Circular Slot Printed Microstrip Notch Band UWB Antenna for Wireless Communication Applications

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Abstract: A compact ultrawideband (UWB) microstrip antenna with integrated band-notch functionality is proposed in this work. The antenna comprises a circular radiating patch with a concentric slot to enhance impedance matching and extend operational bandwidth from 3.1–10.6 GHz, defined by 10 dB return loss. A sharp notched band in the X-band (7.3–8.1 GHz) is achieved by embedding a split ring resonator (SRR) on the radiating patch, effectively suppressing resonant surface currents and minimizing interference. Furthermore, a partial ground plane integrated with a defected ground structure (DGS) is employed to improve impedance bandwidth and return loss. The antenna is fabricated on an FR4 substrate (εr = 4.4, tanδ = 0.02) with compact dimensions of 20 × 20 mm². Simulated results confirm S11 < –10 dB across the UWB band, excluding the notched frequency, with a notch depth exceeding –5 dB. The radiation pattern remains quasi-omnidirectional with stable gain outside the notched region. The proposed antenna ensures efficient spectral utilization, reduced mutual interference, and is well-suited for UWB applications such as ground-penetrating radar (GPR), body area networks (BANs), and vehicular radar. The design methodology also offers potential for future tunable notch-band antennas using active switching elements.
Keywords: Band-notch, UWB antenna, microstrip slot antenna, split ring resonator, defected ground structure, compact design

I. INTRODUCTION

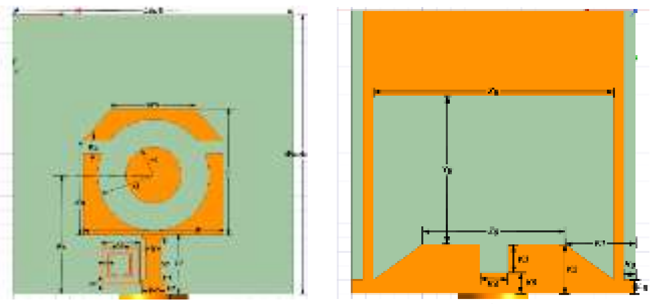
Ultra-Wideband (UWB) technology has gained significant attention in recent years due to its capability to support short-range, high-data-rate wireless communication with low power spectral density. UWB systems typically operate over a frequency range of (3.1 to 10.6 GHz). Such wide bandwidths allow for high-resolution imaging, precise ranging, and secure communications. UWB antennas must exhibit broad impedance bandwidth, compact size, stable radiation patterns, and high efficiency.

Microstrip monopole antennas are ideal candidates due to their low profile, ease of integration with RF circuits, and cost-effectiveness. However, UWB antennas often face co-channel interference from nearby narrowband systems like X-band satellite services (7–8.5 GHz) and WLAN (5.2/5.8 GHz). To overcome this, embedded frequency rejection techniques—specifically band-notching—are essential to ensure electromagnetic compatibility and reduce interference.

To address this challenge, recent research has focused on UWB antenna designs that incorporate notched band characteristics, enabling selective rejection of interfering frequency bands while preserving wideband operation [1], [4], [5]. Techniques such as H-shaped slots [1], parasitic elements [4], and etched resonators like CSRRs and SRRs [6], [9] have proven effective in generating stable and sharp notched responses. These methods allow compact integration while maintaining good impedance bandwidth and radiation performance.

Furthermore, innovations in reconfigurable and multifunctional antenna systems using components like PIN diodes or varactors demonstrate adaptability to varying spectral environments [2], [3]. Such designs are particularly relevant for portable, wearable, and cognitive radio applications requiring real-time frequency agility and compact form factors.

In this work, a circular slot printed microstrip monopole antenna is proposed, designed on an FR4 substrate (εr = 4.4, tanδ = 0.02), with a microstrip feed and partial ground plane featuring a Defected Ground Structure (DGS) for enhanced impedance matching. A concentric circular slot is introduced in the radiating patch to improve bandwidth via capacitive coupling and field perturbation. To achieve a sharp and selective band-notch response in the X-band (7.3–8.1 GHz), a Split Ring Resonator (SRR) is incorporated near the feed region. The SRR acts as a sub-wavelength resonant LC structure that induces strong localized current cancellation and high reflection at the targeted stopband.



(a) (b)

Fig. 1. Geometry of the proposed microstrip slot antenna. (a) Front view (including a microstrip-fed slotted modified patch). (b) Bottom view (including modified ground plane with slots).

II.ANTENNA DESIGN AND STRUCTURE

The proposed ultrawideband (UWB) antenna is a compact microstrip-fed monopole structure designed for high-efficiency performance and band-notch functionality. It is fabricated on a low-cost FR4 epoxy substrate with a relative permittivity (εr) of 4.4, substrate thickness of 1.6 mm, and a loss tangent of 0.02. The overall footprint of the antenna is 20 × 20 mm², making it suitable for integration in compact wireless systems. A 50-ohm microstrip feedline is used to excite the antenna, ensuring proper impedance matching throughout the UWB operating range.

$L_{sub} = 20$		$W_{sub} = 20$	
Patch		Ground Plane	
$r_1 = 2$	$P_S = 1$	$t_f = 1.1$	$Y_g = 10.5$
$r_2 = 4$	$R_S = 8.5$	$Z_a = 2.8$	$K_1 = 5$
$W_n = 6$	$Y_f = 3$	$Z_b = 0.392$	$K_2 = 3.5$
$K_n = 6.75$	$L_f = 4.25$	$Z_c = 0.34$	$K_3 = 2$
$L = 9$	$H_f = 1$	$Z_d = 0.196$	$K_4 = 2$
$W = 10$	$W_f = 1.6$	$H_g = 0.8$	$K_1 = 5$

Table I
Parameters of Antenna (Unit: Millimeter)

The radiating element consists of a circular patch with a centrally etched concentric slot. This circular slot introduces capacitive coupling and additional resonant modes, which effectively enhance the impedance bandwidth of the antenna. Through this design, a wide operational bandwidth ranging from 3.1 GHz to 10.6 GHz is achieved, satisfying the requirements for UWB communication systems.

To mitigate interference within the X-band (7.3–8.1 GHz), a Split Ring Resonator (SRR) is integrated near the feedline. The SRR behaves as a sub-wavelength LC resonator, generating a localized high-Q stopband that suppresses undesired surface currents in the targeted frequency range. This structure enables the antenna to reject signals in the notched band effectively without degrading performance in the remaining UWB spectrum.

The ground plane, located on the bottom side of the substrate, is implemented as a partial structure with a defected ground section in the form of a rectangular slot. This defected ground structure (DGS) alters the surface current flow, introduces controlled reactance, and improves impedance matching. As a result, the return-loss performance is significantly enhanced, and a broader bandwidth is achieved. The combined effects of the circular slot, SRR, and DGS contribute to superior impedance characteristics and stable radiation performance across the desired frequency band.

All structural parameters of the antenna are carefully optimized using full-wave electromagnetic simulation tools to achieve desired results. The simulated return-loss curve confirms that S11 remains below –10 dB across the UWB band, except within the notched region, where a notch depth greater than –5 dB is achieved. This confirms the effectiveness of the SRR in generating the required rejection band. The final dimensions of all key antenna components are summarized in Table I.

III. RESULT AND DISCUSSION

The proposed circular slot UWB antenna was analysed through full-wave electromagnetic simulations to evaluate its performance in terms of impedance matching, radiation behaviour, and surface current distribution. These evaluations confirm the antenna's suitability for ultra-wideband applications, along with the ability to suppress specific frequency bands through a notching mechanism.

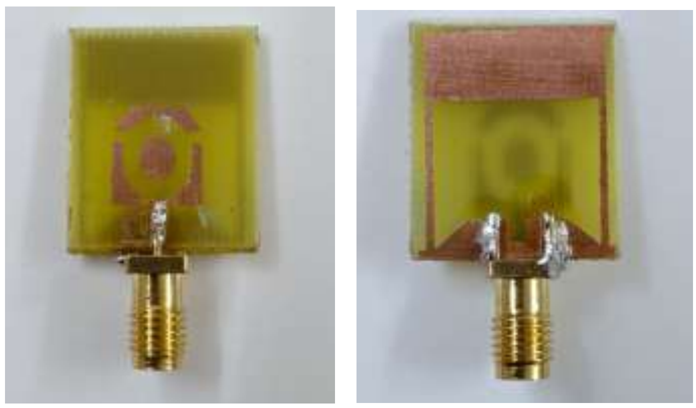


Fig 2. Prototype Antenna

A. Return Loss (S11) Characteristics

The simulated S-parameter (S11) results demonstrate that the antenna achieves effective impedance matching across the entire ultra-wideband range from 3.1 GHz to

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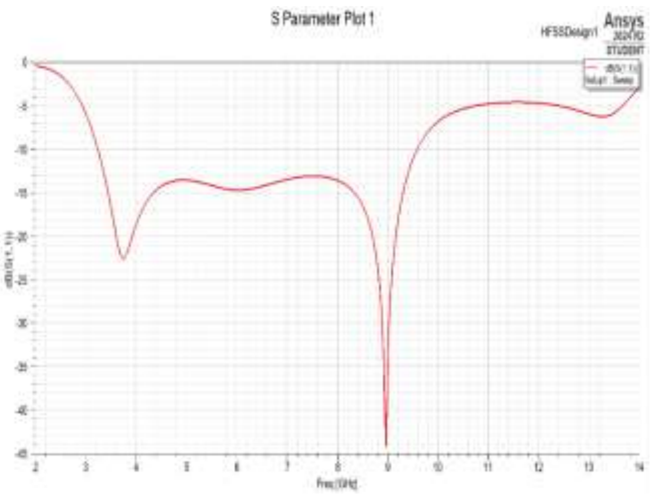
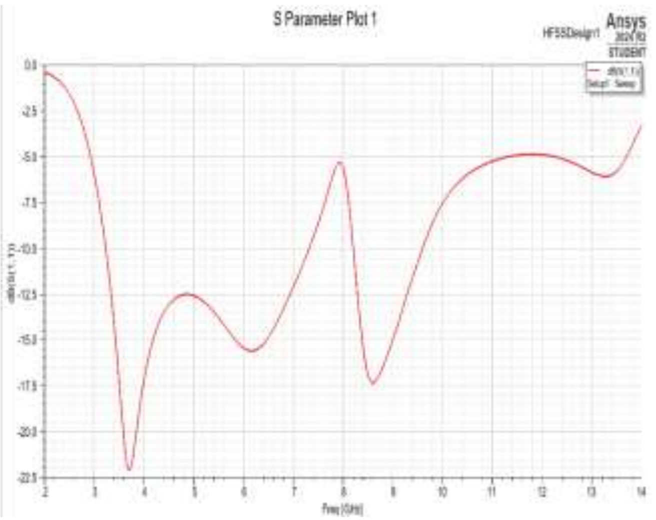
10.7 GHz. The return loss remains below –10 dB throughout this band, which indicates that most of the transmitted power is efficiently radiated. However, a distinct notch appears between 7.3 GHz and 8.1 GHz, where the return loss rises above –10 dB. This signifies strong rejection of signals in that frequency range, corresponding to WLAN interference.



(a)

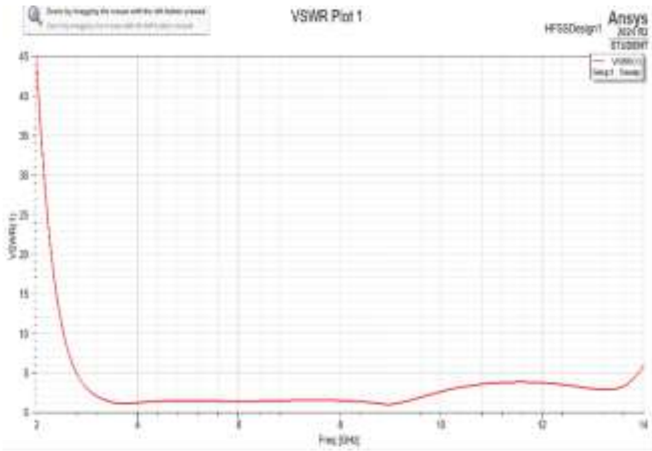


(b)

Fig. 3*. Simulated S11 for UWB Antenna****. (a): Simulated S11 for UWB Antenna (Without Notch). (b): Simulated S11 for Notch-Band Antenna (With Notch)*

B. Voltage Standing Wave Ratio (VSWR)

VSWR for the UWB antenna remains below 2 across the band, implying good impedance matching. For the notched configuration, the VSWR rises sharply in the notch range, reaching values greater than 4, confirming the antenna's rejection capability at that frequency.



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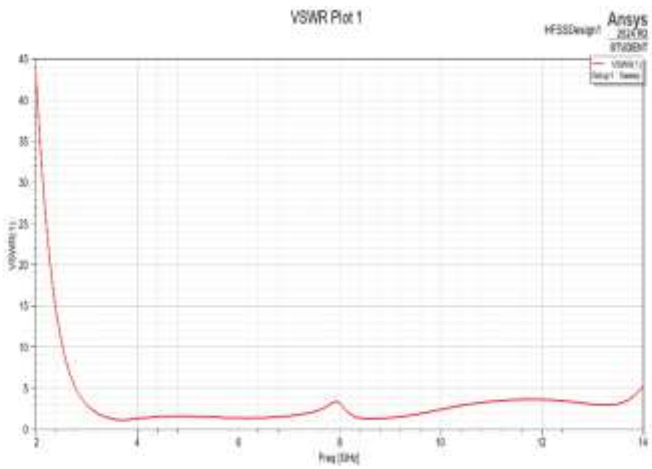

(b)

Fig 4. Simulated Voltage Standing Wave Ratio for UWB Antenna. (a): Simulated VSWR (UWB Without Notch). Simulated VSWR (With Notch)

C. Radiation Pattern and Gain

Radiation patterns were also simulated to verify the antenna's omnidirectional performance. Across multiple frequencies, the antenna exhibits nearly omnidirectional patterns in the H-plane and dipole-like behaviour in the E-plane. This radiation behaviour is desirable for UWB communication systems, ensuring consistent coverage regardless of antenna orientation. The gain remains relatively stable, ranging between 2 dBi and 5 dBi in the passband, with a notable drop observed near the notched frequency band due to intentional signal rejection.

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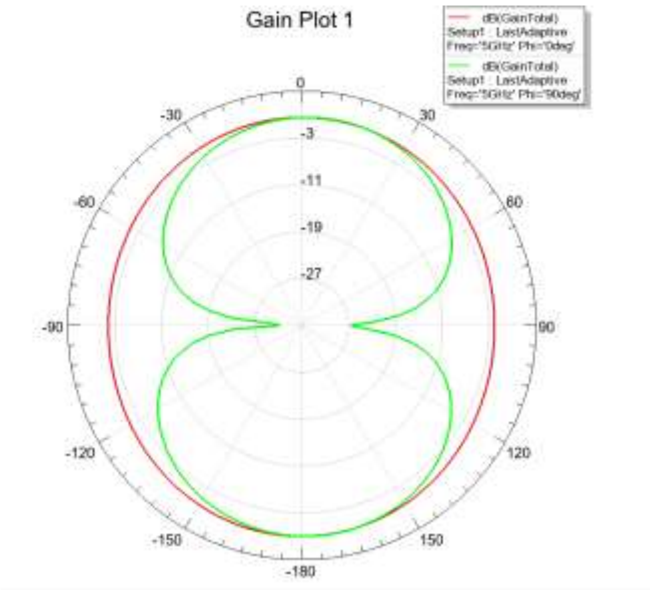

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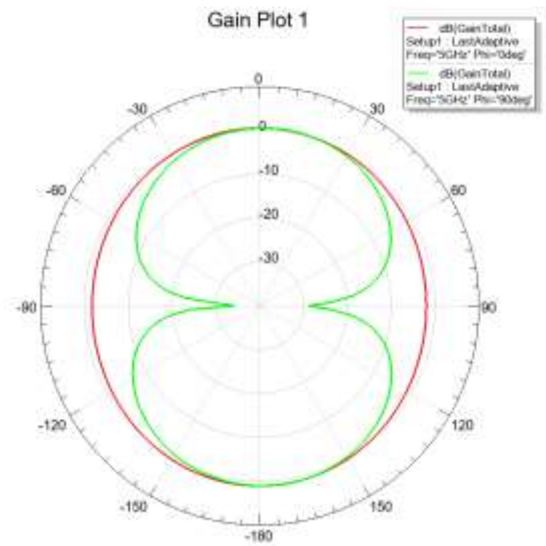

(b)

Fig 5. Simulated Radiation Pattern and Gain for UWB Antenna. (a): Radiation Pattern at 5 GHz (UWB and Notch Comparison). (b): Radiation Pattern at 8 GHz (Notch Band Effect Shown)

D. Surface Current Distribution

The surface current distributions further explain the notch phenomenon. At 5 GHz, in UWB mode, the current is uniformly spread along the feedline and patch, promoting radiation. In contrast, the notched structure shows high current concentration around the circular and square slots, causing impedance mismatch and destructive interference, which suppresses radiation at that frequency.

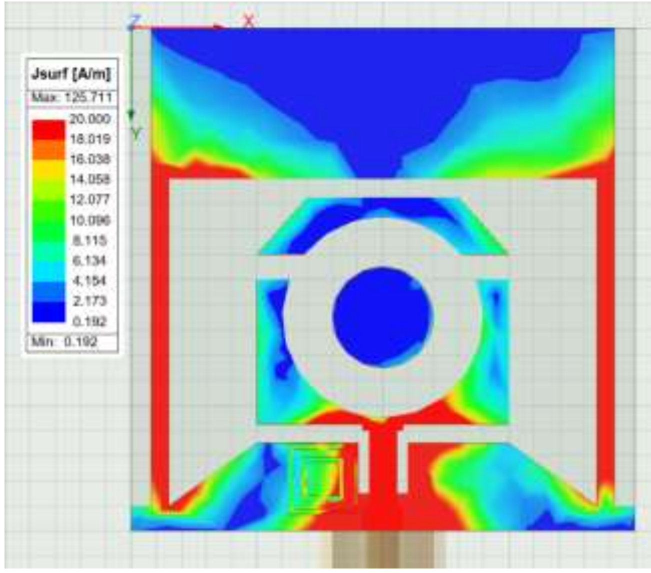

Fig 6. Surface Current Distribution

IV. CONCLUSION

In this paper, a novel circular slot printed monopole antenna with integrated Split Ring Resonator (SRR) has been proposed and evaluated for Ultra-Wideband (UWB) communication systems requiring in-band interference suppression. The antenna is realized on a low-cost FR4 substrate ($\varepsilon r = 4.4$, h = 1.6 mm), achieving a measured impedance bandwidth of 3.1 GHz to 10.6 GHz ($|S11| < -10$ dB), compliant with FCC-defined UWB specifications. A well-defined notch band from 7.3 GHz to 8.1 GHz is achieved through the inclusion of an SRR near the feedline, acting as a sub-wavelength resonant metamaterial structure, introducing a high-Q stop band by disrupting surface current continuity at the target frequency. The notch efficiently suppresses interference from X-band satellite and radar systems.

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