A Design and Analysis of Inset-fed Rectangular Micro Strip Patch Antenna

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Abstract: ***The paper presents a broadband micro strip patch antenna for wireless communication. Conventional inset-fed rectangular patch antenna was designed, simulated, analyzed to improve on its bandwidth. A micro strip patch antenna consists of a radiating patch on one side of a dielectric substrate and ground plane on the other side. The patch is made of conducting material such as copper or gold and it can take any possible shape. Patch antennas have narrow bandwidth. To enhance these narrow bandwidth edge-cut techniques is used to 160MHz. The other antenna parameters like return loss, voltage standing wave ratio (VSWR), and the gain were equally improved. This technique also ensures that the antenna is suitable for mobile wireless communication applications. High frequency structure simulator (HFSS) software is used for the design and simulation the result of this patch antenna. The designed antenna is good for WiMAX technology.***

Keywords: Patch Antenna, Inset feed, Bandwidth, Wireless Fidelity, VSWR, Radiation pattern

1. Introduction

To overcome the narrow bandwidth constraint, the antenna is designed with the inset-fed edge technique The inset-fed microstrip patch antenna can capture more signals with the improved accuracy. In order to solve for the low efficiency limitation, the antenna is designed with the aim of producing both simulated and measured return loss, *S*11 lower than -10 decibel (dB) ideally to obtain a good performance [1].

Microsrtip antennas are used for number of wireless applications such as WLAN, Wi-Fi, Bluetooth and many other applications Micro strip antenna consists of very small conducting patch built on a ground plane separated by dielectric substrate. This patch is generally made of conducting material such as copper or gold and it take any possible shape. The conducting patch, theoretically, can be designed of any shape like square, triangular, circular, rectangular, however rectangular and circular configurations are the most commonly used. The dimensions of a patch are smaller as compared to the substrate and ground. Dimensions of a micro strip patch antenna depend on the resonant frequency and value of the dielectric constant.

In a wireless communication system, antennas are very useful. An antenna can be defined as a device which radiates and receives electromagnetic energy efficiently and in a desired manner. In other words, an antenna can also be seen as a transformer which transforms electrical signals into electromagnetic waves or converts electromagnetic waves back into electrical signals.

Microstrip antennas for mobile to satellite communications, cellular, GPS, satellite, wireless LAN for computers Wi-Fi, Bluetooth technology, Radio Frequency ID devices and WiMAX.

Micro strip antenna has a drawback of low bandwidth and low gain. The bandwidth can be increased by cutting slots. The Micro strip patch is designed such that its pattern maximum is normal to the patch (broadside radiator). Micro strip patch antennas are widely used in wireless application due to great advantages such as low-profile, high transmission efficiency, light weight, low profile, conformal and planar structure, compactness, low cost and ease of integration with microwave circuit

Micro strip patch antennas have been widely used particularly since they are lightweight, compact and cost effective. The input impedance of these antennas depends on their geometrical shape, dimensions, the physical properties of the materials involved, the feed type and location. Therefore, a subset of antenna parameters can be adjusted to achieve the "best" geometry for matching of a particular resonance. The inset-fed microstrip antenna provides a method of impedance control with a planar feed configuration [2-3]. The experimental and numerical results showed that the input impedance of an insect-fed rectangular patch varied as function of the normalized inset depth [2]. A more recent study proposed a modified shifted 2 Sin form that well characterizes probe-fed patches with a notch [4]. It is found that a shifted 2 Cos function works well for the inset-fed patch [5][6]. The parameters of the shifted cosine-squared function depend on the notch width for a given patch and substrate geometry.

In a communications system, antenna is the most important part, which operates as a transducer for sending and receiving the electromagnetic waves. In this case, antenna becomes as an electrical device or conductive element, which helps convert the radio frequency (RF) or microwave to electrical power and vice versa. Recently, there is a rapid growth of wearable antenna development. Wearable antennas are becoming more and more lightweight that can be integrated into or hidden inside clothing to improve communication links and support a so-called wireless body area network (WBAN) application [7].

2. Feed Techniques

Micro strip patch antenna can be fed by a variety of different methods.The four most popular feed techniques used for the Micro strip patch are

a) Microstrip Line feed

In this type of feeding technique, a conducting strip connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the path and this kind of feed arrangement has the advantage that the feed can be on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance. This is achieved by properly controlling the inset position [8].

b) coaxial feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane [9].

c) Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized [10].

d) Proximity Coupled feed

This type of feeding technique is also called as the electromagnetic coupling scheme, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate [11]. Micro strip inset feed method was used in this design for proper input impedance matching.

3. Design Specification for Patch Antenna

The Performance of the Micro strip patch antenna depends on its resonant frequency, dimension. For an efficient radiation, the practical width of the patch can be calculated by using the following. [3,4]

Step1: Calculation of the width (W):
The width of the Micro strip Antenna is given as

$$W=\frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r+1}}$$

W = Width of the patch

Where **c** is the velocity of light ε_r is the dielectric constant of substrate, f *is* the antenna working frequency

Step2: Calculation of effective dielectric constant ($\varepsilon reff$):

$$\varepsilon reff=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{1/2},\ w/h>1$$

ε_r is the dielectric constant of the substrate and ε_{reff} is the effective dielectric constant

Step3: Calculation of extension length(ΔL):

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

Step4: Calculation of effective length (Leff):

$$L=\frac{C}{2fr\sqrt{\varepsilon reff}}-2\Delta L$$

Step5: Calculation of actual length of patch (L):
$L = Leff - 2\Delta L$

Step6: Calculation of ground plane dimensions (Lg and Wg):
$Lg = 6h + L$
$Wg = 6h + W$

The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [2]

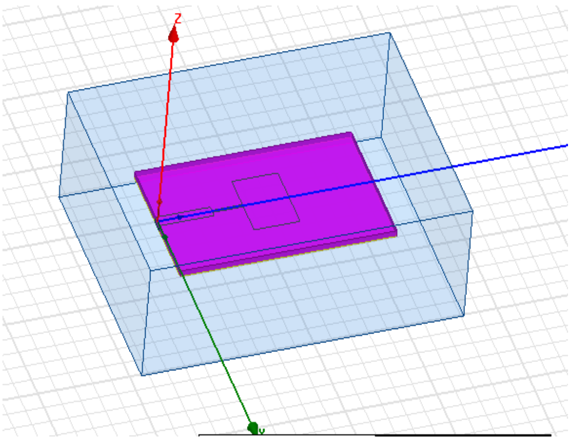
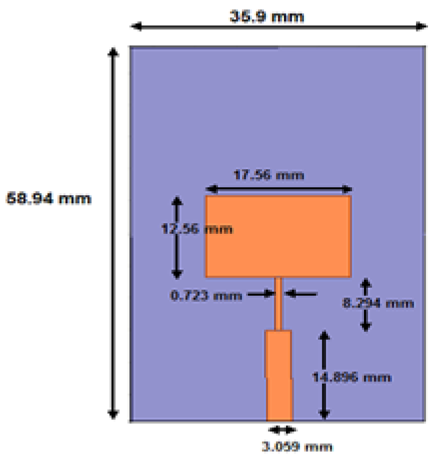


Figure 1: Structure of Micro strip Patch Antenna



4. Simulation Results and Analysis

The software used to model and simulate the Parallel Micro strip patch antenna is High Frequency Simulation Software HFSS version 13. It has been widely used in the design of Patch antenna, Wire antenna, MICs,. It can be used to determine and plot the reflection parameters, Voltage Standing Wave Ratio (VSWR), Radiation patterns, Polar Plots etc. bandwidth of the simulation and measurements are 16% and 18%.

Return Loss

It is a parameter which indicates the amount of power that is "lost" to the load and does not return as a reflection. Return Loss is a parameter to indicate how well the matching between the transmitter and antenna take place. It is the S11 of an antenna parameter . A graph of s11 of an antenna vs frequency is called its return loss curve.

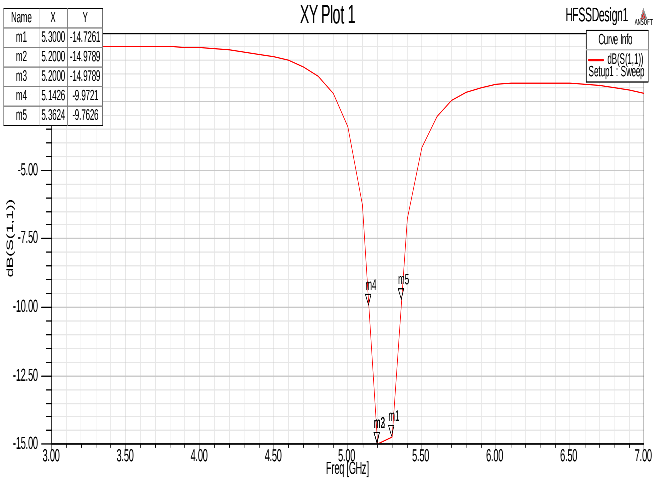


Figure 2: Return loss (S11 plot) for the inset fed conventional patch antenna

VSWR

The parameter VSWR is a measure that describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this no power is reflected from the antenna, which is ideal.

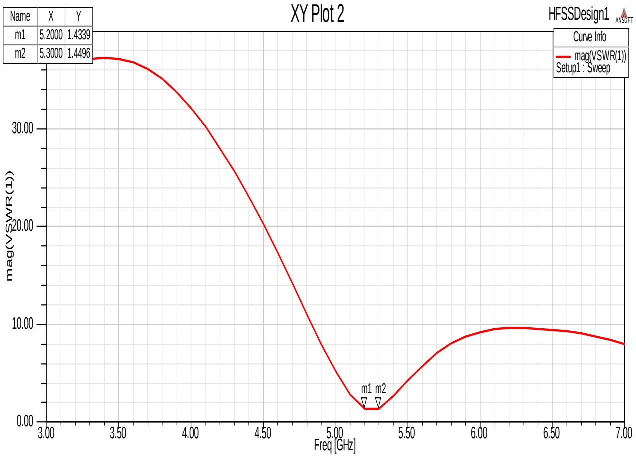


Figure 3: Voltage Standing Wave Ratio (VSWR) Plot for the inset fed conventional patch antenna

Radiation Pattern

Micro strip patch antenna radiates normal to its patch Surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. Figure shows the gain plot for Inset feed.

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle (θ) and the azimuth angle (φ). It is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as 2D polar.

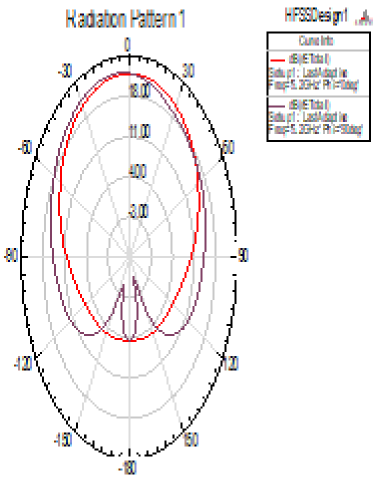


Figure 4: Radiation pattern (Phi) for the inset fed conventional patch antenna

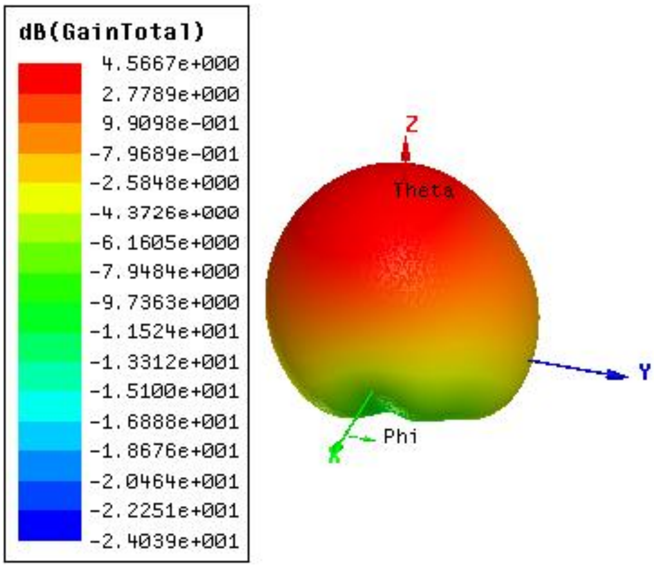


Figure 5: Total gain dB plot for the inset fed modified patch antenna

Antenna parameters	Inset fed rectangular Patch Antenna
Operating Frequency (GHz)	5.2
Substrate Material	FR4
Thickness of substrate	1.6mm
Ground and Patch Material	PEC
Resonant Freq (GHz)	5.2
Return Loss (dB)	-14.97
VSWR	1.43
Bandwidth (MHz)	(5.3-5.14)GHz=0.16 160Mhz

5. Conclusions

This research work has analyzed the design and simulations of microstrip patch array configurations for 5.2 *GHz* The disadvantage of low bandwidth of a rectangular patch antenna, improved. Bandwidth of 160 MHz of that of the conventional rectangular patch with an inset feed technique, to achieve a better impedance matching. The antenna resonates at 5.2GHz and has a bandwidth of (5.3GHz – 5.14GHz) which is good for the middle band WiMAX technology. There were improvements on other antenna parameters such as the Gain, Return Loss, VSWR and radiation pattern from the simulation result plots as show in the above table.

Also for most mobile and hand held communication devices where patch antennas are being used, small sizes are desired. In this work, in addition to the improved antenna parameters making it suitable for mobile and portable hand held applications. From the simulation result better bandwidth and performance improvement can be achieved. The return loss at 5.2 GHz frequency is below -10 dB which shows that there is good matching at frequency points. The simulation results show that the Inset feed excitation technique provides more gain and perfect impedance matching as compared to the other feed excitation technique. Also the main advantage of this feeding technique is that feed can be given anywhere inside the patch which makes easier fabrication compared to other feed technique.

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