Microstrip Patch Antenna Array

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Abstract— A Microstrip patch antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The patch is normally made of conducting material such as copper or gold and can take any possible shape. In order to simplify analysis and performance estimation, generally square, rectangular, circular, triangular, and elliptical or some other common shape patches are used for designing a microstrip antenna. In order to reduce the size of the microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrow bandwidth. Hence a trade-off must be realized between the antenna performance and antenna dimensions. Microstrip patch antenna in wireless communication is gaining importance as a most powerful technological trend. ITS immense potential promises significant change in near term future of wireless application fields. current technological trend has focused much more attention towards Microstrip patch antenna has some advantages (low cost, light weight, conformal & low profile), but it has little disadvantages too- like low gain, low efficiency, low directivity and narrow bandwidth. These disadvantages can be overcome by implementation of number of patch elements to form an array, improvement in performance is observed. In this review paper, performance characteristics for 2, 4, 8, 16 patch elements configured in 2*1, 2*2, 8*1 and 4*4 (respectively) array format has been analysed and compared.

Key words: Microstrip Patch Antenna, Array, Feed Mechanism, Impedance Matching, Return Loss, Radiation Patterns, Gain Directivity and Bandwidth

I. Introduction

Generally wireless sensor nodes have been using omni-directional antennas to broadcast data. But these antennas are not very efficient as they suffer from poor spatial reuse, high collisions, decreased throughput and are not energy efficient. Usage of directional antennas which radiate in a particular direction is more efficient as it can lead to significant energy savings. They reduce beam width by concentrating power in a certain direction. In this paper, the performance of conventional omni-directional quarter wave monopole antenna, rectangular patch antenna array, triangular patch antenna array and Eshaped patch antenna array are compared. The antenna arrays have been designed, simulated and tested. The antenna arrays designed are fabricated and then are mounted on a sensor node. The performance analysis in terms of power consumption, received signal strength and packet delivery ratio is performed for individual antenna arrays.

A. Wireless sensor network:

Wireless Sensor Network (WSN) is one of the emerging technologies due to recent advancements in the field of wireless technology and hardware which has led to the evolution of low-cost and low-power sensors. WSN uses unlicensed ISM (Industrial, Scientific and Medical) frequency band and can operate unattended even in remote terrains which are in accessible. With the advent of low-cost sensors there has been tremendous upsurge for the use of WSNs in the areas of military applications, habitat monitoring, healthcare, traffic surveillance and much more.

WSN is composed of sensor nodes which are designed to sense the given environment, processing and communicating sensed data to other nodes in the network. WSN nodes are limited in computational capabilities, memory and power. Sensor nodes have to survive on small, finite sources of energy which is usually available in the form of battery power. Majo source of power consumption in sensor node is in transceiver of communication module. Longer the communication range, higher the power required to transmit signals. One of the major research area sin WSN is the development of low power communication system equipped with efficient antenna system. [6]

B. Microstrip patch antenna used in WSN:

The antennas used in WSN should be smaller in sizeso that it can be mounted on WSN node. In order to obtain directional beam pattern and to makesize of the antenna compact, the microstrip technique is usedfor the fabrication of antennas. Microstrip antennas, due tofeatures such as light weight, small size, planar structure,easy fabrication, low cost, dual frequency of operation and linear and circular polarization support are very attractive for applications such as radar, mobile and wireless networks [2]. Microstrip patch antenna is composed of a radiating patch a tone end of the substrate and ground plane at another end. The radiation pattern in these antennas is obtained due to fringing fields created between the patch and ground plane. Depending on the permittivity ε_r, thickness and height of the substrate, the radiation pattern can be manipulated [1]. The advantage of microstrip patch antenna is that depending on the substrate material used, the size of the antenna can be varied accordingly. Microstrip antenna radiates a relatively broad beam broadside to the plane of the substrate. There are dozens of variations in the patch shape which includes rectangular, triangular, circular etc., feeding techniques, substrate configurations and array geometries.

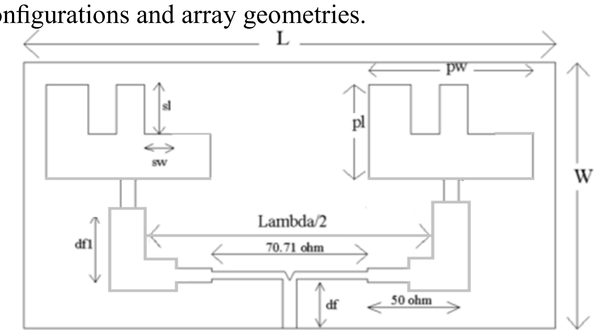


Fig. 1: Geometry of E-shaped patch antenna array[6]

II. DESIGN METHODOLOGY

A. *Introduction:*

The antenna is designed in this project by the transmission line modal. The first step is for the design microstrip antenna is to find the various dimension of antenna. The microstrip antenna has mainly important parts are substrate, patch and feed. When the all dimensions of antenna are funded then many software tools are used for the simulation of antenna. Some of these are IE3D,CST and Ansys HFSS. I used the HFSS in this project. The electromagnetic simulation softwares capable for solving general microstrip antenna structures.

B. *Ansoft HFSS Software:*

HFSS is stands for high frequency structural simulator. This software is use for designing the high frequency and high speed component used in the modern electronic devices. For the understanding of the EM environment is very critical for the accurately predicting that how a subsystem or component, system or end product perform in fields. HFSS adresses the various entire ranges of the EM problems, including losses due to reflection, radiation, attenuation and coupling. The power behind HFSS lies in the mathematics of the finite element and this is integral, proven automatic adaptive meshing technique. With the help of HFSS, the physics define the mesh; but the mesh does not define the physics. Based on this input, HFSS automatically generate the most efficient, appropriate, and accurate mesh for the simulation.

C. *Antenna Design:*

For design a rectangular patch antenna first of all the dimensions of antenna are calculate. The dimension are calculate step by step. First of all calculate the width of patch. After calculate the width ε_{reff} is calculated. Similarly step by step L_{eff}, ΔL, L_g, $W_g$are find. When these dimensions are finded then the antenna design and simulated in the software

III. SIMULATION STEPS

1) Step 1: When whole design is completed, click on validate to check if there is any error in our design, if any, correct it.
2) Step 2: Assign solution setup, in that we provide setup name, add the solution frequency, assign maximum number of passes (i.e 20), and then give maximum delta 0.0.
3) Step 3: Create sweep name sweep type(Discrete), Assign frequency set up, in that provide start and stop frequency and count (100).
4) Step 4: Click on analyse all.
5) Step 5: Wait till the simulation gets completed. This may take some time.
6) Step 6: Once the simulation is over, go to HFSS>Results>create terminal solution data report> rectangular plot, Radiation pattern, Polar plot, etc. analyse above one by one
7) Step 7: Change the operating frequency and number of passes for finer results.

IV. SIMULATION RESULTS

A. *Return Losses:*

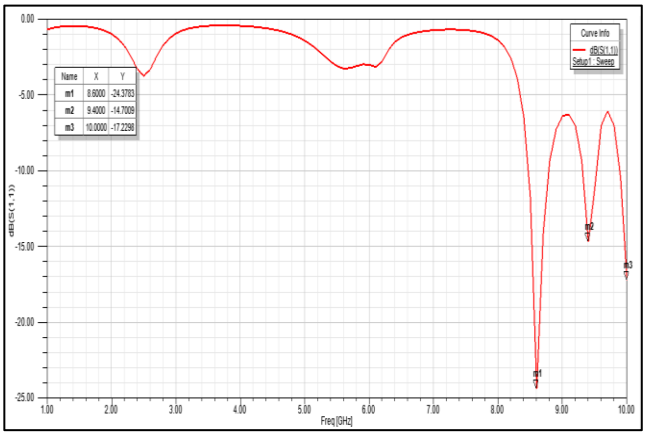


Fig. 2: Return loss V/ S Frequency plot

From the plot it can be observed that return loss at frequency 8.6 Ghz, 9.4Ghz and 10Ghz are maximum which is near by -24.37dB.

B. *VSWR:*

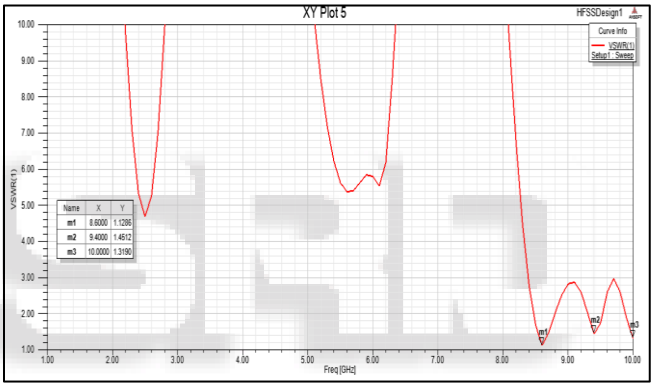
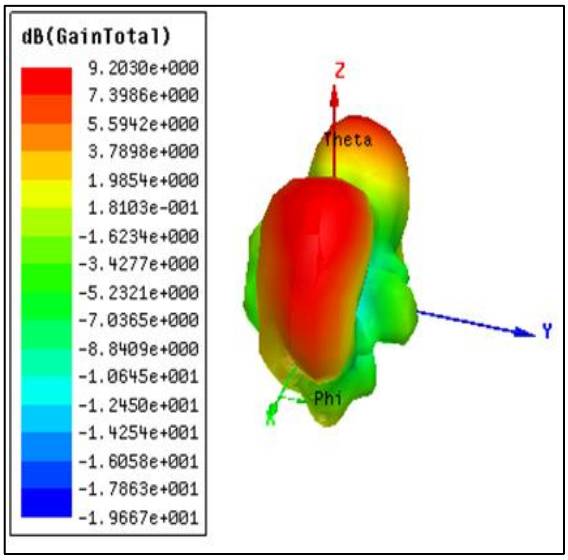
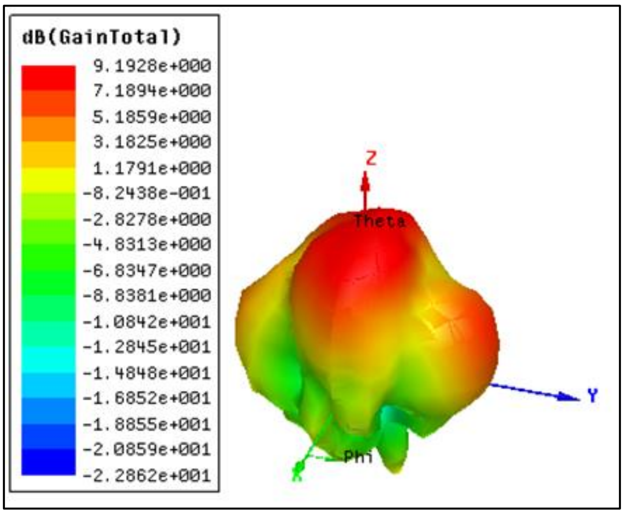


Fig. 3: VSWR V/S Frequency plot

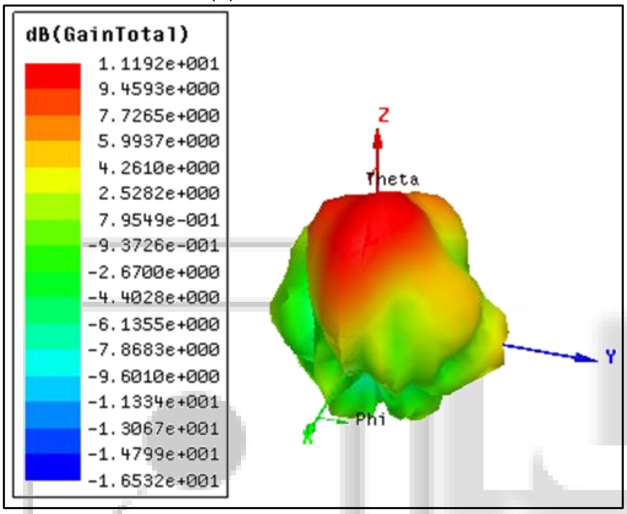
C. *GAIN:*



(a) Gain at 8.4 GHz



(b) Gain at 9.4 GHz



(c) Gain at 10GHz

Fig. 4: Polar plot of gain

D. Bandwidth:

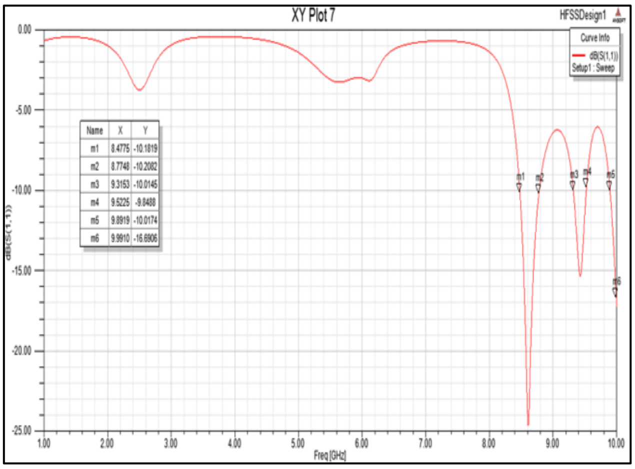


Fig. 5: Bandwidth of microstrip patch antenna

In usual case, we refer the antenna bandwidth with respect to -10dB return loss bandwidth. The -10dB points on the curve are at frequencies of 8.47GHz and 8.77GHz. So the B.W. is the difference between these two frequencies.

B.W. = 8.47-8.77= 300MHz

V. Conclusion and Future Work

From the simulation analysis of microstrip patch antenna it can be observed that the designed of F-shaped microstrip patch antenna has a gain 11.1db and optimized return losses -24.37 at a frequency of 8.6 GHZ. It can also observed that position of feed point has a serious effect on the performance of the designed antenna. The power consumption, RSSI and packet delivery ratio are the main metrics that we have used in analyzing the performance of antenna systems. The results obtained from these metrics indicate that the microstrip patch antenna arrays perform better than omni-directional antenna due to increased gain. Incorporating slots in patch antennas improve gain and reduces return loss thereby resulting in increased coverage range. It can be concluded that due to increased signal quality and coverage range achieved by microstrip patch antenna arrays designed, the number of intermediate hops from source to sink in a WSN can be decreased which in turn reduces transmission delay. It also plays a vital role in energy conservation due to less number of transmissions and receptions within the network. EPA exhibits superior performance compared to RPA and TPA. The future work can be done towards miniaturizing and optimizing antenna arrays design by choosing suitable substrate material.

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