Lab 3: Transistor Circuits and JFETs

This Lab is Too Long by 50%

3.1 Goals of this Lab

Following our introduction to transistors in Lab 2, this time we will study some common transistor circuits. Finally, there is a short introduction to one type of transistor of the FET technology family, the JFET. For convenience, the transistor connection conventions are reproduced below in Fig. 1.

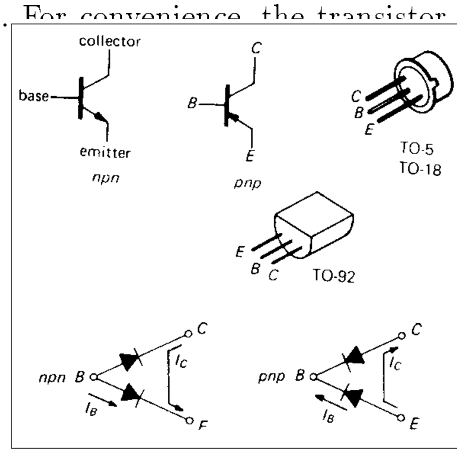

Figure 1: Transistor connections.

3.2 Emitter Follower

Wire up the emitter follower circuit shown below in Fig. 2. Input a sine wave with amplitude symmetric about ground. Compare input and output of your follower. Increase the input amplitude beyond 5 V. Sketch the input and output wave forms.

3.2.1

Replace the emitter resistor connection to ground with a connection to -15 V, as shown in Fig. 3. Keep the 270 Ω base resistor. (Ignore the dashed boxes for now.) Again look at input and output wave forms. Sketch the results and note any changes.

3.2.2

We wish to measure the input and output impedances of our follower. Set up an input source and output load circuit as indicated by the dashed boxes in Fig. 3. The capacitor allows the DC transistor behavior to remain unchanged, while at higher frequency the capacitor becomes negligible and the load impedance is approximately given by the 1 kΩ resistor. To see this show that the load impedance is $R\left[1 + 1/(\omega RC)^2\right]^{1/2}$. Plot this as a function of frequency using the component values for R and C.

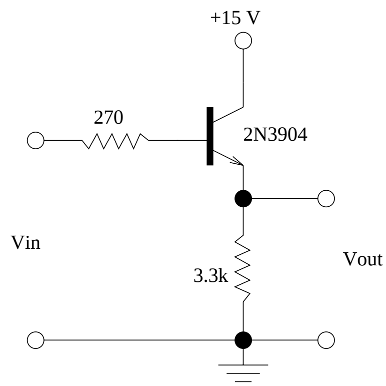

Figure 2: Basic emitter follower.

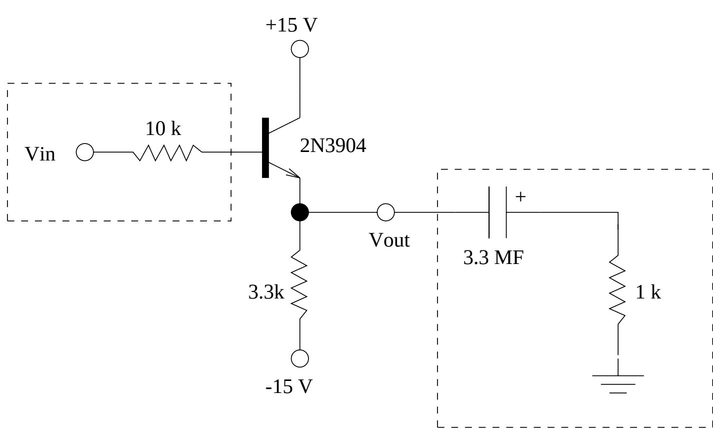

Figure 3: Symmetric follower with input (source) and output (load) stages shown in the dashed-line boxes.

To measure Z_{out}, we consider the Thevenin equivalent circuit with the load, consisting of the 1 kΩ load in parallel with the 3.3 kΩ emitter resistor, in series with Z_{out}, hence forming a voltage divider. Operating at a frequency well above ω_{3db} of the load, measure the output amplitude with and without the 1 kΩ load to determine Z_{out}.

To measure Z_{in}, remove the load. The entire follower now represents an impedance Z_{in} in series with the 10 kΩ source resistor. Hence, by measuring the signal amplitude on each side of the 10 kΩ resistor, we can determine Z_{in}. This may be difficult to measure.

An important point of the emitter follower is that it represents a large input impedance and a small output impedance. The input impedance is about $Z_{\text{in}} \approx \beta Z_{\text{load}}$, whereas $Z_{\text{out}} \approx Z_{\text{source}}/\beta$, where Z_{load} is the load to be driven by the emitter-follower including any emitter resistor (3.3 kΩ here), and Z_{source} is the source impedance of the signal being delivered to the emitter-follower. Do these expectations agree with your measurements ?

3.3 Current Source

The arrangement shown in Fig. 4 (left) can serve as an approximate current source. Use the 10 kΩ variable resistor on your prototype board as the load to be driven by the current source. Again, measure the collector current delivered to the load by the voltage drop across the 1 kΩ resistor. Starting with the highest value, vary (*slowly!*) the load resistance while measuring the current. How good is this current source? At what value of R does the delivered current deviate by more than 20% from the initial value?

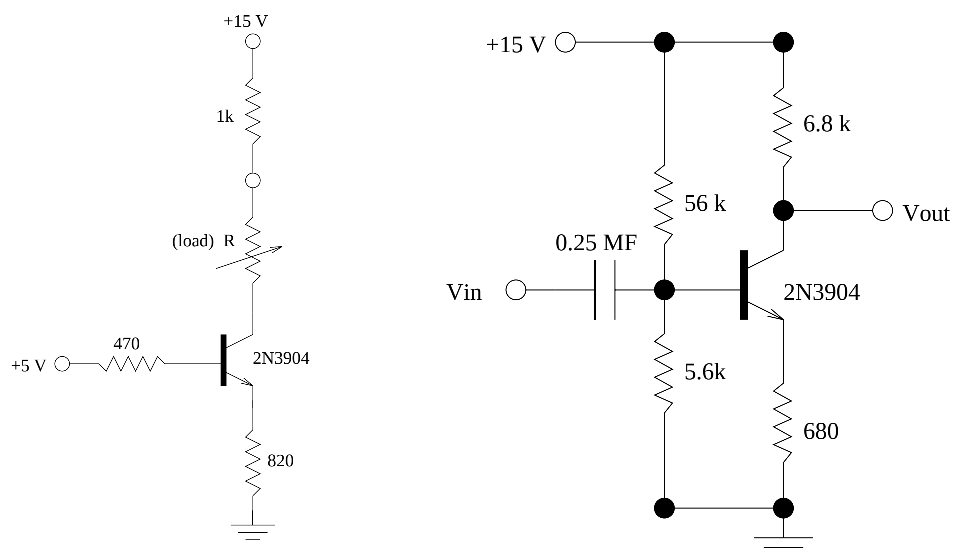

Figure 4: A simple current source (left), and a common emitter amplifier (right).

3.4 Common-emitter Amplifier

Set up the common-emitter amplifier shown in Fig. 4 (right). Input a small-amplitude sine wave. Measure the voltage gain of the amplifier $V_{\text{out}}/V_{\text{in}}$ over the frequency range 50 Hz to 10 kHz. Make a rough plot of gain versus $\log_{10}$ of frequency. What is the measured ω_{3db} point? Does this agree with your expectation?

3.5 JF

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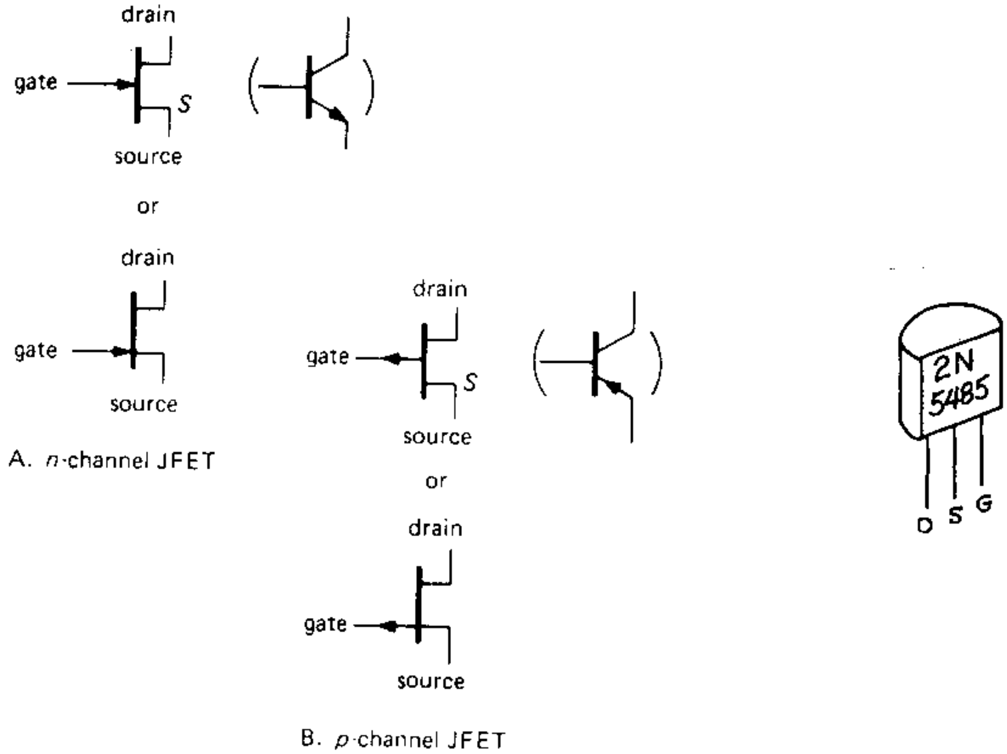

Figure 5: JFET terminal conventions.

Construct the source follower circuit shown in Fig. 6. Use a 2N5485 JFET, which comes in a TO-92 package. Input a small-amplitude sine wave and measure the voltage gain of this circuit. Use f in the 1 kHz to 10 kHz range. (What is the ω_{3db} point of the input filter?)

3.5.1

One of the outstanding features of the JFET is its large input impedance. Attempt to measure Z_{in} as we did in Section 3.2.2: Place an (appropriate) resistor in series with the input of your JFET follower, thus making a voltage divider with which the signal amplitude on both sides of the resistor can be measured.

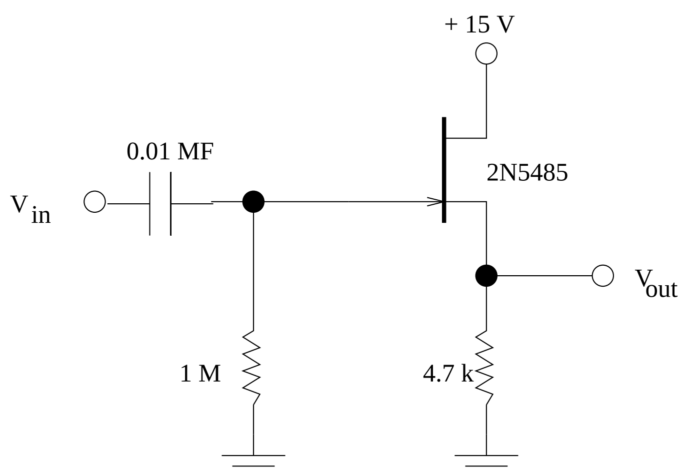

Figure 6: Basic JFET source follower.