Summary of Covered Topics

**Important concepts:**
- Impedance
- Amplification
- Frequency/Fourier Analysis
- Feedback

**Important electronics components and equipment:**
- Resistors, capacitors, inductors.
- Special components: transformers, photodiodes, thermistors, and Peltier coolers.
- Diodes, BJTs, and FETs.
- Op-amps and comparators.
- Multimeters, oscilloscopes, and function generators.
- Breadboards, prototyping boards, and soldering irons.
- Circuit simulation and layout software.
Final Exam

- Tuesday, April 29, 2008: Small Hall 238, 1:30pm-4:30pm.
- 3 hours long.
- It will cover all the topics covered in the class and lab.
- You can expect some variations on the quiz and design exercise materials.
- Some questions will be on practical lab knowledge.
- Some problems will involve combining knowledge from different chapters.
Physics 351: Electronics II
What to expect?

- Mostly **DIGITAL** electronics
  - Logic gates.
  - Operations.
  - ADCs, DACs, and opto-couplers.
  - Counters, registers, and digital memory.

- A fair bit on **FPGAs**
  - C-like programming.
  - Complex digital circuits.

- A little bit on **microprocessors**
  - C programming.

- **Digital Signal Processing (DSP)** ... or how to make an analog circuit with digital concepts.
Voltage Regulators (I)

Voltage regulators produce a constant output voltage despite variations in the input.

Pin 1. Input  
2. Ground  
3. Output

TO-220-3  
Heatsink surface connected to Pin 2.

Input \[ C_{in}^* \] 0.33 \( \mu F \) \[ C_0^{**} \] Output

MC78XX
Voltage Regulators (II)

MC7800, MC7800A, MC7800AE, NCV7800

ELECTRICAL CHARACTERISTICS \((V_{\text{in}} = 10 \text{ V}, I_{\text{O}} = 500 \text{ mA}, T_{\text{J}} = T_{\text{low}} \text{ to } 125^\circ \text{C} \text{ (Note 1)}, \text{ unless otherwise noted})\)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>MC7805B, NCV7805</th>
<th>MC7805C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage ((T_J = 25^\circ \text{C}))</td>
<td>(V_O)</td>
<td>4.8 5.0 5.2</td>
<td>4.8 5.0 5.2</td>
</tr>
<tr>
<td>Output Voltage ((5.0 \text{ mA} \leq I_O \leq 1.0 \text{ A}, P_O \leq 15 \text{ W}))</td>
<td>(V_O)</td>
<td>- - -</td>
<td>4.75 5.0 5.25</td>
</tr>
<tr>
<td>7.0 Vdc (\leq V_{\text{in}} \leq 20 \text{ Vdc})</td>
<td></td>
<td>8.0 Vdc (\leq V_{\text{in}} \leq 20 \text{ Vdc})</td>
<td></td>
</tr>
<tr>
<td>Line Regulation ((\text{Note 4}))</td>
<td>(R_{\text{gline}})</td>
<td>5.0 5.0 5.25</td>
<td>0.5 20</td>
</tr>
<tr>
<td>7.5 Vdc (\leq V_{\text{in}} \leq 20 \text{ Vdc, 1.0 A})</td>
<td></td>
<td>8.0 Vdc (\leq V_{\text{in}} \leq 12 \text{ Vdc})</td>
<td></td>
</tr>
<tr>
<td>Load Regulation ((\text{Note 4}))</td>
<td>(R_{\text{gload}})</td>
<td>- 1.3 100</td>
<td>- 1.3 25</td>
</tr>
<tr>
<td>5.0 mA (\leq I_O \leq 1.0 \text{ A})</td>
<td></td>
<td>5.0 mA (\leq I_O \leq 1.5 \text{ A} \text{ (T}_{A} = 25^\circ \text{C}))</td>
<td></td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>(I_O)</td>
<td>- 3.2 8.0</td>
<td>- 3.2 6.5</td>
</tr>
<tr>
<td>Quiescent Current Change ((\text{Note 4}))</td>
<td>(\Delta I_O)</td>
<td>- - -</td>
<td>- 0.3 1.0</td>
</tr>
<tr>
<td>7.0 Vdc (\leq V_{\text{in}} \leq 25 \text{ Vdc})</td>
<td></td>
<td>5.0 mA (\leq I_O \leq 1.0 \text{ A} \text{ (T}_{A} = 25^\circ \text{C}))</td>
<td></td>
</tr>
<tr>
<td>Ripple Rejection ((f = 120 \text{ Hz}))</td>
<td>(R_{R})</td>
<td>- 68</td>
<td>- 63</td>
</tr>
<tr>
<td>Dropout Voltage ((I_O = 1.0 \text{ A}, T_J = 25^\circ \text{C}))</td>
<td>(V_{I} - V_{O})</td>
<td>2.0</td>
<td>- 2.0</td>
</tr>
<tr>
<td>Output Noise Voltage ((T_A = 25^\circ \text{C})) (10 \text{ Hz} \leq f \leq 100 \text{ kHz})</td>
<td>(V_{\text{IN}})</td>
<td>- 10</td>
<td>- 10</td>
</tr>
<tr>
<td>Output Resistance (f = 1.0 \text{ kHz})</td>
<td>(R_O)</td>
<td>- 0.9</td>
<td>- 0.9</td>
</tr>
<tr>
<td>Short Circuit Current Limit ((T_A = 25^\circ \text{C})) (V_{\text{in}} = 35 \text{ Vdc})</td>
<td>(I_{SC})</td>
<td>- 0.2</td>
<td>- 0.6</td>
</tr>
<tr>
<td>Peak Output Current ((T_J = 25^\circ \text{C}))</td>
<td>(I_{\text{max}})</td>
<td>- 2.2</td>
<td>- 2.2</td>
</tr>
<tr>
<td>Average Temperature Coefficient of Output Voltage</td>
<td>(T_{C_{V}})</td>
<td>- -0.3</td>
<td>- -0.3</td>
</tr>
</tbody>
</table>

1. \(T_{\text{low}} = 0^\circ \text{C} \text{ for MC786XXC, MC786XAC,}\)
   \(= -40^\circ \text{C} \text{ for NCV78XX, MC786XXB, MC786XAB, and MC786XXAE} \text{.}\)

2. Load and line regulation are specified at constant junction temperature. Changes in \(V_O\) due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
**Comparators** are specialty op-amps designed to be used with **positive feedback** or **no feedback**.

Comparators are two-state devices which output either a **high signal** or a **low signal** depending on whether an input voltage is above or below a reference voltage.

A comparator is like an **IF** statement in computer programming.

**Op-amp equation:** \( V_{out} = Gain \times (V_+ - V_-) \)

Since \( Gain \sim 10^5-10^6 \),

If \( V_+ > V_- \), then \( V_{out} = + V_{supply} \) (HIGH)

If \( V_+ < V_- \), then \( V_{out} = - V_{supply} \) (LOW)
The LM2903 comparator

Output is configured for use with a pull-up resistor
The merits of positive feedback:

- Speed-up the choice of HIGH output or LOW output.

- Introduce **hysteresis** into comparator behavior (i.e. circuit output depends not just on the input, but on its history).

Noisy signal leads to “false” triggering.
Schmitt Trigger

Hysteresis suppresses “false” triggering due to noise.