Comparison analysis performance microstrip antennas for software and measurement

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Abstract. In antenna design there are several antenna software that can be used to design for example CST, Microsoft office AWR, Advance Digital Signal (ADS). After calculating using the antenna formula, then it is designed using antenna software. Antennas are printed and measured to determine the performance parameters of the antenna. When designing by calculating using formulas, and software, which is then measured using the Vector Network Analyser (VNA). In this study, it can be seen the level of error using antenna software, as well as measurements on performance parameters. The antenna size is 49x49 mm\textsuperscript{2} both using antenna software and measurement. The result of performance parameters return loss are -47.43 dB, bandwidth of 163.7 MHz and VSWR 1.009 using software at the frequency 2.4 GHz. The result performance parameters by measurement, return loss decreases to -12 dB, bandwidth of 119 MHz and VSWR 1.111 at frequency 2.334 GHz. The difference in the performance parameter values between software and measurement can be influenced by several factors are when printing antenna, soldering that is to hot causes copper in the antenna to become hot so it affects the propagation of electromagnetic waves.

1. Introduction

Antennas can be defined as conductors that are used to receiver or transmitter electromagnetic waves into free space or received electromagnetic waves from free space. Electrical energy emitted from the transmitting antenna is converted into electromagnetic waves then by antenna, the electromagnetic waves are transmitted to free space. At the receiving antennas, electromagnetic waves are converted back into electrical energy by using an antenna [1-3].

Microstrip antennas have several advantages compared to other antennas. Easy modelling and fabrication, low cost of printing, being able to provide better performance and compatibility with data communication devices via wireless LAN with the use of fast internet access. In this study, the patch antenna designed and analysed is a rectangular patch using left handed metamaterial technique which functions to make the permeability value to make the magnetic field ≤ 0 and the permittivity value to make the electric field ≤ 0 with the performance parameters observed are gain, VSWR, return loss and bandwidth antenna.[4]. Microstrip antenna has three basic parts:

a. Radiation (patch) is the part located at the very top of antenna made from a conductor which functions to radiate electromagnetic waves.
b. The substrate is a medium whose function to transmit electromagnetic waves from the feed system.

c. The ground plane is the lowest layer that functions as a reflector that reflects signals.

2. Method of Antennas

In this study, the method used is qualitative. The first antenna size obtained through formulas and calculations, then the size obtained in the calculation is designed using antenna software. After the performance are obtained according to the desired return loss ≤ -10 dB, VSWR ≤ 2 and wide bandwidth at the desired work frequency. Then the antenna designed using the software was printed with the same size and measured using vector network analyser (VNA) to get the desired performance parameters at the desired frequency cut off [4].

2.1. Dimensional design of patch antennas

The patch antenna dimension is the antenna dimension in the shape of rectangular obtained by using equation 1 [4-7].

\[ W = \frac{c}{2f_0 \sqrt{\varepsilon_r}} \]  \tag{1}

Where \( W \) is the width of the patch antenna, \( c \) is the velocity of light, \( \varepsilon_r \) is the permittivity of the antenna material, \( f_0 \) is the resonant frequency of the antenna. To determine the length of patch (L), parameter \( \Delta L \) is required, which is the increase in length of L. The increase in length of L (\( \Delta L \)) can be calculated by equation 2 [4-7].

\[ \Delta L = 0.412 \left( \frac{\varepsilon_{\text{eff}} + 0.3 \frac{W}{h} + 0.262}{\varepsilon_{\text{eff}} - 0.258 \frac{W}{h} + 0.013} \right) \]  \tag{2}

Where \( h \) is the thickness of the substrate, \( \varepsilon_{\text{eff}} \) is the dielectric constant which can be calculated by equation 3 [4-7].

\[ \varepsilon_{\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} + \frac{1}{\sqrt{\varepsilon_r + 1}} \frac{h}{W} \]  \tag{3}

The patch length (L) can be calculated by equation 4 [4-7].

\[ L = L_{\text{eff}} - 2\Delta L \]  \tag{4}

Where \( L_{\text{eff}} \) is the effective length which can be calculated using equation 5 [4-7].

\[ L_{\text{eff}} = \frac{c}{2f_0 \sqrt{\varepsilon_{\text{eff}}}} \]  \tag{5}

2.2. Antenna based on software

Microstrip antenna is designed by using antenna software to get the value of performance parameters, return loss ≤ -10 dB, VSWR ≤ 2 and wide bandwidth. In this study, the antenna designed was a rectangular patch microstrip antenna with technique left handed metamaterial (LHM) at frequency cut off 2.4 GHz. In antenna design based on software, obtained patch dimensions of 27×35mm2, substrate dimensions of 49x49 mm2. The antenna design that is designed using software antenna can be seen as in Figure 1.

2.3. Antenna based on measurements

Microstrip antenna that has been designed using software, then printed to measure its performance parameters using vector network analyser (VNA). By using the same substrate and patch sizes as the software, the patch dimensions are 27×35mm², substrate dimensions are 49x49 mm². The antenna design using measurements can be seen as in Figure 2.
3. Result and Discussion

The return loss value obtained at the 2.4 frequency is -47.34 dB. The upper frequencies for the value of return loss ≤ -10 dB are 2.4734 GHz and 2.3189 GHz can be seen in figure 3, and VSWR at the frequency 2.4 GHz is 1.009 can be seen in figure 4.

The upper frequencies for the value of VSWR ≤ 2 are 2.4776 GHz and lower frequency are 2.3139 GHz using software antenna. The return loss by measurement at the 2.334 GHz frequency is -12 dB. The upper frequencies for the value of return loss ≤ -10 dB are 2.334 GHz and lower frequency is 2.215 GHz. From the above data it can be seen that the bandwidth achieved from the design using antenna software and measurement [8,9]:

\[
\text{Bandwidth} = \text{frequency upper} - \text{frequency lower} \tag{6}
\]

Bandwidth for simulation = 2.4776 GHz – 2.3139 GHz = 0.1637 GHz = 163.7 MHz

Bandwidth for measurement = 2.334 GHz – 2.215 GHz = 0.119 GHz = 119 MHz
After experimenting with simulations and measurements, the results obtained specifications of the performance parameters in the form of return loss, VSWR and desired bandwidth as in Table 1.

| Parameters          | Simulation | Measurement |
|---------------------|------------|-------------|
| Frequency resonance | 2.4 GHz    | 2.334 GHz   |
| Return loss         | -47.34 dB  | -12 dB      |
| VSWR                | 1.009      | 1.11        |
| Bandwidth           | 163.7 MHz  | 119 MHz     |
| Patch dimension     | 27x35 mm²  | 27x35 mm²   |
| Substrate dimension | 49x49 mm²  | 49x49 mm²   |
The value of return loss at the middle frequency of 2.4 GHz using simulation is -47.34 dB while at the time of measurement the optimal return loss value shifts at the middle frequency to 2.334 GHz at -12 dB. Return loss has decreased very significantly at the time of measurement. For the VSWR value at the center frequency of 2.4 GHz, it has a value of 1.009, when the measurement of the VSWR value is shifted at 1.11 with frequency of 2.334 GHz. The value of VSWR has decreased and center frequency has shifted. For bandwidth in the middle frequency of 2.4 GHz is 163.7 MHz. At the time of measurement, the bandwidth width decreased to 119 MHz at the frequency of 2.334 GHz. The graph of return loss and VSWR comparison between simulation and measurement can be seen as in Figure 5 and Figure 6.

![Graph of Return Loss Comparison](image1)

**Figure 5.** Comparison of simulation and measurement return loss

![Graph of VSWR Comparison](image2)

**Figure 6.** Comparison of simulation and measurement VSWR

4. **Conclusion**

From this study the results obtained between software and measurement in real have a shift in value of return loss, VSWR and different bandwidth width. This is caused when making measurement, the presence of soldering on the feeder line to connect the antenna with a vector network analyser (VNA) if it is too hot can cause reduced performance parameters return loss, VSWR and bandwidth at the desired frequency that is 2.4 GHz.
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