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Circular Polarised Feed Line Patch Antenna based on Liquid Crystals for WLAN applications

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***Abstract*— The design of a circular polarized (CP) feed line patch antenna based on Liquid Crystals (LCs) is presented for use in 2.4 GHz Wireless Local Area Network (WLAN), applications. The use of liquid crystals to control signals at microwave, mm wave and THz wavelengths has many practical advantages in terms of cost, integration and ease of fabrication. The CP of the patch antennas is assured by corner truncated technique. The improvement of antenna performance as the return losses parameter, the loss tangent and the radiation pattern is ensured by the use of two materials that are liquid crystals and the FR4-epoxy, where a method to increase the peak gain and decrease the return loss of the antenna is proposed. Good agreement is achieved between the simulated and measured results.**

***Keywords*— Liquid crystals, FR4-epoxy, Circular Polarization, Microstrip Antenna, WLAN Applications**

I. Introduction

Wireless communications systems have growth drastically in the last years. For this reason, multifunction antennas have been developed to achieve multiple operations over several wireless services [1]. There is an increase in demand for microstrip antennas with improved performance for wireless communication applications [2] are widely used for this purpose because of their planar structure, low profile, light weight, moderate efficiency and ease of integration with active devices [3][4]. CP patch antenna based on LCs [5][6][7] can easily be integrated in communication systems and fabricated on printed circuit boards e.g. fabricated on laptops for WLAN applications[8][9]. Recent advancement in high speed WLAN and similar applications need the antenna of broad bandwidth, small size, high gain, and enhanced efficiency. The patch antennas used, for example, in portable equipment sometimes need to satisfy severe constraints on physical dimensions, and the need for miniaturization is called for. The basic feeds for the patch [10] are a probe feed using a coaxial transmission line below the ground plane or an edge feed using a coplanar microstrip transmission line connected to an edge of the patch. The edge-fed patch is a very low profile antenna [11] that also can include other components using microwave integrated circuit techniques and the feed network when arrayed. This offers the advantage of low-cost, controlled-dimension construction. The performance of microstrip antennas are sensitive to the dielectric substrate proprieties as thickness, Dielectric constant and loss because it is important to have a material that is manufactured with proper quality control over material uniformity (especially εr), has low loss, and has a selection of thicknesses and sheet sizes. As frequency increases, these are even more important considerations.

In the present work, a low profile feed line patch antenna is proposed with dielectric substrate as FR4 with $\varepsilon r=4.4$ and LCs with $\varepsilon r=2.9$. Firstly, a CP feed line patch antenna, designed for WLAN applications at the resonant frequency is 2.4 GHz, is presented with details of the structure, simulation and measurement results. Secondly, a method to increase the peak gain and decrease the return loss of the antenna is proposed.

II. CONCEPTION AND SIMULATION OF A COMPACT CP FEED LINE PATCH ANTENNA BASED ON LCs

A. *Conception of a CP feed line patch antenna*

The structure of the CP feed line patch antenna based on LCs as shown in Figures 1 and 2. In a first step, the HFSS

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(High frequency structure simulator), designed antenna was simulated to determine the patch size at a 2.4 GHz resonance frequency and a RHCP (Right Hand Circular Polarisation) assured by corner truncated technique. The antenna design is still based on a microstrip feed line, it is composed of a LC material is inserted by capillarity is again 15 mm × 4 mm long and width rectangular LC cavity. A prototype nematic LC structure of high dielectric anisotropy from 2.7 to 2.9 is given by K15 (5CB) of Merck [12]. The dielectric substrate contains a material FR4 with εr=4.4. The two slots in the patch antenna are preferable to reduce the size of the antenna structure and the antenna is excited with a 50 Ω microstrip line.

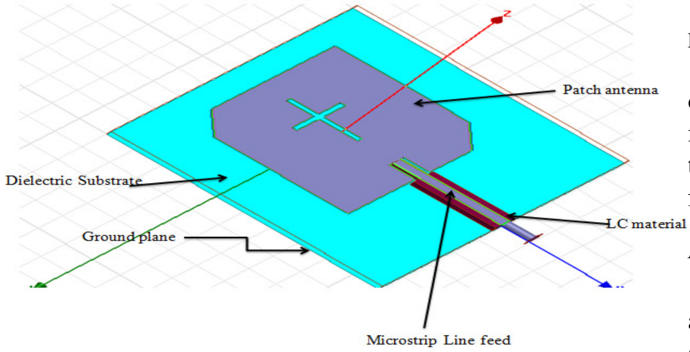

Fig. 1. Structure of the CP feed line patch antenna based on LCs

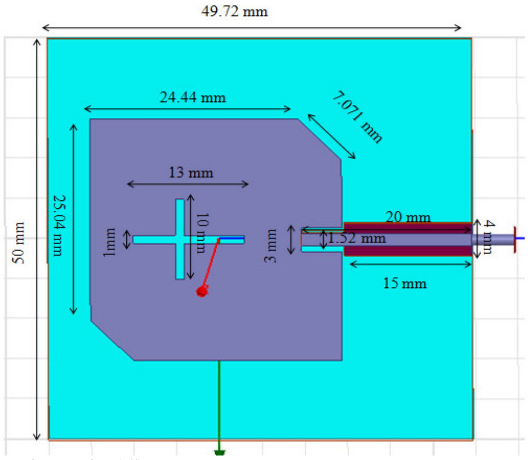

Fig. 2. Size of a CP feed line patch antenna

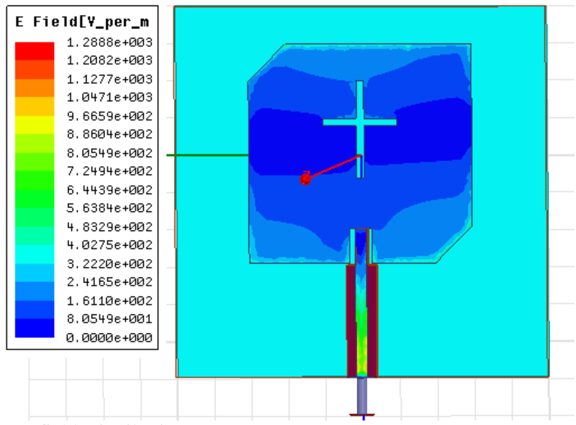

Fig. 3. E-field Distribution

Figure 3 shows a Electric field (E-field) for the TE_{10} mode of the antenna at a center frequency of 2.4 GHz, the relative magnitude of the electric field is proportional to the density of the field lines. The simulations show that the magnitude of E-field is concentrated at the center of the patch antenna.

B. Simulation of a CP feed line patch antenna

The HFSS was used to optimize the dimensions of the antenna to obtain a resonant frequency of 2.4 GHz for WLAN applications. The width of cavity is secured to the LC value and a 4mm were obtained best performance.

Figure 4 shows that the simulated return loss is centred around 2.4 GHz. It can be seen that the return loss achieved -41.27 dB from εr=2.9 and -27.33 dB from εr=2.7. We noticed that the variation between the different permittivity is -13.94 dB (33.77%). The shape and size of the slot, as well as the driving frequency, determine the radiation control of the radiation patterns is required.

Figures 5 depict a VSWR results for two different permitivity. It can be seen that the VSWR equal to 0.74 with εr=2.7 and 0.15 with εr=2.9.

It can be seen from Figure 6 that the return loss simulated achieved -41.27 dB to 2.4 GHz and the measured return loss achieved -16.66 dB to 2.314 GHz. The resonance frequency variation (ΔFr) between simulated and measured is 86 MHz corresponding to a frequency agility of 3.58%. We noticed that the use of the LC decrease the return loss of the antenna of a value of -24.61 dB (59.63%). The bandwidths simulated and measured at -10 dB are, respectively, 64 and 60.6 MHz. This little variation between measurement and simulation data may result from a gap in the precision of the values found for the LC dielectric permittivities.

Figure 7 presents the peak gain of the proposed CP patch antenna. In the 2.4 GHz band, the peak gain is about 4.6 dB with less than. It can fulfill the requirements of indoor wireless applications very well.

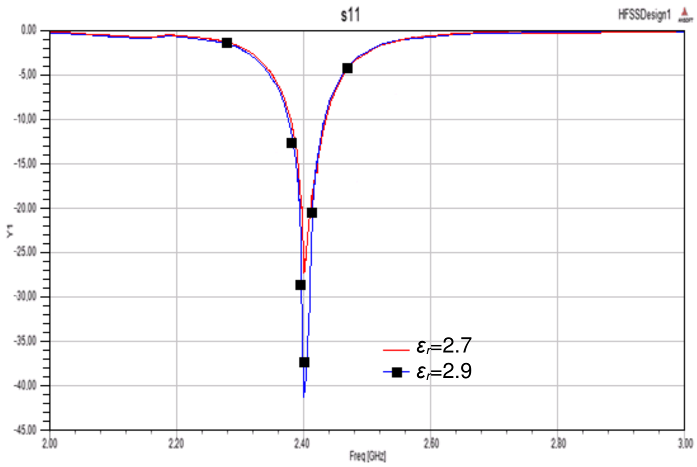

Fig. 4. Simulated return losses for two different permittivities and a width of LC substrate w=4 mm by (HFSS)

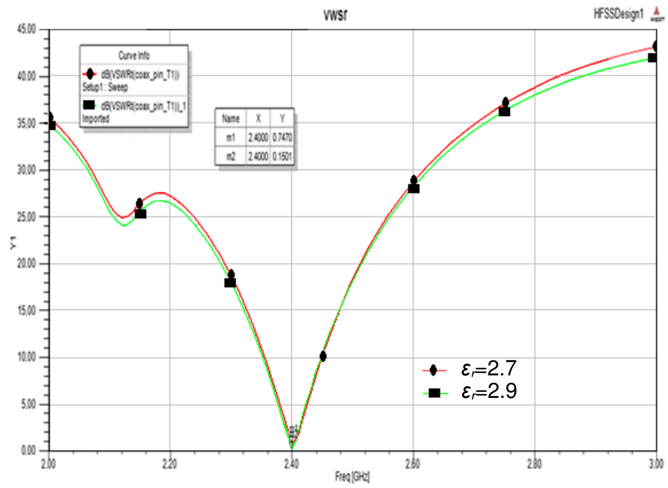

Fig. 5. Simulated VSWR for two different permittivities and a width of LC substrate w=4 mm by (HFSS)

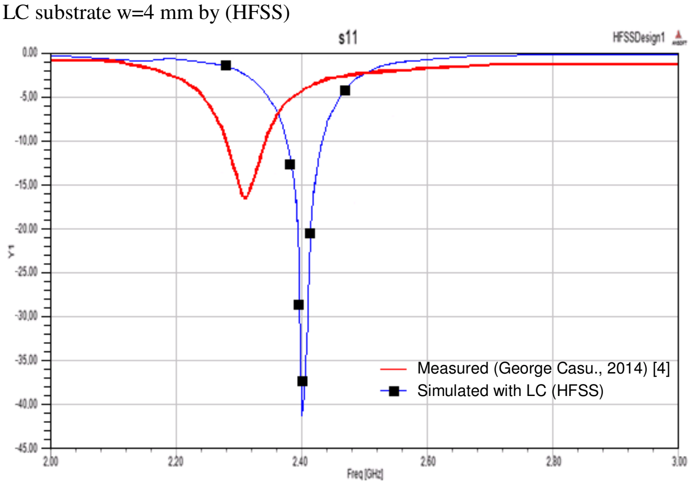

Fig. 6. Simulated and measured return losses

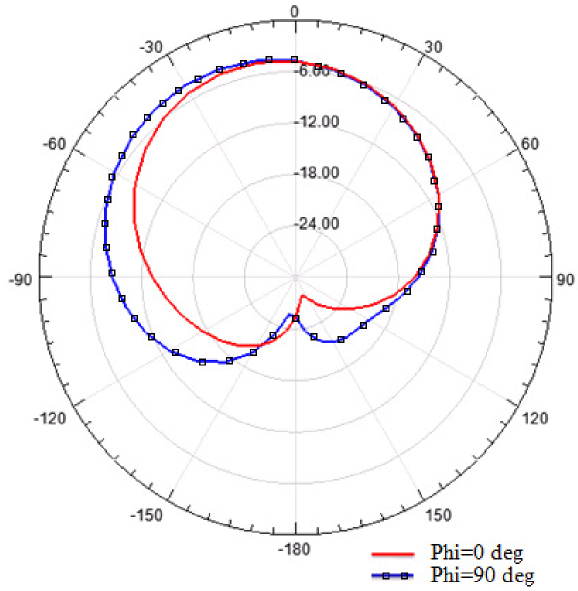

Fig. 7. Simulated Radiation pattern for two different values of Phi

III. Conclusions

Circular polarized feed line patch antenna at 2.4 GHz wireless radio band, it achieves simulated return loss -41.27 dB and the measured return loss achieved -16.66 dB from 2.3 to 2.4 GHz. This material decrease the return loss of the antenna of a value of -24.27 dB (59.63 %).The results of simulated radiation patterns patch antenna have greatly improved about 4.6 dB. The designed antenna is suitable for WLAN application.

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