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Performance Analysis of Truncated Triangular Microstrip Patch Antenna

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Abstract
In this paper, using the basic principles of microstrip patch antenna, we design a truncated triangular microstrip patch antenna (MPA) by truncating two small circular slots. The design of the antenna structure is achieved by truncating two circular slots and placing a single coaxial feed. The antenna is designed on a Bakelite substrate of relative permittivity 4.78 and mounted above the ground plane at a height of 0.15 cm. The performance of the design is evaluated on the basis of reflection coefficient, gain, return loss, voltage standing wave ratio (VSWR) and radiation pattern. The proposed antenna shows better results as compared to the conventional triangular patch antenna.

Keywords
Triangular MPA, Return loss, bandwidth, truncated MPA

I. Introduction
Antennas that are fabricated using microstrip techniques on printed circuit board(PCB) are called Microstrip antennas. A microstrip antenna consist of a radiating patch on one side of a dielectric substrate that has a ground plane on the other side. Microstrip antenna are also called printed antennas. Microstrip antenna operates at microwave frequencies. Advantages like low cost, light weight, conformal configuration with the circuit components of the microstrip antenna has made it preferable in modern communication systems[1],[2]. Microstrip antenna patches can have any continuous shapes. The commonly used shapes are rectangular, circular and triangular etc. Triangular shape antenna is most preferable because of its high gain and low return loss. Applications of microstrip antenna are in mobile communication system, direct broadcast television, GPS system, wireless LAN etc. Performance of an antenna is measured in terms of Bandwidth and return loss[3]-[4].

This paper deals with a triangular antenna truncating out two circular slots keeping the total effective area of the triangular area almost constant. The side length of the triangular patch before and after truncation remains same. The aim of this design is to reduce the return loss and increase the bandwidth percentage compared to the conventional triangular microstrip antenna.

This paper is organized into the following sections. Section II presents an insight into the antenna structure and design considerations. Experimental details and related results are included in Section III. Finally Section IV concludes the paper.

1. Antenna Structure & Design Consideration

A. Antenna Geometry
Fig. 1 presents a conventional triangular MPA having side length *a* and is printed on a substrate of thickness *h* and relative permittivity ϵ_r. The ground plane of area same as that of the substrate is placed at the bottom surface of the radiating patch.

This antenna is modified in its geometry by cutting out two circular slots on the patch. This antenna is named as truncated triangular MPA. In this geometry the two circular slots of radius *r* each are truncated. The geometry is shown in Fig 2.

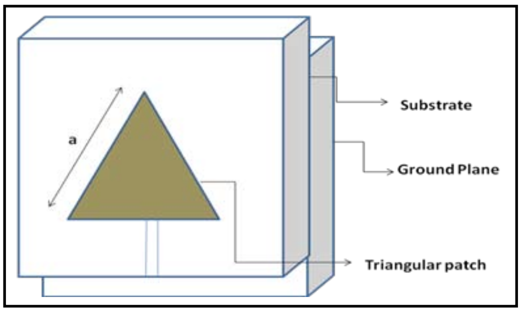

Fig. 1: Triangular Microstrip Patch Antenna.

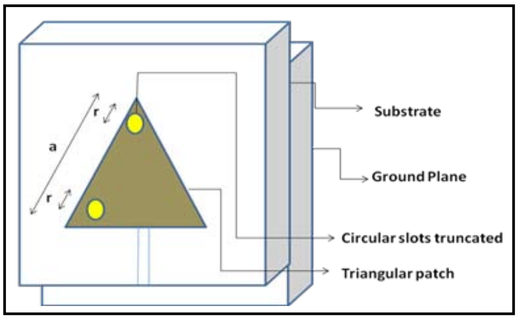

Fig. 2: Triangular Microstrip Patch Antenna with Truncated circular slot.

B. Design Parameters:
The fundamental mode resonant frequency of such antenna is given by

$$f_r = \frac{2c}{3a\sqrt{\varepsilon_r}}$$

Where *c* is the velocity of light in free space, *a* is the side length of the antenna and ε_r is the dielectric constant of the substrate. The fundamental frequency for this design calculated by,

$$f_r = \frac{2c}{3a_{eff}\sqrt{\varepsilon_{eff}}}$$

Where a_{eff} and ε_{eff} are the effective side length and effective dielectric constant, which is given by,

$$a_{eff} = a + \frac{h+\Delta}{\sqrt{\varepsilon_r}}$$

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$$\epsilon_{eff} = \frac{\varepsilon_r(h+\Delta)}{h+(\varepsilon_r * \Delta)}$$

Where Δ is the air gap calculation, given by,

$$\Delta = 0.14 * \left(\frac{c}{f_o} - h\right) * \sqrt{\varepsilon_r}$$

The various parameters used for the design of antenna are:

Relative dielectric constant=	4.78
Substrate thickness=	0.15 cm
Resonant frequency for triangular patch=	3 GHz
The side length for the triangular antenna is given by =	3cm
Radius of small truncated circular area=	0.5 cm

II. Simulation Results

The simulation has been carried out using matlab simulation software.

A. Radiation pattern

The radiation pattern for conventional triangular MPA and Truncated triangular MPA has been shown in fig 3.

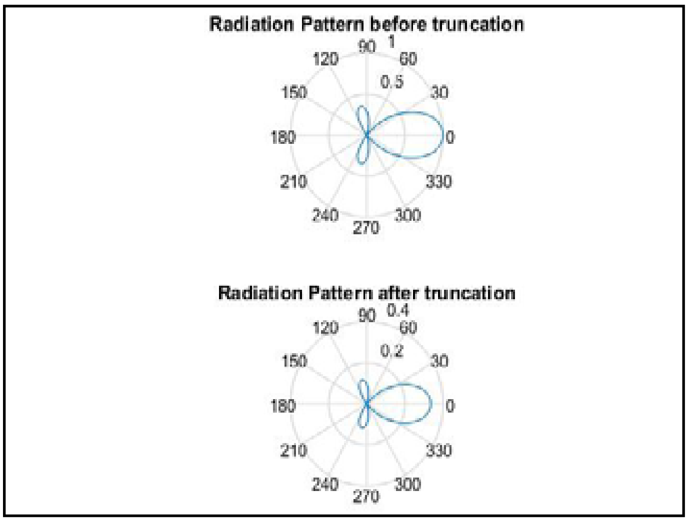

Fig. 3: Radiation pattern before and after truncation of triangular MSA.

B. Reflection Coefficient Vs Frequency

Fig 4 shows the comparison of reflection coefficient vs. frequency curve for conventional and truncated triangular MPA. The simulated resonant frequency of the antenna as shown in the result is 3.1 GHz.

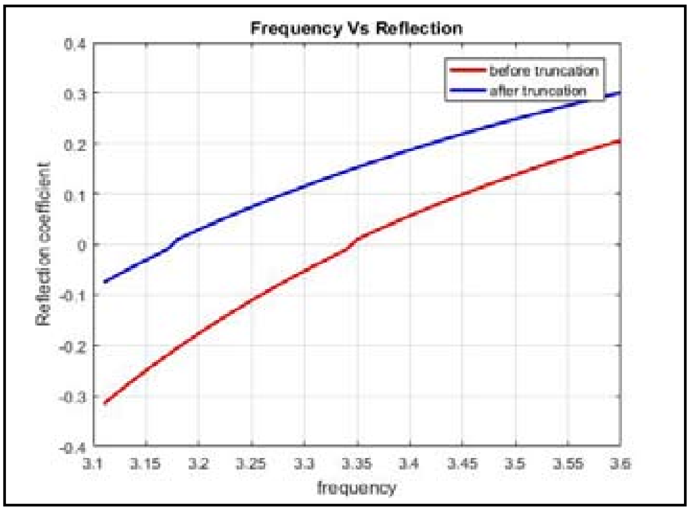

Fig. 4: Reflection Coefficient before and after truncation of triangular MSA.

C. Frequency vs Return Loss

Comparison of Return Loss vs. Frequency curve between conventional MSA and truncated MPA is shown in fig 5. The conventional MSA shows a return loss of -37.08 dB whereas truncated MPA shows a return loss of -43.08 dB. The frequency vs. return loss curve is shown in fig. 5

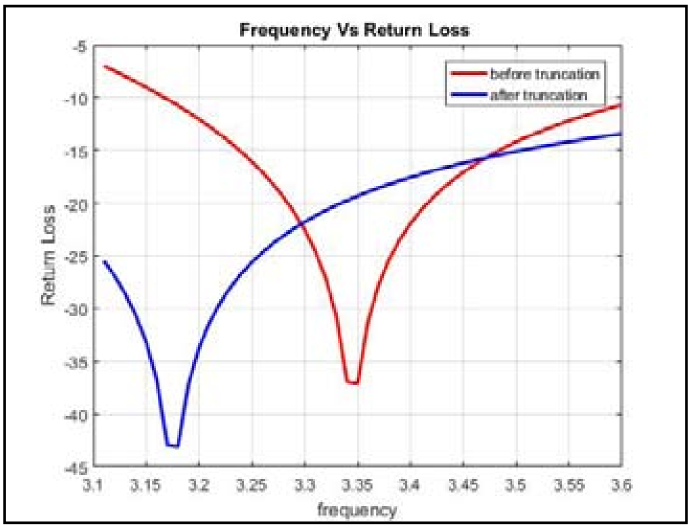

Fig. 5: Return Loss before and after truncation of triangular MSA.

D. Bandwidth Calculation

The triangular microstrip antenna with finite ground plane resonates at 3.35 GHz frequency, with impedance bandwidth BW= 1.7 % (3.32 GHz to 3.38 GHz) at center frequency 3.35 GHz. Now, the triangular patch is modified by truncating two circular slots of 0.5 cm radius each. The new design is simulated which resonates at 3.18 GHz with impedance BW = 5.03 % (3.1 GHz to 3.26 GHz) at center frequency 3.18 GHz. The new impedance BW is approximately 3 times the BW of the conventional MPA without any truncation.

E. VSWR vs. Frequency

The VSWR for conventional triangular MPA and Truncated triangular MPA has been shown in fig 6.

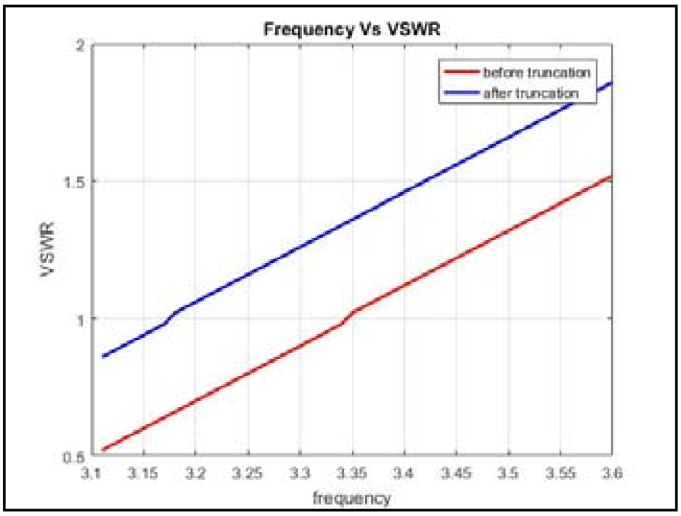

Fig. 6: VSWR before and after truncation of triangular MSA.

Table 1: Summarized Performance Comparison of Antenna with & Without Truncation.

PARAMETER	VALUE
Effective Area before truncation	0.210900
Effective Area after truncation	0.212155
Reflection_coefficient before truncation	0.206349
Reflection_coefficient after truncation	0.300699
VSWR before truncation	1.520000
VSWR after truncation	1.860000
Return_loss before truncation	-37.086427 dB
Return_loss after truncation	-43.086427 dB
Bandwidth before truncation	1.7 %
Bandwidth after truncation	5.03 %

III. Conclusion

This work studies the performance analysis of triangular MPA truncating two circular slots without affecting the total effective area so as to increase the bandwidth percentage and lower the return loss. The summarized performance comparison of the antenna with and without truncation are listed in table 1. Here the truncated MPA resonates at 3.18 GHz giving a bandwith % increase of 3 times than the conventional MPA. We also find the return loss is considerably reduced to -43.08 dB with truncation. This makes the antenna more reliable. We also plot the radiation pattern and derive the VSWR and reflection coefficient for both the truncated and non truncated MPA.

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