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Monopole Antenna Design Analysis for TNI AD Satellite Telecommunication

Vincensius Arga Yoda[1], Erfan Rohadi[2], and Arwin Datumaya Wahyudi Sumari [1]

[1] *Electrical Engineering, State Polytechnic Of Malang, Malang, Indonesia*
[2] *Information Technology, State Polytechnic Of Malang, Malang, Indonesia*

Corresponding Author: Vincensius Arga Yoda, 2051180019@student.polinema.ac.id

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Abstract

Antenna that is made dynamically, light and cheap are the characteristics of microstrip antenna. Microstrip antennas have the characteristics of working at high frequencies according to the antenna calculations if the dimensions are small, the working frequency becomes high frequency. So the monopole microstrip antenna is the solution to the existing military communications. This research will study a monopole antenna design with small dimensions using parameters in millimeters (mm). This antenna works at a working frequency of 3.73 GHz. The substrate used has a size of 99.53 mm x 84.35 mm with a thickness of 0.787 mm, = 4.4×1012F·m1 and an impedance of 50 . Antenna performance can be seen from the value of Return Loss, Bandwidth, VSWR, and Radiation Pattern of the antenna. The simulation result data is presented using the WIPL-D software based on the Method of Moment. This indicates that at 3.73 GHz the highest gain value is 5.4 dB, VSWR 1.46 with a bandwidth of 10.18% and a return loss of -14.44 dB. This result is sufficient to meet the satellite communication in the coverage area of the C Band which works in the frequency range of 3-4 Ghz.

Keywords : Monopole, Bandwidth, VSWR, Return Loss, Gain, C Band

1 Introduction

Communication in the military involves a variety of devices ranging from very large dimensions such as airplanes to the smallest such as mobile phones. With the many needs for wireless communication on military devices, an antenna is needed that can support communication needs that can be embedded in various military devices [1]. Dynamic, light and inexpensive antennas are the characteristics of microstrip antennas. Microstrip antennas have the characteristics of working at high frequencies according to the antenna calculations if the dimensions are small, the working frequency becomes high frequency. So the monopole microstrip antenna is the solution to the existing military communications. Analysis and design Monopole antennas intended for the purpose of receiving voice signals from high frequency devices are generally small external antennas. The external Monopole antenna can be used for many military devices and ensures long distance communication with those devices.

Based on the above conditions, the author's aim is to design and analyze an antenna with a simple design, small and efficient dimensions, very easy installation, cheap and fulfills the characteristics of the antenna to support movement in combat training in a military environment. The antenna that will be discussed is an analysis of monopole antenna design in the military world. This research will study a monopole antenna design with small dimensions using parameters in millimeters (mm). This antenna works at a working frequency of 3.73 GHz. The substrate used has a size of 99.53 mm x 84.35 mm with a thickness of 0.787 mm, = 4.4×1012F·m1 and an impedance of 50 . Antenna performance can be seen from the value of Return Loss, Bandwidth, Impedance, and Radiation Pattern of the antenna. The simulation result data is presented using WIPL-D software based on the Method of Moment [2].

This scientific and research contribution is the development of monopole antennas that can be used in various military devices so that maintenance and replacement are easier and cheaper. Furthermore, the design of an antenna using the WIPL-D EM Simulator based on MoM (Method Of Moment) so that it can realize the desired antenna design results, according to needs with a predetermined working frequency or the best design before fabrication is carried out to continue experimental and simulation studies[3].

2 Method

Referring to a previous study entitled A new small high-gain wideband rectangular patch antenna for X and Ku bands has been presented [4]. Slight difference in antenna design and usability in the frequency range used is the C band. Figure 1 is a design by setting the antenna parameters, namely the horizontal length (ws) and (wp) of about 99.53 mm x 84.35 mm, the simulated vertical height (h) of about 1.6 mm in order to achieve the impedance adjustment at the center frequency will be set in such a way as to get the characteristic antenna at 3.73 GHz frequency [5]. By paying attention to the characteristics of return loss, gain, VSWR, antenna bandwidth at the working frequency and performing numerical analysis of the simulation results of the first experiment in order to obtain the expected antenna characteristics [6].

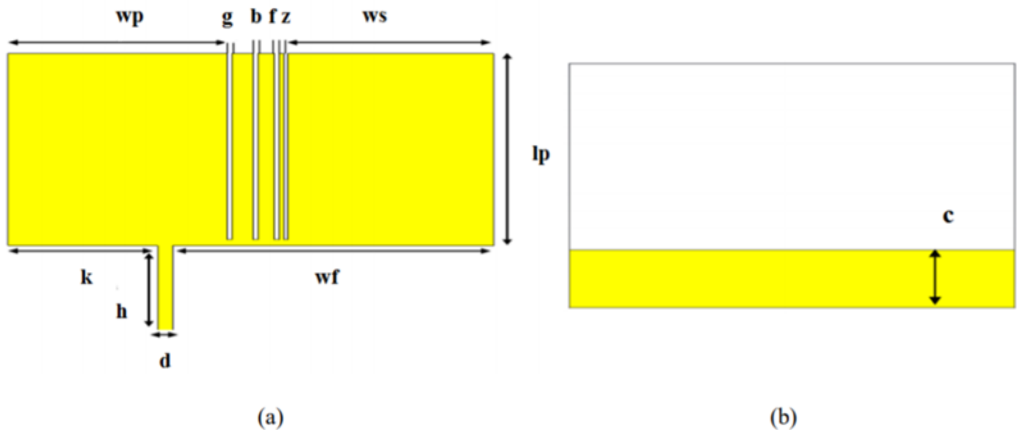


Figure 1: (a) Monopole antenna geometry (b) the back of the substrate

The monopole antenna has the following parameters in millimeters (mm):

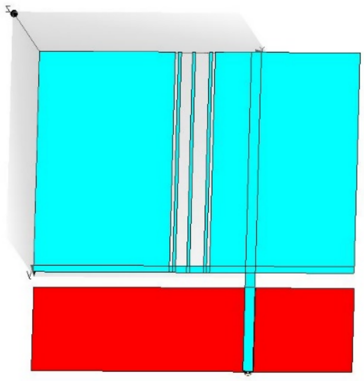
Table 1: Antenna Dimensions

Frequency Of Work	3.7 Ghz
Wp	34.30 mm
g	0.70 mm
b	3.30 mm
f	2.65 mm
z	0.75 mm
ws	32.20 mm
lp	52.81 mm
wf	50.25 mm
d	2.35 mm
h	23.54 mm
k	23.40 mm
c	20.09 mm

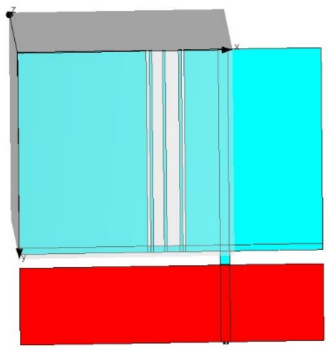
Based on the dimensions of the antenna above, simulations can then be carried out using the WIPL-D simulation application using MoM (Method of Moment) to obtain the values of the VSWR, return loss, gain and bandwidth parameters. It is expected that this monopole antenna can work on the C Band frequency which is in the 3-4 Ghz frequency range.

3 Results and Discussion

The plans that have been prepared are then applied through WIPL-D. Figure 2 show a design view in WIPL – D.



(a)



(b)

Figure 2: Design in the WIPL app – D (a) Front View (b) Back View

After carrying out the modeling process, the next step is to collect data in the form of Return Loss, VSWR, Polaradiation (Gain), and Bandwidth. Figure 3 shows the results of the Return Loss.

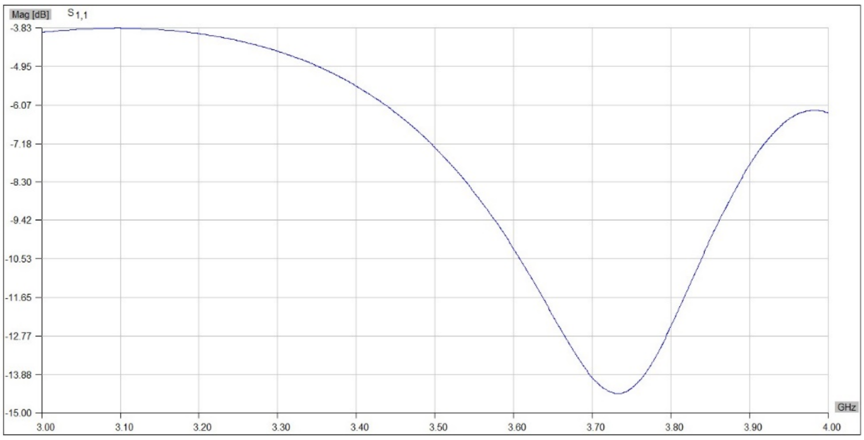


Figure 3: Return Loss

The graph of Return Loss shows < -13 dB, in detail the results obtained are -14.44 dB with a frequency range of 3-4 Ghz, precisely working at a frequency of 3.7 Ghz. These results indicate the suitability of the performance of the antenna where the recommended return loss < -10 dB shows good [7]. From the return loss, the bandwidth can be obtained from the width of the highest peak frequency minus the lowest frequency. Here is the formula for bandwidth.

$$Bandwidth = \frac{f_2 - f_1}{f_c} \tag{1}$$

Description:

Bandwidth = antena (%)

f_2 = Highest frequency (Hz)

f_1 = Lowest frequency (Hz)

f_c = Middle frequency (Hz)

By using the above formula, the bandwidth that can be generated from the calculation is 10.18%. With a frequency range from the highest and lowest at 3.45 – 3.97 Ghz.

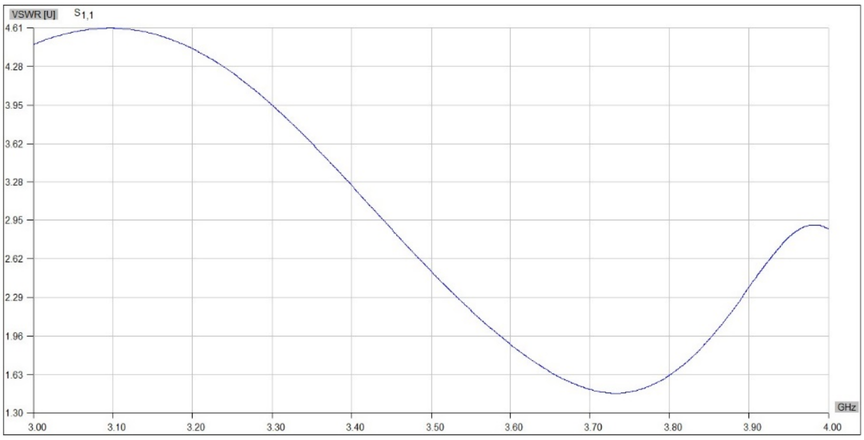


Figure 4: VSWR (Voltage Standing Wave Ratio)

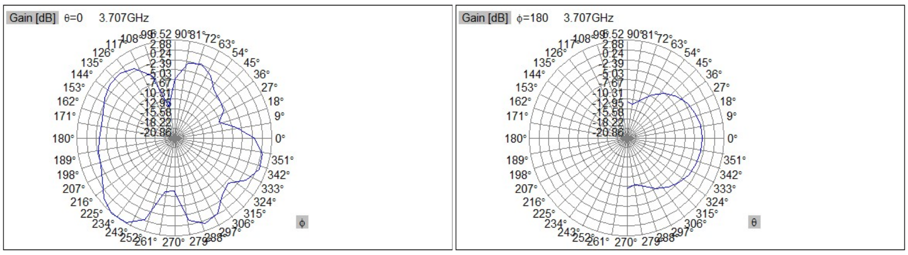
The next parameter is VSWR (Voltage Standing Wave Ratio) in Figure 4, it is known that VSWR is < 2 to be more precise 1.46. These results show that the VSWR value is almost close to the value of 1.00, which means that this antenna can be used properly at a frequency of 3.7 GHz.

$$VSMR = \frac{|V_m ax|}{|V_m in|} = \frac{|1+\Gamma|}{|1+\Gamma|} \tag{2}$$

The voltage reflection coefficient (Γ) has a complex value, which represents the magnitude and phase of the reflection. For some simple cases, when the imaginary part of is zero [13], then:

1. Γ = -1 : maximum negative reflection, when the line is shorted
2. Γ = 0 : no reflection, when the channel is perfectly matched.
3. Γ = +1 : maximum positive reflection, when the line in the circuit is open.

A good antenna is when the VSWR is 1 which means there is no reflection when the channels are in a perfect matching state. However, this condition is difficult to obtain in practice. Therefore, the standard VSWR value allowed for antenna manufacturing is VSWR $\leq$ 2. VSWR is a parameter that is taken into account so that the antenna can work properly. From the results of the VSWR obtained a large gain that is raised by this antenna. Figure 5 shows an overview of the radiation polarization or gain that occurs during the simulation.



(a) (b)

Figure 5: (a) Polaradiation ϕ cut (b) Polaradiation θ cut

Next is the radiation polarization parameter, in this radiation pattern the magnitude of the gain obtained can be determined. In the simulation, this antenna produces a gain of 5.4 dB. The results obtained are quite large amplifiers issued by this antenna which refers to previous research that the antenna produces a gain of 4.91 dB. With several experiments that have been done, the author finally got a better gain.

The gain or gain of an antenna is closely related to the directivity, which is a quantity related to the efficiency of the antenna and its directional capability [14]. There are two types of gain (gain) on the antenna, namely absolute gain (absolute gain) and relative gain (relative gain). However, in this antenna, using absolute gain, the absolute gain on an antenna is defined as the ratio between the intensity in a certain direction and the radiation intensity obtained if the power received by the antenna is radiated isotropically. The radiation intensity associated with the radiated power isotropically equal to the power received by the antenna (P_in) divided by 4π. Absolute gain can be calculated by:

$$G = 4\pi \frac{U(\theta, \phi)}{P_{in}} \tag{3}$$

Description:

G = antenna gain (dB)

U = Antenna radiation intensity (watt)

P_{in} = total input power received by the antenna (watt)

An antenna can obtain good or bad gain results from the size of the antenna and the substrate material used by the antenna. Table 2 shows a comparison of gain improvements to the antenna that the authors have done from previous studies

Table 2: Comparison of the antenna used with previous studies

Antenna	Bandwith (Ghz) at < 10 dB VSWR < 2	Antenna Size (mm^3)	Gain (dB)
This work	3.45 - 3.97	99.53 x 54.3 x 0.787	5.4
	10.8 – 13.55	18 x 20 x 1.58	4.91
[9]	9.7 – 11.7	30 x 21 x 1.5	5.35
[10]	10.8 - 12.7	20 x 25 x 0.254	5.05
[11]	9.75 – 11.85	40 x 40 x1.6	2.04
[12]	10.47 – 11.48	20 x 17.5 x 1.6	3.99

4 Conclusion

From the results of this study, it can be concluded that this monopole microstrip antenna can work as expected. The parameter results from the simulation show that this antenna can work at a working frequency of 3.7 Ghz which is the C Band category. In other words, this antenna can be used for satellite communication. Other parameters show the amount of VSWR obtained, which is < 2 more precisely 1.44, the gain obtained is 5.4 dB and the return loss is – 14.44 dB. from the results that have been obtained, the authors conclude that using a monopole antenna is quite proper to use in satellite communications in the C Band frequency.

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