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

- Wednesday, May 13, 2009: Small Hall 238, 2pm-5pm.
- 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

Heatsink surface connected to Pin 2.

Input

\[ C_{in}^* = 0.33 \, \mu F \]

MC78XX

Output

\[ C_{O}^{**} \]
# Voltage Regulators (II)

## MC7800, MC7800A, MC7800AE, NCV7800

### Electrical Characteristics (V\text{in} = 10 \, \text{V}, I_{\text{D}} = 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></td>
<td></td>
<td>Min</td>
<td>Typ</td>
</tr>
<tr>
<td>Output Voltage (T\text{J} = 25^\circ \text{C})</td>
<td>V\text{O}</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Output Voltage (5.0 mA ≤ I\text{D} ≤ 1.0 A, P\text{D} ≤ 15 W)</td>
<td>V\text{O}</td>
<td>4.75</td>
<td>5.0</td>
</tr>
<tr>
<td>7.0 V\text{dc} ≤ V\text{in} ≤ 20 V\text{dc}</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8.0 V\text{dc} ≤ V\text{in} ≤ 20 V\text{dc}</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Line Regulation (Note 4)</td>
<td>R\text{line}</td>
<td>5.0</td>
<td>100</td>
</tr>
<tr>
<td>7.5 V\text{dc} ≤ V\text{in} ≤ 20 V\text{dc}, 1.0 A</td>
<td></td>
<td>-</td>
<td>1.3</td>
</tr>
<tr>
<td>8.0 V\text{dc} ≤ V\text{in} ≤ 12 V\text{dc}</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Load Regulation (Note 4)</td>
<td>R\text{load}</td>
<td>1.3</td>
<td>100</td>
</tr>
<tr>
<td>5.0 mA ≤ I\text{D} ≤ 1.0 A</td>
<td></td>
<td>-</td>
<td>1.3</td>
</tr>
<tr>
<td>8.0 mA ≤ I\text{D} ≤ 1.5 A (T\text{A} = 25^\circ \text{C})</td>
<td></td>
<td>-</td>
<td>0.15</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>I\text{g}</td>
<td>3.2</td>
<td>8.0</td>
</tr>
<tr>
<td>Quiescent Current Change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0 V\text{dc} ≤ V\text{in} ≤ 25 V\text{dc}</td>
<td>\Delta I\text{g}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8.0 mA ≤ I\text{D} ≤ 1.0 A (T\text{A} = 25^\circ \text{C})</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ripple Rejection</td>
<td>RR</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>8.0 V\text{dc} ≤ V\text{in} ≤ 10 V\text{dc}, f = 120 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dropout Voltage (I\text{D} = 1.0 A, T\text{J} = 25^\circ \text{C})</td>
<td>V\text{I} - V\text{O}</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>Output Noise Voltage (T\text{A} = 25^\circ \text{C})</td>
<td>V\text{n}</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>10 Hz ≤ f ≤ 100 kHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Resistance f = 1.0 kHz</td>
<td>r\text{O}</td>
<td>0.9</td>
<td>-</td>
</tr>
<tr>
<td>Short-Circuit Current Limit (T\text{A} = 25^\circ \text{C})</td>
<td>I\text{SC}</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td>V\text{in} = 35 V\text{dc}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Output Current (T\text{J} = 25^\circ \text{C})</td>
<td>I\text{VMAX}</td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Average Temperature Coefficient of Output Voltage</td>
<td>T\text{CO}</td>
<td>-0.3</td>
<td>-</td>
</tr>
</tbody>
</table>

1. T_{\text{low}} = 0^\circ \text{C} \text{ for MC7800C, MC7800AC,} = -40^\circ \text{C} \text{ for NCV7800, MC7800AX, MC7800AE, and MC7800XEB}

2. Load and line regulation are specified at constant junction temperature. Changes in V\text{O} due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
**Comparators**

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).
Schmitt Trigger

Hysteresis suppresses “false” triggering due to noise.