Principles of communication systems

EET3202, CUNY City Tech, Fall 2023

Homework #03 (Due on Sep 21)

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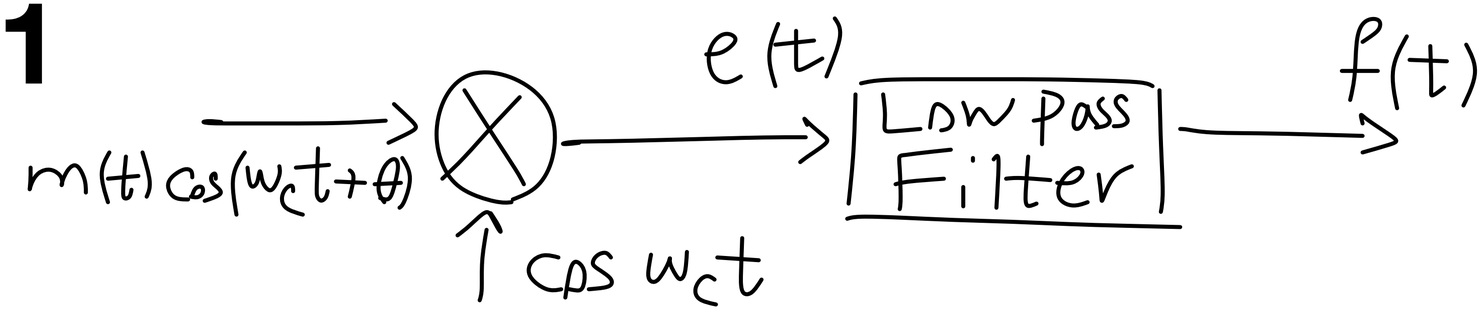
Problem 1

Effect of phase shift in demodulation

Assume we have a modulated signal that we transmit. During transmission in the channel the signal picks up a phase so when it arrives at the receiver we have $s(t) = m(t)\cos(w_c t + \theta)$.

The Receiver demodulates this signal by multiplying it with a cosine wave with the same frequency as the diagram shows.

Problem 1
Continued...



1. Calculate $e(t)$.

2. The multiplied signal goes through a low pass fiter which blocks all frequencies above w_c. What is the final signal $f(t)$ at the output of the fiter?
   * your answer should be a function of θ.

3. what happens if $\theta = \frac{\pi}{2}$?

4. what is the effect of phase shift θ ?

Problem 2

Modulation of a multi-tone message

A multitone message contains more than a single frequency.

Let's assume my message is

$$m(t) = \frac{1}{4}\cos\left(2\pi(10^3)t\right) + \frac{3}{4}\cos\left(2\pi(2.3\times10^3)t\right)$$

It contains two tones at 1 kHz and 2.3 kHz.

1. plot the spectrum (Fourier transform) of m(t).

Problem 2

Continued...

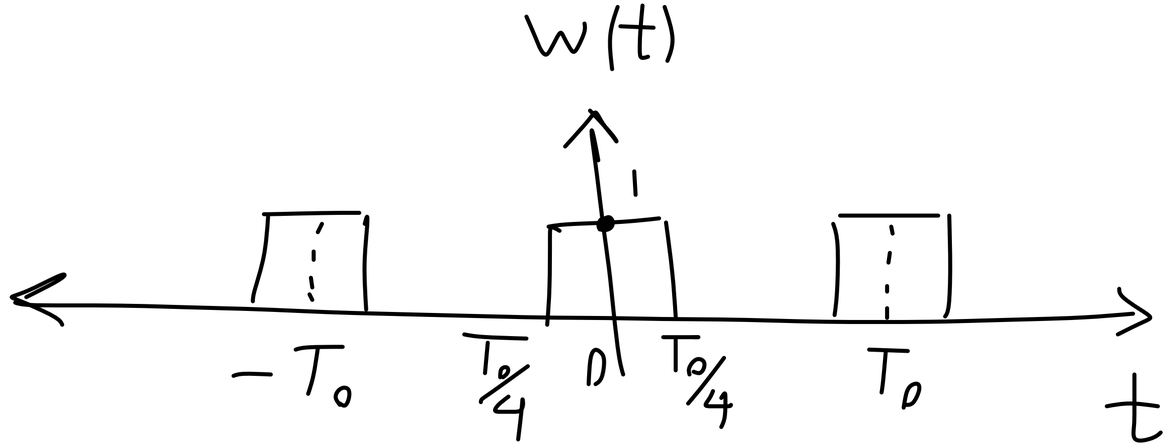
2. We modulate our message signal $m(t)$ with a carrier with frequency 10 kHz.

(a) plot the spectrum of the modulated signal.

(b) Denote the lower and upper subbands.

Pronlem 3

Fourier series of a pulse train



Any periodic signal such as w(t) can be written down as a Fourier series ($f_0 = \frac{1}{T_0}$)

$$w(t) = \sum_{n=-\infty}^{\infty} C_n e^{j2\pi n f_0 t}$$

The coefficients are calculated as follows

$$C_n = \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} w(t) e^{-j2\pi n f_0 t} \, dt$$

Problem 3

Continued...

The goal is to approximate $w(t)$ with its three lowest frequencies:

$$w(t) = C_0 + C_1 e^{j2\pi f_0 t} + C_{-1} e^{-j2\pi f_0 t} + C_2 e^{j2\pi 2f_0 t} + C_{-2} e^{-j2\pi 2f_0 t}$$

Calculate $C_0, C_1, C_{-1}, C_2, C_{-2}$

* You can calculate C_n for any n and then replace n with the proper values.