UNIVERSITY OF CALIFORNIA, LOS ANGELES
CS M117

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Discussion Section: 1B

Modulation

Pre-laboratory Home Work # 1 (Due 04/06)

(HW and theoretical calculations in lab manual must be typed)

Section A

(T, Chapter 1; pg. 1-54)

Communication Networks

1. (2) What are two reasons for using layered protocols?

1.) Layered protocols helps split the task into smaller sub tasks and dedicating each layer for a sub task, that make the code easier to read, handle and maintain.
2.) The changes in one sub task does not propagate to the other. That is the layers are independent and so it emulates the principle of modularity.

2. (2) What is the principal difference between connectionless communication and connection-oriented communication?

Connection-oriented communication requires a dedicated communication link to be first set up between the sender and receiver. The steps follow through, first initializing the connection, then data is transferred and then the connection is closed/released.
In connectionless communication the steps described above are not required. There is no dedicated channel of communication to be set up. It simply uses some transfer protocol such as UDP to transfer the data between sender and receiver.

3. Which of the OSI layers handles each of the following?
(a) (1) Dividing the transmitted bit stream into frames.
(b) (1) Determining which route through the subnet to use.

a.) Data Link Layer
b.) Network Layer

4. (2) A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte header is added. What fraction of the network bandwidth is filled with headers?

Fraction of network bandwidth is filled with headers = $(n*h)/(M + n*h)$
n = number of layers
M = length of messages in bytes
h = the header added at each layer

5. (2) List ways in which the OSI reference model and the TCP/IP reference model are the same, now list two ways in which they differ.

Same:

1.) Both models are layered models.
2.) The Physical, Network and Transport layers have the same functionality in both.

Different:

1.) They each have different number of layers.
2.) The TCP/IP protocols are used but the model is neglected, and we see that TCP/IP doesn't have a separate presentation layer.

Section B

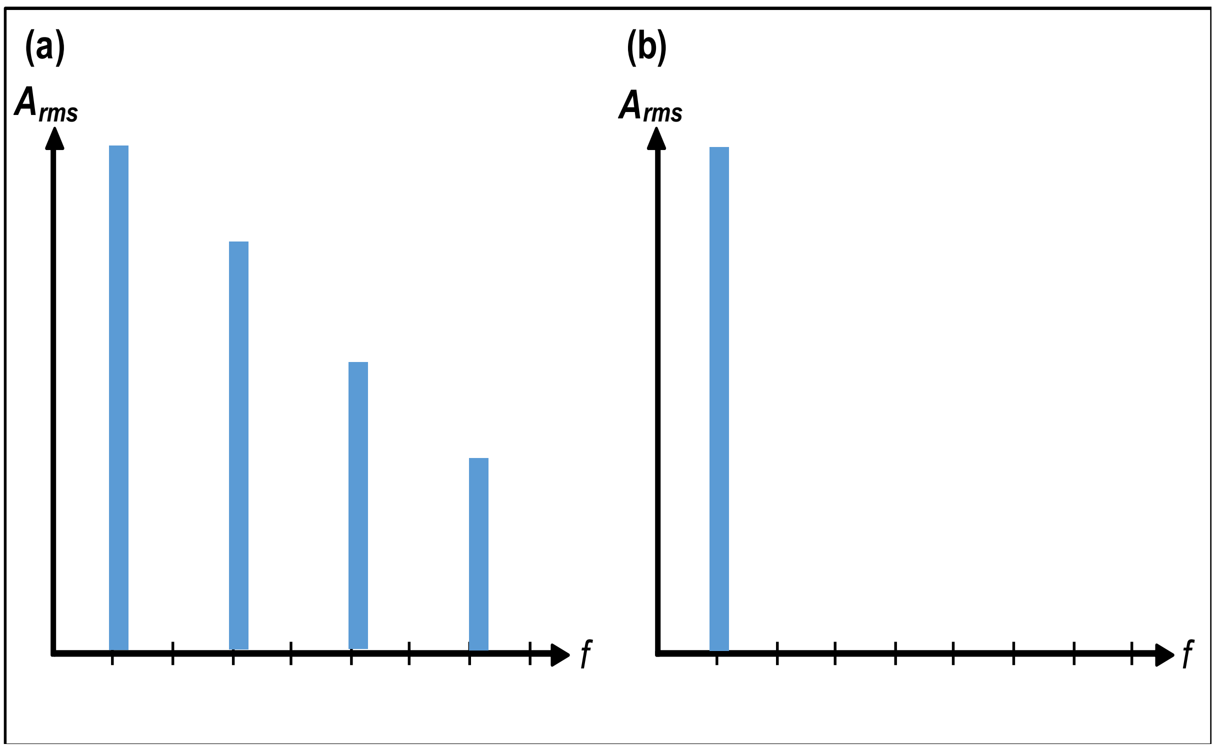
Amplitude Modulation and Frequency Modulation

A rectangular waveform signal has a value of $+A$ for some continuous interval during the period (the "mark"), and has a value of $-A$ for the remainder of the period (the "space"). The "duty cycle" d of the rectangular wave is defined as the length of the positive interval divided by the period.

1) The effective amplitude spectrum of a signal is built from the RMS voltages of each frequency represented in the Fourier series for that signal.

(a) (1) If the amplitude of square wave signal is A_{max} = 4V, and frequency is f; draw the effective amplitude spectra (through the 8th harmonic) for functions.

(b) (1) If the amplitude of sinusoidal wave signal is A_{max} = 4V and frequency is f; draw the effective amplitude spectra.



2). (2) The carrier signal $S_c(t) = A_c \cos(2\pi f_c t)$ is amplitude modulated by a baseband square wave signal $S_m(t)$ with amplitude $A_m = A_c$ (varies between $+A_c$ and $-A_c$) and frequency f_m. Write the Fourier series for the modulated signals $S(t)$, for DSBTC AM (where the baseband DC offset is equal to $+A_c$) and DSBSC AM. Include the AM constructional coefficient K_{AM}.

DSBTC $S(t) = \frac{A_c^2}{K_{AM}} \cos(2\pi f_c t) + \frac{2A_c^2}{K_{AM}\pi}\left[\cos(2\pi(f_c - f_m)t) - \frac{1}{3}\cos(2\pi(f_c - 3f_m)t) + \frac{1}{5}\cos(2\pi(f_c - 5f_m)t) - \cdots\right] + \frac{2A_c^2}{K_{AM}\pi}\left[\cos(2\pi(f_c + f_m)t) - \frac{1}{3}\cos(2\pi(f_c + 3f_m)t) + \frac{1}{5}\cos(2\pi(f_c + 5f_m)t) - \cdots\right]$
DSBSC $S(t) = \frac{2A_c^2}{K_{AM}\pi}\left[\cos(2\pi(f_c - f_m)t) - \frac{1}{3}\cos(2\pi(f_c - 3f_m)t) + \frac{1}{5}\cos(2\pi(f_c - 5f_m)t) - \cdots\right] + \frac{2A_c^2}{K_{AM}\pi}\left[\cos(2\pi(f_c + f_m)t) - \frac{1}{3}\cos(2\pi(f_c + 3f_m)t) + \frac{1}{5}\cos(2\pi(f_c + 5f_m)t) - \cdots\right]$

3) (1) Write the formula (using Bessel functions) for the frequency modulated signal when the baseband signal is $S_m(t) = A_m \sin(2\pi f_m t)$ and the carrier signal is:

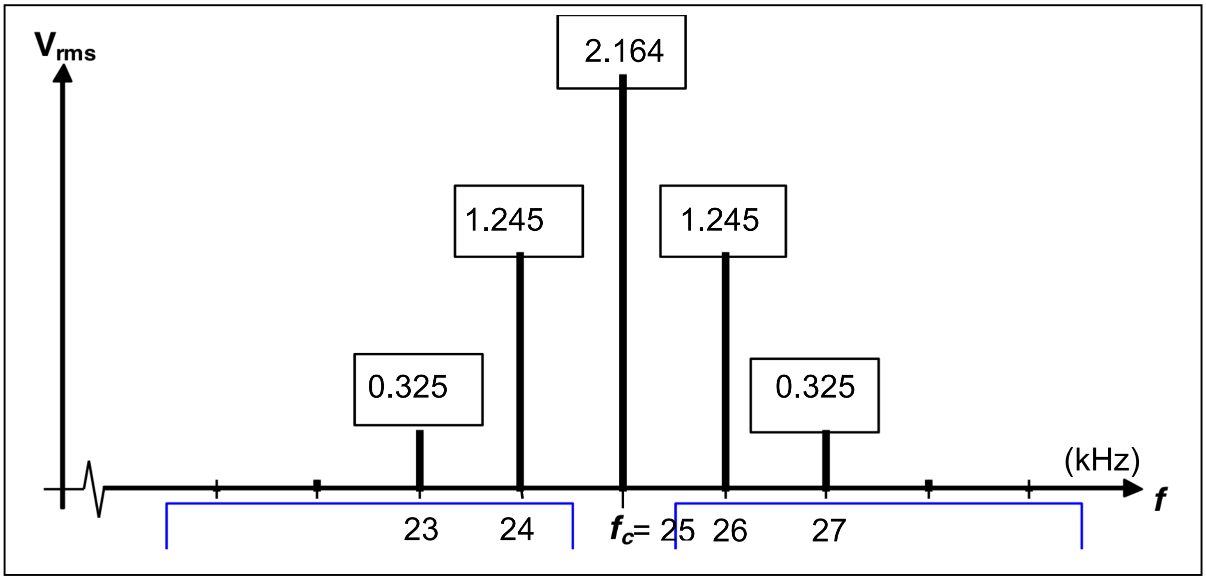
$$Sc(t) = A_c \cdot \cos(2\pi f_c t + \phi),$$

$$S(t) = A_c J_0(k_f)\cos(2\pi f_c t) + A_c \sum_{n=1}^{\infty} J_n(k_f)[\cos\left(2\pi(f_c - nf_m)t + \frac{n\pi}{2}\right) + \cos\left(2\pi(f_c + nf_m)t + \frac{n\pi}{2}\right)]$$

4) (2) Write the formula for the frequency modulation index k_f with baseband signal $S_m(t) = A_m \cos(2\pi f_m t)$, and calculate k_f when $A_m = 4\text{V}$, $f_m = 1000$ Hz and $K_{FM} = 2\pi$ x 340.

$$k_f = \frac{K_{FM} A_m}{2\pi f_m} = \frac{2\pi \cdot 340 \cdot 4}{2\pi \cdot 1000} = 1.36$$

5) <u>(2)</u> Using the formula obtained in question (3) above and the Bessel function table given in the course reader, calculate and plot the power spectrum (<u>amplitudes</u> and <u>frequencies</u>) for the frequency modulated signal with a sinusoidal carrier signal (A_c = 4V and f_c = 25 kHz) and a sinusoidal baseband signal (A_m = 3V and f_m = 1000 Hz). Assume the generator has FM constructional coefficient $K_{FM} = 2\pi$ x 340. Use these figures as the theoretical prediction in Part D of the experiment.



6) <u>(1)</u> What is a useful approximation for the bandwidth of an FM signal in terms of k_f and the bandwidth of the baseband signal?

Because calculating the bandwidth for FM signal is non trivial, we use *Carson's Rule* as follows:

$$B_{FM} = 2 \cdot B \cdot (k_f + 1)$$

Where B_{FM} is the *effective bandwidth of the FM signal* and B is the *effective bandwidth of the baseband signal.*