

University of Wales Trinity Saint David

Wales Institute of Science and Art



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Electronic Circuits testing and Applications

Vehicle Electronics ACHA4031

Joe Dashwood

2404498

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1 Task 3

1.1 Scope Time Division Calculations (6)

$$\text{Charge} = \Delta \text{Source}(1 - e^{t/\tau})$$

$$\text{Charge} = \Delta \text{Source}(1 - e^{-1}) \text{ [when } t = \tau \text{]}$$

$$\text{Charge} = \Delta \text{Source} * 0.632$$

$$(3.2v - 1v) * 63.2\% + 1v = 2.3904$$

$$\text{Capacitance (C)} = 1\mu F$$

$$\text{Resistance (R)} = 100\Omega$$

$$\text{Time constant } (\tau) = R \times C$$

$$\text{Wave frequency} = 250\text{hz}$$

$$\text{Wave period} = 1/f = 0.004$$

$$\text{Number of time divisions} = \text{wave period}/\text{wave frequency} = 0.004/250 = 16\mu s$$

1.2 Function Generator output square wave (6)

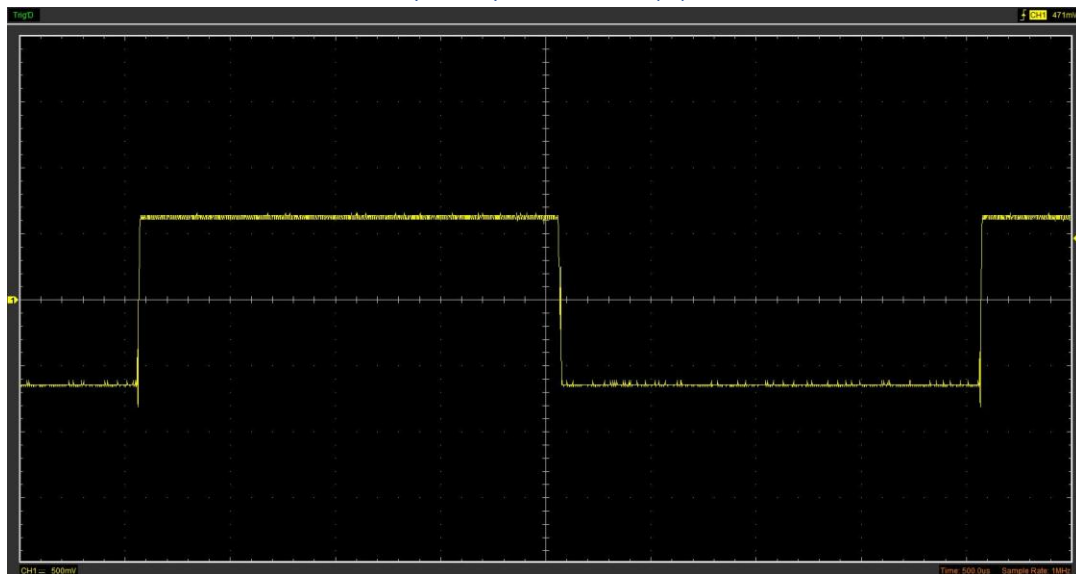


Figure 1 - Square wave generated by the function generator

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

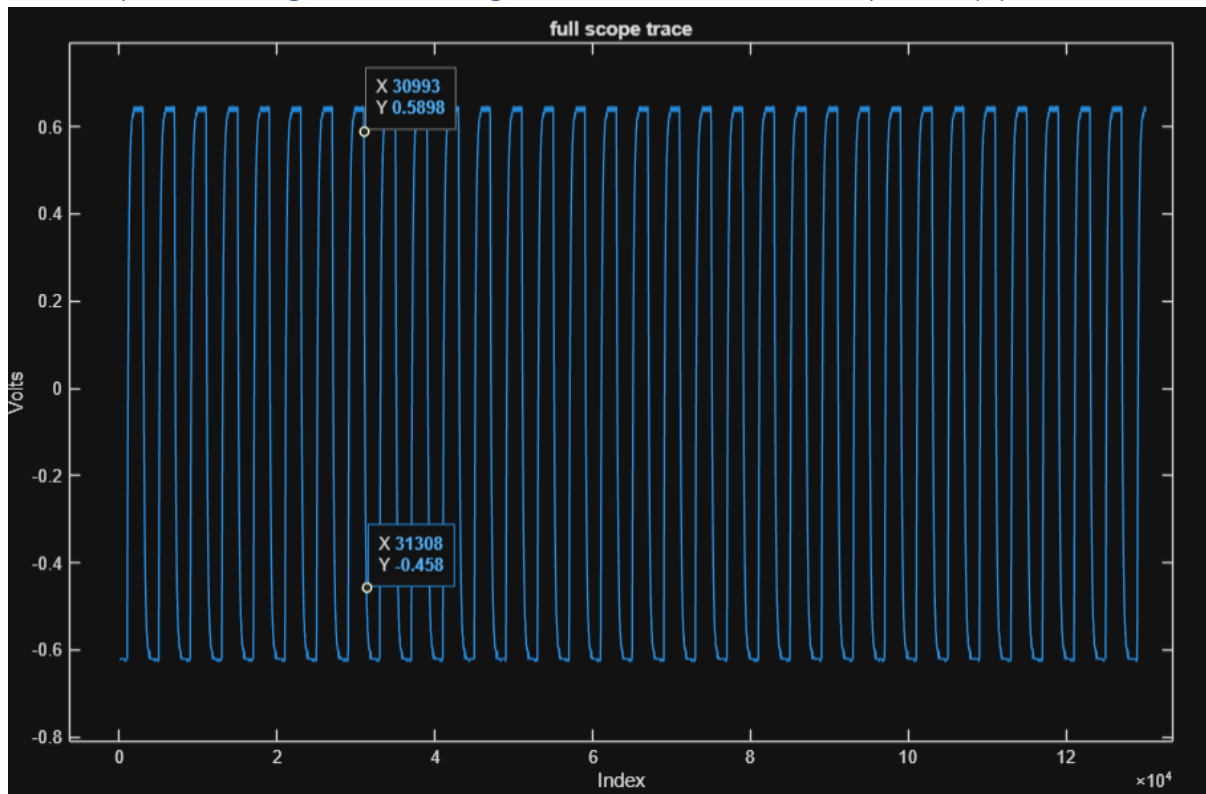


Figure 2 - Charge and discharge wave of the circuit marked at two distinct points for further calculations

1.4 Basic Capacitor Calculations (6)

The time constant of an RC circuit is calculated using the following method: $\tau = R \times C$.

In this experiment, a 100 Ohm resistor was used, and a capacitor with a capacitance of 1μ farad.

Therefore: $100 \times 1 \times 10^{-6} = 100 \times 10^{-4} \text{ S } [100\mu\text{s}]$

1.5 Capacitor discharge table (5)

Time (s)	Voltage (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
0.00299	0.96	-0.04082199	x	x	x
0.00303	0.7341	-0.30911002	-0.26828803	3.3E-05	-8129.94016
0.00306	0.5584	-0.58267973	-0.27356971	3.3E-05	-8289.99114
0.00309	0.4204	-0.86654864	-0.28386891	3.3E-05	-8602.08826
0.00313	0.3012	-1.19998078	-0.33343214	3.3E-05	-10104.0043
0.00316	0.2259	-1.48766286	-0.28768207	3.3E-05	-8717.63856
0.00319	0.1443	-1.93586081	-0.44819796	3.3E-05	-13581.7563
0.00323	0.0879	-2.43155547	-0.49569466	3.3E-05	-15021.0503
0.00326	0.0377	-3.27809518	-0.84653971	3.3E-05	-25652.7185

Table 1 - Capacitor discharge table

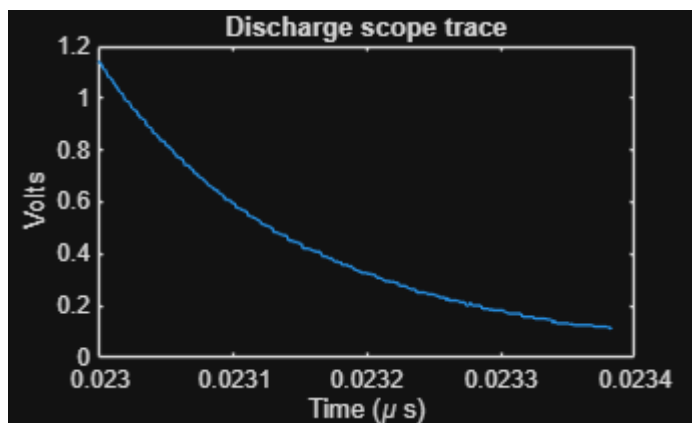


Figure 3 - Discharge scope trace

1.6 Plot log(V) Gradient (5)

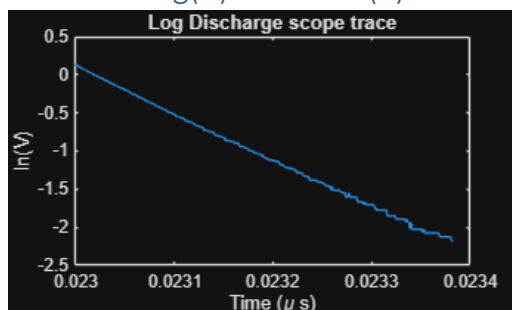


Figure 4 - Graph to show the natural log of the voltage against the time directly from the recorded data in MATLAB

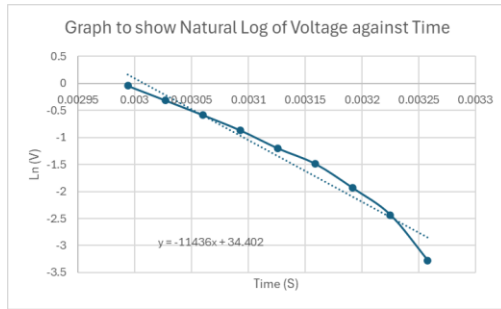


Figure 5 - Graph to show the natural log of the voltage against time from the calculations made in Excel.

1.7 Gradient Calculations and Compare (8)

1.7.1 Gradient Calculations

$$C = \tau/R$$

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

1.7.2 Comparison table

	Capacitance	Delta	Percentage difference
Actual	1 μF	x	X
Marker Calculation	81.5 μF	+ 80.5 μF	8050%
Gradient Calculation	87.4 μF	+ 86.5 μF	8650%

Table 2 - table to compare expected results with recorded results

1.8 Capacitor Uses (5)

Capacitors are used widely in electrical, automotive and motorcycle applications. Some examples of this are:

Starter motors – in some cases capacitors produce a short burst of energy to the starter motor when cranking the engine to reduce the strain on the battery.

HVAC systems – Capacitors help motors in HVAC compressors start up smoothly and efficiently.

Power supply filtering – Capacitors smooth out noise caused by the AC current before a rectifier transforms it to DC current.

Energy storage (such as a UPS) – Large capacitors provide power instantly to electronic device after power cuts, allowing enough time for projects on computers to be saved and safely shut down to avoid data corruption.

ECU Stabilising – Capacitors filter electrical noise in ECUs and stabilise the voltage passing through the components in the ECU to protect them.

Start stop systems – Similar to starter motors, capacitors provide energy to the starter motor to save wear and strain on the battery.

Analogue audio systems (such as radio noise filtering) – Capacitors filter out unwanted noise from radio signals which improves the clarity of the audio.

Lighting systems – Capacitors regulate the flow of current going into the bulbs which helps to reduce flicker.

Power factor correction – Capacitors reduce wasted power and improve efficiency by counteracting inductive loads.

Infotainment systems – Capacitors stabilise power going to the amplifiers, display, and charging ports to prevent flickering or instability.

1.9 Inaccuracies Question (5)

There are many factors that affect the accuracy of the results in this experiment, such as errors with equipment, environmental conditions and human error. Inaccuracies can occur when recording the data if the testing equipment is incorrectly set up. It is important to make sure the oscilloscope is calibrated correctly before measuring to avoid any inaccuracies (Keysight Labs, 2018).

As seen in chapter 1.7.2, the difference between the expected value and recorded values is significant. This indicates that there has been an error due to the calculations made, or with the equipment itself. According to the manual provided by HANTEK (2021), the oscilloscope has a self-calibration feature, requiring the device to warm up for 20 minutes before use. This was not followed before measurement. The accuracy of the calculations is uncertain and would benefit from a further review or a repeat of the experiment.

1.10 Risk Question (10)

Modern vehicles are becoming ever increasingly connected to the internet, as well as often software driven. While many of these systems are convenient for drivers and passengers, the vehicle becomes more vulnerable to security threats.

ISO/SAE 21434:2021 is an international standard that aims to mitigate vehicle system cyber-attacks throughout the lifetime of a vehicle. It promotes industry wide consistency on how to handle these threats and build trust with consumers and manufactures.

Modern vehicles have many entry points for cyber-attacks, and according to Automotive IQ (2025) in 2023 over 90% of all cyber incidents were executed remotely. Wireless entry points into vehicle CANBUS systems can be through infotainment systems, vehicles that have keyless entry systems, over the air updates and even mobile apps. Furthermore, vehicles have also become connected to other vehicles, and external infrastructure, that if compromised becomes a surface for cyber-attacks to spread (Aliwa et al., 2021). Though less common, there are also physical entry points into vehicle systems, such as the OBD-2 communications port, USB ports, and even charging ports on electric vehicles.

CANBUS systems first appeared in the early 90s by Bosch as a way of streamlining electronic connections in vehicles. By modern standards, it lacks protection against cyber-attacks, as it is completely un-encrypted (Bozdal et al., 2020). Therefore, vehicle manufacturers have to implement safety features themselves. CANBUS has no safety systems built in, so any signals can be sent straight to the ECU.

Many vehicles now have capabilities to receive software and firmware updates wirelessly, and automatically. Often, manufacturers will send out security patches and updates for their vehicles Over-the-air (OTA), which presents additional security risks. Malicious code can be maliciously injected over the update signals if they are intercepted (Guillen, Schmidt and Sigl, 2026). This can result in attackers gaining access to the vehicle's systems, gaining access to any data stored in the car, being able to control features remotely such as door locks, brakes, steering, throttle, and more.

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