

Design of an Ultra Wide Band MIMO Microstrip Patch Antenna

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ARTICLE DETAILS

Article History

Published Online: 12 June 2019

Keywords

MIMO, Microstrip Patch, Ultra Wide Band, CST.

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ABSTRACT

The general objective of this paper is to analyze and design of Multiple input and multiple output (MIMO) antennas with a compact planar profile that operates in the entire UWB range (3.1- 10.6 GHz) and desired antenna performance characteristics. The study of this paper shows isolation structures and draft of two- element MIMO antennas for which techniques have been discussed to take the edge off mutual coupling that arises between the two elements. Two structures of multiple input and multiple output (MIMO) patch antenna have been designed and analyzed for their radiation characteristics, isolation, bandwidth and channel capacity. The antenna which has Multiple-Input-Multiple-Output (MIMO) system enhances the data speed and without added bandwidth or transmit power it increases the channel capacity with the technique of installing number of antennas to attain an array gain and diversity gain for transmission that results in refining the spectral efficiency and reliability. Seeing MIMO involves several antennas so mutual coupling is the challenge that rises. Altogether UWB MIMO system needs a more isolation of less than -16 dB and for fabrication purpose it must be compact to make it compatible with integrated circuit.

1. Introduction

With the increase in the telecommunication traffic Ultra wide band (UWB) technology has become more popular and for the advancement in data rate and channel capacity the Federal Communications Commission (FCC) have allocated 3.1- 10.6 GHz for UWB applications. Since then there is an increase in design of UWB antenna with different structure like circular, rectangular, and elliptical or any feasible structure. One of the advantages of Multiple-Input-Multiple-Output (MIMO) systems is that without utilizing the added bandwidth the channel capacity is remarkably increased. A two-element UWB MIMO E-Shaped, circular shaped antenna system is presented in this paper using Microwave studio CST software and their results are obtained which includes return loss, radiation pattern, mutual coupling and directivity.

1.1. Why we use MIMO system?

The main objective of this design is to enhance the channel capacity while avoiding the requirement of added bandwidth or transmit power.

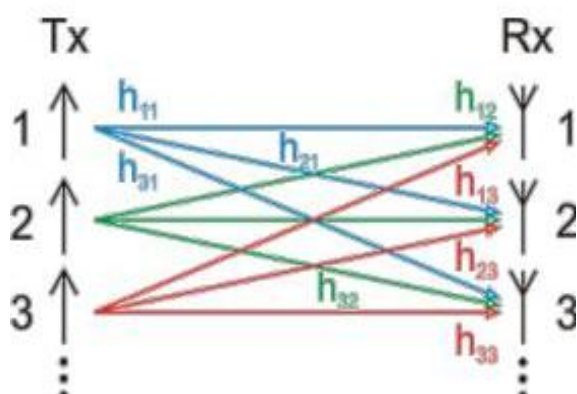


Figure 1. MIMO Channel Model

2. Literature Review

With the research and growth in the wireless communication the UWB technology has overtake the conventional technology that is used in application like Bluetooth, GPS etc. UWB technology has gone through many challenges before it overcome conventional technology. UWB has a consequence effect on antenna design. The concept of UWB has attracted researchers for designing antenna for UWB systems that require a two element antenna with a functional bandwidth covering the whole UWB (3.1- 10.6 GHz) and competent of receiving on affiliated frequencies at that instant [2]. Consequently, the antenna characteristics and performance have to be undeviating, uniform and predictable across the UWB. The designing of UWB antenna with different structure has challenges to attain low mutual coupling, high radiation efficiency and wide impedance bandwidth. UWB antennas attain a bandwidth, greater than 100% of the centre frequency so that there is minimum reflection and maximum return loss across the antenna input terminal [2]. Low VSWR, return loss of greater than 10dB and low mutual coupling is necessary to obtain high directivity and high radiation efficiency. This must be attained because UWB transmission is of high sensitivity and very low power [1].

3. Proposed Work

This project is a step forward in the advancement of the communication system. The project require the help of Microwave Studio CST software and the basic communication modules, also two structure (E-shaped, circular shaped) of antenna have been designed (see figure3 and 4) and their results are compared.

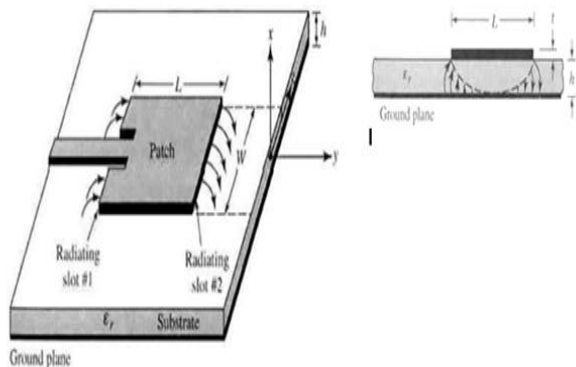


Figure 2. Top and side image of microstrip patch antenna

3.1 UWB E-shaped patch antenna

For the design of E-shaped antenna (see Figure 3) its fabrication is done on FR4 substrate (low cost and easily available) Printed Circuit Board (PCB) which is established on the simulation specification with loss tangent (tanδ) of around 0.02, dielectric constant (εr) of 4.4, thickness of the substrate (h) and copper foil (t) is 1.6mm and 35µm respectively (see Table 1). Finally the analysis is done on the frequency range from 3.1-10.6 GHz (see Figure6).

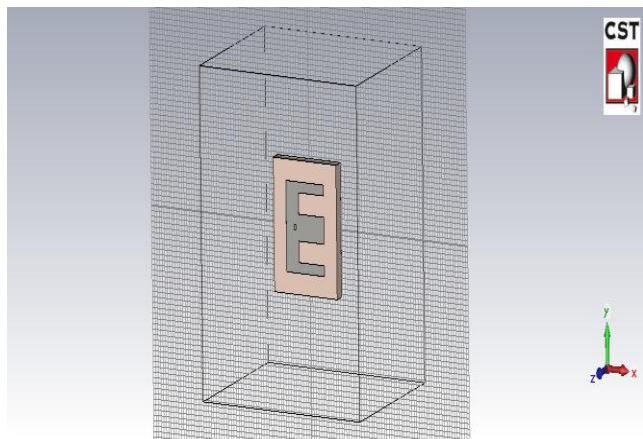


Figure 3. Design of UWB MIMO E-shaped patch antenna

Table-1

Parameter for the proposed UWB MIMO antenna

SYMBOL	SIZE(mm)
W_{sub}	36
L_{sub}	34
L_{sub_a}	18
L_{sub_b}	12.5
W_{patch}	19
L_{patch}	12
W_{lim_a}	2
L_{lim_a}	4.5
W_{lim_b}	2.0
L_{lim_b}	5
L_{gnd}	11.9

Source: Compiled by Authors

3.2 UWB Circular shaped patch antenna

The circular shaped antenna is fabricated on FR4(low cost and easily available) substrate Printed Circuit Board (see Figure 4) which is established on the simulation specification with dielectric constant (εr) of 4.4, thickness of substrate(h) of 1.6mm ,loss tangent (tan δ) of 0.02 and copper foil thickness (t) of 35µm. (see Table 2). The investigation is done on the frequency range from 1 GHz-10 GHz and simulation is observed The simulation results displayed in the later section demonstrate fair agreement with the measurement results(see Figure7).

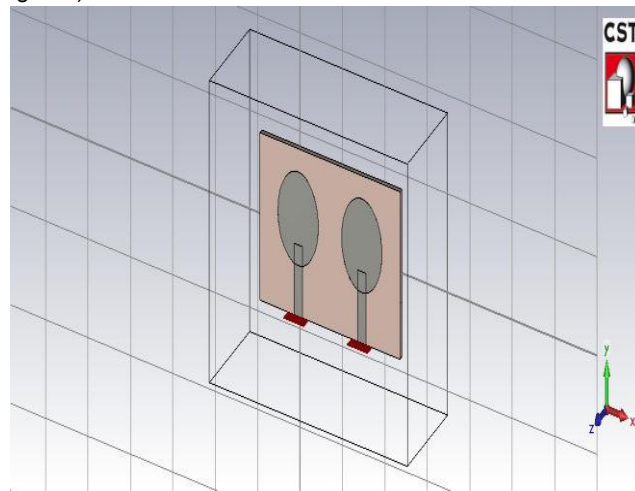


Figure 4. Design of UWB MIMO Circular shaped patch antenna

Table-2

Parameter for the proposed UWB MIMO antenna

SYMBOL	SIZE(mm)
W_{sub}	36
L_{sub}	34
r	8.5
h	2.6
W_{patch}	5
L_{patch}	13
L_{gnd}	6

Source: Compiled by Authors

4. Results

4.1 UWB MIMO E-shaped patch antenna

From the simulation result it is observed that with L_{gnd} of 34mm the antenna shows narrowband response. However, the return loss of the antenna signifies with S_{11} parameter shows improvement when the length ground patch is decreased and we obtained the best result at the height of ground plane, L_{gnd} of 12.8 mm. When the ground is transformed from patch type to a radio antenna that replaces the ground with its half of the length known as monopole type, there is significant improvement in the return loss. In order to further improve its overall bandwidth, two steps of specialized type of cable is used known as feed line.

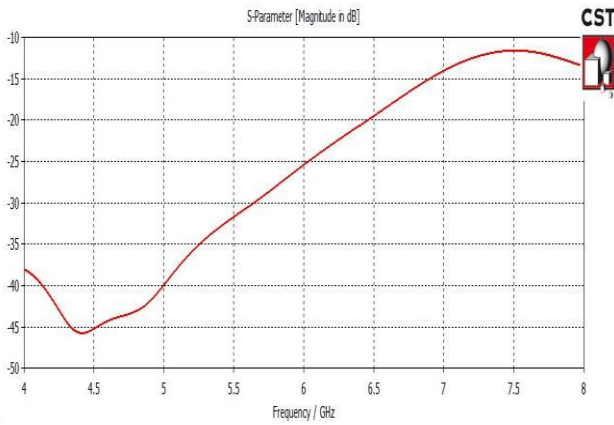


Figure 5. Measured Return Loss (S_{11} Parameter)

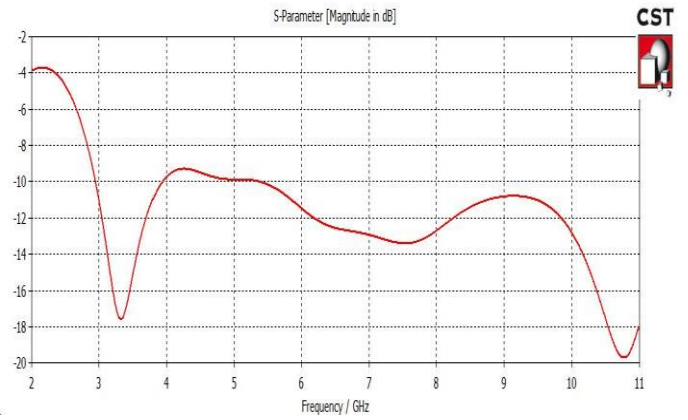


Figure 7. Measured return loss

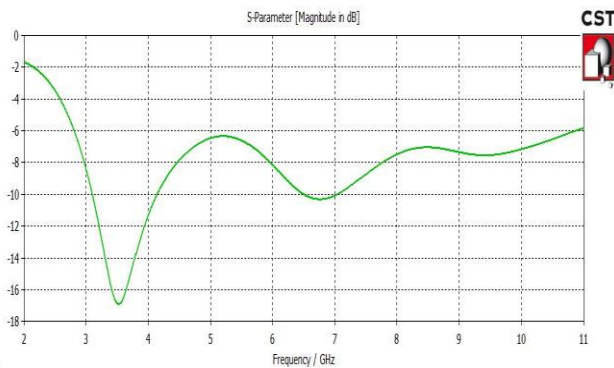


Figure 6. Measured S_{12} Parameter

4.2 UWB MIMO circular-shaped patch antenna

It is observed that for L_{gnd} of 6 mm and Radius of 8.5 mm, the antenna response is like narrowband. However, the response of return loss improves dramatically when the ground is transformed from patch type to a radio antenna that replaces the ground with its half of the length known as monopole type.

5. Discussion and Conclusion

The project has proved to be advance in the field of communication as its technological aspects. The advancement in the system and over the existing system will prove to be a lot more beneficial as it has high data rate and high channel capacity. This conclusion has been taken out by thinking of two dimensions of two-element UWB MIMO antennas keeping two attributes in mind, viz. isolation and bandwidth.

The circular shaped antenna shows the better return loss over the UWB range (3.5 to 10.6 GHz). The simulation shows that the Isolation is better than -14dB in every part of UWB. In this proposed antenna of circular shaped it is found that bandwidth covers almost the entire UWB from 3.5 to 10.6 GHz. As the result shows there is no mutual coupling and this type is appropriate for mobile MIMO application. On the other hand the result of E-shaped antenna has also the better return loss but not the entire range of ultra wide band. In future work we can add more number of antennas in array by calculating the various geometrical parameter using mathematical formulae or through MATLAB programming keeping the mutual coupling as low as possible and high return loss.

References

1. J.Powell, "Antenna Design for Ultra Wideband Radio," M. A. Sc. Thesis, Massachusetts Institute of Technology, USA, May 2004.
2. G.Brzezina, "Planar Antennas in LTCC Technology for Ultra-Wideband Applications," M.A.Sc. Thesis, Carleton University, Canada, 2005.
3. K.H.Chiang and K. W. Tam, "Microstrip monopole antenna with enhanced bandwidth using defected ground structure," IEEE Antennas Wireless Propag. Lett., vol. 7, pp. 532–535, 2008.
4. D.Guha, M.Biswas, and Y.M.M. Antar, "Microstrip patch antenna with defected ground structure for cross polarization suppression," IEEE Antennas Wireless Propag. Lett., vol. 4, pp. 455–458, 2005.