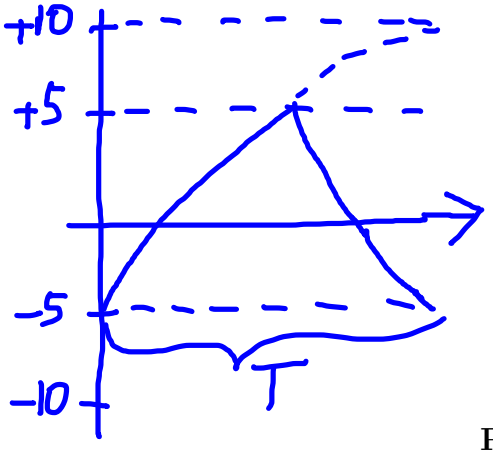
EE 322 Advanced Electronics, Spring 2013
Exam 3
Friday April 26, 2013

Rules: This is a closed-book exam. You may use only your brain, a calculator and pen/paper. Each numbered question counts equally toward your grade.

Note: The questions are designed to test your conceptual understanding, not your ability to do many pages of math. If you find yourself doing long calculations there is a high probability that you are doing something wrong.

Relaxation Oscillators

1. A relaxation oscillator has $L_+ = -L_- = 10\,\text{V}$ and $V_{TH} = -V_{TL} = 5\,\text{V}$, and time-constant $\tau = 1\,\text{ms}$. What is the oscillation period?



$$\Rightarrow e^{-\frac{T}{2\tau}} = \frac{1}{3}$$

$$T = 2\tau \ln 3$$

$$= 2 \cdot 10^{-3} \ln 3$$

$$= 2.20\,\text{ms}$$

PLLs

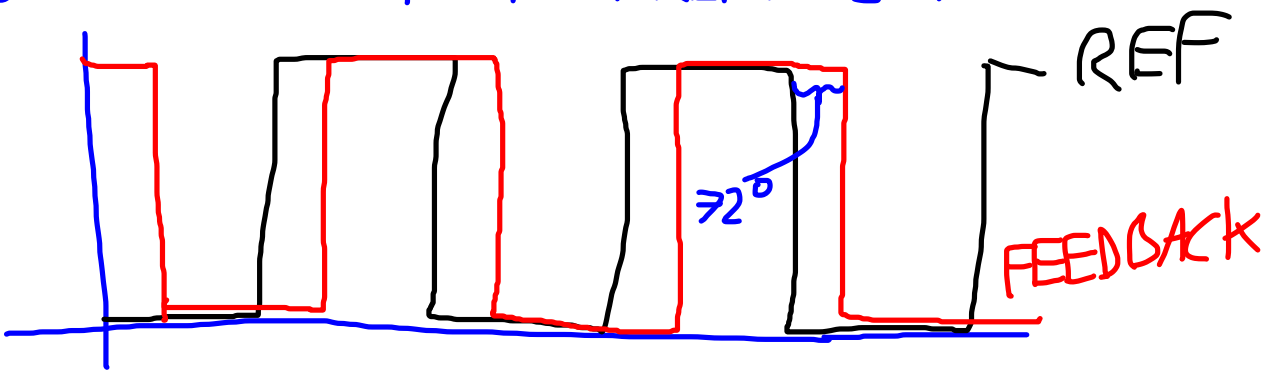
Consider a PLL with a XOR phase detector producing output levels of 0 and 5 V. The VCO is modeled as $f = 2\,\text{kHz} + 1\,\frac{\text{kHz}}{\text{V}} \times V_{\text{in}}$, and the VCO output is fed directly back to the phase detector without division.

2. For $f = 4\,\text{kHz}$ compute the phase difference between the reference signal and the feedback signal (both have 50% duty cycle) and sketch several periods with the phase labeled accurately.

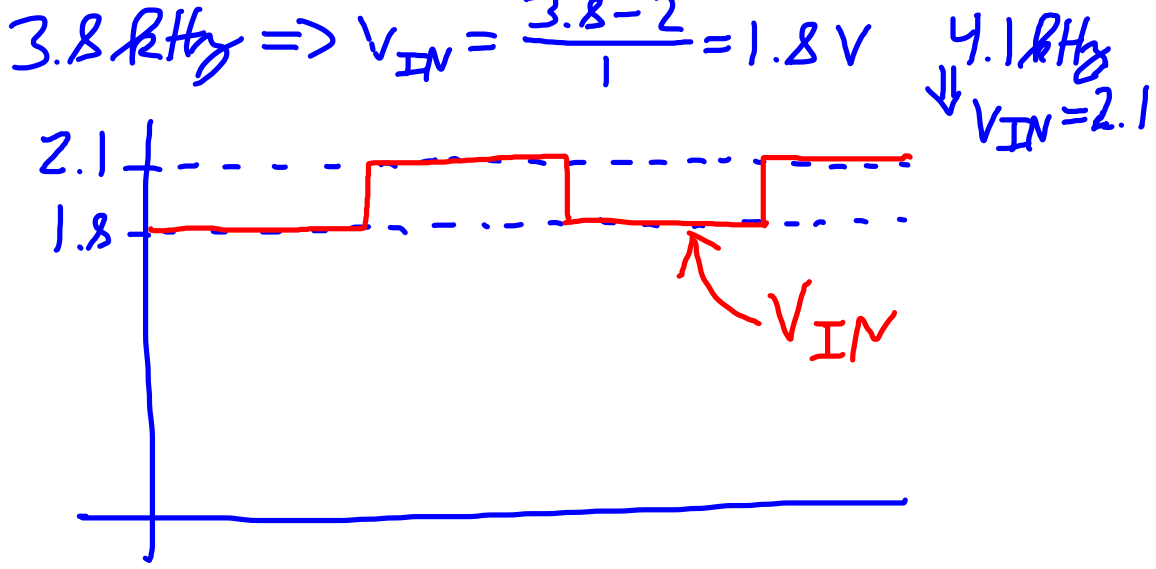
PLL INPUT IS $\frac{4-2}{1} = 2\,\text{V}$

THEN WE HAVE $\frac{\Delta\varphi}{180} = \frac{2}{5} \Rightarrow \Delta\varphi = 72^\circ$

POSITIVE SLOPE MEANS REFERENCE LEADS.

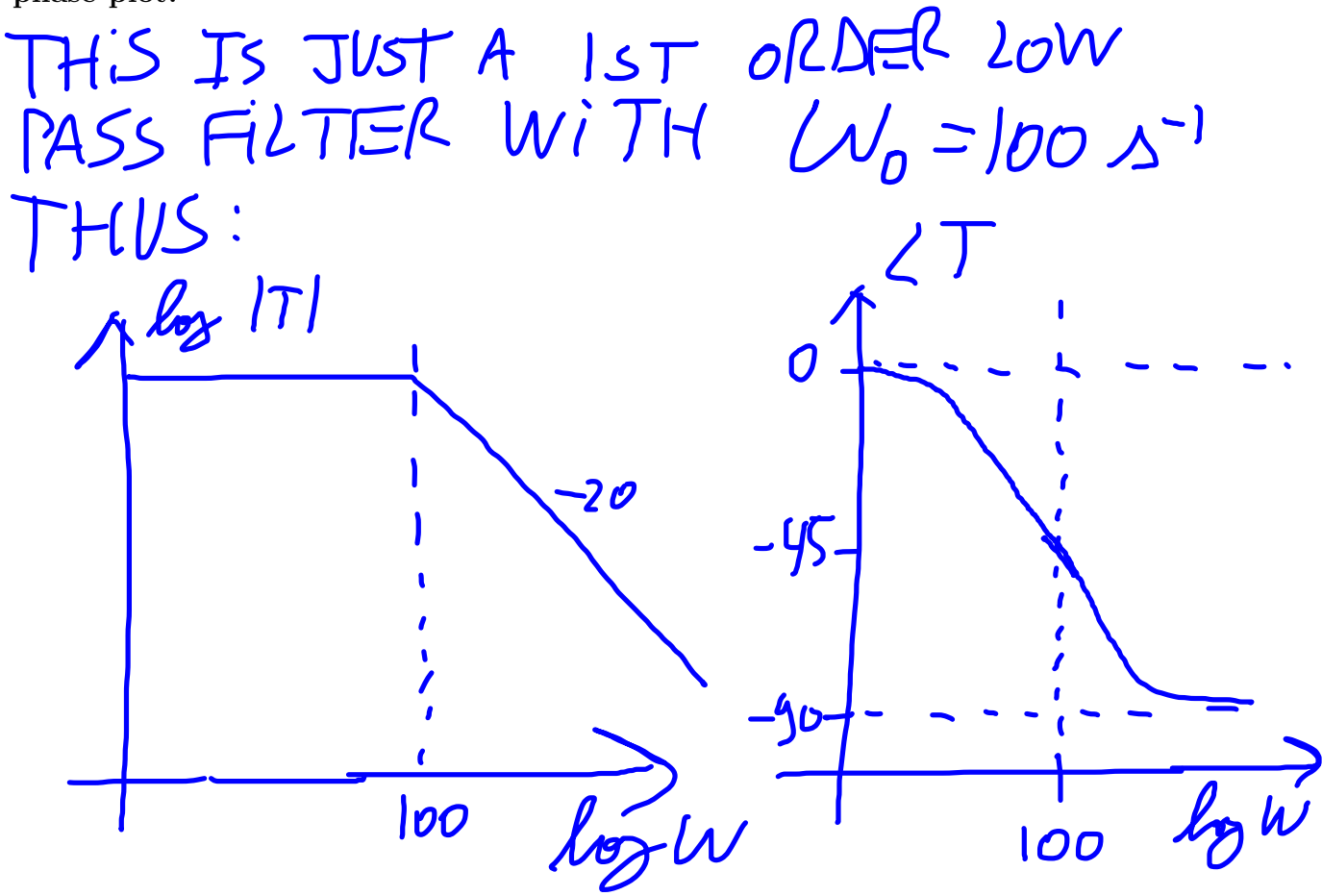


3. **For the same PLL sketch the input to the VCO to scale when the input signal is frequency-shift-key modulated between 3.8 kHz and 4.1 kHz.**

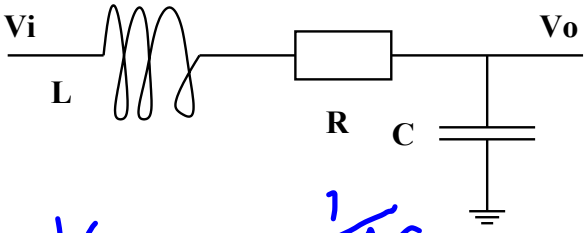


Filters

4. **Accurately plot the amplitude and phase of a filter which has a single pole at $-100 + j0$ rad/s. Use log-log for the amplitude plot and log-lin for the phase plot.**



5. **Derive the transfer function for this filter as a ratio of polynomials in s.**



$$\frac{V_o}{V_I} = \frac{\frac{1}{sC}}{\frac{1}{sC} + sL + R}$$

$$= \frac{1}{1 + s^2 \cdot LC + sCR}$$

$$= \frac{\frac{1}{LC}}{s^2 + s\frac{R}{L} + \frac{1}{LC}}$$

6. **What kind of filter is it?**

LP

7. **If $L = 1\,\text{mH}$, $C = 100\,\text{nF}$, and $R = 100\,\Omega$, what are ω_0 and Q?**

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-3} \cdot 10^{-7}}} = 10^5\,s^{-1}$$

$$\frac{\omega_0}{Q} = \frac{R}{L} \Rightarrow Q = \omega_0 \frac{L}{R} = 10^5 \frac{10^{-3}}{100}$$

$$= 1$$