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Radiation Pattern Reconfigurable Antenna for WBAN and WLAN Applications

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ABSTRACT

In this paper, a reconfigurable microstrip patch antenna with parasitic arms for controlling the direction of the radiated beam for wireless body area network (WBAN) and wireless local area network (WLAN) is presented. The realized gain of the antenna changes from 1.93dB (off-body mode) to 1.4 dB (on-body) mode. The operating frequency band centered at 2.45 GHz frequency remains unaltered with a bandwidth of 80 MHz.
Keywords: Reconfigurable antenna, Wearable antenna, WBAN, WLAN, Microstrip antenna

I. INTRODUCTION

Wireless Body Area Network (WBAN) is an inter connection of wireless links between sensor nodes located at different locations on the human body. In WBAN, there exists two modes of communications; on-body mode and off-body mode. On-body mode refers to the communications between different sensor nodes located at different areas on the body. Whereas in the case of off-body mode, the communication exist between body worn devices and a remote base station or a mobile device through which the data recorded can be transmitted to a medical practitioner for analysis. or can be used to track down the patient health conditions in an ambulance.

In order to switch the signal from on-body mode to off body mode, a system is required to switch the signal from on-body mode to off-body mode of communication in the ISM band. In the literature, a significant amount of work has been published related to WBAN. But there has been only very few papers that are available in the literature regarding a sensor node that is capable of switching the beam from on-body mode to off-body mode. Some of the recent research works published in this area [1], [3], [4], [7]. The paper describes the use of the lower patch antenna to generate radiation pattern for on-body communication and the upper patch antenna to generate radiation pattern for the off-body communication. A patch antenna using textile material as substrate is used to realize a switchable on/off-body communication with pin diodes[2], [6]. A dual feed, dual radiation pattern dielectric resonator antenna for BAN applications has been proposed in [5], [8] where one of the two feeds is excited at a time to switch the beam pattern. In this paper, a reconfigurable microstrip patch antenna suitable for WBAN and WLAN application is introduced.

II. METHODS AND MATERIAL

A. Antenna Design

The antenna design of the proposed antenna is shown in Fig. 1. A cylindrical phantom is considered to know the effect of the antenna when it is close to the muscle at 2.45 GHz. The antenna is placed at a distance of 2mm from the phantom.

The inset fed microstrip patch antenna with on-phantom optimized dimensions is used as the radiating element. Two parasitic elements with switches SW_L (SW_{L1} + SW_{L2}) and SW_R (SW_{R1} + SW_{R2}) are placed at a specific distance from the radiating element. For proof of concept copper strips were used instead on switches. In the ON-state, the switches were replaced by a shorting strip, and the OFF states were realized by open. Switches are connected in such a way that the beam can be tilted by controlling their ON/OFF states. Here the concept is to change the parasitic arms as reflector and director alternatively to achieve on-body and off-body mode of communications. The microstrip patch and parasitic arms are printed on the same side of a FR4 substrate of dielectric constant ε_r = 4.4 and thickness 1.6 mm. The dimension of the ground plane underneath the patch is optimized as 50 mm X 60 mm for the specific application. All the simulations were carried out using CST microwave studio 2016.

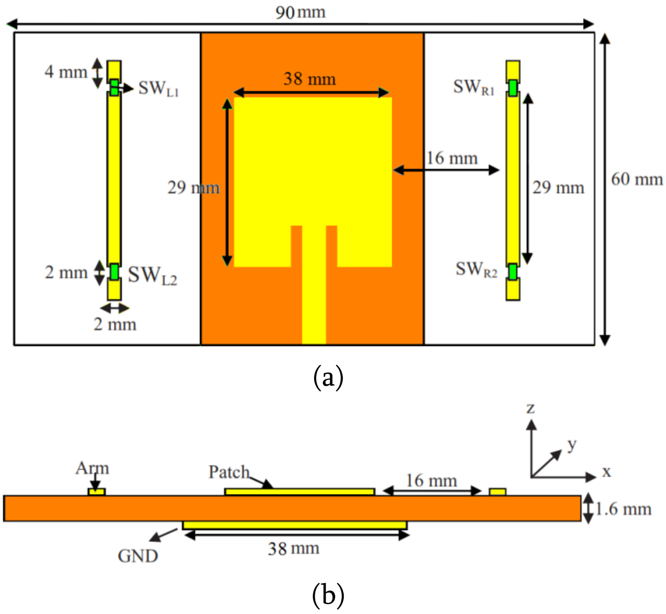


Figure 1. Geometry of the antenna (a) Top view (b) Side View

B. Design Equations

The equations used to design the antenna are given below.

Design Frequency, f_r = 2.45GHz

Substrate material = FR4

Substrate height, h =1.6mm

Substrate permittivity, ε_r=4.4

Patch thickness, t=0.035mm

microstrip width calculation:

$$W = \frac{C}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}} \qquad (1)$$

Effective permittivity, ε_e:

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{10h}{w}\right]^{-0.5} \qquad (2)$$

Fringing Length, ΔL:

$$\Delta L = \frac{h}{\sqrt{\varepsilon_e}} \qquad (3)$$

Effective length of microstrip, L_e:

$$L_e = \frac{C}{2f_r\sqrt{\varepsilon_e}} \qquad (4)$$

Length of microstrip, L:

$$L = L_e - 2\Delta L \qquad (5)$$

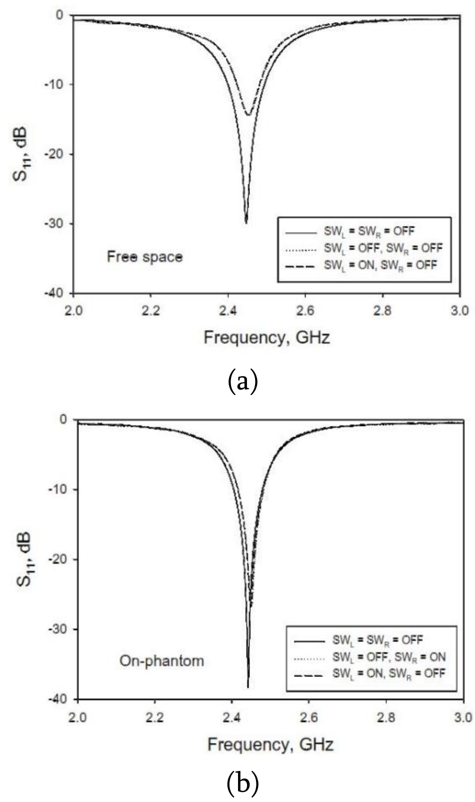
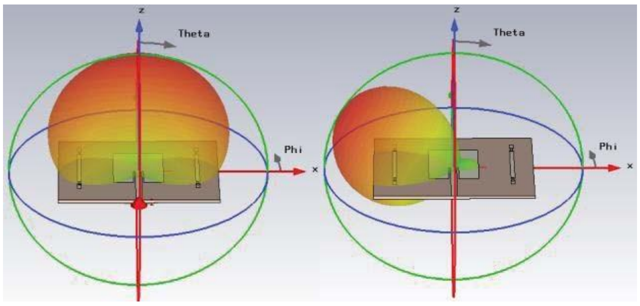


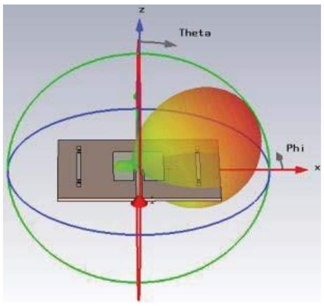
Figure 2. Simulated return loss of the antenna for different switching operation (a) Free space (b) phantom

III. RESULTS AND DISCUSSION

Figure 2 shows the simulated and the measured reflection coefficient results of the antenna for three different configurations of the switching states. When switches SW_L (SW_{L1}+ SW_{L2}) and SW_R (SW_{R1} + SW_{R2}) are in the OFF state, the antenna radiates in the bore sight direction suitable for off-body mode of communications. The corresponding radiation pattern for the off-body mode in free space and on-phantom is depicted in Fig. 3(a) and 4 (a) respectively. When SW_{L1} and SW_{L2} are in the ON state and SW_{R1} and SW_{R2} are in the OFF state, the corresponding parasitic arm acts as a reflector tilting the beam to ±60 degrees from the normal when in free space and ±20 degrees from the normal when in close proximity to the phantom muscle tissue. The corresponding radiation pattern

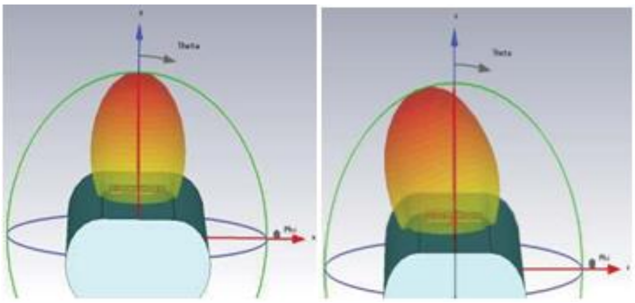


(a) (b)



(c)

Figure 3. Radiation pattern of the antenna in free space a) All switches in OFF state b)Left switches in ON state c) Right switches in ON state



(a) (b)

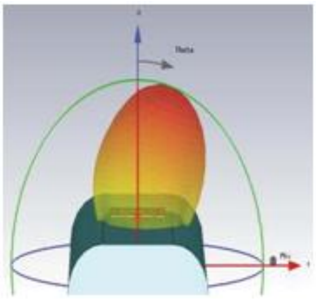


Figure 4. Radiation pattern of the antenna on phantom a) All switches in OFF state b)Left switches in ON state c) Right switches in ON state

plot in free space and on- phantom is shown in Figure 3 (b) and 4 (b) respectively, which makes this antenna suitable for on-body mode of communications. Similarly, when SW_{L1} and SW_{L2} are in the OFF state and switches SW_{R1} and SW_{R2} are in the ON state, the parasitic arm on the right acts as a reflector and direct the beam as shown in Figure 3 (c) when in free space and as in Figure 4 (c) when in close proximity to the phantom. In all these switching states, the frequency of operation remains the same.

IV. CONCLUSION

A radiation pattern reconfigurable antenna at 2.45 GHz has been developed for wireless body area and wireless local area network applications. The resonance frequency of the antenna remains the same for the different configurations of the pattern despite being in close proximity to human muscle tissue. A ±20 degree of beam tilt was achieved for the antenna while on-phantom.

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