The City College of New York

EE 22100 EE Lab#6

11/01/2017

Experiment 6: Introduction to Measurement Statistics and Interpretation

Fall 2017

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Purpose

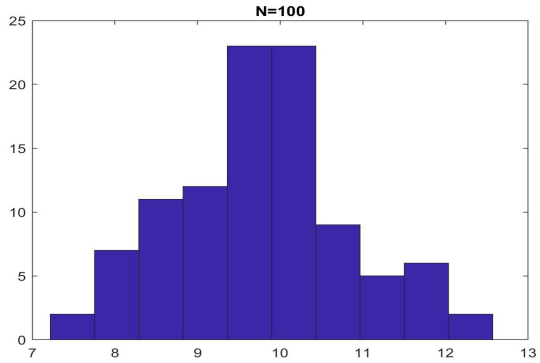
The purpose of this lab is to be familiar with the concepts of measurement errors and precision. This will help us learn use tools to quantify uncertainty.

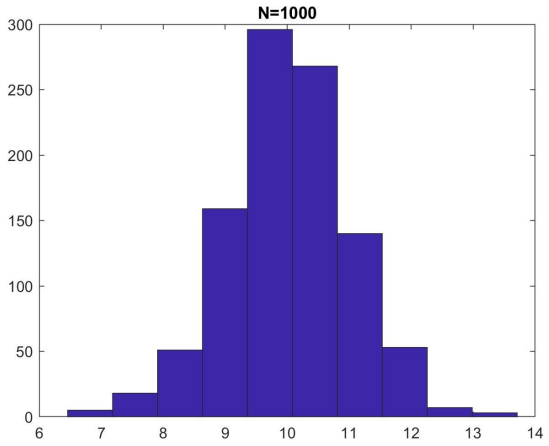
Equipments

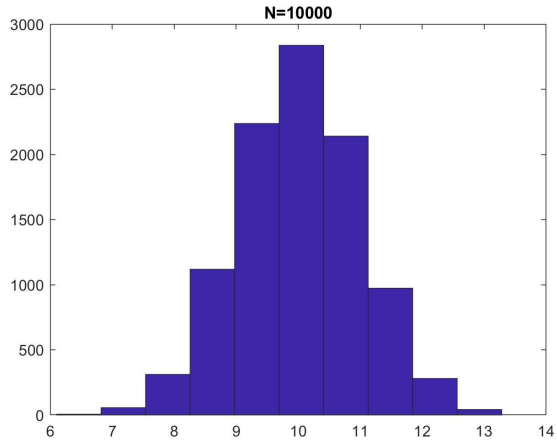
- ➔ Digital Multimeter
- ➔ DC power supply
- ➔ Breadboard
- ➔ Diode
- ➔ 1k resistor
- ➔ 13 ohm resistor (1%tolerance)
- ➔ 13 ohm resistor (5% tolerance)
- ➔ MATLab
- ➔ LABVIEW

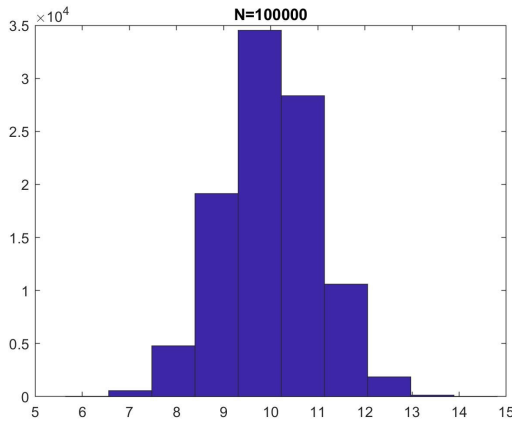
Pre Lab Analysis

Ex #1: For a Gaussian random variable of mean 10 and std=1, generate random ensembles of length N=100,1000,10000,100000,1000000 and calculate the mean, std and their errors from theoretical values and plot the results.


N=100
25
20
15
10
5
0
7
8
9
10
11
12
13


N=1000
300
250
200
150
100
50
0
6
7
8
9
10
11
12
13
14


N=10000
3000
2500
2000
1500
1000
500
0
6
7
8
9
10
11
12
13
14


N=100000
×10^4
3.5
3
2.5
2
1.5
1
0.5
0
5
6
7
8
9
10
11
12
13
14
15

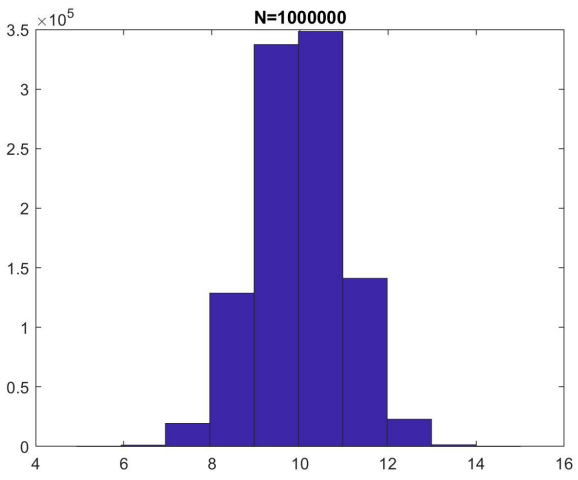

N=1000000
×10^5
3.5
3
2.5
2
1.5
1
0.5
0
4
6
8
10
12
14
16

Table 1:Theoretical Mean and Standard Deviation and calculated mean, STD and %Error

N		Theoretical		Calculated		%Error	
		Mean	STD	Mean	STD	AVG	STD
100		10	1	9.7825	1.062	2.175	0.62
1000		10	1	10.0278	0.9885	0.278	0.115
10000		10	1	10.0103	0.9925	0.103	0.075
100000		10	1	9.9994	0.9979	0.006	0.021
1000000		10	1	10.0007	1.0009	0.007	0.009

As the N increases the percent error decreases.

- Ex#2: Build your own functions in Matlab to calculate the mean and standard deviation and see if it agrees with the default functions.

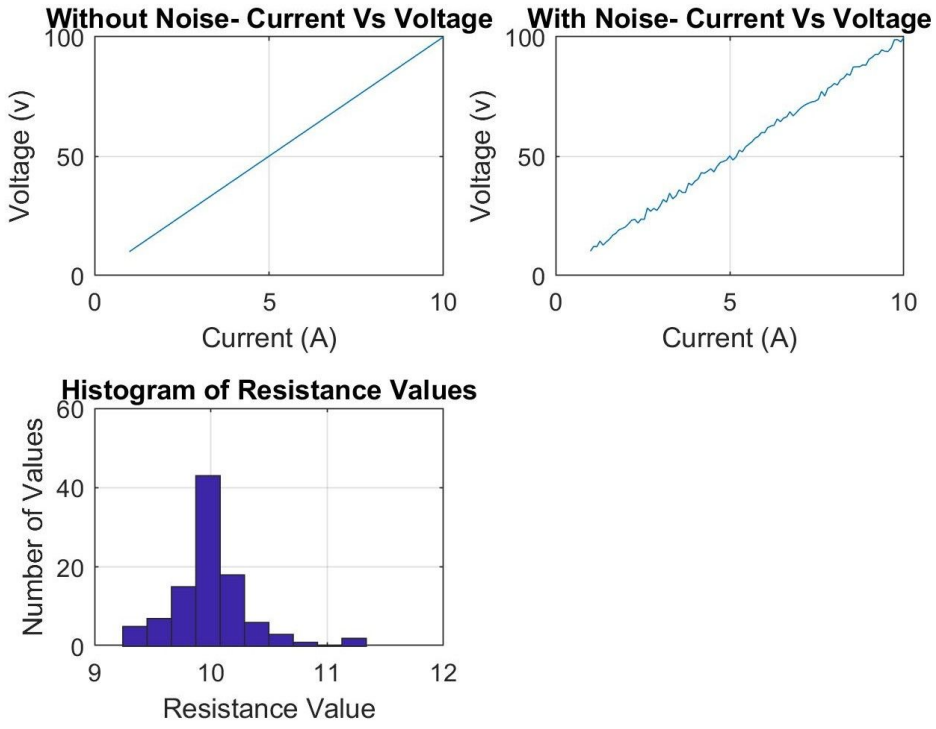
  ➔ **MATLAB Code for function**

```
function [m,s] = stat(x)
n = length(x);
m = sum(x)/n;
std= sqrt(sum((x-m).^2)/(n-1));
end
```

Default Function		Own Function			PERCENT ERROR	
AVG	STD	MEAN	STD		MEAN	STD
9.7825	1.062	9.7825	1.062		0	0
10.0278	0.9885	10.0278	0.9885		0	0
10.0103	0.9925	10.0103	0.9925		0	0
9.9994	0.9979	9.9994	0.9979		0	0
10.0007	1.0009	10.0007	1.0009		0	0

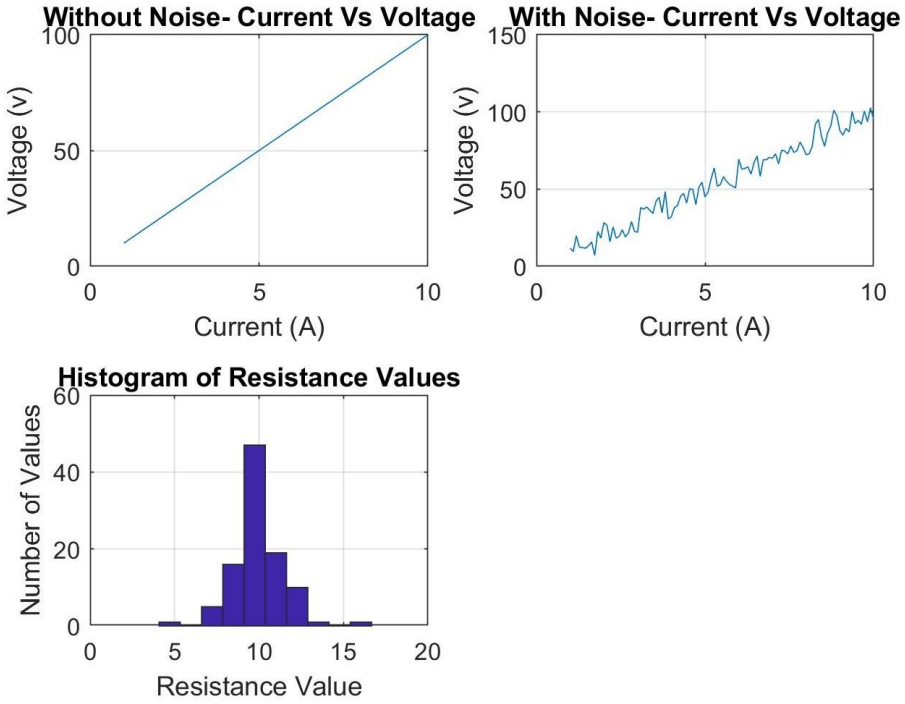
There was no difference when we used our own function versus the default function.

- ❏ Ex#3: Choosing, Vnoise=1v, calculate the slope of the curve and store the result. Repeat 100 times adding the same noise amplitude and plot the histogram of resistance values.
  - ➔ Repeat for Vnoise= 5v and Vnoise= 20V
  - ➔ Noise= 1V



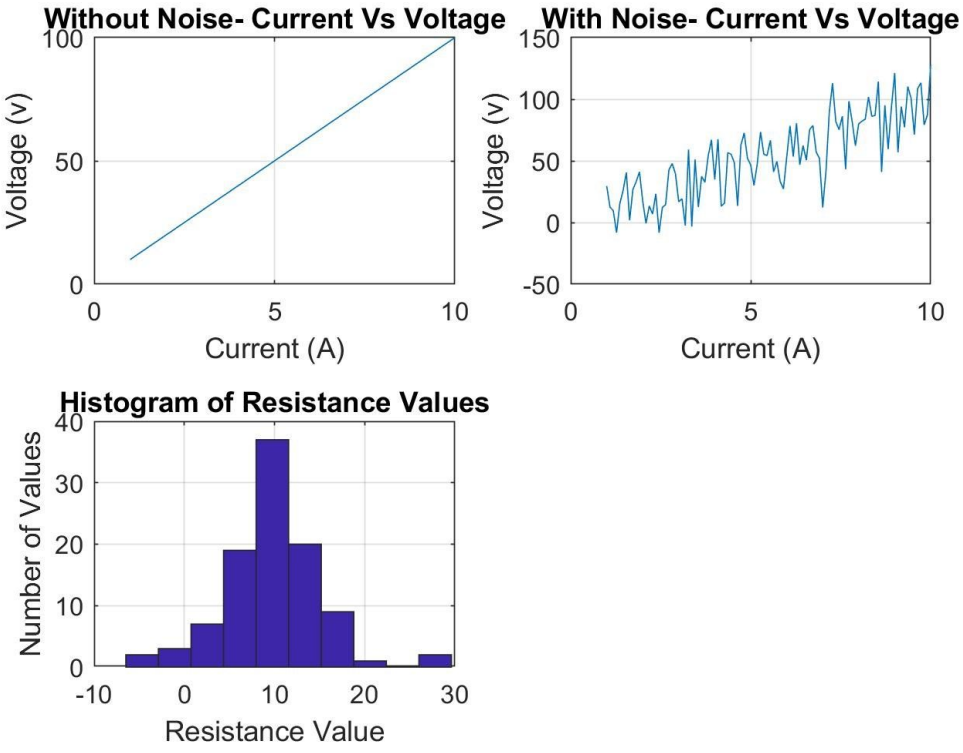
The slope for the line is 9.9984 and the y-intercept is -0.1261.

Noise=5V



The slope is 10.0156 and the y-intercept is -0.132

VNoise=20V

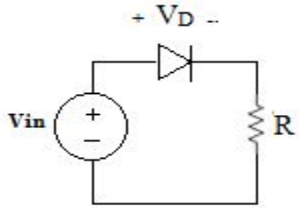


The slope is 9.9626 and y-intercept is -1.3379

These graphs tell us that as the noise increases the y-intercept and the slope alsos increases.

Experimental Procedure:

For the first experiment we used the 100 13ohm resistor with uncertainty of 1% that was constructed into a sheet of metal and measured all the 100 resistors. Then recorded the resistor of each resistor. We did the same for the 13 ohm resistor with uncertainty of 5%.



For the second part of the experiment, we constructed the circuit shown on figure above. Then using the digital multimeter placing between the diodes and the VI LABVIEW "voltagesweep.vi", we sweep the voltage of the diodes.

Question: Ex#1

1. For a Gaussian random variable of mean 10 and std=1, generate random ensembles of length N=100, 1000, 10000, 100000, 100000, 1000000 and calculate the mean, std and their errors from the theoretical values and plot the results. You should clearly see how the errors get less.

Post Lab

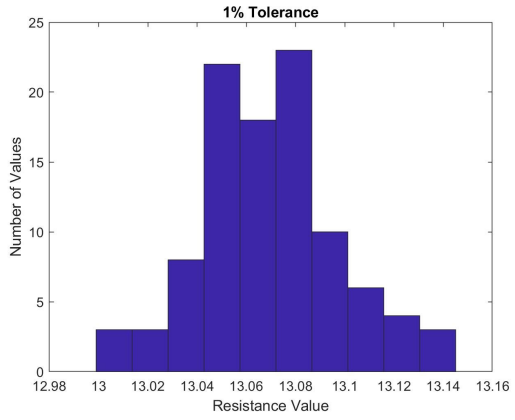
Ex#1

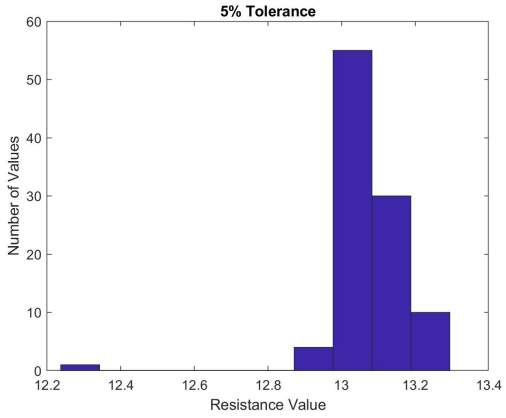
The table shows the average resistor of the 100 resistors and the standard deviations.

Tolerance		Calculated Mean		Calculated STD		Manufacturer Uncertainty	
1%		13.06972		0.027565		13+ or - 0.13	
5%		13.105		0.114978		13 + or - 0.65	

The average mean values are less than the manufacturer uncertainty.

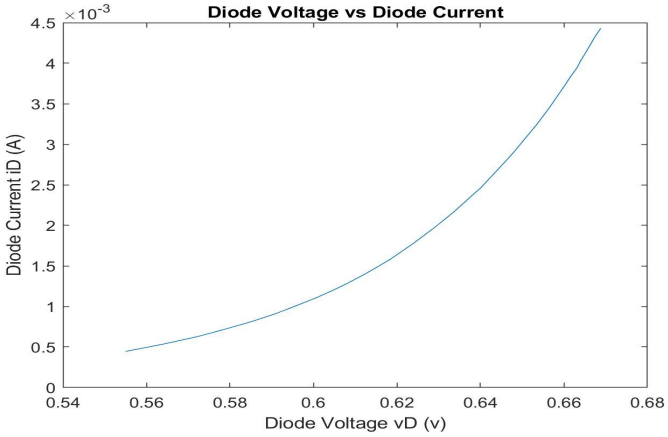
➔ Histogram for 1% and 5%



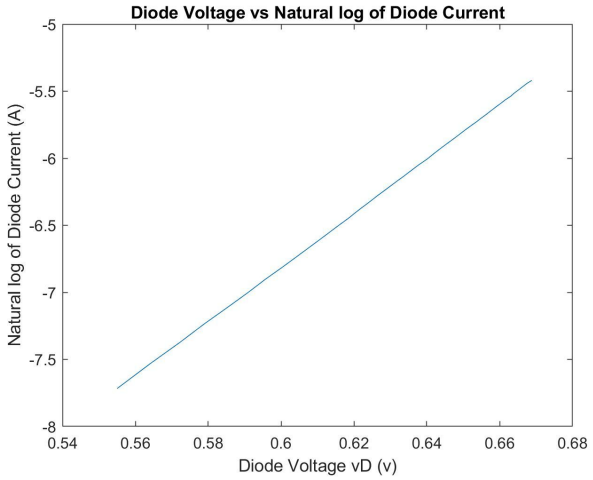


The 1% value were distributed in a bell curve manner where there were few resistors going above 13.13 which is the manufacturer uncertainty. We could say it does fall into random errors category. The 5% were also distributed in a somewhat bell curve manner and there were no resistor going over the uncertainty. So i think it also falls into random error category.

EX#2



This shows that the current is not dependant on the voltage.



This shows the current and voltage are exponentially dependant.

Using the polyfit on matlab we found the slope of the graph to be 20.2587 and y-intercept to be -18.9696

Using the formulas

- ➔ ln(iD)=ln(Io)+(Vd/(nVt)) where Vt=25mV
- ➔ n=1/(20.2587*.025)=1.9744 which falls between 1 and 4.

- ➔ Io=e^(-18.9696)=5.77*10^(-5) which falls into the range between 10^(-15) and 10^(-7)

Conclusion

This experiment shows that there are errors in measurements, and it could be at random. From the 13 ohms resistors and the circuit with the diodes, we were able to prove that errors exists. The 13 ohms resistor did not have perfect value of 13 for all the resistors and all of them were off by certain value. From this experiment we also proved that the diode current and diode voltage are exponentially dependant of each other.