EE 322 Advanced Electronics, Spring 2013
Exam 4
Friday May 3, 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.

Linear regulator

A linear regulator is build from a 5.6 V Zener diode with $r_z = 5\,\Omega$ in series with a $100\,\Omega$ resistor. A input voltage is applied with mean 10 V and ripple amplitude 1 V.

1. **What is the amplitude of the ripple on the output with no load?**

$$\Delta v_0 = \frac{r_z}{R} \Delta v_I = \frac{5}{100+5} \times 1 \approx 0.05 V$$

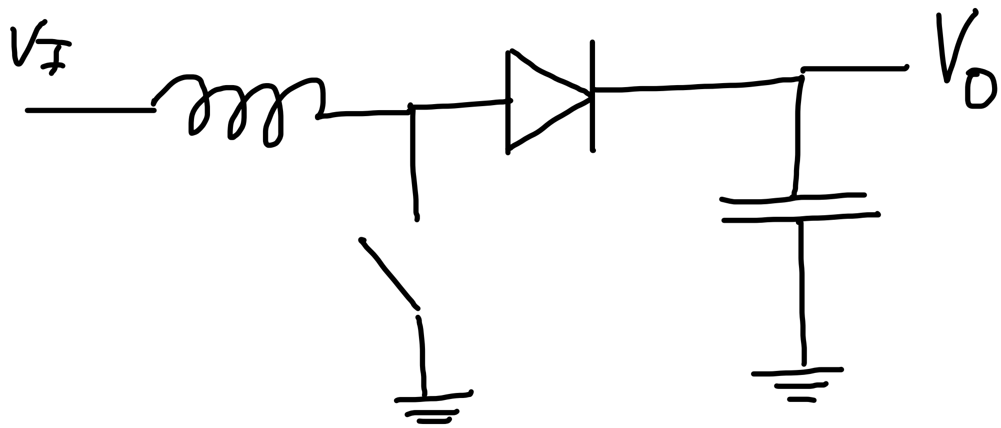
2. **At what load current is the regulator at edge of regulation at the bottom of the ripple? The edge of regulation is the point where the current through the Zener diode drops to zero.**

$$I = \frac{V_{IN} - V_{RIPPLE} - V_Z}{R} = \frac{10 - 1 - 5.6}{100} = 0.034\ A$$

$$= 34\,mA$$

Switching regulator

3. Draw the simple step-up regulator discussed by Horowitz & Hill.

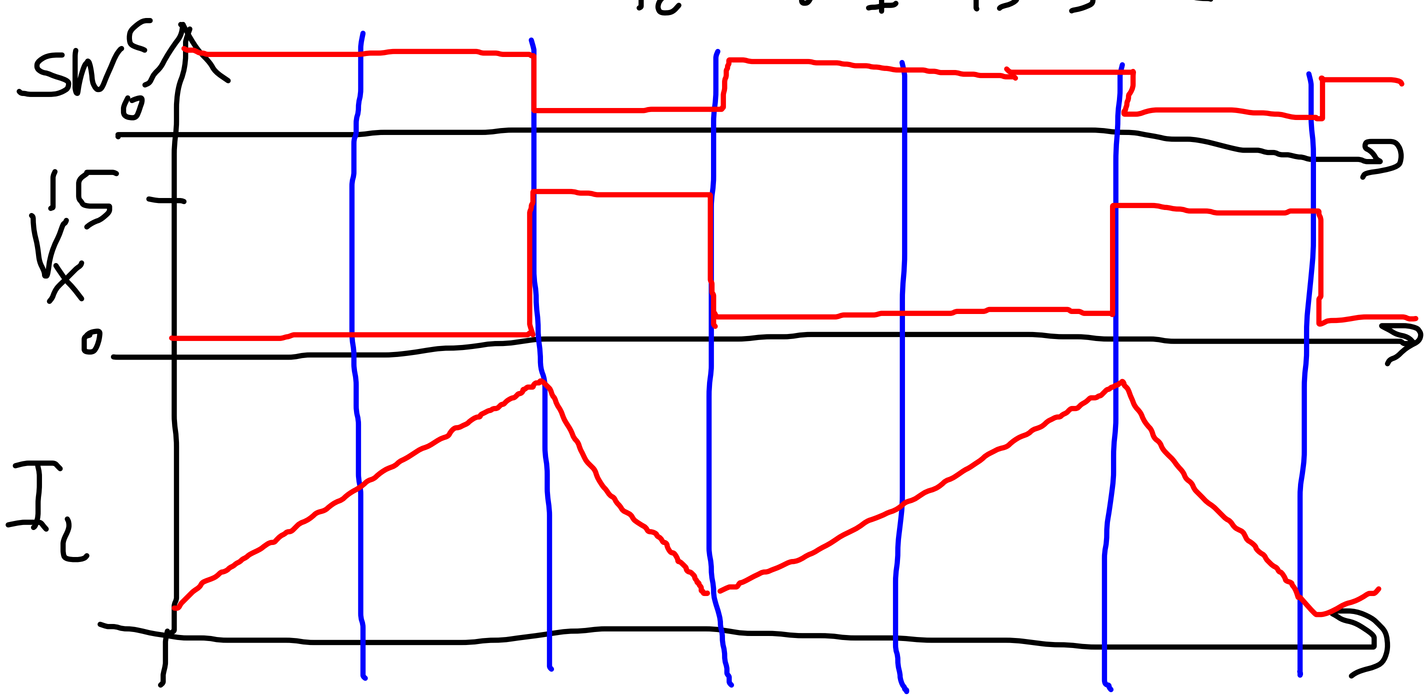


4. Plot the voltage at the point where the switch, the inductor, and the diode meet, as well as the current through the diode, to scale on both time and voltage/current axis for a input of 5 V and a output of 15 V.

FIRST DERIVE THE EQUATION $V = L\frac{dI}{dt}$ $\frac{dI}{dt} = \frac{V}{L}$

$\frac{dI}{dt}_c T_c = -\frac{dI}{dt}_o T_o$ $V_{Lc} T_c = -V_{Lo} T_o$

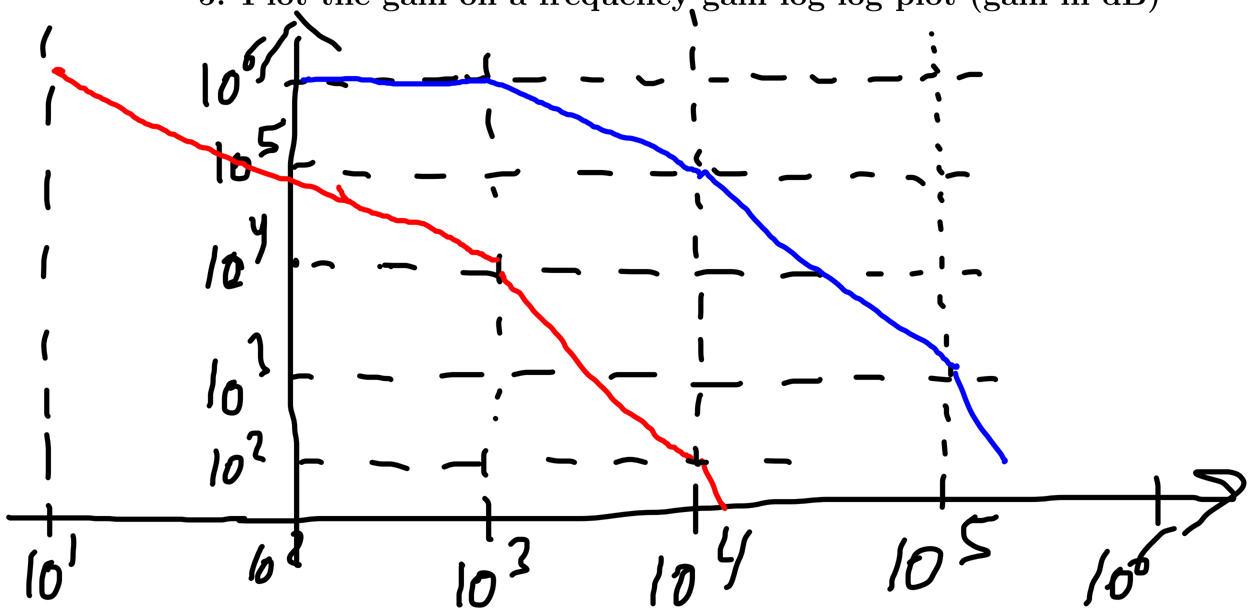
$V_I T_c = (V_o - V_I) T_o$ $\frac{T_o}{T_c} = \frac{V_I}{V_o - V_I} = \frac{5}{15-5} = \frac{1}{2}$



Bode plot stability analysis

An amplifier has open-loop DC gain $A_0 = 10^6$, poles at 1000 Hz, 10 kHz, and 100 kHz.

5. Plot the gain on a frequency-gain log-log plot (gain in dB)



6. Specify a dominant pole which will make the amplifier stable to a closed-loop gain of 10^4.

WE NEED A DOMINANT POLE WHICH WILL DECREASE THE GAIN AT 10^3 BY A FACTOR OF 10^2. THAT POLE MUST BE LOCATED AT FREQUENCY 10^2 SMALLER THAN THE POLE AT 10^3.

THUS THE NEW DOMINANT POLE IS AT FREQUENCY 10 Hz

DRAWN IN RED ABOVE.

Relaxation oscillator

A relaxation oscillator has a RC time constant $\tau = 1\,\text{ms}$, and $L_+ = 5\,\text{V}$, $L_- = 0\,\text{V}$, $V_{TH} = 4\,\text{V}$, and $V_{TL} = 1\,\text{V}$.

7. Compute the oscillation period.

THE TWO HALF OSCILLATION PERIODS ARE OF THE SAME DURATION. THUS:

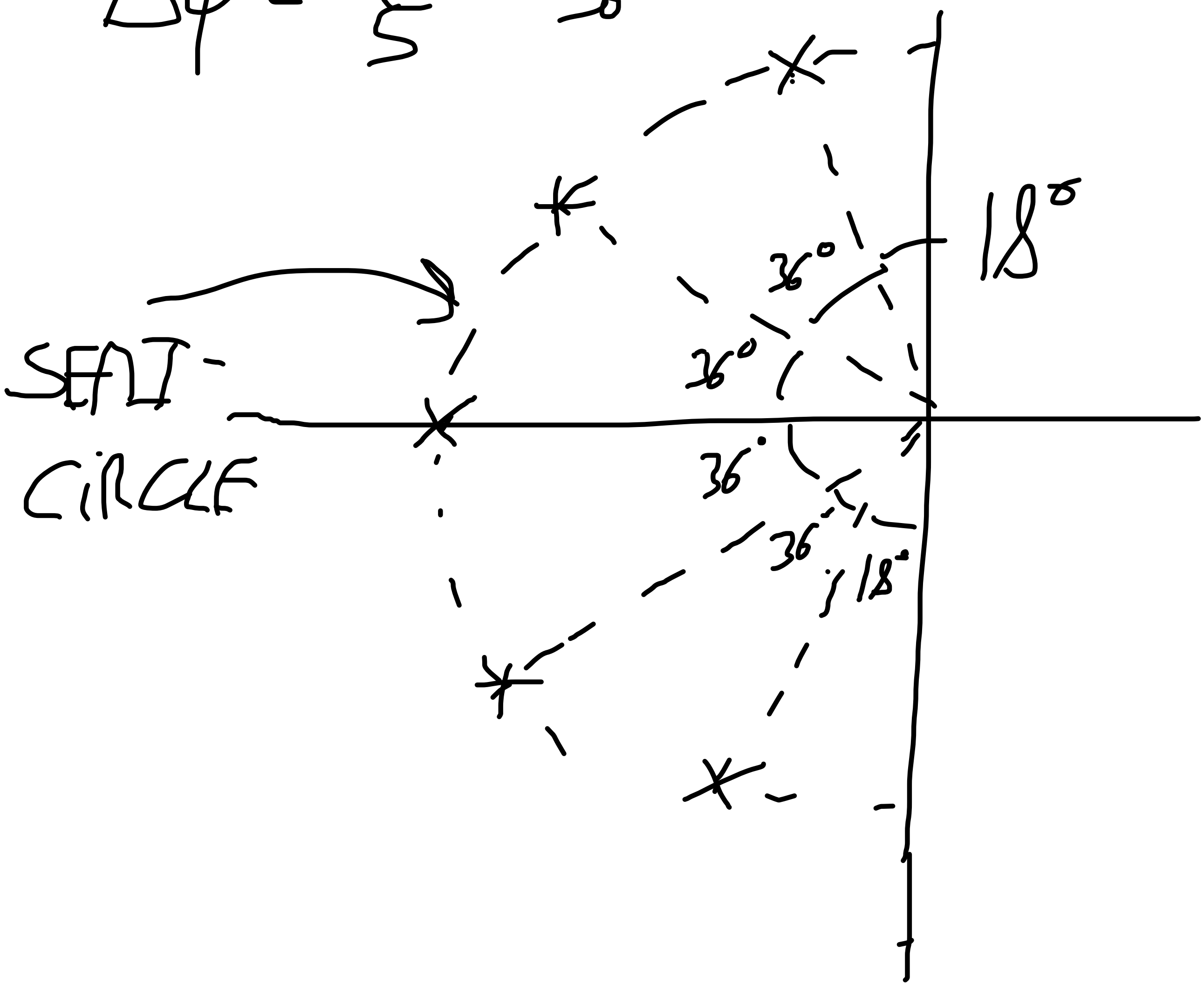
$$e^{-\frac{T/2}{\tau}} = \frac{1}{4}$$

$$T = 2\tau \ln 4 = 2.77\ \text{ms}$$

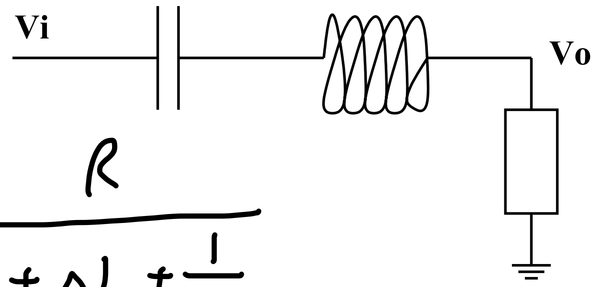
Active filter

8. Draw the pole-zero plot for a 5th-order Butterworth filter, providing all necessary information to evaluate the accuracy of your plot.

$$\Delta\varphi = \frac{180^\circ}{5} = 36^\circ$$



9. **For the following circuit give Q and ω_0.**



$$\frac{v_O}{v_I} = \frac{R}{R + sL + \frac{1}{sC}}$$

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

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

$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad \frac{\omega_0}{Q} = \frac{R}{L}$$

$$Q = \frac{L\omega_0}{R} = \frac{L}{R\sqrt{LC}} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

10. **What kind of filter is this?**

FILTER MAGNITUDE GOES TO ZERO AT HIGH AND LOW FREQUENCY AND IT HAS A FACTOR s IN THE NUMERATOR. IT MUST BE A BANDPASS FILTER.