A Low-profile Dual-polarized Ultra-wideband Metal Antenna Array

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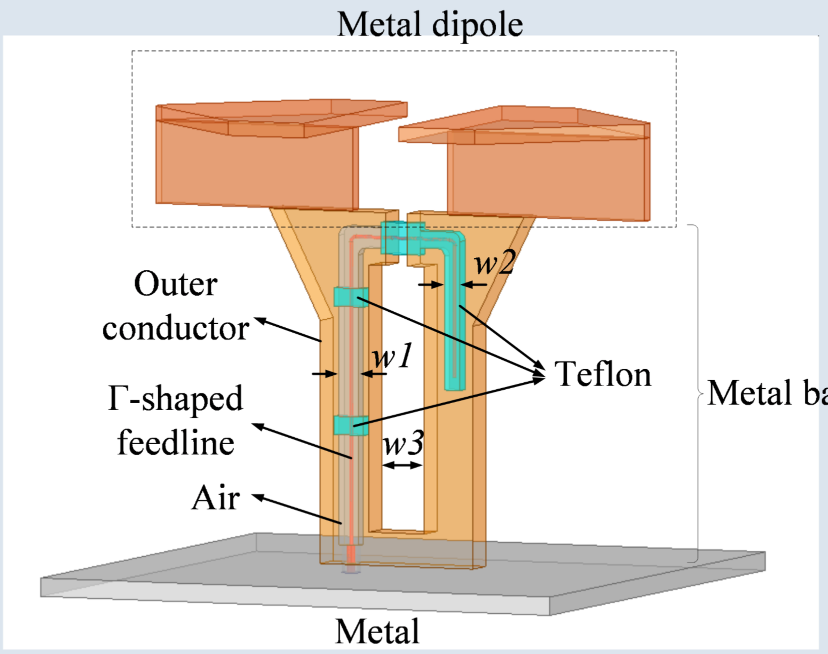
Abstract

A dual-polarized ultra-wideband phased array composed of low-profile metal antennas is presented. The design allows for practical implementation of the tightly coupled dipole arrays (TCDAs) at VHF-UHF frequencies. Integrated metal dipole and Marchand balun are designed to ensure the antenna structure's robustness. The dipole consists of vertical and planar components, resulting in a low profile and good impedance matching. The antenna array exhibits an operational bandwidth of 4.6:1 for ±45° scanning in all planes, maintaining active VSWR <3. Orthogonal port isolation remains below -26 dB when scanning in E-/H-planes. The element spacing and profile of the array are $0.535\lambda_h$ and $0.44\lambda_h$ (λ_h refers to the wavelength at the highest operating frequency in free space), respectively.

Introduction

- Dual-polarized ultra-wideband antenna arrays are critical components for multifunctional systems, which utilize multiple polarizations and frequency bands to realize high-throughput communication and remote sensing capabilities.
- TCDAs have emerged as an attractive candidate for low-profile UWB designs. Most of the reported TCDAs relied on printed circuit board (PCB) design for high manufacturing accuracy and ease of fabrication. However, these PCB designs could hardly satisfy the practical needs of the robust structure and high power capacitance for VHF or UHF operations. This manuscript presents a low-profile dual-polarized ultra-wideband metal antenna array based on the TCDA concept.



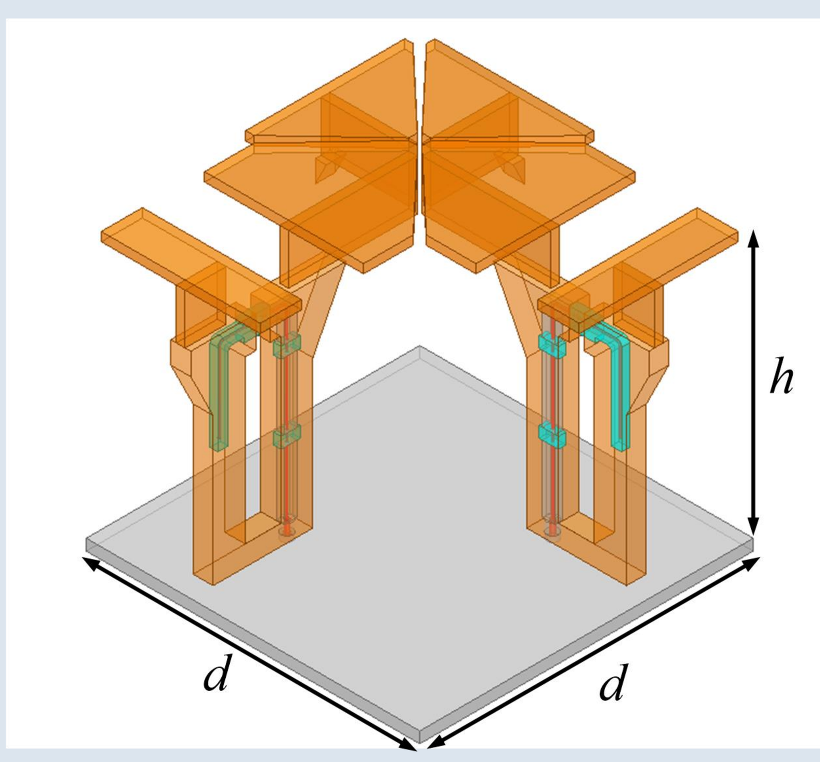


Fig. 1. Single antenna design and the unit cell of the dual-polarized array.

Design and Simulation

- The proposed metal antenna array topology is shown in Fig. 1. Inspired by PCB Marchand baluns composed of microstrip lines or striplines, a Γ-shaped probe is designed as feedline of the metal balun, while the metal shell works as ground/outer-conductor but with better shielding property compared to the ground plane of microstripline of stripline. The dipole of the proposed array is a combination of vertical and planar components to achieve ultra-wide bandwidth while minimizing the antenna profile. The total profile (h) of the proposed antenna array is only $0.44\lambda_h$, with element spacing (d) of $0.535\lambda_h$. The ends of the planar dipole are triangular to prevent intersections and enhance inter-element capacitance.
- Fig. 2 depicts the active VSWR of the simulated infinite array. For broadside and E-plane scanning (θ≤45°) within the operating frequency band, the active VSWR remains normally below 2.5; for H-plane scanning, the active VSWR <3.

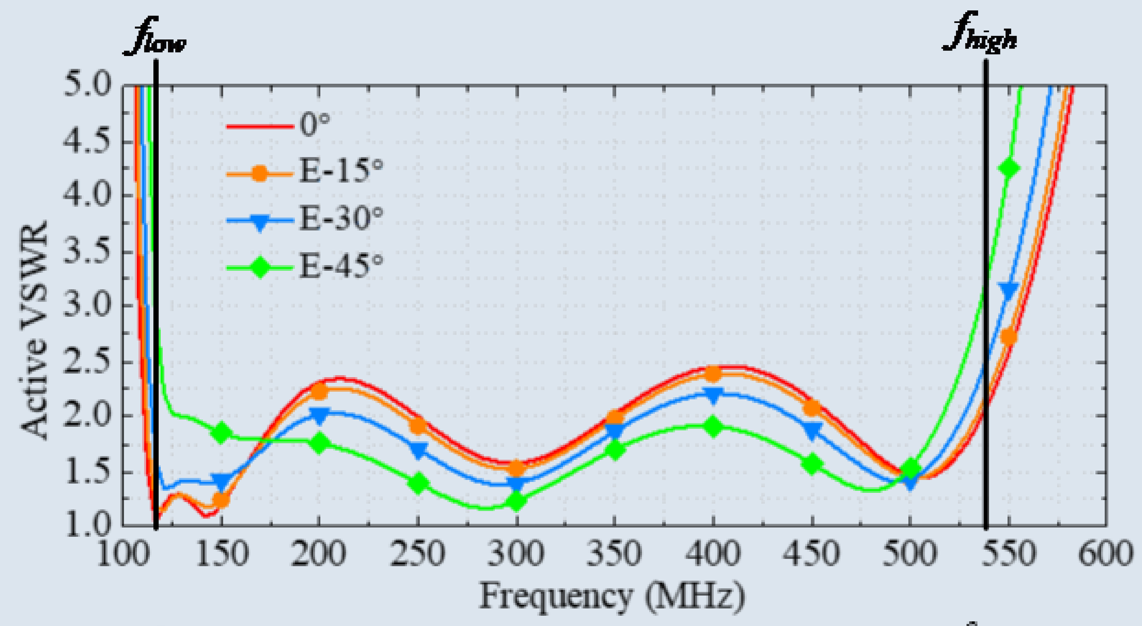
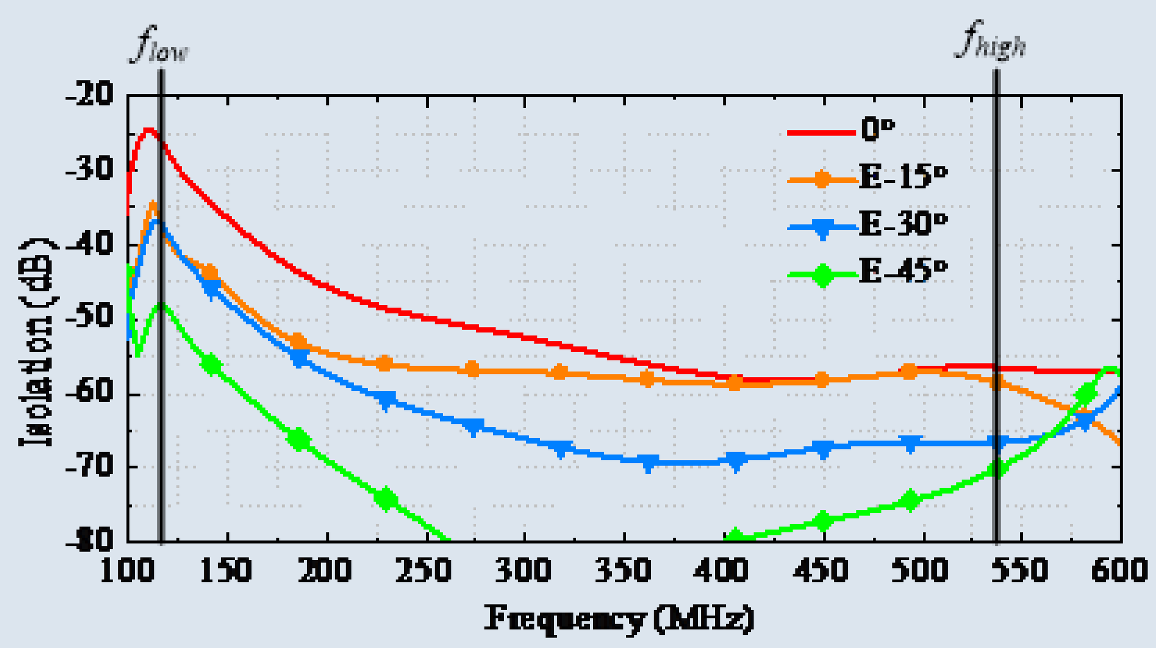


Fig. 2. Active VSWR of the infinite array antenna versus frequency for 0°-45° scanning in E-/H-plane.

- The orthogonal port isolation of the infinite array antenna for 0°-45° scanning is shown in Fig. 3. The isolation remains <-26 dB at broadside and <-37 dB for E-/H-plane scanning. The simulated results for 0°-45° scanning in D-plane maintain below -20 dB, as presented in Fig. 4.



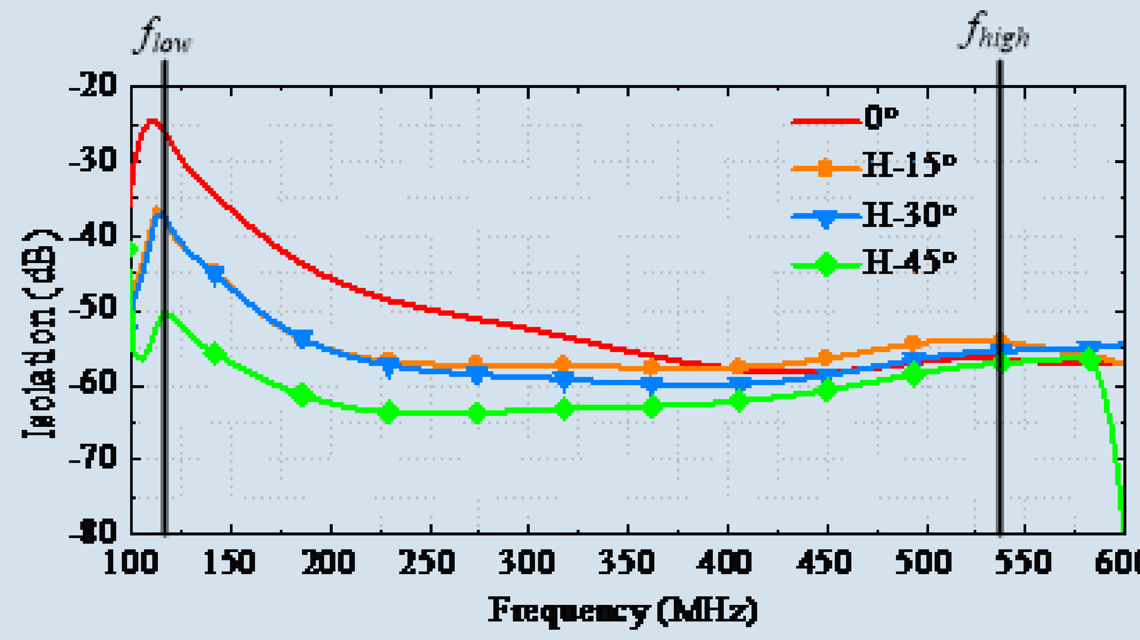


Fig. 3. Orthogonal port isolation of the infinite array antenna versus frequency for 0°-45° scanning in E-/H-plane.

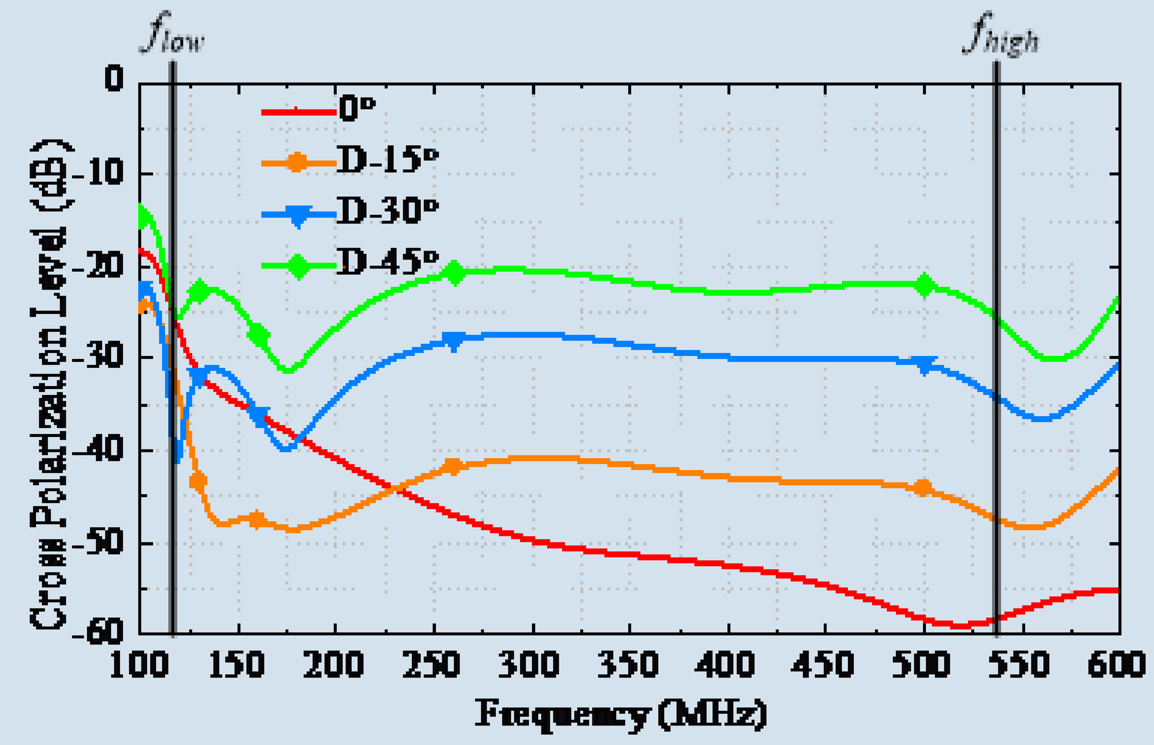


Fig. 4 Cross-polarization level of the infinite array antenna versus frequency for 0°-45° scanning in D-plane.

- The simulated broadside gain of the embedded element is shown in Fig. 5. A maximum drop of 0.8 dB is observed within the operating frequency band.

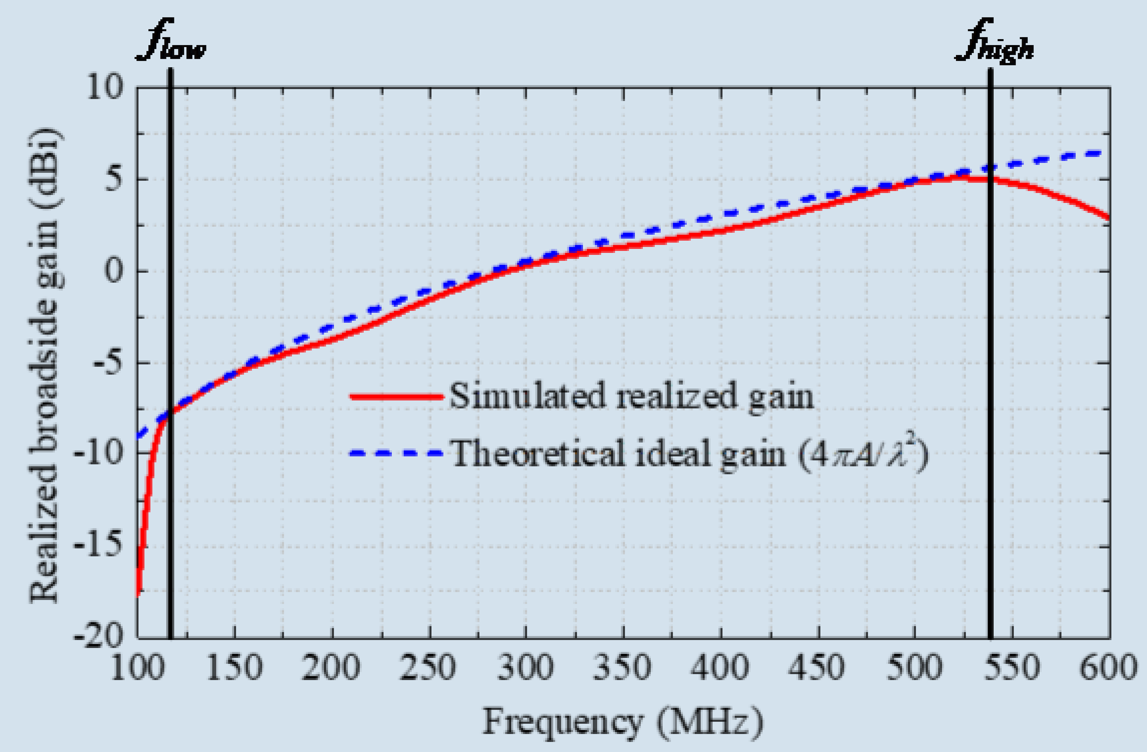


Fig. 5 Embedded element broadside realized gains compared to theoretical values.

Conclusion

A low-profile dual-polarized ultra-wideband tightly coupled dipole array operating at VHF-UHF frequencies is presented. For structural robustness and ease of fabrication, a metal . Marchand balun integrated with the dipole is designed. The dipole is composed of both vertical and planar components, thus minimizing the antenna thickness to only $0.44\lambda_h$ while maintaining 4.6:1 bandwidth for ±45° scanning.

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