**How to Cite**:
Ramya, P. (2022). Design and fabrication of jean substrate based textile antenna for GSM band application. *International Journal of Health Sciences*, *6*(S2), 8413–8420. https://doi.org/10.53730/ijhs.v6nS2.7157

# Design and fabrication of jean substrate based textile antenna for GSM band application

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***Abstract*---**Soft computation is well equipped and successfully implemented in the field of antenna design in this paper ANN and Genetic algorithms are used to design a fabric based micro strip patch antenna at the center frequency, fc of 1.45 GHz. Textile materials are apt to be produced in the form of wearable antenna substrates owing to their reduced dielectric constant or relative permittivity properties. Specifically, in this article, jeans fabric having the relative permittivity, Ɛr = 1.70, along with a thickness of 1.00 mm is selected to be a substrate. Initially, Radial basis networks is used to design a micro strip patch antenna configuration equipped with an edge feeding mechanism. Then , Genetic algorithm is applied for optimization of proposed antenna parameters Finally Wearable textile micros trip patch antenna is created, merged, and concealed within the clothing, correctly. It is revealed from simulation and fabrication measurement outcomes that the proposed antenna properties are desirable for a body centric communication, which is at the $f_c$ = 1.45 GHz.

***Keywords*---**antenna, hybrid, wearable antenna, microstrip patch antenna, genetic algorithm, ANN.

## Introduction

In the last few years, there has been a constant development in the communications and telemedicine domain. Wearable compact antennas play an important role in each kind of wearable communication in telemedicine systems. The features of wearable antennas is important for telemedicine and mobile health care systems. In health care settings, implantation of antennas in the body of humans is vital to ensure supervision consistently. But, these processes develop owing to the disintegration on various angles in the human body and characteristics of biological material. In this condition, wearable antennas offer critical benefits. The textile antennas enjoy huge utilization in telemedicine and health care settings. It can be exploited for short-distance communication along


*Manuscript submitted: 9 March 2022, Manuscript revised: 18 April 2022, Accepted for publication: 1 May 2022*

with high-speed data and reduced power dissipation for constant real-time monitoring of the data pertaining to psychological patients. In healthcare monitoring systems, Wireless Body Area Networks (WBAN) demand extensive bandwidth so that consistent patient monitoring can be ensured. Hence, wearable and portable antennas has a prominent part to play in designing and developing telemedicine systems. Currently, wearable antennas have gained much popularity in monitoring the activities of human body involving sports, battlegrounds, exercise, and healthcare systems. There has been a widespread usage of this technology owing to its important characteristics, including reduced cost, low-power dissipation, and improved data rate.

Obtaining these features is very difficult for RF engineers using different analysis and design cycles. Review [1-6] shows that now a day's soft computing ANN are used extensively for RF engineering, it reduces the complex and minimizing time consuming mathematical operation of designing antennas, like MOM. A variety of Artificial neural network models are designed with the intent to attain operating frequencies of different types of micro strip antenna. The proposed work is focused on the use of Radial basis network in the area of wearable micro strip antenna design.. As a test case, inset feed textile based microstrip Antenna is considered since it involves determination of several parameters. As such this proposed work develops an ANN model which provides design parameters of an inset feed wearable micro strip antenna for a desired frequency range at 1.45 GHZ.

**Genetic Algorithm**

GA is the most popular optimization techniques, one more artificial approach that takes its inspiration from the biological system of humans. This is an optimization methodology that is influenced by "natural selection" and forms the foundation of genetics. GA is a search technique that can be useful in dealing with the common features of electromagnetism much efficiently compared to other optimization approaches. Gene forms the basic block of genetics algorithm and it includes binary encoding of different parameters. A set of genes is called as chromosomes. In GA, typically, a population is initialized with a set of randomly chosen solutions. Every solution constitutes a group of characteristics that can be modified or mutated to achieve better solutions. Usually, these solutions are denoted using the binary format as bits of zeros and ones. The evolution step goes through several iterations and the population is called as generation. The objective function or the cost function of every single individual present in the particular population is assessed during every iteration to compute the fitness function. The individuals having the highest fitness value are chosen from the population and the genome belonging to every individual undergoes mutation to create a generation for the next level. Primarily, there are two constraints to use GA:

- A precise genetic definition of the solution.
- A fitness function to assess the solution domain.

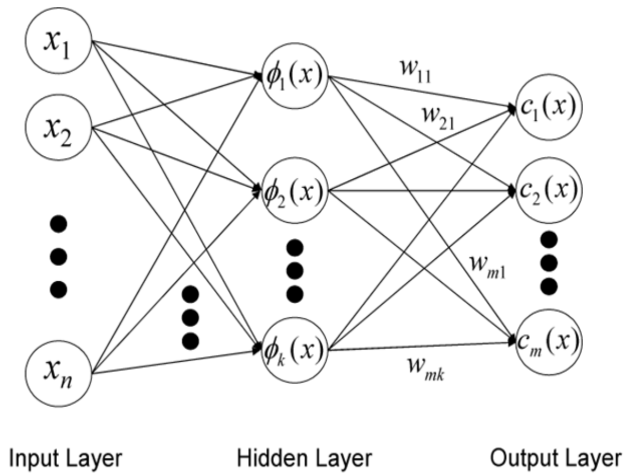
Every solution pertaining to a certain population is given as an array made up of bits. The size of these arrays are typically predefined such that crossover is easy and convenient. Crossover can be carried out between chromosomes having different lengths, however it highly complicates the whole process. Multiple modern techniques such as genetic, evolutionary and gene expression programming represent the chromosomes in the form of a tree, graph that are sized variably. Once the right genetic representation and fitness functions are specified, a GA performs the initialization of a population consisting of the solutions and later enhances it by repetitively applying the mutation, crossover, inversion and selection process.

In this paper genetic algorithm is used to optimize the antenna parameters such as length and width of the antenna by keeping other parameter as constant. The antenna feed on the Jean substrate is kept constant as 3 x 1.8 mm. The substrate's thickness is 1.6 mm, relative permittivity is 1.7mm and loss tangent is 0.009. A micro strip patch antenna is designed using optimized value of length and width on ADS software and validated the performance of proposed antenna with GA optimizationtechnique.

The various steps followed are as stated below:

Step 1: Resonant frequency is selected as fitness function.
Step 2: Length and width of the antenna has been obtained in ADS
Step 3: The optimized value of length and width of 36 mm and 20 mm have been obtained from Genetic algorithm.

**RBF Networks**




RBF is basically a feed forward neural network that includes one hidden layer, which makes use of the radial basis activation functions for hidden neurons are known as radial basis function networks. RBF network is used for different RF modeling purpose. The architecture of a classic RBF network is illustrated in figure 1.The parameters wij and ϕij form the centers and standard deviations of radial basis activation functions. The popular radial basis activation functions include Gaussian and Multiquadratic. With the inputs x, the overall input given to the ith hidden neuron γ I is expressed using

$$\gamma_i = \sqrt{\sum_{j=1}^{n}\left(\frac{x_j - c_{ij}}{\lambda_{ij}}\right)^2}, i = 1,2,3,\dots\dots\dots .N$$

Where N refers to the number of hidden neurons. The output value obtained from the $i^{th}$ hidden neuron is defined by $c_{ij} = \sigma(\gamma_i)$ where $\sigma(\gamma_i)$ indicates a radial basis function.

$$y_k = \sum_{i=0}^{N} w_{ki} z_{ki}$$

At last, the outputs obtained from the RBF network are computed using the hidden neurons where $w_{ki}$ signifies the weight of the link between the $i^{th}$ neuron of the hidden layer and the $k^{th}$ neuron of the output layer. The RBF network's Training parameters w are given by $w_{k0}$, $w_{ki}$, $c_{ij}$, $\lambda_{ij}$, where k = 1, 2, . . . m, i = 1, 2, . . . n.

**Antenna Design**

**Antenna Design Procedure Using ADS**

1. Open the ADS software and create a new workspace and new cell.
2. Open the layout window and draw the rectangular patch antenna with a length of 36mm and width of
3. 20 mm.
4. Give the feed line for the patch antenna and place another rectangular patch antenna over our design.
5. Now go to edit and click on merge to select the union-intersection option and then increase the length of the
6. feed till it gets attached with our design and insert the port.
7. 5. Click on the substrate icon and create a new substrate with the following specifications:
8. 6. Add the substrate from add substrate tab as jeans with dielectric constant 1.6 and thickness 3.5 millimeters.
9. 7. Give the conductor and ground as copper with a thickness of 35 microns.
10. 8. Go to frequency plan and specify the adaptive frequency as 0-4GHz and then add another frequency tab as
11. single and click on simulate.
12. 9. Now a graph window appears, in that check, your return loss dB is under -10dB and also check whether the
13. frequency range obtained is equal with the designed frequency range.
14. 10. Return to your layout window and click on the far-field icon and select solution set up, click on the
15. frequency range you have obtained in the graph.
16. 11. Now in the far-field tab click on the plot properties and select display antenna parameters to get the gain

17. and directivity obtained for your layout design and also check the far-field radiation pattern.
18. 12. In the far-field tab, click on the plot properties and choose far field cut off and check the tab is enabled, and check the directivity pattern obtained for your design.

**Genetic Algorithm**

1. Select the population of chromosome
2. Assess the  fitness function of every chromosome
3. Created the new population as given in the following steps
4. On the basis of theirfitness two chromosomes are chosen as parent from a population
5. Crossover occurs between the parents to create a new off spring.
6. Mutation is performed at every locus for mutating the new offspring.
7. With the off springs, a new population is created and the whole process is performed again.
8. If the optimization condition is fulfilled the process will terminate and retrieve the value, otherwise the process will be performed again with the population.

**Steps of design**

1) Development of the neural network structure: The ANN network is founded on three layers. These three layers include input layer, output layer and the hidden layer. The input layer and the output layer have single or multiple dataset taking a matrix form. The hidden layer is dependent on these two layers and the weights linking these layers. The estimation of the number of hidden layers must be done. The synaptic weight and biases initially are defined in random.
2) ANN model's Training: The input dataset is compared with the output dataset and the synaptic weights between the two layers is modified as and when every layer completes. The training becomes complete if the network responds to all kinds of inputs and yield the output parameters exactly.
3) Testing the designed ANN model: The new model is validated by sending few input parameter values in random except the training data and the respective output values that the ANN model provides are gathered.
4) Validating the ANN model: With the parameters of the output design, the simulation of the antenna models are performed on the ADS software and the comparison between the results of the simulation and the inputs provided to the user are carried out to compute the amount of error.

**Results**

This section discusses both the simulation and original performance measurement achieved with the wearable microstrip line feed patch antenna in the free environment. The simulation is carried out with the help of the ADS software while the measurements are performed employing the Vector Network Analyzer e (VNA). The simulation of the antenna performance and measurement are perfected achieved in terms of return loss (S11), impedance matching, three dimensional (3D) radiation pattern, and gain. In an antenna, S11 constitutes a parameter, which represents the overall amount of power dissipated to the load and is not reflected back. Optimally, the antenna must attain the S11 of the antenna below -10 dB so that the performance can be reasonable. Fig. 3 shows the S11 parameter simulation in terms of magnitude in dB and phase in the developed wearable textile microstrip patch antenna. It is evident that the antenna positioned on the free space yields the S11 parameter of -16.0000 dB at the fc = 1.45 GHz.

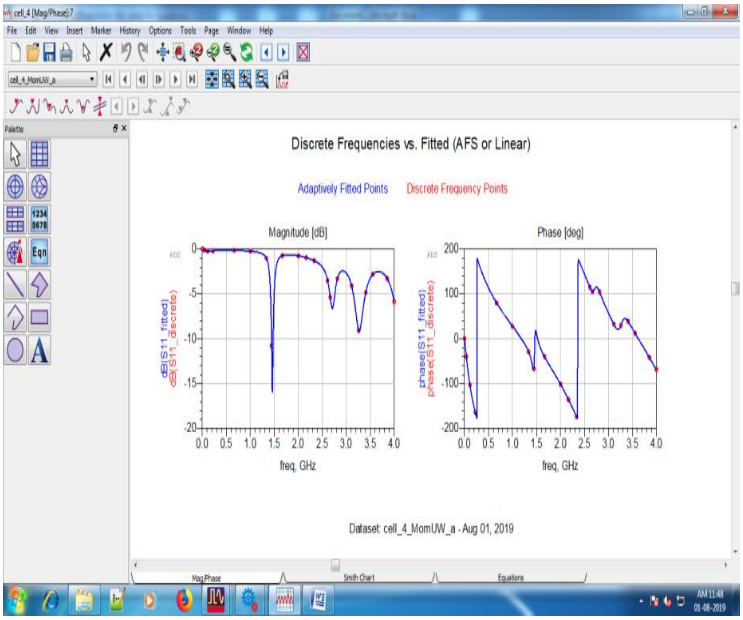


Fig.3. Return Loss Simulation using ADS Software

The radiation pattern is given by the level by which the strength of radio waves from the antenna are directionally dependent. İt is depicted in Fig. 4 that the designed wearable microstrip patch antenna produces simulated 3D omnidirectional waves where the same amount of power of the radio wave is discharged in every direction that is perpendicular to the antenna. The omnidirectional pattern is adjustable with the human body due to the distinct posture and flexibility of the human body. Therefore, an omnidirectional pattern is necessary in designing the wearable textile microstrip patch antenna.

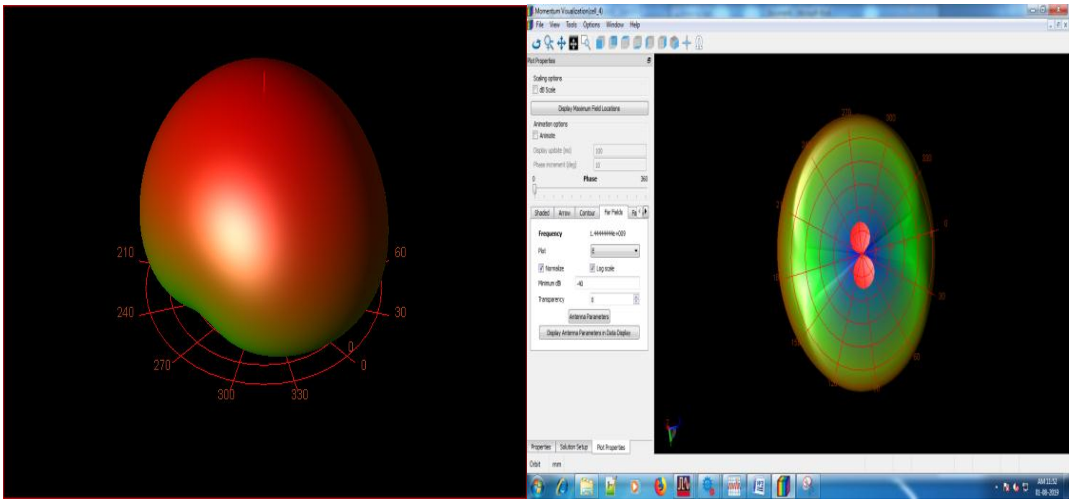
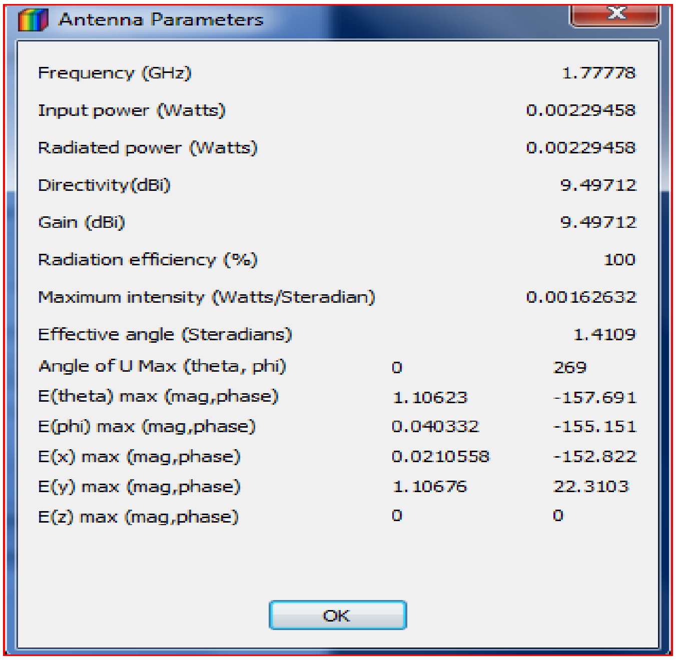


Fig.4. 3D Radiation Pattern Simulation employing ADS Software

Gain, directivity, and radiated power constitute the performance indicators of the antenna. In Fig. 5, the gain, directivity, and power radiated simulated measurements versus frequency is depicted. The antenna yields a gain of 9.49712 dB, the directivity of 9.49712 dB, and dissipated power of 0.00229458 watts at fc = 1.77778 GHz, correspondingly. To summarize, all the measurements indicate that the performance of the wearable textile microstrip antenna is much superior. Fig. 6 shows the directivity graph.


Antenna Parameters

| | | |
|---|---|---|
| Frequency (GHz) | | 1.77778 |
| Input power (Watts) | | 0.00229458 |
| Radiated power (Watts) | | 0.00229458 |
| Directivity(dBi) | | 9.49712 |
| Gain (dBi) | | 9.49712 |
| Radiation efficiency (%) | | 100 |
| Maximum intensity (Watts/Steradian) | | 0.00162632 |
| Effective angle (Steradians) | | 1.4109 |
| Angle of U Max (theta, phi) | 0 | 269 |
| E(theta) max (mag,phase) | 1.10623 | -157.691 |
| E(phi) max (mag,phase) | 0.040332 | -155.151 |
| E(x) max (mag,phase) | 0.0210558 | -152.822 |
| E(y) max (mag,phase) | 1.10676 | 22.3103 |
| E(z) max (mag,phase) | 0 | 0 |

OK

Fig.5. Antenna Parameters

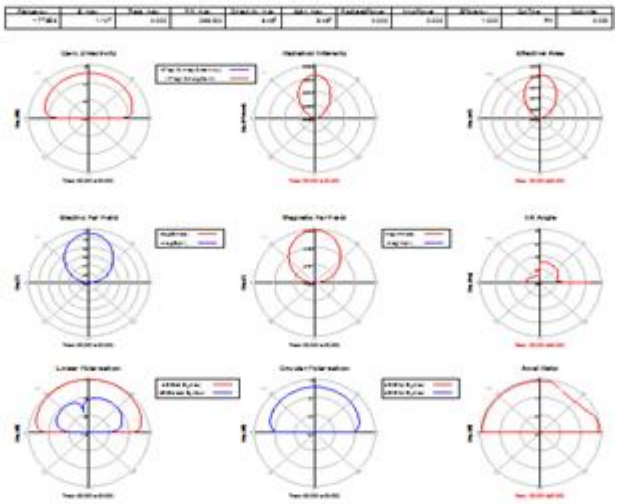


Fig.6. Directivity Graph

## Conclusion

The microstrip antenna is an apt choice for wearable applications, since it can be made with the help of fabric substrate materials. In this article, soft computing methods was implemented to design a wearable micro strip antenna. The antennas introduced exhibit a high degree of versatility and can be easily operated at different frequency spectrums. It can be confirmed that these textile microstrip patch antennas may slowly take the place of patch antennas on standard PCB substrates for different applications and the efficiency of the artificial models can be increased with respect to the accuracy at the expense of time taken for computation.

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