Design of a Microstrip Wideband Antenna

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This paper presents an investigation on a microstrip wideband antenna by combining few rectangular patch antennas from different frequencies. The microstrip patch antenna operates for the range of 5.4 -5.5 GHz. Duroid substrates with $\varepsilon_r = 2.33$, copper substrate thicknesses and height of 0.0356 mm and 0.5 mm respectively. A data analysis has been done to compare the return loss and VSWR from the antenna.

1. Introduction

Microstrip antennas may be mounted on substrates of various shapes such as the rooftop of a car. Normally, a microstrip antenna was mounted on a dielectric-coated metallic sphere serves as a canonical problem for the analysis of conformal antenna. The input impedance and the electromagnetic field of microstrip antennas have been analyzed using an electric surface-current model [1], a transmission-line model [2-3], and a cavity model theory with the dyadic Green's function formulation [4]. In practical application, microstrip antennas are very popular because they have the advantages of low profile, lightweight, low cost, conformability, and ease of fabrication and integration with RF devices [4]. Probably the most serious limitation of the microstrip antenna was the narrow bandwidth for a simple patch element, which was usually around few percents. Few years ago, a lot of methods have been proposed to enhance the bandwidth such as adding an impedance matching network stack patch, edge-coupled parasitic patch, or lossy materials [5]. However some of the approach could not solve the problem totally. The EM waves fringe off the top patch into the substrate, reflecting off the ground plane and radiates out into the air. Radiation occurs mostly due to fringing field between the patch and ground as shown in figure 1.

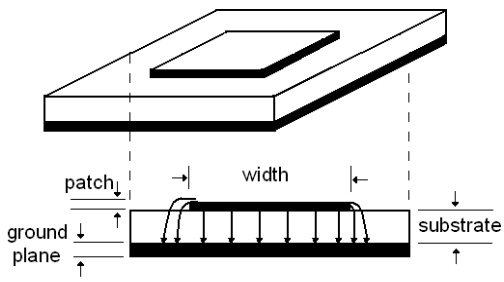

Figure 1: Operations of Microstrip Antenna

The radiation efficiency of the patch antenna depends largely on the permittivity of the dielectric. Ideally, a thick dielectric, low permittivity and low insertion loss is preferred for broadband purposes and increases efficiency [6]. Feeding technique: Microstrip antenna can be fed by a variety of methods. These methods can be classified into two categories contacting and non-contacting. Feeding technique can be influence the input impedance and polarization characteristics of the antenna. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes). This paper will explain a design of wideband microstrip connected directly to the edge of the microstrip patch approach. The conducting strip with smaller size as compared to the patch has the advantages to be etched on the same substrate to provide a planar structure.

2. Design Procedure

The aim of the design was to provide good frequency input impedance, match resonant frequency and perfect polarization for frequency range from 5.4 – 5.5 GHz. The dimension of rectangular patch antenna can be calculated as explain in [8]. Length of the patch has been extended to obtain the effective length of the patch to ensure the maximum power transfer in the antenna. Feed point was determined to locate a point that match to the input impedance between feeder and patch. With aid from CAD the location of the feed with the patch at 50Ω can obtained easily.

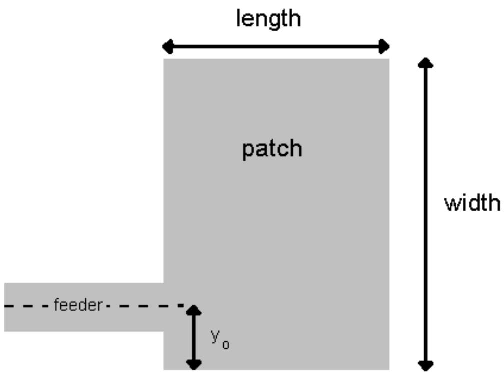

Figure 2: Dimension of Rectangular Patch Antenna

Figure 2, shows a single patch antenna before combining to other patches. Length and width of the patch are difference according to the design frequency. Generally the patch size is inversely proportional to frequency. Figure 3 shows the configuration of the wideband microstrip antenna consists of four rectangular patches at different frequency f_1, f_2, f_3 and f_4. Table 1 shows the value of resonant frequency in designing microstrip wideband antenna in the range of frequency from 5.4 – 5.5GHz.

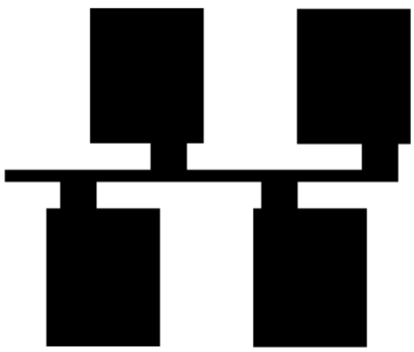

Figure 3: Top View Microstrip Wideband Antenna

The optimum value for range 5.4 – 5.5 GHz can be obtained. After optimization process Electromagnetic simulation was used to demonstrate the distribution of the electric field around the microstrip patch antenna.

Table 1: Value of Resonant Frequency

Antenna	Frequency
Patch 1	5.41 GHz
Patch 2	5.43 GHz
Patch 3	5.47 GHz
Patch 4	5.5 GHz

3. Result and Discussion

A comparison result between simulation and measurement were plotted in the same graph. Figure 4 shows the return loss of the wideband antenna against frequency. The simulation optimum value was 24.277 dB at 5.408 GHz. While measurement result was 22.888 dB at 5.7 GHz. Return loss for measurement result at 5.408 GHz is 2.337 dB. It was clearly shows that the measurement result was shifted to the higher operating frequency. This situation occurs may be due to the fabrication process. The size of the fabricated antenna is smaller than the simulated dimensions.

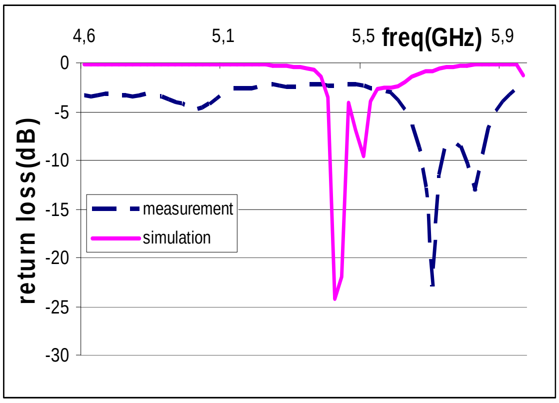

Figure 4: Simulation and Measurement Result for Return Loss

Same situation is shown by figure 5 and 6. The simulation result for voltage standing wave ratio (VSWR) for the antenna was between 5.4 - 5.5 GHz with lowest value of 1.13. While the measurement values shows at 5.7 GHz about 1.17. The value from simulation was smaller than from the measurement. This again shows the simulation result was better than measurement. It was prove that the antenna was properly matched at the design frequency. The bandwidth of the microstrip wideband antenna was calculated. In simulation, the bandwidth was about 13.976 %, while in a measurement result was 11.75%. The smaller amount of the bandwidth may be result from the different size of the patches.

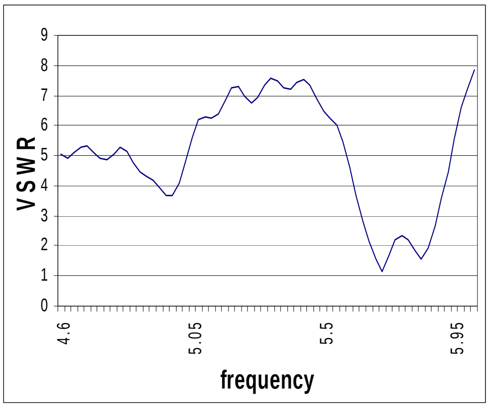

Figure 5: Simulation Result for VSWR Value

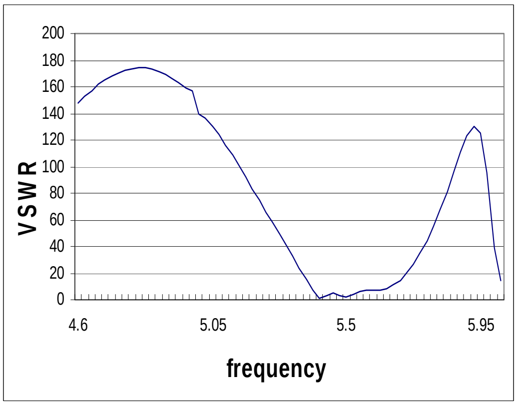

Figure 6: Measurement Result for VSWR Value

4. Conclusion

The performance of a wideband antenna has been investigated. The return loss and VSWR were obtained from both simulation and measurement. From simulation and measurement compare the result was slightly shifted about 0.28 GHz. The maximum return loss was less than 24.277 dB in simulation while 22.888 dB was obtained from the measurement. The best VSWR was 1.13 from simulation while measurement was 1.161. The bandwidth obtained from simulation was wider compared to measurement. A small changing dimension has affected the measurement result. The feeding technique also can influence the result. It can increase mode order and introducing distortions in the pattern and impedance.

5. Future Development

The performance of the antenna depends on what type of feed. In this study, feed line was chosen. For future, other type of feeding network can be developed to compare the antenna performances. A truncate patch antenna also can be proposed for future development, to analyze the antenna characteristics

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