EE 567

Homework 8

Due Monday, November 13, 2017

Work all 4 problems.

Problem 1. A receiver front end has a noise figure of 8 dB and a gain of 60 dB and a bandwidth of 12 MHz. The input signal power is 10^{-11} W. The antenna temperature is 175 K. Find $T_e,\ T_s,\ N_{out},\ SNR_{in}$ and SNR_{out}.

Problem 2. EE 567 2017 Midterm Exam Problem 7. In class we considered an ideal (no noise) reception of a BPSK signal

$$r(t) = A\cos(2\pi f_c t)$$

where A has the same sign for T seconds. We showed how to process this signal to determine the information (i.e., the sign of A) by mixing this signal with a locally generated signal and then integrating for T seconds (lowpass filtering) before making our decision. Suppose at the receiver we do not know the exact value of f_c (we do know the phase is 0) so we use $f_c + \Delta f$ for the frequency in the local mixing signal. Hence, Δf represents a frequency error. If $T = 1$ second find the largest value of Δf so that the power in the signal after lowpass filtering is not degraded more than 1 dB relative to the case when $\Delta f = 0$.

You can write your answer as a function of the sinc function where $\text{sinc}(x) = \sin(\pi x)/(\pi x)$.

Note: You may assume that $f_c \gg 1/T$ so that after lowpass filtering any terms containing sinusoids with high frequencies may be ignored.

Problem 3. EE 567 2017 Midterm Exam Problem 8. In class we considered the linearized model of a PLL via

$$\frac{d\phi_e(t)}{dt} + 2\pi k_0 \int_{-\infty}^{\infty} \phi_e(\tau)h(t-\tau)d\tau = \frac{d\phi_1(t)}{dt}$$

where $\phi_1(t)$ was the input phase to be tracked and $\phi_e(t) = \phi_1(t) - \hat{\phi}_1(t)$ was the resulting phase estimate error. Suppose the transfer function of the loop filter, $H(f)$, is of the form

$$H(f) = \frac{1}{j2\pi f + \sqrt{2}}.$$

Find the closed loop transfer function, that is, find the transfer function relating the Fourier transform of the estimate of $\phi_1(t)$ to the Fourier transform of $\phi_1(t)$.

Problem 4. EE 567 2017 Midterm Exam Problem 9. Suppose you transmit to someone the message signal

$$m(t) = \begin{cases} \dfrac{\sin^2(t)}{t^2}, & t \neq 0, \text{ msec} \\ 1, & t = 0. \text{ msec.} \end{cases}$$

The actual transmission is accomplished by using DSB-SC via

$$s(t) = m(t)\cos(2\pi f_c t)$$

where, $f_c = 1$ MHz. At the receiver a bandpass filter is applied to $s(t)$. Suppose an ideal bandpass filter $H_B(f)$ is used with height unity centered at $\pm f_c$ that extends from $f_c - B$ to $f_c + B$ and $-f_c - B$ to $-f_c + B$.

Let us define a distortion measure as

$$D_B = 20 \cdot \log_{10} \frac{\int_{-\infty}^{\infty} |S(f)H_B(f)|df}{\int_{-\infty}^{\infty} |S(f)|df} \quad \text{(dB)}$$

so that no distortion corresponds to $D_B = 0$ dB. Determine the smallest value of B such that $D_B > -1$ dB.