Software Radios (EC 415 - Spring 2022)

Department of Electrical and Computer Engineering

Boston University

General Information

Time & Location: Tuesday and Thursday, 1:30-3:15pm, PSY B43 Instructor: Professor Jeff Carruthers (jbc@bu.edu) Course Web Site: https://curl.bu.edu:9999/ec415/spring2022/ Required Textbook: https://pysdr.org

Syllabus

Course objectives: This course is an introduction to the foundations and design of communication systems, at an advanced undergraduate-level. The objectives of this course are three-fold: (1) Gain fundamental knowledge of the key concepts and components of modern communication systems; (2) Gain holistic understanding of communication systems through the design of a rudimentary, but complete system via Python simulation; (3) Gain experience in the design of practical communication systems, using software-defined radios (SDRs) and the GNU Radio programming ecosystem.

<u>Contents</u>: We expect to cover the following topics:

Fundamental concepts: Electromagnetic spectrum, channels, frequency division multiplexing, carrier frequency, bandwidth, licensed/unlicensed bands, signals, noise, interference, signal to noise ratio (SNR), channel capacity, data rate, transmission power, decibels.

Signals and systems: Complex numbers (I/Q, polar representation), Fourier transforms, Linear Time Invariant (LTI) systems, convolution, analog to digital conversion (ADC), sampling, quantization, Nyquist frequency, digital to analog conversion (DAC), interpolation and reconstruction, Discrete and Fast Fourier Transforms (DFT/FFT), practical filtering.

Modulation: Oscillators, mixers, Amplitude Modulation (AM), Quadrature Amplitude Modulation (QAM), Frequency Modulation (FM), On-Off Keying

(OOK), Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), constellation diagrams.

Channel models and corruption: Broadband and narrowband noise, fading, multi-path interference, intersymbol interference (ISI).

Encoding and decoding: Alphabet, symbols, symbol rate (baud rate), framing and frame synchronization, pulse shaping, matched filters, eye diagrams, downsampling, soft decisions.

GNU radio: GNU Radio Companion (GRC), basic blocks, flowgraphs, spectrum visualization, modulation/demodulation, filtering, reverse engineering.

Advanced concepts and components (time permitting): automatic gain control (AGC), carrier synchronization, clock synchronization and recovery.