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Electronic Circuits Testing and Applications

Electronic Control Systems ACHA4010

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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)	2
1.5	Drop in Voltage Question (4)	2
1.6	Different Voltage Readings Question (5)	2
1.7	Rectifiers use in Automotive applications Question. (4)	3
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)	5
2.3	Capacitor charge and discharge wave marked at correct points. (3)	5
2.4	Basic Capacitor Calculations (3)	6
2.5	Capacitor discharge table (4)	6
2.6	Gradient Plot and calculations (4)	7
2.7	Capacitor Uses (5)	7
2.8	Inaccuracies Question (4)	8
3	References	9

Figure 1 Shows a function generator output sine wave with a voltage peak of 4.67 making a 9.34 peak to peak sine wave. Frequency = 9.952Hz and Time = 100mS.	1
Figure 2 Shows an unsmoothed rectifier wave. Voltage = 7.16V, Frequency = 9.805Hz and Time = 102mS.	2
Figure 3 This shows a smoothed wave once the capacitor was placed in the circuit.	2
Figure 4 demonstrates the meaning of VRMS (Storr 2013)	3
Figure 5 Shows a rectifier for an alternator (Wagendass 2024)	4
Figure 6 Shows the function generator output square wave. Voltage = 8.78V, Frequency = 8.228Hz and Time = 122mS	5
Figure 7 Shows a capacitor charge and discharge wave. Voltage marked at 63.2% which has been calculated below. Voltage at 63.2% = 5.38V, Frequency = 15.68Hz and Time = 63.8mS	5
Figure 8 Shows a graph with the natural log of voltage against time. Showing the gradient and regression value.	7

1 Task 2

1.1 Scope Time Division Calculations (4)

$$Frequency = 10Hz$$

Equation 1 This equation is used to solve for frequency.

$$Frequency (Hz) = \frac{1}{Time (seconds)}$$

Equation 2 was used to calculate a time division on the oscilloscope by rearranging Equation 1.

$$Time (seconds) = \frac{1}{10Hz}$$

$$Time = 0.1 seconds$$

1.2 Function Generator output sine wave (3)

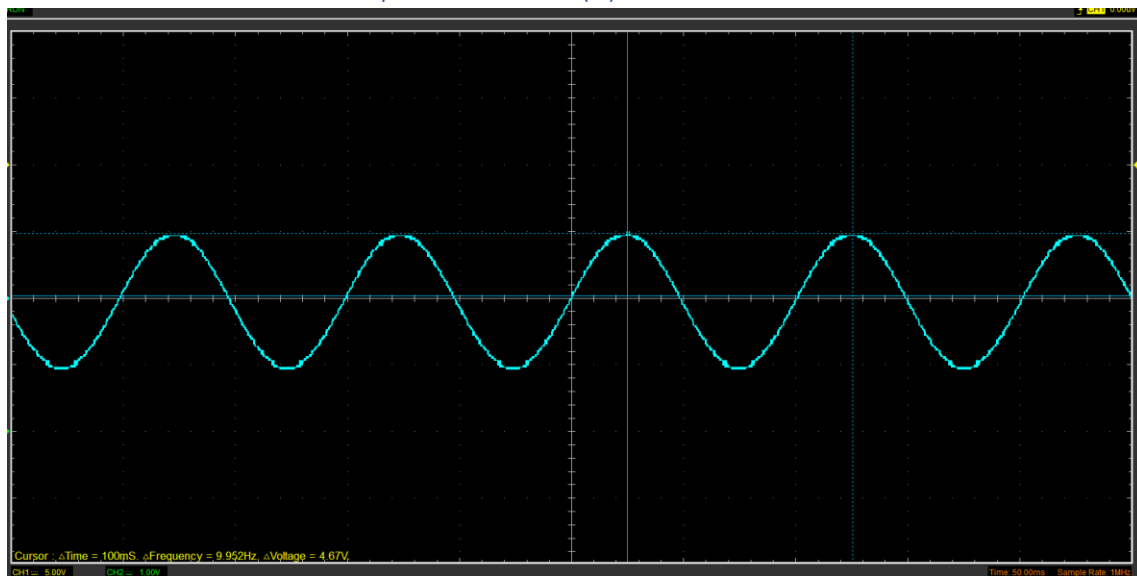


Figure 1 Shows a function generator output sine wave with a voltage peak of 4.67 making a 9.34 peak to peak sine wave. Frequency = 9.952Hz and Time = 100mS.

1.3 Unsmoothed Rectifier Wave (3)

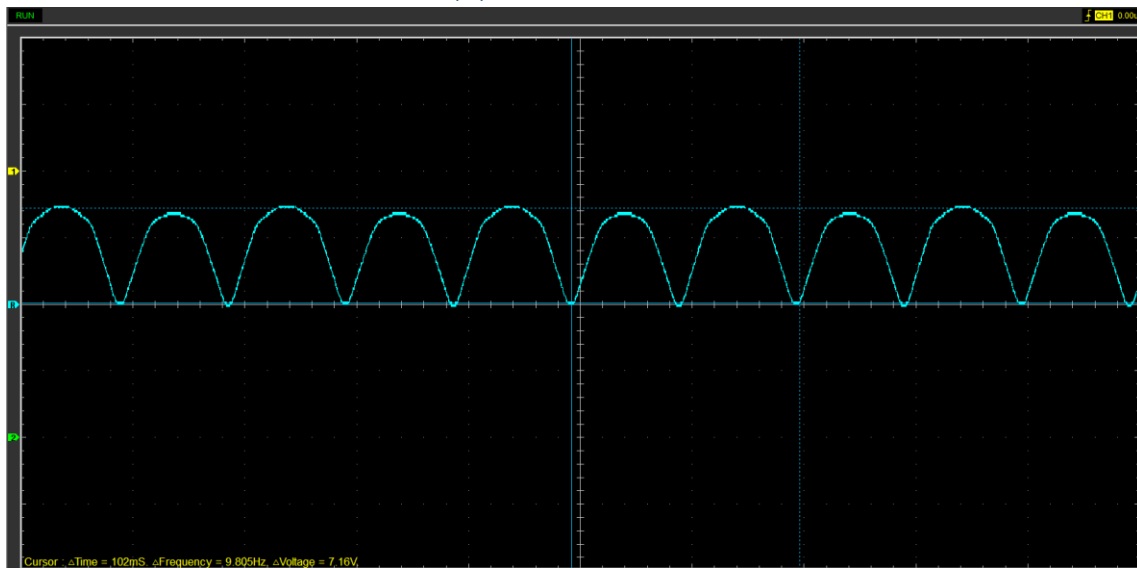


Figure 2 Shows an unsmoothed rectifier wave. Voltage = 7.16V, Frequency = 9.805Hz and Time = 102mS.

1.4 Smoothed Rectifier Wave with capacitor (3)

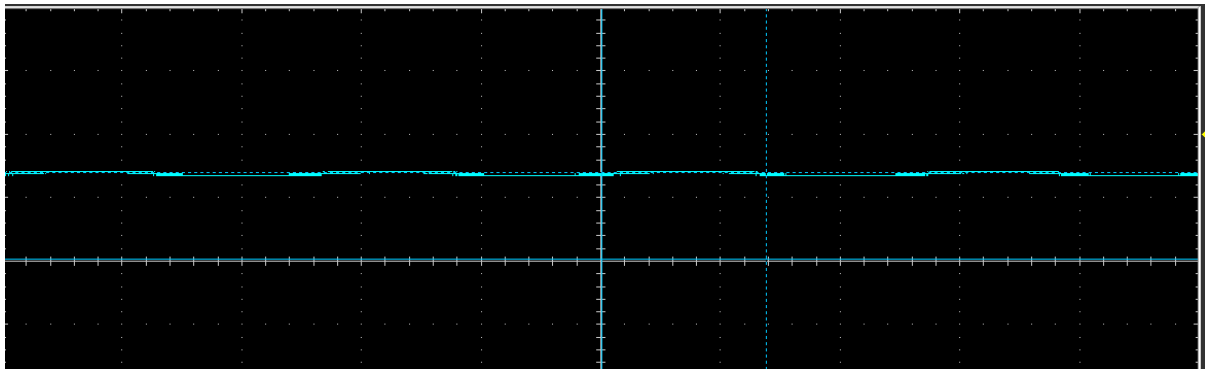


Figure 3 This shows a smoothed wave once the capacitor was placed in the circuit. Voltage = 6.86V.

1.5 Drop in Voltage Question (4)

Rectifiers have diodes placed in the circuit. Diodes have a potential barrier of 0.7V. In this rectifier circuit four diodes are in series, these require 2.8V to operate all together. The voltage drop is caused by the load resistor and the diodes. The load resistor causes the electrons to slow down, this is due to the lattice structure within the resistor. When the electrons collide with the structure this causes a force that opposes the current and thus creating a reaction voltage that opposes the applied voltage (Dahigaonkar 2022).

1.6 Different Voltage Readings Question (5)

Equation 3 was attained by (Rijk de Wet 2024).

$$V_{RMS} = \frac{V_{pk}}{\sqrt{2}}$$

$$V_{RMS} = \frac{4.67}{1.414}$$

$$V_{RMS} = 3.302V$$

Voltage Root Mean Squared (VRMS) is equivalent to the DC voltage of an AC source as shown in Figure 4. (Storr 2013) The power dissipated due to heating affect is the same for AC and DC. When dealing with AC signals, the magnitude is constantly changing with time. This cannot be related to DC outputs as they are constant. VRMS allows a comparison between AC and DC outputs. If the RMS is the same for both AC and DC, then the amount of power dissipated is the same (WatElectronics 2020).

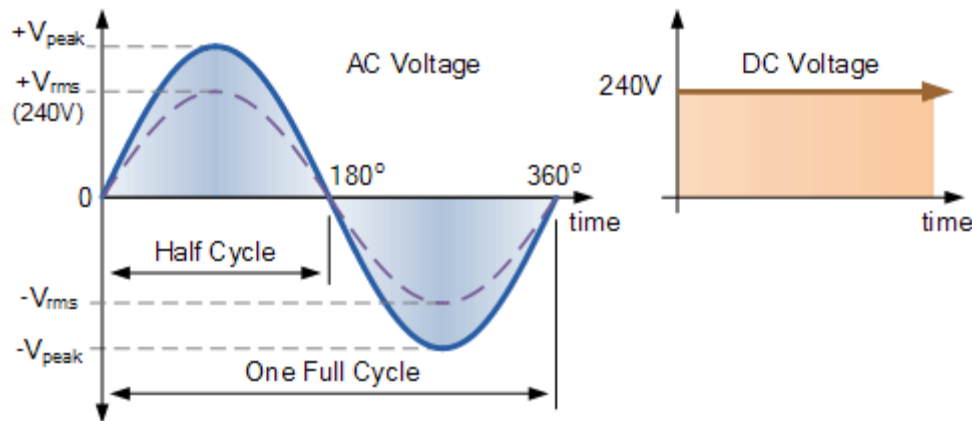


Figure 4 demonstrates the meaning of VRMS (Storr 2013).

1.7 Rectifiers use in Automotive applications Question. (4)

Full wave rectification can convert AC to DC more efficiently than half wave rectifiers. There is also reduced power loss which allowed for no voltage signal to be wasted (Electrical4U 2021). Rectifiers are used for charging the vehicles battery. A rectifier circuit is used to convert the AC to DC from the alternator. As the alternator is connected to the engine, the speed of the alternator varies with engine speed. Therefore, a regulator is used to ensure a steady output is produced. (Evans 2021). Light Emitting Diodes (LED) are heavily used in the automotive industry for external and internal lighting. LED lights are energy efficient, but they require rectifiers to convert the current from Alternating Current (AC) to Direct Current (DC). Half wave rectifiers are used in the automotive industry as they are cost effective, this is due to the circuit's simplicity. The alternator produces AC but majority of the electrical components in the vehicle operate on DC. This means rectifiers are having to be used on most electrical aids and comforts such as; Electric power steering, Electric Control Unit (ECU), Audio systems etc.



Figure 5 Shows a rectifier for an alternator (Wagendass 2024).

1.8 Probing Question (4)

The function generator is used to produce an input waveform for the rectifier circuit. When setting up the circuit there was a common ground. This shared ground could cause interference which could affect the accuracy of results. Ground loops can cause noise which leads to distortion in the waveforms. For example, noise can be created from faulty probe wires. Oscilloscope use trigger settings to synchronise the waveforms so that they are represented together on the screen. If these settings have not been calibrated for both signals, then the waveforms will not be displayed together. When probing a circuit input and output simultaneously it can increase the load on the circuit, this can then provide inaccurate results. Furthermore, some circuits output and input can have a relation to one another, to attain accurate results probe each signal independently. Insufficient channels on the oscilloscope will limit the number of probes being used to collect data. When probing it ensures that there is good contact with grounds and circuit. Furthermore, ensure that the grounds are isolated or that there are separate ground points for the oscilloscope and function generator (Lacoste 2019).

2 Task 3

2.1 Scope Time Division Calculations (4)

$$Time\ Period = R \times C \times 20$$

$$Time\ Period = 10000 \times 104 \times 10^{-6} \times 20$$

$$Time\ Period = 20.8$$

$$Time\ Division = \frac{20.8}{10}$$

$$Time\ Division\ (seconds) = 2.08$$

$$Frequency = \frac{1}{20.8}$$

$$Frequency\ (Hz) = 0.048Hz$$

2.2 Function Generator output square wave (3)

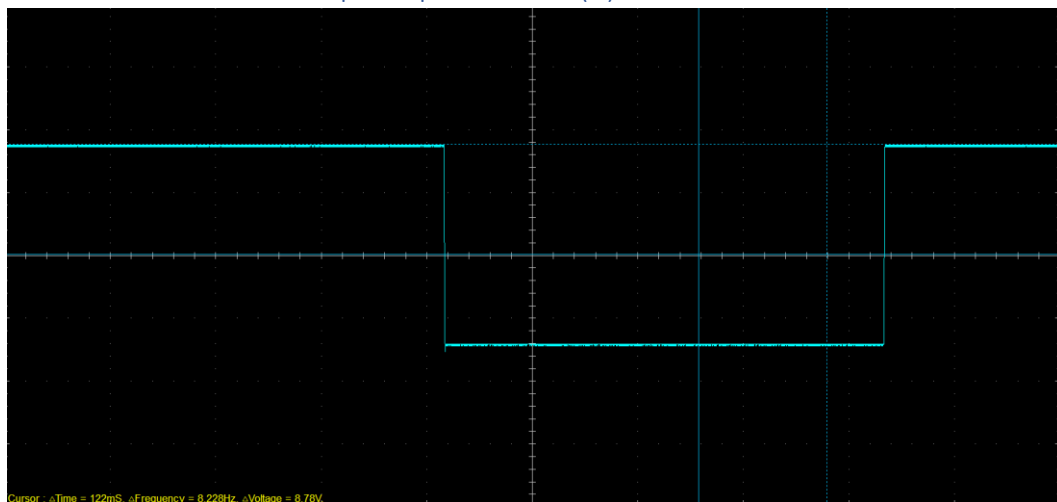


Figure 6 Shows the function generator output square wave. Voltage = 8.78V, Frequency = 8.228Hz and Time = 122mS

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

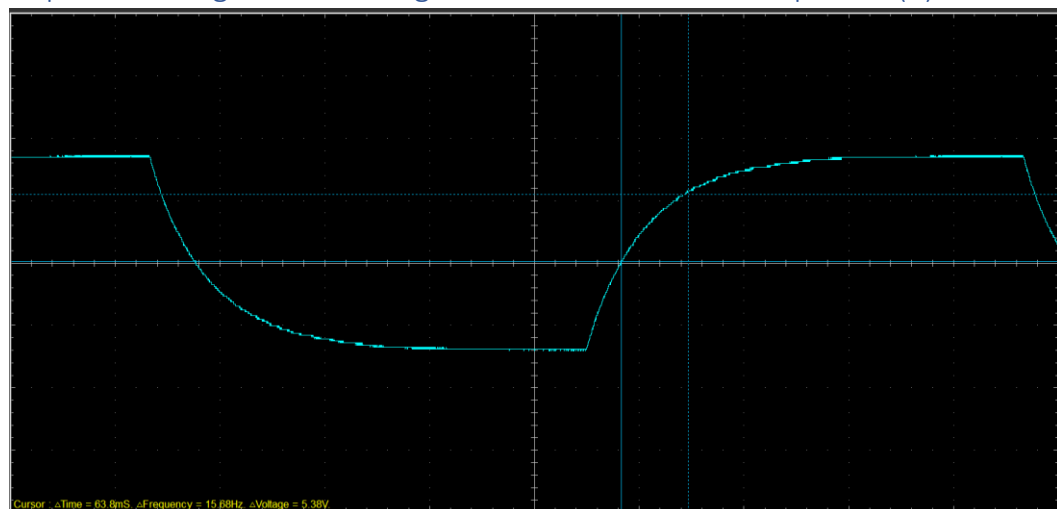


Figure 7 Shows a capacitor charge and discharge wave. Voltage marked at 63.2% which has been calculated below. Voltage at 63.2% = 5.38V, Frequency = 15.68Hz and Time = 63.8mS

2.4 Basic Capacitor Calculations (3)

$$P = 8.78V$$

$$= (8.53 - 0) \times (0.632 - 0)$$

$$= 5.39V$$

$$\tau = R \times C$$

$$\tau = 10000 \times 104 \times 10^{-6}$$

$$\tau = 0.104$$

2.5 Capacitor discharge table (4)

Table 1 Shows the capacitor discharge table of all the variables used to produce a graph of $\ln(V)$ vs Time.

	Time (seconds)	Voltage	V+	$\ln(V)$	dy	dx	dy/dx
1	0.04996	2.3216	7.3216	1.990829	x	x	x
2	0.05107	1.3176	6.3176	1.843339	-0.14749	0.00111	-132.873
3	0.05218	0.5647	5.5647	1.716443	-0.1269	0.00111	-114.321
4	0.05329	-0.1255	4.8745	1.584018	-0.13243	0.00111	-119.302
5	0.0544	-0.6902	4.3098	1.460891	-0.12313	0.00111	-110.924
6	0.05551	-1.0667	3.9333	1.369479	-0.09141	0.00111	-82.3538
7	0.05662	-1.3804	3.6196	1.286364	-0.08312	0.00111	-74.8786
8	0.05773	-1.6941	3.3059	1.195709	-0.09065	0.00111	-81.671
9	0.05884	-1.9451	3.0549	1.116747	-0.07896	0.00111	-71.1368

2.6 Gradient Plot and calculations (4)

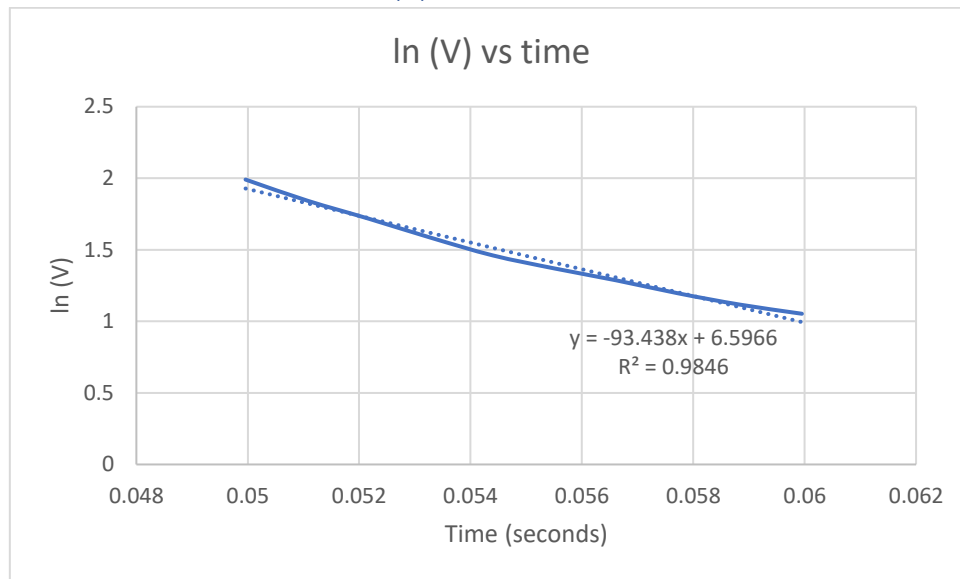


Figure 8 Shows a graph with the natural log of voltage against time. Showing the gradient and regression value.

$$R \times C = \tau = \frac{1}{-\text{Gradient}}$$

$$\tau = \frac{1}{-93.438}$$

$$\tau = 0.01$$

$$C = \frac{0.01}{10000}$$

$$C = 1 \times 10^{-6} \text{ Farads}$$

2.7 Capacitor Uses (5)

1. Brake energy regeneration – this system stores kinetic energy made by the braking system. This energy is temporarily stored in a capacitor before being recycled to make the car continue.
2. Stabilise electrical system output.
3. Protecting batteries from large loads.
4. Air Conditioning
5. Window wipers and motors
6. Engine Electronic Control Units (ECU)
7. Power Steering
8. Air bag controls
9. Electric Vehicle (EV) chargers
10. DC/DC Converters – convert high voltage to low voltage for instrument systems.

(Nick Powers 2015)

2.8 Inaccuracies Question (4)

When measuring capacitance, it is vital that the discharge is not measured. The discharge of the capacitor is constantly changing over the discharge period. This means that the voltage is decreasing until the electrical energy has been released (IBE Electronics 2023). Interference can cause the waveforms to be distorted, this will affect the overall values which are later drawn from the waveforms. Noise can be caused from human and natural sources, which can also have an affect on the readings from the waveforms. Capacitors have tolerances like resistors, this is mentioned on the side of the capacitor, this can be considered when dealing with the final values. Equipment has a large effect on the accuracy of results. If better equipment is used this eliminate any errors and increase accuracy of results. Additionally, the equipment that is used must be calibrated correctly to ensure measurements are correct. The breadboards and wires used can cause bad connections throughout the circuit which can lead to inaccurate figures.

3 References

Layout for submission Task 2_3.

Task 3 capacitors.

DAHIGAONKAR, M., 2022. *Voltage Drop Causes and Effect.*

ELECTRICAL4U, May 16, 2021-last update, Full Wave Rectifier: What is it? (Circuit Diagram And Formula) | Electrical4U. Available: <https://www.electrical4u.com/full-wave-rectifiers/> [Mar 22, 2024].

E-MOBILITY ENGINEERING, 2022. *Supercapacitor applications.*

EVANS, P., 2021. *Car Alternator- How Alternators Work.*

IBE ELECTRONICS, 2023. *How to Measure a Capacitor with a Multimeter and Five Operating Errors to Avoid.*

LACOSTE, R., 2019. *The Art of Voltage Probing.*

NICK POWERS, 25 September, 2015-last update, Capacitor Powered Cars: Capacitors in Automotive Applications. Available: <https://www.arrow.com/en/research-and-events/articles/capacitors-in-automotive-applications> [Mar 19, 2024].

RIJK DE WET, Mar 06, 2024-last update, RMS Voltage Calculator | Common Waveforms. Available: <https://www.omnicalculator.com/physics/rms-voltage> [Mar 21, 2024].

STORR, W., 2013a. *RMS Voltage of a Sinusoidal AC Waveform.*

STORR, W., 2013b. *RMS Voltage of a Sinusoidal AC Waveform.*

WAGENDASS, 20 March, 2024-last update, Rectifier for alternator DENSO 421000-0021. Available: <https://wagendass.com/en/rectifier-for-denso/10436-rectifier-for-alternator-DENSO-421000-0021.html> [Mar 20, 2024].

WATELECTRONICS, 2020. *RMS Voltage : Theory, Different Methods and Its Equation.*