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Bandwidth Enhancement of Microstrip Antenna with Psi (Ψ) Slot at 2.45 GHz for WLAN Application

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ABSTRACT: One of the major limitations of the microstrip antenna is narrow bandwidth. Various techniques can be used to improve it's BW In this paper a square microstrip antenna with psi (ψ) shaped slot at 2.45GHz has been proposed to enhance the Bandwidth and Gain. The proposed antenna structure consists of a square microstrip antenna with a Psi shaped slot, feed line, and limited size of the ground plane. The proposed square microstrip antenna has designed at a frequency of 2.45GHz on FR4 substrate material and various antenna performance parameters Viz., return loss, VSWR, and Gain & Directivity… are found by using a High-frequency structure simulator (HFSS). From the simulation results, the percentage BW is calculated and it is obtained as 22% and gain is 7 dBi. These values are more than that of a conventional microstrip antenna BW (1-3%) and gain (1-2 dBi))

KEYWORDS: Square Microstrip Antenna, Psi shaped slot, Feed line, Limited ground plane, Return loss, Radiation pattern, %BW

I. INTRODUCTION

Due to the recent developments in modern technologies microstrip antenna plays a major role in wireless and mobile communications. There is a lot of demand for microstrip antenna as a wireless device. [1]Microstrip antennas are found several numbers of applications from the last decades in military and commercial fields. [1,2]The major advantages of microstrip antennas are low profile, small in size, light in weight and ease of integration with active devices, low cost of production Etc... Microstrip antennas suffer from many inherent disadvantages; they have a narrow bandwidth, poor radiation, and low gain. The bandwidth of the microstrip antenna is around 1% to 3%, which is a major limiting factor for wideband applications

Hence microstrip antennas became a major research topic for researchers in the field of antenna engineering. Considerable research has been done on microstrip antennas in recent years to exploit their small size at a lower cost. Although these antennas have proved to be excellent radiators for various applications, [9]narrow slot(s) on the patch with the ground plane. These advancements have witnessed corresponding progress in various areas where microstrip antennas are used. One of the applications of the proposed antenna design is selected for Wireless Local Area Network (WLAN), which is based on the IEEE 802.11b standard and its frequency range is from 2.4GHz to 2.48GHz. Inserting a slot on the ground plane and stacked patch supported by the wall, the bandwidth can improve up to 25% without significant change in the frequency [4].In this paper bandwidth enhancement of square microstrip antenna (SMA) is proposed by using a combination of two techniques, one is making Psi shaped slot and the other one is the use of a limited finite ground plane.

(a)Square microstrip antenna with Psi shaped slot: The simplest form of a square microstrip antenna[3,4] consists of a square shape patch on one side of the dielectric substrate material and the ground plane on the other side. The proposed microstrip antenna structure consists of a square patch antenna with a slot of Psi (Ψ) shape, microstrip feed line, and a limited finite ground plane. (b) Psi (Ψ) shaped slot: Many techniques have been implemented from the past three decades to improve the BW of microstrip antenna, which includes [3]modifying the shape of the patch, making slots [] on the patch (U-slot[5], V-slot, X-slot[4] H-slot, E-slot, diagonal slot, square, ring slot antennas, Etc.), by different feeding methods in a single layer and multilayer configurations[7,8]. Thick, low permittivity substrates have also been used which further increases the size and inductivity of the antenna.

Hence a new shape of the slot, i.e. a Psi shape slot, is incorporated in this design to improve the BW.

The Psi shape slotis formed by combining a total of six slots (three long vertical slots, one long and two horizontal slots) as shown in figure 1 for the geometry of the proposed antenna. [6]

A quarter wavelength of 50 ohms line is used to couple power from source to input terminals of SMA. A finite limited size of the ground plane is used in this design to resonate antenna properly[7,8].

II. DESIGN OF SQUARE MICROSTRIP ANTENNA WITH Psi (Ψ) SHAPED SLOT:

The design of SMAwith Psi slot to obtain results at a frequency of 2.45 GHz is described in this section

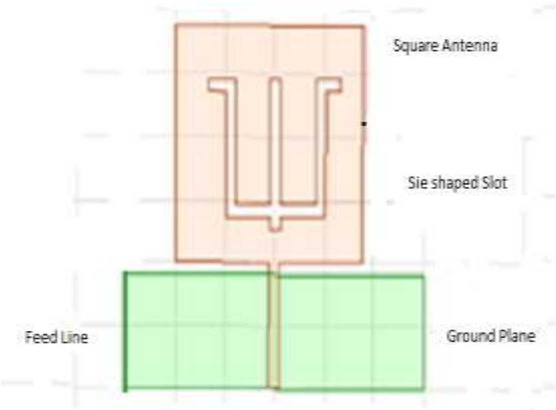

Fig.2.1: The geometry of SMA with Ψ shaped slot

Figure 2.2: PSi (Ψ) Shaped Slot

The geometry of the proposed antenna structure of SMA with Ψ slot is shown in figure 1 and the Ψ slot is separately shown in figure 2. In the design of SMA with Ψ slot, the substrate material Fr4 (Glass-Epoxy) with a dielectric constant of 4.4 and thickness of 1.60 mm, has been used.

SMA: The dimensions of the square patch at a frequency of 2.45 GHz have been derived by using the Transmission line model [3,6]. The side (L) of the patch is calculated as 39.75 mm. The prosed antenna structure is made on single-layer substrate material Fr4.

Feed Line: The antenna is fed with a 50Ω, quarter wavelength matching line.

Ground Plane: A limited Finite ground plane is used for this square patch. A slot of Ψ shape is made on SMA. The Ψ shape slot is formed by combining a total of six slots (three long vertical slots, one long and two horizontal slots) as shown in figure 1 for the geometry of the proposed antenna. The slot length (LS) is considered as less than λ/4 and width (WS) is less than λ/10. The lengths and widths of all of six numbers slots, for making a Ψ shaped slot, are calculated and shown in table 2. 50A λ/4 length of Feedline: The SMA is fed with a 50 Ω impedance matching line of quarter wavelength (λ/4) It is etched on the top portion of the substrate material (Fr4). The dimensions of the feed line, The length (LF), and width (WF) are calculated. The optimized values of LF and WF to get satisfying results in the simulation test are shown in table 2. Ground Plane: In this design, a ground plane is selected partial length instead of the full size of the substrate. i.e a limited length of the ground plane has been chosen to improve results of SMA.The length (LG) and width (WG)) of the ground plane are shown in table 2.1

Table 2.1: Optimized Design Parameters

f	ε_r	h	L_P	W_P	L_F	W_F	L_G	W_G
2.45 GHz	4.4 mm	1.6 mm	37 mm	37 mm	20 mm	2. mm	18 mm	60 mm

The PSi (Ψ) Shaped slotted SMA with the above design values is analyzed by using high-frequency structure simulations (HFSS) software.

III. SIMULATION RESULTS:

With the help of HFSS [10] software the proposed antenna structure described above is modeled and simulated. The HFSS is the industry-standard software for 3 D full-wave EM simulation tools. With the help of the HFSS software tool, various performance parameters of proposed antenna viz, return loss, VSWR, and radiation patterns (Elevation & Azimuth), are obtained at a frequency of 2.45 GHz. The resulting plots are shown in Figures 3.1 to 3.4.(a)Return loss: The return loss for the proposed antenna structure is plotted as a function of frequency in Figure 3(a). It is observed from the return loss plot (Fig. 3.1) that the return loss at 2.45 GHz is – 20.08 dB. Impedance BW has been calculated. The impedance bandwidth is defined as the range of frequencies over which the return loss is better than -10 dB and the value of VSWR is less than 2. The maximum bandwidth of this design is 22%. The value of VSWR at 2.45 GHz is 1.15is calculated from figure 3(b).

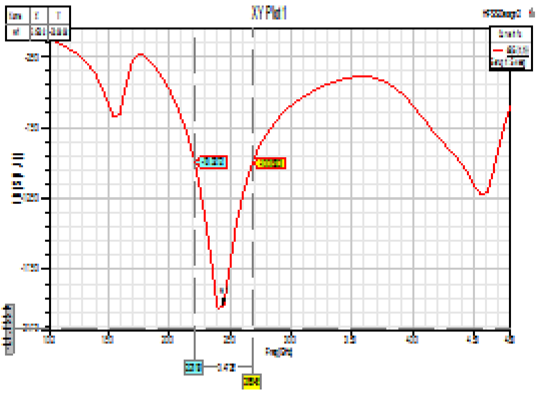

Figure 3.1: Return loss versus frequency

The impedance bandwidth is calculated as 447.5MHz (2.6854-GHz -2.2119 GHz) and the percentage Bandwidth can be calculated as.

$$\textbf{\% BW} = \frac{2.68-2.21}{2.45}\ \textbf{X100} \approx \textbf{20}$$

The SMA with Ψ shaped slot antenna has maximum radiation normal to the patch geometry (broadside direction). The radiation pattern plots in the elevation plane (at $\phi = 0^o$, and $90^{o)}$ and 3D radiation pattern are shown in Figures 3.2 to 3.4). The value of total gain 6.97dB ≈ 7 dB is obtained from the radiation pattern.

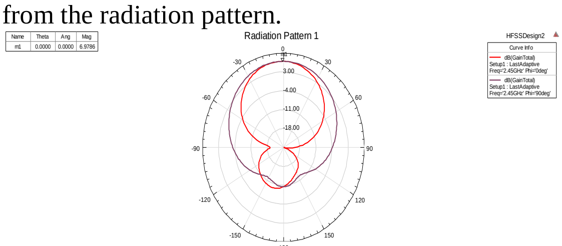

Figure 3.2: Total gain plot

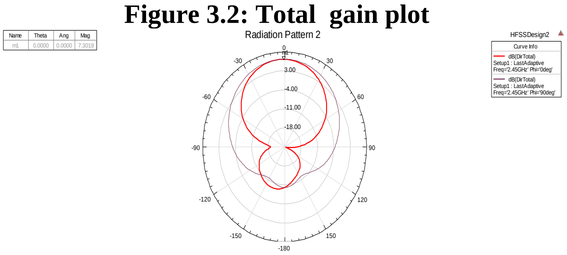

Figure 3.3: Directivity plot

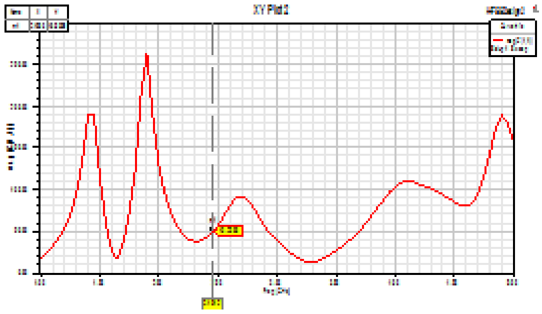

Figure3.4: Input impedance plot

Simulation Results: Table 4.1

Parameters of proposed antenna	**Value**
Resonated Frequency	2.45GHz
Return Loss	-20.0dB
VSWR	1.223
BW	20%
Total gain	6.97dBi
Directivity	7.3 dBi
Input impedance	50Ω

IV. CONCLUSION AND FUTUREWORK

For enhancingthe BW of microstrip antenna a new design of Square Microstrip antenna with psi (Ψ) Shaped Slot at 2.45 GHz using Fr4 substrate for WLAN Applicationantenna has been proposed. Wide bandwidth has been achieved by incorporating psi (Ψ) Shaped Slot in the antenna with a limited finite size of the ground plane. This proposed design results in increasing the % BW as 20, also helps in improving the gain of the antenna which is resulted as 7 dB at a frequency of 2.45GHz The antenna performance parameters and radiation pattern are obtained from HFSS and satisfactory results are found, which are suitable for most of the wireless LAN systems.

By using low loss dielectric substrate materials, the percentage BW may be increased up to 40 and gain may be increased to 6-8 dB instead of using Fr4 substrate with a high value of ε_r4.4 material.

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