Department of ECE Breadth Exam
TTG: Communications, Signal Processing and Controls
Analog & Digital Communications

Please write neatly and show all your work.

1. *Concepts.*

   (a) What is meant by modulation and why is it useful/necessary?

   (b) What are some of the drawbacks of DSB-SC modulation? Are there other analog systems that overcome these drawbacks?

   (c) State the sampling theorem and describe the aliasing phenomenon.

   (d) Describe binary Pulse Code Modulation (PCM). What is its minimum bandwidth in terms of the bit rate?

   (e) State some advantages of digital communications over analog communications.

2. *Analog Communications.* Consider the following angle modulated signal:

$$s(t) = 10\cos(2\pi f_c t + 0.1\sin(2000\pi t)),$$

   with carrier frequency $f_c = 1$ MHz. Estimate its bandwidth.

3. *Digital Communications.*

   (a) A compact disc (CD) is used to record a speech. Audio bandwidth is 15 KHz. However, a sampling rate of $f_s = 44.1$ KHz is used. The speech is to be recorded using binary PCM, with $L = 65536$ quantization levels. Find the bit rate (number of binary digits per second) required to encode the audio signal and the minimum bandwidth required to transmit the encoded signal.

   (b) What is Nyquist's ideal pulse shape? Carefully state why it is ideal with respect to inter-symbol interference (ISI) and bandwidth.