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UWB Reconfigurable Microstrip Antenna for Wireless Sensor Networks Applications

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***Abstract*—With the progress in wireless communications techniques in recent years, a new promising concept of wireless sensor networks has received a well deserved attention by researchers all over the world. Embedded sensors offer intelligent devices and systems that are able to react to events and physical conditions of the real world. The most important component in sensor is its TX/RX antenna. In this paper, UWB printed monopole antenna with embedded reconfigurable multi band frequency rejection notches is proposed. Frequency notch is achieved by using a ground-plane slot (GPS) and lumped capacitors. Reconfigurability is introduced in a way you can independently switch ON/OFF the band notches by mean of RF switches. Simulation results are verified with measurements**

***Index Terms*—Deultra Wide Band(UWB); Microstrip Antenna; Reconfigurability; Notch band and rejection; Wireless sensors; RF switches.**

I. Introduction

The advances in low-power integrated digital electronics and their combination with the microelectro- mechanical systems (MEMS) have led the way to the emergence of the micro sensors that can collect various types of data. Processing collected data reveals the properties and/or events in the vicinity of the sensor. The recent technology advances continue to further reduce the size and the cost of these sensors and facilitate their integration with the wireless communication equipments. This has fostered the development of applications that use a large set of such sensors, some being disposable and unattended. The earlier wireless sensor network applications required low data rates, limited information interrogation, and reduced memory requirements and often included passive radio frequency identification devices (RFID). However, the emerging applications of wireless sensor networks such as the applications in homeland security including identifying and tracking containers during shipment, in providing the military with effective means for addressing logistics needs and protected supply chain, in providing remote care for the immobile patients, in responding to natural disasters, and in realizing the so called Internet of Things require much more advanced capabilities and development of active intelligent radio frequency identification devices (IRFID). Unlike passive RFIDs, IRFIDS have built-in processors, larger memories, intelligent data storage and forwarding capabilities. One important task associated with a wireless sensor is the transmission of the collected data to the outside world by means of the radio frequency (RF) communication. Unfortunately, of all the components associated with a sensor, the RF communication part, especially the electromagnetic antennas and their integration with the digital signal processing (DSP) algorithms have not been the focus of research for a long time. Recently, UWB has become a very promising wireless technology for many advanced applications because of the attractive benefits it provides such as its resistance against jamming and multipath fading, low complexity and cost, low power requirements and finally penetrating capabilities. According to the FCC the spectral mask of UWB for commercial applications is of frequency band 3.1 to 10.6 GHz. UWB suffers the co-existence of other narrow band communicationsystems in its frequency domain like WLAN for IEEE 802.11a/b/g operating in 5.15-5.825 GHz and ISM Bluetooth operating at 2.4 GHz as well as WiMax operating in 3.3-3.7GHz. This interferes with the UWB systems degrading the overall system performance in terms of increasing pulse distortion and bit error rate (BER). Printed monopole antennas are good candidates for such sensor systems because of its wide impedance bandwidth, omni directional radiation pattern and small size. These features are attractive for integration with portable UWB devices. Therefore UWB printed monopole antenna with embedded Multi frequency band notch rejection and frequency switchable capabilities is desired. The embedded band notches are 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. In this paper a new design is proposed for a compact UWB microstrip monopole antenna with reconfigurable multi band embedded filter capability. The design introduce the ability to switch independently ON/OFF 3 band notches within the UWB spectral mask via 3 digital bit in order to avoid the coexistence of interfering communication systems that mentioned above. This antenna can act as a good candidate for UWB wireless sensor networks applications.

II. Antenna and Band Notch Design

Many UWB printed monopole antennas with enhanced impedance bandwidth have been reported as in Several techniques have been used such as stepping or tapering the radiator from the fed line , dding slot to the radiator or adding slit to

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the ground plane [8].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). The designed antenna performance is as illustrated in figure 1, Starting with a simple 50 microstrip fed UWB printed rectangular monopole antenna with intuitive dimensions on the top plane as that obtained in]. The substrate used has a dielectric constant (r=3.38), substrate height (h=0.814mm) and loss tangent tan=0.00027. For impedance bandwidth enhancement the radiator action stepped from the fed line as shown in Fig. 1 (a). As the

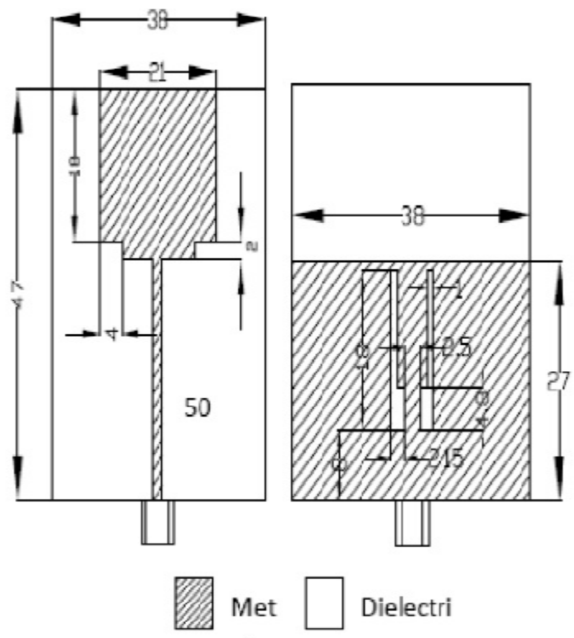

Fig. 1. Antenna Geometry(left) Top view (right) Bottom view(unit:mm)

size reduction is a challenge in wireless sensor devices,. The antenna ground plane dimensions are optimized with the radiator dimensions and the step size to obtain maximum bandwidth. The antenna size is 21mm x 20mm with ground plane dimensions of 38mm x 47mm which presents reduced size than similar function antennas stated in literature . A pair of slots is then cut in the ground plane as shown in Fig.1 (b). They act as a parasitic half wave resonator coupled to the rectangular monopole [8]. So at the resonance frequency of these slots a band notch in the antenna BW exists. Ground slot was designed to create a band notch at WLAN (5.1-5.8GHz) with maximum rejection ratio at center frequency. Lumped capacitors C1 and C2 are added to the two slots at distance d. from upper side end of each one, as shown in Fig. 2 (a), to miniaturize the slot size. Each slot could be then considered as L-C resonator and the lumped capacitor is added to tune its resonant frequency. Because the overall

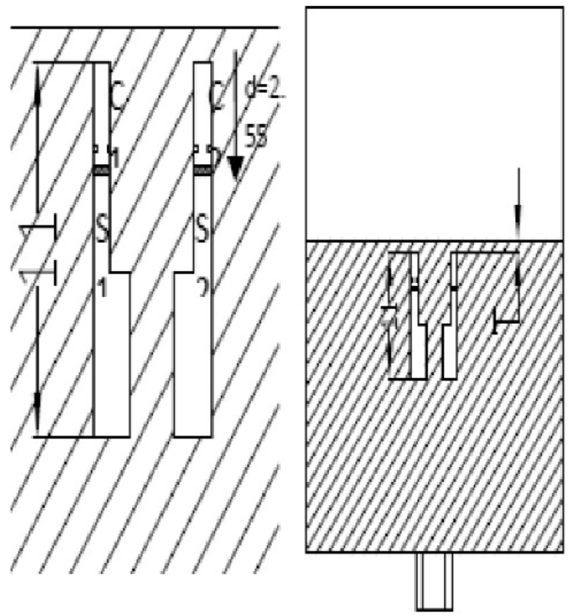

Fig. 2. (left) Optimized slots with capacitor and switches(right) Back view

capacitance increases by adding the lumped capacitor so the resonance frequency decreases and hence more reduction in antenna size is achieved. A parametric analysis for the effect of the value of the lumped capacitor and its position from the edge of the slot on the resonance frequency is shown in Fig. 3. The added capacitor decreases the resonance frequency.

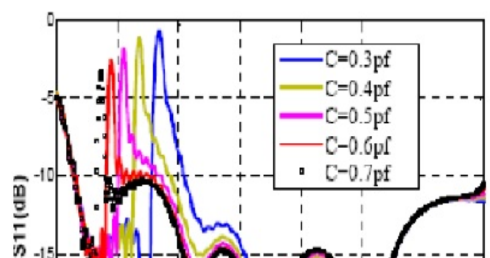

Fig. 3. Parametric study for the effect of capacitor

This could be useful for tunable band notch if varactors are used. On the other hand, the position of the capacitor affects the resonance frequency too. It decreases as the capacitor go away from the side of the slot. This could be attributed to the electric field distribution inside the slot. It is known that for the fundamental mode of the slot resonator, the electric field is maximum at the middle of the slot. Therefore the effect of the capacitor is maximum at this position. While moving the capacitor away from the middle of the slot, its effect begin to decrease till it vanishes at the side end where the electric field tends to zero. It is also worth mentioning that the capacitor improves the rejection at the band notch. Based on this study, the optimized slot length for the band notch (5.1-5.8GHz) is with width d= $4mm$ and slot length= $11mm$. It worth mentioning that this is not the minimum.

1) Results of Reconfigurability of the frequency band notch: The RF switches S1 and S2 are realized in simulation as metal pads with dimensions 0.3x1mm. This model is ideal for the real commercial pin diode switch HPND-4005 as stated in and cited in . The RF switches for reconfigurability could be realized by means of either the commercial prod Simulation and measured results for both the ON/OFF state is shown in Fig. 4 dimension of the slot that could be obtained for the desired resonance frequency rather it is the minimum constrained to the bandwidth required. Good agreement between

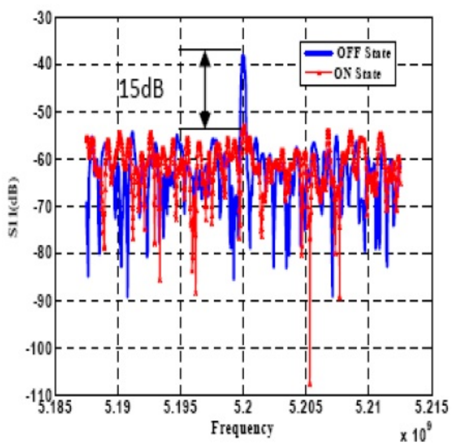

Fig. 4. Measurement of received signal in the two states of single bit notch antenna

the measured and simulated result are observed. The proposed antenna is put in a TX-RX system where the antenna under test is connected to a transmitter and another antenna connected to a spectrum analyzer. This system was operated at the notch frequency 5.2GHz in the two ON/OFF states. The measured data from the spectrum analyzer are shown in Fig. 5. It is clear that the rejection between the two states is about 15 dB at the frequency 5.2GHZ, which is the maximum rejection, obtained along the band notch. Fig. 6 shows a prototype of the fabricated antenna. This antenna is with 1 bit frequency reconfigurable band notch at WLAN band duct HPND-4005 or MEMS technology. Simulation and measured results for both the ON/OFF state is shown in Fig. 4. . Simulation and measured results for both the ON/OFF state is shown in Fig. 4.switches for reconfigurability could be realized by means of either the commercial product HPND-4005 or MEMS technology. . Simulation and measured results for both the ON/OFF state is shown in Fig. 4.

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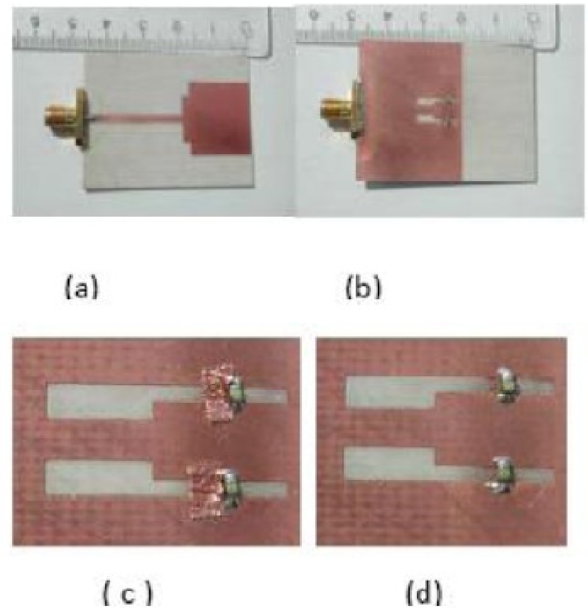

Fig. 5. Fabricated single bit notch antenna (a) Top view. (b) Bottom view. (c) Magnified portion of the slot in ON state and (d) OFF state.

15 dB at the frequency 5.2GHZ, which is the maximum rejection, obtained along the band notch. Fig. 6 shows a prototype of the fabricated antenna. This antenna is with 1 bit frequency reconfigurable band notch at WLAN band. The previous work is extended by the same procedure to include more band notches by adding more resonating slots at the desired rejection bands. Capacitors and RF switches are added to miniaturize the slots and make effect switch able fabrication and experimental measurements of these two antennas will be considered in near future work for verifying the simulation results. Fig 7a shows antenna with dual and notches at

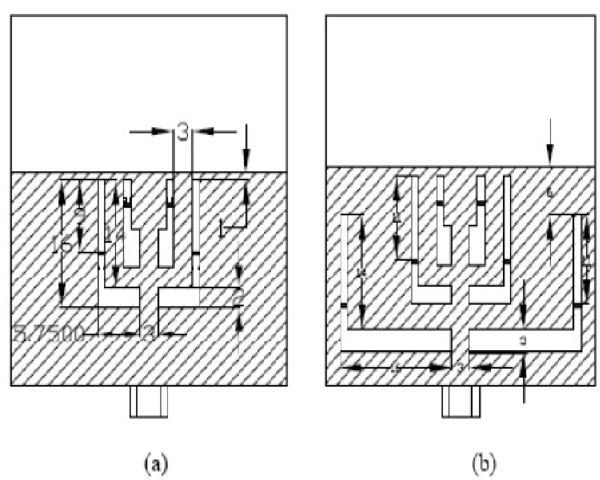

Fig. 6. Back Plane (a)Dual band notch.(b) Tri band notch

WiMAX band (3.1-3.9) and WLAN and (5.1-5.8GHz). Fig 7b shows antenna with triple notches at Bluetooth band (2.4GHz), WIMAX (3.3- .9GHz) and WLAN (5.2- 5.8GHz). Simulation results f the two antennas for the NO/OFF states of all witches are shown in Fig 8a and Fig 8b, respectively.

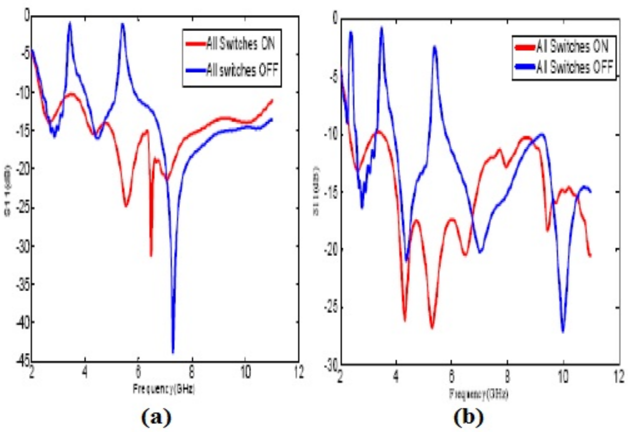

Fig. 7. Simulation results for S11 of the (a) two states of dual band notch UWB antenna and (b) two states of triple band notch band antenna.

III. Conclusion

Compact UWB printed monopole antenna covering 2.3-11GHz) band S11¡-10dB with embedded 3-bit digitally switch able tri band notches is proposed. The here band notches are covering the famous narrow band communication systems WLAN802.11a/b/g (5.1- .8GHz), Bluetooth (2.4GHz) and WiMAX (3.3- .7GHz). This antenna could be used for different communication systems operating within the UWB at the ISM band, WLAN band and WiMax band. Moreover for UWB system the antenna could adapt for environmental changes if one of the in-band interferers exists by blocking it via selecting the appropriate group f switches. On the other hand if no co-existing interferers the antenna acts like normal UWB with all witches OFF. This reconfigurability feature is attractive for wireless communication devices as in ireless sensors applications. Continuous monitoring end following up for patients and living alone elderly persons becomes a possible solution nowadays due to he tremendous progress in communications and information technologies. These systems when it will each to mature stage will save life for a lot of persons. Therefore, wireless sensor networks and telemedicine applications become hot topic of research all over the world now. Many research literatures are being published everyday however a complete user friendly system for telemedicine and continuous real time following up and monitoring still doesn't exist. therefore, authors hope that this antenna design and its similar could help in an efficient practical realization of such wireless sensor network applications.

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