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Designing and Analysis of Compact Crown Circular Patch Antenna by Using Artificial Nural Networks

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***Abstract:* — It is very demanding from commercial and military applications to have small size low profile multiband antenna. This proposed work gives a path to transform a dual band antenna into multiband antenna. The geometry of the antenna is defined by designing some circular crown fractal-like erosion in a conventional rectangular patch structure and found the best suited positions for slots which can give multiband operations. Fortunately finally selected position gives enhanced bandwidth and satisfactory return and other characteristics also. In this work we first proposed small size antenna which works on single resonance frequency then it is modified to get multiple resonance frequency operations. For newly designed multi band slot cutted shape antenna gives satisfactory results. Then the results are also processed by the ANN (Artificial Neural Network). Resonance frequency is simulated by IE3D simulator and then simulated results are used o train the neural network, both the results found are almost close to each, very less mean squared error occurs. It gives Return loss for all resonant frequencies less than -10db, VSWR less than 2 with multiband resonance frequencies. Applications of this multiband antenna are in the X, Ku and K band of Super High Frequency range.**

***Index Terms*—Multiband Antenna, Crown Circular Fractal, Rectangular Patch, ANN, Super High Frequency, Return Loss, VSWR**

I. INTRODUCTION

Multiple band antennas are always in interest on antenna researchers. If our design can be operated on more than one resonant frequency and simultaneously with proper impedance matching and wide bandwidth than it become very convenient to use a single antenna for more than one application. Though fractals are always good to have in design whenever need is to have more number of resonant frequencies. That's why this proposed work has compact crown circular and elliptical combinations of fractal.

After simulating on every possible position of these fractals of proposed geometry, finally got the best position on which three resonant frequencies are working.

Design inspiration comes from the paper [1], in which the design will resonate on X, K and Ku band. Initially in this paper also designed rectangular patch resonant on single frequency and after cutting some slots the patch will resonant on multiband frequency. If we compare this referred design the proposed design is completely changed by this reference design but they both are resonating on same bands of IEEE designated radar bands(X, K, and Ku).

II. DESIGNING OF MULTIBAND COMPACT CROWN CIRCULAR FRACTAL PATCH ANTENNA FOR X, Ku BAND

This proposed antenna is designed on FR4 substrate with dielectric constant $\varepsilon_r = 4.7$ and tangent loss of 0.02, substrate thickness h =1.588mmIn this FR-4 "FR" stands for "Flame Retardant", and denotes that safety of flammability of FR-4.

In [2] the compact crown circular fractal based geometry is being used. But in this proposed design the whole fractal geometry is being developed on a rectangular patch of length L, and width W. Difference between these two designs (referred one and proposed basic design) are clearly shown that after using this rectangular patch resonant frequency and their bands becomes greatly changed and design becomes multiband. The proposed antenna structure is shown in figure 1.

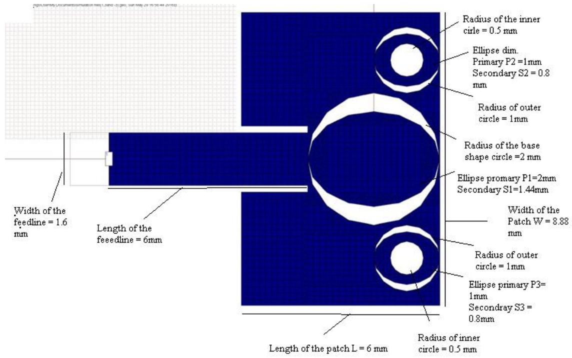

Figure1. Compact Crown Circular Fractal antenna for operating on multiband application (Position of the C1 and C2 are (1, 3) and (1,-3) respectively).

Dimensions of Compact Crown Circular Fractal Shape Patch Multiband Antenna

Dimensions of Rectangular patch

1. Length of the rectangular patch L = 6 mm
2. Width of rectangular patch W = 8.88 mm

Dimensions of base shape central circular fractal

1. Fractal (circular) shape cutted in center of rectangular patch radius R = 2mm
2. Primary axis length of Ellipse inside the center circle (P1) = 1 mm
3 Secondary axis length of Ellipse inside the circle (S1) = 1.44 mm

Dimensions of the C1

1 Circle cutted above the center circle radius (R1) = 1 mm
2 Primary axis length of ellipse inside the circle,(P2) = 1mm
3 Secondary axis length of ellipse inside the circle, (S2) = 0.8 mm
4 Radius of the circle cutted inside the ellipse = 0.5 mm

Dimensions of the C2

1 Circle cutted above the center circle radius (R2) = 1 mm
2 Primary axis length of ellipse inside the circle, (P3) = 1mm
3 Secondary axis length of ellipse inside the circle (S3) = 0.8 mm
4. Radius of the circle cutted inside the ellipse = 0.5 mm

This is an inset feed microstrip rectangular patch antenna. The position of two small circles above and below the center circle matters for designing the multiband fractal shape antenna.

III. RESULTS AND CONCLUSION

Return Loss

For proposed design the return loss parameter is highly satisfactory. Fig. 2 shows that by varying the position of fractals of radius R2 and R3 can give the multiband operation. This return loss curve has three dips for the 5-20GHz range of frequency

This newly designed multiband antenna has very clear and properly isolated with the nearest resonance frequencies. Multiband frequencies are 9.59GHz, 13.88 GHz, 16.9 GHz.

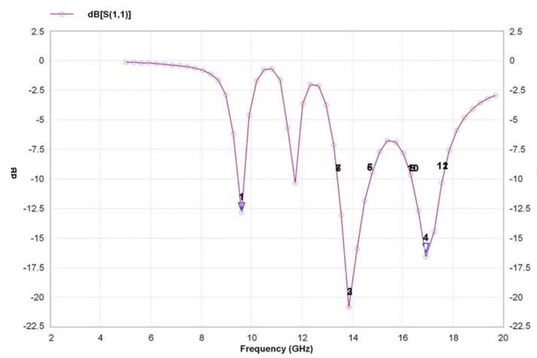

Figure.2 The return loss of the multiband newly formed fractal shape microstrip antenna for different values of position of R1(x1,y1)and R2(x2,y2) respectively (0.5,3) and (0.5,-3)

VSWR

Voltage Standing Wave Ratio for newly formed antenna is within the required range on each resonance frequency it is below the level of 2, that is commendable result on such all frequencies. This range of VSWR for 9.59 GH is 1.6, for 13.88 GH is 1.2and for 16.9 GH is 134, shows all are in satisfactory range.

IV. CONCLUSION

This proposed compact crown circular fractal patch antenna works for multiband frequency. Chosen position of circular fractal are in such a way that their resonance frequencies lies in the range of SHF applications radar band which is designated by IEEE as X, K and Ku band. It fulfills the demand of satellite communication, radar, high performance aircraft and many more other modern communication system which requires multiband operation on these bands. This modified finally selected compact patch antenna resonant for 9.59GHz, 13.88 GHz, 16.9 GHz which lies in X(8-12 GHz), Ku(12-18 GHz).

If the fractal dimensions could be changed then the complete patch will resonant for all bands (X, Ku and K).This newly changed dimensions of fractal shape patch is being discussed next.

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V. DESINGNING of FINAL COMPACT CROWN CIRCULAR FRACTAL PATCH ANTENNA for X, K and Ku BAND APPLICATIONS

Dimensions of the central circular fractal shape is now changed from its previous design and results in multiband operation. This becomes a conclusion to this proposed design that instead of using three different antenna for X, Ku and K band application, this finally designed antenna will resonant on the same band of all mentioned application of radar communication .

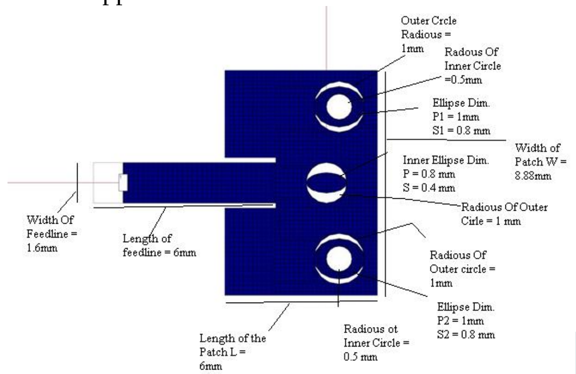

Figure 3 .Compact Crown Circular Patch Antenna for X, Ku and K Band Applications {position of C1 and C2 are (0.5,3) and (0.5,-3) respectively}

As shown in fig. the dimensions of the C1 and C2 fractal shapes are same as the previously designed patch antenna, but the dimensions of the center base circle s now changed and this changed one design resonant with following features.

Results and conclusion

Return Loss

As shown in figure 3 that this modified patch antenna gives multi frequency operation. It has three resonance frequencies first is at 10.0833 GHz second one is 13.08 GHz, third 23.58GHz

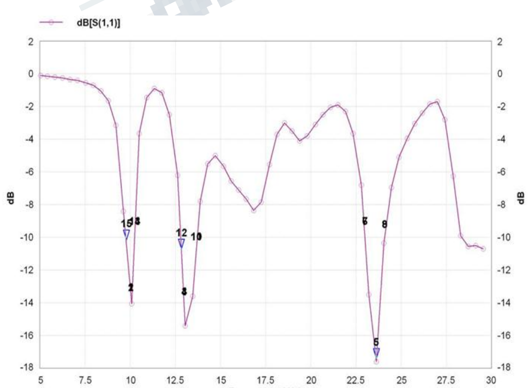

Figure 4 Return Loss Vs Frequency of Finally Designed Compact Crown Circular

VSWR

Range of VSWR is all at satisfactory level resonance frequency 10.0833 GHz has 1.49,second one is 13.08 GHz, has 1.41 and third 23.58GHz has 1.31.

VI. ANALYSIS OF COMPACT CROWN CIRCULAR FRACTAL PATCH ANTENNA USING ARTIFICIAL NURAL NETWORK

Artificial neural networks are inspired by the sophisticated functionality of human brain. In human brain number of interconnected neurons working and process the information in parallel form. Basically it is a crude electronic model which is successfully demonstrated by researchers up to certain level of intelligence on silicon.

An artificial neural network (or simply neural network) consist of an input layer of neurons (or nodes, units) one or two (or even sometimes three) hidden layer of neurons and a final layer of output neurons.

Each connection is associated with a numeric number called weight.

The output, hi1 of neuron I in the hidden layer is

$$h_i = \sigma \sum_{j=i}^{N} . \left(V_{ij} + x_j + T_i\right)^{hid}$$

Where σ ( ) is called activation (or transfer) function.

N-number of input neurons,

Vij the weights, xJ input to the input neurons

The main motive to design this activation function is though the number of neurons are in the range of thousands so besides introducing nonlinearity into the system, it is good to be fit non-linear function. It is used to bind the value of neuron and resultant neural network is not paralyzed by divergent neurons. Numbers given to the input neurons are independent variables and those who returned from the output neurons are dependent variable to the function which is being approximated by the neural network. Input to/from neural network can be binary (yes/no) or colors (Red, Green etc.) when it works satisfactorily

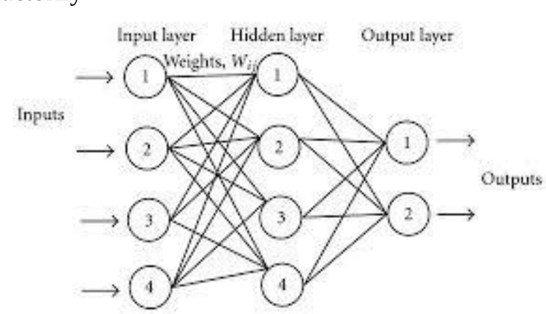

Figure 5.Architecture of a Neural Network

Training an Artificial Neural Network

First of all we need to structure a network for a particular application, now the network is ready to be trained. Initially weights are randomly chosen then training starts.

Two methods can be used for training

Supervised Training

Unsupervised Training

In this training the inputs and outputs are given initially and structure processes further and compare its resulting output against the desired one output. Error between the actual one and desired are propagate through back similar to feedback circuits. The set of data which enables the training called "Training Set". In this proposed "Compact Crown Circular Fractal Patch Antenna" only supervised training is used to train the network.

Data Generation for ANN

The design of "Compact Crown Circular Fractal patch Antenna", which was the basic design(figure 1) of this proposed work is taken for calculating the resonance frequency of the patch antenna on ANN.

In this design two compact crown circular patches are being designed on rectangular patch with one base circle fractal s also cutted on center of patch. Simulation is being done by using IE3D simulator for different coordinate values of both the crown patches X1, Y1 and X2, Y2 in some limited range. Keeping the C1 and C2 dimensions, base circle dimensions, εr and h constant and corresponding cutoff frequency are recorded. This recorded resonant frequency has been used as a training data and test data for calculating error between these two types of simulations.

The position of C1 and C2 is being varied to see the effect on the resonance frequency and total 53 samples are taken as data for training the ANN. It was observed by the IE3D results that antenna performance could be controlled by introducing these fractals and their shapes on rectangular patch. By referring to [3] training algorithm Levenberg Marguaradt (LM) has most less mean square error between the estimated and simulated one.

VII. RESULT AND CUNCLUSION

It is shown from table I the LM algorithm with the structure is the optimal model to achieve optimal values of parameters of proposed antenna. It was observed that total number of 721 epochs is needed to reduce MSE level to a low value with LM. We have achieved a very low value of performance goal, which is the mean square error.(MSE) Which clearly indicates that trained ANN model is an accurate model for designing the compact crown fractal microstrip patch antenna which will resonant on X, K and Ku band of applications.

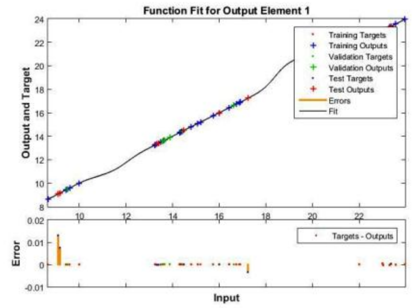

Figure 6.Function Fit for Output

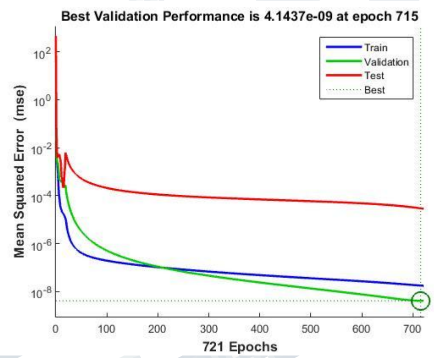

Figure 7 Number of epochs to achieve minimum mean square error level

Table I Comparison of results of IE3D with ANN For Resonance Frequency of Multiband Compact Crown Circular Fractal Patch Antenna

S.N.	X1 , Y1 coordinate, For C1	X2 , Y2 coordinate, For C2	Target Output /Output of IE3D(Resonance Frequencies in GHZ)	Output Of ANN	Mean Square Error(MSE)
1	(0,3)	(0,-3)	15.08	15.0799895	1.04969E-05
2	(0,3.1)	(0,-3.1)	9.18	9.17253046	0.00746954
3	(0,3.1)	(0,-3.1)	13.4	13.40016517	-0.000165169
4	(0,3.1)	(0,-3.1)	23.56	23.56009824	-9.82356E-05
5	(0,3.2)	(0,-3.2)	9.5	9.50005147 1	-5.1471E-05
6	(0,3.2)	(0,-3.2)	13.566	13.56600034	-3.43688E-07
7	(0,3.2)	(0,-3.2)	23.36	23.35978693	0.000213067
8	(0,3.3)	(0,-3.3)	9.5	9.50005147 1	-5.1471E-05
9	(0,3.3)	(0,-3.3)	13.5	13.50007443	-7.44343E-05
10	(0,3.3)	(0,-3.3)	23.3	23.30034112	-0.000341123

VIII. CONCLUSION

The inset fed micro strip patch antenna is a versatile structure which can be modified from dual to multiband operation, the addition of simple first iteration fractals can change this patch as multi frequency antenna with comparatively large bandwidth.ANN is used on this patch for calculating the mean squared error, and found it very less as shown in table I. There is one comparison in figure 8, in which the proposed design and the design by which the inspiration is taken are clearly shows the modification which makes it multi frequency antenna. The paper concludes that results obtained using present ANN

Techniques are quite satisfactory and followed the experimental trend also.

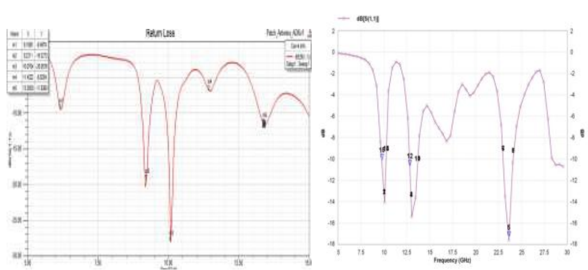

Figure 8 Comparison between the Referred patch on SHF Range Applications and the Comparatively Simplex Finally Designed Compact Crown Circular Fractal Patch Antenna (For 3GHz-30 GHz.

FUTURE SCOPE

Much literature is available on the parameter performance modifications which are based on Artificial Neural Networks. So a great scope is there in microstrip patch antenna designing and parameter analysis and optimization on Neural Networks.

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