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Design of a Multiband Patch Antenna Using Split Ring Resonator for LTE, Wi-Fi and WLAN Applications

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Abstract: *This paper presents the design and analysis of a compact multiband patch antenna integrated with Split Ring Resonator (SRR) technology for wireless communication systems, including LTE, Wi-Fi, and WLAN. The antenna is simulated using CADFEKO and exhibits multiple resonances at 2.46 GHz, 3.81 GHz, and 5.10 GHz, making it suitable for commonly used wireless frequency bands. The proposed antenna achieves a return loss better than –30 dB at 2.46 GHz and a VSWR of approximately 1.02, indicating excellent impedance matching. Surface current distribution and realized gain patterns are analyzed to evaluate the radiation characteristics. The design shows promising performance for compact and efficient multiband wireless systems*

Keywords: Multiband antenna, SRR, patch antenna, CADFEKO, Wi-Fi, LTE, WLAN, Metamaterials

I. INTRODUCTION

In recent years, multiband antennas have become increasingly essential for integrating multiple wireless standards into a single device. Conventional patch antennas often fail to meet multiband requirements without compromising size or efficiency. Metamaterial-based structures such as Split Ring Resonators (SRRs) offer an effective solution by introducing resonant characteristics that enable compact, high-performance multiband designs. This paper proposes an SRR-loaded patch antenna targeting LTE, Wi-Fi, and WLAN bands using simulation in CADFEKO.

II. ANTENNA DESIGN

The proposed multiband antenna consists of a rectangular micro strip patch with integrated Split Ring Resonator (SRR) structures to support multiple frequency bands. The design is optimized to resonate near 2.46 GHz, 3.81 GHz, and 5.10 GHz, which align with LTE, Wi-Fi, and WLAN applications.

Section	Parameter	Description / Value
2.1 Substrate Specification	Material	FR4
	Dielectric constant (ε_r)	4.4
	Loss tangent (tan δ)	0.02
	Thickness (h)	1.6 mm
2.2 Patch Design	Design Model	Transmission line model to support TM_{10} mode at 2.46 GHz
	Resonant Frequency Formula	$f_r = \frac{c}{2L\sqrt{\varepsilon_{\text{eff}}}}$
	Patch Width (W)	~38 mm
	Patch Length (L)	~29 mm

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Section	Parameter	Description / Value
	Feed Position	Offset by 6 mm from center along X-axis
2.3 Split Ring Resonator (SRR) Structure	Outer ring size	12 mm × 12 mm (square)
	Ring width	1 mm
	Gap between rings	1 mm
	Ring slit (gap in rings)	0.5 mm
	Number of rings	2 (concentric)
	Placement	Central region of the patch with maximum current density for maximum magnetic coupling
	Purpose	Create additional resonant modes, enabling multiband operation without increasing antenna size

Simulation Setup
The antenna is designed and simulated in CADFEKO:
- Software: CADFEKO
- Feed mechanism: Coaxial probe feed
- Excitation: VoltageSource1
- Frequency sweep: 2.0 GHz to 6.0 GHz
- Boundary: Radiation boundary with open space configuration

Figures:

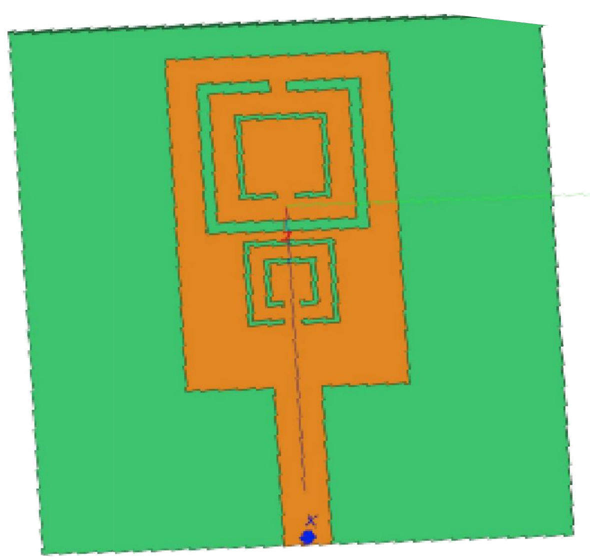

Fig. A. 3D model view of the antenna structure

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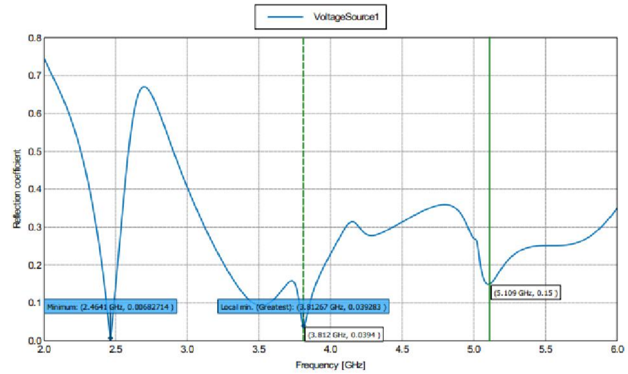

Fig. B. Reflection coefficient (S11) plot

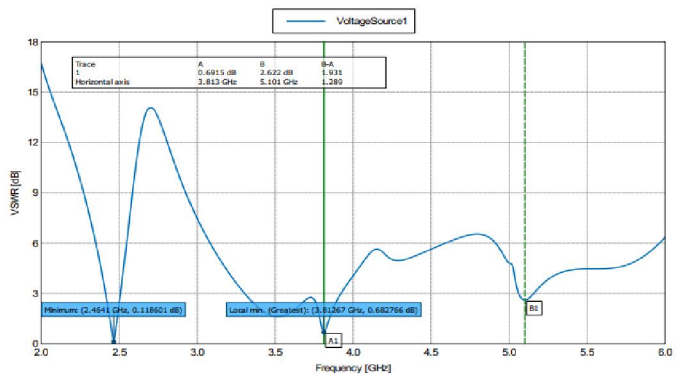

Fig. C. VSWR vs frequency

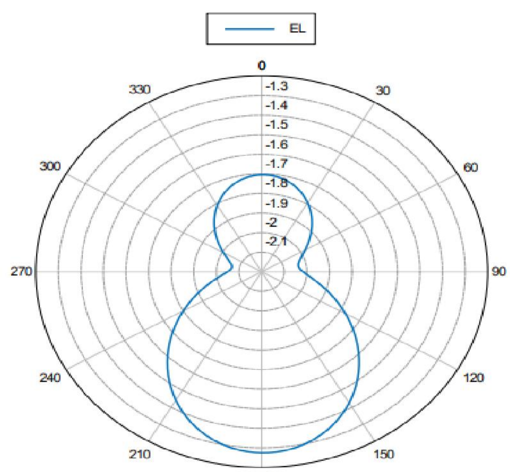

Fig. D. Realized gain pattern at 2.5 GHz

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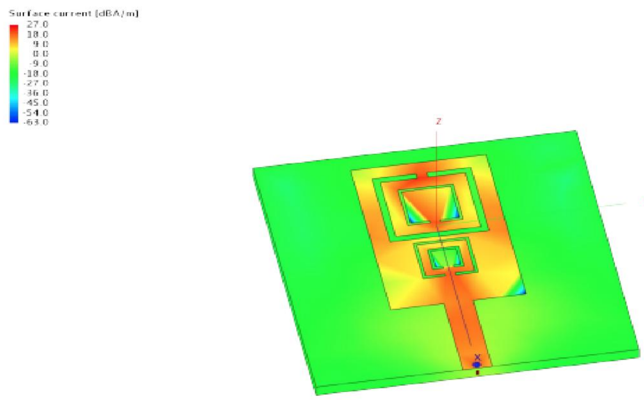

Fig. E. Surface current distribution

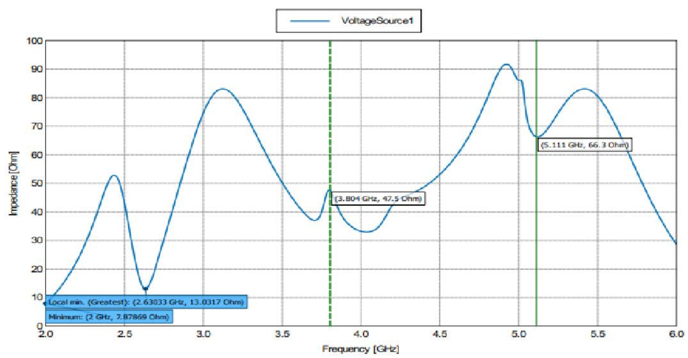

Fig. F. Impedance vs frequency plot

III. RESULTS AND DISCUSSION

The simulated return loss (S11) plot shows resonances at 2.464 GHz (–43 dB), 3.812 GHz (–17.8 dB), and 5.109 GHz (–16.5 dB), confirming multiband behavior. The VSWR values at these frequencies are 1.02, 1.36, and 1.75 respectively, all below the acceptable limit of 2, which indicates good impedance matching. The realized gain pattern at 2.5 GHz is approximately –1.5 to –1.8 dBi, which is suitable for short-range wireless communication. The impedance analysis shows values near 50 ohms at resonant frequencies, further supporting efficient power transfer. The surface current distribution confirms strong resonance around the SRRs, highlighting their effective contribution to multiband performance. This design demonstrates that SRRs can successfully induce multiple resonant paths within a compact structure.

IV. CONCLUSION

A compact multiband SRR-loaded patch antenna has been successfully simulated to operate at LTE, Wi-Fi, and WLAN bands. The results show good return loss, VSWR, and impedance matching at target frequencies. This design is a suitable candidate for integration into portable wireless communication systems.

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