Irish Interdisciplinary Journal of Science & Research (IIJSR)
Vol.6, Iss.2, Pages 36-42, April-June 2022

Design of 5.3 GHz Microstrip Array Antenna for WBAN Applications

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DOI: http://doi.org/10.46759/IIJSR.2022.6206

Article Received: 15 February 2022 *Article Accepted: 21 April 2022* *Article Published: 31 May 2022*

ABSTRACT

Microstrip array antenna generally consists of a patch antenna on the surface of a Printed Circuit Board (PCB) with a metal foil on the other side of the board. They operate at microwave frequencies. The reason behind their popularity in recent decades is, they have a thin planar profile so that can be easily mounted on a variety of applications including aircraft and missile projects. They offer the excellent convenience of integrating the antenna on the same printed circuit board with the remaining part of the circuit. These advantages make it unique and stand different amidst a variety of antennas present today! In this paper, a Microstrip array antenna is proposed and designed for Wireless Body Area Networks. They are primarily intended to be applied in the fields of wearable computing devices for medical applications. The proposed system resonates at a frequency of 5.3GHz. The substrate used here has a width of 29.2mm with length and height of 23.5mm and 2mm respectively. They employ multiple patches in a two dimensional array whose width is 17.2mm and length is 11.5mm. All these specifications offer an amazing way of designing a phased array of antennas that contributes to have polarization ability. This paper demonstrates how a Microstrip array antenna could offer several advantages like ease of fabrication, light weight, low volume and smaller dimension and how they could be employed in a variety of prospects when compared to other conventional antennas.

Keywords: *WBAN, Patch, Microstrip, Antenna.*

1. Introduction

Depending upon the applications, antennas are classified into various types.

Wire antennas:

These are monopole antennas where wire starts to act as an antenna once it leaves the transmitter, receiver or tuner. They are used for personal applications and automobile applications.

Aperture antennas:

Waveguides are examples of aperture antennas. An antenna with aperture at end is generally called as aperture antennas. Space craft and air craft are applications of aperture antennas.

Reflector antennas:

Light weight and simplicity features of reflector antennas make it a perfect fit for its use in microwave communication, satellite communication etc.

Lens antennas:

These antennas employ convergence and divergence properties of lens for antenna functionalities. They are primarily employed for very high frequency applications.

Micro Strip antennas:

Micro strip antennas are generally termed as low profile antennas. Antennas with low height and width come under low profile antennas. Here, a dielectric material is mounted between metal patches. They emit very low radiation. They are famous for low profile applications like satellites, missiles, cars, air crafts and space crafts.

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Array antennas:

In array antennas, multiple antennas are connected together to transmit or receive radio waves. The radio waves radiated by each antenna combine to enhance power radiated in desired directions and cancels power radiated to other directions.

Microstrip array antennas satisfy all functional requirements of printed circuit technology. Wireless Body Area Networks support a variety of medical applications from monitoring the health condition of infants to tracking the health of old adults. WBAN is one of the fastest growing technologies and it has a better definition for the future. It provides perfect health monitoring scopes without affecting the normal constraints of life. There are many technologies available for health monitoring applications. It is always a hectic job to make a correct decision to select which correct option would be better. In this paper, a Microstrip array antenna for WBAN application [3] is designed and simulated using High Frequency Structure Simulation (HFSS) Software. The proposed patch antenna resonates at a 5.3GHz frequency.

2. Design of Microstrip Array Antenna

Here antenna is mounted on the Printed Circuit Board using photolithographic techniques. They usually employ microwave frequencies. Several metal foils are patched up on one side of Printed Circuit Board and a metal foil ground plane on another side of board. There is variety of multiple metal foil patches in two dimensional arrays. They have become popular nowadays due to their thin planar profile that can easily be incorporated into surfaces of consumer products, missiles and air crafts. As shown in the (fig.1), a dielectric material is present in between a metal patch foil present in the upper layer and a metal foil ground plane.

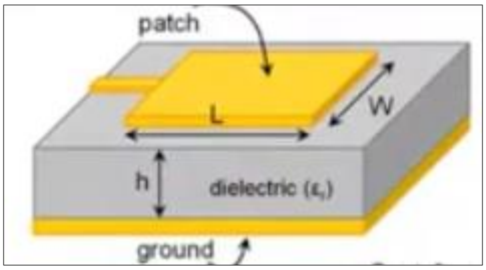

Fig.1. Substrate of Microstrip Array Antenna

In order to provide a better antenna performance, a thick dielectric substrate having a low dielectric constant is used here. Therefore we can obtain high efficiency, better radiation and large radiation.

Antenna Design

The proposed system resonates at a frequency of 5.3GHz. The substrate has a relative permittivity of $\varepsilon_{r=4.4}$ with a thickness of 2mm. The dimensions of the proposed antenna can be calculated as follows [1]:

(i) Width of the Patch:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where,

c =free space velocity of light.

fr = resonating frequency.

ε_r= relative permittivity of substrate.

Here,

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

$$W = \frac{3*10^\wedge 8}{2*5.3}\sqrt{\frac{2}{4.4+1}}$$

W=71.2 mm

(ii) Effective dielectric Constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}}$$

Where,

h = Thickness of the substrate.

W= Width of the patch.

Here,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}}$$

$$\varepsilon_{reff} = \frac{4.4 + 1}{2} + \frac{4.4 - 1}{2}[1 + 12\frac{2}{17.2}]^{-\frac{1}{2}}$$

$$\varepsilon_{reff} = 2.7 + 1.2\ (1 + 1.39)^\wedge\ ½$$

$$\varepsilon_{reff} = 2.7 + 1.8$$

$$\varepsilon_{reff} = 4.5\ \text{mm}$$

(iii) Effective Length:

$$L_{eff} = \frac{c}{2f_{r\sqrt{\varepsilon_{reff}}}}$$

Here,

$$L_{eff} = \frac{c}{2f_{r\sqrt{\varepsilon_{reff}}}}$$

$$L_{eff} = \frac{3 * 10^\wedge 8}{2 * 5.3_{\sqrt{4.5}}}$$

$L_{eff} = 13.3$ mm

(iv) Patch length extension:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)}$$

Here,

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)}$$

$\Delta L = 0.824(42.52/39.85)$

$\Delta L = 0.824(1.06)$

$\Delta L = 0.873$ mm

(v) Length of the patch:

$L = L_{eff} - 2\Delta L$

Here,

$L = L_{eff} - 2\Delta L$

$L = 13.3 - 2(0.873)$

$L = 11.5$ mm

(vi) Length of the substrate:

$L_g = 6h + L$

$L_g = 6(2) + 11.5$

$L_g = 23.5$ mm

(vii) Width of the substrate:

$W_g = 6h + W$

$W_g = 6(2) + 17.2$

$W_g = 29.2$ mm

3. Analysis of Microstrip Array Antenna

The proposed Microstrip array antenna can be simulated and analysed using HFSS antenna simulation software. The design geometry of proposed Microstrip array antenna is displayed below. These Microstrip array antennas can be used over a multitude of applications including medical, entertainment and military. The major objective of antenna designed in this paper is to employ them in WBAN wearable device applications. One of the key features of these wearable electronics is, they have to allow wireless communication to or from the body through wearable antennas.

The Microstrip array antenna (fig.2) is generally low in profile and easy to fabricate. Hence it is a good choice for wearable devices. These wearable devices can be used for health monitoring systems [2] in Covid-19 pandemic situations, which is a primary WBAN application.

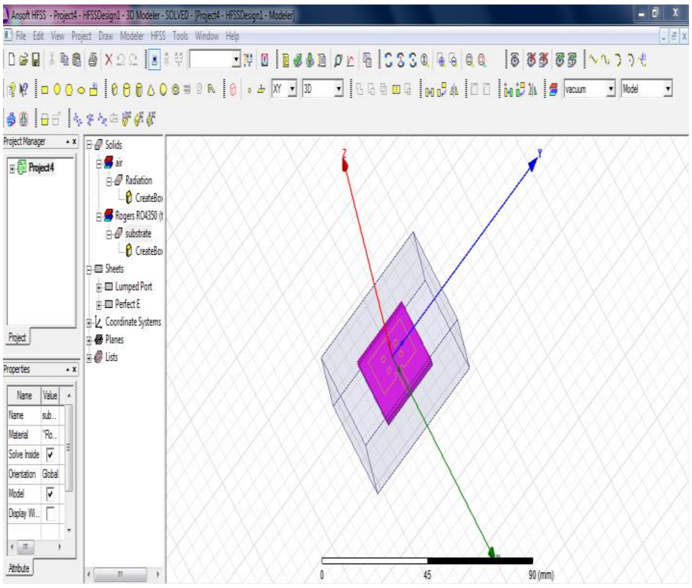

Fig.2. Design of proposed antenna

4. Simulated Results

The parameters S11 for the designed antenna were calculated and the simulated return loss results are shown in the fig.3. The antenna resonates at 5.3 GHz frequency and its return losses are figured up in the following curve analysis.

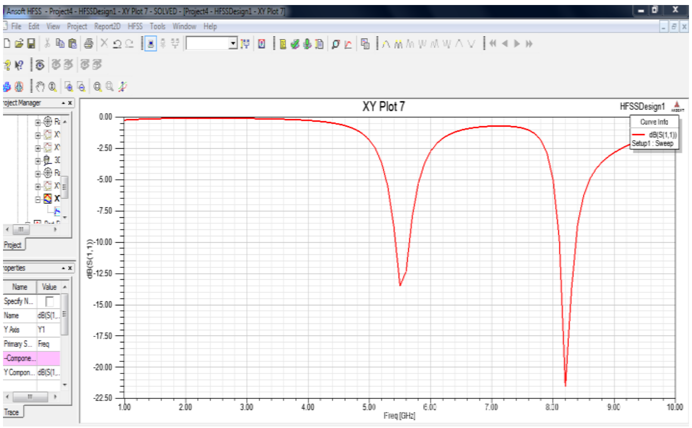

Fig.3. Simulated return loss curve

The antenna covers WBAN standard (5.3 GHz band for feasible usage for medical applications). The return loss value obtained is very low and it is close enough for the specified frequency band for 5.3GHz applications. The radiation pattern and polar plot for the designed Microstrip array antenna are shown in the following fig.4 and fig.5.

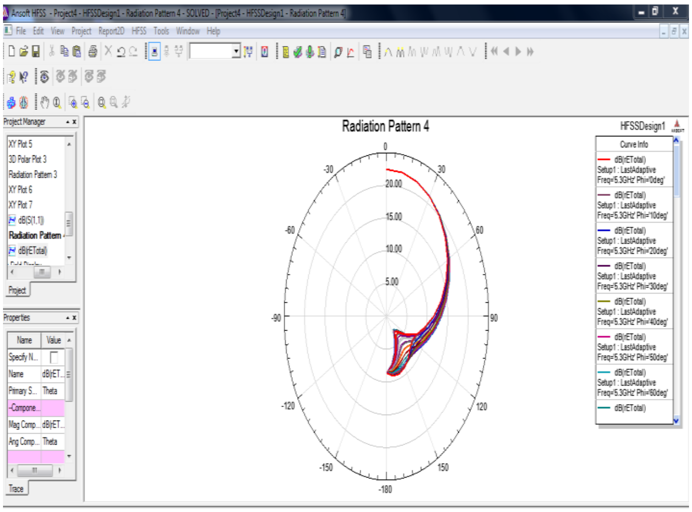

Fig.4. Radiation Pattern of Microstrip Array Antenna

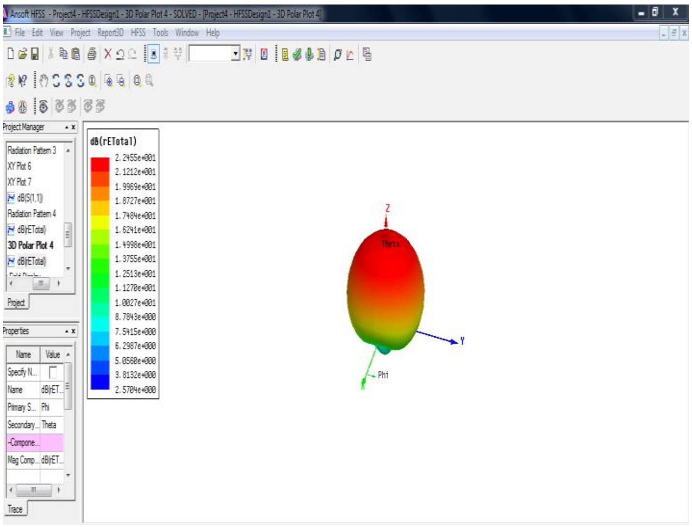

Fig.5. Polar Plot of Microstrip Array Antenna

5. Conclusion

A Microstrip array antenna is thus designed and simulated using HFSS Antenna Simulation Software. This is operating in the frequency of 5.3 GHz which is best suited for WBAN applications. The frequency level generated is much feasible for WBAN applications. The directivity of this array antenna designed is high and hence the efficiency of this antenna is relatively high than other antennas available in the market today. This project is simulated successfully and is taken into the next level for real time implementation.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public or not-for-profit sectors.

Consent for publication

Authors declare that they consented for the publication of this research work.

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