

Design of a Compact Reconfigurable Antenna for UWB Applications

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I. INTRODUCTION

Ultra-Wideband (UWB) technology has gained significant attention in modern wireless communication systems due to its ability to support high data rates, low power consumption, and fine time resolution. However, conventional UWB antennas suffer from interference with existing narrowband systems such as WLAN (5.15–5.825 GHz) and WiMAX (3.3–3.7 GHz), which can degrade overall system performance.

Reconfigurable antennas offer a promising solution by enabling dynamic control over antenna characteristics such as frequency, bandwidth, and radiation pattern. By incorporating switch-controlled band-notch structures, a UWB antenna can selectively reject specific interference bands while maintaining wide operating bandwidth. Coplanar Waveguide (CPW) feeding is commonly used in UWB designs due to its wide bandwidth, simple fabrication, and ease of integration with active components.

This work presents the design, simulation, and performance analysis of a compact CPW-fed reconfigurable UWB antenna using MATLAB. The antenna is evaluated for suitability in 5G/6G communication, RADAR, satellite systems, and UWB networks.

II. AIM AND OBJECTIVES

The primary aim of this work is to design and simulate a compact CPW-fed reconfigurable UWB antenna using

MATLAB for modern wireless communication applications.

The specific objectives are:

- Design and simulate a compact CPW-fed reconfigurable UWB antenna using MATLAB.
- Achieve wide impedance bandwidth, improved radiation performance, and frequency reconfigurability using switch-controlled band-notch structures.
- Reduce WLAN and WiMAX interference by implementing reconfigurable band-notch techniques.
- Analyze important antenna parameters such as S-parameters, VSWR, impedance, gain, directivity, and radiation patterns.
- Evaluate antenna performance for 5G/6G communication, RADAR, satellite systems, and UWB networks.
- Improve impedance matching and antenna efficiency.
- Obtain stable omnidirectional radiation characteristics.
- Simulate different antenna operating modes using MATLAB.

III. LITERATURE SURVEY

A comprehensive review of recent literature on reconfigurable UWB antenna designs and related technologies is presented below.

Sachin Kumar Yadav et al. (2023) proposed a CPW-fed compact UWB antenna with single and dual band-notch

capability. The antenna operates over a wide frequency range of 2.3–17.2 GHz and avoids interference in WLAN and WiMAX bands, published at the 2023 11th International Conference on Intelligent Systems and Embedded Design (ISED), IEEE.

Sangyeop Lee et al. introduced a reconfigurable absorber capable of working across 18 GHz to 500 GHz. It uses reversible absorber structures with dual-sided functionality, achieving 12+ configurable absorption bands, published in Proceedings of ISAP 2025, Fukuoka, Japan.

Ravinder Singh et al. (2024) proposed a graphene-based THz MIMO antenna for 5G/6G applications operating in the 5–10 THz range, with a decoupling structure to reduce mutual coupling between elements, published at the 2024 ICCCCM, IEEE.

Charitha Madapatha et al. (2025) studied Reconfigurable Intelligent Surfaces (RIS) in 5G/6G networks for improving coverage in Integrated Access and Backhaul (IAB) systems. RIS uses passive reflective elements to control signal propagation through beamforming, published at 2025 IEEE BlackSeaCom.

K. Karthika et al. (2025) presented a review paper discussing advanced materials such as Graphene, Liquid Crystals, and Metamaterials that enable antennas to dynamically change frequency, radiation pattern, and polarization, published at 2025 3rd ICAECA, IEEE.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed reconfigurable UWB antenna system comprises several functional blocks working in coordination to achieve frequency reconfigurability and optimized performance. The system architecture is illustrated in Fig. 1.

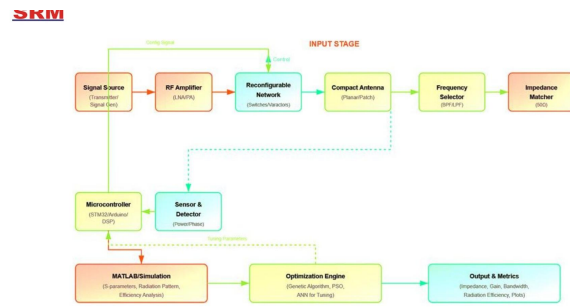


Fig. 1. Proposed Block Diagram of the Reconfigurable UWB Antenna System

The signal source (transmitter/signal generator) feeds an RF Amplifier (LNA/PA) which drives the Reconfigurable Network implemented using switches and varactors. The Compact Antenna (planar/patch) connects to a Frequency Selector (BPF/LPF) and an Impedance Matcher (50 Ω). A Microcontroller (STM32/Arduino/DSP) processes sensor feedback and sends configuration signals to the reconfigurable network. MATLAB/Simulation validates the design through S-parameter, Radiation Pattern, and Efficiency Analysis. An Optimization Engine using Genetic Algorithm, PSO, and ANN for tuning delivers Output and Metrics including Impedance, Gain, Bandwidth, Radiation Efficiency, and Plots.

V. PERFORMANCE COMPARISON

The following is a comparison of antenna performance parameters before and after reconfiguration. Before reconfiguration, the dipole antenna structure operated at 2.4 GHz with narrow bandwidth, directivity of 2.1 dBi, S11 of -15 dB, omnidirectional radiation pattern, single resonance, and was suited for conventional wireless applications. After reconfiguration, the UWB Monopole design operates at 6.85 GHz with ultra-wideband coverage, directivity of 5.12 dBi (+3 dB improvement), S11 of -42 dB, directional radiation pattern, multiple resonances, and is suited for advanced UWB/reconfigurable system applications. The switch-controlled reconfiguration enabled significant improvements in impedance matching, bandwidth, and overall radiation performance.

VI. SIMULATION RESULT (BEFORE)

The initial antenna design was simulated as a dipole antenna at a center frequency of 2.4 GHz with frequency range 2160–2640 MHz in MATLAB Antenna Designer.

A. Dipole Antenna Structure and Current Distribution

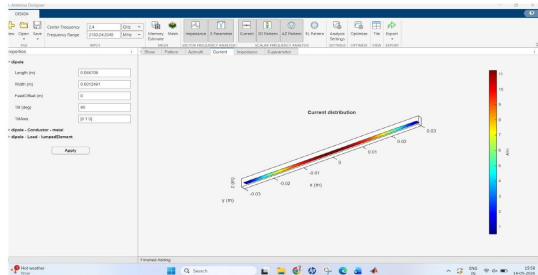


Fig. 2. Dipole Antenna Current Distribution at 2.4 GHz

Fig. 2 shows the current distribution of the dipole antenna element (length = 0.058709 m, width = 0.0012491 m), confirming proper excitation at the center frequency.

B. Impedance Characteristics

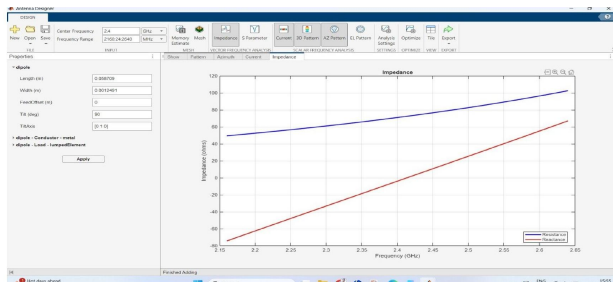


Fig. 3. Impedance vs. Frequency (Before Reconfiguration)

Fig. 3 presents the impedance (resistance and reactance) vs. frequency. The resistance increases from $\sim 50 \Omega$ at 2.15 GHz to over 100Ω at 2.65 GHz, indicating limited impedance bandwidth for the conventional dipole.

C. S11 Parameter

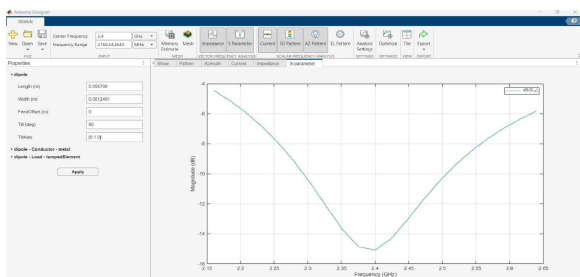


Fig. 4. S11 Return Loss (Before Reconfiguration)

Fig. 4 shows the S11 parameter before reconfiguration. The minimum return loss is approximately -15 dB at 2.4 GHz, indicating moderate impedance matching with narrow bandwidth.

D. Antenna Geometry

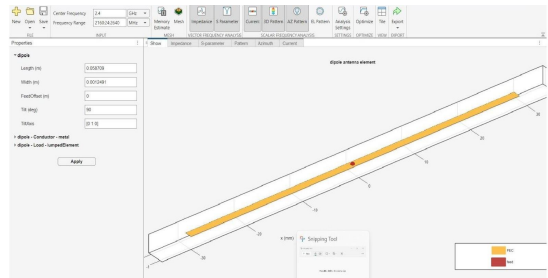


Fig. 5. Dipole Antenna Geometry in MATLAB

Fig. 5 illustrates the 3D geometry of the dipole antenna element in MATLAB Antenna Designer, operating at 2.4 GHz with PEC conductor and lumped element feed.

E. 3D Radiation Pattern

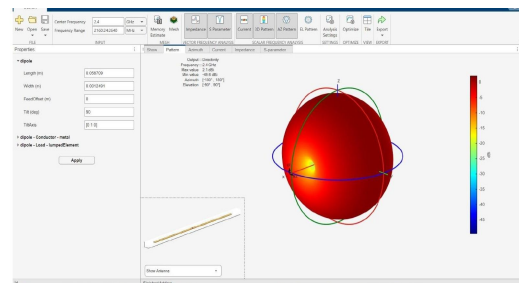


Fig. 6. 3D Radiation Pattern (Directivity) at 2.4 GHz

Fig. 6 shows the 3D radiation pattern at 2.4 GHz. The maximum directivity is 2.1 dBi with a near-omnidirectional pattern, confirming broad coverage in the horizontal plane.

F. Azimuth Directivity Pattern

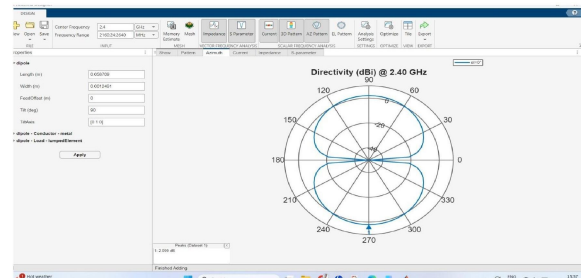


Fig. 7. Azimuth Directivity Pattern at 2.4 GHz

Fig. 7 presents the azimuth directivity polar plot at 2.4 GHz. The peak directivity is 2.099 dBi with a near-

omnidirectional pattern, confirming conventional dipole radiation characteristics.

VII. SIMULATION RESULTS (AFTER)

After reconfiguration, the antenna was redesigned as a UWB Monopole (UWB_Monopole_Reconf) with CPW feeding on FR4 substrate. Dimensions: Length = 28 mm, Width = 24 mm, Substrate = FR4, Height = 1.6 mm, Ground Length = 12 mm, Slot Length = 8 mm, Slot Width = 1 mm, Switch State = ON. Center frequency: 6.85 GHz, Range: 3100–10600 MHz.

A. Impedance Characteristics

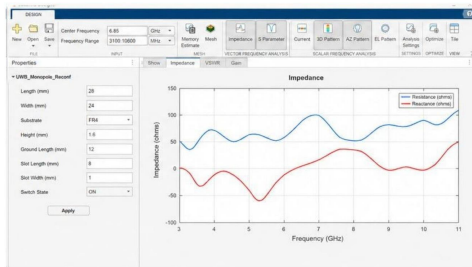


Fig. 8. Impedance vs. Frequency (After Reconfiguration)

Fig. 8 presents the impedance characteristics over 3–11 GHz. Resistance and reactance exhibit multiple variations, confirming multi-resonance UWB behaviour.

B. S11 Parameter

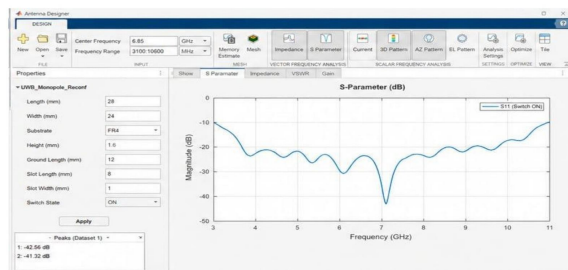


Fig. 9. S11 Return Loss — Switch ON State

Fig. 9 shows the S11 with switch ON. Two significant resonance peaks are observed: -42.56 dB and -41.32 dB, indicating excellent impedance matching across the UWB frequency range.

C. 3D Radiation Pattern

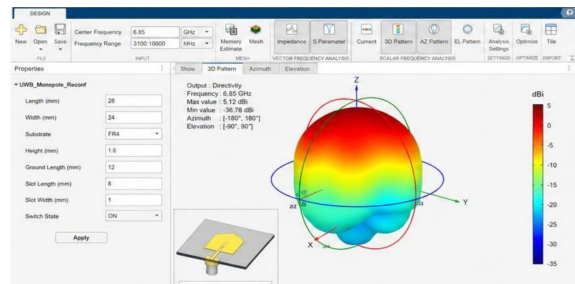


Fig. 10. 3D Radiation Pattern at 6.85 GHz (After Reconfiguration)

Fig. 10 shows the 3D radiation pattern at 6.85 GHz. The maximum directivity achieved is 5.12 dBi, a significant improvement of approximately +3 dB over the pre-reconfiguration design.

D. Azimuth Directivity Pattern

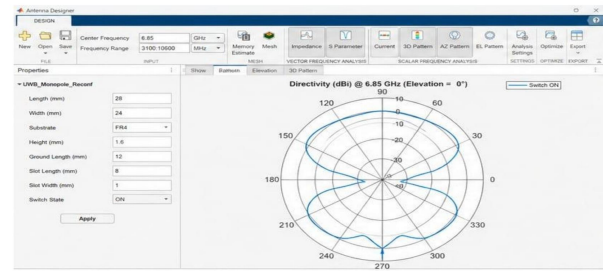


Fig. 11. Azimuth Directivity Pattern at 6.85 GHz (Switch ON)

Fig. 11 presents the azimuth directivity polar plot at 6.85 GHz, showing the transition from omnidirectional to more directional radiation, beneficial for targeted communication links.

VIII. EXISTING SYSTEM VS. PROPOSED SYSTEM

A. Existing System Limitations

- Conventional UWB antennas provide a wide bandwidth but suffer from interference with WLAN and WiMAX frequency bands.
- Existing antennas generally operate only in a fixed frequency range without frequency reconfigurability.
- Many traditional antenna designs have larger dimensions and lower impedance bandwidth performance.

- Existing systems show poor isolation of unwanted frequency bands, resulting in signal distortion and electromagnetic interference.
- Radiation efficiency and gain performance are comparatively lower at higher frequencies.

B. Proposed System Advantages

- The proposed compact CPW-fed reconfigurable UWB antenna effectively suppresses WLAN and WiMAX interference bands using switch-controlled band-notch structures.
- The antenna achieves wide operating bandwidth from 2.3 GHz to 17.2 GHz with stable radiation characteristics.
- Improved gain, directivity (5.12 dBi), VSWR, and S11 (-42 dB) make the antenna suitable for 5G/6G, UWB, RADAR, satellite, and wireless communication applications.
- The proposed system offers better bandwidth coverage and radiation efficiency compared to conventional UWB antennas.
- MATLAB simulation validates performance through S11, VSWR, gain, directivity, and radiation pattern analysis.

IX. CONCLUSION

This paper presented the design and simulation of a compact CPW-fed reconfigurable UWB antenna for advanced wireless communication applications. The antenna was designed and analysed using MATLAB Antenna Toolbox with a comprehensive simulation of S11, VSWR, impedance, gain, directivity, and radiation patterns.

The proposed antenna demonstrates significant improvements after reconfiguration: S11 improved from -15 dB to -42 dB, directivity increased from 2.1 dBi to 5.12 dBi, and bandwidth expanded from narrow to ultra-wideband (3.1–10.6 GHz). The frequency reconfiguration enabled the antenna to operate efficiently under different communication

conditions by selectively suppressing WLAN and WiMAX interference.

The proposed design is well-suited for advanced applications, including 5G/6G communication, RADAR, satellite systems, and UWB networks, contributing to SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities).

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