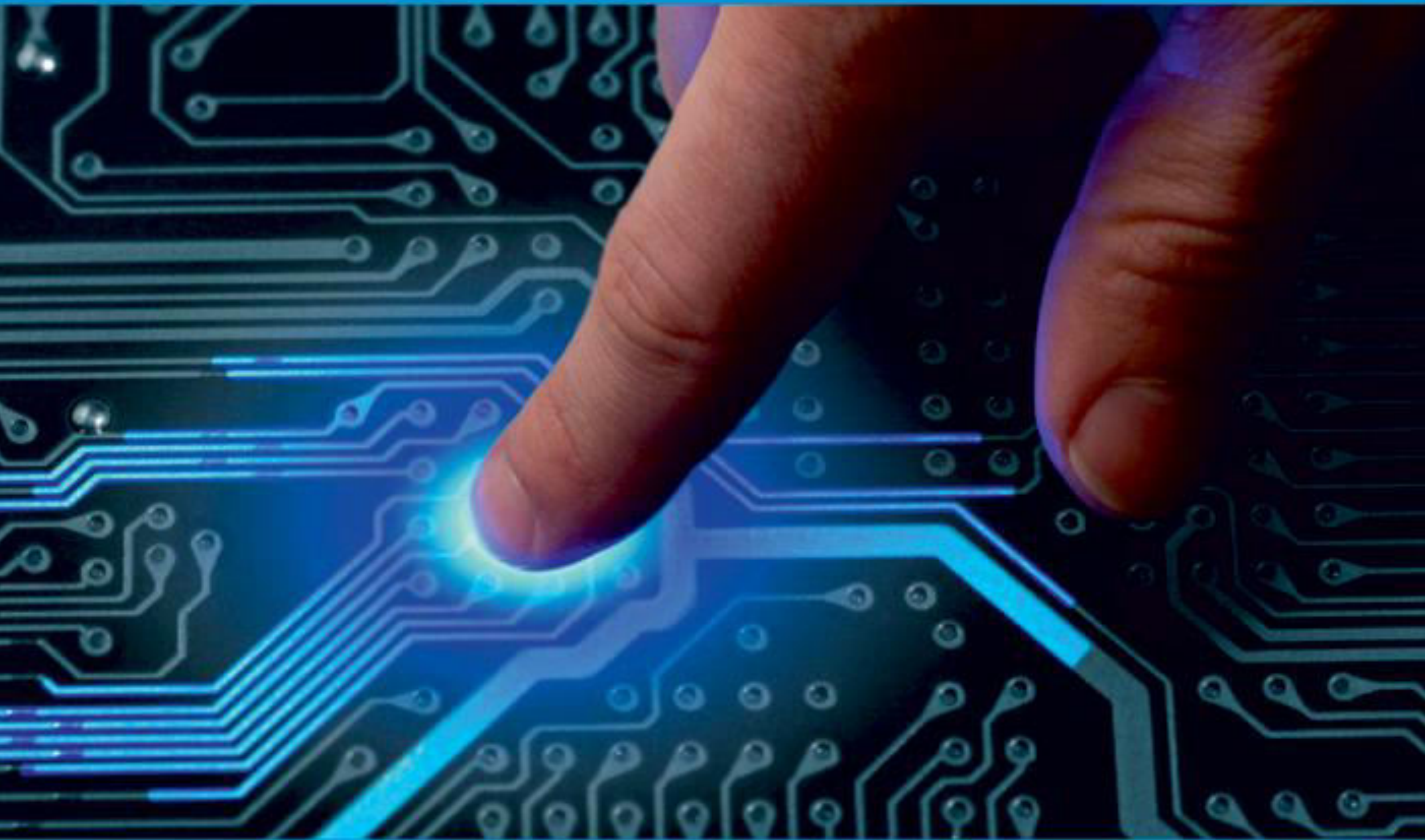
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 3, March 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

Design And Simulation ofa Compact Ultra – Wideband Multiple – Input Multiple – Output (MIMO) Antenna for Various Applications

M. Srinivasa Rao[1], K. Pavan Kumar[2], B.Harshavardhan[3], B.Veerababu[4], K.Rashesh[5]

Assistant Professor, Department of ECE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India[1]

UG Student, Department of ECE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India [2]

UG Student, Department of ECE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India [3]

UG Student, Department of ECE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India [4]

UG Student, Department of ECE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, Andhra Pradesh, India [5]

ABSTRACT: A Design and Simulation of a Compact Ultra-Wideband (UWB) multiple-input multiple-output (MIMO) antenna for various applications is proposed in this paper. The Multiple-input Multiple-output (MIMO) antenna includes 4 monopole antennas, which are fabricated on FR-4 substrate. The impedance bandwidth of the proposed Antenna is from 2 to 12 GHz, and the isolation of two adjoining antennas is much less than−20 dB in often frequency band of the proposed Antenna. The current distribution of the proposed antenna is analysed and observed through simulation, and the radiation characteristics and properties of the proposed antenna are enhanced by increasing or improving the parasitic radiation patch and digging holes with inside the radiation patch. Four monopole antennas are positioned with polarization orthogonality, and the adjoining antennas are separated through slot to reduce the coupling current on the floor, thus consequently efficaciously enhancing the isolation of the antenna. We introduced slots between the adjacent antennas to reduce the interference and information loss. For demonstration, a prototype covering 2 to 12 GHz is implemented, designed and simulated. The experimental outcomes are in suitable settlement with the simulation ones, which verifies the design concept. The Proposed antenna is Designed, optimized and Simulated in a Ansys HFSS (High-Frequency Structure Simulator) Software 17.2 Version and verifies the design concept. Finally, After Simulation we observed S-Parameters, VSWR and Current Distribution of the Proposed Antenna for different cases.

KEYWORDS: Ultra-Wideband, MIMO, FR-4 substrate,Impedance Bandwidth, Isolation, Current distribution, Radiation, Polarization, Coupling current.

I. INTRODUCTION

We preferred UWB (Ultra-Wideband) antenna because of its advantages of low power consumption, high data rate, large capacity, good anti-interference, high resolution, low cost and achieving effective broad bandwidth and so on. Many Wireless Communication Systems will consist of Ultra-Wideband (UWB) antenna for fast data transmission, reception, positioning, location identification, sensing, and tracking. And also, UWB antennas are mainly used in noncarrier frequency pulse radar and a large number of research results have emerged. There are many fundamentally different applications that use Ultra-Wideband (UWB) antennas, and as a general approach, different customized and designed antennas are needed depending on the desired radiation characteristics.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

UWB(Ultra-Wideband) communications have inherently having very wide bandwidth in which, according to Shannon's theorem, these systems can support high and fast data rates. So, UWB transceivers can be used for the transmission of high data rate, wireless communications, which are mostly used for PAN Communications.

MIMO (multiple inputs, multiple outputs) is an antenna technology which is used for mainly wireless communications in which many antennas consist multiple transmitters and receivers are used at both the source (transmitter) and the destination (receiver) at the same time. The antennas at each end of the communications circuit are combined to reduce errors, optimize data speed and improve the capacity of radio transmissions and channel by enabling data to travel over many signal paths at the same time.

We have considered the technology of MIMO (Multiple-input Multiple-output) to improve and enhance the data transmission and reception rate and also to enhance the channel capacity. So, to improve further Communication data rate, we have used the combination of Ultra-Wideband (UWB) and Multiple-input Multiple-output (MIMO) technology. By using these combined UWB and MIMO technology, there is a strong development of 4G and 5G technology is supported.

To maintain our proposed Antenna, compact, we designed our Antenna with effective UWB properties and the research focused for achieving high isolation of the Antenna.In this paper, based on four monopole antennas, we achieved high impedance bandwidth by optimizing the parasitic patch current and radiation unit. The four monopole antennas are positioned Polarization orthogonal, and improved the polarization isolation of each antenna unit. The rectangle slot is added to the monopole's ground. By introducing slots between the adjacent antennas to reduce coupling current effectively and to improve the isolation between the antenna's units. Finally, we observed and analyzed the S-Parameters, current distribution and VSWR.

II. RELATED WORK

The concept of designing this Ultra-wideband MIMO antenna consists of four monopole antennas was introduced by the author Wang Youcheng and we made some modifications in the antenna design to improve isolation and to reduce return loss of the Antenna.Our aim to develop and design this antenna to produce satisfactory isolation and decoupling.The proposed antenna will operate at several frequencies. The major parameters associated with this antenna are Reflection coefficient(S11), Return Loss, VSWR and should be small in size. The performance of the designed antenna was evaluated by observing Current Distribution at resonant frequencies.

We initially proposed single monopole antenna, we observe that there is a narrow frequency bandwidth and inefficient radiation. By using of four monopole antennas, we overcome the limitations of single antenna by improving the bandwidth and efficient radiation.And also, for a good radiating element return loss should be less than -10dB and VSWR is less than 2 is achieved by our proposed antenna. Andalso, we would like to design different shapes of antenna by introducing slots between the adjacent antennas to avoid mutual coupling and information loss. Also, by introducing slots between the adjoining antennas we can improve the isolation of each antenna unit.

Initially, we designed Single Antenna in the HFSS Software and observed the results of the single antenna design. We observed the S-Parameters in this designed single antenna and we have observed that it is operates as SISO (Single-input and Single-output) antenna with inefficient radiation and narrow bandwidth. Also, we observed that for single Antenna the S11(reflection coefficient) is -11dB.So, to reduce the return loss and to improve the isolation we considered four monopole antennas positioned in Polarization Orthogonality.

To overcome the limitations of single antenna we considered four monopole antennas includes UWB and MIMO technology because of its advantages and applications. We designed our proposed MIMO antenna by considering two cases i.e., i)Antenna Model Analysis with strips and without slots. ii)Antenna Model Analysis with strips and with slots. We designed the proposed antenna for the above two cases in the HFSS software based on the dimensions table which will be given in the design methodology section. We designed and simulated the antenna model for the above two cases in the HFSS software and observed the simulation results i.e., S-Parameters, VSWR and current distribution of the proposed antenna for the above two cases. So, to design the proposed MIMO antenna in HFSS software first we have to learn the basics of HFSS software and start designing the proposed antenna based on the dimensions table given in the design methodology section.

III. PROPOSED ANTENNA DESIGN METHODOLOGY

The main purpose to design our proposed antenna is to reduce return loss and coupling current and to increase the isolation of the antenna using UWB and MIMO technology for various applications.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |
|| Volume 11, Issue 3, March 2023 ||
| DOI: 10.15680/IJIRCCE.2023.1103032 |

In this designing of proposed MIMO antenna,we considered two different cases of antenna array model analysis and observed the simulation results for the antenna array of two different cases.
The considered two cases are:

Case i)Antenna Model Analysis with Strip and without Slots

Case ii) Antenna Model Analysis with Strip and Slots

So, the implementation of antenna design for the above two cases in the HFSS software will be discussed below.

A. *Design Theory of MIMO Antenna:*

Here,we considered microstrip antenna for the design of proposed MIMO antenna.The microstrip antenna consists of one pole is conducting patch and the other side is ground of the microstrip.In this proposed antenna we considered shape of the radiating conducting patch is circular.Based on the reciprocity theorem, we have removed elliptical area on the ground in the designing of antenna.In the case 1,we don't have any slot or any interval between the adjoining antennas.so,because of no slots between the antennas and small intervals between the antenna unitsthere is a strong coupling current and effects the radiation performance of the antenna and consequently reduces the isolation of the adjoining antenna units.

So, to reduce coupling current and to improve the radiation characteristics and also to enhance the isolation between the adjoining antenna units we introduced slots between the antenna units.We used Polarization and slot isolation to enhance the isolation and got good simulation results.In the ground we added parasitic radiation patches to improve and expand the bandwidth of the low frequency band of the antenna. An elliptical area is removed on the ground to improve the impedance characteristics of the proposed antenna. Finally dimensions of the antenna is optimized in HFSS software.The proposed antenna structure and dimensions will be given in the Fig 1 and table 1.

B. *Design Considerations:*

To design our proposed antenna, we considered FR-4(Flame Retardant) Substrate and fabricated four monopole antennas on the substrate.

- Type of the Substrate: FR-4
- Dielectric of the Substrate:4.4
- Size of the Substrate: 94mm x 94mm
- Thickness of the Substrate: 1mm
- Tangent loss:0.02

The ground and radiating materials, we considered copper material for the ground and radiating materials. Based on the dimensions table we considered and designed our proposed antenna in the HFSS software.The blue colour area describes ground and red colour area describes the radiating patch of the MIMO antenna.

Table 1: Dimensions of the Proposed Antenna (unit: millimetres (mm))

L	M	L1	L2	L3
94	94	13.6	22.1	6.5
L4	L5	L6	L7	L8
7.2	42.5	1.5	2.5	47.2

C. *Steps That We Followed to Design andSimulate Our Proposed Antenna:*

Step 1: Based on the Dimensions table in the above table 1, we designed Our proposed MIMO antenna for the two different cases in the Ansys HFSS software.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

Step 2:First we simulated the Antenna Model analysis with strips and without slots i.e., case 1 by clicking "Analyze all" in the HFSS software and observed the simulation results.
Step 3:We Observed S-Parameters i.e., S11 and S12,VSWR and current distribution for the Antenna model with strips and slots i.e., case 1.
Step 4:Now,we simulated the Antenna Model Analysis with strips and slots i.e., case 2 by clicking "Analyze all" in the HFSS software and observed the simulation results i.e., S-Parameters and Current Distribution.
Step 5:Finally,we compared the both simulation results of the Antenna model for the two cases.And we can conclude that our proposed antenna is efficient or not and performance of the antenna by observing the Antenna Parameters in the HFSS software.

D. *Implementation of Antenna Design:*

In this designing of MIMO Antenna, we considered two cases to design and simulate the Antenna Array in these two cases and observe the S-parameters, VSWR and Current Distribution of the designed Antenna Array.

Case i) Antenna Model Analysis with Strip and without Slots:

In this case 1,we are designed our proposed antenna consists of four monopole antennas which are placed orthogonality for high transmission and reception. Based on the dimensions table in the above table 1 in the design considerations, we designed this antenna as shown in the Fig.1 and simulate it on the software to observe the results in the HFSS software.
To increase the coupling between the radiation patch and the ground, we added rectangular strip on one side of the ground.Consequently, it will improve the characteristics of the low frequency band.There will be weak coupling current between the four antenna units in the high frequency band then effect of isolation of the low frequency band is mostly considered.

Antenna Design with Strips and without slots:

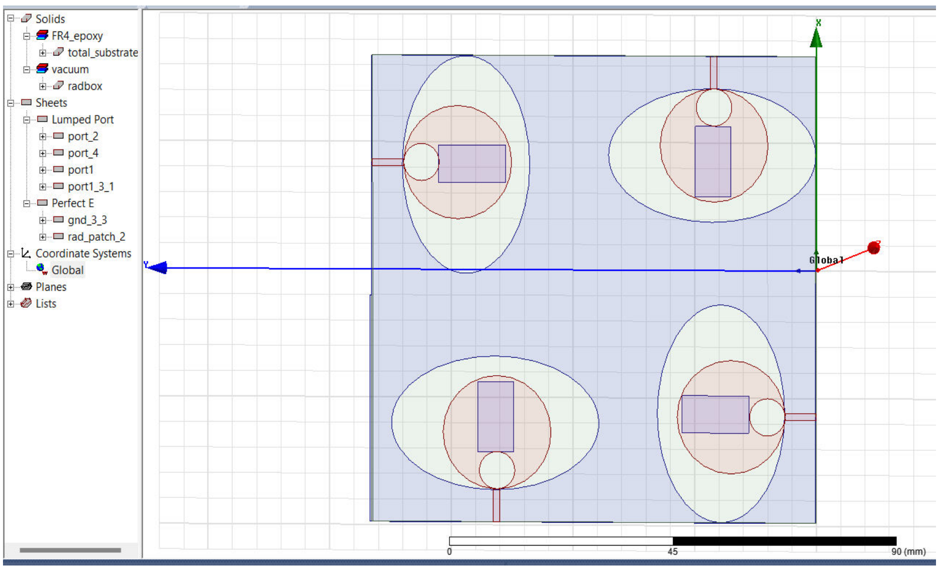


Fig 1. Design of Antenna Model with Strips and without Slots

Case ii) Antenna Model Analysis with strips and with slots:

In this case 2,we are designed our proposed antenna consists of four monopole antennas which are separated by slots to avoid mutual coupling and to reduce interference and information loss. Based on the dimensions table in the above table in the design considerations, we designed this antenna as shown in the Fig.2 and simulate it on the software to observe the results in the HFSS software.

Here, we have introduced slots between the adjoining antenna units on the ground to reduce return loss and coupling current and also to improve the isolation of the antenna units.Because of the Compact structure of proposed

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

antenna, when an antenna unit works the low frequency current is coupled to other antenna units through the ground,thus will reduce the isolation degree between the antenna units. To cut off the coupling current is a good way.We Simulate this designed antenna with slots and observed the results in the HFSS software. We analysed S-parameters and Current Distribution of the designed Antenna with strip and slots.

Antenna Design with Strips and Slots:

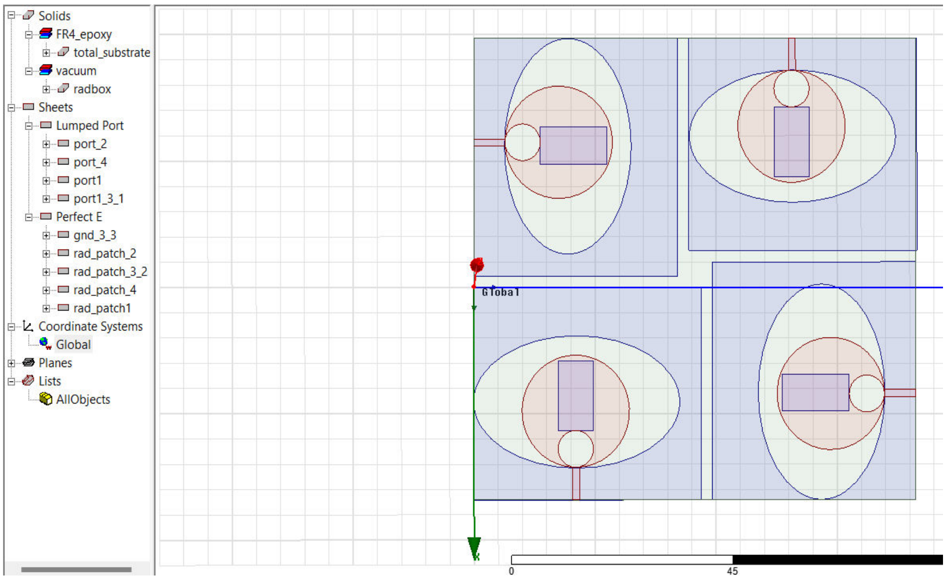


Fig 2. Design of Antenna Model with Strips and Slots

IV. SIMULATION RESULTS

We Observed and analyzed simulation results for the above two cases in the HFSS software for the Antenna Model analysis with strips and without slots i.e.,case 1 and Antenna Model analysis with strips and with slots i.e., case 2.

Case i) Simulation Results:

We Observed the Simulation results of the designed Antenna with strip and without slots i.e., case1 and improved the S-Parameters compared to the single antenna design.We Analyzed the S11(Reflection coefficient of Antenna unit 1) plot and resonated at two different frequencies i.e., at 5.4GHz and 8. 65GHz.We observed that S11 is -22dB at 5.4GHz and -27dB at 8. 65GHz as shown in the Fig.3.Also S22(Reflection Coefficient of Antenna unit 2) is -15dB at 5.5GHz and -28dB at 8.7GHz as shown in the Fig.4.As the above same we observed Reflection Coefficients for 3 and 4 antenna units and We have observed that Reflection Coefficient is less than -10 dB as shown in the Fig.5 i.e., we can say that proposed antenna has low return loss and efficient antenna for many applications.So,at that resonant frequencies Transmission is fast without any losses.Many applications are operated at those resonant frequencies for example Wi-fi is operated at 2.5,5 and 6GHz. So,we can use our antenna in Wi-fi Applications and so on.Also, we can use this antenna in many UWB Applications.We know 5G is operating in the frequency 2~12 GHz.

Also,we have observed S21 (Antenna Isolation) and concluded that S21 is less than -20dB (S21 < -20dB) as shown in the Fig.6. Also, we simulated VSWR for the designed Antenna with strip and without slots at Reflection coefficient resonant frequencies and we observed that VSWR is1.4 at 5.4GHz and 0.8 at 8.65 GHz.So, VSWR is less than 2. so, it is acceptable.For the designed antenna, we simulated S11 VSWR and S22 VSWR for the antenna without slots and observed that VSWR<2 as shown in the Fig.7 and Fig.8.so we can conclude that the antenna is efficient and the performance of the antenna is good.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

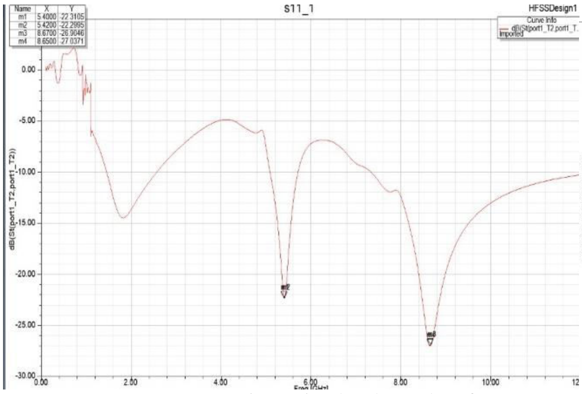


Fig 3. SimulatedS11 plot of case 1

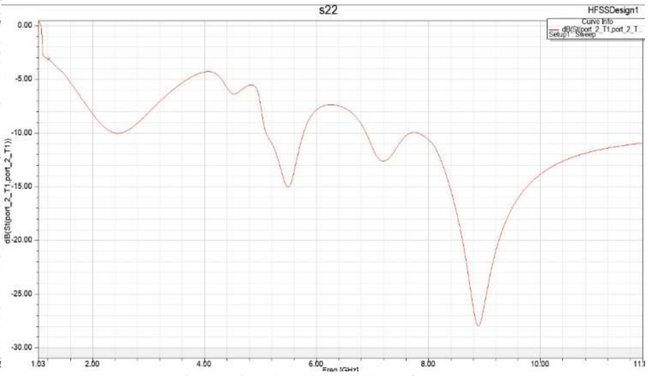


Fig 4. Simulated S22 plot of case 1

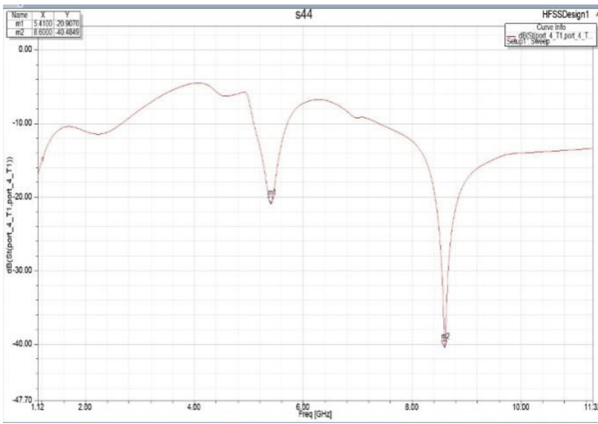


Fig.5. Simulated S44 plot of case 1

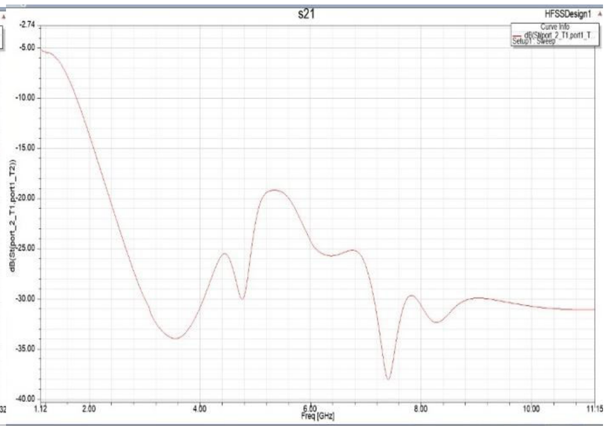


Fig 6. Simulated S21 plot of case 1

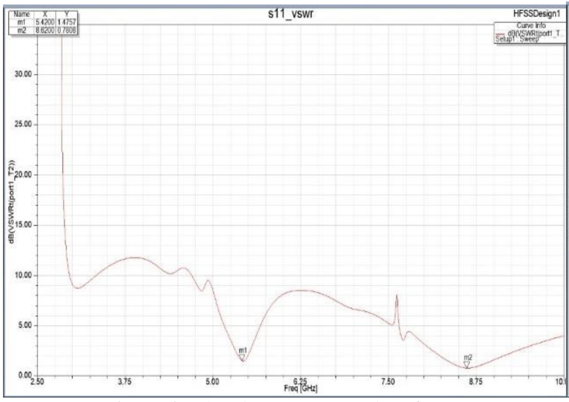


Fig.7. Simulated VSWR_S11 plot of case 1

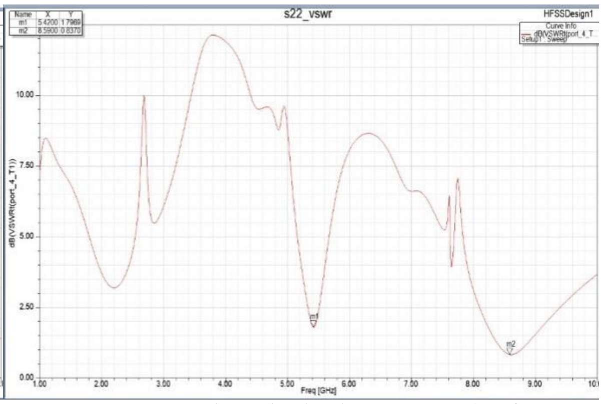


Fig 8. Simulated VSWR_S22 plot of case 1

Case ii) Simulation Results:

We Observed the Simulation results of the designed Antenna with strip and with slots i.e., case 2and simulated S11 plot for the designed antenna with slots and antenna is resonated at two different frequencies i.e., at 2.2GHz and 5. 3GHz.We Observed that S11 is -17dB at 2.2GHz and 5. 3GHz as shown in the Fig.9.So we can use this antenna in Wi-fi applications as we know Wi-fi applications are operated at 2.3GHz. And also, IoT applications we can use this Antenna.Also, we have simulated S22 plot as shown in the Fig.10 and Current Distribution at resonant frequencies of S11 plot as shown in the Fig.11.

We can conclude that by introducing slots between the adjoining antenna units we can reduce the coupling current and enhanced the isolation between the antenna units. We Simulate this designed antenna with slots and observed the results in the HFSS software. We analyzed S-parameters and Current Distribution of the designed Antenna with strip and slots

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

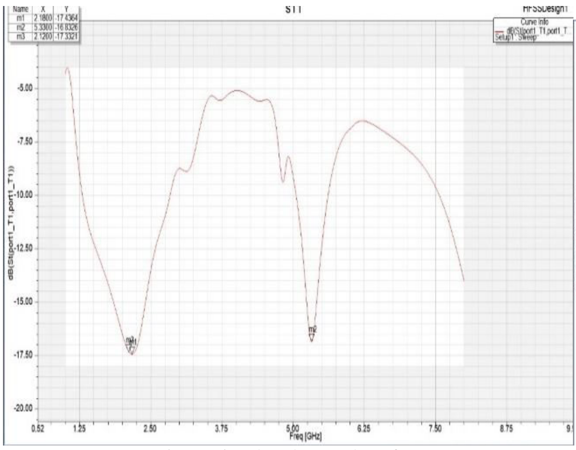


Fig.9. Simulated S11 plot of case 2

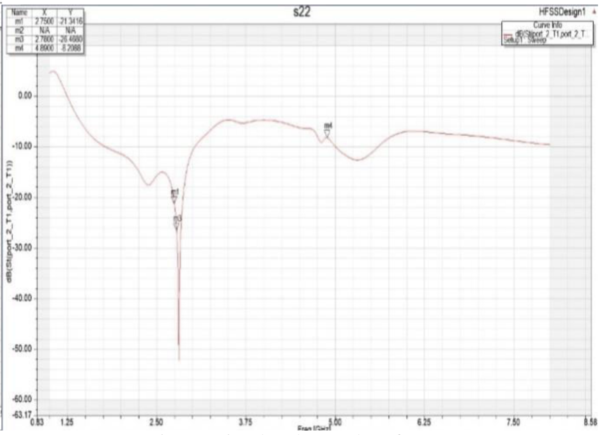


Fig 10. Simulated S22 plot of case 2

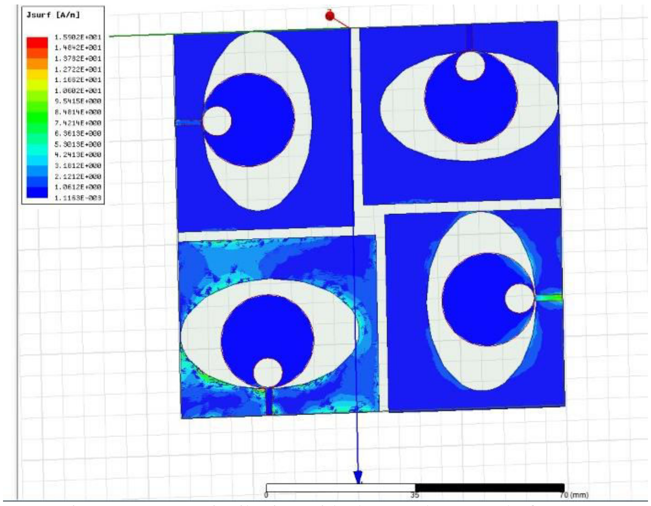


Fig.11. Current Distribution with slots on the ground of case 2

V. CONCLUSION AND FUTURE WORK

The simulation results showed that the proposed Compact Ultra-Wideband MIMOAntenna Model in two cases performs better with Return Loss i.e., S11 is less than -10dB from 2 to 12 GHz. and the isolation of the two adjoining antennas is less than -20dB in the most frequency band. The VSWR for the antenna is less than 2 and VSWR is always positive which is acceptable.By increasing the parasitic radiation patch we have improved the antenna radiation characteristics. By introducing slots between the adjoining antennas, we have reduced the coupling current and enhanced the isolation of the antenna units. By observing the surface current distribution of Compact UWB MIMO antenna, the effect of slot isolation is strongly demonstrated.

The Future Scope of our Compact Ultra-Wideband Multiple-input Multiple-output (MIMO) Antenna is to develop more efficient antenna by changing shape of the antenna and also using different materials, we can make our proposed Antenna more efficient for various applications like Wi-fi Applications,Mobile Communication, Wireless Applications, UWB applications,IoT Applications, Military Applications and so on.We can use our proposed antenna in 4G and 5G technology is strongly supported for fast communication rate.

REFERENCES

[1] Najam, A.I., Duroc, Y., Tedjni, S.: ‘UWB-MIMO antenna with novel stubstructure’, Progr Electromagn Res C,2011, 19, pp. 245–257

[2] Ren, J., Hu, W., Yin, Y., et al.: ‘Compact printed MIMO antenna for UWBapplications’, IEEE Antennas Wireless Propag. Lett., 2014, 13, pp. 1517–1520

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 3, March 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1103032 |

[3] Tang, M.C., Ziolkowski, R.W., Xiao, S.: 'Compact hyper-band printed slotantenna with stable radiation properties', IEEE Trans. Antennas Propag.,2014, 62, pp. 2962–2969

[4] Wang, Y., Fang, G.Y., Zhang, F., et al.: 'RC-loaded planar half-ellipse antennafor impulse radar application', Electron. Lett., 2015, 51, pp. 1841–1842

[5] Zhang, S., Lau, B.K., Sunesson, A., et al.: 'Closely-packed UWB MIMO/diversity antenna with different patterns and polarizations for USB dongleapplications', IEEE Trans. Antennas Propag., 2012, 60, pp. 4372–4380

[6] Haritha, A., Srinivasan, A.K., Shanmuganantham, T.: 'Compact printed UWBdiversity slot antenna for MIMO applications. Int. Conf. on Antenna Testingand Measurement Society, Pune, India, 2018

[7] Khan, M.S., Capobianco, A.D., Iftikhar, A., et al.: 'Ultra-compact dualpolarized UWB MIMO antenna withmeandered feeding lines', IET Microwave.Antennas Propag., 2017, 11, pp. 997–1002

[8] Mao, C.X., Chu, Q.X.: 'Compact coradiator UWB-MIMO antenna with dualpolarization', IEEE Trans. Antennas Propag., 2014, 62, pp. 4474–4480

[9] Li, J.F., Chu, Q.X., Li, Z.H., et al.: 'Compact dual band-notched UWB MIMOantenna with high isolation', IEEE Trans. Antennas Propag., 2013, 61, pp.4759–4766

[10] Li, L., Cheung, S.W., Yuk, T.I.: 'Compact MIMO antenna for portable devicesin UWB applications', IEEETrans. Antennas Propag., 2013, 61, pp. 4257–4264

[11] Adamiuk, G., Beer, S., Wiesbeck, W., et al.: 'Dual-orthogonal polarizedantenna for UWB-IR technology', IEEE Antennas Wireless Propag. Lett.,2009, 8, pp. 981–984

[12] Olver, A.D.: 'Handbook of microstrip antennas', Electron. Commun. Eng. J.,1991, 3, p. 52

[13] 'ANSYS HFSS',http://www.ansys.com-/products/electronics/ansys-hfss,

INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.379

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

9940 572 462 6381 907 438 ijircce@gmail.com

Scan to save the contact details