Quiz 2 Review Sheet

6.101 Analog Electronics Lab

March 19, 2007

Study Materials

- Class handouts
- Labs 4-5
- Neaman, Chapter 9. Section 15.3 through 15.4.1.

Opamp Operation

Ideal Opamp assumptions:

- The output attempts to make the voltage difference between its inputs zero (at least with negative feedback).
- The inputs draw no current.
- $v_+ = v_-$

More General Relations:

- $V_{out} = A_v(v_+ - v_-)$
- Gain bandwidth product is constant. If you increase the gain in a negative feedback situation you decrease the bandwidth. The op amp can be generalized as a one pole system with high DC gain, a long time constant producing a low frequency dominant pole which results in a high unity gain frequency.
- Op amp generally has good supply rejection, common mode rejection, low output resistance (due to feedback), and high input resistance.

Opamp Configurations:

- Inverting configuration - $A_v = -\frac{R_f}{R_{in}}$
- Non-inverting configuration - $A_v = 1 + \frac{R_f}{R_{in}}$
- General finite open loop gain analysis result: $\frac{V_{out}}{V_{in}} = \frac{A}{1+\beta A}$ where β is the feedback transfer function, generally a resistor divider back to the input. See class handout.
- Integrator - $A_v = -\frac{1}{sC_{int}R_f}$ for frequencies about an order of magnitude above $f_{3dB} = \frac{1}{2\pi R_f C_{int}}$
- Differentiator - $A_v = -sC_{diff}R_{in}$ for frequencies about an order of magnitude below $f_{3dB} = \frac{1}{2\pi R_{in} C_{diff}}$
- Precision rectifier - No recovery time or diode drop, rectifies to zero.

- Bipolar output stage - Feedback reduces crossover distortion.
- AGC - Dynamically adjust gain based on signal level.
- Difference Amplifier:

$$v_o = \left(1 + \frac{R_f}{R_1}\right)\left(\frac{\frac{R_3}{R_2}}{1 + \frac{R_3}{R_2}}\right) v_2 - \frac{R_f}{R_1} v_1$$

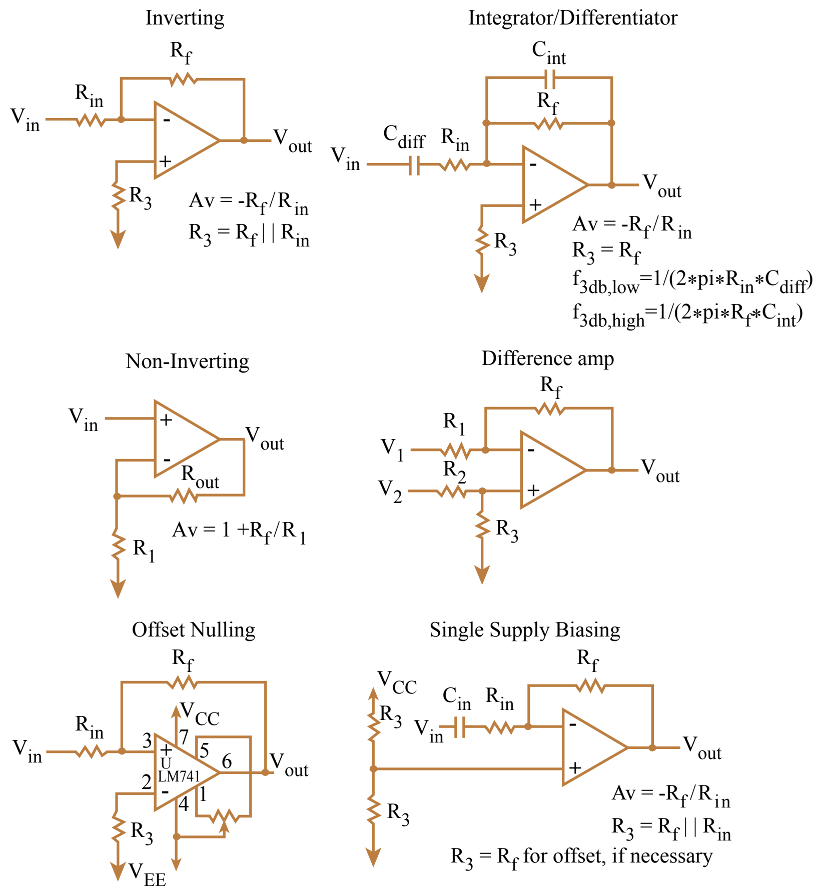
  If $\frac{R_3}{R_2} = \frac{R_f}{R_1}$ then $v_o = \frac{R_f}{R_1}(v_2 - v_1)$.
- Single supply bias circuits - bias the positive input at a DC value if only one supply is available.
- Offset nulling circuits - use a potentiometer and the offset nulling pins to reduce the offset voltage. Also, use resistors on the positive input to reduce offset as in the case of the inverting amplifier. If there is no DC path to ground due to an input coupling capacitor then the offset resistor is simply the feedback resistor (see diagrams).
- Comparator - set one input as a reference and move the other input above and below this reference to send the output to either rail.
- Schmitt trigger - Uses positive feedback, changes its reference levels to create hysteriesis. Neaman 15.3
- Astable Oscillator - uses a Schmitt trigger approach. Charge and discharge capacitor with output voltage to bounce between reference levels. Neaman 15.4.1.
- Adder - use multiple input resistors for different inputs and a single R_f. Use superposition to combine contribution from each source.

Benefits of Feedback:

- Stabilize gain against device variations - temperature, process mismatch, power supply.
- Reduces distortion, rejects disturbances.
- Lowers output impedance, raises input impedance.
- **However** - Feedback can lead to oscillations and loss of stability, and reduces stage gain. Care must be taken in designing feedback systems.

DB

- DB - $dB = 10 \log\left(\frac{P_{out}}{P_{in}}\right) = 20 \log\left(\frac{V_{out}}{V_{in}}\right)$



Some common opamp circuit configurations.

Figure by MIT OpenCourseWare.