EE 483L/583L Antennas for Wireless Communications
Spring 2026 Laboratory 1- Antenna Pattern Plotting

Background

For this lab, you will calculate some quantities and plot some antenna patterns for a small loop antenna.

Project

A small, thin-wire, circular loop antenna in free space, centered on origin on the *x*-*y* plane, has far-field electric and magnetic fields given by

$$\bar{E} = \hat{a}_\phi \, \eta_0 \frac{\pi S I_0 \sin(\theta)}{\lambda^2} \frac{e^{-jkr}}{r} \text{ and } \bar{H} = -\hat{a}_\theta \frac{\pi S I_0 \sin(\theta)}{\lambda^2} \frac{e^{-jkr}}{r}$$

where S is the surface area of the loop and I_0 is the input current. Assuming the loop is lossless, has an input current of $20\angle 0°$ A, and a radius of $a = \lambda/50$:

1) Find functions for $\bar{E}$ (V/m) and $\bar{H}$ (A/m) in terms of k, r, and θ.
2) At r = 10 m, find a function for the magnitude of the electric field $|\bar{E}|$. Also, find maximum $|\bar{E}|$ (V/m and dBVm).
3) Plot polar radiation patterns for $|\bar{E}|$ (V/m and dBVm w/ 10 to -20 dBVm scale) at r = 10 m.
4) Plot **normalized** polar radiation patterns for $|\bar{E}|$ (unitless and dB w/ 0 to -30 dB scale).
5) Find function for the time-average Poynting vector $\bar{W}_{rad}$ (W/m^2). Find time-average power P_{loop} radiated by this antenna.
6) Find function for the radiation intensity U_{loop} of the antenna. Also, find maximum radiation intensity $U_{loop,max}$ (W/Sr and dBW).
7) Plot polar radiation patterns for U_{loop} (W/Sr and dBW w/ 5 to -25 dBW scale).
8) Plot **normalized** polar radiation patterns for the U_{loop} (unitless and dB w/ 0 to -30 dB scale).
9) Find function for the directivity D_{loop} of the antenna. Also, find maximum directivity $D_{loop,max}$ (unitless and dBi).
10) Plot polar radiation patterns for the D_{loop} (unitless and dBi w/ 5 to -25 dB scale).
11) Plot **normalized** polar radiation patterns for D_{loop} (unitless and dB w/ 0 to -30 dB scale).

Conclusions

Compare and discuss the different radiation patterns. Which are similar? Which are identical?

Short report is due Monday, February 2, 2026 at class.

Notes: Put all pairs of like quantity plots on a single page. All polar radiation patterns are in the elevation plane coinciding with *x*-*z* plane, i.e., plot with respect to θ when $\phi = 0$ and 180° (want plots to be symmetric about $\theta = 0$ or *z*-axis). Orient all polar plots to **put $\theta = 0$ at top**.

Hints:

- Consider what the MATLAB command '`view([90 -90])`' does to a polar() plot.
- U (dBW) = $10 \log_{10}[\, U / (1\text{ W})]$. |E| (dBVm) = $20 \log_{10}[\, |E| / (1\text{ V/m})]$.
- To normalize a quantity not in dB, find maximum value. Then, divide all values of quantity by maximum, e.g., $Q_{norm}(x) = Q(x) / Q_{max}$. Therefore, $Q_{norm}(x) \le 1$ (unitless) & $Q_{norm}(x)$ (dB) ≤ 0.