Homework 1
(Due Date: Sept 6th, 11:59PM, submit through eCampus)

You MUST use the provided latex template for writing your answers. You are free to use any Latex editor you wish. A free, friendly version is at overleaf.com. Upload the two latex files and you will be ready to edit them and produce a pdf.

1 Signal Encoding

(a) Solve the following problems from Section 2.10 in [1]: 3, 8, 9, and 12. [16pts]

(b) Covert the following values for power from [W] to [dBm]: 1.25×10^{-4}W, 2.5×10^{-4}W, 5×10^{-4}W, 1×10^{-3}W, 2×10^{-3}W, 4×10^{-3}W, 8×10^{-3}W. In one sentence explain what pattern you observe. [3pts]

(c) Decompose a signal $(1 + 0.1\cos(5t))\cos(100t)$ into a linear combination of sinusoid functions and find the amplitude, frequency and phase of each component. Hint: use the identity for $\cos(a)\cos(b)$. [5pts]

(d) How are binary values represented in amplitude shift keying and what is the limitation of this approach? [3pts]

(e) Given a bit rate of 10Mbps and carrier frequency of 20MHz, draw an ASK signal for the bit sequence 10110. [10pts]

(f) Given a bit rate of 10Mbps and carrier frequency of 20MHz, draw an FSK signal for the bit sequence 10110. [10pts]

(g) What SNR ratio is required to achieve a bandwidth efficiency of 1.0 for ASK and FSK? [10pts]

2 Channel Capacity, Models

(a) Show that the pathloss for the log-distance propagation model is $PL(d) = PL(d_0)+10\alpha \log_{10} d/d_0$. [4pts]

(b) (6 points) Consider a transmitter-receiver pair at distance d. Assume the log-distance path loss model, with path loss exponent $\alpha = 2.4$. The path loss is 40dB when distance is d_0. Determine the path loss in [dB] for distance $d = 2d_0$ and $4d_0$. At what distance is the path loss 64dB? [5pts]

(c) Consider three nodes A, B and C placed along a straight line, in the order A, B, C. Assume that d(A,B) = 30m and d(B,C) = 20m. All nodes use transmit power 1mW when transmitting. Assume a log-distance propagation model, with pathloss exponent $\alpha = 3$, and pathloss at distance $d_0 = 1m$ as 20dB, noise spectral density $N_0/2 = 4 \times 10^{-21}$ W/Hz and bandwidth $W = 10$MHz. Also assume that the rate of reliable information delivery on a link is given

by $Wlog_2(1 + SINR)$. Each node may either transmit or receive at any given time, but not both simultaneously. Determine the maximum throughput achievable for a flow from node A to node C, when using the route: A−⟩B−⟩C. Assume that there is no other traffic in the network. Hint: the maximum throughput is achieved when the two links (AB and BC) are enabled different percentages of time, e.g., link AB might be active 40% of time and link BC might be active 60% of time - these numbers are just examples). Think about when each link should be active. [30pts]

(d) Given a channel of intended capacity of 20Mbps, the bandwidth of the channel of 3MHz. What signal-to-noise ratio is required to achieve this capacity? [5pts]

3 Spread Spectrum and OFDM

(a) Solve the following problems from Section 2.10 in [1]: 13. [3pts]

(b) What is the fundamental requirement in OFDM? [3pts]

(c) What are the main strengths of OFDM? [3pts]

(d) What are the main differences between OFDM and OFDMA? [3pts]

(e) What are the benefits of each of the following OFDMA approaches: adjacent subcarriers, regularly spaced subcarriers and randomly spaced subcarriers? [3pts]

(f) List three benefits of spread spectrum. [3pts]

(g) What is the relationship between the bandwidth of a signal before and after it has been encoded using spread spectrum? [3pts]

(h) What is the relationship between the bandwidth of a signal before and after it has been encoded using DSSS? [3pts]

(i) What is CDMA? [3pts]

(j) For a 20Mbps LTE data stream with a symbol time of 66.7μsec, how many subcarriers are created? [10pts]

(k) Assume we wish to transmit a 56Kbps data stream using spread spectrum. Find the channel bandwidth required to achieve a 56Kbps channel capacity when SNR=0.1, 0.01 and 0.001; [10pts]

4 Coding and Error Control

Consider two wireless nodes A and B. They choose the (7,4) single error correcting code as their channel encoding mechanism. Map the following 7-bit messages received to the corresponding 4-bit data. Refer to Hamming(7,4) code discussed in class.

(a) 0110111 [2pts]

(b) 1010101 [2pts]

(c) 1110011 [2pts]

(d) 1110110 [2pts]

(e) 1111100 [2pts]

5 Wireshark

Study the provided "Wireshark Lab: ICMP v7.0".

(a) Please answer the 4 questions in the "ICMP and Ping" section. [20pts]

(b) Please answer the 10 questions in the "ICMP and traceroute" section. [20pts]

6 Submission Instructions

Please submit the PDF as obtained from the provided latex template. Name your submission as ⟨your lastname⟩.hw1.pdf and submit it on ecampus.

References

[1] Jochen Schiller, *Mobile Communication*, Addison Wesley, Inc., New York, 2nd edition.