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Design of Equilateral Triangular Microstrip Patch Antenna with Co-axial Feeding Technique

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***Abstract*-This paper presents design of equilateral triangular Microstrip patch antenna with operating frequency at 2.45 GHz, for wireless communication systems. The Industry, Scientific and Medical (ISM) Band, unlicensed with the range 2.40 - 2.4835 GHz is used as the operation band. The maximum bandwidth can be achieved by controlling the distance between the patch antennas and by adjusting the probe feed position. Return loss of -29 dB with VSWR 1.05 at 2.45GHz. The results show that the proposed antenna has the impedance bandwidth of 80MHz. The antenna parameters are investigated and optimization is performed by varying the feed position and substrate dielectric constant. The input and radiation characteristics are examined and compared. The various parameters are measured and practical results are presented and discussed.**

General Terms: **Microstrip antenna, dielectric constant, resonant frequency.**

Keywords:**ETMA,VSWR,RL.**

I. INTRODUCTION

Microstrip patch antennas are widely implemented in many applications in wireless communication due to their attractive features. Therefore they are extremely compatible for embedded antennas in handheld wireless devices. Some of their principal advantages are light weight, low volume, low fabrication cost,easy to mount, low profile, conformal, linear and circular polarization possible, easy to implement by position of feed, dual frequency use possible, solid state devices easily integrated. The patch using a simple coaxial probe feed The bandwidth of the MSA increases with an increase in the substrate thickness *h* or with a decrease in the dielectric constant ε*r*. However, there is a practical limit on increasing the *h*, and if increased beyond 0.1λ0, surface-wave propagation takes place, resulting in degradation in antenna performance. Also, with an increase in *h*, the probe inductance increases and probe compensation techniques have to be employed to obtain impedance matching. There are several ways to overcome this problem such as use modified patch shape [2] and use array technique [3]. Although rectangular and circular geometries are most commonly used, other geometries having greater size reduction find wide applications in wireless communication systems, where the prime concern is compactness. The triangular patch antenna configuration is chosen because it has the advantage of occupying less metalized area on substrate than other existing configurations [4].

Early microstrip antennas used either a microstrip feedline or a coaxial probe feed. These two feeding methods are very similar in operation, and offer essentially one degree of freedom (for a fixed patch size and substrate) in the design of the antenna element through the positioning of the feed point to adjust the input impedance level. Although coaxial probe feed has some advantages over microstrip feedline such as less spurious radiation.

II. ANTENNA DESIGN

A. Design of a Single Element Equilateral Triangular Patch Microstrip Antenna

A probe-feed single patch ETMA is designed simulated for resonant frequency 2.45 GHz on a infinite ground plane. The probe feed technique has been used, since; the feed can be placed at any place on the patch to match with its input impedance (usually 50 ohm).

B. Resonant Frequency

The equilateral triangular patch has a side length‘S’ and printed on a substrate of thickness ‘h’ with relative dielectric constant ‘€r’.

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The resonant frequency of ETMA with side length S is given as [2],

$$f_{mn} = \frac{2c\sqrt{m^2 + n^2 + mn}}{3Se\sqrt{€e}} \quad (1)$$

For above resonant frequency calculations of ETMA fringing fields are considered. Where Se is the effective side length,$€e$ is effective dielectric constant & c is velocity of light.m & n indicates transmission line mode.

The following equations give the formula for calculation of effective length & effective dielectric constant of ETMA, by considering fringing fields.

$$Se = S + \frac{h}{\sqrt{€e}} \quad (2)$$

$$€e = \frac{€r + 1}{2} + \frac{€r - 1}{2}\left[1 + \frac{10h}{\frac{s}{2}}\right]^{-1/2} \quad (3)$$

h= height of a dielectric substrate.
€r=dielectric constant.

C. Antenna Parameters

Let S be the side length of the equilateral triangular patch is fabricated on a FR-4 substrate of height 1.6 mm with relative dielectric constant whose loss tangent (*tan* δ) of 0.002. The patch side length is calculated for the 2.45 GHz resonant frequency with considering parameters mentioned. At first the feed position is varied and its effect on the input impedance, S11 and V.S.W.R. are measured. The coaxial cable impedance in general 50 Ω. Here a feed location point is to be finding out on the conducting patch where patch impedance is 50 Ω. This feed point gives maximum radiation because of proper matching.

For fundamental TEM (m=1, n=0), the equation (1) of resonant frequency calculation can be modified as,

$$f = \frac{2c}{3Se\sqrt{€e}} \quad (4)$$

From theoretical calculation for side length of 37.7 mm resonant frequency found to be 2.45 GHz, which is the centre frequency of 2.4GHz-2.5GHz ISM band. The ETMA antenna characteristics were analyzed using HFSS EM software simulation package.

III. Analysis Of Results

From simulation resonant frequency found to be 2.45 GHz at S=37 mm with S_{11} parameter -29.03 dB. For different feeding positions, the return loss was measured. At S/2.3 co-axial feeding location, maximum return loss is obtained.

The following table shows the simulated return loss for different feeding locations. The feeding point co-ordinates can be given as, P(X,Y,Z)=(X,18.5,0).So X is changed along the length of equilateral triangle.

Table I. Variation in return loss with respect to Feeding location

Feeding Location (X) (In mm)	Return Loss (In dB)
28	-2.22
27	-2.37
26	-2.5
25	-2.76
22	-4
20	-5.7
18	-9.6
17.5	-11.47
17	-14.57
16.5	-18.68
16	-29
15.5	-25
15	-15.5
14	-7.85

The following simulated results shows the important characteristics of ETMA,

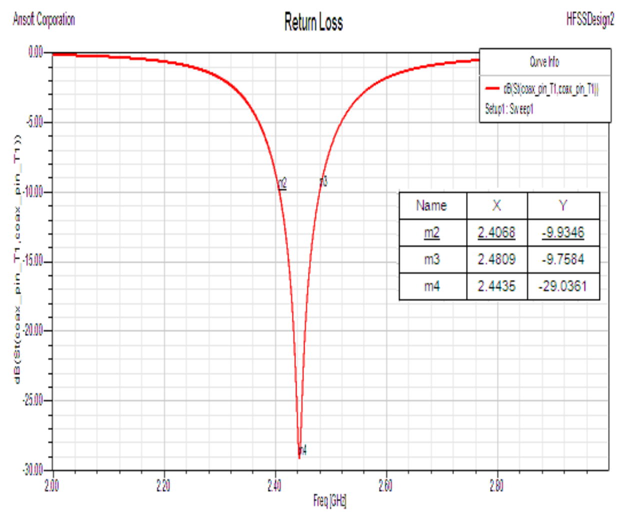

Fig.1.Return Loss of -29.03 dB at 2.45GHz.

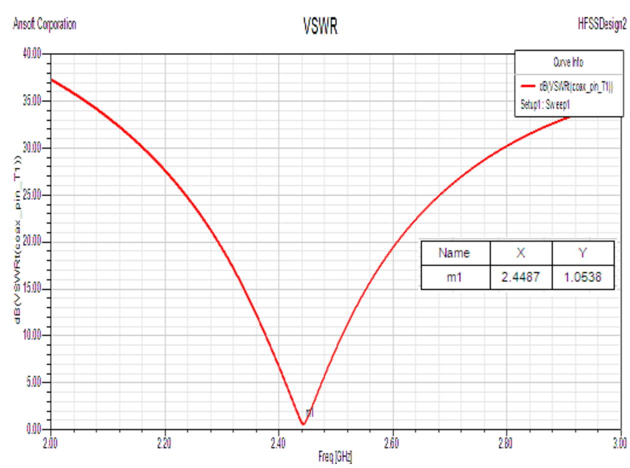

Fig.2.VSWR of 1.0538 at 2.45GHz.

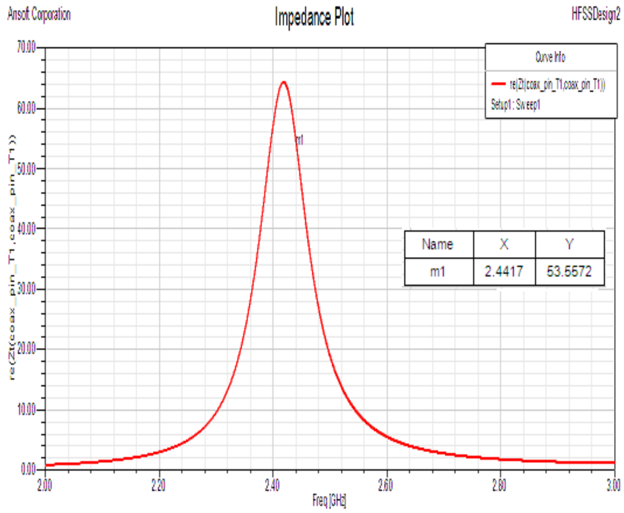

Fig.3.Impedance plot.

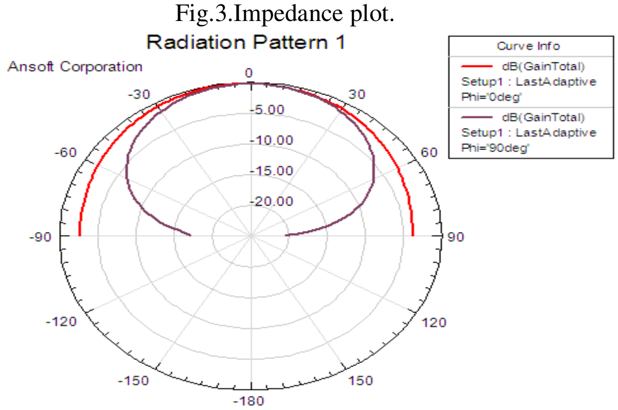

Fig.4.Radiation Pattern.

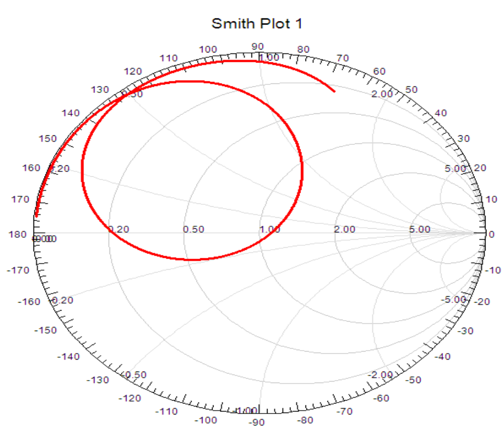

Fig.5.Smith Chart

CONCLUSION

In conclusion, design and simulated results of probe feed single element equilateral triangular Microstrip antenna and with good matching, input and radiation characteristics with varying feed position is presented. The results demonstrated that the bandwidth and radiation properties of the antenna with triangular slot have better performance than the antenna without triangular slot. The antenna was designed to have a good return loss and radiation pattern. The corresponding return loss obtained from simulation is -29.03 dB and VSWR is 1.0538, while the resulted directivity of array antenna is 6.16 dB .The value of impedance is passing through 1 on both the smith chart ,it shows perfect matching of probe impedance and patch impedance. It is also shown that the geometry with triangular slot has an influence towards the performance of the antenna characteristics.

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