1. Bipolar Junction Transistor Diode Model

Consider the package drawing, schematic symbol and logical representation of an npn transistor shown in Figure 1:

(a) Test this 2N3904 transistor by measuring $R_{BC}$, $R_{BE}$ and $R_{CE}$ in both directions. Makes sense?

2. Transistor Switch

Consider the transistor switch circuit shown in Figure 2:

(a) Predict the behavior of the switch shown.
(b) Make the circuit.
(c) Does it work?

3. Emitter Follower

Consider the circuit in Figure 3:

(a) Predict $V_2$ as a function of $V_1$.
(b) Build the circuit as shown.
(c) Set $V_1$ to a 3 $V_{pp}$, 1kHz sine wave, symmetrical about 0V. Explain $V_2$
(d) Use the DC offset on your function generator to add 5 $V_{DC}$ to $V_1$. Measure $V_2^{AC}$ and $V_1^{DC}$. Compare to theory.
(e) $Z_{in}$ at the base is just an equivalent resistor $\beta \cdot R_E$ to ground. Calculate $Z_{in}$ for the circuit shown.
(f) To measure $Z_{in}$, add a 330k$\Omega$ base resistor $r$ as shown in Figure 4. Using the same $V_1$ as part D, measure $V_1^{AC}$ and $V_B^{AC}$ and use this to calculate $Z_{in}$.
(g) The emitter output can be modeled as shown in Figure 5, from which $Z_{out}$ is $\frac{r}{\beta} || R_E$ and where $r$ is the source resistance. Calculate $Z_{out}$ for the circuit shown.
(h) Measure $Z_{out}$ by measuring $V_2$ without and with the AC load shown in Figure 6. Make sure $V_2$ is sinusoidal and use the Fluke DMM if you need greater accuracy. Why do we use a blocking capacitor?
(i) Calculate $\beta$ from $Z_{in}$ and $Z_{out}$. Note: They will neither be 100 nor equal!
4. Emitter Follower with Bias Circuit

Consider the circuit shown in Figure 7:

(a) Build the bias circuit shown, but do not connect it to the transistor yet.

(b) Set \( V_1^{AC} = 1 \ V_{pe} \) at 1kHz, \( V_1^{DC} = 0 \). Measure \( V_2^{AC}, V_2^{DC} \); lower the frequency and measure \( f_{3dB} \). Compare with theory.

(c) Connect \( V_2 \) to the transistor base. Does \( V_2 \) change? Explain.

(d) Measure \( V_3^{AC} \) and \( V_3^{DC} \). Compare with theory.

5. Current Source

Consider the current source circuit of Figure 8:

(a) Calculate \( I_C \). Does \( I_C \) depend upon the pot resistance?

(b) Using your ohmmeter, set the pot to 0Ω. Then make the circuit.

(c) Observe \( I_C \) and \( V_L \) across the load (Fluke DMM for \( V_L \)) as the 10kΩ pot is increased from 0. Measure the voltage compliance (the voltage range across the load over which the current is constant). Compare with theory.

6. Common Emitter Amplifier

Consider the amplifier circuit shown in Figure 9:

(a) Calculate \( V_2^{DC} \), the AC gain, the low frequency 3dB point, and \( Z_{out} \) for this amplifier circuit.

(b) Make the circuit.

(c) Measure the above quantities. Design an AC load (similar to 3H above) to deduce \( Z_{out} \). Compare with theory.