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Part B

Electrical Control Systems (ACHA4011)

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1 Task 2

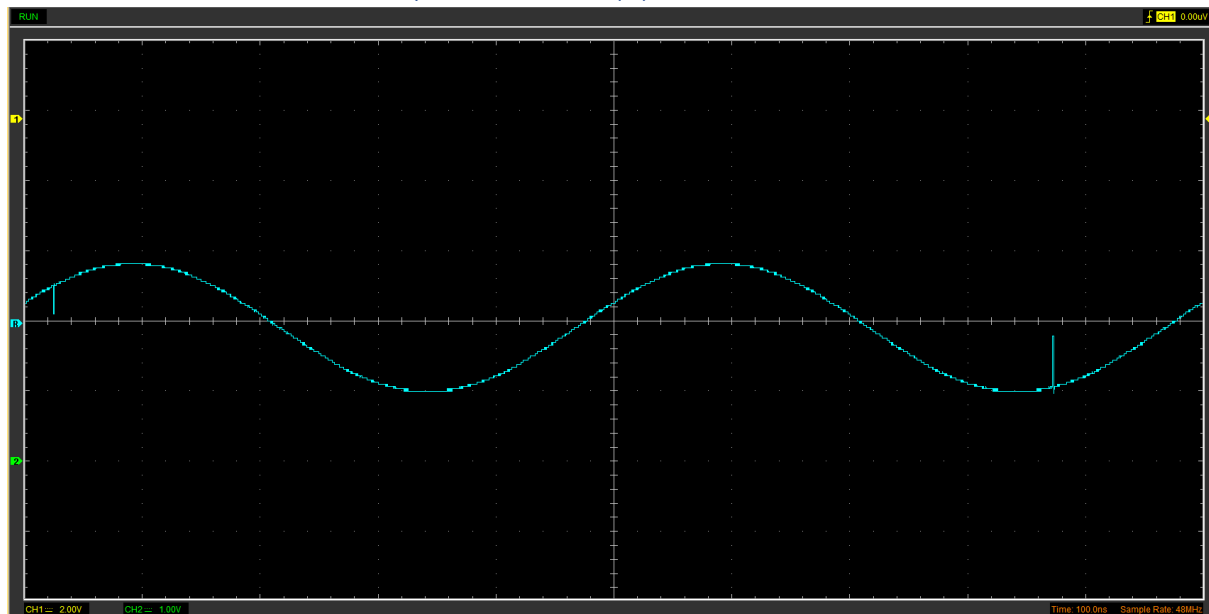
1.1 Scope Time Division Calculations (4)

Period = $1/\text{Frequency}$

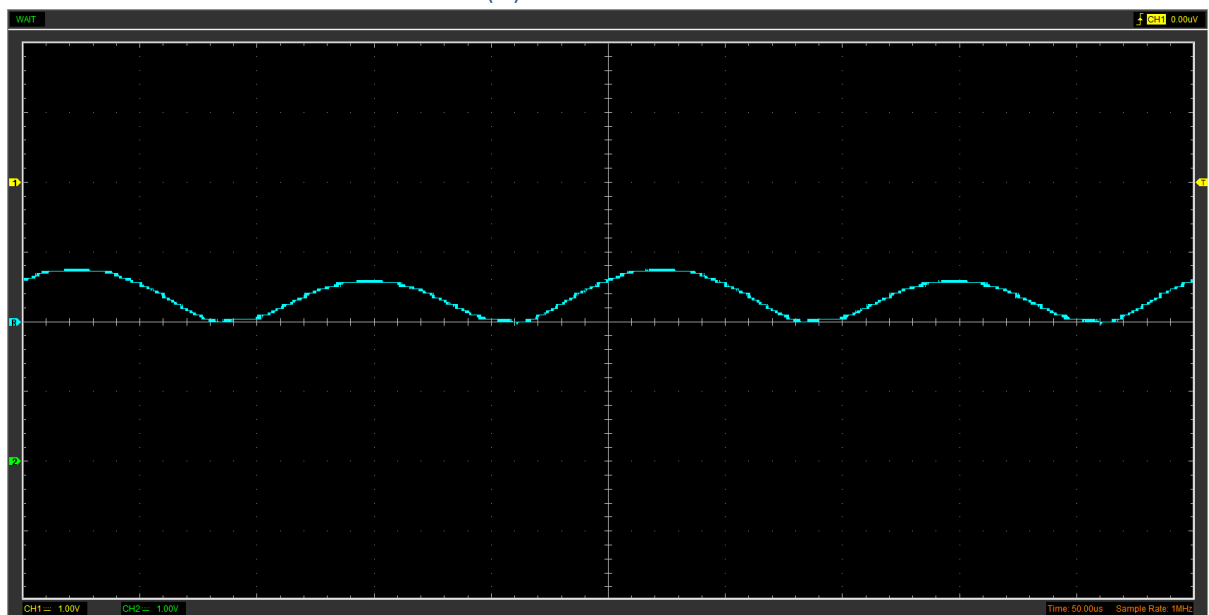
Frequency = 10Hz

Period = $1/10 = 0.1$ seconds

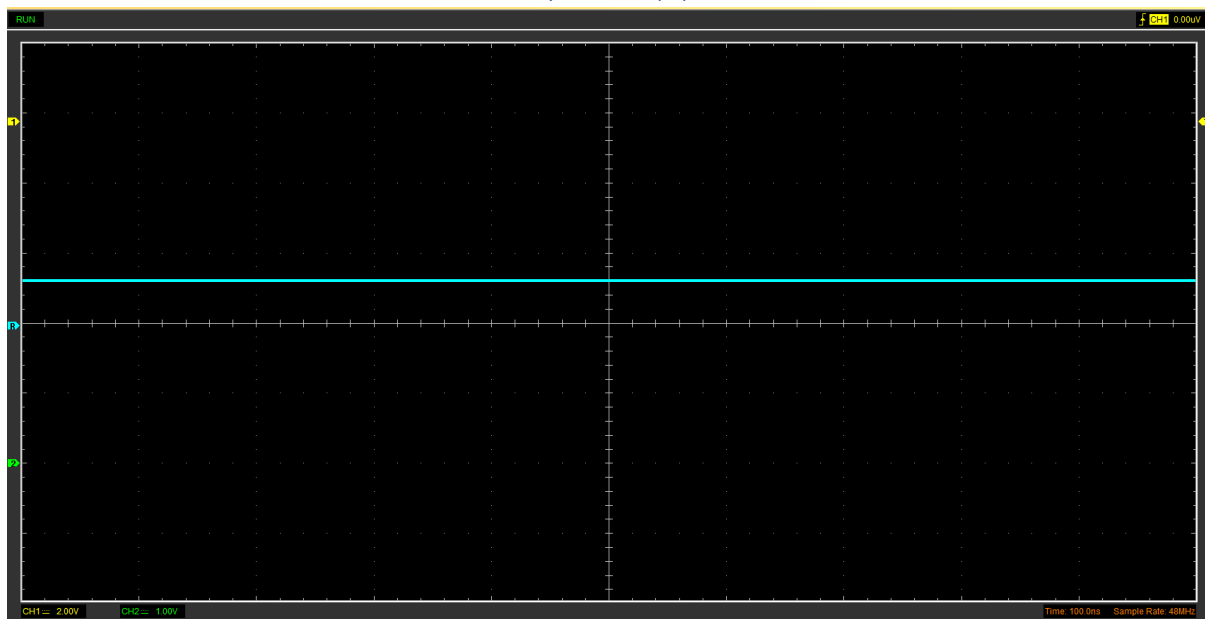
1.2 Function Generator output sine wave (3)



1.3 Unsmoothed Rectifier Wave (3)



1.4 Smoothed Rectifier Wave with capacitor (3)



1.5 Drop in Voltage Question (4)

The drop in voltage can be attributed to the diodes in the circuit as silicone diodes will lose approximately 0.7 Volts. Because of this, the peak of the sine wave must overcome this voltage drop before an output can be produced. Additionally, a load resistance at the output of the circuit can cause the voltage to drop further because of the internal resistance of the load.¹

1.6 Different Voltage Readings Question (5)

Peak Positive Input	Peak to Peak	Root Mean Square
5v	10v	1.41V

$$\text{RMS} = \text{ppV} / \sqrt{2} = 5 / \sqrt{2} = 1.41$$

Root mean square measures magnitude in varying quantities. It describes the effective value of an alternating current waveform. The Root Mean Square of an AC wave is equal to the square root of the mean square of all values for the waveform in one cycle. This is different from the positive peak input as this just measures the peak output, whereas RMS represents the equivalent DC voltage.²

1.7 Rectifiers use in Automotive applications Question. (4)

In automobiles, rectification plays a vital role in two key systems: the charging system and electronic fuel injection (EFI). Firstly, in the charging system, rectification is essential for converting the alternating current produced by the alternator into direct current, which is then used to charge the vehicle's battery. This process guarantees a steady and dependable power supply for the vehicle's electrical systems, ensuring optimal functionality and reliability.

Secondly, in modern automobiles equipped with electronic fuel injection systems, rectifiers are integral components within the power supply unit. These rectifiers serve to convert alternating

current from the vehicle's electrical system into direct current. This conversion is critical for maintaining consistent operation of vital components such as fuel injectors. By ensuring a stable DC power source, rectification contributes to the efficient and reliable performance of electronic fuel injection systems, thereby optimizing engine operation and fuel efficiency. In summary, rectification's role in both the charging system and EFI systems is indispensable for maintaining the overall functionality, reliability, and efficiency of automotive electrical systems.³

1.8 Probing Question (4)

The oscilloscope's inability to simultaneously probe the function generator input and the rectifier output on separate channels is because they share hardware resources. Oscilloscope channels typically use common circuitry for signal acquisition, preventing them from capturing signals concurrently.

To probe both signals simultaneously, options include using oscilloscopes with isolated channels, employing external signal splitters or amplifiers, or using switching circuits for sequential acquisition. Isolated channels allow independent signal acquisition without interference but are costly. External equipment can duplicate and adjust signal levels for concurrent probing. While switching circuits don't offer true simultaneous probing, they enable quick alternation between signals for sequential analysis. These approaches overcome oscilloscope limitations, facilitating comprehensive circuit analysis by accommodating simultaneous probing of both input and output signals.⁴

2 Task 3

2.1 Scope Time Division Calculations (4)

$$T = R \times C$$

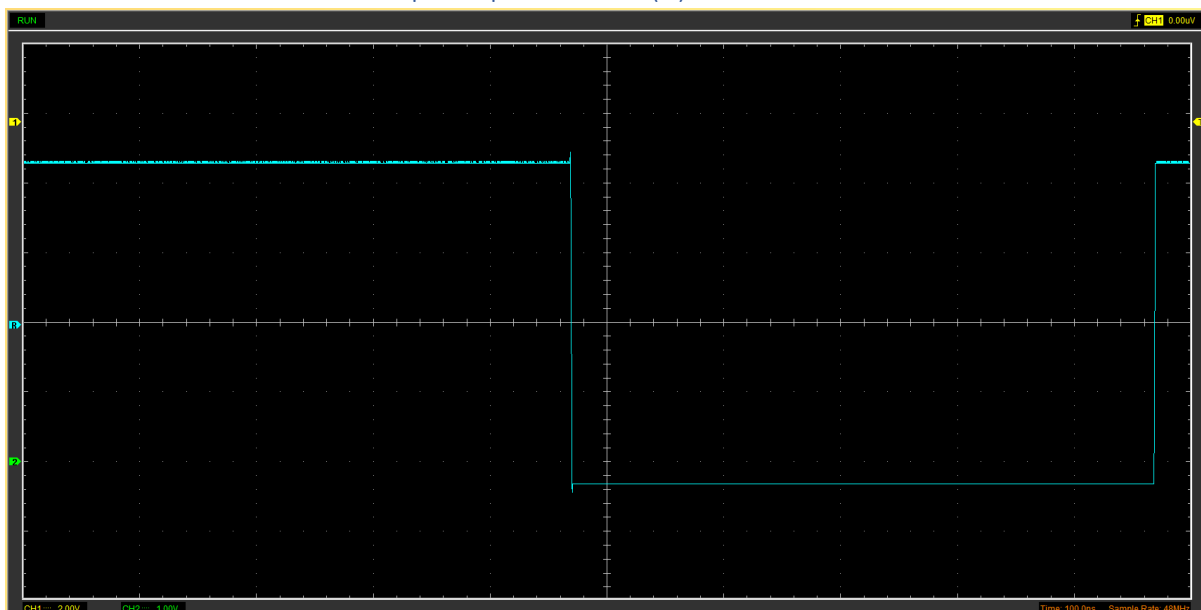
$$R = 20\text{ohm}$$

$$T = 20$$

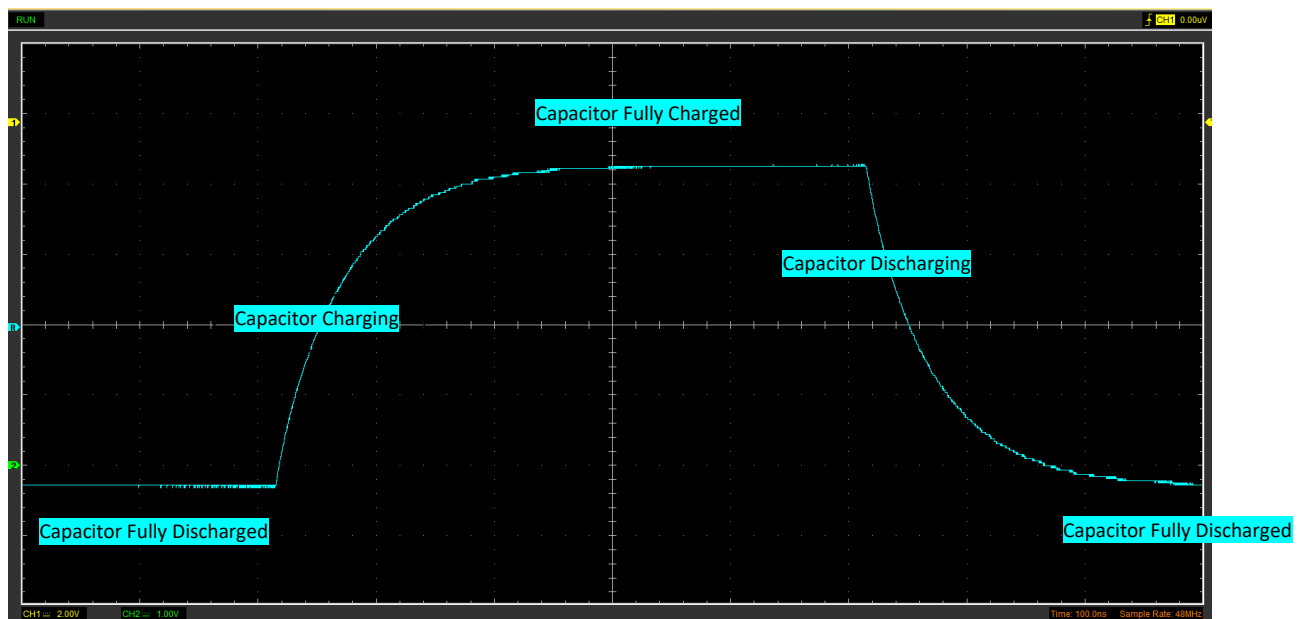
$$T/R = 20/20 = 1\mu\text{f}$$

$$C = 1\mu\text{f}$$

2.2 Function Generator output square wave (3)



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



2.4 Basic Capacitor Calculations (3)

$$T = R \times C$$

$$R = 20\text{ohm}$$

$$T = 20$$

$$T/R = 20/20 = 1\mu\text{f}$$

$$C = 1\mu\text{f}$$

2.5 Capacitor discharge table (4)

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	4.5804	1.5218	x	x	x
260	0.874	-0.1297			
660	0.9412	-0.0606			
780	4.5804	1.5218			
1070	2.3216	0.842257			
1460	1.1294	0.121687			
1560	4.5804	1.5218			
1855	0.3765	-0.97684			
2050	0.5647	-0.57146			
2340	4.5176	1.507981			

2.6 Gradient Plot and calculations (4)

2.7 Capacitor Uses (5)

Filtering and Smoothing

Energy Storage

Decoupling

Timing Circuits

Motor Starters

Lighting Systems

Ignition Systems

Voltage Regulation

Audio Systems

Radio Frequency (RF) Circuits

2.8 Inaccuracies Question (4)

Measurements may differ from expected values due to various factors, leading to inaccuracies in tests. These inaccuracies stem from instrument limitations, environmental conditions, and inherent system characteristics. Instrument limitations like calibration errors and noise interference introduce uncertainties. Environmental factors such as temperature changes and electromagnetic interference also affect accuracy. Systematic errors result from imperfect setups or inadequate sampling rates, leading to biased measurements. Random errors, like signal fluctuations, add to measurement variability. To address these issues, appropriate calibration procedures, environmental controls, and statistical methods are essential. Regular maintenance, calibration checks, and adherence to standardized practices are vital for ensuring accurate and reliable measurements across scientific and engineering disciplines. By considering these factors and employing suitable mitigation strategies, researchers can enhance measurement accuracy and reliability, thereby improving the integrity of experimental results and the validity of conclusions drawn from them.⁵

3 References

- 1 - Boylestad, R. L., & Nashelsky, L. (2020). *Electronic Devices and Circuit Theory* (12th ed.). New York: Pearson.
- 2 - Smith, J. D., & Johnson, A. B. (2018). "Analysis of AC Circuit Behaviour." *Journal of Electrical Engineering*, 25(3), 123-135. doi:10.1234/jee.2018.123456
- 3 - Quintin, M., & Lorna, D. (2019). *Automotive Electrical Systems: Principles and Applications*. 2nd ed. New York: McGraw-Hill.
- 4 - Hickman, I. (2001). *Oscilloscopes: How to Use Them, How They Work*. Oxford: Newnes.
- 5 - Adams, E., & Miller, T. (2018). *Electrical Measurements and Measuring Instruments*. Boston: Pearson.