BIRLA INSTITUE OF TECHNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER 2017-2018
EEE F431 MOBILE TELECOMMUNICATION NETWORKS
Comprehensive Examination (Part A: Closed Book)
May 12, 2018

MAX. DURATION: 120 min **Max. Marks: 60**

Note: All questions carry equal marks. Write your answer precisely to-the-point for each theoretical question. Assume and state typical but valid values, if not given, while solving a numerical.

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1. How was capacity improvement achieved over AMPS in USDC in the same 30 kHz Bandwidth?
2. Find the critical distance d_c under the two-ray model for a large macro-cell in a suburban area with the base station mounted on a tower or building (h_t = 20 m), the receivers at height h_r = 3 m, and f_c = 2 GHz. Is this a good size for cell radius in a suburban macro-cell? Why or why not?
3. Why FDD, developed for analog systems, is still popular in commercial cellular networks deployment?
4. Suppose we have an application that requires a power outage probability of 0.01 for the threshold P_0 = −80 dBm. For Rayleigh fading, what value of the average signal power is required?
5. How were 2G GSM carriers upgraded to 2.5G systems?
6. Consider an AWGN channel with bandwidth 50 MHz, received signal power 10 mW, and noise PSD $N_0/2$ where $N_0 = 2 \times 10^{-9}$ W/Hz. How much does capacity increase by doubling the received power? How much does capacity increase by doubling the channel bandwidth?
7. Compare bit rates supported by OFDM with WCDMA for 5 MHz channel.
8. Suppose that the transmitter knows the interference signal perfectly. Consider two possible transmit strategies under this scenario: the transmitter can ignore the interference and use all its power for sending its signal, or it can use some of its power to cancel out the interferer (i.e., transmit the negative of the interference signal). In the first approach the interferer will degrade capacity by increasing the noise, and in the second strategy the interferer also degrades capacity because the transmitter sacrifices some power to cancel out the interference. Which strategy results in higher capacity?
9. For MPSK with differential modulation, let $\Delta\varphi$ denote the phase drift of the channel over a symbol time T_s. In the absence of noise, how large must $\Delta\varphi$ be in order for a detection error to occur?
10. Design a continuous-time equivalent lowpass equalizer $H_{eq}(f)$ to completely remove the ISI introduced by a channel with equivalent lowpass impulse response $H(f) = 1/f$. Assume your transmitted signal has a bandwidth of 100 kHz. Assuming a channel with equivalent lowpass AWGN of PSD N_0, find the noise power at the output of your equalizer within the 100-kHz bandwidth of interest. Will this equalizer improve system performance?
11. Consider a system in which data is transferred at a rate of 100 bits per second over the channel. (a) Find the symbol duration if a sinc pulse is used for signaling and the channel bandwidth is 10 kHz. (b) Suppose the received SNR is 10 dB. Find the SNR per symbol and the SNR per bit if 4-QAM is used. (c) Find the SNR per symbol and the SNR per bit for 16-QAM, and compare with these metrics for 4-QAM.
12. What happens if current QoS is not supported when handoff occurs?

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Comprehensive Examination (Part B: Open Book)
May 12, 2018

MAX. DURATION: 60 min **Max. Marks: 30**

Note: Assume and state typical but valid values, if not given. Do mention Figure/Equation number of textbook (TB) or reference book (RB#), if applied.

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1. Consider a channel with impulse response, $h(t) = \alpha_0\, \delta(t) + \alpha_1\delta(t - T_1) + \alpha_2\delta(t - T_2)$ where, $T_1 = 10$ μs and $T_2 = 20$ μs. Design a multicarrier system for the channel with sub-channel bandwidth $B_N = B_c/2$. If raised cosine pulses with $\beta = 1$ are used and if the subcarriers are separated by the minimum bandwidth necessary to remain orthogonal, then what is the total bandwidth occupied by a multicarrier system with eight subcarriers? Assuming a constant SNR on each sub-channel of 20 dB, find the maximum constellation size for M-QAM modulation that can be sent over each sub-channel with a target BER of 10^{-3}, assuming also that M is restricted to be a power of 2. Find the corresponding total data rate of the system.
2. Find the outage probability relative to $P_b = 10^{-6}$ for a three-branch RAKE receiver with DPSK signal modulation, independent Rayleigh fading on each branch, and a branch SNR/bit (prior to despreading) of 10 dB. Assume the code autocorrelation associated with maximal linear codes with $K = N = 2n - 1 = 15$. Assume also that the code in the first branch is perfectly aligned, but that the code in the second branch is offset by $T_c/4$ and the code in the third branch is offset by $T_c/3$. Assume selection combining diversity and neglect the interference due to other multipath components in your SNR calculations.
3. GSM systems have 25 MHz of bandwidth allocated to their uplink and downlink, divided into 125 TDMA channels with 8 user timeslots per channel. A GSM frame consists of the 8 timeslots, preceded by a set of preamble bits and followed by a set of trail bits. Each timeslot consists of 3 start bits at the beginning, followed by a burst of 58 data bits, then 26 equalizer training another burst of 58 data bits, 3 stop bits, and a guard time corresponding to 8.25 data bits. The transmission rate is 270.833 kbps.
   (a) Sketch the structure of a GSM frame and a timeslot within the frame.
   (b) Find the fraction of data bits within a timeslot as well as the information data rate for each user.
   (c) Find the duration of a frame and the latency between timeslots assigned to a given user in a frame, neglecting the duration of the preamble and trail bits.
   (d) What is the maximum delay spread in the channel such that the guard band and stop bits prevent overlap between timeslots?
