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212
OSCILLOSCOPE

OPERATORS MANUAL

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212 OSCILLOSCOPE

INTRODUCTION

The 212 Oscilloscope is a dual-channel portable oscilloscope using all solid state and integrated circuitry (except the CRT). The small size of the 212 makes it an extremely portable oscilloscope for on-location maintenance in many fields of application.

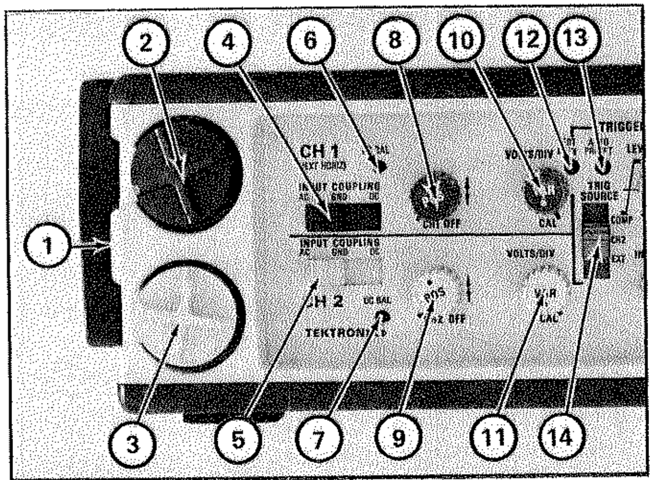
SAFETY CONSIDERATIONS

CAUTION

When battery operated, store the AC plug in the insulated compartment. The RFI circuitry connected between the instrument common and the AC power plug can cause small amounts of current from an elevated reference to be present on the AC power plug, imposing a possible shock hazard.

CONTROLS AND CONNECTORS

Controls and connectors necessary for operation of the 212 (with the exception of the POWER (BATTERY) indicator on the front panel) are located on the right side of the instrument. To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each control and connector. A brief description of each control and connector, along with some of the more important instrument specifications, are given here.



1\. POWER (BATTERY) Indicator—red light (on front panel) to indicate when the instrument is on. When light extinguishes, battery charge is low and about 10 minutes of operating life remain.

2 & 3. VOLTS/DIV—selects vertical deflection factor (vertical VARiable control must be in CAL position for indicated deflection). Calibrated position accuracy within 5%. Vertical system bandwidth; 1 mV/div, 100 kHz; 2 mV/div, 200 kHz; 5 mV/div, 400 kHz; 10 mV/div to 50 V/div, 500 kHz.

4 & 5. INPUT COUPLING—selects the method used to couple the channel input signal to the vertical amplifier system.

AC—DC component of input signal is blocked. Low frequency limit (−3 dB point) is approximately 2 Hz.

GND—vertical amplifier input circuit is grounded. The applied input signal is connected to ground through a large resistor to provide a pre-charge path for the AC input coupling capacitor.

DC—all components of the input signal are passed to the vertical amplifier system.

6 & 7. STEP ATTEN BALance—a screwdriver adjustment to balance the vertical amplifier system for minimum trace shift when switching deflection factors.

8 & 9. Vertical POSition—controls the vertical position of the appropriate trace. OFF detent turns the channel off.

10 & 11. VOLTS/DIV VARiable—provides a continuously variable deflection factor between the calibrated settings of the VOLTS/DIV switch for the appropriate vertical channel. Extends the maximum deflection factor to at least 125 volts/div.

12\. VERTical GAIN—screwdriver adjustment to set the gain of the vertical amplifier system.

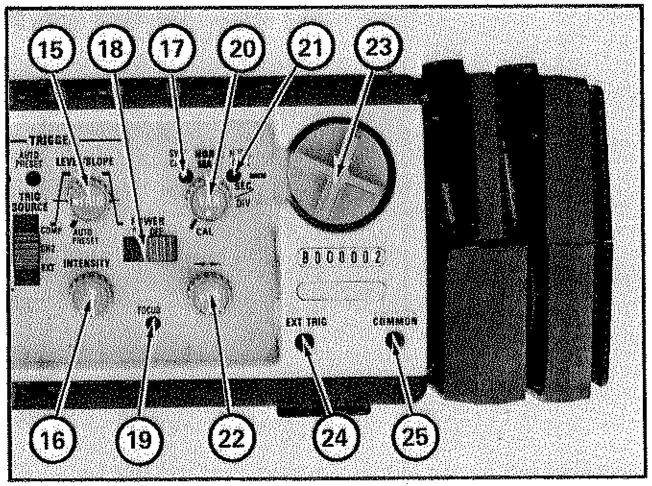
13\. AUTO PRESET—screwdriver adjustment to set the AUTO PRESET trigger point for automatic trigger operation.

14\. Trigger SOURCE—selects the source of the trigger signal.

COMP—the sweep is triggered from a DC coupled sample of the vertical deflection signal after the vertical switching.

CH 2—the sweep is triggered from an AC coupled sample of the vertical deflection signal before the vertical switching and only from Channel 2.

EXT—the sweep is triggered from the DC coupled signal applied to the EXT TRIG banana jack.



15. LEVEL/SLOPE—selects the amplitude point and the slope of a trigger signal on which the sweep is triggered. When the indicator dot is to the left of center, the sweep is triggered on the positive-going slope of the trigger signal; to the right of center, on the negative-going slope. When the LEVEL/SLOPE control is set to the AUTO PRESET detent, the sweep is automatically triggered at a preset level on the positive-going slope. Stable triggering requires a minimum of 0.2 division internal signal or 1.0 volt external signal amplitude.

16. INTENSITY—controls brightness of CRT display.

17. SWP CAL—screwdriver adjustment to provide calibrated sweep timing.

18. POWER—controls power to the instrument. Does not interrupt charging current to the internal batteries when the instrument is connected to an AC line voltage.

19. FOCUS—screwdriver adjustment to obtain a well-defined display.

20. HORIZ MAG—provides continuously variable sweep magnification to a minimum of approximately five times the sweep rate indicated by the SEC/DIV switch.

21. HORIZontal GAIN—screwdriver adjustment to set the basic gain of the horizontal amplifier system.

22. Horizontal POSition—controls the horizontal position of the trace.

23. SEC/DIV—selects horizontal sweep rate (horizontal VAR must be in CAL position for indicated sweep rate). Calibrated sweep rate accuracy within 5%. X-Y position allows for X-Y operation with CH 2 supplying the vertical deflection and CH 1 the horizontal deflection.

24. EXT TRIG—banana jack for input of an external trigger signal.

25. COMMON—banana jack to establish common ground between the 212 and the external signal source or equipment under test.

OPERATING POWER INFORMATION

Internal Battery Operation

The 212 is designed primarily for operation from the internal rechargeable batteries. The operating time provided from the internal batteries depends upon trace intensity, and battery charge and discharge temperature. Typical operating time from fully charged batteries at maximum trace intensity when charged and operated at +20°C to +30°C (+68°F to +86°F) is 4.5 hours. Longest operating time is provided at lower trace intensity.

The POWER (BATTERY) indicator provides an indication of the operating power. When the light extinguishes not more than 10 minutes of instrument operating power remains. The 212 possesses an automatic battery protection circuit to prevent excessive discharge and the resulting battery damage if the instrument is operated below the battery charge level of approximately 10 volts.

Battery Charging

The charging characteristics of the nickel-cadmium (NiCd) cells used in the 212 vary with the temperature at

which they are charged. Batteries charged at about +20°C to +30°C (+68°F to +86°F) will deliver more energy than when the same batteries are charged at a higher or lower temperature.

To charge the batteries, connect the instrument to an AC line and set the POWER switch to the OFF position. Allow at least 16 hours for the batteries to reach full charge. For longest operating life of the batteries, increase the charge time of the instrument to at least 24 hours once a month. This procedure balances the charge on all the cells in the battery and reduces the possibility of any individual cell becoming reverse charged.

The nickel-cadmium cells will self-discharge when the instrument is stored and not used for extended periods of time. The rate at which this self-discharge occurs is dependent upon the storage temperature and humidity. If the 212 is to be stored for extended periods, particularly at either high ambient temperature or high humidity, it is recommended that the batteries be run through a full charge cycle (16 hours) about every two weeks, or that the instrument be left connected to the AC line.

Typical Charge Capacity (reference to charge/discharge at +20°C to +30°C):

CHARGE TEMPERATURE	OPERATING TEMPERATURE −15°C (+5°F)	+20°C to +30°C (+68°F to +86°F)	+55°C (+131°F)
0°C (+32°F)	40%	60%	50%
+20°C to +30°C (+68°F to +86°F)	65%	100%	85%
40°C (+104°F)	40%	65%	55%

AC Operation

CAUTION

Due to the capacitive line input circuit, sudden voltage changes may cause damaging input current transients. Avoid operating this instrument from square-wave inverter supplies, or other sources that produce large voltage transients.

If the internal batteries of the 212 become discharged to the minimum operating level, continued operation can be

obtained by connecting the instrument to an AC power source. Due to the circuitry connected with the internal battery charger, the AC power line voltage must be at least 110 volts for operation in this manner. Also, when operated with fully-charged batteries from an AC line below about 110 volts and at a maximum trace intensity, the internal batteries discharge slowly. Approximately 36 hours of continuous operation can be obtained with fully charged batteries at maximum intensity and a 104-volt line. The internal batteries cannot be recharged while the instrument is being operated from the AC line.

If the instrument is to be operated on a power line other than 110 to 126 VAC, 58 to 62 Hz, refer to Option Information.

TABLE 1

AC Power Source Information

212 Power Supply	Voltage Range	Frequency
Standard	110 to 126 VAC	58 to 62 Hz
Option 1	220 to 250 VAC	48 to 52 Hz
Option 2	90 to 110 VAC	48 to 52 Hz

Operating Temperature

The 212 can be operated from the batteries in ambient air temperatures between −15°C and +55°C (+5°F and +131°F). The instrument should only be connected to an AC line source in ambient temperatures between 0°C and +40°C (+32°F and +104°F).

Option Information

Your instrument may be equipped with one or more options. This section describes those options or directs the reader to where the option is documented.

OPTION 1

Option 1 equips the 212 for operation from a 220 to 250 V ac 48 to 52 Hz power line source. A power cord cable assembly, for adapting to appropriate power plugs, is included with Option 1 instruments. Refer to the 212 Service manual for additional information concerning Option 1.

OPTION 2

Option 2 equips the 212 for operation from a 90 to 110 V ac 48 to 52 Hz power line source. Refer to the 212 Service manual for additional information concerning Option 2.

GENERAL OPERATING INFORMATION

Intensity Control

The INTENSITY control determines the brightness of the display presented on the CRT. Since the brightness of the CRT display affects the amount of current drained from the batteries, the INTENSITY control should be set to the minimum usable level. This will allow maximum operating time from the internal batteries. The setting of the INTENSITY control may affect the correct focus of the display; therefore, a slight re-adjustment of the FOCUS may be necessary when the intensity level is changed. To protect the CRT phosphor, do not turn the INTENSITY control higher than is necessary to provide a satisfactory display. Be careful that the INTENSITY control is not set too high when changing the SEC/DIV switch from a fast to a slow sweep rate.

Graticule

The graticule of the 212 is internally marked on the faceplate of the CRT to provide accurate, no-parallax measurements. The graticule is marked with six vertical and 10 horizontal divisions. Each major division is segmented into five minor divisions at the center vertical and horizontal lines. The vertical gain and the horizontal timing are calibrated to the graticule so accurate measurement can be made from the CRT display.

Vertical Deflection Factor

The amount of vertical deflection produced by a signal applied to one of the vertical channels is determined by the signal amplitude and the setting of the appropriate VOLTS/

DIV switch and its VAR control. The calibrated deflection factors indicated by the VOLTS/DIV switch apply only when the VOLTS/DIV VAR control is set to the CAL detent.

The VOLTS/DIV VAR control provides continuously variable (uncalibrated) vertical deflection factors between the calibrated settings of the VOLTS/DIV switch. The VOLTS/DIV VAR control extends the maximum vertical deflection factor to at least 125 volts/division (in the 50 volts position).

Signal Connections

Two high-impedance signal probes are internally attached to the 212. These probes provide a one-megohm input impedance and a shielded input cable to prevent pickup of electrostatic interference. Without the use of a probe attenuator, the vertical deflection factors can be read directly from the appropriate VOLTS/DIV switch.

Signals can be connected to the EXT TRIG banana jack with short unshielded leads under most conditions. Be sure to establish a common ground between the 212 and the equipment under test. Attempt to position the unshielded leads away from any source of interference to avoid errors in triggering. If interference is excessive with unshielded leads, use a coaxial cable with a suitable adapter.

Ground Considerations

Reliable signal measurements cannot be made unless both the oscilloscope and the unit under test are connected together by a common reference (ground) lead in addition to the signal lead or probes. The ground straps on the attached probes provide the best ground. Also, a ground lead can be connected to the 212 chassis COMMON banana jack to establish a common ground with the signal source.

Input Coupling

The INPUT COUPLING switches allow a choice of the coupling method for the applied signals. The type of display desired and the applied signal will determine the coupling method to use.

In the AC coupling position, the DC component of the signal is blocked by a capacitor in the input circuit. The

low-frequency response in the AC position is about two hertz (−3 dB point). Therefore, some low-frequency attenuation can be expected near this frequency limit. Attenuation in the form of waveform tilt will also appear in square waves which have low-frequency components. The AC coupling position provides the best display of signals with a DC component which is much larger than the AC component.

The GND position provides a ground reference at the input of the appropriate vertical channel without the need to externally ground the probe. The signal applied to the probe is internally disconnected from the input circuit and connected to ground through a one-megohm resistor. The input to the vertical amplifier is held at ground potential.

The DC coupling position can be used for most applications. This position allows measurements of the DC component of a signal, and must be used to display signals below about 10 hertz as they will be attenuated in the AC position.

Pre-Charging. The GND position can be used to pre-charge the input coupling capacitor of the channel to the average voltage level of the signal applied to the probe.

The following procedure should be used whenever one of the probe tips is connected to a signal source having a different DC level than that which was previously applied.

1. Before connecting the probe to a signal source with a large DC component, set the INPUT COUPLING switch to GND.

2. Connect the probe tip to ground to allow the input coupling capacitor to fully discharge. Then, connect the probe to the signal source.

3. Wait several seconds for the input coupling capacitor to charge.

4. Set the INPUT COUPLING switch to AC. The display will remain on the screen so the AC component of the signal can be measured in the normal manner.

Trigger Source

The Trigger SOURCE switch allows for selectivity in determining the source to trigger the sweep. For most applications, the sweep can be triggered internally. In the COMP position, the trigger signal is obtained from the vertical deflection system after the vertical switching has occured. Therefore, in the dual-trace mode of operation, the display will be triggered on the chopping signal and not necessarily on the selected slope of the LEVEL/SLOPE control. In this position the 212 will trigger on at least 0.2 division of the applied signal within the bandwidth limits of the instrument.

In the CH 2 position of the Trigger SOURCE switch, the trigger signal is again obtained internally, but is selected before the vertical switching and only from CH 2 of the vertical deflection system, on at least 0.2 division of the applied capacitively coupled signal. In the dual-trace mode, if the displayed signals are time related, both channels can be triggered on the selected slope with the Trigger SOURCE switch in this position. However, it is not necessary for the CH 2 POSition control to be out of the OFF detent for a trigger to be present in the CH 2 position.

An external signal connected to the EXT TRIG jack can be used to trigger the sweep in the EXT position of the Trigger SOURCE switch. The external signal must be time-related to the displayed signals in order to obtain a stable display. An external trigger signal of 1 volt to 20 volts can be used to provide a triggered display when the internal signal is too low in amplitude for correct triggering, or contains signal components on which it is desired not to trigger.

The external trigger signal is useful when signal tracing in amplifiers, phase-shift networks, wave-shaping circuits, etc. The signal from a single point in the circuit under test can be connected to the EXT TRIG banana jack. Then the sweep is triggered by the same signal at all times to allow amplitude, time relationship, waveshape changes, or signals at various points in the circuit to be examined without resetting the trigger controls.

Trigger Slope

The LEVEL/SLOPE control determines whether the trigger circuit responds on the positive-going or negative-going portion of the trigger signal. When the indicator dot is to the left of center, the trigger circuit responds on the

positive-going portion of the triggering waveform (notice the positive-going waveform on the left side of the control). To the right of center, the trigger circuit responds to the negative-going portion of the triggering waveform (notice the negative-going waveform on the right side of the control). Since this instrument does not have an internal delay line, the display might not start on the selected slope, particularly when the displayed waveforms have a high repetition rate. When several cycles of a signal appear in the display, the selection of the trigger slope is often unimportant. However, if only a certain portion of a cycle is to be displayed, correct settings of the LEVEL/SLOPE control is important to provide a display which starts on the desired slope of the input signal.

Trigger Level

In addition to selecting the trigger slope, the LEVEL/SLOPE control determines the voltage level of the trigger signal at which the display is triggered. The horizontal line marked on the waveforms to the left and right of the LEVEL/SLOPE control represents the zero-volt level of the trigger signal. As the LEVEL/SLOPE control is rotated away from this line, the displayed waveforms start at a point corresponding to the position of the indicator dot on the associated slope waveform. For example, if the LEVEL/SLOPE control is turned clockwise from the line on the positive-going slope, the displayed waveform starts at a more positive level.

The AUTO PRESET detent provides automatic selection of the triggering level on the positive slope of the trigger signal. When the LEVEL/SLOPE control is set to this position, the sweep is automatically triggered at the preset level; when out of this position the effect is that of a normal triggering mode.

Horizontal Sweep Rate

The SEC/DIV switch provides 16 calibrated sweep rates ranging from 500 milliseconds to five microseconds/division (HORIZ MAG control set to CAL). The HORIZ MAG control provides continuously variable sweep magnification to at least five times the sweep rate indicated by the SEC/DIV switch.

When making time measurements from the graticule, the area between the first-division and ninth-division vertical lines provides the most linear measurement. Therefore, the

first and last division of the display should not be used for making accurate time measurements. Position the start of the timing area to the first-division vertical line and set the SEC/DIV switch so the end of the timing area falls between the first- and ninth-division vertical lines.

X-Y Operation

In some applications, it is desirable to display one signal versus another signal (X-Y) rather than against time (internal sweep). The X-Y position of the SEC/DIV switch provides a means for this type of operation. In this position the Y (vertical) signal is connected to the input of CH 2; the X (horizontal) signal is applied to the input of CH 1 and has a deflection range from less than one millivolt to 50 volts/division at a reduced bandwidth of 50 kilohertz.

Since the X and Y channels of this instrument are not time matched, some inherent phase shift can be expected in the display. Take this phase shift into consideration when making measurements in the X-Y mode.

OPERATOR'S ADJUSTMENTS

To assure measurement accuracy, several basic instrument parameters should be checked occasionally and, if necessary, adjusted to meet specifications. These are readily accessible as screwdriver adjustments on the instrument side panel. The following provides brief calibration information for these external adjustments. The operator should be familiar with the instrument's operation before attempting to make these adjustments.

Vertical Gain

Connect the CH 1 probe tip to an accurate 0.2 volt source (such as a TEKTRONIX 067-0502-01 Standard Amplitude Calibrator). Set the VOLTS/DIV switch to 50 m and set the VERT GAIN adjustment for exactly four divisions of deflection.

Step Attenuator Balance

CH 1: Obtain a free-running trace with no signal applied to the vertical channel input and CH 2 POSition control set to the OFF detent. While switching the appropriate VOLTS/DIV switch between 50 m and 1 m, adjust the CH 1 STEP ATTEN BAL for minimum trace shift between adjacent positions.

CH 2: Obtain a free-running trace with no signal applied to the vertical channel input and CH 1 POSition control set to the OFF detent. While switching the CH 2 VOLTS/DIV switch between 50 m and 1 m, adjust the CH 2 STEP ATTEN BAL for minimum trace shift between adjacent positions.

Horizontal Gain

Set the SEC/DIV switch to X-Y. Connect the CH 1 probe tip to an accurate 0.2 volt source (such as a TEKTRONIX 067-0502-01 Standard Amplitude Calibrator). Set the CH 1 VOLTS/DIV switch to 50 m and the CH 2 POSition control to midrange. Adjust the HORIZ GAIN adjustment for exactly four horizontal divisions of deflection between dots.

Horizontal Timing

Connect the CH 1 probe tip to some accurate timing standard (such as the TEKTRONIX 2901 Time-Mark Generator). With the SEC/DIV switch set to 1 m, apply one millisecond time marks. Adjust the Trigger controls for a stable display. Adjust the SWP CAL adjustment for exactly eight divisions of deflection between the second and tenth time mark (one time mark/division).

Focus

Set the SEC/DIV switch to X-Y and the INPUT COUPLING switch's to GND. With no signal applied, adjust the FOCUS for optimum focus of the CRT display (a single dot).

Auto Preset

Connect the CH 1 probe tip to a sine-wave signal source within the bandwidth limits of the 212. Set the LEVEL/SLOPE control to the AUTO PRESET detent and adjust the VOLTS/DIV and SEC/DIV switches for a display approximately four divisions in amplitude with one cycle of signal displayed every two or three divisions. Vertically center the display about the center horizontal graticule line using the CH 1 POS control. Adjust the AUTO PRESET adjustment so the CRT display starts on the center horizontal graticule line.

APPLICATIONS

The following applications are not described in detail, since each application must be adapted to the requirements of the individual measurement. This instrument can also be

used for many applications which are not described in this handbook. Contact your local TEKTRONIX Field Office or representative for assistance in making specific measurements with this instrument.

Voltage Measurements

1. AC Signals

a. Set the INPUT COUPLING switch to GND and the VOLTS/DIV to an appropriate setting (VOLTS/DIV VAR to CAL). Vertical deflection factor equals the product of the VOLTS/DIV setting and the probe attenuation factor. Without the addition of a probe attenuator, the vertical deflection factor can be read directly from the VOLTS/DIV switch (VOLTS/DIV VAR in CAL). Connect the probe tip to the signal source and switch the INPUT COUPLING to the AC position.

b. Select the desired SEC/DIV setting and adjust the Trigger LEVEL/SLOPE control for a triggered display. Position the display within the graticule area for measurement.

c. Measure the peak-to-peak amplitude of the display or waveform, in graticule divisions (see Fig. 3).

d. Voltage (peak-to-peak) = measured amplitude in divisions, multiplied by the vertical deflection factor (VOLTS/DIV X Probe attenuation factor).

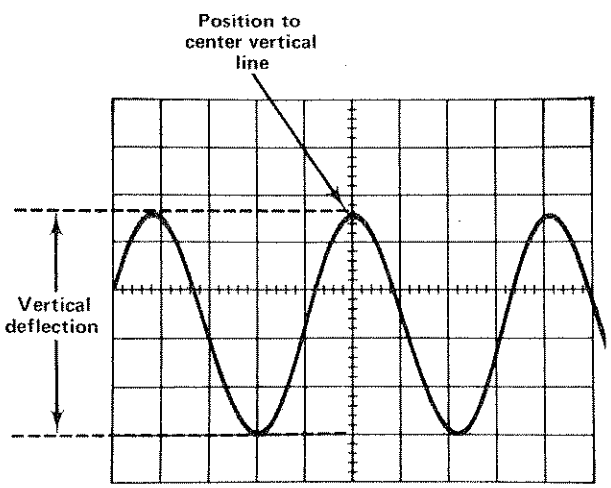


Fig. 3. Measuring peak-to-peak voltage.

NOTE

This technique may also be used to make measurements between two points on the waveform other than peak-to-peak.

2. Instantaneous Voltage

Instantaneous voltage is measured with respect to some reference potential (usually ground). This reference level is first established by positioning the trace along a graticule line with the reference potential applied to the input; then, the instantaneous voltage is applied and measured above or below the reference line or voltage. In this type of measurement, the INPUT COUPLING switch must be in the DC position. This method can also be used to measure the DC component of a waveform, since the average or DC value can be measured as a voltage above the reference level.

a. Set the vertical deflection factor to an appropriate setting for the voltage to be measured, (VOLTS/DIV VAR to CAL) and set the Trigger LEVEL/SLOPE to AUTO PRESET.

b. Switch the INPUT COUPLING switch to GND if the reference is to be at ground, or to DC if the reference is to be a voltage level. Touch the probe tip to the reference voltage and vertically position the trace to a reference on any horizontal graticule line. This reference position will depend on the polarity and amplitude of the input signal. Do not change the setting of the POSition control after the reference has been set.

c. Remove the probe tip from the reference and connect it to the signal source. Adjust the SEC/DIV switch for the desired display.

d. Measure the vertical amplitude in divisions from the point to be measured to the reference line.

e. Voltage = measured amplitude (in divisions), multiplied by the deflection factor.

3. Voltage Comparison

For applications in which the signal voltage is to be compared to some signal reference amplitude, it may be

desirable to establish a different deflection factor than those available with the VOLTS/DIV switch. A deflection factor conversion constant, based on a specific reference amplitude, is established as follows:

a. Apply a reference signal of known amplitude to the input.

b. Adjust the display amplitude to an exact number of graticule divisions using the VOLTS/DIV switch and its VAR control. Do not change this setting after the reference has been established.

c. Deflection factor conversion constant equals:

$$\frac{\text{Reference Signal Voltage}}{\text{VOLTS/DIV setting} \times \text{Display Amplitude in divisions}}$$

d. Adjusted deflection factor for any setting of the VOLTS/DIV switch equals the VOLTS/DIV setting multiplied by the conversion factor.

e. The peak-to-peak amplitude of any signal compared to this reference is measured as follows:

Set the VOLTS/DIV switch to a setting that will provide sufficient deflection to make a measurement. Do not move the VAR setting.

$$\text{Signal Amplitude} = \begin{matrix}\text{Adjusted}\\\text{deflection}\\\text{factor}\end{matrix} \times \begin{matrix}\text{Signal}\\\text{deflection}\\\text{in divisions}\end{matrix}$$

4. Elevated Reference

Another method of making a voltage measurement with respect to a voltage level rather than ground, is to connect the 212 probe ground clip directly to the desired reference voltage.

CAUTION

The 212 probe ground clips and the instrument COMMON input jack are electrically connected. Do not apply dis-similar voltage potentials to them.

This method of establishing a floating reference can be used when the oscilloscope COMMON is not elevated from earth ground more than 250 V RMS sinusoidal minus the AC power line RMS voltage (i.e., when AC power line RMS

voltage is 117 V, the maximum allowable potential on the probe ground clip or COMMON is 250 − 117 = 133 V RMS). When battery operated with the AC power plug secured in its insulated compartment, the maximum safe potential between the probe clip or COMMON and the case exterior is 500 V RMS or 700 V DC + peak AC, (see Safety Considerations). Use the same measurement procedure given for instantaneous voltage. Remember that the DC reference line presented when the INPUT COUPLING switch is set to GND is an elevated voltage, not ground, and is present on both probe ground clips and the COMMON input jack. To determine the actual instantaneous voltage with respect to earth ground, add the reference voltage to the result of the Instantaneous Voltage Formula.

Time-Duration Measurements

Time between two or more events can be measured directly on the graticule as follows:

NOTE

See the topic entitled HORIZONTAL SWEEP RATE concerning non-linearity of first and last divisions of display.

a. Using the graticule, measure the horizontal distance between the two events.

b. Multiply the distance measured by the SEC/DIV control setting to obtain the time interval. The HORIZ MAG must be in the CAL position.

Frequency Measurements

Using the methods described in the preceding application, measure the period (time required for one cycle or time for a given number of cycles) of a recurrent waveform. The frequency of the waveform can then be easily calculated, since frequency is the reciprocal of the time period. For example, if the period of a recurrent waveform is accurately measured and found to be 20 μs, the frequency is 50 kHz. If the time for 10 cycles is 10 ms, the frequency is

$$\frac{1 \times 10}{10 \text{ ms}} \quad \text{or } 1 \text{ kHz}$$

To calculate the period of a known frequency:

$$\text{Time} = \frac{1}{\text{frequency}}$$

Phase Measurements

Since a complete cycle of a sinusoidal waveform represents 360°, the oscilloscope graticule can be calibrated in degrees/division by using the SEC/DIV switch and the HORIZ MAG. Adjust the span of a reference waveform so that one cycle covers a given number of divisions. (Figure 4

illustrates how the graticule can be calibrated for 45° per division.) The phase difference of a signal from the reference equals the displacement from the calibrated points on the graticule.

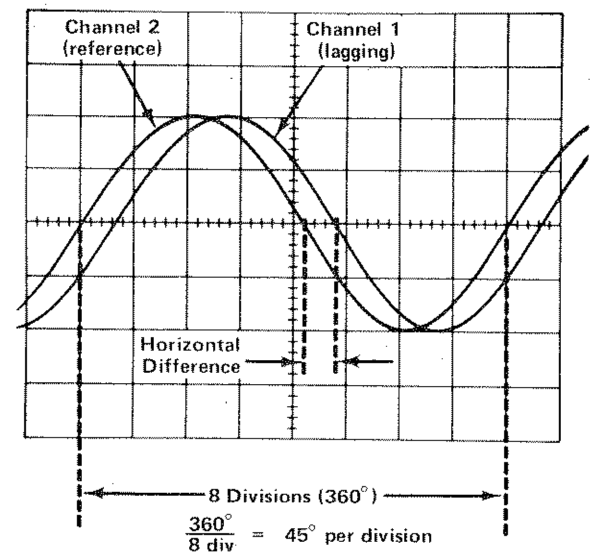


Fig. 4. Measuring phase difference.

When making phase measurements, maintain a constant amplitude point on the triggering signal so the two input signals are compared indirectly to this reference, and directly to each other. The trigger signal must have sufficient amplitude to insure stable triggering and be frequency related to the waveforms on which phase measurements are to be made; however, the phase of the trigger signal is not critical. It is essential that after triggering conditions are established, there is no change during any phase measurement.

The amplitude of the display should be large to improve accuracy. Accuracy also depends upon keeping the waveforms centered about the horizontal graticule centerline.

Phase comparison between two signals of the same frequency can be made (up to the frequency limit of the vertical system) using the dual-trace feature of the 212.

a. Set the VOLTS/DIV and VAR of both channels to display 4 or 5 divisions of vertical deflection.

b. Connect the reference signal to CH 2 and set the Triggering SOURCE switch to CH 2, connect the signal to be compared to the CH 1 probe tip.

c. Set the Triggering LEVEL/SLOPE for a stable display and set the SEC/DIV switch to display about one cycle of signal. Position the display to graticule center.

d. Turn the HORIZ MAG control until one cycle of the reference signal (CH 2) occupies exactly 8 divisions horizontally. (See Fig. 4.) Each division now represents 45° of the displayed 360° (eight divisions).

e. Measure the horizontal difference between corresponding points on the display.

f. Multiply the measured distance in divisions by 45°/divisions to obtain the phase difference.

$$\text{Phase Difference} = \text{Distance in divisions} \times \frac{45^\circ}{\text{division}}$$