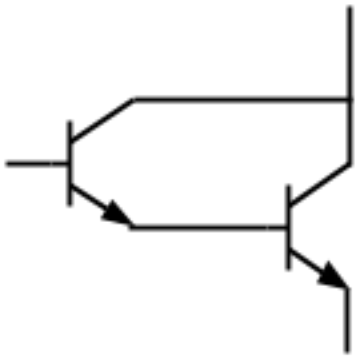

Figure 1: Two NPN BJTs connected to form a Darlington pair.

Figure 2: A diode connected NPN Device.

1 Warm-Up Problems

1. The configuration of transistors in Figure 1 is referred to as a Darlignton Pair or simply a Darlington.
   (a) What is the effective Beta of the Darlington Pair? i.e. the ratio of current injected into the left transistor to the combined collector current.
   (b) What is the effective Vbe,on of the Darlington Pair? i.e. the total voltage drop from the base of the left transistor to the emitter of the right one.
   (c) If Vbe and Vce of the Darlington are varied, what regions of operation do each of the transistors pass through?

2. The configuration of transistors in Figure 2 is referred to as a diode connection
   (a) What region of operation does a diode connected BJT operate in?
   (b) What is the large signal I-V relationship of a diode connected BJT?
   (c) Why is this called a diode connection?

2 Lab Introduction

In this lab we will be characterizing some of the device parameters of bipolar junction tranistors (BJTs). The learning goals are listed below:

1. Understand large signal models of NPN and PNP transistors, including regions of operation.
2. Relate large signal measurements of BJT behavior to small signal measurements.
3. Get practice biasing both NPN and PNP BJTs.

References: *Hays and Horowitz Lab Manual 94, 97*

3 Measurements of BJT Parameters

1. Measure the diode drop across the base-emitter and collector-base diodes of a 2N3904 diode using the diode mode of the Elenco multimeter. Explain why the collector-base diode drop is slightly smaller than the base-emitter drop. Hays and Horowitz has a relevant explanation on page 94.
2. Measure the $\beta, g_m, V_{ce,sat}$ and r_π of a 2N3904 transistor. Vary the collector current over at least the three decades from 100µA to 100mA when measuring these quantities. Be careful not to saturate your transistor when you take these measurements because β, g_m and r_π are only defined in the forward active region; consider monitoring the collector voltage as you take your data. Check your results for self consistency: what's the relation between r_π and g_m? I_c and g_m? Also compare your results against datasheets. Note that h_{fe} is commonly used synonym for β.
3. Put your transistor in the lab's curve tracer and capture the curve tracer data. Extract the Early Voltage, V_A from the curve tracer data and compare it to the datasheet.
4. For extra credit you may repeat steps 2-4 with a 2N3906 transistor.

Required Data: Diode drop measurement and explanation. Curves of $\beta, g_m, V_{CE,SAT}$ and r_π vs. I_C with appropriate summaries of experimental setup and equivalent circuit models for each measurement. Curve tracer output and V_A estimate.