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Research paper

A Wearable Double Band Button Antenna for BANs

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Abstract

In this paper we have proposed to describe the design and fabrication of a Double Band Button Antenna for wearable BAN range applications. The BAN range is a set of frequencies in the ISM band. The ISM band is reserved for Industry, Scientific, Medicine related band. BAN devices are fabricated for on body wearable applications such that they can monitor vital bodily functions at all times as in certain cases it may be necessary to constantly monitor bodily functions of the wearer. In this paper we have chosen to implement a dual band button antenna that is designed to operate for 2.45 GHz and 5 GHz. The Button Dual Band Antenna will have a return loss of -32.5 dB and -16.8 dB at the respective frequencies.

Keywords: *BAN; Dual Frequency; ISM Band; Medical Applications; Wearable;*

1. Introduction

There are many types of patch antennas manufactured in the present day. Starting from small PCB antennas to giant satellite antennas. Each of the antennas have their own significance. The antenna under discussion here is a button antenna that is made for general everyday wearable applications. There are many applications of such button antennas but its main application is sending medical data of the wearer to a data accumulator. A Body area network (BAN), is also renamed as Wide BAN (WBAN) or a Body Sensor Network (BSN). These are remote wearable electronics processing gadgets. BAN devices embedded inside the body of human or mounted on the surface of body, it is decided based on the based on the applications. It is fixed with the wearable cloths and human can wear it at different location with the cloths like at hand, knee or pockets.

2. BAN and ISM Band

The concepts of BAN and ISM band are described in the next section.

2.1. Body Area Network

The fast paced development in physiological sensors, low-control coordinated circuits, and remote monitoring has empowered another age of remote sensor systems, now utilized for many purposes, for example, tracking movement, tracking some functions. The BAN field is an interdisciplinary territory which could permit reasonable and continuous security through keeping regular checks with continuous updates of restorative records through the Internet which is shown in Fig. 1. Various savvy physiological sensors can be coordinated into a wearable remote BAN, which can be utilized for PC helped recovery or early recognition of medicinal conditions. This territory depends on the practicality of embedding little bio-sensors inside the human body that are agreeable and that don't disable ordinary exercises. Basically the devices shouldn't harm daily bodily functions of the wearer in any diminishing or endangering manner.

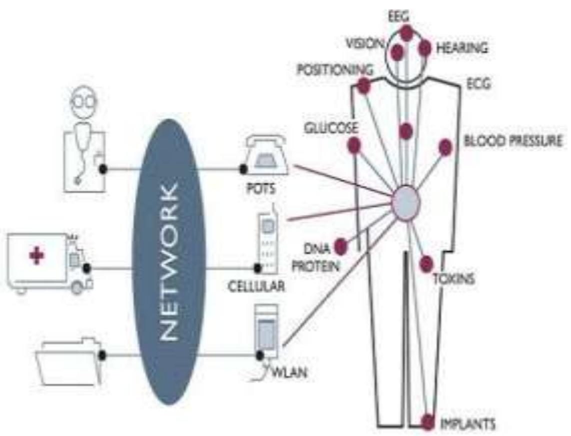

Figure 1: Positions of BAN Devices for On-Body Applications [16].

2.2. Medical, Scientific and Industrial Band

The industrial, scientific, and medical radio band (ISM band) insinuates a get-together of radio frequencies or parts of the radio range that are comprehensively put something aside for the usage of radio frequency (RF) imperativeness proposed for coherent, helpful and present day uses.

3. Applications in the BAN Ranges

BAN devices have been designed for some primary applications-

3.1 Monitoring

BAN devices can be used to monitor the bodily functions of patients, whether it is monitoring the heart beats of a heart patient or the blood sugar levels of a diabetic patient. The devices can be used to monitor such bodily data and will send the gathered data to some data sink that will constantly analyze the body's condition.

3.2 Quick Action Devices

Sometimes a person may be in an emergency or threat at a faraway location. The blood sugar levels of the patient may drop rendering the person helpless. BAN devices can be programmed to automatically inject the bloodstream with the required insulin content to stabilize the patient. Similarly they can be programmed in such a manner for other purposes as well.

3.3 ISM frequencies in BAN

The first ISM specifics were designed such that the group of frequencies would be utilized basically for non-communication purposes, for example, heating. These applications are still for the most part used consequently. For a few people, for the most part experienced ISM device is the home microwave grill working at 2.45 GHz which uses microwaves to cook food materials. Present day heating systems are another enormous application in this field. For instance response heating, microwave heating, plastic softening, and plastic welding frames. In recuperative applications, shortwave and microwave diathermy machines use radio waves in the ISM gatherings to apply significant warming to the body for loosening up and recovering. All the more starting late hyperthermia treatment uses microwaves to warm tissue to destroy tumor cells.

The expanding complexity of microelectronics and the fascination of further possible applications for ISM, has in late decades prompted a blast of services of these bands for short range correspondence frameworks for remote gadgets, which are presently by a long shot the biggest services of these groups. These are in some cases called "non ISM" uses since they don't fall under the initially imagined industrial, scientific, and medicinal application precincts. One of the biggest applications has been Wireless Fidelity (Wi-Fi). The IEEE 802.11 Wireless Fidelity, models on which every remote framework is based by utilizing the ISM band ranges. For all intents and purposes all PCs, tablet PCs, PC printers and cellphones now have 802.11 remote modems utilizing the 2.4 and 5.7 GHz ISM groups. Bluetooth is another systems administration innovation utilizing the 2.4 GHz band. Close field specialized gadgets. For example, proximity cards and contact-less bright cards utilize the lower recurrence 13 and 27 MHz ISM groups. Other short range gadgets utilizing the ISM groups are: remote amplifiers, fetus screening devices, carpark entryway openers, remote doorbells, and keyless section frameworks for vehicles, radio control channels for UAVs (drone- copters), wireless surveillance frameworks, RFID frameworks for stock, and wild animal following frameworks.
Some electrodeless light plans are ISM gadgets, which utilize RF emanations to energize fluorescent tubes. Sulfur lights are economically accessible plasma lights, which utilize a 2.45 GHz magnetron to warm sulfur into a brilliantly shining plasma.

4. Literature Survey

Generally e-textile antennas are used for on-body applications. The textile fabrics are incorporated into the wearer's clothing by means of stitching or patches etched onto the clothing. But however clothing fabrics have chances of bending. There may be a possibility of bending that could disrupt the signaling device. A button antenna provides sturdiness that is required. It can be replaced for certain applications with a button instead of textile patch. Although there is a good signal obtained by wearable textile patch antennas. There is some instability caused because of the structural deformation or bending of the fabric [1-5].

This structural deformation can be reduced by using a button type wearable antenna. It is observed that on structural deformation or antenna bending there is some instability in the graph and the gain can change according to the degree of curvature change upon bending. If the fabric is durable and there is no change in the radii then there isn't a huge variation in gain. But this doubt can be eliminated by the use of button type circular antenna [6-10].

This paper proposes a method to simulate this button type wearable antenna for BAN application on Ansoft HFSS. The fabrication was performed and assessed on Vector Network Analyzer. This paper is organized as follows: Introduction and literature survey are describe in section 1 to 4. The motivation and proposed design and their results are discussed in the section 5 to 7 and section 8 concludes the paper.

5. Motivation for Design

As mentioned the main motivation to design this antenna was to provide an alternative to general textile antennas in a bid to improve sturdiness and stress tolerance of the antenna. Another design was proposed [11-14]. Which aimed at presenting a similar design of the button antenna. The improvement and changes to the design which we have proposed would make the button antenna cost effective while producing nearly the same results thus enabling mass production of the prototype to be available for the common man.

6. Design Methodology

Design procedure and its methods are explained in the details in the next sections.

6.1. Design of Patch

Various Wearable gadgets and frameworks have been created with the point of disentangling the human PC interface, lessening size and expelling the requirement for physical association. The receiving wire depicted in this paper is a minimal inflexible metallic structure over a little ground plane.

In terms of scale this antenna can be worn as a general shirt button or as a pant button. Dual Button Antenna is used in case where the appearance of the button does not get altered even on changing the disc diameters shown in Fig. 2.

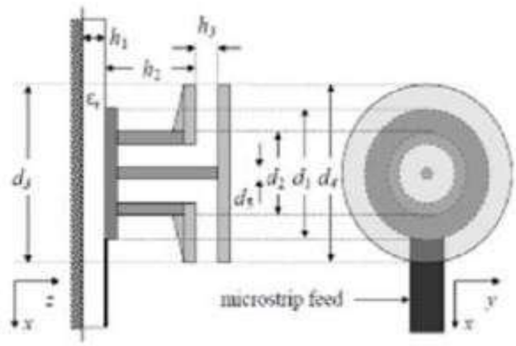

Figure 2: Cross Section of Button Antenna Design [15]

6.2. Formulae and Definitions

The following equations are used for the design of wearable button antenna for the given specifications.

$$d = F\sqrt{\{1 + \frac{2*h}{\pi * F * \varepsilon r}\left[\ln\left(\frac{\pi * F}{2*h}\right) + 1.773\right]\}}$$

$$a = \frac{F}{\sqrt{\{1 + \frac{2*h}{\pi * F * \varepsilon r}\left[\ln\left(\frac{\pi * F}{2*h}\right) + 1.773\right]\}}}$$

$$F = \frac{8.79 * 10^9}{f\sqrt{(\varepsilon r)}}$$

h = height

εr =Relative permittivity

The above formulae give values for heights and diameters of the button antenna dimensions. They are a set of given standard formulas used in the design and fabrication of circular patch antennas.

The basis for designing the button antenna is that the cloth fabric shouldn't act as a substrate with the ground plane being just big enough to fit on as a part of a pant. While all the above conditions are met, the antenna should give a similar radiation pattern to the textile antenna in the dual band. The antenna is designed for the mentioned application and its design parameters are mentioned in the Table 1. The designed values of design variables are mentioned in the Table 2. The prototype can be made by using copper tape on the substrate according to the given dimensions. The antenna is fabricated for the mentioned specification and sheeting is also done which is shown in Fig.3. The parameters have been designed keeping in mind the requirement of dual resonance.

Fig 3: Side View of Fabricated Prototype Antenna

Table 1: Design Parameters

S No	Parameter	Value
	Thickness of Conductor	35µm
	Substrate	FR4
	Operating Frequency(s)	2.45GHz & 5GHz
	Relative Permittivity(ε_r)	4.6
	Substrate height(h)	31.8mm
	Loss tangent(tanδ)	0.02
	Feed Line Width	7.0mm

Table 2: Designed Valued and Antenna Dimensions

S No	Design Variable	Variable Value
1	d_1	12.4mm
2	d_2	7.0mm
3	d_3	16.4mm
4	d_4	14.6mm
5	d_5	2.0mm
6	h_1	1.8mm
7	h_2	7.4mm
8	h_3	1.5mm

7. Results and Analysis

The simulation results shown in Fig.4 shows that a relatively smooth curve appears where resonance occurs at 2.45 GHz and 5 GHz at designed values. The designed returns losses for 2.45 GHz and 5 GHz are -30.5 dB and -16.5 dB respectively. The observed return losses are -33.6 dB and -17.5 dB. In comparison the measured curve observed that a relatively spiked curve. The resonance occurs at 2.45 GHz and 5 GHz. The designed returns losses for 2.45 GHz and 5 GHz are -30.5 dB and -16.5 dB respectively. The observed return losses are -34.6 dB and -15.9 dB. The bending test also done for this antenna and it shows that the tolerance is upto 3.5 dB under physical test.

Parametric Comparison: The difference from a compared work [15] is that there is no dielectric involved in this design. Due to this factor there is an offset in the reflection coefficient which can be adjusted on fine tuning. This significantly reduces the cost and fabrication time of the prototype.

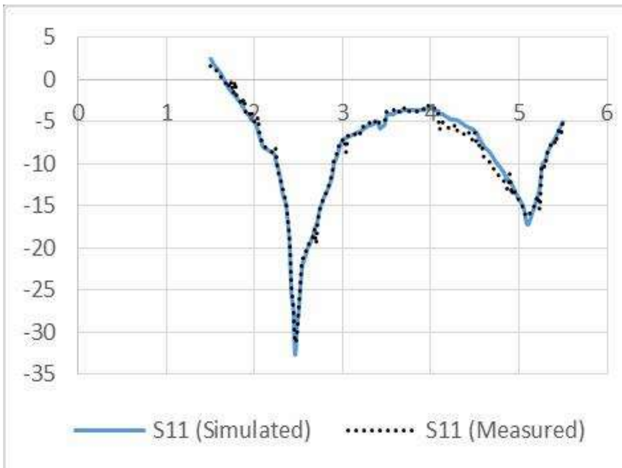

Figure 4: Comparison of Simulated and Measured Curves

8. Conclusion

This paper aimed at presenting a design of a Double Band Button Antenna at 2.45 GHz and 5 GHz frequencies. After performing the design, fabrication and analysis it can be observed that the required resonance at the desired dual bands has been nearly achieved. There is a 3 dB variation in the designed and obtained return loss. We can safely say that this variation of the reflection coefficient is in the tolerable range of the antenna specifications. Also the design has a given cost effective way to get the same results. In conclusion the paper can have further development and further scope through actual implanted testing of patients. Furthermore data analysis can be performed on the data transmitted. For example, a recovering heart patient's heartbeat data can be further analyzed to keep track of the patient's progress. Such a process can be performed for other medical cases as well. Furthermore the antenna can be improved by descaling thus standing by the trend of miniaturization of electronic devices.

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