

Kuwait University

Physics Department

Physics 107

Oscilloscope in AC Measurements

Introduction

In our life today we depend on electricity to operate all electric devices. Most of these electric devices are powered by an AC signal. The main reasons for the wide use of the AC signal are lower cost of both production and transmission and convenience of distribution.

In this experiment an AC sinusoidal signal will be investigated through **Cathode Ray Oscilloscope** (CRO). The AC signal will be considered the input to the CRO, and students will do some changes manually to the input and they will notice these changes at the CRO display. Then a diode and a resistor will be included in the circuit and the output voltage across the resistor will be tested at the CRO to see the signal produced from this circuit.

Objectives

- To familiarize your self with the use of CRO.
- To investigate a normal AC input signal at CRO.
- To determine the Time period and Amplitude of an AC signal.
- To investigate a signal produced from a circuit, which include a diode, and thus studying the effect of the diode.

Equipment to be Used:

- AC Power Supply (Analog trainer).
- Diode.
- Cathode Ray Oscilloscope (CRO).
- 390 Ω resistor.

Theory

AC Voltage

Alternating current or voltage, periodically changes its magnitude and direction of flow. It flows first in one direction and then in the opposite direction. The most common AC voltage or current is a *sinusoidal* function of time. A sinusoidal voltage may be described by an equation of the form:

$$V(t) = V_o \sin(\omega t) \quad (1)$$

where ω is the angular frequency, $\omega = 2\pi f$, and f is the frequency of alternation measured in Hz and equals to the reciprocal of the period T needed to complete one cycle. Therefore, $T = 1/f$. The term V_o , in Equation (1) above, represent the maximum value of the voltage which means the voltage V at time $t = \frac{\pi}{2\omega}$.

The waveform that represent an AC signal described by Equation (1) is shown below.

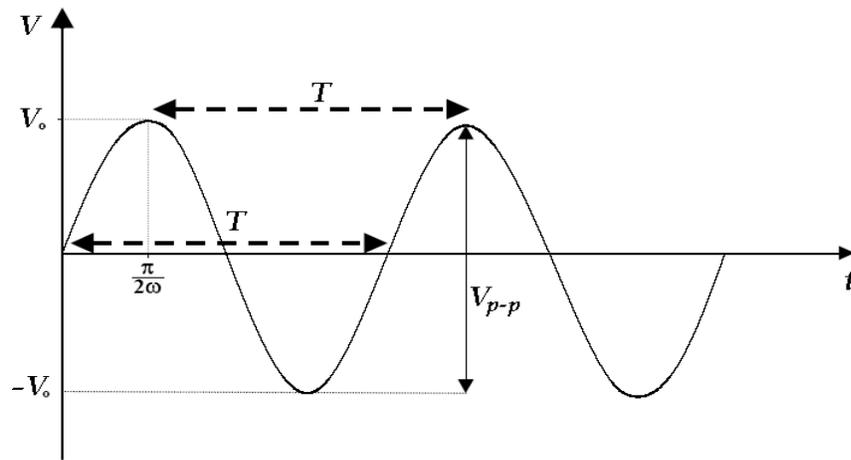


Figure 1. Sinusoidal wave with its peak-to-peak voltage V_{p-p} and its period T

AC voltage and currents cannot be measured with a DC-meter because the pointer cannot change direction quickly enough. They can be measured either with an AC meter or an Oscilloscope. The Oscilloscope shows how voltage varies with time. See Figure 2.

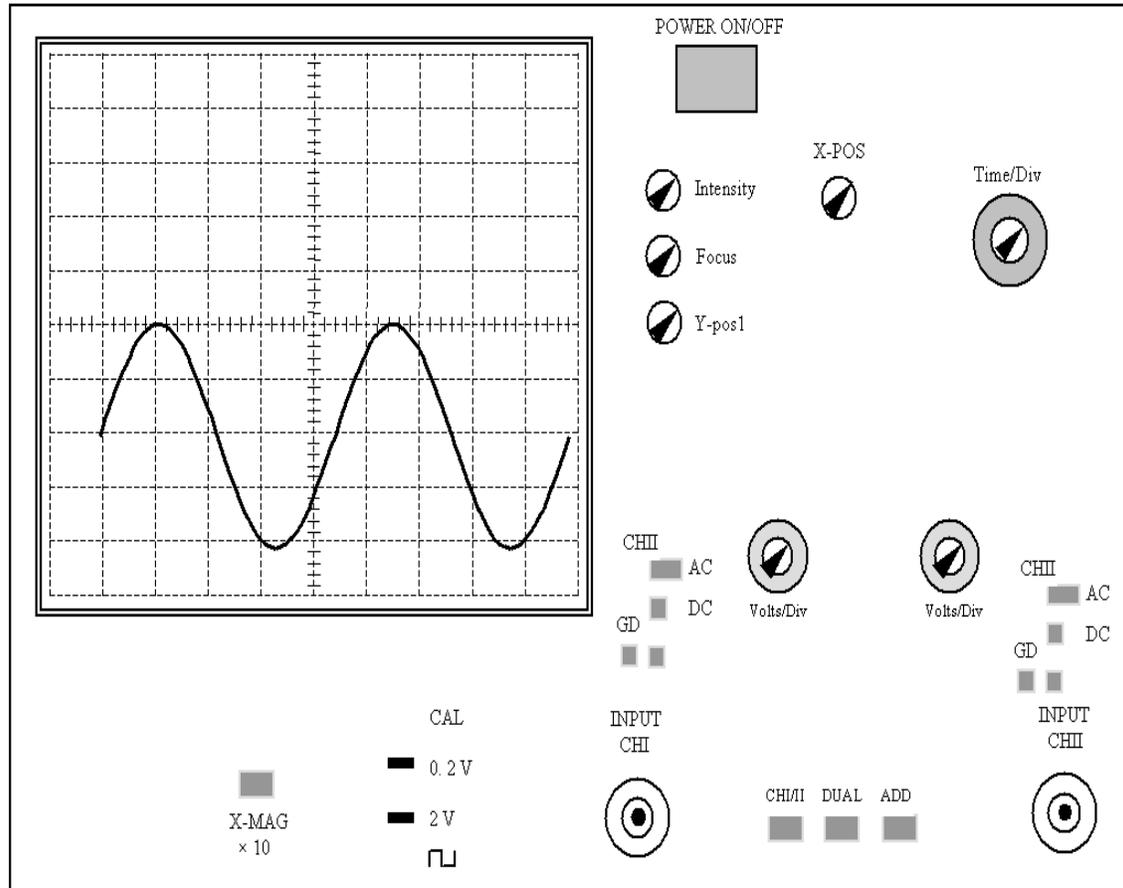


Figure 2. Cathode Ray Oscilloscope (CRO).

The magnitude of an AC voltage may be characterized by the amplitude V_o , but a more common practice is to use the "root-mean-square" voltage, which is indicated by V_{rms} . The "root-mean-square" voltage depends on the type of the AC signal. For an AC sinusoidal signal:

$$V_{rms} = \frac{V_{p-p}}{2\sqrt{2}} \quad (2)$$

For a square signal:

$$V_{rms} = \frac{V_{p-p}}{2} \quad (3)$$

In addition to the term "root-mean-square", another term of the same meaning is used. This term is known as the "**effective value**". This is the value that has the same heating effect as a known direct current or voltage. For example, if an unknown alternating voltage has the same heating effect as a direct voltage of 15 V, the alternating voltage is known to have an effective value of 15 V.

The effective values of current and voltage are used in most calculations concerning AC circuits. In general, any measured value of current or voltage in any AC application is, in fact, an effective value unless otherwise specified.

Diode in AC Circuit

From the previous experiment you have identified the diode, and you know that if a diode is connected to a circuit with a DC power supply and your diode is in a forward biasing then there will be a current passing through the circuit, but if the diode is in a reversed biasing then there will be no current. In this part of the experiment we will use the channels of the CRO to investigate the behavior of the voltage across a resistor in an AC circuit that includes a diode as compared to the voltage of the AC power supply in this circuit. Refer to Figure 3.

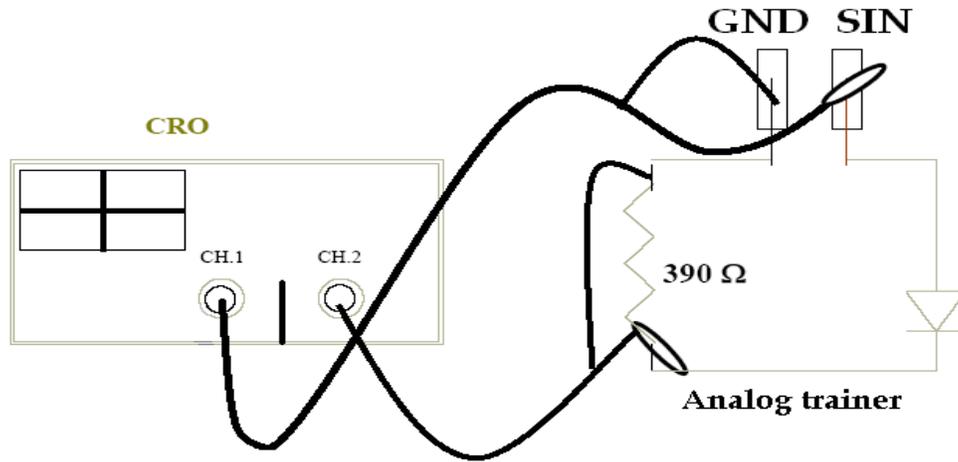


Figure 3. Connecting CRO to AC circuit with diode.

Connecting an AC Power supply to a circuit in which the diode is connected in series to a resistor, and then you connect one of the channels of CRO across the power supply input and the second channel across the resistor output of the circuit, then you will see two signals on the CRO, first from power supply and second one is from resistor. If you compare between the two signals you will see the difference between both signals (input and output) because the diode is included in the circuit. You can expect the shape of the output signal "the output of the circuit" from the concept of forward and reversed biasing, so either you will see only the positive half of the cycle signal and negative half is cut, or you will see the negative half only and the positive half is cut. This process is called rectification.

Procedure

Part One: AC Voltage

- 1) **Connect** the probe to the Channel-1 of the CRO to the analog trainer as shown in Figure 3 below and switch it on.

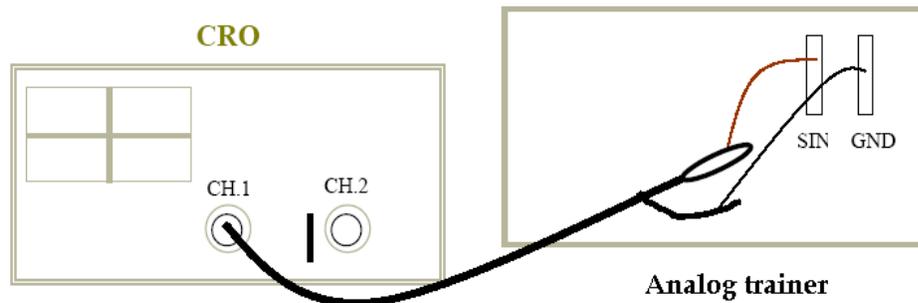


Figure 4.

- 2) **Focus** the electron beam of the CRO in the middle of the screen (in the origin), using the buttons:
 - * GNG & X-Y \longrightarrow to convert the signal to point.
 - * X-POS & Y-POS \longrightarrow to move the point horizontally and vertically.
- 3) **Connect** the probe of the CRO to the Sin and GND of generator of the analog trainer.
- 4) **Adjust** your CRO, so that you can see your Sin signal clearly on the CRO display. You should see between one complete cycle and two complete cycles. Your adjustments basically depends on two buttons, they are "VOLTS/DIV" and "TIME/DIV". Notice that the "VOLTS/DIV." button changes your scale vertically and the "TIME/DIV" changes your scale horizontally.
- 5) **Adjust** the frequency of the AC power supply from the heathkit trainer using the button on the top right corner of the heathkit.

- 6) From the CRO, measure the period T of the signal. To do so, **measure** (in divisions & subdivisions) the horizontal distance between two successive peaks or two successive points if they are in phase and **multiply** this distance by the reading of the "TIME/DIV" button which is the scale of the time axis. **Record** your data in Table 1.
- 7) From the CRO, measure the voltage V_{p-p} of the signal. To do so, **measure** (in divisions & subdivisions) the vertical distance between most top point and most bottom point peak-to-peak and **multiply** this distance by reading of the "VOLTS/DIV" button which is the scale of the voltage (amplitude) axis. **Record** your data in Table 1.
- 8) **Compute** the frequency $f = 1/T$ and the "root-mean-square" voltage V_{rms} of the circuit, as indicated in Equation (2), and **record** your results in Table 1.

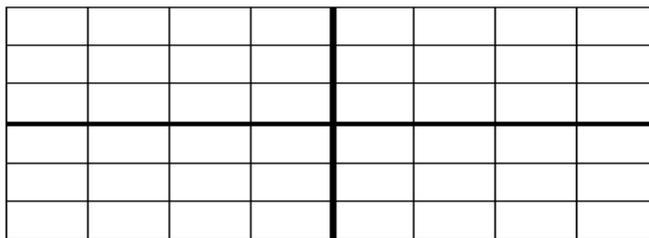
Table 1.

Frequency knob location	Period T (s)	Voltage V_{p-p} (V)	Frequency f (Hz)	Voltage V_{rms} (V)
←				
↑				
→				

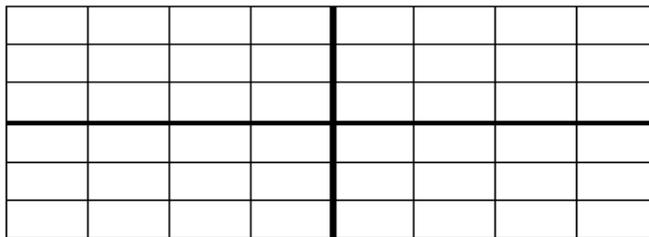
Part Two: Diode in AC Circuit

- 1) **Connect** the CRO to the circuit shown in **Figure 3**. (make sure that you **connect** CH-1 of the CRO to the AC power supply and CH-2 across the resistor as illustrated in the Figure).
- 2) **Adjust** the CRO so that it can display both channels (the two signals) simultaneously. You can do so by pressing the button **DUAL** on the CRO.
- 3) To get a clear and reasonable signals **adjust** both channels by adjusting the "VOLTS/DIV" button for each channel. Similarly, **adjust** the "TIME/DIV" button to adjust the time for both. Notice that the time axis is common for both.
- 4) When you see both signals on the CRO display, **sketch** both signals in the specified location in Plot 1.
- 5) **Compare** the two signals and discuss the difference between them.

Plot 1.



*Original signal
(Input AC Voltage)*



*Output signal
(Resistor Voltage)*

Comment on the relation between the input and the output voltage signals.

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Conclusion: