EE 103/ ECE 103 Signals and Systems

Instructor: Prof. Sung-Mo "Steve" Kang

Office: BE 239

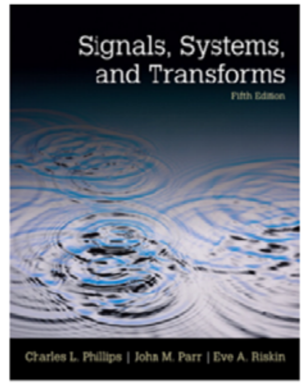
Office Hours (tentatively) M, F 4-5 pm
W 1-2 pm

Course website
ee103-fall18-01.courses.soe.ucsc.edu

Lectures posted at webcast.ucsc.edu
U: ee-103-1 P: SMK123

Textbook

eCopy available



Weekly 15 minutes quiz (9 quizzes/quarter)
on Mondays, unless otherwise announced

Mid-term Exam on Oct. 31 (W) in class

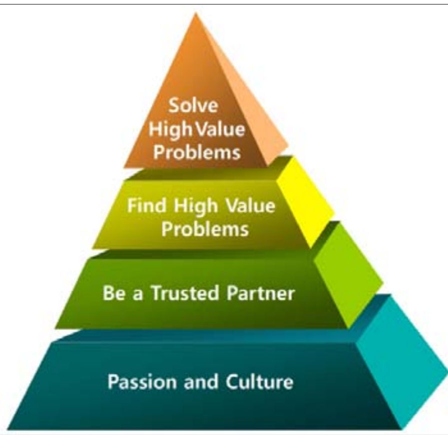
Final Exam on Dec 12 (T) 4-7 pm

Final grading based

- 20% Quizzes (Average of best 7 out of 9)
- 30% Mid-term score
- 50% Final Exam score

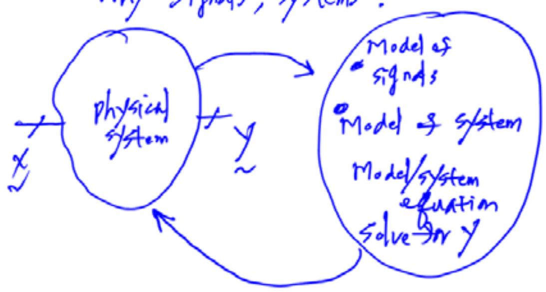
Exams closed book, No calculator

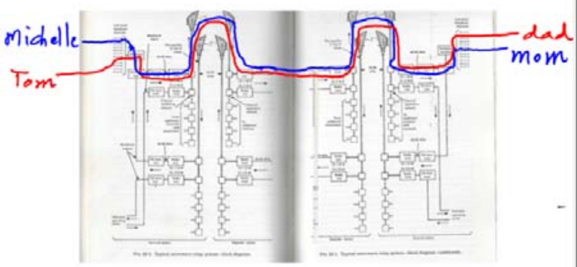
How can you do well
in this course and beyond ?

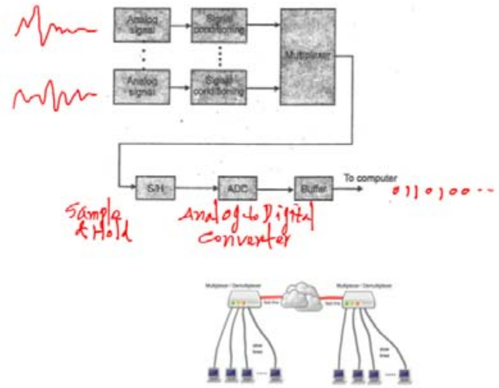


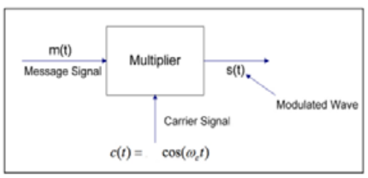
Motivation

why Signals, Systems ?

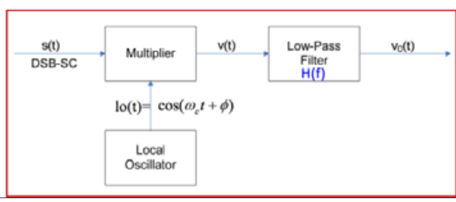


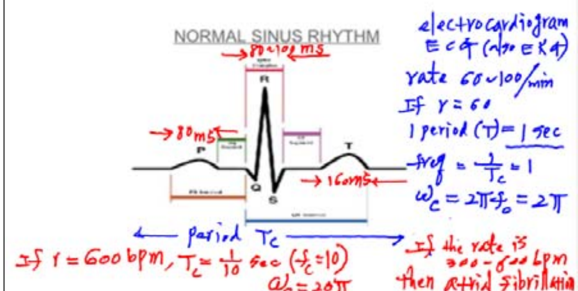






Demodulation scheme of your friend:





Electro Cardio Gram (ECG) signal

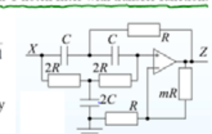
Heart rate ?
Periodic or non peridic ?
Healthy or non healthy ?

} diagnosis through Signal Analysis

ECE 103L #6 Filter Design

1. In the lab we analyzed filtering 60 Hz power-line noise from ECG signal using a digital (signal processing) filter. Now let's try to an analog (circuit) filter approach to remove the 60 Hz line-noise. Following is an active twin-T notch filter with transfer function:

$$H(\omega) = \frac{Z(\omega)}{X(\omega)} = \frac{(1+m)\left((2j\omega RC)^2+1\right)}{(2j\omega RC)^2 + 4(1-m)j\omega RC + 1}$$



Here `m` is the ratio of the two feedback resistance which determines the gain and quality for the filter. The drop frequency of this twin-T notch filter is $f_{drop}=1/4\pi RC$. For designing a 60 Hz drop filter, let's use `R=10 kΩ` and `C=133 nF`.

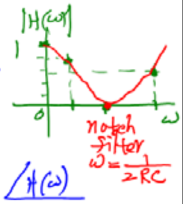
(a) For `m={0.8, 0.9}` plot the magnitude and phase response of `H(ω)` with a range of `f=ω/2π=[0, 200 Hz]`.

(b) Consider the ECG signal used during the class (`ecg_signal.mat`) as the input (`x(t)=ecg`) of a 60 Hz twin-T notch filter with `m=0.9`. Using the functions `fft()` and `ifft()`, determine the `X(ω)`, `Z(ω)`, and `z(t)`[`z(t)` is the output signal from the twin-T notch filter]. Plot `x(t)`, `X(f)`, `Z(f)`, and `z(t)` in a 4x1 subplot for the range of $-250 \le f \le 250$ and $0 \le t \le 2.5$.

[Please pay attention to the proper use of `fftshift()` and `ifftshift()` while solving this problem.]

For $m=0$ case

$$H(\omega) = \frac{(2j\omega RC)^2+1}{(2j\omega RC)^2+4j\omega RC+1} = |H(\omega)| \angle H(\omega)$$



f	$\omega = 2\pi f$	$\lvert H(\omega)\rvert$	$\angle H(\omega)$
0	0	1	$\angle 0^\circ$
$\frac{1}{2\pi 4RC}$	$\frac{1}{4RC}$	$\frac{(\frac{1}{2}j)^2+1}{(\frac{1}{2}j)^2+\frac{j}{2}+1} = \frac{0.75}{0.75+\frac{j}{2}} = 0.8$	$\angle 0 - 33.7^\circ$
$\frac{1}{2\pi 2RC}$	$\frac{1}{2RC}$	$\frac{j^2+1}{j^2+j2+1} = \frac{0}{0+j2} = 0$	$\angle -90^\circ$
$\frac{1}{2\pi RC}$	$\frac{1}{RC}$	$\frac{(2j)^2+1}{(2j)^2+j4+1} = \frac{-3}{-3+j4} = 0.6$	$\angle 180^\circ - 126.1$