

“Radiofrequency and Microwave Metamaterials”

(Is it possible to bridge the gap between engineers and physicists?)

Prof. Silvio Hrabar

Professor of Electrical Engineering, University of Zagreb, Unska 3, 10000 Zagreb, Croatia

Abstract: This course reviews the field of RF and microwave metamaterials and related structures. In the first part, the emphasis is given both on basic background physical phenomena and real-world engineering applications. In the second part, the inevitable connection between RF and microwave metamaterials and plasmonic/graphene/optical metamaterials and metatronics is analyzed. In the third part, the basic idea and applications of active metamaterials is discussed. Finally, some emerging trends in active/reconfigurable metamaterials are highlighted.

Schedule

Block 1 : „Basic physics“

Tuesday 18.04

room 301/5

14:00 – 15:00

1. Basic physics of metamaterials (intuitive review of Maxwell equations and constitutive equations, relation to transmission line theory, generation of artificial negative and zero-valued permittivity/permeability using resonant approach.

15:00- 15:10 Coffee break

15:10 – 16:10

2. Polarization/magnetization of simple passive metamaterial particles (capacitively loaded loop, inductively loaded dipole, split-ring resonator). In-class experimental demonstration #1.

Wednesday 19.04

room 440

10:00 – 11:30

3. Combining inclusions into three-dimensional arrays, the basic idea of volumetric metamaterial, interaction between inclusions, intuitive homogenization.

11:30- 11:40 Coffee break

11:40 – 13:00

4. Phase, group and energy velocity in passive metamaterials, forward and backward propagations. Phenomenon of lead/lag phase compensation, subwavelength propagation in anisotropic structures. In-class experimental demonstration #2.

Block 2 : „Passive metamaterials“

Friday 21.04
room 301/5

14:30-15:30

5. Applications of passive metamaterials in subwavelength waveguides and resonators.

15:30- 15:40 Coffee break

15:40 – 16:40

6. Applications of passive metamaterials in antennas, simulations and experimental demonstration .

Monday 24.04
room 301/5

10:00-11:00

7. Basic idea of passive metasurface, DB metasurface, application in radiofrequency engineering (one lecture, 60 minutes).

11:00- 11:10 Coffee break

11:10 – 12:10

8. Connection between RF and microwave metamaterials and plasmonic/graphene/optical metamaterials and metatronics, The idea of scaled RF replicas of plasmonic nano-spheres, plasmonic waveguide, D-dot wire and D-dot loop. In-class experimental demonstration #3.

Block 3: „Active metamaterials“

Wednesday 26.04
room 440

10:00 – 11:30

9.

Bandwidth/loss limitation of passive metamaterials. Foster theorem, basic idea of negative capacitor and negative inductor , stability, dispersion compensation. Basic idea of broadband non-Foster metamaterials.

11:30- 11:40 Coffee break

11:40 – 13:00

10. Superluminal metamaterials, self-oscillation broadband non-Foster metamaterials and devices, applications in antenna technology In-class experimental demonstration #4.

Block 4 : „New directions in active RF and microwave metamaterials“

Friday 28.04

room 301/5

10:00-11:00

11. PT metamaterials, basic idea and difference between electromagnetic and circuit-theory interpretations. Stability problems, applications in radiofrequency and microwave engineering

11:00- 11:10 Coffee break

11:10 – 12:10

12. Active metasurface, broadband magnetic and magnetic/electric conductors and associated devices, non-reciprocal, non-linear and self-oscillating surfaces, EM field ‘teleportation’ systems.