Microstrip Patch Antenna for C-band RADAR applications with Coaxial fed

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Abstract:

In this paper a novel design of small sized, low profile coaxial fed Rectangular patch antenna with triangular slots at the four corners, center with wavy edges is proposed for the frequency of C Band application with the substrate RT duroid 5880(™) whose relative permeability is 2.2 and a loss tangent of 0.0009 . Different parameters like return loss which is 14.8368dB at 7.1GHz with elliptical polarization, gain along θ, Ø directions, radiation pattern in 2D & 3D where the 2-D gain is 7.2dB, 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 C-band radar applications.

Introduction:

The IEEE C-band is a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 4.0 to 8.0 GHz, which is followed by radar manufacturers and users. The C band is a name given to certain portions of the electromagnetic spectrum, including wavelengths of microwaves that are used for long-distance radio telecommunications. The C-band and its slight variations contains frequency ranges that are used for many satellite communication transmissions, some Wi-Fi devices, cordless telephones, and weather radar systems[6]. For satellite communications, the microwave frequencies of the C-band perform better under adverse weather conditions in comparison with K_u band (11.2 GHz to 14.5 GHz) microwave frequencies, which are used by another large set of communication satellites.

Radar applications use relatively high power pulse transmitters and sensitive receivers.

So radar is operated on bands not used for other purposes. Most radar bands are in the microwave part of the spectrum, although certain important applications for meteorology make use of powerful transmitters in the UHF band. Single-frequency phased-array radars[6] that must perform both surveillance and weapon control for air defense operate at these frequencies as well as at S band. This frequency region is well suited for long-range, precision-tracking radars.

Microstrip patch antennas [5][7-11] are widely used because they are of light weight, compact, easy to integrate and cost effective.

However, the serious problem of patch antennas is their narrow bandwidth due to surface wave losses and large size of patch for better performance. As a result various techniques to enhance the bandwith are proposed [4]. Techniques to reduce size include different structural techniques, shorting techniques, where a microstrip line or patch is shorted with the ground plane of the antenna. Different loading techniques can be used; such as using external lumped components to reduce the size of the antenna, which result in reduced overall performance and gain, while increasing the cost of the antenna [3].

Keeping in view of inserting slots in patch antenna a low profile coaxial fed Rectangular patch antenna with triangular slots at the four corners, center with wavy edges is proposed. Various antennas for c-band have been proposed[1-2] keeping in view of WLAN applications.

The proposed antenna parameters like return loss with elliptical polarization, gain along θ, Ø directions, radiation pattern in 2D & 3D, E & H field distributions, current distributions are simulated using HFSS 13.0 which is a high-performance full-wave electromagnetic(EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields.

Design Considerations:

The proposed structure of the antenna is shown in Fig. (1).The antenna is simulated on an RT duroid substrate with a dielectric constant of 2.2 and a loss tangent of 0.0009. The thickness of the substrate is 0.32cm. The size of the antenna is 0.2mm, which is suitable for most Radar applications. Patch with triangular slots at the four corners, center with wavy edges is proposed for the frequency of C Band application

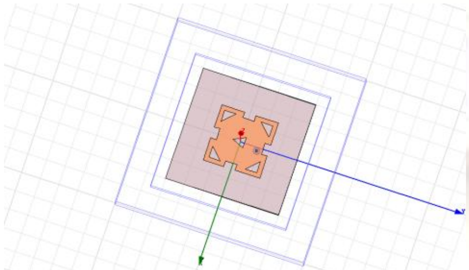

Fig. 1. Ansoft-HFSS generated antenna model

The patch can also 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 shaped patch shown in Fig. (1) are these are designed at operating frequency 7.1GHz

.III. SIMULATION RESULTS

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.

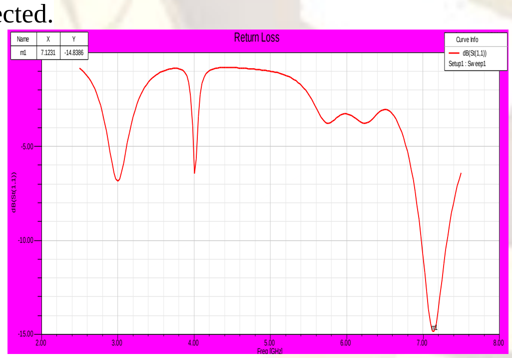

Fig2: Return loss.

A return loss of -14.8386dB is obtained at 7.1231GHz.

Gain:

The ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

2-D Gain:

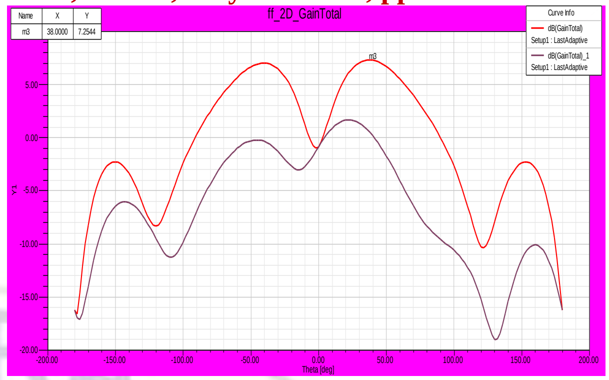

Fig3: 2-D Gain.

3-D Gain:

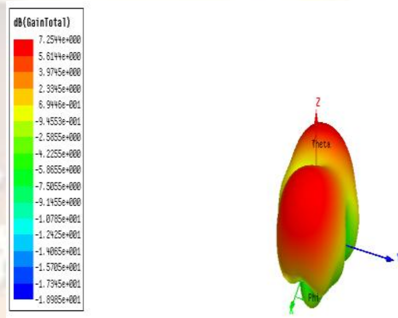

Fig4: 3-D Gain

Figure (4-5) shows the antenna gain in 2D &3D patterns. The gain of proposed antenna at 7.1GHz is obtained as 7.2dB where the gain above 6dB is acceptable.

E-field pattern:

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.

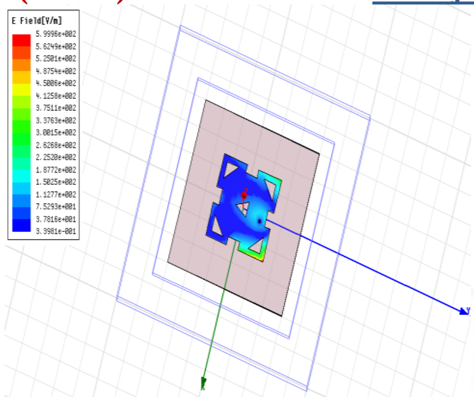

Fig5: E-Field pattern.

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 5

H-field Pattern :

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.

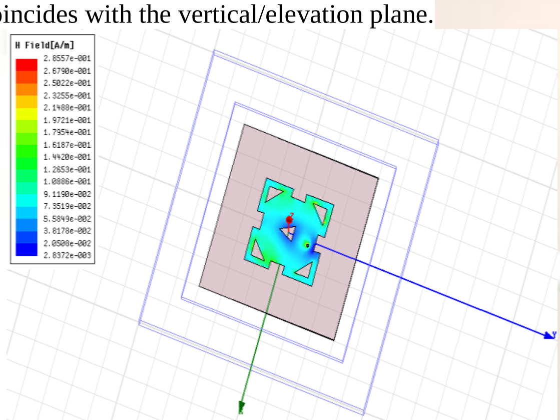

Fig6: H-Field pattern.

The measured intensity of a magnetic field in the patch is shown as in Fig 6.

Vector E- Field:

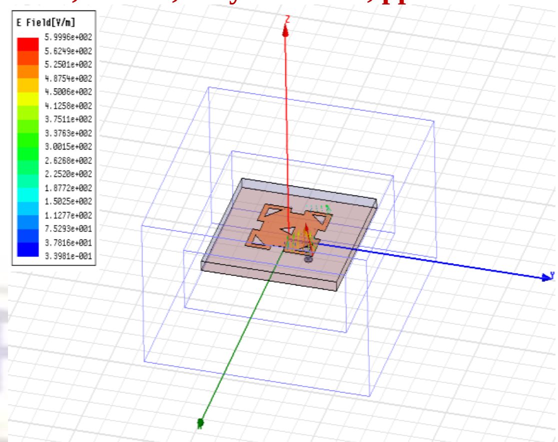

Fig7: Vector E-Field pattern.

The field equations of Einstein Cartan Evans (ECE) are used to develop the concept of the static electric field as a vector boson with spin indices −1, 0, +1, which occur in addition to the vector character of the electric field. The existence of the electric vector boson in physics is inferred directly from Cartan geometry, using the concept of a spinning space-time that defines the electromagnetic field. When the electromagnetic field is independent of the gravitational field the spin connection is dual to the tetrad, producing a set of equations with which to define the electric vector boson. Angular momentum theory is used to develop the basic concept.

Vector H- Field:

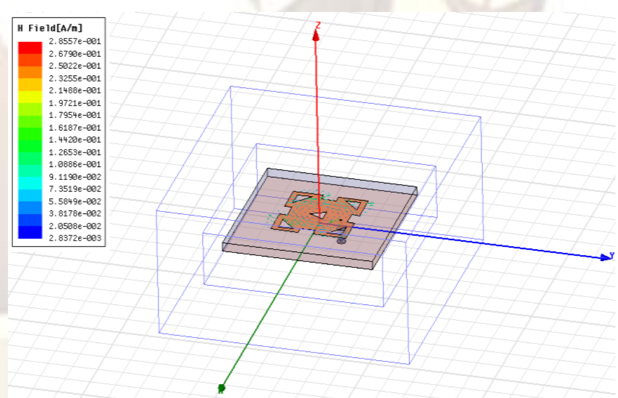

Fig8: Vector H-Field pattern.

The E-Field Vector and H-Field vectors of proposed patch antenna are obtained as shown in Fig 7,8.

Current Distrubution:

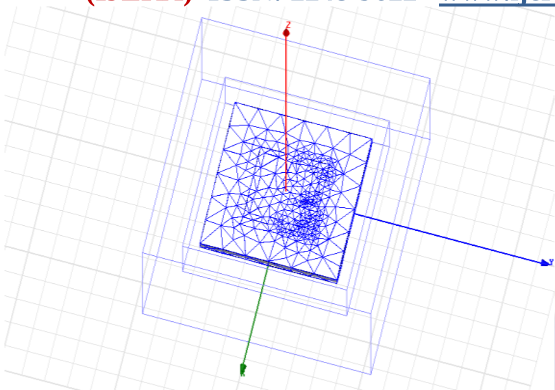

Fig9: Mesh Pattern

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 as in Fig9.

Radiation pattern:

The radiation pattern or antenna pattern describes the relative strength of the radiated field in various directions from the antenna, at a constant distance.

Radiation pattern of Gain in total:

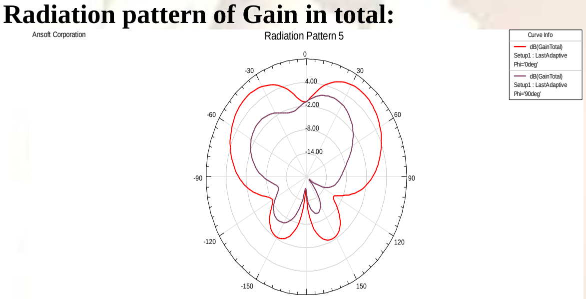

Fig10: Radiation pattern of Gain in total.

Radiation pattern of Gain in Theta direction:

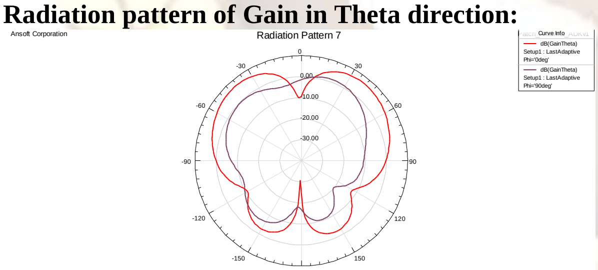

Fig11: Radiation pattern of Gain in Theta direction.

Radiation pattern of Gain in Phi direction:

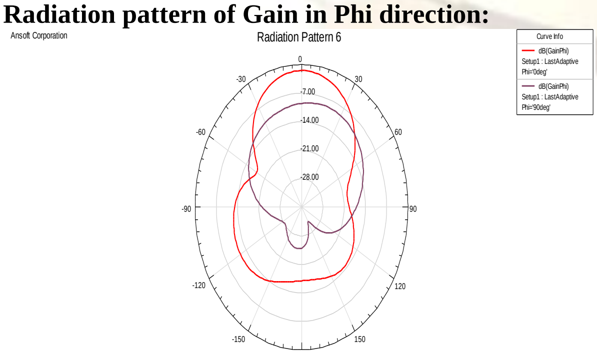

Fig12: Radiation pattern of Gain in Phi direction.

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 10,11,12.

Axial Ratio:

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

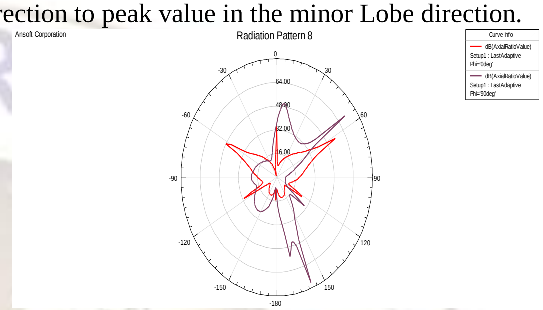

Fig13: Axial Ratio.

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 13

Conclusion:

Finally, the optimum dimension of elliptically polarized patch antenna on RT duroid substrate for C-band Radar applications has been investigated. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required 7GHz frequency band.

V. ACKNOWLEDGMENTS

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