Final Exam ESE 471

May 2 or 7, 2014

Your Name: Solutions

Your ID #: ______________________

Show your work in detail to get the full credit. There are 4 problems.

1. (25 pts). In an AM bandpass communication system, the signal in the channel, $s(t)$, is shown as

$$s(t) = 100\sin\left[\left(w_c + w_a\right)t\right] + 500\cos w_c t - 100\sin\left[\left(w_c - w_a\right)t\right].$$

Without the modulating signal (i.e., $m(t) = 0$), $s(t) = 500\cos w_c t$.

(a) Find $m(t)$.

(b) If $s(t) = x(t)\cos w_c t - y(t)\sin w_c t$, determine $x(t)$ and $y(t)$ from the above $s(t)$.

(a) $S(t) = Re\left[500 e^{jW_c t}\right] + Re\left[-j100 e^{j(W_c+W_a)t} + j100 e^{j(W_c-W_a)t}\right]$

$= Re\left[500\left(1 - j(2j)\frac{100}{500}\left(\frac{e^{jW_a t} - e^{-jW_a t}}{2j}\right)\right)e^{jW_c t}\right]$

$= Re\left[\underset{\uparrow \atop A_c}{500}\underbrace{\left(1 + \frac{2}{5}\sin W_a t\right)}_{1+m(t)} e^{jW_c t}\right]$

$m(t) = \frac{2}{5}\sin W_a t$

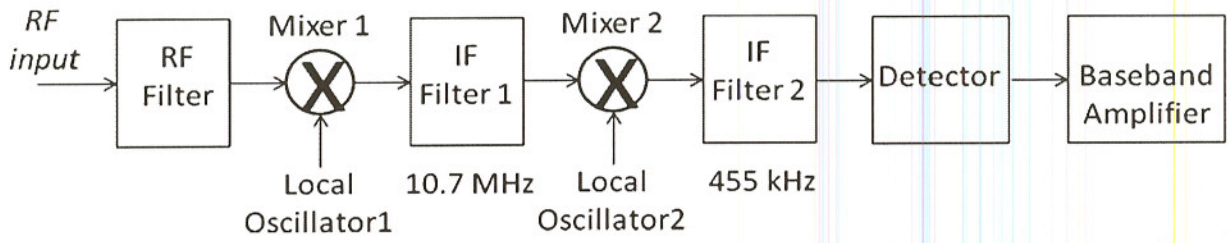
(b) $g(t) = A_c[1 + m(t)]$ for AM

$= 500\left(1 + \frac{2}{5}\sin W_a t\right)$

$= x(t) + jy(t)$

$x(t) = 500\left(1 + \frac{2}{5}\sin W_c t\right)$ $\quad y(t) = 0$

2. (25 pts). An FM radio is tuned to receive FM broadcasting stations of frequency between 144 and 148 MHz. A block diagram for the radio receiver is shown below. The radio receiver is the dual-conversion type that has two mixers and two IF filters. Suppose that the first IF filter is set at 10.7 MHz and the second one is set at 455 kHz. Determine the frequencies of the local oscillators 1 and 2.



Since the RF input has fuequencies between 144 – 148 MHZ, the Local oscillator 1 must have fuequency between 154.7 MHz and 158.7 MHz to bring the RF input to the first IF filter fuequeny 10.7 MHz.

Similarly, to bring the signal at the first IF filter to 455 kHz at the second IF filter, the Local oscillator 2 must have fregueny of 11.155 MHz.

3. (25 pts). Signal in the channel, $s(t)$, is shown to be $s(t) = 500\cos\left[w_c t + 20\cos w_1 t\right]$ where

$f_1 = \frac{w_1}{2\pi} = 1\ kHz$ and $f_c = \frac{w_c}{2\pi} = 100$ MHz.

(a) If $s(t)$ is a phase modulated signal with the phase deviation constant = 100 rad / V, determine $m(t)$.

(b) If $s(t)$ is a frequency modulated signal with the frequency deviation constant = 10^6 rad / $(\text{V} \bullet \text{second})$, determine $m(t)$.

(a) $\theta(t) = D_p m(t) = 20\cos\omega_1 t$

$= 100 \cdot m(t)$

$m(t) = \frac{20}{100}\cos(2\pi \cdot 1k \cdot t)$

$m(t) = 0.2\cos(2\pi \cdot 1k \cdot t)$

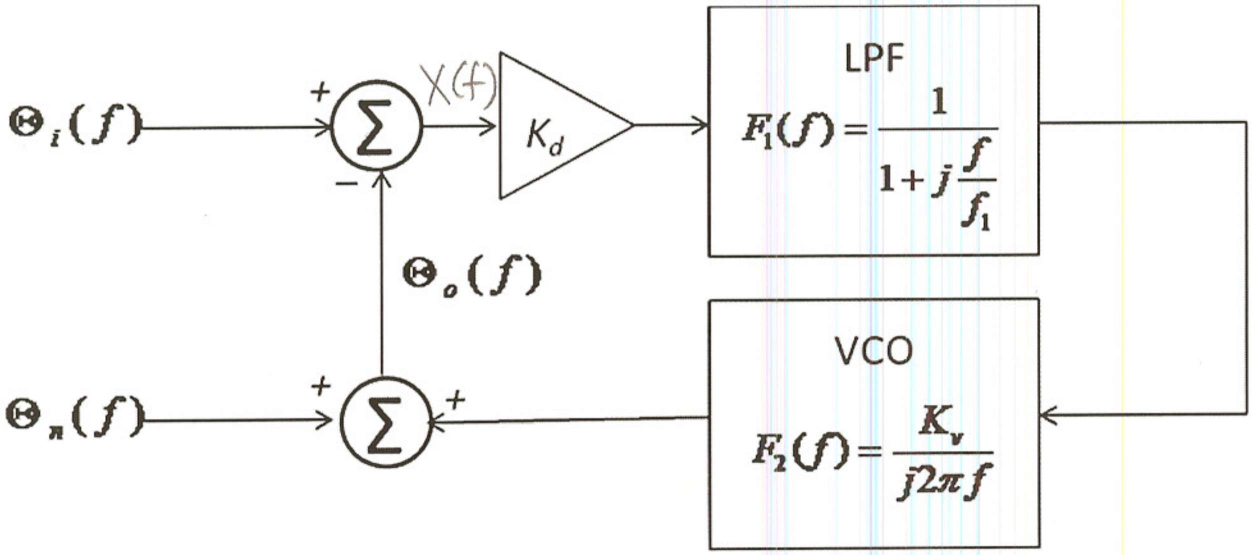
(b) $\theta(t) = D_f \int_{-\infty}^{t} m(\lambda)\,d\lambda = 20\cos\omega_1 t$

$m(t) = \frac{1}{D_f}\frac{d}{dt}(20\cos\omega_1 t)$

$m(t) = \frac{-20\,\omega_1}{10^6}\sin\omega_1 t$

$m(t) = -\frac{4\pi}{100}\sin(2\pi \cdot 1k \cdot t)$

4 (25 pts). The following is a baseband model for a PLL. Phase noise, $\Theta_n(f)$, is added in the process. Determined $\Theta_o(f)$ in terms of $\Theta_i(f)$ and $\Theta_n(f)$.



$$X(f) = \Theta_i(f) - \Theta_o(f)$$

$$\Theta_o(f) = X(f)\cdot K_d \cdot F_1(f) \cdot F_2(f) + \Theta_n(f)$$

$$= \left(\Theta_i(f) - \Theta_o(f)\right) \cdot K_d \cdot F_1(f) \cdot F_2(f) + \Theta_n(f)$$

$$\left(1 + K_d \cdot F_1(f) \cdot F_2(f)\right)\Theta_o(f) = \Theta_i(f) \cdot K_d \cdot F_1(f) \cdot F_2(f) + \Theta_n(f)$$

$$\Theta_o(f) = \frac{K_d \cdot F_1(f) \cdot F_2(f)}{1 + K_d \cdot F_1(f) \cdot F_2(f)}\,\Theta_i(f) + \frac{1}{K_d \cdot F_1(f) \cdot F_2(f)}\,\Theta_n(f)$$