

2.2GHz & 8GHz Patch Antenna Design, Simulation, and Testing

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Abstract—This report briefly analyzes the results of simulations for optimized 2.2GHz and 8GHz patch antennas. The 2.2GHz patch antenna was manufactured with thin copper tape and physically tuned. Discrepancies between the simulated and manufactured antenna are investigated. Optimized models of both patch antennas were able to achieve resonance at their respective design frequency with an insertion loss below -20dB. The manufactured 2.2GHz antenna had its length reduced beyond the design length to achieve resonance at the design frequency. The return loss of the physical antenna was much greater than what is observed in the simulation.

I. INTRODUCTION

The purpose of this lab is to design, simulate, fabricate, and analyze a 2.2GHz patch antenna. In addition, an 8GHz patch antenna is designed and simulated. For the 2.2GHz antenna, simulated S_{11} parameters are compared to S_{11} parameters measured by a vector network analyzer (VNA) over a frequency range. An antenna layout is prepared for the 2.2GHz patch in ADS software. The antenna used for empirical measurements is a copper tape based prototype fabricated using a sharp edge and manual labor. The length of the physical patch is reduced until primary resonance is achieved at the design frequency of 2.2GHz.

Patch antennas are advantageous in certain situations where a very thin and low-profile antenna is required to conform with the physical structure requirements of a system. The thin nature of the metal patch also makes it very malleable and easy to fit on any surface. They can also fit various shapes such as rectangles or ellipses.

Patch antennas are narrowband antennas; therefore, their applicability is limited to single-frequency operation which is still relevant in communication technology such as WiFi or cellular networks.

II. OPTIMIZED 2.2GHz PATCH DESIGN

The designed patch antenna has two insets symmetrical about the microstrip feed. The design in ANSYS simulation software is shown in Fig. 1. Its dimensions are tabulated in Table I. The fabricated equivalent of the patch antenna is seen in Fig. 2. Its dimensions are also tabulated in Table I. From

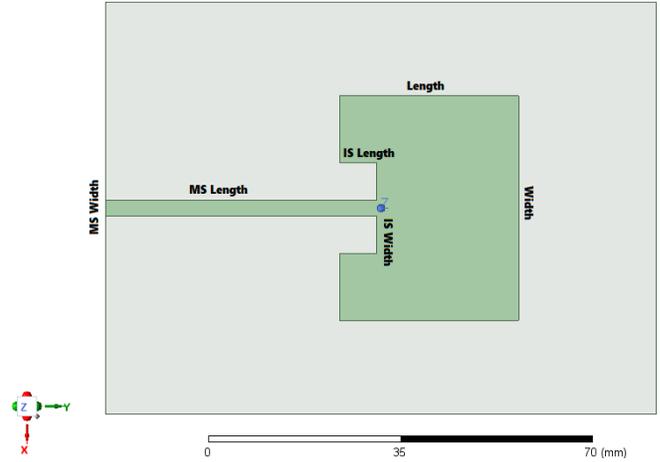


Fig. 1. Dimensioned model of the designed patch antenna. Dimension values found in Table I.

the tabulated dimensions, it is clear that the length of the patch had to be reduced to 32.3mm to achieve a low insertion loss at 2.2GHz.

TABLE I
 SIMULATED 8GHz PATCH DIMENSIONS

Dimension	Design Length [mm]	Fabricated Length [mm]
Width	41.4700	41.7
Length	33.0189	32.3
MS Width	3.0590	3.0
MS Length	43.1811	49.0
IS Width	6.8474	6.5
IS Length	6.8506	6.8

III. 2.2GHz PATCH ANALYSIS

The S_{11} reflection parameter for the simulated and fabricated patch antenna are plotted over a range of frequencies in Fig. 3. Although the points of maximum resonance are both at 2.2GHz for the simulated and fabricated patch, the fabricated path has a much greater return loss with an S_{11} parameter of -12.38 dB compared to -24.46 dB.

As highlighted in the prior section and observed in Table I, there is some discrepancy between the fabricated and



Fig. 2. Photograph of fabricated 2.2GHz patch antenna. Dimension values found in Table I.

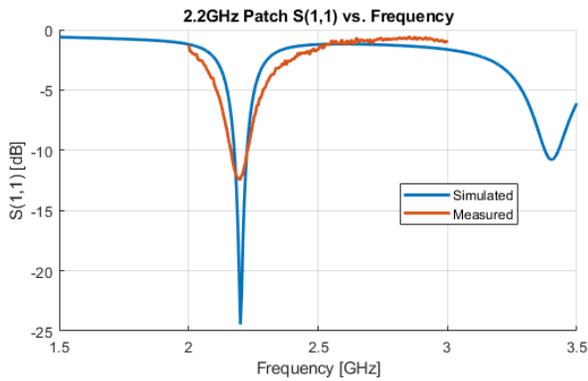


Fig. 3. Simulated and measured insertion loss S_{11} with respect to frequency.

optimized (simulated) lengths. This is due to the poor precision of the manufacturing process of cutting copper tape by hand with a sharp edge. The discrepancies could drastically influence the return loss at 2.2GHz.

Another major factor influencing the return loss is the alignment of the fabricated patch. As seen in Fig. 2, the patch is skew on the substrate. As a result, the microstrip is not parallel to coax-microstrip feed input which leads to more

reflection at the load and throughout the microstrip line. The radiation pattern of this antenna is shown in Fig. 5.

IV. OPTIMIZED 8GHz PATCH DESIGN

An 8GHz patch antenna was designed for low insertion loss with an input impedance of 50Ω . It's optimized dimensions are tabulated in Table II. The S_{11} parameter is plotted from an input of 6.5GHz to 9.5GHz in Fig. 4. From this plot, it is clear that the greatest point of resonance is at 8GHz and the insertion loss is below -20dB which is considered tolerable.

TABLE II
SIMULATED AND FABRICATED 2.2GHz PATCH DIMENSIONS

Dimension	Design Length [mm]
Width	39.5704
Length	32.6874
MS Width	1.00553
MS Length	34.0909
IS Width	6.06016
IS Length	7.52764

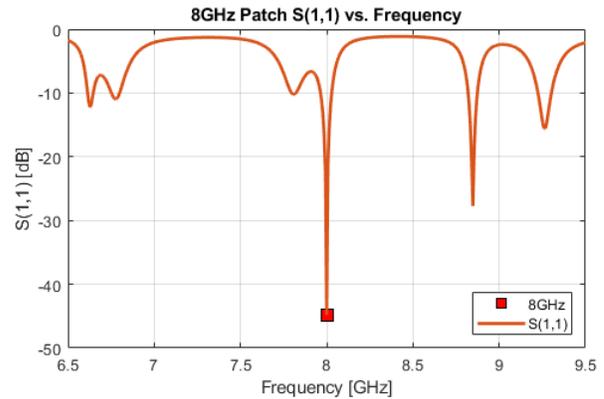


Fig. 4. Simulated 8GHz patch design insertion loss S_{11} with respect to frequency.

The radiation pattern of this antenna is shown in the gain plot Fig. 6.

V. CONCLUSIONS

From the results of this experiment, it can be concluded that small imperfections of less than 0.5mm in patch antenna dimensions can greatly impact the effectiveness of the antenna. Simulations demonstrated a much lower insertion loss than what was measured by the VNA on the imperfect antenna prototype. Furthermore, the length of the copper patch had to be tuned to achieve a center frequency of 2.2GHz. Further investigation into the influence of modifying the shape of the patch may have yielded better results.

As for the 8GHz antenna, it was observed that adding insets to the patch greatly reduced the insertion loss and improved the antenna gain. Tuning the length of the patch and insets had significant impact on the reduction of the insertion loss. Furthermore, decreasing the width of the microstrip feed line

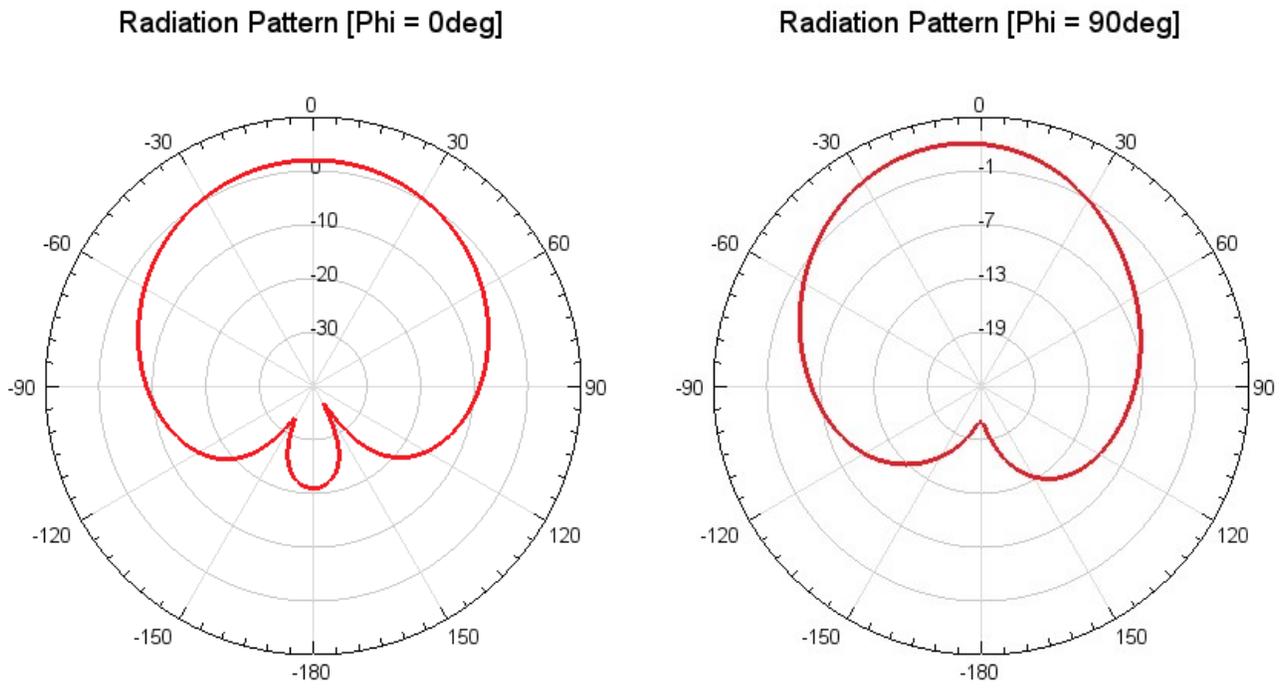
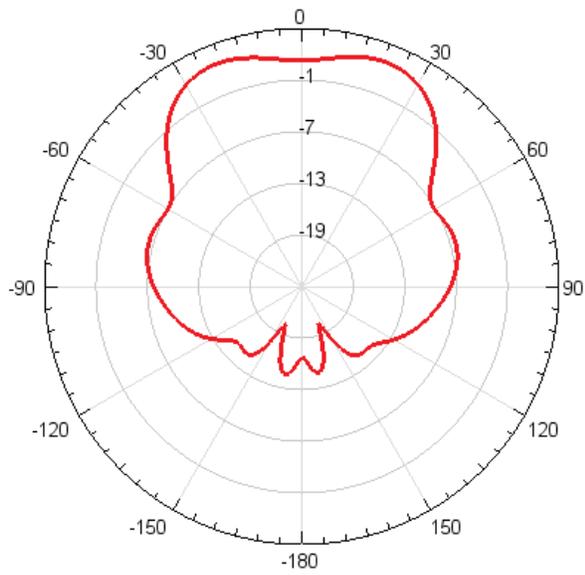


Fig. 5. Radiation pattern of the simulated 2.2GHz patch antenna in both principal cuts.

helped bring the insertion loss' center frequency to the design frequency of 8GHz and match to the antenna of near 50Ω input impedance.

Radiation Pattern [Phi = 0deg]



Radiation Pattern [Phi = 90deg]

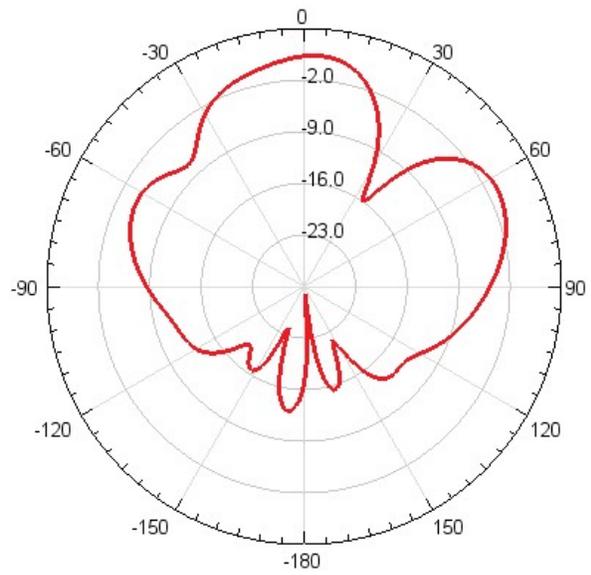


Fig. 6. Radiation pattern of the simulated 8GHz patch antenna in both principal cuts.