Reconfigurable UWB Printed Monopole Antenna with Band Rejection Covering IEEE 802.11a/h

Ahmed H. Khidre(1) student member, Hala A. Elsadek member, IEEE(2) and H. F. Ragai(1) member, IEEE

1 Electronics and Communication Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt
2 Microstrip Department, Electronics Research Institute, Giza, Egypt, helsadek@mcit.gov.eg

Abstract
Reconfigurable microstrip UWB printed monopole antenna has been designed, analyzed, fabricated and measured with WLAN/Hyperlan2 band rejection characteristic. Band notch is realized by adding a parasitic patch in the back plane cutting it into two parts which are connected by means of two RF switches. The on and off state of these switches enables and disables the band notch and hence reconfigurability is introduced. Simulation and experimental results are compared and the simulated radiation pattern for the two states (On/Off) are presented. Also parametric study for optimizing different design parameters is investigated.

Key words: Ultra wideband antenna, microstrip monopole, notch band, switches, reconfigurability

1. Introduction

Recently, UWB has become a very promising wireless technology for many applications because of the attractive benefits it provides such as its resistance against jamming and multipath fading, low complexity and cost, power requirements and finally penetrating capability. According to the FCC the spectral mask of UWB for commercial applications is of frequency band 3.1 to 10.6 GHz [1].Printed monopole antennas are good candidates for such systems because of their wide impedance bandwidth, omni directional radiation pattern and small size. These features are attractive for integration with portable UWB devices. Many UWB printed monopole antennas with enhanced impedance bandwidth have been reported as in [2]-[6]. Several techniques have been used such as stepping or tapering the radiator from the feed line [2], [3], adding slot to the radiator [3] or adding slit to the ground plane [4]. Under some environmental circumstances UWB suffer the co-existence of other narrow band communication systems like WLAN for IEEE 802.11a/h range used in America and HYPERLAN2 used in Europe operating in 5.15-5.825 GHz. in turn interfere with the UWB system degrading the overall system performance because of increasing pulse distortion and bit error rate (BER).Therefore, UWB printed monopole antenna with band notch and reconfigurable capability is desired. The built in Band notch is useful for the ease of integration, reducing microwave component and as a consequence the overall size. The Reconfigurability helps in the adaptation against environmental changes in order to increase the performance. Band notch UWB antenna has been reported in [8]-[10].In this paper a new simple design is proposed for a low cost band notch UWB printed monopole antenna with reconfigurable capability with the ability to create and cancel band notch in the UWB spectral mask covering the in-band co-existing systems.

2. Antenna Design

The antenna geometry is shown in Fig.1(a) and Fig.1(b).First of all a simple 50Ω microstrip fed UWB printed rectangular monopole antenna is designed. Intuitive dimensions on the top plane is obtained as in [4]-[6].The material used is the low cost FR4 with dielectric constant ($\varepsilon_r$=4.7), substrate height (h=1.5mm) and loss tanδ=0.02 which is useful for mass production. For impedance bandwidth enhancement a slit is added in the ground plane [3] and the radiator is tapered from the feed line [2] as shown in Fig.1 (a) and (
b). The effect of (W1, L1, h) and (Ws, Ls) are studied in[5], [7], respectively. The ground plane dimensions are optimized with the radiator and slit dimensions with the tapering angle to obtain maximum bandwidth. Then a patch is added in the back plane as a parasitic half wave length resonator coupled electrically to the rectangular monopole. Slot is cut into the parasitic patch as shown in Fig.1(b).The two patch parts are connected by means of two RF switches S1 and S2 which are here modeled as metal pad with dimensions 0.3x0.9mm [10]. Although this model is ideal it gives a very good approximation for the real commercial pin diode switch HPND-4005 manufactured by HP as stated in [12] cited by [10]. The role of the switches here is to reconfigure the antenna between the on/off states. A state where the antenna exhibit a band notch covering the bandwidth of the WLAN for IEEE 802.11a/h which is 5.15-5.825 GHz and the other where the antenna exhibit a band notch covering the bandwidth of the WLAN for IEEE 802.11a/h where the antenna exhibit a band notch covering the bandwidth of the WLAN for IEEE 802.11a/h which is 5.15-5.825 GHz. Then a patch is added in the back plane as a parasitic half wave length resonator coupled electrically to the rectangular monopole. Slot is cut into the parasitic patch as shown in Fig.1(b).The two patch parts are connected by means of two RF switches S1 and S2 which are here modeled as metal pad with dimensions 0.3x0.9mm [10]. Although this model is ideal it gives a very good approximation for the real commercial pin diode switch HPND-4005 manufactured by HP as stated in [12] cited by [10]. The role of the switches here is to reconfigure the antenna between the on/off states. A state where the antenna exhibit a band notch covering the bandwidth of the WLAN for IEEE 802.11a/h which is 5.15-5.825 GHz and the other where the band notch is removed and the antenna bandwidth returned flat. The RF switches could be realized by means of either the commercial product HPND-4005 or MEMs technology. The dimensions of the parasitic patch (LP, WP, LP1, LP2), its position relative to the ground plan (g), position of the switches relative to the parasitic antenna (P) and relative to each other and their number affect the band notch characteristics. These characteristics are represented in: notch center frequency, its bandwidth and how shallow the notch is (S11 is large as much as possible). The optimization of these parameters is a design issue that is explained in next section.

3. Simulation Results and Discussions

Numerical simulations are carried out using Zeland IE3D10 to study the effect of these parameters on the notch characteristics. As shown in Fig.2, LP affects the notch center frequency significantly as expected because this dimension is the resonant length (λ/2), but it has no effect on the band width of the notch. It was found that LP1 and LP2 give same results upon varying them provided that their sum with the width of the cut is constant and equal to LP (LP=LP1+LP2+Cut width C). On the other hand as shown in Fig.3, WP significantly affects the BW of the notch, particularly it controls the lower frequency edge of the notch rather than the higher frequency edge. Also, changing WP has slight effect on the notch center frequency. Fig.4 shows the effects of varying g, it is observed that it affect both the BW of the notch and the shallowness of it. As g increases the bandwidth decreases and the notch get less shallow (S11 get smaller). This can be explained due to the weakness of the coupling between the parasitic patch and the feed as it go far from the ground plan. Upon the previous parametric analysis of the proposed design the parasitic patch is optimized to acquire the required band width 3.1-10.6 GHz with notch 5.1-5.84GHz in case of the ‘ON’ state and the flat band 3.1-10.6GHz in case of the off state. The optimized dimensions chosen are shown in Fig.1(b). The simulation result of the return loss for the two states of the antenna is shown in Fig.7. It is clear when the switches are off the bandwidth (S11<-10dB) is flattened while when switches are on band notch of 5-6.1GHz is created. The radiation pattern is also simulated at 3, 8, 10GHz for both the E-plane(y-z) and H-plane(x-z). The results are shown in fig.5 (a), (b) and (c), respectively. It is obvious from the overall view of these patterns that the antenna behavior is quite similarly to typical printed monopole antenna. From simulation results, in the on state a sharp decrease of the antenna gain at 5.3 GHz, the center frequency of the notch, is observed. For other frequencies outside the notched frequency band, the antenna gain is similar for the two states with average gain 6dBi.

4. Experimental measurements

Fig.7 shows the comparison between measured and simulated results in the on and off state of the switches. It is clear that there is agreement achieved between the results which verifying the designs. For the on state there is a shift in the notch center frequency by 10%. This is attributed to the consideration done in simulation that the dielectric is infinite existence which is not the case for practical fabrication. Fig.6 shows the photo of the proposed fabricated antennas.

5. Conclusion

A simple design for reconfigurable UWB rectangular printed monopole antenna with inherent band notch is presented. Reconfigurability is achieved by two RF switches on the back parasitic patch. The on state of the switches exhibit 5.1-6 GHz band notch while the off state flatten the antenna bandwidth 3.1-10.6 GHz (S11<-10dB). Antenna maximum gain is 2.75dBi with variation along the band less than 6dBi and it drops around the band notch by about 8dBi at the center frequency of the notch 5.3GHz. The proposed antenna acquired approximate Omni directional radiation pattern as the conventional monopole operates at the lower frequencies while for the higher ones it acquires quasi Omni directional
pattern. This antenna could adapt for environmental changes in which if the in-band interferers exist it can block them when switches are on while if they do not exist it acts as normal UWB antenna when switches are off. This is very attractive for UWB devices (e.g: USB dongles, mouse, keyboards and laptops) that require ease of integration and compact packaging.

6. Acknowledgement

The experimental work is supported by the microstrip department of the Electronic Research Institute.

References

Fig. 2: Simulated return loss for different values of LP at g=1mm, WP=12mm

Fig. 3: Simulated return loss for different values of WP at LP=9mm, g=1mm
Fig. 4: Simulated return loss for different values of g at LP=9mm, WP=12mm

Fig. 5: Simulated radiation pattern at different frequencies

Fig. 6: Fabricated antenna photos a: antenna top view, b) antenna with switches in on state and c) antenna with switches in off state
Fig. 7 Comparison between measured and simulated results