Antenna and Radiowave Propagation – ECEG 4304

Group Assignment

Python-Based Antenna Analysis and Design

Important: This assignment carries significant weight in the course evaluation and assesses your overall understanding of antenna theory and design; please allocate the necessary attention and rigor to each task.

1. Overview & Objectives

The goal of this group assignment is to implement antenna analysis and design tasks using **Python**. You will become familiar with Python libraries for numerical computation, EM-based antenna simulation, and plotting. In your report, include well-documented Python scripts, clear plots, and concise written observations.

Key Libraries (hints):

- **NumPy** for array and math operations
- **SciPy** (e.g. scipy.special) for Bessel functions, Chebyshev polynomials, etc.
- **Matplotlib** (including mpl_toolkits.mplot3d) for 2D/3D plotting
- **scikit-rf** (skrf) for network/S-parameter handling (optional)
- **NEC-Python** or **pynec** for NEC-based EM simulation (optional)

2. Group Organization

- **Group Size:** 4–5 students per group
- **Submission Date:** Will be announced separately
- **Deliverables (per group):**
    1. A single PDF report containing:
        - Design equations & parameter selection
        - Plots and pattern diagrams
        - One-paragraph observations for each task
    2. All Python source files, well commented

3. Tasks

3.1 Wire Antennas

1. **Dipole Impedance & Directivity vs. Length**
    - Write a Python script that, for dipole lengths from 0.1 λ to 2.5 λ:
        - Computes input impedance and using analytical formulas.
        - Computes the maximum directivity .
    - **Plot:**
        - and vs. on one graph.
        - vs. on another.
    - **Summarize** in one paragraph key resonant lengths and directivity peaks.
2. **Circularly Polarized Helix Antennas @ 600 MHz**
    - **Normal Mode** (short helix) and **Axial Mode** (long helix) designs.
    - Implement design equations for helix radius, pitch, and number of turns.
    - (Optional) Use NEC-Python wrapper to simulate and extract:
        - 3D/2D radiation patterns
        - Axial ratio (for polarization)
        - Input bandwidth around 600 MHz
    - **Report:** Essential parameters and pattern/polarization plots.
3. **Yagi–Uda Antenna @ 900 MHz, Gain ≥ 10 dB**
    - Calculate approximate director/reflector lengths and spacings.
    - (Optional) Simulate in NEC-Python to verify tuning and gain.
    - **Report:** 2D/3D patterns, polarization, impedance bandwidth.

3.2 Antenna Arrays

1. **Uniform Linear Array of Dipoles**
    - For array sizes and element spacings from 0.1 λ to 2.0 λ:
        - Compute maximum directivity vs. spacing.

- **Plot:** Directivity curves for each on a single graph.
- Summarize how spacing and number of elements affect directivity.

2. **Dolph–Tschebyscheff Linear Arrays**
    - Use scipy.special.chebyt for Chebyshev tapers at side-lobe levels of 20 dB, 30 dB, 40 dB.
    - For fixed and :
        - Compute and plot the array factor for each taper.
    - Compare side-lobe levels and beamwidths against uniform taper.

4. Report & Submission

- **Title Page:** Course, assignment title, group members
- **Introduction:** Aims and tools used
- **Design Methodology:** Equations, library choices, simulation setup
- **Results:**
    - Labeled figures (2D & 3D)
    - One-paragraph observations per task
- **Conclusion & Discussion**
- **Appendix:** Python code listings

Submit your report and Python source files via a **public GitHub repository**. Send the repository URL and tag your final commit with your group ID in email:

1. Send email to: ephrem.teshale@aait.edu.et
2. Email should contain names and AAU ID of all group members.
3. Title of Email: [AAiT-AntPropag] – Submission of Assignment 3

The submission deadline will be communicated separately.