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A NOVEL MICROSTRIP T-SLOT ANTENNA ON LIQUID CRYSTAL SUBSTRATE FOR X BAND APPLICATIONS

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Abstract:

Recent advances in X band include satellite communications, Terrestrial communications and motion detection. In this paper we simulated and presented the results of radiation pattern, return loss, power dissipation and quality factor of Microstrip T-slot antenna for Radar applications. The results of antenna are simulated by using Concerto software. The compact aperture area of antenna 23.65mm X 2.7mm is etched on liquid crystal substrate with relative permittivity 2.8 and loss tangent of 0.0004.

INTRODUCTION:

Microstrip antenna in its simplest configuration consists of a radiating patch on one side of a dielectric substrate which has ground plane in another side. The dielectric material which is used in this paper is liquid crystal has dielectric constant of 2.8 and loss tangent of 0.0004. The proposed antenna operates in Ku band for Radar applications, where T-shape slot reduces antenna size and increases the bandwidth and efficiency [1-3]. The radiating element in this paper is T slot rectangular patch and it is characterized by its length, width, slot size, input impedance, gain and radiation patterns. A rectangular aperture has less complexity in fabrication compared to other apertures [4-6].

Liquid crystals are having some unique combination of properties that make them ideally suited for high density electronic substrate applications. They are having excellent electrical properties up to millimeter wave frequencies, virtually impermeable to moisture, Low coefficient of thermal expansion (CTE) 8 or 17 ppm/^{0}C , very low moisture absorption, <0.04% by weight and excellent dimensional stability (<0.1%) [7-8].

Concerto is a state of the art system for high frequency field simulation. The main components are modeller, quick wave simulator, quickwave2D, CLASP, SOPRANO/EV and post processor. This provides a complete tool chain for RF and microwave electromagnetic design for use on 32 or 64 bit windows platform.Modeller is used to generate data and models for electromagnetic simulation.Quickwave simulator uses a finite difference time domain (FDTD) method with conforming elements ideally suited to the analysis of microwave devices. Quick wave 2D also uses FDTD to simulate asymmetric geometrics such as circular waveguides, horn antennas and coaxial connector. CLASP uses the method of moments (MOM) to calculate antenna radiation patterns. The post processor displays and performs further calculation results of CLASP analysis.

DESIGN SPECIFICATION FOR PROPOSED ANTENNA:

The geometrical configuration of proposed antenna is shown in Fig (1) and dimensions are specified in Table (1). The antenna is etched on 24.64 x 12.3mm liquid crystal substrate with dielectric constant 2.8. The antenna is symmetrical with respect to longitudinal direction with co axial feed line. The substrate thickness is 1.15.The geometrical parameters of antenna has ground plane of size L=24.64 mm and W=12.3mm.Feed location along X axis is 6mm and feed location along Y axis is 6mm with inner radious 0.6mm and outer radious 3mm.

L1=23.65mm	W1=2.7mm
L2=11.3mm	W2=3.5mm
L3=15.05mm	W3=1.7mm
L4=1.1mm	W4=4.9mm
L5=11.25mm	W5=1.25mm
L6=0.5mm	W6=0.5mm

Table (1)：Antenna dimensions

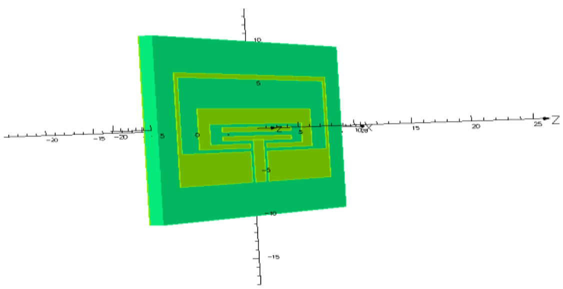


Fig (1) T shaped micro strip patch antenna

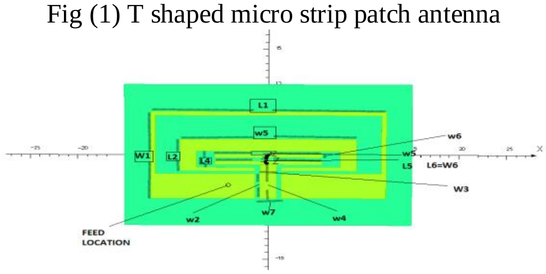


Fig (2) Dimensional view of T shaped micro strip patch antenna

RESULTS AND DISCUSSIONS:

The proposed rectangular patch T-slot antenna has been modeled in concerto and shown in Fig (1) and Fig (2). The performance of the proposed antenna interms of output parameters is analyzed using CONCERTO.

Return Loss:

The simulated results of return loss is shown in Fig (3).The frequency range of this T-slotted antenna is 8 GHz to 12 GHz(X band range).The return loss observed for the designed model is -21.82dB at 10 GHz operating frequency.

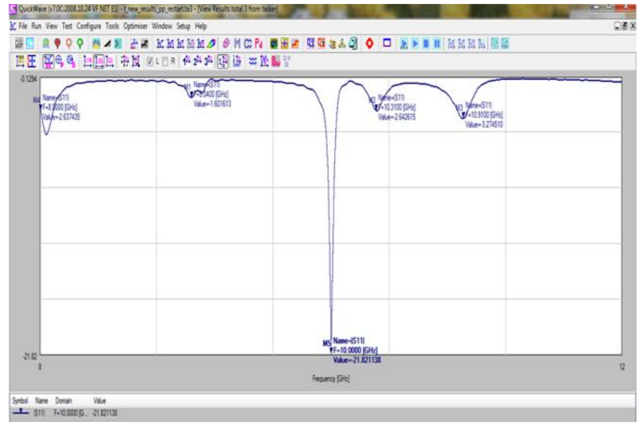


Fig (3) Return loss

Radiation pattern in 3D view:

Fig (4) shows the simulated 3D radiation pattern in log form by using CONCERTO software which is modified in linear form in Fig (5).The results depict, E_θ and E_Φ polarization patterns in azimuth cut (x-y plane) and the elevation cut (y-z plane and x-z plane) for the antenna frequency of 10GHz.The radiation pattern yields the antenna gain as 7.046431+e dB in linear polarization.

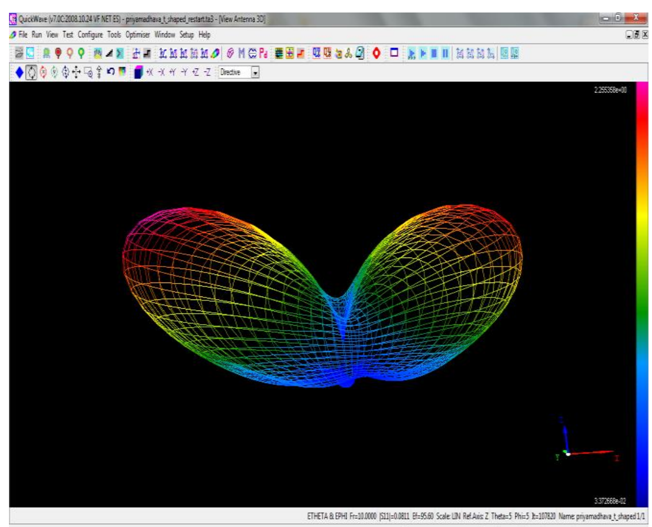


Fig (4) 3D radiation pattern in log form

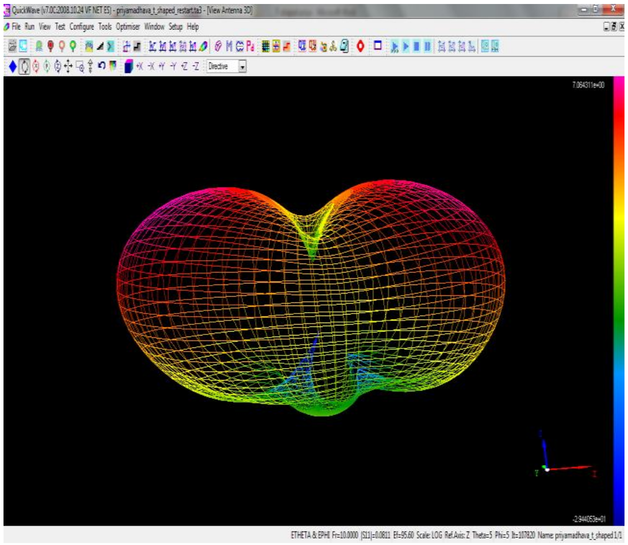


Fig (5) 3D radiation pattern in linear form

Radiation pattern in 2D view:

Radiation pattern of the proposed antenna in polar coordinates is observed for $\Phi=0^0$ and 90^0 where θ varies between -90^0 to 90^0 .Fig (6) and Fig (7) shows the radiation patterns in polar coordinates as linear form for the two cases $\Phi=0^0$ and 90^0 respectively.

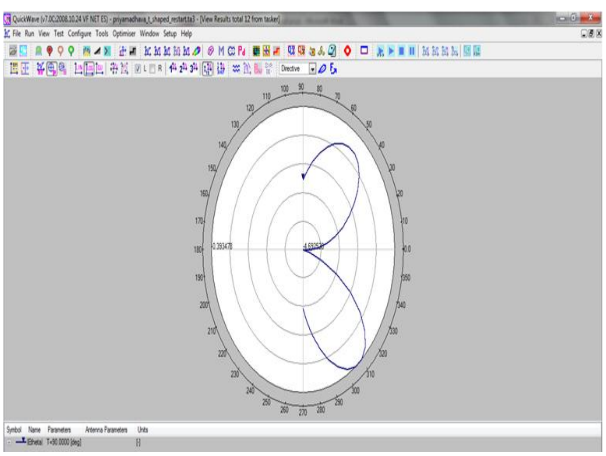


Fig (6) Polar results (at $\Phi=0^0$) linear form

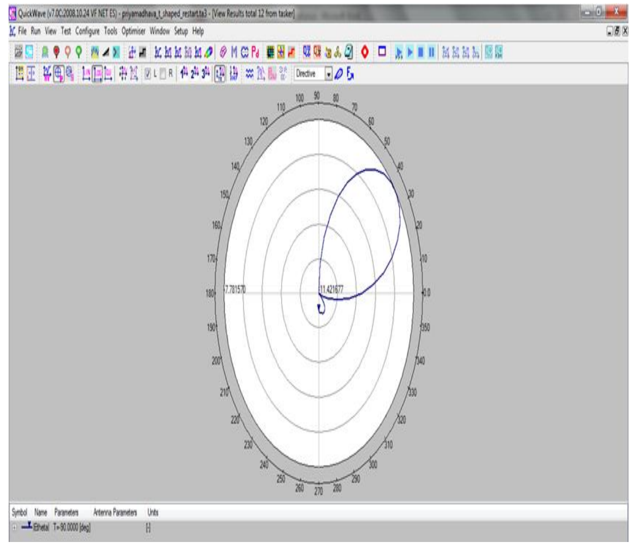
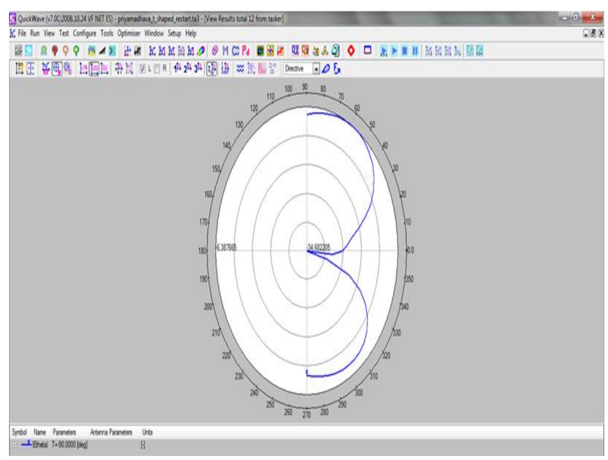


Fig (7) Polar results (at $\Phi=90^0$) linear form

Fig (8) and Fig (9) shows the radiation patterns in polar coordinates as log form for the two cases $\Phi=0^0$ and 90^0 respectively. And the scale is set for gain at -34.682205 and -19.124832 for $\Phi=0^0$ and 90^0 respectively.



Fig(8)Polar results (at$\Phi=0^0$) log form

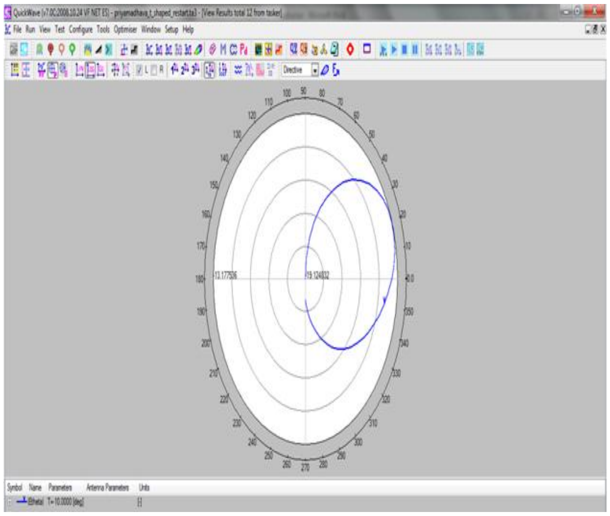


Fig (9) Polar results (at $\Phi = 90^0$) log form

These radiation patterns help us to find out the type of polarization of proposed antenna. The gain difference between these two radiation patterns is less than 3dB so we conclude that the proposed antenna has broad or linear polarization with respect to feed.

Field distributions in different directions:

Total electric and magnetic field distributions in X, Y, Z axis has been shown in Fig (10)

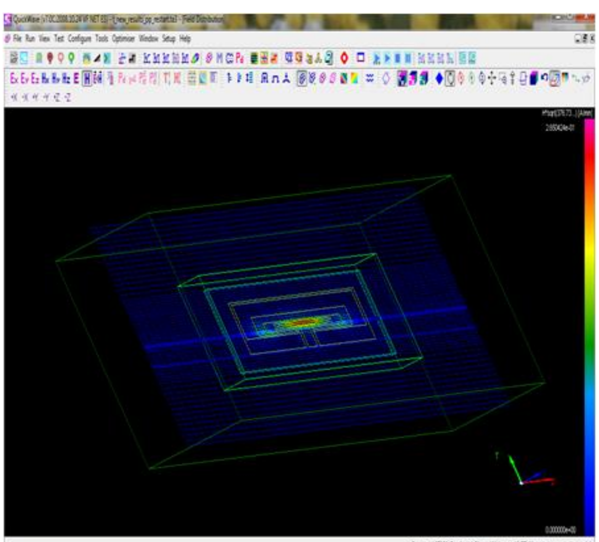


Fig (10) E Field distributions

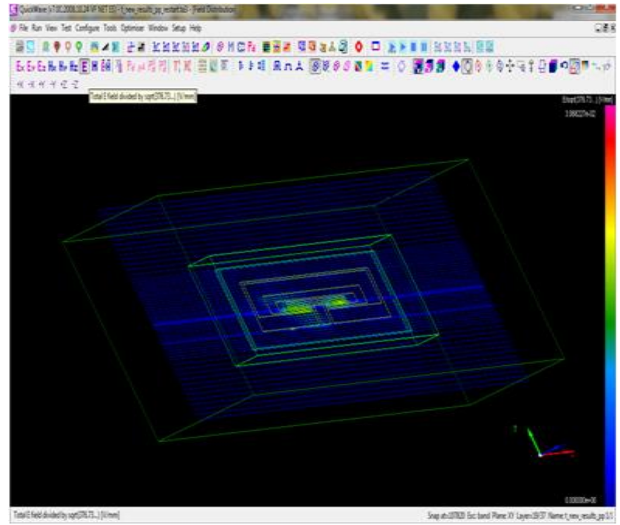


Fig (10) Total E and H Field distributions

Reflection coefficient from smith chart:

Reflection coefficient for the proposed antenna designed at 10 GHz is calculated by using smith chart as shown in Fig (11)

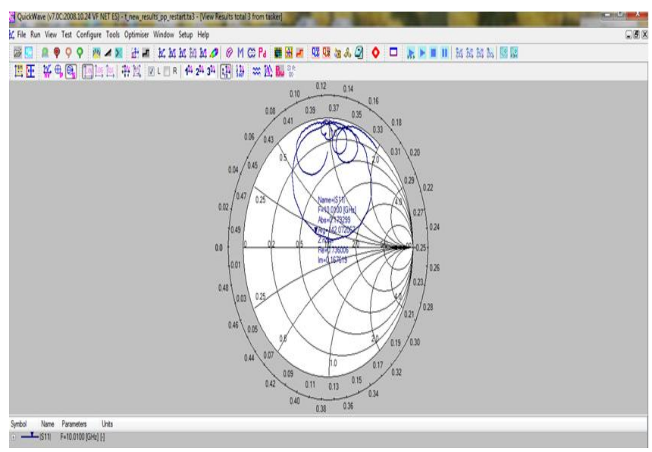


Fig (11) Smith chart

Quality factor and energy:

Electric field energy, magnetic field energy and total filed from the proposed antenna are calculated by CONCERTO and same is presented in Fig (12).The quality factor is the additional parameter that can be observed in Fig (12)

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which can able to specify the quality of the designed antenna.

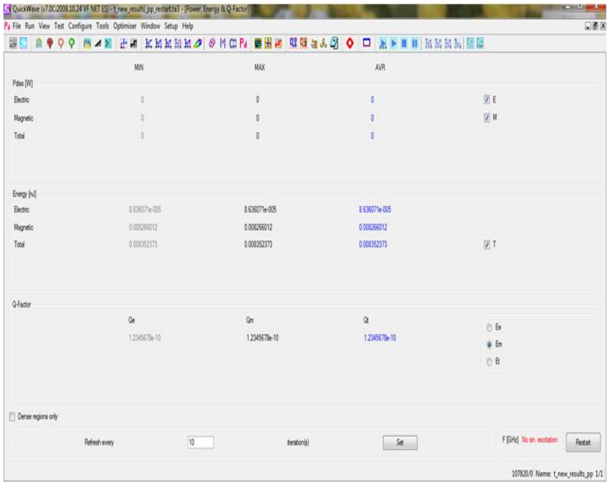

Fig (12) Quality factor and energy: Electric filed energy 8.63e^{-005} magnetic field energy 0.008266012, total 0.008352373, Q-factor-1.23456e^{-10}

Antenna probe results:

Fig (13) shows the antenna probe results at 10GHz.

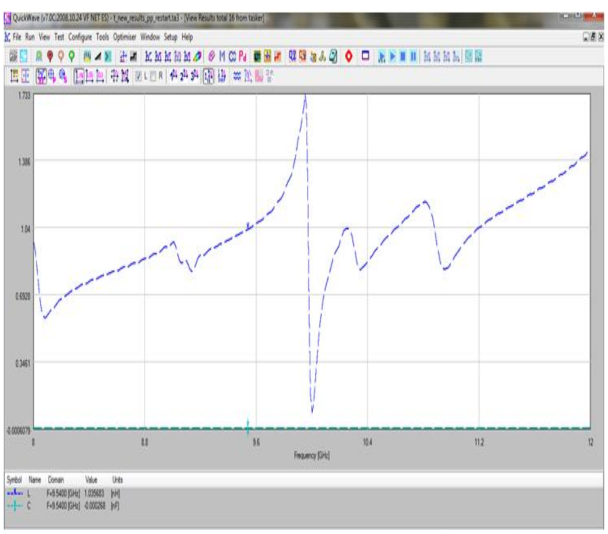

Fig (13) Antenna probe results L=1.035683nH, C=0.000268nF

Impedance and Admittance values of probe (Real and Imaginary) at 10GHz:

Fig (14) shows the impedance and admittance values observed for the proposed antenna at 10GHz.It was observed that Re (Z) =54.771259ohms and Im (Z) =108.337440 ohms at F=9.95 GHz and Re(Y) =0.000401mhos and Im(Y) =-0.014380 mhos at F=11.13 GHz.

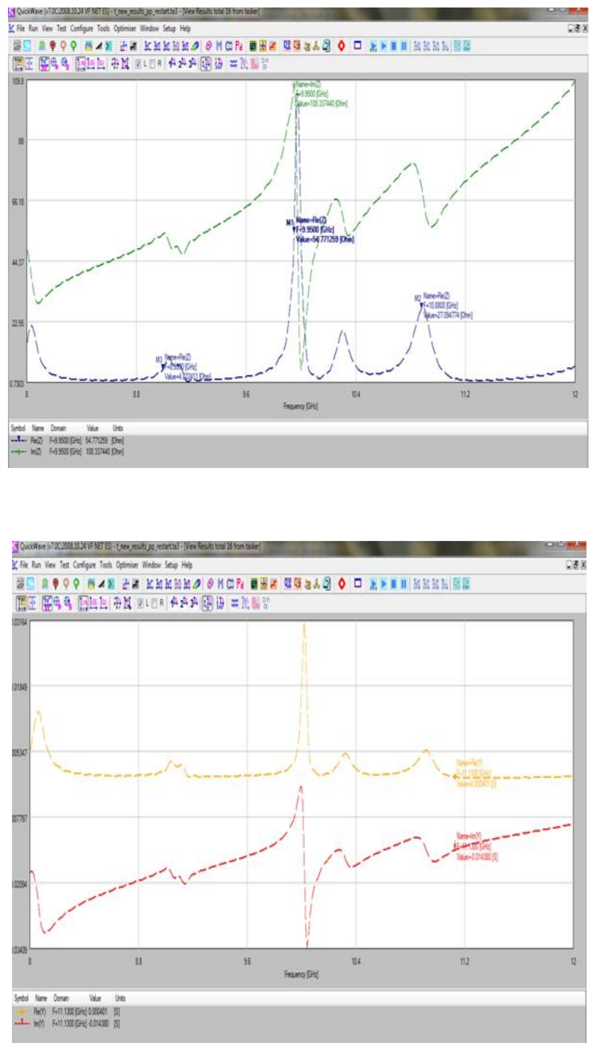

Fig (14) Impedance and admittance values of probes (real and imaginary) at 10 GHz

CONCLUSION:

Single frequency operation of rectangular patch antennas with T-slot shape has been investigated by FDTD (finite difference time domain) technique. The T slot antenna with liquid crystal as a substrate resonates at 10 GHz frequency .The antenna is giving the gain of 7.064dB, quality factor $1.23456e^{-10}$ and energy 0.008352373 nJ. The results are giving the moral encouragement for the applicability of advanced substrate materials in the microstrip patch antenna modeling and design.

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