Jurnal Akta Teknik Elektro
(Journal of Electrical Engineering Acta)
e-ISSN No. 2798 – 477X

# Circle Patch Microstrip Antenna Simulation for Frequency 3.5 GHz

Wildan, Dwi Astuti Cahyasiwi, SyahAlam, Mohd Azman Zakariya, Harry Ramza

***Abstract* — This research proposed microstrip circular patch antenna simulation at a working frequency 3500 MHz. The antenna has been designed using a Duroid RT5880 substrate with dielectric constant ($\varepsilon_r$) = 2.2, substrate thickness (h) = 1.575 mm, and tangent loss = 0.0009 with microstrip line feeding. The simulation result, return loss value obtained -26.385, VSWR value 1.09, gain value 7.64 dBi, total radiation efficiency value -0.6489 dB, and bandwidth value 72 MHz (3468.8 MHz – 3541.9 MHz).**

***Keywords* —** Micro-strip Antenna, circular patch, simulation antenna

***Abstrak* — Pada penelitian ini diusulkan simulasi antena mikrostrip circular patch pada frekuensi kerja 3500 MHz. Antena dirancang menggunakan substrat Duroid RT5880 dengan konstanta dielektrik ($\varepsilon_r$) = 2.2, tebal substrat (h) = 1.575 mm, dan rugi – rugi tangensial = 0.0009 dengan microstrip line feeding. Hasil simulasi diperoleh nilai return loss -26,385, nilai VSWR 1,09, nilai gain 7,64 dBi, nilai efisiensi radiasi total -0,6489 dB, dan nilai bandwidth 72 MHz (3468,8 MHz - 3541,9 MHz).**

***Keywords* —** Antena Mikrostrip, patch melingkar, simulasi antena

## I. INTRODUCTION

An antenna is a device can transmit and receive the electromagnetic waves. In wireless communication, the antenna is an important device that can connect two ports through the transmittance of the electromagnetic wave [1]. In the application of antenna, it is widely used in many varying forms and applications. Many forms of antenna that are mostly applied such as; wire antenna, aperture antenna, microstrip antenna, array antenna, reflector antenna, and lens antenna. From several patterns of antennas have been selected microstrip antennas because the advantages are having a small shape and easy manufacturing process[2].

The development of telecommunication technology related to the mobile communication continues to grow along with the times.

Starting from that which can only be used for call and send messages now who can access the latest ones can do control remotely using only a Smartphone. This 5G technology is able to control remotely and this tech is the fifth from its generation which still developing in mobile communication. Generally in wireless communication that utilizes electromagnetic wave radiation works at certain frequencies, as well as 5G technology in Indonesia will use the mid band frequency at 3.5 GHz which is currently used by satellites [3]. By referring to these sources, this study focuses on creating antennas that can work on these frequencies well.

In this study a simulation process will be carried out to get the antenna results that can work well at a frequency of 3.5 GHz. The microstrip antenna that will be created has a circular radiating element with Rogers RT5880 substrate. The design starts from the classical calculation to get the initial dimensions of the antenna and then a modification process to get maximum results. The simulation process was carried out in the CST 2015 software to determine the performance of the antenna that will be made before the fabrication process is carried out. The performance will be observed based on geometry shape of antenna from the modification process. The performance that will be seen in the antenna includes return loss, VSWR, and bandwidth.

## II. RESEARCH METHODS

### *A. Research Methods*

To get the desired antenna there are several stages that must be passed in the sequence of research:

1. Problems identification, by formulating the background for research purposes
2. Study literature, by collecting data from reference books and journals relating to research on circular microstrip antennas.
3. Designing, by designing and determining the type of patch, model, substrate, and power supply used in the simulation.
4. Testing, which is doing a simulation process and modification to get the desired results.Perancangan Patch Antena.

First, Antenna was designed by determining the type of substrate to be used, because the substrate will use have an impact on the performance and dimensions of the antenna produced. The selection of substrate is based on the substrate thickness (h) and the dielectric substrate constant (εr) it has. The more thick substrate will be affect to increase of radiation power, reduce conductor losses, and improve bandwidth impedance. The thicker substrate also increases the weight, dielectric losses, surface wave losses, and unrelated radiation from the examiner feeder. The dielectric substrate constant has an effect like the thickness of the substrate. A small value of εr will increase the edge area of the circumference of the patch, and will radiate it. Therefore the substrate with the value εr ≤ 2.5 has better results [4].

Using a thick substrate and a large εr value will increase dielectric losses and this will reduce antenna efficiency [5].Therefore substrate is used to avoid decreasing the efficiency of the antenna, the chosen substrate in this study was Rogers RT5880 which has a substrate thickness of 1.57 mm and a value of εr = 2.2.More complete substrate specifications can be seen in table 1 [6]

**Table1Specification of Duroid / Rogers Substrate RT5880**

| Parameter | Value |
|---|---|
| Dielectric Constant Substrate | 2.2 |
| Substrate Thickness | 1.57 mm |
| Material Conductivity | $2 \times 10^7 \, {}^{S}/_{m}$ |
| Loss DielectricTangent | 0.0009 |
| Relative Permeability Constants | 1 |

From table 1 antenna that will be create using Rogers RT5880 substrate which has h = 1.57 mm thickness and εr = 2.2 value, an antenna with a 3.5 GHz working frequency created by using a circle patch. Circle patch is a radiating element with a radius of A, to find the value of A can use equation (1) [5]. Antennas are expected to have return loss values ≤ -15 and VSWR ≤ 1.5 as the initial reference.
.

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}} \quad (1)$$

dengan:

a = circle radius (mm)
h = substrate thickness (mm)
$\varepsilon_r$ = permittivity dielectric substrate
F = logarithmic function of the radiating element

From the above equation to get the value of the logarithmic function of the radiating element using 2.

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

dengan:

$f_r$ = resonance frequency (MHz)
$\varepsilon_r$ = permittivity dielectric substrate

*B. Designing the feeder Channels*

To send a waves from the transmission line to the antenna needs a feeder channel that connects the outer connector with the antenna patch.to get a matching antenna state, a transmission line is needed with a characteristic impedance of 50 Ohm, therefore the feeder channel is modified to have an impedance of 50 Ohm [2].Determination the width of feed channel must be modified to have an impedance of 50 Ohm, a method that can be used to get the width of feed channel can use the macros menu in the 2015 CST software.

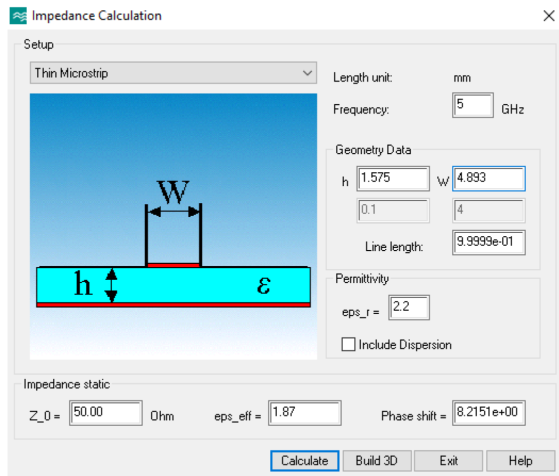


**Figure1.Feed Channel Width Calculation**

By using the CST 2015 software, you can get the width of the feed channel from the microstrip antenna. Steps to calculate the width of the feed channel by selecting the following menu Macros - Calculate - Calculate Analytical Line Impedance - Thin Microstrip.After that the display will open as shown in Figure 1. From the display in Figure 1, by entering the value of the substrate thickness h, the dielectric constant εr, and the width of the feeder channel W to obtain a value of 50 Ohms on $Z_0$.

## III. SIMULATION RESULT

Using (1) and (2) can be obtained a value that can be used to make the first design of the antenna that looks like in Figure 2.

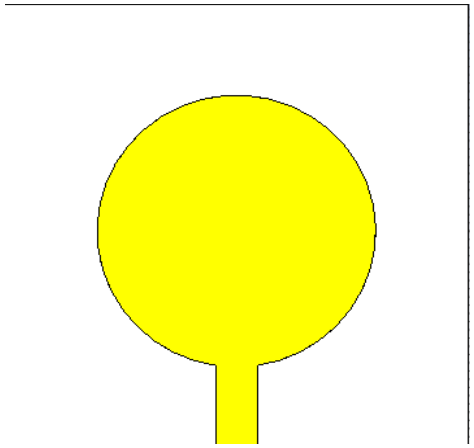

**Figure 2.First antenna dimensions**

From the results of calculations in equation (1) the value of a antenna is 15.94 mm, the width of the feeder channel is 4.89 mm as shown in Figure 2, after the simulation process on the software, the return loss value is -2.5569 dB and VSWR 6.84.The result has not reached the expected value, therefore to achieve or exceed the expected value, iterates the value of a and uses the insert feed to get the expected results. To find out the difference of each iteration applied the changing will be noted in table 2 and the image of the antenna after iteration is shown in Figure 3.

**Table 2. Size Modification Comparison**

| Shape | fPeak (MHz) | Reference Impedance (Ohm) | Return Loss | VSWR | Bandwidth -10dB (MHz) |
|---|---|---|---|---|---|
| Start | 3604 | 50.24 | -2.5569 | 6.84 | Insufficient |
| Modif 1 | 3490 | 50.11 | -2.5 | 6.99 | Insufficient |
| Modif 2 | 3554 | 50.04 | -2.865 | 6.11 | Insufficient |
| Modif 3 | 3462 | 50.04 | -2.884 | 6.07 | Insufficient |
| Modif 4 | 3518 | 50.05 | -3.68 | 4.789 | Insufficient |
| Modif 5 | 3546 | 50.05 | -6.6 | 2.756 | Insufficient |
| Modif 6 | 3504 | 50.04 | -26.385 | 1.09 | 75.8 |

From table 2, the antenna exceeds the expected value, namely Return loss ≤ -10 and VSWR ≤ 1.5 in modification to 6.By using an antenna radius of 16.94 mm, the width of the feeder channel is 4.92 mm and adding an insert feed with a length 13 mm and a width 1.3 mm can make an antenna that meets the expected value, the shape of the antenna can be seen in Figure 3

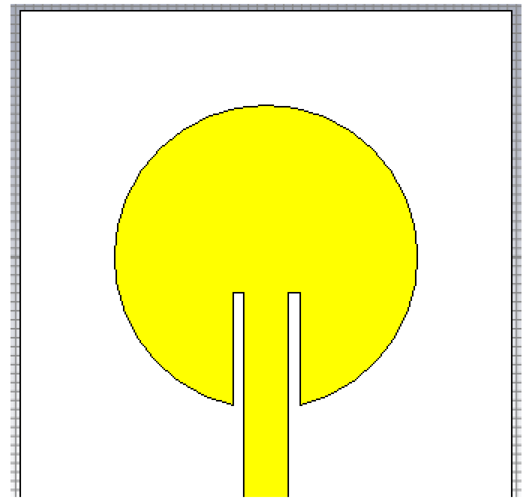

**Figure 3. Last antenna dimensions**

Figure 3 is the work result of the antenna after the simulation process is carried out. The value of return loss, bandwidth, and VSWR from the antenna can be seen in Figure 4 and Figure 5

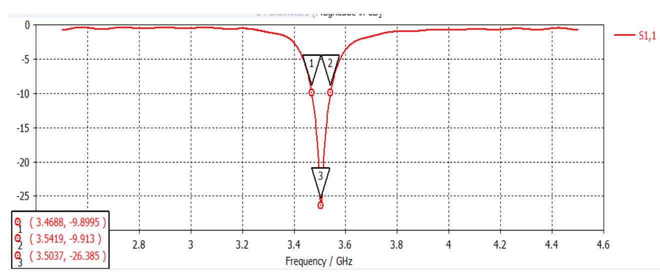


**Figure 4. S-Parameter dalam dB**

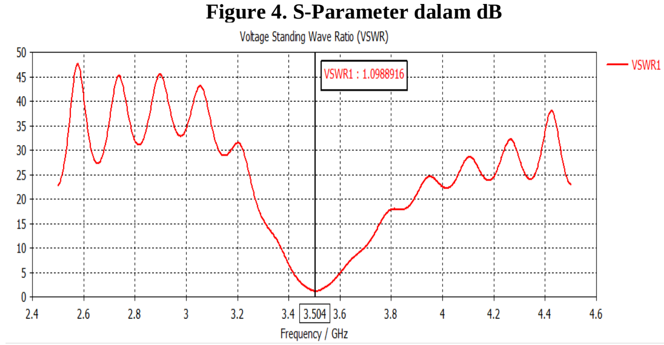


**Figure 5. Grafik VSWR**

In Figure 4 can be seen the value of the return loss of -26,385 dB with the bandwidth obtained at 75.8 MHz. While in Figure 5 obtained VSWR at 1:09, which means that the antenna can radiate almost all power flowed and little power is reflected back from the antenna.

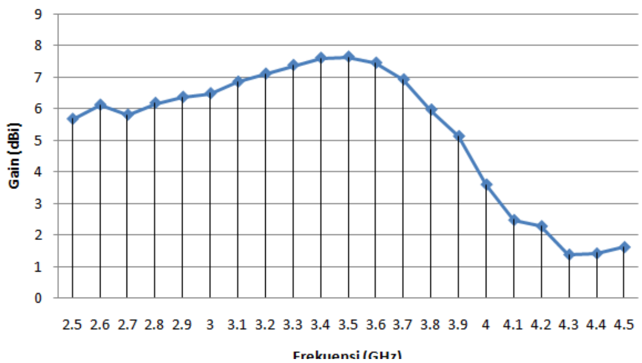


**Figure 6.Simulation Gain Graph**

Figure 6 shows a graph of the gain obtained in the antenna simulation process. gain at the middle frequency of 3.5 GHz at 7.64 dBi.

## IV. CONCLUSION

From the simulation, it was found that the circle antenna with a radius of 16.94 mm, the width of the feeder channel is 4.92 mm and an insert feed with a length of 13 mm and a width of 1.3 mm can produce an antenna with a return loss of -26,385 and VSWR of 1.0989. The use of inset feeds on an antenna can affect the performance of the antenna. Total antenna radiation efficiency obtained for -0.6489dB and gain obtained in 3504 ferkuensi GHz at 7.64 dBi. Although the microstrip antenna has small dimensions but it still gain little bandwidth, the bandwidth of this study was attained at 3,504 GHz frequency only by 72 MHz. This bandwidth is too small if it is used to capture information from many channels.

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Articles received on July 21, 2019.

**Wildan**
Wildan from the Electrical Engineering Study Program, Faculty of Engineering, Muhammadiyah University Prof. Dr. HAMKA, Jakarta. His research fields are antennas, microwaves and satellite technology (Authors of e-mail: ahmadwildan49@gmail.com).

**Dwi Astuti Cahyasiwi**
Cahyasiwi from the Electrical Engineering Study Program, Faculty of Engineering, Muhammadiyah University Prof. Dr. HAMKA, Jakarta. His research fields are about antennas, microwaves, wave propagation phenomena, and antenna simulations (telephone: + 62 813-1842-3076; email: dwi.cahyasiwi@uhamka.ac.id).

**Syah Alam**
Alam from the Department of Electrical Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta, INDONESIA. The research studied was antennas, microwaves, the phenomenon of propagation (telephone: + 62 857-1003-4984; e-mail: alam.elo15@gmail.com).

**Mohd Azman Zakariya**
Azman is from the Electrical and Electronic Engineering Department, faculty of engineering, Universiti Teknologi Petronas, Malaysia. His research fields are RF and Microwave Engineering, and Communication system. (telephone: + 60 19-557-3695; e-mail: mazman_zakariya@utp.edu.my).

**Harry Ramza**
Ramza is from the Electrical Engineering Study Program, Faculty of Engineering, Muhammadiyah University Prof. Dr. HAMKA, Jakarta. The research fields studied were Optical Instrumentation, Fiber Optic Sensors, Optical Antennas (telephone: +6221 813 – 1251 – 7572 ; e-mail: hramza@uhamka.ac.id).