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Electronic Circuits Testing and Application

Vehicle Electronics and Code

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2500220

19/04/2026

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1 Task 3

1.1 Scope Time Division Calculations (6)

$$f = \frac{1}{\tau}$$

$$\therefore \tau = \frac{1}{f}$$

$$\therefore \tau = \frac{1}{250}$$

As there are ten time divisions:

$$\tau = \frac{0.004}{10}$$

$$\therefore \tau = 400 \mu S$$

Therefore, the scope setting used will be:

$$\tau = 500 \mu S$$

1.2 Function Generator output square wave (6)

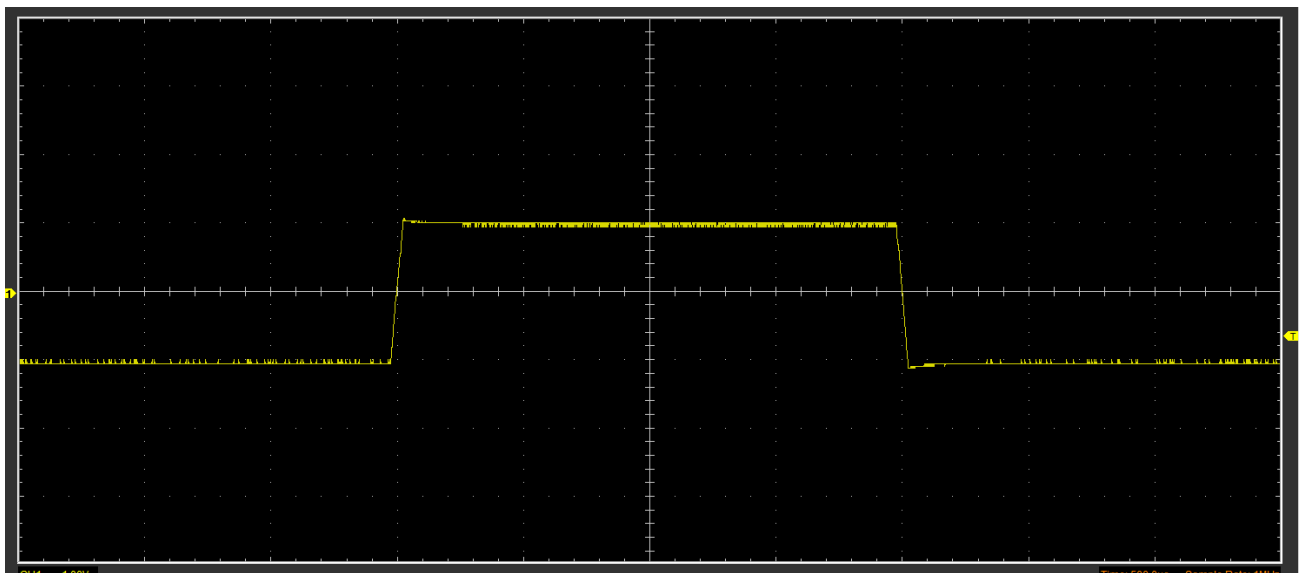


Figure 4 Square Wave function Generator

CH1 1.00V	
Output	
CH1	
Maximum	1.10V
Minimum	-1.10V
Peak to Peak	2.20V
Top	1.10V
Base	-1.10V
Middle	0.00uV
RMS	1.02V
Amplitude	2.20V

Figure 5 Values and Data Points from Square Wave on Function Generator

1.3 Capacitor charge and discharge wave marked at correct points. (6)

Unfortunately, due to a corrupted file, these waves were unable to be shown with the data points marked, included are the screenshots previously taken.

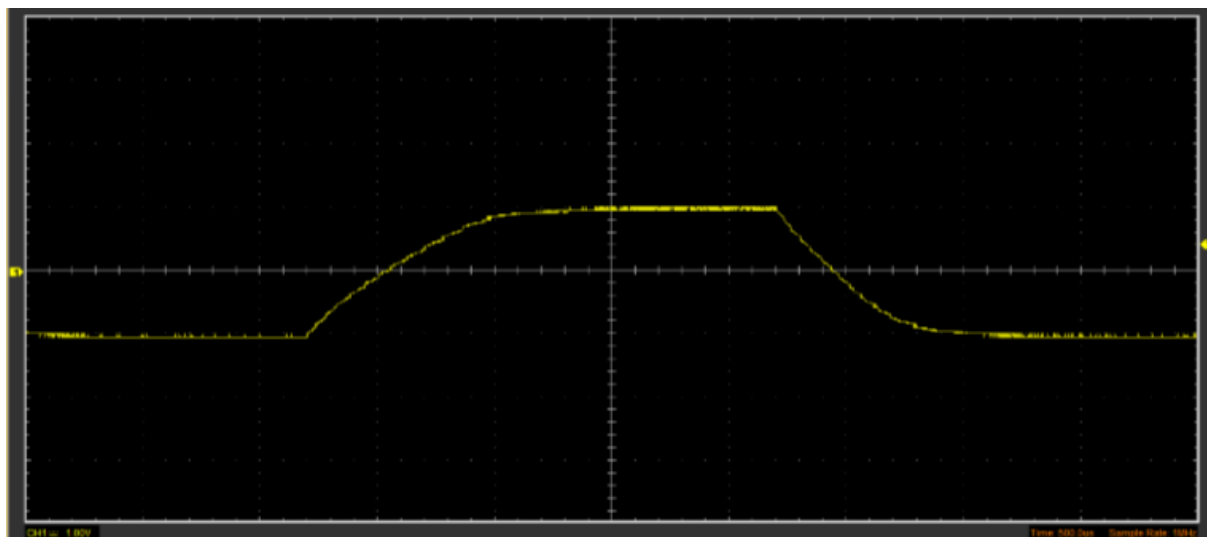


Figure 3 Capacitor Wave Function Generator

Output	
CH1	
Maximum	1.04V
Minimum	-1.04V
Peak to Peak	2.07V
Top	1.04V
Base	-1.04V
Middle	0.00uV
RMS	868mV
Amplitude	2.07V

Figure 4 Value and Data Points of the Capacitor Wave on the Function Generator

1.4 Basic Capacitor Calculations (6)

General Equation for Capacitance:

$$\tau = RC$$

Formula to Calculate Capacitance from Wave:

$$(peak(V) - start(V) \times 63.2\% + start(V)) = V \text{ top curser}$$

Equation calculated using Max and Min from Figure 2 due to corrupted file:

$$(1.04 - (-0.52)(V) * 63.2\% + (-0.52)(V)) = 0.8476$$

$$\therefore C = 0.848 \mu F$$

1.5 Capacitor discharge table (5)

Table 3 Capacitor Discharge Table

Time (s)	Voltage (V)	ln (V)	dy = y2 – y1 dy = ln(V)2- ln(V)1	dx = x2- x1 dx = Time2 – Time1	dy/dx
0.002384	1.9117	0.647992899	x	x	x
0.002431	1.7235	0.544357107	-0.103635792	4.7E-05	-2205.016842
0.002478	1.5039	0.408061734	-0.136295373	4.7E-05	-2899.901554
0.002525	1.4098	0.34344785	-0.064613884	4.7E-05	-1374.763481
0.002572	1.1902	0.17412136	-0.16932649	4.7E-05	-3602.691279
0.002619	1.0333	0.032757564	-0.141363796	4.7E-05	-3007.74034
0.002666	0.8451	-0.168300315	-0.20105788	4.7E-05	-4277.827227
0.002713	0.7196	-0.329059777	-0.160759461	4.7E-05	-3420.414074
0.00276	0.5941	-0.520707624	-0.191647847	4.7E-05	-4077.61376
0.002807	0.5	-0.693147181	-0.172439557	4.7E-05	-3668.926743

1.6 Plot log(V) Gradient (5)

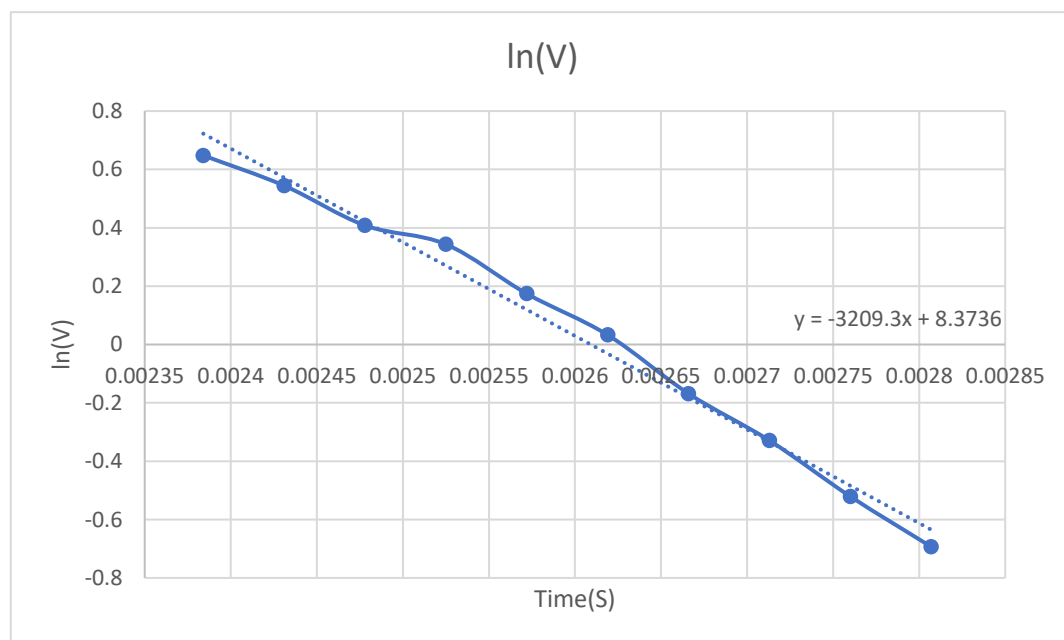


Figure 6 Graph of $\ln(V)$ Against Time, from which the Gradient of $\ln(V)$ can be calculated

1.7 Gradient Calculations and Compare (8)

1.7.1 Gradient Calculations

In a discharging Capacitor,

$$V = V_0 e^{-\frac{t}{RC}}$$

Then logs were taken to both sides,

$$\ln V = \ln V_0 - \frac{t}{RC}$$

Therefore, from log relationships,

$$\ln V = a - bt$$

It can be said that

$$b = -\frac{1}{RC}$$

Therefore, to find τ

$$\tau = -\frac{1}{\text{gradient}}$$

From the graph,

$$\text{Gradient} = -3209.3$$

$$\therefore \tau = 3.116E - 04 \text{ s}$$

Therefore, to calculate capacitance,

$$C = \frac{\tau}{R}$$

$$C = \frac{3.116E - 04}{330}$$

$$C = 0.944 \mu F$$

1.7.2 Comparison table

Table 4 Comparison of Capacitance

	Capacitance	Delta	Percentage difference
Actual	1 μF	x	X
Marker Calculation	0.85 μF	0.15	15.24%
Gradient Calculation	0.94 μF	0.06	6.19%

1.8 Capacitor Uses (5)

Capacitors can be used to filter, smoothing out fluctuations in supply power to give a stable dc voltage, by storing energy when higher voltages are available to give out when power drops below a certain range. This can therefore be used to help noise reduction in circuits (MacArthur, 2025). The effective quick charging and discharging of a capacitor can also be utilised for energy storage and power boosting, this can be particularly important in a motorsport engineering capacity due to supercapacitors, this allows for energy recovery systems (ERS) to be used, which collects and stores energy from cars, for example under braking, and allows for boosts in power to be used in electric and hybrid vehicles (Muralee Gopi *et al.*, 2025).

Other uses of capacitors include being used in starter motors, capacitors in this application allow for high starting torque, to allow the motor to start and get up to speed at which point the capacitor runs idle, the capacitors store energy and discharge it quickly when the motor is first turned on to give enough torque to get the motor running (Science Insights, 2026). Capacitors can also be used in timing circuits and be used to control frequency, by releasing through a resistor, the necessary time delay can be achieved. Capacitors can also be used to multiply voltages; this is useful when a high voltage is necessary but only a low voltage source is available. It works from the idea of the charging capacitor, discharging sequentially in an electric field, where voltages are then added, increasing the final output voltage (Matan, 2023).

1.9 Inaccuracies Question (4)

The results from the capacitor experiment show that while close to the original stated value, there was still a margin of error, of 6% - 15%. While in experimental testing this is reasonably good, some elements of the experiment and data workings can lead to inaccuracies in results. This could firstly be due to the measuring equipment used. The measuring tools may have had a larger, than expected tolerance or not have been calibrated recently or accurately, this could lead to results being taken that were close to the original values but with a error, that may be exacerbated through calculation due to the multiplication of values, therefore increasing errors (Yu *et Al.*, 2011). Another point of error could have occurred during the data selection, as points roughly at the top and bottom of the curve were selected, if these values where the absolute values of these ranges perhaps a more accurate value may have been obtained.

Environmental factors and selection of capacitor also impact result accuracy, differing gaps between plates, larger internal resistance in wires or circuit components and dielectric imperfections (if applicable) such as air gaps, can all lead to small variations in calculated values compared with expected values (IBE Electronics, 2023).

1.10 Risk Question (10)

The ISO assesses risk using fact-based criteria, they take activities and components that may pose risks, such as security threats to a vehicles CANBUS system and consider the threats and vulnerabilities of these and the associated potential consequences of them. This is then further broken down into the likelihood and impact of the consequences and graded. The grading system used for this is the TARA method, Threat Analysis and Risk Assessment (Wittenstein, 2024). This makes it easier to identify which risks to prepare for and have mitigations in place to prevent or reduce the effect of the threats (ISO/IEC *et Al.*, 2022).

Cybersecurity entry points are where attacks get access to a network or system, they can come through a variety of methods including, human error, a software vulnerability or endpoint devices (Silber, 2025). "CAN bus (Controller Area Network) is a communication system used in vehicles/machines to enable ECUs (Electronic Control Units) to communicate with each other." (Falch, 2025). The issues this presents from a cybersecurity perspective is critical as the safety of passengers and the reputation of car brands are on the line.

The system itself inheritably is fundamentally flawed, with so many devices connected to each other the likelihood of exploitation of the system, being effective is seriously high. The high number of connected vehicles allows for numerous ways into the system, which could wreak havoc among the automotive industry. However, it's not just hardware that can be controlled in these attacks, due to how interconnected cars are now with Bluetooth and Apple Car Play, these attacks can now steal personal information and data, which poses different solutions to the problems (Michaels, 2025). Some solutions have been suggested such as user authentication, encryption and intrusion detection (Bozdal *et Al.*, 2020).

Systems can also have increased vulnerability when updates are completed. With engineering comes advancements in technology, therefore systems often go through updates, but if the firmware is incorrectly installed or tapered with these can create weaknesses that may be exploited to gain access to the system itself (Sarsam, 2023).

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