EE100B
Experiment 4

Basic Output-Stage Circuits

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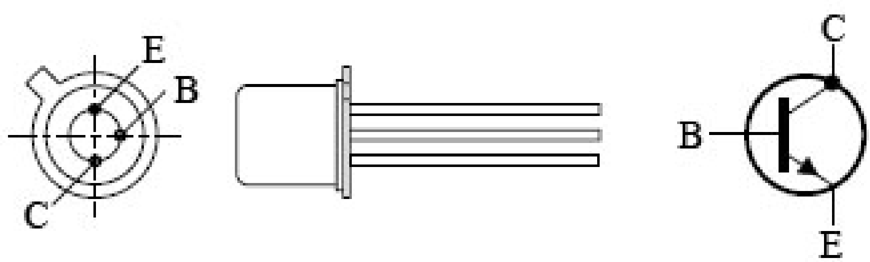
Objective

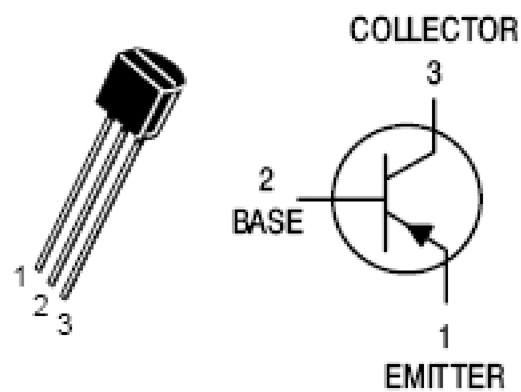
To familiarize with basic output-stage topologies. Class-A and Class-B examples will be explored.

Equipment

2 non BJTs (2N2222), 1 pnp BJT (2N3906), 1 diode (1N914), resistors (100Ω, 1kΩ, 10kΩ), function generator, oscilloscope, digital multimeter, DC power supply, breadboard



2N2222 npn transistor



2N3906 pnp transistor

Figure L4.1 BJT Base Diagrams

Prelab

Read the sections of your textbook relevant to this laboratory session.

The Class-A Follower

1. DC Bias
   For the circuit shown in Figure L4.2, assuming that D_1 and Q_2 are matched, what current flows into the emitter of Q_1, assuming that β is very high? If R_2 is changed to a 1kΩ resistor, what will I_{E1} become? If β=100, what voltage drop occurs in R_1?

2. Signal Operation
   For the circuit shown in Figure L4.2, what are the upper and lower limits of v_B for a load of R_L = 10kΩ, assuming that β is very high?

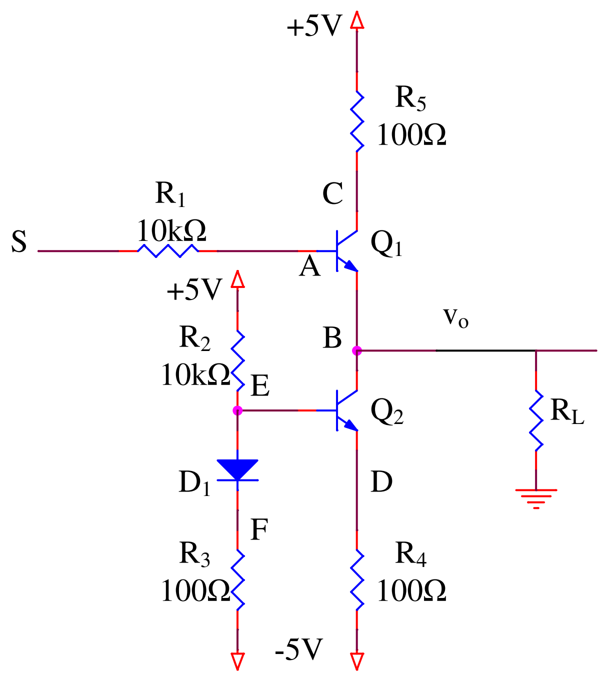


Figure L4.2 A Class-A BJT Follower with Emitter-Current Bias

The Class-B Follower

1. DC Bias
   For the circuit as shown in Figure L4.3, what emitter current flows into each transistor for high β, with R_L = 10kΩ, when v_S = +3V, 0V, and -7V?
2. Signal Operation
   For the circuit as shown in Figure L4.3, sketch the waveform at node B, with v_S being a triangle wave of ±1V amplitude, and R_L = 10kΩ. Assume β is high and $|V_{BE}|$=0.7V. What are the largest unclipped signal peaks at node B with R_L = 10kΩ, if β=100? (Be careful to include R_2, R_3).

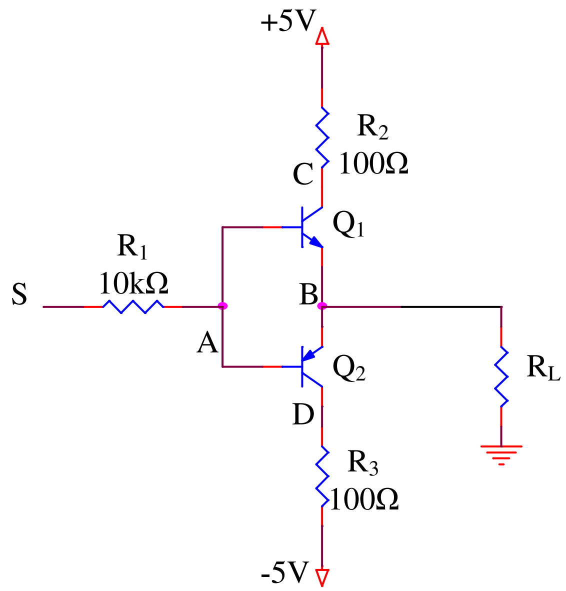


Figure L4.3 A Class-B Complementary BJT Output Stage

Laboratory Procedure

The Class-A Follower

In the circuit shown in Figure L4.2, Q_2 and the associated components supply a constant current to the follower Q_1. Resistors R_3 and R_4 serve to equalize the currents in D_1 and Q_2 whose junctions are likely to be quite different in size. Resistor R_5 serves simply to allow one to monitor the bias current directly. Resistor R_1 represents the internal resistance of a typical signal source.

1. DC Bias
   Assemble the circuit as shown in Figure L4.2 with S grounded and no load connected to node B. Adjust the supplies to ±5V as closely as you can. Measure the voltages at nodes A, B, C, D, E and F. Estimate the collector current of Q_1 and its β.

Consider β and r_e at the current levels you have measured. Notice that the currents in D_1 and Q_2 are nearly the same (due to R_3 and R_4).

2. Signal Operation
   Change the circuit in Figure L4.2 to R_2=1kΩ, a load R_L=10kΩ, and node S connected to a function generator providing a 0.2 V_{pp} triangle wave at 1 kHz. With the oscilloscope, measure the voltages at nodes S, A and B. Calculate the voltage gains from S to B (v_B/v_S) and A to B (v_B/v_A). Also measure the input resistance at A.

While observing nodes S and B, with both oscilloscope channels direct-coupled with zero volts at the screen center, raise the input voltage until first the output waveform is chipped at one peak, then the other. What are the peak output voltages at each case?

Consider the values of input resistance and gain you find here in view of the conclusions you could draw using the data obtained from the part 1 (DC Bias) above. As well, correlate the peak limiting values with voltage measurements taken in part 1 above.

<u>The Class-B Follower</u>

1. DC Bias
   Assemble the circuit in Figure L4.3 with node S grounded, R_L=10kΩ, and supplies at ±5V. Use the multimeter to measure the voltages at nodes A, B, C and D, to verify that there is no standing bias current in the circuit.
2. Signal Operation
   With a 0.2 V_{pp} triangle wave applied to node S initially and a load 10kΩ connected to node B, measure nodes S, A and B with the two-channel oscilloscope. With nodes S and B displayed on an oscilloscope, slowly increase the input signal, noting the peak value of the signal at S for which output at node B is just noticeable. Continue to increase the input amplitude until a $1V_{pp}$ output is observed at S and A. Observing node B, increase the input signal until the output peaks just begin to limit. Note their value and the corresponding peak values at nodes S and A. Estimate device β at the peaks. What have you discovered?