International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING

ISSN:2147-6799 www.ijisae.org Original Research Paper

Design and Development of Two Port MIMO Antenna at ISM Band for WBAN Applications

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Submitted: 29/01/2024 **Revised**: 07/03/2024 **Accepted**: 15/03/2024

Abstract: A Multiple Input Multiple Output antenna having 2-ports is discussed on this paper, which is presented for WBAN applications. The antenna is presented with the dimensions of 46x20x1.6 mm3. Here, the FR-4 epoxy as the substrate has been used and its loss tangent and relative permittivity are 0.002 and 4.4 respectively. The designed proposed antenna is operating in the frequency of 2.4GHz and 5.8 GHz with reflection coefficient of less than -22dB. Antenna Simulation has been carried out using HFSS. By simulating the designed antenna various parameters like gain, radiation pattern, S parameters, Z - parameters are obtained. An antenna system prototype has been created, and test results indicate that the suggested antenna system performs well in the frequency bands of WBAN applications.

Keywords: *FR-4 substrate, MIMO, WLAN, WBAN, gain.*

1. Introduction

Various Wireless Communication systems particularly 4G LTE uses this MIMO antenna, so that the speed of the data transfer can be increased. Rate of Data transfer can be increased by using multiple numbers of antennas. These MIMO antennas are preferably used in WLAN applications. Here, the design of multiple input multiple antenna having 2 bands is designed with minimal size, cost operating at WBAN frequency (2.4 and 5.8 GHz) is presented.

IEEE 802.11ac and 802.11n are the main IEEE standards which uses MIMO antennas. These 2 standards can support two antenna elements at WBAN frequency (2.4 and 5.8) GHz and can also hold 4 elements of antenna for one mobile station at the frequency range of 4.9 to 5.725 GHz [1]. A MIMO antenna of two ports is required at frequency of 2.4GHz and a MIMO antenna of two ports is required at 5.8GHz simultaneously. Previously many types of MIMO antennas are discussed and studies in order to meet WBAN applications. Major challenge is embedding the MIMO antenna in small devices like tablets or smart phones while maintaining mutual coupling or low isolation [2].

A number of dual-band WBAN antennas have been proposed so far. In order to obtain dual-band characteristics, the previously designed dual-band WBAN antennas are often realized by creating slots or including parasitic branches. Dual-band slot antennas are reported on and examined in [3-5].

The dual-band antennas in [6] are constructed utilising parasitic branches. However, some of these antennas are substantial in size, while others have intricate structural designs. A small asymmetric coplanar strip-fed dual-band antenna for 2.4GHz WBAN applications is examined [7]. The antenna is made smaller by using two loaded capacitance terminations. The gain is extremely poor though the proposed antenna's structure is complex.

The study of various designs of the antenna includes 2-ports at frequency of 2.4 GHz [8], the antenna with more than 2 ports at frequency of 2.4GHz [9], the antenna with 2-ports at frequency of 5GHz [10], the antenna with 4-ports at frequency of 5GHz [11], 2-port dual-band antenna at frequencies 2.4/5GHz designs [12], 2-port dual band antenna with re-configurable design [13].

Uncorrelated ports are to be used in the antenna in MIMO systems in order to obtain the better performance. Embedding the required antenna in small devices is a challenging and is a complex task. While embedding the antenna inside the small device less isolation and mutual coupling has to be maintained. This design does not require reconfiguration, it is the main advantage of the design.

2. Antenna Design Parameters

If you are using Word, use either the Microsoft Equation Editor To design the antenna, we use FR-4 epoxy substrate. The loss tangent and relative permittivity are chosen 0.002 and 4.4 respectively The total area of this design is 45×20mm2.The primary elements used in designing the antenna are 4 slots located in the corners of the substrate. Series feeding is used in 2 port dual band antenna and is having mono pole slot length 15 mm, lower band excitation is controlled by this slot. To control the excitation of upper band another slot of length 16mm is used.

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The antennas are chosen based on a variety of purposes, and the interactions between them are examined and minimized. For the MIMO WBAN application, two identical T-shaped printed monopole antennas were designed. In order to operate in the WBAN communication frequency bands, two horizontal printed poles with strips are constructed. The WBAN antennas with better broadside radiation patterns are obtained by the investigation of the interaction between the MIMO antenna and WBAN antennas.

Reduction of size is important, it can be done by closely spacing radiation at 0.5mm. Micro strip feed lines of 50 ohms having widths of 3 and 0.8 mm are used for exciting the antenna. The feed lines lengths are 3 and 5.5 mm respectively. The width, length and location of designed antenna have more influence on impedance matching.

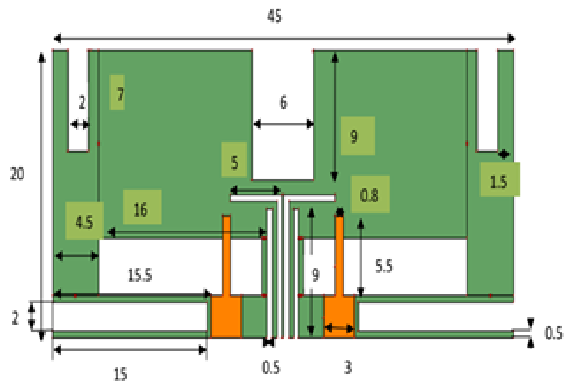

Fig.1. Geometrical view of proposed antenna

Fig.2 Prototype view

The ground plane's length and the width of the L-shaped or reversed L-shaped branch can be correctly adjusted to provide effective impedance matching. Additionally, the proposed antenna is significantly impacted by the parameter r. As a result, the performance for the lower and upper WBAN bands can be altered by adjusting the size of the antenna. The analogous circuits of the inverted U-shaped reactive loadings are shown in Fig. 1.

3. Results and Discussion

Multipart Based on the HFSS, the proposed dual-band WBAN antenna is examined. In order to confirm the analysis effectiveness, the dual-band WBAN antenna is fabricated and measured [Fig. 2]. Fig. 3 shows a comparison of the measured and simulated reflection coefficients (S11s), with the measured S11 being acquired using the Keysight PNA-X Microwave Network Analyzer N5244A.

The simulation of this dual band two port MIMO antenna is done by using HFSS Simulation Software. The s-parameter of this antenna is less than -10 dB at frequency 2.4-2.5 GHz.

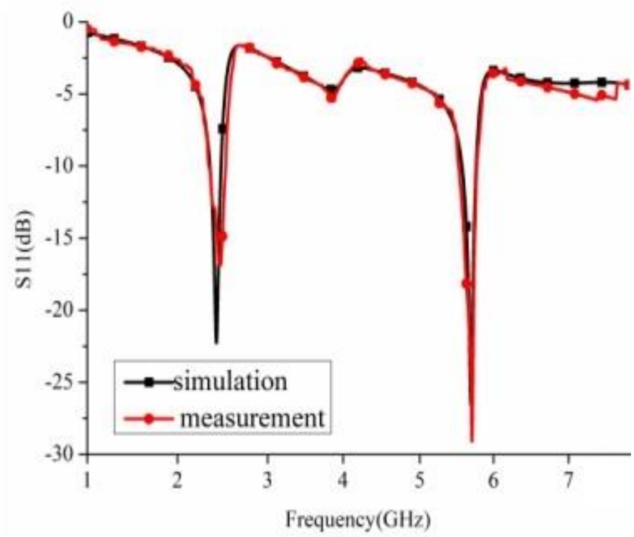

Fig.3. S-Parameter characteristics

The measurement result and simulated S11 match up nicely, which supports the simulations' accuracy. The fabrication inaccuracy, soldering, and stability of the FR4 substrate are possible causes of the slight discrepancy between the measurement and simulation. Fig. 4 displays the dual-band antenna's measured radiation patterns. At 2.43 GHz and 5.8 GHz, the designed antenna exhibits omnidirectional radiation patterns.

The Voltage standing wave ratio appears to be 1:2 ratio at the resonating frequency. From the Z parameters graph shown in Fig.3, it is observed that the impedance matching at resonant frequency seems to be good. Better Impedance matching around 50Ω is exhibited from the proposed antenna at frequency 2.45GHz as shown in Fig.3. In Fig.4 we can observe the gain of the antenna to be 1.2dBi at the resonating frequency 2.45GHz. Radiation patterns (Elevation and Azimuth patterns) and current distributions are shown in Fig.5. Comparison of both simulation and measured results are tabulated in Table 1. Here, we can observe good relation between the E-plane and the H-plane., not here.

Table 1. Comparison results of Simulation and measured results

Parametrs	***Simulation***	***Measurement***
Reflection Coefficient	-22dB	-18dB
Impedance Matching	50Ω	50Ω
Bandwidth	2.4-2.48	2.4-2.5
Gain(dBi)	1.4dBi	1.2dBi
Efficiency (%)	72	70

Isolation of 14 dB is observed at the lower band having 60% total radiation efficiency with the gain of 1.2 dBi at 2.45GHz frequency. Fig. 7 represents the 2 dimensional radiation pattern for XY and YZ planes .Polarization of antenna is done in +X directions at a resonating frequency of 2.45 GHz , second port is polarized in the direction of +y at frequency 3GHz , these slots operation is similar to that of Closed end ones. Bidirectional Broadside pattern in +Z direction is resulted because of the radiation pattern of ports is much alike that of X axis oriented Small Magnetic Dipoles.

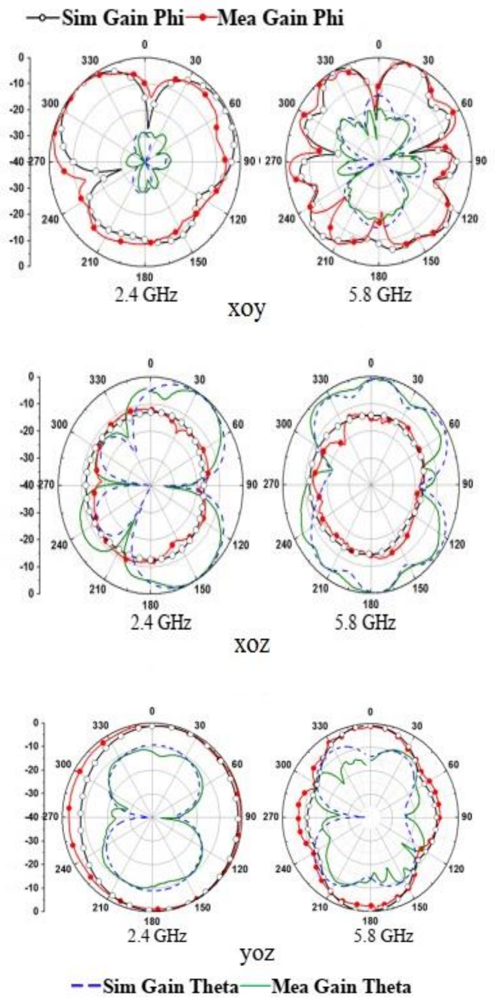

Fig.4: Radiation pattern

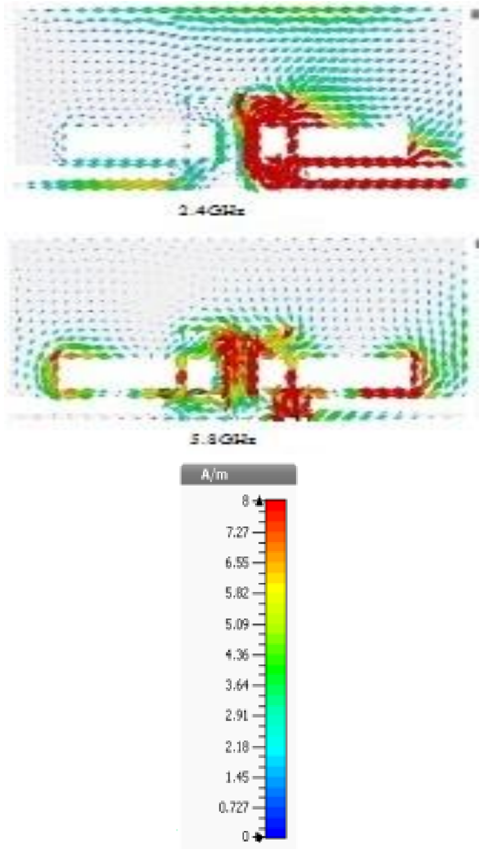

Fig.5. Current distribution

Fig. 4 displays the dual-band antenna's measured radiation patterns. At 2.43 GHz and 5.8 GHz, the designed antenna exhibits omnidirectional radiation patterns. According to comparison data shown in Table 2, the proposed antenna performs better than conventional antennas

4. Conclusion

The proposed antenna is compact, it consists of multiple ports. It is designed for 802.11 MIMO applications .One can observe, two ports which are operating at 2.4GHz and 5.8GHz shows better isolation than 14dB at resonant frequency. One can also observe two ports operating with isolation better than 12dB between antennas. The volume of the total design is 45x20x1.6mm3 providing better

Table 1. Comparison results of Simulation and measured results

Ref. No	*Bandwidth*	*Gain(dBi)*	*Efficiency(%)*
[12]	2.4-2.48	0.05	41
[13]	2.4-2.5	0.5	60
Proposed Model	2.4-2.5	1.2	70

isolation than 10 dB and showing efficiency 70%. The proposed antenna system is multifunctional is a better choice for the ISM Band and WBAN terminal systems.

Conflicts of interest

The authors declare no conflicts of interest.

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