© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Design Methodology to Reduce Loss Due To Mismatch in Patch Antenna Using ANSOFT HFSS for Ultra wide Band Applications

S. Saranya, S. Aparna, R. Karthiyayini, R. Aruna
Department of Electrical Communication Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India

ABSTRACT

Recently the need of antennas in the ultra-wideband (UWB) has increased. The UWB frequency range varies from 3.1-10.6GHz .This frequency band also includes WLAN band which ranges from 5.1-5.9GHz. An antenna that is designed for UWB applications should not interfere with this WLAN band. Therefore to avoid the interference, an antenna with a notch-band performance has to be designed. The proposed antenna consists of a stepped square radiating patch and two rod-shaped parasitic structures for generating band-notched function. Generally, the structure of patch and the feeding shapes of the antenna will be changed to obtain a wider bandwidth. In the proposed antenna, a notched ground plane with a single square slot is placed at the bottom to provide a wide usable bandwidth (3-14.5 GHz). The bandwidth of proposed antenna is wider than the bandwidth of the existing antenna. The proposed design is very much simpler and reduces the Design complexity of the antenna design.
Keywords: Ultrawide Band, Square Slot, WLAN Band, Microsrip Feed, Mismatch.

I. INTRODUCTION

Commercial ultra-wideband (UWB) systems require small low-cost antennas with omnidirectional radiation pattern and large bandwidth. It is a well-known fact that planar antennas present really appealing physical features, such as simple structure, small size, and low cost Due to all these interesting characteristics, planar antennas are extremely attractive to be used in emerging UWB applications, and growing research activity is being focused on them. In this antenna design slots are used in the ground plane to perform the band-notch function. By these notches, an additional two resonances are excited, and hence the bandwidth is increased. For UWB systems, the frequency range is between 3.1-10.6GHz, hence it can interfere with the existing wireless communication system such as wireless local area network (WLAN) (5.15-5.35, 5.725-5.825), so the UWB antenna with a notch-band frequency is required. The notch-band is provided by using two rod-shaped parasitic structures that reject 5.1-5.9GHz WLAN band. The bandwidth is increased by using a square slot at the bottom ground plane.

II. METHODS AND MATERIAL

1. Existing Designs

Mohammad Ojaroudi et al proposed a design, in which a printed monopole antenna for ultra-wideband (UWB) applications is presented. This antenna consists of a square radiating patch with two rectangular slots and a ground plane with inverted T-shaped notch, which provides a wide usable fractional bandwidth of more than 120%(3.12-12.73 GHz).This antenna is simple and small in size. This antenna does not have any band rejection performance.

A. Nouri et al proposed a design, in which a simple and compact UWB printed monopole antenna with filtering characteristic is presented. This antenna consists of a defected ground structure (DGS) and a radiating patch with arc-shaping step that is notched by removing two squares at the bottom. The designed antenna has a small size and provides only a bandwidth of more than 128% between 3.1 and 14 GHz, with notch frequency band at 5.13-6.1GHz.

Kyungho chung et al proposed a design, in which a novel and compact ultrawide band(UWB) micro strip fed monopole antenna having frequency band notch function is designed. to increase the bandwidth of an antenna, a narrow slit is used. By inserting a modified inverted U-slot on the proposed antenna, the frequency band notch characteristic is obtained. This antenna satisfies the frequency band between 3-11 GHz while showing the band rejection performance in the frequency band of 5.0-5.9GHz.

M. Mehranpour et al proposed a design, in which a antenna with L-shaped and an E-shaped slot along with a ground plane embedded with V-shaped protruded strip is designed. This slot provides a wide usable bandwidth of 2.89-17.83 GHz. These slots provide a dual band-notch function. These different slots that are used to attain wide bandwidth made the antenna design, a complex one.

2. Proposed Design

The proposed antenna is shown in Fig. 1. The antenna consists of a notched square plane and a notched ground plane with a square slot. This square slot plays an important role in attaining ultrawide bandwidth. The substrate that is used for printing the microstrip feed is FR4-epoxy with of thickness 1.6 mm, permittivity 4.4, permeability 1.

The optimal parameters of the designed antenna are as follows:

A_{sub}=12 mm, B_{sub}=18 mm, A_r=10 mm, B_r=9 mm, A_s=3 mm, B_s=1 mm, A_f=2 mm, B_f=7 mm, B_1=2.5 mm, B_2=10.5 mm, B_3=1.5mm, B_4=4 mm, B_5=0.7 mm, B_6= 9 mm,B_7=1.5 mm, B_8=1 mm,B_9=1 mm,B_{10}=3.5 mm,A1=4mm,A2=0.8 mm,A_3=A_4=4 mm.

The total length of the microstrip fed radiating patch can be given by A_f+B_s+B_r. The width of patch is A_r. The position for the substrate is taken at the origin. The position of the patch from the origin is
(1,17).

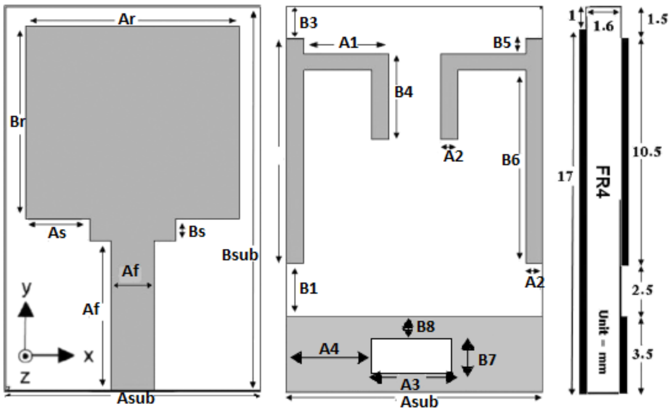


Figure 1. Geometry of proposed antenna in millimeters

The radiation boundaries are used to simulate open problems that allow waves to radiate infinitely far into space. To obtain the best result, a solid air boundary is defined with a distance of λ/4.

A. Design equations for patch antenna

The length of the patch antenna controls the resonant frequency. The below equation gives the relation between the length of patch antenna and the resonant frequency:

$$f \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

The width of the microstrip patch antenna is given by the below equation:

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

The following equation roughly describes how the bandwidth scales with these parameters:

$$B \propto \frac{\varepsilon_r - 1}{\varepsilon_r{}^2}\frac{W}{L}h$$

B. Software used

The designed antenna is simulated using Ansoft HFSS-High Frequency Structure Simulator. HFSS is the industry-standard software for S-parameter, full-wave SPICE extraction and electromagnetic simulation of high-frequency and high-speed components. HFSS is widely used for the design of on-chip embedded passives, PCB interconnects, antennas, RF/microwave components. HFSS uses the Finite Element Method (FEM) to solve Maxwell‘s equations. It is a numerical technique for finding approximate solutions to boundary value problems for differential equations.

C. Design procedure in HFSS

The design procedure first includes creating the model or geometry with feed. Then the boundaries are assigned to simulate the open problems that the waves to radiate infinitely far into space. Then assigning the excitations followed by setting up the solution. The frequency at which the antenna has to be operated is given and sweep values are given. Then the results are processed.

D. FEM Methodology:

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It is also referred to as finite element analysis (FEA). FEM subdivides a large problem into smaller, simpler, parts, called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem.

HFSS uses adaptive meshing technique. It is an interactive simulation system whose basic mesh element is a tetrahedron. This allows you to solve any arbitrary 3D geometry, especially those with complex curves and shapes, in a fraction of the other techniques.

III. RESULTS AND DISCUSSION

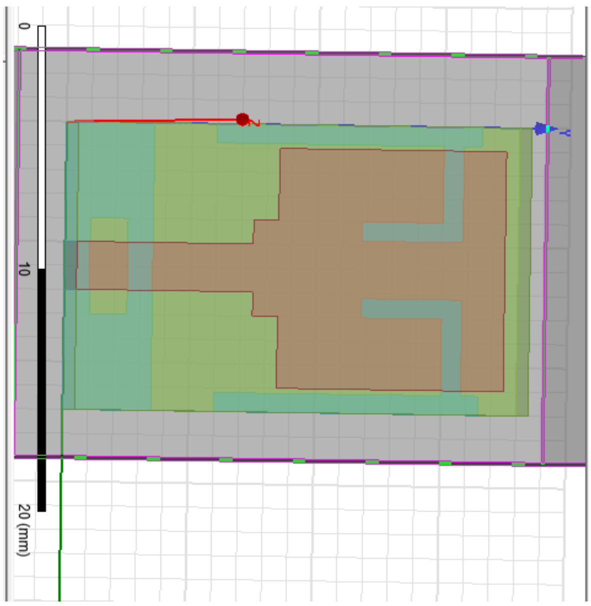


Figure 2. 3D Geometry of proposed antenna

The impedance bandwidth is obtained using the slotted ground plane and square notch patch with step. In order to increase the impedance bandwidth, a square slot is inserted in the ground plane of designed antenna. The slotted ground plane of the designed antenna provides one more resonance and two more resonance as shown in fig.3. The monopole antenna with slotted ground plane has wider impedance matching in comparison to the same antenna without slots in the ground plane .By slotting the ground plane with V-shaped slots and adjusting the parameters of slots, two more resonance can be excited at the frequencies 11.5 and 14.5 and as a result, the bandwidth is increased.

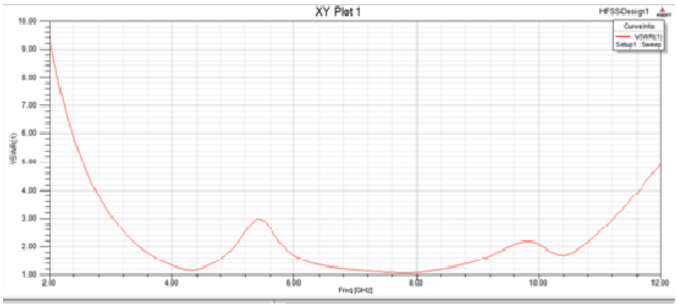


Figure 3. VSWR vs Frequency

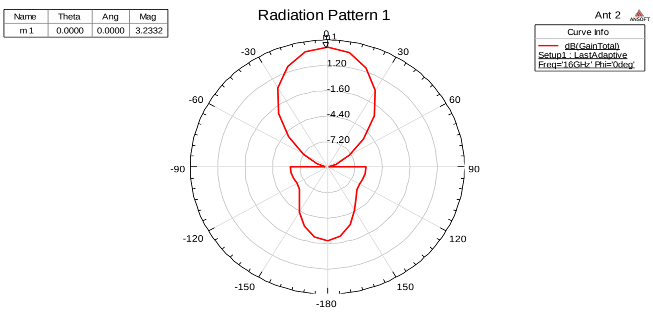
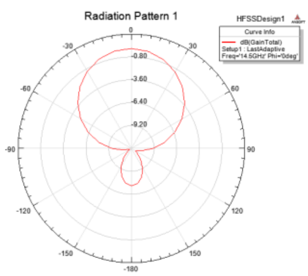
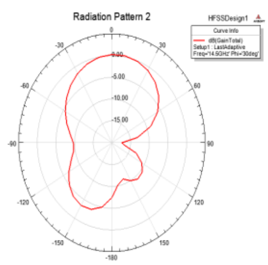


Figure 4. Radiation pattern





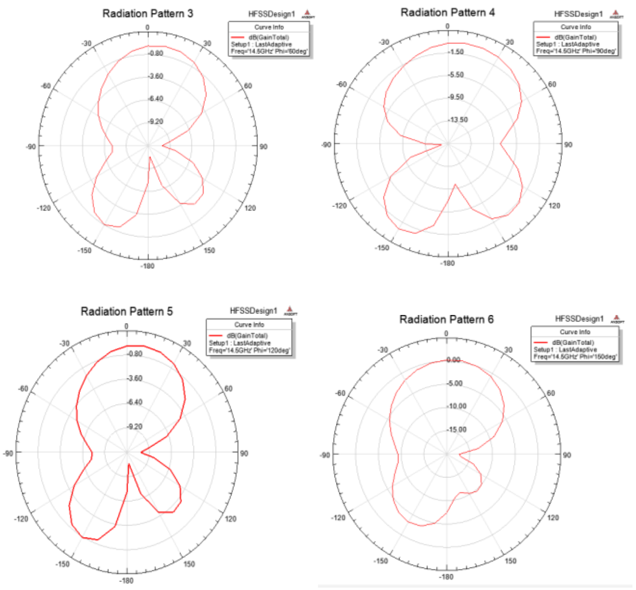


Figure 4a. Radiation patterns at different angles

Table showing the measured values of antenna parameters

ANTENNA	OPERATING FREQUENCY	VSWR	GAIN
Proposed antenna	8.2 GHz	1.03	3.23dB

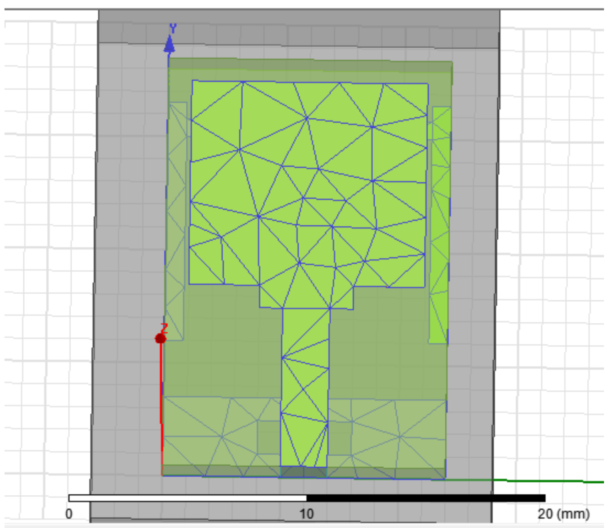


Figure 5.. Mesh analysis plot

To realize the band notched monopole antenna, two rod-shaped parasitic elements are placed at the back of the substrate and are coupled to the radiating patch. At the notch frequency, the current flows of parasitic elements are more dominant, and the currents if elements are oppositely directed between them and the radiation patch. Therefore, the resultant radiation fields cancel out, and high attenuation near the notch frequency is produced. As a result the antenna does not radiate efficiently at the notch frequency.

Fig.4 shows the overall radiation pattern of the designed antenna and Fig.4.1 shows the radiation patterns of the proposed antenna at different angles. The radiation pattern shows that gain of the antenna varies at different angels. Fig.5 shows the mesh analysis of the antenna which is designed.The VSWR value of proposed antenna is comparatively minimum to the existing antennas which indicates that minimum loss due to mismatch.Higher VSWR values have more loss due to mismatch.The parameter Gain is also high for the proposed antenna comparatively.

IV. CONCLUSION

A novel compact microstrip-fed printed monopole antenna with single band-notched characteristics has been proposed for UWB applications. By embedding a square slot with proper dimensions and position in the ground plane, two more resonances are excited, and as a result, wide impedance bandwidth from 3 to 22.5 GHz is achieved, and also a rejection band around 5.1-5.9 GHz can be achieved with a pair of rod-shaped parasitic structures on the backside of the substrate. Since there is only one square slot in the ground plane the proposed antenna is easy to design and fabricate also.

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