

Grating-Lobe Suppression with Metasurface Radomes

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Spacing antenna elements at distances greater than half-wavelength implies the transition of a higher-order Floquet mode into propagating regime when the beam is scanned off-broadside, resulting in the appearance of grating lobe. Sparsification allows for the realization of a given aperture while significantly reducing the number of elements. This considerably decreases the number of amplifiers and radio frequency chains, thereby lowering both the cost and complexity of the hardware. Additionally, increasing the element spacing reduces mutual coupling. From a signal processing perspective, realizing larger apertures enhances user targeting and the efficiency of spatial multiplexing. This is achieved by improving angular resolution, which increases the ability to detect more signals through direction-of-arrival (DoA) estimation. In communication systems, the presence of grating lobes is typically mitigated with co-prime or nested arrays and advanced algorithmic techniques for grating lobe suppression. However, these approaches impose a significant computational load. If we aim to avoid their implementation, the aforementioned benefits are confined to a limited angular range. It is well-known that for large arrays, the transition of the $n = -1$ mode from evanescent to propagating implies a blind spot due to the interaction between the elements. This results in strong mismatching, referred to as scan blindness. This paper aims to show that a grating-lobe-free scanning for a sparse array can be achieved by incorporating a metasurface radome, or metadome (MTD). In the presented scenario, the original antenna is composed by $N = 9$ elements spaced by a distance of $d = 0.6247\lambda$. This implies that the propagation constant of the $n = -1$ Floquet wave of the periodic structure enters the visible region for a pointing direction of $\theta_0 = 36.925^\circ$. A MTD is designed to expand the grating-lobe-free region of the original antenna to an angular range of $\pm 70^\circ$. Full-wave simulations are presented, demonstrating the absence of the secondary lobe when the MTD is introduced over the original antenna. This finding reveals that the benefits of sparse transmitters can be preserved, while eliminating blind spots and suppressing the secondary lobe, without adding signal processing complexity.

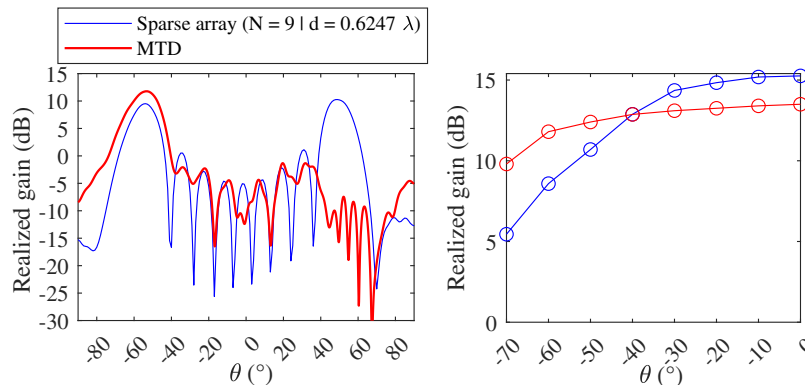


Figure 1: (Left). Realized gain of the MTD system compared to the linear array for $\theta_p = -55^\circ$. (Right). Realized gain comparison across the entire scan range.