Summary of Covered Topics

Important concepts:

- Impedance
- Amplification
- Frequency/Fourier Analysis
- Feedback

Important electronics components and equipment:

- Resistors, capacitors, inductors.
- Special components: tranformers, 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 pratical lab knowledge.
- Some problems will involve combining knowledge from different chapters.

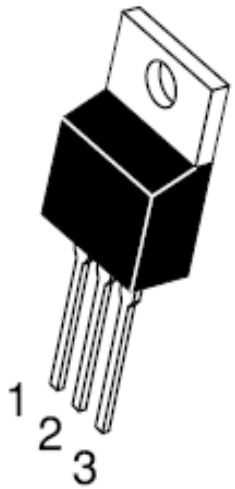
Physics 351: Electronics II
What to expect?

- Mostly **DIGITAL** electronics
  - → Logic gates.
  - → Operations.
  - → ADCs, DACs, and opto-couplers.
  - → Counters, registers, and digital memory.
- A fair bit on **FPGA**s
  - → 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)

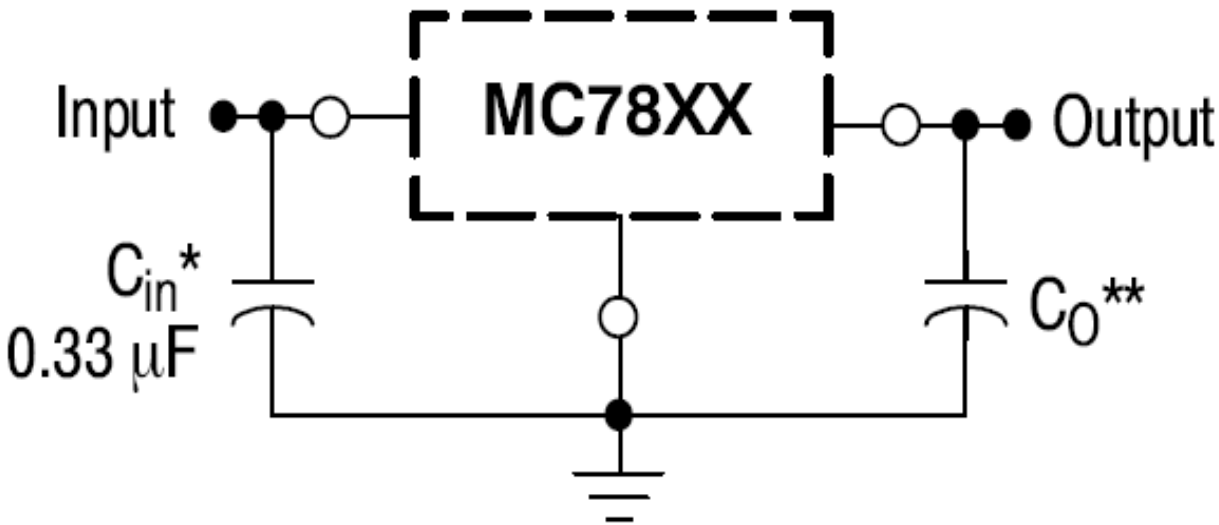
Voltage regulators produce a constant output voltage despite variations in the input.

Pin 1. Input
2. Ground
3. Output



TO–220–3

Heatsink surface
connected to Pin 2.



Voltage Regulators (II)

MC7800, MC7800A, MC7800AE, NCV7800

ELECTRICAL CHARACTERISTICS (V_{in} = 10 V, I_O = 500 mA, T_J = T_{low} to 125°C (Note 1), unless otherwise noted)

Characteristic	Symbol	MC7805B, NCV7805			MC7805C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage (T_J = 25°C)	V_O	4.8	5.0	5.2	4.8	5.0	5.2	Vdc
Output Voltage (5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W) 7.0 Vdc ≤ V_{in} ≤ 20 Vdc 8.0 Vdc ≤ V_{in} ≤ 20 Vdc	V_O	 – 4.75	 – 5.0	 – 5.25	 4.75 –	 5.0 –	 5.25 –	Vdc
Line Regulation (Note 4) 7.5 Vdc ≤ V_{in} ≤ 20 Vdc, 1.0 A 8.0 Vdc ≤ V_{in} ≤ 12 Vdc	Reg_{line}	 – –	5.0 1.3	100 50	– –	0.5 0.8	20 10	mV
Load Regulation (Note 4) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_A = 25°C)	Reg_{load}	 – –	1.3 0.15	100 50	– –	1.3 1.3	25 25	mV
Quiescent Current	I_B	–	3.2	8.0	–	3.2	6.5	mA
Quiescent Current Change 7.0 Vdc ≤ V_{in} ≤ 25 Vdc 5.0 mA ≤ I_O ≤ 1.0 A (T_A = 25°C)	ΔI_B	 – –	 – –	 – 0.5	 – –	 0.3 0.08	 1.0 0.8	mA
Ripple Rejection 8.0 Vdc ≤ V_{in} ≤ 18 Vdc, f = 120 Hz	RR	–	68	–	62	83	–	dB
Dropout Voltage (I_O = 1.0 A, T_J = 25°C)	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage (T_A = 25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	–	10	–	–	10	–	$\mu V/V_O$
Output Resistance f = 1.0 kHz	r_O	–	0.9	–	–	0.9	–	mΩ
Short Circuit Current Limit (T_A = 25°C) V_{in} = 35 Vdc	I_{SC}	–	0.2	–	–	0.6	–	A
Peak Output Current (T_J = 25°C)	I_{max}	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	TCV_O	–	-0.3	–	–	-0.3	–	mV/°C

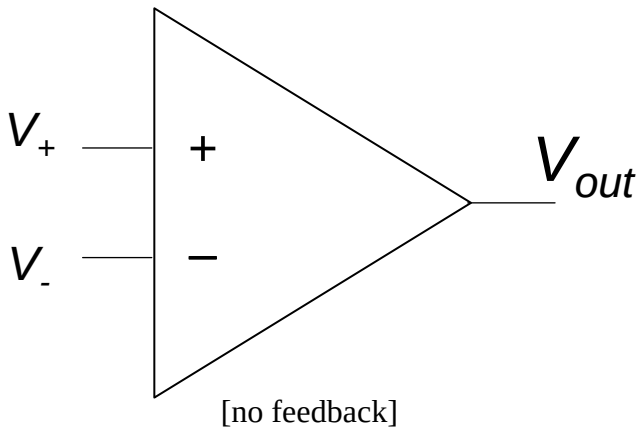
1. T_{low} = 0°C for MC78XXC, MC78XXAC,
   = −40°C for NCV78XX, MC78XXB, MC78XXAB, and MC78XXAEB
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Comparators

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.



[no feedback]

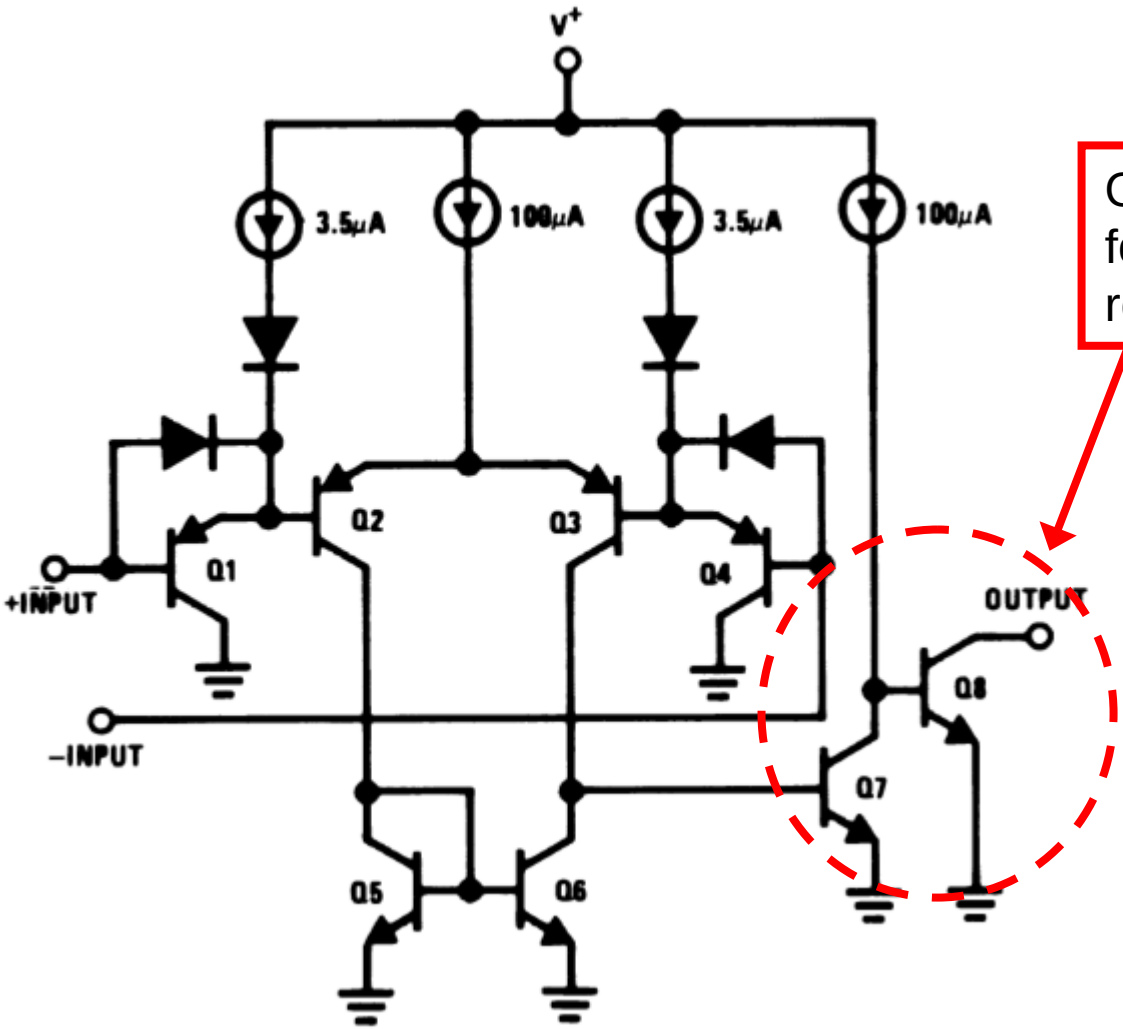
Op-amp equation: $V_{out} = Gain \times (V_+ - V_-)$

Since $Gain \sim 10^5\text{-}10^6$,

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

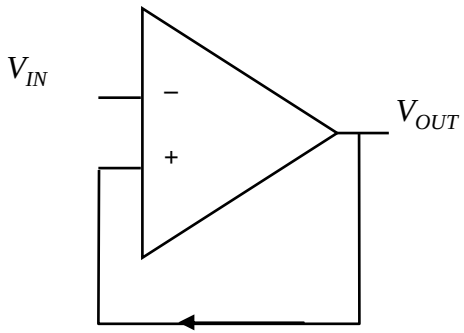
If $V_+ < V_-$, then $V_{out} = -V_{supply}$ (LOW)

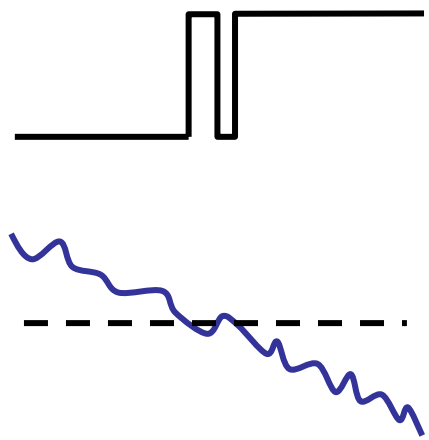
The LM2903 comparator



Output is configured for use with a pull-up resistor

Positive Feedback





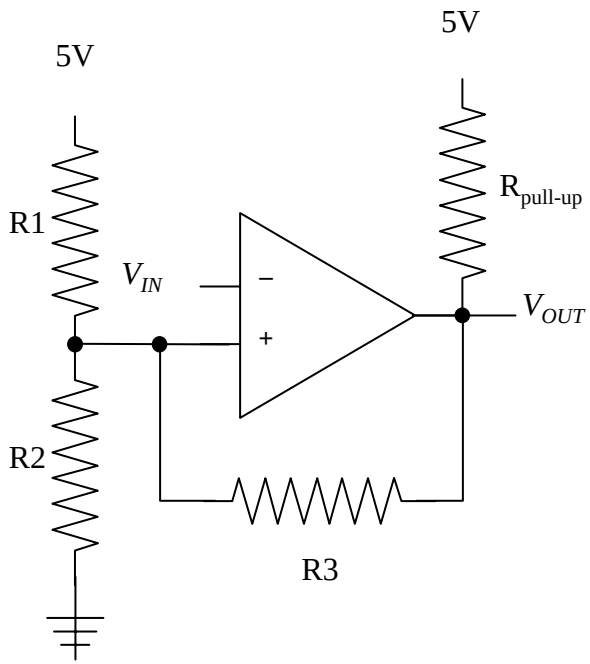
Noisy signal leads to
“false” triggering

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.