A Grid Array Patch Antenna For 3G Wireless Applications

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Abstract—Current scenario has seen an unprecedented revolution in the field of wireless technology where the large bulky sized Yagi Uda Array’s have been replaced by small sized, light weight & mechanically robust & compatible phased array structure for their diversified applications in the field of GPS, RADAR & other SATELLITE services. One such promising array structure is the patch antenna array that in spite of possessing the aforesaid attributes has another added advantage of conformability to its host surfaces & higher operating frequencies. All the requisite parameters of the patch antenna have been simulated with the aid of IE3D ZELAND software version14.10 for testifying the various parameters of the propounded patch array.

Keywords—Impedance bandwidth, Rectangular patch, FR4 substrate, WLAN systems

I. INTRODUCTION

A micro strip antenna generally consists of a dielectric substrate sandwiched between a radiating patch on the top and a ground plane on the other side as shown in fig.1. The patch is generally made of a conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. For simplicity of analysis, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape. Micro strip antennas are used in various viable areas as embedded antennas in handheld wireless devices such as cellular phones, and also employed in satellite communications, direct broadcast satellite services, global positioning system, medical hyperthermia usage etc. They also have the attractive features of low profile configuration, lightweight, inexpensive, easy fabrication and conformability to mounting hosts [1].

However, in spite of possessing such an indispensable salient features, a patch antenna still suffers from more drawbacks as compared to conventional antennas. Although, they are few in number but still degrades the operationability of a patch array like narrow impedance bandwidth band width, Low efficiency, low Gain, extraneous radiation from feeds and junctions, & low power handling capacity. However, prominent among them is the secreted impedance bandwidth which decays significantly as the frequency of operation increases.

Various methods have been suggested as a remedy of the above limitation like introduction of fractals on the patch of the antenna, decreasing the Q factor of patch by increasing the substrate height, decreasing the dielectric constant of the dielectric material medium, use of the multiple resonator located in one plane, electromagnetically coupled patch Antenna, use of multilayer configuration with multilayer resonators stacked vertically. Prominent among these is the introduction of fractals on radiating patch of the geometry of various shapes like E-shape[2], U-shaped[3], L shaped[4].

Thus, with regards to the above mentioned method here a patch array geometry is proposed in which truncated slots are dug both horizontally & vertically resembling the shape of a plus sign on the radiating patch of the geometry. This practice improves the impedance bandwidth of a patch array to the extent where it could be used for practical WLAN, HIPERLAN, WI-FI & other wireless applications. Usually, feeding methods like aperture coupling, proximity feed, coaxial feed, micro strip feed line have been developed to feed the patch. Although, in the present paper we have used probe feed to feed the patch which offers its inherent advantages like compactness & interfacing convenience.

Fig.1 A Micro strip patch antenna

The proposed geometry is simulated to resonate at a frequency of near about 3.6 GHz which is of utmost importance for providing wireless broadcasting services in INDIA & abroad. Also, the propounded geometry reveals a return loss of -25dB at a resonant frequency of 3.61GHz which is one of the decisive factors for the practical implementation of a patch antenna in the microwave band.
II. ANTENNA STRUCTURE & DESIGN

The geometry of this antenna is simple and condensed. The antenna design consists of two substrate layers, a top substrate layer called as antenna substrate and a bottom substrate called the feed substrate. The radiating plane is placed above the antenna substrate, which is made from FR4 dielectric substrate of height 1.6 mm. The proposed patch antenna has a rectangular ground plane (shown in green color in fig.2) of sides 42.8mm x 27.425mm with a rectangular shape radiant patch (Orange Color rectangular shape shown in fig-2) of dimension 35.65mm x 24.85mm. The left most corner of the antenna is assumed to be at origin O (0, 0). Rectangular geometry is predominantly chosen as it yields the best possible results for the improvement of the various parameters of a patch. As is evident from the figure of the proposed geometry, there is an exhibition of the small truncated slots of rectangular shapes both laterally & transversally on the radiating patch of the geometry resembling the structure of an antenna grid array.

These slots are especially dug to improve/enhance the return loss/S-11 parameter of the patch antenna which is one of the remarkable limitations of a conventional patch.

The various parameters of the proposed geometry are mentioned below as:
- Substrate : FR-4
- Dielectric Constant ($\varepsilon_r$) : 4.44
- Loss tangent (Tan $\delta$) : 0.002
- Thickness : 1.6 mm
- Permeability ($\mu_r$) : 1

The designing of this grid array antenna is done at a meshing frequency of 4 GHz.

III. ANTENNA CHARACTERISTICS

Simulation results of the proposed geometry shows a considerable dip in the return loss with the maximum dip of -25db occurring at almost a frequency of 3.6GHz as shown in fig.3.

This dip is crucial as it decides the operating frequency & bandwidth of the proposed geometry. The sharper the dip in the return loss of the curve, the better is the directivity & beam width of the antenna.

This type of dip is useful especially for wireless 3G services in INDIA like EDGE, GPRS, GSM, UMTS, PCS & services that extend towards LTE.

Also, with the advent of 4G technology in INDIA & abroad, need & facilitation of smart MIMO antennas could be easily fulfilled with the aid of this resonating patch structure with its installation as a polarized duplexer, it could be used for real time monitoring feed of the locations where human access is practically impossible especially in catastrophic, turbulent or disastrous situations.

Fig.3. Return loss the proposed geometry

The next curve in this section is the VSWR curve as depicted in fig.4. The value of VSWR lies near unity for the interval between 3.6GHz to 3.625GHz portraying the practical viability of the proposed geometry as the maximum value of VSWR is unity & if any antenna demonstrates a value of VSWR near unity, it infers that the losses due to reflection from both the incident & reflected ends are minimum, minimizing the formation of evanescent modes along with the revelation of nodes & antinodes along the transmission distance. Thus, the proposed geometry proves to be an excellent insulator insulating the reflected power from the incident one.
Next is the curve of the axial ratio versus frequency curve. As per the curve, there is a continuous fluctuation of the axial ratio value between 0.05 to 0.55 for the frequency values between 3.5 to 3.7 GHz exhibiting that the proposed geometry can be used for producing linearly polarized waves, segregating the difference between the horizontally & vertically polarized waves is the position of feed, if the feed is located at a point on the diagonal of the radiating patch or if truncated slots are dug at the corners of the proposed geometry & if insertion of p-i-n diodes is implemented in these slots in parallel with their excitation by a phase quadrature feed, it is possible to achieve polarization diversity with the aid of the proposed geometry which remains to be the future prospect of this geometry.

Likewise, is the case for the antenna efficiency which also degrades severely as the frequency of operation increases. Talking in terms of efficiency, this antenna may not be an ideal candidate which at par remains to be the future prospect of this antenna.

The next curve in the antenna analysis & synthesis is the smith chart of the proposed geometry which is shown below.
3dimensional free space which is usually represented by the pointing vector associated with any uniform plane wave.

Lastly, the 3-D view of the proposed geometry is shown in fig.8 for a better visualization & assessment of the proposed geometry.

![Fig.8. 3D view of the proposed geometry](image)

IV. CONCLUSION

Mobile communication today demands high speed wireless systems for providing enhanced connectivity but unfortunately the communication equipments for supporting this platform are very scarce in number. Some still do fulfill these requirements to some extent but still the demand for smart antennas remains a major issue when talking in terms of the weight, size, cost, expenditure etc.

In this context, a micro strip patch antenna proves to be an excellent remedy leveraging & encompassing the aforesaid assets for providing WLAN, Wi-max, GSM, WI-FI & other 2G & 3G services in INdia & abroad. Further, this configuration could be used for providing polarization diversity, frequency diversity & multiband operations in the microwave band if the location of feed or the truncation of fractals is appropriately chosen which remains to be the future enhancements of this geometry.

REFERENCES


