IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

Simulation and Study of a Triangular Microstrip Patch Antenna

Sanjay M. Palhade
Associate Professor, Department of Physics
Shri Shivaji College of Arts Commerce & Science, Akola, India
smpalhade65@gmail.com

Abstract: *This study considers the simulation and study of a probe fed triangular microstrip patch antenna developed on a FR4 type substrate. The antenna design is first simulated using Sonnet Lite™ electromagnetic (EM) analysis software. Sonnet Lite™ is memory limited free version of commercial Sonnet™ electromagnetic analysis tool. It is based on method of moments technique to solve electromagnetic boundary value problem. The simulation predicted antenna resonant frequency to be 2360 MHz, Return Loss bandwidth of 36 MHz and input impedance of 52.72 Ohm. The antenna is then studied for its return loss (RL), voltage standing wave ratio (VSWR) and impedance (ZIn1) to determine its resonant frequency. The antenna resonant frequency is found to be 2380 MHz and its return loss bandwidth to be 60 MHz. The antenna radiation pattern is then measured at 2380 MHz. The RL, VSWR and ZIn1 of antenna predicated by Sonnet Lite™ are compared with their measurements which show a good agreement.*

Keywords: Microstrip Patch Antenna, Maxwell's Equations, Electromagnetic Simulation, Sonnet Lite™, Method of Moments

I. INTRODUCTION

Antenna is the most important component of wireless technology [1]. The modern wireless applications require planner, conformal and smaller antennas. Microstrip patch antenna has conformal metallic patch on grounded substrate [2, 3]. Considerable research efforts have taken place to make microstrip patch antenna smaller [4]. Modern small sized mirostrip patch antennas have met the ever growing need of miniature and wireless enabled single board computing systems such as Raspberry Pi, BBC micro:bit, ESP32 etc [5, 6, 7]. Triangular microstrip patch antenna offers about 50% size reduction over rectangular one. Therefore, triangular microstrip patch antenna has been extensively studied during the last 30 years [8].

The present work studies a triangular microstrip patch antenna developed on a FR4 type substrate. The antenna design is first simulated using Sonnet Lite™ electromagnetic (EM) analysis software. Sonnet Lite™ is memory limited free version of commercial Sonnet™ electromagnetic analysis tool. It is based on method of moments technique to solve electromagnetic boundary value problem [9, 10]. The antenna is then studied for its return loss (RL), voltage standing wave ratio (VSWR) and impedance (ZIn1) to determine its resonant frequency. The antenna radiation pattern is then measured at its resonant frequency. The RL, VSWR and ZIn1 of antenna predicated by Sonnet Lite™ are compared with their measurements.

II. METHODOLOGY

2.1 Simulation of Antenna Design

The antenna structure is composed of a triangular copper patch on a grounded FR4 type substrate, shown in Figure 1. The measured geometrical dimensions of the patch, substrate and the probe feed location are shown in the Table 1. The value of dielectric constant of the substrate is taken to be 4.6.

The simulation setup of antenna design using Sonnet Lite™ involves 3 steps. First step is to set units for geometrical and electrical quantities. The second step is to set size of box for simulation and the cell size for meshing of patch. The length and width of box are set equal to the actual measured values of substrate length and width. The substrate dielectric properties and its thickness is also set here. The third step is to draw the triangular copper patch at the centre of the bottom of the box defined in the second step. The layer of thickness 1.5 mm, below the patch is assigned dielectric constant 4.6.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

This layer rests on the bottom of the simulation box which is metallic. The feed probe is modelled as a via port at the location specified in the Table 1. The medium above the patch is air, hence it is assigned dielectric constant equal to 1. The geometrical antenna parameters base edge length L_B and side edge length L_S are used to draw copper triangle in Sonnet Lite™. The antenna structure created in the above steps is simulated in the signal frequency range from 2300 MHz to 2500 MHz.

Table 1: Antenna Parameters

Antenna Parameter	Value	Antenna Parameter	Value
Patch Base L_B	36 mm	Substrate length L_G	90 mm
Patch Side L_S	38 mm	Feed X_f	6 mm from base
Substrate height h	1.5 mm	Dielectric constant	4.6
Substrate length L_G	90 mm		

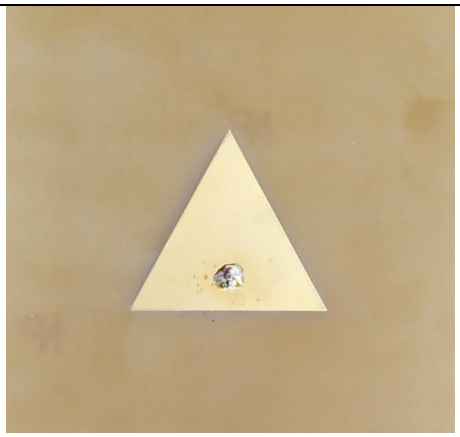


Figure 1: Triangular Patch Antenna

The results of simulation of the antenna for Return Loss (RL) are presented in the graph for S11 which is shown in Figure 2. The graph presents magnitude of S11 in dB versus the frequency.

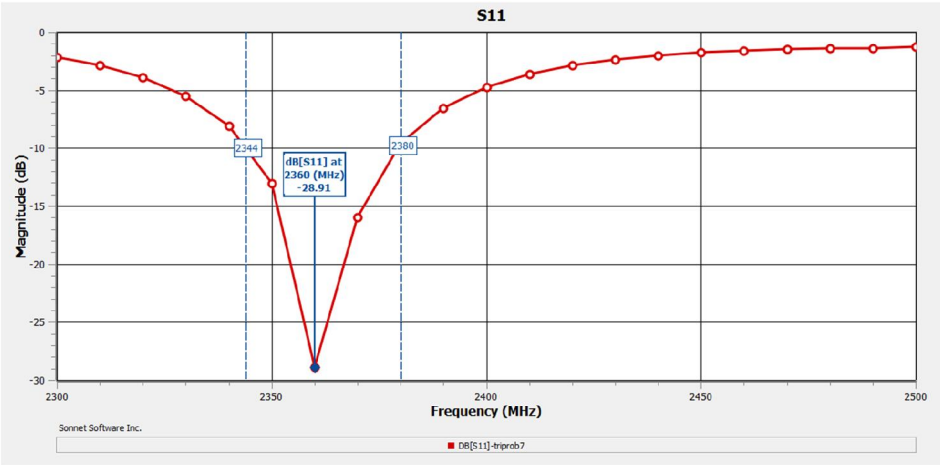


Figure 2: Return Loss Simulation

The results of simulation of the antenna for Voltage Standing Wave Ratio (VSWR) are presented graphically in the Figure 3.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

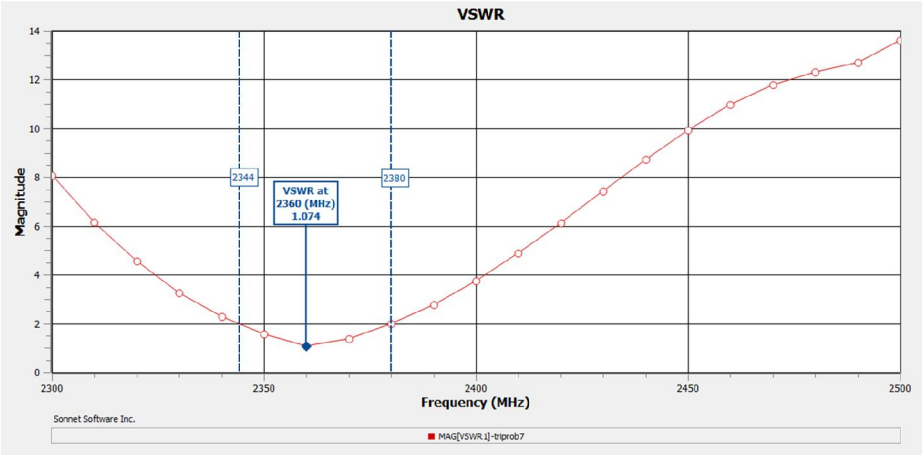


Figure 3: VSWR Simulation

The simulation results for feed point impedance (ZIn1) are graphically shown in the Figure 4.

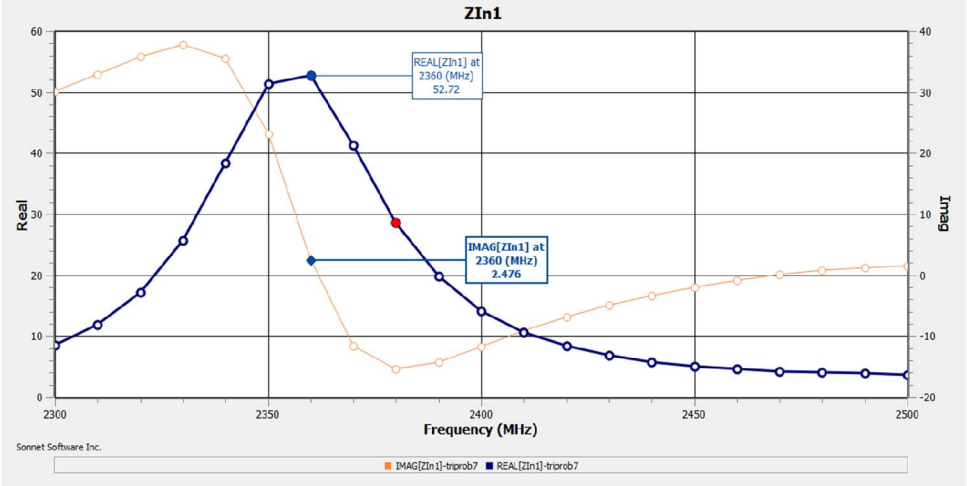


Figure 4: ZIn1 Simulation

The Return Loss, VSWR and feed point impedance ZIn1 results for simulation shows that the antenna design is resonant at 2360 MHz. The operational antenna bandwidth will be from 2344 MHz to 2380 MHz. The VSWR will remain below 2 from 2344 MHz to 2380 MHz.

2.2 Antenna Measurements

The antenna Return Loss and VSWR measurements have been performed using a Scalar Network Analyzer. The scalar network analyzer setup used in this work consists of RF generator capable of providing RF signal from 35MHz to 3000MHz, RF detector to detect rf signal and Directional Coupler [11, 12]. These measurements have been performed from 2300 MHz to 2500 MHz so as to cover the resonant frequency 2360 MHz predicated by the simulation. The results of Return Loss measurements compared with those predicted by the simulation are graphically presented in the Figure 5.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

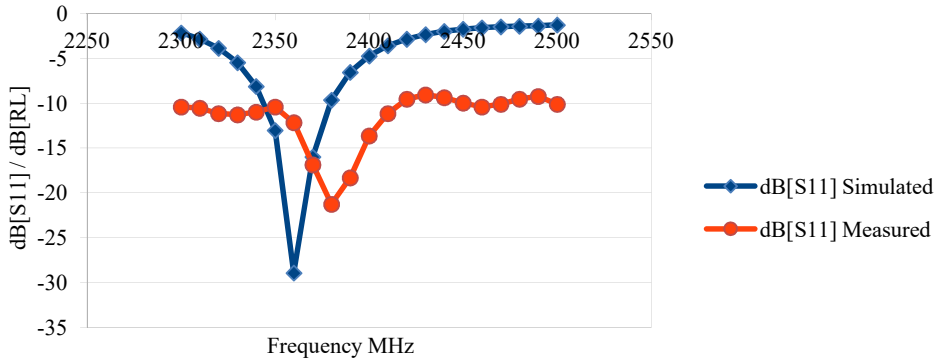
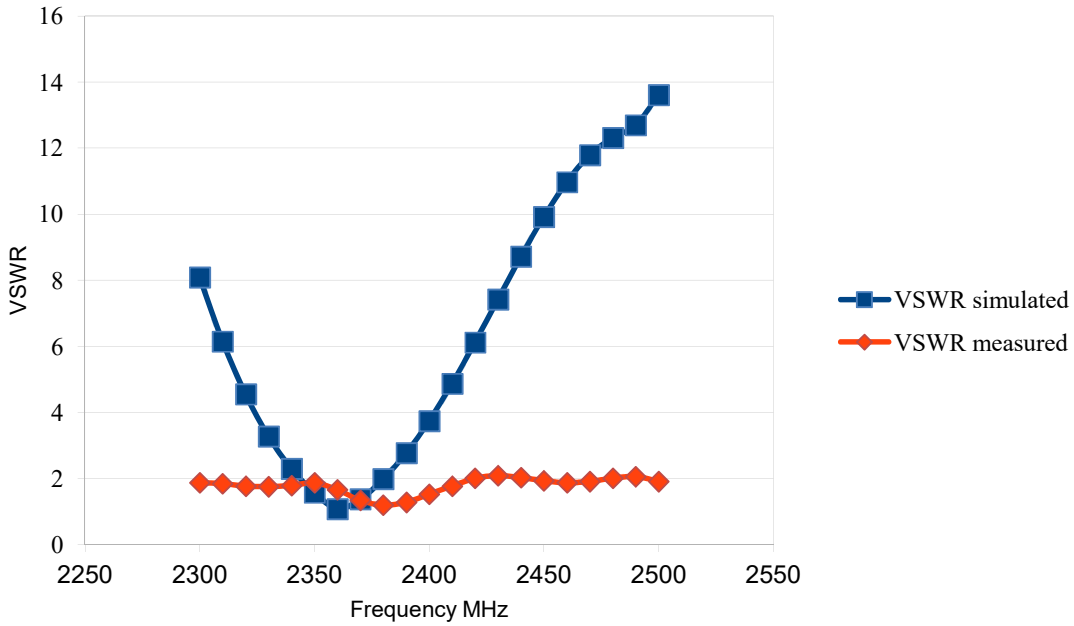


Figure 5: Return Loss

The antenna VSWR measurements compared with simulation predicated are graphically presented in Figure 6. The measured VSWR bandwidth is 60 MHz from 2350 MHz to 2410 MHz



The measured antenna input impedance at the feed location compared with the simulation predicated is graphically presented in Figure 7.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

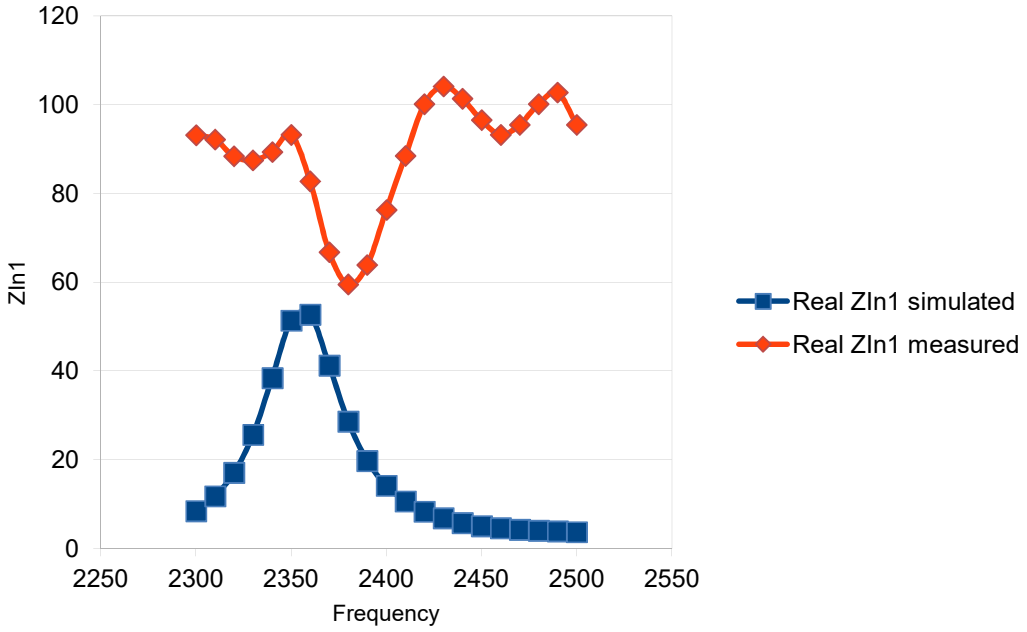


Figure 7: Input Impedance

The antenna radiation pattern measured at the resonant frequency 2380 MHz is shown in Figure 8.

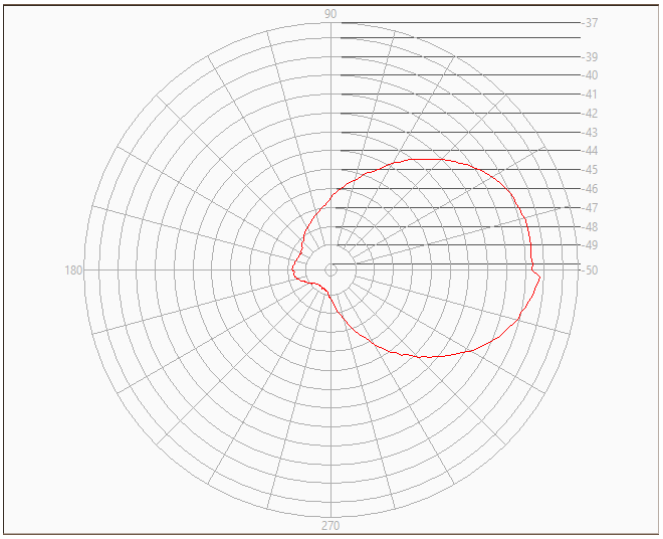


Figure 8: Antenna Radiation Pattern

III. RESULTS AND DISCUSSION

The predicted values of Resonant Frequency, Return Loss bandwidth, minimum VSWR, VSWR bandwidth, input impedance at feed location and their measured values of the antenna are shown in the Table 2.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, December 2022
Impact Factor: 6.252

Table 2: Antenna Parameters

Antenna Parameter	Simulation Predicted	Measured
Resonant Frequency	2360 MHz	2380 MHz
Return Loss Minimum	-28.91	-21.25
Return Loss Bandwidth	36 MHz	60 MHz
VSWR minimum	1.074	1.189
VSWR bandwidth	36 MHz	60 MHz
Input Impedance at feed location	52.72 Ohm	59.48 Ohm

IV. CONCLUSION

In this work a triangular microstrip patch antenna developed on FR4 type substrate material is first simulated and then studied. Method of moments based electromagnetic simulation software SonnetTM Lite is used to model and simulate the antenna. Antenna simulation model based on the geometrical parameters and physical properties of the antenna structure is developed. Using SonnetTM Lite simulation of the antenna structure, the antenna Return Loss (RL), the antenna VSWR and the antenna input impedance at the feed location (ZIn1) are obtained. The simulation of antenna structure predicted the antenna resonant frequency to be 2360MHz. The simulation predicted the Return Loss and VSWR bandwidths to be 36 MHz each and feed location impedance to be 52.72 Ohm at 2360 MHz. The Return Loss (RL), Voltage Standing Wave Ratio (VSWR) and ZIn1 of the antenna are measured in the frequency range from 2300 MHz to 2500 MHz using a Scalar Network Analyzer setup. The actual resonant frequency of the antenna is then found to be 2380 MHz from Return Loss measurements of the antenna. The Return Loss and VSWR bandwidths are found to be 200 MHz and the feed location input impedance ZIn1 to be 59.48 Ohm at 2380 MHz. Finally, the radiation pattern of the antenna is measured at the resonant frequency 2380 MHz.

V. ACKNOWLEDGMENT

The author wish to express his heartfelt thanks to the principal of Shri Shivaji College of Arts, Commerce and Science, Akola for his support and help to undertake this research work. The author takes this opportunity to thank Research Development Committee of college for providing instrumentation and facilities of the Central Instrumentation Cell (CIC) which is established in the college under the DST-FIST Level 0 support. The author is grateful to the Department of Science and Technology (DST), Govt. of India. The author gratefully acknowledges the help and assistance from the members of CIC.

REFERENCES

[1]. J. D. Kraus, Ronald J. Marhefka and Ahmad S. Khan, Antennas and Wave Propagation, McGraw-Hill Education, 2017.
[2]. K. R. Carver and J. W. Mink, “Microstrip Antenna Technology,” IEEE Trans. Antennas Propagat., Vol. AP-29, No. 1, pp. 2–24, January 1981.
[3]. Anil Pandey, Practical Microstrip and Printed Antenna Design, Artech House, 2019.
[4]. Kyohei Fujimoto and Hisashi Morishita, Modern Small Antennas, Cambridge University Press, 2014
[5]. Available : https://www.raspberrypi.com/
[6]. Available : https://microbit.org/
[7]. Available : https://www.espressif.com/en/products/socs/esp32
[8]. Maity, S. and Gupta, B., “Approximate investigation on isosceles triangular microstrip antenna in fundamental mode”, Microw. Opt. Technol. Lett., Vol. 59, No. 3, pp. 614-618, 2017
[9]. Available : https://www.sonnetsoftware.com/
[10]. J. C. Rautio and R. F. Harrington, "An Electromagnetic Time-Harmonic Analysis of Shielded Microstrip Circuits," in IEEE Transactions on Microwave Theory and Techniques, vol. 35, no. 8, pp. 726-730, Aug 1987
[11]. Ananjan Basu, An Introduction to Microwave Measurements, CRC Press, 2014
[12]. Hiroyuki Arai, Measurement of Mobile Antenna System, Artech House, 2013