

University of Wales Trinity Saint David

Wales Institute of Science and Art



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Part 2 and 3 electrical

ACHA4010

Oliver Wilson

2203893

24/03/2024

Contents

1	Task 2	1
1.1	Scope Time Division Calculations (4)	1
1.2	Function Generator output sine wave (3)	1
1.3	Unsmoothed Rectifier Wave (3)	2
1.4	Smoothed Rectifier Wave with capacitor (3)	3
1.5	Drop in Voltage Question (4)	3
1.6	Different Voltage Readings Question (5)	3
1.7	Rectifiers use in Automotive applications Question. (4)	4
1.8	Probing Question (4)	4
2	Task 3	5
2.1	Scope Time Division Calculations (4)	5
2.2	Function Generator output square wave (3)	6
2.3	Capacitor charge and discharge wave marked at correct points. (3)	7
2.4	Basic Capacitor Calculations (3)	8
2.5	Capacitor discharge table (4)	9
2.6	Gradient Plot and calculations (4)	10
2.7	Capacitor Uses (5)	10
2.8	Inaccuracies Question (4)	11
3	References	12

Figure 1-sine wave	1
Figure 2-rectified wave	2
Figure 3-smoothed rectified wave.....	3
Figure 4-square wave input	6
Figure 5-charge time constant.....	7
Figure 6- charge from bottom to top.....	7
Figure 7- time constant discharge	8
Figure 8-discharge top to bottom	8
Figure 9-voltage of figure 8.....	8
Figure 10- MATLAB graph and point of measurement	9
Figure 11- gradient plot $\ln(v)$ v time	10
 Table 1- capacitor discharge table	 9

1 Task 2

1.1 Scope Time Division Calculations (4)

$$F = 10 \text{ Hz}$$

$$\text{Period} = 1/\text{Frequency}$$

$$\text{Period} = 1/10 = 0.1 \text{ second}$$

$$t/\text{div} = 0.1/5$$

$$t/\text{div} = 0.02\text{s} = 20\text{ms}$$

1.2 Function Generator output sine wave (3)

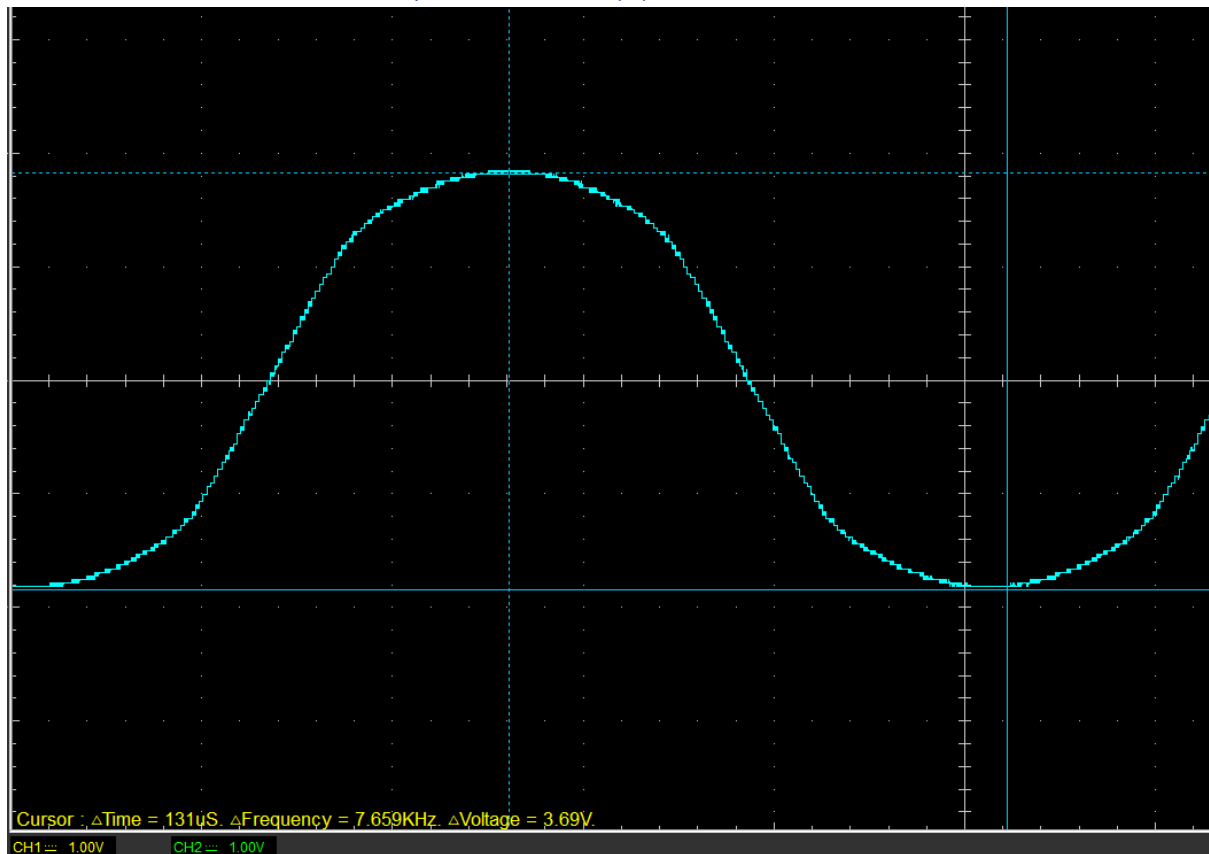
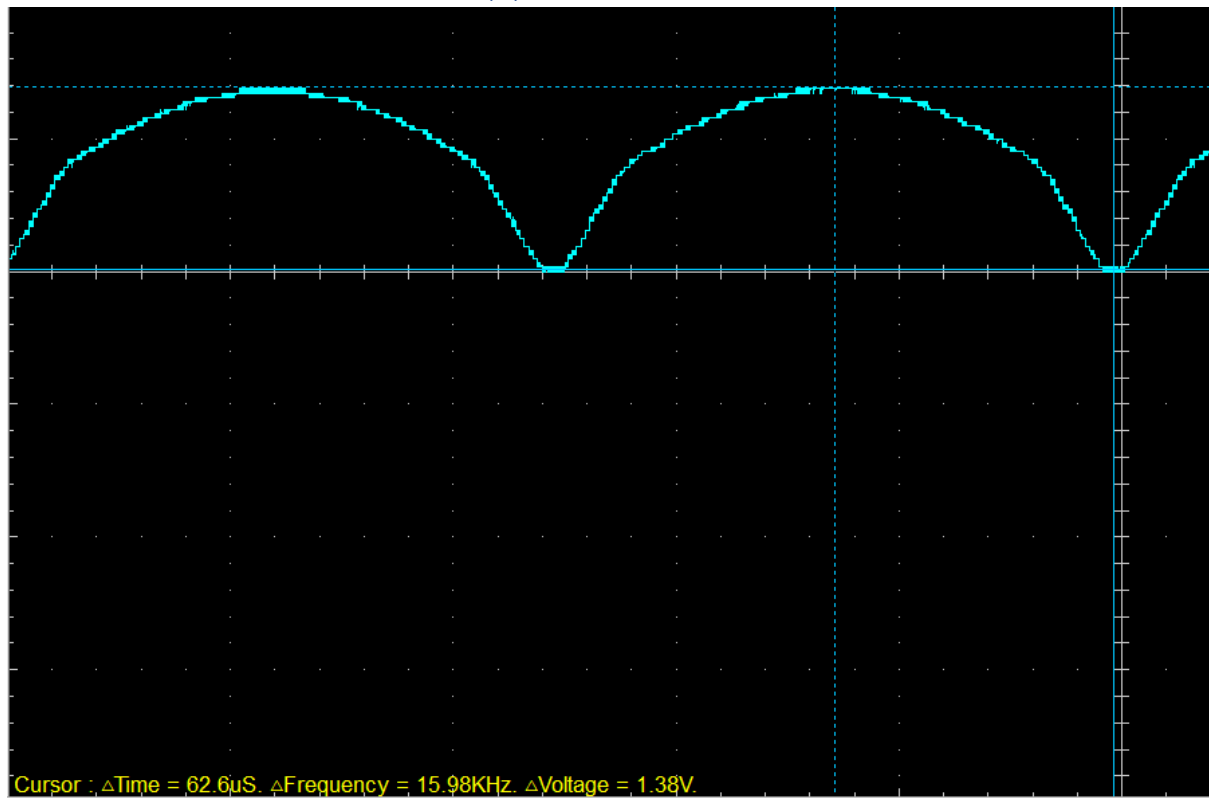


Figure 1-sine wave

1.3 Unsmoothed Rectifier Wave (3)

*Figure 2-rectified wave*

1.4 Smoothed Rectifier Wave with capacitor (3)

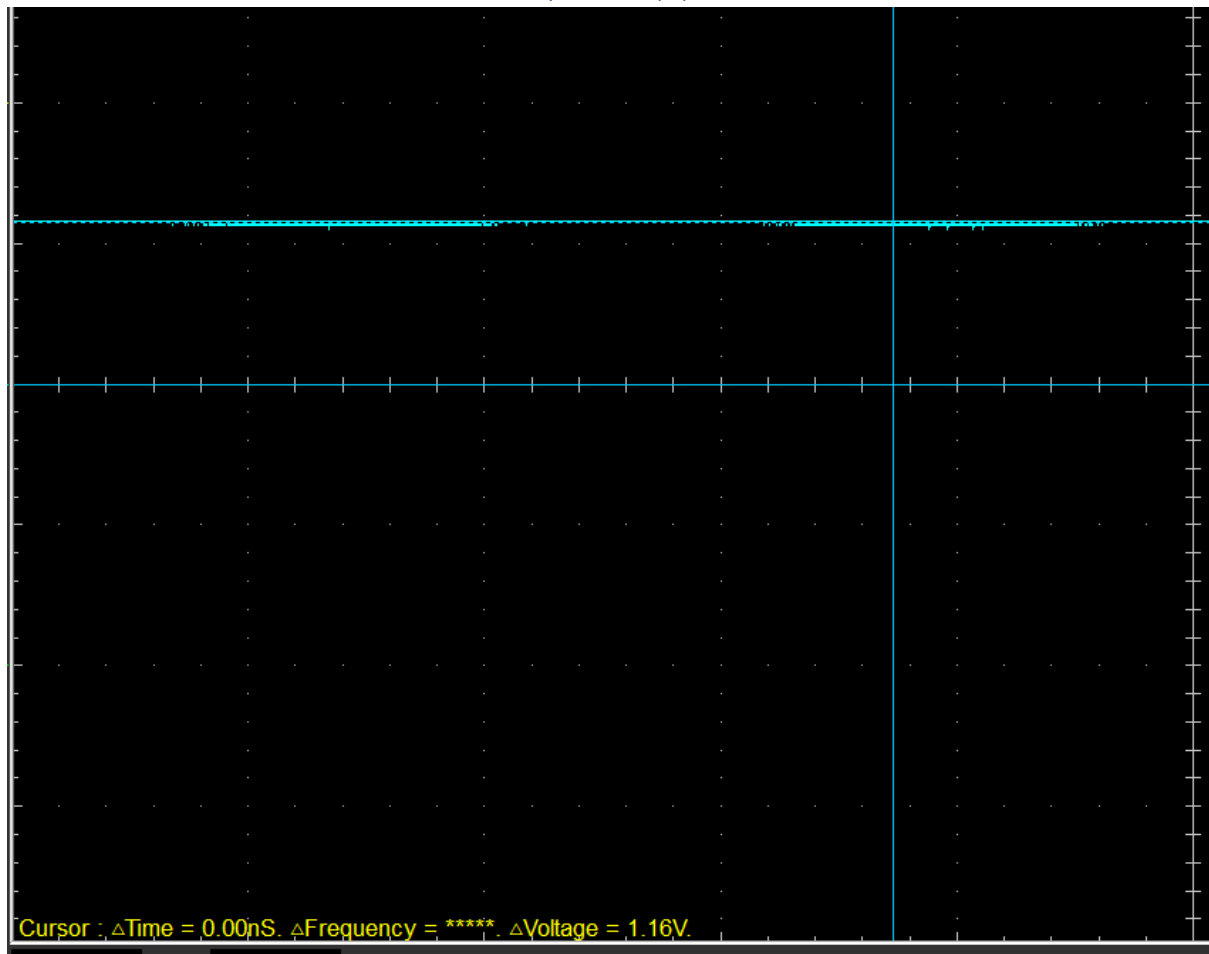


Figure 3-smoothed rectified wave

1.5 Drop in Voltage Question (4)

The drop in voltage from the original sine wave to the rectified output is due to the ac current being halved as its changed to dc. The ac no longer travels past the 0 point on the negative side creating a fully rectified circuit. The resistance of the circuit such as the diodes internal resistance will lose some of the voltage.

1.6 Different Voltage Readings Question (5)

Peak to peak =3.69

Peak voltage =1.38

RMS = Peak Voltage/ $\sqrt{2}$

Use rms which is $RMS = 1.38/\sqrt{2}$. it makes it to 0.976 volts.

The Root mean square shows the magnitude of the ac input wave. The RMS value is the wave form required from a sine wave to achieve the same heat value if that of a dc circuit. The RMS is calculated by squaring the input signal, averaging it then taking the square root. For a sine wave the equation is $RMS = \frac{A}{\sqrt{2}}$ A is = to peak voltage. (HATHAWAY, 2024)

1.7 Rectifiers use in Automotive applications Question. (4)

Rectified current is changing ac to dc, this application is used in the automotive industry in items such as an alternator. The diodes in the alternator prevent negative current flow through the system and converts the power from ac to dc which allows for the voltage generated to be used in the battery and to power the electronics in the loop. (quick start, 2024)

Other uses for rectified power are becoming increasingly more significant in EV charging stations, the charging stations need to change 3 phase AC current from the grid into a dc current for the car to be plugged into and charged. Chargers need to be able to provide high voltages up to 350 kw reliably to charge the batteries (SITHARA S. G. ACHARIGE, 2023)

1.8 Probing Question (4)

A limiting factor of probing using the oscilloscopes in class is the number of inputs available to take the reading. In class using the hantek modules, a single probe and a ground wire were used to collect data before and after the led and the resistor to show the rectified wave. By testing on the diodes for the rectifier, the switching of the diodes as the ac current is produced means that one side of the rectifier can be measured at a time with the current setup. By using a signal splitter in conjunction with the oscilloscope the signal can be duplicated and produce a reading on the hantek software allowing for simultaneous results. (open Ai, 2024)

2 Task 3

2.1 Scope Time Division Calculations (4)

$$T=RC$$

Resistor used was a 100K so $R=100k\Omega$

Capacitor used was a 104 so $C = 0.1\mu F = 0.1 \times 10^{-6} F$

$$T = 100000 \times 0.1 \times 10^{-6} = 0.01s$$

$$\text{Time for 20 periods} = 0.01 \times 20 = 200ms$$

$$\text{frequency} = 1/\text{period} = 1/0.01 = 100Hz$$

$$\text{Divisions per period} = 3$$

$$t/div = 0.01/3 = 0.0033s = 3.3ms$$

2.2 Function Generator output square wave (3)

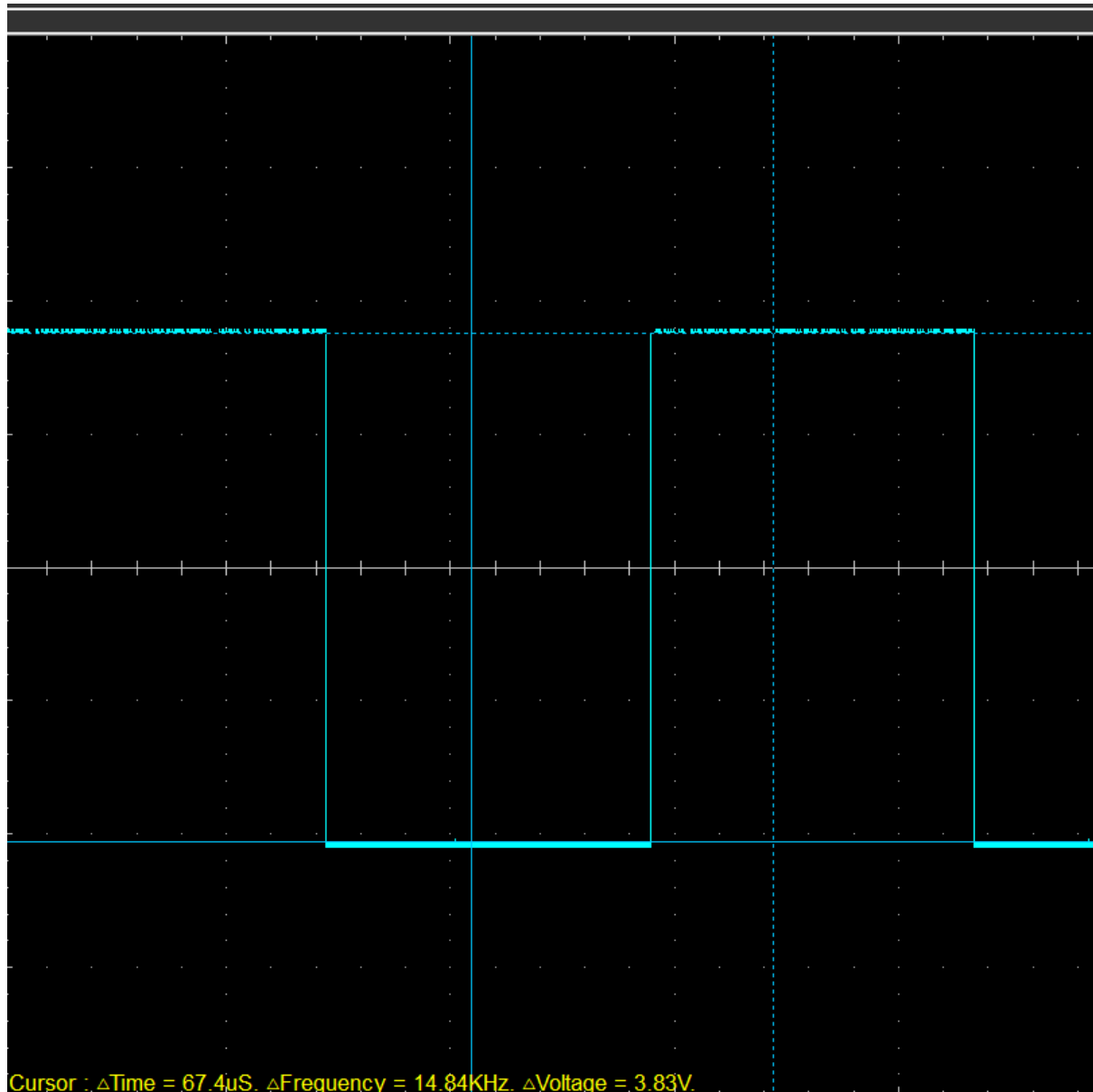


Figure 4-square wave input

2.3 Capacitor charge and discharge wave marked at correct points. (3)

Charge

To calculate time constant for the capacitor

$$(V_{\max} - V_{\min}) \times 63.2\% = V_{T1}$$

$$V_{\max} = 3.5\text{v}$$

$$V_{\min} = 0\text{v}$$

$$V_{T1} = (3.5-0) \times 0.632 = 2.212\text{v}$$

Discharge

$$V_{T1} = (3.5-0) \times 0.368 = 1.288\text{v}$$

Charge

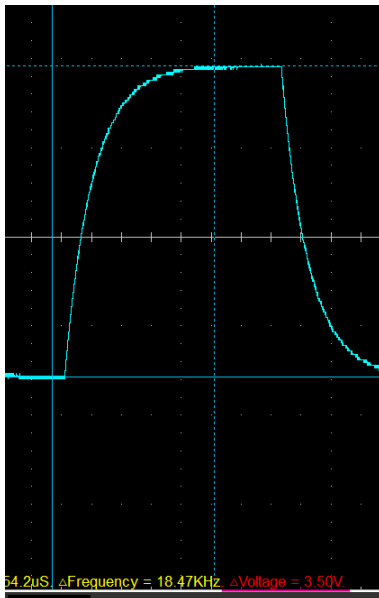


Figure 6- charge from bottom to top

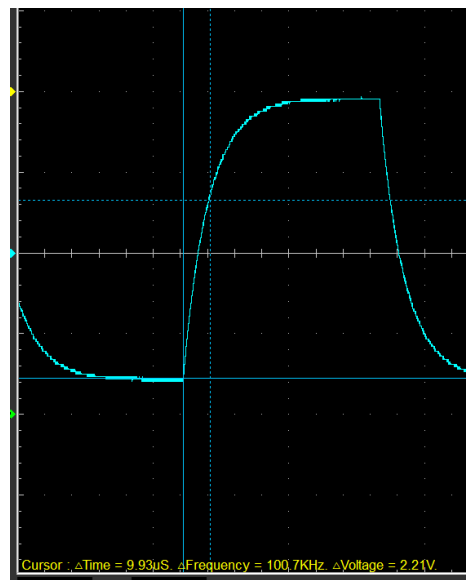


Figure 5-charge time constant

Discharge

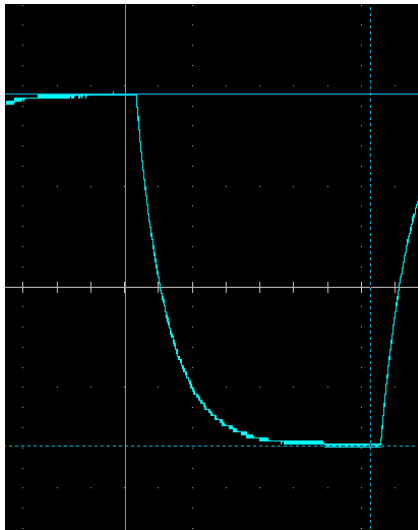


Figure 8-discharge top to bottom

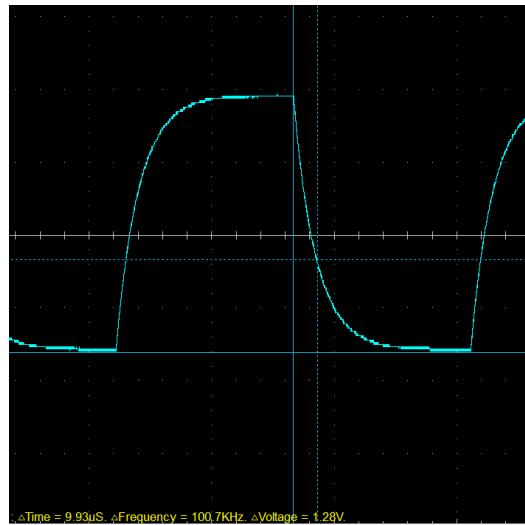


Figure 7- time constant discharge

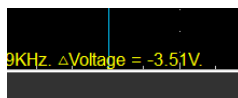


Figure 9-voltage of figure 8

2.4

Basic Capacitor Calculations (3)

$$T=RC$$

$$\text{Time period} = 9.93 \times 10^{-6} \text{ seconds}$$

$$C=t/r$$

$$C=9.93 \times 10^{-6} / 100\,000$$

$$C= 9.93 \times 10^{-8} \text{ farads}$$

$$(\text{This approximates to } = 10 \times 10^{-8} \text{ farads} = 0.1 \times 10^{-6} \text{ farads})$$

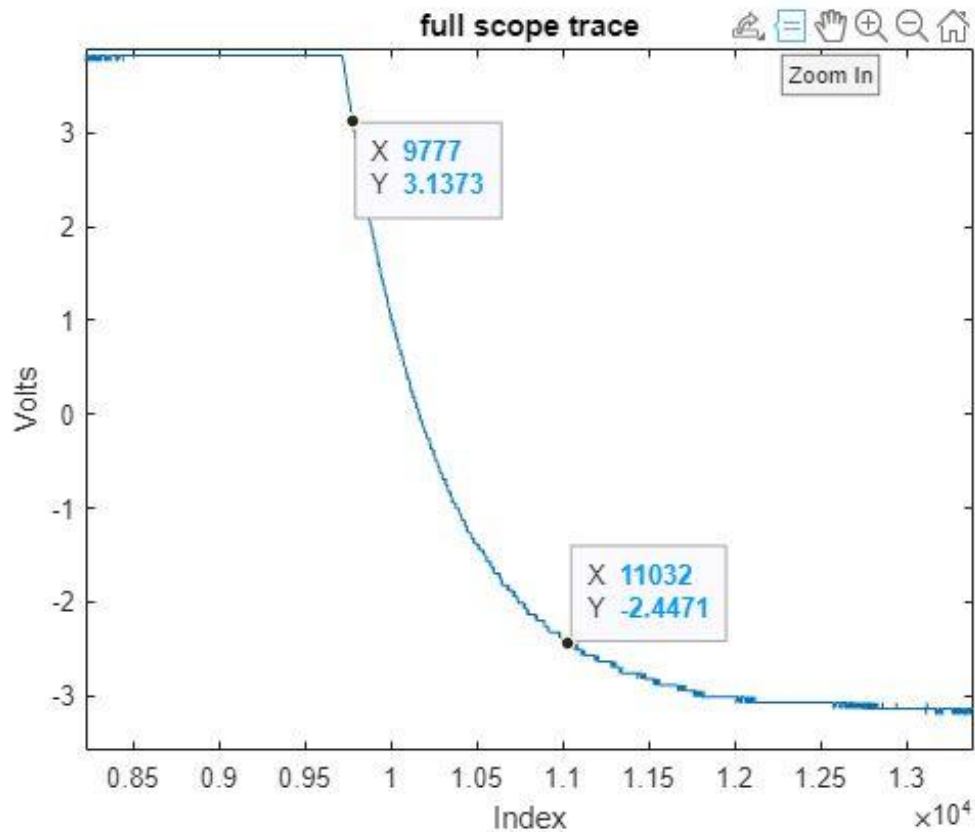


Figure 10- MATLAB graph and point of measurement

2.5 Capacitor discharge table (4)

Table 1- capacitor discharge table

Time (s)	Voltage (V)	V+	ln (V)	$dy = y_2 - y_1$ $dy = \ln(V)_2 - \ln(V)_1$	$dx = x_2 - x_1$ $dx = \text{Time}_2 - \text{Time}_1$	dy/dx
0.097	3.8275	8.8275	2.177872	x	x	x
0.09844	2.4471	7.4471	2.007825	-0.17005	0.00144	-118.088
0.09988	1.1294	6.1294	1.813097	-0.19473	0.00144	-135.228
0.10132	0.1882	5.1882	1.646387	-0.16671	0.00144	-115.771
0.10276	-0.5647	4.4353	1.489595	-0.15679	0.00144	-108.883
0.1042	-1.1294	3.8706	1.35341	-0.13619	0.00144	-94.5734
0.10564	-1.5686	3.4314	1.232968	-0.12044	0.00144	-83.6397
0.10708	-1.8824	3.1176	1.137063	-0.0959	0.00144	-66.6006
0.10852	-2.1961	2.8039	1.031011	-0.10605	0.00144	-73.6473

2.6 Gradient Plot and calculations (4)

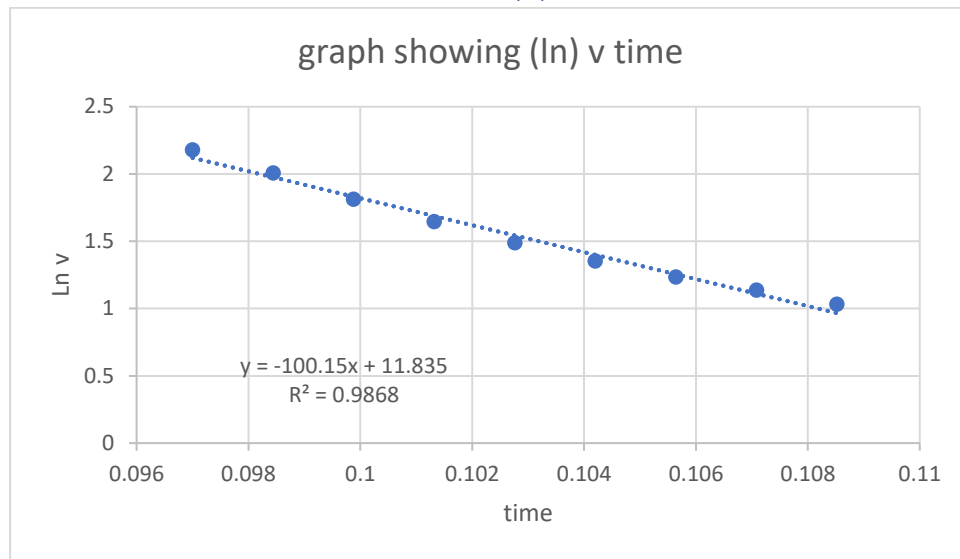


Figure 11- gradient plot $\ln(v)$ v time

$$R \times C = T = 1/\text{gradient}$$

$$T = 1/-100.15 = -9.85 \times 10^{-3}$$

$$T = 9.985 \times 10^{-3}$$

$$C = t/r$$

$$C = 9.985 \times 10^{-3} / 100000$$

$$C = 9.985 \times 10^{-8} \text{ farads}$$

$$C = 0.0985 \text{ uf}$$

(This approximates to $= 10 \times 10^{-8} \text{ farads} = 0.1 \times 10^{-6} \text{ farads}$)

Percentage difference in values is calculated using

$$(\text{Value1} - \text{Value2}) / ((\text{Value1} + \text{Value2}) / 2)$$

$$\Delta\% = \left(\frac{(9.985 \times 10^{-8} - 9.93 \times 10^{-8})}{\frac{(9.985 \times 10^{-8} + 9.93 \times 10^{-8})}{2}} \right) * 100 = 0.55\%$$

2.7 Capacitor Uses (5)

- Energy storage- used as a short-term power storage capable of fast discharge to power or rectify ac input
- Used for smoothing a rectified circuit- by discharging between the voltage drops to maintain a smooth wave form.
- Ecu smoothing.
- Noise filtering
- Ignition system

- Starter motor
- LED lighting
- EV charging
- Timing circuits
- Voltage regulation

Capacitors are used to smooth out the input waves, if they're not being used to rectify an ac input then they are being used for rapid energy storage and discharge.

2.8 Inaccuracies Question (4)

During the tests conducted the equipment used had a varying degree of reliability, some of the wires were faulty and needed trial and error to get the circuit working properly. When measuring the circuit, the wire would work in certain positions so the readings taken could vary between runs. On the measuring of components with the oscilloscope, a range of inaccuracies can occur that can affect the validity of the results such as distortion, resolution on the screen and marker placement. In having a distorted reading, there is difficulty in taking an accurate measurement from the graphs also the same with resolution on screen. Improving the reliability of results would be better equipment used such as a better oscilloscope for measurements, also use a more reliable circuit setup not involving a breadboard to reduce the interference and to increase the quality of the results. (Hancock, 2010)

All components used to create the circuit will have a tolerance within their specification due to the inconsistencies in quality of materials used and the manufacture process.

3 References

Hancock, J. (2010). *Evaluating Oscilloscope Sample Rates vs. Sampling Fidelity:How to Make the Most Accurate Digital Measurements*. American Society for Engineering Education.

HATHAWAY, R. &. (2024, march 22). *root mean square*. Retrieved from science direct:
<https://www.sciencedirect.com/topics/engineering/root-mean-square#:~:text=RMS%20is%20the%20square%20root,signal%20energy%20in%20time%20do>
main.

open Ai. (2024, march 19). Retrieved from ChatGPT (3.5) [Large language model]. :
<https://chat.openai.com>

quick start. (2024, march 20). *quick start*. Retrieved from What is the Bridge Rectifier in an Alternator and What Does It Do?: <https://alternatorparts.com/what-is-the-bridge-rectifier-in-an-alternator-and-what-does-it-do-faq.html#:~:text=The%20Bridge%20Rectifier%20is%20the,that%20are%20one%20way%20gates>.

SITHARA S. G. ACHARIGE, M. E. (2023). *Review of Electric Vehicle Charging Technologies, and Converter*. IEEE.