Investigation on Octagonal shape complimented Microstrip antenna for low frequency operations using CSA-Algorithm

P. Venu Madhav, Dr. M.Siva Ganga Prasad

Abstract— Recent communication systems have a large demand for obtaining addressing the control, sense, identification, data and video transmission. Many researchers have contributed to overcome these limitations with various ideas and methods and still some researchers are carrying it forward to meet the ever-increasing demand for small antennas [1] and welcoming challenges. This paper describes the work carried out on optimized octagonal shape complimented from a square patch[2] for a dimension that is computed using the clonal selection algorithm(CSA-algorithm)   to perform the complement slit in a square patch that resonates at a frequency of 3GHz. when compared with a Square patch that resonates at the same, but gives better performance, offers better radiation characteristics, gain and bandwidth. The details of the construction, simulation and fabrication results are discussed and found to be more suitable for small frequency applications.

Index Terms— Microstrip patch antenna, radiation pattern, VSWR, Octagonal Structure, Square patch, Gain, bandwidth.

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1 INTRODUCTION

The recent trends in antenna modelling is miniaturization of antennas for small system applications. A typical wireless network and mobile systems demand small antennas. A. Wheeler[3] who started working on small antennas in 1947, showcased the performances of small antennas, introduced the fundamental limitations of small antennas.   These requirements have stimulated the study and research for small antennas laying new design and innovative ideas in geometrical modelling of the antennas. Impedance matching of antennas particularly for small size is a difficult task. One of the methods to overcome the impedance matching is by using metamaterials, use of materials with single negative, transmission line model etc.. but the use of few metamaterials for fabrication and verification of the model is limited to simulation only. Many of the antenna models are currently fabricated using FR4 as the dielectric substrate as it largely available in the market and costs less.   various methods to enhance the antenna parameters for better performance have been discussed by earlier researchers. For small antennas, the most important factor is the balance and unbalanced geometries of the antenna structure and the feedline to over or minimize the measurement errors.

Clonal selection algorithm is a better choice for a smooth shape. It shows how two geometrical models adaptively intrude and act upon increasing the electrical length of the patch. The

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purpose of increasing the electrical length through complimented octagonal shape is to increase the volumetric area for

the signal to pass through. In clonal selection algorithm, an antigen is treated as the solution for a problem, that is recognized by the anti body. Each antibody represents a possible solution to the problem. Inorder to demonstrate the performance of the octagonal model it is compared with the experimental existing values of the regular square patch. In this proposed work the CSA method is used to calculate the value of the side of the octagon.

2 CONSTRUCTION OF SQUARE PATCH:

2.1 Review Stage

The constructional details for a square patch antenna is considered initially with a ground plane on one side of the dielectric substrate and radiating patch is on the other side. The patch is made-up of conducting material (Copper). The dimension of the square patch is calculated for operating the antenna at 3GHz. the height of the substrate is taken at 1.6mm, the substrate chosen is FR4_epoxy and it offers good dielectric constant. For good antenna performance, a thick dielectric substrate with low dielectric constant is chosen and it offers larger bandwidth, better efficiency and good radiation.

At the first iteration the patch size is taken as 50mm, and then a small portion of the patch is cut like a square in the centre, thus forming a slit and resembling a 2nd iteration as a fractal structure [4]. The side of the 2nd iteration square that is detracted from the centre in the form of a slit is 20mm. and thus making the enter patch size to be optimized for a side of 30mm nearly. Theoretically the side of the patch is calculated and matched to the width at a frequency of 3GHz, given by

$$\mathrm{w} = C/(2\mathrm{fr}\sqrt{((\varepsilon r + 1)/2)}) = 30\mathrm{mm} \ \dots \quad (1)$$

The bottom of the substrate is covered entirely by a ground plane and offers good fringing field between patch and ground plane making the antenna to radiate. At this point

	Freq(GHz)	dB(-S_{11})	VSWR
Square Patch observations	1.18	15.57	3.36
	2.67	33.73	0.35
	2.98	20.40	1.66

Width of substrate (W)	50mm
Length of the substrate (L)	50mm

much focus is not given to square patch.

2.2 Study of S11 Parameter:

The study of the S11 parameter tell us the insertion loss of the antenna. The insertion loss is the ratio of reflected power to the input power of the antenna. Usually antennas radiate more efficiently for a designed frequency or range of frequencies. At these frequencies, the radiation power should be almost equal to that of the input power. So, it is to be expected from the plot of S11 that it will be flat line through with a dip in the operating frequency range. From the plot, the square patch antenna with centre subtracted is found to be resonating at 1.18GHz, 2.67GHz, 2.98 GHz with power of -15dB, -33dB and -20dB. The operating frequency of the antenna is found to be at 2.67GHz and moderate other resonating frequencies.

The radiation characteristics of the proposed antenna are studied. The elevation and azimuth radiation patterns are shown in the figure below. The radiation pattern for 2.98 GHz are measured and observed that the antenna displays good radiation characteristics. From the 2D radiation pattern (Theta) characteristics it is observed that the radiation of the antenna lies between the 0 to 90 as major radiation i.e... in the first quadrant and limited radiation in the second quadrant. It is to be noted that some side lobes also exit in the third and 4th quadrants, resulting as radiation loss. The 3-D radiation pattern is also obtained.
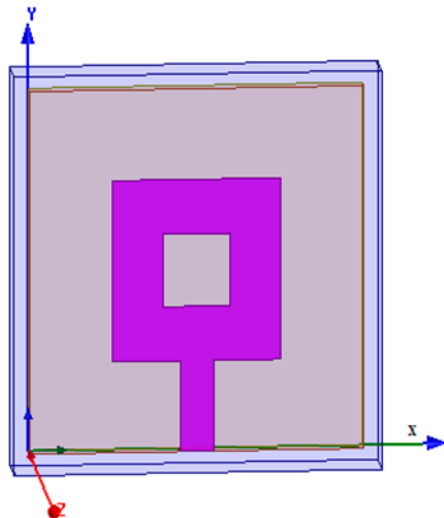
During practical testing, it is observed that the SMA connectors for feeding the antenna, additional connector losses when connected to the test setup also have a slight effect on the measured results.
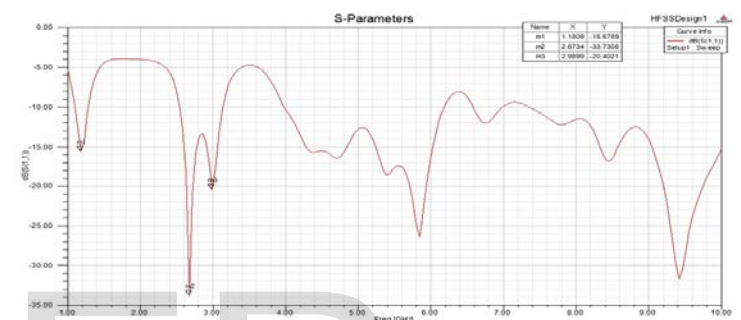

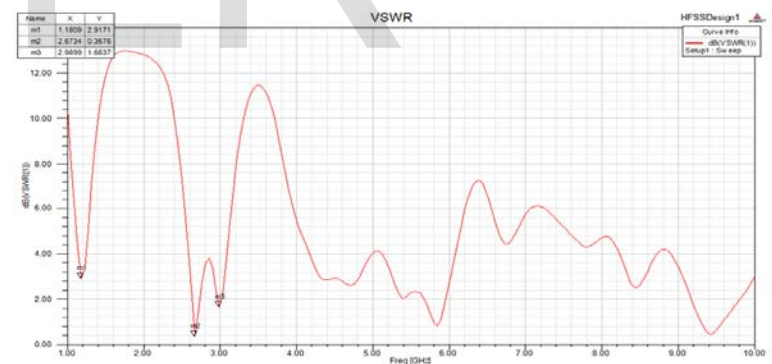Figure 2 S-parameters for 1.18GHz, .2.67GHz & 2.98 GHz

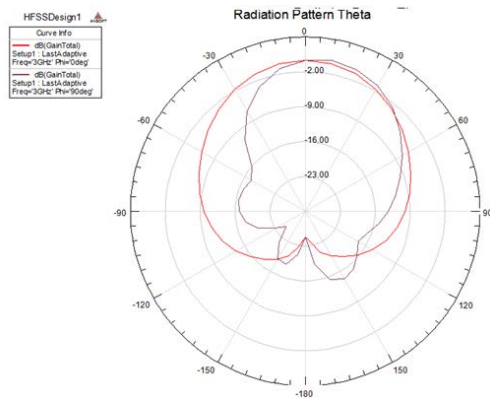Figure 3 VSWR for 1.18GHz, .2.67GHz & 2.98 GHz

Figure 1 Square Patch antenna

Square patch antenna dimensions:

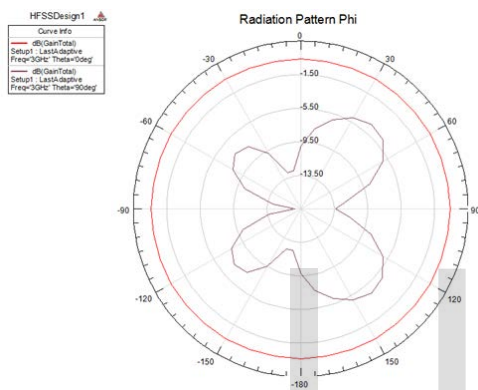| Parameter	Dimension
Dielectric constant (ε_r)	4.4
Height of the substrate (H)	1.6mil
Resonance frequency f_r	3GHz
Side of the patch (S)	30mm

Figure 4 Radiation Pattern (Theta)
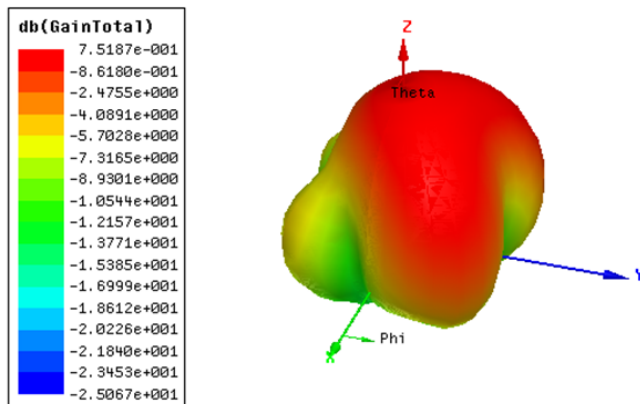

Figure 5 Radiation Pattern (Phi) Total Gain

Figure 6 3-D Radiation Pattern (Gain)

3. OCTAGONAL STRUCTURE

In-order to produce electrically small antennas, reducing the resonating frequency is a better choice but it increases the length of the antenna, as we know that the length of the antenna is inversely proportional to the frequency of operation.

The principle behind realizing electrically small antenna, lowering the resonance frequency of an antenna by a given dimension / structure.   In the above we used a square structure

for operating the antenna at 3GHz, and here we are going to change the structure as an octagon to decrease the electrical length in comparison with square and should offer better radiation characteristics, good gain and other antenna measuring parameters.

The most efficient way of lowering the antenna resonance frequency while keeping the dimensions unchanged is to design the antenna with slow wave structure in which the electromagnetic wave travels a transmission path with smaller phase velocity. These wired slow wave structures have an advantage of ease of fabrication, low cost and constructed in planar form, and can be accommodated in smaller handsets like mobile phones or wireless systems.

In an octagon, all sides and angles are same, when we draw 8 lines from the center to the vertices we get 8 congruent triangles whose areas when added gives the area of an octagon. To draw an octagon from a square, firstly split the length of the side of a square into $1/3^{rd}$ draw along the marking a create 9 squares from the main square. Diagonally cut the squares in all the corners so that the visibility of the octagon is obtained. Now remove the triangles that are newly formed at the four corners using etching solution to decrease the patch size and the octagonal geometry for the antenna produces a lengthened current flow, a planar antenna on which a slot or a notch is placed, thus lowering the resonant frequency.

The clonal selection algorithm(CSA) is used to calculate the resonant frequency of an octagonal shape antenna. The clonal selection algorithm draws attention for researcher in different fields. Burnet in 1958 has first defined the CSA with three steps – cloning- of most stimulated antibodies, mutation-rate proportionality, and evaluation- to maintain diversity of the antibody. The rate proportionality is to measure with respect to the shape of the square and octagon to reduce the resonating frequency. The phase velocity on this surface for a wave travelling is modified by lengthening the current path L_i to L_f and is given by

$$V_P = (L_i / L_f)c \quad \dots \quad (2)$$

Where L_i is initial length, L_f – final length, c- velocity of light in free space.

Multiband operation can be obtained by using several slots on a planar structure by which the current flows on several paths and each resonant frequency corresponds to one length of the current path.

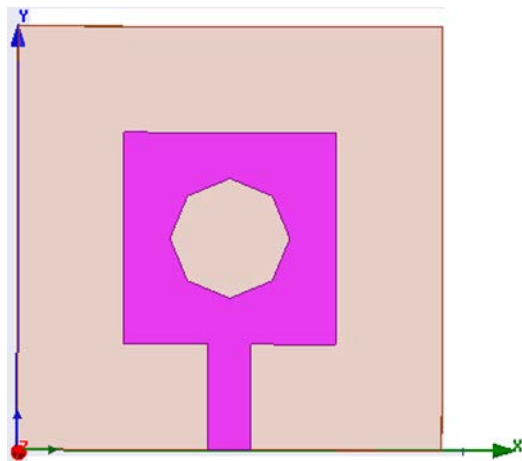|	Freq(GHz)	dB(-S_{11})	VSWR
Octagon observations	1.22	3.99	12.82
	2.67	34.81	0.31
	3.03	25.23	0.95

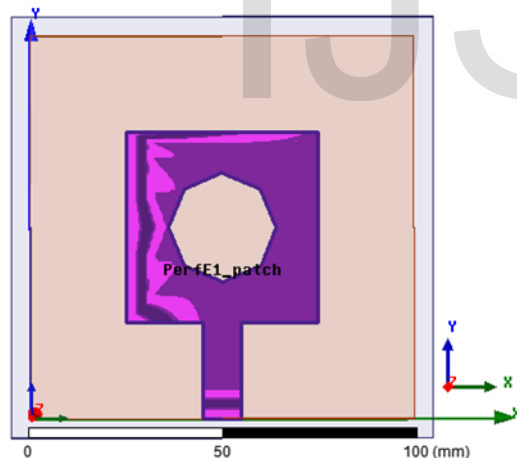Figure 7 Square patch with octagon as slot

Figure 8 Radiation of the patch

Improving bandwidth:

Balanis described that bandwidth [5] of an antenna can be improved with the geometrical configuration when we use the available total volume of the patch. This is an idealized concept that as the antenna can never occupy fully the space or volume that circumscribes the antenna. It may be followed by filling such space or volume efficiently i.e. to use the space with the octagonal geometry as much as possible.

Hence, the volumetric variations in the design brings out the model as a hybrid model, material and the geometry are also considered to overcome the size constraint in improving the gain of the antenna.

Table 1 Octagonal Patch Dimension

Parameter	Dimension
Dielectric constant (ε_r)	4.4
Height of the substrate (H)	1.6mil
Resonance frequency f_r	3GHz
Side of the patch (S)	30mm
Width of substrate (W)	50mm
Length of the substrate (L)	50mm

3.1 GAIN IMPROVISATION

To increase the gain of the antenna, one must see that the current distribution on an antenna element[6] to be uniform. Per chu, the ideal current distribution to attain maximum gain with a given size of an antenna is uniform and the gain at this condition is given by $\pi r/4\lambda$ where r is the radius of the sphere enclosing the antenna.

3.2 RADIATION

The radiation field for an antenna is measured in two methods one method is near field region that is close to the antenna and the other method is a far field region away from the antenna. The far field region is used to calculate the phase and any error that arise due to finite size of the antenna. The radiation characteristics of the proposed octagonal antenna are studied.

The elevation and azimuth radiation patterns are shown in the figure below. From the radiation pattern at 3.05 GHz it is observed that the antenna displays good radiation characteristics. From the 2D radiation pattern (Theta) characteristics it is observed that the radiation of the antenna lies between the 0 to 90 with reduced main lobe and low return loss i.e... in the first quadrant and remained the same in the second quadrant

It is to be noted that some side lobes also exit in the third and 4th quadrants, resulting as radiation loss. From the S11 parameters it is observed that the antenna resonates at 1.22 GHz, 2.67GHz and 3.03 GHz. it is found with the change in the geometric shape from square to octagon there is a frequency shift of 0.03GHz, with good return loss, when compared with other resonating frequencies both the antennas are giving almost same output. The 3-D radiation pattern is obtained doesn't have varied difference.
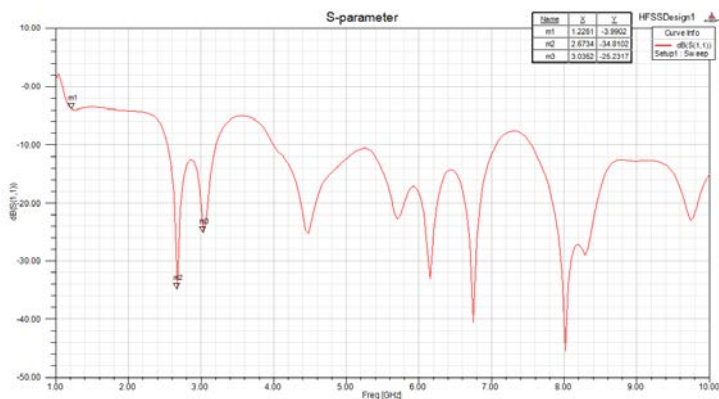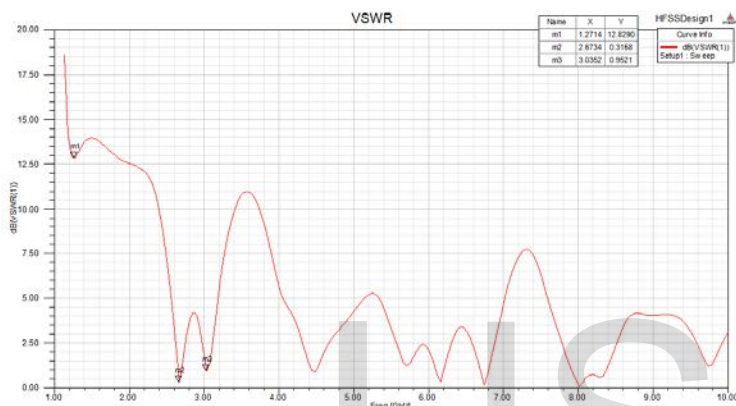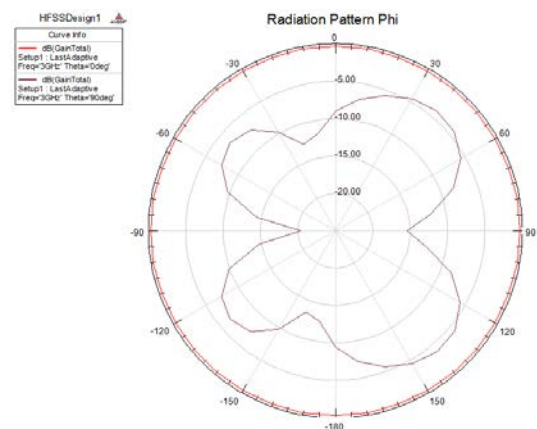
Figure 9 S- Parameter Measurements

Figure 12 Radiation Pattern Phi
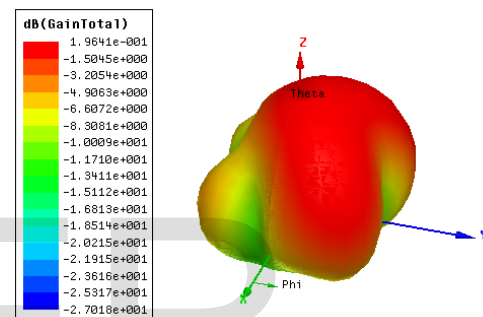

Figure 10 VSWR- Measurement

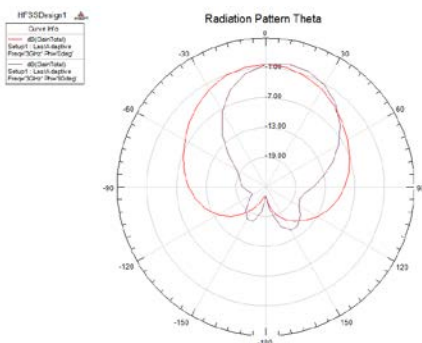Radiation Pattern:

Figure 13 3-D Radiation Pattern

Figure 11 Radiation pattern theta

4 CONCLUSION

The search for an optimal solution is subjected to predefine criterial like gain, bandwidth, return loss etc. but for a clonal Selection algorithm cloning- of most stimulated antibodies, mutation- rate proportionality, and evaluation. Using the clonal selection algorithm [7], it is visible that through the octagonal geometry Vs the square patch as a slit the octagonal patch gives better performance in terms of gain and bandwidth at lower frequencies[8], the 3-d radiation pattern resembles the samein both the cases.

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