RECTANGULAR MICROSTRIP PATCH ANTENNA ON LIQUID CRYSTAL POLYMER SUBSTRATE

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ABSTRACT

Patch antennas are one of the most attractive antennas for integrated RF front end systems due to their compatibility with microwave integrated circuits. To fulfill the demand of integrated RF front end systems, a design of microstrip patch antenna with optimum performance at 12 GHz is investigated. It is also investigated how the performance properties of a microstrip patch antenna are affected by varying the dielectric constant of substrate and width to length ratio of the patch. In this present work a liquid crystal polymer substrate with dielectric constant of 3.1 is taken and the total simulation is done using the software Ansoft-HFSS.

Keywords : *Microstrip Patch, LCP Substrate.*

1. INTRODUCTION

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handling wireless devices such as cellular phones, pagers etc... The telemetry and communication antennas on missiles need to be thin and conformal and are often in the form of Microstrip patch antennas.

A Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure (1). The patch is generally made of conducting material such as copper or gold and can take any possible shape [1]. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane [2]. Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch [3].

In this paper Liquid Crystal Polymer (LCP) is used as substrate material. LCP is an emerging dielectric material that has gained attention in recent few years as a potential high performance microwave flexible substrate and packaging material [4]. Liquid Crystal Polymer is much cheaper than other available dielectric materials. They are Low cost (~ 2 / 5 $ ft for 2-mil single-clad low-melt LCP) make it attractive for high frequency designs at minimum cost. They have low dielectric constant (2.9-3.2 for $f < 105$GHz) and low loss tangent (0.002-0.0045 for $f < 105$GHz). LCP has a unique property of low moisture absorption (water absorption<0.004%). LCP material can be laminated without using additional adhesive layers owing to its thermoplastic nature. So in general LCP offers an excellent combination of electronic, thermal, mechanical and chemical properties that make it as a promising substrate for electronics packaging [5].

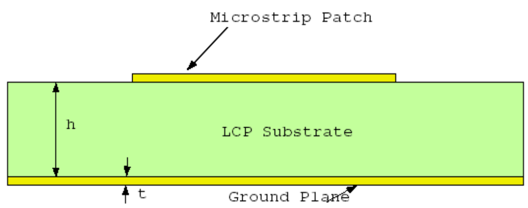


Figure (1) LCP-Microstrip Patch Antenna

2. DESIGN CONSIDERATION

For a rectangular patch, the length L of the patch is usually 0.3333λ*o*< *L* < 0.5 λ*o*, where λ*o* is the free-space wavelength. The patch is selected to be very thin such that t << λ*o* (where *t* is the patch thickness) [6]. The height *h* of the dielectric substrate is usually 0.003 λ*o* <=*h*<=*0.05* λ*o.* A 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 [7]. The ease of insetting and low radiations is advantages of probe feeding as compared to microstrip line feeding.

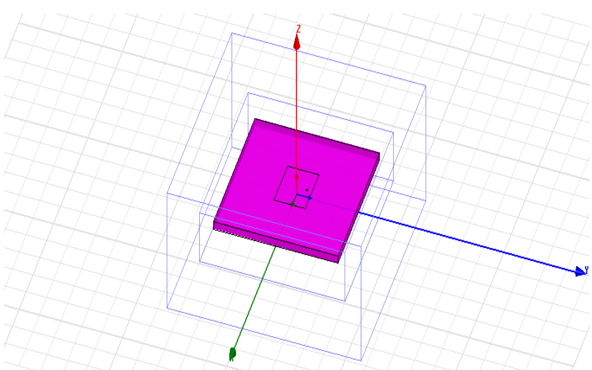


Figure (2) Ansoft-HFSS Generated Rectangular Patch antenna Model

The figure (2) shows the proposed Rectangular patch antenna on LCP substrate using the Ansoft-HFSS.

3. SIMULATION RESULTS

The return loss -13.6 dB is obtained at the frequency 10.2 GHz is shown in figure (2).

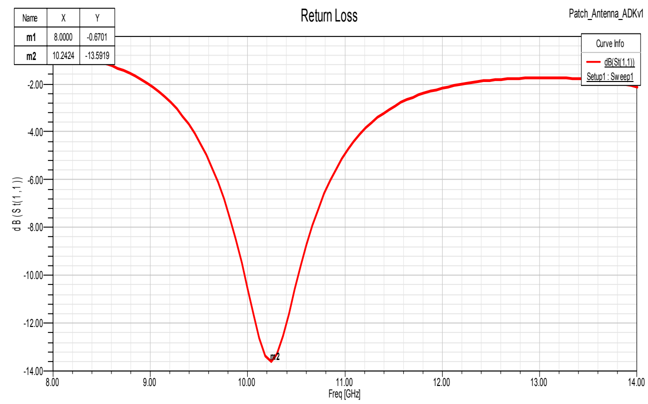


Figure (3) Return loss

The bandwidth increases as the substrate thickness increases (the bandwidth is directly proportional to *h* if conductor, dielectric, and surface-wave losses are ignored). However, increasing the substrate thickness lowers the *Q* of the cavity, which increases spurious radiation from the feed, as well as from higher-order modes in the patch cavity. Also, the patch typically becomes difficult to match as the substrate thickness increases beyond a certain point (typically about 0.05 λ0) [8].

Figure (4) shows that the input impedance of the port was matched with the normalized Z_C value of 50 at the desired frequency. The rms value and the bandwidth obtained from the input impedance plot is 0.713 and 9.2638 GHz respectively.

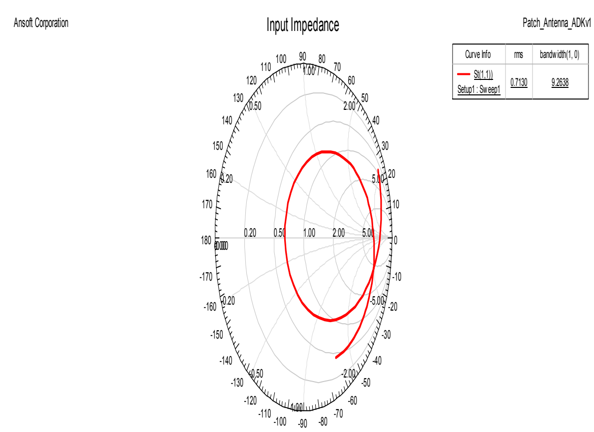


Figure (4) Input-Impedance plot

Figure (5) and (6) shows the 3D and 2D gain total for the proposed LCP-Rectangular patch antenna.

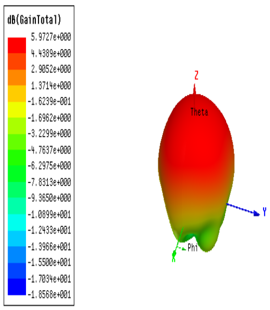


Figure (5) 3D-gain Total

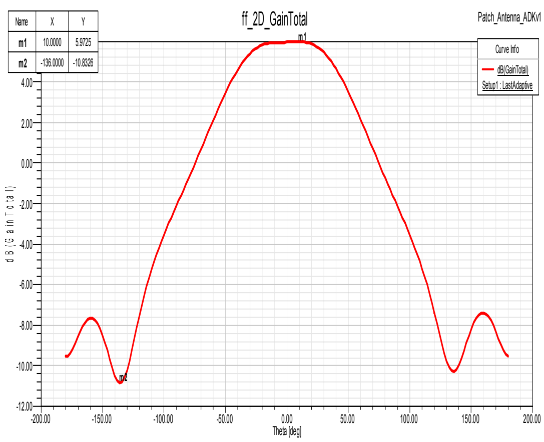
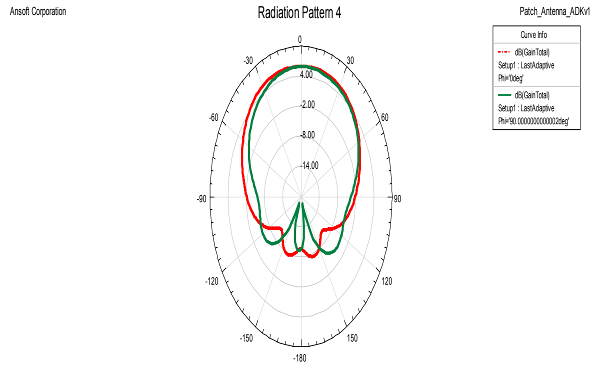
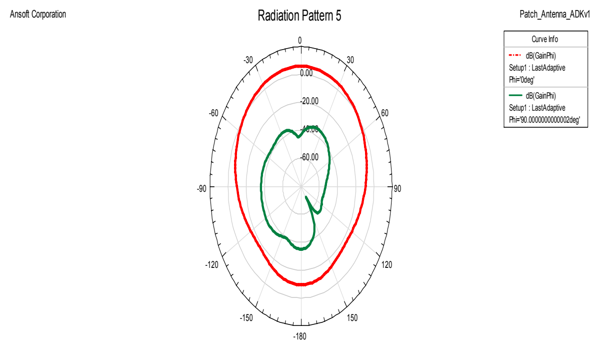


Figure (6) 2D-gain total

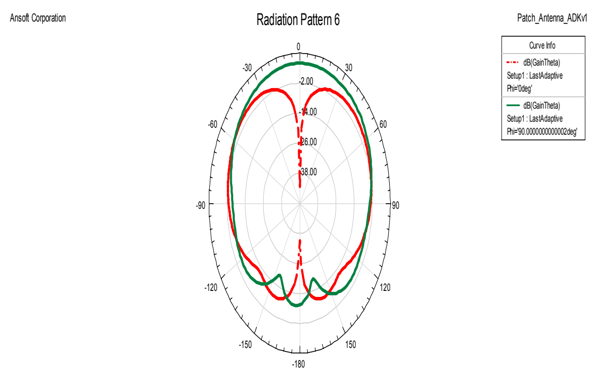
Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. Figure (7) below shows the gain of the antenna at 10 GHz for φ = 0 and φ = 90 degrees.



Gain Total



Gain Phi



Gain Theta

Figure (7) Elevation Pattern for φ = 0 and φ = 90 degrees

4. FIELD DISTRIBUTION

The 3D field distribution plots give the relationship between the co-polarization (desired) and cross-polarization (undesired) components. Moreover it gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna. Figure (8) and (9) clearly shows the patch antenna E-field and H-field distribution.

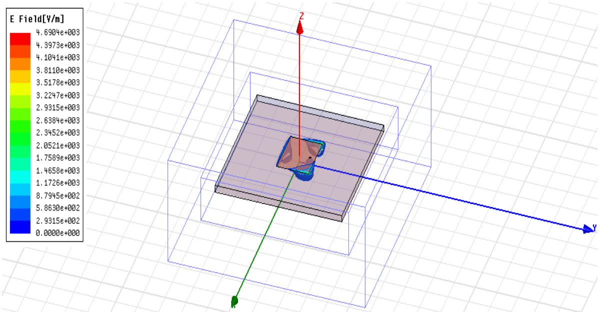


Figure (8) E-field distribution

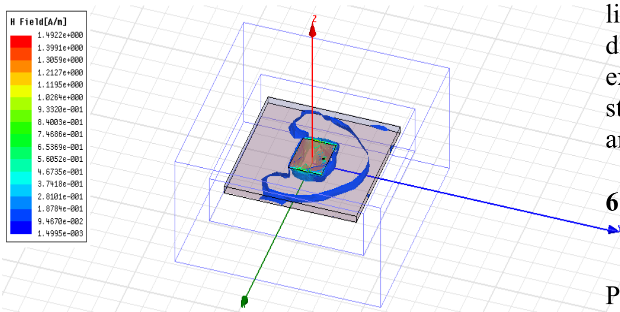


Figure (9) H-field Distribution

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain to the highest possible degree of accuracy. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen or for physical simulation such as finite element analysis or computational fluid dynamics. The triangulated zones in the mesh shown in figure (10) indicate the points in the grid where the current distributed is concentrated.

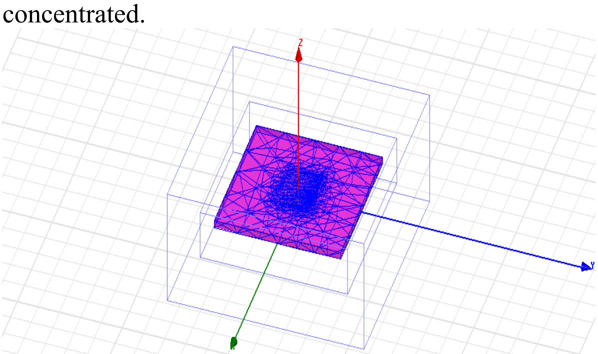


Figure (10) Ansoft-HFSS Mesh pattern of the patch antenna

S-parameters are calculated from the average current distribution of the cross section, and thus the exact current distribution is not required to be precise.

5. CONCLUSION

Experimental implementation of this work involves the LCP dielectric characterization at microwave frequencies, which has been investigated. The measured parameters were also in good agreement with the simulated results. The results shown here demonstrate the applicability of Liquid crystal polymers for the development of low-cost, lightweight antennas on an "all-package" solution for future communication and remote sensing systems. The investigation has been limited mostly to theoretical study due to lack of distributive computing platform. Detailed experimental studies can be taken up at a later stage to find out a design procedure for balanced amplifying antennas.

6. ACKNOWLEDGEMENT

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