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Design and Simulation of Rectangular Slotted Patch Antenna with Air Gap

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Abstract

A compact and ultra-wideband CPW-fed antenna with wide band frequency characteristic has been proposed, and the simulation results are discussed. Due to its electrical characteristics such as very small volume, wide impedance bandwidth, WiMAX band rejection, omnidirectional radiation pattern, and small group delay, the proposed antenna is expected to be a good candidate in various UWB systems.The bandwidth of the proposed antenna to be 2.7 GHz and a center frequency of 2.6GHz is obtained with return loss of -18.58dB. VSWR is less the 2 in the range of frequency 1.8 to 4.6 GHz. The proposed antenna is sutable for hend held device, WIMAX, mobile communication, and wireless applications.

1. Introduction

Microstrip antennas are extensively studied due to their low profile, and low cost characteristics [1, 2]. The modern trends in wireless communication need wide bandwidth antennas, through which audio and video information can be transmitted. The need for increasing the information transfer rate also demands bandwidth enhancement, without sacrificing the performance [1]. These requirements put together, provide a challenging list of specifications that demand innovation in antenna design beyond known conventional techniques [2, 4, 5, 6]. There are several approaches to improve the bandwidth such as, increasing the substrate thickness [9], introducing parasitic element either in co-planar or stack configuration[2, 6, 7, 8] and modifying the shape of a common radiator patch[10], using multimoding techniques[11], impedance matching[3], resistive loading[1, 3].

The use of a number of resonant modes is a very successful approach in the design of broadband microstrip antennas. The basic idea underlying this approach has been borrowed from the coupled resonators in which two or more resonators are stagger-tuned to cover the frequency range of interest. In this paper, we propose a microstrip-fed, rectangular slotted patch antenna with wide rectangular slot on the ground plane [12] for wireless applications. To enhance the gain an air gap is introduced between substrate and slotted ground plane and due to that effective dielectric become low and thickness of the substrate will also increase. The proposed antennas are designed for wireless applications in the range between 3.1 GHz to 10.6 GHz. The HFSS software [17] and transmission line model [16] have been used to design and simulate the proposed antenna.

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2. Antenna Design

The proposed antenna is shown in Fig.1. The geometry and dimensions of the proposed antenna, which is a CPW-fed monopole printed on a FR4 substrate with size of 20mm X 30 mm, thickness h = 1.6 mm, relative permittivity = 4:4, dielectric loss tangent = 0:02. The width of the feed line and the gap are 2mm and 0.5 mm, respectively. Distance between patch and ground plane are 2mm. The feed dimensions are selected for obtained 50- impendence. Which is easily fitted into hand-held device.The perimeter of the wide rectangular slot in ground plane has a value of approximately 2λ (λ_{is} the guided wavelength at lowest frequency of operating
Band) and the value of λ can be calculated by the equation

$$\lambda = \frac{\lambda_o}{\sqrt{\varepsilon_{eff}}}$$

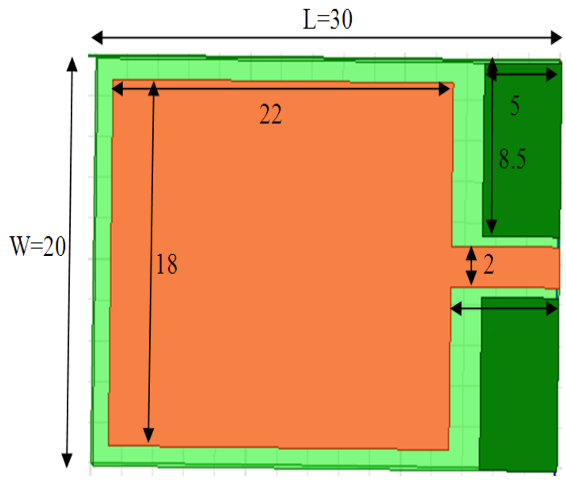

Fig: 1. Geometry of the Proposed Antenna

3. Parametric Studies

3.1Return Loss

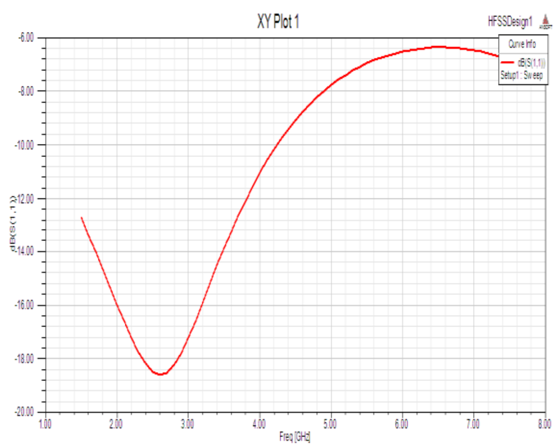

Fig: 2 S-parameter plots for Return loss v/s frequency

The CPW feed used is designed to have a feed-line width of 2 mm and feed path length of 7 mm. A frequency range of 1.5-8.0 GHz is selected and step size of 0.1 GHz is selected over this range to obtain accurate results.

The center frequency is selected as the one at which the return loss is minimum. As described in chapter 1, the bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -10 dB (-10 dB corresponds to a VSWR of 2 which is an acceptable figure). The bandwidth of the antenna (as shown below in Figure 15) to be 2.7 GHz and a center frequency of 2.6GHz is obtained with return loss of -18.58dB.

3.2Effect of air gap (h_a)

It is observed that height of air gap affects the lowest and highest resonant frequency shifting them downwards as air gap height increases. The coupling of all three resonant frequencies is also improved as h_a increases. The widest bandwidth is achieved when h_a is taken to be 5.0 mm as shown in Fig. 3.

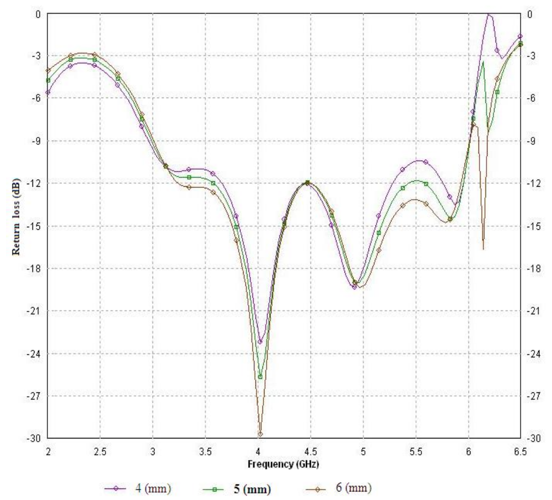

Fig: 3. Return loss characteristics for different air gap (h_a)\

3.3VSWR

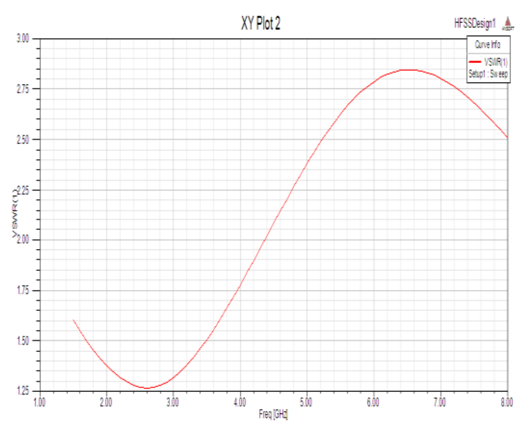

Fig: 4. VSWR v/s frequency plot

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible. When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Energy not transferred to the antenna is reflected back towards the transmitter. It is the interaction of these reflected waves with forward waves which causes standing wave patterns.

Matching the impedance of the antenna to the impedance of the feed line is typically done using an antenna tuner. The tuner can be installed between the transmitter and the feed line, or between the feed line and the antenna. Both installation methods will allow the transmitter to operate at a low VSWR. Ideally, VSWR must lie in the range of 1-2 which is achieved in figure 16 for the frequency 2.6 GHz.

Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. Figure 4.5 below shows the gain of the antenna at 2.6 GHz for φ = 0 and φ = 90 degrees.

The maximum gain is obtained in the broadside direction and this is measured to be 1.87 dBi for both, φ = 0 and φ = 90 degrees.

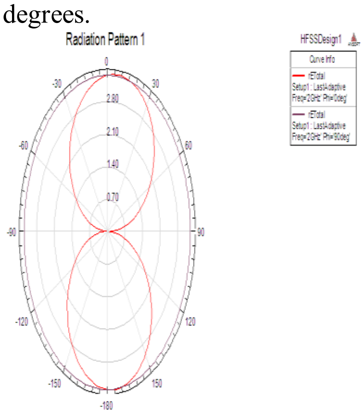

Fig: 5. 2D Pattern of rE Total for φ = 0 and φ = 90 degrees

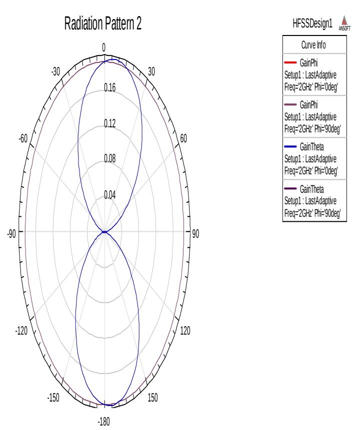

Fig: 6. 2D Pattern of gain Total for φ = 0 and φ = 90 degrees

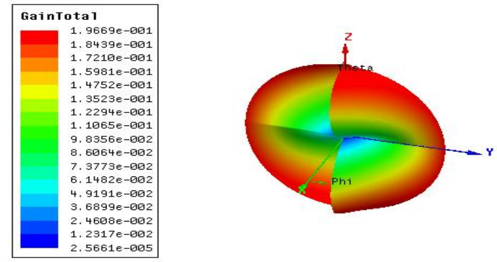

Fig: 7. 3D Pattern of gain Total for φ = 0 and φ = 90 degrees

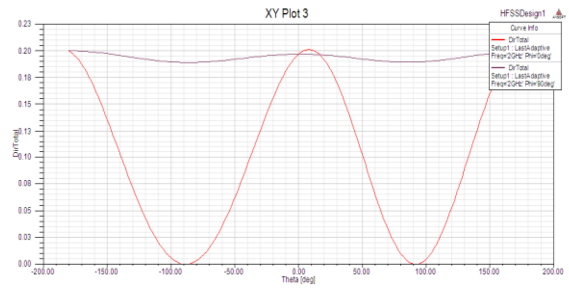

Fig: 8. Directivity Plot

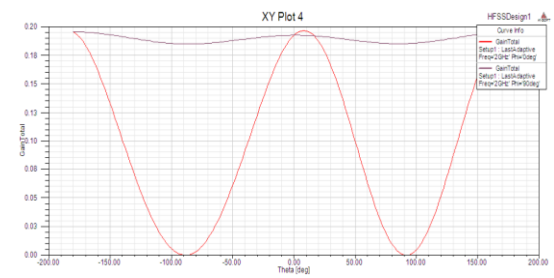

Fig: 9. Gain Plot

4. Result and Discussion

The software used to model and simulate the Microstrip patch antenna is Ansoft HFSS. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields.

5. Conclusion

A compact and ultra-wideband CPW-fed antenna with wide band frequency characteristic has been proposed, and the simulation results are discussed. Due to its electrical characteristics such as very small volume, wide impedance bandwidth, WiMAX band rejection, omnidirectional radiation pattern, and small group delay, the proposed antenna is expected to be a good candidate in various UWB systems. The bandwidth of the proposed antenna to be 2.7 GHz and a center frequency of 2.6GHz is obtained with return loss of -18.58dB. VSWR is less the 2 in the range of frequency 1.8 to 4.6 GHz.

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