Scan Loss Reduction in Ultra Wide-Angle Scanning Phased Array Antenna

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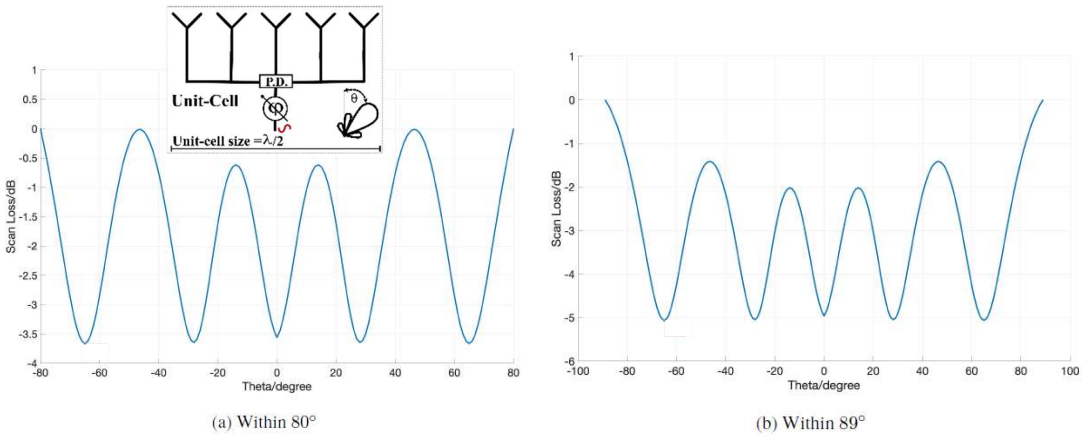
In the rapidly evolving field of wireless communication and radar systems, phased array antennas stand out for their ability to electronically steer the beam direction. However, these systems often encounter a significant challenge known as scan loss, particularly at higher scanning angles. This loss is attributed to the decrease in the power of the main lobe at scan angles away from the broadside peak. It is also associated with an increase in sidelobe level. The scanloss directly impacts the efficiency and performance of the antenna system. Addressing this challenge is crucial for the advancement of wide-scan phased array antennas [1].

This abstract presents an extension of [2], demonstrating significant enhancements in very wide-scan coverage, achieving ranges of ±80° and up to ±89° for a large array. Central to the study is the concept of widening the embedded element pattern's beam-width, a strategy that directly addresses the issue of gain reduction during beam scanning. A key innovation introduced in this study is replacing traditional half-wavelength unit-cell with specially designed sub-array. This sub-array design consists of a different number of miniaturized elements (5-elements), compared with 3-elements in [2], with an excitation weight through a constant internal power divider (P.D.), depicted in Figure 1. This unit-cell configuration is useful and controllable in achieving a broader embedded pattern beam-width without the occurrence of grating lobes.

This investigation includes simulation results for a large array (composed of 3000 unit-cells), demonstrating a maximum scan loss of 3.7dB over a ±80° scan range, Figure 1(a). This is achieved through a constant and specific amplitude distribution and phase adjustment inside the unit-cell. It is observed that the scan coverage extends to ±89° with a slightly increased allowable gain reduction to 5dB, Figure 1(b). These results demonstrate a significant improvement in scan performance, highlighting the practical applicability of the proposed method in enhancing phased array antenna characteristics, especially in very wide-angle scanning scenarios. Furthermore, the method presents viable, cost-effective solutions for enhancing the performance of these critical components in modern communication infrastructure.



(a) Within 80° (b) Within 89°

Figure 1. Normalized envelope of the steered beams' peak for the large array. Each unit-cell consists of a 5-element sub-array, internally weighted as voltage-amplitude:[0.23,0.64,0.26,0.64,0.23] and phase-difference: 88°. (a) coverage within ±80°, (b) coverage within ±89°.

1. R. J. Mailloux, Phased array antenna handbook. Artech house, 2017.

2. A. Emadeddin and B. L. G. Jonsson, ''A new unit-cell architecture applied to active wide-angle scanning phased array,'' in *15th European Conference on Antennas and Propagation (EuCAP*), Dusseldorf, Germany, 2021, pp. 1-4, doi: 10.23919/EuCAP51087.2021.9411390.