Design of Microstrip Patch Antenna used in Wireless Body Area Network (WBAN)

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Abstract—A wearable antenna is meant to be a part of the clothing used for communication purposes, which includes tracking and navigation, mobile computing and public safety. In this project a microstrip patch antenna with inset feed technique for 5.8 GHz and a U-slotted MPA with co-axial feed for body area network the gain of 5.12 dB for 5.8 GHz is proposed. The antenna with dimension of 21.8 mm x 25.6 mm & 50mm x 40mm on RT-Duroid& Air Substrate is presented. The antenna is designed, simulated, optimized and analyzed using Microwave Studio CST software. The antenna performance is observed in terms of return loss, radiation pattern, Directivity and realized gain. In addition the specific absorption ratio (SAR) distributions (for Microstrip patch antenna with inset feed ) is measured for consideration in use.

Key words: Microstrip, Antenna Characteristics, Feeding Technique, WBAN

I. INTRODUCTION

A wearable antenna is meant to be a part of the clothing used for communication purposes, which includes tracking and navigation, mobile computing and public safety. In this project a microstrip patch antenna with inset feed technique for 5.8 GHz and a U-slotted MPA with co-axial feed for body area network the gain of 5.12 dB for 5.8 GHz is proposed. The antenna with dimension of 21.8 mm x 25.6 mm & 50mm x 40mm on RT-Duroid& Air Substrate is presented. The antenna is designed, simulated, optimized and analyzed using Microwave Studio CST software. The antenna performance is observed in terms of return loss, radiation pattern, Directivity and realized gain. In addition the specific absorption ratio (SAR) distributions (for Microstrip patch antenna with inset feed ) is measured for consideration in use.

II. ANTENNA CHARACTERISTICS

An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing an antenna for your application as follows:

- Antenna radiation patterns
- Power Gain
- Directivity
- Polarization

III. MICROSTRIP PATCH ANTENNA

In its basic form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1.

![Microstrip Patch Antenna](image)

**Fig. 1: Microstrip Patch Antenna**

The patch is normally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. In order to simplify analysis and performance estimation, generally square, rectangular, circular, triangular, and elliptical or some other common shape patches are used for designing a microstrip antenna.

The patch is selected to be very thin such that t << λ₀ (where t is the patch thickness). The height h of the dielectric substrate is usually 0.003 λ₀ ≤ h ≤ 0.05 λ₀. The dielectric constant of the substrate (εr) is typically in the range 2.2 ≤ εr ≤ 12. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good performance of antenna, a thick dielectric substrate having a low dielectric constant is necessary since it provides larger bandwidth, better radiation and better efficiency.

IV. FEEDING TECHNIQUES

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories: contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch.

![Different Feeding Techniques](image)

**Fig. 2: Different Feeding Techniques**
V. WIRELESS BODY AREA NETWORK (WBAN)

Wireless communication technologies have undergone explosive growth since the end of the last century, and more and more advanced communication technologies have been deployed to provide the most enjoyable communications for people than ever expected. The increasing use of wireless technologies and the advances in electronics have empowered the development of wireless body area network (WBAN). A WBAN consists of a number of nodes, placed on and/or around, and/or implanted in the human body, which can communicate with each other through wireless links.

In addition, WBAN also has the capability to connect with other wireless networks, such as Wi-Fi and cellular networks. With WBAN, the sensor node can continuously monitor the real-time physiological parameters such as the temperature, blood pressure, heart rate, electrocardiogram (ECG), electroencephalogram (EEG), respiration rate, and SpO2-level and provide feedback to the user or medical personnel. Further, the actuator node in WBAN can act as a drug delivery system. For example, the actuator can start the injection of predetermined dose of insulin when a sudden drop of glucose is detected for diabetes patients. With the wireless nature of the network and the wide variety of sensors/actuators, WBAN provides a greater physical mobility for a patient and the connectivity for the elderly in managing their daily life and medical conditions.

WBAN supports both medical and nonmedical applications with diverse application requirements. The nodes in the network can be sensors/actuators or personal devices.

VI. ANTENNA FOR WBAN APPLICATION

Low-frequency technology intended for short-range information exchange. Number of units placed inside or in proximity of the human body. Communicate externally with other networks.

A. Substrate Materials:

The choice of substrate used is an important factor in the design of a microstrip antenna. Important qualities of the dielectric substrate include:
- The microwave dielectric constant
- The frequency dependence of this dielectric constant which gives rise to
- “material dispersion” in which the wave velocity is frequency-dependent
- The surface finish and flatness
- The dielectric loss tangent, or imaginary part of the dielectric constant, which
- sets the dielectric loss
- The cost
- The thermal expansion and conductivity
- The dimensional stability with time
- The surface adhesion properties for the conductor coatings
- The manufacturability (ease of cutting, shaping, and drilling)

VII. DESIGN PROCEDURE

The patch width (W) is calculated using the following formula,

\[ W = \frac{C}{(2Fr)} \sqrt{\frac{1}{\varepsilon_{\text{reff}}}} \]

Where, \( C \) is the velocity of electromagnetic wave, \( \varepsilon_\text{r} \) is the relative permittivity of the dielectric material. The effective dielectric constant of the patch is calculated using the following formula,

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

Where, \( h \) is the height of the substrate. The patch length determines the resonant frequency and is a critical parameter in design because of the inherent narrow bandwidth of the patch. The design value for \( L \) is given by,

\[ L = \frac{C}{2Fr} \sqrt{\varepsilon_{\text{reff}} - 2\Delta L} \]

Where, \( \varepsilon_{\text{reff}} \) is the effective permittivity, \( \Delta L \) is the extended incremental length of the patch due to the fringing field. The additional line length \( \Delta L \) on either ends of the patch length, due to the effect of fringing fields, is given by,

\[ \Delta L = \left( h \times 0.412 \left( \varepsilon_{\text{reff}} + 0.3 \right) \left( \varepsilon_{\text{reff}} + 0.264 \right) \right) \left( \varepsilon_{\text{reff}} - 0.258 \right) \left( h/w + 0.8 \right) \]

The effective patch length \( L_{\text{eff}} \) is written as,

\[ L_{\text{eff}} = L + 2\Delta L \]

The characteristic impedance is given by,

\[ Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{\text{reff}}}} \left[ \frac{h}{w} + 1.393 + 0.667 \ln \left( \frac{w}{h} + 1.444 \right) \right] \quad \text{for} \quad w > h \]
The inset feed point distance $Y_0$ is calculated using the below formula,

$$ R_{in}(y=y_0) = \frac{1}{2} G_r \cos^2 \left( \frac{\pi}{L} y_0 \right) $$

Where, $R_{in} = 1/2G_r$

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Table 1: Design specification of Inset feed MPA

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Table 2: Design specification of U-Slotted MPA

VIII. DESIGN & SIMULATED RESULT

The performance of the Simple MPA with inset feed and a U-Slotted patch antenna has been simulated using CST. The proposed antenna structures are given in figure

Fig. 4: Front View of MPA for 5.8 GHz with inset feed.

Fig. 5: Front View of U Slot MPA with Co-axial feed.

Fig. 6: Return loss for 5.8 GHz (Inset feed)

Fig. 7: Return loss for 5.8 GHz (U Slot MPA with Co-axial feed)

Fig. 8: 3D Radiation pattern of the Inset feed MPA for 5.8 GHz (Inset feed)

Fig. 9: 2D Radiation pattern of the Inset feed MPA for 5.8 GHz (Inset feed)
conductivity of the skin is the main player in the absorption of the radiated power. In this project the lowest SAR 10g occurs at 5.8 GHz of inset feed MPA. The maximum SAR (rms, 10g) [W/Kg] is 0.0190563.

It is seen that the U-Slotted microstrip antenna achieved good performance, which well meets the requirements of WBAN applications with smaller size. The further work will focus on investigating methods of improving bandwidth and gain by varying the ground plane and patch size; a significant impedance bandwidth can be achieved. It can be considered as a key parameter for return loss and bandwidth enhancement.

X. CONCLUSION

The project proposes a microstrip patch antenna with inset feed & U-Slot MPA with co-axial feed for body area network application. The proposed antennas are made of RT-Duroid & Air Substrate. As it is designed for body area application the inset feed microstrip patch antenna has been tested by placed at approximately 10mm above the human tissue. The Biological human tissue voxel model consists of Skin, Skeleton muscle, Bone & Blood. This model is imported from CST Microwave studio. Structure of the MPA above the tissue designed for 5.8 GHz with inset feed is shown in fig.

The performance of the proposed antenna, including realized gain, return loss and SAR distribution, is sufficient for use in WBAN applications. It can be seen that the gain of the antenna when it is proximity to the body is degraded as expected when compared with the gain in free space. The gain for 5.8 GHz has dropped from a maximum of 5.12 dB (at the absence of the human tissue) to a minimum of 3.77 dB (at the presence of the body).

This can be explained due to the distortion, reflection and absorption caused to the EM waves to the body tissue (note that the patch is facing the free space while the ground plane is facing the body & The antenna has been placed approximately 10mm above the origin, in this case from the bottom of the ground plane). The

REFERENCE


