PHYSICS 281
EXPERIMENT 6
Oscilloscope

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OBJECT:

To familiarize with the use of oscilloscope and the measurement of DC and AC voltages, amplitude, period and frequency. To learn the method of measuring high resistance through measurement of RC constant.

APPARATUS:

Oscilloscope, probes, variable DC power supply, and function generator.

THEORY:

The oscilloscope is a unique and probably the most important test instrument of an electrical engineer or any scientist working with electronic devices. The basic component of the oscilloscope is the cathode ray tube (CRT), as illustrated in Figure 1.

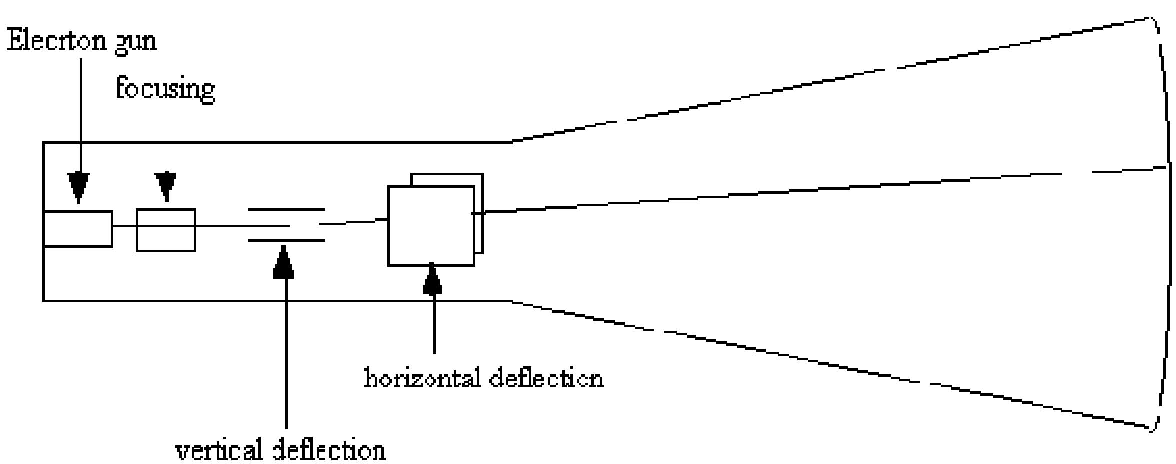

Figure 1. Construction of CRT

Electrons from a heated cathode or filament are accelerated through a potential difference into a focusing element to become a well collimated and focused beam. The electron beam enters into two sets of parallel deflection plates. The first pair of parallel plates is more sensitive and used for the signal channel. It causes vertical deflection. The second pair of plates causes horizontal deflection and is usually used for time sweeping. The electron beam coming out of the deflection plates heats the CRT screen with fluorescent coating and make a bright spot at certain position determined by the voltages applied across the two pairs of deflection plates. If both voltages are varying in time, the electron beam will trace a two dimensional curve on the screen.

Figure 2 shows one of such a two dimensional curve, a sinusoidal wave function. The horizontal movement of the electron beam is controlled by a voltage that increases as a linear function of time. This voltage is sometimes called the saw tooth voltage or ramp voltage. The curve traced by the electron beam on the screen is actually the waveform as a function of time of the signal applied across the vertical deflection plates. The time measurement (horizontal axis) is determined by the frequency of the sweeping voltage provided by a built-in saw tooth waveform generator, while the voltage measurement (vertical axis) is determined by the amplification of the internal amplifier. Both the saw tooth generator and the amplifiers are accurately calibrated by the manufacturer so that the user can read the time and signal voltages directly from the knob settings on the front panel of the oscilloscope.

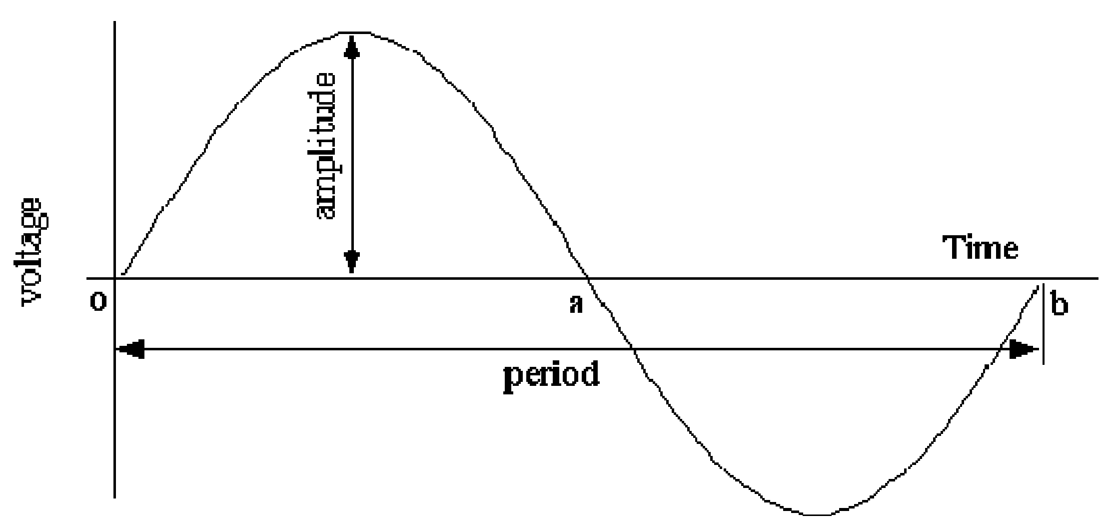

Figure 2. A sinusoidal waveform

In Figure 2, the time interval between points o and b is called the period because the waveform repeats itself again from the point b on. The maximum signal is called the amplitude of the waveform, which is measured from the time axis, which is supposedly at the vertical center of the waveform, to the peak of it. The period is usually very short (from a few nanoseconds to a few milliseconds for most measurements), and the whole curve of Figure 2 would cause a fluorescent flash for as long as the fluorescence lasts, which is about a second or so, too fast for any practical measurement. In order display a static waveform, the electronics is designed such that the electron beam keeps on repeating the same track on the screen. This requires that the electron beam always starts at the same point of the waveform. Namely, the horizontal sweep waveform and the signal waveform have to be synchronized. There are controls on the front panel for adjusting the trigger level and polarity to achieve stable synchronization. If the signals are not synchronized, the waveform will be seen running on the screen.

PROCEDURE:

1. Turn on the power switch. (It could be quite a challenge to find one for some models!) You may need to wait for seconds to see something shown on the screen. Find the "Intensity" knob and adjust the intensity such that the figure on the screen is bright enough for you to see, but not too bright to burn up the screen. The problem is more serious if you see only a single dot on screen. Reduce the intensity immediately when this happens. Get help from your instructor if you are completely lost.

2. Adjust the "Focusing" knob to obtain the finest trace on the screen. The better focused beam is usually brighter. You need to reduce the intensity accordingly to protect the screen.

3. Set the time scan to the scale of 10 ms per division. Set the "Input" switch of both channels to "Ground". Adjust the "X position" knob so that the horizontal sweep line is centered on the screen. This is the time axis.

4. Adjust "Y position" knobs to see which channel is used. If the knob controls the Y position of the sweep line, that channel is used. Make sure Channel One is used and adjust the Y position so that the sweep line is centered vertically.

Apply a few volts of DC voltage to Channel One input, using a BNC probe. Notice the change of the vertical position of the time axis. Set the Y sensitivity knob to the more sensitive scale, but not too sensitive to send the sweep line off screen, for more accurate measurement. Record the DC voltage on your data page as read from the screen. This is how you measure the voltage of a waveform or pulse. Now switch the polarity of the input voltage. What happens to the sweep line? Switch the "Input" from "DC" to "AC". What happens to the sweep line? Why?

5. Connect the output of the function generator to the input of channel One. Turn on the function generator. Set the waveform to sinusoidal wave and the frequency to kHz range. Try to obtain a few periods of a stable sine wave on the screen by adjusting the time base and the triggering level. Make sure the triggering source is set at Channel One. This is probably the most challenging part of the experiment. If you have great difficulties in obtaining a stable waveform after reasonable effort, get some help from your instructor.

6. Measure the period and the amplitude of the sine wave. Record the numbers.

7. Now change the sensitivity of the y axis and measure the amplitude again. Do you get the same voltage? Which scale setting gives you the best measurement ?

8. Change the time base to the adjacent settings. You may need to readjust the triggering to stabilize the waveform. What happens to the waveform ? Measure the period again. Do you get the same value for the period ?

9. Now switch the waveform from sinusoidal to square wave. There is a switch on the waveform generator for choosing the waveforms. Measure the pulse height, the period and the pulse width of the square wave. Record the data.

10. Repeat step 9 with a saw tooth waveform.

Reminder: Check you math, check the units, check your graph, do not forget to follow the format for your lab report (see syllabus).