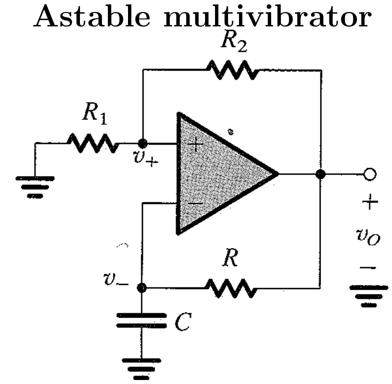
EE 322 Advanced Electronics, Spring 2013
Exam 2
Wednesday April 3, 2013

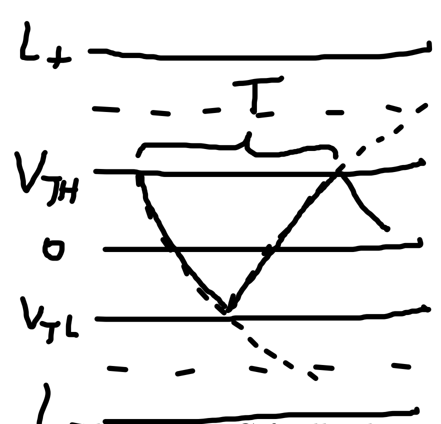
Rules: This is a closed-book exam. You may use only your brain, a calculator and pen/paper. Each numbered question counts equally toward your grade.

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.

Astable multivibrator



1. If $R_2 = 2R_1$, and $R = 1\,\mathrm{k}\Omega$, and $C = 1\,\mu\mathrm{F}$, what is the oscillation period of this astable multivibrator?

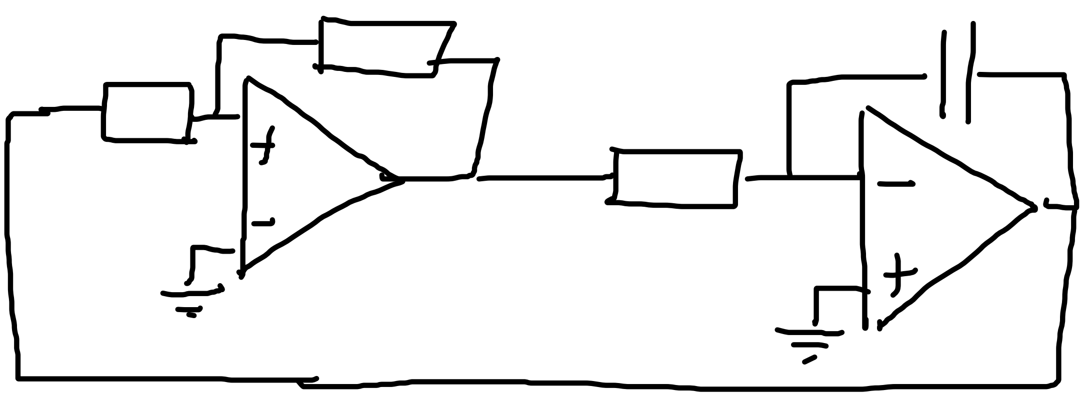


$$e^{-\frac{T/2}{\tau}} = \frac{1}{2}$$

$$T = 2\tau \ln 2 = 2RC \ln 2$$

$$= 2\cdot 10^{-3} \ln 2 = 1.39\ \text{ms}$$

2. Replace the RC feedback circuit with a integrator to create a triangle wave generator (does the integrator output feed back to the inverting or non-inverting?)



3. If the output saturation levels are $L_+ = -L_- = 5\,\text{V}$, and the integrator input resistance is $100\,\text{k}\Omega$, pick the capacitor of the integrator to produce a period of 1 ms.

$$Q = CV = \frac{T}{2} I = C(V_{TH} - V_{TL}) = \frac{T}{2}\frac{L_+}{R}$$

$$C = \frac{T}{2}\frac{L_+}{R}\frac{1}{V_{TH} - V_{TL}}$$

$$= \frac{10^{-3}}{2}\frac{5}{10^5}\frac{1}{10/3} = 7.5\,\text{nF}$$

Stability

An amplifier has poles at 10^3, 10^5, and 10^7 Hz and DC gain 10^6.

4. To what gain is it stable with 45° phase margin?

45° STABILITY IS AT SECOND POLE. AT SECOND POLE GAIN IS DOWN BY 10^2. THUS THE AMPLIFIER IS STABLE TO $10^6/10^2 = 10^4$.

5. Specify a dominant pole that will make it stable to a gain of 10^3.

THE FIRST POLE BECOMES THE SECOND POLE AND MUST BE PUSHED DOWN BY FACTOR 10^3. THUS NEW DOMINANT POLE MUST BE AT FREQUENCY 10^3 SMALLER.

$$\frac{10^3\,\text{Hz}}{10^3} = 1\,\text{Hz}$$

6. What is the bandwidth of both the modified and unmodified amplifier when used with feedback that produces a closed-loop gain of 10^4?

THE UNMODIFIED HITS 10^4 AT 10^5 Hz SO THAT IS ITS BANDWIDTH.

THE MODIFIED HITS 10^4 AT 10^2 Hz SO THAT IS ITS BANDWIDTH.

Linear oscillator

Consider a phase shift oscillator which consists of three LP filters followed by a inverting amplifier that feeds back in to the string of LP filters. Notice this is different from the textbook's HP filters. For simplicity assume the LP filters are buffered.

7. What will be the phase of each LP filter at oscillation?

-60°

8. What will be the oscillation frequency in terms of the LP filter time-constant τ? Be careful the answer is a little different from the one you memorized from the book.

THE TRANSFER FUNCTION IS $T = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{1}{1 + j\omega RC}$

FOR PHASE TO BE -60° PHASE OF DENOMINATOR MUST BE 60° $= \frac{1}{1 + j\omega\tau}$

$\omega\tau = \tan 60^\circ = \sqrt{3}$

$\omega = \frac{\sqrt{3}}{\tau}$