Microwave Links and Circuits

1. **Course number and name:** 020PCHES3/020MLCES3 Microwave Links and Circuits

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours + 5 lab hours

3. **Name of course coordinator:** Elias Rachid

4. **Instructional materials:** Professor textbook and course material

5. **Specific course information**
   a. **Catalog description:**
   Free space propagation loss – Effects of atmospheric phenomena – Diffraction and diffusion – RF analog and digital links – microwave junctions – microwave filters used microstrip technology – Microwave sources – S-matrix of quadripole (attenuators, phase shifters), hexapole (T in planes H and E, Y), octopole – 3dB, 30dB coupler, Magic Tee) – anisotropic junctions (insulator, circulator) – Transistors (bipolar and FET) – Diodes (Tunnel, Gunn, IMPATT) – Sources (Triode, pentode, TOP, klystron and magnetron).

   b. **Prerequisites:** 020EMENI3/020ECMNI3 Electromagnetism or 020EMECI3 Electromagnetism

   c. **Selected Elective** for CCE students

6. **Specific goals for the course**
   a. **Specific outcomes of instruction:**
   - Study and analyze the propagation in free space.
   - Find the reflection coefficient, reflection point, divergence factor, resulting field, the effect of the refractive index on the trajectory of the waves, fades due to large variations scale of atmospheric refraction and guidance through a tropospheric conduit.
   - Find the effect of atmospheric gases, fading and distortion due to multipath and attenuation due to precipitation.
   - Calculate the loss due to the diffraction by the edges without thickness and with rounded heads, multiple edges (methods of Daygout and Peterson Epstein).
   - Design the link in analogue and digital radio-relay transmission.
   - Study the reciprocal junctions.
   - Calculate the diffusion matrix S of a junction without and with losses.
   - Recognize the S matrix of the quadri-poles (attenuators, phase shifters,), hexa-poles (Tees in planes H and E, Y) and octo-poles (coupler 3dB-30dB, magic tee).
   - Study the non-reciprocal anisotropic junctions (insulator, circulator).

- Become familiar with transistors (bipolar and FET) and diodes (Tunnel, Gunn, IMMPATT) in microwave.
- Describe microwave sources (Triode, pentode, TOP, klystron and magnetron).
- Synthesis of microwave filters using micro-strips.

b. PI addressed by the course:

PI	1.1	1.2	1.3	2.2	2.3	6.2
Covered	x	x	x	x	x	x
Assessed	x	x	x	x	x	x

7. Brief list of topics to be covered

- Propagation of EM waves in free space: free space propagation equation, visibility propagation model and Fresnel ellipsoid (2 lectures)
- Influence Reflection: Reflection coefficient, propagation over a smooth spherical earth, reflection point, divergence factor and resulting field (2 lectures)
- Influence of the troposphere: effect of the refractive index on the trajectory of the waves, fading due to large-scale variations of atmospheric refraction and guidance by a tropospheric duct (1 lecture)
- Effects of atmospheric phenomena: effect of atmospheric gases, fading and distortion due to multiple paths, attenuation due to precipitation (2 lectures)
- Diffraction and diffusion: diffraction by the edges without thickness and with rounded heads, multiple edges (methods of Daygout and Peterson Epstein) (2 lectures)
- Analogue and digital radio links (1 lecture)
- Analog link transmission using radio-relay systems (1 lecture)
- Digital link transmission by radio-relay systems (1 lecture)
- Mini-project: radio-relay link (2 lectures)
- Microwave circuits: isotropic junctions in microwave frequency: Junction, matrix S (3 lectures)
- The couplers: quadripoles, Hexaples, Tees, octopoles (couplers 3dB, couplers 30dB, tees, 3magiques), and applications (3 lectures)
- Anisotropic junctions: Faraday Effect, microwave ferrites, insulators, circulator and applications (Guided exercise session) (3 lectures)
- Synthesis of microwave filters (Guided exercise session) (3 lectures)
- Microwave transistors and diodes (1 lecture)
- Microwave sources (2 lectures)
- Lab experiments: Simulation on IE3D (2:30 lab hours)
- Lab experiments: Microwave measurements (2:30 lab hours)