# Investigating the current running through a npn BJT transistor

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## Abstract

In this experiment we varied the voltage supplied to the base of a npn BJT transistor, and measured the current running through the collector to form a data set which we fitted to the Ebbers-Moll equation. From this fit we calculated the thermal voltage ($V_T$) and saturation current ($I_s$). Both these paramaters have strong temperature dependence and from our fit we determined an experimental value for the boltzman constant of $k = 1.378 \times 10^{-23} \pm 8.4 \times 10^{-26} \frac{J}{K}$ for the silicon transistor and a value of k = $5.6 \times 10^{-23} \pm 4.000 \times 10^{-24} \frac{J}{K}$ for the germanium transistor. We also determined an experimental value for the band gap of the transistors with a $E_g = 1.48 \pm 0.012eV$ for silicon and $E_g = 0.158 \pm 0.003eV$ for germanium.

## 1 Introduction

### 1.1 Physics Motivation

The npn Bipolar Transistor (BJT) is a device made of two n doped semiconductor regions called the collector and emitter sandwiched between a p doped base region.

### 1.2 Historical context

## 2 Theoretical background

Provide some more theoretical details for your measurements. Give formulas and references which provide a specific theoretical context for your measurements.

# 3 Experimental setup

## 3.1 Apparatus

Ideas behind the particular technique should be briefly discussed. Enclose references. Sketches, pictures, and suitable schematics should be included and explained concisely. All major components of the system should be mentioned and their role clearly motivated. This section is not simply a list of components and it is not an instruction manual.

## 3.2 Data Collection

## 3.3 Data Analysis

We setup our circuit to have a variable supply of voltage to the base ($V_{be}$) while measuring the collector current ($I_c$) readings from the pico ampmeter . We took the dataset of $V_{be}$ vs $I_c$ and fitted it to Ebbers moll equation

$$I_c = I_s(e^{\frac{V_{be}}{V_T}} - 1). \tag{1}$$

$V_T = \frac{kT}{e}$ where e is the charge of an electron, T is the temperature in Kelvin, and k is boltzman constnt. By fitting our dataset to this equation we determined an experimental value for $V_T$. We then repeated our measurements with variable temperature and created a linear graph of $T$ vs $V_T$ where we expect the slope to equal $\frac{k}{e}$.

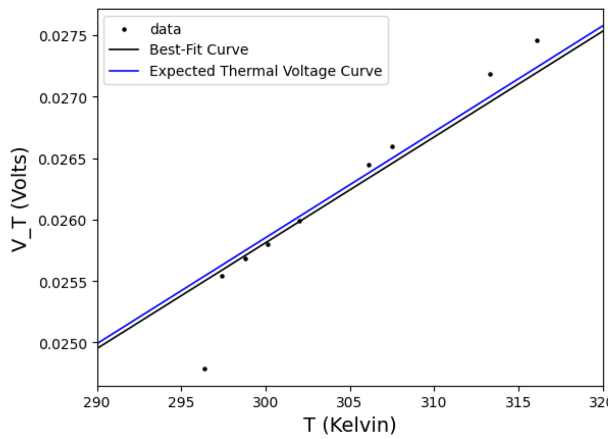


Figure 1: Temperature vs Thermal Voltage graph. The data points collected are represented by the black dots, our best-fit slope is the solid black curve, and the expected slope of $\frac{k}{e}$ is the solid blue curve.

# 4 Results

Clearly present the result of your analysis. Make sure you include the uncertainties. No experimental result can be quoted without an error attached to it.

Your results should be compared with predictions and other measurements.

# 5 Summary and conlcusions

Summarize briefly the results of the experiment. Acknowledge (i.e., thank for) contributions or help of your partner(s) and or others (TA, machine shop, software used, ...).

## References

[1] R. Feynman, *QED*, Ch.7.

[2] R.Dalitz, Proc. Roy. Soc. (London) **A64**, 667 (1951)