Indian Institute of Technology Bombay

Department of Electrical Engineering

Handout CSP-1 EE 103 Introduction to Electrical Engineering

Homework 1 Oct 8, 2023

Question 1) Identify the scientists shown in the slides. Write their name against each slide number, and one line describing their main contribution to electrical engineering.

Question 2) In addition to the exercises on slide-9, here is kind of a more general problem. Suppose you have 5 distinct voltage levels that you can communicate over the line. At $\beta = 10^6$ switchings per second, what do you think is the average data-rate (in terms of number of bits per second) that we can push through the line. Can you generalize this to any positive integer k of Voltage levels.

Note: The real dawn of digital communication happened with answering a related question. If it helps, you can assume that the bits are generated by independent fair coin tosses, with HEAD and TAIL taken as 0 *and* 1 *respectively.*

Question 3) Can you decode the Morse code title of Slide 13.

Question 4) On Slide 14, explain the difference between time modulation and amplitude modulation. Suppose you have a telegraph receiver which can only find the amplitude of the incoming signal (over appropriate time intervals). Will you still be able to decode the message.

Question 5) Can you find the message in Slide 15. If you are interested in knowing cryptography, **The Code Book, Simon Singh** is a fantastic read.

Question 6) Suppose we are given a function $x(t)$, where t denotes time. Let us define

$$g(u) = \int_{u-\frac{T}{2}}^{u+\frac{T}{2}} x(t)dt, \text{ where } T = 2 \times 10^{-4} \text{ seconds.}$$

For the following cases, plot g(u) as a function of u, in the interval $-5 \le u \le 5$.

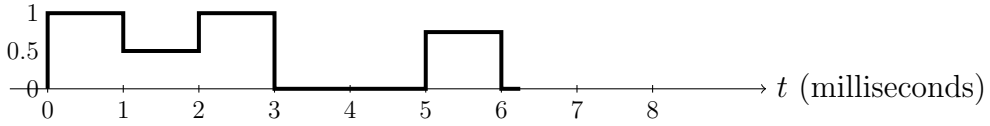
(a)

$$x(t) = \sin(10000\pi t), \text{ for all } t.$$

(b)

$$x(t) = \begin{cases} 1, & \text{when } |t-n| < 0.25, n \in \{0, \pm 1, \pm 2, \ldots\} \\ 0, & \text{otherwise} \end{cases}$$

Question 7) In Slide 22, suppose the input voltage levels are as in the following waveform.



We can think that the signal values to be conveyed are $\{1, 0.5, 1, 0, 0, 0.75, 0, \ldots\}$Volts.

(a) For a carrier frequency of 5kHz, sketch the appropriate AM waveform.

(b) Suppose we use an FM system where 0Volt will correspond to 5kHz and 1Volt corresponds to 10kHz at the output. Can you draw the FM output for the given levels.