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ELEC 5606 **Assignment #2** **Prof. J.S. Wight**

Due: November 11, 2025

1. A frequency modulated signal having a peak frequency deviation, $\Delta\omega i = 2\pi\ (5\text{x}10^3)$ rad/sec is applied to a second order loop. As the modulating frequency is increased, the phase error reaches a maximum value at $\Omega=2\pi\ (10^3)$ rad/sec. At this same modulating frequency, the output U_2 from the loop filter provides a transfer function magnitude $m_o\ /\ m_i = 2\text{dB}$

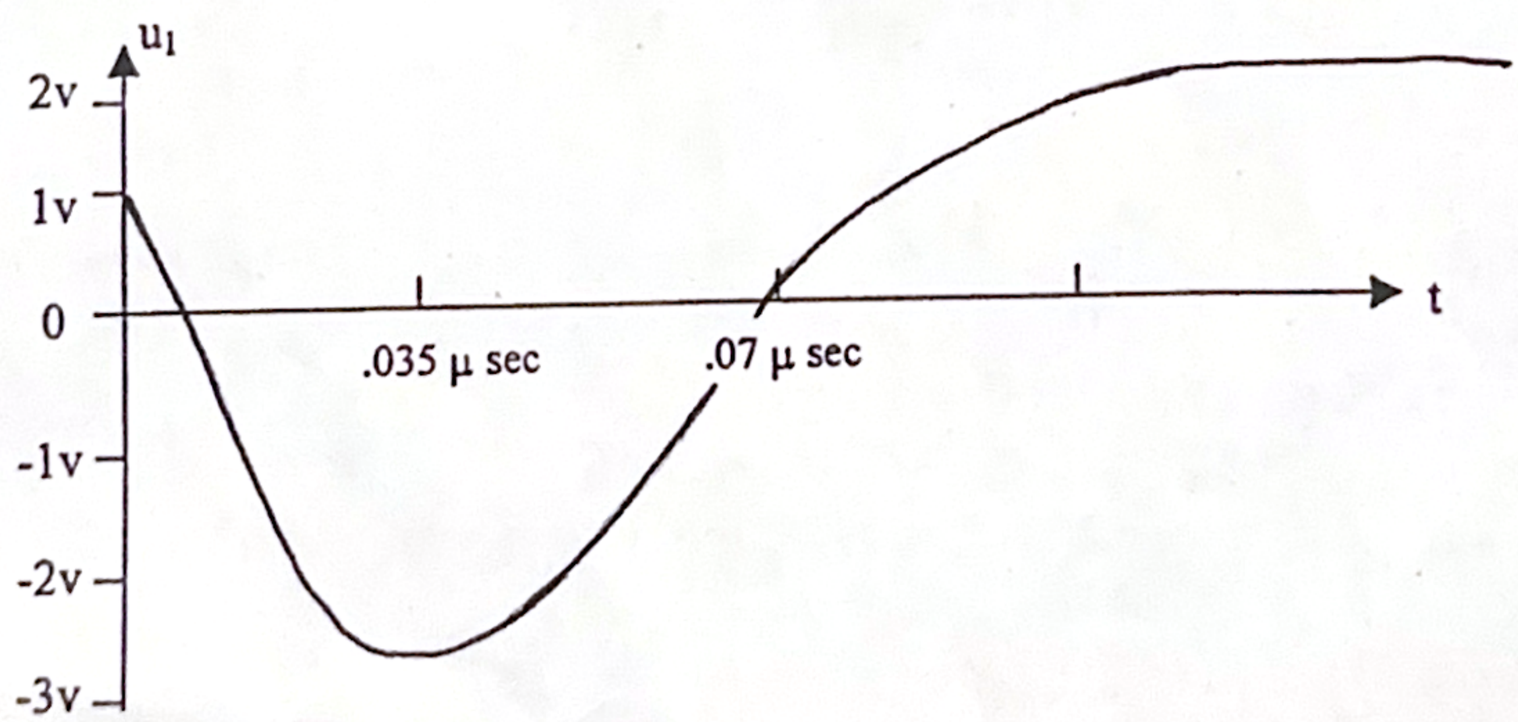
   - What are the values for the loop natural frequency and damping constant?

2. A signal having an initial frequency offset (with respect to the loop VCO) of $5\pi \text{ x } 10^6$ rad/sec is applied to a loop having a synchronization bandwidth $K = 4\pi \text{ x } 10^6$ rad/sec. The loop then tunes to a frequency offset of $3\pi \text{ x } 10^6$ rad/sec.

   - What type of loop is this?

3. The phase detector output voltage u_1 for a first order loop was observed as the loop acquired lock to a 5 MHz offset input.

   - What is the phase detector sensitivity value and what is the VCO sensitivity value?



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4. An incoming signal to a receiver is frequency modulated by a signal occupying the spectrum of 100 Hz to 5 KHz.

   The signal has a power level of S = -100 dBm.

   The incoming Gaussian noise has a one-sided power spectral density of N_o = -168 dBm / Hz.

   - Using a second order loop with a loop filter $(1 + \tau_2 s) / (1 + \tau_1 s)$ such that $\xi = 1 / \sqrt{2}$, choose K and ω_n.
   - What frequency deviation Δf_i can be used such that the maximum modulation induced phase error is 0.5 radians?
   - What is the VCO phase variance due to noise?
   - Calculate the Signal-to-Noise Ratio at the Discriminator output.

5. A signal applied to a PLL demodulator has a frequency modulation with a Power Spectral Density given by:

$$S\left(\frac{W}{Hz}\right) = \frac{5.75\ x\ 10^{-9}}{f^2+1}$$

   This signal is accompanied by White Additive Gaussian noise having a Power Spectral Density of:

$$S\left(\frac{W}{Hz}\right) = 4\ x10^{-17}$$

   - Determine the optimum Transfer Function (as defined by Wiener) in order to minimize the difference in the variance of the Transfer Function output signal and the input modulation.
   - What loop geometry will provide this Transfer Function?
   - What is the loop Synchronization Bandwidth?