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Research Article

# Liquid Crystal Bow-Tie Microstrip antenna for Wireless Communication Applications

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***Abstract***

In this paper we presented the design and analysis of Bow-Tie antenna on liquid crystal substrate, which is suitable for the Bluetooth/WLAN-2.4/WiBree/ZigBee applications. The Omni-directional radiation patterns along with moderate gain make the proposed antenna suitable for above mentioned applications. Details of the antenna design and simulated results Return loss, Input impedance, Radiation Patterns, E-Field, H-Field and Current Distributions, VSWR are presented and discussed. The proposed antenna is simulated at 2.4 GHz using Ansoft HFSS-11.

*Keywords:* Bow-tie, Microstrip, LC

## 1. Introduction

In recent years Microstrip antennas have been widely used in both theoretical research and engineering applications due to their light weight and thin profile configurations, low cost of fabrication, reliability, conformal structure and ease of fabrication [1-2]. In this paper bow-tie is designed at 2.4 GHz for wireless LAN applications. The bow-tie patch actually is the combination of imaginary image of two triangular patches which are fabricated on a single substrate [3-4]. Bow-tie antennas are mostly used in the communication scenario over the rectangular patches due to their compact nature [5-6].

Liquid crystal material is used as substrate in this proposed antenna designing. Liquid crystals are anisotropic materials which show both the properties of a crystal and a liquid. The nematic LCs are chosen for this operation because they are having best dielectric properties at microwave and mm-wave frequencies [7]. Liquid Crystals and Liquid crystal polymers are much cheaper than other available
dielectric materials. They are Low cost, low weight materials and they have low dielectric constant (2.9-3.2 for f < 105GHz) and low loss tangent (0.002-0.0045 for f < 105GHz). LCs have a unique property of low moisture absorption (water absorption <0.004%). So in general LC offers an excellent combination of electronic, thermal, mechanical and chemical properties that make it as a promising substrate for electronics packaging [8].

The liquid crystal substrate material is used in the making of this proposed antenna instead of RT-duroid [6]. The Liquid crystal substrate is having the dielectric constant of 2.97 and the loss tangent of 0.003.

## 1. Antenna Design

Figure (1) shows the dimensions of the microstrip bow-tie antenna. ‘a’ is the side length and ‘θ’ is the angle of the equilateral triangle. L1, L2, W1 and W2 are the dimensions of the matching network [8-9].

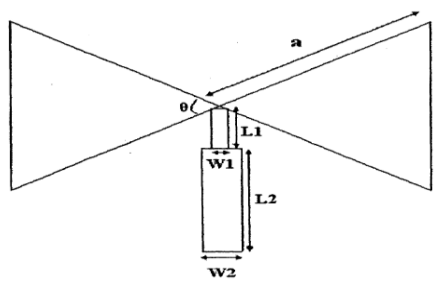


**Fig. 1.** Antenna Schematic

$$f_r = \frac{ck_{mn}}{2\pi\sqrt{\varepsilon_r}} \quad (1)$$

$$f_r = \frac{2c\sqrt{m^2+mn+n^2}}{3\alpha\sqrt{\varepsilon r}} \quad (2)$$

Where:



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$f_r$ : is the resonance frequency

$k_{mn}$ : is the resonating modes

c: is the velocity of light in free space

α: is the side length of the bow-tie strip

When triangular resonator is surrounded by a perfect magnetic wall then this expression will be valid.

Figure (2) shows the HFSS generated bow-tie antenna with the specifications applied to the design. The inner width is 1mm, outer width 18.8mm, arm length 17.1mm, gap port length 1mm, substrate thickness 1.58mm, substrate dimension along x-axis 40mm, substrate dimension along y-axis 60mm. The bows are connected to the microstrip feedline and the ground plane through a stub and mitered transition to match the bow-tie with the 50 Ω feedline.

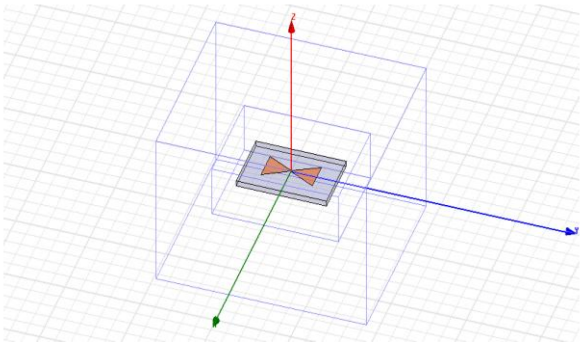


**Fig. 2.** The HFSS generated bow-tie antenna

## 3. Results and Discussion

The return loss and VSWR are computed using Ansoft HFSS and they are shown in figure (3) and figure (4).

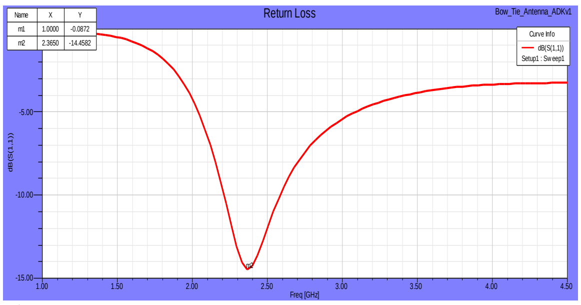



**Fig. 3.** Return Loss

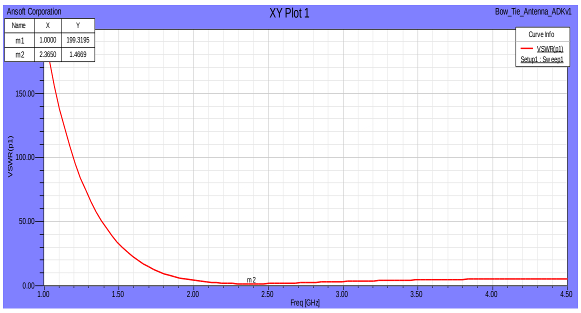



**Fig. 4.** VSWR

The return loss of -14.45 and the VSWR 1.4669 is obtained at 2.4 GHz from the simulated results. The input impedance plot for the proposed antenna is shown in figure (5). The rms of 0.6760 and bandwidth of 1.9192 is obtained from the results. The 3D gain is shown in the figure (6).

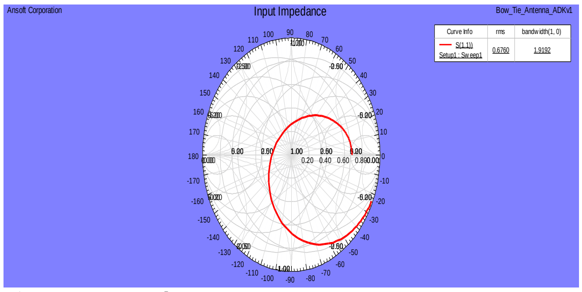



**Fig. 5.** Input impedance

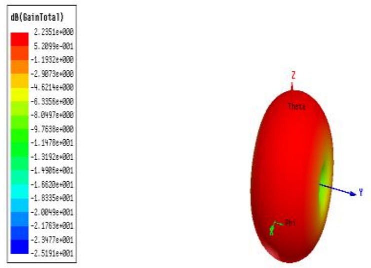
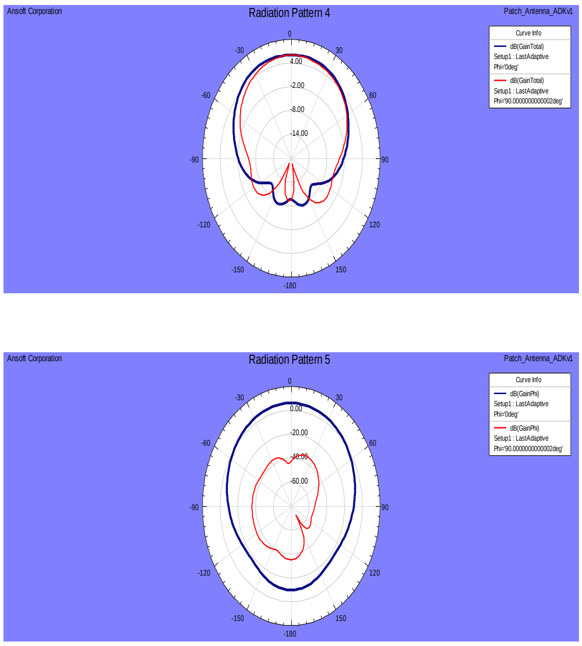



**Fig. 6.** 3D gain

The co-polarized ($E\Phi$) and cross-polarized ($E\theta$) far-field radiation patterns for the proposed antenna is computed at 2.4 GHz. Figure (7) shows the radiation patterns of the bow-tie antennas.



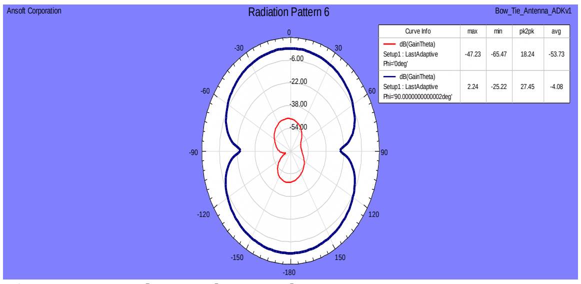



**Fig. 7.** Gain-total, gain phi, gain theta

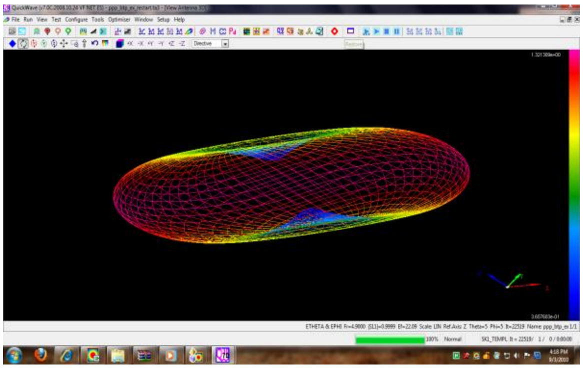


**Fig. 8.** Gain-Theta

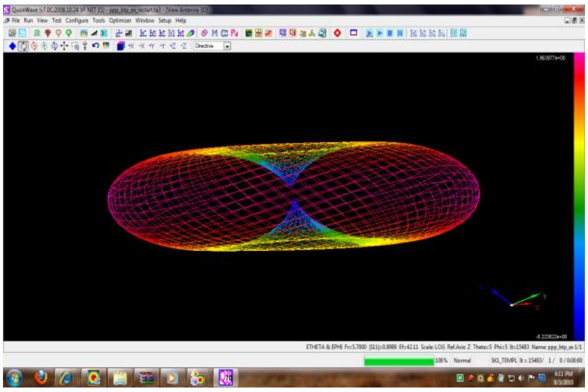


**Fig. 9.** Gain – Phi

The radiation patterns give the good agreement between the simulated and the measured results. 3D radiation pattern results for the proposed antenna using concerto software is given in the figure (8) and figure (9). The antenna parameters are simulated from the HFSS are listed and shown in table (1).

**Table 1.** Antenna Parameters

| Quantity | Value |
|---|---|
| Max U | 0.12471 w/sr |
| Peak directivity | 1.669 |
| Peak gain | 1.6731 |
| Peak realized gain | 1.5672 |
| Radiated power | 0.939 w |
| Accepted power | 0.93675 w |
| Incident power | 1 w |
| Radiation efficiency | 1.0024 |
| Front to back ratio | 1.0308 |

## 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 (10) and (11) clearly shows the microstrip bow-tie antenna E-field and H-field distribution.

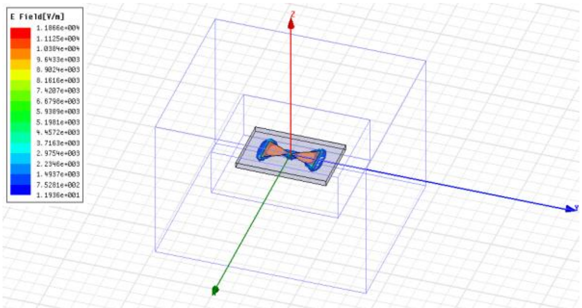



**Fig. 10.** E-Field Distribution

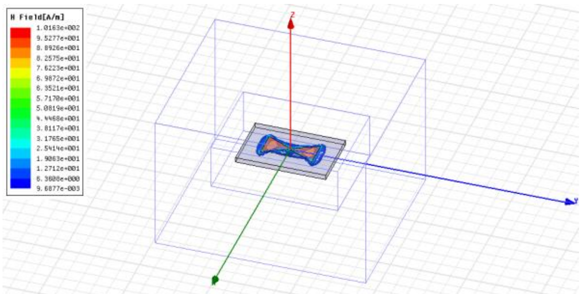



**Fig. 11.** H-Field Distribution

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 (12) indicate the points in the grid where the current distributed is concentrated.

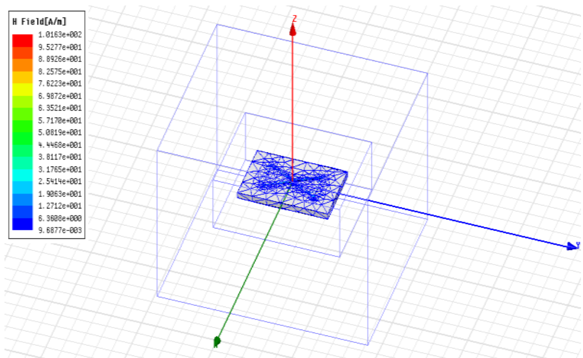



**Fig. 12.** Mesh Generation

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. Conclusions

Experimental implementation of this work involves the LC 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 crystals for the development of low-cost, lightweight antennas on "all-package" solution for future wireless 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.

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