Exp. (2) Oscilloscope

Objective:

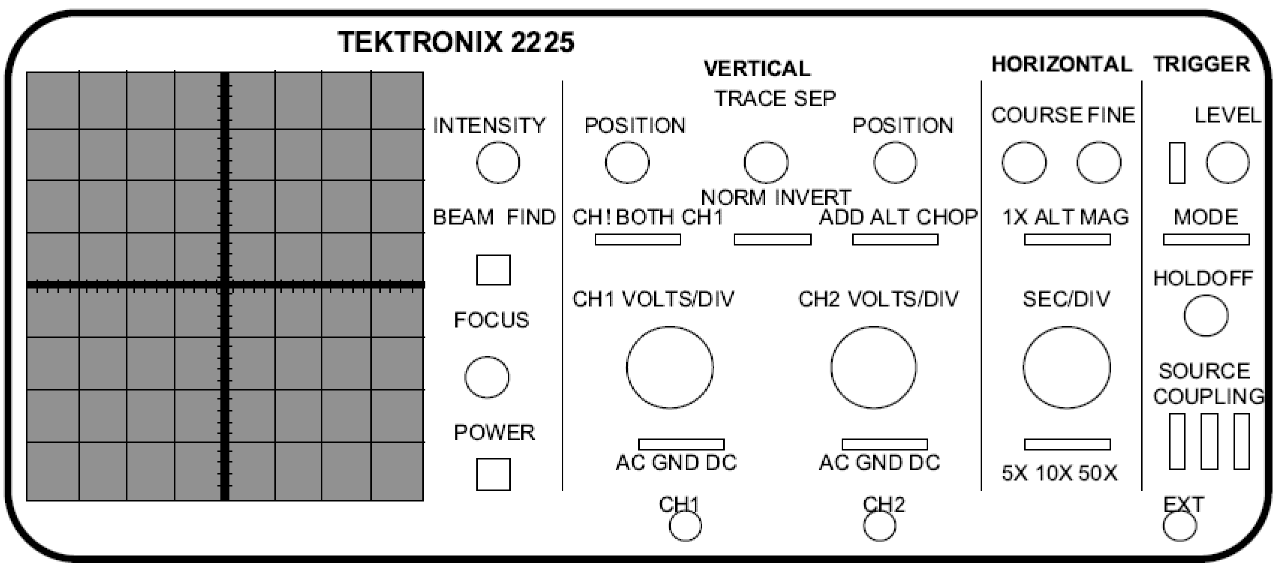
(1) Be able to describe the operation of the oscilloscope and use it:
(2) To use the oscilloscope to measure DC voltages.
(3) Analyses AC signals using the oscilloscope and measure the period and frequency of the time varying waveforms or signals.

Equipment:

Oscilloscope, sine and square wave generator, 1.5 volt battery, a supply of coaxial cables, AC power supply.

Theory:

An oscilloscope is an electronic test instrument that displays electrical signals graphically, usually **as a voltage (vertical or Y axis)** versus **time (horizontal or X axis)** as shown in **figure 2.1**. The intensity or brightness of a waveform is sometimes considered the Z axis.



There are some applications where other vertical axes such as current may be used, and other horizontal axes such as frequency or another voltage may be used.

Oscilloscopes are also used to measure electrical signals in response to physical stimuli, such as sound, mechanical stress, pressure, light, or heat. For example, a

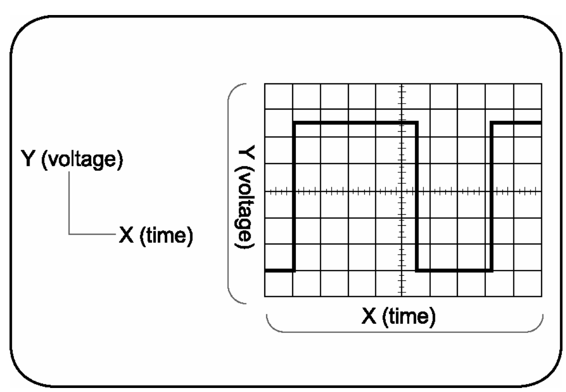


Figure 2.1: Typical Oscilloscope Display

television technician can use an oscilloscope to measure signals from a television circuit board while a medical researcher can use an oscilloscope to measure brain waves.

An oscilloscope contains various controls that assist in the analysis of waveforms displayed on a graphical grid called a graticule.

The graticule, as shown in **figure 1**, is divided into divisions along both the horizontal and vertical axes. These divisions make it easier to determine key parameters about the waveform. I most cases the screen has 10 divisions horizontally and 8 divisions vertically. The main component of the oscilloscope is the cathode ray tube (CRT) on whose screen the externally applied electrical signal is detected.

In its barest essentials, the operation of the CRT (Fig.2.2) can be understood as an application of the basic principle that similar electrical charges repel each other while unlike charges attract.

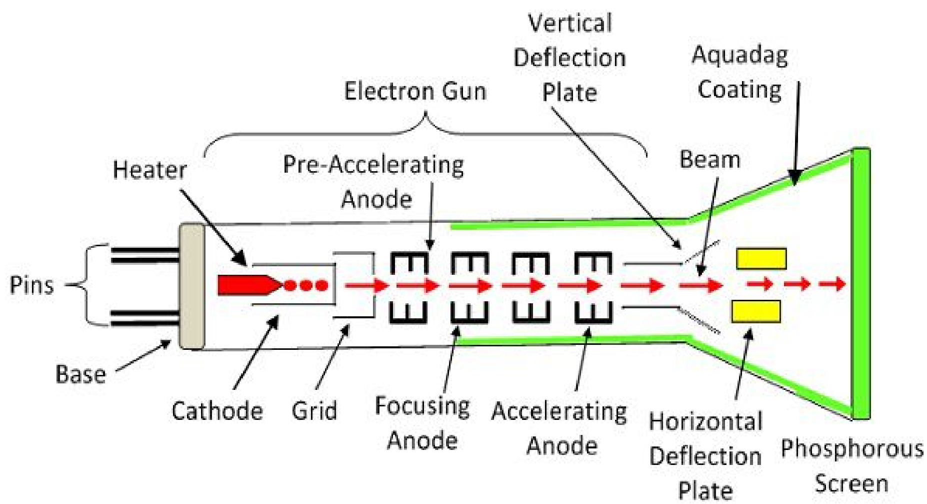


Figure 2.2 A simplified diagram of the CRT.
Cathode-ray tube - Liberal Dictionary.com

In the CRT electrons are emitted by a heated, negatively charged filament (the cathode), and travel in a beam toward a positively charged plate (the anode). Depending on the properties of the plate and the speed of the electrons, cathode-ray tubes can generate x-rays, visible light, and other frequencies of electromagnetic radiation. They are central to most television screens, in which the electron beams form images on a phosphor-coated screen. The type of oscilloscope used in the experiment allows two signals to be applied to two separate vertical input terminals, and the two signals can be observed simultaneously on the screen of the CRT. In this experiment only one of the inputs is used.

The following information describes the primary front panel Features the turn-on procedure, and the signal application procedure for oscilloscope.

Primary Front Panel Features:

1. POWER. Applies line power.
2. INTEN. Controls brightness of display.

3. FOCUS. Controls sharpness and clarity of display.
4. X. Controls horizontal position of display;
5. SEC/DIV. Controls sweep time of display.
6. VARIABLE. Varies sweep speed- in CAL'D position, sweep speed is as selected by TMM/DIV setting.
7. Y. Controls vertical position of display;
The following instructions are written for input signals to both channel I (CH-1) and channel 2 (CH-2).
8. INPUT Y. Vertical signal input.
9. VOLTS/DIV. Selects vertical deflection sensitivity measured in volts per division.
10. DC-AC. Selects direct (DC) and (AC) coupling to vertical amplifier.
11. GND. In ground (GND) position, disconnects input signal used.
12. VERT MODE. Selects channel or channels to be displayed on CRT.
13. TRIGGER. Selects point on signal that starts the horizontal sweep.

Procedure:

Part I: Preparing the oscilloscope for "first time operation".

1. **Switch on** the oscilloscope to warm up (it takes a minute or two).
2. Do **not** connect the input lead at this stage.
3. Set the "**DC-GND-AC**" switch to **DC**.
4. Set the **SWP/X-Y** switch to **SWP** (sweep).
5. Set **"TRIGGER MODE"** to **AUTO**.
6. Set TRIGGER SOURCE switch to **INT** (internal, the y input).
7. Set the **VOLTS/DIV** to **1V/DIV** (a moderate value).
8. Set the **TIME/DIV** to **10ms/DIV** (a moderate speed).
9. Turn the time base **VARIABLE** control to **1** or **CAL.**
10. Adjust **Y-VERTICAL CONTROL** (up/down) and **X-HORIZONTAL CONTROL** (left/right) to give a **trace across the middle of the screen**, like the picture.
11. Adjust **INTENSITY** (brightness) and **FOCUS** to give a bright, sharp trace.
12. The oscilloscope is now ready to use.

Part II: Measurement of DC and AC voltages using oscilloscope: Using channel 1 (Ch.1) controls only:

1. Set the "DC-GND-AC" switch on GND. (Grounded zero input voltages)
2. Adjust the vertical position control knob so that the horizontal trace is vertically centered on the screen
3. Set the "DC-GND-AC" switch to AC. (Appears as AC sine signal on the screen).

4. Turn the variable, “VAR” dark gray knob, voltage control fully clockwise.
5. Measure the voltage of a **1.5 volt battery** connected to the input of Channel
The surrounding light gray knob, “VOLTS\ DIV”, can be adjusted to change the vertical scale calibration in volts per centimeter above and below the zero (central) or ground position. The calibration is correct ONLY when the dark gray knob is fully clockwise.

- Voltages are measured on an oscilloscope by first counting the number of divisions of vertical deflection and then multiplying by the VOLTS\ DIV setting.
- DC voltage = Vertical deflection of the trace × vertical sensitivity (V/DIV)
- Measure the battery voltage for several setting of the VOLTS\DIV knob such as 5.0V\DIV, 2.0 V\DIV and 0.5 V\DIV.
- What is the best setting of the V/DIV knob if you want to measure the voltage most accurately?
- Note what happens to your voltage measurement if the variable dark gray knob is not fully clockwise.
- Reverse the polarity of your battery and again measure the voltage. If you do not get the same value as before, your trace was probably not vertically centered when the DC-GND-AC switch was in the ground position. If such is the case, you can still get an accurate results by taking the average of the result for the two polarities, why?

6. Set the DC-GND-AC switch to AC with the battery still connected. Explain what happens.
7. Attach the function generator to the horizontal input, set the DC-GND-AC switch to AC. With the “TRIGGER MODE” at AUTO, set the TRIGGER SOURCE switch to ch1. You are now ready to measure AC voltage from the function generator. Connect the output of the generator and set the function selector to sine wave position. Turn on the generator and set the frequency to 60Hz. Adjust the 20V peak-to-trough max control on the generator until you measure 4 volts peak-to-peak on your oscilloscope. Adjust the TRIGGER LEVEL control knob if the wave displaced on the oscilloscope is not satisfactory. Refer to the instructor to verify that you are observing the signal correctly. Note that the setting of the horizontal time scale, TIME/DIV affects how many cycles of the 60Hz sine wave is seen on the screen at one time. Setting the TIME/DIV at 10ms/DIV (10 millisecond per division) will cause only several cycles to be displayed. In making the peak-to-peak voltage measurement it is not necessary see the trace centered vertically. You can use horizontal and vertical control knobs to move the pattern up or down and lefts and rights, such that until a convenient pattern is traced where one maxima or minima exactly on a scale division.

Part III: Measurement of the period and frequency of A. C. signals using the oscilloscope

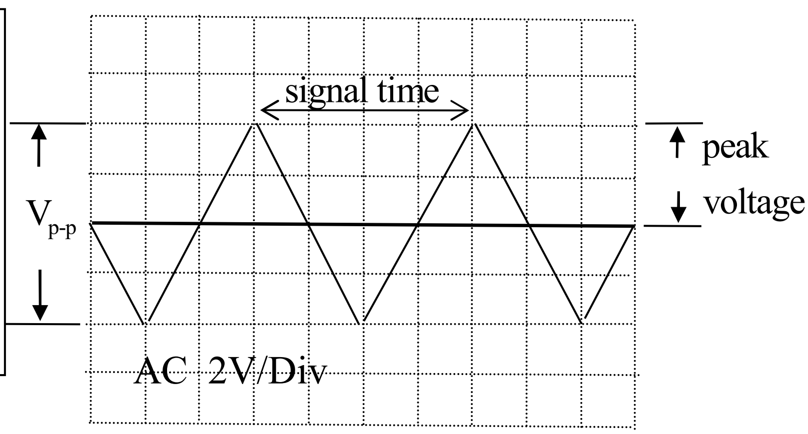
(1) Use the pattern obtained in step 7 above, partII, for the 60Hz, 4V peak-to-peak sine wave and adjust the TIME/DIV knob until 1 or 2 cycles are displaced.
(2) Measure the horizontal scale for the time period T of one cycle of the signal oscillation, by counting the number of TIME divisions constituting one cycle on the screen.
(3) Find T by multiplying the number of divisions constituting one cycle on the screen (these well be the number of divisions between two successive maxima) by the settings of the TIME/DIV knob which appears at the left of the screen,
(4) Compute the frequency $f = \frac{1}{T}$ and compare it with the known input value.
(5) Repeat the above steps for several frequencies obtained from the frequency generator for 200 Hz, 1000 Hz, 1500 Hz, and 10,000 Hz.
(6) For each case adjust the TIME/DIV so that only 1 or 2 cycles are displaced.
(7) Compute the frequency obtained from oscilloscope for each case and compare it with the frequency of the function generator given by dial settings and shown on its display small screen.
(8) Find the percentage error for each measurement (no perfect agreement well be noticed) $P.E. = \frac{f_{gen} - f_{osc}}{f_{gen}} \times 100\%$

Fig. 2.3

$V_{p\text{-}p}$ = number of vertical divisions × value of V/Div.

V_p = amplitude = ½ $V_{p\text{-}p}$.

Signal frequency f = 1/T
Signal time T= no. of horizontal Div. × Time/Div.



Experiment No. 2
Oscilloscope

Name: …………………………………………………………………………… Day and Date: …………………………

Student's No.: ……………………………………………………………………………… Sec.: ……………………….

Partners Names: ………………………………………………………………………………………………………..

Data and Calculation:

Part 1: Measure the voltage of the Battery.

Battery voltage: ……………………………..volt.

	5.0 V/DIV	2.0 V/DIV	1.0 V/DIV	0.5 V/DIV
Positive voltage				
Negative voltage				
Signal voltage				
Percentage error				

Q1: Which division gives the best results?

Part 2: Measure the frequency

Signal frequency(Hz)	Number of divisions constituting one cycle	T=(n*Time/Div) (s)	f=1/T S^{-1}	Percentage error

Q2: Find the frequency of the electricity which comes from the electricity company, and at home too?

No. of Div. for 1 cycle = ……………………………………………………………………………………………..

Time/Div = ……….

T = …….

f = 1/T = ……………………………………………………………………………………………………….