Antenna Design of Ultra-Wide Band with Added Band and Notches for Engineering Application

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Abstract

This project presents the design of Ultra-Wideband (UWB) antennas. The UWB (3.1-10.6 GHz.) antenna is created Bluetooth band (2.4 GHz.) and rejected WLAN (5.8 GHz) and WiMAX (3.5 GHz.) bands. Adding the Bluetooth band is a good practice for increasing bandwidth of antennas. Rejecting the WLAN (5.8 GHz) and WiMAX (3.5 GHz.) bands is also performed for preventing Interference. The designed antenna is tested by simulating Return Loss (S11) parameter. All pass bands have Return Loss less than -10 dB but the notched bands have Return Loss more than -10 dB. Designing and simulating antennas are performed by using Zeland program. The designed UWB antenna will be fabricated in types of printed with rectangular shape and small size.

Keywords: UWB Microstrip antenna, Patch antenna, Slot antenna, added band, notched band

1. Introduction

Now a day, the wireless communication systems have influenced for the commercial application.The important part of thewireless communication systems is the antenna.The patched slot antenna is goodpracticefor wireless systems because it has wide bandwidth, easy to design, easy to fabricate, compactness, light weight, and low cost.

A lot of techniques for designing microstrip antennas have been researched suchasprinted wide slot antenna for wide-band applications [1]; a compact multiband monopole antenna[3]; integrating the Bluetooth band to the UWB antenna[4].In [6], a dual notch band UWB slot antenna is obtained by cutting aslits in the ground plane.

The development of wireless communication makes the need for Ultra-wideband (UWB) system. This system has the high performancefor receiving and transmitting information. The otherwise, the Bluetooth system is also necessary in wireless communication. Therefore, Adding theBluetooth band to the wideband antenna is also desirable.

In the Ultra-wideband (UWB) system have the existence bands such as the wireless local areanetwork (WLAN) operating at 5.8 GHz and worldwide interoperability for microwaveaccess (WiMAX) operating at 3.5 GHz. These existence bands will make the interference problem.To prevent interference in the UWB systems, the existing wireless systems such as should be rejected.

In this paper, the technique for adding the Bluetoothfrequency band at 2.4 GHz without increasing the size of the antenna and two frequency notched bands centered at 3.5 GHz (WiMAX band) and 5.8 GHz (WLAN band) to a UWB printed slot antenna are proposed. The extra band and dual band notches, which are independent of each other, are created by attaching the strip lines of a quarter-wavelength to the ground plane near the feed line. The center frequency of the notched bands can be finely tuned bychanging the length of the strip lines. The simulation results arecarried out using Zeland program, and the measured results are presented.

2. Design of Antenna

The structure of the UWB antenna with the capability of adding and rejecting bands is shown in Fig. 1.The antenna is printed on FR4 substrate with a size of 28x23mm², thickness(h)of 1.6 mm, relative permittivity(ε_r) of 4.4, and loss tangentof 0.0017.

The patch antenna and the slot antenna are creating the UWB frequency. The technique for creating the Ultra-Wideband is the Stub Tunning [1]. It is the great technique for matching between Microstrip feed line and the slot antenna. The slot antenna has an octagonal shape and the patch antenna has a rectangular shape with beveled bottom edges. The beveling of the patch results in a better impedance matching. To increase the impedance bandwidth of the slot antenna, the lower edge of the slot near the feed line is also beveled by an angle of ∞.

The microstrip feed line is below the rectangular
patch. It is pasted in the medium bottom side of the microstrip antenna. It is the main feed point for transmitting and receiving thesignal. Thus, the Microstrip feed line canperformed byusingthe following formula [2]:

$$Z_0 = \frac{120}{\sqrt{{}^{\varepsilon}reff}\,\left(\frac{w}{h}+1.393+0.667\ln\left(\frac{w}{h}+1.444\right)\right)} \quad (1$$

$${}^{\varepsilon}reff = \frac{{}^{\varepsilon}r+1}{2} + \frac{{}^{\varepsilon}r-1}{2}\,\left[\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}\right. \quad (2$$

Thepatchantenna is the important component of the UWB antenna because it is the part of radiatingenergy and impedance matching.For designingthe rectangular patch,the following formula canpractice [3].

$$L_{reff} = \frac{C}{2f_o\sqrt{{}^{\varepsilon}reff}} \quad (3$$

$$W_p = \frac{C}{2f_o\sqrt{\frac{(\varepsilon r+1)}{2}}} \quad (4$$

$$L = L_{reff} - 2\Delta L \quad (5$$

$$\Delta L = 0.142h\,\frac{({}^{\varepsilon}reff+0.3)(\frac{w}{h}+0.264)}{({}^{\varepsilon}reff-0.258)(\frac{w}{h}+0.8)} \quad (6$$

To design a suitable UWB Microstripantenna, the parameters are obtained as follows: Wg = 28mm, Wp = 10mm, Wf=2.6 mm, Ws = 14mm, Wa = 1mm, Wb = 7mm, Lg = 23mm,

Lp1 = 7.5mm, Lp2 = 2.5mm, Lf = 7.5mm, Lp = 7.5mm, Ls = 11.5mm, La = 0.5mm, Lb = 3mm, and
∞ = 14°

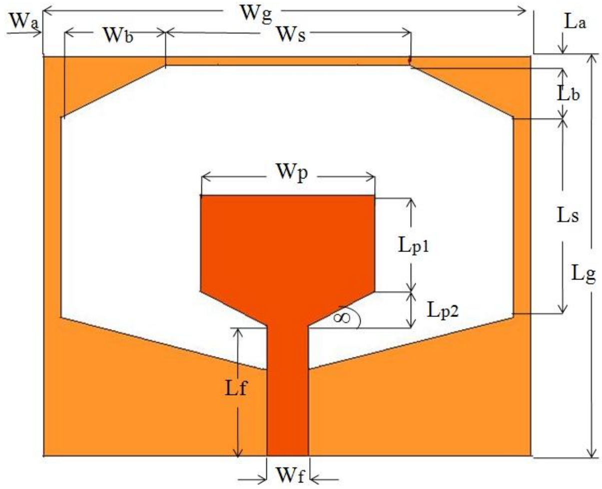

Fig1 StructureofUltra-wide band Microstrip Antenna

To provide theBluetooth band below the UWB range, one should create an resonance frequency(2.4GHz). An open-circuit transmission line of a quarter-wavelength [4] can provide this resonance.Ifthis technique is the resonant circuit, it isthe series resonantcircuit.At this lower frequency band, the UWB antenna is inactive. Hence, it can be used as the ground plane for the stripline to provide the required resonance frequency. To have an efficient resonant band, thestrip should be fed from the high concentrated current area ofthe structure. The current distribution is strong in the ground plane near the feed line. Therefore, to create an extra band centered at 2.4 GHz without increasing the overall size of the antenna, one can attach a beveled L-shaped strip of a quarter-wavelength and appropriate width in the ground plane near the feed line.

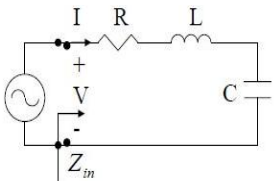

Fig 2 Series resonant circuit

To create a band-notch within the UWB range, one needs to short out the transmission line of a quarter-wavelength at the required notch center frequency. The center frequency of WiMAX is 3.5 GHz and the center frequency of WLAN is 5.8 GHz. A short-circuitmicrostrip line of a quarter-wavelength [5] can provide this behavior. If this technique is the resonant circuit, it isthe parallel resonantcircuit.Thus, to create a notch band within the UWB frequency, a beveled L-shaped strip of a quarter wavelength placed beside the patch and fed from thehigh concentrated current area in the ground plane can be used. The length of stubs can be optimized for tuning of the notch center frequency.

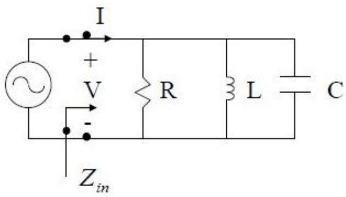

Fig 3Parallel Resonant Circuit

To have good impedance matching in UWB, these beveled L-shaped strips should be placed near the ground and beveled by an angle of ∞. Attaching anystrips to the UWB antenna structure has a little effect on the impedance matching of the original UWB antenna.

Fig 4is shown the complete structure of the proposed antenna with the geometry of the beveled stubs. The total length of any of the beveled L-shaped strips can be obtained approximately from the following formula [7]:

$$L_{strip\,.} = \frac{C}{4f\sqrt{\frac{\varepsilon_r+1}{2}}}$$

where, ε_r is the dielectric constant, c is the velocity of light
in free space, and f is the center frequency of the desired bands.

To add the extra Bluetooth band, the stub with a length ofLbluetooth = L1 + L2 = 21mmand the width of strip is 0.6 mm.To reject the frequencies of 3.5 GHz (WiMAX) and 5.8 GHz(WLAN), the stubs with lengths of Lwlan = L3 + L4 = 9.3mmandLwimax = L5 + L6 =15.8mmand the width of strip is 0.25 mm. By optimization method, the dimensions of the strips are as follows: L1 =11 mm, L2 = 9.1mm, L3 = 7.2mm, L4 = 1.2mm, L5 = 10mm, and L6 = 5.4mm

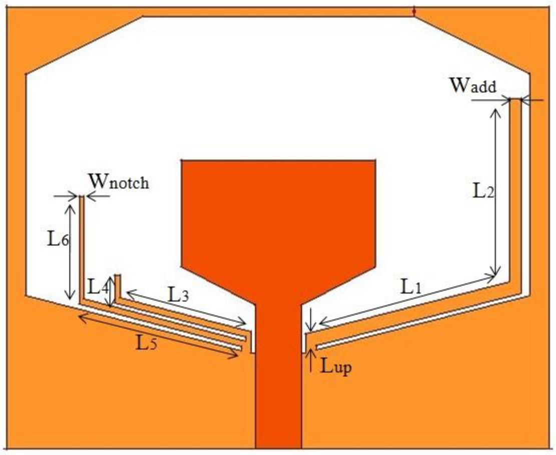

Fig 4The structure of the proposed antenna

3. Illustrations

The simulated reflection coefficient of the printed UWB slot antenna with Bluetooth band and without WiMAX and WLAN band, it is seen that the patch-fed slot antenna without the strips provides an impedance bandwidth covering 3.1–10.6 GHz. The addition of a strip line to the right part of the antenna is creating the Bluetooth band at 2.4 GHz. The otherwise, the addition of two-strip to the left part of the antenna is creating the WiMAX band at 3.5 and the WLAN band at 5.8 GHz.

Fig. 10 shows the measured and simulated reflectioncoefficient of the proposed UWB antenna with the Bluetooth bandand dual notched bands. From this figure, the simulated reflection coefficient has the notched WiMAX band about -0.25dB and the notched WLAN band about -0.34 dB, while the added Bluetoothband is about
-15.20 dB. In addition, the measured reflection coefficient has the notched WiMAX bands about -0.15dB and the notched WLAN band about -0.60 dB, while the added band is the -25.25dB level. Thus, it means the good impedance matching in the microstrip antenna.

Fig 5Fabricated antenna

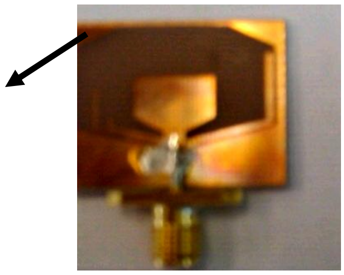

Fig 6The strip line for resonance frequencies at 2.4 GHz

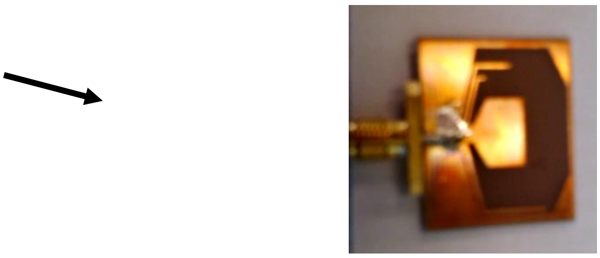

Fig 7The strip lines for resonance frequencies at
3.5 GHz and 5.8 GHz

Fig 8Testingof the fabricated proposedantenna

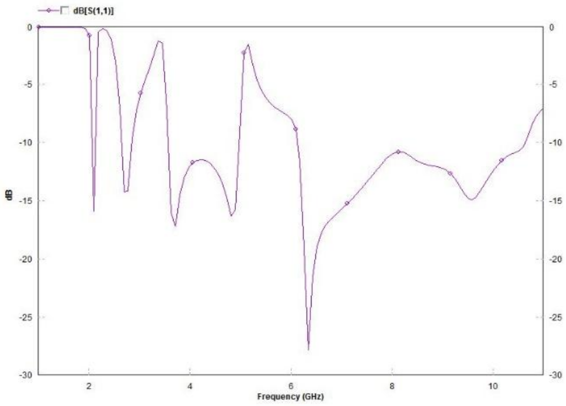

Fig 9Simulation results of the proposedantenna

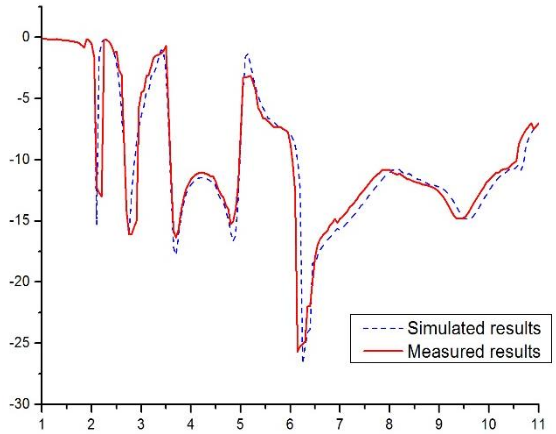

Fig 10Comparethe simulation resultsbetween simulated results and measured result

4. Conclusions

The design of aUWBslot antenna with an Bluetooth band and dual notched bands has been presented. TheUWBslot antenna has an octagonal shape. By attaching three beveled L-shaped strip lines of a quarter-wavelength to the ground plane of the slot near the feed line, an extra band at 2.4 GHz (Bluetooth band) and two notchedbands centered at 3.5 GHz (WiMAX) and 5.8 GHz (WLAN) are created. The addition of the strip lines to the slot antenna does not change the behavior of the original UWB slot antenna. The quality of the added and rejected bands is quite good. The measured results agree with the simulated.

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