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Comparision of Microstrip and Co-axial Feed Triangular Patch Antenna Array for Ku Band

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Abstract: This paper demonstrates the analysis of triangular patch antenna array with microstrip feed and co-axial feed techniques for broadband satellite services (12.2-12.7 GHz) in Ku band. For long distance communications, the gain and directivity of an antenna should be very high which cannot be accomplished by the single element antennas as their radiation pattern is relatively wide. The directivity and gain of an antenna can be increased by arranging several antennas in space and interconnect to produce a directional radiation pattern referred to as an 'array'. The proposed triangular patch antenna array is designed and simulated by using HFSS (High Frequency Structural Simulator) software. The gain of present antenna array for four elements with line feed and co-axial feed is 8.09 dB and 8.92 dB at 12.5 GHz frequency.

Keywords: Triangular microstrip patch antenna, microstrip-line feed, co-axial probe feed, antenna array, gain, directivity, Ku band.

I. INTRODUCTION

In the recent years, the demand for electronic circuits made them to come up with small, lightweight and low cost radiating structure with high gain and directivity. This lead to the invention of several antenna structures, of which, printed microstrip antenna arrays became very popular. In its basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. Antenna array – a configuration of multiple antennas are arranged to achieve high gain. Arrays of antennas are used to direct radiated power towards a desired angular sector and also offer improved directivity compared to a single – radiator antenna. Because of all these advantages, here we are considering triangular shaped patch antenna array for wireless communication that works at Ku band (12-18 GHz) applications. In Europe, Ku-band downlink is used from 10.7 GHz to 12.75 GHz for direct broadcast satellite services, such as Astra. Satellite technology is developing fast, and the applications for satellite technology are increasing all the time.

While designing triangular patch antenna, we are having four types of feeding techniques which include microstrip-line feed, co-axial probe feed, aperture coupled feed and proximity coupled feed. The present antenna array is designed with microstrip and probe feed techniques and a comparison is made in between them. In microstrip feed technique, a conducting strip is directly connected to the edge of the patch, while in probe feed technique, the inner conductor of the coax is attached to the radiation patch and the outer conductor is connected to the ground plane.

II. TRIANGULAR PATCH ANTENNA

The triangular shaped microstrip patch is one of the most common shapes having a wide range of applications ranging from simple circuit elements to modern wireless antennas which is shown in fig 1.

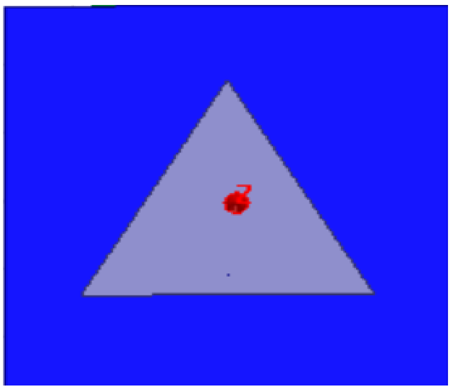

Fig 1: Geometry of triangular patch antenna with coax feed

The triangular shaped patch is physically smaller than other patch geometries having radiation properties similar to the rectangular patch and with lower radiation loss. The Q-factor of triangular patch resonator is higher than that of a circular patch and hence can be used for designing low loss MIC's.

The microstrip patch is designed so its maximum radiation pattern is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch.

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III. DESIGN CONSIDERATIONS

The design procedure of microstrip patch antenna includes the dielectric constant of the substrate, the resonant frequency, and the height of the substrate. Depending on the type of feeding technique, the parameters like radiation efficiency, directivity, and return loss are influenced. The geometrical dimensions of patch are smaller than electric dimension due to the presence of fringing fields between patch and ground plane .

For designing triangular patch antenna, the side of triangle can be calculated as

$$a = \frac{2c}{3f_r\sqrt{\mathcal{E}_r}}$$

Where,
'C' is velocity of light in free space, 'f_r' is resonant frequency and '$\mathcal{E}_r$' is relative permittivity of material.

Height of triangular patch can be given as,

$$h = \frac{\sqrt{3}\,a}{2}$$

Height of substrate can be given as,

$$H \le \frac{0.3 * c}{2\prod f\sqrt{\mathcal{E}_r}}$$

Design parameters of proposed triangular microstrip patch antenna are shown in below table I,

TABLE I : Triangular patch antenna design parameters

Parameter	Value
Operating frequency	12.5 GHz
Dielectric material	FR-4 epoxy
Dielectric constant	4.4
Operating wavelength	11.4 mm
Side of triangular patch	7.6 mm
Height of triangular patch	6.6 mm
Height of substrate	0.546 mm

The top and side view of triangular patch antenna array for four elements with line feed is shown in fig 2 and fig.3.

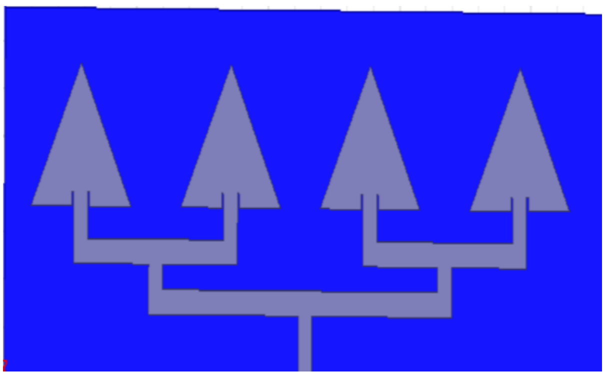

Fig 2: Top view with microstrip feed

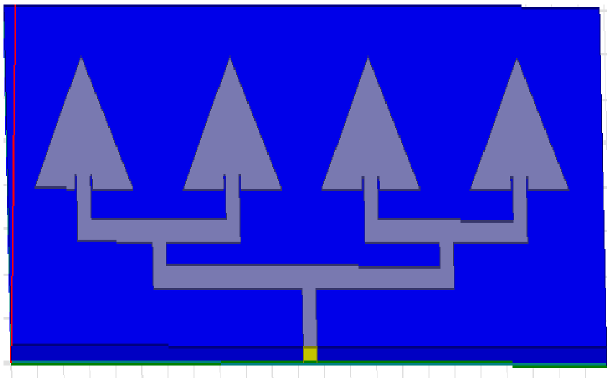

Fig 3: Side view with microstrip feed

The top and side view of four element triangular patch antenna array with coax feed is shown in fig 4 and fig 5.

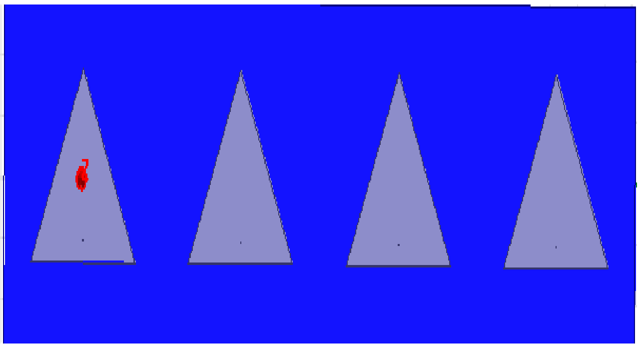

Fig 4: Top view with coax feed

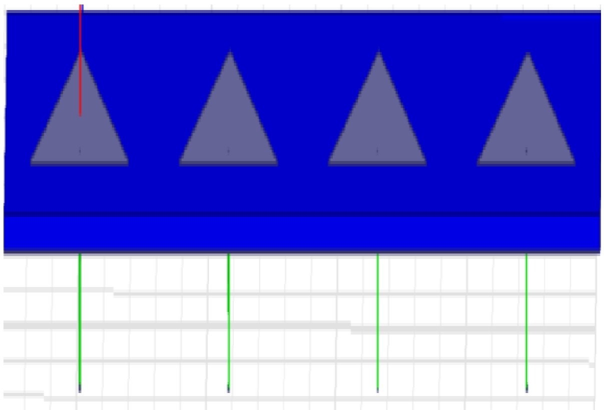

Fig 5: Side view with coax feed

IV. SIMULATION RESULTS

The proposed triangular patch antenna array has been simulated by using HFSS software 14.0. In this paper, various parameters like return loss, VSWR, gain and directivity are analyzed and a comparison is made between line feed and coax feed triangular patch antenna array.

RETURN LOSS:
Return loss (S_{11}) parameter represent how much power is reflected from the antenna. Return loss is a measure of how well devices or lines are matched. The return loss for proposed antenna array with line feed and coax feed is 34.04 dB and -26.5 dB which is shown in fig 6 and 7.

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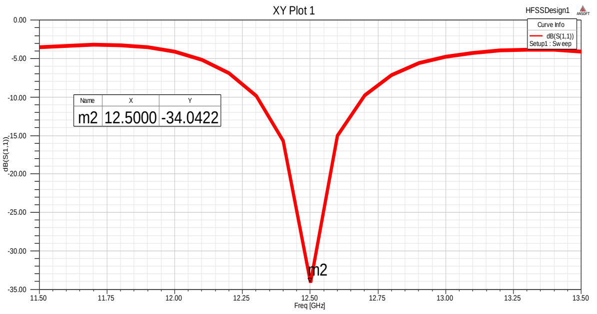

Fig 6: Return loss Vs frequency plot with microstrip feed

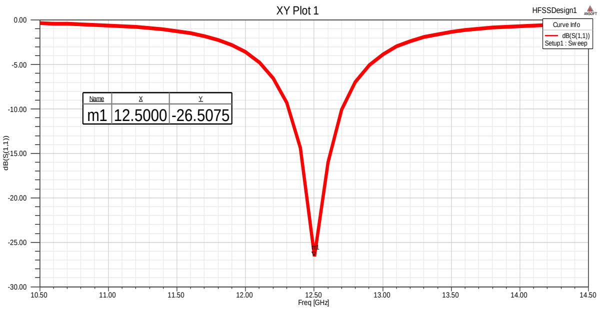

Fig 7: Return loss Vs frequency plot with coax feed

VOLTAGE STANDING WAVE RATIO (VSWR):

VSWR is a measure that numerically describes how the antenna impedance is matched with transmission line impedance. The VSWR for proposed triangular patch antenna array for line and coax feed is 0.34 dB and 0.82 dB which is shown in fig 8 and 9.

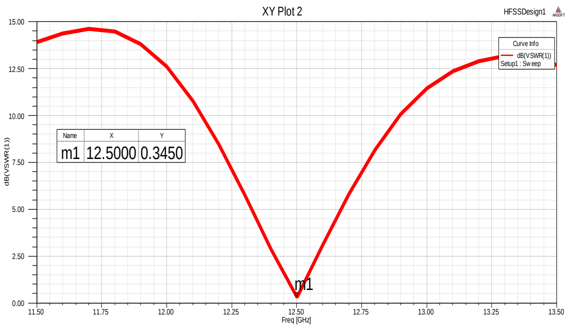

Fig 8: VSWR Vs frequency plot with microstrip feed

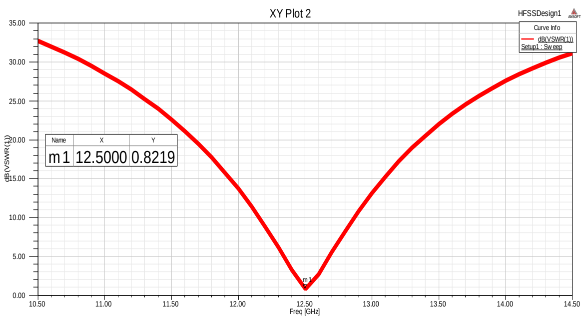

Fig 9: VSWR Vs frequency plot with coax feed

RADIATION PATTERN:

Radiation pattern is a graphical representation of the radiation properties of antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far field region and is represented as a function of the directional coordinates.

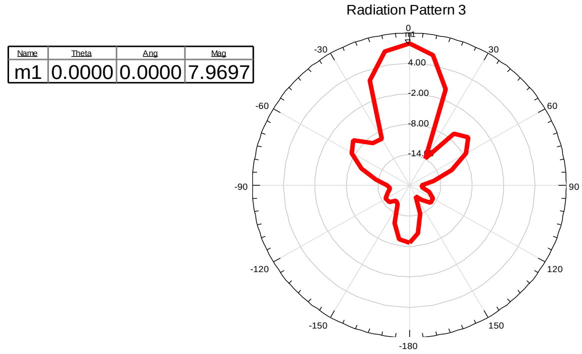

Fig 10: Radiation pattern with microstrip feed

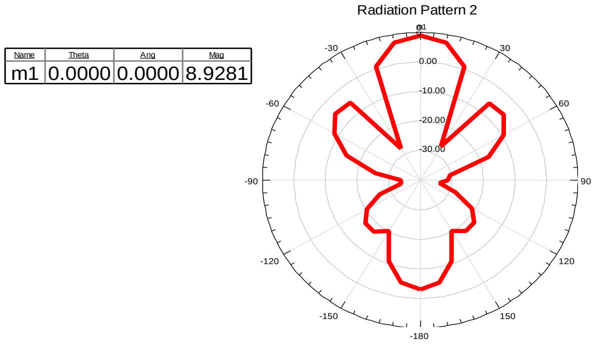

Fig 11: Radiation pattern with coax feed

GAIN:

Antenna gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source. The gain of the present antenna array with microstrip and coax feed is 8.09 dB and 8.92 dB which is shown in fig 12 and fig 13.

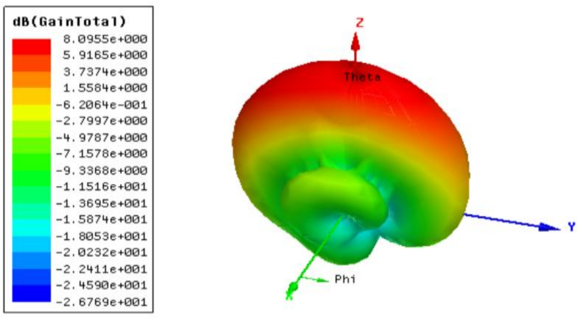

Fig 12: 3-D Radiation pattern with microstrip feed

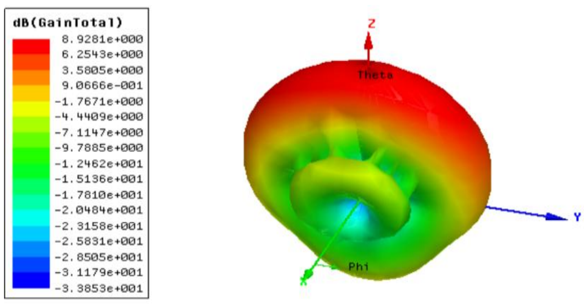

Fig 13: 3-D Radiation pattern with coax feed

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From the simulated results, we can observe the following comparison

TABLE II: Comparison of various performance parameters of four element triangular patch antenna array

Type of feed	microstrip	Coax
Freq.(GHz)	12.5	12.5
Return loss(dB)	-34.04	-26.5
VSWR (dB)	0.34	0.82
Gain (dB)	8.09	8.92

V. CONCLUSION

In this paper, we have compared various parameters like return loss, VSWR, and gain of both microstrip and coax feed triangular patch antenna array for Ku band. After comparing the performance of present antenna array with both feeding techniques, it is found that the gain of antenna array with probe feed give better results than microstrip feed because there is no spurious feed radiation in coax feed.

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BIOGRAPHIES

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