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Electronic Circuits Testing and Applications

Electrical Control Systems

ACHA4010

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1 Task 1

1.1 A

$$R = \frac{V}{I} > R = \frac{12V}{0.5A} = 24\Omega$$

1.2 B

$$I_T = I_A + I_B + I_C > 0.3A + 0.1A + 0.1A = 0.5A > = 0.1A$$

1.3 c (i)

$$P = I^2 R > \frac{P}{I^2} = R = \frac{0.9J}{0.3A^2} > = 10\Omega$$

1.4 c (ii)

$$V_T = V_A = V_B = V_C$$

$$V_T = 12V$$

$$@B @C \quad V = 12V \quad I = 0.1A > R = \frac{V}{I} = 120\Omega$$

1.5 c (iii)

$$12V$$

1.6 c (iv)

$$R_T = R_A + R_D + R_E$$

$$V = 5$$

$$I = 0.3$$

$$\frac{V(0.5)}{I(0.3)} = R_T(40\Omega)$$

$$40 - 10 - 24 = 6\Omega$$

$$V_D = I(0.5) \times R(6) = 3V$$

1.7 d

$$V_T = 2V \quad I_T = 0.5A$$

$$I_1 = \frac{0.5}{4} = 0.125A$$

$$\frac{V(2)}{I(0.125)} = R(16)$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{16} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} = \frac{1}{4}$$

$$R_T = 4\Omega$$

1.8 e

$$V = IR = 12V$$

1.9 f

1.10 g

2 Task 2

2.1 Scope Time Division Calculations

$$f = \frac{1}{p} > p = \frac{1}{f} > p = \frac{1}{10\text{Hz}} > = 10\text{MHz}$$

$$\frac{10 \text{ waves per second}}{10} = 1 \text{ full period} = 10\text{ms}$$

2.2 Function Generator output sine wave

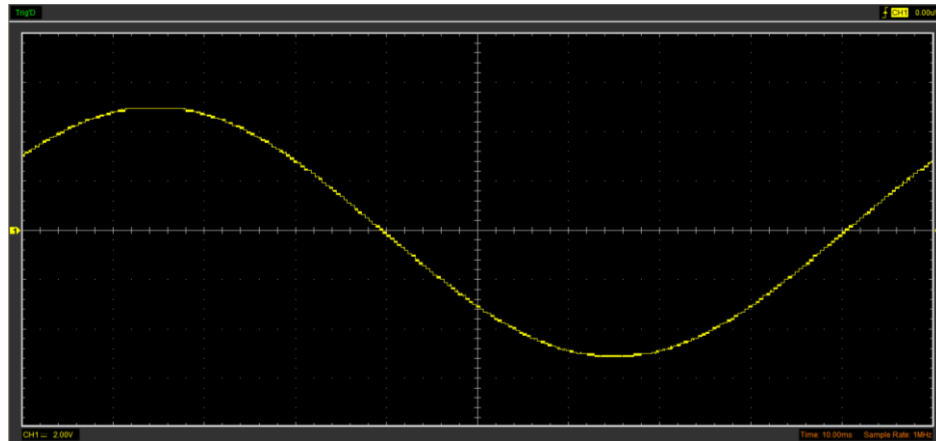


Figure 1: 1 full period of the Function Generator producing a Sine Wave. Peak Voltage at 4.96V. Graph produced in HanTek Software.

2.3 Unsmoothed Rectifier Wave

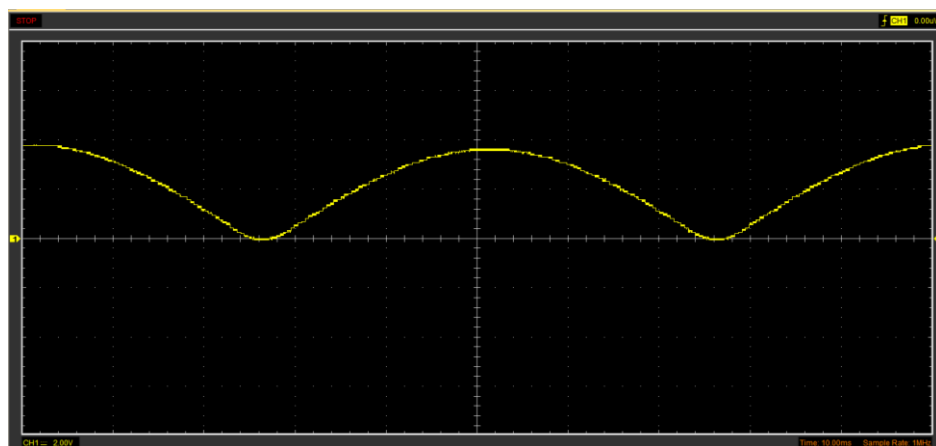


Figure 2: the Function Generator Sine Wave has been rectified by the circuit. Peak Voltage at 3.83V. Graph produced in HanTek Software.

2.4 Smoothed Rectifier Wave

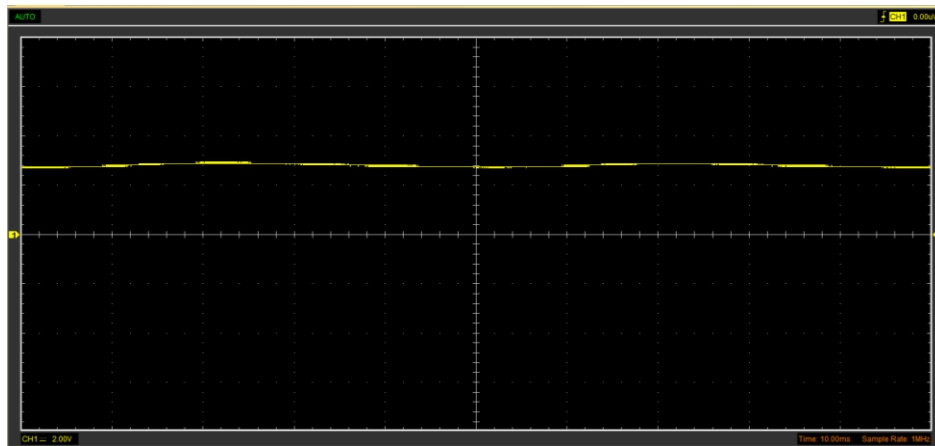


Figure 3: the Rectified Function Generator Sine Wave has been smoothed out by the introduction of a capacitor. Peak Voltage at 2.95V. Graph produced in HanTek Software.

2.5 Drop in Voltage Question

The sine wave voltage is peaked at 4.96V. In a theoretical sense it is expected for the rectified peak voltage to be the same, however, once the AC voltage is converted into the pulsating DC current, the peak voltage is at 3.89V. Once the capacitor is added and the rectified wave becomes smoothed out, the peak voltage is 2.95V. A selection of real world factors cause this drop in voltage:

- The forward facing diodes: The use of the diodes required a small voltage drop to operate, this is usually a 0.7V drop across the circuit for each diode.
- Ripple Voltage: With the DC voltage output pulsing, this means an element of residual AC characteristics/componentry is present and causes a further voltage to drop in the overall DC output.
- Capacitor Use: The operation of the capacitor has a level of natural resistance and causes a voltage drop across it.

All these minor voltage drops and factors across the circuit do add up to create a voltage drop of 1.07V and 2.01V respectively. (Forrest, M. 2000)

2.6 Rectifiers use in Automotive applications Question.

Using rectifiers in automobiles allows for the various electrical components to function correctly. Rectifies are used to convert the AC current produced by the engine's alternator to charge the battery. The constant supply of DC current regulates the AC powers voltage output, avoiding extreme voltage fluctuation and prevents damage to the electrical systems. The battery is essential to power headlights, radio etc, as well as hold charge to power up the starter motor when required. (Denton, T 2017)

2.7 Probing Question

When attempting to probe across the function generator and rectifier's simultaneously, the oscilloscopes failed to take a reading. This is because the numerous components were connected to the same ground connection allowing multiple current routes, known as a ground loop. Ground loop provides an unwanted current flow between components leading to interference and inaccurate measurements as well as potentially damaging the devices. To complete accurate voltage measurements the ground is used as a common reference point. It is essential that each device is correctly grounded and there are no voltage differences. The use of

- Transformers – allowing a primary and secondary winding current, electrically isolated from each other
- Differential Amplifiers – measuring two different ground signal connections without connecting to one common ground.
- Separate Ground Connections – connecting the signals to different grounds physically avoiding the opportunity for the current to loop.

The use of isolated or differential probes allows for simultaneous probing to take place. Isolated probes isolate the probe tip from the rest of the circuit via, usually, an isolated transformer. Isolated probes commonly measure high voltage situations but also work for low voltage circuits. Differential probes work by taking two readings across the circuit and using a differential amplifier to measure the voltage difference between the inputs. It is possible to use a differential probe to measure the voltage of the function generator as well as the rectifier output simultaneously.

In summary, the use of transformers, differential amplifiers or isolated/differential probes would work when wanting simultaneously to probe a circuit and avoid ground looping. (Dickson, R., Doug, L. 2013)

3 Task 3

3.1 Scope Time Division Calculations

$$f = \frac{1}{p} > p = \frac{1}{f} > p = \frac{1}{10\text{Hz}} > = 10\text{MHz}$$

$$\frac{10 \text{ waves per second}}{10} = 1 \text{ full period} = 10\text{ms}$$

3.2 Function Generator Output Square Wave

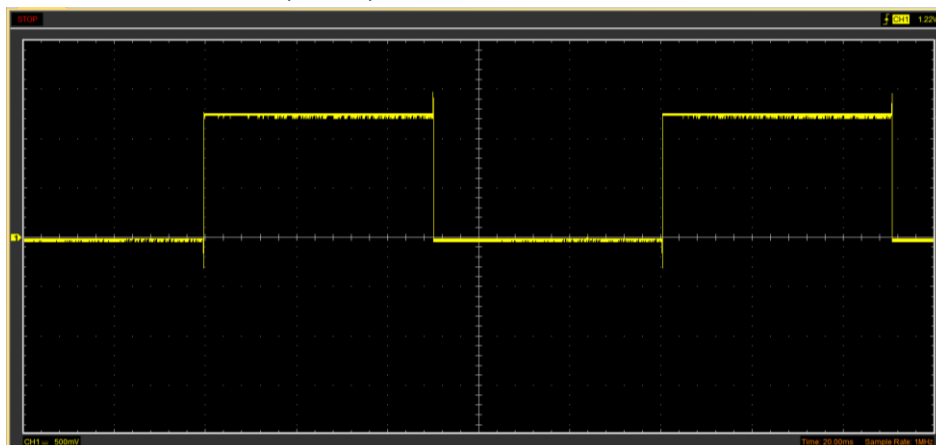


Figure 4: 1 full period of the Function Generator producing a Square Wave. Peak Voltage at 1.80V. Graph produced in HanTek Software.

3.3 Function Generator Output Sine Wave

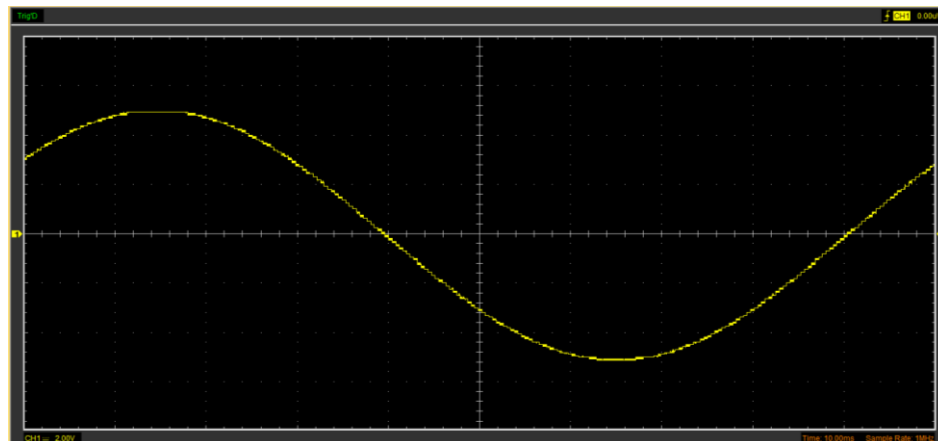


Figure 5: 1 full period of the Function Generator producing a Sine Wave. Peak Voltage at 4.96V. Graph produced in HanTek Software.

3.4 Capacitor charge and discharge wave marked at correct points

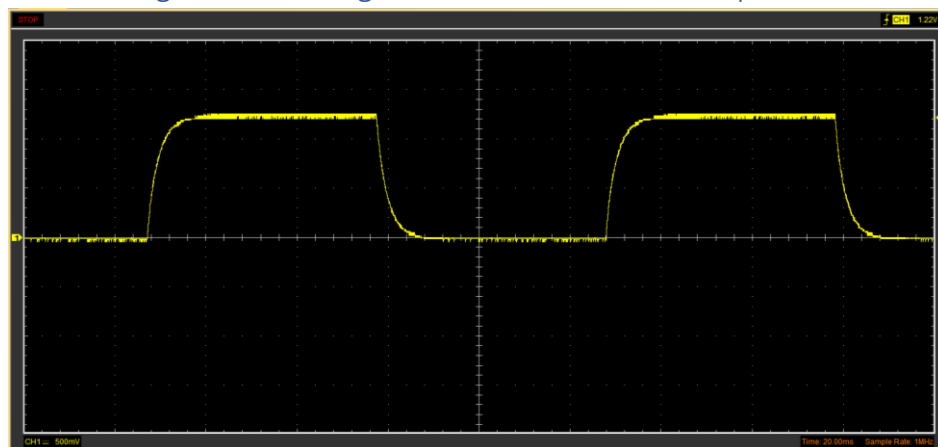


Figure 6: 2 complete charges and discharges of the capacitor circuit. Peak Voltage at 1.3V. Graph produced in HanTek Software.

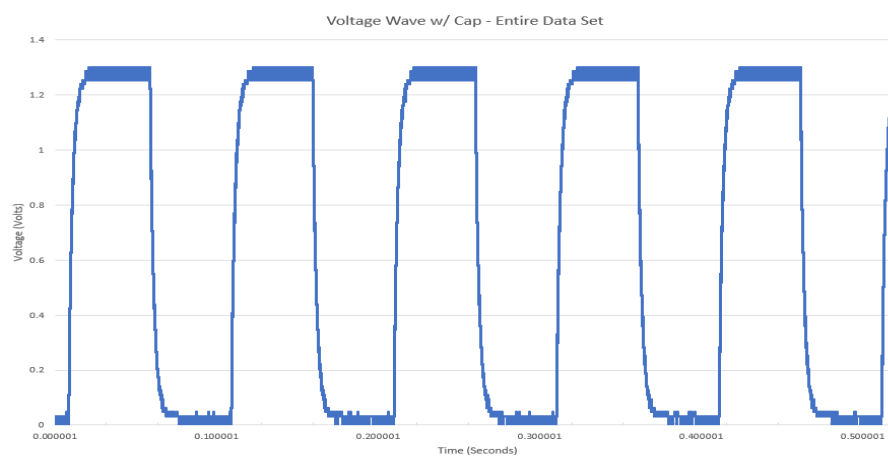


Figure 7: an Excel generated graph displaying 5 periods of the capacitor circuit results. Peak Voltage at 1.3V.

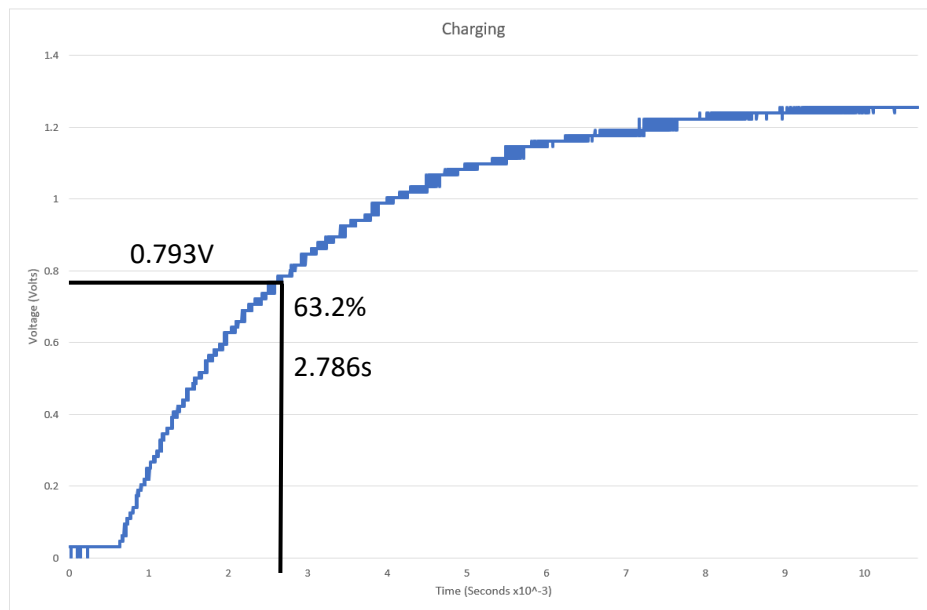


Figure 8: a refined graph showing the charging period of the capacitor results. The graph includes a visual representation of the 63.2% charging capacitance-time theory. Graph produced in Excel.

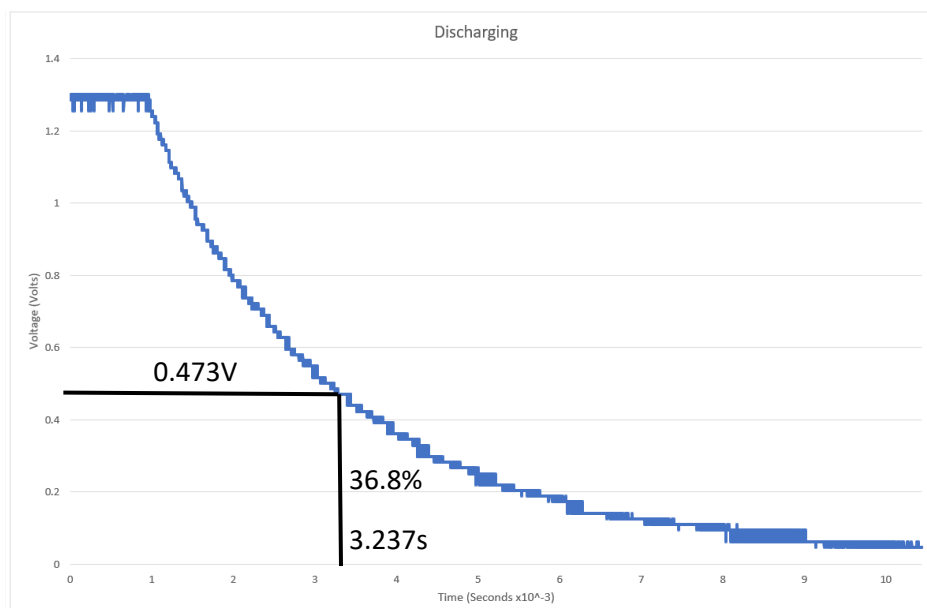


Figure 9: a refined graph showing the discharging period of the capacitor results. The graph includes a visual representation of the 36.8% discharging capacitance-time theory. Graph produced in Excel.

3.5 Basic Capacitor Calculations

$$\text{Time} = \text{Resistance} \times \text{Capacitance}$$

$$4.7 \times 10^{-4} = 100 \times 4.7 \times 10^{-6}$$

3.6 Capacitor discharge table

Table 1: an Excel table generated from the circuit and HanTek data, displaying 10 points taken from the discharge graph and data. Results include the Excel Line position, the Time Variance between each point, the voltage levels and the log of the voltage.

Discharge Points										
Point Number	1	2	3	4	5	6	7	8	9	10
Line (Excel)	59000	59500	60000	60500	61000	61500	62000	62500	63000	63500
Time Variance (Seconds)	0	0.000500	0.001000	0.001500	0.002000	0.002500	0.003000	0.003500	0.004000	0.004500
Voltage (V)	1.2549	0.9883	0.7844	0.6589	0.5491	0.4393	0.3608	0.2981	0.251	0.204
LnV	0.227055888	-0.011768984	-0.24284	-0.41718	-0.59947	-0.82257	-1.01943	-1.21033	-1.3823	-1.58964

3.7 Gradient Plot and calculations

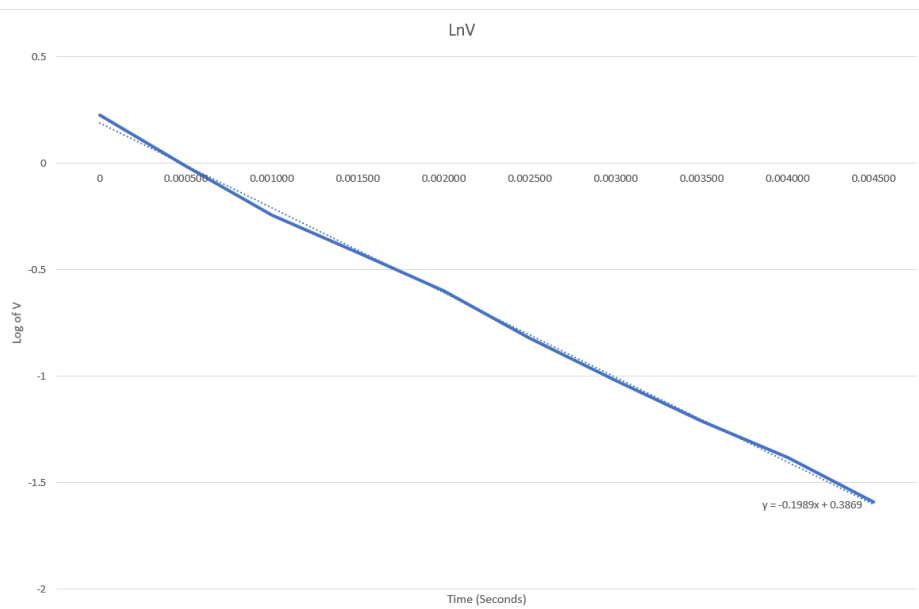


Figure 10: an Excel generated graph displaying the log results of voltage against time, crucially with the trendline and equation displayed.

Table 2: an Excel generated table displaying the percentage and exact variance of capacitance between the listed, charging, discharging and graphical figures.

Results	Fixed Figures	Charging Figures	Discharging Figures	Graphical Figures
Capcitanace (F)	0.0000047	0.00002786	0.00003237	0.001989
Resistor Resistance (Ohms)	100	100	100	100
Variance (%)	N/A	142	37	199
Variance (V)	N/A	0.00002316	0.00002767	0.0019843

3.8 Inaccuracies Question

It is always to be expected that specified results and measured results to be different, however it is essential to analyse why this variance would occur. Table 2 includes the results of 4 different measures of capacitance. The 'Fixed Figures' are determined based upon the factory produced results. The remaining 3 are determined based upon the equipment, environmental and measurement factors. (Yu. 2013)

- Equipment Factors: the equipment used in completing the circuit results is 'cheap' and have major tolerance/accuracy issues compared to more expensive components. From the equipment used in creating the circuit to the measurement equipment any sort of errors or variance will be exaggerated.
- Conduction of the experiment: the set-up, measurement and mathematical techniques used in completing the experiment all provide a different level of accuracy/errors. The 'cheap' components didn't provide an easy, precise way to create the circuit. The measurement points were completed across the circuit by hand and direct contact as opposed to being implemented into the circuit. To complete a couple sets of results the data has been through numerous points of inaccuracy. Once the results have been taken down a mathematical theory has been used to generate a result. The theory uses a specific point of the capacitors charging and discharging rate, something which is not consistent across the capacitor due to equipment tolerances.
- Environmental Factors: the behaviour of capacitors and resistors can be affected by temperature, humidity, and any electromagnetic interference. All factors which have not been controlled or recreated to match the original manufacturing testing scenario.

(Sinclair., Dunton J. 2007) (James, R. 2023)

4 References

Denton, T (2017) *Automobile Electrical and Electronic Systems*

Dickson, R., Doug, L. (2013) *Electronics All-In-One Desk Reference for Dummies: UK Edition*

Forrest, M. (2000) *Getting Started in Electronics*.

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