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Optimizing Dual-Band Pan Slot Antenna Performance with Liquid Crystal Polymer

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Abstract

Harnessing the exceptional properties of Liquid Crystal Polymer (LCP), we introduce a groundbreaking dual-band pan slot antenna design that achieves remarkable high gain and superior radiation characteristics. By leveraging LCP's key attributes, including its vertical integration capability, near-hermetic nature, and robust electrical and mechanical properties, we have ingeniously utilized this substrate material to create cost-effective and highly flexible smart antennas. Notably, our antenna boasts a compact footprint, measuring just 39.7mm x 32.5mm x 4mm. Through extensive simulations, our design has consistently demonstrated an impressive gain of 8.13 dB. This antenna resonates at two distinct frequencies, precisely at 3.8 GHz and 5.2 GHz, making it exceptionally well-suited for deployment in WLAN (Wireless Local Area Network) applications.

Introduction

Modern microwave mobile communication systems are increasingly seeking antennas with standard attributes: low profile, broad bandwidth, multi-band operation, and high gain. Microstrip antennas have emerged as a versatile solution, particularly for microwave mobile devices that require dual and multi-band capabilities. The unique features of microstrip patch antennas have captured significant attention in applications such as wireless communication handset terminals and mobile vehicular terminals [1] In the pursuit of designing dual-frequency, dual-polarized microstrip antennas, a multitude of parameters come into play, introducing complexity in both design and fabrication. Addressing this complexity, intricate feeding structures are employed to minimize feed-line radiation and interconnect loss. Moreover, the thickness of the substrate can impact the antenna's bandwidth and efficiency [2]. Our current work has been meticulously executed to mitigate losses and ensure optimal design outcomes. Achieving impeccable impedance matching necessitates a careful approach during the connection of the coaxial feed-line with a characteristic impedance of 50 Ω [3]. Leveraging the attributes of liquid crystal polymer (LCP) as our substrate material, we unlock its potential for high performance at microwave frequencies. With its low dielectric constant, minimal loss tangent, and low water absorption coefficient, LCP emerges as an excellent substrate choice for compact antenna design

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[4]. Notably, its coefficient of thermal expansion can be tailored through thermal treatments, allowing seamless integration of integrated circuits into system-on-package modules. The flexible nature of LCP permits folding, rolling, and shaping, making it suitable for conformal antenna applications. This holistic approach underscores the importance of innovative materials and designs in advancing microwave communication systems for an evolving mobile landscape.

Antenna geometry

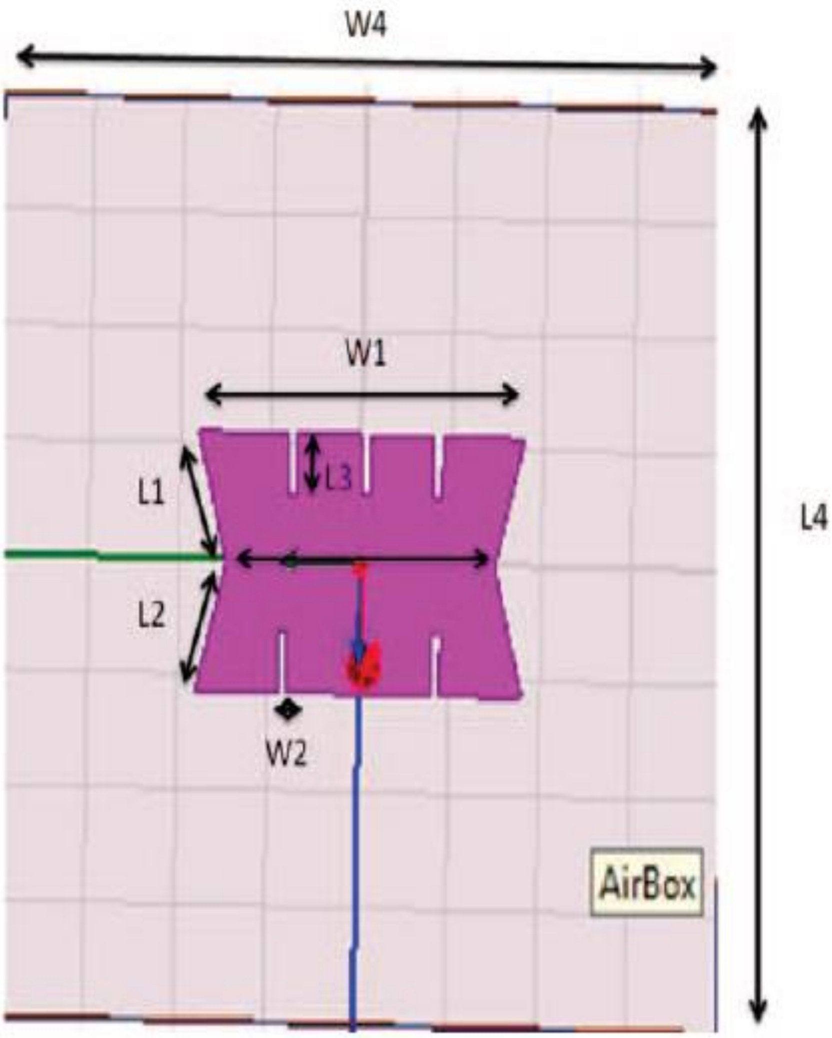

Fig. 1. Pan Slot Antenna

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Results

	Dimension (mm)
W1	12
W2	0.5
L1	5
L2	5
L3	2.5
W4	32.5
L4	39.7

Table 1. Antenna Dimensions

Fig.2. Prototype of Pan Slot Antenna

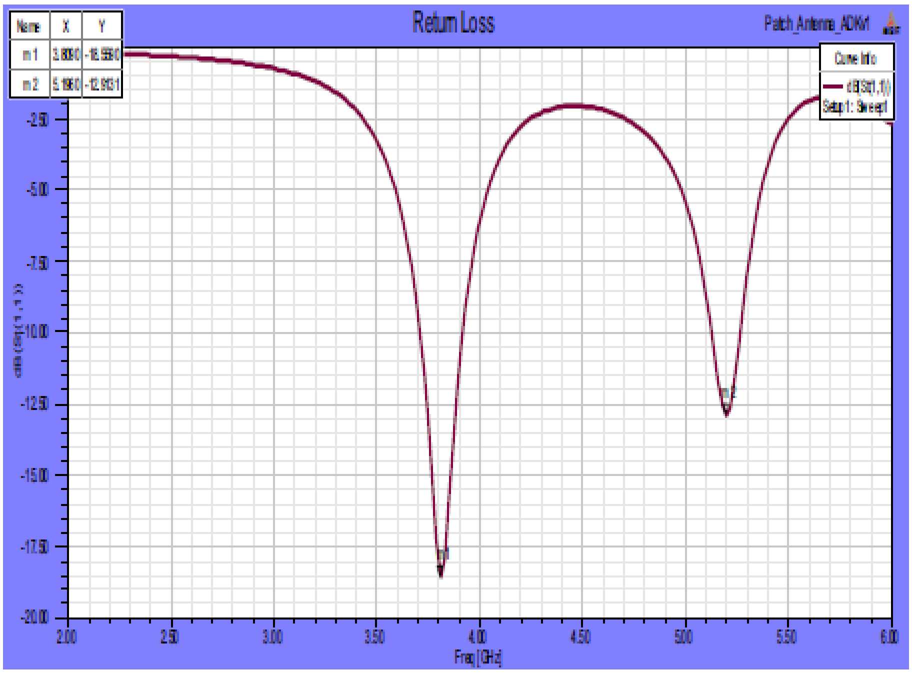

Fig. 3. Return loss vs. Frequency

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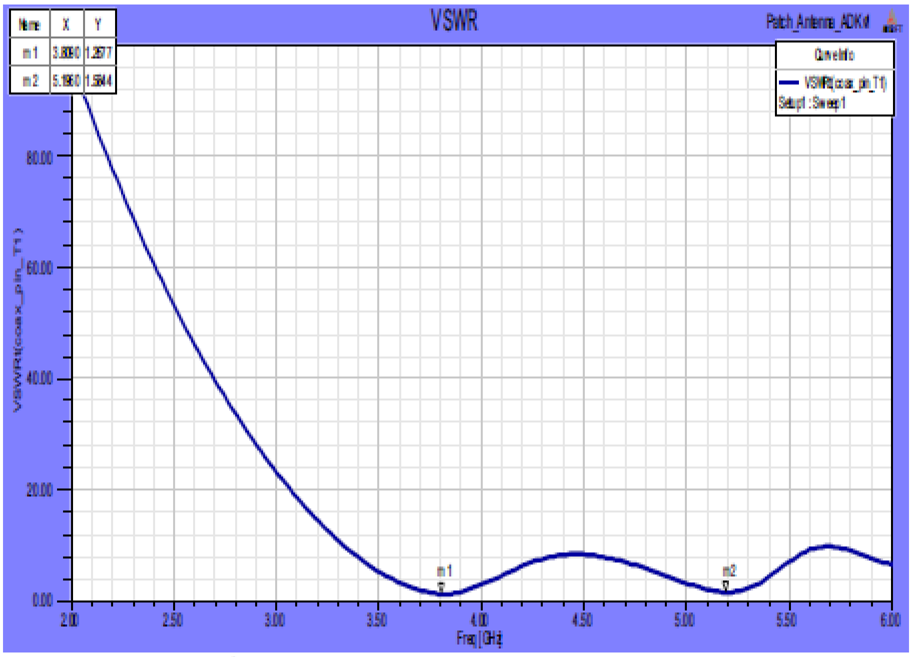

Fig. 4. VSWR vs. Frequency

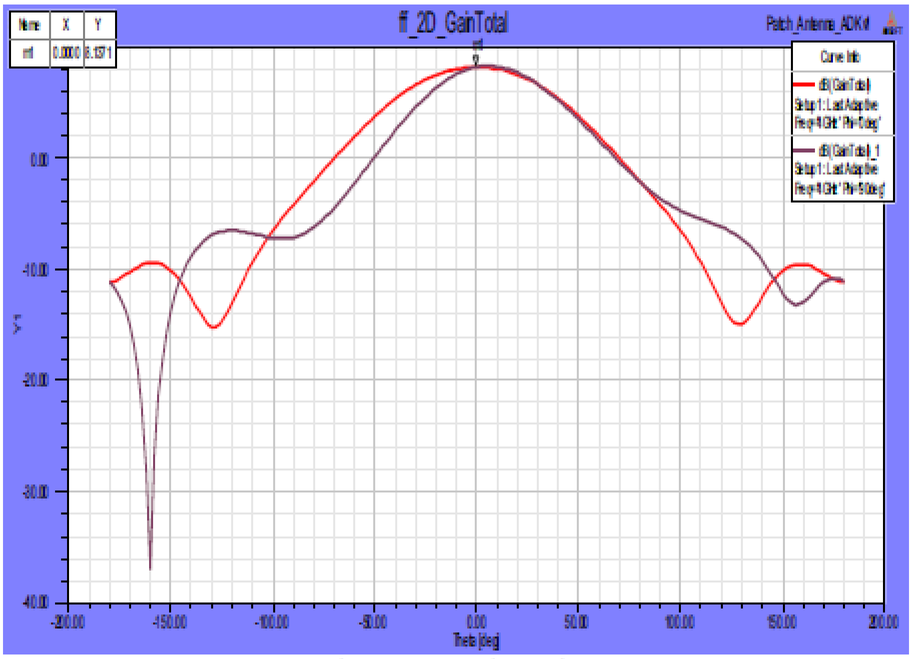

Fig. 5. Gain Plot

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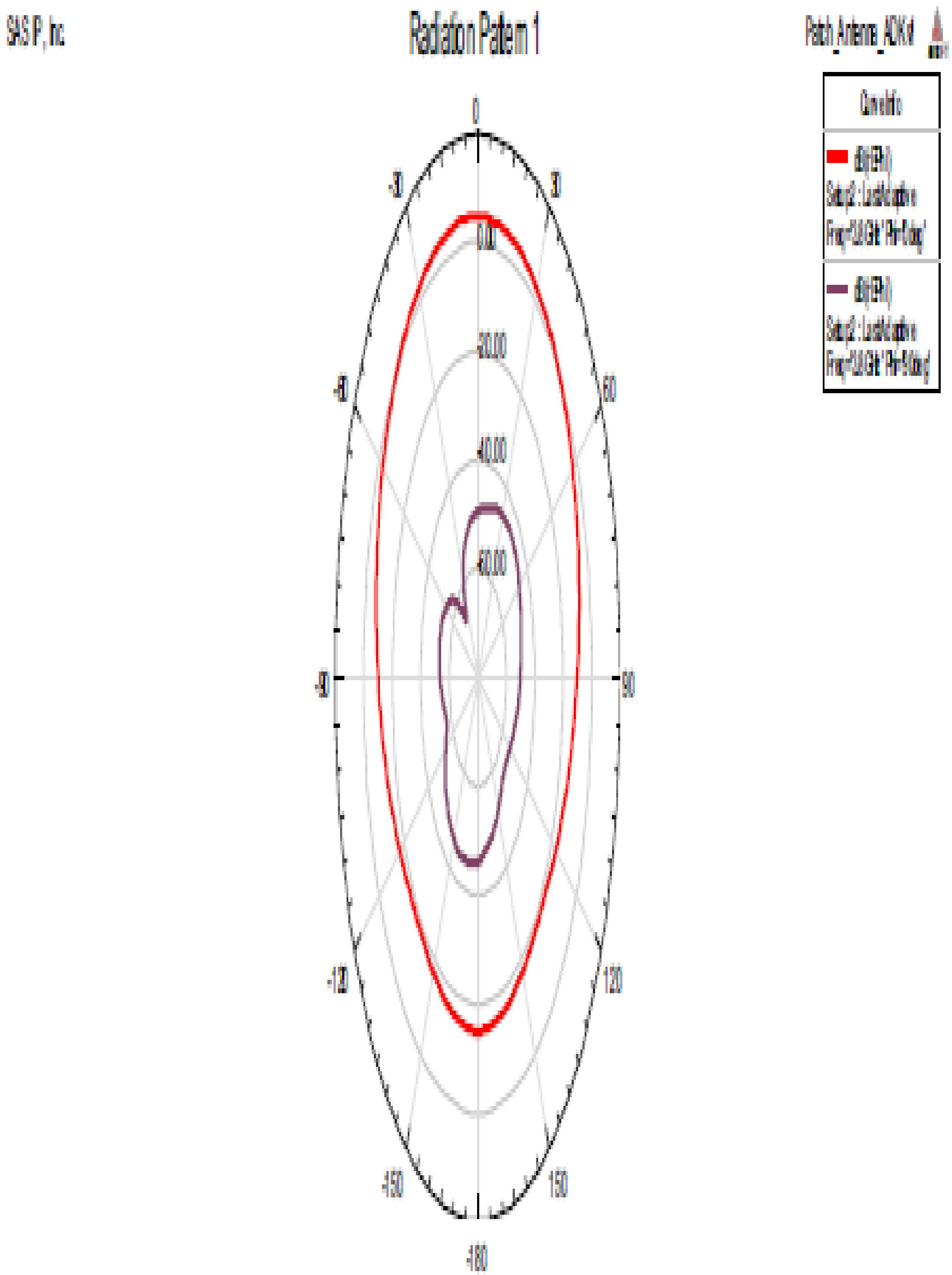

Fig. 6a. E-Plane Radiation pattern at 3.8 GHz

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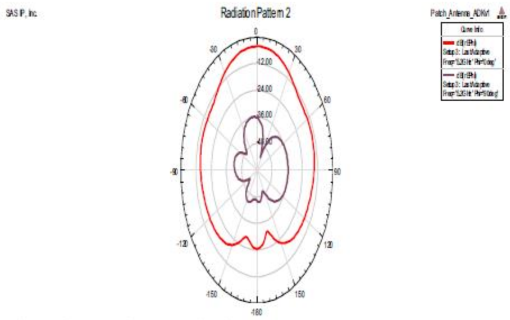


Fig. 6b. E-Plane radiation Pattern at 5.2 GHz

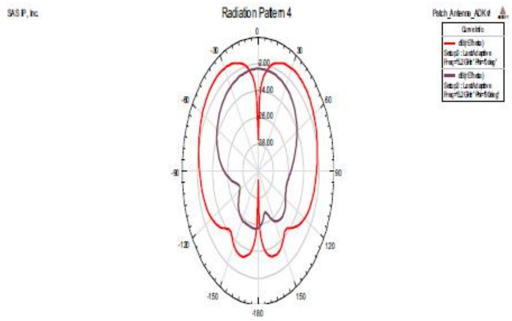


Fig. 7b. H-plane Radiation Pattern at 5.2 GHz

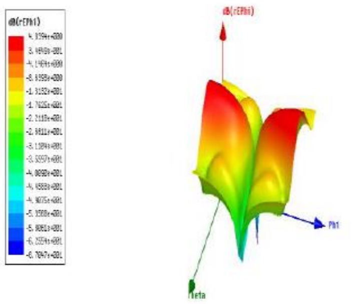


Fig. 6c. E-Plane Radiation Pattern in 3D at 3.8 GHz

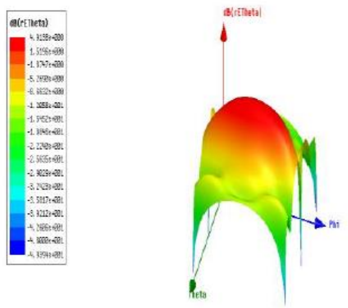


Fig. 7c. H-plane Radiation Pattern in 3D at 3.8 GHz

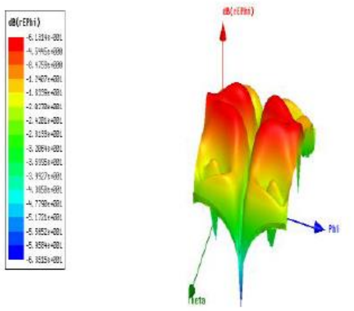


Fig. 6d. E-Plane Radiation Pattern in 3D at 5.2 GHz

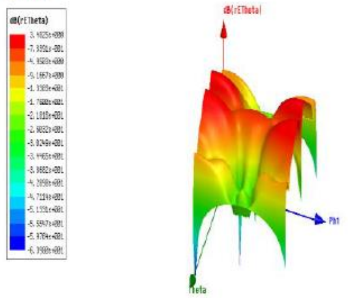


Fig. 7d. H-Plane Radiation Pattern in 3D at 5.2 GHz

It is noted that the cross polarization in both the planes are quite high and is largely due to the strong horizontal components of the surface current which can lead to increased cross polarization levels.

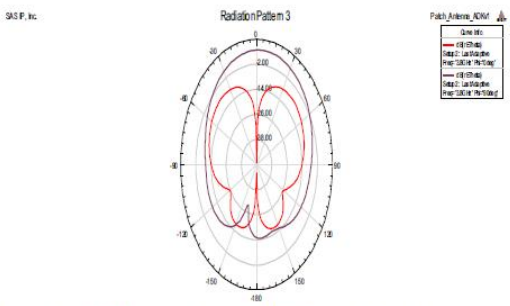
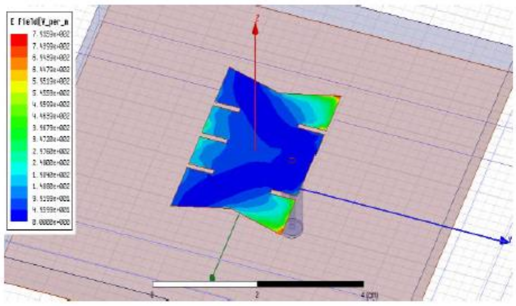


Fig. 7a. H-plane radiation Pattern at 3.8 GHz

The E – field, H – field and surface current distributions are shown in figure (8), figure (9) and figure (10) respectively. The antenna additional parameters are given in table (2) and maximum field data is given in table (3).



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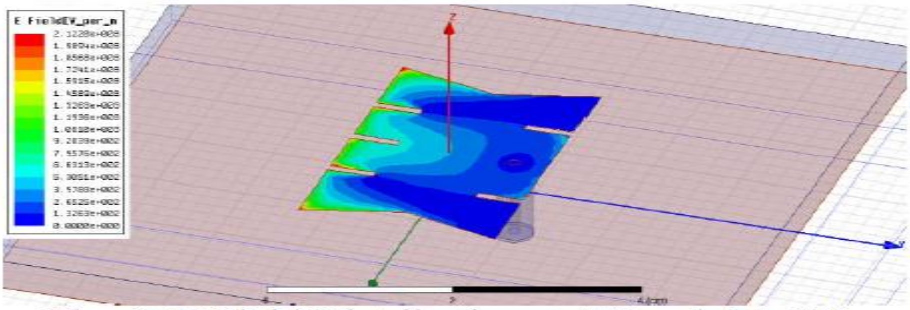

Fig. 8. E-Field Distribution at 3.8 and 5.2 GHz

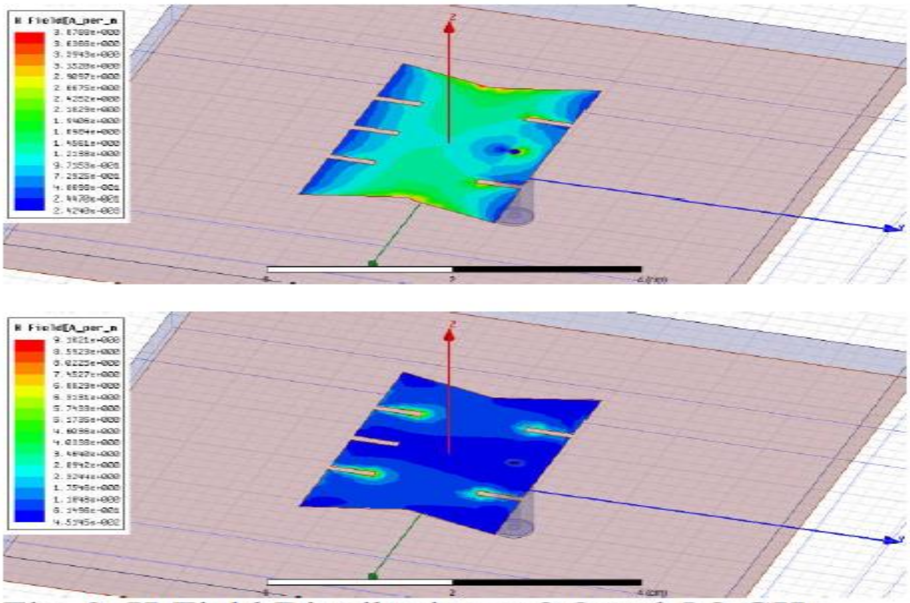

Fig. 9. H-Field Distribution at 3.8 and 5.2 GHz

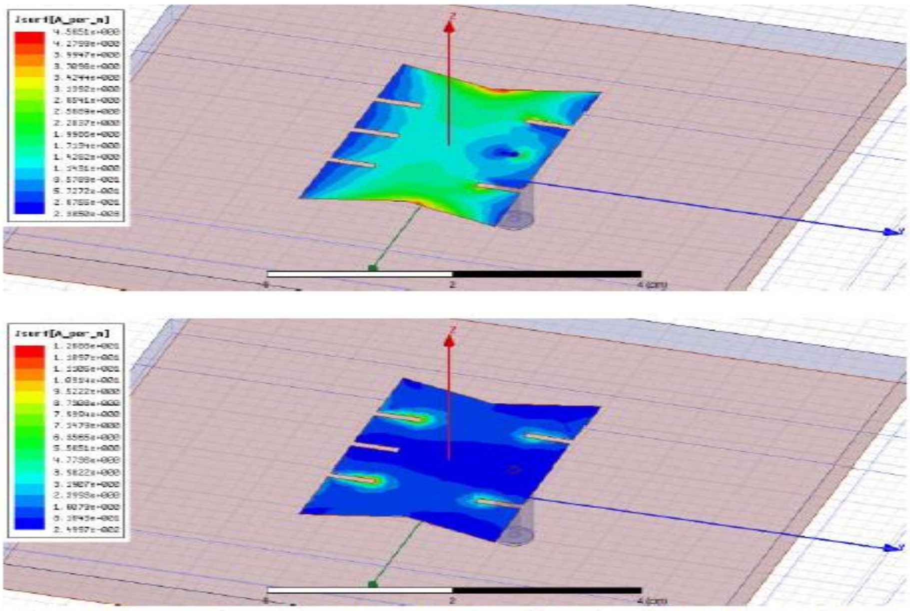

Fig. 10. Surface Current Distribution at 3.8 and 5.2 GHz

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Quantity	Value
Max U	0.0017786
Peak Directivity	6.6863
Peak Gain	6.6532
Peak realized Gain	5.0178
Radiated Power	0.0033428
Accepted Power	0.0033595
Incident Power	0.0044544
Radiation Efficiency	0.99504
Front to Back ratio	126.45

Table 2. Antenna Additional parameters

rE-Field	Value	At φ	At θ
Total	1.159 V	90°	6°
X	0.33995 V	5°	32°
Y	1.1543 V	90°	4°
Z	0.52233 V	90°	42°
At Phi	1.1457V	180°	0°
At Theta	1.158 V	90°	6°
LHCP	0.90468 V	165°	16°
RHCP	0.90595 V	15°	18°

Table. 3. Maximum Field data

Conclusion

We have introduced an innovative dual-band pan slot antenna, which has been successfully designed and implemented. The simplicity of the antenna's design and fabrication is a notable feature, with the use of the flexible LCP substrate material. The antenna's dimensions are compact, measuring 39.7mm x 32.5mm x 4mm, while demonstrating excellent radiation characteristics at both operating frequencies. Our design has achieved an impressive gain exceeding 8dB, coupled with a substantial 2% bandwidth enhancement. These performance metrics position the antenna as a valuable candidate for various applications, particularly in WLAN (Wireless Local Area Network) systems.

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