# Design And Analysis Of Wideband Microstrip Antenna Using Bowtie Patch For L-Band And C-Band Applications

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**ABSTRACT**
This study aims to design and implement a wideband microstrip antenna with a Sweep W Patch Defected Ground Structure (DGST) as a signal receiver in the L-Band and C-Band frequency bands. The development method used is the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), with a focus on the patch geometry design stage, ground structure optimization, and prototype realization. The design process was carried out using CST Studio Suite 2019 software to obtain performance parameters such as return loss, VSWR, gain, and bandwidth. The simulation results show that the Sweep W Patch DGST antenna design has performance that is close to the technical specifications, especially at frequencies of 1.14 GHz, which is close to the L-Band, 4.37 GHz, and 4.8 GHz, which is close to the C Band. The antenna prototype was then realized and tested using a Vector Network Analyzer (VNA), with return loss measurements reaching –16.55 dB at a frequency of 1.218 GHz. Although there was a deviation from the simulation results, the antenna performance was still within tolerance limits and showed matching impedance characteristics. This study successfully demonstrated that optimizing the patch and ground geometry effectively improves the wideband characteristics of microstrip antennas. These results can be used as learning material in the field of radio communication and as a reference for further development of multiband antenna designs.

**Keywords:** Microstrip Antenna, Defected Ground Structure, Wideband, Return Loss,L-Band, C-Band

## 1. INTORDUCTION

The development of modern communication technology requires devices that are efficient, compact in size, and capable of operating simultaneously across various frequency bands. One of the main components in communication systems is the antenna, particularly the microstrip antenna, which has the advantages of being compact, lightweight, and easy to fabricate using standard printed circuit board (PCB) techniques (Balanis, 2016; Pozar, 2012; Stutzman & Thiele, 2012). Microstrip antennas are widely used in satellite, radar, air navigation, and mobile communication systems. However, these antennas have a fundamental limitation in the form of relatively narrow bandwidth (Harianto et al., 2020). With the increasing need for broadband communication, research on multiband and wideband antennas has developed rapidly. Technologies such as slotting (U-slot, E-slot), fractal patches, and Defective Ground Structures (DGS) have proven capable of expanding bandwidth and improving antenna impedance matching (Astuti et al., 2022). At the same time, unconventional patch shapes such as bowties have begun to be explored due to their simple structure and broadband response capabilities (Solanki et al., 2017). Thus, multiband microstrip antennas are a promising solution to meet the demands of modern communication in the L-Band and C-Band. Although various approaches have successfully expanded the bandwidth of microstrip antennas, there is still a research gap, especially regarding the exploration of alternative patch shapes such as bowties. Previous studies have focused on antennas based on rectangular patches, circular patches, or slot modifications (Nurahman Tatang et al., 2020; Rahayu & Wiharso, 2019). In fact, bowtie patches have characteristics that can produce double resonance and a wider frequency response thanks to optimal current. Furthermore, most research on bowties is still limited to WLAN or high-speed data communication applications (Solanki et al., 2017), while implementations for L-Band and C-Band applications, especially using FR-4 substrates that are commonly used due to their low cost and wide availability, have not been widely explored (Lestariningati, 2015). This is an important research gap, as the L-Band (1–2 GHz) is widely used in secondary radar and aviation navigation, while the C-Band (4–8 GHz) is widely used in satellite communications, weather radar, and wireless communication backbones (Priyono et al., 2019) Therefore, a more in-depth study of wideband microstrip bowtie antenna design is needed to accommodate these frequency requirements. A number of studies have been conducted to overcome the bandwidth limitations of microstrip antennas. (Laagu, 2023) designed a circular patch microstrip antenna for C-Band applications and successfully obtained a bandwidth of up to 4000 MHz with a return loss of –25 dB. Another study by (Nurahman Tatang et al., 2020)developed an inverted L microstrip antenna for GPS applications at 1215–1237 MHz, which showed quite good performance in the L-Band. Astuti et al. (2022) and Fadilah et al. (2022) combined the DGS technique with a microstrip patch to increase the fractional bandwidth to more than 13% at a center frequency of 3.5 GHz. Meanwhile, Rachmatullah (2022) proposed a bowtie antenna with proximity coupled for LoRa applications, and the results showed an improvement in bandwidth compared to conventional rectangular antennas. However, most of these studies are still limited to a single frequency band or use special substrates that are expensive. Therefore, the integration of the bowtie method with ground plane optimization techniques on FR-4 substrates is still rarely found, especially for multiband applications in the L-Band and C-Band. This research contributes by proposing a wideband microstrip antenna design based on a bowtie patch using inexpensive and easily fabricated FR-4 substrates (Yudha Bagaskara et al., n.d.). This approach is combined with the Defected Ground Structure (DGS) technique and patch geometry optimization through parameter sweep to expand the bandwidth and improve the antenna impedance matching. In this way, the antenna is designed to operate on two main frequency bands, namely L-Band and C-Band, which are widely used in modern communication and navigation systems (Werfelli et al., 2016). The main contribution of this research is the production of an antenna prototype that has not only been validated through simulation using CST Studio Suite 2019, but also tested experimentally using a Vector Network Analyzer (VNA), thereby obtaining accurate empirical data on the antenna's performance. Thus, the results of this study are expected to enrich the literature on multiband microstrip antenna design and serve as a practical reference for the development of similar antennas in broadband communication applications (Okpatrioka, 2023). The main objective of this study is to design, simulate, and test the performance of a bowtie patch based wideband microstrip antenna capable of operating simultaneously in the L-Band and C Band. Specifically, this study aims to: (1) produce a bowtie antenna design with optimal geometric parameters using CST Studio Suite software; (2) fabricate an antenna prototype based on FR-4 substrate to assess its physical realization; (3) to test the antenna characteristics using a VNA to obtain the return loss, VSWR, gain, and bandwidth parameters; and (4) to analyze the conformity between the simulation results and actual testing. By achieving these objectives, this study is expected to address the need for a simple, inexpensive, yet effective multiband wideband antenna to support modern communications. In addition, this research also provides benefits in the field of education, as it can be used as a practical learning medium for cadets at the Surabaya Aviation Polytechnic regarding antenna design and software-based electromagnetic simulation.

## 2. RESEARCH METHOD

This research uses the Research and Development (R&D) method with the ADDIE model approach, which includes five main stages: Analysis, Design, Development, Implementation, and Evaluation. This method was chosen to ensure that the development process of a wideband microstrip antenna based on a bowtie patch with a Defected Ground Structure (DGS) ran systematically, starting from the identification of requirements, design, simulation, to antenna performance testing. This research was conducted at the Surabaya Aviation Polytechnic Laboratory for the design and simulation stages, while testing was carried out in a laboratory environment using a Vector Network Analyzer (VNA) measuring device. The research period lasted from the analysis to the evaluation stage for several months, in accordance with the applicable academic schedule. The subject of this research was the design of a wideband microstrip antenna prototype, while the object of testing was the antenna characteristics, including return loss, bandwidth, and gain parameters in the L-Band and C-Band frequency bands.

## 3. DESIGN

In designing this antenna, the target was for the antenna to operate in the L-Band and C-Band frequency bands, specifically in the range of frequencies obtained from the tests, namely 1-2 GHz for the L-Band and 4-8 GHz for the C-Band. This frequency range was then used as a reference in determining the main parameters of the antenna design, such as patch dimensions, substrate type, and target values for return loss, bandwidth, and VSWR. These specifications were determined in advance before the simulation process was carried out using CST Studio Suite 2019 software to ensure that the design results could meet the desired performance characteristics on both frequency bands.

**Table 1.** Design

| Antenna Specification | Description |
|---|---|
| Frequency | 1.5 GHz |
| VSWR | $\leq 2$ |
| Mounting Method | Microstrip Line |
| Return Loss | $\leq -10\ dB$ |
| Patch / Ground | Copper |
| Gain | >0 dB |

The next step is applied in the CST Microwave Studio 2019 software so that the antenna design can be in accordance with what was planned. Then there is the substrate, which is a crucial element in microstrip antenna design because it functions as a connector for electromagnetic waves. The material chosen for the manufacture of this antenna is FR-4 lossy, which is a common material for high frequency use. In addition, the specification data for the FR-4 lossy substrate is available in the CST Microwave Studio 2019 database. The substrate specifications used in the microstrip antenna design in this study are as shown in the following table.

**Table 2.** fr-4 Epoxy Specification

| Characteristics | Ideal Value |
|---|---|
| Konstanta dielektrik relative ($\mathcal{E}r$) | 4.4 |
| Ketebalan Substrat (fr-4 *Epoxy)* | 1.6 mm |
| Ketebalan Konduktor (Tembaga) | 0.035 mm |

The microstrip antenna to be designed will operate at a frequency of 1.5 GHz. Given that fr = 1.5 GHz, Ɛr=4.4, and the speed of light (c) = $3.3.10^8$, the formula for the patch width in equation (1) is as follows:

Patch Width

$$W = \frac{c}{2f_0\sqrt{\frac{(\mathcal{E}r+1)}{2}}} = \frac{3\times10^8}{2\times1500MHz\sqrt{\frac{4.4+1}{2}}} = 60.8\text{mm} \quad \textbf{(1)}$$

Next, to calculate the value of the patch length L (according to equation 1), the values of the dielectric constant ($\mathcal{E}reff$) , Effective Length (Leff), and Length Extension (ΔL) are required.

Groundplane Length

$$\boldsymbol{\mathcal{E}eff} = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2}\left[1+12\,\frac{h}{w}\right]^{-\frac{1}{2}}$$

$$= \frac{4.4+1}{2} + \frac{4.4-1}{2}\left[1+12\,\frac{1.6}{60.8}\right]^{-\frac{1}{2}}$$

$$= 2.7 + 1.7 \times 0.8717 = 4.18m \quad \textbf{(2)}$$

$$\boldsymbol{Leff} = \frac{c}{2f_r\sqrt{\mathcal{E}eff}} = \frac{3\times10^8}{2\times1.5\times10^9\sqrt{4.18}} = 0.0489\ m \sim 48.9mm \quad \textbf{(3)}$$

$$\boldsymbol{\Delta L} = 0.412\text{h}\,\frac{(\mathcal{E}\text{eff}+0.3)\left(\frac{\text{W}}{\text{h}}+0.264\right)}{(\mathcal{E}\text{eff}-0.258)\left(\frac{\text{W}}{\text{h}}+0.8\right)} = 0.412\times1.6\ \frac{(4.18+0.3)\left(\frac{60.8}{1.6}+0.264\right)}{(4.18-0.258)\left(\frac{60.8}{1.6}+0.8\right)} = 0.743\ mm \quad \textbf{(4)}$$

From the above equation, we obtain the value so that the length of the patch (L) in the equation.

$$\boldsymbol{L} = Leff - 2\Delta L = 48.9\text{ mm} - 2\times0.743$$

$$= 47.4\text{ mm} \quad \textbf{(5)}$$

The design of the ground plane and substrate dimensions is given by the equation

$$W_g = W + 6h = 60.8 + 6\ \times 1.6 = 60.8 + 9.6$$

$$= 70.4\ mm \quad \textbf{(6)}$$

$$L_g = L + 6h = 47.4 + 6\ \times 1.6 = 47.4 + 9.6 = 57\ mm \quad \textbf{(7)}$$

From the analysis results of several Bowtie patch antenna parameters, a table can be compiled that presents a summary of the CST Microwave Studio 2019 application parameters. A summary of the calculations can be seen in Table.

**Table 3.** Calculation Results for Antenna Dimensions

| No | Part | Symbol | Specifications |
|---|---|---|---|
| 1. | Patch Width | W | 60.8 mm |
| 2. | Patch Length | L | 47.4 mm |
| 3. | Feeding Width | Wf | 3 mm |

| | | | |
|---|---|---|---|
| 4. | Feeding Length | Lf | 48.5 mm |
| 5. | Groundplane Width | Wg | 71mm |
| 6. | Groundplane Length | Lg | 77mm |

## 4. RESULTS

At this stage, the antenna design process was carried out using CST Studio Suite 2019 electromagnetic simulation software. The initial design focused on the Bowtie patch shape because this shape has wideband characteristics that are suitable for multi-frequency applications. The Bowtie structure is capable of providing resonance in more than one band, depending on design parameters such as flare angle, patch length and width, and substrate and ground plane configuration. The following image shows the initial design results at the design stage.

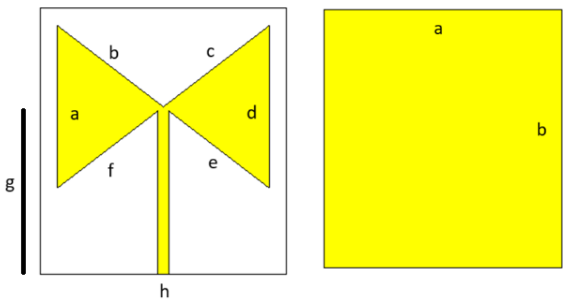



**Figure 1** Initial Design Results

**Table 4.** Bowtie Antenna Dimension Sizes

| No | Keterangan | Simbol | Satuan |
|---|---|---|---|
| 1 | Patch Length (L) | La,Ld | 47 mm |
| 2 | Width of the Sloped Side (W) | Wb, Wc, We, Wf | 38,5 mm |
| 3 | Feeding Length (Lf) | Lfg | 48,5 mm |
| 4 | Feeding Width (Wf) | Wfh | 3 mm |
| 5 | Ground Width (Wg) | Wga | 71 mm |
| 6 | Ground Length (Lg) | Lgb | 77 mm |
| 7 | Substrate Width (Ws) | Wsa | 71 mm |
| 8 | Substrate Length (Ls) | Lsb | 77mm |
| 9 | Substrate Height (h) | h | 1,6 mm |
| 10 | Ground Patch Height (t) | t | 0,035 mm |

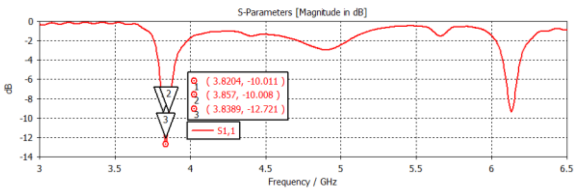



**Figure 2** Return Loss Value

Figure 2 shows the simulation results of the return loss (S11) parameter from the initial bowtie antenna design. It can be seen that the antenna resonates at three main frequencies, namely 3.8204 GHz with a return loss value of –10.011 dB, 3.857 GHz with a value of –10.008 dB, and 3.8389 GHz with a value of –12.721 dB. These three values indicate fairly good performance because they are below the minimum threshold of –10 dB, which means that the antenna is capable of radiating power efficiently at these frequencies. The operating frequency range of these results falls within the early part of the C-Band spectrum (4–8 GHz), indicating that the initial antenna design has wideband characteristics that are potential for broadband communication applications. Figure 3 shows the Voltage Standing Wave Ratio (VSWR) values for the bowtie antenna design. It can be seen that the minimum VSWR value occurs at a frequency of 3.8359 GHz with a value of 1.6055. This value is below the general threshold of 2, indicating good impedance matching at that frequency. The signal reflection from the antenna back to the source is relatively small, indicating fairly high radiation efficiency. However, the operating frequency still does not fully cover the target range in the L-Band (1–2 GHz) or the upper C-Band (up to 8 GHz). Therefore, these initial simulation results provide a positive initial overview, but further optimization of the antenna geometry is still needed so that the operating frequency can be expanded to cover the entire L-Band and C-Band ranges more effectively.

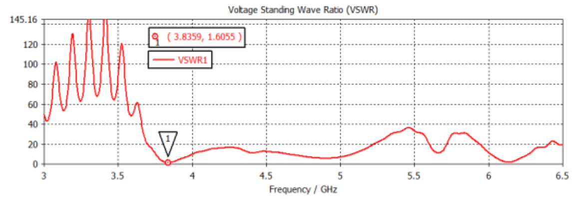



**Figure 3 VSWR**

After the initial bowtie antenna design was completed and simulated, the next step was to perform an optimization process through parameter sweep to evaluate the effect of dimensional variations and geometric configurations on antenna performance. This stage aims to obtain better antenna characteristics in reaching the L-Band (1–2 GHz) and C-Band (4–8 GHz) frequency ranges, as well as ensuring that the return loss value remains below –10 dB and the VSWR does not exceed a value of 2, in accordance with broadband communication antenna performance standards. The parameter sweep process was carried out by varying several important elements in the antenna structure, such as the length and width of the bowtie patch, the dimensions of the feeding path, and the size of the ground plane. Each parameter variation was simulated using CST Studio Suite 2019 software to see its effect on resonance frequency, bandwidth width, return loss value, and impedance matching (VSWR). The results of this simulation provide a deep understanding of the relationship between antenna geometry and performance, enabling the selection of an optimal configuration that meets design requirements. This stage is crucial in ensuring that the designed antenna is truly capable of operating in the target frequency band and has good radiation efficiency in various communication applications within the L-Band and C-Band spectrum.

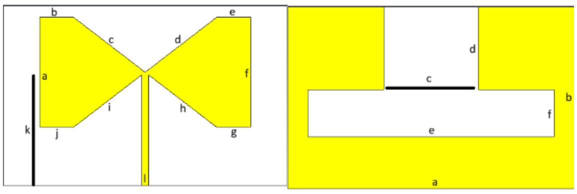


**Figure 4** Return Loss Value

**Table 5.** Bowtie Antenna Dimension Sizes

| No | Keterangan | Simbol | Satuan |
|---|---|---|---|
| 1 | Patch Length (L) | La,Lf | 47 mm |
| 2 | Width of Flat Side (W) | Wb, We, Wg, Wj | 14,5 mm |
| 3 | Width of Sloped Side (W) | Wc, Wd, Wh, Wi | 38,5 mm |
| 4 | Feeding Length (Lf) | Lfk | 48,5 mm |
| 5 | Feeding Width (Wf) | Wfl | 3 mm |
| 6 | Ground width (Wg) | Wga | 121 mm |
| 7 | Ground Length (Lg) | Lgb | 77 mm |
| 8 | Slot Width (Wc) | Wgic | 40 mm |
| 9 | Slot Length (Wd) | Lgid | 35 mm |
| 10 | Partial Ground Width (Wgp) | Wgpe | 104 mm |
| 11 | Partial Ground Length (Lgp) | Lgpf | 20 mm |
| 12 | Substrate Width (Ws) | Wsa | 121 mm |
| 13 | Substrate Length (Ls) | Lsb | 77 mm |
| 14 | Substrate Thickness (h) | h | 1,6 mm |
| 15 | Ground Patch Thickness (t) | t | 0,035 mm |

Figure 6 shows the results of the modified bowtie microstrip antenna design with the addition of a Defective Ground Structure (DGS) on the ground plane. This design retains the same patch size as the previous design, but its performance is improved through the application of the DGS technique, with complete parameters as listed in Table 6. The antenna patch has a length of 47 mm, with a flat side width of 14.5 mm and a slanted side width of 38.5 mm. The feeding line has a width of 3 mm and a length of 48.5 mm, while the ground size reaches 121 mm (width) and 77 mm (length). The addition of DGS is done by making a slot measuring 40 mm (width) and 35 mm (length), and applying a partial ground measuring 104 mm and 20 mm in length. These changes aim to improve the antenna's performance in terms of impedance matching and expand its operating bandwidth, allowing the antenna to respond better to a wider frequency range. With the DGS technique, it is expected that the antenna will be able to produce more optimal resonance characteristics in the L-Band and C-Band, which are important in supporting broadband communication applications such as radar, satellite communications, and wireless networks.

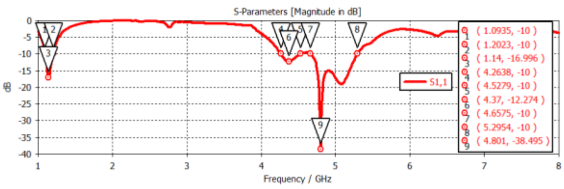



**Figure 5** S-Parameter Sweep Patch DGST

Figures 5 and 6 show the simulation results of the S-parameters (S11) and VSWR of the modified bowtie antenna design with a Defected Ground Structure (DGS). These simulation results are the most optimal compared to all previously tested designs, with performance characteristics showing good impedance matching and frequency response in line with the target communication band range.

Based on the S-parameter data, a return loss value of –16.997 dB was achieved at a frequency of 1.1405 GHz, which is within the L-Band (1–2 GHz), a return loss of -12.274 at a frequency of 4.37 within the C-Band (4-8 GHz) coverage, and a return loss of –38.348 at frequencies from 4.657 GHz to 5.295 GHz within the C-Band (4-8 GHz) coverage. These values indicate that the antenna is capable of responding to frequencies in the L Band and C-Band spectrums with fairly good impedance matching, where the power reflected back to the source is very small. This is also reinforced by the VSWR graph results in Figure 4.47, which shows VSWR values of 1.3293 at a frequency of 1.14 GHz, 1.024 at a frequency of 4.8 GHz, and 1.6433 at the same frequency of 4.37 GHz, which means that the signal reception efficiency is very good. Thus, these simulation results reflect that the addition of the DGS structure and the adjustment of the patch dimensions have a positive effect on antenna performance, particularly in expanding the bandwidth and adjusting the operating frequency response in L-Band and C-Band applications, which are widely used in radar systems, satellite communications, and wireless networks.

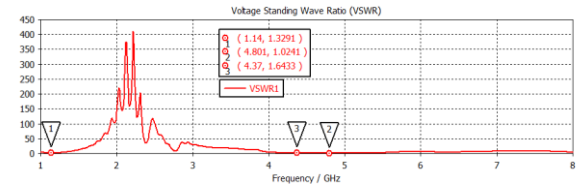
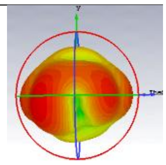



**Figure 6** VSWR

**Table 6.** Simulation Results

| Return Loss | VSWR | Bandwidth | Gain | Pola Radiasi |
|---|---|---|---|---|
| -16.9 dB, -12.274 dB, -38.495 dB | 1.3291, 1.0241, 1.6433 | 108,8 MHz,264,1 MHz, 638 MHz | 5,548 dBi |  |

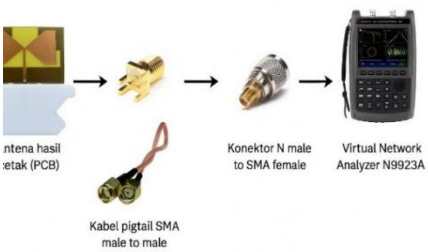
Although the simulation results have shown wideband characteristics in line with the design targets, antenna performance validation cannot rely solely on simulation data. Therefore, the antenna prototype was fabricated and tested using a Vector Network Analyzer (VNA) to confirm the computational results and evaluate possible deviations due to fabrication factors and measurement conditions. The antenna prototype was tested using a Vector Network Analyzer (VNA) with a measurement frequency range between 800 MHz and 3 GHz. This range was selected in accordance with the capabilities of the equipment available in the laboratory. Therefore, although the antenna design simulation showed resonance characteristics up to frequencies above 4 GHz, physical testing was only able to verify the antenna's performance in the L-Band and early part of the C-Band. This limitation was a factor that affected the full validation of the antenna's entire working spectrum. Nevertheless, the measurement results still show a wideband characteristic trend that is close to the simulation results, so the design can be considered sufficiently valid for initial applications in the L-Band.

**Figure 7** Antenna Fabrication

Figure 8 shows the testing process of the Sweep W Patch DGST antenna prototype using a Vector Network Analyzer (VNA) measuring device. The antenna prototype was connected to the VNA via an SMA connector and an SMA Male to Male Pigtail cable to obtain S11 (Return Loss) parameter data. In this testing process, the frequency range used was from 800 MHz to 3 GHz, in accordance with the working capacity of the VNA device available in the laboratory. Therefore, observations of antenna performance could only be carried out directly on the L-Band frequency band, while testing for frequencies above 3 GHz (C-Band) could not yet be carried out. These actual measurement results are then compared with the simulation data to evaluate any performance deviations that may arise due to dimensional tolerances in the fabrication process, imperfect connections, or environmental conditions during testing.

**Figure 8** Antenna Measurement Scheme

Prototype antenna testing was carried out using a systematically arranged tool configuration to ensure accurate measurement results. The printed antenna (PCB) was first connected to a PCB to SMA female connector that was soldered directly to the antenna feeding line. This connector serves to connect the RF signal from the microstrip line to the outside world. Next, the signal is transmitted through an SMA male to male pigtail cable, which connects the antenna to an N male to SMA female connector converter. This converter is used to match the cable port with the VNA (Agilent/Keysight N9923A) input port, which uses an N-type interface. A Vector Network Analyzer (VNA) is then used to measure antenna performance parameters, such as Return Loss (S11) and Voltage Standing Wave Ratio (VSWR) at various operating frequencies. The results from the VNA are displayed in the form of an S11 magnitude graph against frequency and can be used to determine the antenna's operating bandwidth and its impedance matching to 50 Ohms.



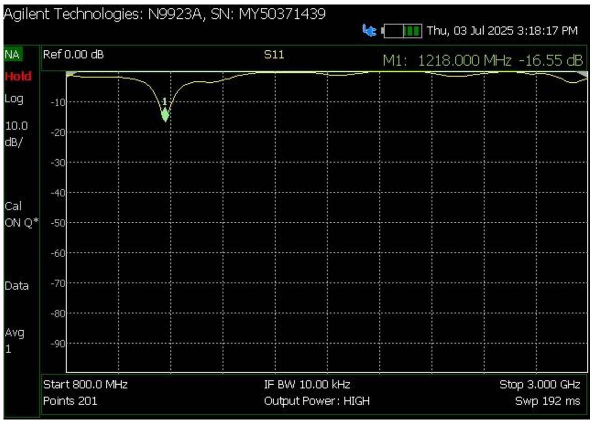




**Figure 9** Return Loss Measurement Results

Figure 9 shows the Return Loss measurement results of the Sweep W Patch DGST antenna prototype using the Agilent Technologies N9923A Vector Network Analyzer. Based on the S11 graph, a minimum Return Loss value of –16.55 dB was obtained at a frequency of 1.218 GHz, which is very close to the L-Band frequency band, particularly in the range covering the GPS L2 signal. This Return Loss value indicates that the antenna has fairly good impedance matching performance, with low reflection power so that most of the energy can be optimally received by the antenna. The sharp decrease in Return Loss value at this resonance point also indicates that the antenna has bandwidth characteristics suitable for supporting navigation applications in the L-Band spectrum. The measurement frequency range was from 800 MHz to 3 GHz with 201 sampling points, adjusted to the VNA tool's capability limit . Therefore, validation of the antenna's performance in the C-Band spectrum could not be performed directly. When compared to previous simulation data showing a Return Loss value of –16.997 dB at a frequency of 1.14 GHz, there is a frequency deviation of ±78 MHz. This deviation is still within reasonable limits and can be caused by several factors, such as fabrication dimensional tolerances, irregularities in the dielectric constant of the substrate, and the influence of environmental conditions during testing. Overall, these Return Loss test results reinforce that the Sweep W Patch DGST antenna design has been successfully realized with consistent performance relative to the simulation results, and is suitable as a reference for the next stage of development.

**Table 7.** Summary of Simulation Results and Measurement Results

| Simulation | Parameter | | |
|---|---|---|---|
| | Resonance Frequency | Bandwidth | Return Loss |
| Simulation Results | 1,093 GHz – 1,202 GHz | 108,8 MHz | -10 dB |
| Prototipe Measurement Results | 1,196 GHz – 1,242 GHz | 46 MHz | -10 dB |

Based on Table 7, which compares the simulation data and physical measurements of the Sweep W Patch DGST antenna prototype, it can be concluded that the antenna implementation successfully approximates the performance designed in the simulation stage. For the resonance frequency parameter, the simulation results show a range between 1.093 GHz and 1.202 GHz, while the physical measurement results show a range between 1.196 GHz and 1.242 GHz. This indicates a frequency deviation of approximately 71 MHz at the beginning and 40 MHz at the end, which is still within reasonable limits considering the dimensional tolerance, fabrication process variations, and limitations of the actual substrate characteristics compared to ideal simulations. For the bandwidth parameter, the simulation produced a value of 108.8 MHz, while physical measurements produced a bandwidth of 46 MHz. Meanwhile, the Return Loss parameter continues to show good performance, with values below the threshold of –10 dB in both methods. The simulation results show a minimum return loss of –10 dB, and physical measurements also show a minimum return loss at the same limit. In general, a comparison between the simulation results and physical testing shows that the antenna prototype has been successfully realized effectively. The deviations that appear are still within technical tolerance limits and do not significantly affect overall performance. This indicates that the design process, selection of the Sweep Patch method and DGST structure, as well as the fabrication stages have been carried out correctly and can be used as a basis for further implementation or testing on a real-time satellite navigation system scale.

## 5. Discussion

Physical testing focused on measuring S-parameter (S11) parameters, with Return Loss as the main indicator for evaluating antenna impedance matching to the targeted operating frequency, particularly in the L-Band and C-Band spectrums. The selection of this testing focus was based on the limitations of the available measurement equipment, mainly because the Vector Network Analyzer (VNA) used only covered a frequency range of up to 3 GHz, as well as the limitations of the laboratory facilities, which did not allow for comprehensive gain and radiation pattern testing. Therefore, the validation of antenna performance in this study focuses on Return Loss and resonance frequency analysis, as a basis for assessing whether the antenna design has worked close to the targeted specifications. Meanwhile, testing of gain parameters, actual VSWR, and three dimensional radiation patterns is planned for the next stage of development, if this prototype is used as part of further research or actual satellite navigation system applications. Based on the entire process, from design, simulation, physical realization, to Return Loss testing, it can be concluded that the Sweep W Patch DGST microstrip antenna has been successfully realized with performance close to the simulation results. The physical measurement of Return Loss was –16.55 dB at a frequency of 1.218 GHz, indicating excellent impedance matching performance and consistent with the simulation data, which recorded –16.997 dB at a frequency of 1.14 GHz. The resonance frequency deviation of 78 MHz is still within reasonable tolerance limits, considering the possibility of dimensional variations during fabrication, changes in the dielectric constant of the substrate, and environmental conditions during measurement. However, it should be noted that the measured bandwidth only reached 46 MHz, which is narrower than the simulated bandwidth of 108.8 MHz, although it still covers part of the GPS band, especially around the L2 frequency. These results indicate that the antenna design has met the basic criteria for GPS signal reception, especially in the L2 frequency band, although a comprehensive performance evaluation has not yet been carried out because testing of the radiation pattern, gain, and actual VSWR parameters has not been performed. Thus, the results of this study provide initial validation of the antenna design and can be used as an important reference for further development of wideband microstrip antennas, both in terms of optimizing patch and ground dimensions, increasing bandwidth, and for more comprehensive three-dimensional radiation characteristic testing.

## 6. Conclusion

The wideband microstrip antenna was designed by selecting a bowtie patch shape because it has characteristics that enable it to cover a wide bandwidth. The design was carried out through stages of analysis, theoretical calculation of antenna dimensions, simulation using CST Studio Suite, and a fabrication process to obtain an antenna that works in the L-Band and C-Band. Design parameters that affect antenna performance include the shape and size of the patch, the width and length of the feeding line, the dimensions and configuration of the ground plane, and the use of additional structures such as feeding inserts, U-slots, and Defective Ground Structures (DGS). These factors affect impedance matching, bandwidth width, resonance frequency, and antenna radiation patterns. Testing of the antenna prototype using a VNA showed that the measurement results were close to the simulation results, with the antenna capable of responding to more than one frequency range in the L-Band and C-Band spectrum. This indicates that the design has been validated and has the potential to be used in various broadband communication applications.

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