

Mimo Antenna Design For Frequency Ultra Wideband Work With High Isolation

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Abstract— MIMO UWB antenna is one of the main technologies for wireless communication that has a high capacity and data rate. One significant advantage of MIMO (Multiple Input Multiple Output) combined with UWB (Ultra Wideband) is its ability to reject interference, effectively canceling out dominant and unwanted wavefronts that affect antenna performance. Therefore, designing a MIMO UWB antenna system that has improved isolation between ports is a challenge for the authors. In this research, it was designed by modifying a UWB MIMO antenna using FR-4 Epoxy as the substrate. FR-4 Epoxy is characterized by a dielectric constant (ϵ_r) of 4.4, a loss tangent of 0.035, and a thickness of 1 mm. The resulting antenna achieved a working frequency range of 2.3-11 GHz, making it suitable for Ultra Wideband (UWB) communication applications. Notably, the antenna demonstrated enhanced isolation between the two ports, with isolation levels of -34.77 dB in the lower band and -34.917 dB in the higher band. These results indicate significant improvements in minimizing interference and enhancing signal quality, positioning the modified UWB MIMO antenna as a promising solution for high-performance wireless communication systems. The research findings highlight the potential of using FR-4 Epoxy as a substrate to achieve superior isolation and performance in MIMO UWB antenna systems.

Keywords— Antenna, wireless, Ultrawideband, MIMO.

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I. INTRODUCTION

In The past decade, a big proliferation and fast evolution has occurred in wireless mobile communications, which pushes researchers to look forward and seek new technologies that can provide massive and fast data transmission. Multiple input–multiple-output (MIMO) is a multiplexing technology by adopting multi antennas both at transmitter and receiver, which can enhance the channel capacity by taking full use of the rich scattering environment and without sacrificing additional spectrum or power [1], [2]. For its outstanding performances, MIMO technology will be widely used in the next generation of wireless communications. Meanwhile, ultrawideband (UWB) is also another technology that can provide massive data transmission at a time by occupying an extremely wide frequency band. For reducing power consumption and interference with other protocols, its signal transmission is confined in a very low level, which is under 41 dBm/MHz [3].

Since the Federal Communications Commission (FCC) released 3.1–10.6 GHz for unlicensed accessing and commercial use [3], UWB technology has been extensively studied, and lots of UWB antennas have been reported. Thus, to reach a high data rate, even as high as 1 Gb/s, a more advanced technology should be used. A combination of MIMO and UWB technology may be a good solution, which has been first reported systematically by Kaiser et al. in [4]. Until now, several reports on the MIMO antenna of UWB can be reached, in which different methods have been taken to obtain a good isolation. By placing antenna elements

orthogonally, i.e., their radiation orientations are orthogonal, [5] achieves a high isolation (dB) at 3.1–5.15 GHz.

Reference [6] proposes a UWB MIMO antenna (2.27–10.2 GHz) by placing elements far enough and inserting parasitic stubs between them to achieve a high isolation dB at most of the band). Reference [7] reveals a wide antenna (3.1–5 GHz) that works in the lower UWB range, in which a high

isolation (dB) is achieved by monopoles' orientation rotations and ground plane cut. In [8], a treelike structure was inserted between two elements to achieve a good isolation (dB) of the proposed UWB MIMO antenna. For all the mentioned UWB MIMO antennas above, some kinds of decoupling methods are inevitably used to achieve good isolations. This is always the common and effective way to do that, but the decoupling structures, more or less, occupy spaces in the MIMO antenna. Some of them make the MIMO antenna design more complicated, while the others make its size larger.

In this research, a completely different concept is proposed in which high isolation in an MIMO antenna can be achieved without using any extra decoupling structures or methods. This can be achieved by adopting antenna elements with obvious asymmetrical structures and radiation orientations. Quasi-self-complementary antenna (QSCA) is one of them and also has a wideband operation, and there are many reports that can be found, such as [9], [11]. As an example, a UWB MIMO antenna with lower wireless local area network (WLAN) coverage is proposed in this letter, and a type of quasi-self-complementary UWB monopole antenna is selected as an element. To fully investigate the potential of the selected UWB monopole antenna, not only a two-element UWB MIMO antenna is proposed, but a UWB MIMO antenna with the same four elements is also discussed.

II. MATERIALS AND METHOD

In this final project, a MIMO UWB microstrip antenna will be designed. Before designing an antenna, we must first know the specifications of the antenna to be designed and calculate the dimensions of the antenna with a rectangular patch.

A. Research Flow

The antenna design flow diagram starts from determining the dimensions of the antenna. Then designing and simulating the antenna design using CST Studio 2019 software.

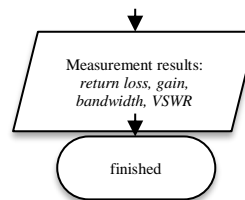
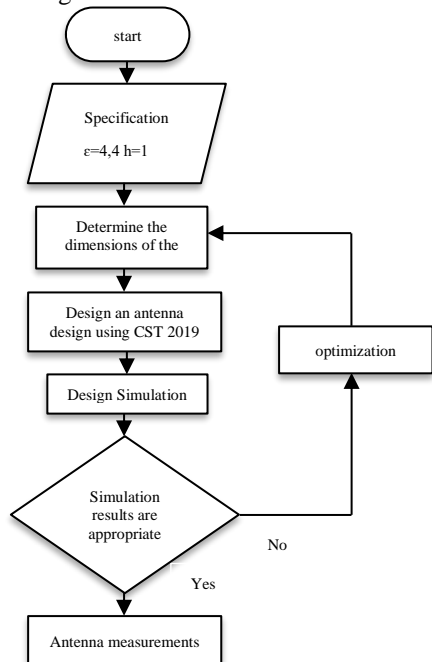


Fig 1. Research Flow

B. Antenna Dimensions

The dimensions of the antenna used are 41mm x 30mm x 1mm. The size of the final antenna design can be seen in Fig 2.

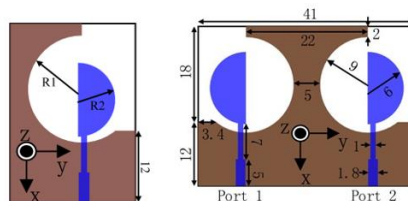


Fig 2. Reference Antenna Design Dimensions

After making several changes to the dimensions of the antenna, the simulation results can be obtained as desired. In the modified antenna, the dimensions of the circular patch are changed to 5.2mm, the width of feedline 2 is changed to 2.5mm. The antenna design can be seen in fig 3.

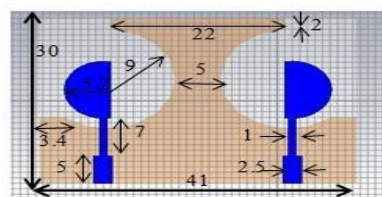


Fig 3. Antenna Design

TABLE I.
ANTENNA DIMENSION

Parameters	Mark	Description
L	41	ground height
W	30	ground width
Lg	5	feedline height 1
Wg	1.8	feedline width 1
Lf	7	feedline height 2
Wf	1	feedline width 2
a	6	finger patch
h	1	substrate thickness

The MIMO UWB microstrip antenna design with a frequency range of 2.19–11.07 GHz is not obtained using a formula but rather from reference papers that will be modified and parametric studies carried out to obtain optimal results in accordance with specifications.

C. Fabricated Antenna

This antenna is designed with FR-4 (Epoxy) substrate

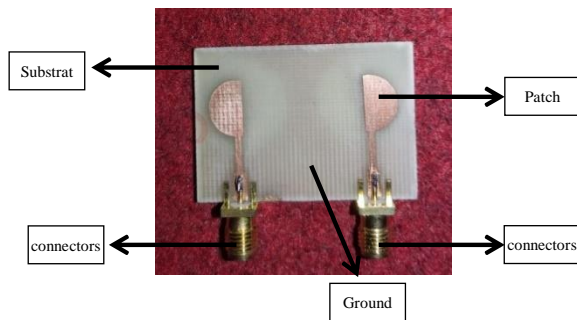


Fig 4. Fabricated Antenna

III. RESULT AND DISCUSSION

After completing the antenna design, the antenna design is obtained. From this design, fabrication and measurements were carried out to obtain values for antenna parameters, such as working frequency, return loss, isolation, VSWR, gain, bandwidth, correlation coefficient and radiation pattern shape.

A. Comparative Analysis of Optimized (Modified) Antenna Simulation with Reference Antenna Simulation

The design simulation process was carried out in this final project, new parameters were obtained, then analysis was carried out including parameters of working frequency, return loss, isolation, VSWR, bandwidth, gain and radiation pattern.

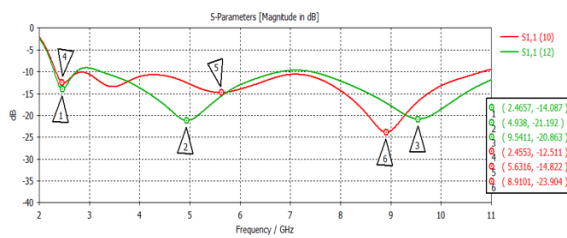


Fig 5. Return Loss Comparison

In figure 5 above is a comparison of the return loss of the reference design and the design in this final project. Where the return loss value in the reference antenna simulation results at working frequencies 2.4 GHz and 4.9 GHz (2–4 GHz) is -14.087 dB and -21.192 dB which is shown in green on curve markers 1 and 2. Then the return value loss at a working frequency of 9.5 GHz (7.4–11 GHz) is -20.863 dB as shown by curve marker 3.

Meanwhile, the return loss value in the design simulation results in this final project at a working frequency of 2.4533 GHz and 5.631 GHz (3–7 GHz) is -12.511 dB and -14.822 dB which are shown in red at curve markers 4 and 5. And the return loss value at a working frequency of 8.91 GHz (7–10.8GHz) is $-23,944$ dB with curve marker 6. From figure 4.4, The best return loss value is -23.944 dB for the antenna designed in this final project.

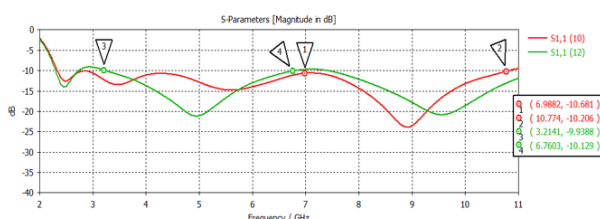


Fig 6. Bandwidth Comparison

In figure 6 From the results obtained, the modified antenna bandwidth has a better value than the reference antenna bandwidth, namely 3546 MHz.

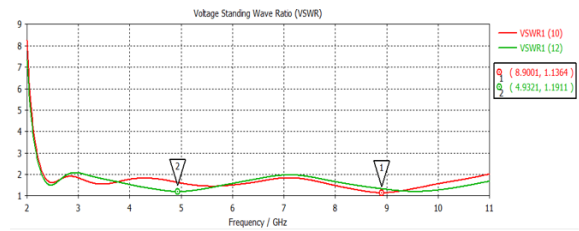


Fig 7. VSWR Comparison

In Figure 7 above, the best VSWR value for the antenna from the reference antenna simulation is 1.1911 dB at a frequency of 4.9 GHz which is shown in green and curve marker 2. Then the best VSWR value for the antenna from the simulation results in this final project design is equal to 1.1364 dB when the frequency is 8.9 GHz and shown at curve marker 1.

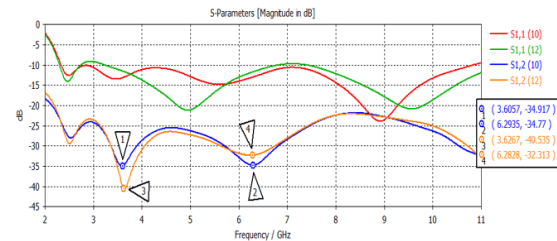


Fig 8. Insulation comparison

It can be seen in Figure 8 where the maximum insulation at the lower and upper frequencies on the modified antenna is -34.77 dB and -34.917 dB shown in blue as well as curve markers 1 and 2. And the results for the reference antenna in this final project have an insulation of -32.213 dB and -40.535 dB is shown in orange as well as curve markers 3 and 4.

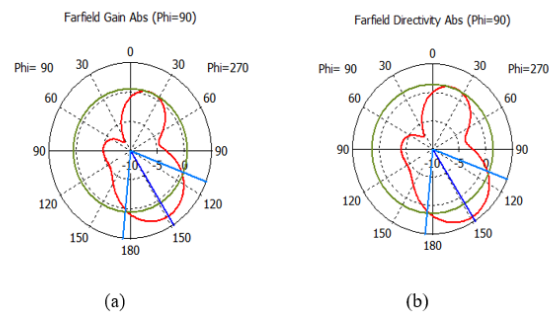


Fig 9. a) Design antenna radiation pattern, b) Reference antenna radiation pattern

Figure 9 (a) shows the antenna radiation pattern after modification and Figure 9 (b) is the reference antenna radiation pattern. The radiation pattern of the two antennas, both design and reference, has a bidirectional radiation pattern. A bidirectional radiation pattern is a radiation pattern that is the same in all directions and captures signals in every corner of the transmitting antenna. The modified simulation

results have met the expected radiation pattern, namely bidirectional.

B. Comparison of Optimized (Modified) Antenna Simulations with Fabricated Antenna Measurement Results

After carrying out the measurement process, the author tried to measure the measurement results with simulation results related to several parameters including working frequency parameters, return loss, and VSWR.

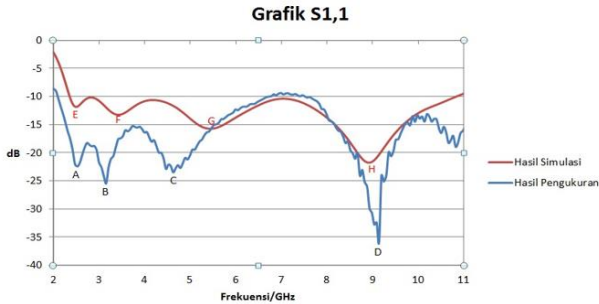


Fig 10. Return Loss Comparison

In figure 10 above is a comparison of the design return loss in this final project and the measurement results from the antenna fabrication. Where the return loss value in the modified antenna simulation results at working frequencies of 2.5 GHz and 3.5 GHz (2–4 GHz) is -13.087 dB and -14.192 dB which is shown by red color on the curve markers E and F. Then the return loss value at the working frequency of 5.5GHz (4–7.3 GHz) is -16.263 dB which is shown on the curve marker G. Lastly for the return loss value of the modified antenna at the working frequency of 9 GHz (7.3-11 GHz) of -21.988 dB with the H curve marker.

Meanwhile, the return loss value in the measurement results of the fabricated antenna in this final project at a working frequency of 2.4533 GHz and 3.131 GHz (2–4 GHz) is -23.511 dB and -25.122 dB which are shown in Blue on curve markers A and B. And the return loss value at a working frequency of 4.51 GHz (3–7 GHz) is -24.44 dB with curve marker C. Lastly for the return loss value from the results of measurements of fabricated antennas at a working frequency of 9.1 GHz (7.3-10 GHz) of -36.944 dB with curve marker H. From figure 4.4, the best return loss value is -36.944 dB from the results of measurements of fabricated antennas in the final project This.

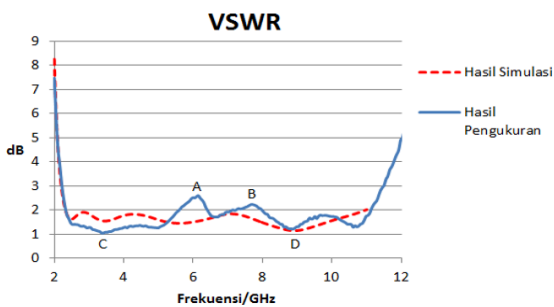


Fig 11. VSWR Comparison

For the VSWR measurement results of the fabricated antenna, the best result from the simulation of the fabricated antenna is 1.071 dB at a frequency of 3.3 GHz which is shown in blue and the curve marker C. Then the best VSWR value for the antenna from the simulation results in this final project design is 1.1864 dB when frequency 8.9 GHz and shown on curve marker D.

In the results of measuring the VSWR value of the fabricated antenna, there were poor results, namely at frequencies 6 GHz and 7.89 GHz with values of 2.57 dB and 2.2 dB shown on curve markers A and B.

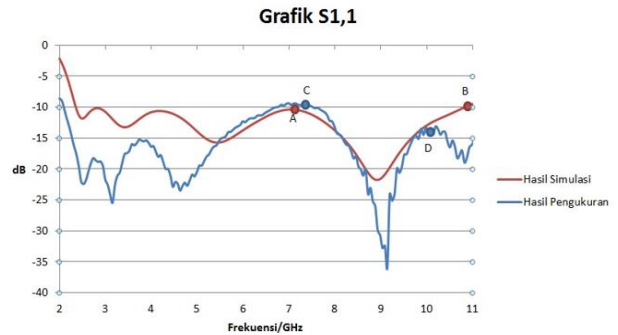


Fig 12. Bandwidth Comparison

From figure 13 above, the bandwidth value for the simulation results of the modified antenna is 3.5 GHz marked in red graph. Meanwhile, the bandwidth value for the modified antenna measurement results is 2.7GHz, marked with a blue graph.

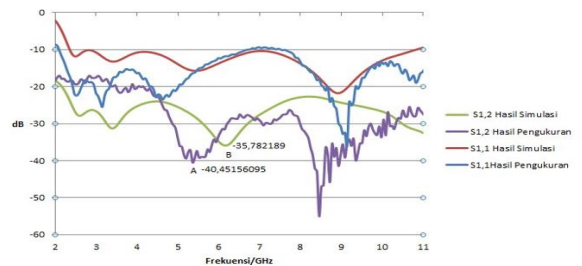


Fig 13. Insulation comparison

In mutual coupling measurements at a working frequency of 2-3 GHz it does not comply with the specified provisions, namely >20 dB. In the results S11 and S12 from the measurements of the fabricated antenna, sticking insulation occurs, namely at a frequency of 4.5 GHz. This can be influenced by errors during the coding process and other things.

TABLE II. COMPARISON OF FINAL RESULTS FOR ANTENNA PARAMETER VALUES

No	Parameter	Reference antenna	Modified antenna simulation results	Measurement results
1.	Frequency (GHz)	3.10-10.06	2.3-10.7	2.3-11
2.	Return loss (dB)	-20.867	-23.898	-36.944
3.	Bandwidth (GHz)	3.510	3.558	2.76
4.	Gain (dBi)	3.5	3.9	-
5.	VSWR(GHz)	1.1911	1.1364	1.071

From the data above, you can see a comparison of the values of the antenna parameters, starting from reference

antenna value data, modified antenna value data and modified antenna measurement data. Such as working frequency, return loss, isolation, VSWR, gain, bandwidth, correlation coefficient and radiation pattern shape.

CONCLUSION

MIMO microstrip antenna for portable UWB devices. The simulation results show that the proposed antenna design meets the specifications which include a better return loss value of -23.944 dB, better isolation, especially in the upper UWB band, namely -40.535 dB, higher bandwidth. width on top band 3546 MHz, then the increased gain from -4 - 4 dBi, and the radiation pattern almost perfect unidirectionality across the UWB.

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