Printed Monopole Antenna for UWB Application

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Abstract- In this paper a novel printed monopole antenna for ultra wide band applications is proposed. To increase the impedance bandwidth of an antenna, a rectangular slit is inserted in the ground plane and two square notches are introduced on the upper corners of the patch. In the proposed antenna, modified U slots are used in the radiating patch to reject the IEEE802.11a and HIPERLAN/2 bands used for WLAN applications. The 2:1 VSWR bandwidth of the proposed antenna covers the entire UWB application range from 3.1 GHz to 10.6 GHz with the band rejection of the frequency band 5.0 GHz to 5.85 GHz.

Index Terms- Band rejection, Impedance improvement, Printed monopole antenna, UWB antenna

I. INTRODUCTION

The aim of the new generation of the wireless mobile communication is to provide flexible data rates and wide varieties of applications to the mobile users, while serving as many users as possible. This goal has to be achieved under the constraint of limited spectrum and power. The limited spectrum availability requires a new technology that can coexists with the other devices that operates in the same frequency band.

Ultra wideband (UWB) is a system, which can coexist with other licensed and unlicensed narrow band system. The design of an antenna for the UWB devices is a challenging issue. According to the FCC regulation the bandwidth released for the unlicensed commercial UWB application is 3.1 GHz to 10.6 GHz. Within this operating frequency the antenna should have stable response in terms of impedance matching, gain, radiation pattern polarization etc. At the same time it should be of small size, conformal, low cost and should be easily integrated into the RF circuits.

In spite of the approval of the spectrum of 3.1 GHz. to 10.6 GHz. for the UWB application it is better to avoid the interference with the existing unlicensed wireless technologies such as IEEE 802.11 a operating in the frequency band 5.150 – 5.875 GHz.

Printed monopole antenna, due to low cost, small size, conformal ability, is a good candidate for the UWB applications [1-3]. Moreover other required characteristics can be improved by slight modification in the regular shaped patch. Various techniques to improve the matching over a broad bandwidth have been proposed. These include the use of feed gap optimization [4], bevels [5], ground plane shaping [6] multiple feeds [7], and offset feeding techniques [8]. Different configurations of the slots such as U shaped, V shaped and I shaped have been proposed in the radiating patch to provide band notch characteristic [9-11].

In this paper, a rectangular printed monopole antenna with a rectangular slit in the ground plane and two notches on the upper corners of the patch has been proposed. Rectangular slit in the ground plane and two notches on the upper corners of the patch helps in improving the impedance bandwidth of the antenna. Besides this a narrow slot of modified U-shape is added to the radiating patch to introduce the band-notching effect. Simulation results have been obtained by using IE3D Electromagnetic simulator, which is based on method of moment.
II. ANTENNA DESIGN AND GEOMETRY

Fig. 1 shows the geometry of the top layer, which is the radiating patch of the proposed ultra wideband antenna consisting of a patch with two notches at the upper corners with modified U slot and microstrip feed line. The structure of the truncated ground plane with rectangular slit is shown in the Fig. 2. First of all a printed monopole antenna is designed on a FR4 substrate of thickness 1.6 mm and relative permittivity 4.4. The dimensions of the patch and the ground plane are 12 mm × 20 mm (W₁ × L₁) and 30 mm × 10 mm (W₂ × L₂) respectively. A rectangular slit of dimension W₂ x L₂ is added in the ground plane to improve the impedance bandwidth. Using iterative procedure the size of the rectangular slit in the ground plane is first optimized for the impedance matching over the entire range. Then two notches at the upper corners are added and again using iterative procedure, optimization is carried out for further improvement in the impedance matching [12]. Dimensions of rectangular slits in the ground plane and notches at the upper corner of the patch are 2.28 mm x 4.26 mm (W₂ x L₂) and 3 mm X 3mm (W₃ x L₃) respectively.

To obtain the band rejection characteristic, an inverted U-slot is inserted in the radiating patch. The configuration is shown in the in Fig 1. As a first order of approximation, the required slot length to obtain the notch frequency is given by [13]:

$$L_{\text{slot}} = \frac{0.45\varepsilon}{\lambda_{\text{notch}}} \sqrt{\varepsilon_{\text{eff,slot}}} = W_{s} + 2L_{s} - 2W_{s1} = 0.45\lambda_{\text{eff,slot}} (1)$$

Where $\lambda_{\text{eff,slot}}$ is the wavelength at the center frequency of the rejection band. The effective wavelength of the slot is given by

$$\lambda_{\text{eff,slot}} = \frac{\lambda_{s}}{\sqrt{\varepsilon_{\text{eff,slot}}}} (2)$$

and $\varepsilon_{\text{eff,slot}}$ is the effective dielectric constant of the narrow slot structure.

$$\varepsilon_{\text{eff,slot}} = \frac{\varepsilon_{r} + 1}{2} (3)$$

This value is used as a starting point for optimizing the slot length to obtain the required band-rejection. The slot length and width were optimized to obtain the desired band rejection. It was found that the slot length has a greater impact on the band-rejection than the slot width. Therefore, the two parameters $W_{s}$ and $L_{s}$ are the most significant factors to design the required band. The length of $L_{\text{slot}}$ is 14 mm. Further to improve the impedance matching two notches at the upper corner of the slots were introduced with the optimized dimensions of $L_{d}$ and $W_{d}$, which are 1.21 mm and 0.75 mm respectively. The final configuration of antenna is shown in the Fig. 3a and 3b.
III. RESULTS

The designed antenna is modeled and simulated using the IE3D electromagnetic simulation software. The results were observed in terms of return loss, gain and radiation pattern. The simulated result with the band notch characteristics are shown in the Fig. 4 - Fig. 6.

Fig. 4 shows the return loss characteristics. As seen the return loss is less than -10 dB over the frequency range from 3 to 12 GHz signifying good impedance matching characteristics over the entire UWB band. A band notch characteristic between 5.0 GHz to 5.85 GHz is also evident in the figure, which is used to reject the undesired band. Fig. 5 shows the gain characteristics of the antenna. The gain varies between 1 dBi to 4 dBi over the desired frequency range. The radiation pattern characteristics for the frequency 3.1 GHz, 6.32 GHz and 10.04 GHz are depicted in Fig. 6a, Fig. 6b and Fig. 6c respectively. The simulated result of return loss is compared with the experimental result. The experimental result shows a good agreement with the simulated result. Little shift may be attributed to the fact that the substrate FR4 used for the fabrication of the antenna does not possess uniform characteristics in terms of its material properties.
VI. CONCLUSION

A printed monopole antenna with band notch characteristic has been designed. A rectangular slot in the ground plane and two notches at the upper top corners are used to improve the VSWR performance of the monopole antenna. Band-notch characteristic is achieved by inserting a modified inverted U-slot. The proposed antenna has the frequency band of 3 GHz to over 12 GHz for VSWR less than 2.0 with a rejection band around 4.6 GHz to 5.85 GHz. Therefore, the antenna can be used in UWB systems to reduce interference between UWB and WLAN communication systems when the two radios are collocated.

ACKNOWLEDGMENT

The authors acknowledge the financial support granted under the Self-Assistance Program (SAP).
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