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Design and Comparative Performance Analysis of Conventional and Truncated Microstrip Patch Antennas Using CST Studio Suite

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Abstract: This paper presents a comparative electromagnetic simulation study of two microstrip patch antenna configurations: a conventional rectangular patch and a patch with truncated corners. Both designs were modelled in this design using an FR-4 substrate with a relative permittivity of 4.4 and a reported substrate thickness of 1.5 mm. The antenna responses were evaluated over a simulated frequency range of 0–5 GHz, with particular attention to operation near 2.5 GHz for the conventional design and 2.6 GHz for the truncated design. The reported results indicate that the truncated configuration provides a wider -10 dB impedance bandwidth (1.18 GHz, compared with 1.09 GHz for the conventional design) and a deeper minimum reflection coefficient at selected frequencies. Input impedance, voltage standing-wave ratio (VSWR), far-field patterns, and efficiency were also examined. The comparison suggests that corner truncation can alter impedance matching and radiation characteristics; however, the reported changes in reactance and efficiency show that the geometry involves trade-offs. The results are based on simulation, and experimental validation and a more detailed account of the design novelty are recommended before drawing application-specific conclusions.

Keywords: microstrip patch antenna; truncated corners; CST Studio Suite; S11; impedance bandwidth; VSWR; radiation efficiency

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1. Introduction

Microstrip patch antennas are widely used in wireless systems because of their low profile, planar construction, and ease of integration with printed circuits [1].Their performance depends on the patch geometry, substrate properties, feed arrangement, and ground-plane configuration. Small changes to patch geometry can affect the resonant response, impedance matching, and radiation characteristics[2].

A patch antenna (also known as a rectangular microstrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane[3]. They are the original type of microstrip antenna consisting of two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves[4]. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used[5].

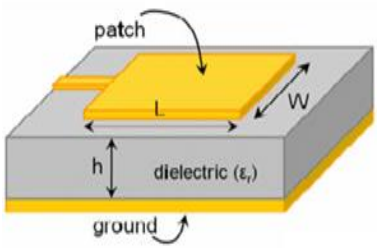


Figure 1: Example of a patch antenna

This study compares a conventional rectangular patch with a modified patch in which the corners are truncated. The aim is to evaluate how this geometric modification affects simulated antenna performance[6,7]. The analysis focuses on the reflection coefficient, impedance bandwidth, VSWR, input impedance, field patterns, and reported efficiency measures. The study is a simulation-based comparison; no measured prototype results are included in the source paper.

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2. Antenna Configurations and Simulation Method

2.1 Antenna configurations

Two configurations were considered: (i) a conventional rectangular microstrip patch antenna (base design) and (ii) a patch antenna with truncated corners (truncated design). The source work presents the layouts and three-dimensional models of both configurations. The purpose of the comparison is to assess the performance differences associated with the corner modification.

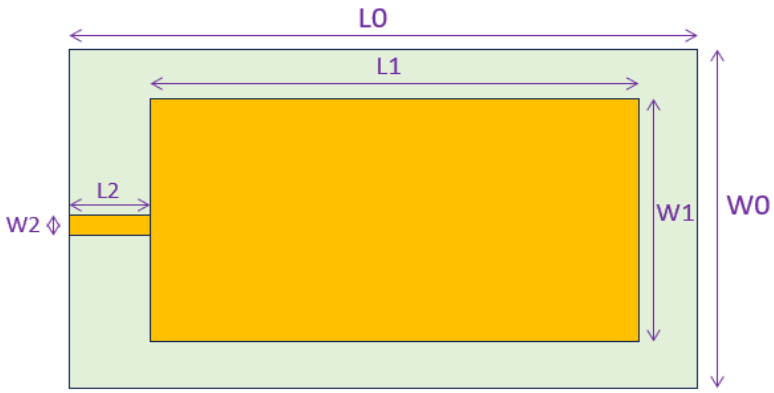


Figure 2 : Design of Antenna in consideration (Base Design)

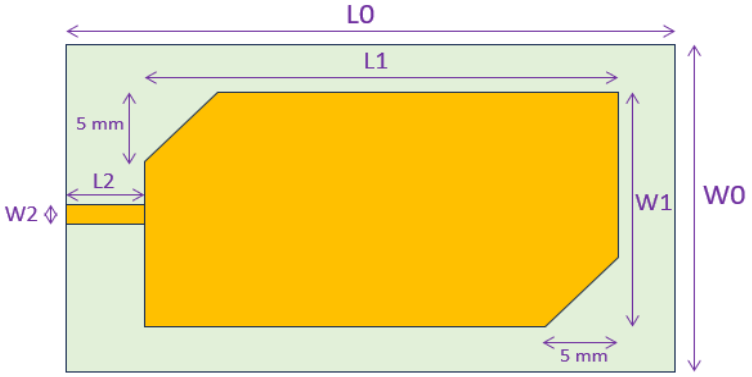


Figure 3 :Design of Antenna in consideration (Truncated Design)

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2.2 Materials and geometric parameters

The antennas were modelled with an FR-4 substrate and copper conductors[9]. The source work specifies a relative permittivity of 4.4 for FR-4, a substrate thickness of 1.5 mm, and a copper thickness of 0.035 mm. The listed substrate dimensions are 47.04 mm × 38.48 mm, while the patch dimensions are 38.04 mm × 29.48 mm. The excitation strip is listed as 5.2 mm long and 1 mm wide. The report describes the material definitions as loss-free; this assumption should be reviewed because it can influence predicted efficiency and losses.

Parameter	Symbol	Reported value
Substrate material	—	FR-4
Relative permittivity	εr	4.4
Substrate thickness	h	1.5 mm
Copper thickness	t	0.035 mm
Substrate length	L0	47.04 mm
Substrate width	W0	38.48 mm
Patch length	L1	38.04 mm
Patch width	W1	29.48 mm
Feed-strip length	L2	5.2 mm
Feed-strip width	W2	1.0 mm
Simulation frequency range	—	0–5 GHz

2.3 Simulation procedure and evaluated metrics

Both antenna configurations were simulated in CST Studio over the reported 0–5 GHz range. The report compares the base design near 2.5 GHz and the truncated design near 2.6 GHz. The evaluated quantities include S11, impedance bandwidth at the -10 dB threshold, VSWR, the real and imaginary parts of input impedance, far-field E- and H-field patterns, radiation efficiency, total efficiency, and three-dimensional radiation patterns.

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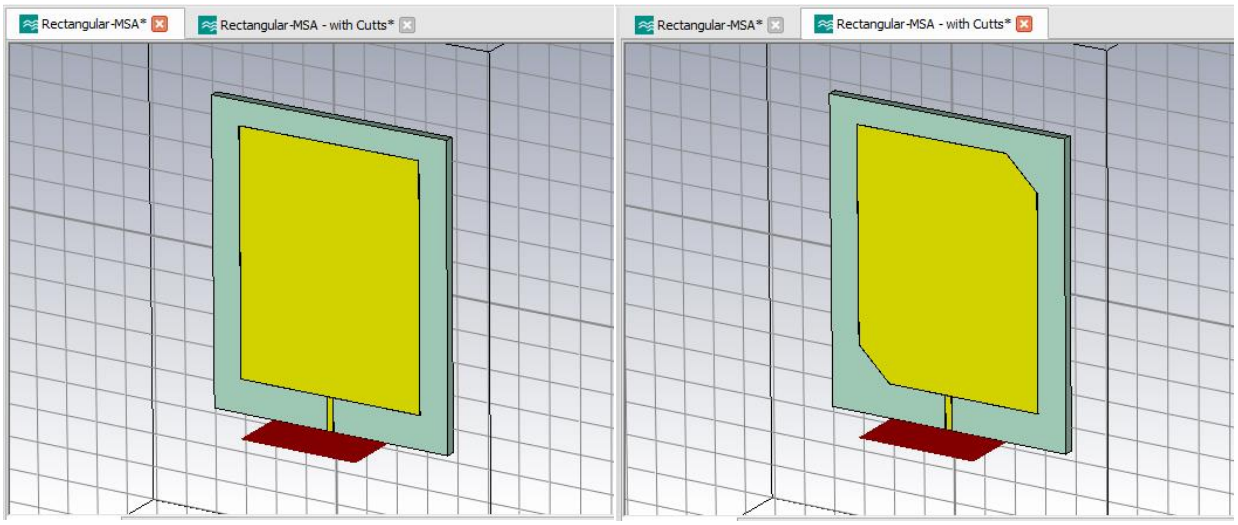


Figure 4 : 3D model of the antenna of consideration - left: Base design, right: Truncated Design

3. Results and Discussion

3.1 Reflection coefficient and impedance bandwidth

According to the paper simulation results, the conventional design has a -10 dB impedance bandwidth of 1.09 GHz over approximately 1.99–3.08 GHz, with S11 reported as -26.814 dB at 2.5 GHz. The truncated design is reported to have a bandwidth of 1.18 GHz and S11 of -30.65 dB at 2.6 GHz. The work also identifies a value of -31.71 dB for the truncated design at 2.52 GHz. Because the stated resonant frequencies and minima are not all at the same frequency, the final manuscript should include a consistent comparison at a common frequency as well as each design's own resonant frequency.

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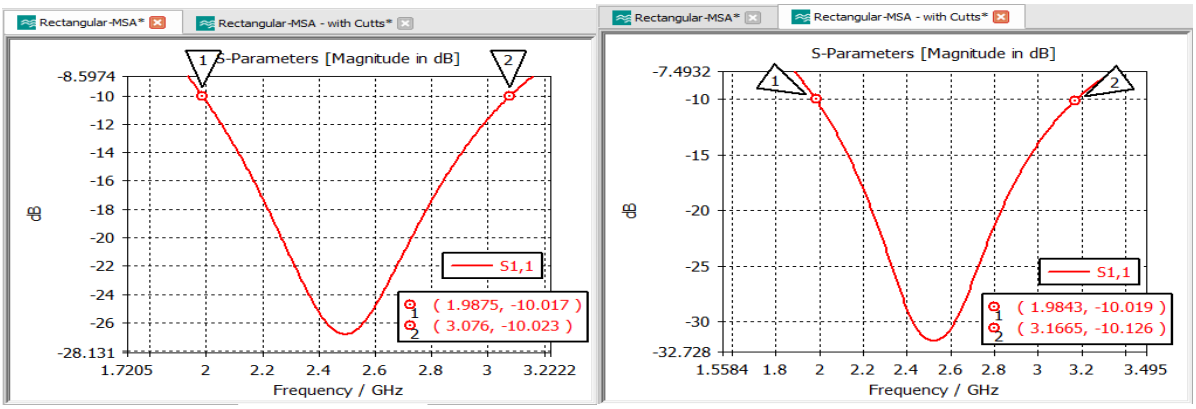


Figure 5: S-Parametric results for - left: Base design, right: Truncated Design

3.2 VSWR and input impedance

The work states that the truncated design provides an improved VSWR near 2.6 GHz. It also reports a real input impedance of approximately 49 Ω for the truncated design, with a value of 49.2 Ω at 2.52 GHz. The imaginary part is described as inductive for the simulated antennas, while the conventional design is reported to have an imaginary impedance of 1.367 Ω at its simulated frequency. These values should be checked against the exported CST data and reported at clearly specified frequencies before submission.

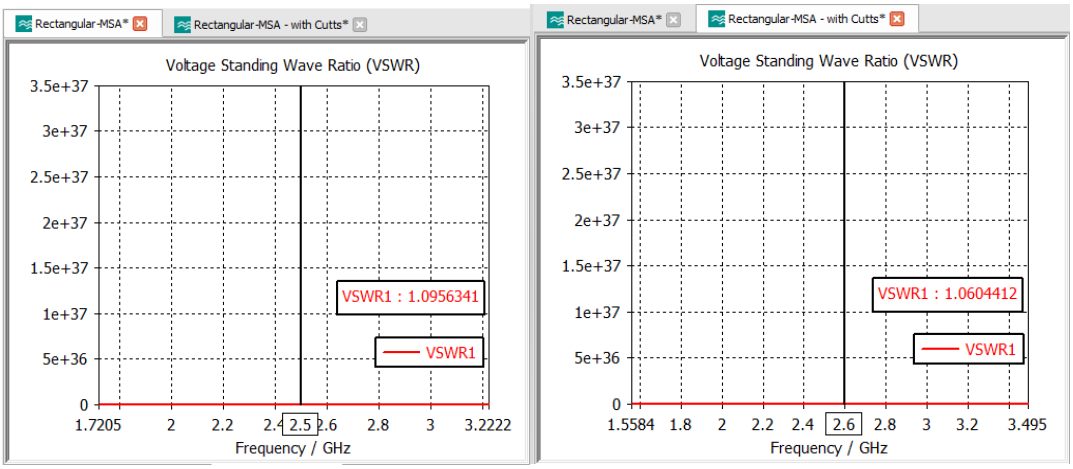


Figure 6: Voltage Standing Wave Ratio (VSWR) - left: Base design, right: Truncated Design

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3.3 Radiation patterns and field distributions

Far-field E-field and H-field plots were generated for the two configurations. The source report gives maximum E-field values of 16.1 dBV/m for the base design at 2.5 GHz and 16.3 dBV/m for the truncated design at 2.6 GHz. It reports corresponding H-field values of -36.3 dBA/m and -36.1 dBA/m. These field magnitudes depend on the simulation setup and normalization; they should not be interpreted as direct substitutes for antenna gain or directivity. The radiation patterns should be presented with their coordinate planes, polarization, frequency, and normalization clearly identified.

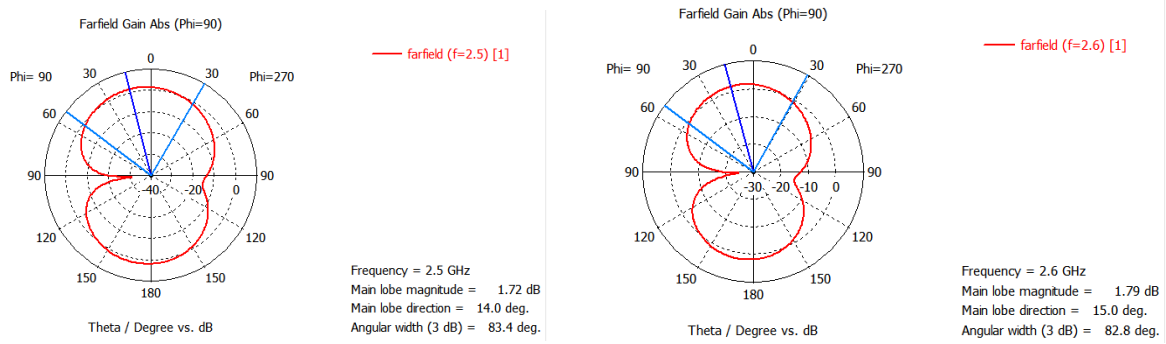


Figure 7: 2D HPBW plot of antenna radiations for - left: Base design, right: Truncated Design

3.4 Efficiency

The report gives radiation efficiency for the truncated design as -0.922 dB and total efficiency as -1.207 dB, compared with a reported total efficiency of -1.279 dB for the base design. Since efficiency is commonly reported as a percentage or as a ratio, the manuscript should state explicitly whether the plotted values are efficiencies converted to dB and provide the corresponding linear or percentage values. The loss-free material settings reported in the original model should also be reviewed before using these results to support practical performance claims.

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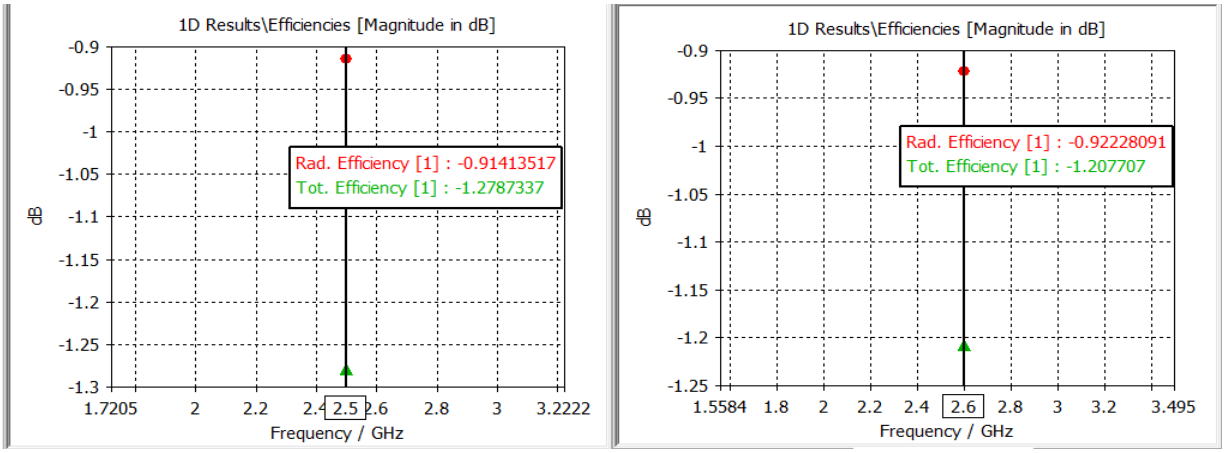


Figure 8: Radiation efficiency of the Antenna (dB) - left: Base design, right: Truncated Design

3.5 Summary of the work comparison

Metric	Conventional design	Truncated design
Reported evaluation frequency	2.5 GHz	2.6 GHz
Reported S11 at evaluation frequency	-26.814 dB	-30.65 dB
Reported -10 dB bandwidth	1.09 GHz	1.18 GHz
Reported total efficiency	-1.279 dB	-1.207 dB
Real input impedance	2.49GHz	≈49 Ω; 49.2 Ω at 2.52 GHz

4. Conclusion

A comparative CST simulation of a conventional rectangular microstrip patch antenna and a corner-truncated configuration has been presented. Based on the values reported in the source report, the truncated design exhibits a modestly wider -10 dB impedance bandwidth and a deeper S11 minimum at the stated evaluation frequency. The reported input impedance and efficiency results also indicate that the geometric modification changes the antenna's impedance and radiation behaviour. These findings should be treated as preliminary because the two designs are evaluated at different frequencies, some reported quantities require clarification, and no experimental validation is provided. Future work should verify the CST data, compare both designs at common frequencies, document the exact truncation dimensions and feed/port setup, use realistic material losses, and, where possible, compare simulations with measurements.

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