EE 564

Homework 9

Due Monday April 28, 2014

Work 2 problems.

Problem 1. Suppose the input to a decision-feedback PLL (DFPLL) is a signal of the form

$$s(t) = A\cos[2\pi f_c t + \phi(t)]$$

and it is corrupted by additive narrowband noise

$$n(t) = x(t)\cos 2\pi f_c t - y(t)\sin 2\pi f_c t$$

where $x(t)$ and $y(t)$ are independent stationary Gaussian noise processes with (two-sided) power spectral density $N_0/2$ W/Hz. This may be written as

$$n(t) = n_i(t)\cos[2\pi f_c t + \phi(t)] - n_q(t)\sin[2\pi f_c t + \phi(t)]$$

where

$$\begin{aligned} n_i(t) &= x(t)\cos\phi(t) + y(t)\sin\phi(t) \\ n_q(t) &= -x(t)\sin\phi(t) + y(t)\cos\phi(t). \end{aligned}$$

This receive signal is multiplied by the quadrature carriers

$$\begin{aligned} c_i(t) &= \cos(2\pi f_c t + \hat{\phi}) \\ c_q(t) &= -\sin(2\pi f_c t + \hat{\phi}), \end{aligned}$$

where $\Delta\phi = \hat{\phi} - \phi$. Show that the product signal is

$$\begin{aligned} r(t)\cos(2\pi f_c t + \hat{\phi}) &= \frac{1}{2}\left[A(t) + n_i(t)\right]\cos\Delta\phi \\ &- \frac{1}{2}n_q(t)\cos\Delta\phi + \text{ double frequency terms.} \end{aligned}$$

Problem 2. The detector makes a decision on the symbol that is received every T seconds. In the absence of errors this decision results in the value $A(t)$. The decision $A(t)$ is the used to multiply the product signal involving the second quadrature carrier $c_q(t)$ which has been delayed by T seconds. Show that the resulting error signal that drives the lop filter is

$$e(t) = \frac{1}{2}A^2(t)\sin\Delta\phi + \frac{1}{2}A(t)\left[n_i(t)\sin\Delta\phi - n_q(t)\cos\Delta\phi\right] + \text{ double frequency terms.}$$