

3.5 GHz Patch Microstrip Antenna Design Using CST STUDIO 2019 Software

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Abstract— Design, simulation, fabrication, and analysis of 3.5 GHz *Microstrip Patch* is a *microstrip antenna* building that has a small size and is simple. In today's era, microstrip patch antennas play an important role and are very useful because they are compact, easy to integrate, and lightweight. Therefore, quite a lot of people use it. This antenna is designed to operate in the frequency range of 3.4-3.6 GHz. This antenna is usually applied to satellite communications, radar communications, military, and smartphones. Microstrip antenna design is done by using three methods, namely simulation, measurement, and fabrication. The simulation method is software from design using *CST STUDIO SUITE 2019 software*, the measurement method is using Network Analyzer software, and for fabrication method is the result of antenna design done on PCB. From the simulation results of the 3.5 GHz microstrip antenna design using CST STUDIO SUITE 2019, antenna parameters such as *Radiation Pattern*, *VSWR*, and *Return Loss* were obtained. When fabricating, it is recommended that PCB cuts must be equilateral because this affects the measurement results, and when soldering must be careful and careful so that the results at the time of fabrication are not much different from the results during simulation in CST. If an error occurs during fabrication, the fabricated antenna fails due to lack of accuracy and caution in fabrication.

Keywords— Microstrip Antenna, 3.5 GHz Frequency, Radiation Pattern, VSWR, Return Loss.

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I. INTRODUCTION

Antennas are devices that function to convert electromagnetic wave energy from wired media to air or vice versa from air to wired media. Since it is an intermediate device between wired and aerial media, the antenna must have properties that match the wired media"[1]". These devices are connected to other wireless access points so that data and information can exchange data and information over wireless channels without interference"[9]". In the basic concept of antennas, some basic antenna parameters need to be considered. These parameters are Return loss, Voltage Standing Wave Ratio (VSWR), Radiation pattern, Gain, Polarization, and Bandwidth.

Microstrip antennas have advantages including their small and simple shape. Since many people use these communication tools, the need for small antennas that still work well despite their smaller size is increasing. These antennas are usually applied to satellite communications, radar communications, military, and smartphones. Microstrip antennas can be used for 4G or 5G networks. To produce good data transmission quality, a good antenna is needed, microstrip antenna is the best antenna for wireless communication at high frequencies for now. Microstrip patch antennas (MPAs) have become a good choice for these wireless communication systems because they can be adapted to a variety of applications.

It is now possible to manufacture complex structures efficiently and cost-effectively using a method known as

additive manufacturing rather than the traditional subtractive manufacturing method. The use of microstrip antennas has differences such as the coverage area, easy fabrication, small size, and lightweight, and can be integrated with existing communication devices”[8]”. In addition to having advantages, the use of microstrip antennas also has several disadvantages, among others, low gain, narrow bandwidth, low efficiency, and small size increase the accuracy of high measurements in the design and manufacture.

The 3.5 GHz microstrip antenna Model uses CST STUDIO SUITE 2019 and provides an overview of the measured antenna parameters, namely radiation pattern, VSWR, Return Loss, and Bandwidth. Both the frequency range that the antenna can receive and the bandwidth that it can transmit depend on the dimensions and shape of the antenna. Because they only come in two sizes, microstrip antennas are usually cheap, simple, and easy to make. Therefore, quite a lot of people use it.

II. METHOD

A. Tools and Materials

The tools needed are computer or laptop devices that have CST STUDIO SUITE 2019 software to help design and calculate antenna parameters before fabrication and measurement. The materials used for fabrication are PCBs and some other solvent materials.

B. Antenna Specifications

The antenna that will be designed in this final project is a microstrip patch antenna. This antenna operates by receiving and transmitting electromagnetic waves at a frequency of 3.5 GHz. The microstrip antenna design should have a VSWR of less than 2 so that the low VSWR value can be a good impedance adjustment between the antenna and the transmission line so that the power transmitted from the transmitter can be efficiently transferred to the antenna without much reflection. The design and simulation were carried out using the CST Studio Suite 2019 software application. The following are the specifications of the microstrip antenna to be designed.

TABLE I
ANTENNA SPECIFICATIONS

Specifications	Value
Radiation Pattern	3.5 GHz
VSWR	≤ 2
Return loss	≤ -10 dB
Gain	3 dB

C. Antenna Design

The first thing to do is to calculate the antenna patch in the form of length and width, obtained a patch length of 20 mm and a width of 26 mm. Furthermore, the calculation of the ground plane dimensions on the patch element is carried out and the results are obtained with a ground length of 29.81 mm and a ground width of 35.92

mm. The calculation results with the initial antenna dimension equation are shown in the table below.

TABLE 2
ANTENNA PARAMETER

Parameter	Value (mm)	Information
Width of substrate	26	W
Length of substrate	20	L
Ground patch length	29.81	Lg
Ground patch width	35.92	Wg
Length of patch	7.12	Lp
Width of substrate	1.6	h
Width of feedline	1.4	wf
Optimization	3.4312/3.5	op
Conductor width	0.00335	t

From the results of the calculation of the equations that have been carried out, the dimensions of the length and width of the patch element and the ground plane of the antenna element to be simulated are obtained, then the overall antenna dimension design process is carried out on the microstrip antenna.

After obtaining the dimensions of the antenna element, the next step in designing a microstrip patch antenna is to determine the antenna frequency. The frequency used in the microstrip antenna is 3.5 GHz. The next display is the selection of units to be used in the design. This design uses Gigahertz (GHz) frequency units, millimeter (mm) length units, and nanosecond (ns) time units which can be seen in the following figure.

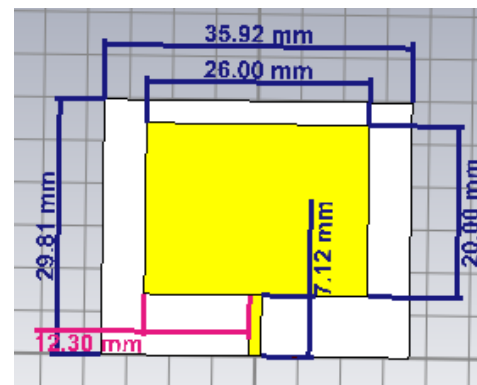


Fig. 1 Antenna Patch Mikrostrip

III. RESULTS AND DISCUSSION

A. Design in CST

In the process of simulating a microstrip patch antenna at a frequency of 3.5 GHz, the calculation of antenna dimensional parameters discussed in the previous section will be simulated using CST STUDIO SUITE 2019 software. After the results of the antenna simulation, parameters such as VSWR, return loss, radiation pattern will be obtained.

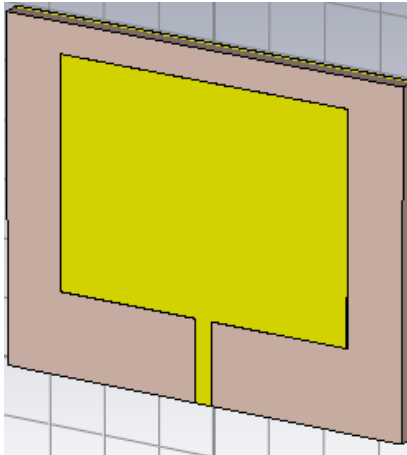


Fig. 2 Front View Antenna Design (Patch)

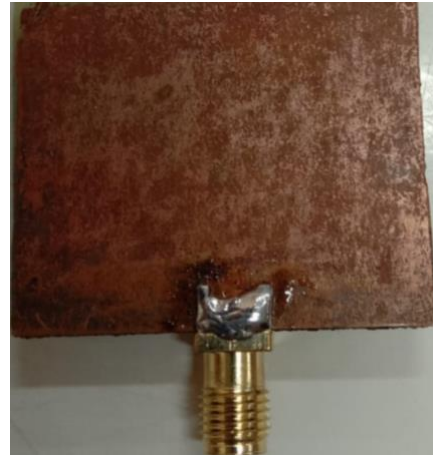


Fig. 5 Back View



Fig. 3 Design of the Antenna from the Rear View (Ground)

B. Fabrication Results

The fabricated antenna is made from FR-4 substrate material. The materials used for fabrication are PCB and SMA female connector. The fabrication of the metamaterial patch antenna can be seen in the figure below.

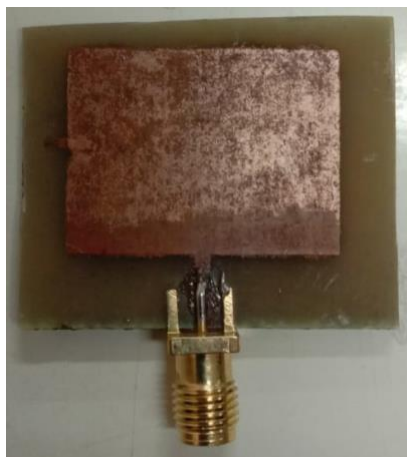


Fig. 4 Front View

C. Measurement of VSWR

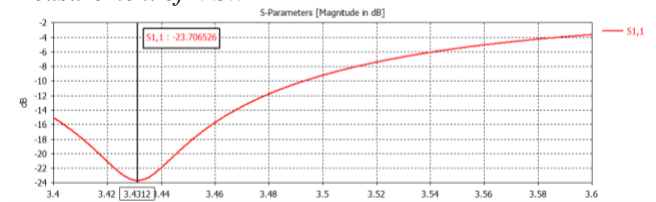


Fig. 6 Results of S-Parameters Simulation

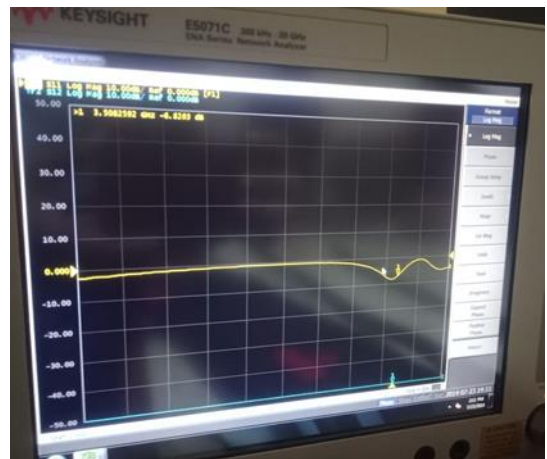


Fig. 7 Results of S-Parameters Measurement

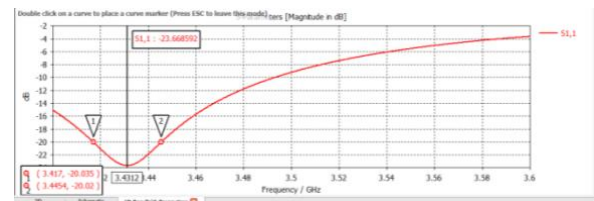


Fig. 8 Bandwidth from Simulation Results

The analysis is done to compare the simulation results with the measurements taken. The return loss value of an antenna is the ratio of the reflected power back to the radiated power. Bandwidth is the operating frequency range of the antenna, limited by two frequencies with certain return loss values according to the antenna function. In the simulation, the return loss value is -23.7065 dB and the bandwidth is 21.2 MHz. The measurement results show a return loss value of -23.6685 dB.

The return loss read on the antenna has met the desired parameter standard (≤ -10 dB) so that the antenna can be realized. However, when the antenna has been fabricated, there are errors in fabrication so that the measurement results of the antenna using the Network Analyzer that has been fabricated do not match the measurement results using CST.

D. Measurement of VSWR

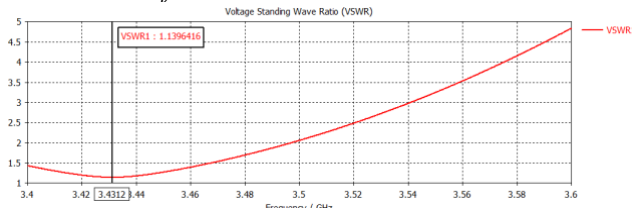


Fig. 9 Results of VSWR Simulation

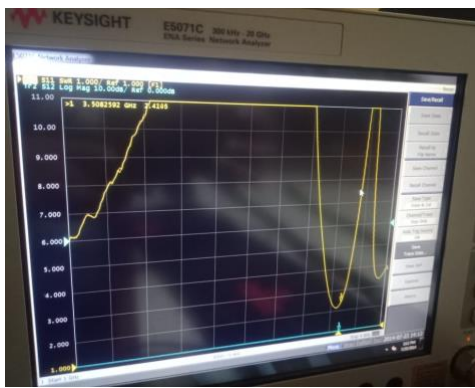


Fig. 10 Results of VSWR Measurement

For simulation results, the VSWR at a frequency of 3.5 GHz is 1.1402, while the measured value after fabrication is 2. The VSWR reading on the antenna does not meet the desired parameter standard (≤ 2) due to errors during fabrication, so the VSWR on the realized antenna is less successful.

E. Measurement of Gain

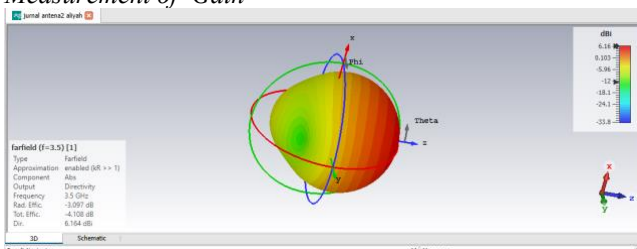


Fig. 11 Simulation Results of Gain

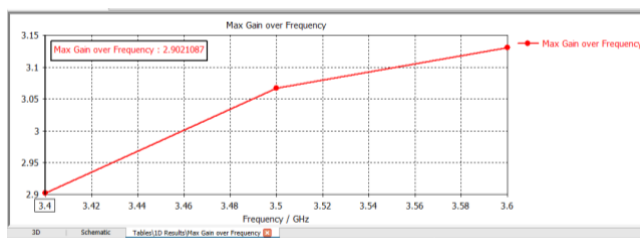


Fig. 12 Simulation Results of Gain

Gain refers to the ability of an antenna to increase the strength of a signal received from a specific direction.

F. Measurement of Radiation Patterns

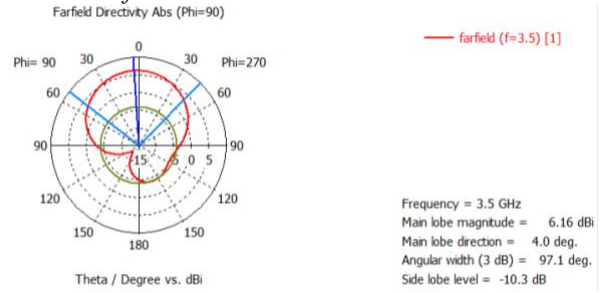


Fig. 13 Results of Radiation Pattern Simulation

Based on the image above, it can be seen that the radiation pattern obtained is a unidirectional radiation pattern, emitting only in one direction.

IV. CONCLUSION

The design of a microstrip patch antenna working at 3.5 GHz frequency has been completed and fabricated and measured. The antenna simulation results show VSWR and return loss at the center frequency of 3.5 GHz of 1.1402 and -23.7065 dB, respectively. The bandwidth of the microstrip patch antenna is 21.2 MHz in the frequency range of 3.41 - 3.44 GHz, respectively. Meanwhile, the measured VSWR and return loss are 1.14 and -23.6685 dB, respectively. The VSWR and return loss parameters have met the antenna specifications in the CST simulation. While the measurement results using Network Analyzer all parameters are significantly different from the simulation results. This is caused by the shape and size of the antenna that is not the same, because when cutting the PCB the sides on the antenna are not the same, then when soldering must be careful so that the results of the fabrication are not much different from the CST simulation results. Then the inaccuracy of measuring instruments can also cause discrepancies between simulation results and measurement results.

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