Analog and Digital Communications

1. **Course number and name:** 020CONES3 Analog and Digital Communications

2. **Credits and contact hours**: 6 ECTS credits, 3x1:15 course hours

3. **Name(s) of instructor(s) or course coordinator(s):** Hadi SAWAYA

4. **Instructional materials:** course handouts; slides; in-class problem:

5. **Specific course information**
   a. **Catalog description:**
   Narrow band signals – linear modulations : AM, Double Side Band, Single Side Band – Frequency modulation : Spectrum, Modulator, Demodulator , Phase Locked Loop – Performance in presence of Noise – Digital communications system – Pulse Amplitude Modulation – QAM, PSK, ASK, MSK, GMSK modulations – Coherent Reception of linear modulations – Base band and narrow band models of a digital communication system – Inter Symbol Interference – Eye diagram – Nyquist channel – performance of linear modulations over a Nyquist channel – Reception in presence of ISI – Equalization : Linear, DFE, MSE – Mobile and selective channels – OFDM modulation - performance of digital modulations over a Rayleigh flat fading channel – Diversity – MIMO channels – Alamouti scheme – Carrier and time Synchronization: Differentially coherent reception – Squaring method – Costas Loop.

   b. **Prerequisites:** 020THSES2 Signal theory

   c. **Required:** Required for CCE students

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   - Describe the modulation and demodulation technics used in analog and digital communications: AM, SSB, FM, PAM, QAM, PSK, ASK, MSK, FSK, OFDM.
   - Analyze and calculate the power consumption of an analog or digital communication system.
   - Evaluate the performance of a communication system in presence of noise by calculation the signal to noise ratio in an analog communication system or the error probability in a digital communication system.
   - Analyze the effects of the linear distortions introduced by the channel, like crosstalk and ISI, and apply the reception technics for selective channels like equalization and OFDM.
   - Recognize the synchronization problems.

- Recognize the fading problem in mobile communications and the technics used to overcome this problem.

b. PI addressed by the course:

PI	1.1	1.2	1.3	6.1	6.2	6.3	6.4
Covered	x	x	x	x	x	x	x
Assessed			x	x	x	x	x

7. Brief list of topics to be covered

- Narrow band signals, AM and SSB modulations: spectrum, bandwidth, modulation, demodulation. (6 Lectures)
- Frequency modulation (FM): spectrum, bandwidth, Armstrong modulator, discriminator, Phase Locked Loop, Receiver structure, stereo signal. (5 Lectures).
- Signal to noise ratio calculation for the different modulations. (3 Lectures).
- Structure of a digital communication system, baseband PAM modulation, QAM, PSK, ASK, MSK and FSK modulations. (7 Lectures).
- Coherent reception of linear modulations, narrow band and base band models, linear distortions introduced by the channel, crosstalk, Inter Symbol Interference (ISI), Eye diagram, Nyquist channel, raised cosine function. (3 Lectures).
- Reception in presence of noise, maximum likelihood a posteriori detector, adapted filter, Symbol and Bit Error Rate calculation, Introduction to carrier and symbol synchronization (4 Lectures).
- Reception in presence of ISI, Zero-Forcing and Mean Square Error equalizers, Decision Feedback Equalizers. (3 Lectures)
- Selective channels, OFDM modulation, performance of digital modulations over a Rayleigh flat fading channel, Diversity, Introduction to MIMO channels, Alamouti scheme. (3 Lectures)
- Lab: SDR and USRP radio with Matlab, frequency offset problems and compensation in coherent demodulation, AM modulation and demodulation using SDR, Frequency modulation and demodulation, Phase Locked Loop, Simulation of a digital communications system using Matlab, Performance of digital modulations in the presence of noise, adaptive filtering. (4 Lab lectures of 3:00 hours each)