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DESIGN AND ANALYSIS OF BROADBAND MICROSTRIP PATCH

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Abstract

This paper explains about the various broad band and minimization technique in square microstrip patch antenna. To study the broad band characteristics in patch antenna for WLAN and Wireless Communications. To carve a U shaped slot on simple co-axial fed patch antenna and study its return loss characteristics and the radiation characteristics and compare them with traditional patch antenna. Further the analysis is carried on with a shorting wall at the edge. The extended patch from the upper region combining with the lower region form the shorting wall. Different feed are been used for obtaining the improved impedance of the microstrip antenna. We Can Use U slot for obtaining the plane operation i.e. E-plane data of the antenna. Using these techniques we obtained the bandwidth in required percentage of analysis. This technique is used to minimize the patch antenna surface area. The shorting wall method is used for the minimization of the antenna values that are to be obtained. One of the advantages of microstrip patches over conventional antennas is their small size. However, there are many present day applications where even these small radiators are too large. A microstrip antenna incorporated with a single shorting wall is found to provide reduction in overall area with respect to a conventional patch. The microstrip antenna has now reached maturity, wherein only a few mysteries about its behavior are still undiscovered. The patch antenna has been rapidly used in various fields like space technology, aircrafts, missiles, mobile communication, GPS system, and broadcasting. Patch antennas are light in weight, small size, low cost, simplicity of manufacture and easy integration to circuits. Simulation are been obtained using HFSS software.

Index Terms: *HFSS U slot, microstrip antenna, and bandwidth AND SHORTING WALL DIMENISION*

1. INTRODUCTION

The need for a low profile and compact antennas is on rise with the rapid development of the wireless communication devices. Due to low fabrication cost and compactness of the patch antennas many researchers are working in this area [2]. Also these antennas are light weight and easy to install. To maintain compactness and multiple bands yet to remain high gain of the antenna is still a challenge to the antenna designers. Typically dual frequency operations can be obtained by using multilayer stack patches and little attention has been paid to single layer microstrip antennas. Several techniques of microstrip antennas are known, prominent among them are the use of stacked patches. The stacked patch antenna has multi layer structure consisting of several parasitic radiating elements placed one above the other and above the driven element. However this approach has the inherent disadvantage of increased overall thickness and issues related to aligning various layers precisely. But slot antennas are ahead of this. Because of the booming demand in wireless communication system and UHF applications, microstrip patch antennas have attracted much interest due to their low profile, light weight, ease of fabrication and compatibility with printed circuits [5]. However, they also have some drawbacks, such as narrow bandwidth, low gain spurious feed radiation limited power handling capacity . To overcome their inherent limitation of narrow impedance, bandwidth and low gain, many techniques have been proposed and investigated, e.g., for probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches using optimization program in java and the genetic algorithm [6]. When we change the shape of a microstrip antenna and it is covered with a dielectric layer , its properties like resonance frequency, gain are changed which may seriously degrade or upgrade the system performance .

The major inconvenience of microstrip antennas is their low bandwidth. One of the methods to increase the bandwidth, which has lower increment in antenna volume behind, is the use of a U-slot in the single layer single patch antenna [1]. In 1995 a broad band single layer probe fed patch antenna with a u-shaped slot was presented by Huynh and Lee . In this a symmetric type of this antenna with 30% bandwidth and probe with 1.27 mm diameter and center operating frequency of 4.5 GHz with Foam substrate has been presented. Since probes that are available for us have 1.27 mm diameter, in the case of designing the antenna for this probe and lower frequencies the ratio of probe diameter to wave length will be reduced [9]. The reduction in probe diameter results in the increment in the fringe inductive at the feed. Through an example we will show that this phenomenon causes in reduction in the bandwidth.

It is well known that microstrip antennas have very narrow impedance bandwidth, typically a few percent. One of the methods of widening the bandwidth is to cut a U-shaped slot on the patch of the coaxially fed rectangular patch antenna. The other method is to use a U-slot patch proximity coupled by microstrip feed line terminated with a novel ¦-shaped stub [2]. The design of microstrip antennas at microwave frequencies is closely related to the feeding technique. There are several problems associated with classical feeding techniques, such as coaxial probe or proximity feeds:

1) Performance can be severely degraded by the size of the feed, which can be comparable to the size of the patch itself, and

2) Soldering of probe-feeds is prone to repeatability problems.

On the other hand, the aperture coupled feeding technique has intrinsic properties which make it an attractive feature for microwave applications. In this work, U-slot aperture-coupled microstrip antenna which makes three resonances is presented. The relationships between antenna structure and behavior are analyzed using its resonant frequencies. Based on this study, the feasibility of wideband U-slot patch antenna is demonstrated experimentally.

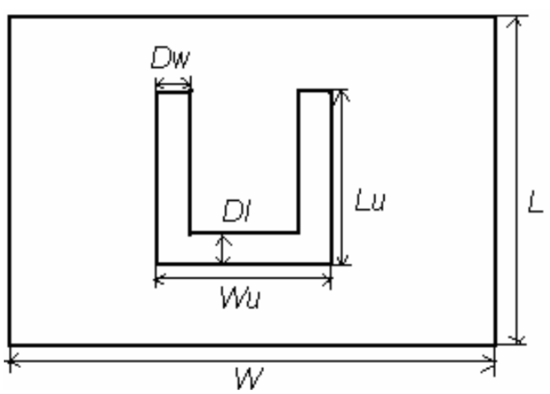

Fig. 1: U Slot geometry

In its most 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 as shown in Figure 2 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.

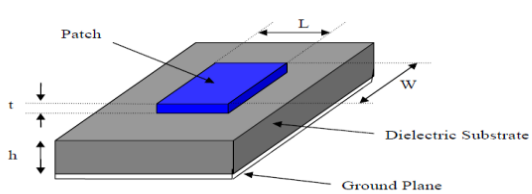

Fig-2 Structure of microstrip antenna

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shape For a rectangular patch, the length L of the patch is usually $0.3333\lambda < L < 0.5\lambda$, where λ is the free-space wavelength. The patch is selected to be very thin such that o $t \ll \lambda$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\lambda \leq h \leq 0.05\lambda$. The dielectric constant of the substrate is typically in the range $2.2 \leq \varepsilon_r \leq 12$. 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 [5]. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance.

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch [5]. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

The patch's radiation at the fringing fields results in a certain far field radiation pattern. This radiation pattern shows that the antenna radiates more power in a certain direction than another direction. The antenna is said to have certain directivity. This is commonly expressed in dB. An estimation of the expected directivity of a patch can be derived with ease [11]. The ringing fields at the radiating edges can be viewed as two radiating slots placed above a ground plane. Assuming all radiation occurs in one half of the hemisphere, this results in a 3 dB directivity. This case is often described as a perfect front to back ratio; all radiation towards the front and no radiation towards the back. This front to back ratio is highly dependent on ground plane size and shape in practical cases. Another 3 dB can be added since there are 2 slots. The slots are typically taken to have a length equal to the impedance width (length according to the yaxis) of the patch and a width equal to the substrate height. Such a slot typically has a gain of about 2 to 3 dB (cfr. simple dipole). This results in a total gain of 8 to 9 dB. The rectangular patch excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside). The directivity decreases when moving away from broadside towards lower elevations. The 3 dB beam width (or angular width) is twice the angle with respect to the angle of the maximum directivity, where this directivity has rolled off 3 dB with respect to the maximum directivity. An example of a radiation pattern can be found below. So far, the directivity has been defined with respect to an isotropic source and hence has the unit dB*i*. An isotropic source radiates an equal amount of power in every direction. Quite often, the antenna directivity is specified with respect to the directivity of a dipole. The directivity of a dipole is 2.15 dB*i* with respect to an isotropic source. The directivity expressed with respect to the directivity of a dipole has dB*d* as its unit.

1.2 Antenna Gain

Antenna gain is defined as antenna directivity times a factor representing the radiation efficiency. This efficiency is defined as the ratio of the radiated power (Pr) to the input power (Pi). The input power is transformed into radiated power and surface wave power while a small portion is dissipated due to conductor and dielectric losses of the materials used [13]. Surface waves are guided waves captured within the substrate and partially radiated and reflected back at the substrate edges. Surface waves are more easily excited when materials with higher dielectric constants and/or thicker materials are used. Surface waves are not excited when air dielectric is used. Several techniques to prevent or eliminate surface waves exist, but this is beyond the scope of this article. Antenna gain can also be specified using the total efficiency instead of the radiation efficiency only. This total efficiency is a combination of the radiation efficiency and efficiency linked to the impedance matching of the antenna.

1.3 Polarization

The plane wherein the electric field varies is also known as the polarization plane. The basic patch covered until now is linearly polarized since the electric field only varies in one direction. This polarization can be either vertical or horizontal depending on the orientation of the patch [13]. A transmit antenna needs a receiving antenna with the same polarization for optimum operation. When the antenna is rotated 90°, the current flows in the vertical plane, and is then vertically polarized. A large number of applications, including satellite communication, have trouble with linear polarization because the orientation of the antennas is variable or unknown. Luckily, there is another kind of polarization circular polarization. In a circular polarized antenna, the electric field varies in two orthogonal planes (x and y direction) with the same magnitude and a 90° phase difference. The result is the simultaneous excitation of two modes, i.e. the TM10 mode (mode in the x direction) and the TM01 (mode in the y direction). One of the modes is excited with a 90° phase delay with respect to the other mode. A square polarized antenna can either be right hand square polarized (RHSP) or left hand square polarized (LHSP). The antenna is RHCP when the phases are 0° and 90° for the antenna in the figure below when it radiates towards the reader, and it is LHCP when the phases are 0° and 90°.

1.4 Bandwidth

Another important parameter of any antenna is the bandwidth it covers. Only impedance bandwidth is specified most of the time. However, it is important to realize that several definitions of bandwidth exist impedance bandwidth, directivity bandwidth, and polarization Bandwidth, and efficiency bandwidth. Directivity and efficiency are often combined as gain bandwidth [14]. *Impedance bandwidth/return loss bandwidth* this is the frequency range wherein the structure has a usable bandwidth compared to certain impedance, usually 50 Ω. The impedance bandwidth depends on a large number of parameters related to the patch antenna element itself (e.g., quality factor) and the type of feed used. The plot below shows the return loss of a patch antenna and indicates the return loss bandwidth at the desired S11/VSWR (S11 wanted/VSWR wanted). The bandwidth is typically limited to a few percent. This is the major disadvantage of basic patch antennas. Several techniques to improve the bandwidth exist, but these are beyond the scope of this article.

2. SIMULATION RESULTS

The plot explains the construction of square patch antenna in HFSS software.

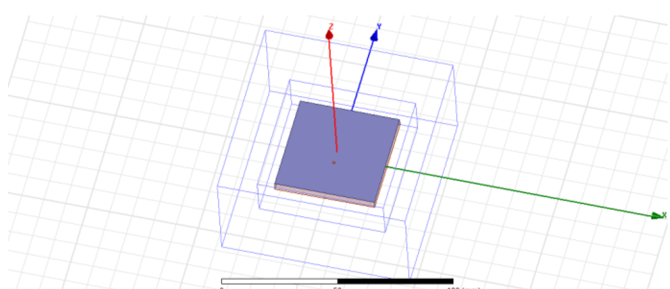

Fig-3 Geometry of square patch antenna

The plot explains about the return losses of the patch antenna that is obtained in terms of db values.

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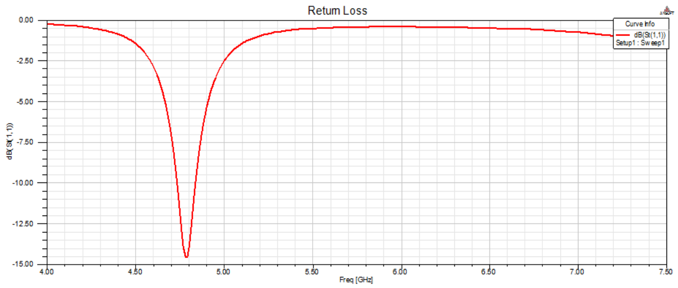

Fig-4 Return Loss Parameter characteristics of Patch Antenna.

This plot explains about radiation pattern of patch antenna for the values of phi 0 degree and 90 degree.

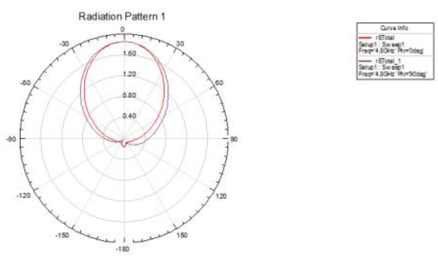

Fig-5 Radiation Pattern of Patch Antenna for all theta and phi=0deg and 90 deg.

This plot explains about the input impedance of patch antenna.

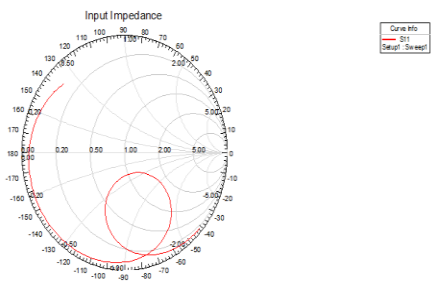

Fig-6 Input impedance characteristics of patch antenna

The plot explains the construction of U-shaped slot patch antenna in HFSS software.

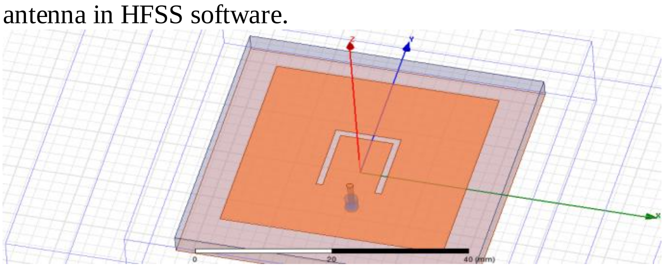

Fig-7 U-shaped slot patch antenna

This plot explains about the reflection coefficients characteristics of U-shaped slot antenna.

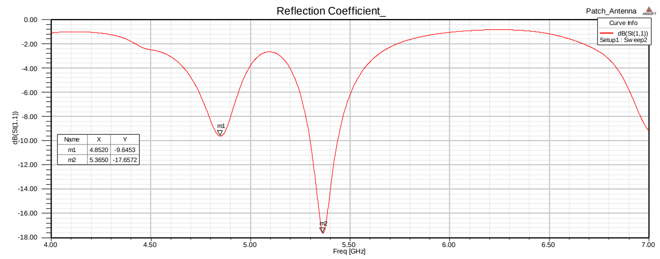

Fig-8 U-shaped reflection coefficient characteristics

This plot explains about the input impedance of U-shaped slot patch antenna.

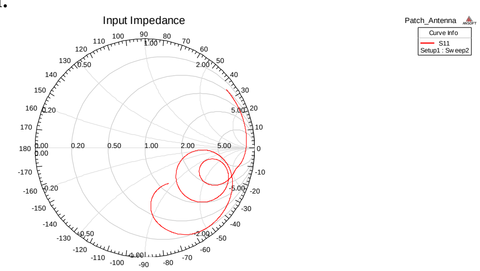

Fig-9 U-shaped input impedance slot patch antenna

This plot explains about radiation pattern of U-shaped slot patch antenna.

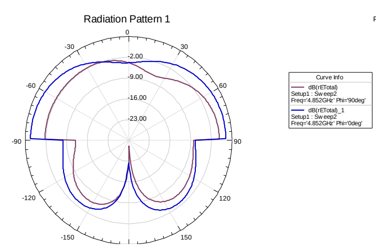

Fig-10 radiation pattern of U-shaped patch antenna

This plot explains about the VSWR characteristics of slot patch antenna.

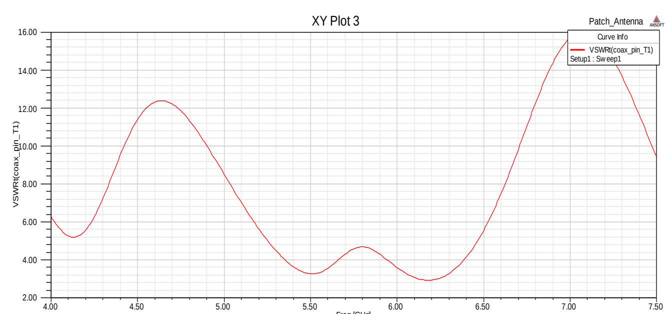

Fig-11 VSWR of U-shaped slot patch antenna

This plot explains about the reflection coefficients of shorting wall.

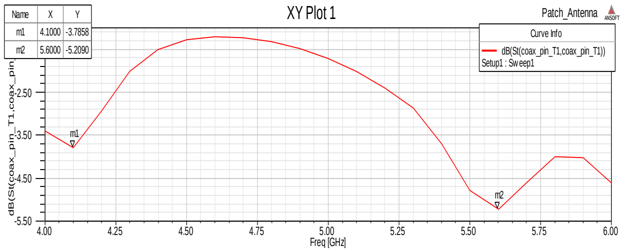

Fig-12 Reflection coefficents of Shorting wall

This plot explains about radiation pattern of shorting wall.

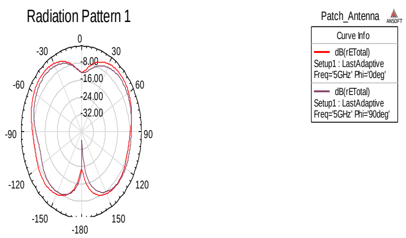

Fig-13 Radiation pattern of shorting wall

The plot explains the construction of shorting wall square patch antenna in HFSS software

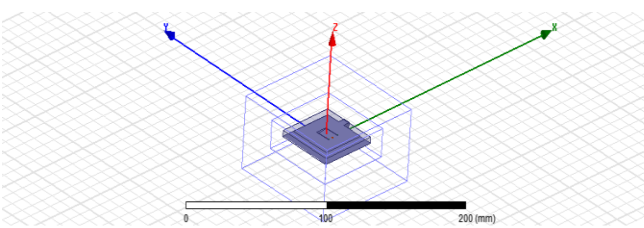

Fig-14 Geometry of shorting wall

3. CONCLUSION

In this paper a broadband asymmetric U-slot patch antenna with narrow probe presented. From this antenna capabilities compared to symmetric U-slot patch antenna, it can be indicated that, it has reduced size, lower probe diameter, without reduction in bandwidth, compared to antenna in precious works, and being possible to have more bandwidth than it with similar conditions, although it uses a simple structure. Its low size and being possible to fabricate using pcb technique, can be used in array applications. This antenna can be recommended when a circular polarization is used, but in linear polarization applications, it has high cross polarization level, which should be noticed in its application. Designer should note that the resonant frequencies should be placed the most far apart each other, but the broad band conditions also should be verified.

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