Intro to Transistors

- NOTE: 4/7/2017: slides not finished, “Fritzing” wiring diagrams not in sync yet. Check back noon 4/8/2017
- Orientation and Scope of this session
  - Conventional current flow notations used everywhere
  - Functional, functional, functional
  - References to theory but stressing application
  - A few simple device types and a few use cases
- Starting from Square One: Electricity and Ohm’s Law
  - Water Analogy
  - Resistor combination equations and exercises
- Bipolar transistor operation
  - Hands on Exercises
- N Channel (logic level) Field Effect transistor operation
  - Exercises

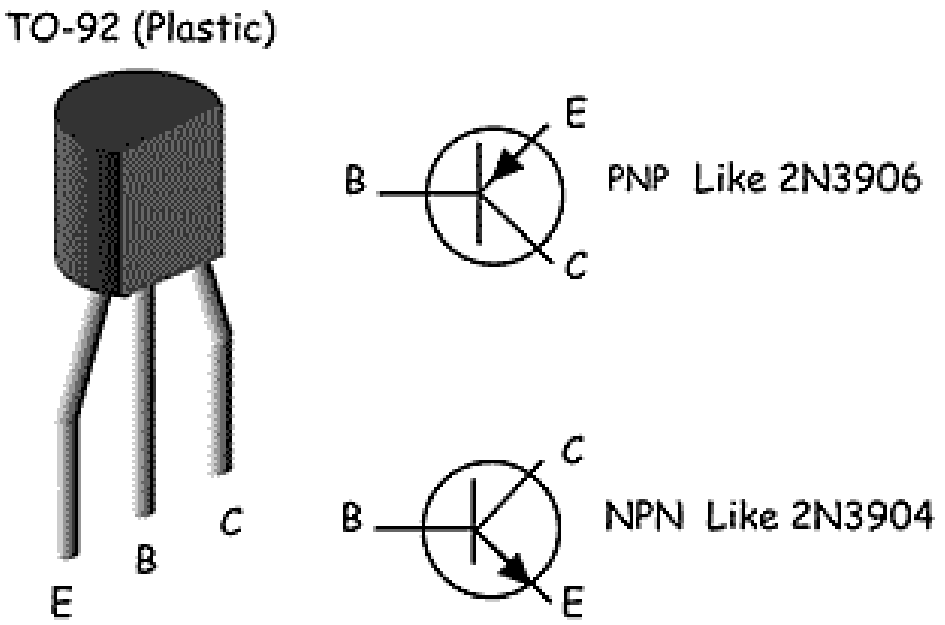
Junction Transistors

- Three terminals: Emitter, Base, Collector
- Many sizes and characteristics
- All share this behavior:
  - In normal operation relatively small changes of current flow through the base control larger current flow through the emitter and collector
  - See figure 4.51 on page 436 of Practical Electronics for Inventors, Scherz and Monk, 3rd edition, 2013. (A copy will be passed around at the session)

Measuring volts easy: amps harder

- We’ll measure voltage in our circuits for three reasons:
  - The digital meter reading voltage usually won’t interfere with the circuit. Measuring current can affect circuit operation due to “burden voltage” (the small, but sometimes significant voltage drop used to measure the current)
  - Have to swap leads with most meters
  - Forgetting to swap back can blow a fuse

Physical vs Schematic



Operation: NPN Details

- (“Simple Common Emitter” simulation with http://everycircuit.com)

Exercise 1: Duplicate the simulation

- BOM (bill of materials & Common-Emitter-1 Fritzing diag):
  - Solderless breadboard (aka “protoboard”) with RED LINE FURTHEST FROM YOU
  - 4.5 volt battery pack (connects to TOP RED AND BLACK RAILS ONLY) and pushbutton switch
  - Little blue “102” 1k ohm trimmer potentiometer (variable resistor) and “brown black green” 1000000 ohm resistor
  - “brown black orange” 10000 ohm resistor
  - 2N3904 NPN transistor (black with three leads marked EBC on flat side)
  - Breadboard and alligator clip jumpers and multimeters

Amps = Volts / Ohms

- Measure voltage from one end to the other of the 10k (10,000 aka “brown black orange”) resistor
- While doing this, adjust the potentiometer
- How does the current through the resistor change?
- Over and over with electronics: having two of the three values for variables of Ohm’s Law reveals the third value.

But it doesn’t DO anything!

- (Getting to Blinky CE simulation 1)
- Exercise in parallel:
  - BOM adds an LED
  - Adjust trim pot while watching LED

LED not doing anything!

- What could be wrong?
- How much current does the LED require to light? More than 40-odd microamperes!
  - Typical LEDs like this work well with 1-20 milliamperes
- How to get more current?
- Fix the collector resistor
  - LED drops two volts, so resistor drops three (transistor resistance ignored)
  - 5 milliamperes = three volts / 600 ohms (510 close enough)
  - Replace 10k resistor with “green brown brown” 510 ohm resistor

LED Still Not ON???

- What's happening with the LED?
  - Figure out current through LED
- Why isn't there enough current through the LED?
- Transistor gain is 100: To get 5 mA "out", how much current has to go "in" transistor?
- Adjust base resistor
- Readjust trim pot as needed

FET Transistor

- Switches current, but switching mechanism basically different