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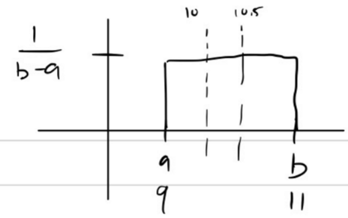
Section 002

Lab 3: Application of Probability and Statistics in ECEN

Task 1—Probabilistic Analysis of Analog Circuit Components

Task 1

1.) $f_C(c) = \begin{cases} \frac{1}{b-a} & a < c < b \\ 0 & \text{otherwise} \end{cases}$



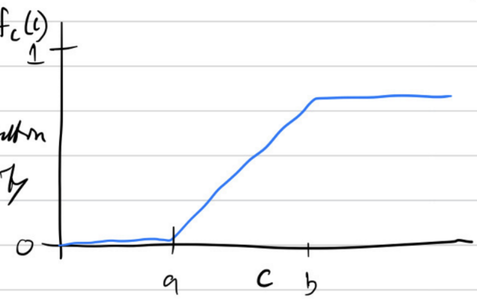
$\int f_C(c)\,dc = 1 \Rightarrow \frac{b-a}{b-a} = 1$ If C lies between a and b the area under the curve will be 1. Otherwise the area will be 0.

2.) 25%, When we integrate, we just take the difference between b and a, in both 10 <-> 10.5 uF and 9.75 uF <-> 10.25 uF is the same. Its 1/4 of the area under the curve.

3.) $Pr(C \geq X) = 0.01$ Find value of X.
1% ↗ 1% of 2 = .02 so $\boxed{X = 10.8}$

A company would use this to show that it is very precise and the top end of the tolerance range.

4.) $F(c) = Pr(C \leq c) = \int_{-\infty}^{c} f_C(c)\,dc$



This is called the cummulative distribution function because it shows the probability of c at every point of a function w/ respect to c.

5.) 50%, 9 to 10 uF is half of the area under the curve in (1) therefore we will a 50% probability.

6.) 50% -> 25% -> 12.5% -> 6.25% -> $\boxed{3.125\%}$
(1, 2, 3, 4, 5)

7.) Matlab Code -> $\boxed{0.6230}$ See Code ✓

8.)
1. Electrical components and their values and tolerances
2. Margin of Error – what will be our margin of error when planning for a project.
3. Latency and how latency builds on each other through embedded systems.
4. Hit/Miss Rates in Computer Science.

Code for Task 1.7:

```
%%% Lab 3 Task 1 MATLAB Code %%%
n = 10;
p = 1/2;
k = 5;
prob = binomialpdf(n,p,k)
function ans = binomialpdf (n, p, k)
% n is number of trials
% p is probability
% k is number of possible successes
   ans = 0;

   for i = k:n
       ans = ans + nchoosek(n,i)*p^i*(1-p)^(n-i);
   end

end
```

Task 2—Statistical Analysis of Filter Corner Frequencies from Lab 2

Task 2:

1.) $\dfrac{1}{2\pi R_e C} = \dfrac{1}{2\pi(47)(10^{-6})} = \boxed{3386.275 \text{ Hz}}$

2.) Actual Values:

47k Resistor 46.774 Ω

1μF Capacitor 0.920 μF

3.) $\dfrac{1}{R_e C} = \dfrac{1}{47(1\times10^{-6})} = \boxed{21276.60 \text{ rad/s}}$

$\dfrac{1}{R_e C} = \dfrac{1}{(46.774)(.92\times10^{-6})} = \boxed{23238.48 \text{ rad/s}}$

The difference between these is our actual values are not exactly ideal, but are still within the tolerance values.

4.) 1μF ± 10% Between .9μF and 1.1μF

47Ω ± 5% Between 44.65Ω and 49.35Ω

High $W_c = \dfrac{1}{R_e C} = \dfrac{1}{(49.35)(1.1\mu F)} =$ 18421.30 rad/s

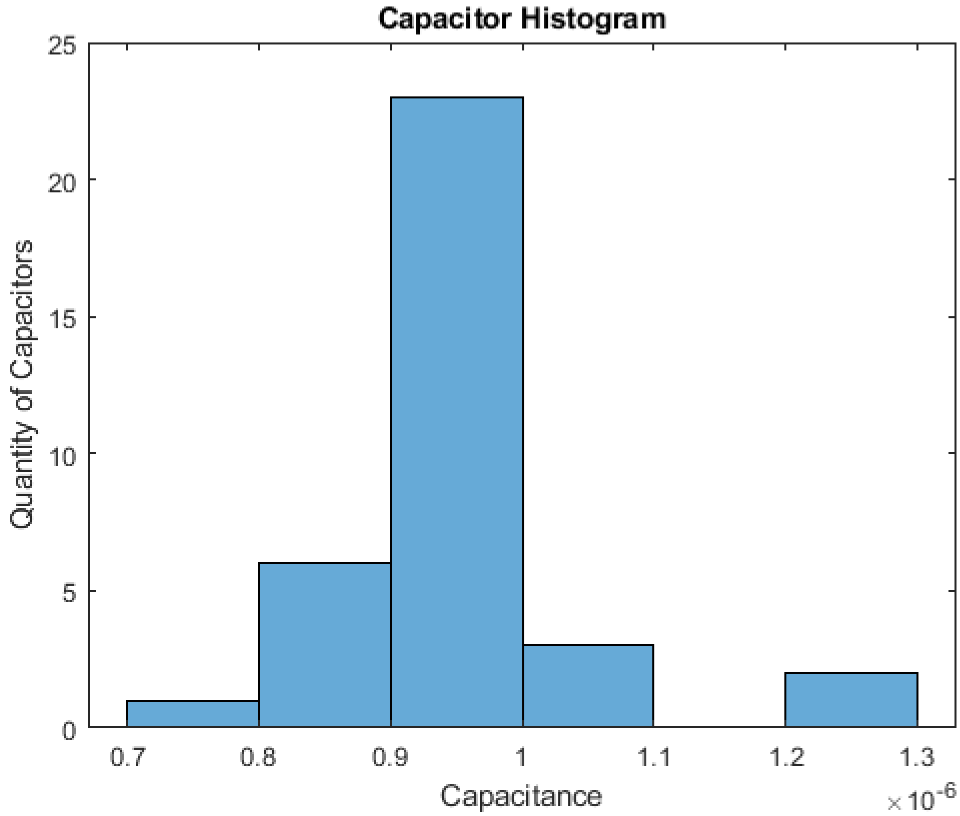
2931.84 Hz

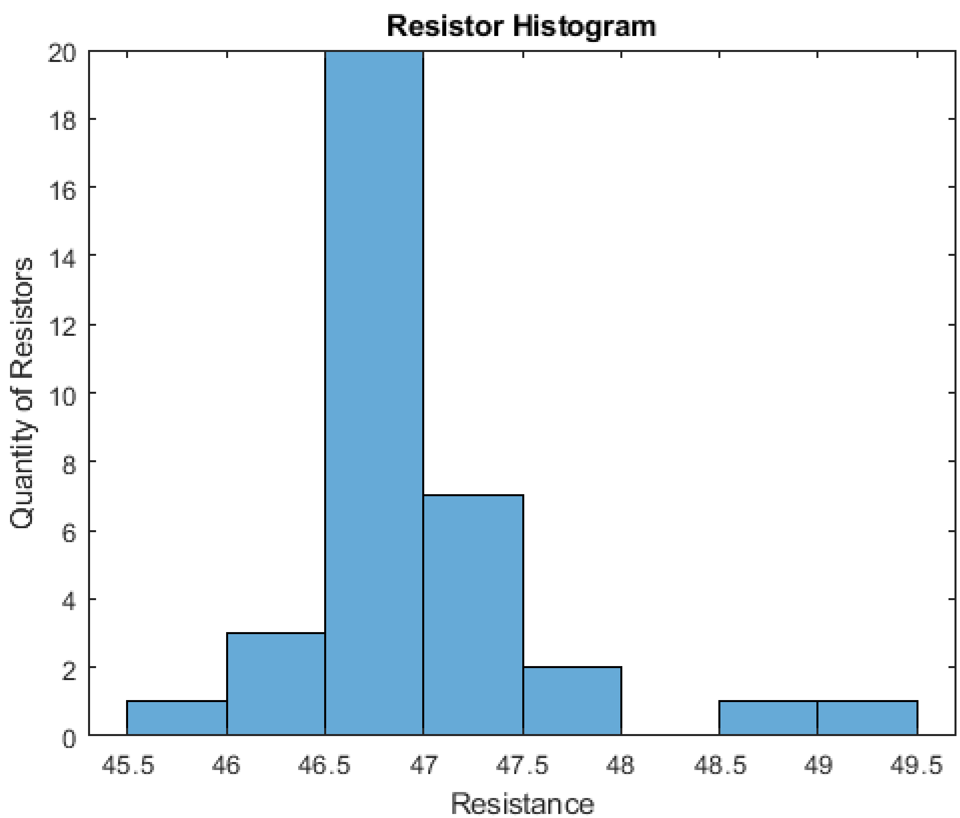
low $W_c = \dfrac{1}{R_e C} = \dfrac{1}{(44.65)(.9\mu F)} =$ 24884.91 rad/s

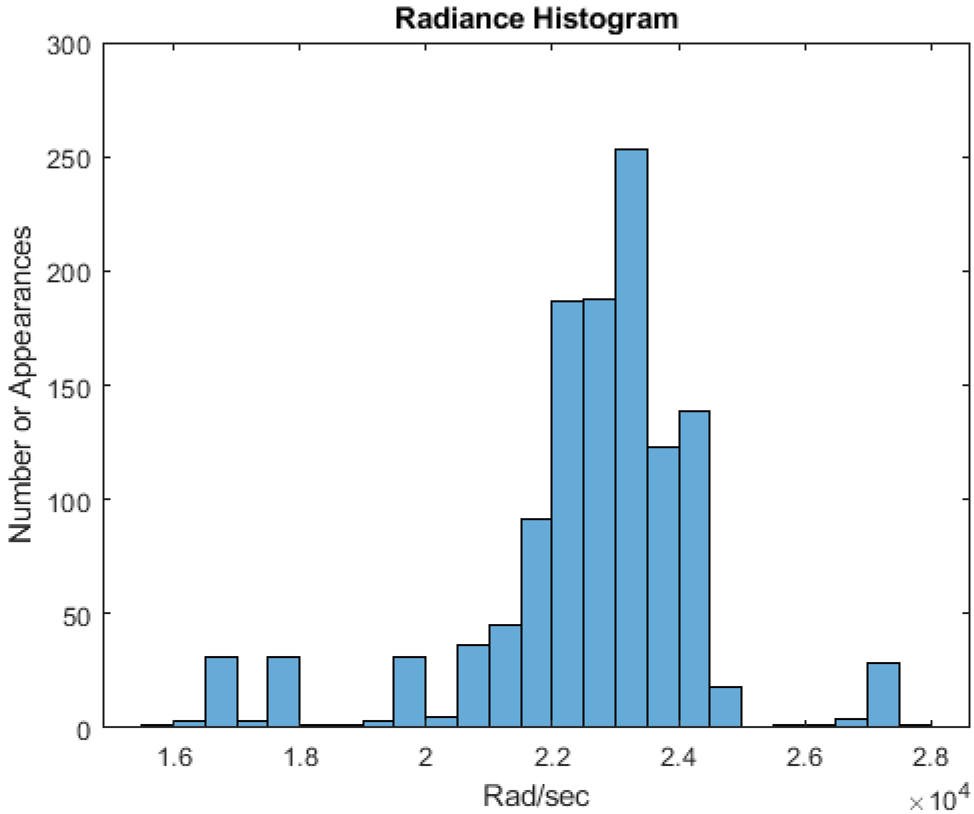
3960.556 Hz

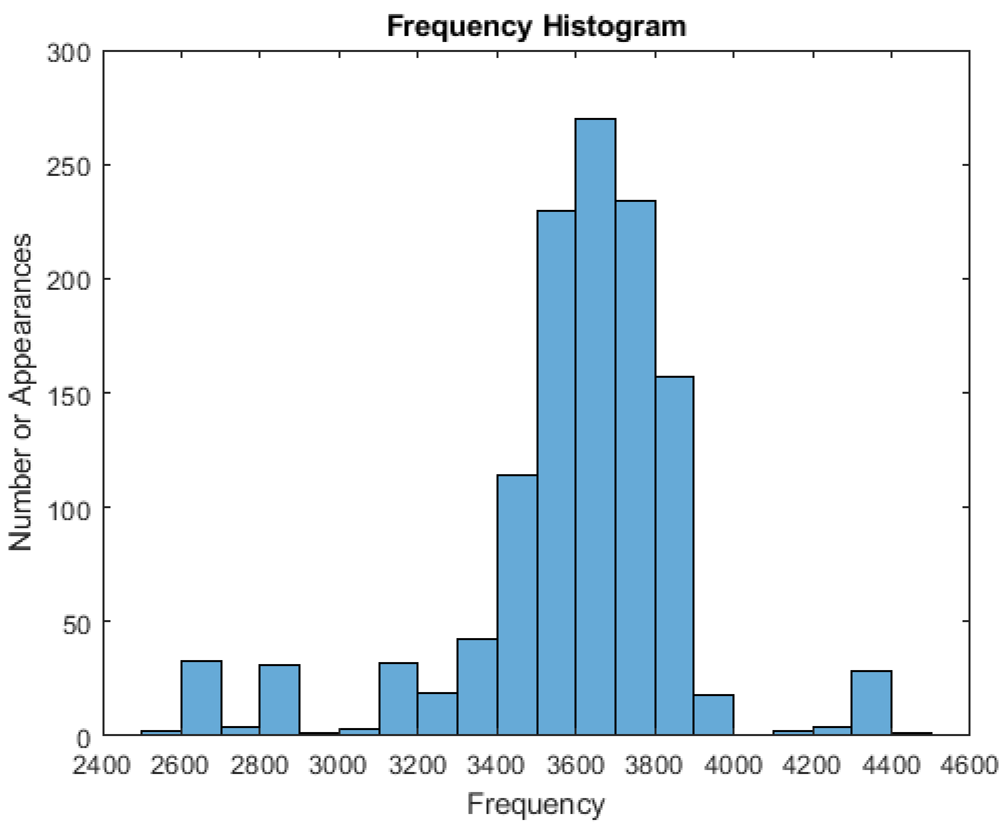
Between	2931.84 Hz 18421.30 rad/s	and	3960.556 Hz 24884.91 rad/s

10% tolerance is the highest tolerance we can accept.


Capacitor Histogram
Quantity of Capacitors
Capacitance
0 5 10 15 20 25
0.7 0.8 0.9 1 1.1 1.2 1.3
× 10^-6


Resistor Histogram
Quantity of Resistors
Resistance
0 2 4 6 8 10 12 14 16 18 20
45.5 46 46.5 47 47.5 48 48.5 49 49.5


Radiance Histogram
Number or Appearances
Rad/sec
×10^4
0
50
100
150
200
250
300
1.6
1.8
2
2.2
2.4
2.6
2.8


Frequency Histogram
Number or Appearances
Frequency
0
50
100
150
200
250
300
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600

MATLAB Code for Task 2:

```
%%% Lab 3 Task 2 Matlab Code %%%
clc, clear, close all;
load("ecen380_lab3_capacitors.mat","C");
load("ecen380_lab3_resistors.mat", "R");
C_mean = mean(C);
R_mean = mean(R);
C_dif = var(C);
R_dif = var(R);
figure(1);
histogram(R);
title("Resistor Histogram");
xlabel("Resistance");
ylabel("Quantity of Resistors")
figure(2);
histogram(C);
title("Capacitor Histogram");
xlabel("Capacitance");
ylabel("Quantity of Capacitors");
w = [];
f = [];
for i = 1:numel(R)
   for j = 1:numel(C)
       w_temp = 1/(R(i)*C(j));
       w = [w w_temp];
       f = [f w_temp/(2*pi)];
   end
end
figure(3)
histogram(w);
title("Radiance Histogram");
xlabel("Rad/sec");
ylabel("Number or Appearances");
figure(4)
histogram(f);
title("Frequency Histogram");
xlabel("Frequency");
ylabel("Number or Appearances");
function ans = binomialpdf (n, p, k)
% n is number of trials
% p is probability
% k is number of possible successes
ans = 0;
for i = k:n
   ans = ans + nchoosek(n,i)*p^i*(1-p)^(n-i);
end
end
```

Task 2.8
The randomness of the component value can play a big role in designing a circuit. The values can quickly add up to bringing a circuit to have an output far from what is desired. By calculating knowing the tolerance of the components and calculating variance and likelihood of the values, it is much easier to know the range of possible outputs for a circuit and make it within our desired range using the given components.

Conclusion

Throughout this lab we learned the importance and uses of statistics in engineering. This lab opened my eyes because before I had never really considered statistics an important part of engineering. We analyzed some analog circuit components and calculated the probabilities of certain situations. We also learned about the Cumulative distribution and the Probability Distribution function. We were able to apply what we learned and use MatLab to calculate different probabilities. In Task 2 we analyzed Corner Frequencies in rad/sec as well as Hz. We compared the ideal values of our components to the actual value of our components. We then took the dataset of our entire class's components and analyzed them using matlab. We created several histograms to display our findings in an easy to see way.