Oscilloscope Lab

Introduction:

The purpose of this lab is to introduce students to the basic tools used by engineers and technicians in analyzing electronic equipment: the function generator, the analog oscilloscope, and the digital oscilloscope. The oscilloscope is a tool commonly used by engineers and technicians to analyze and troubleshoot electronic systems. In addition, real signals, such as those which carry voice or data, can be very complex and difficult to analyze. The function generator is a device used to generate an electronic signal with specific known characteristics, thereby enabling an engineer or technician to test and examine a circuit.

During this lab, the student will use the function generator to generate a number of signals and to analyze those signals using either of the ‘oscilloscopes’. The student will become familiar with the basic waveforms -- sine, square, and triangle waves -- and the components of the waveforms -- amplitude, period, and frequency. At the conclusion of this lab the student should feel comfortable using the function generator and the oscilloscopes.

Equipment:

Qty	Equipment
1	Leader LFG-1300S Function Generator
1	BNC to 2 alligator clips cable
1	Tektronix 2225 Analog Oscilloscope
1	Tektronix P6103 10X probe
1	Hewlett-Packard 54502A Digital Oscilloscope
1	HP 10430A 10X probe

Equipment Introduction:

Part I - Introduction to the Function Generator

Overview:

The function generator is used to generate a wide range of alternating-current (AC) signals. A diagram of the Leader LFG-1300S Function Generator is shown below in Figure 1.

- The front panel is divided into six major control groups:
    1) Frequency Selection Group;
    2) Sweep Group;
    3) Amplitude Modulation Group;
    4) DC Offset Group;
    5) Function, or Waveform Group; and
    6) Output Group.

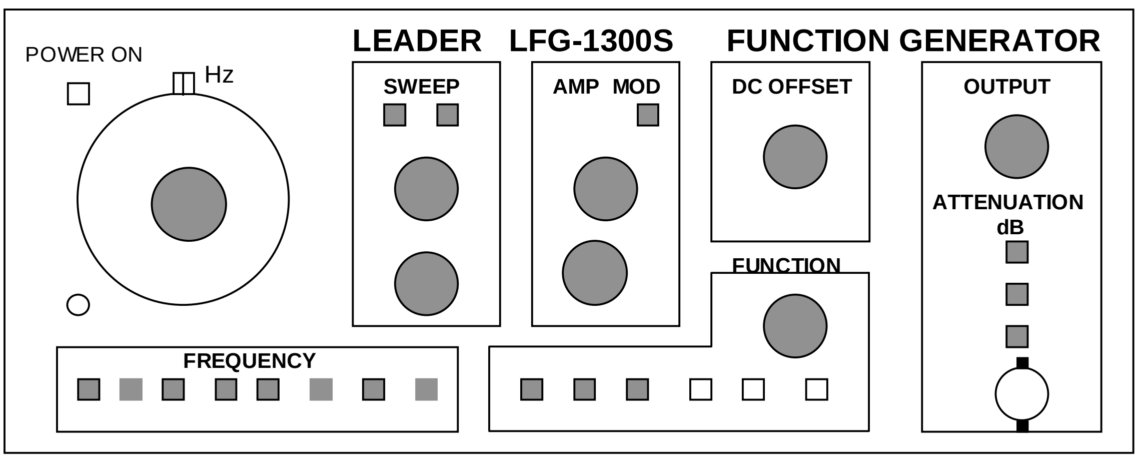


Figure 1. Front Panel of Function Generator

- The power switch on the upper left-hand corner of the unit. The green LED will indicate that the unit is on.

- The three most important groups for this lab are the **frequency**, **function**, and **output groups**. The remaining three groups, the **sweep**, **amplitude modulation**, and the **DC offset groups**, will be briefly covered in the lab setup procedures. Should the student desire more detailed descriptions of these groups, the Leader Function Generator manual is available in the lab.

Frequency Selection Group:

These controls are used select the operating frequency of the function generator. This group consists of the frequency control knob and the eight frequency multiplier selection buttons.

For example, to set the function generator to an operating frequency of 2000 Hz (2 kHz):

- Rotate the frequency control knob to 2.
- Select the 1 kHz frequency multiplier button.

  With the result that: 2.0 * 1 kHz = 2.0 kHz.

Example two sets the function generator to an operating frequency of 5.5 kHz:

- Rotate the frequency control knob to 0.55.
- Select the 10 kHz frequency multiplier button.

  With the result that: 0.55 * 10 kHz = 5.5 kHz.

Output Group:

1. These controls are used to adjust the amplitude of the generator's output signal. The group consists of the **amplitude-control knob**, the three **attenuation buttons** and the fused 50 ohm **BNC connector**.

- Although the amplitude knob is not indexed, the amplitude ranges from a few millivolts to approximately 20 volts.
- We will set the amplitude levels by aligning the white line on the amplitude knob to the three o'clock position (90 degrees right), the nine o'clock position (90 degrees left), or the twelve o'clock position (straight up).
- Notice that rotating the knob fully to the left does not result in a zero amplitude signal.
- The attenuation buttons are used to attenuate (decrease) the amplitude of the signal by a factor measured in decibels. The following relationship will assist in working with the attenuation buttons:

  $(dB) = -10 * \log_{10} (P_{out}/P_{in})$ (if *power* is the unit of measurement)

  or

  $(dB) = -20 * \log_{10} (V_{out}/V_{in})$ (if *voltage* is the unit of measurement)

- Example:

  Given a 1 volt input signal, what is the change in voltage amplitude if the 10 dB attenuation button is depressed?

Beginning with the equation defined above:

$(dB) = -20 * \log_{10} (V_{in}/V_{out})$

$10dB = -20 * \log_{10} (V_{in}/V_{out})$

$-0.5 \text{ dB} = \log_{10} (V_{in}/V_{out})$

$10^{-.5} = V_{out}/V_{in}$

$V_{out}/V_{in} = 0.3162$

- From here, the output voltage can be stated in terms of the input voltage and vice-versa:

$V_{in} = V_{out}/0.3162$

or

$V_{out} = V_{in} * 0.3162$

Since the initial input voltage (V_{in}) was 1 volt the output voltage (V_{out}) must be 0.3162V or 316 millivolts.

- **Note**: The attenuation buttons are additive. In other words, if the 10 dB and the 20 dB buttons are both pressed in, the combined attenuation of the input signal is 30 dB.

2. The fused 50 ohm BNC connector is used for connecting the function generator to other equipment. The most common connection used to connect the function generator to other equipment is a cable with a BNC connector on one end and two *alligator* clips on the other end.

- One end of the cable, the base, is used to connect the cable to the BNC connector on the function generator. The other end, which has two 'alligator' clips: one positive (red) and one negative (black), is used to connect the function generator to the device or circuit under study.

- To connect the cable to the function generator:

1. Hold the cable's BNC connector, the base, in one hand.

2. Line up the two grooves on the cable's BNC connector with the two pegs on the outside of the function generator's BNC connector.

3. Push the cable's BNC connector over the function generator's BNC connector until it is fully seated.

4. Rotate the cable's BNC connector in a clockwise manner until it is firmly secured to the function generator's BNC connector.

Function/Waveform Selection Group:

This group is used to select the shape of the generated waveform. The group is made up of the six wave-selector buttons. The six waveforms that the function generator can produce are the **sine** wave, the **square** wave, the **triangl**e wave, two **sawtooth** waves, and the **variable-width pulse** wave.

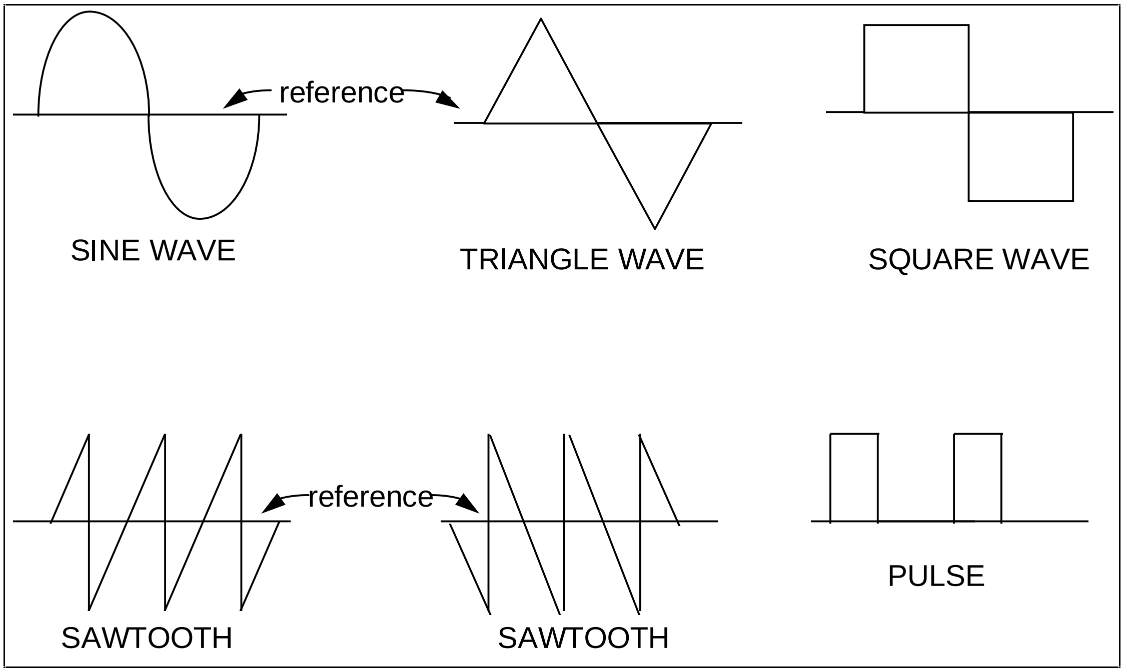


Figure 2: Available Generated Waveforms

- In this lab you will become familiar with the three fundamental signals (waveforms), the **sine** wave, the **square** wave and the **triangle** wave.

Waveforms:

This section will provide you with some background on waveforms and on measuring waveforms. It is especially important that you understand how to measure waveforms. This is a skill that is not only important to this lab, but also to the T-1 Lab and in labs for other Telecommunications Courses.

- There are two types of alternating-current signals, which are also called waveforms:
    - **Periodic**
    - **Aperiodic**
- **Periodic** signals, such as sine or triangle waves, behave in a uniform manner and repeat themselves over a given length of time. Each repetition of a repeating signal is called a **period** or a **cycle**.

- **Aperiodic** signals, such as analog voice, behave in a non-uniform manner and do not repeat themselves over any given length of time.

  Note: In this lab, we will only work with periodic signals.

- When working with AC signals, there are three properties of the signal that we are concerned with: **amplitude**, **period** and **frequency**.

- The **amplitude** of the wave is defined as the maximum magnitude of the wave. The amplitude is the vertical component of the signal and is measured in units of volts (V). Since we are dealing with an AC signal, the voltage will change over a period of time. The maximum voltage of a signal during its cycle is commonly referred to as the **peak voltage (V_p)**.

- The amplitude can be measured from the reference line to the peak (V_p) or from peak-to-peak (V_{pp}). See Figure 3 below.

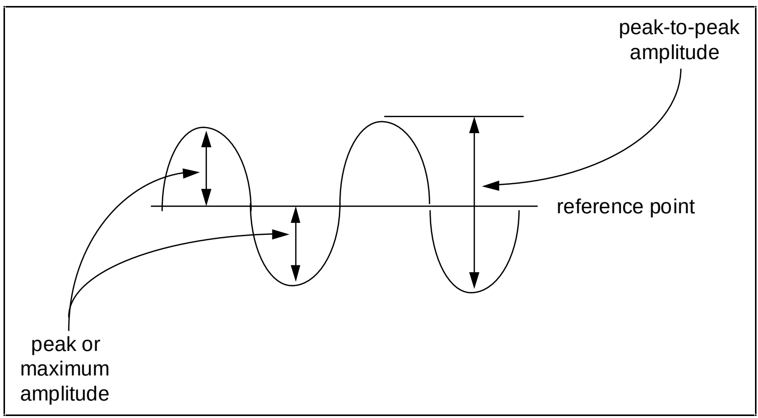


Figure 3: Measuring Amplitude.

- With a periodic signal that is symmetrical (equi-distant above and below the reference point), the peak-to-peak voltage is equal to twice the peak voltage:

  $V_{pp} = 2 * V_p$

- The **period (T)** of the signal is defined as the time it takes for a signal to complete one full **cycle.** The period is the horizontal component of the signal, measured in units of seconds (s). In Figure 4, the period of the signal is measured as 250 milliseconds (250.0 x 10^{-3}s).

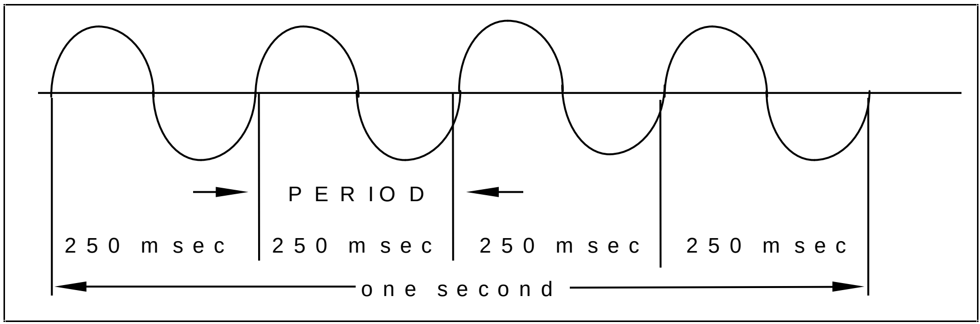


Figure 4: Measuring Period.

- The **frequency (f)** of the signal is defined as the rate at which a periodic signal repeats. It is usually measured in units of **Hertz (Hz)**, where 1 Hz = 1 cycle per second.

- In Figure 4, above, you can see four(4) cycles occurring within one second; therefore, the signal has a frequency of 4 Hz.

- The frequency, f, of a wave is inversely related to its period (T):

  f = 1/T

- Example:

  The period of the signal is 250 milliseconds, therefore the frequency of that signal is:

  f = 1/T
  f = 1/250 milliseconds
  f = 4 hertz

Abbreviation	**Prefix Name**	**Factor**
T	Tera	10^{12}
G	Giga	10^{9}
M	Mega	10^{6}
K	Kilo	10^{3}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

Table of Scientific Prefixes

PART II - Introduction to the Tektronix 2215 Analog Oscilloscope

Overview:

An oscilloscope is an electronic measuring device which provides a two-dimensional visual representation of a signal. Because the oscilloscope allows the user to see the signal(s), their characteristics can be easily measured and observed. The oscilloscope displays a graph of voltage (on the vertical axis) versus time (on the horizontal axis). Most electrical circuits can be easily connected to the oscilloscope typically with probes.

- There are four major control groups on the Tektronix oscilloscope: (1) the **Display group**; (2)the **Vertical group**; (3) the **Horizontal group;** and (4) the **Trigger group**. See Figure 5, below.

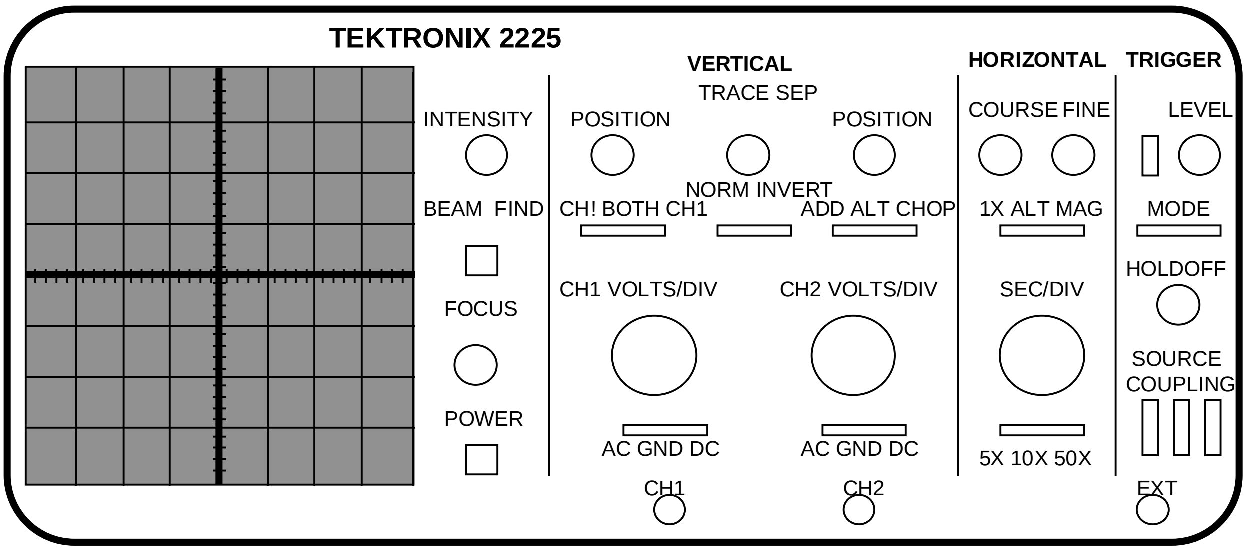


Figure 5: Front Panel of Analog Oscilloscope

Display Group

This group is used to display and adjust the signal for optimal viewing. It consists of the **display screen**, the **intensity-control knob**, the **beam-find button**, the **focus-control knob**, and the **power switch**.

- The **display screen** is laid out in a 8 by 10 centimeter grid. The oscilloscope draws a 'trace' or graph by moving an electron beam across the phosphor coating on the inside of the cathode-ray tube (CRT). The excited phosphorous glows for a short period of time, thereby tracing the path of the beam.

- The **intensity-control knob** is used to adjust the brightness of the trace. The level should be set to the user's preference; however, increasing the intensity beyond a certain point will make the trace "fuzzy." The intensity level should never be increased past the point where the trace has sharply defined edges.

- The **beam-find button** allows the user to locate the electron beam anytime it's off-screen. Push the beam find button to temporarily reduce the vertical and horizontal deflection voltages so that the beam always appears within the 8 by 10 centimeter screen.

- The **focus-control knob** adjusts the electron beam for optimal trace resolution.

Vertical Group:

This group is used to adjust the vertical components (Y-axis) and the vertical position of the signal. This group consists of the **vertical-position knobs**, **channel-selector switch**, **volts-per-division-selector knobs**, **input-coupling switch**, the **channel-mode-selector switch**, the **channel-2-invert switch**, and the **BNC connectors.** Because the Tektronix 2225 oscilloscope is a two channel oscilloscope, there is one set of switches for each channel.

- The **vertical-position controls** are used to vertically move the trace of one channel or the other.

- The **channel-selector switch**, labeled ‘CH1/BOTH/CH2’, selects which channels are displayed on the screen.

- The **volts-per-division-selector knob** sets the vertical scale for each channel's trace.

    1. Since a 10X probe is used in this lab, all readings should be made from the ‘10X’ box on the knob.

    2. Each channel can have a different vertical scale.

    3. A *division* is one "block" on the screen.

    4. Each *tick mark* is one-fifth (0.2) of a *division.*

    5. This knob is marked in both volts and millivolts.

- The **input-coupling switch**, labeled ‘AC/GND/DC’, selects the coupling mode of that channel's display. AC means that only the alternating portion of the signal is displayed. DC will display both the alternating portion of the signal, plus any DC component. GND shows the 0 V reference level.

- The **trace-separation knob** is used in conjunction with the **horizontal-magnification controls**, to be discussed later.

- The **channel-mode-selector switch**, labeled ‘ADD/ALT/CHOP’, is activated only when BOTH is selected on the **channel-selector switch**. ADD graphically adds the Channel 1 signal to the Channel 2 signal. If the **channel-2-invert switch** (‘NORMAL/INVERT’) is set to INVERT, then ADD will in fact subtract the Channel 2 signal from the Channel 1 signal. ALT traces one channel, then the next. CHOP works like ALT, but jumps back and forth between the two channels during a single trace.

Horizontal Control Group:

The Horizontal Control Group consists of the **coarse and fine position knobs**, the **horizontal-magnification switch**, the **seconds-per-division-selector knob**, and the **magnification-scale-selector switch**.

- The **coarse** and **fine-position-knobs** allow the horizontal movement of the traces in a rough manner and in a precise manner, respectively. These are used to position the traces in a manner that makes measurement both more convenient and more precise.

The **horizontal-magnification switch** ('X1/ALT/MAG') selects the regular (X1) and/or a horizontally magnified trace.

1. The **trace separation knob** in the Vertical-Control Group allows for the vertical separation of the X1 trace from the magnified trace when ALT is selected.

2. If ALT or MAG is selected, then the **magnification-scale-selector switch** ('5X/10X/50X') is activated.

- The **seconds-per-division knob** sets the time base (horizontal) scale. It is marked in seconds, milliseconds, and microseconds.

  Note: There is only one horizontal scale for both channels.

Trigger Group

In order to display a signal, the oscilloscope must be able to 'lock' onto that signal; the function of the triggering controls is to do just that. Triggering can be a complicated topic, and is beyond the scope of this lab. For more details, the student is referred to the Tektronix manual. The trigger group is made up of the **trigger level knob**, the **rising/falling edge switch**, the **trigger mode switch**, the **holdoff knob**, the **trigger source switches**, and the **trigger coupling switch**.

- The **trigger-level knob** sets the voltage level at which the oscilloscope will 'trigger'. If a signal is 'running' -- that is, not stable -- the trigger level may be too high or too low for the oscilloscope to recognize the signal. Often you can lock in a running signal by rotating this knob to the left and to the right. This adjustment provides a mechanism for ignoring small (low voltage) signals that are well below the level of the signal you ar interested in. This knob is not indexed.

- The **rising/falling-edge switch** selects whether the oscilloscope will trigger on the positive (rising) or negative (falling) edge of the signal.

- The **trigger-mode switch** will normally be set to AUTO, but sometimes it is necessary to use NORM. Other settings are not relevant to this lab.

- The **holdoff knob** affects the delay associated with triggering. The student should consult the manual if more information is desired.

- The **trigger-source switches** select which signal the oscilloscope will attempt to lock onto. Possible choices include CH1, CH2, VERT MODE, or EXTERNAL. Selecting CH1 or CH2 will make the oscilloscope attempt to trigger on those channels. If no input is available on that channel, there may be problems when attempting to view both channels simultaneously. For this reason, *it is recommended that this switch be left on VERT MODE*, which provides an automatic trigger on either CH1 or CH2.

- The **trigger-coupling switch** is another more complicated feature which will not be discussed here. *This switch should typically be set to AC*.

How To Make Readings on the Oscilloscope:

- Peak-to-Peak Voltage:

  Use the vertical-position knob to place a peak (positive or negative) on a horizontal line, keeping the peak on the screen.

  Use the horizontal-position knob to set the next (opposite sign) peak on the center vertical line.

  Count the number of divisions between the positive and negative peaks.

  Note: The divisions are further subdivided into 1/5 (0.2) by the tick marks.

  Multiply the number of divisions from step 3 by the volts/div setting for the channel in use.

- Period:

  Use the horizontal-position knobs to align any edge of the signal with a vertical line.

  Use the vertical-position knob to place the next identical edge crossing on the X-axis.

  Count the number of divisions along the horizontal line to the next crossing in the same direction.

  Multiply the number of divisions from step 3 by the sec/div setting.

  Note: The divisions are subdivided into fifths (0.2) by the 'tick marks'.

- Frequency:

  Measure the period of the signal (T).

  Calculate frequency (f) using $f = 1/T$.

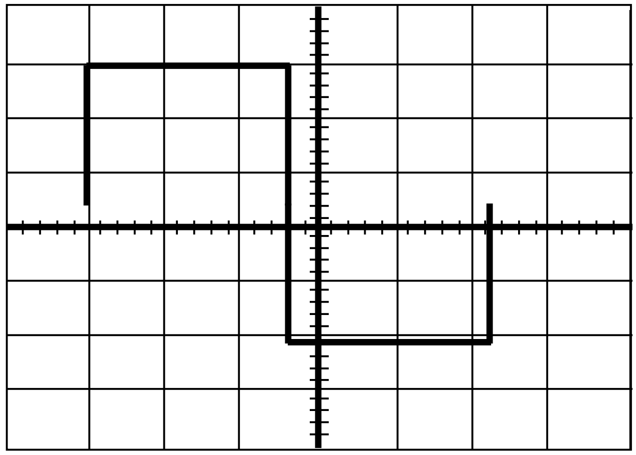


Figure 6: Measuring a Signal.

- Example:

Assuming the **Volts/Div** knob reads 2 V/div, the above peak-to-peak voltage would be:

V_{pp} = 2 volts/div * 4.2 div = 8.4 volts

Assuming the **Sec/Div** control knob read 50ms, the above period would be:

T = 50 milliseconds/div * 5.25 div = 2625.0 milliseconds = 2.625 seconds

PART III - Introduction to the HP 5402A Digital Oscilloscope

Overview:

The digital oscilloscope is a test and measuring device, similar to the analog oscilloscope. Instead of displaying a signal by deflecting an electron beam that is tracing across a CRT, the digital oscilloscope uses a processor to sample, digitize, and display the incoming analog signal on the display screen. The digital oscilloscope has a user interface which allows the user to manipulate and measure the displayed signal. It can be used to store, retrieve, and print waveforms. It can also be programmed to make measurements automatically or to control other devices. Because the HP 5402A digital oscilloscope is a multi-purpose piece of equipment, it would be very time consuming to explain out all of its functionality. It is strongly recommended that the student become familiar with the following reference manuals if more details are needed:

- HP 54502A 400 MHz Digitizing Oscilloscope Front-Panel Reference
- HP 54502A 400 MHz Digitizing Oscilloscope Programming Reference

These references can be found at the lab tables in the Telecommunications Lab (Room 834).

Front Panel Reference:

The HP 54502A 400 MHz Digitizing Oscilloscope controls are organized into six functional areas or groups: (1) the **Display Group**, (2) the **System-Control Group**, (3) the **Menu Group** (4) the **Setup Group**, (5) the **Entry Group**, and (6) the **Signal-Input Group**.

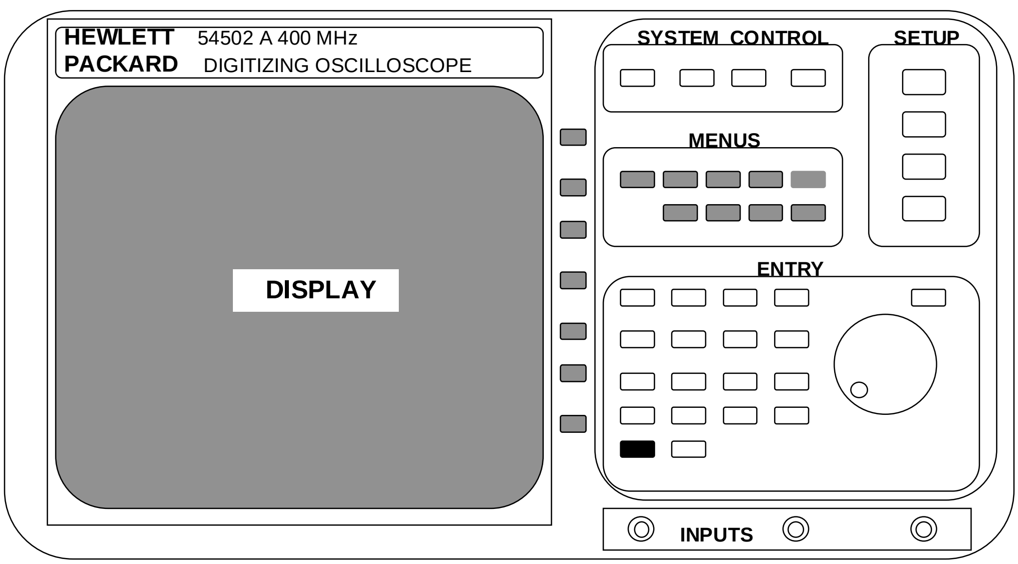


Figure 7: Front Panel of Analog Oscilloscope

The power switch is a rocker switch located at the back of the machine, immediately above the power cord.

- The **display group** consists of the **display screen** and the **programmable menu selection buttons** immediately to the right of the screen. The function of these buttons is dependent on the menu selected. An option appearing on the screen may be selected by striking the button to the right of it.

- The **system-control group** includes the **RUN/STOP** and the **SINGLE buttons**, which control the screen refreshing, and the **CLEAR DISPLAY button** which clears the screen.

- The **menu group** contains a selection of menus whose function is similar to the front panel controls on the analog oscilloscope. The procedures below will serve to familiarize you with the similarities. There is also a **Δt/Δv menu** which is helpful in making measurements of voltage, period, and frequency.

- The **setup group** includes the **AUTOSCALE button**, which resets the oscilloscope to default settings and automatically adjusts horizontal and vertical scales for the signal that is input.

- The **entry group** is used to enter data. The **numeric keypad** is augmented with four **unit selection buttons**, which give a selection of seconds, milliseconds, microseconds, nanoseconds, volts, and millivolts. Alternatively, the **data entry wheel** can be used to adjust settings instead of entering a specific value. The entry group also contains a number of **automatic measurement functions**, which are accessed using the **blue shift button**.

- The **signal-input group** consists of the BNC connectors for each channel, and an auxiliary connector.

Making Measurements with the Digital Oscilloscope:

There are two ways to make measurements with the HP digital oscilloscope: (1) by using the Δt/Δv markers, or (2) by using the automatic measurements functions. The procedures for both these methods are outlined in the lab procedures.

Lab Procedures:

Part I - Analog Oscilloscope Procedures:

Overview:

In this part of the lab, you will use the function generator to generate a signal and then use the analog oscilloscope to make some measurements of the data. If you need any assistance in identifying or configuring the equipment, please see the on-duty GSA.

Function Generator Setup:

- Turn on the function generator.
- Make sure that the Sweep, Amplitude Modulation, and DC offset groups are turned OFF.

Note: The Sweep and Amplitude Modulation buttons should be in the OUT position, and the DC offset knob should be pushed IN.

- Select a TRIANGLE wave.
- Set frequency to **1.0 kHz**.
- Set the amplitude knob to **12 o'clock**.
- Make sure all the attenuation buttons are OUT.
- Attach the BNC end of the cable to the BNC socket in the function generator's Output Group.
- Tie back the black lead alligator clip by clipping the black alligator clip to the insulated wire to avoid short circuits and blown fuses.

Analog Oscilloscope Setup:

- Turn on the power to the oscilloscope.
- Connect the Tektronix 10X probe to the Channel 1 input on the oscilloscope.
- Tie back the black lead on the probe, then expose the hook and clip it to the red alligator clip on the function generator cable.
- Set CH1/BOTH/CH2 switch to **CH1**.
- In the Vertical Control Group, set the Channel 1 AC/GND/DC switch to **GND**.

- Use the CH1 vertical position knob to move the ground (0V) reference (horizontal line) to the center line on the screen.

- After referencing the signal to ground, set the AC/GND/DC switch to **AC**.

- Intensity knob: adjust the signal intensity and focus to a comfortable level, by using the intensity and focus knobs, respectively.

  Note: Keep the signal intensity to within a reasonable range to minimize the chances of burning the phosphor and damaging the display screen.

- Set the Volts-per-Division knob to **2 V/div**.

  Note: you are using a 10X probe, so be sure to take all readings from the 10X position.

- Set the NORMAL/INVERT switch to **NORMAL**.

- Set the ADD/ALT/CHOP switch to **ALT**.

- Set X1/ALT/MAG to **X1**.

- Set the seconds-per-division knob to **0.1 ms/div**.

- Set the rising/falling-edge switch to **positive**.

- Set the trigger-mode switch to **AUTO**.

- Set the trigger-source switch to **VERT MODE**.

- Set the trigger-coupling switch to **AC**.

  Note: If the signal is still running, try adjusting the trigger level or holdoff knobs.

- Make sure that the 'cal' knobs on the V/div and S/div knobs are both pushed in and turned all the way to the right. They will click into position. This is so the scope will be calibrated properly.

Procedures:

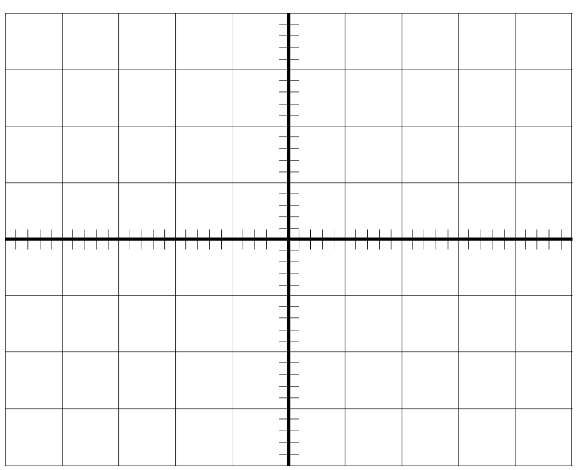
1. Using the settings completed above, answer the following questions.

- (1.1) What is the setting on the Volts/Div control knob? _______ volts/div
- (1.2) How many vertical divisions from peak-to-peak? _______ div
- (1.3) What is the peak to peak voltage (V_{pp})?

  V_{pp} = _______ volts/div * _______ div = _______ volts
- (1.4) What is the setting on the Sec/Div control knob? _______ ___ seconds/div
- (1.2) How many horizontal divisions from positive going crossing to positive going crossing? _______ div
- (1.5) What is the period of the signal (T)?

  T = _______ seconds/div * _______ div = _______ ___ seconds
- (1.6) What is the frequency of the signal (f)? _______ ___ hertz
- (1.7) Draw the displayed signal on Graph 1.

  Be neat, to scale, and concise.
  Be sure to note the (scale) *V/div* and *Sec/div* settings.



Graph 1

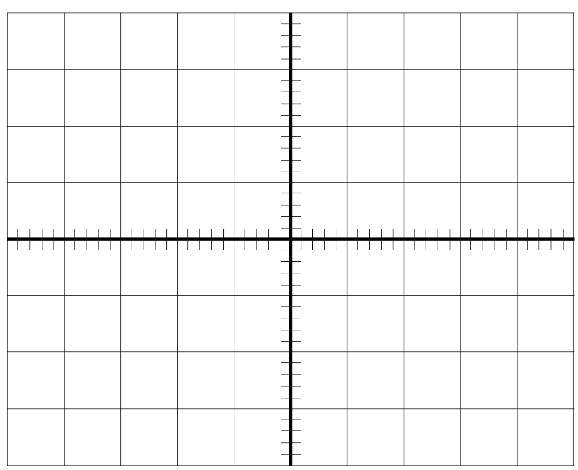
2. Next you will adjust the function generator to output another signal and repeat the measurements in Step 1.

- Generate a **square wave** between **5 and 10 kHz** with an amplitude setting of **3 o'clock**.
- Adjust the *V/div* and *Sec/div* settings to maximize the display of the signal on the CRT. Make sure you show the signal from peak-to-peak and at least one full cycle (period) of the signal.
- (2.1) What is the setting on the Volts/Div control knob? _______ volts/div
- (2.2) How many vertical divisions from peak-to-peak? _______ div
- (2.3) What is the peak to peak voltage (V_{pp})?

  V_{pp} = _______ volts/div * _______ div = _______ volts
- (2.4) What is the setting on the Sec/Div control knob? _______ ___ seconds/div
- (2.2) How many horizontal divisions from positive going crossing to positive going crossing? _______ div
- (2.5) What is the period of the signal (T)?

  T = _______ sec/div * _______ div = _______ ___ seconds
- (2.6) What is the frequency of the signal (f)? _______ ___ hertz.
- (2.7) Draw the displayed signal on Graph 2.

  Be neat, to scale, and concise.
  Be sure to note the (scale) *V/div* and *Sec/div* settings.



Graph 2

3. In this part of the lab, you will experiment with the triggering of the analog oscilloscope. You will need to make some changes to the controls of the analog oscilloscope and the function generator, and you will then have to answer a few questions.

- Set TRIGGER MODE to **NORM**.
  Set TRIGGER SOURCE to **CH1**.
- Turn the TRIGGER LEVEL knob all the way to the **right**.
  Turn the TRIGGER HOLDOFF knob all the way to the **right**.
- Generate a **1.4 kHz sine wave** with the function generator; setting the **amplitude knob all the way to the left**. Then display the signal on the oscilloscope.
- On the oscilloscope, turn the horizontal position (coarse) knob **until the left edge of the trace is shown**.
- While watching the display, turn the TRIGGER LEVEL knob to the **left** until you get a steady display.
- Keep turning the TRIGGER LEVEL knob **to the left**, and watch the trigger level go down. Note that the oscilloscope ceases to trigger when the level moves below the signal.
- Set the TRIGGER LEVEL **as close to the top of the signal** as possible while still retaining a steady picture.
- (3.1) What is the peak-to-peak voltage (V_{pp})? _______ volts
- On the function generator, depress the 10 dB attenuation button.
- Use the TRIGGER LEVEL knob to steady the display. It's a delicate adjustment, so watch the screen carefully while you turn the knob to the left.
- (3.2) Why did the signal run or disappear? (not steady or not locked)
- (3.3) Without changing the V/div setting, what is the new V_{pp}? _______ volts
- (3.4) Using the formula on page 3, calculate the attenuation in dB? _______dB (note sign!)
- Disconnect the analog oscilloscope, and turn off the power.

Part II - Digital Oscilloscope Procedures:

Overview:

In this part of the lab, you will use the function generator to generate a signal and then use the digital oscilloscope to make some measurements of the data. If you need any assistance in identifying or configuring the equipment, please see the on-duty GSA.

Digital Oscilloscope Setup:

- Generate a **6kHz triangle wave** with the **amplitude turned fully to the right** using the function generator.

- Connect the HP probe to the **Channel 1** input on the oscilloscope, then connect the probe to the red lead from the function generator.

- Press the **AUTOSCALE** button to make the oscilloscope automatically adjust its settings.

- Select the Channel menu by pressing the **CHAN** button.
  Select **Channel 1**.
  Set v/div to **5.0 v/div**, if it is not already set.
  Set offset to **0 volts**, if not already set.
  Select **AC**.
  Select **1MΩ**, if not already set.
  Select **More** by pressing the button to the right of the more label.
  Make sure that **10:1** is selected. If not, use the wheel to set it.
  Press the **More** button.

- Select the Time base menu by pressing the **TIME BASE** button.
  Set the time base to **50 μs/div**, if not already set.
  Set delay to **0 seconds**.
  Select reference: **center**, if not already set.
  Set window: **off**, if it is on.
  Select **realtime**.

- Select the Trigger menu by pressing the **TRIG** button.
  Select **AUTO**.
  Select **EDGE**.
  Select source: **channel 1**.

- Select the Display menu by pressing the **DISPLAY** button.
  Select **NORM**.
  Set persistence: '**minimum' or 'single'**.
  Set No. of screens: **1**.
  Select **GRID**.
  Set connect dots: **ON**.

PROCEDURES:

1. Using the settings completed above, answer the following questions.

- Select the Δt/Δv menu by pressing the **Δt/Δv** button.
- Select Vmarkers and Tmarkers.
- Select Vmarker 1, then use the data entry wheel to set the marker at the bottom of the signal. Be sure to adjust the voltage level not the channel number.
- Similarly, set Vmarker 2 to the top of the signal.
- (1.1) Read ΔV at the bottom of the screen.

  Vmarker 1: ________ ___ volts

  Vmarker 2: ________ ___ volts

  ΔV: ________ ___ volts

- (1.2) Using the same procedure as for the Vmarkers, set the ΔT start marker to either a positive or negative peak.
- (1.3) Similarly, set the ΔT stop marker to the next positive or negative peak. (Choose the same polarity as you did in Step 1.2.)
- (1.4) Read ΔT and 1/ΔT (period and frequency) at the bottom of the screen.

  Start Marker: ________ ___ seconds

  Stop Marker: ________ ___ seconds

  ΔT (period): ________ ___ seconds

  1/ΔT (frequency): ________ ___hertz

- Turn the markers off.

2. Using the automatic measurement capability of the digital oscilloscope, you will repeat the measurements you made in Step 1.

- (2.1) Press the blue shift button, press button 1 (V_{pp}), and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.
- (2.2) Measure V_{pp}: ________ ___ volts

  Note: If 'm#' or 'f#' appears in reverse text at the bottom of the screen, use the entry wheel to change this to 'c#'. If this fails, try hitting RECALL and CLEAR simultaneously to reset the oscilloscope. You would then need to restart with the pressing the AUTOSCALE in the digital oscilloscope setup section.

- (2.3) Press the blue shift button, press button 9 (Freq.), and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.

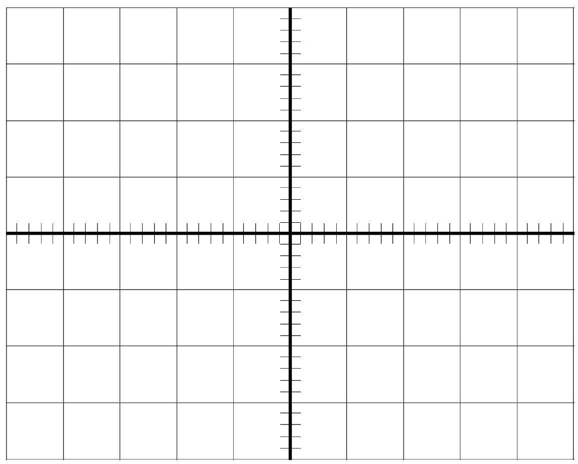
  Measure Frequency (f): ________ ___ hertz

- (2.4) Press the blue shift button, press button s-V (period) to the right of button 9, and then press button 1 for channel 1 when 'c#' appears at the bottom of the screen in reverse text.

  Measure Period (T): ________ ___ seconds

- (2.5) Draw the displayed signal on Graph 3.

  Be neat, to scale, and concise.
  Be sure to note the (scale) *V/div* and *Sec/div* settings.



Graph 3

- To clear the measurements from the screen, press the blue shift button and then press the clear button.

- Disconnect the digital oscilloscope from the function generator and turn it off.

- Make sure all probes and connectors are disconnected from the equipment and neatly placed on the shelf above the work area.

- Be sure to turn off both oscilloscopes and the function generator.