International Journal of Engineering Research and Development
e-ISSN: 2278-067X, **p**-ISSN : 2278-800X, www.ijerd.com
Volume 5, Issue 4 (December 2012), PP. 52-56

Triple Band Triangular and Exponential Serrated MSP Antennas for S and C Band Applications

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Abstract:- Serrated Microstrip Antennas are gaining their importance in the applications of dual and multiband antenna systems. A Serrated cutting edge has many small points of contact with the material being cut. The Serrations are mainly used in the Compact Antenna Test Range (CATR) measurements for the measurement of antenna parameters. In Serrations, by having less contact area than a smooth blade or other edge, the applied force at each point of contact is relatively greater and the points of contact are at a sharper angle to the material being cut. The present paper deals with the performance evaluation of Triangular Serrated Microstrip antenna and combination of Triangular – Exponential serrations. The simulated output parameters like Return loss, gain, input impedance and field distributions along with radiation patterns are presented in the current work.

Keywords:- Dual and Multiband, Serrations, CATR, field distributions.

I. INTRODUCTION

Serrations are common both in nature and in man made objects. In nature, serrations are commonly seen in the cutting edge on the teeth of some species like shark. However, it also appears on non-cutting surfaces, for example on leaf margin or other plant part. The CATR provides a relatively new method of measuring the far field characteristics of Microwave antennas. The Test antenna is illuminated by a collimated beam of energy from a parabolic reflector. The diffractions from the edges of the reflector are minimized by serrating the edges of the reflector [1-5].

The Microstrip antennas are being used in many advanced applications of the communication systems. The aperture of the microstrip patch will be mould similar to the serrated CATR [6-7]. By placing different shapes of serrated apertures on the MSP antenna, giving results for multiband applications. This was recently observed while taking the equally spaced linear serrated edges [8-10]. The present model deals with non-linear triangular serrated aperture based MSP antenna and linear triangle – exponential serrated MSP antenna. The performance evaluation of both the models are simulated using commercial, finite element method based Electromagnetic Simulator, so called Ansoft HFSS.

II. EVALUATION OF SERRATED EDGES

The Exponential serrations designed at the x-axis boundaries of the MSP antenna are represented as follows in figure 1.2.

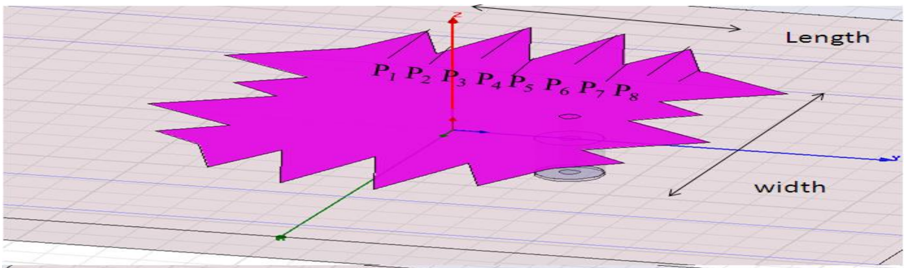
$F(x^{|}) = t.e(-a_1p_1) + t(1-e(-a_1x^{|}))$ $\quad 0 < x^{|} < p_1$
$= t.e\text{-}a_2(x^{|}-p_1)$ $\quad p_1 < x^{|} < p_2$
$= t.e(-a_3(p_3-p_2)) + t\{1-e(-a_3(x^{|}-p_2))\}$ $\quad p_2 < x^{|} < p_3$
$= t.e(-a_4(x^{|}-p_3))$ $\quad p_3 < x^{|} < p_4$
$= t.e(-a_5(p_5-p_4))+\{1-e(-a_5(x^{|}-p_4))\}$ $\quad p_4 < x^{|} < p_5$
$= t.e(-a_6(x^{|}-p_5))$ $\quad p_5 < x^{|} < p_6$
$= t.e(-a_7(p_7-p_6))+t\{1-e(-a_7(x^{|}-p_6))\}$ $\quad p_6 < x^{|} < p_7$
$= t.e(-a_8(x^{|}-p_7))$ $\quad p_7 < x^{|} < p_8$

The Triangular serrations obtained at the y-axis boundaries of the MSP antenna are represented as follows

$F(y^{|}) = (t.y)/p_1$ $\quad 0 < y^{|} < p_1$
$= -t(y-p_2)/(p_2-p_1)$ $\quad p_1 < y^{|} < p_2$
$= t(y-p_2)/(p_3-p_2)$ $\quad p_2 < y^{|} < p_3$
$= -t(y-p_4)/(p_4-p_3)$ $\quad p_3 < y^{|} < p_4$
$= t(y-p_4)/(p_5-p_4)$ $\quad p_4 < y^{|} < p_5$
$= t(y-p_6)/(p_6-p_5)$ $\quad p_5 < y^{|} < p_6$

$= t(y-p_6) / (p_7-p_6) \qquad p_6 < y' < p_7$

$= t(y-p_8) / (p_8-p_7) \qquad p_7 < y' < p_8$



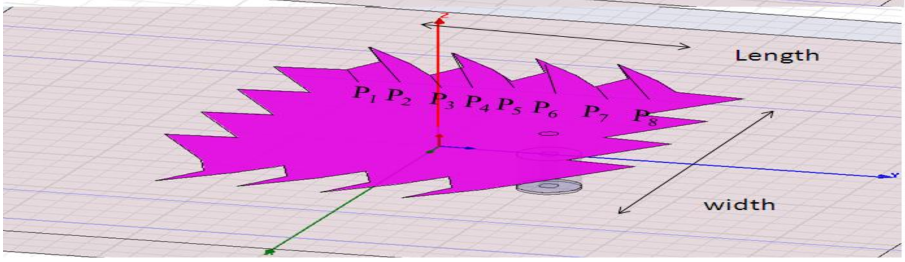


Figure 1.1 Triangular Serrated MSPA **Figure 1.2** Triangular-Exponential MSPA

S.No	Input parameters	Triangular Serrated MSPA	Triangular-Exponential Serrated MSPA
1	Patch Length	25.7 mm	38.6 mm
2	Patch Width	19.5 mm	29.4 mm
3	Substrate Length	60 mm	90 mm
4	Substrate Width	60 mm	90 mm
5	Substrate Height	1.8 mm	2 mm
6	Feed Position	6.5 mm	9.6 mm
7	Feed length	4.3 mm	6.8 mm

Table 1. Antenna Design Input Parameters

Figure 1 shows the triangular serrated and exponential triangular serrated antenna models. The dimensions of the MSP antennas are tabulated in the table 1 for both the models.

Results and Discussion:

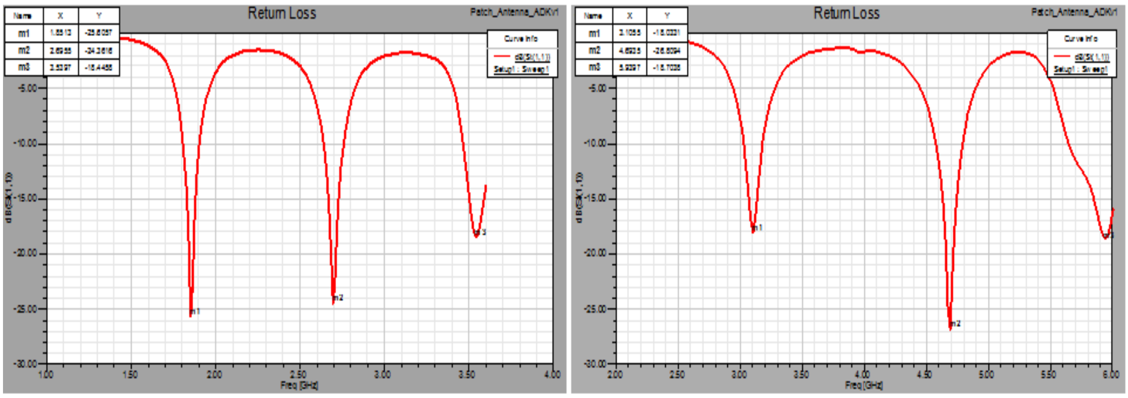


Figure 2. Return loss Vs Frequency

The return loss obtained for two cases are shown in the figure 2. For triangular serrated antenna the resonating frequencies are 1.8, 2.6 and 3.5 GHz respectively with return loss of -24, -25 and -18.4 dB. Whereas for exponential triangular serrated patch antenna the resonating frequencies are at 3.1, 4.6 and 5.9 respectively with return loss of -18, -26 and -18.7 dB. Both the antennas are resonating at independent frequencies and the return loss obtained for these cases are showing acceptable range of less than -10 dB.

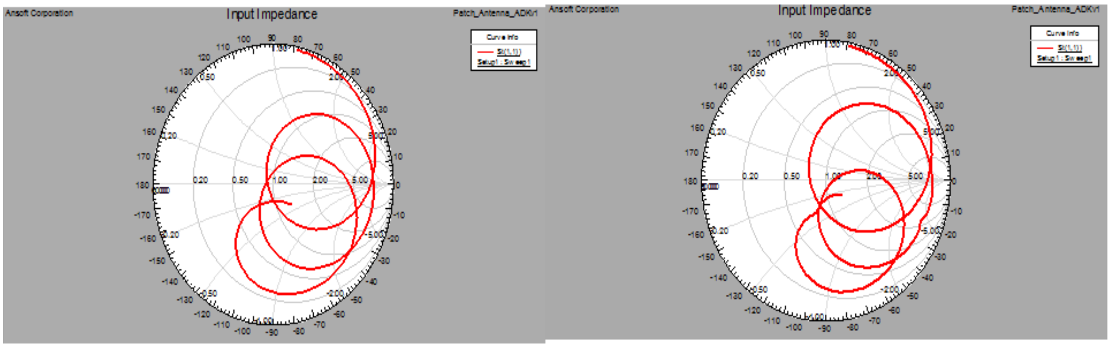


Figure 3. Input Impedance smith chart

Input impedance is defined as the impedance presented by the antenna at its terminals or the ratio of the voltage to current at its terminals. If the antenna is not matched to the interconnecting transmission line, a standing wave is induced along the transmission line. The ratio of the maximum voltage to the minimum voltage along the line is called the Voltage Standing Wave Ratio (VSWR). The VSWR obtained for these two antennas are also satisfying the condition of VSWR<2 at all resonating frequencies. The bandwidth enhancement of 0.53% in the case of triangular serrated and 0.62% in the case of exponential triangular serrated is observed.

The antenna radiation pattern is the display of the radiation properties of the antenna as a function of the spherical coordinates (θ, ϕ). In most cases, the radiation pattern is determined in the Far-Field region for constant radial distance and frequency. A typical radiation pattern is characterized by a main beam with 3 dB beamwidth and sidelobes at different levels. The antenna performance is often described in terms of its principal E- and H-plane patterns. For a linearly polarized antenna, the E- and H-planes are defined as the planes containing the direction of maximum radiation and the electric and magnetic field vectors, respectively. Figure 4 shows the radiation pattern of antennas at E-Plane and H-plane respectively.

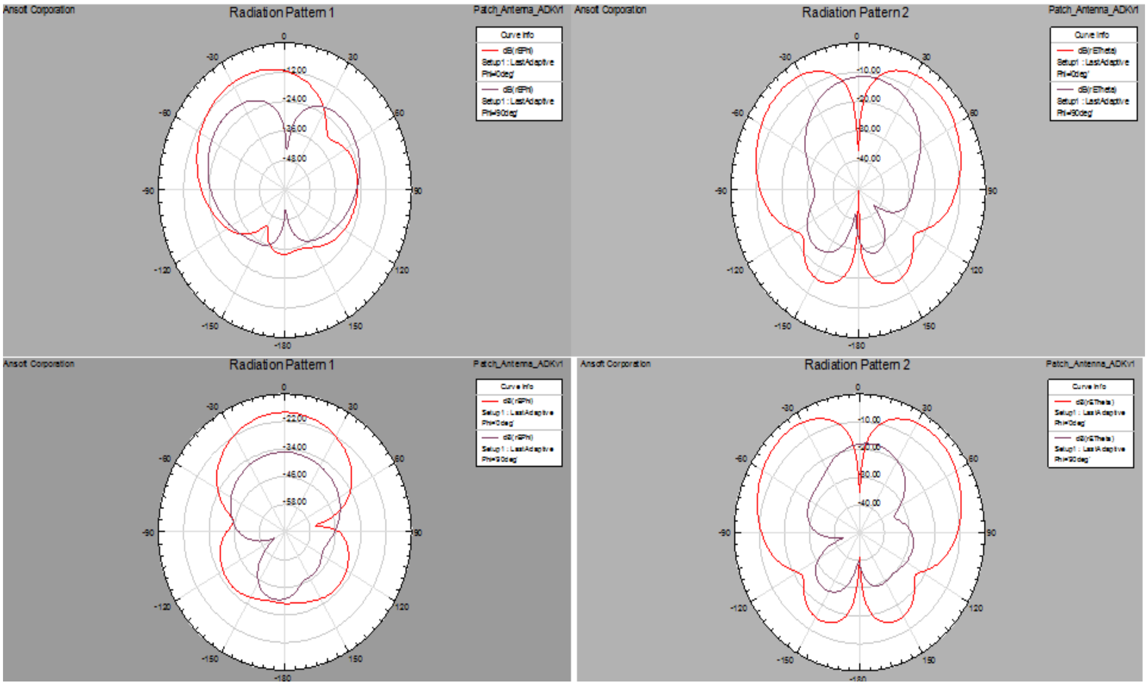


Figure 4. Co-Polarization and Cross Polarization Radiation Patterns

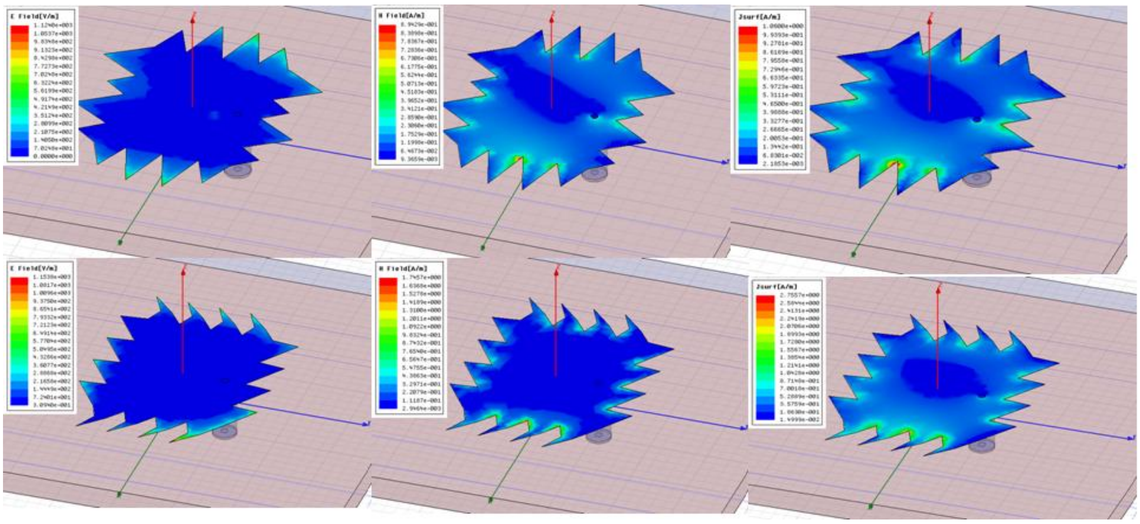


Figure 5. Electric Field, Magnetic Field and Current Distribution Plots

The patterns of antennas can be measured in transmit or receive mode. Some types of antennas must be measured under both transmit and receive conditions. In general, the pattern of an antenna is three-dimensional. Because it is not practical to measure a three-dimensional pattern, a number of two-dimensional patterns are measured. A two-dimensional pattern is referred to as a pattern cut. Pattern cuts can be obtained by fixing f and varying q (elevation pattern), or fixing q and varying f (azimuth pattern). To achieve the desired pattern cuts, the mounting structure of the system must have the capability to rotate in various planes. Figure 5 shows the Electric field, magnetic field and current distributions of both the antennas at fundamental resonating frequency.

Antenna Parameters:

Quantity	Value	Units
Max U	0.0005901	W/sr
Peak Directivity	6.2018	
Peak Gain	6.0917	
Peak Realized Gain	2.2142	
Radiated Power	0.0011957	W
Accepted Power	0.0012173	W
Incident Power	0.0033491	W
Radiation Efficiency	0.98225	
Front to Back Ratio	22.462	

Maximum Field Data:

rE Field	Value	Units	At Phi	At Theta
Total	0.66704	V	180deg	38deg
X	0.49701	V	170deg	-32deg
Y	0.35557	V	20deg	-42deg
Z	0.45563	V	170deg	54deg
Phi	0.45218	V	25deg	-38deg
Theta	0.62429	V	170deg	38deg
LHCP	0.60389	V	5deg	-36deg
RHCP	0.47982	V	165deg	-36deg

Antenna Parameters:

Quantity	Value	Units
Max U	0.000437	W/sr
Peak Directivity	5.4189	
Peak Gain	5.3137	
Peak Realized Gain	1.7539	
Radiated Power	0.0010134	W
Accepted Power	0.0010335	W
Incident Power	0.003131	W
Radiation Efficiency	0.9806	

Maximum Field Data:

rE Field	Value	Units	At Phi	At Theta
Total	0.57402	V	15deg	-38deg
X	0.39972	V	0deg	32deg
Y	0.36383	V	20deg	-32deg
Z	0.36847	V	10deg	54deg
Phi	0.37321	V	20deg	-30deg
Theta	0.50703	V	10deg	38deg
LHCP	0.57105	V	15deg	-36deg
RHCP	0.39492	V	0deg	30deg
Ludwig3/X dominant	0.48665	V	0deg	40deg

Table 2 Antenna output parameters

III. CONCLUSION

The triangular and exponential triangular serrated microstrip patch antennas are designed and comparative analysis is presented in this paper. Both these antennas are resonating at different frequencies and shown triple band characteristics with acceptable return loss and VSWR<2. The peak gain and peak directivity of triangular serrated antenna is showing superior values compared to exponential triangular serrated antenna. As per the bandwidth is concerned there is an enhancement of 0.12% for the case of exponential triangular serrated antenna over the triangular serrated antenna. The serrated aperture patch antennas can be used for dual band, triple band and multiband applications by employing hybrid complex structures of different shapes.

ACKNOWLEDGMENTS

Authors like to express their thanks to the management of K L University and management of ANU College of Engineering and JNTU Kakinada for their support and encouragement during this work.

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