PLANAR INVERTED-F ANTENNA ON LIQUID CRYSTAL POLYMER SUBSTRATE FOR PCS, UMTS, WIBRO APPLICATIONS

B. T. P. Madhav[1], VGKM Pisipati[1], N. V. K Ramesh[2], Habibulla Khan[3] and P. V. Datta Prasad[4]
[1]LCRC-R & D Center, K L University, Guntur, A. P., India
[2]Department of ECM, K L University, Guntur, A. P., India
[3]Department of ECE, K L University, Guntur, A. P., India
[4]Hindu College, Machilipatnam, A. P., India
E-Mail: madhav.mtech@gmail.com

ABSTRACT

In recent years, the demand for compact handheld communication devices has grown significantly. Devices having internal antennas have appeared to fill this need. Antenna size is a major factor that limits device miniaturization. In the past few years, new designs based on the microstrip antennas (MSA) and planar inverted-F antennas have been used for handheld wireless devices because these antennas have low-profile geometry and can be embedded into the devices. This paper presents a planar inverted F antenna on liquid crystal polymer substrate for PCS, UMTS and WIBRO applications. The proposed model is designed and simulated using Ansoft-HFSS. Return loss, input impedance smith chart, 3D-gain; 2D-gain, gain-phi, gain-theta, VSWR, E-field, H-field and Mesh generation are presented from the simulation results.

Keywords: model, planar inverted-F antenna, microstrip antenna, liquid crystal polymer substrate.

INTRODUCTION

Mobile convergence is an emerging trend in the wireless communication industry. Modern multi-standard mobile phones are required to provide a variety of location independent services like voice, data, video, the Internet and multimedia content without compromising on their weight, volume and performance. Therefore, it is important to develop compact internal multiband antennas for these mobile terminals while maintaining good return loss and radiation performance over the desired frequency bands. Because of the compact and low profile nature, planar inverted-F antennas (PIFAs) are promising structures for these applications. Planar inverted-F antennas also exhibit low SAR values and experience less detuning effects in comparison with external or internal printed monopole antennas [1, 2]. Conventional PIFA has limited bandwidth of 4% to 12% for a -10 dB return loss [3].

The PIFA typically consists of a rectangular planar element, ground plane, and short-circuit plate of narrower width than that of the shortened side the planar element. In this paper, we propose a PIFA based multiband internal antenna that can support three frequency bands. The antenna is designed to operate at PCS (Personal Communication Services, 1880 - 1990 MHz), UMTS (Universal Mobile Telecommunications System, 1.9-2.17 GHz), and WiBro (wireless broadband 2300-2390 MHz) frequency bands. Multiple frequency bands have been realized by using slots and quarter-wave length resonating strips. A matching stub and multiple short circuiting strips are utilized for improving impedance matching across the targeted frequency bands.

Liquid crystal polymer (LCP) offers such a unique combination of properties. This material has gained much consideration as a potential high performance microwave substrate and packaging material recently [4, 5]. Its low dielectric constant and low loss tangent [6] in tandem with low water absorption coefficient [7] and low cost make it a first choice material for developing multilayer antennas. Additionally, its CTE can be adjusted through thermal treatments, facilitating integration of integrated circuits in SOP modules. Furthermore, LCP, being a flexible material, leads to convenient deployment of antennas in space. Large sheets of LCP containing antennas can be flexed, rolled up, and easily deployed.

The Ansoft-HFSS antenna design kit generated proposed antenna on liquid crystal polymer substrate is shown in Figure-1.

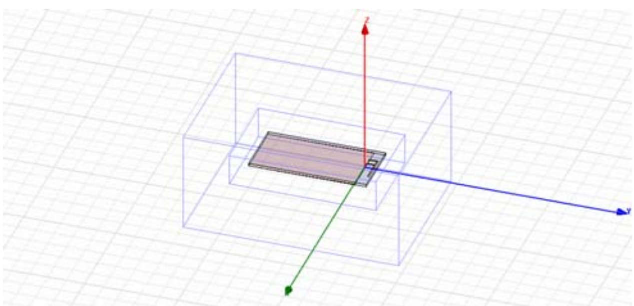

Figure-1. Planar inverted F antenna.

ANTENNA DESIGN

The design variables for this antenna are the height, width, and length of the top plate, the width and the location of the feed wire. A semi rigid coax with a center conductor is used to form the PIFA feed wire. The outer conductor of the coax is soldered to the edge of a small hole drilled in the ground plane at the specified feed point. A liquid crystal substrate with permittivity 2.9 and loss tangent 0.002 is taken and simulated.

The patch dimension along x-axis is 52.7mm and patch dimension along y-axis is 73.2mm. Shorting plate width is 53.5mm, substrate along x-axis and y-axis is 82.3mm. Coaxial feeding is used in this model and feed

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

along y-axis is -21.5mm, coaxial inner radius is 2.1mm and outer radius is 7.3mm.

RESULTS AND DISCUSSIONS

The simulation results are giving good agreement for the applicability of the proposed antenna. The return loss for the proposed antenna is shown in Figure-2. The return loss obtained at three frequencies are -28.12, -24.24, -30 at 1.9, 2.1, 2.3GHz, respectively.

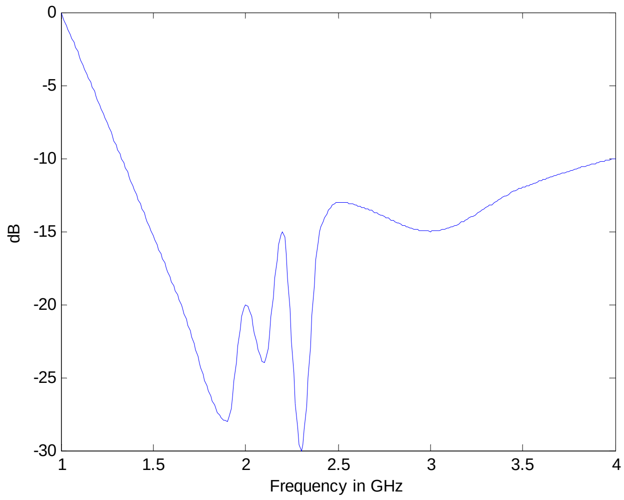

Figure-2. Return loss.

The impedance matching of the PIFA is obtained by positioning of the single feed and the shorting pin within the shaped slot, and by optimizing the space between feed and shorting pins. The Figure-3 shows the input impedance smith chart. The rms and bandwidth obtained from the chart is 0.794 and 1.74, respectively.

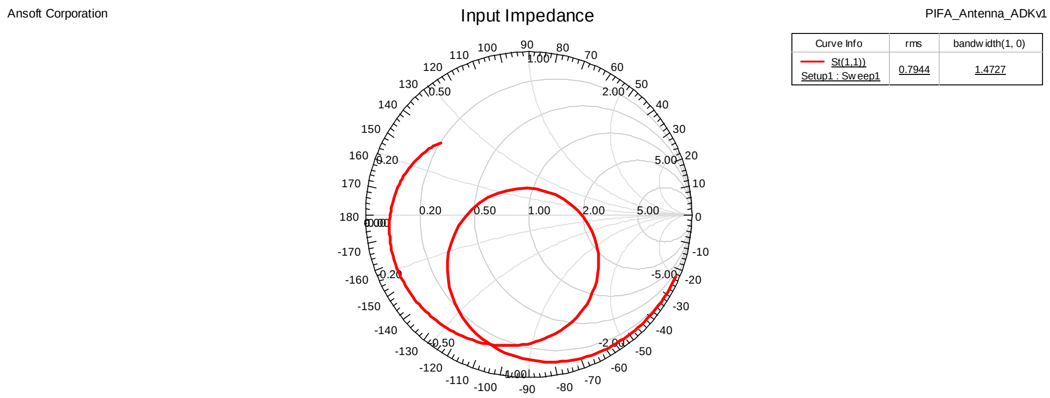

Figure-3. Input impedance smith chart.

Figure-4. 3D-gain total.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

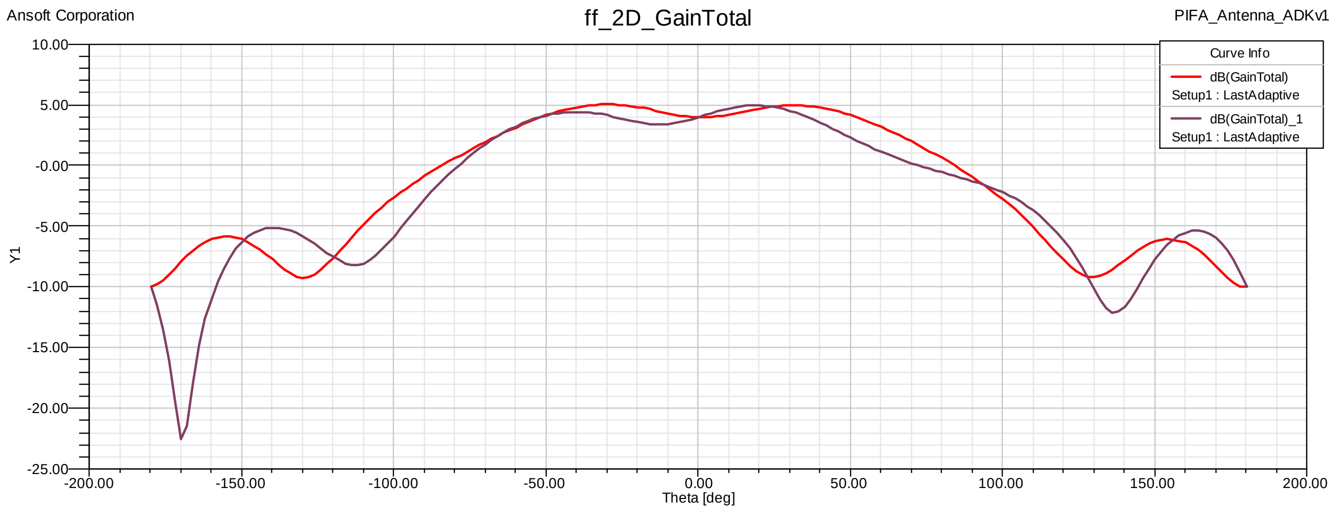

Figure-4. 2D-gain total.

The radiation pattern of the PIFA is the relative distribution of radiated power as a function of direction in space. In the usual case the radiation pattern is determined in the far-field region and is represented as a function of directional coordinates. Radiation properties include power flux density, field strength, phase, and polarization.

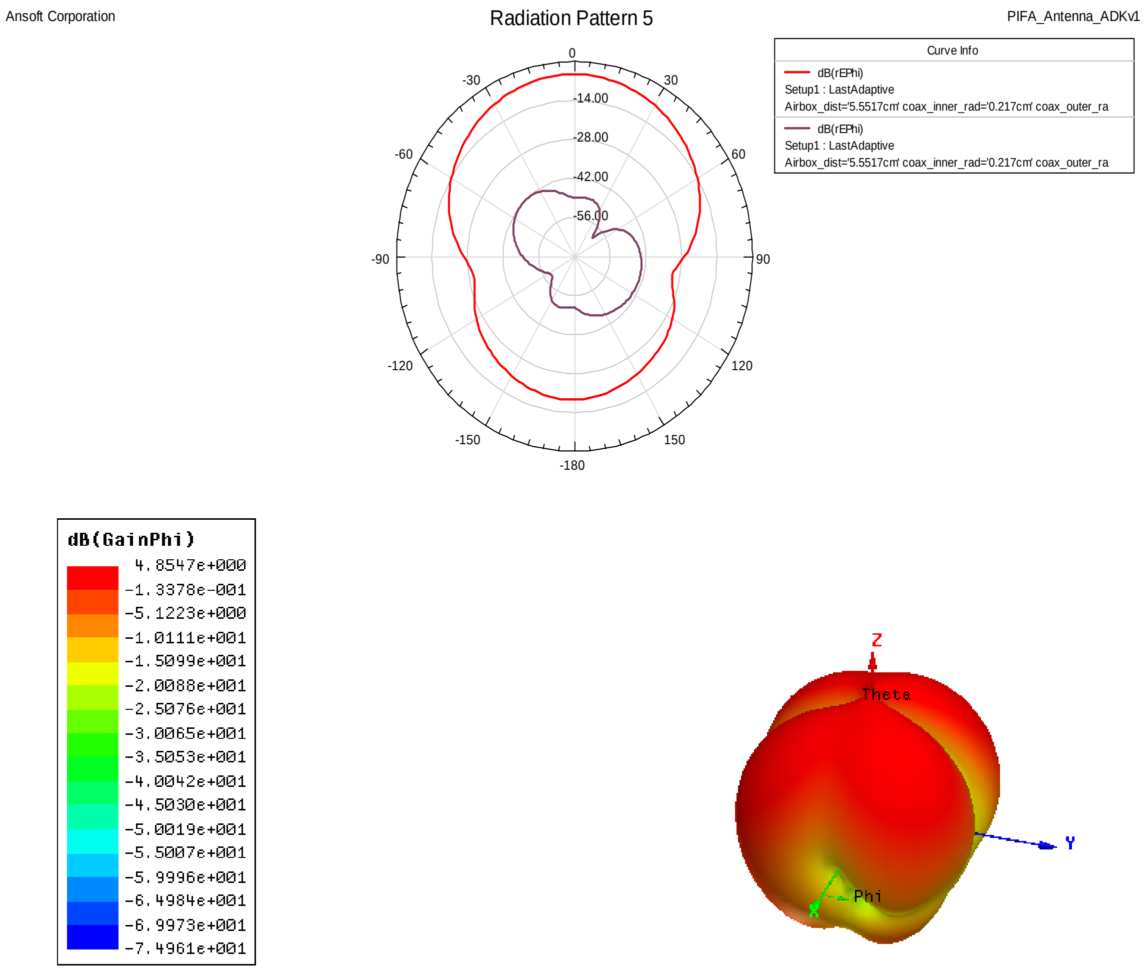

Figure-5. Gain phi at '0'deg and '90'deg.

The co-polarization and cross polarization curves in polar and 3D patterns shown in Figures 5 and 6 represents the gain-phi and gain-theta at '0'deg and '90' deg.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

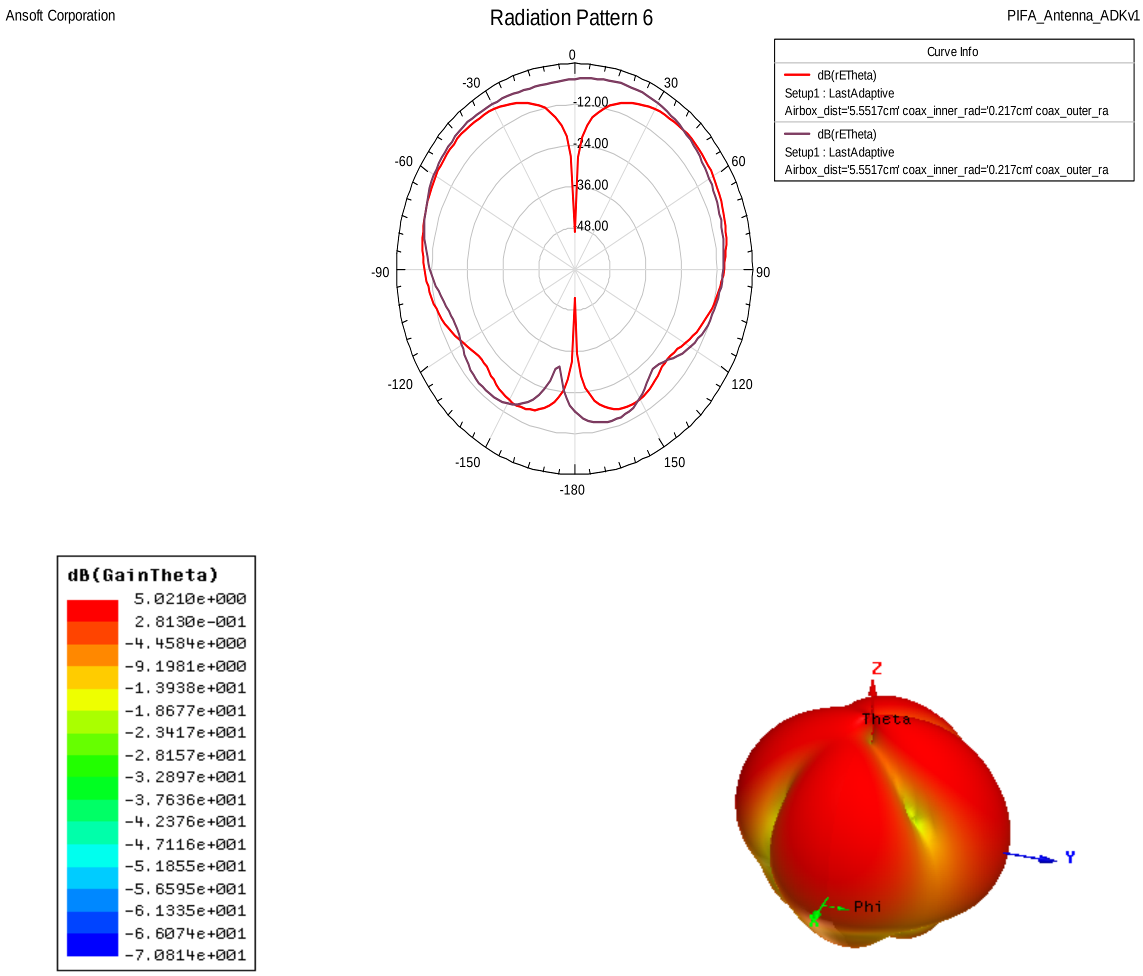

Figure-6. Gain theta at '0'deg and '90'deg.

Figure-7 shows the VSWR curve for the proposed PIFA. The VSWR obtained at the desired frequency is < 2 and it is 1.387.

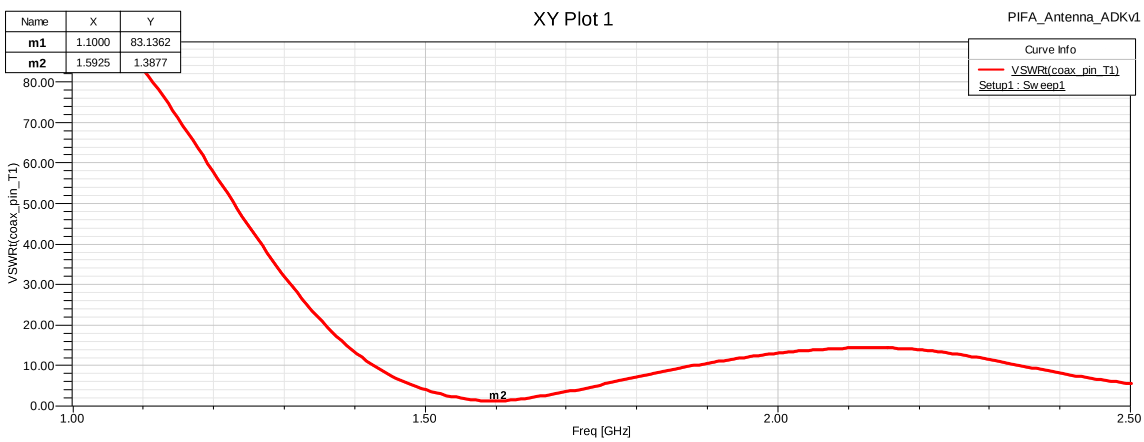

Figure-7. Frequency vs. VSWR.

The dominant component of the electric field Ez is equal to zero at the short-circuit plate while the intensity of this field at the opposite edge of the planar element is significantly large. For fields Ex and Ey there is pointy part, which corresponds to the feed source. Means that the electric line of force is directed from feed source to the ground plane. Then, when the width of the short-circuit plate is narrower than the planar element, the electric field

VOL. 6, NO. 4, APRIL 2011 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Ex and Ey start generating at all open-circuit edges of the planar element. These fringing fields are the radiating sources in PIFA.

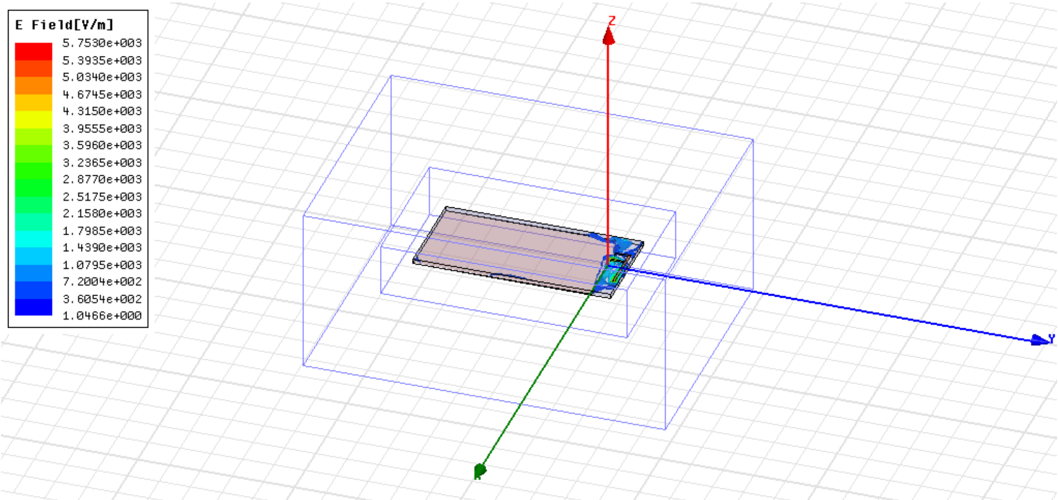

Figure-8. E-field distribution.

The Figures 8 and 9 show the electric and magnetic field distributions of the proposed PIFA.

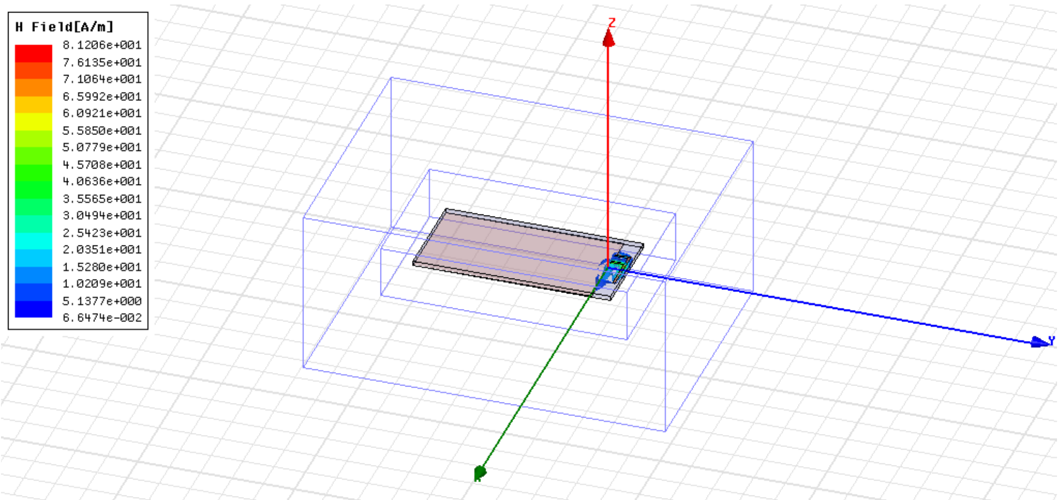

Figure-9. H-field Distribution.

PIFA has very large current flows on the undersurface of the planar element and the ground plane compared to the field on the upper surface of the element. Due to this behavior PIFA is of the best candidate when is talking about the influence of the external objects that affect the antenna characteristics. Figure-10 shows the current distribution on the planar inverted F antenna.

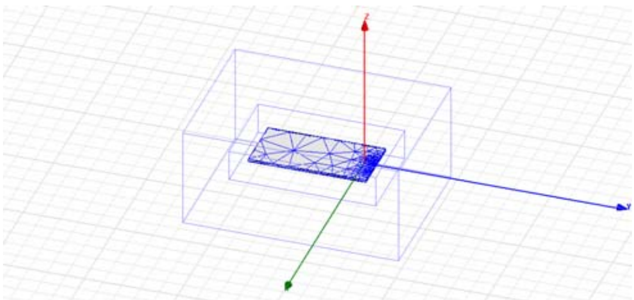

Figure-10. Mesh generation.

ARPN Journal of Engineering and Applied Sciences

CONCLUSIONS

The experimental investigations showing good results for the applicability of this proposed liquid crystal antenna at microwave frequencies. The results are in very good agreement with the industry and standard published antenna-requirements with respect to ease of fabrication, compactness and volume miniaturization compared to other antennas so far designed for similar applications. The results shown here demonstrate the applicability of Liquid crystals for the development of low-cost, lightweight antennas on an "all-package" solution for future communication systems.

ACKNOWLEDGEMENTS

The authors B.T.P. Madhav, Prof. VGKM Pisipati expresses their thanks to the management of K L University and Department of Electronics and Communication Engineering for their support. Further, VGKM Pisipati acknowledges the financial support of Department of Science and Technology through the grant No.SR/S2/CMP- 0071/2008.

REFERENCES

[1] David M. Pozar. 2004. Microwave and RF design of wireless systems. John Wiley and sons. 3rd Edition.

[2] K. H. Chan, K. M. Chow, L. C. Fung and S. W. Leong. 2005. SAR of internal antenna in mobile phone applications. Microwave and Optical Tech. Letters. 4: 286-290.

[3] M. Jayewardene, P. McEvoy, J. C. Vardaxoglou, O. A. Saraereh. 2006. Quad-band handset antenna for GSM900/ DCS1800/ PCS1900/UMTS bands. Proceedings IEEE IWAT.

[4] H. Park, K. Chung and Jaehoon Choi. 2006. Design of Planar Inverted-F Antenna with Very Wide Impedance Bandwidth. IEEE Microw. and Wireless Comp., Lett. 16(3).

[5] Dalia M. Nashat, *et al*. 2005. Single feed compact quad-band PIFA antenna for wireless communication applications. IEEE Trans. on AP. 53(8): 2631-2635.

[6] Marta M-V., *et al*. 2006. Integrated planar multiband Antennas for Personal Communication Handsets. IEEE Transactions on Antennas and Propagation. 54(2).

[7] D. C. Thompson, O. Tantot, H. Jallageas, G. E. Ponchak, M. M. Tentzeris and J. Papapolymerou. 2004. Characterization of liquid crystal polymer (LCP) material and transmission lines on LCP substrates from 30-110 GHz. IEEE Trans. Microwave Theory Tech. 52(4): 1343-1352.

[8] M. M. Tentzeris, J. Laskar, J. Papapolymerou, S. Pinel, V. Palazzari, R. Li, G. DeJean, N. Papageorgiou, D. Thompson, R. Bairavasubramanian, S. Sarkar and J.-H. Lee. 2004. 3D Integrated RF and millimeter-wave functions and modules using liquid crystal polymer (LCP) system-on-package technology. IEEE Trans. Adv. Packag. 27(2): 332-340.