ECE 327: *Electronic Devices and Circuits Laboratory I*

Notes for Lab 1 (Bipolar (Junction) Transistor Lab)

1. Introduce bipolar junction transistors
   - "Transistor man" (from *The Art of Electronics* (2^{nd} edition) by Horowitz and Hill)
     - Transistors are not "switches"
     - Base–emitter diode current sets collector–emitter *resistance*
     - Transistors are "dynamic resistors" (i.e., "*trans*fer res*istor*")
     - Act like closed switch in "saturation" mode
     - Act like open switch in "cutoff" mode
     - Act like current amplifier in "active" mode
   - Active-mode BJT model
     - Collector resistance is dynamically set so that collector current is β times base current
     - β is assumed to be very high ($\beta \approx 100$–200 in this laboratory)
     - Under most conditions, base current is negligible, so collector and emitter current are equal
     - $\beta \approx h_{fe} \approx h_{FE}$
     - Good designs only depend on β being large
     - The active-mode model:
       - Assumptions:
         - Must have $v_{EC} > 0.2\,\text{V}$ (otherwise, in saturation)
         - Must have very low input impedance compared to βR_E
       - Consequences:
         - $i_B \approx 0$
         - $v_E = v_B \pm 0.7\,\text{V}$
         - $i_C \approx i_E$
     - Typically, use base and emitter voltages to find emitter current. Finish analysis by setting collector current equal to emitter current.
   - Symbols
     - Arrow represents base–emitter diode (i.e., *emitter* always has arrow)
     - *npn* transistor: Base–emitter diode is "***n**ot **p**ointing i**n***"
     - *pnp* transistor: Emitter–base diode "***p**oints i**n** **p**roudly*"
     - See part pin-outs for easy wiring key
   - "Common" configurations: hold one terminal constant, vary a second, and use the third as output
     - *common-collector* ties collector to DC voltage so that variations in base cause variations in emitter ("**emitter follower**" or "voltage buffer")
     - *common-base* ties base to DC so that variations in emitter cause variations in collector ("current buffer" or "**current source**")
     - *common-emitter* ties emitter to DC so that variations in base cause variations in collector ("voltage **amplifier**")
       - emitter can be *degenerated* by a resistor between emitter and DC
       - *emitter degeneration* adds feedback and increases linearity
         - Increased base–emitter voltage $\implies$ increased collector current $\implies$ increased R_E voltage $\implies$ decreased base–emitter voltage (i.e., negative feedback ensures base–emitter voltage of $\sim$0.7 V)
         - With high β or high R_E, collector current is independent of transistor nonlinearities (i.e., only depends on v_B and R_E; linear amplifier of v_B)
       - emitter degeneration improves thermal stability (i.e., power dissipates across R_E instead of transistor)

2. Laboratory experience

- When taking plots, save as CSV or BMP
  - Saving as BMP prevents extra work, but make sure scope plots show all required information
    * Intervals between horizontal and vertical divisions should be clear
    * In most cases, channel grounds should be shown
    * Channels should be labeled in report (e.g., "top waveform is input")
  - If saving as CSV, be sure to...
    * Label axes and show units
    * Identify waveforms (e.g., "input" and "output")
- Variable resistors: Potentiometers or resistance boxes
- Follow lab *book*
- Use handouts for guidance on particular circuits
  - Procedure (and troubleshooting)
  - Schematics and explanations
  - Pin-outs (avoid use of electrolytic capacitors)