Python Project

John Lewis, Ethan Anderson, Israella Mayer

Probability and Statistics for EECE

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# Introduction & Objective

Probability and statistics are fundamental tools for Electrical and Computer Engineers, used in analyzing data, understanding variability, designing systems, and making decisions under uncertainty. This project provided an opportunity to apply the concepts and software tools learned to a problem or dataset of interest within the ECE domain.

# Project Scope

Our chosen topic is to model the reliability and accuracy of components like resistors, capacitors, and transistors through confidence intervals. By taking a set of samples from the available components in inventory, we can calculate confidence intervals with varying alpha values and degrees of freedom.

The random variables we will be working with are measurements of the different components. For example, the resistance of resistors in ohms, the capacitance of capacitors in farads, and the transconductance of transistors in siemens are all random variables which we will be able to create confidence intervals for using our Python program.

We will obtain our data by taking measurements for different values of components which we will borrow from the components inventory. We will use the corresponding tools, i.e. multimeters and oscilloscopes, to sample the relevant data.

We aim to quantify the deviation in our components from their intended values using confidence intervals. Using graphical representations and the matplotlib library, we will generate interpretable and visual graphics for the data and confidence intervals.

# Procedures

We measured 25 resistors advertised at 10 Ohms each; 20 capacitors advertised as 47 nano-farads each, and 15 2N3904 BJTS. For the transistors, we used a digital multimeter and a DC Power Supply to measure the IC current with a thermal voltage of 26mV.

Transconductance = Collector current / thermal voltage

When we measured the transconductance, we used the common emitter circuit configuration. Then, we measured the collector current to find the transconductance for each individual transistor.

The test statistics for each component data set are as follows.

## Data:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Number (n)** | **Sample Mean** | **Standard Deviation** |
| **Transistors** | 15 | 0.1941 | 0.0106 |
| **Resistors** | 25 | 9.9729 | 0.0576 |
| **Capacitors** | 20 | 49.465 | 0.4591 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Critical Value** | | | **Margin of Error** | | |
|  | C90 | C95 | C99 | C90 | C95 | C99 |
| **Transistors** | 1.761 | 2.145 | 2.977 | 0.0049 | 0.0059 | 0.0082 |
| **Resistors** | 1.706 | 2.056 | 2.779 | 0.0189 | 0.0228 | 0.0308 |
| **Capacitors** | 1.729 | 2.093 | 2.861 | 0.1775 | 0.2149 | 0.2937 |

### Graphs

**BJT:**

A diagram of a normal distribution

AI-generated content may be incorrect.

**Capacitor:**

A diagram of a normal distribution

AI-generated content may be incorrect.

**Resistor:**

A diagram of a normal distribution

AI-generated content may be incorrect.

We can see that according to the sample mean and margins of error, the expected mean of the resistors falls within all 3 confidence intervals. Therefore, we can be confident that the true mean resistance value for our 10-ohm resistors is within an allowable range of the sample mean. The same is not true for capacitors. The expected mean does not fall within the 90% or 95% confidence intervals, only the 99% confidence interval. This means that even if we are 95% confident that the true mean is within the interval, our sample mean is not within the interval and therefore we may not conclude that the mean capacitance of our sample is representative of the population.

# Summary

In this project, we used Python to generate confidence intervals for data sets. In our specific application, we used components from the parts library, including resistors, capacitors, and transistors. We then analyzed the data obtained using our program and determined whether the components were, with varying degrees of confidence, truly within some predetermined margin of the advertised mean. We found that the components were, for the most part, within a reasonable margin of the expected mean. Since we only used 15 – 25 components for each test, we were forced to use the t-distribution to calculate our intervals. In an ideal case, we would have used upwards of 40 or 50 components to get a truly representative sample. Another limitation of our analysis is that our program requires each data point be submitted individually into the command line. Ideally, we could change the program to take in a .csv file or some other file type to improve ease of use.

Overall, this has been a truly interpretive project to showcase, put on trial, and demonstrate our understanding of confidence intervals and probability.