Band-Notched Small Slot Antenna with Enhanced Bandwidth by Using Parasitic Structures inside Slots for UWB Applications

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1. Abstract

In this paper a novel ultra wideband slot antenna with frequency band-stop performance is designed and manufactured. The proposed antenna consists of a square ring radiating stub with an S-shaped parasitic structure inside the square ring and a ground plane with a rectangular slot with an H-shaped parasitic structure inside the slot. In the proposed structure, by cutting rectangular slot with an H-shaped parasitic structure inside the slot in the ground plane, additional resonance is excited and hence much wider impedance bandwidth can be produced, especially at the higher band. In order to create band-rejected function we use an S-shaped parasitic structure inside the square ring radiating stub. The fabricated antenna has a frequency band of 3.01 to over 11.07 GHz with a rejection band around 5–6 GHz. Good VSWR and radiation pattern characteristics are obtained in the frequency band of interest. Simulated and measured results are presented to validate the usefulness of the proposed antenna structure for UWB applications.

2. Introduction

Communication systems usually require smaller antenna size in order to meet the miniaturization requirements of radio-frequency (RF) units [1]. It is a well-known fact that planar slot antennas present really appealing physical features, such as simple structure, small size, and low cost. Due to all these interesting characteristics, planar slot antennas are extremely attractive to be used in emerging UWB applications, and growing research activity is being focused on them. Consequently, a number of planar slot antennas with different geometries have been experimentally characterized [2]-[5].

The frequency range for UWB systems between 3.1–10.6 GHz will cause interference to the existing wireless communication systems for example the wireless local area network (WLAN) for IEEE 802.11a operating in 5.15–5.35 GHz and 5.725–5.825 GHz bands, so the UWB antenna with a band-notch function is required [6-8].

In this paper, we present a new design of compact wideband slot antenna with band rejection characteristic for UWB applications. In this antenna, rectangular slot with H-shaped parasitic structure inside it cut in the ground plane was used for enhance of bandwidth and an S-shaped parasitic structure inside the square ring radiating stub was applied to generate a band notch performance. The fabricated antenna has the frequency band of 3.01 to over 11.07 GHz with a rejection band around 5–6 GHz. The size of the designed antenna is smaller than the slot antennas reported recently [2]-[5]. Good return loss and radiation pattern characteristics are obtained in the frequency band of interest.
3. Antenna Design and Configuration

The proposed slot antenna fed by a 50-Ohm microstrip line is shown in Fig 1, which is printed on a FR4 substrate of thickness 0.8 mm, and permittivity 4.4. The radiating stub is connected to a feed line with the width of 1.5 mm and the length of 4 mm. The basic antenna structure consists of a square radiating stub, a feedline, and a ground plane with a rectangular slot. The proposed antenna is connected to a 50Ω SMA connector for signal transmission.

![Figure 1: Geometry of proposed microstrip-fed slot antenna, (a) side view, (b) rectangular slot with an H-shaped parasitic structure, (c) square radiating stub with an S-shaped parasitic structure.](image)

Regarding Defected Ground Structures (DGS), creating slots in the ground plane provides an additional current path. Moreover, this structure changes the inductance and capacitance of the input impedance, which in turn leads to change the bandwidth. The DGS applied to a microstrip line causes a resonant character of the structure transmission with a resonant frequency controllable by changing the shape and size of the slot [2]. Therefore, by cutting a rectangular slot with an H-shaped strip protruded inside the slot in the ground plane and carefully adjusting its parameters, much enhanced impedance bandwidth may be achieved. As illustrated in Figure 1, the S-shaped parasitic structure is placed inside the square ring radiating stub. Based on Electromagnetic Coupling Theory (ECT), this coupled strip perturbs the resonant response and also acts as a half-wave parasitic structure. At the notch frequency, the current flows are more dominant around the S-shaped coupled strip. As a result, the desired high attenuation near the notch frequency can be produced [3].

4. Results and Discussions

The proposed microstrip-fed slot antenna with various design parameters were constructed, and the numerical and experimental results of the input impedance and radiation characteristics are presented and discussed. The Ansoft simulation software high-frequency structure simulator (HFSS) [9] is used to optimize the design.

Return loss characteristics for ordinary slot antenna, with rectangular slot with an H-shaped parasitic structure in the ground plane, and the proposed antenna are compared in Fig 2 (a). As shown in Fig. 2 (a), it is observed that the upper frequency bandwidth is affected by using the rectangular slot with an H-shaped parasitic structure inside the slot in the ground plane and the notch frequency bandwidth is sensitive to the S-shaped parasitic structure inserted inside the square ring radiating stub. Also input impedance of the proposed monopole antenna, on a Smith Chart is shown in Fig. 2 (b).

To understand the phenomenon behind this additional resonance performance, the simulated current distributions on the ground plane for the proposed antenna at 10.3 GHz are presented in Fig. 3 (a). It is found that by using rectangular slot with an H-shaped parasitic structure in the ground plane, third resonance at 10.3 GHz can be achieved. Another important design parameter of this structure is the S-shaped parasitic structure. Fig. 3 (b) presents the simulated current distributions on the radiating stub at the notch frequency (5.5 GHz). As shown in Fig. 3 (b), at the notch frequency the current flows are more dominant around of the S-shaped parasitic structure.
The measured and simulated VSWR characteristic of the proposed antenna was shown in Fig. 4 (a). The fabricated antenna has a frequency band of 3.01 to over 11.07 GHz with a rejection band around 5.02 to 5.98 GHz. As shown in Fig. 4 (a), there exists a discrepancy between measured data and the simulated results this could be due to the effect of the SMA port, and also the accuracy of simulation due to the wide range of simulation frequencies. To confirm the accurate return loss characteristics for the designed antenna, it is recommended that the manufacturing and measurement process need to be performed carefully.
Figures 4 (b), (c) and (d) show the measured radiation patterns including the co-polarization and cross-polarization in the H-plane (x-z plane) and E-plane (y-z plane). The main purpose of the radiation patterns is to demonstrate that the antenna actually radiates over a wide frequency band. It can be seen that the radiation patterns in x-z plane are nearly omnidirectional for the three frequencies.

5. Conclusion

In this paper, a novel design of ultra wide band slot antenna with variable band notch function is proposed. The presented slot antenna can operate from 3.01 to 11.07 GHz with VSWR < 2, and with a rejection band around 5.02 to 5.98 GHz. By cutting rectangular slot with an H-shaped strip protruded inside the slot in the ground plane additional resonance at higher frequency range is excited and much wider impedance bandwidth can be produced. In order to generate a frequency band-stop performance we use square ring radiating stub with an S-shaped strip protruded inside the square ring. The designed antenna has a small size. The measured results show good agreement with the simulated and measured results. Experimental results show that presented slot antenna could be a good candidate for UWB applications.

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References