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Research Article

Human Breath Detection Using Textile Antenna

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Abstract

In the advancement of bio medical devices amidst the situation of pandemic ,people suffer from breathing issues and several devices are taken on account to measure the breathing patterns of the individuals ,the field of interest in RF and microwave applications inspired to design a wearable antenna used on - body wireless communication systems to operate on 2.45 GHz WLAN band .A microstrip patch antenna design is proposed based on the substrate there is performance improvisations , the substrates differ by material and thickness taken polyester with permittivity of 1.9 .The antenna is supposedly designed to have a value of VSWR<2 and a healthy gain for measuring the signal strength and evaluate into breathing frequencies categorised for males and females When it is wearable ,there is different type of design methodologies involved namely silver plated fabric , Inverter F antenna , 3D printed patch antenna etc. ,the reason for choosing microstrip patch antenna is that it has ground plane to avoid frequency radiation entering into the human body and with advancement in miniaturisation of devices microstrip patch antenna is best on sight The proposed antenna is designed on CST (Computer Simulation Technology) and results are provided .

1. Introduction

When we discuss about wearable antenna aka smart textiles involves carrying of Microstrip patch antenna based on our proposal integrating the antenna into clothing or a chest band is crucial [1-9].Instead of having contact based measurements like ECG ,EMG,EEG conductive tapes sticked to the human body may provide discomfort to the patients ,antenna are supposed to be non-invasive also patients does not feel pain wearing them .Smart textiles are widely used in many industries such as medicinal applications [10] ,sports [11] and for military applications [12] .The advantage of having wearable antenna is that it can be used to observe several physiological functions mainly breathing rate shows the signs of heart attacks [13,14].The radiation results of the proposed antenna can be subjected to advanced data processing the return loss, gain of the antenna ,radiation pattern, directivity and voltage standing wave ratio (VSWR) can be measured .These results shall be transmitted to internet /wireless communication systems such as General Packet Radio Services (GPRS) and Long Term Evolution (LTE) services [15-17]. We use an operating frequency of 2.45 GHz WLAN band advised by ISM (Industrial, Scientific and Medicine) bands to be less hazardous [18].

When there is a mechanical deformation in the physical structure of the antenna ,there is a frequency shift changes and alterations in the dielectric properties of the antenna which is used to measure RSSI –Received signal strength indication via Bluetooth protocol related with the gain of antenna and strength of the radiation to observe human breathing and estimate breathing rate in patients on real time .For male it is 0.3 Hz and for female it is 0.5 Hz with the breathing rate of 21 bpm(breathing per minute) and 30 bpm respectively .The antenna is covered with super hydrophobic coating as sweat (moisture) may affect the operating frequency of the antenna and the reduction of bandwidth of the antenna [19,20].

2.Design of the antenna

The I-shaped slotted antenna design is efficiently improving the gain of the antenna to 9db – 12db varying due to the mechanical deformation of the antenna and the dielectric changes strictly the size of the substrate and the ground plane is 54 * 65 mm and the thickness of the substrate (polyester) = 0.4mm.

The proposed antenna is designed and simulated by using computer simulation technology (CST) software, the operating frequency of the antenna is 2.45GHz and design parameters are calculated by the given formula.

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$$W = \frac{c}{2f_o\sqrt{\left(\frac{\varepsilon_r+1}{2}\right)}} \quad \text{…(1)}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \quad \text{...(2)}$$

$$L_{reff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \quad \text{...(3)}$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad \text{…(4)}$$

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

$$L_g = 6h + L \quad \text{…(6)}$$

$$W_g = 6h + W \quad \text{…(7)}$$

The designed antenna has an ability to withstand the application of water on it, as it's enhanced with superhydrophobic coating such as an on a human body sweat might contain moisture that's enough to alter the dielectric properties of the antenna.

S.NO	PARAMETERS	DIMENSIONS
1.	Design or operating frequency(fo)	2.45GHz
2.	Dielectric constant	1.90
3.	Height of substrate	0.4mm
4.	Loss tangent	0.01
5.	Patch width(W)	33.5mm
6.	Patch length(L)	33.5mm
7.	Width of ground plane (Wg)	54mm
8.	Length of ground plane (Lg)	65mm
9.	Dielectric strength(V/mil)	500
10.	Feed width	2mm
11.	Feed length	15.75mm

Table 1: Parameter of proposed antenna

The designed patch antenna provided with ground will avoid the radiation propagation through the patients body yet it's desirable to use full grounded micro strip patch antenna.

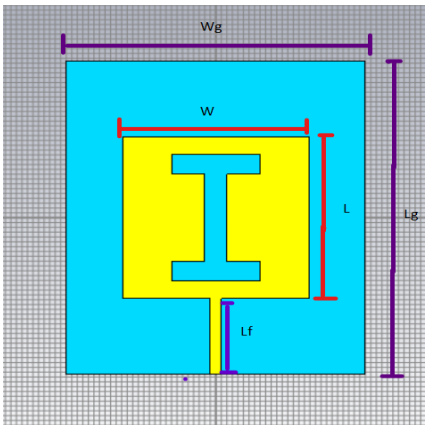

Figure 1: General representation of proposed antenna

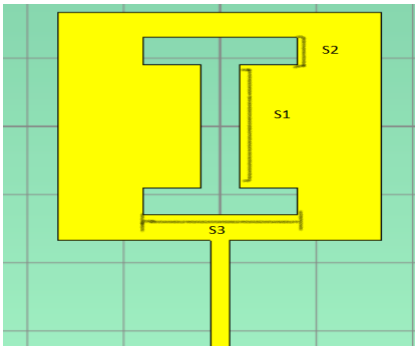

Figure 2: Front view of Patch Antenna

S1 = 18 mm

S2 = 4 mm

S3 = 16 mm

We can have the breathing pattern results from the variation of the signal strength from the antenna at 2.45GHz from the T-shirt and can be further processed at the home-made base station.

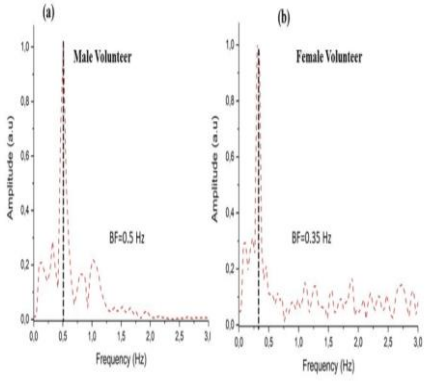

Figure 3: Breathing frequency output

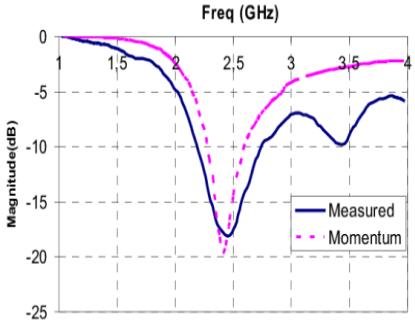

Figure 4: Return loss

We can also detect the breathing frequency using a filter having sampling period of 20Hz in order to measure the highest breathing frequency of 1.2Hz which goes with Shannon constant. Band pass filter with cut off frequency of 0.11Hz – 20Hz is set, signal is treated using signal processing fast Fourier transform to detect the dominant frequency.

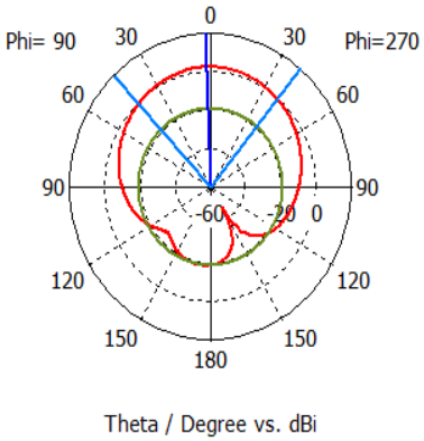

Figure 5: Polyester Gain

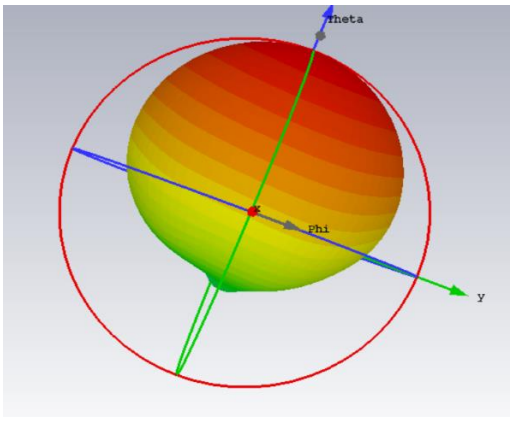

Figure 6: Radiation Pattern

Gain and the return loss of the antenna shows how efficacious the devices, provided the S.D radiation pattern of the antenna the signal strength various and return loss shows how the central frequency shift occurs due to physical deform action of the sensor. Gain related to the RSSI and isotropic radiated power used to derive the breathing cycle differentiation between male and female.

Conclusion

The design of antenna placed in the middle of the chest for showing contactless and non-invasive polyester substrate antenna. It can be used for several medical conditions such as asthma , covid-19 , sleep apnea etc. The healthy breathing frequency for male is 0.5Hz and for female is 0.33Hz with breathing rate of 21 breath per minute and 30 breath per minute for male and female respectively.

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