Laboratory Exercise No. 3 – BJTs
Electronics I

Equipment Required: Power supply, function generator, multimeter, oscilloscope, solderless breadboard, various resistors, BJTs (2N2222A), and hookup wire.

Objectives

1. Measure the $i - v$ characteristics of a small-signal $npn$, bipolar junction transistor (BJT).
2. Measure the properties of a BJT-Resistor being used as a switch or inverter.
3. Measure the properties of a BJT-based amplifier.

Introduction

The bipolar junction transistor (BJT) is a three-terminal device used for switching and amplifier applications. It is similar to the MOSFETs studied earlier; however, there are notable differences. First, it requires a base current to generate a collector current instead of a gate-to-source voltage creating a drain current as in the MOSFET. Second, the physics of operation are considerably more complex in the BJT than in the MOSFET. Third, there are two different types of BJTs – $npn$ and $pnp$ – whereas MOSFETs can be either enhancement mode or depletion mode and either $p$-channel or $n$-channel constituting four different MOSFET versions.

The BJT is not used as much as in the past because of the MOSFET. However, it still sees considerable use in low-noise applications and ultra-highspeed applications.

Measurements

1. Begin by getting a data sheet for the 2N2222A $npn$ transistor.
2. Measure the $i - v$ characteristics of the BJT. Build the following circuit (Figure 1). Note, it is important to keep all wires as short as possible and use a single point ground. Set $i_B$ to 10 $\mu$A and measure $v_{CE}$ and $i_C$ as $v_{CE}$ is varied from 0 to 10 V. To vary $v_{CE}$, you can either vary $R_L$ or $V_{supply}$. Repeat this experiment with $i_B$ equal to 20 $\mu$A, 30 $\mu$A and 40 $\mu$A. Plot the $i - v$ characteristics of this BJT. The horizontal axis should be $v_{CE}$ and the vertical axis $i_C$. The various $i_B$ values generate a family of curves. Compare your experimental results to simulation results using a tool such as PSpice.
3. Using the same circuit, obtain a plot of $v_{CE}$ versus $v_{BE}$ and compare to simulation results.
4. Using the same circuit (Figure 1), set the supply voltage to 10 V and $R_L$ equal to 1000$\Omega$. Set the function generator to produce a square wave going from 0-5 V. The frequency should be around 1 kHz for now. On the oscilloscope, observe $v_{BE}$ and $v_{CE}$ and plot your results. What is the value of the slope, $\Delta v_{CE}/\Delta v_{BE}$, near its steepest point? Comment on the function this circuit is performing.
5. Build the following circuit (Figure 2). Set the supply voltage to 9 V. Set $V_{bias}$ to obtain $v_{CE} = 4$. This will be the bias or Q-point for the amplifier. Set $v_{in}$ to 10 mV peak-to-peak at 1 kHz. Measure the following signals: $v_{in}$, $v_{BE}$, $v_{CE}$, and $v_{out}$. What is the
Figure 1: A circuit used to obtain the $i - v$ characteristics of a BJT and observe inverter operation.

Figure 2: A BJT inverting amplifier with separate signal and bias voltage supplies.

amplification factor for this circuit? Simulate the circuit in PSpice or similar program.
6. Increase $v_{in}$ while observing $v_{CE}$. **At what input level does $v_{CE}$ become visibly distorted?** Vary $V_{BB}$ to see if you can increase the input signal before visible distortion occurs. **What values of $v_{CE}$ and $v_{BE}$ allow the largest $v_{out}$ before visible distortion sets in?**

**Verbal Lab Report**

The Verbal Lab Reports should be done individually. Be prepared to set up any of the circuits in the lab, make measurements, and explain the meaning of the measurements.