5223
Digitizing Oscilloscope
Operators Manual

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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, but may 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.

AS MARKED ON EQUIPMENT

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, 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


Static-Sensitive Devices.


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

AS MARKED ON EQUIPMENT


DANGER—High voltage.


Protective ground (earth) terminal.


ATTENTION—refer to manual.

WARNINGS

POWER SOURCE

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

USE THE PROPER POWER CORD

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition.

For detailed information on power cords, refer to Section 1 General Information.

Refer cord and connector changes to qualified service personnel.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating), can render an electric shock.

USE THE PROPER FUSE

To avoid fire hazard, use only the fuse specified in the parts list for your product, and which is identical in type, voltage rating, and current rating.

Refer fuse replacement to qualified service personnel.

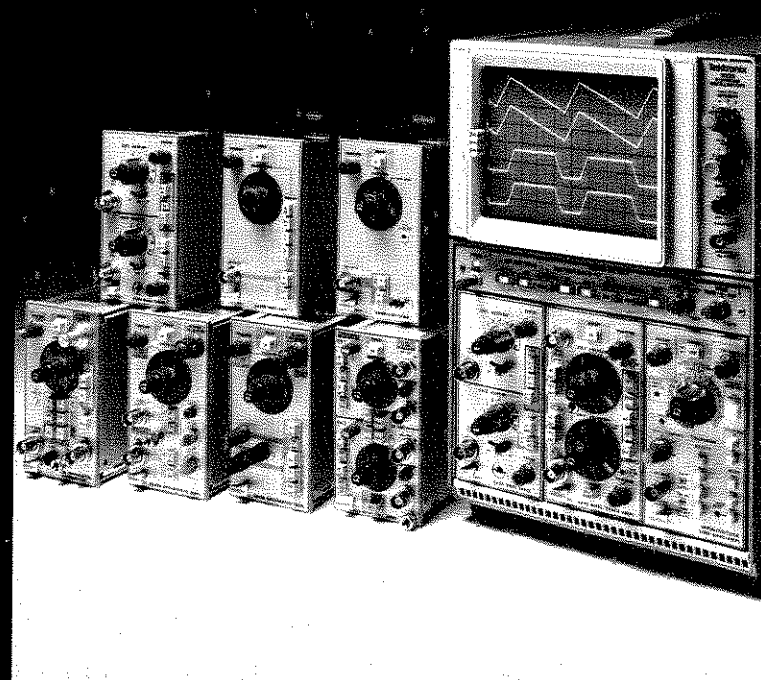
DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an atmosphere of explosive gases unless it has been specifically certified for such operation.

DO NOT REMOVE COVERS OR PANELS

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

5223



General Information

INTRODUCTION

The 5223 Digitizing Oscilloscope will simplify your measurement tasks through easy-to-use digital storage. The ease of use centers around the storage-related MEMORY CONTENTS controls arranged in a horizontal row just above the plug-in compartments. To capture and digitize a signal, you simply press the DISPLAY button that corresponds to the vertical compartment you are working with (left or right), then press the SAVE button. The SAVE button stores the displayed waveform in memory for future viewing and analysis.

In summary, the 5223 offers ease of use through advantages found only with digital storage.

GENERAL INFORMATION

This section contains a description of the instrument, a brief description of the Service manual, information on instrument installation, packaging for shipment, instrument conversion, rackmount information, specifications and standard accessories.

The Specifications portion includes three tables that list the 5223's Characteristics (Electrical, Environmental, and Physical); a Standard Accessories list, and full-page Dimensional Drawing.

5223 DESCRIPTION

The TEKTRONIX 5223 Digitizing Oscilloscope is a digital storage instrument with a real-time bandwidth of 10 megahertz. The 5223 is capable of displaying real-time and stored waveforms simultaneously (four real-time waveforms and four stored waveforms, if dual channel amplifier units are used); the real-time waveforms need not be related to the stored waveforms. Stored waveforms can be expanded vertically and horizontally by a factor of 10, using front-panel controls. The left and right stored vertical signals can be displayed against each other in the X-Y mode, using the L VS R front-panel display function. The roll mode is useful when viewing low-frequency signals. Rear-panel connectors provide access to the internal analog and control signals to record stored waveforms using associated equipment (i.e., X-Y plotter). The 5223 accepts most 5000-series plug-in units; the flexibility of the plug-in feature, and variety of plug-in units available, allows the system to be used for many measurement applications.

SERVICE MANUAL

The first two sections of the Service Manual contain information which is covered in the first three sections of the Operators Manual.

WARNING

The servicing instructions contained in the Service Manual are for use by qualified service personnel only. To avoid electric shock or other personal injury, do not perform any servicing unless you are qualified to do so.

Section 3—Theory of Operation contains basic and general circuit analysis that may be useful for servicing the instrument.

Section 4—Maintenance describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, subassemblies, and individual components.

Section 5—Calibration contains procedures to check the operational performance and electrical characteristics of the instrument. Procedures also include methods for adjustment of the instrument to meet specifications.

Section 6—Instrument Options contains a description of available options and locations of incorporated information for those options.

Section 7—Replaceable Electrical Parts contains information necessary to order replaceable parts and assemblies related to the electrical functions of the instrument.

Section 8—Diagrams and Circuit Board Illustrations includes detailed circuit schematics, locations of assembled boards within the instrument, voltage and

waveform information, circuit board component locators, and locations of adjustments to aid in performing the Adjustment and Performance Check portion of the Calibration procedure.

Section 9—Replaceable Mechanical Parts includes information necessary to order replaceable mechanical parts and shows exploded drawings which identify assemblies.

INSTALLATION

INITIAL INSPECTION

This instrument was inspected both mechanically and electrically before shipment. It should be free of mars or scratches and should meet or exceed all electrical specifications. To confirm this, inspect the instrument for physical damage incurred in transit and test the electrical performance by following the Operators Checkout Procedure in Section 2, Operating Instructions. Verify Performance Requirements by referring a qualified service person to the servicing sections of the Service Manual. If there is damage or deficiency, contact your local Tektronix Field Office or representative.

POWER CORD INFORMATION

WARNING

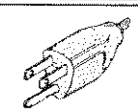
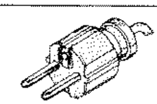
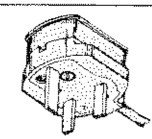
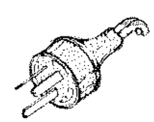
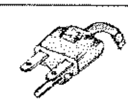
AC POWER SOURCE AND CONNECTION. This instrument operates from a single-phase power source. It has a three-wire power cord and a two-pole, three-terminal grounding-type plug. The voltage to ground (earth) from either pole of the power source must not exceed the maximum rated operating voltage, 250 volts.

Before making connection to the power source, determine that the instrument is adjusted to match the voltage and frequency of the power source, and has a suitable two-pole, three-terminal grounding-type plug. Refer any changes to qualified service personnel.

GROUNDING. This instrument is safety class I equipment (IEC designation). All accessible conductive parts are directly connected through the grounding conductor of the power cord to the grounding contact of the power plug.

The power input plug must only be inserted in a mating receptacle with a grounding contact. Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric shock hazard.

For electric shock protection, the grounding connection must be made before making connection to the instrument's input or output terminals.

Plug Configuration	Usage	Nominal Line-Voltage (AC)	Reference Standards	Option #
	North American 120V/15A	120 V	[1]ANSI C73.11 [2]NEMA 5-15-P [3]IEC 83	STANDARD
	Universal Euro 240V/10-16A	240 V	[4]CEE (7), II, IV, VII [3]IEC 83	A1
	UK 240V/13A	240 V	[5]BS 1363 [3]IEC 83	A2
	Australian 240V/10A	240 V	[6]AS C112	A3
	North American 240V/15A	240 V	[1]ANSI C73.20 [2]NEMA 6-15-P [3]IEC 83	A4

[1]ANSI—American National Standards Institute
[2]NEMA—National Electrical Manufacturer's Association
[3]IEC—International Electrotechnical Commission
[4]CEE—International Commission on Rules for the Approval of Electrical Equipment
[5]BS—British Standards Institution
[6]AS—Standards Association of Australia

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Figure 1-1. Power cord and plug identification information.

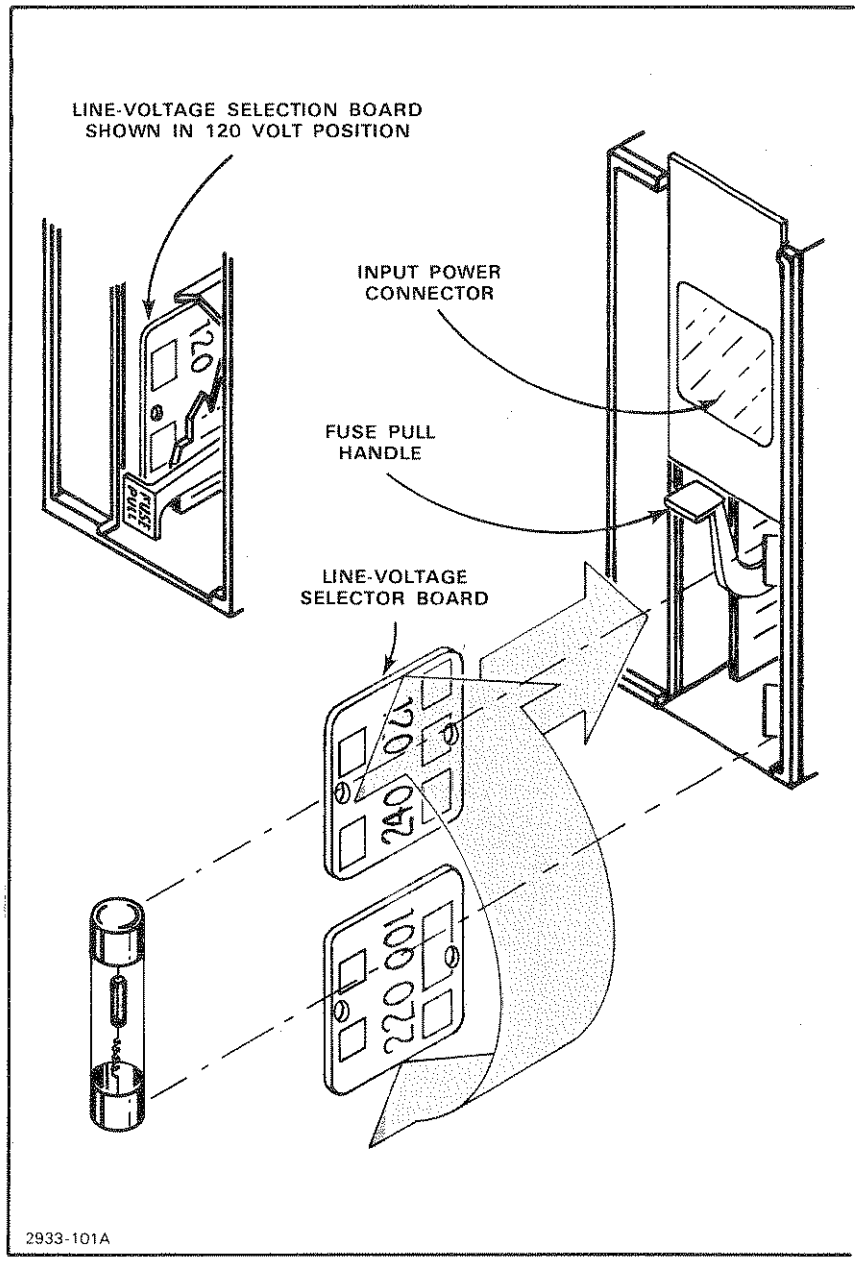

Figure 1-2. Line voltage range selection.

Line-Voltage Selection/ Fuse Replacement Procedure

1. Disconnect input power cable from instrument.
2. Slide plastic fuse cover up over power cord connector area.
3. Pull out on FUSE PULL handle and remove fuse.
4. Insert a scribe into the hole in the Line-Voltage Selector Board and remove.
5. Position Line-Voltage Selector Board for desired operation voltage (Selected operating voltage range will be displayed at top of Line-Voltage Selector Board when installed. See drawing.).
6. Push Line-Voltage Selector Board firmly into Input Power connector slot.
7. Return FUSE PULL handle to normal position.
8. See table on instrument rear panel, to select proper fuse and install in fuse holder.
9. Slide plastic fuse cover over fuse area.
10. Connect line power cord to instrument.
11. Set POWER Switch to ON.

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Figure 1-2 (cont). Line voltage range selection.

TABLE 1-1
Power-Cord Conductor Identification

Conductor	Color	Alternate Color
Ungrounded (Line)	Brown	Black
Grounded (Neutral)	Blue	White
Protective Grounding (Earthing)	Green-Yellow	Green-Yellow

The power-cord plug required depends upon the ac input voltage and the country in which the instrument is to be used. Should you require a power-cord plug other than that supplied with your instrument, refer to the Reference Standards listed in Figure 1-1.

LINE VOLTAGE AND REGULATING-RANGE SELECTION

CAUTION

To prevent damage to the instrument, always check the Line Voltage Selector Board (see Fig. 1-2) located on the rear of the instrument before connecting the instrument to the supply circuit.

The Line Voltage Selector Board allows selection of four line voltage ranges. To convert from one range to another, change the power cord and plug to match the power-source receptacle, then insert a scribe into the hole in the Line Voltage Selector Board and remove. Select the desired voltage range using the table printed on the rear of the instrument and insert the line voltage selector Board as shown in Figure 1-2.

OPERATING TEMPERATURE

The 5223 can be operated where the ambient air temperature is between 0° and +50° C and can be stored in ambient temperatures from −55° to +75° C. After storage at temperatures outside the operating limits, allow the chassis temperature to reach a safe operating limit before applying power.

The 5223 is cooled by air exhausted by the fan and drawn in through holes in the side, and bottom panels; additional air is drawn in through the top panel in the rackmount configuration. To ensure proper cooling of the instrument, maintain the clearance provided by the feet on the bottom and allow at least 2 inches clearance (more if possible) at the top, sides, and rear of the instrument.

OPERATING POSITION

Two stands, mounted on the bottom of the instrument at either side, permits the instrument to be tilted up about 10° for more convenient crt viewing.

INSTRUMENT DIMENSIONS

A drawing showing the major bench model and rackmount model dimensions of the instrument is shown if Figure 1-3 and 1-4.

PACKAGING FOR SHIPMENT

If this instrument is to be shipped for long distances by commercial transportation, it is recommended that the instrument be packaged in the original manner. The carton and packaging material in which your instrument was shipped should be saved and used for this purpose.

Also, if this instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following: Owner of the instrument (with address), the name of a person at your firm who can be contacted, complete instrument type and serial number, and a description of the service required.

If the original packaging is unfit for use or not available, package the instrument as follows:

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions; refer to Table 1-2 for carton test srength requirements.

TABLE 1-2
Shipping Carton Test Strength

Gross Weight (lb)	Carton Test Strength (lb)
0-10	200
10-30	275
30-120	375
120-140	500

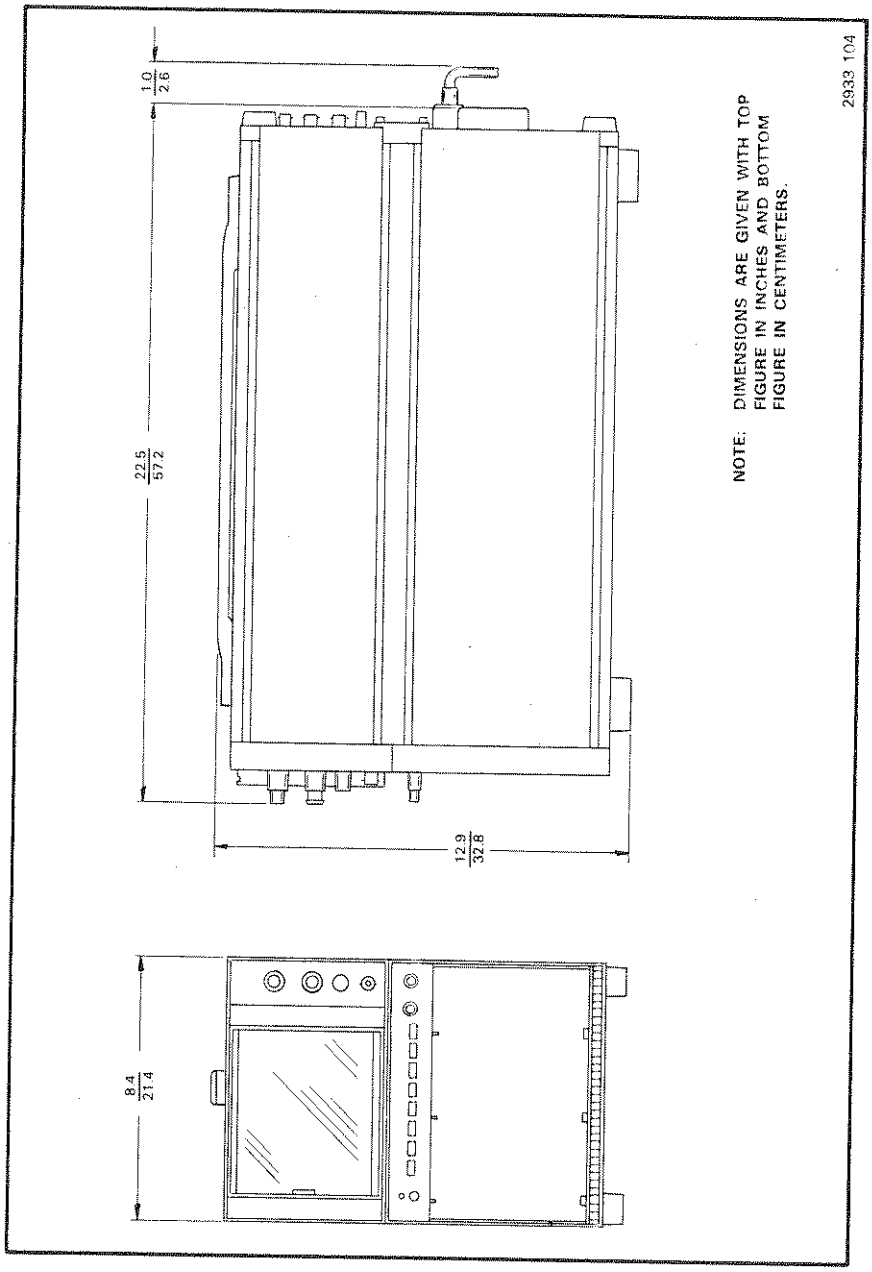

Figure 1-3. 5223 dimensional drawing.

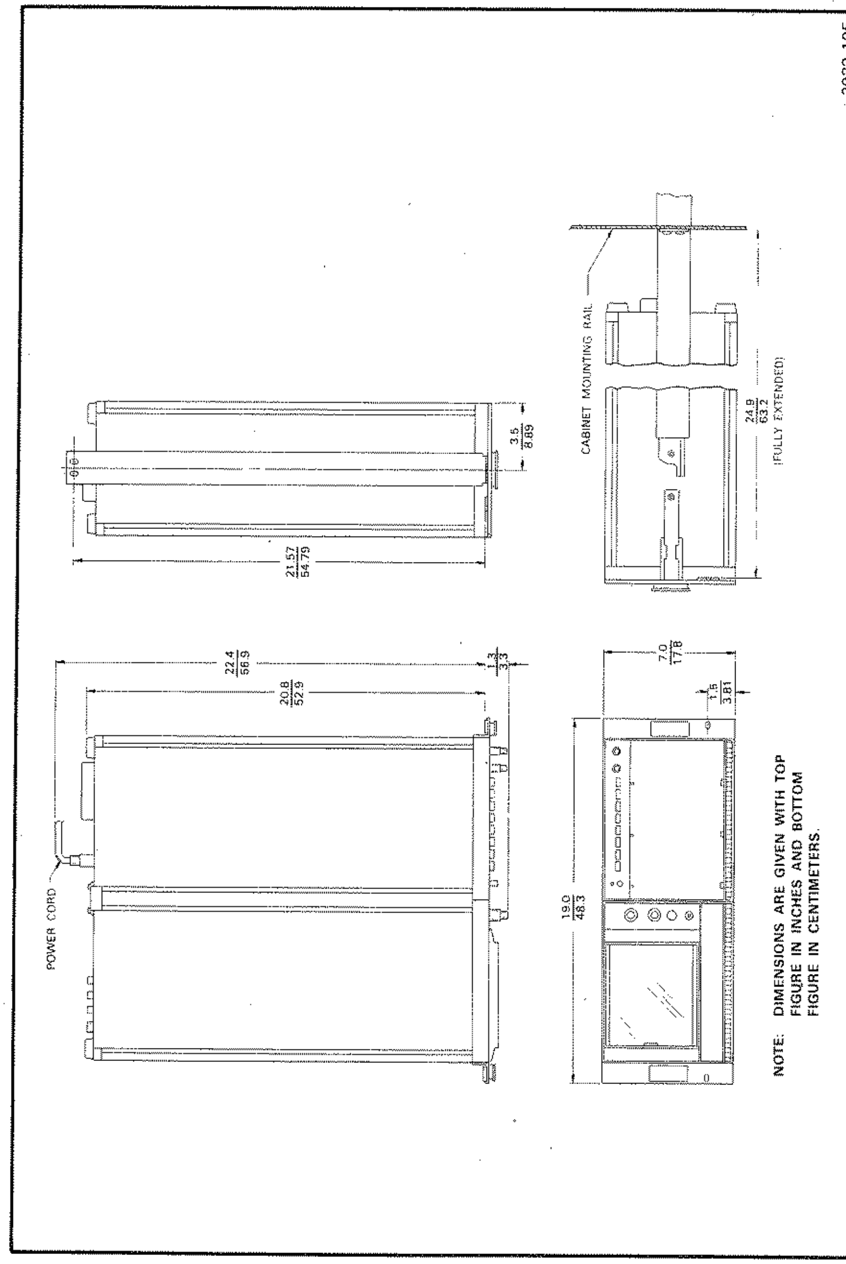

Figure 1-4. 5223 rackmount dimensional drawing.

2. Enclose the instrument with polyethylene sheeting or equivalent to protect the finish of the instrument.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing three inches on each side.

4. Seal the carton with shipping tape or with an industrial stapler.

5. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

INSTRUMENT CONVERSION

The 5223 acquisition module and the display module can be fastened together stacked or side by side; this permits operation as a bench oscilloscope, or in a standard 19-inch rack. The two modules can quickly be converted from a bench model to a rackmount model or vise versa. Refer field conversion to qualified service personnel.

RACKMOUNT INFORMATION

REMOVING OR INSTALLING THE INSTRUMENT

After initial installation and adjustment of the slide-out tracks, the instrument can be removed or installed by following the instructions given in Figure 1-5. No further adjustments are required under normal conditions.

SLIDE-OUT TRACK LUBRICATION

The special finish on the sliding surfaces of the tracks provides permanent lubrication. However, if the tracks require additional lubrication, a thin coat of paraffin can be rubbed onto the sliding surfaces.

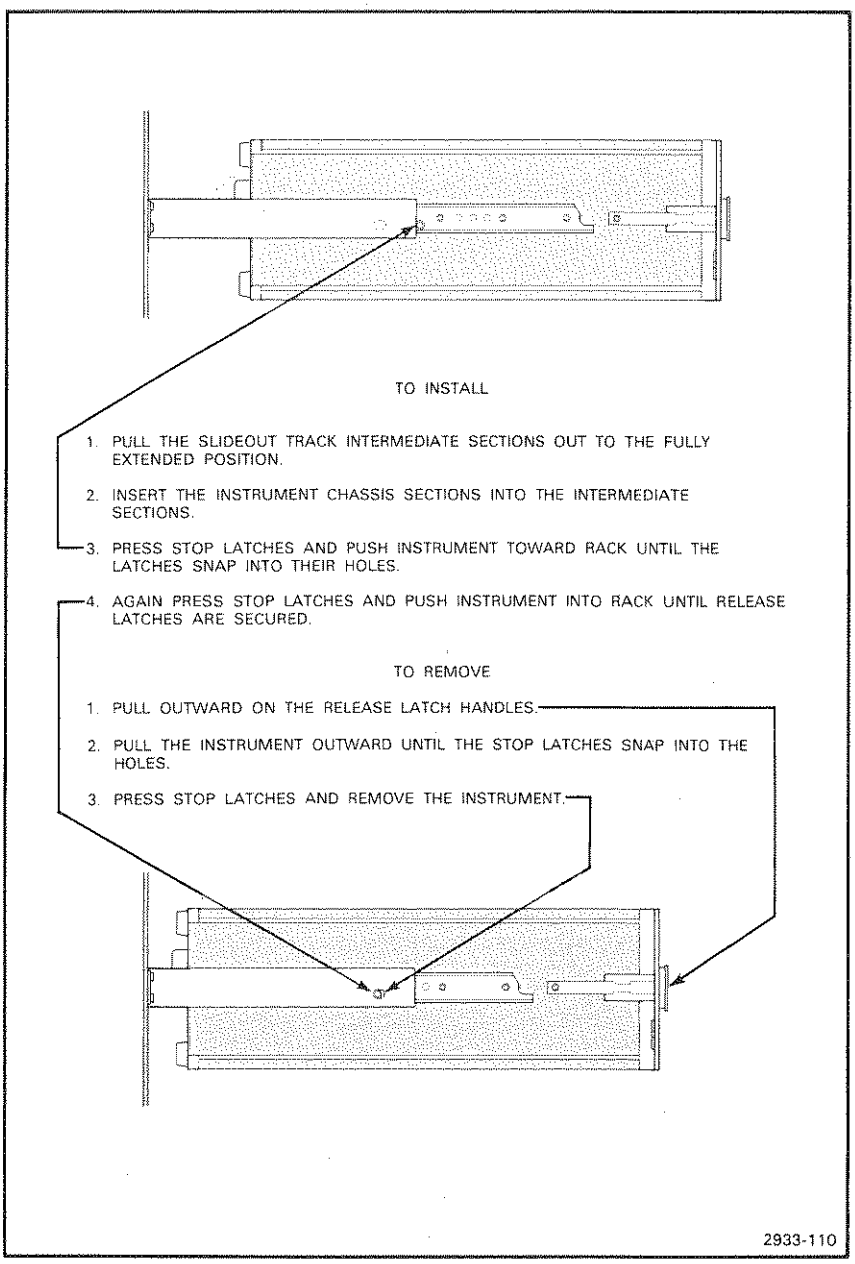

Figure 1-5. Installing and removing the instrument.

SPECIFICATION

The electrical characteristics listed in Table 1-3 apply when the following conditions are met: (1) Calibration of the instrument must have taken place at an ambient temperature between +20° and +30° C, (2) the instrument must be allowed a 20-minute warm-up period, (3) all specifications are valid at an ambient temperature of 0° to +50° C, unless otherwise stated, (4) the instrument must be in an environment that meets the limits described in Table 1-4.

Any applicable conditions not listed above are expressly stated as part of that characteristic. Environmental characteristics are listed in Table 1-4 and Physical characteristics are listed in Table 1-5. See Figures 1-3 and 1-4 for dimensional drawings.

TABLE 1-3
Electrical Characteristics

Characteristic	Performance Requirement
VERTICAL AND HORIZONTAL	
Bandwidth (With 067-0680-00 Calibration Fixture)	
Vertical	
Real Time and Stored	Dc to at least 12 MHz, with 8 div reference.
Horizontal	
Real Time	Dc to at least 7 MHz, with 8 div reference.
Maximum Horizontal Calibrated Sweep Rate	
Real Time	20 ns/div.
Vertical Aberrations	
Real Time and Stored	3% or less, peak-to-peak with display centered. (Both + and − 5 division steps from 067-0680-00 Calibration Fixture).

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TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
VERTICAL AND HORIZONTAL (Cont)	
Vertical Signal Accuracy (With 067-0680-00 Calibration Fixture)	
Real Time	±1%.
Stored	±3%.
Chart Output	200 mV/div ±5%.
DC Gain Match	
Real Time vs Stored Horizontally	Within ±2%.
Real Time vs Stored (With Calibrated 5B25N at 0.5 ms/div)	Within ±3%.
Left Vert vs Right Vert Real Time	Within ±1%.
Vertical Low Frequency Linearity	
Real Time, Stored and Chart Output	±0.2 div or less error over any two divisions of the graticule area (measured with 067-0680-00 in "Gain" position).
Horizontal Low Frequency Linearity	
Real Time	±0.15 div or less over any one division of center 8 divisions of the graticule area, when adjusted for no error on second and tenth graticule lines (measured with 067-0680-00).
Vertical Dynamic Range	
Right Vertical Stored	At least ±5 div.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
VERTICAL AND HORIZONTAL (Cont)	
Vertical Dynamic Range (cont)	
Left Vertical Stored	At least ±4 div.
Vertical Delay Line	
Real Time	Permits viewing leading edge of displayed waveform.
X-Y Operation	
Real Time	Less than 2 degrees phase shift, dc to 20 kHz, between horizontal compartment and either vertical compartment.
Left Vert vs Right Vert	
Stored (Single Channel only; except at 100 μs/div) with two 5A38's, 5A45's or 5A48's	Less than 5 degrees phase shift between vertical compartments at 10 MHz.
Vertical	
Digitizer Resolution	0.01 division (10 bits).
Maximum Digitizing Rate	1 mega-sample per second, for one vertical compartment only. 1/2 mega-sample per second, for both vertical compartments.
Real Time Channel Switching	
With 5B25N Time Base set to 0.1 ms/div range or slower	
Chop Switching Rate	Time/division ÷ 100. Chop clock is trailing edge (positive-going) of sample pulse.
Chop Blanking Duration	450 to 600 ns.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
VERTICAL AND HORIZONTAL (Cont)	
Real Time Channel Switching (cont)	
Alternate Switching Rate	Channel switches at end of each sweep.
With 5B25N Time Base at 50 μs/div range or faster in Chop or Alternate	Channel switches at end of each real-time sweep.
Without Digitizer Time Base or with 5B25N in Amplifier Mode	
Chop Switching Rate	300 kHz ±25%.
Chop Blanking Duration	Less than 50%.
Alternate Switching Rate	Channel switches at end of each sweep.
Vertical Switching Sequence (Chop or Alt)	Each vertical plug-in compartment (in chop or alternate) is allocated two segments for display. Thus, if two dual-channel plug-ins are installed, the display sequence is left CH 1, right CH 1, left CH 2, right CH 2. If a single channel plug-in is installed, or selected, the display defaults to all the segments allocated to that plug-in.
Horizontal Channel Switching (Chop or Alt)	The channel switch for the horizontal plug-in compartment operates at the same rate as the left/right vertical channel switch. When using a dual-channel plug-in (amplifier or time-base), the display sequence is A, B, A, B. . .(CH 1, CH 2, CH 1, CH 2). Thus time base A (or CH 1) is slaved to Left Vertical compartment and time base B (or CH 2) is slaved to Right Vertical compartment.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
Z-AXIS AMPLIFIER	
External Input	
Input Voltage	A voltage swing of 5 V (dynamic range + to −5 V) will fully modulate beam, dc to 1 MHz with intensity control set as necessary.
Usable Frequency Range	Dc to 5 MHz.
Input Impedance	Resistance, 10 k ±10%. Capacitance, 50 pF maximum.
Maximum Safe Input	40 V (dc + peak ac).
CRT DISPLAY	
Geometry	Bowing or tilt ≤0.1 division.
Orthogonality	±0.2 division total variation over 8 divisions.
Linearity	With a normal 8 × 10 div square raster or time markers, max deviation from straight line: horizontal, 0.1 division; vertical, 0.1 division.
Phosphor	P31.
Deflection	Electrostatic with mesh magnification.
Acceleration Potential	15 kV overall.
Graticule	
Scale	8 × 10 divisions with 1.22 cm/division.
Scale Color and Type	Orange internal-graticule lines, with 5-division risetime markings.
Beamfinder	Brings trace within graticule area and increase trace intensity to a visible level.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
MEMORY	
Memory length	1 K data points per vertical compartment, shared by multiple trace plug-ins.
Pretrigger Marker	Waveform is intensified prior to trigger point.
ROLL MODE	Operative at 100 ms/div and slower.
DISPLAY OUTPUTS (Chart Output)	
Maximum Clock Rate	220 Hz ±30%.
Minimum Clock Rate	14 Hz ±20%.
Impedance	1 KΩ ±10%.
Amplitude	200 mV/div ±5%.
PEN LIFT	
Normally Open	Relay closes during each MEMORY waveform output.
Duration	300 ms minimum, 1.5 s maximum.
Maximum Voltage	30 V, dc or peak ac.
Maximum Current	200 mA, dc or peak ac.
Maximum VA	5.
POWER SUPPLY	
Line Voltage Ranges (RMS)	90-117 V. 102-132 V. 191-249 V. 204-250 V maximum.
CALIBRATOR	
Voltage	300 mV, ±1%.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
CALIBRATOR (Cont)	
Current	3 mA, ±1%.
Frequency	1 kHz, ±1%.
Duty Cycle	50%, ±2%.
Output Impedance	100 Ω, ±1%.
CONNECTORS	
Camera Power	Three-contact connector compatible with TEKTRONIX C59 camera.
PLUG-IN OUTPUTS	
Amplitude	50 mV/div ±5%.
Bandwidth	
Vertical	At least 15 MHz.
Horizontal	At least 7.0 MHz.
Output Impedance	50 Ω ±10%.
Offset	±100 mV (no load).
Noise and Crosstalk Between Any Plug-In Combination (Reference 8 Div Input)	Less than 5 mV (dc to 5 MHz). Less than 10 mV (dc to 20 MHz). Less than 25 mV (dc to 100 MHz).
SS RESET INPUT (Single-Sweep Reset)	Rear panel connector and camera bezel connector. Closure to ground causes reset.
A GATE OUT OR SAMPLE CLK OUT	
Amplitude	0.8 V max low to 2.4 V min high.

TABLE 1-3 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
CONNECTORS (Cont)	
A GATE OUT OR SAMPLE CLK OUT (cont)	
Rise Time	
From 0.8 V to 2.0 V with 50 pF and 1 MΩ Load	
SAMPLE CLK OUT	50 ns.
A GATE OUT	100 ns max.

TABLE 1-4
Environmental Characteristics

Characteristics	Performance Requirement
Temperature	
Operating	0° to 50° C.
Storage	−55° to +75° C.
Altitude	
Operating	To 15,000 feet (4,500 m).
Storage	To 50,000 feet (15,000 m).
Vibration	
Operating and Nonoperating	Tested to MIL-28000B SECT. 4.5.5.3.1 Type 2. Class 5, Style E & F.
Shock	
Nonoperating	Tested to MIL-T-28800B SECT. 4.5.5.4.1 Type 2. Class 5, Style E & F.

TABLE 1-4 (CONT)
Environmental Characteristics

Characteristic	Performance Requirement
Bench Handling	Tested to MIL-T-28800B SECT. 4.5.5.4.4 Type 2. Class 5, Style E & F.
Transportation	National Safe Transit Assoc., Pre-Shipment Test procedure.
Vibration of Packaged Product	NSTA. Project 1 A-B-1.
Drop of Packaged Product	NSTA. Project 1 A-B-2.
EMC	Tektronix Product Design Standard 062-2866-00.

TABLE 1-5
Physical Characteristics

Characteristics	Information
Ventilation	Safe operating temperature maintained by ac fan. Automatic resetting thermal cutout protects instrument.
Finish	Anodized front- and rear-panel with blue-vinyl painted aluminum cabinet.
Cabinet Version	
Net Weight, With Feet and Handle	37-1/2 lbs. (16.19 kg).
Outside Dimensions	See Figure 1-3.
Rackmount Version	
Net Weight	42 lbs. (19.1 kg).
Outside Dimensions	See Figure 1-4.

SYSTEM ELECTRICAL SPECIFICATION

Your Tektronix 5223 Digitizing Oscilloscope system provides exceptional flexibility in operation with a wide choice of general- and special-purpose plug-in units. The type number of a particular plug-in unit identifies its usage as follows:

The first digit (5) denotes the oscilloscope system for which the plug-in is designed (5000-series).

The second letter describes the purpose of the plug-in unit:

A—Amplifier unit
B—"Real time" time-base unit
C—Curve tracer
L—Spectrum analyzer
S—Sampling unit

The third and fourth digits of the plug-in type number do not carry any special connotation.

A "N" suffix letter added to the normal four-digit type number identifies a unit not equipped with the circuitry necessary to encode data for the 5000-series readout system (available in 5400 series only).

Table 1-6 lists the vertical specifications which are system dependent. For more complete specifications on plug-in units for the 5000-series oscilloscope system, refer to the Tektronix Products catalog.

Table 1-7 lists the horizontal specifications which are system dependent. For more complete specifications on plug-in units for the 5000-series oscilloscope system, refer to the Tektronix Products catalog.

Table 1-8 lists some special purpose plug-in units available for use with the 5223 Oscilloscope.

STANDARD ACCESSORIES

1 ea ..... Operators Manual
1 ea ..... Service Manual
1 ea .....Faceplate Filter (installed)
1 ea ..... Power Cord

TABLE 1-6
5223 Oscilloscope Vertical System Specification

Product	Type	Minimum Deflection Factor	Bandwidth −3 dB	CMRR
5A13N	Single	1 mV/div	2 MHz	10,000:1
5A15N	Single	1 mV/div	2 MHz	
5A18N	Dual	1 mV/div	2 MHz	
5A19N	Single	1 mV/div	2 MHz	1,000:1
5A21N	Single (voltage and current)	50 μV/div 0.5 mA/div	1 MHz	100,000:1
5A22N	Single	10 μV	1 MHz	100,000:1
5A23N	Single	10 mV/div	1.5 MHz	
5A24N	Single	50 mV/div	2 MHz	
5A26	Dual	50 μV/div	1 MHz	100,000:1
5A38	Dual	10 mV/div	10 MHz	
5A45	Single	1 mV/div	10 MHz	
5A48	Dual	1 mV/div	10 MHz	

TABLE 1-7
5223 Oscilloscope Horizontal System Specification

Product	Type	Sweep Rate	Mag	Single Sweep	Volts/Div Ext Mode
5B25	Digitizer	0.2 μs to 5 s	10X	Yes	50 mV

TABLE 1-7 (CONT)
5223 Oscilloscope Horizontal System Specification

Product	Type	Sweep Rate	Mag	Single Sweep	Volts/Div Ext Mode
5B10N		1 μs to 5 s	10X	Yes	50 mV and 500 mV
5B12N	Dual Delaying	A, 1 μs to 5 s; B, 2 μs to 5 s	10X	Yes	50 mV and 500 mV
5B13N		1 μs to 100 ms			50 mV
5B31	Digital Delaying	0.2 μs to 5 s	10X	Yes	50 mV
5B40		0.1 μs to 5 s	10X	Yes	50 mV
5B42	Delaying	A, 0.1 μs to 5 s; B, 0.1 μs to 0.5 s	10X 10X	Yes	50 mV
5B44	Dual Delaying	50 ns to 2 s	10X	Yes	50 mV

TABLE 1-8
Special Purpose Plug-In Units

Product	Description
5CT1N	Semiconductor Curve Tracer
5L4N	Low-Cost Spectrum Analyzer
5S14N	1 GHz Sampling

TABLE 1-9
5223 Plug-In Incompatibilities

Plug-In Unit Type	Operating Conditions	Symptom	Cause
5A14	More than one trace displayed from plug-in unit and 5223 operating in memory mode (digitizer time-base unit installed in horizontal compartment).	Memory display is incoherent and/or distorted; real-time display is distorted at time-base unit sweep rates of 0.5, 0.2 and 0.1 millisecond/division.	Plug-in channel switch settling time too slow, 5223 not designed to accommodate more than two channels in one memory.
5A18N (with Serial Numbers below B128131)	5223 operating in memory mode (digitizer time-base unit installed in horizontal compartment), and 5A18N operating in chop mode.	Memory and real-time displays are distorted at time-base unit sweep rates of 0.5, 0.2 and 0.1 milliseconds/division.	Channel switch settling time too slow; for solution of problem refer qualified service personnel to the 5223 service manual.
5A26N (with Serial Numbers below B051662)	When 5223 is operating in memory mode (digitizer time-base unit installed in horizontal compartment), and 5A26N is operated in chop mode.	Memory and real-time displays are distorted at time-base unit sweep rates of 0.5, 0.2 and 0.1 milliseconds/division.	Channel switch settling time too slow; for solution of problem refer qualified service personnel to 5223 service manual.
5A48 (with Serial Numbers below B078993)	When 5223 is operating in memory mode (digitizer time-base unit installed in horizontal compartment), and 5A18N is operated in chop mode.	Memory and real-time displays are distorted at time-base unit sweep rates of 0.5, 0.2 and 0.1 milliseconds/division.	Channel switch settling time too slow; for solution of problem refer qualified service personnel to 5223 service manual.

TABLE 1-9 (CONT)
5223 Plug-In Incompatibilities

Plug-In Unit Type	Operating Conditions	Symptom	Cause
5L4N (with Serial Numbers below B07000)	Physically locked out of 5223 when installed in both vertical compartments. When installed in 5223 right vertical and horizontal compartments, unit operates in real-time mode without memory capability.		For solution of problem refer qualified service personnel to 5223 service manual.
5S14N	Physically locked out of 5223 when installed in both vertical compartments. When installed in 5223 right vertical and horizontal compartments, unit operates in real-time mode without memory capability.		Mechanical interference of post against internal components. 5S14N can be operated in 5223 if post is removed; however, 5L4N with Serial Numbers below B07000 will be damaged when operated in 5223 with post removed.
5B10 5B12 5B13	Sweep rates of 1 microsecond/division and faster.	Leading edge of pulse(s) not displayed.	Trigger circuitry too slow.
5B10 5B12 5B13	Composite trigger mode.	Will only trigger off signal from left vertical plug-in unit.	5223 will not allow composite trigger mode operation of these plug-in units.

Operating Instructions

To operate this instrument effectively, the user must become familiar with the operation and capabilities of the instrument. This section describes the use of front- and rear-panel controls and connectors.

NOTE

Detailed operating information for a specific plug-in is given in the instruction manual for that unit.

OPERATING TEMPERATURE

The 5223 can be operated where the ambient air temperature is between 0° and +50° C. The instrument can be stored in ambient temperature between −55° and +75° C. After storage at a temperature beyond the operating limits, allow the chassis temperature to come within the operating limits before power is applied.

WARNING

To avoid electric-shock hazard, see Installation in the General Information section of this manual before operating this instrument.

A thermal cutout in the acquisition module provides thermal protection and disconnects the power to the instrument if the internal temperature exceeds a safe operating level. This device will automatically restore power when the temperature returns to a safe level.

PLUG-IN UNITS

The 5223 is designed to accept up to three Tektronix 5000-series plug-in units. This plug-in feature allows a variety of display combinations and also allows selection of bandwidth, sensitivity, display mode, etc., to meet many measurement requirements. In addition, it allows the oscilloscope system to be expanded to meet future measurement requirements. The overall capabilities of the resultant system are, in large part, determined by the characteristics of the plug-ins selected[1].

INSTALLATION

To install a plug-in unit into one of the plug-in compartments, align the slots in the top and bottom of the plug-in with the associated guides in the plug-in compartment. Push the plug-in unit firmly into the plug-in compartment until it locks into place. To remove a plug-in, pull the release latch on the plug-in unit to disengage it and pull the unit out of the plug-in compartment. It is not necessary that all of the plug-in compartments be filled to operate the instrument, the only plug-ins needed are those required for the measurement to be made. Blank plug-ins or front panels should be used to ensure proper airflow through the instrument. When the instrument is adjusted in accordance with the adjustment procedure given in the service manual, the vertical and horizontal gain are standardized. This allows calibrated plug-in units to be changed from one plug-in compartment to another without readjustment. However, the basic adjustment of the individual plug-in units should be checked when they are installed in this system to verify their measurement accuracy. See the plug-in service manual for verification procedure.

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[1] **Refer to Table 1-9, 5223 Plug-in Incompatibilities in this manual for operating restrictions concerning a particular plug-in unit, when used in the 5223 Digitizing Oscilloscope.**

PLUG-IN SELECTION[1]

The plug-in versatility of the 5223 oscilloscope allows a variety of display modes with many different plug-ins. The following information is provided here to aid in plug-in selection.

To produce a single-trace display, install a single-channel vertical unit (or dual-channel unit set for single-channel operation) in either of the vertical (left or right) compartments. For dual-trace displays, either install a dual-channel vertical unit in one of the vertical compartments or install a single-channel vertical unit in each vertical compartment. A combination of a single-channel and a dual-channel vertical unit allows a three-trace display; likewise, a combination of two dual-channel vertical units allows a four-trace display. The 5223 does allow the operation of a plug-in unit with more than two channels (e.g. 5A14N), but in the real-time mode only.

To obtain a vertical sweep with the input signal displayed horizontally, insert a time-base unit into one of the vertical compartments and a amplifier unit in the horizontal compartment. If a vertical sweep is used, there is no retrace blanking and the time-base unit triggering must be accomplished externally.

For X-Y displays, either a 5A-series amplifier unit or a 5B-series time-base unit having an amplifier channel can be installed in the horizontal compartment to accept the X signal. The Y signal is connected to a 5A-series amplifier unit installed in a vertical compartment.

Special purpose plug-in units may have specific restrictions regarding the compartments in which they can be installed. This information will be given in the instruction manuals for these plug-ins.

GENERAL OPERATING INFORMATION

DISPLAY SWITCHING LOGIC

The electronic switching for time-shared displays is produced at the plug-in interface within the mainframe; however, the switching logic is selected in the plug-in units. The system allows several combinations of plug-ins and Display switch settings. Refer to the individual plug-in manuals for specific capabilities and operating procedures[1].

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[1] **Refer to Table 1-9, 5223 Plug-in Incompatibilities in this manual for operating restrictions concerning a particular plug-in unit, when used in the 5223 Digitizing Oscilloscope.**

Switching Sequence

Four display time slots are provided on a time-sharing basis. When two vertical plug-ins are active, each receives two time slots, so the switching sequence is: left, right, left, right, etc. The two time slots alloted to each plug-in are divided between amplifier channels in a dual-trace unit; if two dual-trace plug-ins are active, then the switching sequence is: left Channel 1, right Channel 1, left Channel 2, right Channel 2, etc. If only one vertical plug-in is active, it receives all four time slots. The switching sequence is the same for both the alternate and chopped display modes[1].

VERTICAL DISPLAY MODE

Display On

To display a signal, the Display button of the applicable vertical plug-in unit must be pushed in to activate the unit. If two plug-ins are installed in the vertical compartments and the signal from only one of the units is desired, set the Display switch of the unwanted unit to Off (button out). If neither plug-in is activated, the signal from the left unit is displayed. Both plug-ins can be activated for multi-trace displays[1].

Alternate Mode

The alternate position of the time-base unit Chop/Alt switch produces a display that alternates between activated plug-ins and amplifier channels with each sweep of the time base. The switching sequence is described under Display Switching Logic in this section. Although the Alternate mode can be used at all sweep rates, the Chop mode may provide a more satisfactory display at sweep rates from about one millisecond/division to five seconds/division. At these slower sweep rates, alternate-mode switching becomes difficult to view.

Chopped Mode

The Chop position of a nondigitizing time-base unit Display switch produces a display that is electronically switched between channels at a 300-kilohertz rate. The switching sequence is discussed earlier. In general, the Chop mode provides the best display at sweep rates slower than about one millisecond/division or whenever dual-trace, single-shot phenomena are to be displayed. At faster sweep rates, the chopped switching becomes apparent and may interfere with the display.

The 5B25N chopped switching rate can be determined by dividing the Time/Division switch setting by 100 at sweep rates of 0.1 millisecond/division and slower; at sweep rates of 50 microseconds/division and faster the channel switching occurs at the end of each sweep, i.e., it operates in alternate mode only.

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[1] **Refer to Table 1-9, 5223 Plug-in Incompatibilities in this manual for operating restrictions concerning a particular plug-in unit, when used in the 5223 Digitizing Oscilloscope.**

Dual-Sweep Displays

When a dual-sweep time-base unit is operated in the horizontal compartment, the alternate and chopped time-shared switching for either the A or B sweep is identical to that for a single time-base unit. However, if both the A and B sweeps are operating, the 5223 operates in the independent pairs mode. Under this condition, the left vertical unit is always displayed at the sweep rate of the A time base and the right vertical unit is displayed at the sweep rate of the B time base (nondelayed sweep only). This results in two displays that have completely independent vertical deflection and chopped or alternate sweep switching[1].

X-Y OPERATION

In some applications, it is desirable to display one signal versus another (X-Y) rather than against an internal sweep. The flexibility of the plug-in units available for use with the 5223 provides a means for applying a signal to the horizontal deflection system for this type of display. Some of the 5B-series time-base units can be operated as amplifiers, in addition to their normal use as time-base generators. For more information on X-Y displays, see the discussion on L VS R in this section of the manual.

RASTER DISPLAY

A raster-type display can be used to effectively increase the apparent sweep length. For this type of display, the trace is deflected both vertically and horizontally by sawtooth signals, and is accomplished by installing a 5B-series time-base unit in the left vertical compartment, as well as one in the horizontal compartment. Normally, the unit in the vertical compartment should be set to a slower sweep rate than the time-base unit in the horizontal compartment; the number of horizontal traces in the raster depends upon the ratio between the two rates.

Information can be displayed on the raster using the Z-AXIS INPUT to provide intensity modulation of the display. This type of raster display can be used to provide a television-type display.

CONTROLS AND CONNECTORS

The 5223 Digitizing Oscilloscope front- and rear-panel controls and connectors are shown in Figure 2-1 and Figure 2-2. A brief, functional description of each control and connector is included in the illustration. Refer to Detailed Operating Information for additional information.

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[1]**Refer to Table 1-9, 5223 Plug-in Incompatibilities in this manual for operating restrictions concerning a particular plug-in unit, when used in the 5223 Digitizing Oscilloscope.**

Foldout for
Front-panel controls, connectors and indicators.
Figure 2-1.

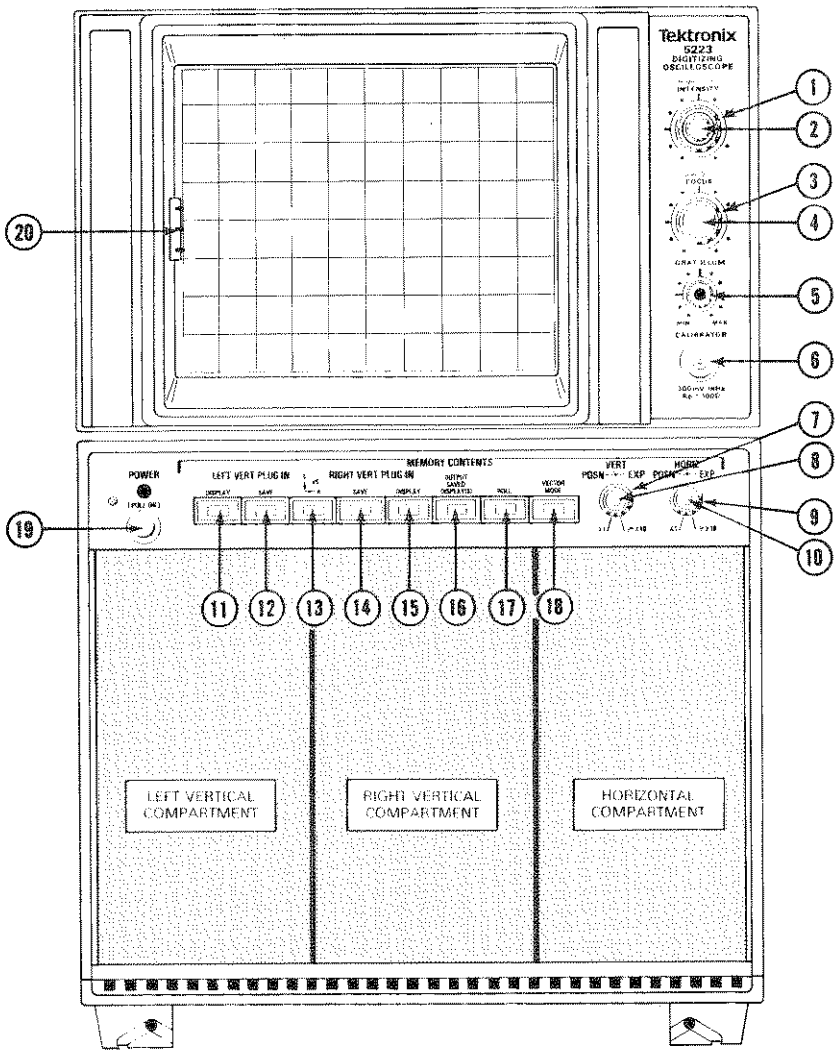

Figure 2-1. Front-panel controls, connectors and indicators.

2933-201A

FRONT-PANEL DESCRIPTIONS

(1) **INTENSITY**—Controls brightness of real-time display.

(2) **MEM INTEN**—Controls brightness of memory display.

(3) **FOCUS**—Control to optimize crt display definition.

(4) **BEAMFINDER**—Switch, when pressed, compresses and intensifies display so that it is visible within the graticule area.

(5) **GRAT ILLUM**—Control varies level of graticule illumination.

(6) **CALIBRATOR**—Connector provides a 300 mV, 1 kHz, square-wave voltage for calibrating amplifiers or compensating probes.

(7) **VERT POSN**—Control positions the memory display vertically.

(8) **VERT EXP**—Control expands the memory display vertically.

(9) **HORIZ POSN**—Control positions the memory display horizontally.

(10) **HORIZ EXP**—Control expands the memory display horizontally.

(11) **DISPLAY**—Switch produces a digitized display of the left vertical plug-in signal(s) on the crt.

(12) **SAVE**—Switch causes the left vertical digitized waveform to be saved (memory cannot be updated until button is released).

(13) **L VS R**—Switch causes the left memory to be displayed on the Y axis (vertical) and the right memory to be displayed on the X axis (horizontal).

(14) **SAVE**—Switch causes the right vertical digitized waveform to be saved (memory cannot be updated until this button is released).

(15) **DISPLAY**—Switch produces a digitized display of the right vertical plug-in signal(s) on the crt.

FRONT-PANEL DESCRIPTIONS (Cont)

(16) **OUTPUT SAVED DISPLAY(S)**—Switch makes available a voltage analog of the saved memory display(s) at the rear-panel MEMORY Y and X connectors.

(17) **ROLL**—Switch causes the memory display(s) to move from right to left on the crt (in a Y-T mode). Thus the most recently acquired data is at the right of the display(s) (operational with digitizing time-base only and sweep rates equal to or slower than 0.1 second/div).

(18) **VECTOR MODE**—Switch joins dots in the memory display.

(19) **POWER (Switch and Indicator)**—Switch controls power to instrument. Indicator illuminates when power is applied to instrument.

(20) **Camera Power Connector (not labeled)**—Three pin connector provides power for camera operation and receives single-sweep-reset signal from compatible camera systems.

Foldout for Rear-panel controls and connectors. Figure 2-2.

FRONT-PANEL DESCRIPTIONS (Cont)

(16) **OUTPUT SAVED DISPLAY(S)**—Switch makes available a voltage analog of the saved memory display(s) at the rear-panel MEMORY Y and X connectors.

(17) **ROLL**—Switch causes the memory display(s) to move from right to left on the crt (in a Y-T mode). Thus the most recently acquired data is at the right of the display(s) (operational with digitizing time-base only and sweep rates equal to or slower than 0.1 second/div).

(18) **VECTOR MODE**—Switch joins dots in the memory display.

(19) **POWER (Switch and Indicator)**—Switch controls power to instrument. Indicator illuminates when power is applied to instrument.

(20) **Camera Power Connector (not labeled)**—Three pin connector provides power for camera operation and receives single-sweep-reset signal from compatible camera systems.

Foldout for Rear-panel controls and connectors. Figure 2-2.

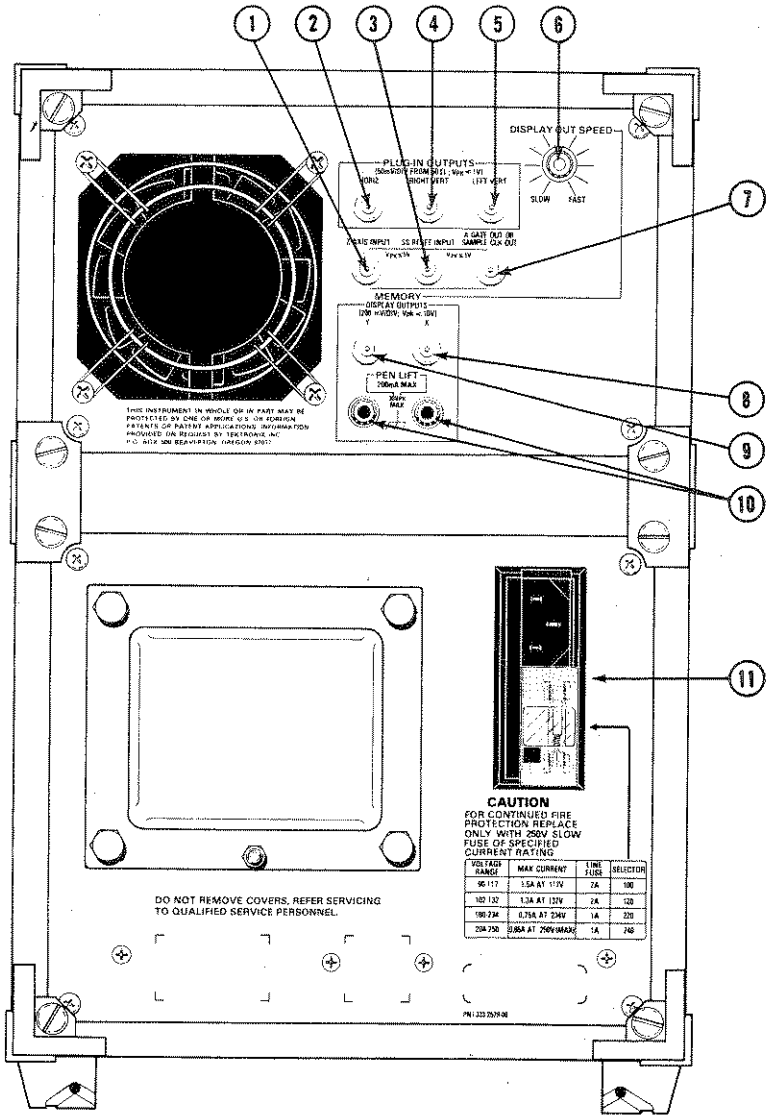

Figure 2-2. Rear-panel controls and connectors.

REAR-PANEL DESCRIPTIONS

(1) **Z-AXIS INPUT**—Connector for external input to intensity modulate the display(s).

(2) **HORIZ**—Connector makes available the horizontal plug-in signal(s).

(3) **SS RESET INPUT**—Connector for input of remote single-sweep reset.

(4) **RIGHT VERT**—Connector makes available the right-vertical plug-in signal(s).

(5) **LEFT VERT**—Connector makes available the left-vertical plug-in signal(s).

(6) **DISPLAY OUT SPEED**—Controls the rate at which the saved memory display(s) is converted to an analog voltage and made available at the MEMORY X and Y connectors.

(7) **A GATE OUT OR SAMPLE CLK OUT**—Connector makes available the time-base gate.

(8) **MEMORY X** —Connector provides a voltage analog of the memory horizontal signal(s).

(9) **MEMORY Y**—Connector provides a voltage analog of the memory vertical signal(s).

(10) **PEN LIFT**—Connectors provide control to auxiliary equipment (i.e., X-Y plotter) when front-panel OUTPUT DISPLAY cycle is activated.

(11) **Line-Voltage Selector, Power Cord Connector and Fuse Holder**—Board insert to select line source voltage.

OPERATORS CHECKOUT PROCEDURE

The Operators Checkout Procedure may be used to verify proper operation of the front-panel controls and for familiarization with the instrument. Only instrument functions (not measurement quantities or specifications) are checked in the procedure; therefore, a minimum amount of test equipment is required. If performing the Operators Checkout Procedure reveals improper performance or instrument malfunction, check the operation of associated equipment; then refer to qualified service personnel for repair or adjustment of the instrument.

TEST EQUIPMENT REQUIRED

The test equipment listed below was used in preparing the Operators Checkout Procedure. Other test equipment which meets these requirements may be substituted. When other equipment is substituted, the control settings or setup may need to be altered.

a. Tektronix 5B25N Digitizing Time-Base unit, 5A45 Amplifier unit, and a 5A48 or 5A38 Dual Trace Amplifier unit.

b. Cables (2 Required)

Description: Length, 42 inches; connectors, bnc.

Type Used: Type RG-58/U, 50-ohm coaxial, Tektronix part 012-0057-01.

c. T Connector

Description: Connectors, bnc to bnc.

Type Used: Bnc to bnc connector, Tektronix Part 103-0030-00.

PRELIMINARY SETUP

1. Set the front-panel controls as follows:

INTENSITY	2 o'clock
FOCUS	midrange
MEM INTEN	counterclockwise
GRAT ILLUM	counterclockwise
POWER	(pushbutton in)
MEMORY CONTENTS	all pushbuttons out
VERT POSN	midrange
HORIZ POSN	midrange
VERT EXP	X1 (counterclockwise)
HORIZ EXP	X1 (counterclockwise)

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2. Check that the instrument rear-panel Line Voltage Selector setting (see number 11 of Fig. 2-2) corresponds to the power available (both voltage and frequency), and connect the 5223 to the power source. (For more information, see Operating Power Information in the General Information section of this manual.)

3. Install 5A-series amplifier units in the left and right vertical plug-in compartments. Install a 5B-series digitizer time-base unit in the horizontal plug-in compartment.

4. Pull the POWER switch out.

5. Set the time-base unit to 1 millisecond/division (magnifier to X1) and triggering to auto mode with ac coupling from the right source.

6. Set the left and right vertical plug-in unit display switches in. If plug-in is a dual-trace unit, select only one channel.

7. Press the BEAMFINDER switch and position the displayed traces to the center of the crt graticule with the left, right, and time-base plug-in units' position controls. Release the BEAMFINDER switch.

8. Rotate the INTENSITY control until the display is at a desirable viewing level.

9. Connect a bnc cable from the CALIBRATOR output to the input of the right vertical plug-in unit, and set the deflection factor to 0.1 volts/division (for a three division display).

10. Set the time-base unit triggering slope to +, from the right source, and adjust trigger level for a stable display.

Display Focus

11. Rotate the FOCUS control and observe the square-wave display. Notice that the thickness of the trace varies. Set the FOCUS control for a well-defined trace.

Graticule Illumination

12. Rotate the GRAT ILLUM control throughout its range and notice that the graticule lines are illuminated as the control is turned clockwise.

Vertical Deflection System

13. Connect the CALIBRATOR output to the input connectors of both amplifier units with two bnc cables and a bnc T connector. Set the deflection factor of the left amplifier unit to display about 3 divisions of signal on the crt.

14. Position the displayed waveform to the upper half of the graticule, with the left amplifier unit position control.

15. Position the displayed waveform to the lower half of the graticule, with the right amplifier position control.

16. Set the time-base unit Display switch to ALT. Two traces should be displayed on the crt. The top trace is produced by the left amplifier unit and the bottom trace is produced by the right amplifier unit; the sweep for both traces is produced by the time-base unit. Set the sweep rate of the time-base unit to 50 milliseconds/division; notice the display alternates between the left and right amplifier plug-in units, after each sweep. Turn the time-base sweep rate switch throughout its range; notice that the display alternates between amplifier units at all sweep rates.

17. Set the time-base unit Display switch to CHOP. Rotate the time-base unit sweep rate switch throughout its range. A dual-trace display should be presented at all sweep rates. Notice that both amplifier units are displayed by the time-base unit on a time-sharing basis. Set the time-base unit sweep rate to 1 millisecond/division.

18. Position the start of the traces to the left graticule line with the time-base unit position control.

Triggering

19. Set the time-base unit triggering source switch to left and adjust the triggering slope control for a stable display. Disconnect the input signal from the right amplifier unit input connector. Notice that the remaining display is stable.

20. Set the time-base unit Triggering Source switch to Right. Notice that the display is unstable.

21. Remove the calibrator signal from the left amplifier unit and connect it to the input of the right amplifier unit. Notice that the display is again stable.

Memory Contents

22. Set the MEMORY CONTENTS RIGHT VERT PLUG-IN DISPLAY switch to the in position, notice that the switch is illuminated and that there are two square-waves displayed on the crt. (The MEMORY CONTENTS VERT POSN and MEM INTEN control may have to be rotated to obtain a memory display on the crt.)

23. Set the time-base unit sweep rate to 0.1 millisecond/division and notice that one cycle is displayed for 10 divisions.

24. Set the MEMORY CONTENTS RIGHT VERT PLUG-IN SAVE switch to the in position.

25. Set the time-base unit sweep rate to 1 millisecond/division and notice that the memory display remains the same while the real-time display changes to one cycle/division.

26. Disconnect the bnc cable from the input of the right amplifier plug-in unit and notice that the memory display is retained even through the real-time signal is removed.

27. Set the MEMORY CONTENTS RIGHT VERT PLUG-IN DISPLAY switch to the out position and notice the stored display disappears.

28. Set the MEMORY CONTENTS RIGHT VERT PLUG-IN DISPLAY switch to the in position and notice that the stored display reappears.

29. Press the MEMORY CONTENTS OUTPUT SAVED DISPLAY(S) switch and notice that the stored display disappears and then reappears after a period of time determined by the DISPLAY OUT SPEED control (see number 6 of Fig. 2-2).

30. Set the MEM INTEN control fully clockwise. Set the MEMORY CONTENTS VECTOR MODE switch to the in position and notice that the rising and falling edges of the signal brighten.

31. Set the time-base unit sweep rate to 0.5 seconds/division.

32. Set the MEMORY CONTENTS RIGHT VERT PLUG-IN SAVE switch to the out position.

33. Rotate the right vertical plug-in unit position control so the dot moves up and then down approximately two divisions as the spot crosses the crt. Notice that the stored display is updated after the dot reaches the right side of the crt.

34. Set the MEMORY CONTENTS ROLL switch in. Rotate the right vertical plug-in unit position control so the dot moves up and then down approximately two divisions and notice that the display is continually updated at the right side of the crt while the display moves from right to left.

35. Set all of the MEMORY CONTENTS switches to the out position.

36. Connect the calibrator signal to the input of the left amplifier unit.

37. Set the time-base unit sweep rate to 0.1 millisecond/division and triggering for ac coupling from the left source.

38. Set the MEMORY CONTENTS LEFT VERT PLUG-IN DISPLAY switch to the in position, notice that the switch is illuminated and that there are two square-waves displayed on the crt. (The MEMORY CONTENTS VERT POSN and MEM INTEN controls may have to be rotated to obtain a memory display on the crt).

39. Set the MEMORY CONTENTS LEFT VERT PLUG-IN SAVE switch to the in position.

40. Set the time-base unit sweep rate to 1 millisecond/division and notice that the memory display remains the same while the real-time display changes to one cycle/division.

41. Disconnect the bnc cable from the input of the left amplifier plug-in unit and notice that the memory display is retained even though the real-time signal is removed.

42. Set the MEMORY CONTENTS LEFT VERT PLUG-IN DISPLAY switch to the out position and notice that the stored display disappears.

43. Set the MEMORY CONTENTS LEFT VERT PLUG-IN DISPLAY switch to the in position and notice that the stored display reappears.

44. Press the MEMORY CONTENTS OUTPUT SAVED DISPLAY(S) switch and notice that the stored display disappears and then reappears, after a period of time determined by DISPLAY OUT SPEED control (See Number 6 of Fig. 2-2).

45. Set the time-base unit sweep rate to 0.5 seconds/division.

46. Set the MEMORY CONTENTS LEFT PLUG-IN SAVE switch to the out position.

47. Rotate the left vertical plug-in unit position control so the dot moves up and then down approximately two divisions as the spot crosses the crt. Notice that the stored display is updated after the dot reaches the right side of the crt.

48. Set the MEMORY CONTENTS ROLL switch in.

49. Rotate the left vertical plug-in unit position control so the dot moves up and then down approximately two divisions as the spot crosses the crt. Notice that the display is continually updated at the right side of the crt and that the display moves from right to left.

50. Set the time-base unit sweep rate to 1 millisecond/division.

51. Set the MEMORY CONTENTS L VS R switch to the in position. Notice that the left plug-in amplifier unit position control positions the dot vertically and the right amplifier plug-in unit position control positions the dot horizontally.

This completes the Operators Check Out procedure.

DETAILED OPERATING INFORMATION

GRATICULE

The graticule is marked on the inside of the crt faceplate, providing accurate, parallax-free measurements. The graticule is divided into eight vertical and ten horizontal divisions. Each divison is a 1.22 centimeter square divided into five minor divisions along each axis. The vertical gain and horizontal timing of the plug-in units are calibrated to the graticule so that accurate measurements can be made from the crt. The illumination of the graticule lines can be varied with the GRAT ILLUM control.

Figure 2-3 shows the graticule and defines the various measurement lines. The terminology defined here will be used in all discussions involving measurements from the graticule. The markings: 0%, 10%, 90%, and 100% on the left side of the graticule are for accurate rise-time measurements.

LIGHT FILTER

The tinted face-plate filter minimizes light reflections from the face of the crt to improve contrast when viewing the display under high-ambient-light conditions. This filter may be removed for waveform photographs or for viewing high-writing-rate displays. To remove the filter, pull outward on the bottom of the plastic crt mask and remove it from the crt bezel. Remove the tinted filter; leave the clear plastic faceplate-protector (implosion shield) installed and replace the mask. The face-plate protector should be left in place at all times to protect the crt face from scratches and the operator from crt implosion.

WARNING

Do not remove the clear plastic implosion shield covering the crt face plate; the implosion shield provides protection to the operator from crt implosion.

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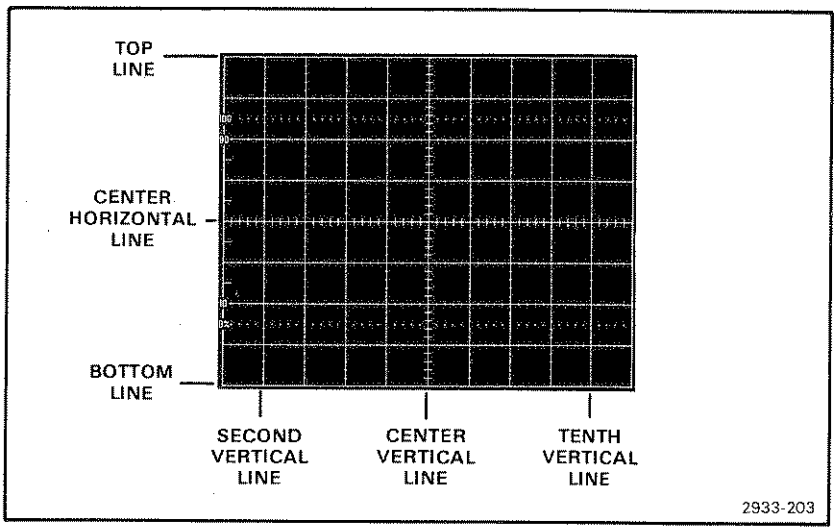

Figure 2-3. Definition of graticule measurement lines.

INTENSITY CONTROLS

The INTENSITY control determines the brightness of the real-time display. The MEM INTEN determines the brightness of the stored display. This control is operational only when either the MEMORY CONTENTS LEFT or RIGHT VERT PLUG-IN DISPLAY switch(s) is set to the in position.

BEAMFINDER

The BEAMFINDER helps to locate a display that overscans the crt viewing area vertically and/or horizontally. When the BEAMFINDER button is pressed, the display is compressed and intensified within the graticule area. To locate and reposition an overscanned display, use the following procedure:

1. Press the BEAMFINDER switch; while the display is compressed adjust the vertical and horizontal position controls to center the display. Change the vertical and horizontal deflection factors until the vertical deflection is about four divisions high and the horizontal deflection is about six divisions wide. (The horizontal deflection needs to be reduced only when operating in an X-Y mode.)

2. Release the BEAMFINDER switch; the display should remain within the graticule area.

MEMORY CONTENTS

The 5223 with a digitizer time-base unit installed in the horizontal compartment has the capability of storing real-time waveforms in memory and then displaying the stored waveform. The MEMORY CONTENTS switches and controls are used to perform this function. After obtaining a real-time display with the MEMORY CONTENTS switches in the out position, press the DISPLAY switch for the appropriate vertical plug-in unit, a duplicate waveform will be displayed (the MEM INT, VERT POSN, and HORIZ POSN controls may need adjusting to position the waveform onto the crt display area). In the DISPLAY mode the redisplayed waveform is constantly being updated. This can be demonstrated by grounding the input signal; the memory display will then be an updated base line along with the real-time display, if the digitizer time-base unit is in the auto mode.

However, when the appropriate SAVE switch is pressed, the memory waveform is saved in the 5223 memory. To demonstrate the SAVE function, obtain a real-time display with the time-base unit in Auto mode. Press the DISPLAY switch, press the SAVE switch and disconnect the input signal. The real-time display will change to a base line and the saved memory display will remain unchanged.

The MEMORY CONTENTS VERT POSN and VERT EXP controls can be used to position and expand the stored waveform vertically. The MEMORY CONTENTS HORIZ POSN and HORIZ EXP controls can be used to position and expand the stored waveform horizontally.

L VS R

The L VS R mode allows X-Y comparisons of two signals. The L VS R mode allows a signal applied to the Left Vertical plug-in unit to be displayed against a signal applied to the Right Vertical plug-in unit. For X-Y Comparisons the left vertical plug-in unit provides the Y axis and the Right Vertical plug-in provides the X axis. Acquisition of both vertical compartments occurs simultaneously; this feature allows X-Y displays of frequencies from dc to 10 megahertz with less than 5 degrees phase shift. Optimum performance is provided when identical plug-in units are used (e.g., 5A38, 5A45, or 5A48) and are operated in the single channel mode. For the best display, one cycle only of the slowest signal should be displayed. The storage capabilities of the 5223 are such that these signals do not have to occur at the same time. To demonstrate this capability, apply a signal to the left vertical unit and press the MEMORY CONTENTS LEFT VERT PLUG-IN SAVE switch, then apply a signal to the right vertical unit and press the MEMORY CONTENTS RIGHT VERT PLUG-IN SAVE switch. Press the L VS R switch; the left vertical signal is displayed on the Y axis and the right vertical signal is displayed on the X axis.

ROLL MODE

The Roll mode is operational with a digitizer time-base unit only, at sweep rates of 0.1 seconds and slower. In this mode, the signal is digitized and recorded on the right-hand side of the display; the recorded digitized signal moves across the crt from the right to the left much like a strip chart recorder.

To demonstrate the Roll mode, use the following procedure:

1. Install a digitizer time-base unit in the right horizontal compartment, and an amplifier unit in the left vertical compartment.

2. Set all of the 5223 MEMORY CONTENTS switches to the out position. Press the MEMORY CONTENTS LEFT VERT PLUG-IN DISPLAY switch.

3. Set the VERT POSN and HORIZ POSN controls to midrange.

4. Set The VERT EXP and HORIZ EXP controls fully counterclockwise.

5. Set the digitizing time-base unit sweep rate to 0.5 seconds/division, and the triggering mode to auto.

6. Rotate the left amplifier plug-in unit position control and notice that the memory display is updated at the end of the real-time sweep.

7. Press the MEMORY CONTENTS ROLL switch and notice that the real-time sweep disappears.

8. Rotate the left amplifier plug-in unit position control and notice that the stored display is updated at the right hand side of the crt screen.

9. Rotate the left amplifier plug-in position control and at the same time press the MEMORY CONTENTS LEFT PLUG-IN SAVE switch; notice that the display is now stationary.

VECTOR MODE

The MEMORY CONTENTS VECTOR MODE switch is used to reduce the effect of perceptual aliasing. Perceptual aliasing is a type of optical illusion inherent in dot displays. When stored data are displayed as points, the eye tends to visually connect adjacent points; however, the closest dots in screen position, may not be the next in sequence. In addition to perceptual aliasing, dot displays can also show an "envelope error" that occurs when the dots do not fall on the peaks of the signal. See Figure 2-4.

Perceptual aliasing is easily remedied by adding vectors to the display as shown in Figure 2-5. But the envelope error can still persist because the vectors are straight lines joining the data points. The actual signal could still lie outside the waveform traced by the vectors, if the digitizer did not sample the peak points of the waveform. Each type of display construction (dots or vectors) yields a different useful storage bandwidth. Dot displays will need more samples-per-cycle on the crt screen to help

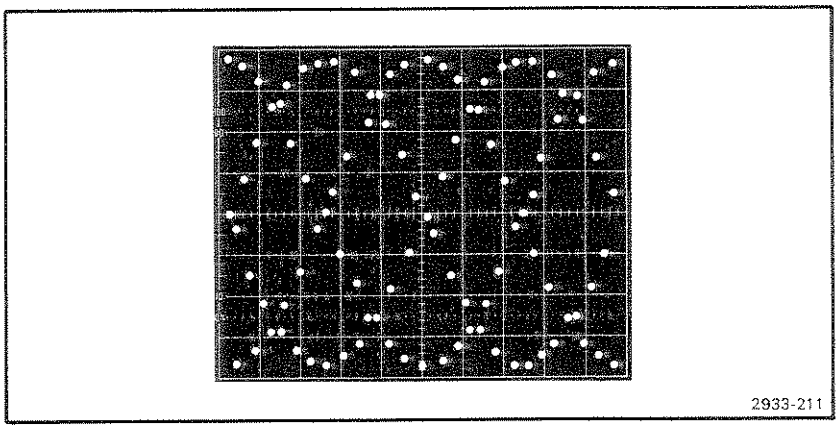

Figure 2-4. Perceptual aliasing illustrated.

alleviate perceptual aliasing and envelope errors. Vector displays need less samples-per-cycle since the vectors help reduce the effect of perceptual aliasing. To estimate the useful storage bandwidth for single-shot storage of sine waves, use the following rules-of-thumb:

$$\text{Approximate Useful Bandwidth for Dot Displays} \approx \frac{\text{maximum sampling rate}}{25}$$

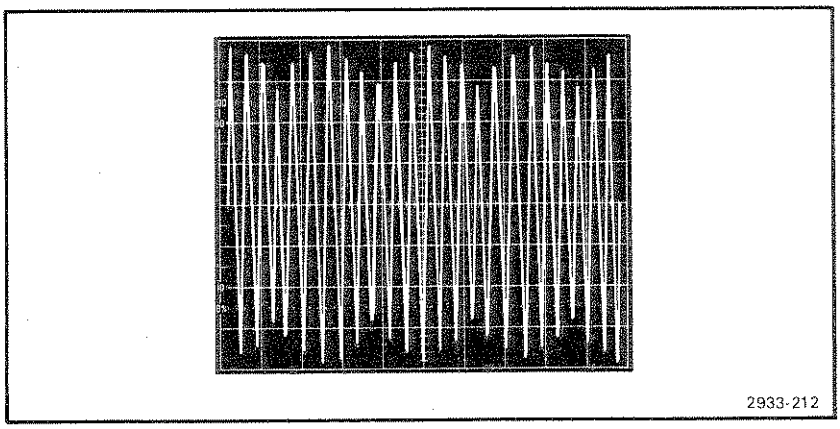

Figure 2-5. Vector Mode display.

$$\text{Approximate Useful Bandwidth for Vector Displays} \approx \frac{\text{maximum sampling rate}}{10}$$

(Envelope Error is approximately 5%)

CALIBRATOR OUTPUT

The CALIBRATOR provides a convenient signal for checking basic vertical gain and sweep timing. The calibrator signal is also very useful for adjusting probe compensation as described in probe instruction manuals. In addition,the calibrator can be used as a convenient signal source for application to external equipment.

Voltage

The CALIBRATOR provides an accurate voltage of 300 millivolts, into a high impedance load.

Repetition Rate

The repetition rate of the CALIBRATOR is 1 kilohertz. The CALIBRATOR circuit uses frequency-stable components to maintain accurate frequency and a constant duty factor. Thus, the CALIBRATOR can be used for checking the basic sweep timing of time-base units (1-kilohertz rate only).

Wave Shape

The square-wave output signal of the CALIBRATOR can be used as a reference wave shape when checking or adjusting the compensation of passive, high-resistance probes. The square-wave output from the CALIBRATOR has a flat top; so that any distortion in the displayed waveform is due to improper probe compensation.

DISPLAY PHOTOGRAPHY

A permanent record of the crt display can be obtained with an oscilloscope camera system. The instruction manual for the Tektronix oscilloscope cameras include complete instructions for obtaining waveform photographs.

The 5223 crt bezel provides integral mounting for Tektronix oscilloscope cameras. The three pins located on the left side of the crt bezel connect power to compatible camera systems. Control signals are also received from Tektronix automatic cameras to allow camera-controlled single-shot photography (see camera manual for further information).

INPUT/OUTPUT SIGNALS (Rear-Panel)

A Gate Out or Sample Clock Out

One of two signals can be selected to be available at the A GATE OUT/SAMPLE CLK OUT connector. The source of this signal is the time-base unit installed in the horizontal compartment. The A Gate is a positive-going rectangular pulse. The duration of the A Gate signal is the same as the duration of the respective time-base sweep.

Refer Selection of SAMPLE CLK OUT signal to qualified service personnel only.

Plug-In Outputs

Signals from the left and right vertical plug-in units are available at the LEFT VERT and RIGHT VERT rear-panel connectors. Likewise, the horizontal signal is available at the HORIZ connector. These outputs are provided as a convenient signal source of the vertical and horizontal deflection signals.

Intensity Modulation

Intensity (Z-axis) modulation can be used to relate a third item of electrical phenomena to the vertical (Y-axis) and the horizontal (X-axis) coordinates without affecting the waveshape of the displayed signal. This is accomplished by changing the intensity of the displayed waveform to provide a "grey scale" display.

The voltage amplitude required for visible trace modulation depends on the setting of the INTENSITY and MEM INTEN controls. A 5 volt peak-to-peak signal will completely modulate the display at the appropriate intensity setting; lower amplitude signals can be used to change the relative trace brightness. Negative-going signals decrease display intensity and positive-going signals increase the display intensity. Refer to the General Information section in this manual for specifications on Z-axis signal requirements.

Time markers applied to the rear-panel Z-AXIS INPUT connector provide a direct time reference on the display. With an uncalibrated horizontal sweep, or with X-Y mode operation, the time markers provide a means of reading time directly from the display. If the markers are not time-related to the display waveform, use a single-sweep display.

Remote Single-Sweep Reset

An external single-sweep-reset signal can be applied to a time-base unit installed in the horizontal plug-in compartment through the rear-panel SS RESET INPUT connector. This remote reset function is a duplication of the manually-operated single-sweep reset function (pushbutton) located on the front panel of the 5B-series

time-base units[1]. The signal source for the external single-sweep reset function can be either active (pulse generator, logic circuit, etc.) or passive (switch or relay); closure to ground causes reset.

Memory Display Outputs

The X and Y MEMORY DISPLAY OUTPUTS signals can be used by associated equipment (i.e., X-Y plotter) to make a permanent record of the waveform information stored in the 5223 memories. When the front-panel OUTPUT SAVED DISPLAY(S) switch is pressed a voltage analog of the appropriate memory information is made available on a one shot basis at a rate determined by the DISPLAY OUT SPEED control. To insure proper operation, the front-panel DISPLAY and SAVE switches should be set to their in position. During this cycle the crt display defaults to real-time operation after which the stored display returns to the crt.

Pen Lift

The PEN LIFT function is used in conjunction with the X-Y plotter to cause the writing pen to engage the paper. The function can be set, when activated, to cause a switch closure or opening. Refer selection to qualified service personnel only.

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[1] **Refer to Table 1-9, 5223 Plug-in Incompatibilities in this manual for operating restrictions concerning a particular plug-in unit, when used in the 5223 Digitizing Oscilloscope.**

Applications

The 5223 Digitizing Oscilloscope and its associated plug-in units provide a very flexible measurement system. The capabilities of the overall system depend mainly upon the plug-ins that are chosen. This section contains information that describes the techniques for making basic oscilloscope measurements.

BASIC OSCILLOSCOPE MEASUREMENT TECHNIQUES

The following measurement techniques are not described in detail, since each application must be adapted to the requirements of the individual measurement. Specific applications for the individual plug-in units are described in the manuals for these units. Contact your local Tektronix Field Office or representative for additional assistance.

The following books describe oscilloscope measurement techniques which can be adapted for use with this instrument.

Robert G. Middleton, *Scope Waveform Analysis*, Howard W. Sams & Co. Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1961.

Robert G. Middleton and L. Donald Payne, *Using the Oscilloscope in Industrial Electronics*, Howard W. Sams & Co., Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1961.

John F. Rider and Seymour D. Uslan, *Encyclopedia of Cathode-Ray Oscilloscopes and Their Uses*, John F. Rider Publisher Inc., New York, 1959.

John F. Rider, *Obtaining and Interpreting Test Scope Traces*, John F. Rider Publisher Inc., New York, 1959.

Rufus P. Turner, *Practical Oscilloscope Handbook*, Volumes 1 and 2, John F. Rider Publisher Inc., New York, 1964.

PEAK-TO-PEAK VOLTAGE MEASUREMENTS—AC

To make peak-to-peak voltage measurements, use the following procedure:

1. Set the input coupling on the vertical plug-in unit to Gnd and connect the signal to the input connector.

2. Set the input coupling to AC and set the Volts/Div switch to display about 5 or 6 vertical divisions of the waveform. Check that the variable Volts/Div control (red knob) is in the Cal position.

3. Adjust the time-base triggering controls for a stable display and set the Time/Div switch to display several cycles of the waveform.

4. Turn the vertical Position control so that the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top of the waveform is in the viewing area. Move the display with the

horizontal Position control so that one of the upper peaks is aligned with the center vertical reference line (see Fig. 3-1).

5. Measure the vertical deflection from peak-to-peak (divisions).

NOTE

This technique may also be used to make measurements between two points of the waveform, rather than peak-to-peak.

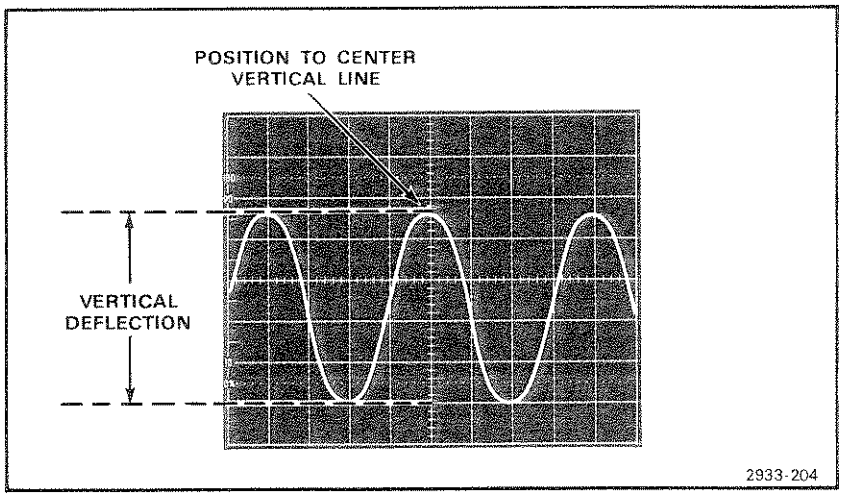

Figure 3-1. Measuring peak-to-peak voltage of a waveform.

6. Multiply the distance (in divisions) measured in step 5 by the Volts/Div switch setting. Also include the attenuation factor of the probe, if applicable.

EXAMPLE: Assume a peak-to-peak vertical deflection of 4.6 divisions and a Volts/Div switch setting of 5 V.

4.6 (divisions) × 5 (Volts/Div setting) = 23 volts peak-to-peak

NOTE

If an attenuator probe is used that cannot change the scale factor readout (Volts/Div), multiply the right side of the above equation by the attenuation factor.

INSTANTANEOUS VOLTAGE MEASUREMENT—DC

To measure the dc level at a given point of a waveform, use the following procedure:

1. Set the input coupling of the vertical plug-in unit to Gnd and position the trace to one division above the bottom line of the graticule (or other selected reference line). If the voltage to be measured is negative with respect to ground, position the trace one division below the top line of the graticule. Do not move the vertical Position control after this reference has been established.

   NOTE

   To measure a voltage level with respect to a voltage other than ground, make the following changes to step 1: Set the input coupling switch to dc and apply the reference voltage to the input connector; then position the trace to the reference line.

2. Connect the signal to the input connector. Set the input coupling to dc (the ground reference can be checked at any time by setting the input coupling to Gnd).

3. Set the Volts/Div switch to display about 5 or 6 vertical divisions of the waveform. Check that the variable Volts/Div control (red knob) is in the Cal position. Adjust the time-base triggering controls for a stable display.

4. Measure the distance in divisions between the reference line and the point on the waveform at which the dc level is to be measured. For example, in Figure 3-2 the measurement is made between the reference line and point A.

5. Establish the polarity; the voltage is positive if the signal is applied to the + input connector and the waveform is above the reference line.

6. Multiply the distance measured in step 4 by the Volts/Div switch setting. Include the attenuation factor of the probe, if applicable (see the note following the Peak-to-Peak Voltage Measurement example given previously).

EXAMPLE: Assume that the vertical distance measured is 4.6 divisions, the polarity is positive, and the Volts/Div switch setting is 2 V.

4.6 (divisions) × 2 (Volts/Div) = +9.2 volts instantaneous

COMPARISON MEASUREMENTS

In some applications, it may be necessary to establish a set of deflection factors other than those indicated by the Volts/Div of Time/Div switches. This is useful for comparing signals to a reference voltage amplitude or period. To establish a new set of deflection factors based upon a specific amplitude or period, proceed as follows:

Vertical Deflection Factor

1. Apply a reference signal of known amplitude to the vertical connector. Using the Volts/Div switch and variable Volts/Div control,

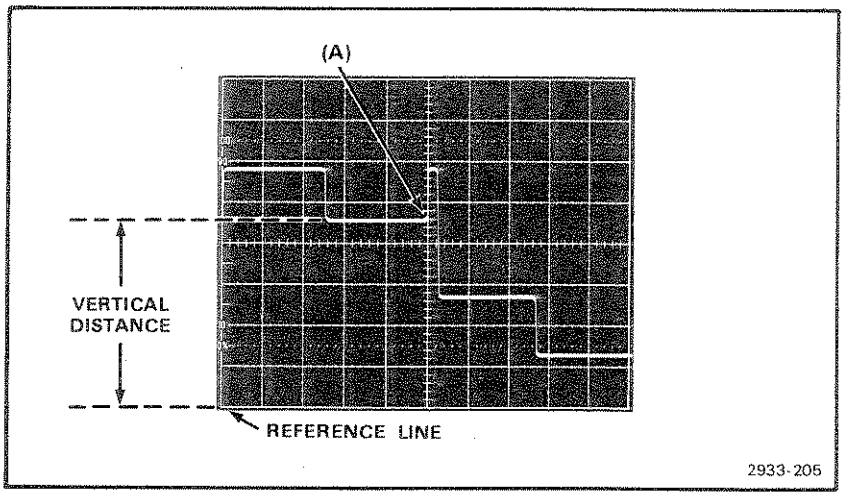

Figure 3-2. Measuring instantaneous dc voltage with respect to a reference voltage.

adjust the display for an exact number of divisions. Do not move the variable Volts/Div control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (volts) by the product of the deflection in divisions (established in step 1) and the Volts/Div switch setting. This is the Deflection Coversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{deflection (divisions)} \times \text{Volts/Div setting}}$$

3. To determine the peak-to-peak amplitude of a signal compared to a reference, disconnect the reference and apply the signal to the input connector.

4. Set the Volts/Div switch to a setting that provides sufficient deflection to make the measurement. Do not readjust the variable Volts/Div control.

5. To establish a modified deflection factor at any setting of the Volts/Div switch, multiply the Volts/Div switch setting by the Deflection Conversion Factor established in step 2.

Modified Deflection Factor = Volts/Div setting × Deflection Conversion Factor

6. Measure the vertical deflection in divisions and determie the amplitude by the following formula:

Signal Amplitude = Modified Deflection Factor × Deflection (divisions)

EXAMPLE: Assume a reference signal amplitude of 30 volts, a Volts/Div switch setting of 5 V and a deflection of four divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

$$\frac{30\ V}{(4)\ (5\ V)} = 1.5$$

Then, with a Volts/Div switch setting of 2 V, the Modified Deflection Factor (step 5) is:

(2 V) (1.5) = 3 volts/division

To determine the peak-to-peak amplitude of an applied signal that produces a vertical deflection of five divisions with the above conditions, use the Signal Amplitude formula (step 6):

(3 V) (5) = 15 volts

Sweep Rate

1. Apply a reference signal of know frequency to the vertical input connector. Using the Time/Div switch and variable Time/Div control, adjust the display so that one cycle of the signal covers an exact number of horizontal divisions. Do not change the variable Time/Div control after obtaining the desired deflection.

2. Divide the period of the reference signal (seconds) by the product of the horizontal deflection in divisions (established in step 1) and the setting of the Time/Div switch. This is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal period (seconds)}}{\text{horizontal deflection (divisions)} \times \text{Time/Div switch setting}}$$

3. To determine the period of an unknown signal, disconnect the reference and apply the unknown signal.

4. Set the Time/Div switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the variable Time/Div control.

5. To establish a Modified Deflection Factor at any setting of the Time/Div switch, multiply the Time/Div switch setting by the Deflection Conversion Factor established in step 2.

Modified Deflection Factor = Time/Div switch setting × Deflection Conversion Factor

6. Measure the horizontal deflection in divisions and determine the period by the following formula:

Period = Modified Deflection Factor × horizontal deflection (divisions)

EXAMPLE: Assume a reference signal frequency of 455 hertz (period 2.2 milliseconds), a Time/Div switch setting of 0.2 millisecond, and a horizontal deflection of eight divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

$$\frac{2.2 \text{ ms}}{(8)\,(0.2 \text{ ms})} = 1.375$$

Then, with a Time/Div switch setting of 50 ms, the Modified Deflection Factor (step 5) is:

(50 ms) (1.375) = 68.75 milliseconds/division

To determine the time period of an applied signal which completes one cycle in seven horizontal divisions, use the Period formula (step 6):

(68.75 ms) (7) = 481 milliseconds

This product can be converted to frequency by taking the reciprocal of the period (see application of Determining Frequency).

TIME PERIOD MEASUREMENT

To measure the time (period) between two points on a waveform, use the following procedure:

1. Connect the signal to the vertical input connector, select either AC or DC input coupling, and set the Volts/Div switch to display about four divisions of the waveform.

2. Set the time-base triggering controls to obtain a stable display. Set the Time/Div switch to the fastest sweep rate that will permit displaying one cycle of the waveform in less than eight divisions (some nonlinearity may occur in the first and last graticule divisions of display). Refer to Figure 3-3.

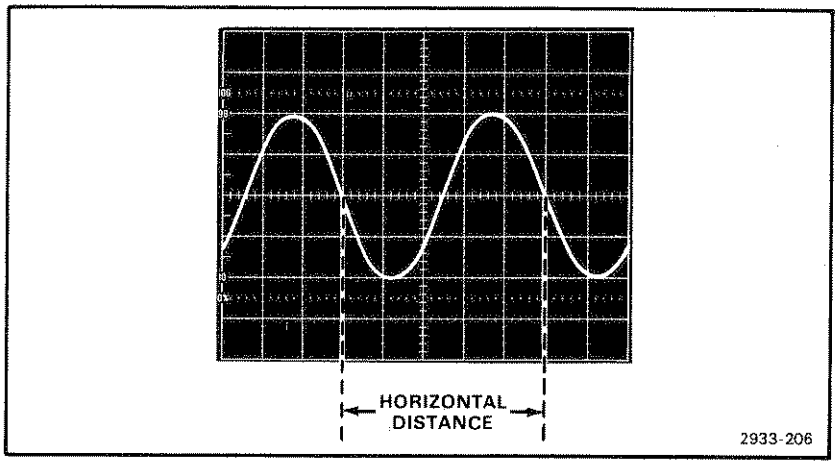

Figure 3-3. Measuring time duration (period) between points on a waveform.

3. Rotate the vertical Position control to center the displayed waveform on the center horizontal graticule line. Adjust the horizontal Position control to center the time-measurement points within the center eight divisions of the graticule.

4. Measure the horizontal distance between the time measurement points. Be sure the variable Time/Div control is in the Cal position.

5. Multiply the distance measured in step 4 by the setting of the Time/Div switch.

EXAMPLE: Assume that the horizontal distance between the time-measurement points is five divisions and the Time/Div switch is set to 0.1 millisecond. Using the formula:

horizontal distance (divisions) × Time/Div switch setting = (5) (0.1 ms) = 0.5 ms

The period is 0.5 millisecond.

DETERMINING FREQUENCY

The time measurement technique can also be used to determine the frequency of a signal. The frequency of a periodically recurrent signal is the reciprocal of the time duration (period) of one cycle. Use the following procedure:

1. Measure the period of one cycle of the waveform as described in the previous application.

2. Take the reciprocal of the period to determine the frequency.

EXAMPLE: The frequency of the signal shown previously in Figure 3-3, which has a period of 0.5 millisecond, is:

$$\frac{1}{\text{period}} = \frac{1}{0.5\text{ ms}} = 2 \text{ kilohertz}$$

RISE-TIME MEASUREMENT

Rise-time measurements employ basically the same techniques as the time-period measurements. The main difference is the points between which the measurement is made. The following procedure gives the basic method of measuring rise-time between the 10% and 90% points of the waveform.

1. Connect the signal to the input connector.

2. Set the Volts/Div switch and variable Volts/Div control to produce a display exactly five divisions in amplitude.

3. Center the display about the center horizontal graticule line with the vertical Positions control.

4. Set the time-base triggering controls to obtain a stable display. Set the Time/Div switch to the fastest sweep rate that will display less than eight divisions between the 10% and 90% points on the waveform (see Fig. 3-4).

5. Adjust the horizontal Position control to move the 10% point of the waveform near the second vertical line of the graticule.

6. Measure the horizontal distance between the 10% and 90% points. Be sure the variable Time/Div control is in the Cal position.

7. Multiply the distance measured in step 6 by the setting of the Time/Div switch.

EXAMPLE: Assume that the horizontal distance between the 10% and 90% points is four divisions and the Time/Div switch is set to 1 ms.

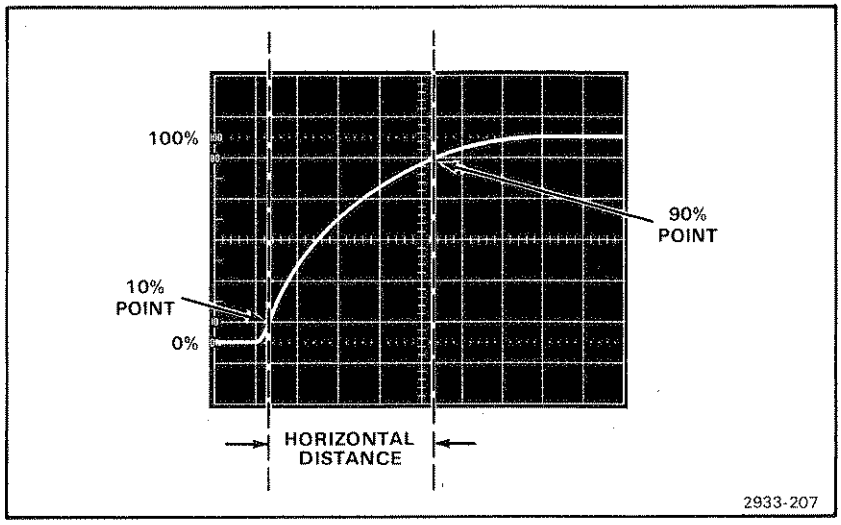

Figure 3-4. Measuring risetime.

Using the period formula to find rise time:

horizontal distance (division) × Time/Div switch setting = (4) (1 ms) = 4 ms

The rise time is 4 milliseconds.

TIME DIFFERENCE MEASUREMENTS

When used in conjuction with a calibrated time-base plug-in unit, the multi-trace feature of the 5223 Digitizing Oscilloscope permits measurement of time difference between two or more separate events (for information on X-Y measurements refer to the L VS R discussion in Section 2 of this manual). To measure time difference, use the following procedure:

1. Set the input coupling switches of the amplifier channels to either AC or DC.

2. Set the Display switch on the time-base unit to either Chop or Alt. In general, Chop is more suitable for low-frequency signals. More information on determining the mode is given under Vertical Display Mode in Section 2 of this manual.

3. Set the vertical plug-in triggering switches to trigger the display on channel 1 (or left plug-in) only.

4. Connect the reference signal to the channel 1 input connector and the comparison signal to the channel 2 (or center plug-in) input connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have similar time-delay characteristics to connect the signal to the input connectors. Trigger the time base on the reference signal.

5. If the signals are of oppostie polarity, invert the channel 2 (or center plug-in) display. (Signals may be of opposite polarity due to 180 degree phase difference; if so, take this into account in the final calculation.)

6. Set the Volts/Div switches to produce about four divisions of displayed waveform.

7. Set the time-base triggering controls for a stable display. Set the Time/Div switch for a sweep rate which shows three or more divisions between the measurement points, if possible; make sure that the Variable Time/Div control is in the Cal position.

8. Adjust the vertical Position controls to bring the measurement points to the center horizontal reference line.

9. Adjust the horizontal Position control so the channel 1 (or left plug-in) waveform (reference) crosses the center horizontal line at a vertical graticule line.

10. Measure the horizontal distance between the two measurement points (see Fig. 3-5).

11. Multiply the measured distance by the setting of the Time/Div switch.

EXAMPLE: Assume that the Time/Div switch is set to 50 ms and the horizontal distance between measurement points is four divisions. Using the formula:

Time/Div switch setting × horizontal distance (division) = (50 ms) (4) = 200 ms

The time delay is 200 milliseconds.

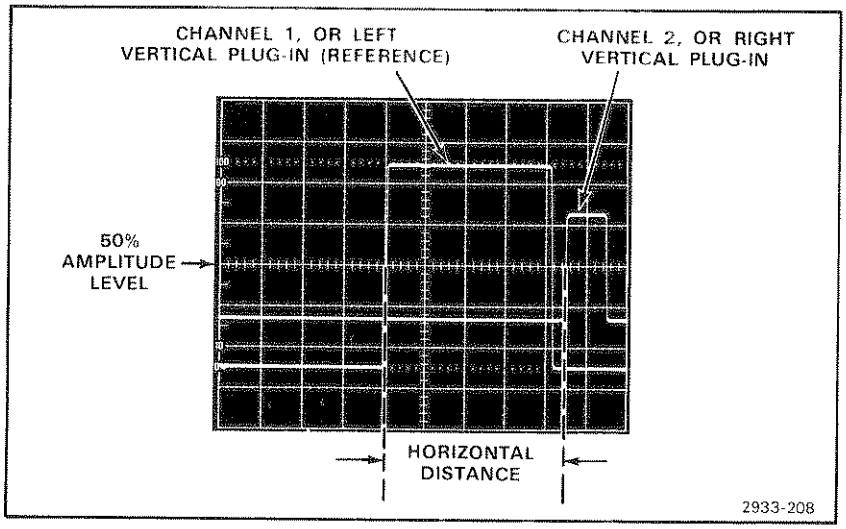

Figure 3-5. Measuring time difference between two pulses.

MULTI-TRACE PHASE DIFFERENCE MEASUREMENT

Phase comparison between two or more signals of the same frequency can be made using a dual-trace plug-in or two single-trace plug-ins. This method of phase difference measurement can be used up to the frequency limit of the vertical system. To make the comparison, use the following procedure:

1. Set the input coupling switches of the amplifier channels to either AC or DC.

2. Set the Display switch on the time-base unit to either Chop or Alt. In general, Chop is more suitable for low-frequency signals and the Alt position is more suitable for high-frequency signals. More information on determining the mode is given under Vertical Display Mode in Section 2 of this manual.

3. Set the vertical plug-in triggering switches to trigger the display on channel 1 (or left plug-in) only.

4. Connect the reference signal to the channel 1 input connector and comparison signal to the channel 2 (or center plug in) input connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have similar time-delay characteristics to connect the signals to the input connectors.

5. If the signals are of opposite polarity invert channel 2 (or center plug-in) display. (Signals may be of opposite polarity due to 180 degree phase difference; if so, take this into account in the final calculation.)

6. Set the Volts/Div switches and the variable Volts/Div controls so the displays are equal and about five divisions in amplitude.

7. Set the time-base triggering controls to obtain a stable display. Set the Time/Div switch to a sweep rate which displays about one cycle of the waveform.

8. Move the waveforms to the center of the graticule with the vertical Position controls.

9. Turn the variable Time/Div control until one cycle of the reference signal (channel 1, or left plug-in) occupies exactly eight divisions between the second and tenth vertical lines of the graticule (see Fig. 3-6).

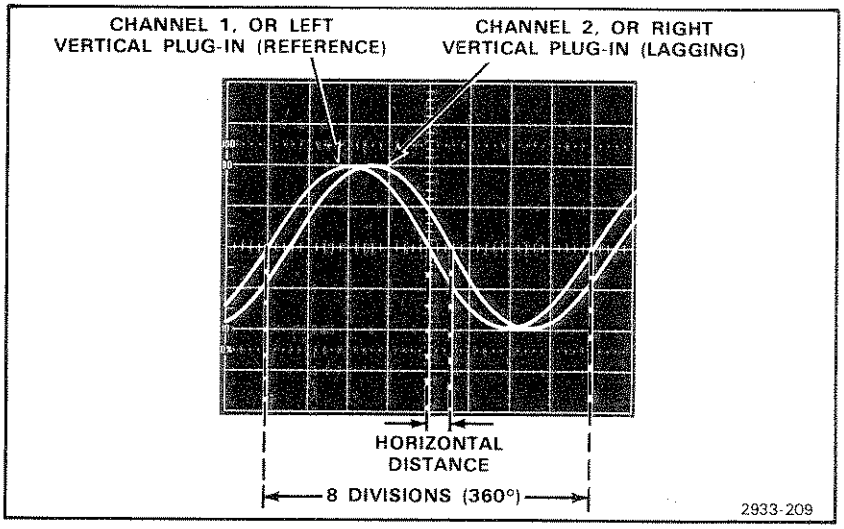

Figure 3-6. Measuring phase difference.

Each division of the graticule represents 45 degrees of the cycle (360 degrees divided by 8 divisions = 45 degrees/division). The sweep rate can be stated in terms of degrees as 45 degree/division.

10. Measure the horizontal difference (in divisions) between corresponding points on the waveforms.

11. Multiply the measured distance (in divisions) by 45 degrees/division (sweep rate) to obtain the exact amount of phase difference.

EXAMPLE: Assume a horizontal difference of 0.6 division with a sweep rate of 45 degrees/division as shown in Figure 3-6. Use the formula:

$$\text{horizontal difference (divisions)} \times \text{sweep rate (degrees/divisions)} = (0.6)(45 \text{ degrees}) = 27 \text{ degrees}$$

The phase difference is 27 degrees.

HIGH RESOLUTION PHASE MEASUREMENT

More accurate dual-trace phase measurements can be made by increasing the sweep rate (without changing the variable Time/Div control setting). One of the easiest ways to increase the sweep rate is with the sweep magnifier (X10) button on the time-base unit. The magnified sweep rate is automatically indicated by the knob-skirt scale-factor readout.

EXAMPLE: If the sweep rate were increased 10 times with the magnifier, the magnifier sweep rate should be 45 degrees/division divided by 10 = 4.5 degrees/division. Figure 3-7 shows the same signals as used in Figure 3-6, but with the sweep magnifier button pushed in. With a horizontal difference of six divisions the phase difference is:

$$\text{horizontal difference (divisions)} \times \text{magnified sweep rate (degrees/divisions)} = (6)(4.5 \text{ degrees}) = 27 \text{ degrees}$$

The phase difference is 27 degrees.

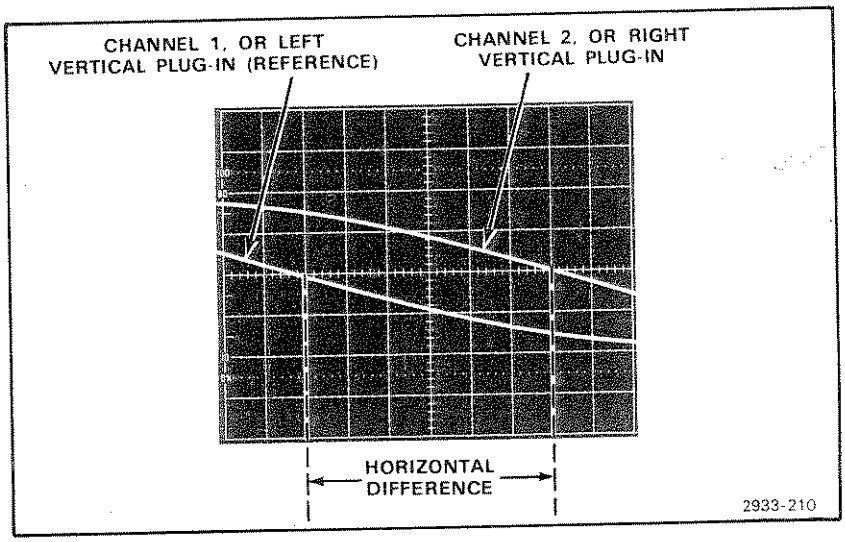

Figure 3-7. High-resolution phase difference measurement with increased sweep rate.

Instrument Options

Your 5223 may be equipped with one or more instrument options. A brief description of each available option is given in the following discussion. Option information is incorporated into the appropriate sections of the manual. Refer to Table 4-1 and the Table of Contents for location of option information. For further information on instrument options, see your Tektronix Products Catalog or contact your Tektronix Field Office.

LIST OF OPTIONS

OPTION 5

Allows the instrument to operate from a 48 to 440 Hz line frequency. Option 5 is available for the rackmount 5223 only (not available on the bench model) and is installed at the factory.

OPTION 10

A separate Operators and Service manual is available for the 5223 Option 10 (GPIB) instrument.

OPTION A1

The standard power cord is replaced with the Universal European 240-volt type power cord (Tektronix Part 161-0066-09).

OPTION A2

The standard power cord is replaced with the United Kingdom 240-volt type power cord (Tektronix Part 161-0066-10).

OPTION A3

The standard power cord is replaced with the Australian 240-volt type power cord (Tektronix Part 161-0066-11).

OPTION A4

The standard power cord is replaced with the North American 240-volt type power cord (Tektronix Part 161-0066-12).

INSTRUMENT OPTION IDENTIFICATION

OPTION 5

Nomenclature on the rear panel will indicate if Option 5 is installed.

OPTION 10

A plate on the rear panel will indicate that Option 10 is not installed.

OPTION A1, A2, A3, AND A4

Refer to Figure 1-1 in this manual to determine type of cord used with your instrument.

TABLE 4-1
Option Information Locator

Option	Location in Manual		Information
	Section	Heading	
5	4 Instrument Options	Option 5	Gives a brief description of Option 5.
10	4 Instrument Options	Option 10	Gives a brief description of Option 10.
A1	1 General Information	Power Cord Information Figure 1-1	Lists details of Option A1.
	4 Instrument Options	Option A1	Gives a brief description of Option A1.
A2	1 General Information	Power Cord Information Figure 1-1	Lists details of Option A2.
	4 Instrument Options	Option A2	Gives a brief description of Option A2.
A3	1 General Information	Power Cord Information Figure 1-1	Lists details of Option A3.
	4 Instrument Options	Option A3	Gives a brief description of Option A3.
A4	1 General Information	Power Cord Information Figure 1-1	Lists details of Option A4.
	4 Instrument Options	Option A4	Gives a brief description of Option A4.

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