Physics 375, Laboratory 6
Transistor Properties

Overview

The purpose of this experiments is to measure the current-voltage curves of different types of transistors and to use them in simple DC circuits.

Background

The zener diode is a diode designed to run with reverse bias. When the reverse current exceeds a specified minimum, the voltage drop across the zener becomes constant independent of the reverse current.

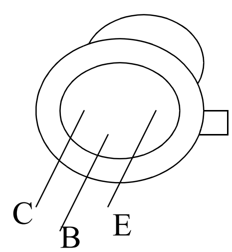
The transistor is a non-ohmic device with three-terminals. There are two basic types of transistors, the field effect transistor (FET) and the bipolar junction transistor (BJT).

A junction field effect transistor (JFET) is made from a junction of a p-type and n-type semiconductor, but the junction is used to control the conductance in one of the semiconductor layers. The drain and source terminals are connected to ends of one semiconductor, and the gate is connected to the other semiconductor. The transconductance g_m measures the ratio of the out put current to the applied voltage.

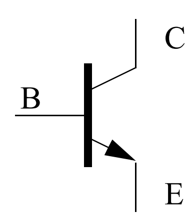
A bipolar junction transistor (BJT) is made from two junctions of a p-type and n-type semiconductor. The base-emitter junction acts like a diode. However, when a current flows from the base to emitter (I_B) of the transistor, a current is induced to flow from the collector to emitter (I_C) such that $I_C = \beta I_B$, where β is a characteristic factor for the transistor.

Components

The 2N2222 is a general purpose npn transistor. The 2N2222 comes in a TO-18 metal case with leads for emitter, base and collector.



2N2222

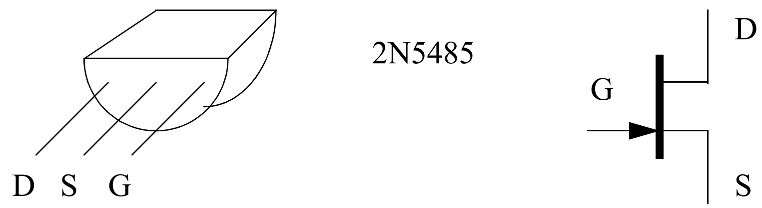


The 2N2222 has maximum ratings as follows:

$V_{CE} < 40$ V, $V_{CB} < 60$ V, $V_{EB} < 6.0$ V

$I_C < 800$ mA, $P = I_C V_{CE} < 1$ W, β is between 50 and 200

The 2N5485 is an n-channel JFET and comes in a TO-92 plastic case with leads for drain, source and gate.



The 2N5485 has maximum ratings as follows:

$V_{DG} < 25$ V, $-V_{GS} < 25$ V

$I_D < 30$ mA, $P = I_D V_{DS} < 300$ mW

1. DC JFET Curves

Connect two power supplies an n-channel transistor (2N5485), potentiometer, and resistor as in figure 1.

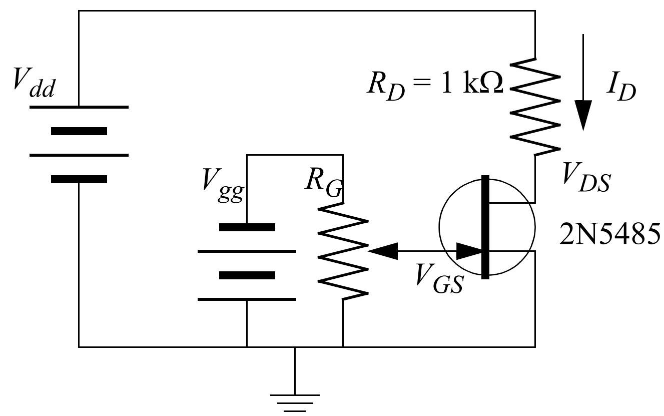


Figure 1: DC JFET Measurement

Use the fixed -15 V power supply for V_{gg} (note the inverted polarity on the schematic) and a 10 kΩ potentiometer as R_G to set the voltage at the gate V_{GS}. Use the variable power supply for V_{dd}. Set $V_{GS} = 0$ V and $V_{dd} = 0.5$ V, and measure V_{DS} with a DMM. Subtract V_{DS} from V_{dd} to get the voltage drop across R_D, and use that to calculate I_D. Repeat the measurement of V_{DS} and I_D for $V_{dd} = 1.0$, 2.0, 4.0, 6.0, 10.0, and 15.0 V, and graph I_D vs. V_{DS}. Find the curve of I_D vs. V_{DS} again for $V_{GS} = -0.5$ V, and -1.0 V. Plot the three curves on a single graph. Plot I_D vs. V_{DS} for the region of constant I_D. Calculate $g_m = \Delta I_D / \Delta V_{GS}$.

2. BJT Transistor Curves

Connect the variable power supply, an npn transistor (2N2222), resistor, and DMM:

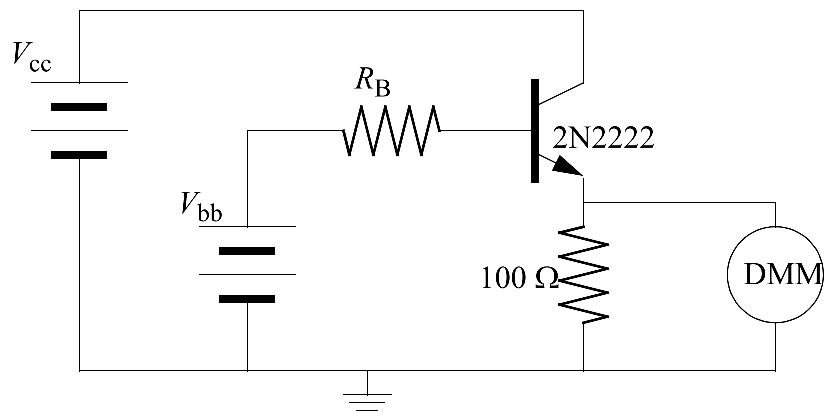


Figure 2: DC BJT Measurement

Use a 1.5 V battery for V_{bb} and the variable power supply for V_{cc}. Use R_B = 470 kΩ, and V_{cc} = 0.1 V, and measure the voltage drop across R_B to get I_B. Now measure the voltage across the 100 Ω resistor, V_E. Calculate V_{CE} and I_C at this value of I_B. Repeat the measurement of V_E for V_{cc} = 0.2, 0.5, 1, 2, and 5 V, and graph I_C vs. V_{CE}. Change R_B = 220 kΩ and repeat the measurement of the curve. Find a third curve by using R_B = 100 kΩ. What value can be derived for β for this transistor.

3. Voltage Source

Build the following circuit using a variable power supply for V_{CC} and the DMM to measure V_{out}.

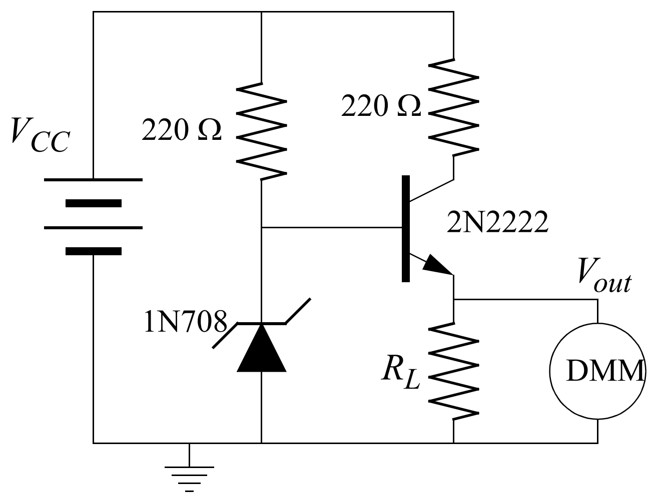


Figure 2: Transistor Voltage Source

Set V_{CC} = 12 V and use R_L = 100 kΩ. Measure V_{out}. Reduce V_{CC} in 2 V steps and measure V_{out} for each step. Set V_{CC} = 12 V and remove R_L and measure $V_{out} = V_{th}$ the Thevenin equivalent voltage for the circuit. Put in R_L = 1 kΩ and measure V_{out}. The Thevenin equivalent resistance for the voltage source forms a voltage divider with R_L.Use the measurement of V_{out} with a load compared to V_{th} to calculate the Thevenin resistance for the voltage source.