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214 OSCILLOSCOPE

OPERATORS

SN B300000 & ABOVE

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-5054-00
Product Group 40

Serial Number ____________

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply and do not appear in this summary.

Terms in This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms as Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the markings, or a hazard to property, including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols in This Manual

⚠ This symbol indicates where applicable cautionary or other information is to be found.

Symbols as Marked on Equipment

⚡ DANGER—High voltage.

⏚ Protective ground (earth) terminal.

⚠ ATTENTION—Refer to manual.

5054-01

Tektronix 214 Dual-Trace Storage Oscilloscope.

INTRODUCTION

The Tektronix 214 Storage Oscilloscope is a solid-state portable instrument designed for general-purpose applications where display storage is desired, along with conventional (NONSTORE) operation. The instrument is mechanically contructed to withstand the extremes associated with portability. The small size of the 214 makes it an extremely portable oscilloscope for on-location maintenance im many fields of application.

SAFETY CONSIDERATIONS

WARNING

When battery operated, store the AC plug in the insulated compartment, see Fig. 1. 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.

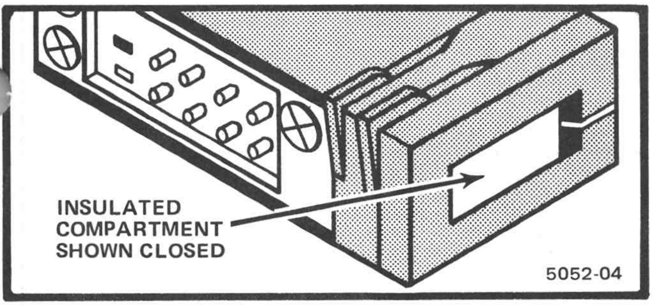

Fig. 1. Rear panel showing insulated compartment.

ACCESSORIES

The instrument is shipped with the following standard accessories:

1	Visor, CRT
1	Case, Carrying
1	Strap, Carrying
1	Operators manual
1	Service manual

For part numbers and further information about both standard and optional accessories refer to the "Accessories" page at the back of this manual. Your Tektronix representative or local Tektronix Field Office can also provide accessories information.

CONTROLS AND CONNECTORS

Controls and connectors necessary for operation of the 214 are located on the front and right side panels of the instrument. The power on off switch is located on the lower left side of the instrument. Vertical controls are color-coded with the tip of the corresponding probe. 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.

WARNING

COMMON and probe ground straps are electrically connected. Therefore, an elevated reference applied to any ground is present on the others-as indicated by the yellow warning bands under the probe retractable hook tips, and the ground strap protective coverings.

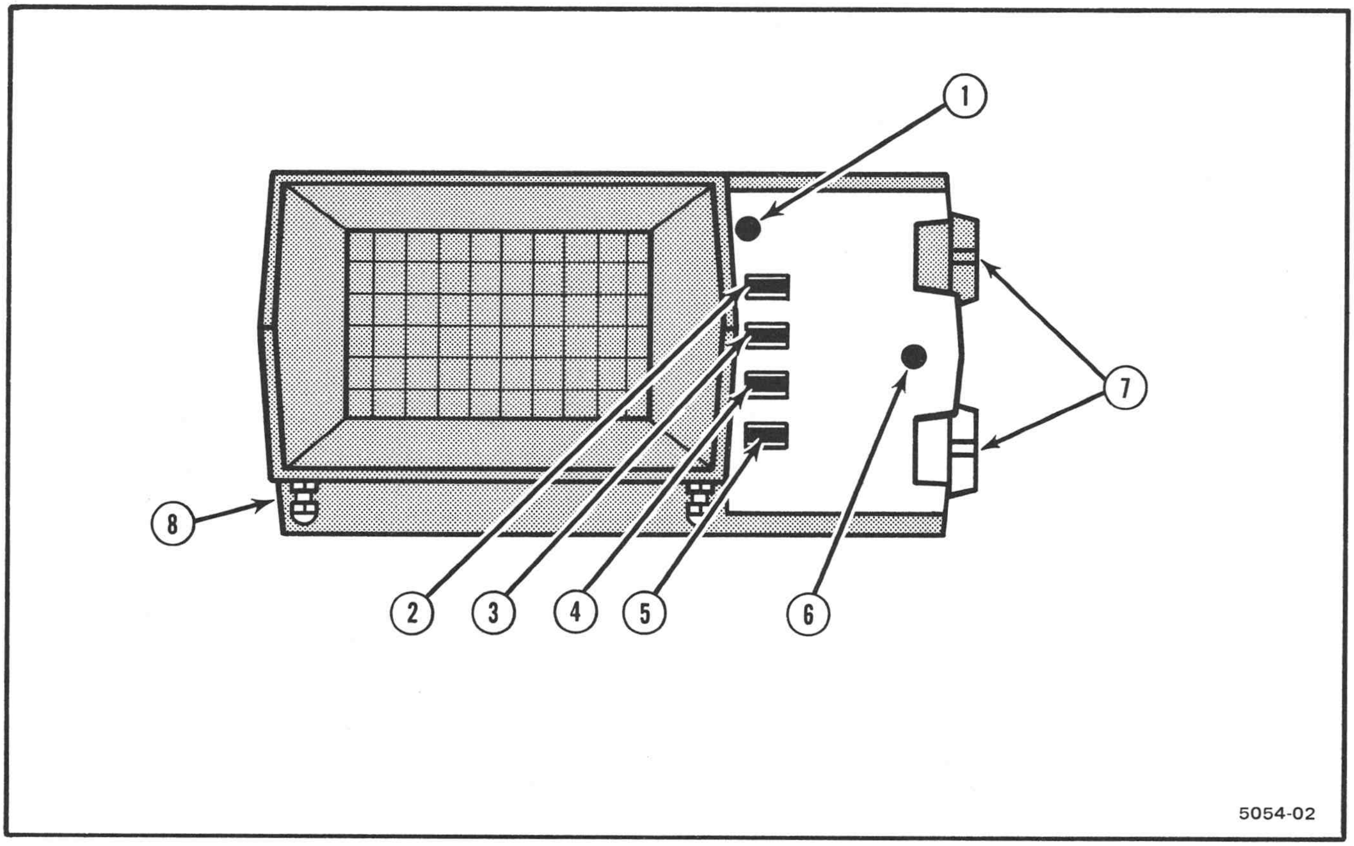

Fig. 2. Front panel controls.

FRONT PANEL CONTROLS

① **READY LED**—Indicates sweep has been reset and a single display will be presented upon receipt of an adequate trigger signal.

② **SINGLE SWP**—When pushed, the sweep operates in the Single Sweep mode. After a sweep is displayed, further sweeps cannot be presented until the RESET button is pressed and released. Automatic Enhance occures in SINGLE SWP storage at sweep rates of 0.1 ms/div and above.

③ **RESET**—When pressed and in the Single Sweep mode, a single display will be presented after correct triggering. Must be pressed again before another sweep can be displayed. When VERT MODE switch is set to BOTH, only one channel will be displayed for each RESET actuation.

④ **STORE**—When pushed, the CRT operates in the Storage mode. With the button out, the CRT operates in the conventional, NONSTORE, mode. Automatic Enhance provides faster storage capabilities when in SINGLE SWP at sweep rates of 0.1 ms/div and faster.

(5) **ERASE**—Momentary contact switch that, when pushed and released, erases a stored display from the CRT.

(6) **POWER (BATTERY)**—Red LED to indicate when the instrument is on. When light extinguishes, battery charge is low and about five minutes of operating life remains.

(7) **VOLTS/DIV**—Selects vertical deflection factor (vertical VAR must be in the CAL position for indicated deflection).

LEFT SIDE PANEL CONTROLS

(8) **Power ON-OFF**—Turns the instrument on or off regardless of whether the internal battery source or an external AC source is being used. Does not interrupt charging current to the internal batteries when the instrument is connected to AC line voltage.

RIGHT SIDE PANEL CONTROLS AND CONNECTORS

(9) **INPUT COUPLING**—Selects method used to couple the channel input signal to the vertical amplifier system.

AC—Input signal is capacitively coupled to the vertical amplifier. The dc component of input signal is blocked. Low-frequency limit (−3 db point) is approximately 2 Hz.

GND—Vertical amplifier input circuit is grounded (does not ground the input signal). Allows precharging the input coupling capacitor.

DC—All frequency components of the input signal are coupled to the vertical amplifier system.

(10) **STEP ATTEN BAL**—Screwdriver adjustment to balance the vertical system for minimum trace shift when changing deflection factors.

(11) **Vertical POS**—Controls the vertical position of the appropriate trace.

(12) **VAR VOLTS/DIV**—Provides a continuously variable uncalibrated deflection factor between the calibrated settings of the VOLTS/DIV switch.

(13) **VERT MODE**—Selects the mode of operation for the vertical amplifier system.

CH 1—Selects only the Channel 1 input signal for display.

BOTH—Selects both Channel 1 and Channel 2 input signals for display.

CH 2—Selects only the Channel 2 input signal for display.

(14) **AUTO PRESET**—Screwdriver adjustment to set the PRESET trigger point for AUTO sweep operation.

(15) **LEVEL/SLOPE**—Selects the amplitude point and slope of the 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 contol is set to the AUTO PRESET detent, the sweep is automatically triggered at a preset level on the positive-going slope.

(16) **INTENSITY**—Controls brightness of CRT display.

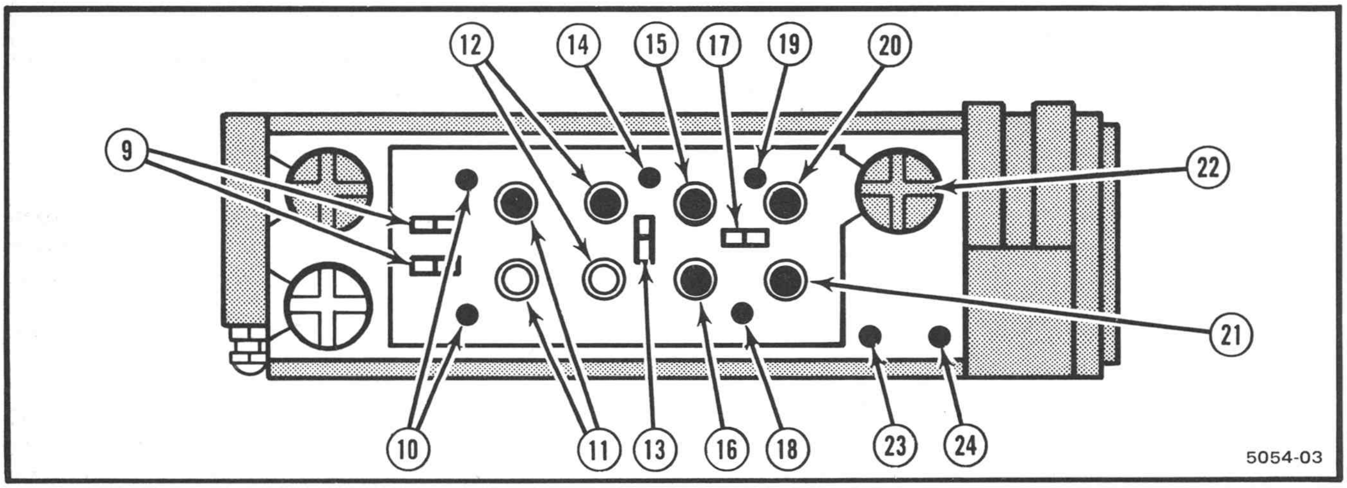

Fig. 3. Right side panel controls.

⑰ **TRIG SOURCE**—Selects the source of the trigger signal.

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

CH 2—Sweep is triggered from an AC-coupled sample of the CH 2 vertical signal before the vertical switching.

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

⑱ **FOCUS**—Screwdriver adjustment to obtain a well-defined display.

⑲ **SWP CAL**—Screwdriver adjustment to provide calibrated sweep timing.

⑳ **VAR HORIZ MAG**—Provides continuously variable sweep magnification to a maximum of at least five times the sweep rate indicated by the SEC/DIV switch.

㉑ **Horizontal POS**—Controls the horizontal position of the trace.

㉒ **SEC/DIV**—Selects the sweep rate (VAR HORIZ MAG must be in CAL detent for indicated sweep rate). X-Y position allows for X-Y operation with CH 2 supplying the vertical deflection and CH 1 the horizontal deflection.

㉓ **EXT TRIG**—Banana jack for input of an external trigger signal.

㉔ **COMMON**—Input banana jack to establish common ground between the 214 and the external signal source or equipment under test. Electrically connected to the probe ground clips.

OPERATING CONSIDERATIONS

OPERATING POWER INFORMATION

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.

INTERNAL BATTERY OPERATION

The 214 is designed primarily for operation from the internal rechargeable batteries. The operating time provided from the internal batteries depends upon trace intensity, STORE or NONSTORE mode, and battery charge and discharge temperature. Typical operating time from fully charged batteries at maximum trace intensity in the NONSTORE mode of operation, when charged and operated at +20°C to +30°C (+68°F to +86°F), is four hours. When operated in the STORE mode, typical operating time is three hours. Longest operating time occurs at lower trace intensity.

The POWER (BATTERY) LED provides an indication of the operating power of the 214. When the light extinguishes, battery charge is low and about five minutes of instrument operating power remains. The 214 has an automatic battery protection circuit to prevent excessive discharge and the resulting battery damage if the battery charge level drops below approximately 10 volts.

BATTERY CHARGING

The charging characteristics of the nickel-cadmium (NiCd) cells used in the 214 vary with the temperature at which they are charged. Batteries charged at about +20°C to +30°C (+68°F to +86°F) 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 eight hours for the batteries to reach full charge. For longest operating life of the batteries, increase the charge time to at least 16 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 reversed charged.

The nickel-cadmium cells will self-discharge when the instrument is non-operational for extended periods of time. The rate at which this self-discharge occurs is dependent on the ambient temperature and humidity. If the 214 is to be stored for extended periods, particularly at either high ambient termperature or high humidity, it is recommended that the batteries be run through a full charge cycle (eight hours) about every two weeks.

AC OPERATION

If the internal batteries of the 214 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 the AC line below about 110 volts and in the STORE mode of operation, the internal batteries will discharge slowly. The internal batteries cannot be recharged while the instrument is being operated from the AC line.

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 will affect the focus of the display in the STORAGE mode of operation. Turn the

INTENSITY off before selecting the STORE mode, then slowly increase the intensity level for the desired display brightness. Careful adjustment of the Focus adjustment at the desired brightness will give the maximum storage writing rate.

NOTE

A high intensity level in the STORE mode will cause the display to spread and may flood the CRT screen.

Slight re-adjustment of the FOCUS may be necessary when changing the intensity level in NONSTORE operation. To protect the CRT phosphor, do not turn the INTENSITY higher than necessary to provide a satisfactory display. Also, be careful that the INTENSITY control is not set too high when changing from a fast to a slow sweep rate, or when changing to the X-Y mode of operation.

GRATICULE

The graticule of the 214 is internally marked on the faceplate of the CRT to provide accurate, parallax-free measurements. The graticule is marked with six vertical and ten horizontal divisions. Each major division is divided into five minor divisions at the center vertical and horizontal lines. The vertical gain and the horizontal timing are calibrated to the graticule so that accurate measurements can be made directly from the CRT display.

CRT CARE

The following precautions will prolong the useful Storage life of the CRT screen in the 214:

1. Use the minimum beam intensity required to produce a clear, well-defined display. A too-high beam intensity may permanently damage the CRT screen, particularly if a bright spot is allowed to remain stationary on the display area.

2. Avoid the repeated use of the same area of the screen. If a particular display is being stored repeatedly, change the vertical position occasionally to use other portions of the display area.

3. Do not leave a Stored display on the screen when it is no longer needed.

4. Operate the instrument in the NONSTORE mode unless Storage is required.

SIGNAL CONNECTIONS

Two high-impedance signal probes are internally connected to the 214. These probes provide a 1 MΩ input impedance and a shielded input cable to prevent pickup of electrostatic interference. The vertical deflection factors can be read directly from the appropriate VOLTS/DIV switch (VAR in CAL detent).

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 214 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.

GROUNDING

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 probe. The ground clips on the attached probes provide the best ground. Also, a ground lead can be connected to the 214 chassis COMMON banana jack to establish a common ground with the signal source.

CAUTION

The 214 probe ground clips and the chassis COMMON input jack are electrically connected. Do not apply dissimilar voltage potentials to them. See Elevated Reference information under "Basic Applications".

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.

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

With AC coupling, 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 2 Hz (−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 that have low-frequency components. The AC coupling position provides the best display of signals with a DC component that is much larger than the AC component.

The GND positon 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, but not grounded, and the 214 input circuit is held at ground potential. This also allows precharging the input coupling capacitor to the average voltage level of the signal applied to the probe.

The GND position is used to precharge the input coupling capacitor. 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.

INSTRUMENT FAMILIARIZATION

VERTICAL CHANNEL SELECTION

Either of the input channels can be used for single-trace displays. Select the desired channel via the VERT MODE switch and apply the signal to the appropriate probe. Controls for each channel are color-coded to the tip of the appropriate probe. For dual-trace operation, set the VERT MODE switch to BOTH and connect the signals to both input probes and adjust the channel POS controls to display the signals. In SINGLE SWP mode with the VERT MODE switch set to BOTH, only one channel will be displayed for each RESET actuation.

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, the attenuation factor, and the setting of the appropriate VOLTS/DIV switch and VAR control. The calibrated deflection factors indicated by the VOLTS/DIV switch apply only when the VAR VOLTS/DIV control is set to the CAL detent.

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

TRIGGER SOURCE

The TRIG SOURCE switch allows for selectivity in determining the source of the signal used to trigger the sweep. For most applications, the sweep can be triggered internally. In the COMP position, the trigger signal is obtained from the the vertical deflection system after the vertical switching has occurred. Therefore, in the dual-trace mode of operation, the display will be triggered on the vertical chopping signal and not necessarily on the selected slope of the LEVEL/SLOPE control. In this position, the 214 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 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. The display will trigger 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 TRIG SOURCE switch in the CH 2 position.

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 to the left 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 to the right of the control). Since the 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, the correct setting 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.

AUTO PRESET

The AUTO PRESET position 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 NORM sweep mode.

NOTE

In Dual-channel operation at a setting of 1 mV/Div, a bright baseline may not appear in Auto-Preset mode.

STORAGE OPERATION

The Storage feature greatly increases the versatility of the 214. The instrument can be operated as a conventional oscilloscope or, with the STORE button depressed, a display can be retained for further analysis.

When the Stored display is no longer desired, the informaton is erased by a waveform initiated by the momentary-contact ERASE button.

To change from the NONSTORE to the STORE mode of operation use the following procedure:

NOTE

It is necessary to readjust the INTENSITY control for optimum display when changing between NONSTORE and STORE operating modes. See Intensity Control information. To get the maximum storage writing rate the Focus adjustment must be adjusted for the desired intensity setting.

1. Turn the intensity level down for no visible display.

2. Depress the STORE button. The CRT screen will be flooded positive.

3. Press and release the ERASE button.

4. Increase the INTENSITY for a well-defined, Stored display. Too much intensity will cause the Stored trace to spread and may flood the CRT screen.

5. Press and release the ERASE button if new information is to be Stored.

6. Press and release the STORE button for normal NONSTORE operation. Increase the INTENSITY.

SWEEP MODE

AUTO

In the AUTO PRESET position of the LEVEL/SLOPE control the sweep is effectively in the AUTO sweep mode. In this position the sweep generator free runs at the sweep rate selected by the SEC/DIV switch, in the absence of an adequate trigger signal, to produce a reference trace. When an adequate trigger signal is applied, the free-running condition ends and the sweep generator is triggered on the preset level to produce a stable display.

NORM

Operation out of the AUTO PRESET position produces the NORM sweep mode, and is the same as in the AUTO PRESET position with a trigger signal applied. However, when no trigger signal is present, the sweep generator remains off and there is no display.

Use the NORM sweep mode to display signals with repetition rates below 7 Hz. This mode provides an indication of an adequate trigger signal as well as the correctness of trigger control setting, since there is no display without proper triggering.

SINGLE SWEEP

When the signal to be displayed is not repetitive or varies in amplitude, shape, or time, a conventional repetitive display may produce an unstable presentation. To avoid this, use the Single Sweep feature of the 214.

To use the Single Sweep mode, first make sure the trigger circuit will respond to the event to be displayed. Set the LEVEL/SLOPE control out of the AUTO PRESET position to obtain the best possible display (for random signals, set the trigger circuit to trigger on a signal that is approximately the same amplitude and fequency as the random signal). Then, push the SINGLE SWP button and press the RESET button. When the RESET button is pressed and released, the next trigger pulse initiates the sweep and a single trace will be presented on the CRT. When the VERT MODE switch is set to BOTH, only one channel will be displayed for each RESET actuation. After this sweep is completed, the sweep generator is "locked out" until reset. The READY light is illuminated when the sweep generator has been reset and is ready to produce a sweep. To prepare the circuit for another Single Sweep display, press the RESET button again.

ENHANCEMENT—The Automatic Enhance feature of this instrument provides a means of Storing Single Sweep displays that exceed the normal writing speed of the CRT. Automatic Enhance occures at 0.1 ms/div and faster sweep rates. During Single Sweep, a short-duration pulse is applied to the Storage screen to briefly increase the Storage level of the CRT.

NOTE

Repeated enhanced traces may cause the complete CRT screen to become stored.

HORIZONTAL SWEEP RATE

The SEC/DIV switch provides 16 calibrated sweep rates ranging from 500 ms/div to 5 μs/div (VAR HORIZ MAG control set to CAL). The VAR HORIZ MAG control provides continuously variable sweep magnificaton to at least five times the sweep rate indicated by the SEC/DIV switch.

When making measurements from the graticule, the area between the first-division and ninth-division vertical lines provides the most linear measurement (see Fig. 4). Therefore, the first and last divisions 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 that the end of the timing area falls between the first- and ninth-division vertical lines.

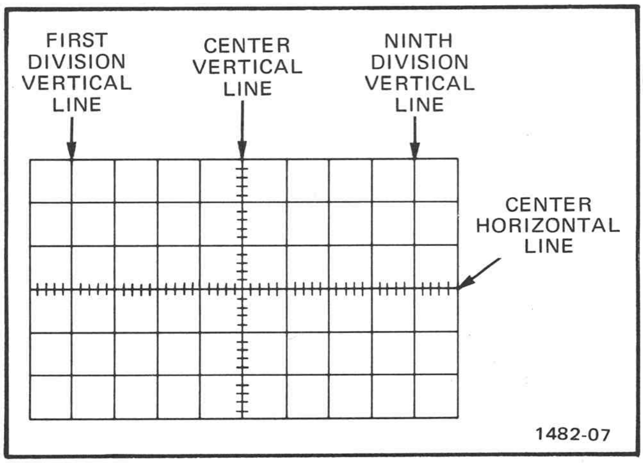

Fig. 4. Definition of measurement lines on 214 graticule.

X-Y OPERATION

Some applications require displaying 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) singal is connected to the input of CH 2. The X (horizontal) signal is applied to the input of CH 1 (EXT HORIZ) and has a deflection range from less than 1 mV to 50 V/div at a reduced bandwidth of 50 KHz.

Since the X and Y channels of the 214 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 verify the operation and accuracy of your instrument, perform the following check and adjustment procedures before making a measurement. Move the power switch to the (ON) position and allow the instrument to warm-up before performing any of the following checks. Warm-up time required is at least five minutes to meet all the instruments' specifications.

If adjustments are required beyond the scope of these operator's checks and adjustments, refer the instrument to a qualified service technician for calibration.

EQUIPMENT REQUIRED

The equipment listed in Table 1, or the equivalent is required to complete these checks and adjustments.

Table 1
Test Equipment

Description	Minimum Specification
Calibration Generator	Standard-amplitude signal levels: 20 mV to 100 V. Accury ±0.3%. Fast-rise signal level, 100 mV to 50 V; Repetition rate, 1 kHz. Rise-time, 100 ns or less; Aberration, ±0.5%.
Leveled Sine-Wave Generator	Frequency, 50 kHz to at least 500 kHz. Output amplitude, variable from 5 mV to 0.2 V p-p. Output impedance, 50 Ω. Amplitude accuracy, constant within 1% of reference frequency as output frequency changes.
Adapter	Connector, probe tip to BNC.

VERT GAIN CHECK

1. Set the VERT MODE switch to CH 1.

2. Connect the CH 1 probe tip to an accurate 20 mV generator.

3. Set the Trigger controls for a stable display.

4. Set the CH 1 VOLTS/DIV switch to 5 mV (VAR VOLTS/DIV to CAL)

5. Check for exactly four divisions of deflection.

6. Set the VERT MODE switch to CH 2 and repeat steps 2 through 5 for Channel 2.

7. Disconnect the probe from the generator.

STEP ATTENUATOR BALANCE

1. Set the VERT MODE switch to CH 1.

2. Set the TRIGGER/SLOPE to Auto Preset.

3. While switching the CH 1 VOLTS/DIV switch between the 50 mV and 1 mV positions, adjust the CH 1 STEP ATTEN BAL for minimum trace shift between adjacent positions.

4. Set the VERT MODE switch to CH 2.

5. While switching the CH 2 VOLTS/DIV switch between the 50 mV and 1 mV positions, adjust the CH 2 STEP ATTEN BAL for minimum trace shift between adjacent positions.

HORIZONTAL GAIN CHECK

1. Set the SEC/DIV switch to X-Y.

2. Connect the CH 1 probe tip to an accurate 0.2V generator.

3. Set the CH 1 VOLTS/DIV switch to 50 mV (VAR VOLTS/DIV to CAL).

4. Set the CH 2 POS control to midrange to display two dots.

5. Check for exactly four divisions of deflection between dots.

HORIZONTAL TIMING CHECK

1. Set the VERT MODE switch to CH 1.

2. Connect the CH 1 probe tip to an accurate time-mark generator.

3. Set the SEC/DIV switch to 1 ms (VAR HORIZ MAG in CAL).

4. Set the Time-mark generator to 1 ms time markers.

5. Check for exactly eight divisions of deflection between the second and tenth time markers (one time marker/division). Adjust the SWP CAL adjustment if necessary.

6. Disconnect the probe from the generator.

FOCUS

1. Set the SEC/DIV switch to X-Y.

2. Set the INPUT COUPLING switches to GND.

3. Adjust the FOCUS for optimum focus of the CRT display (a single dot). To obtain the maximum storage writing rate the Focus Adjustment must be adjusted for the desired intensity setting.

AUTO PRESET

1. Set the VERT MODE switch to CH 2.

2. Connect the CH 2 probe tip to a 1 kHz sine-wave signal generator.

3. Set the LEVEL/SLOPE control to the AUTO PRESET position.

4. Adjust the CH 1 VOLTS/DIV switch and the SEC/DIV switch for a display approximately four divisions in amplitude, with one cycle of signal displayed every two or three divisons.

5. Vertically center the display about the center horizontal line, using the CH 1 POS control.

6. Adjust the AUTO PRESET adjustment so that the CRT display starts on the center horizontal graticule line.

7. Disconnect the probe from the generator.

BASIC 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 that are not described in this manual. Contact your local Tektronix Field Office or representative for assistance in making specific measurements with the 214 Storage Oscilloscope.

VOLTAGE MEASUREMENTS

NOTE

Store Single Sweep operation will give a more usable display for measurement if the signal is non-repetitive or varies in amplitude, frequency, or shape. See Random Signal Measurement application.

AC SIGNALS

1. Set the INPUT COUPLING switch to GND and the VOLTS/DIV switch to an appropriate setting (VAR VOLTS/DIV to CAL). Vertical deflection factor equals the product of the VOLTS/DIV setting and the probe attenuator, the vertical deflecton factor can be read directly from the VOLTS/DIV switch (VAR VOLTS/DIV in CAL). Connect the probe tip to the signal source and switch the INPUT COUPLING to the AC position.

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

3. Measure the peak-to-peak amplitude of the display or waveform, in graticule divisions (see Fig. 5).

4. Voltage (peak-to-peak) equals measured amplitude in divisions, multiplied by the vertical deflection factor (VOLTS/DIV times probe attenuation factor).

NOTE

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

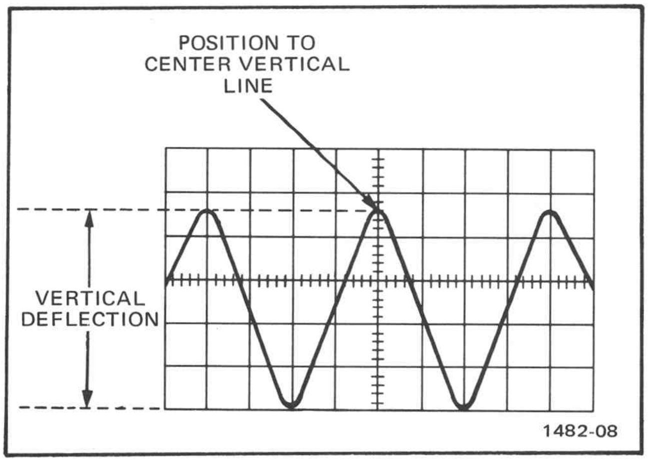

Fig. 5. Measuring peak-to-peak voltage.

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.

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

2. 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 POS control after the reference has been set.

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

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

5. Voltage equals measured amplitude (in divisions), multiplied by the deflection factor.

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 deflecton factor conversion constant, based on a specific reference amplitude, is established as follows:

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

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

3. Deflection factor conversion constant equals:

$$\frac{\text{Reference Signal Voltage}}{\begin{matrix}\text{Volts/Div} \\ \text{Setting}\end{matrix} \quad \text{X} \quad \begin{matrix}\text{Display Amplitude} \\ \text{(in divisions)}\end{matrix}}$$

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

5. 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.

$$\text{Signal Amplitude} = \begin{matrix}\text{Adjusted} \\ \text{deflection} \\ \text{factor}\end{matrix} \quad \text{X} \quad \begin{matrix}\text{Signal} \\ \text{deflection} \\ \text{(in divisions)}\end{matrix}$$

Elevated Reference. When making a voltage measurement with respect to a voltage level other than ground, connect the 214 probe ground clip directly to the desired reference voltage.

CAUTION

The 214 probe ground clips and the instrument COMMON input jack are electrically connected. Do not apply dissimilar voltage potentials to them.

This method of establishing a floating reference can be used when the oscilloscope is connected to a power line, as long as 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

The time interval between two or more events can be measured directly on the graticule as follows:

NOTE

See the topic entitled HORIZONTAL SWEEP RATE concerning nonlinearity of the first and last divisions of display.

1. Using the graticule, measure the horizontal distance between the two events (see Fig. 6).

2. Multiply the distance measured by the SEC/DIV switch setting to obtain the time interval. The VAR HORIZ MAG must be in the CAL detent position.

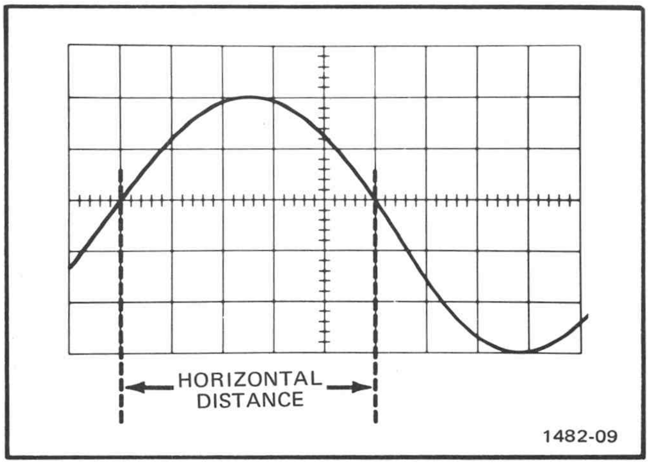

Fig. 6. Measuring the time duration between points on a waveform.

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 0.5 ms, the frequency is:

$$\frac{1}{0.5\ \text{ms}} \quad \text{or} \quad 2\ \text{kHz}$$

To calculate the period of a known frequency:

$$\text{Period} = \frac{1}{\text{Frequency}}$$

RISETIME MEASUREMENTS

Risetime measurement techniques are similar to those of time-duration measurements. The basic difference is the points between which the measurement is made. The following procedure gives the basic method of measuring risetime between the 10% and 90% points of the waveform. Falltime can be measured in the same manner on the trailing edge of the waveform.

1. Connect either probe tip to the signal source. Use the probe ground clip to establish a common ground.

2. Set the appropriate VOLTS/DIV and VAR controls to produce a display of exactly six divisions in amplitude.

3. Vertically center the display on the graticule and set the Trigger controls for a stable display.

4. Set the SEC/DIV switch to the fastest sweep rate that displays less than eight divisions between the 10% and 90% points of the waveform. Determine the 10% and 90% points on the rising portion of the waveform.

5. Adjust the horizontal POS control to move the 10% point of the waveform to the first graticule line. For example, with a five-division display, as shown in Fig. 8, the 10% point is 0.5 division up from the start of the rising portion.

6. Measure the horizontal distance between the 10% and 90% points (VAR HORIZ MAG in CAL).

7. Multiply the distance measured in step 6 by the setting of the SEC/DIV switch.

$$\begin{matrix}\text{Risetime} \\ \text{(Time Duration)}\end{matrix} = \begin{matrix}\text{Horizontal distance} \\ \text{(in divisions)}\end{matrix} \times \begin{matrix}\text{SEC/DIV} \\ \text{setting}\end{matrix}$$

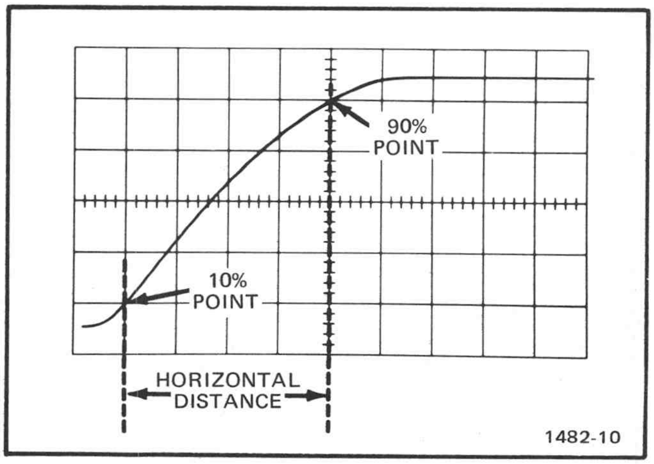

Fig. 7. Measuring risetime.

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 VAR HORIZ MAG. Adjust the span of a reference waveform so that one cycle covers a given number of divisions. (Figure 5 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.

When making phase measurements, maintain a constant amplitude point on the triggering signal so that the two input signals are compared indirectly to this reference, and directly to each other. The trigger signal must have sufficient amplitude to ensure 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, no change is made during any phase measurement.

The amplitude of the display should be large to improve accuracy of the measurement. 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 214.

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

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

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

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

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

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

$$\text{Phase Difference} = \begin{array}{c}\text{Distance}\\ \text{(in divisions)}\end{array} \times \frac{45^\circ}{\text{Division}}$$

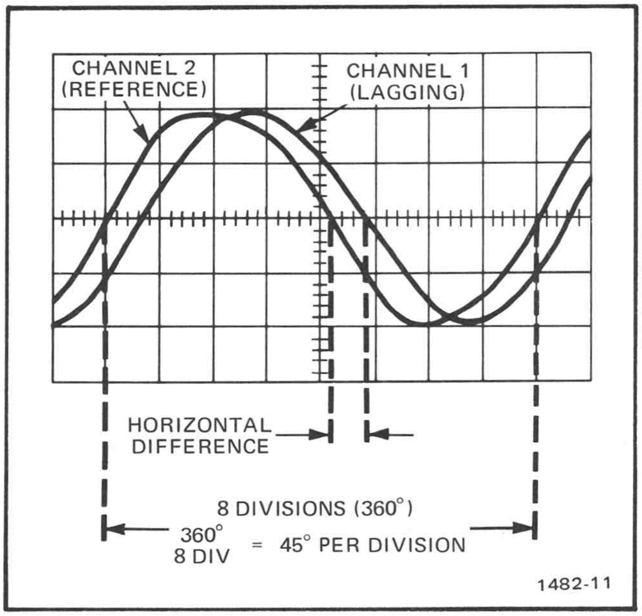

Fig. 8. Measuring phase difference.

RANDOM SIGNAL MEASUREMENTS

Many electrical events occur randomly or are separated by long time intervals. Use the Single Sweep Storage mode of the 214 when evaluating these events.

NOTE

It is necessary to readjust the INTENSITY control for optimum display when changing between NONSTORE and STORE operating modes. See Intensity Control information.

1. Connect the CH 2 probe tip to the signal source. Establish a common ground between the 214 and the signal source.

2. Set the CH 2 VOLTS/DIV switch and the SEC/DIV switch to settings appropriate for the expected waveforms.

3. Set the TRIG SOURCE switch to CH 2 and the LEVEL/SLOPE control out of the AUTO PRESET position.

4. Depress the SINGLE SWP button.

5. Depress the STORE button. After the CRT screen becomes fully flooded, press and release the ERASE button.

6. Press and release the RESET button. Check that the READY light turns on.

When the next event occurs, the sweep will run once, leaving the display Stored on the CRT. Re-adjustment of the CH 2 VOLTS/DIV, SEC/DIV, INTENSITY, and triggering controls may be necessary to obtain a satisfactory display.

LOW-FREQUENCY SIGNALS

Many electrical events are separated by long time intervals. The persistence of the CRT phosphor may not allow a comparison between the start of the display and the end of the display. Use the Storage mode or the Single Sweep Storage mode of the 214 for evaluating these events.

1. Obtain the desired waveform (display).

2. Depress the STORE button; after the CRT screen becomes fully flooded, press and release the ERASE button. This is the storage mode.

NOTE

It is necessary to readjust the INTENSITY control for optimum display when changing between NONSTORE and STORE operating modes. See Intensity Control information. To get the maximum storage writing rate the Focus adjustment must be adjusted for the desired intensity setting.

3. Depress the SINGLE SWEEP button for only one sweep.

4. Press and release the RESET button. Check that the ready light turns on. When the next event occurs, the sweep will run once, leaving the display stored on the CRT screen. Readjustment of INTENSITY control or the Focus adjustment may be necessary to obtain a satisfactory display.

OPTIONS

There are presently two options for the 214. A brief description is given in the following discussions. For further information about instrument options, see your Tektronix Catalog or contact your Tektronix Field Office or representative.

OPTION 1

Option 1 equips the 214 for operation from a 220 V to 250 V nominal ac-power-input source at a line frequency from 48 Hz to 52 Hz. This option does not affect the basic instrument operating instructions presented in this manual.

OPTION 2

Option 2 equips the 214 for operation from a 90 V to 110 V nominal ac-power-input source at a line frequency from 48 Hz to 52 Hz. This option does not affect the basic instrument operating instructions presented in this manual.

SPECIFICATION

The TEKTRONIX 214 Storage Oscilloscope is a portable 500-kHz instrument that combines small size and light weight with the ability to make precision waveform measurements. It is designed for general-purpose applications where display storage is desired, along with conventional (NONSTORE) operation.

PERFORMANCE CONDITIONS

This instrument will meet the following electrical characteristics (Table 2) after complete calibration. These characteristics apply over an ambient temperature range of −15°C to +55°C (+5°F to +131°F) when operating from the internal batteries, and 0°C to +40°C (+32°F to +104°F) when operating from an AC line source, except as otherwise indicated. Warm-up time for given accuracies is at least 5 minutes.

Table 2
Specifications

<table>
<tr><th>Characteristics</th><th colspan="2">Performance Requirements</th></tr>
<tr><td colspan="3">VERTICAL DEFLECTION SYSTEM</td></tr>
<tr><td>Deflection Factor</td><td colspan="2"></td></tr>
<tr><td>Range</td><td colspan="2">1 mV/DIV to 50 V/DIV in a 1-2-5 sequence of 15 steps.</td></tr>
<tr><td>Accuracy</td><td colspan="2">Within ±5% with VAR VOLTS/DIV control in CAL position and gain correctly set at 5 mV/div.</td></tr>
<tr><td>Variable Range</td><td colspan="2">Continuously variable between calibrated settings. Extends maximum deflection factor to at least 125 V/div.</td></tr>
<tr><td rowspan="6">Frequency Response</td><td colspan="2">Six-division, 5-kHz reference signal, with VAR VOLTS/DIV control in calibrated detent.</td></tr>
<tr><td>VOLTS/DIV Setting</td><td>Frequency Response</td></tr>
<tr><td>1 mV/DIV</td><td>DC to 100kHz</td></tr>
<tr><td>2 mV/DIV</td><td>DC to 200kHz</td></tr>
<tr><td>5 mV/DIV</td><td>DC to 400kHz</td></tr>
<tr><td>10 mV/DIV to 50 V/DIV[b]</td><td>DC to 500kHz</td></tr>
<tr><td>AC Coupled Lower Bandwidth</td><td colspan="2">Approximately 2 Hz.[a]</td></tr>
<tr><td>Input Resistance</td><td colspan="2">1 MΩ ±5%.[a]</td></tr>
<tr><td>Input Capacitance</td><td colspan="2"></td></tr>
<tr><td>1 mV/DIV to 50 mV/DIV</td><td colspan="2">Approximately 160 pF.[a]</td></tr>
<tr><td>100 mV/DIV to 50 V/DIV</td><td colspan="2">Approximately 140 pF.[a]</td></tr>
</table>

[a] **Performance Requirement not checked in manual.**

[b] **Performance Requirement not checked in manual above 10 mV/DIV.**

Table 2
Specifications

Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM (cont)	
Maximum Input Voltage	
50 V/DIV to 0.1 V/DIV	600 V (DC + peak AC).[a] 600 V peak-to-peak AC (5 MHz or less).[a]
50 mV/DIV to 1 mV/DIV	600 V (DC + peak AC).[a] 600 V peak-to-peak AC (not over 2 kHz or a risetime ⩾100 nS).[a]
Chopped Mode	From 500 mS/DIV to 2 mS/DIV of time rate at approximately 50 kHz.[a]
Alternate Mode	From 1 mS/DIV to 5 μS/DIV of time rate.[a]
Input Impedance Matching	To within 10%.
TRIGGERING SYSTEM	
Trigger Sensitivity	
Internal	
COMP	0.2 division from DC to 500 kHz.
CH 2	0.2 division from 2 Hz to 500 kHz.
External	At least 1 V from DC to 500 kHz.
Preset Trigger Level	Triggered at preset level on positive slope of triggering signal. Sensitivity same as stated above
Display Jitter	0.5 μS or less at 500 kHz.[a]
External Trigger	
Input Resistance	Approximately 1 MΩ.[a]
Input Capacitance	Approximately 30 pF.[a]
Maximum Usable Input Voltage	8 V (DC + peak AC). 16 V peak-to-peak AC (500 kHz or less).[a]

[a] Performance Requirement not checked in manual.

Table 2
Specifications

Characteristics	Performance Requirements
HORIZONTAL DEFLECTION SYSTEM	
Sweep Rate	
Calibrated Range	500 mS/div to 5 μS/div in a 1-2-5 sequence of 16 steps
Accuracy	Within 5% with VAR HORIZ MAG control in CAL position measured over the center 8 divisions (disregard 1st 0.5 μS of sweep length).
Linearity	Within 5% over any 2 divisions within the center 8 divisions (disregard 1st 10% of total sweep length).
Variable Magnifier	Continuously variable between calibrated settings. Extends maximum sweep rate to at least 1 μS/div.
CH 1 Horizontal Input	
Calibrated Deflection Factor	1 mV/div to 50 V/div.
Variable	At least 5 times magnification (using VAR HORIZ MAG).
Accuracy	Within 10% (with VAR HORIZ MAG in CAL).
X-Y Phasing	Less than 3° to 5 kHz.[a]
Maximum Input Voltage	Same as for CH 1 (vertical).[a]
DISPLAY	
Graticule	
Type	Internal Black line, non-illuminated.[a]
Area	6 divisions vertical by 10 divisions horizontal.[a] Each division equals 0.203 inch.
Phosphor	P31 standard.
ISOLATION	
Input Common to 214 Case Exterior	Maximum floating potential between input common and 214 case exterior is not to exceed 500 V RMS sinusoidal or 700 V (DC + peak AC). (When battery operated with AC power plug secured in the insulated cover.)[a]
Input Common to AC Line	Maximum floating voltage plus AC line voltage is not to exceed 250 V RMS sinusoidal, or 1.4 times the AC line voltage plus (DC + peak AC) not to exceed 350 V.[a]

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[a] **Performance Requirement not checked in manual.**

Table 2
Specifications

Characteristics	Performance Requirements
AC OPERATION	
Line Voltage Range	
Stored Mode	110 V to 126 V AC. Batteries can not be charged during AC operation. Instrument can be operated between 104 V and 110 V with a resulting slow discharge of internal batteries.[a]
Line Frequency	58 to 62 Hz.
Maximum Power Comsumption	3 watts or less at 126 V, 60 Hz.[a]

INTERNAL BATTERIES

Batteries	10 rechargeable A size, nickel-cadmium cells.[a]
Charge Time	
From AC Line	8 hours for full charge (instrument off during charge cycle).[a]
Power (Battery) Indicator	When extinguished indicates approximately 5 minutes of scope operating life left in the batteries.
Battery Excessive Discharge Protection	Instrument operation automatically interrupted when battery charge drops to 10 V, ±0.5 V.[a]
Typical Operating Time	At maximum trace intensity after full charge cycle at +20°C to +30°C.
Nonstore Mode	3.5 to 5 hours. Longest operating time provided at lower trace intensity.[a]
Store Mode	2.5 to 3.5 hours. Longest operating time provided at lower trace intensity.[a]
Typical Charge Capacity	In reference to charge/discharge at +20°C to +30°C (+68°F to +86°F). See chart below.[a]

[a] Performance Requirement not checked in manual.

Typical Charge Capacity

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%

Table 2
Specifications

Characteristics	Performance Requirements
ENVIRONMENTAL	
Temperature	
Operating from Batteries	−15°C to +55°C (+5°F to +131°F)
Operating from AC Line	0°C to +40°C (+32°F to +104°F)
Non-Operating	−40°C to +60°C (−40°F to +140°F)
Altitude	
Operating	To 25,000 ft. Maximum operating temperature decreased by 1°C per 1,000 ft above 15,000 ft.
Non-Operating	To 50,000 ft.
Humidity	
Operating and Non-operating	5 cycles (120 hours) to 95% relative humidity in reference to MIL-E-16400F.
Shock	
Operating and Non-operating	Tested with 2 shocks at 150 g, one-half sine, 1 mS duration each direction along major axes.
PHYSICAL	
Weight (without accessories)	3.5 lb (1.6 kg).
Dimensions (measured at maximum points)	
Height	3.0 in (7.6 cm).
Width	5.25 in (13.2 cm).
Depth	9.5 in (24.1 cm).