THE OSCILLOSCOPE

Objectives

You will adjust a variety of controls on an oscilloscope and connect voltage or signal sources to the scope in order to demonstrate several of the various functions for which an oscilloscope may be used by technicians.

In completing these projects, you will set up and connect an oscilloscope and various voltage/signal source(s), manipulate controls on the equipment, make observations and measurements, draw conclusions, and be able to answer questions about the following items related to the oscilloscope:

- Use of various input/output terminals
- Use of various controls on the front panel
- How to measure voltage(s)
- How to observe waveforms
- How to make phase comparisons
- How to determine frequency

Project/Topic Correlation Information

PROJECT	TEXT CHAPTER	SECTION	RELATED TEXT TOPIC(S)
33 Basic Operation: Familiarization	12	12-1 12-2	Background Information Key Sections of the Scope
34 Basic Operation: Controls Manipulation	12	12-2 12-3	Key Sections of the Scope Combining Horizontal and Vertical Signals to View a Waveform
35 Basic Operation: Vertical Controls and DC V	12	12-2 12-3	Key Sections of the Scope Combining Horizontal and Vertical Signals to View a Waveform
36 Basic Operation: Observing Various Waveforms	12	12-2 12-3	Key Sections of the Scope Combining Horizontal and Vertical Signals to View a Waveform
37 Voltage Measurements	12	12-4	Measuring Voltage and Determining Current with the Scope
38 Phase Comparisons	12	12-5	Using the Scope for Phase Comparisons
39 Determining Frequency	12	12-6	Determining Frequency with the Scope

The Oscilloscope

Basic Operation: Familiarization

PROJECT **33**

Name: ______________________ Date: ____________

PROJECT PURPOSE To familiarize you with the most-used controls on an oscilloscope via observation of an actual oscilloscope and through reading its operating manual.

PARTS NEEDED

- ☐ Oscilloscope with cable(s) (a triggered-sweep dual-trace oscilloscope)
- ☐ Equipment manual for oscilloscope used
- ☐ Audio or function generator with cable(s)
- ☐ VVPS (dc)
- ☐ CIS

SPECIAL NOTE:

The oscilloscope is a versatile test instrument that can visually display the relationship between (1) two electrical quantities, and (2) an electrical quantity and time. In this project, you will become acquainted with the basic jacks and controls, and in some cases, screen menus used in obtaining visual waveforms with the scope.

Due to the wide variety of oscilloscopes in use, both in training facilities and in industry, it is not feasible to give precise instructions for every situation. The spectrum of scopes being used may be from the simplest, triggered, dual-trace oscilloscopes to the most sophisticated digital phosphor scopes with automated measurement and math functions appearing on the screen as alphanumeric readouts. Additionally, some scopes may have computer interfacing capability.

Basically, we will try to give generic enough instructions that you can adapt them to the particular scopes you are using at your training facility. It will be important for you, as the student, to acquire the appropriate operator's manual from your instructor for the type of scope you are using to aid you in performing the various tasks in this project and several following projects.

PROCEDURE

1. Obtain the available scope and the appropriate scope operator's manual. Referring to the oscilloscope and appropriate operating manual, locate and point out to your instructor as many of the listed jacks and controls as possible.

NOTE ➤ Different brands and models may use different names for some of these items. For each item listed, write the name your scope uses that is equivalent to the name we have on our list.

OBSERVATION *Identify the following:*

- Power
  ____________________(equiv.)
- Intensity
  ____________________(equiv.)
- Focus
  ____________________(equiv.)
- Ground Jack
  ____________________(equiv.)
- AC-GND-DC switch
  ____________________(equiv.)
- Vertical Input Jack(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Vertical Position
  ____________________(equiv.)
- Vertical Mode(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Vertical Gain Control(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Horizontal Position
  ____________________(equiv.)
- Horiz. Time Base Control(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Trigger Mode(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Trigger Source(s)
  ____________________(equiv.)
  ____________________(equiv.)
- Trigger Level
  ____________________(equiv.)

CONCLUSION Which controls are used to center the display on the scope screen?

____

____

____

Which controls adjust the speed of the horizontal trace?

____

____

____

Which controls help keep the waveform from moving?

____

____

____

Which controls adjust the height of the waveform for a given signal input?

The Oscilloscope

Basic Operation: Controls Manipulation

PROJECT 34

Name: ____________________ Date: __________

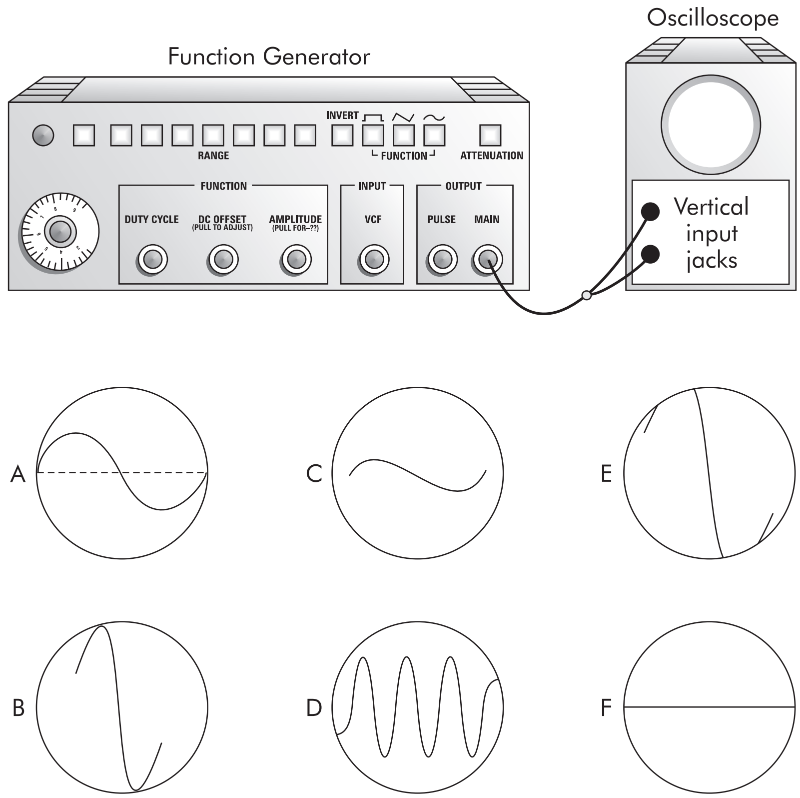

FIGURE 34-1

PROJECT PURPOSE To provide practice in manipulating oscilloscope controls to achieve desired waveforms.

PROCEDURE

1. Connect the function generator or audio generator to the oscilloscope as shown in Figure 34-1. Adjust the generator frequency to 100 Hz.

NOTE ➤ Refer to the signal generator operator manual, as required, to learn how to set the output frequencies of the generator.

2. Using the various controls, obtain as many of the waveforms shown on the opposite page as possible. Demonstrate waveforms A, B, and D for your instructor.

NOTE ➤ If you have trouble achieving stable waveforms (that is, "stopping the waveform(s)"), ask the instructor to help you adjust the trigger control(s), as appropriate.

OBSERVATION *Demonstration of waveforms:*

A ________________________________ D ________________________________

B ________________________________

➤ Instructor initial: _______________

CONCLUSION The main controls manipulated to achieve waveforms were the ___________________ controls and the ___________________ controls.

To obtain the waveform shown in D required changing the ______________________ controls.

3. Disconnect the function generator from the circuit. Make sure the scope is in the dc input mode. Adjust scope controls to obtain a straight horizontal line display that just fills the screen from left to right. (H controls, V and H position controls.)

The Oscilloscope

Basic Operation: Vertical Controls and DC V

PROJECT **35**

Name: ______________________ Date: ______________

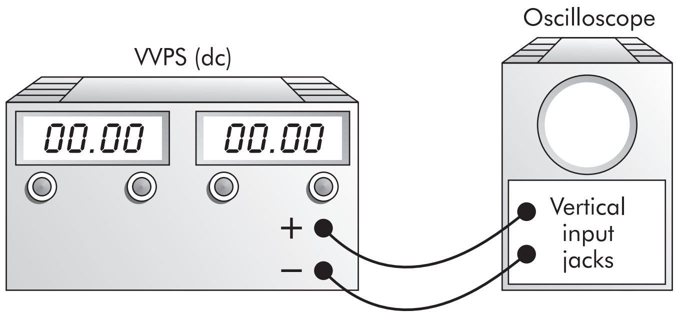

FIGURE 35-1

PROJECT PURPOSE To observe the on-screen results of connecting dc voltage(s) to the vertical input of an oscilloscope. To see the effect of changing, and to practice using, vertical gain control(s).

PROCEDURE

1. Adjust the scope to obtain a straight horizontal line display that just fills the screen from left to right and is centered vertically. Use the horizontal frequency controls and vertical and horizontal position controls, as appropriate.

2. Connect a variable voltage dc source to the vertical input of the scope, (– terminal to ground) (+ terminal to vertical input), Figure 35-1.

3. Set the output of the dc source to approximately 5 V.

4. "Make" and "break" the input connection from the dc source to the vertical input jack and observe the display.

OBSERVATION Does the horizontal trace (line) move when the dc voltage is applied? ________.
Which direction? ____________________.

CONCLUSION The dc voltage applied to the vertical input causes deflection of the scope trace. If the polarity of the input were reversed, would the trace react differently? ________.

Explain. ____

____

____.

5. Reverse the polarity of the connections from the dc source to the vertical input of the scope.

OBSERVATION Does the direction of the display deflection reverse from that shown in step 4? _____.

6. Make appropriate vertical control adjustments to cause the display to "jump" three vertical calibration squares on the scope face "graticule" when the input is connected and disconnected from the scope. When you have made the adjustments, demonstrate this action for your instructor.

NOTE ➤ When NOT connected, the trace should be in the middle of the screen.

OBSERVATION Demonstrate that gain controls have been adjusted to achieve specified results.

➤ Instructor initial: _______________

CONCLUSION Was more than one control adjusted to achieve the desired results? ___________. What were the names of the controls? ____

____

____.

The Oscilloscope

Basic Operation: Observing Various Waveforms

PROJECT 36

Name: ______________________________ Date: ______________

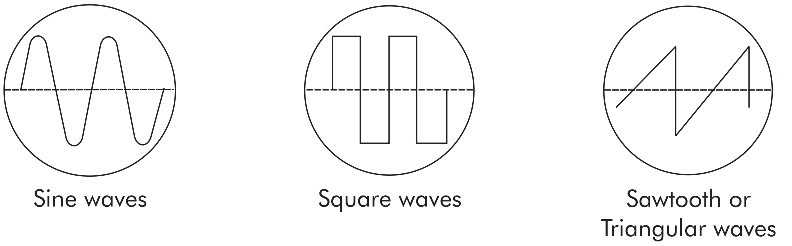

FIGURE 36-1

PROJECT PURPOSE To observe various types of waveforms, using the oscilloscope.

PROCEDURE

1. If appropriate signal/function generator(s) are available, demonstrate to your instructor that you can obtain the waveforms shown in Figure 36-1.

OBSERVATION Sine wave; Square wave; Triangular wave.

➤ Instructor initial: ______________

The Oscilloscope

Voltage Measurements

PROJECT 37

Name: ______________________________ Date: ______________

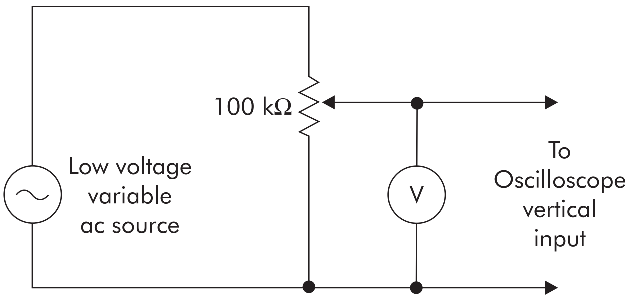

FIGURE 37-1

PROJECT PURPOSE To become familiar with the techniques for measuring voltages with an oscilloscope. To learn to calibrate the scope and interpret the measured values.

PARTS NEEDED

- ☐ Low-voltage variable ac source
- ☐ Oscilloscope
- ☐ DMM
- ☐ CIS
- ☐ 100-kΩ potentiometer
- ☐ Appropriate cables for equipment

SPECIAL NOTE:

The following facts and considerations are important when using the oscilloscope to make voltage measurements:

1. Waveform deflection on the scope indicates the *peak-to-peak* value of the voltage under test.
2. For any **sine wave**, the peak-to-peak deflection on the screen is *directly proportional* to the peak and rms values of the ac applied voltage that produce the peak-to-peak waveform. For example, if the deflection on the CRO screen is 1″ (peak-to-peak deflection) when 1-V rms is applied, it will be 2″ of total deflection when a 2-V rms ac signal is applied. Therefore, it is easy to measure ac voltage values with the scope even though the deflection is peak-to-peak in nature.
3. It is easier to read voltages on the CRO screen when the presentation is a vertical line. To achieve this type of display, set the appropriate horizontal control.

PROCEDURE

1. Connect the circuit as shown in Figure 37-1.

2. Monitor input voltage to the scope with the meter and adjust the ac input voltage to 2 volts rms (as indicated by the meter).

3. Adjust the scope positioning and V and H controls to obtain a vertical deflection of **one square** (peak-to-peak).

> **CAUTION:** Do not move the vertical V/div or variable controls once this is done unless directed to do so. However, you can change the vertical position control for ease of viewing.

CONCLUSION One large square of deflection equals ________ V_{rms}; ________ V_P ; and ________ V_{P-P} . Each small division on the screen equals ________ V_{rms}.

4. Remove the meter. Adjust the source voltage to obtain two squares of deflection.

OBSERVATION Screen deflection is ________ squares.

CONCLUSION What rms value does this deflection represent? ________ V.

5. Now measure the voltage with the meter.

OBSERVATION Voltage measures ________ V.

CONCLUSION Does this answer agree with the scope measurement? ________.

6. Use the meter and adjust the source voltage to 6 volts rms.

OBSERVATION Amount of deflection equals ________ squares.

CONCLUSION Is the change in deflection essentially linear in nature? ________.

7. If a low-voltage transformer is available, **calibrate** the scope and measure an unknown transformer secondary voltage using the oscilloscope as the measuring device.

> **CAUTION:** Do not use exposed 120 VAC connections anywhere in the circuit setup! Be careful! 120 VAC can be lethal!

OBSERVATION Scope is calibrated so that each large square = ________ V_{P-P} or ________ V_{rms}. The unknown voltage is causing ________ large squares of deflection.

CONCLUSION The value of the unknown voltage must equal approximately ________ V_{rms}.

8. Use the meter and verify the measurement taken in step 7 above.

OBSERVATION Meter measures ________ V_{rms}.

CONCLUSION The scope and meter voltage measurements (*are, are not*) ____________________ close to equal.

The Oscilloscope

Phase Comparisons

PROJECT 38

Name: ______________________________ Date: ______________

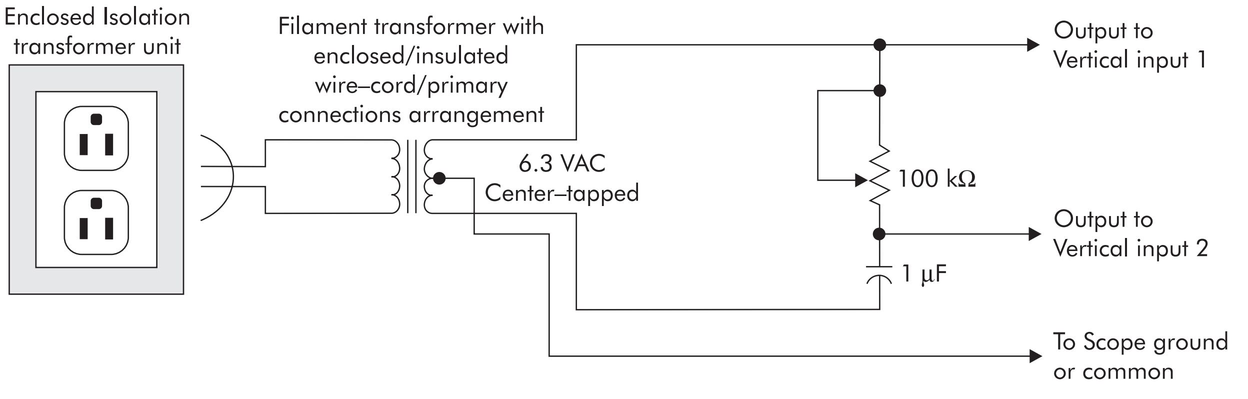

FIGURE 38-1 Variable phase-shift network

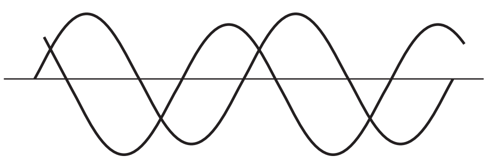

FIGURE 38-2 Superimposed waveforms

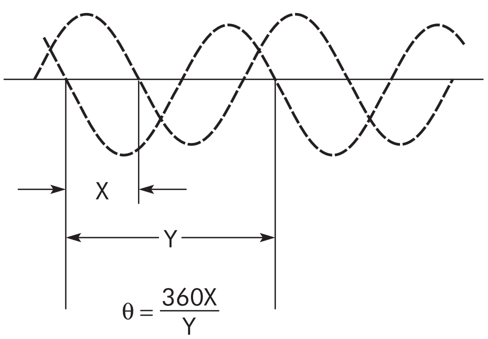

FIGURE 38-3 Calculating phase difference

PROJECT PURPOSE To provide hands-on practice in using the scope with the direct (overlay) phase comparison technique for determining phase difference between signals.

PARTS NEEDED

- ☐ Dual-trace oscilloscope
- ☐ Isolation transformer with outlet sockets
- ☐ *6.3-V filament transformer with insulated connections to power plug
- ☐ 100-kΩ potentiometer
- ☐ 1.0-μF paper/mylar capacitor

***NOTE:** Use a low-voltage ac power supply with center-tapped output, if available.

SAFETY HINTS **CAUTION:** Do not use exposed 120 VAC connections anywhere in the circuit setup! Be careful! 120 VAC can be lethal!

SPECIAL NOTE:

In this project, you will briefly look at an approach that may be used to compare the phase of two sine-wave signals (of the same frequency) using an oscilloscope. This method is by direct comparison of signals using a dual-trace scope.

PROCEDURE

1. Connect the variable phase shift circuit shown in Figure 38-1.
2. Connect the outputs of the network to the dual-trace scope vertical inputs 1 and 2, as appropriate. Adjust the scope H frequency, variable controls, and centering controls to achieve superimposed waveforms, centered on the face of the scope, similar to that shown in Figure 38-2.

OBSERVATION *V* input 1 gain control set at: ________ V/div.

V input 2 gain control set at: ________ V/div.

CONCLUSION Are the *V* levels fed to the two vertical inputs equal? ________.

3. Refer to Figure 38-3. Using the technique shown, determine the phase difference between the two signals you are displaying on your scope.

OBSERVATION Distance X = ________ calibration marks on the scope screen.

Distance Y = ________ calibration marks on the scope screen.

CONCLUSION The number of degrees difference between the two signals is ________ degrees.

4. Change the setting on the 100-kΩ potentiometer enough to see a noticeable change in the phase and repeat steps 2 and 3 from the previous diagram in Figure 38-1.

OBSERVATION Distance X = ________ calibration marks on the scope screen.

Distance Y = ________ calibration marks on the scope screen.

CONCLUSION The number of degrees difference between the two signals is ________ degrees.

The Oscilloscope

Determining Frequency

PROJECT **39**

Name: ______________________ Date: ____________

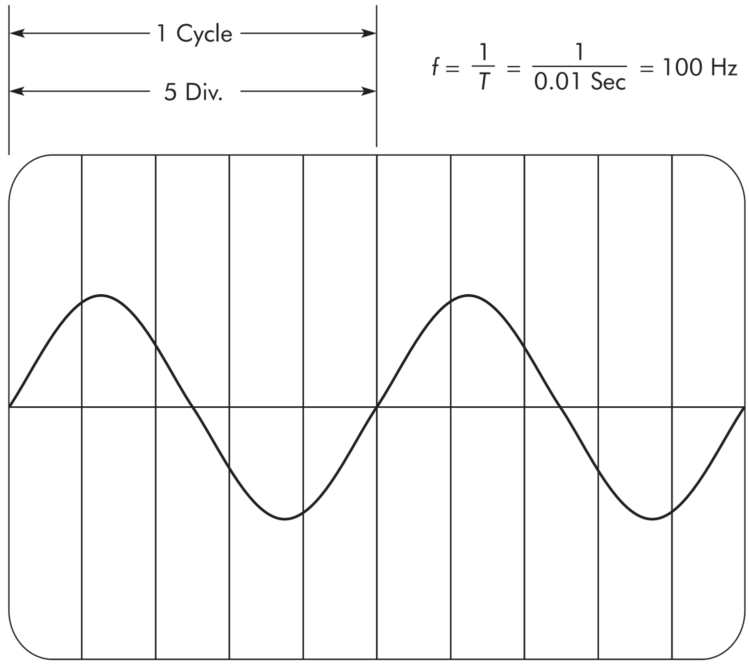

FIGURE 39-1 Scope sweep time setting at 2 ms/div.

PROJECT PURPOSE To provide hands-on practice in determining frequency by using the direct time measurement technique with an oscilloscope.

SPECIAL NOTE:

One method used to determine frequency with an oscilloscope is the direct method. This method uses a scope having a triggered sweep with calibrated sweep times. Since the horizontal sweep is linear and the calibrated sweep provides information about how many milliseconds or microseconds are required for the sweep to travel 1 div. horizontally on the screen, we can easily determine the time for one cycle of the waveform being viewed in Figure 39-1. Once we know the time it takes for one cycle of the waveform (its period), we can then use the $f = 1/T$ formula to find the frequency of the signal causing the pattern. For example, if the calibrated sweep time is set at 2 milliseconds per division and the scope display shows that one cycle of the signal's waveform starts and finishes in 5 horizontal divisions, the signal must have a period of 5×2 ms, or 10 ms. The frequency of the signal equals $1/T$, or 1/0.01 sec = 100 Hz.

PROCEDURE

1. Connect the output of an audio oscillator or function generator to a vertical input on a scope having a calibrated sweep system.
2. Set the sweep for a time of 1 ms per division.

OBSERVATION The number of ms for the sweep to travel all the way across the screen is _______ ms.

CONCLUSION A signal having a frequency of ______________ Hz would cause a waveform display wherein one cycle would take 10 div. on the scope display.

3. Adjust the signal generator frequency to obtain a one-cycle display across 10 divisions.

OBSERVATION Generator frequency dial calibration reads ________ Hz.

CONCLUSION The measured period for this signal is ________ ms. This indicates that the frequency is ________ Hz.
Does the generator calibration approximately agree with the measured signal frequency? ________ What could cause any differences? ______________________
____
____

4. Double the signal input frequency with the scope sweep setting still at 1 ms per division.

OBSERVATION How many cycles of the signal are now displayed? ________ cycle(s).

CONCLUSION The time for one cycle of this frequency is ________ ms; $f =$ ________ Hz.
Increasing the frequency of an input signal while keeping the sweep speed the same causes (*more, fewer*) ____________________ cycles to be displayed.

5. Have the instructor set the frequency of the signal source to a completely different setting. Preferably, the frequency should be set to one that will cause you to change sweep speeds in order to determine the frequency of the signal.

OBSERVATION To get a readable display, the sweep speed had to be changed to _________________ per div.

CONCLUSION The period of one cycle is ________. The frequency determined by the scope's direct measurement system is ________ kHz.

6. Have the instructor check your results in step 5.

OBSERVATION *Instructor:* Indicate whether the measurement is correct.

____ Yes. ____ No.

7. Practice determining other frequencies, as time permits.

PART 8

Summary

The Oscilloscope

Name: ______________________________ Date: ______________

Complete the multiple-choice questions by placing a check in the box next to the best answer option. Respond to the other types of questions by filling in the blanks or responding appropriately.

1. Four important uses of the oscilloscope are
   - ☐ Waveform display, voltage measurement, current measurement, and power measurement
   - ☐ Waveform display, voltage measurement, determining frequency, and power measurement
   - ☐ Waveform display, voltage measurement, determining phase, and power measurement
   - ☐ Waveform display, voltage measurement, determining phase, and determining frequency.

2. Why should the intensity or brightness control be set at the lowest point that makes the display readable?

   ____.

3. What oscilloscope terminal is used as the input terminal for the signal whose waveform is to be viewed?

   ____.

4. If an ac voltage of 125 V_{rms} causes 2 div. deflection on the scope screen, what is the peak-to-peak voltage of a signal that causes a deflection of 5 div. with the scope controls unchanged? Show your calculations below.

   Voltage is ________ $V_{P\text{-}P}$.

5. If a frequency of 150 Hz gives a display on the scope screen of three cycles, what is the frequency of a signal that gives a display of four cycles with the scope controls unchanged? Show your calculations below.

   Frequency is ________ Hz.

6. The most common way in which the scope might be used to show phase comparisons between two signals is

   ____.

7. A scope having a calibrated sweep system can be used to directly determine frequency because the time per division of the ______________________.

   sweep allows us to determine the ______________________ of the signal being observed.

8. What is the frequency of a signal whose display indicates a period of 0.1 ms?

   ____.

9. What is the period of a 25-kHz signal? ____________________.

10. By which of the following two methods can you more accurately measure a given signal's frequency?
    - ☐ Setting the sweep speed so that two cycles of the signal's waveform covers the entire distance of the horizontal sweep
    - ☐ Setting the sweep speed so that four cycles of the signal's waveform covers the entire x-axis display