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A Novel Aperture Coupled Microstrip Patch Antenna for WLAN and WIMAX applications at 5.8 GHz

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Abstract- Microstrip antennas have various advantages especially small size and cost of fabrication of antenna is very less. Because of the above mentioned advantages, microstrip antennas are used in wireless communication systems. But it has drawback of narrow bandwidth. Aperture coupling technique is one which helps to improve this bandwidth upto some extent. Therefore, in this paper this technique has been used. The mathematical model using transmission line and a design at 5.8 GHz (WLAN and WIMAX) has also been discussed. Here the substrates used in aperture feeding have thickness 1.57mm and it is same for both the substrates. The bandwidth at 5.8 GHz comes out to be 340MHz which is good. The VSWR and directivity comes out to be 1.192 and 5.307 dBi respectively. The simulation is done using CST 2010 software.

Keywords: VSWR (Voltage Standing Wave Ratio), WLAN (Wireless Local Area Network), Return loss, Directivity

I. INTRODUCTION

Microstrip antennas have numerous advantages that it has small size, low fabrication cost, light weight and can be easily installed in the systems and it has applications in various systems like aircraft, satellite and spacecraft [1]. Microstrip antennas suffer from the disadvantage of bandwidth which is very narrow. The bandwidth can be improved by a feeding technique called aperture coupling and was proposed by pozar[2] .The aperture coupling technique has two substrates one is feed substrate and other is patch substrate and both the substrates are separated by a ground plane which has a small aperture. Therefore, the maximum energy is coupled from the feed to the patch and because ground is between patch substrate and feed substrate the reflections and radiations will be minimum on the side of feed. The coupling will be maximum if the slot is cut just below the patch and feed is perpendicular to the slot[3]. The availability of various types of substrate material can be chosen to improve antenna performance. The aperture coupling technique is good for implementation as it has flexibility of design and parameters because shapes of slot and patch can be taken. The stacked patch antenna will further improve the bandwidth. But the drawback of multilayered structure is that due to slot in ground plane the radiation pattern will be distorted and radiation efficiency will be reduced. [4].

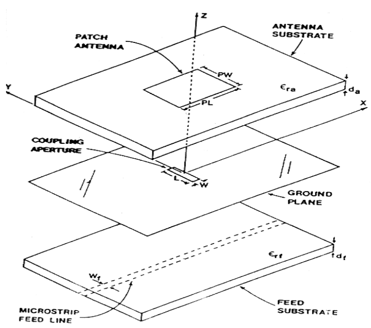


Fig1 Aperture coupled microstrip antenna

II. MATHEMATICAL ANALYSIS USING TRANSMISSION LINE MODEL

Waves are moving in both substrate and air. Due to this the dielectric constant is not considered but effective dielectric constant of material is considered for fringing effects and wave propagation. The effective dielectric constant is calculated by the formula which is as given below in equation (1). [1]

$\frac{W}{h} > 1$

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad (1)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (2)$$

$$L_{eff} = L + 2\Delta L$$

The resonant frequency of microstrip patch antenna is as given below

$$(frc)_{010} = \frac{1}{2L_{eff}\sqrt{\epsilon_{reff}}\sqrt{\mu_0\epsilon_0}} \quad (3)$$

$$W = \frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r + 1}} = \frac{\upsilon_0}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}} \quad (4)$$

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\mu_0\epsilon_0}} - 2\Delta L \quad (5)$$

The length and width of ground is given by

$$L_g = 6h + L$$
$$W_g = 6h + W$$

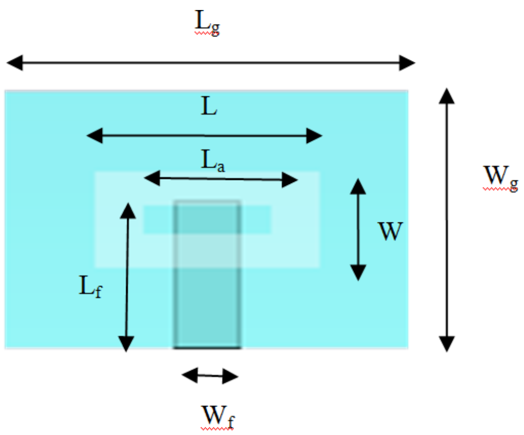
Where
h= substrate thickness
L = Length of patch
W= Width of patch
L_{eff} = Effective length
C= speed of light
ϵ_r = relative permittivity
ϵ_{reff} = effective permittivity

III. DESIGN AND SIMULATION OF APERTURE COUPLED MICROSTRIP ANTENNA AT 5.8 GHZ FOR WLAN AND WIMAX

Based upon transmission line model the antenna is designed using following parameters

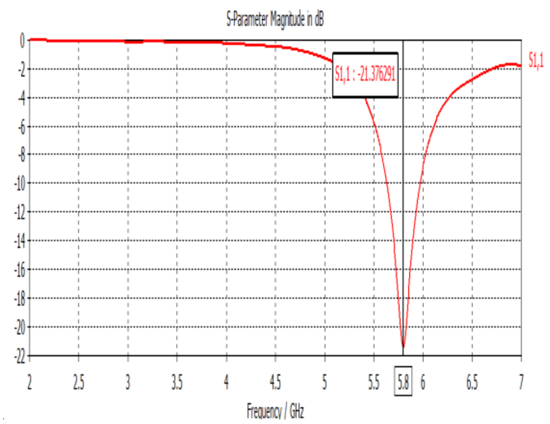
Dielectric constant of the material	4.4
Substrate thickness	1.57 mm
Length of patch	7.7 mm
Width of patch	17mm
Length of aperture	2.4 mm
Width of aperture	8 mm
Length of stub	1.5 mm
Width of feedline	4 mm

Antenna Design



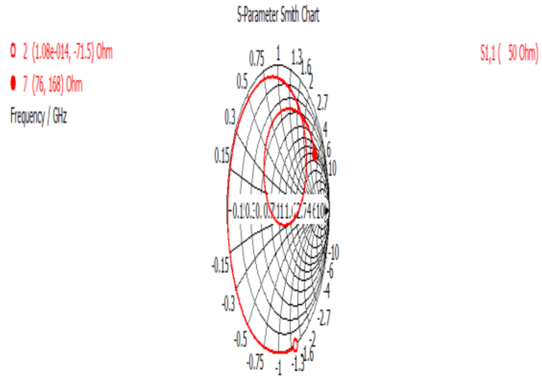
The plot of return loss against frequency

The return loss is a variable in which the power do not return in the form of reflection and is lost to the load.



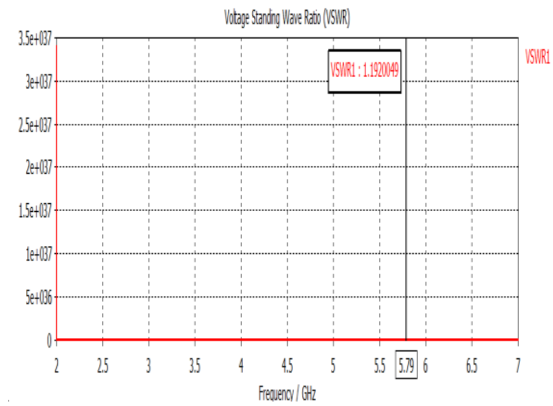
Impedance measured using smith chart

The smith chart shows the impedance when we move from low frequency to high frequency region. The impedance is complex



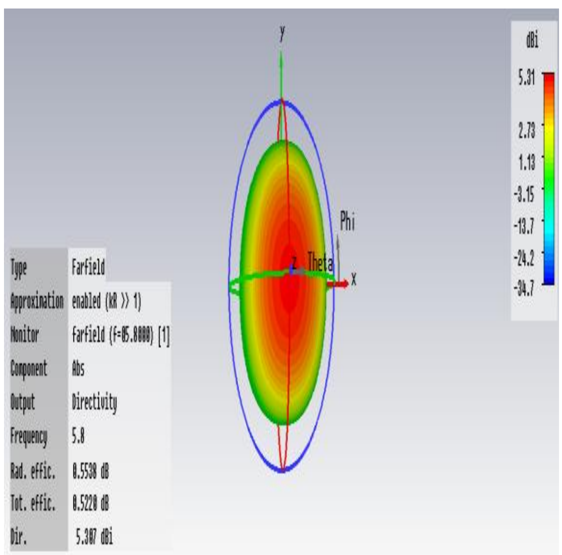
VSWR

Both transmitter and antenna are connected to each other through feedline and the impedance matching should be maximum between the antenna and the feedline means energy transfer between these two should be maximum. If matching is not proper then waves will come back and gets added up there and forms standing waves. For good antenna performance VSWR should be less than 2 and it is satisfying in this design. It is nearly 1.192



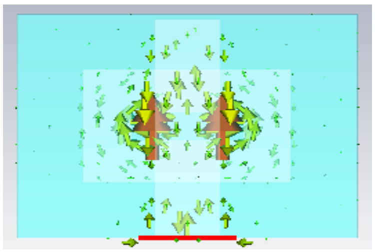
Directivity:

The value of directivity should be greater than 5 dBi and it is 5.307 dBi in this design.



Current Distribution

Basically the current distribution shows the current intensity. It should be maximum at the centre of the patch and minimum at the the edges. Current distribution tells where to cut the slot

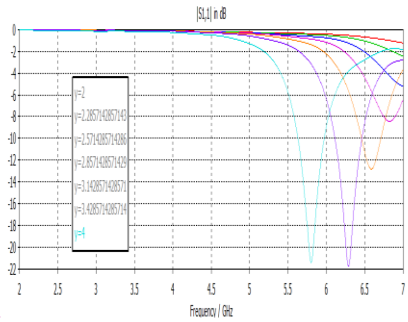


IV. RESULTS OF ANALYSIS

The effect of various parameters is shown below:

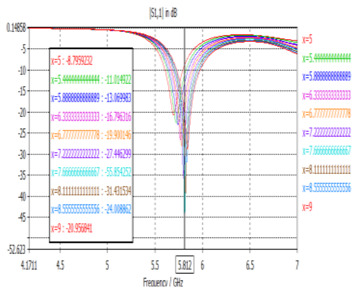
1) The **substrate thickness** affects the bandwidth and level of coupling in antenna upto greater extent. If the substrate is thicker then wider bandwidth can be obtained but coupling for aperture will be decreased and overall size of antenna will become bigger. Therefore there must be trade off between antenna size and bandwidth [6].

2) The **slot length** shows the coupling level of the antenna and it also shows the level of back radiation. Therefore, slot should be cut in a proper way so that impedance matching should be maximum. Effect of varying slot length is as shown below



3) **Stub** has greater impact on the performance of aperture coupled antenna and helps to tune the reactance. If the stub will be shortened then locus will move towards the capacitive side and if lengthening of stub is considered then locus will move towards the inductive side on the Smith chart.

4) On increasing the length of patch antenna the resonant frequency moves towards the lower band and on decreasing the patch length the resonant frequency moves towards upper band. Maximum coupling will be obtained when patch is at the centre[7]



5) The **Resonant frequency** depends on the length of the patch of antenna and on varying the value of patch the frequency will be disturbed.

V. APPLICATIONS OF MICROSTRIP ANTENNA

- Microstrip antennas are used in Global Positioning System at the frequency of 1575 MHz and 1227 MHz.
- It is also used in GSM, Paging, Cellular phones, WLAN and Wide Area Computer Networks.

VI. CONCLUSION

A simple design of aperture coupled microstrip antenna has been discussed according to design specifications and analysis of this design has been done. The return loss comes out to be -21.375 dB calculated with the help of formula$-20\ log_{10}\ \rho$. The bandwidth of 340 MHz has been obtained at the operating frequency of 5.8 GHz. The VSWR in this design is 1.192 and it satisfies the criteria that it should be less than 2. The antenna has good return loss as well as good VSWR at the required frequency of 5.8 GHz. This design will be fabricated using PCB technology and will be tested in vector network analyser. The antenna designed here has small size and low fabrication cost and has numerous applications in WLAN and WIMAX bands as this frequency lies in both the bands.

FUTURE WORK

This design is very good and can be fabricated using Printed Circuit Board technology and will be tested in anechoic chamber and Vector network analyser.

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