MATLAB Mini Project: Beampattern and Beamwidth Analysis of Two Uniform Linear Arrays

Problem Statement

Consider two **Uniform Linear Arrays (ULAs)** positioned along the **x-axis**, separated by a distance of $B\Delta$, where B is an integer value (for example, $B = \frac{N}{2}$; see Figure 1). Each ULA consists of N antenna elements, spaced at Δ. The center of each aperture is located at $\left(\frac{N-1}{2} + \frac{B}{2}\right)\Delta$ and $-\left(\frac{N-1}{2} + \frac{B}{2}\right)\Delta$.

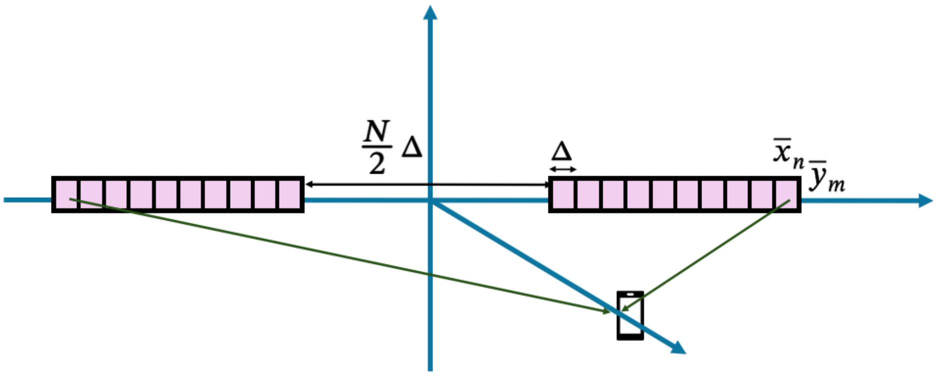

Figure 1: System model

We consider the **focal point** at $(0, 0, F)$ in the Cartesian coordinate system. However, instead of a fixed user location, we analyze how the beamwidth changes when the user's position shifts along the x-axis.

Your task is to analyze and visualize the beamforming performance of this setup. Specifically:

Beampattern Plotting (2D x-z Plane)

- Generate and plot the **normalized array gain** of the system in the **x-z plane**, considering the focal point at $(0, 0, F)$.
- Ensure that the visualization resembles the pattern discussed in class.

Beamwidth Calculation

- Calculate the **beamwidth** of the transmitted signal when the user moves along the **x-axis** (i.e., at different values of x_t).
- This requires integrating the signal pattern over the two separate ULAs, leading to **two integral computations** for the beamwidth analysis.
- Plot the results for different values of B in MATLAB (see the simulation setup section).

Simulation Setup

Use the following setup for your simulation:

- Carrier frequency: $f_c = 15$ GHz

- $\Delta = \frac{\lambda}{2}$, where λ is the wavelength given by $\lambda = \frac{c}{f_c}$, with c being the speed of light.
- Number of antenna elements in each ULA: $N = 64$
- Focal point: $F = 20$ m
- Values of B: 128, 72, 32