Laboratory II: Transistors

A. Transistors: the common-emitter amplifier with bypassed emitter resistor

This laboratory will give you the opportunity to study in greater depth the properties and uses of transistors which were introduced in the Sophomore Labs. You will study, construct, and make measurements on an analog circuit which is widely used in electronics. The common-emitter amplifier with bypassed emitter resistor circuit you will work on here is used in the preamplifier circuits of stereo amplifiers. The fact that the collector voltage can swing above and below the operating point by equal amounts makes the amplifier class-A. With a 15 V supply voltage the collector voltage is 7.5 V measured to ground. (If the transistor were a pnp, it would be the same magnitude collector voltage but negative in sign.)[1]

B. Reading

- R. E. Simpson, *Introductory Electronics for Scientists and Engineers* (Prentice-Hall, Englewood Cliffs, 1987), Chap. 5. Sections 5.8 - 5.10 can be skimmed. Read Chapter 5 section 5.11 for a discussion of the way to characterize four port devices in general and how this applies o the transistor.

- Handout - read it!

C. Annotated list of optional reading

- R. E. Simpson, *Introductory Electronics for Scientists and Engineers* (Prentice-Hall, Englewood Cliffs, 1987), Chap. 4. Chapter 3 may be skipped. Chapter 4 is fascinating material so I strongly suggest reading this chapter if you really want to understand transistor action.

- P. Horowitz and W. Hill, *The Art of Electronics* (Cambridge University Press, Cambridge, 1987), pp. 65-85.
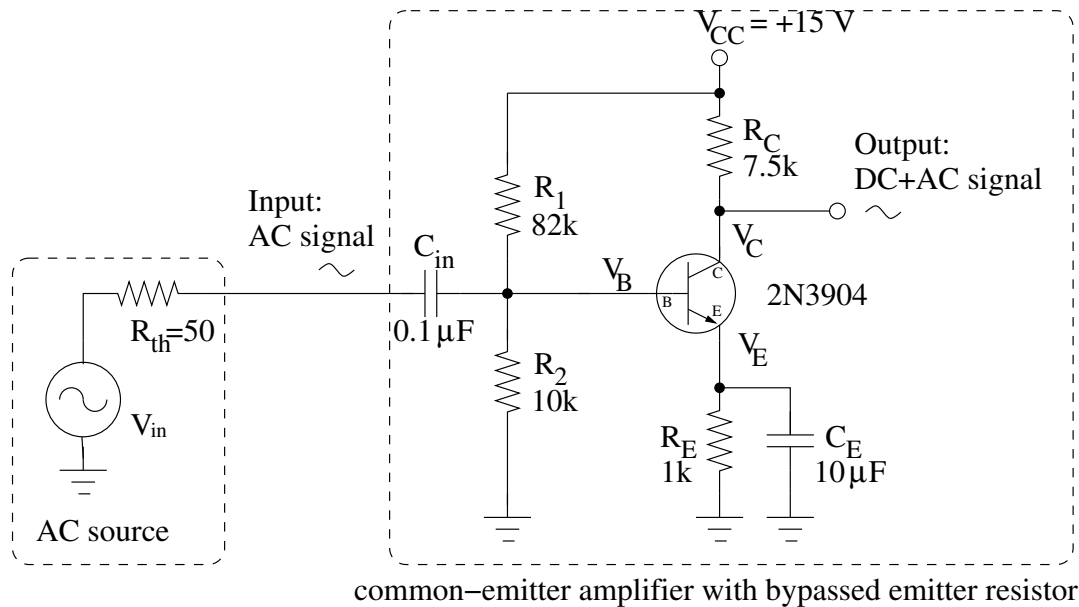
D. Experiment: Grounded emitter amplifier

common−emitter amplifier with bypassed emitter resistor

Figure 1: The Common-emitter amplifier with bypassed resistor: R_C = 7.5 $k\Omega$, R_E = 1.0 $k\Omega$, R_1 = 82 $k\Omega$, R_2 = 10 $k\Omega$, V_{CC} = +15 V, 2n3904 transistor, 10 μF emitter capacitor, 0.1 μF blocking capacitor (on the input).

Wire up the bypassed-emitter-resistor circuit above. Since this circuit has shunt paths it is recommended that the student actually measure the resistance before putting them into the circuit board. The presence of shunt paths makes it impossible to accurately measure the resistances once they are in the circuit. Since the biasing of the transistor depends on the values of the resistors in the voltage divider network, those values must be correct for proper operation ($\pm 5\%$).

Measure the quiescent voltages (no input signal) of the collector, emitter and base and compare them to the theoretical values. See the example in the handout for guidance on calculating these voltages.

Drive the amplifier with a triangular wave at 10 kHz at an amplitude that almost produces clipping– "cutting off" of the output waveform. In order to make the input signal small enough use a 100:1 voltage divider on the output of the signal generator. Make sure you pick the resistors such that the input and output impedance of the voltage divider are reasonable. Discuss your reasoning in the lab report. Compare your observed output with the figure immediately below, Fig. 2. Explain briefly and qualitatively your observed results. (Why the "barn roof" shape?)

Reduce the input to the point where the output signal is only a fraction of a volt and measure the gain of the system. Compare with the theoretical small-signal gain of the system.

Now remove the emitter-bypass capacitor (this step is the exciting one), measure the gain and compare with theory.
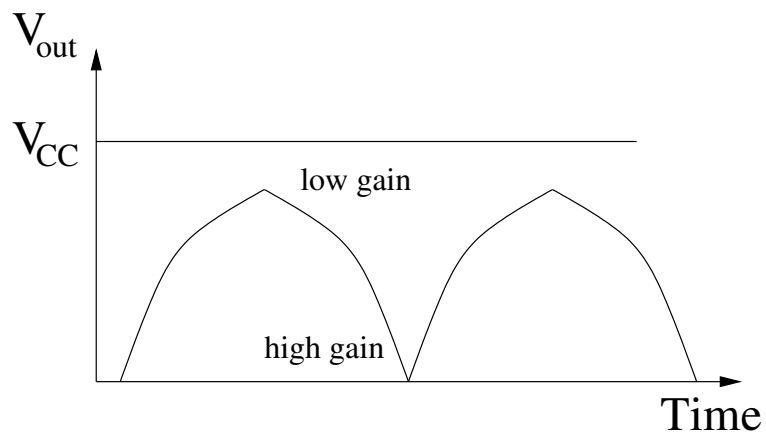
Figure 2: Output distortion.

References

[1] J. Dar and D. T. Horn, *How to Test Almost Everything Electronic*, (TAB Books, PA, 1988), p.70.