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Electronic Circuits Testing and Applications

ACHA 4010

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1 Task 1

1.1 A

$$V = I \times R$$

$$V/I = R$$

$$12\text{v}/0.5\text{a} =$$

$$24 \Omega$$

1.2 B

$$RT = 1/(1/R1 + 1/R2 + 1/Rn)$$

The current passing through A, B and C will be the same as the current passing through the A. Therefore, B and C will be:

$$0.3\text{a}$$

1.3 c (i)

$$P = I^2 \times R$$

$$R = 0.9/(0.3^2)$$

$$R = 10 \Omega$$

1.4 c (ii)

$$V = I \times R$$

$$0.3\text{a} \times 10 \Omega =$$

$$3\text{v}$$

c (iii)

A to E = 5V drop

$$D = 12 - 5 =$$

$$7\text{v}$$

1.5 c (iv)

Ohms law $V = I \times R$

$$7\text{v}/0.3\text{a} =$$

$$23.33 \Omega$$

1.6 d

1.7 e

Ohms law $V=I \times R$ $0.3\text{A} \times 6\ \Omega =$

18v

1.8 f

1.9 g

The resistance of the parallel combination of A, B and C can be calculated using the formula for the total resistance of a parallel combination of resistors.

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}}$$

$$\frac{1}{R(\text{PARALLEL})} = \frac{1}{A} + \frac{1}{B} + \frac{1}{C}$$

Then adding the other resistors

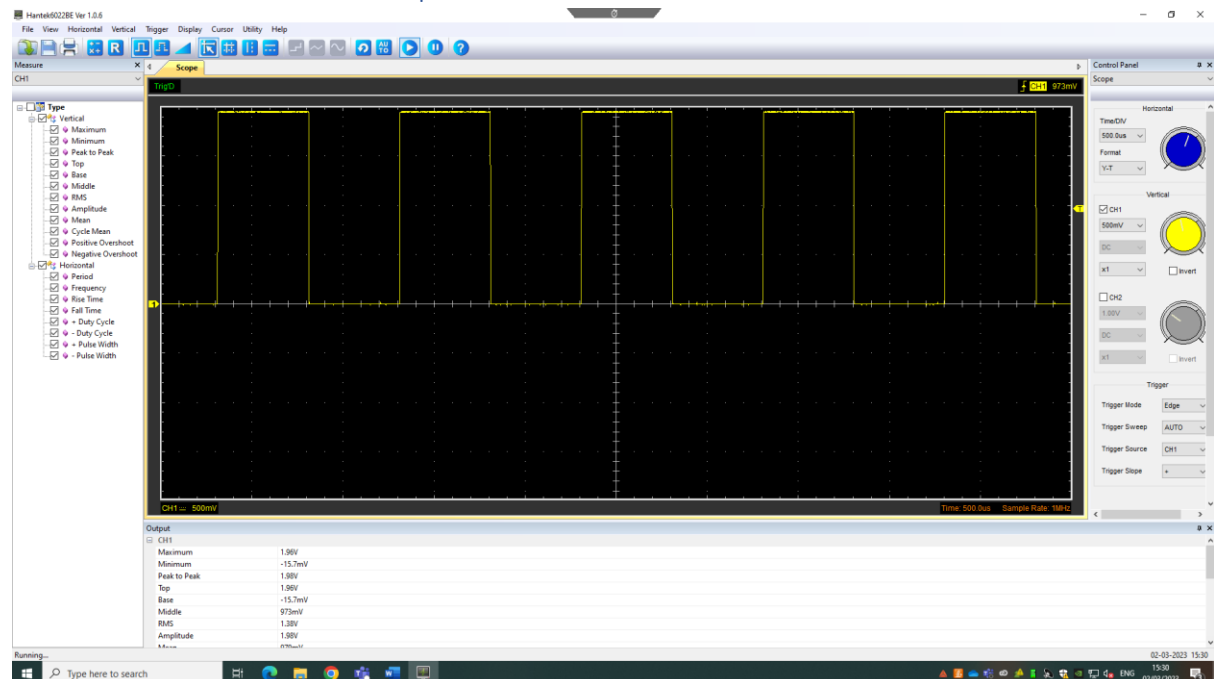
$$R_{\text{total}} = \left(\frac{6}{5}\right) + 1 + 1.2 + 6$$

7.92 Ω

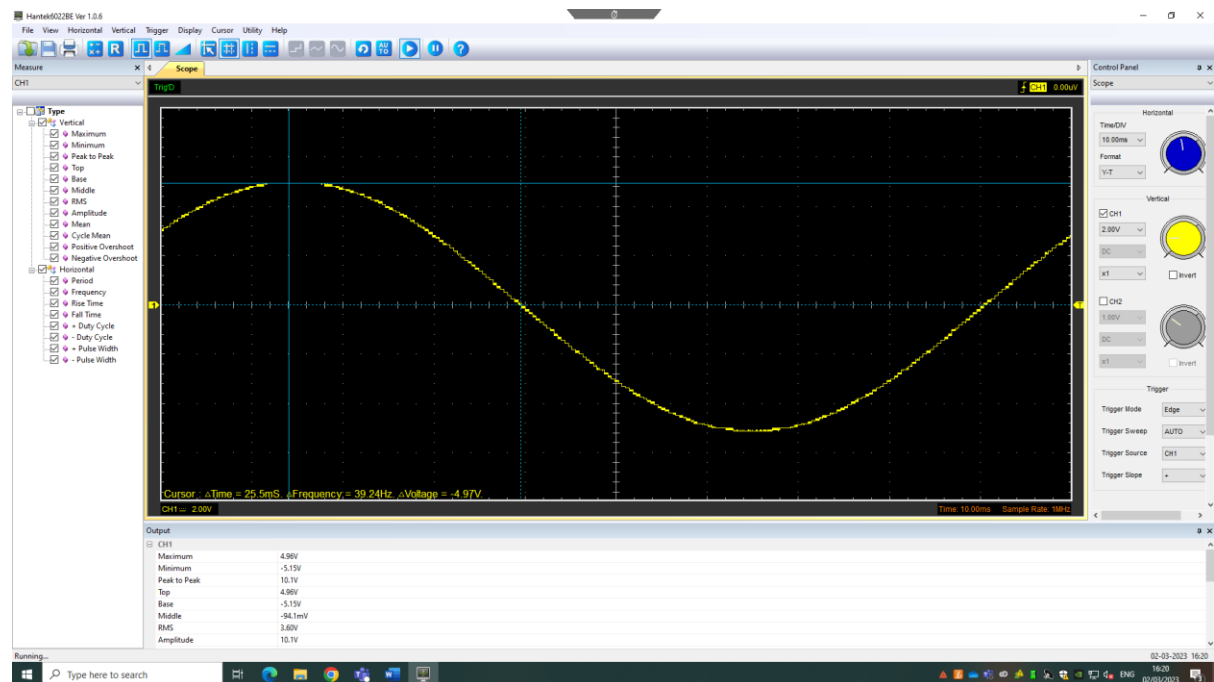
2 Task 2

2.1 Scope Time Division Calculations

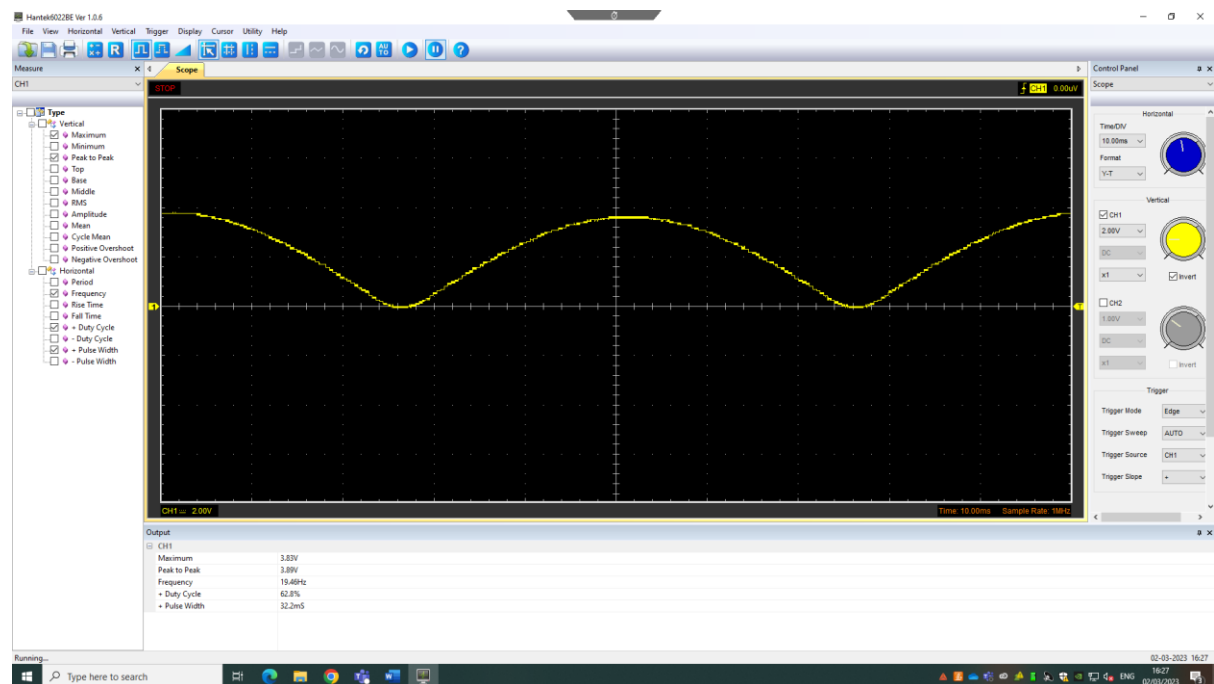
2.2 Function Generator output sine wave



2.3 Unsmoothed Rectifier Wave



2.4 Smoothed Rectifier Wave



2.5 Drop in Voltage Question

The rectifier DC output is lower than the peak of the sine wave input due to several factors. One of the reasons can be voltage drop due to passing through diodes, most bridge rectifiers use silicone diodes, and the voltage drop can be at least 1.2 volts lower than the peak voltage of the AC input (Electronics-notes.com, 2023). Secondly, looking at voltage ripple, often caused by imperfect filtering of power supplies or by the switching action of diodes. Lower voltage ripple is desirable and is often achieved by using high-quality power supplies, proper filtering techniques and careful circuit design (Staff, 2023).

2.6 Rectifiers use in Automotive applications Question.

A rectifier is a device which converts an oscillating two-directional alternating current (AC) into a single-directional direct current (DC) (Arrow, 2018). This ability to convert AC into DC is commonly used in automotive applications to power the vehicles electrical systems.

One of the most common uses of rectifiers in a vehicle is the alternator. Generating AC electricity as the engine runs and then using the rectifier to convert it into DC. This rectified DC power is then used to charge the battery and supply power to the vehicles lights, entertainment system, air condition and other electrical components.

In motorcycles regulator rectifiers are used as part of the charging system, converting the ac power generated by the alternators stator coil, into DC power, allowing power for the lights, horn and any other electrical components, and then regulating it to ensure the power doesn't go over 14.5 volts. Rectification in motorcycles is especially critical because they rely heavily on the battery to start the engine, making it necessary to have a reliable charging system.

Without rectification, the electrical components in a vehicle would not function correctly, causing significant safety and operational issues.

2.7 Probing Question

When probing with an oscilloscope, it is important to be aware of ground loops, these can occur when measuring two points within a circuit. A ground loop can occur when there is a difference in the ground potentials, such as both points being connected to the same ground reference, causing unwanted interference and noise in the measurements and potentially damaging the equipment in the process (Circuitspecialists.com, 2023).

To allow simultaneous probing, one solution is to use differential probes. A differential probe measures the voltage difference between two points in a circuit without connecting the ground of the probe to the circuit ground, thus eliminating the ground loops issue, and allowing for accurate measurements. Typically, more expensive than regular probes but are necessary for certain types of measurements, such as when measuring high-frequency signals or when dealing with isolated or floating circuits (Davies, 2017).

Another possible solution is to use isolation transformers. An isolation transformer is a device which electrically isolates the input and output of the transformer. This also allows for measurements of two points to be measured, avoiding a ground loop. Isolation transformers can be used to isolate a function generator from the rectifier output, this allows for simultaneous probing (Pini, 2020).

Looking at both differential probes and isolation transformers, it is important to note they both have their own limitations which should be considered before use. Isolation transformers can introduce distortion and phase shift in measured signals while differential probes have a limited input range and can be affected by common-mode interference. (Webber, 2009)

In summary, when probing with an oscilloscope it is important to consider ground loops which can occur during the measuring. To allow for simultaneous probing both isolation and differential probes can be used to eliminate ground loop issues and ensure accurate measurements.

3 Task 3

3.1 Scope Time Division Calculations

To calculate the time division for a circuit with a 1k resistance, 0.22 frequency, and 224 cap marking, we need to use the formula for the time constant of an RC circuit:

$$\tau = RC$$

(James, 2023)

where τ is the time constant, R is the resistance in ohms, and C is the capacitance in farads.

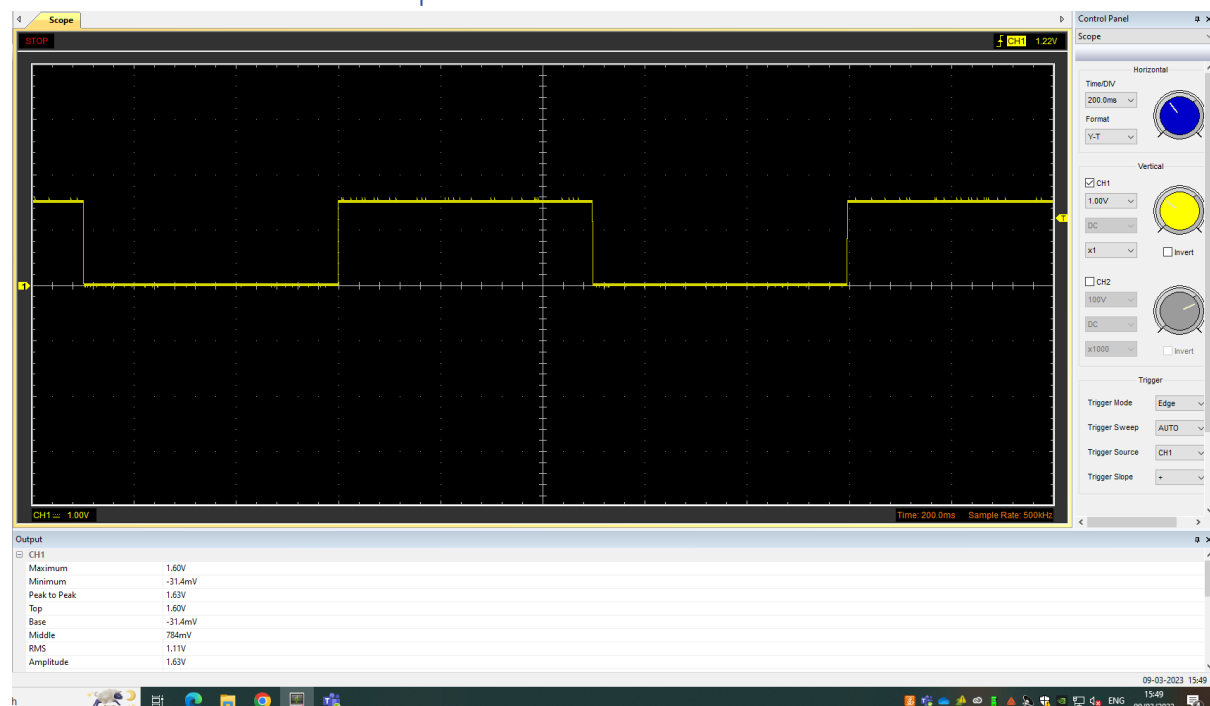
First, we need to convert the capacitance marking of 224 to its value in farads. The marking 224 indicates a capacitance of 220,000 pF or 0.22 μ F (microfarads) since each digit after the first two represents the number of zeros to add to the value in picofarads.

Using this value for capacitance and the resistance of 1k, we can calculate the time constant:

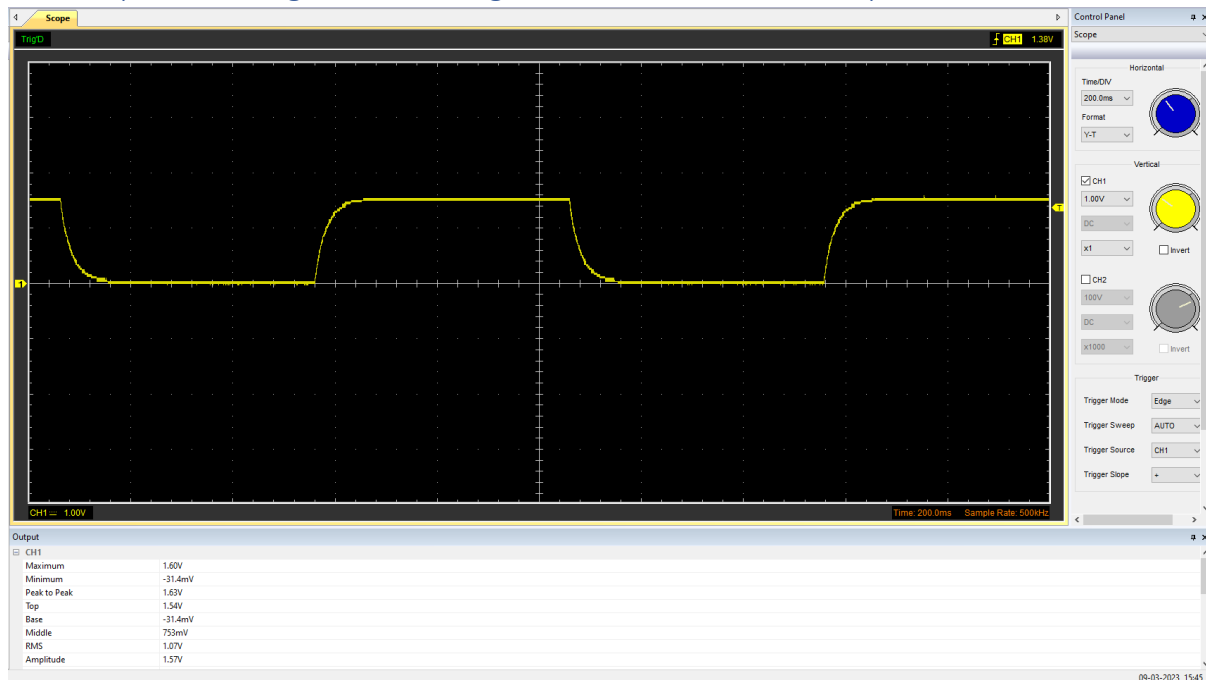
$$\tau = RC = 1k\Omega \times 0.22 \mu F = 220 \text{ microseconds}$$

Therefore, the time division for this circuit would be 220 microseconds.

3.2 Function Generator output sine wave



3.3 Capacitor charge and discharge wave marked at correct points.



3.4 Basic Capacitor Calculations

To determine the voltage and time when discharging at 63.2% with a voltage of 1v and a time of 200.00ms, using the following equation for the voltage across a capacitor during discharge:

$$V = V_0 * e^{(-t/RC)} \quad (1)$$

(labman.phys.utk.edu, 2022)

- “V” represents the voltage across the capacitor at the time “t”.
- “V₀” represents the initial voltage across the capacitor.
- “e” represents the mathematical constant e (2.718) (Snodow et al., 2006).
- “t” represents the time since the start of discharge.
- “R” represents the resistance in the discharge circuit.
- “C” represents the capacitance of the capacitor.

At 63.2% of the initial voltage (V₀) the voltage across the capacitor can be calculated as

$$V = 0.632 * V_0 \quad (2)$$

using this equation along with the given values to find the time required for the capacitor to discharge to 63.2% of its initial voltage:

$$0.632 * V_0 = V_0 * e^{(-t/RC)}$$

Therefore

$$0.632 = e^{(-t/RC)}$$

The natural log of both sides must be taken :

$$\ln(0.632) = -t/RC$$

This must now be rearranged to solve for t

$$T = -\ln(0.63) \cdot RC$$

Substituting the values for $V_0 = 1V$, $t=200.0ms$ to solve for RC :

$$RC = t / (-\ln(0.632)) - 0.458 \cdot t = 91.5ms$$

Now using the value of RC to calculate the voltage across the capacitor at 63.2% of its initial voltage after 200.0ms:

$$V = V_0 \cdot e^{(-t/RC)} = 1V \cdot e^{(-0.2s / 0.0916s)} = 0.632V$$

Therefore, after 200.0ms, the voltage across the capacitor is 0.632v and it takes 91.6ms for the capacitor to discharge to 63.2% of its initial voltage.

3.5 Capacitor discharge table

3.6 Gradient Plot and calculations

3.7 Inaccuracies Question

Inaccuracies in measurement can occur due to reasons such as measurement errors, instrument limitations and environmental factors. When measuring capacitance using an RC circuit, the measurement may be different from the specific value due to several factors.

One common factor that can affect capacitance measurements is the accuracy of the instruments used. Oscilloscopes and function generators have their limitations in terms of frequency response, bandwidth, and accuracy (Margesan, 2003). These can lead to errors in measurement. Additionally, the resistance of the circuit components can vary due to factors such as temperature, ageing, and manufacturing tolerances, also affecting the accuracy during the measuring.

Another factor which can affect capacitance measurements is the environmental conditions, humidity and temperature can affect the electrical properties of the components in the circuit. The presence of external electromagnetic fields and noise can cause interference, leading to further measurement errors.

To minimise inaccuracies in capacitance measurements, it is important to use calibrated instruments, maintain stable environmental conditions, and carefully select the components used in the circuit. As with all experiments, it is recommended to perform testing multiple times, resulting in multiple measurements and then calculate the average to obtain a more accurate value.

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