THE STATE UNIVERSITY OF NEW JERSEY

RUTGERS

College of Engineering
Department of Electrical and Computer Engineering

332:322 **Principles of Communications Systems** **Spring 2004**

Quiz I

There are three questions. You have the class period to answer them. Show all work. Answers given without work will receive no credit. GOOD LUCK!

1. *(50 points)* **Amplitude Modulation:**

   (a) *(20 points)* Carefully sketch and envelope detector for and AM receiver and describe the purpose of each component. You may assume ideal components. Analytically describe the output of the envelope detector when used with an AM signal $m(t)\cos 2\pi f_c t$ where $m(t)$ is both positive and negative as a function of t?

   (b) *(20 points)* In the previous part, what happens if you pass $r(t) = m(t)\sum_{k=1}^{\infty} J_k(100)\cos 2\pi k f_c t$ (where $J_k(\beta)$ is a bessel function) through the envelope detector?

   (c) *(10 points)* Determine analytically and exactly the power in a signal $r(t) = m(t)\cos 2\pi f_c t$ where $m(t)$ is a signal bandlimited to $\pm W$ and $f_c \gg W$. You may assume the power in $m(t)$ is P. This is one of the few cases where scale factors matter, so you are forewarned.

2. *(50 points)* **Frequency Modulation:**

   (a) *(20 points)* Carefully sketch $r(t) = \cos(20000\pi t + \pi m(t))$ where $m(t)$ is a square wave which only takes on values ± 1, has 50% duty cycle and period $T = 200\mu s$. What kind of modulation is this and can $m(t)$ be recovered from $r(t)$?

   HINT: Be VERY CAREFUL with your sketch and don't make assumptions about what you think the answer SHOULD be.

   (b) *(30 points)* Suppose you're given two signals $r_1(t) = \cos(2\pi f_c t + \beta \sin 200\pi f_m t)$ and $r_2(t) = \cos(2\pi f_c t + \beta \sin 2\pi f_m t)$ which comprise a transmitted signal $r(t) = r_1(t) + r_2(t)$. Assume that $f_c \gg 100 f_m$ and $\beta = 10$. Is it possible to recover the program content of $r_1(t)$ and $r(2(t)$ separately? If so, how? If not, why not? Does your answer change if $\beta = 200$?

   HINT: It might help to make a reasonably careful sketch of $R(f)$.

3. *(50 points)* **Cora's PLL:**

   As you have probably learned by now, Cora is sometimes rather contrary, though I prefer to think she's a free thinking. So, when given the problem of designing a PM demodulator for a signal $r(t) = \cos(2\pi f_c t + m(t))$, she decided to modify the usual PLL design and produce her own as shown in FIGURE 3. As you can see, Cora has replaced the usual VCO with one

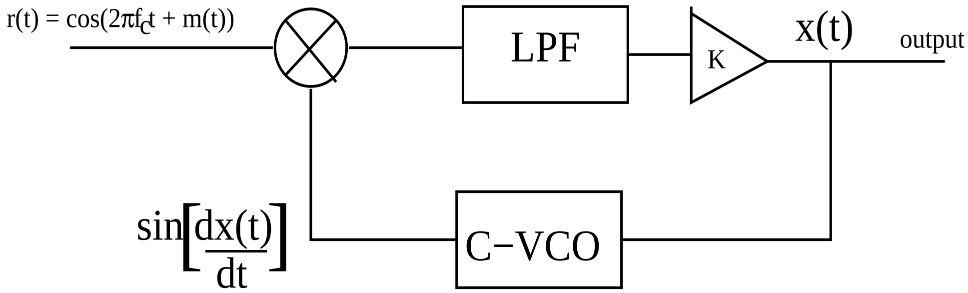

Figure 1: Cora's PLL

of her own design which in response to an input $x(t)$ produces an output $\sin\dot{x}(t)$ where $\dot{x}(t)$ is the first derivative of $x(t)$.

Please analyze Cora's PLL and determine whether it can be used as a PM demodulator. State all assumptions carefully and justify all steps of your analysis. You can choose the size and sign of K and the LPF characteristics as well.