

Department of Electrical Engineering, IIT Madras

Online Mode, Slot C

Jan. to Apr. 2022

EE 3007: RF and Optical Communications (Part A)

Motivation: This Part-A of the course is to expose students to select concepts in wireless communication systems, and using them, to solve design problems where the solution can be obtained by a combination of intuitive reasoning and/or fairly simple numerical or probabilistic techniques. We take examples (lessons) from classical circuit-switched wireless links, and also from modern wireless cellular communications where packet-switching is the norm.

Lesson 1: Signal representation, analog vs digital transmission, typical digital transceiver

Lesson 2: Revisit sampling theorem, and direct (RF) sampling of bandpass signals, **impact of error due to carrier frequency offset (CFO)**

Lesson 3: Guided (wired) versus wireless digital communications – what is the channel? LoS versus non-LoS links; *Running example:* Introduction to a cellular uplink multi-point to point (MPP) channel model with LoS links

Lesson 4: Bi-level signaling thro continuous time, noisy channels, Tx energy and power, **Noise Power**, Rx signal to noise ratio (SNR), and correlation receiver implemented using “matched” filter; *Example:* How does the LIGO detect events?

Lesson 5: Antenna gain, path loss, noise figure, and Rx sensitivity leading to wireless link budget; shadow loss, fading, and link margin; *Examples:* Blue-tooth, GSM, WiFi, and LTE/5G NR

Lesson 6: Analog repeater (amplify and forward relay) versus Digital regenerative repeater (decode and forward relay) to increase link distance

Lesson 7: Service dimensioning on the Cellular Uplink – example from voice service provisioning in 2G TDMA base-stations using the Erlang-B formula

Lesson 8: Uplink Cellular TDMA example; average energy and peak power required for MPP model transmissions; need for ranging; “narrow-banding” at the cost of uplink sum-rate reduction

Lesson 9: Motivation of Direct Sequence spread spectrum-based CDMA for MPP channel; Uplink pole capacity in DS-SS-CDMA for voice links; narrow-banding and conservation of uplink sum-rate; near-far effect due to quasi-orthogonality; inter-play between, cell-radius, uplink capacity, and noise-rise*

Lesson 10*: Quick look at error control in digital links – Forward error control, CRC codes for error detection, and ARQ Protocols; *Example:* Matrix parity check code

Lesson 11*: Introduction to Block Modulation and OFDMA

* *iff* time permits!

Reference Books:

- (a) “*Communication Systems*”, J.G. Proakis and M. Salehi, (Pearson Ed., 2006) – selected topics from Chap.11
- (b) “*Wireless Communications*”, T.S.Rappaport, (Pearson Ed.) – topics from Chap. 1,2, and 8
- (c) “*Data Networks*”, Bertsekas and Gallager, 2nd Ed, (Prentice Hall) – topics from Chap.1 and 2 (for Lesson #11)
- (d) Additional material posted on the URL www.ee.iitm.ac.in/~giri under the link “Teaching”

Assessment Method (for 50marks in Part A):

Quiz 1 – 10; End Sem – 15; The remaining 25 marks will be awarded to take-home assignments and/or mini-project(s). Contact me at ESB-334B, x4420, giri@ee.iitm.ac.in, for more details. Contact details of the TAs will be notified separately. Soft-copies of additional material will be made available at www.ee.iitm.ac.in/~giri for Part-A.

K. Giridhar, Jan.16, 2022
