ENGIN 112: Homework 4

Due date: 10/18/22 5:00 p.m.

Please submit your answers via Gradescope as a single PDF file. You can write your answers electronically or by hand and submit a scan or photo.

Question 1

Assume you make a phone call between two telephones that are connected to the telephone network via the Internet using a VoIP adapter for each phone. Each phone uses a regular, U.S. phone number.

(a) Show an illustration that shows what that connection looks like. You may show the Internet and the phone network as a "cloud" (i.e., no internal details required).

(b) The voice information for this phone call can be carried in three forms: analog, digital in the phone network, and digital in the Internet. State the order in which form the voice information for this call is transferred.

Question 2

Answer the following questions about frequency allocations.

(a) Download the U.S. Frequency Allocation Chart:
`https://www.ntia.doc.gov/files/ntia/publications/january_2016_spectrum_wall_chart.pdf`
Identify a frequency range used for cellular telephony in the chart (e.g., 809MHz–849MHz). What is the label for this frequency range in the chart?

(b) Consider the frequency allocation for the United Kingdom:
`http://www.onlineconversion.com/downloads/uk_frequency_allocations_chart.pdf`
What would you perceive as a challenge when building cell phone infrastructure that crosses national boundaries? (2–3 sentences)

Question 3

Assume you have two oscillators that generate a carrier signal at 850 MHz $\pm$ 80 ppm. Assume that at time t=0 both oscillators are synchronized. Also assume the worst case difference in frequency between the oscillators (i.e., one oscillating as slow as possible within specification and the other oscillating as fast as possible within specification).

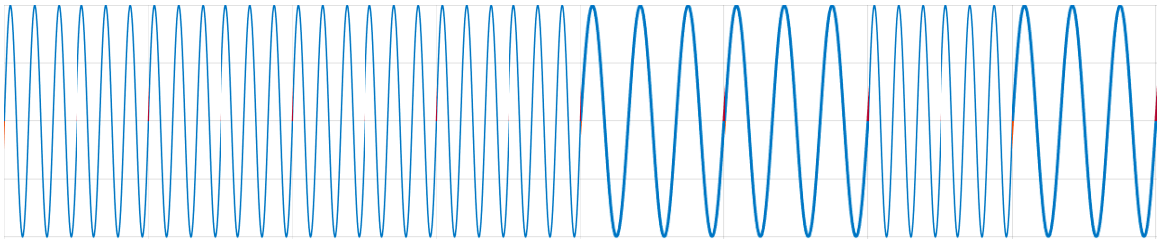
(a) At what time are the two oscillators exactly opposite to each other (i.e., 180 degrees out of phase)? You can calculate this time by assuming that the slower oscillator will have completed x cycles at that time and the faster oscillator will have completed $x + \frac{1}{2}$ cycles.

(b) Assume that you transmit 640 kilobits of binary data per second on this carrier signal. Also assume that the data can be received correctly by the receiver when the phase difference between the sender and the receiver is between 0 degrees and 90 degrees. How many bits can be transmitted correctly before the sender and receiver are out of sync by more than 90 degrees?

Question 4

Please answer the following questions regarding modulation of bits on a signal transmission.

(a) Assuming frequency-shift keying (higher frequency indicating a '1'), what bit sequence is encoded in the following transmission pattern? You may assume that 3 oscillations of the lower frequency are transmitted per bit or 6 oscillations of the higher frequency per bit.



(b) How is the bit sequence '1110100110' encoded with on-off keying?

(c) What problem do you foresee if you were to transmit 100,000 consecutive bits of value 0 (zero) using on-off keying? Would this problem go away if you were to use amplitude-shift keying or frequency-shift keying?

Question 5

Consider a system where three 3-bit numbers (i.e., values between 0 and 7) are transmitted. As an error detection mechanism, the sum of all three numbers (modulo 8 so it also fits into 3 bits) is also transmitted. For example, when transmitting 4, 5, and 2, the sum of 3 is transmitted (4+5+2=11 and 11 mod 8 = 3).

(a) What is the maximum number of bit errors that this mechanism is guaranteed to detect under all circumstances? Give an example of where the mechanism cannot detect an additional bit error beyond the number you answered.

(b) Discuss if you consider this error detection mechanism to be efficient and effective. If you think it works well, state why. If you think it does not work well, explain its shortcomings.

Question 6

Assume an 800 MHz carrier signal arrives at a receiver via two paths that differ in length by a distance of Δd.

(a) For what values of Δd does constructive interference occur? Give the smallest such value.

(b) For what values of Δd does destructive interference occur? Give the smallest such value.

(c) What is the phase difference for a distance of Δd=10m?