Duke University
Department of Physics

Physics 271 Spring Term 2017

WUN2K FOR LECTURE 19

These are notes summarizing the main concepts you need to understand and be able to apply.

- *Operational amplifiers* are the standard implementation of a high-input-impedance, low-output-impedance, high open-loop gain amplifier introduced in lecture 10. They are usually employed with negative feedback. Their transfer functions are typically those of low-pass filters with gain. Standard notation is $A(j\omega)$ for open-loop gain, $H(j\omega)$ for closed-loop gain, and $G(j\omega)$ for approximate closed-loop gain.

- The rules for ideal op-amps (with negative feedback) are:

  1. The current drawn by both inputs is zero.
  2. The op-amp does whatever it needs to do at the output to make the voltage difference between the inputs zero.

  A real op-amp doesn't follow these rules perfectly, but the rules are very helpful for understanding circuit behavior.

- The ideal op-amp rules can be used to understand and devise many useful circuits. Some examples:

  - Noninverting amplifier: feedback network with R_2 between output and V_- input, R_1 between V_- input and ground. The gain is $G(j\omega) = \frac{R_2+R_1}{R_1}$.
  - Inverting amplifier: feedback network with R_1 between input and V_- input, R_2 between V_- input and output. The gain is $G(j\omega) = -\frac{R_2}{R_1}$.

- Current summing junction: with a resistor R between $-$ input and output, $V_{\text{out}} = -RI$. One can sum current sources, or also sum voltages by putting them across resistors in parallel at the input.
- Differentiator: replacing R_1 of the inverting amplifier with a capacitor results in a circuit with $G(j\omega) = -j\omega RC$, which is a high-pass filter that differentiates at low frequency. In combination with the open-loop low-pass properties of the op-amp, one gets an (active) band-pass filter.
- Integrator: replacing R_2 of the inverting amplifier with a capacitor results in a circuit with $G(j\omega) = -\frac{1}{j\omega RC}$, which is a low-pass filter that integrates at high frequency. In combination with the open-loop low-pass properties of the op-amp, one gets a lower-gain (active) low-pass filter.