Design of Coaxial fed Spiral-Slot Microstrip Patch Antenna for DTV Reception with Shorting Plates

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ABSTRACT
In this paper a novel design of small sized, low profile coaxial fed microstrip patch antenna is proposed for terrestrial DTV signal reception applications in the UHF band frequency range of 540-890MHz. Designed model was spiral slot microstrip patch antenna using shorting plates for size reduction. Different parameters like return loss, VSWR, gain along θ, Ø directions, radiation pattern in 2D & 3D , axial ratio, E & H field distributions, current distributions are simulated using HFSS 13.0. The measured parameters satisfy required limits hence making the proposed antenna suitable for DTV reception applications in the UHF band.

***Keywords*- coaxial fed, DTV, FR4, UHF**

1. INTRODUCTION
Conventionally, Yagi antenna has been used together with a TV receiver system to capture the electromagnetic wave energy broadcasted from a TV broadcasting station. This antenna has become more popular among the people living both in urban or rural. The popularity of Yagi antenna is not only due to the excellent characteristics such as gain and directivity but also other benefits like easiness in the process of design/ construction/fabrication, installation, maintenance and inexpensive [5].

Apart from these advantages and ease of practical application, this type of antenna has some limitations in terms of the flexibility of use. If there are 2 to 3 sets of TV receiver device in one house, it will take more towers to install them. The negative impact raised in the environmental issue and the crowded arrangement of the antenna installation where it occupies large space. As the position of the TV receiver changed in the building the configuration of cable connection must be reinstalled. Also the gain insufficiency for remote applications, appearance of grating lobes makes the Yagi disadvantageous.

Nowadays, there is a Yagi antenna for indoor applications widely available in the market place which can be connected to the TV receiver to replace the outdoor one. But in terms of size and model it would require the proper arrangement of the room/space so that the quality of signal reception cannot be interfered due to the mobility of moving objects/people and the influence of interference from electronic devices in the vicinity[3]. For applications in other communication systems to access various DVB services such as from mobile phones, laptops/notebooks and PDAs the newest research and innovations concerning the construction of the internal antenna are very important to conduct. The antenna design must fits perfectly integrated inside a communication device. Some research activities to discover a new internal antenna have been published [6-10].

The results of investigations on a number of the internal antenna designed to be integrated with digital TV receiver has been proposed[4]. The choice of monoplole[16],printed monopole[11-12],dipole antennas[13-14] improve the bandwidth to a greater extent. But, monopole antennas are of large size and difficult to build and integrate. Printed monopole antennas also have numerous advantages like low profile, small size, easy integration but has disadvantage of low broad impedance bandwidth and low omnidirectional radiation pattern. The dipole antennas have large input impedance. So, an impedance matching transformer or balun coil at feed point is required which increases the size of antenna[2][16-20]. Due to the numerous advantages of patch antenna[2][17-20] and in view of various techniques to improve the performance of microstrip patch antenna mentioned in [2], a C-slot to enhance the bandwidth of proposed antenna is proposed[1]. To reduce the dimensions of this antenna shorting plates are placed and slots are increased for the antenna to operate at multiple frequencies thereby receiving multiple band of channels.

In this paper, a compact size patch antenna is proposed with dielectric substrate as FR4 with εr=4.4 and dimensions are base on resonant frequency. Various attempts are made to adjust the dimensions of the patch to impove the parameters like return loss, VSWR, gain along **θ,** Ø directions, radiation pattern in 2-D and 3-D, axial ratio, E and H Field Distributions, Current Distributions using HFSS 13.0 which is a high performance full wave EM field simulator for arbitarary 3D volumetric passive device modelling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modelling, and automation in an easy to learn environment where solutions to your 3D EM problems are quickly and accurate obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of the 3D EM problems.

2. DESIGN CONSIDERATIONS

The proposed structure of the antenna is shown in Fig. (1). The antenna is simulated on an FR4 substrate with a dielectric constant of 4.4 and a loss tangent of 0.02. The thickness of the substrate is 1.6 cm. The size of the antenna is 11x10 cm2, which is suitable for DTV reception. Rectangle shaped patch is taken with slots as shown.

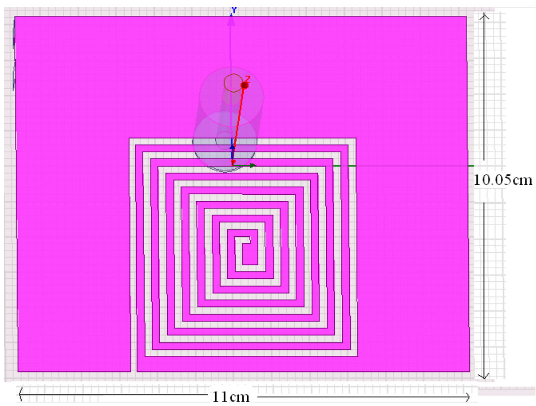

Fig. 1. Geometry of Patch antenna with Slots

The patch can be fed with a probe through ground plane. The probe position can be inset for matching the patch impedance with the input impedance. This insetting minimizes probe radiation. The ease of insetting and low radiations is advantages of probe feeding as compared to microstrip line feeding. The dimensions of rectangular shaped patch shown in Fig. (1) are L=11cm, W=10.05cm which are designed at operating frequency 1GHz. On inserting slots, shorting plates the designed antenna operates at low frequency.

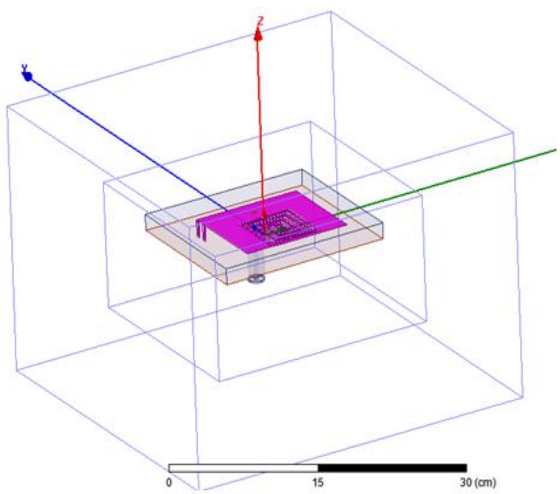

Fig. 2. Ansoft-HFSS generated antenna model

Figure (2) shows the proposed antenna on FR4 Substrate using Ansoft-HFSS.

3. SIMULATION RESULTS

3.1. Return loss

It is a measure of the reflected energy from a transmitted signal. It is commonly expressed in positive dB's.The larger the value the less energy that is reflected.

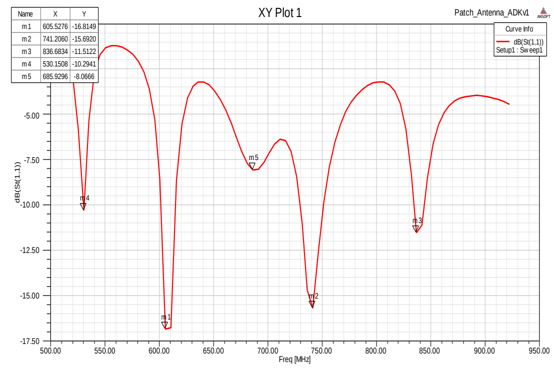

Fig 3. Return loss

Figure (3) shows the return loss Curve for the proposed antenna. Return losses of 16.82dB, 15.69dB, 11.5dB, 10.29dB is obtained at frequencies of 0.6,0.74,0.83,0.53GHz.

3.2.2D Gain & 3D gain Totals

The term Antenna Gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.

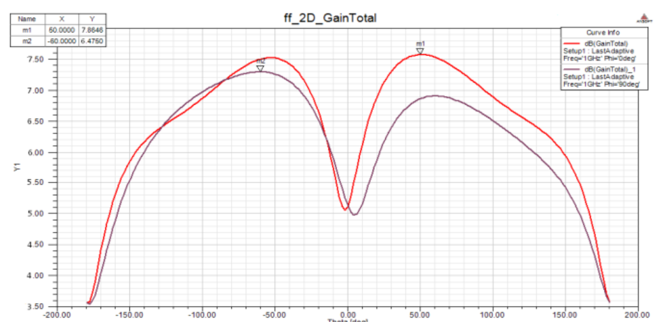

Fig 4. 2D-Gain Total

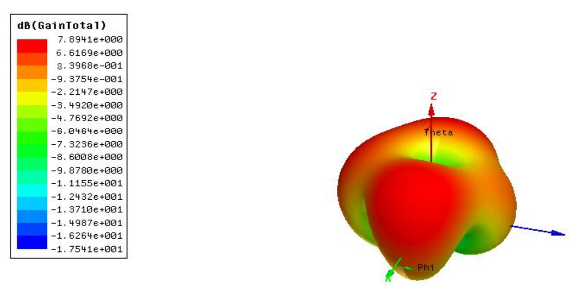

Fig 5. 3D-Gain Total

Figure (4-5) shows the antenna gain in 2D &3D patterns. The gain of proposed antenna is obtained as 7.86dB and 6.47dB. The gain above 6dB is acceptable.

3.3. VSWR

The VSWR is a measure of the impedance mismatch between the transmitter and the antenna. The higher the VSWR, the greater is the mismatch. The minimum VSWR which corresponds to a perfect match is unity.

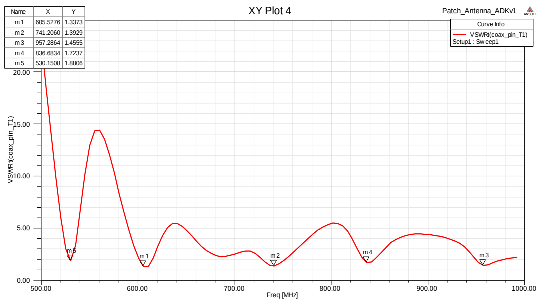

Fig.6. VSWR

The VSWR for the proposed antenna is less than the 2dB. The obtained value is 1.33,1,39,1.45,1.72,1.88 at 0.6,0.74,0.95,0.86,0.53GHz from Fig 6.

3.4. Radiation Patterns

The radiation pattern of an antenna is a plot of the far-field radiation properties of antenna as a function of the spatial co-ordinates which are specified by the elevation angle θ and the azimuth angle φ.It is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity.

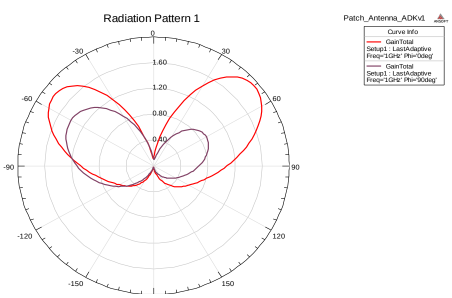

Fig. 7a. Gain in Total

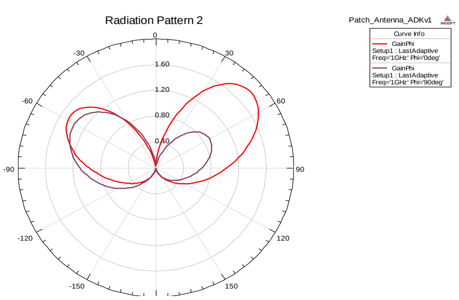

Fig. 7b. Gain along Phi

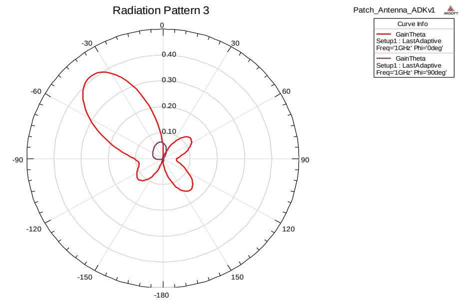

Fig. 7c. Gain along Theta

Since a Micro strip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. The radiation pattern for proposed microstrip patch antenna for gain-Total, phi and theta at 0deg and 90deg is presented in figure 7(a),7(b), 7(c).

3.5. Axial Ratio

Axial Ratio is the ratio of peak value in the major lobe to peak value in the minor Lobe direction.

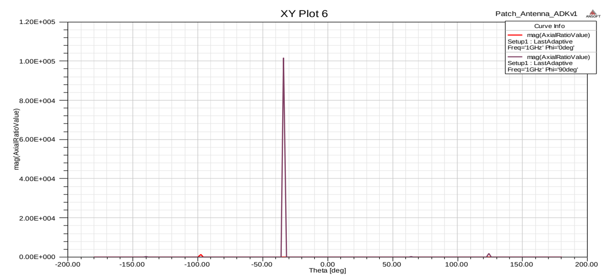

Fig.8. Axial Ratio

Axial ratio which is the ratio of the major axis to the minor axis of the polarization ellipse where the resulting pattern is an oscillating pattern is obtained as in Fig 8

3.6. E- Field Distribution

An electric field can be visualized by drawing field lines, which indicate both magnitude and direction of the field. Field lines start on positive charge and end on negative charge. The direction of the field line at a point is the direction of the field at that point. The relative magnitude of the electric field is proportional to the density of the field lines.

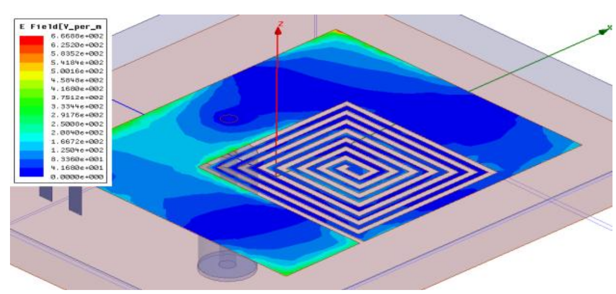

Fig.9a: E-field Distribution

The effect produced by an electric charge that exerts a force on charged objects is the E-Field and its distribution in the patch is as shown in Fig 9a.

3.7. H-field Distribution

In the case of the same linearly polarized antenna, this is the plane containing the magnetic field vector and the direction of maximum radiation. The magnetic field or "H" plane lies at a right angle to the "E" plane. For a vertically-polarized antenna, the H-plane usually coincides with the horizontal/azimuth plane. For a horizontally-polarized antenna, the H-plane usually coincides with the vertical/elevation plane.

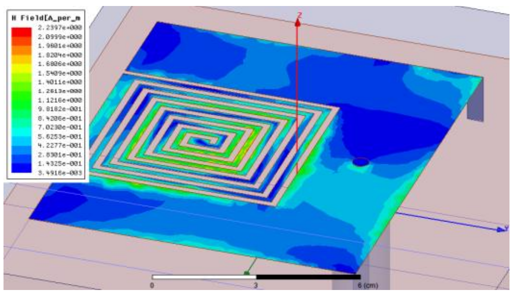

Fig.9b: H-field Distribution

The measured intensity of a magnetic field in the patch is shown in Fig 9b.

3.8. Current Distrubution

Antennas are composed of conductive material on which current distribution determines antenna's defined parameters.

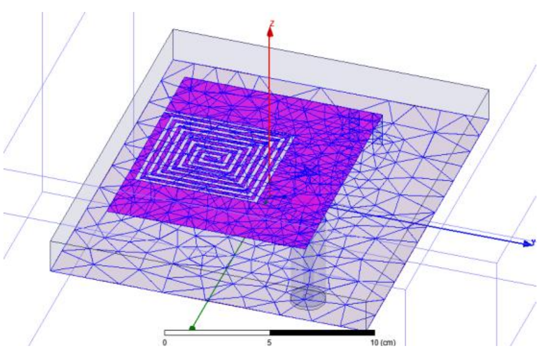

Fig.10: Mesh Pattern

The triangles show the current distribution. Here the number of triangles inside the patch are more than those on the substrate ie.. the current distribution in the patch is more when compared to that inside the substrate in Fig10.

3.9. Field Vectors

The polarization of the EM field describes the time variations of the field vectors at a given point. In other words, it describes the way the direction and magnitude the field vectors (usually E) change in time.

The electric field vector is perpendicular to both the direction of travel and the magnetic field vector. If the field travels in counter clockwise direction, and out of screen, it would be right hand elliptically polarised. If the E-field vector is rotating in opposite direction, the field would be left hand elliptically polarized.

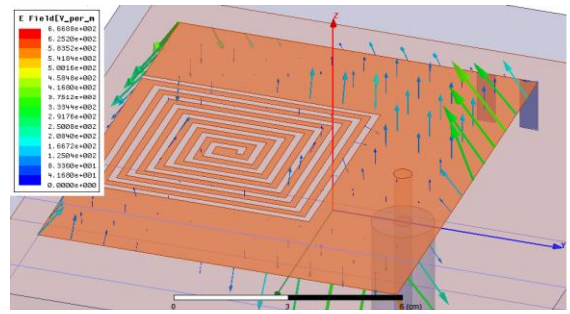

Fig 11a: E-Field Vector

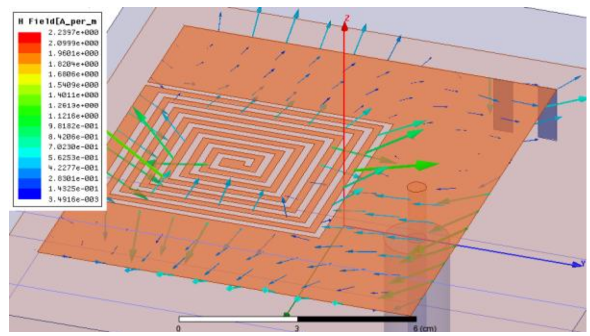

Fig 11b: H-Field Vector

The E-Field Vector and H-Field vectors of proposed patch antenna are obtained as shown in Fig 11a and 11b.

4. CONCLUSIONS

Finally, the optimum dimension of elliptically polarized patch antenna on FR4 substrate for DTV reception applications has been investigated. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required UHF frequency band.

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