Variance in Resistors' Resistance

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AGENDA

01 BACKGROUND

02 Methodology

03 Data Collection

04 Visualization, Analysis

05 Summarization, What is next

Background

- Importance of Resistors in electronics
- Why do precision and consistency matter
- Hypothesis: As the values get bigger, there will be a bigger difference because it is harder to control higher values
- **Do BOJACK and Essmetuin resistors vary significantly in their resistance values?**

METHODOLOGY

Step 1

- Tested 3 types of resistors from two different brands, 10Ω, 2kΩ, and 1MΩ. (30 trials each)

Step 2

- Recorded the values given by multimeter in a spreadsheet, separated by brand and resistance level

Step 3

- Recorded the values given by multimeter in a spreadsheet, separated by brand and resistance level

Step 4

- Conducted statistical analysis as well as made visualizations to show these analysis

Data Collection

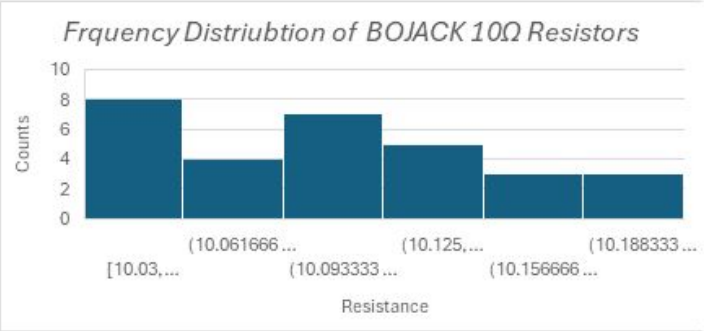
10 Ohms- no outliers

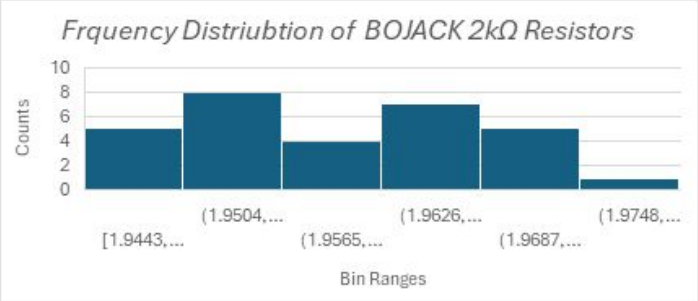
2K ohms- Still fairly centered

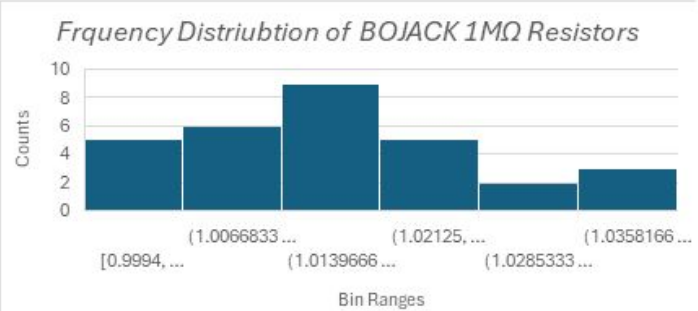
1M Ohm- Essmetuin has most of the data below the 1M ohm threshold while BOJACK has most data above the threshold.

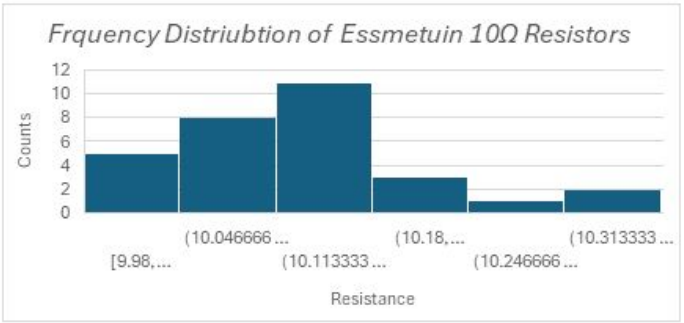
BOJACK 10Ω	ESSMETUIN 10Ω	BOJACK 2kΩ	ESSMETUIN 2kΩ	BOJACK 1MΩ	ESSMETUIN 1MΩ
10.15	10.06	1.9633	1.9518	1.0142	1.0303
10.12	10.13	1.9478	1.9533	1.0198	0.9673
10.2	10.18	1.952	1.965	1.001	0.9943
10.12	10.12	1.972	1.977	1.0074	0.9747
10.06	10.11	1.9605	1.9534	1.0308	0.9993
10.03	10.15	1.9564	1.956	1.0205	0.9678
10.05	10.17	1.9683	1.9525	1.016	0.9711
10.04	10.14	1.9622	1.9647	1.0368	0.9823
10.11	10.18	1.9497	1.9522	1.0278	0.9796
10.07	10.15	1.9646	1.9619	1.0117	0.9906
10.06	10.09	1.9723	1.9683	1.0263	1.0287
10.16	10.1	1.9744	1.9563	1.0027	1.0244
10.1	10.03	1.9508	1.9632	1.0142	1.0021
10.11	10.1	1.9477	1.9548	1.0257	0.9998
10.22	10.07	1.9729	1.967	1.0106	1.0318
10.06	10.02	1.9809	1.948	1.0431	1.02
10.14	10.04	1.9443	1.9622	1.0383	1.0071
10.06	9.98	1.9544	1.9696	1.0252	1.0152
10.07	10.05	1.9686	1.9733	1.0176	1.0033
10.11	10.01	1.9545	1.927	1.0142	0.978
10.17	10.12	1.9494	1.9226	1.0119	0.988
10.03	10.26	1.9565	1.9264	1.0138	0.9915
10.13	10.34	1.9618	1.9515	1.017	0.9897
10.14	10.23	1.965	1.9592	1.0036	0.9922
10.07	10.2	1.9568	1.9372	1.0052	0.9801
10.09	10.22	1.9549	1.9215	1.0352	0.9889
10.1	10.13	1.9685	1.9546	1.0249	0.9853
10.19	10.38	1.9671	1.9223	0.9994	0.9829
10.15	10.17	1.9546	1.9682	1.0091	0.9994
10.18	10.09	1.9713	1.9593	1.0202	0.9787

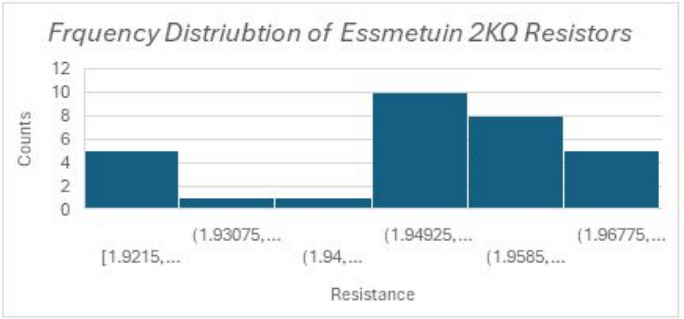
Histograms

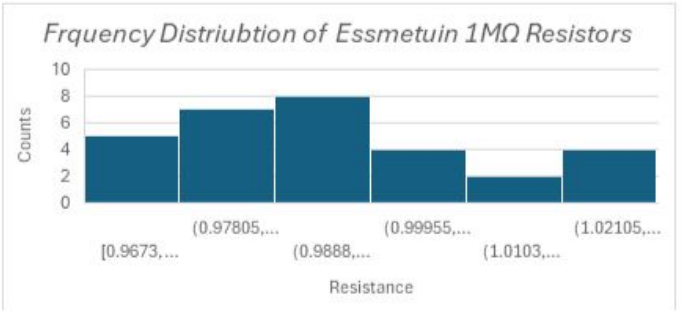

Frquency Distriubtion of BOJACK 10Ω Resistors
Counts
10
8
6
4
2
0
[10.03,...
(10.061666 ...
(10.093333 ...
(10.125,...
(10.156666 ...
(10.188333 ...
Resistance


Frquency Distriubtion of BOJACK 2kΩ Resistors
Counts
10
8
6
4
2
0
[1.9443,...
(1.9504,...
(1.9565,...
(1.9626,...
(1.9687,...
(1.9748,...
Bin Ranges


Frquency Distriubtion of BOJACK 1MΩ Resistors
Counts
10
8
6
4
2
0
[0.9994, ...
(1.0066833 ...
(1.0139666 ...
(1.02125, ...
(1.0285333 ...
(1.0358166 ...
Bin Ranges

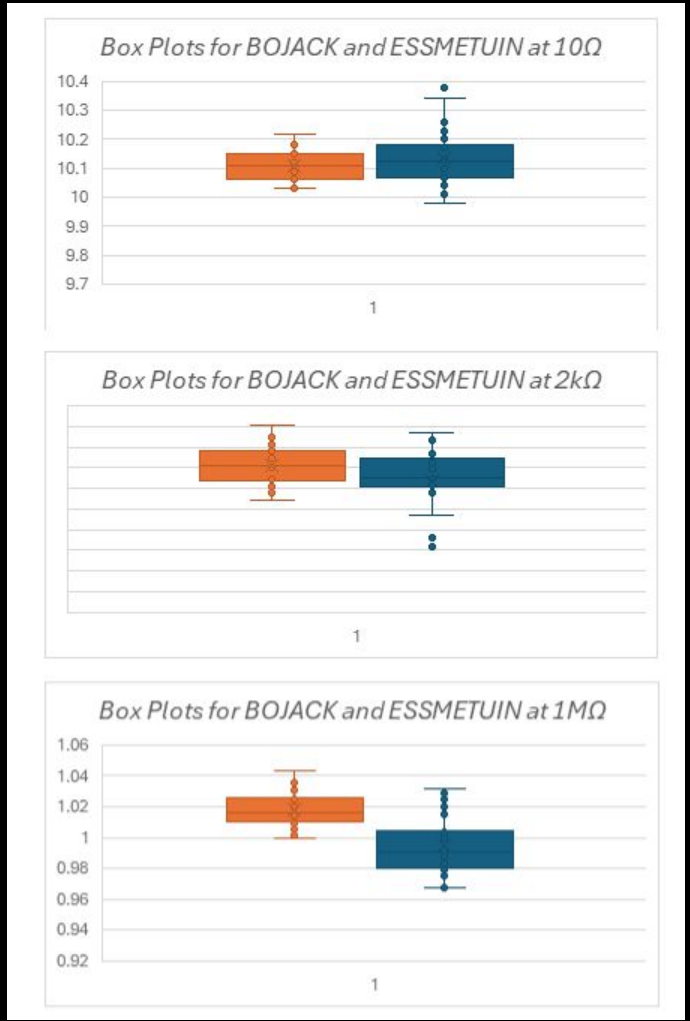

Frquency Distriubtion of Essmetuin 10Ω Resistors
Counts
12
10
8
6
4
2
0
[9.98,...
(10.046666 ...
(10.113333 ...
(10.18,...
(10.246666 ...
(10.313333 ...
Resistance


Frquency Distriubtion of Essmetuin 2KΩ Resistors
Counts
12
10
8
6
4
2
0
[1.9215,...
(1.93075,...
(1.94,...
(1.94925,...
(1.9585,...
(1.96775,...
Resistance

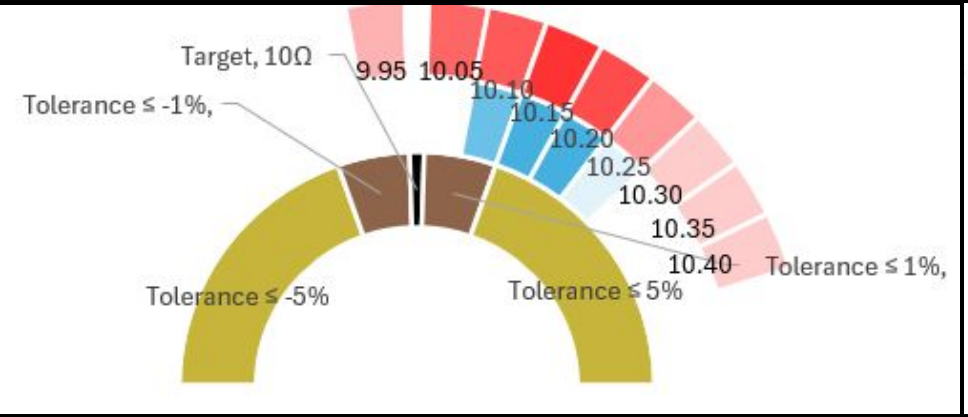

Frquency Distriubtion of Essmetuin 1MΩ Resistors
Counts
10
8
6
4
2
0
[0.9673,...
(0.97805,...
(0.9888,...
(0.99955,...
(1.0103,...
(1.02105,...
Resistance

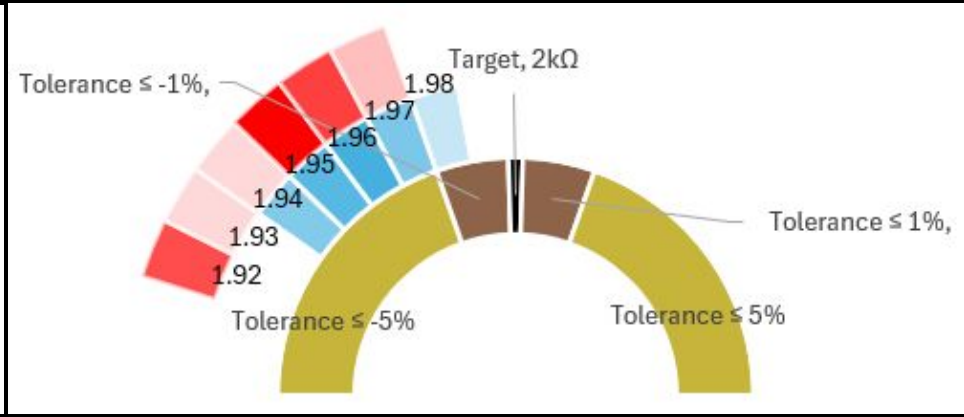
Box Plots

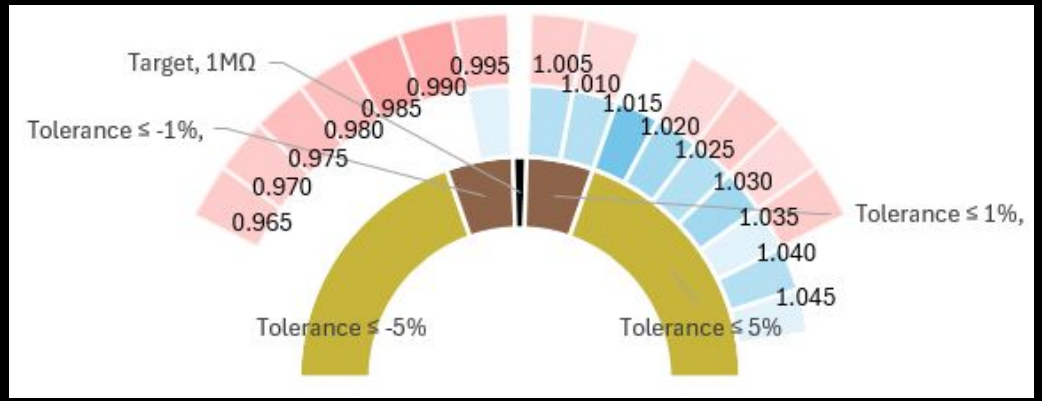
BOJACK in Orange
ESSMETUIN in Blue



Tablau Gauges







	BOJACK 10Ω	ESSMETUIN 10Ω	BOJACK 2kΩ	ESSMETUIN 2kΩ	BOJACK 1MΩ	ESSMETUIN 1MΩ
Mean	10.1097	10.1340	1.9608	1.9533	1.0181	0.9948
Median	10.1100	10.1250	1.9612	1.9554	1.0165	0.9911
Mode(s)	10.06	10.13	0.00	0.00	1.01	0.00
Variance	0.00275505747126	0.00836965517241	0.00009006833333	0.00024468185057	0.00013180110345	0.00034549291954
Standard Deviation	0.052488641	0.09148582	0.009490434	0.01564231	0.011480466	0.01858744
Sample Size	180					

Sample Calculation of 10-Ohm Resistors

10-ohm resistors:

Bojack:

Mean: 10.115

Standard deviation: 0.051

$$\text{CI} = 10.115 \pm 2.045 \times \frac{0.051}{\sqrt[2]{30}} = [10.096,\ \ 10.134]$$

10 Ohms:
BOJACK, [10.096 , 10.134]
ESSMETUIN, [10.100, 10.166]

2K Ohms:
BOJACK, [1.956 , 1.965]
ESSMETUIN, [1.947, 1.959]

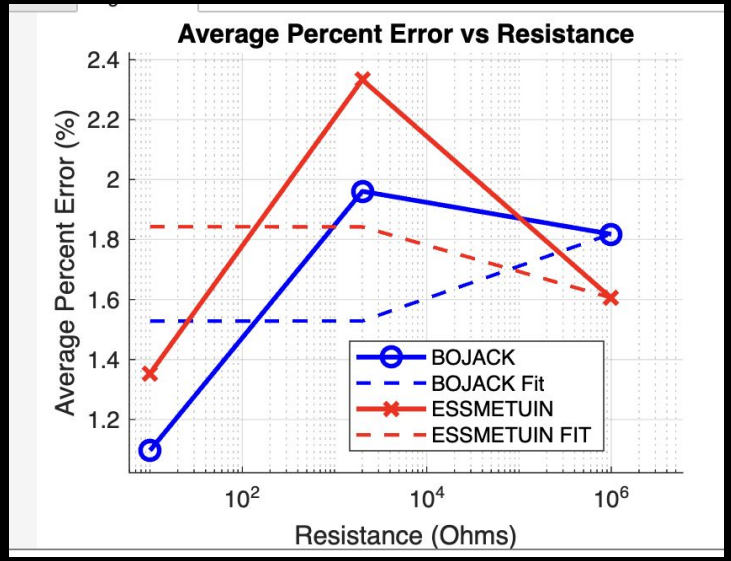
1M Ohms:
BOJACK, [1.013 , 1.021]
ESSMETUIN, [0.988, 1.002]

$$H_0: \mu_0 = Labeled\ \Omega$$

$$H_a: \mu_a \neq Labeled\ \Omega$$

	t_o	p
BOJACK 10Ω	11.44379157	2.84428E-12
BOJACK 2kΩ	-22.63316247	5.60467E-20
BOJACK 1MΩ	8.654428354	1.57285E-09
ESSMETUIN 10Ω	8.022535415	7.56874E-09
ESSMETUIN 2kΩ	-16.33704318	3.63979E-16
ESSMETUIN 1MΩ	-1.528373115	0.137255095

Regression



New to MATLAB? See resources for Getting Started.

```
>> BE2100_FP1
BOJACK Coefficients (T-Test)
```

	Estimate	SE	tStat	pValue
(Intercept)	1.528	0.43223	3.5352	0.17549
x1	2.9083e-07	7.4864e-07	0.38848	0.76411

```
--- ESSMETUIN ANOVA Table ---
ans =
  2x5 table
```

	SumSq	DF	MeanSq	F	pValue
x1	0.037431	1	0.037431	0.077953	0.82667
Error	0.48017	1	0.48017		

Goal: Test if **average percent error** increases with **resistance** for two brands (BOJACK & ESSMETUIN).

Method: Used **simple linear regression** (3 resistance levels: 10Ω, 2kΩ, 1MΩ) in **MATLAB**.

Graph: Resistance on **log scale** to show wide range of values clearly.

Assumptions:

- ❏ Linear relationship between resistance and percent error
- ❏ Random, unbiased error
- ❏ Consistent variation in percent error (30 samples per resistor type)

Results:

- ★ **p-values > 0.05** → not statistically significant
- ★ **Low slopes, low F-statistics** → models explain very little variation
- ★ **Low R values**- no strong correlation

Conclusion:

- ❖ **No strong evidence** of a linear relationship
- ❖ Percent error **does not increase consistently** with resistance

Table 1: BOJACK T-test Coefficients
Table 2: ESSMETUIN ANOVA Table

Summary

- BOJACK: This brand had more consistency and fewer outliers across the board
- Essmetuin: This brand had a wider spread of values and had more outliers leading to questions about quality concerns etc
- Although both are acceptable, BOJACK is preferred due to the reliability.

What is next

- Why does Essmetuin have higher variability? Difference in manufacturing equipment, material, quality etc?
- Although Essmetuin and BOJACK vary, will this have any actual impact on circuits? If not, then is price to performance worth it?
- If we increase the sample size, will we see any significant difference in our findings?

THANK YOU

James Maurer, Abid Ahmad,Cullen Veasley, Jacob Crawford, Rayyan Zia
Camari Dickerson, Tom McCloskey