstrip feed

The following figure 10, shows the gain plot for coaxial feed hexagonal patch antenna array achieved a gain of 9.3498 dB at 9 GHz,

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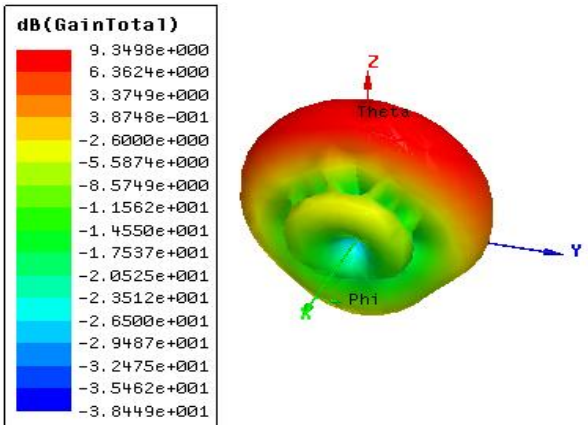

Fig.10. Gain plot for coaxial feed

4. Radiation pattern:

The following shows the radiation pattern for microstrip feed hexagonal patch antenna array,

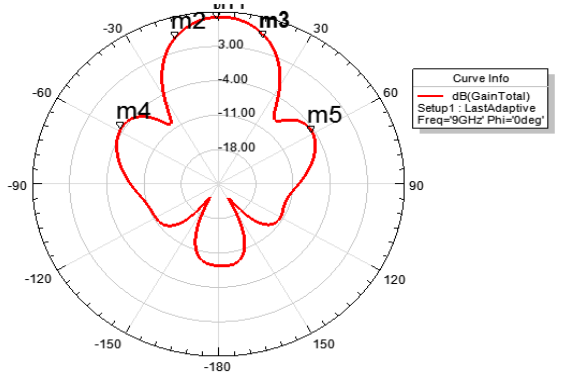

Fig.11. Radiation pattern for microstrip feed

The following shows the radiation pattern for coaxial feed hexagonal patch antenna array,

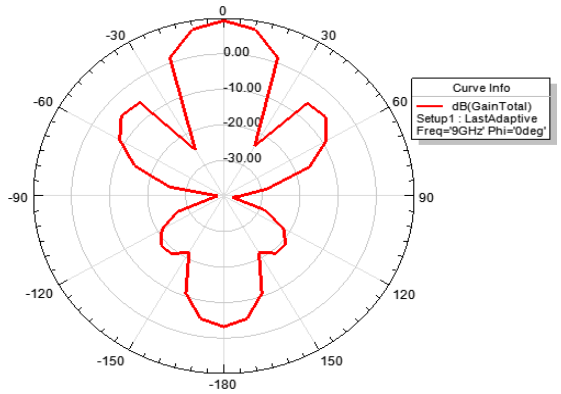

Fig.12. Radiation pattern for coaxial feed

Table-2Output parameters for hexagonal patch antenna array using microstrip and coaxial feed

Type of antenna	Hexagonal patch antenna array with microstrip feed	Hexagonal patch antenna array with coaxial feed
Return loss	-18.81 dB	-22.64 dB
Gain	9.0616 dB	9.3498 dB
VSWR	1.2648	1.1592
Operating wavelength	15.89 mm	15.89 mm

V. CONCLUSION

Finally, hexagonal patch antenna array using microstrip and coaxial feed is designed and simulated using HFSS 14.0 Version and the performance measures such as return loss, VSWR, Gain and Radiation pattern were measured and compared for both the feeds. On comparing the results of both the microstrip and coaxial feed it is observed that hexagonal patch antenna array using microstrip feed produced gain of about 9.0616 dB and coaxial feed produced a gain of 9.3498 dB at same resonant frequency of 9 GHz. Compared to microstrip feed hexagonal patch antenna array designed using coaxial feed provides better results in terms of VSWR, Gain, diversity and return loss.

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BIOGRAPHIES

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