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Effects of Square Patch Antenna With Cut-off Frequency v/s Length -Width Variation

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Abstract— **This paper covers aspects of micro strip antenna designs excited by waveguide. The First aspect is the analysis and design of square patch and the effect of length-width variation on cut-off frequency. This variation is mentioned in table and compared with calculated data using formula. This paper also shows the migration from c-Band to x-Band with increase in length-width. This effect can be removed by using patch antenna with circular slot.**

Keywords— **Antenna Height, Length-Frequency Variation, Circular Slot.**

I. Introduction

Now these days patch antenna are most popularly used in wireless communication applications because of it light weight. We are analyzing a low profile patch antenna as it has number of advantages over other antennas like it is light in weight and inexpensive. This paper basically shows that how the operating frequency varies with the variation of dimensions of designed Patch antenna like length-width. Its designing involve a flat plate over a ground plane. The coupling of electromagnetic energy with patch is provided by coax at the center of conductor. The main important point related to patch antenna is that it is easy to integrate with accompanying electronics.

Due to change in the phase of applied signal at the patch, the electric field remains maximum at one side and minimum at other side. This maximum field can be treated as positive and minimum can be treated as negative electric field. The center of patch exhibit zero electric field. The electric field expand little bit toward the border of patch. This process of development is known as fringing and the developed field is called as fringing fields. This whole process is responsible for the patch to radiate.

II. Antenna Design

The basic design of patch antenna involves square shape conductor and its characteristics are length L,width W and thickness h. These parameters[4] can be theoretically calculated in following steps:

- For a patch antenna in order to get radiation of good quality, width of antenna should be effective as, $w = [v_0/2f_r]\ (2/\ \varepsilon_{r+1})$, here v_0 is the free-space velocity of light.
- Effective dielectric constant $\varepsilon_{reff} = (\varepsilon_r+1)/2 + (\varepsilon_r-1)/2\ [1+12\ h/w]^{-1/2}$ here w/h>1
- Extension of length ΔL can be calculated by $\Delta L/h = 0.412\ [(\varepsilon_{reff}+0.3)(\ w/h+.264)]/[\ (\varepsilon_{reff}\ .0.258)(\ w/h+.8)]$
- The actual length of the patch can be determined by $L= 1/[2fr(\varepsilon_{reff})^{1/2}(\mu_0\varepsilon_0)^{1/2}] - 2\Delta L$

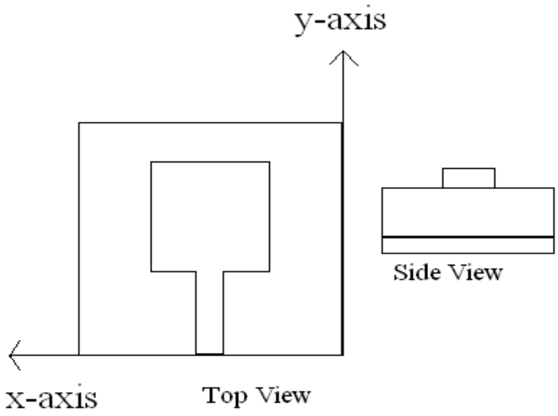

Fig.1 Geometry of Patch Antenna

III. Parameter Used

In this proposed antenna, a micro strip –feed square patch antenna was designed using a FR-4 substrate (relative permittivity of 4.3) with thickness of t=.1588cm and operating frequency of 10GHz. Ground =.003cm, dielectric=.156cm, patch size=.003cm. Designed antenna is simulated for equal length and width of patch antenna Using CST Microwave studio, the results of variation of height and width on patch antenna is recorded and mentioned in table 1 and table 2.

IV. Radiation Pattern

As we know that patch radiate duo to the fringing fields, developed due to the change in phase of applied signal. Patch antenna is a directional antenna that radiate mostly in one particular direction and shows less effect of radiation in the other direction. This type of property of antenna known as directivity which is articulated in dB.A patch is exhibit maximum directivity in the direction perpendicular to the patch when it is exited in its fundamental mode. We can say that it is broadside radiation effect of patch. When excitation moves toward lower elevation, it causes to decrease in its directivity. Generally 3 dB directivity is considered because at this point 3 dB beam width is having the maximum value i.e.

twice the angle with respect to the angle of the maximum directivity.
An example of a radiation pattern can be found below.

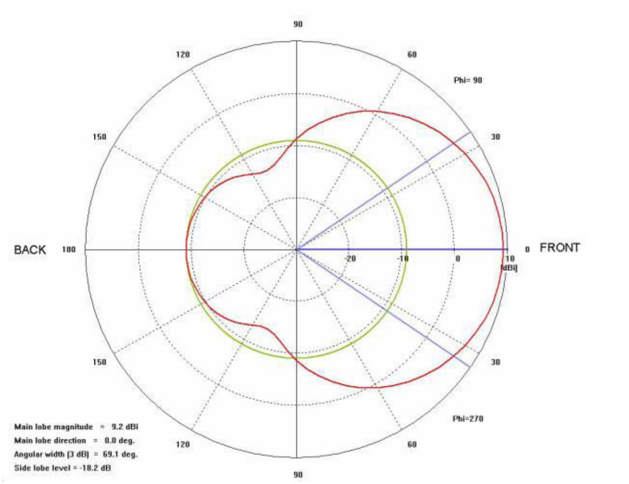

Fig. 2 "Radiation Pattern of Patch Antenna"

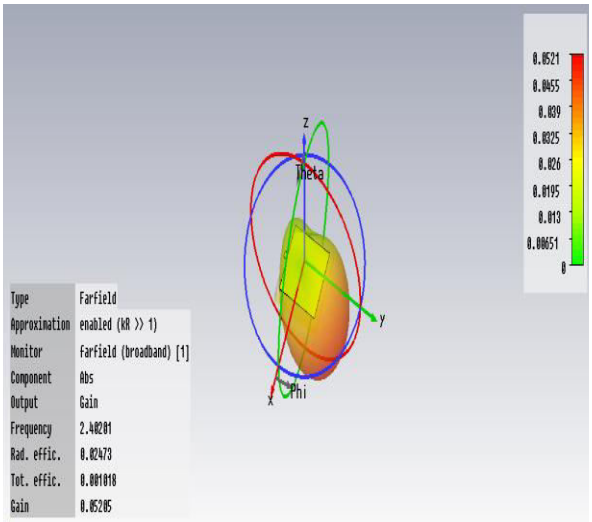

Fig. 3 3D Radiation Pattern of Patch Antenna

Fig.2 and fig.3 represent radiation pattern of far field antenna with square patch. According to figure maximum radiation is towards patch (red color) and minimum at feed line (green color).

V. Effects of Length-Width Variation on Cut-Off Frequency on Micro Strip Patch Antenna

As we know that antenna height is h= $\lambda/4$ and $\lambda=c/f$ here c=3*108 meter/sec. and f is frequency. Table 1 represents variation in cut-off frequency for different length and width It is clear that simulated length and width are nearly equal to calculated data .It can be observed from table 1 that with decrease in length and width ,cut off frequency of antenna migrates from c-band to x-band. This migration of cut-off frequency from C band to X band can be removed by making a patch antenna with circular slot.

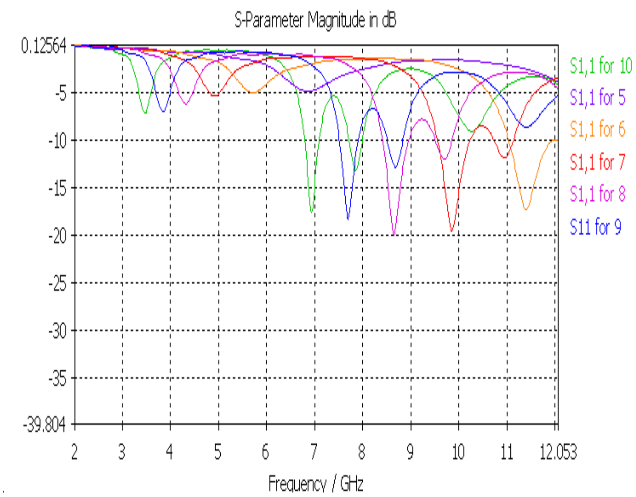

Fig. 4 Gain –Frequency Pattern for variable antenna Parameter

Table I Effect of Cut-off frequency on Simulated and calculated length and width

CUT-OFF FREQUENCY (GHz.)	SIMULATED LENGTH & WIDTH (mm.)	Calculated Length and width (mm.)
6.9	10	10.86
7.7261	9	9.7
8.6542	8	8.6
9.8692	7	7.5
11.439	6	6.5
13.481	5	5.5

VI. Effects of Circular Slot on Micro Strip Patch Antenna

Due to the additional slot perturbation for the horizontal patch surface current path as compared to the reference antenna without slot, surface current paths of the resonant modes can be lengthened, resulting in the decrease of corresponding resonant frequencies [2].

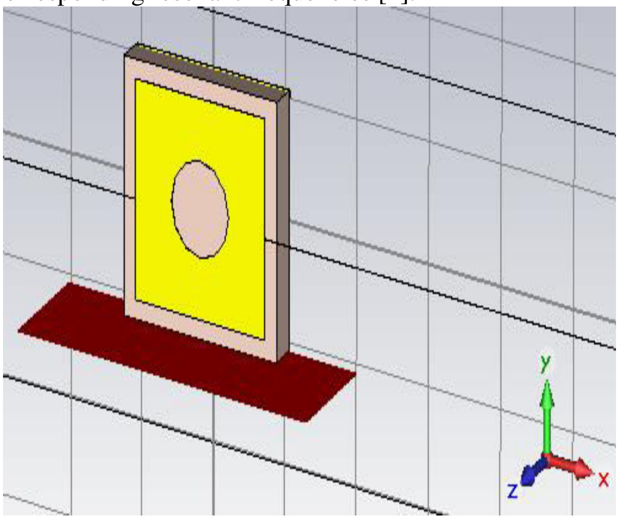

Fig. 5 Micro strip patch antenna with circular slot

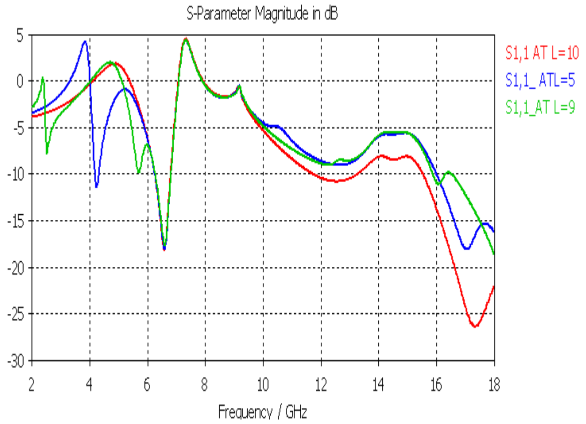

Fig. 6 Gain –Frequency Pattern with circular slot

Above graph represent that with slot in patch antenna, we can get antenna operating at fixed frequency. This can help in mitigation of frequency variation problem.

Table II Effect of Cut-off frequency on Simulated and calculated length with a slot cut on patch

CUT-OFF FREQUENCY (GHz.)	SIMULATED LENGTH & WIDTH (mm.)
6.81	10
6.81	9
6.81	5

VII. Conclusion

A compact micro strip Patch antenna is designed and key parameters of patch antenna have been presented in this paper. Simulated results are optimized by CST and measured is given this paper. Simulated and measured cutoff frequencies are shown in table. It describe that with decrease in length & height cutoff frequency increases which results in migration from c-band (4-8 GHz)to x-band (8-12.5 GHz) in microwave frequency range. The results are very encouraging and the variation of basic parameters of the micro strip patch antenna with slot loading, which are studied theoretically and experimentally, will help any researcher or designer to design patch antenna in their own requirement.

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