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WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

5B25N

DIGITIZER TIME BASE/AMPLIFIER

WITH OPTIONS

SERVICE

INSTRUCTION MANUAL

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

070-2813-00
Product Group 52

Serial Number ____________

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INSTRUMENT SERIAL NUMBERS

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

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

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.

DO NOT SERVICE ALONE

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

USE CARE WHEN SERVICING WITH POWER ON

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

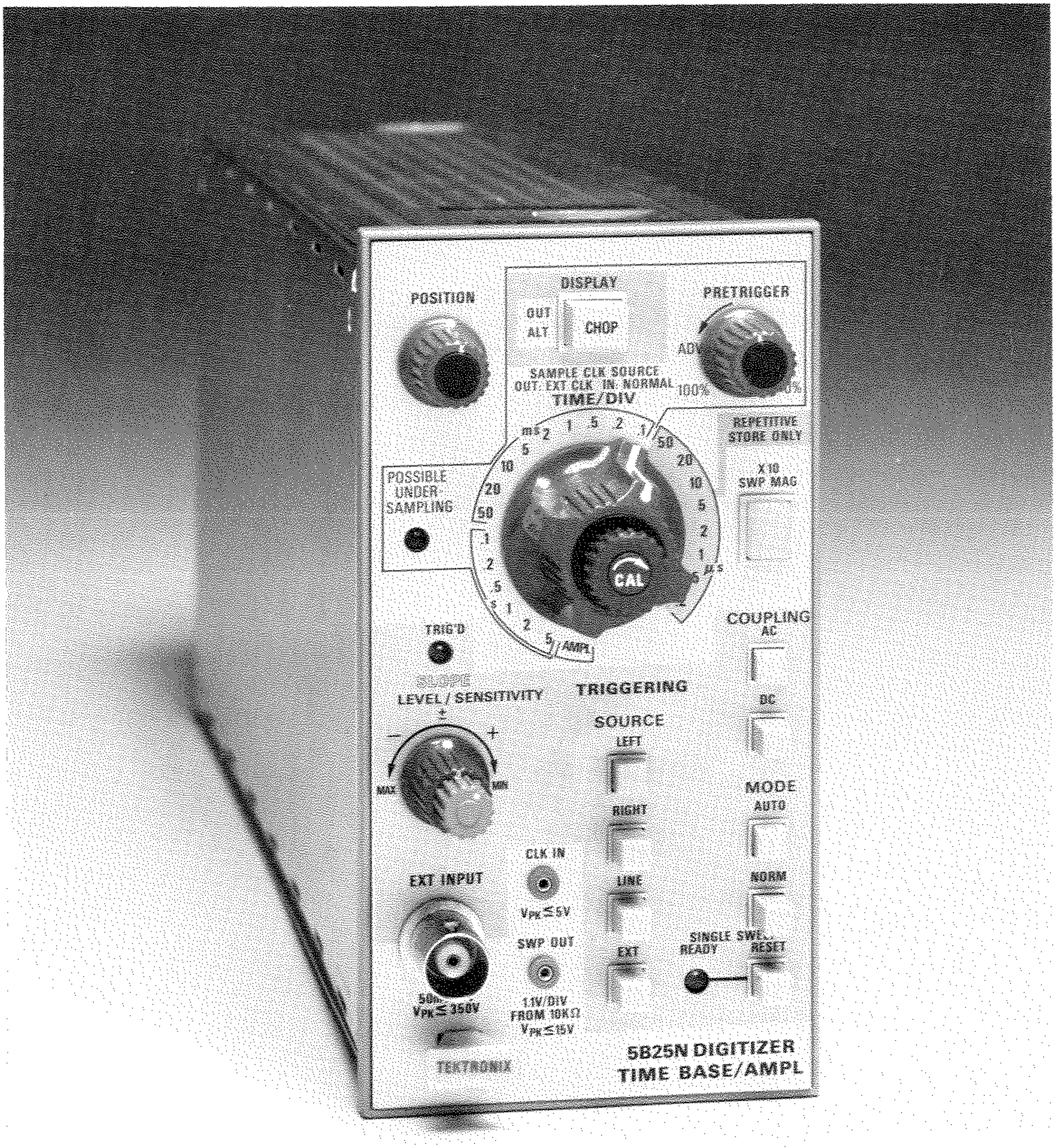
Disconnect power before removing protective panels, soldering, or replacing components.

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.

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.



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5B25N FEATURES

The 5B25N Digitizer Time Base/Amplifier operates with the 5223 Digitizing Oscilloscope mainframe and one or two 5000-series plug-in units to form a digitizing oscilloscope system. It will also operate with a 5400-series oscilloscope mainframe and one or two 5000-series plug-in units to form a non-digitizing oscilloscope system. The 5B25N has calibrated sweep rates from 5s to 0.2 μs per division, triggering from dc to 20 MHz, and a X10 sweep magnifier.

GENERAL INFORMATION

This section contains a basic content description of both the Operators and Service Manuals, a description of the 5B25N, information on instrument installation, packaging for shipment, and specifications. The Specification portion consists of three tables; Electrical, Environmental, and Physical Characteristics.

This section also contains a Standard Accessories list and a full-page instrument dimensional drawing.

The 5B25N Digitizer Time Base/Amplifier operates with a 5223 Digitizing Oscilloscope and one or two 5000-series plug-in units to form a system. The system will digitize a displayed waveform and present a memory display of that waveform after the original event.

OPERATORS MANUAL

The Operators Manual has the following three sections:

Section 1—General Information contains instrument description, electrical specifications, environmental characteristics, standard and recommended accessories, and packaging for shipment instructions.

Section 2—Operating Instructions contains information about operating and checking the instrument operation.

Section 3—Instrument Options contains a description of available options and gives the location of the incorporated information for those options.

SERVICE MANUAL

WARNING

THE SERVICE MANUAL CONTAINS INSTRUCTIONS FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

Section 1—General Information, which contains instrument description, electrical specifications, environmental characteristics, standard and recommended accessories, installation, and packaging for shipment instructions.

Section 2—Operating Information contains information on instrument installation, front- and rear-panel controls, connectors and indicators, internal switches and selectors, Checkout Procedure, and other information relative to operating and checking instrument operation.

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

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

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

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 part of the Calibration procedure.

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

DESCRIPTION

The 5B25N Digitizer Time Base/Amplifier is an essential part of the Tektronix 5223 Digitizing Oscilloscope system. The 5223 Digitizing Oscilloscope mainframe, the 5B25N, and one or two 5000-series plug-in units constitute the 5223 system.

The 5B25N has two features that are essential to a digitizing oscilloscope system, as follows:

1. It notifies the 5223 when to sample its incoming signal.

2. The 5B25N determines which 1024-bit group of signal samples the 5223 will display. The PRETRIGGER control can vary (up to one full sweep before the trigger point) the starting point of a group of samples.

The 5B25N will also operate with a 5400-series oscilloscope mainframe and one or two 5000-series plug-in units to form a complete nondigitizing oscilloscope system. (The "N" after 5B25 means the instrument provides no readout in mainframes with readout capability.)

INSTALLATION

The 5B25N is designed to operate in the horizontal plug-in compartment of the mainframe. It can also be installed in a vertical plug-in compartment to provide a vertical sweep on the crt. However, when used in this manner there are no internal triggering or retrace blanking provisions, and the unit may not meet specifications.

To install the 5B25N in a plug-in compartment, align the grooves in the top and bottom of the instrument with the guides at the top and bottom of the plug-in compartment. Then push the 5B25N in until its front panel is flush with the front panel of the mainframe. Even though the gain of the mainframe is standardized, the sweep calibration of the 5B25N should be checked when installed. The procedure for checking calibration of the 5B25N sweep is given in section 2 under Sweep Functions in the Checkout Procedure.

To remove the unit, pull the release latch (see Fig. 1-1) to disengage it from the mainframe, and pull it out of the plug-in compartment.

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:

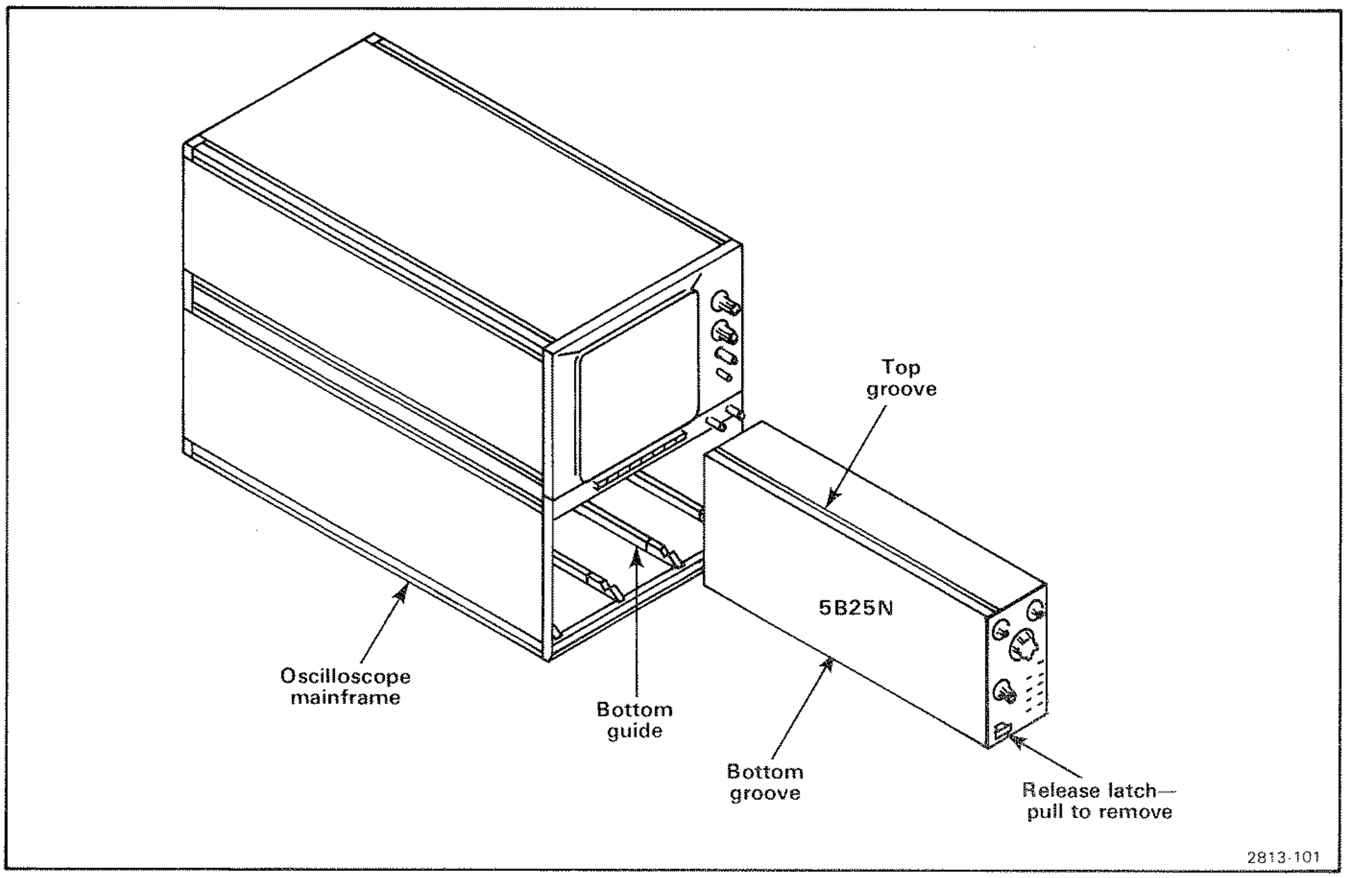

Figure 1-1. Installing and removing the 5B25N.

1. Obtain a corrugated cardboard shipping carton with a 200-pound test strength and having inside dimensions at least six inches greater than the instrument dimensions. this allows for cushioning.

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.

SPECIFICATION

The 5B25N will meet the electrical characteristics listed in Table 1-1 after it is completely calibrated. The following electrical characteristics are valid over an ambient temperature range of 0° to +50° C, provided the 5B25N is calibrated in an ambient temperature of +20° to +30° C, and warmed up for 20 minutes. Except where noted otherwise, these specifications are valid when the 5B25N is installed in a 5223 or any 5400-series mainframe.

TABLE 1-1
Electrical Characteristics

Characteristic	Performance Requirement			
SWEEP GENERATOR				
Sweep Rates				
Calibrated Range	5 s/div to 0.2 μs/div in a 1, 2, 5 sequence. X10SWP MAGnifier extends fastest calibrated sweep rate to 20 ns/div. (The X10 SWP MAG functions on the real-time display only.)			
Variable Range	Continously variable between calibrated sweep rates. Extends sweep rate to at least 12.5 s/div.			
Sweep Accuracy Over Center 8 Divisions	+15° to +35°C		0° to +50°C	
	Unmag	Mag	Unmag	Mag
1 s/div to 0.2 μs/div	3%	4%	4%	5%
2 s and 5 s/div	4%	5%	5%	6%
Excluded Portions of Sweep				
Start of Sweep	0.2 divisions +200 ns.			
End of Sweep	Unmagnified—beyond 10.5 divisions after start of sweep.			
	Magnified—beyond 105 divisions after start of sweep.			

TABLE 1-1 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement
Sweep Length	At least 10.5 div at all sweep rates.
Position Range	
POSITION Control Fully CW	Start of sweep must be to right of graticule center at 1 ms/div.
POSITION Control Fully CCW	Must be at least 10.5 div of sweep to left of graticule center at 1 ms/div.
Sweep Out Voltage	
Open Circuit	1.1 V/div ±5%.
Into 1 kΩ Load	0.1 V/div ±6%.

TRIGGERING

Triggering + or − Slope	
Sensitivity	
Internal Trigger with any 5A30- or 5A40-series Amplifier	0.4 division, dc [1] to 1 MHz. 0.6 division, 1 MHz to 15 MHz.
External Trigger	50 mV, dc[1] to 1 MHz. 200 mV, 1 MHz to 15 MHz.
± Slope	
Sensitivity	
Internal Trigger, AC Coupling	±0.5 division, 30 Hz to 1 MHz. Will trigger to 15 MHz.
External Trigger	±50 mV, dc[1] to 1 MHz. Will trigger to 15 MHz.
Input R and C	1 MΩ ±2% shunted by 24 pF ±4 pF.
Maximum Input Voltage	350 V peak.
Amplifier Mode	
Sensitivity	50 mV/div ±3% at 1 kHz.
Bandwidth	2 MHz minimum @ −3 dB.
Risetime	180 ns maximum.
Aberrations	Less than 5%.

[1] 30 Hz when ac coupled.

TABLE 1-1 (CONT)
Electrical Characteristics

Characteristic	Performance Requirement		
DIGITIZER-RELATED FUNCTIONS			
Digitizer-Related Functions (5223 Mainframe Only)			
Overall Speed Accuracy of Digitized Signal—(Center 8 div). Excluded Portions: First 200 ns or 0.2 div of each waveform	Digitized Waveform	Digitized Waveform Relative to Real-Time Waveform	
		CAL	UNCAL
2 and 5 s/div	3%	4%	6%
1 s - 0.1 ms/div	3%	3%	5%
50 μs - 0.2 μs/div	3%	3%	3%
Pretrigger Adjustment Range	Continosly variable from 0% to 100% of the memory length.		
Possible Undersampling Light	Operates only at sweep speeds of 0.1 ms/division and slower. Lights when there are 8 or fewer sample pulses per trigger event.		
CLK IN Signal			
Voltage Limits	High, +2.4 to +5.0 V Low, −0.5 to +0.4 V		
Frequency Limit, Maximum	1 MHz		
POWER SOURCE			
Power Consumption	Less than 6.5 watts.		

TABLE 1-2
Environmental Characteristics

Characteristic	Information
Temperature	
Operating	0° to +50°C.
Storage	−55° to +75°C.

TABLE 1-2 (CONT)
Environmental Characteristics

Characteristic	Information
Altitude	
Operating	To 15,000 feet (4,500 m).
Storage	To 50,000 feet (15,000 m).
Vibration	
Operating and Non-operating	Tested to MIL-T-28800B Section 4.5.5.3.1 Type 2. Class 5. Style E & F.
Shock	
Nonoperating	Tested to MIL-T-28800B. Section 4.5.5.4.1 Type 2. Class 5. Style E & F.
Bench Handling	Tested to MIL-T-28800B. Section 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	Project 1 A-B-1.
Drop of Packaged Product	NSTA. Project 1 A-B-2.
Humidity	
Operating and Storage	Five days, per MIL-STD-810C, Method 507-1, Procedure 4, except 90-95% RH.
Electromagnetic Compatibility	Tektronix Product Design Standard 062-2866-00.

TABLE 1-3
Physical Characteristic

Characteristic	Information
Net Weight	About 2.06 lb. (0.93 kg).
Overall Dimensions	See Figure 1-2, the dimensional drawing.

STANDARD ACCESSORIES

1 ea .... Operators Manual

1 ea .... Service Manual

For more detailed information refer to the tabbed Accessories page at the rear of this manual.

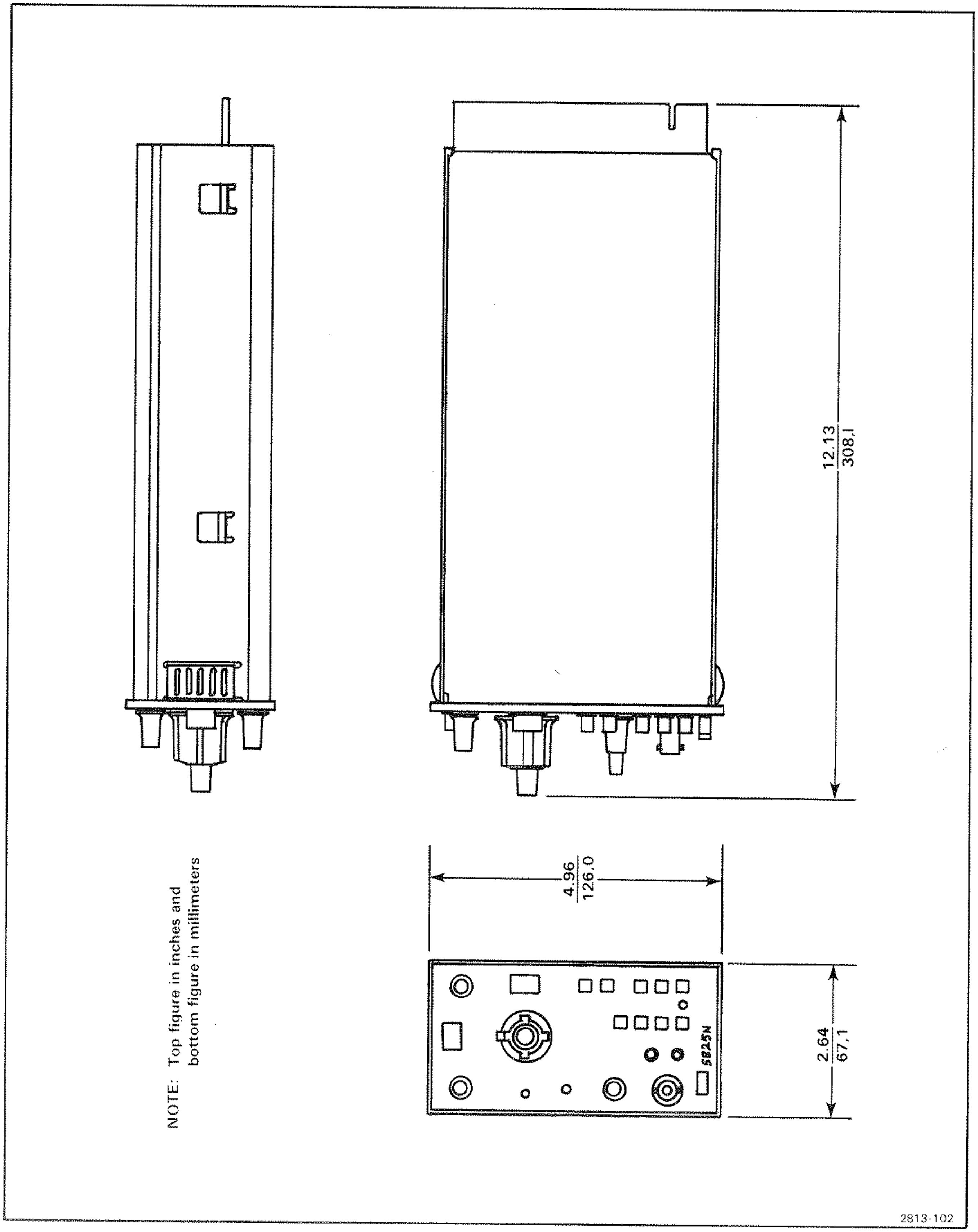

Figure 1-2. Dimensions of 5B25N.

OPERATING INFORMATION

The 5B25N Digitizer Time-Base/Amplifier operates with a Tektronix 5223 or any 5400-series oscilloscope mainframe and one or two 5000-series plug-in unit(s) to form a complete oscilloscope system. This section describes the operation of the front-panel controls and connectors, provides a Checkout Procedure, detailed operating information, and basic applications for the 5B25N.

CONTROLS, CONNECTORS, AND INDICATORS

All controls, connectors, and indicators required for the operation of the time-base unit are located on the front panel. Figure 2-1 provides a brief description of all front-panel controls, connectors, and indicators. More detailed information is given in the Detailed Operating Information section.

CHECKOUT PROCEDURE

The following procedures are provided for checking basic instrument functions. Refer to the description of the controls, connectors, and indicators while performing this procedure. If performing the Checkout Procedure reveals a malfunction or possible misadjustment, first check the operation of the associated equipment, then refer to qualified service personnel for repair or adjustment of the instrument.

PRELIMINARY SETUP

1. Install the time base being checked in the horizontal compartment of the mainframe.

2. Install an amplifier plug-in in the left vertical compartment.

3. Set the time-base controls as follows:

SLOPE	(+)
MODE	AUTO
COUPLING	AC
SOURCE	LEFT
POSITION	Midrange
TIME/DIV	1 ms
CAL	Calibrated (fully clockwise)
X10 SWP MAG	X1 (out)
DISPLAY	CHOP (in)

4. Turn on the mainframe and allow at least 20 minutes warmup.

5. Adjust the mainframe Intensity and Focus controls for a well-defined display. See the oscilloscope mainframe and amplifier unit instruction manuals for detailed operating instructions.

SWEEP FUNCTIONS

Normal Sweep

Perform the following procedure to obtain a normal sweep and to demonstrate the function of the related controls:

1. Perform the preceding Preliminary Setup.

2. Connect a 0.3-volt, 1-kilohertz signal from the mainframe calibrator to the vertical amplifier input.

3. Set the amplifier unit deflection factor for 3 divisions of display.

4. Adjust the LEVEL/SENSITIVITY control for a stable display.

5. Rotate the POSITION control and observe that the trace moves horizontally.

6. Check the waveform display for one complete cycle per division, ±4%. The ±4% includes ±1% for the 5223 calibrator signal and ±3% for the 5B25N sweep.

7. Rotate the CAL control fully counterclockwise and observe that the displayed sweep rate changes to at least the next slower TIME/DIV switch setting (i.e., 2 milliseconds/division). Return the CAL knob to the calibrated position.

Magnified Sweep

Perform the following procedure to obtain a X10 magnified display and to demonstrate the function of the related controls:

1. Obtain a one-cycle-per-division display as described in the preceding Normal Sweep procedure.

2. Press the X10 SWP MAG button. Observe that the cycle displayed at the horizontal center of the graticule expands to about 10 divisions.

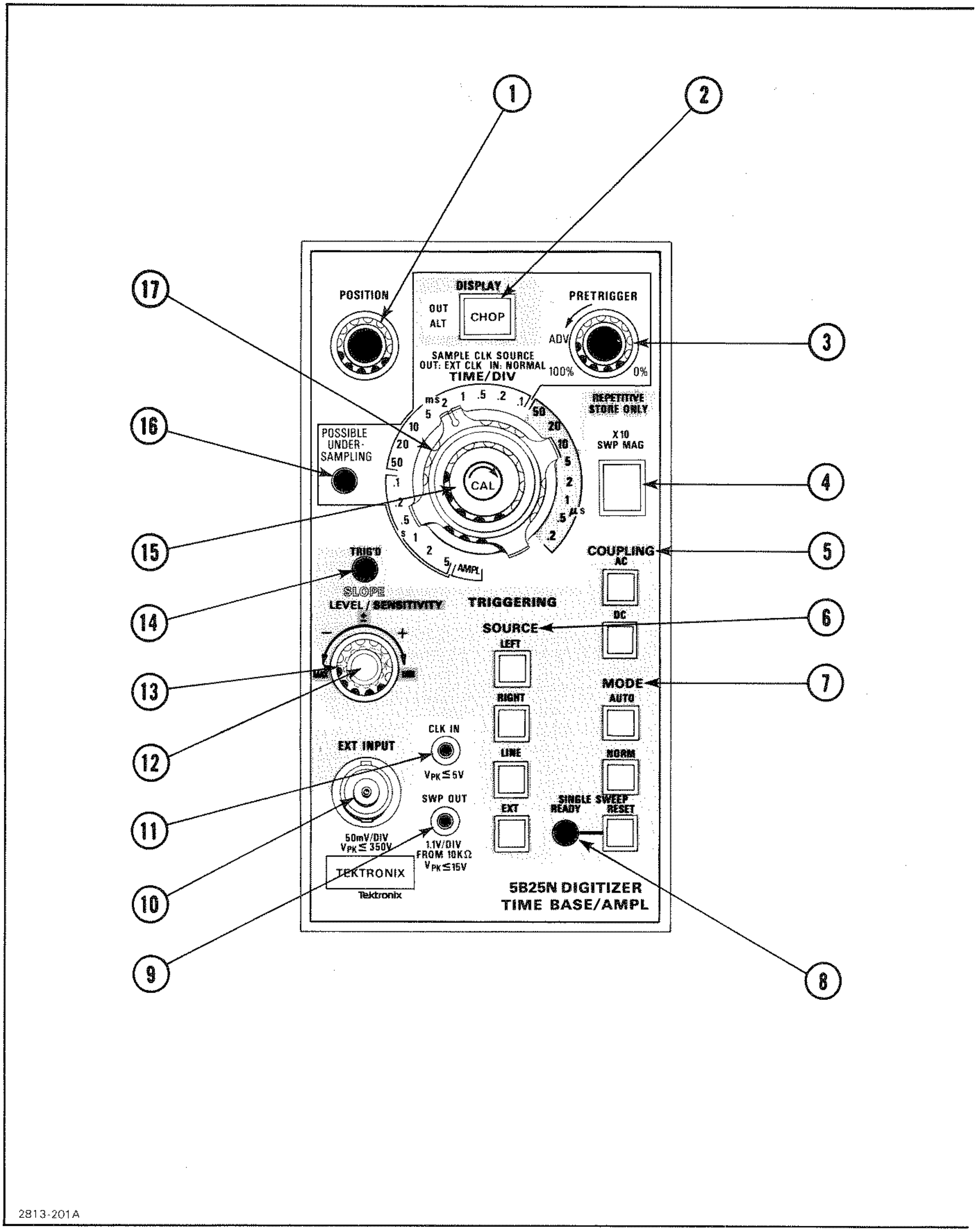

Figure 2-1. Front-panel controls, connectors and indicators.

(1) **POSITION Control**—Positions the crt display horizontally.

(2) **DISPLAY Pushbutton***—Selects display mode of mainframe (chop or alternate).

(3) **PRETRIGGER Control***—Selects the amount of information preceding the trigger point that will be stored in the 5223 memory.

(4) **X10 SWP MAG Pushbutton**—When pressed in, selects X10 magnified sweep. Illuminates when pressed in.

(5) **COUPLING Pushbuttons**—Selects method (AC or DC) of coupling the trigger signal to the trigger circuit.

(6) **SOURCE Pushbuttons**—Selects source (LEFT, RIGHT, LINE or EXT) of the trigger signal.

(7) **MODE Pushbuttons**—Selects the operating mode (AUTO, NORM or SINGLE SWEEP) of the trigger circuit.

(8) **READY Indicator**—Lights when the sweep circuit is armed (SINGLE SWEEP button must be pressed in).

(9) **SWP OUT Connector**—Provides sweep ramp signal for external use.

(10) **EXT INPUT Connector**—Signals applied to the EXT INPUT connector can be:

a. Used to trigger the sweep when the EXT SOURCE button is pressed in, or

b. Displayed when the TIME/DIV control is set to the AMPL position.

(11) **CLK IN Connector**—A pin jack that provides a means of introducing an external sample pulse to the 5B25N.

(12) **SLOPE Control**—Permits sweep to be triggered on negative, positive, or both positive- and negative-going parts of the trigger signal.

(13) **LEVEL/SENSITIVITY Control**—Selects a point on the triggering signal where triggering occurs. When ±SLOPE is selected, adjusts the triggering threshold.

(14) **TRIG'D Indicator**—Illuminates when the sweep is triggered.

(15) **CAL Control**— a. Selects calibrated or uncalibrated sweep rates. Uncalibrated sweep rates can be continuously reduced to at least the next slowest rate.

b. The CAL control is also a pushbutton control which selects the source of sample clock pulses. When the CAL control is pressed in, the 5B25N supplies a sample pulse to the 5223. When the CAL control is released (out), external sample pulses can reach the 5223 via the CLK IN connector on the 5B25N front panel.

(16) **POSSIBLE UNDERSAMPLING Indicator***—Lights when eight or fewer sample pulses are sent to the 5223 per trigger event, i.e., per cycle of repetitive input signal.

(17) **TIME/DIV Control**—Selects the sweep rate of the sweep generator. When in the AMPL position, the time base functions as an amplifier.

* When the TIME/DIV control is in the shaded area (between 0.2μs to 50μs), the PRETRIGGER and DISPLAY controls are disabled and the POSSIBLE UNDERSAMPLING indicator does not function.

2813-201B

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

3. Release the X10 SWP MAG button by pressing it.

Display

This procedure compares the alternate and chopped functions as controlled by the 5B25N DISPLAY button. Use a dual-channel vertical amplifier plug-in set for dual-trace operation, or two single-trace amplifiers with their Display buttons pressed.

1. Set the TIME/DIV control to 10 ms and obtain a display of both channel 1 and channel 2 sweeps. (Or, with two single-trace amplifiers, both left and right traces.)

2. Release the DISPLAY button to set the horizontal display mode to ALTernate.

3. Observe that the display is now switching in the alternate mode, i.e., two channel 1 sweeps and then two channel 2 sweeps. (Or, with two single-trace amplifiers, one left, then one right trace.)

4. Press the DISPLAY button in.

5. Observe that two sweeps are displayed.

TRIGGERING FUNCTIONS

Perform the following procedure to obtain a triggered sweep and to demonstrate the functions of the related controls:

1. Obtain a display as described in the preceding Normal Sweep procedure.

2. Alternately press the AC and DC COUPLING buttons for both the + and − positions of the SLOPE control and check for a stable display (the LEVEL/SENSITIVITY control may be adjusted, if necessary, to obtain a stable display).

3. Apply the 0.3-volt, 1-kilohertz signal from the mainframe calibrator to the vertical amplifier and to the EXT INPUT connector.

4. Press the EXT SOURCE button and set the vertical amplifier deflection factor for a three-division display.

5. Press the AC and DC COUPLING buttons in both the + and − positions of the SLOPE control and check for a stable display (the LEVEL/SENSITIVITY control may be adjusted, if necessary).

6. Press the AC COUPLING button and set the SLOPE control to ± (bislope). Rotate the LEVEL/SENSITIVITY control to the MAXimum position (fully counterclockwise).

7. Observe that the sweep is triggered. Rotate the LEVEL/SENSITIVITY control towards the MINimum position (clockwise).

8. Observe that at some point the sweep becomes untriggered and free-runs. The sweep will start free-running because the ±SENSITIVITY control has moved the + and − triggering points beyond the + and − amplitude extremes of the input signal.

NOTE

DC COUPLING is not recommended in the ± SLOPE mode (from INTernal source) because of inherent dc offset in the trigger path of some vertical plug-in units.

9. Press the LEFT SOURCE and AUTO MODE buttons and adjust the LEVEL/SENSITIVITY control for a free-running display.

10. Press the NORM MODE button and check for no display.

11. Adjust the LEVEL/SENSITIVITY control for a stable display and press the SINGLE SWEEP RESET button.

12. Verify that one trace occurs each time the SINGLE SWEEP RESET button is pressed and released.

13. Disconnect the mainframe calibrator signal from the vertical amplifier input and press the SINGLE SWEEP RESET button. Check for no display and note that the READY indicator is lit.

14. Observe that one trace occurs and that the READY indicator extinguishes when the mainframe calibrator signal is reconnected to the vertical amplifier input.

15. Disconnect the calibrator signal from the vertical amplifier and the 5B25N EXT INPUT connector.

16. Set the TIME/DIV control fully counterclockwise to the AMPL position and press the LINE SOURCE button. Observe that one horizontal trace extends across the entire crt graticule of the mainframe.

POSSIBLE UNDERSAMPLING INDICATOR

Perform the following procedure to demonstrate the function of the POSSIBLE UNDERSAMPLING indicator.

1. Obtain a display as described in the preceding Normal Sweep procedure.

2. Connect a 50 kHz signal from a sine-wave generator to the vertical amplifier input with a coaxial cable and a 50-ohm terminator.

3. Set the amplifier deflection factor to 0.5 V/Div.

4. Adjust the output amplitude of the sine-wave generator to produce a three-division display on the crt.

5. Set the 5B25N TIME/DIV control to 50 μs.

6. Press the 5223 Display Left and Vector Mode buttons.

7. Use the 5223 Vert and Horiz Posn controls to position the memory display so that it can be viewed separately from the real-time display.

8. Observe that rotating the TIME/DIV control counterclockwise one step at a time causes the appearance of the memory display to differ from the real-time display. At some setting the POSSIBLE UNDERSAMPLING indicator will come on, showing that the system is taking too few samples to accurately reconstruct the input signal.

Figure 2-2A, B, and C shows the display at 50 μs, 0.2 ms and 0.5 ms/division. At 50 μs/div (Fig. 2-2A), the memory display (bottom) is a good reproduction of the real-time display (top). At 0.2 ms/div (Fig. 2-2B), the memory display is still a fair reproduction of the real-time display, but some confusing light and dark areas are evident. At 0.5 ms/div (Fig. 2-2C), it is difficult to relate the memory display to the real-time display and the POSSIBLE UNDERSAMPLING indicator is lighted.

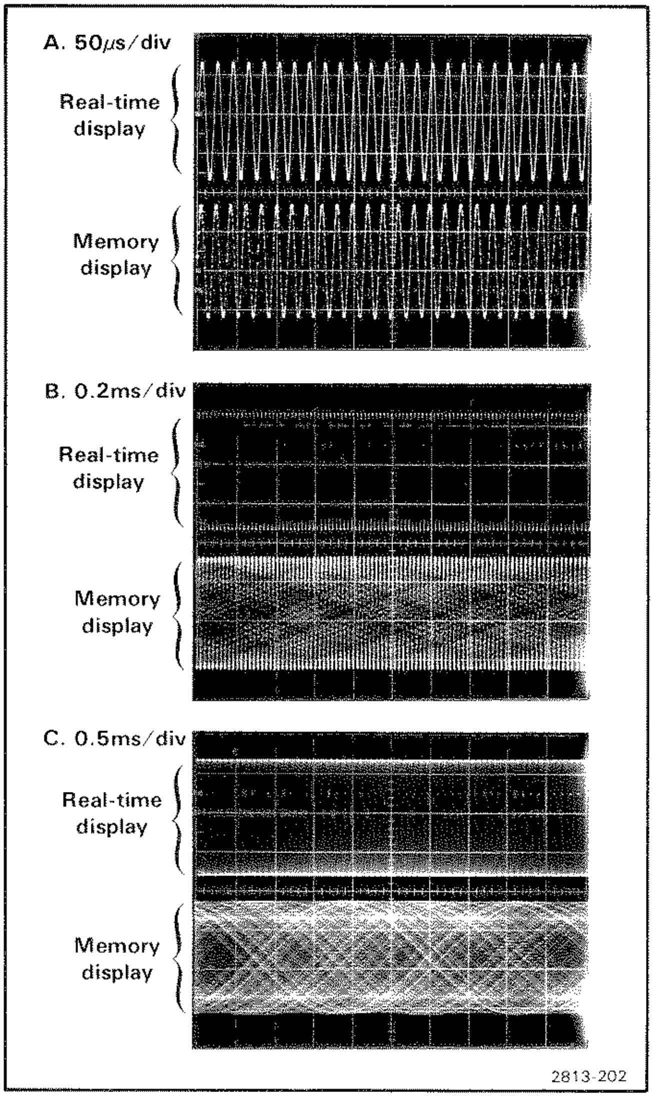

Figure 2-2. Real-time and memory displays of 50 kHz signal at 50 μs, .2 ms, and .5 ms/division.

PRETRIGGER CONTROL

Perform the following procedure to demonstrate the function of the PRETRIGGER control.

1. Obtain a display as described in the preceding Normal Sweep procedure.

2. Connect the Calibrator signal from the mainframe to the input of the vertical amplifier plug-in.

3. Set the deflection factor of the amplifier to provide a two-division display.

4. Press the 5223 Display Left button.

5. Adjust the 5223 Mem Inten control so that the memory display is of low-to-moderate brightness. This will let you easily see the trigger point, because the display is intensified during the time before the trigger event.

6. Use the 5223 Vert and Horiz Posn controls to position the memory display so that it can be viewed separately from the real-time display.

7. Observe that turning the PRETRIGGER control counterclockwise from 0% causes the memory display to move across the screen from left to right. The part of the display that occurred before the trigger point is brighter than the part that occurred after the trigger point. You can verify this by varying the setting of the 5223 Mem Inten control. Figure 2-3 shows a typical display with the PRETRIGGER control set to about 50%.

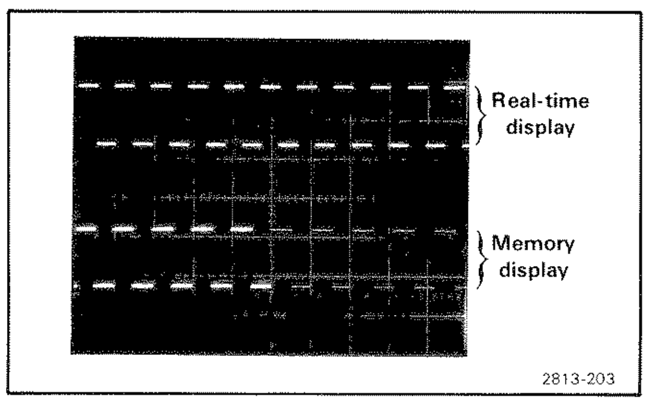

Figure 2-3. Real-time and memory displays of 5223 Calibrator signal with PRETRIGGER control set to about 50%.

DETAILED OPERATING INFORMATION

TRIGGERING SWITCH LOGIC

The TRIGGERING group of controls includes the MODE, COUPLING, and SOURCE pushbuttons which are used to obtain a stable display on the mainframe crt. When an adequate trigger signal is applied and the LEVEL/SENSITIVITY control is correctly set the 5B25N is triggered, as indicated by the illuminated TRIG'D light. Refer to the following discussions or the instruction manuals for the associated oscilloscope mainframe and vertical unit(s) for more information.

TRIGGERING MODE

The MODE pushbutton switches select the mode in which the sweep is triggered.

Auto

The AUTO MODE provides a triggered display with the correct setting of the LEVEL/SENSITIVITY control whenever an adequate trigger signal is applied (see Trigger Level discussions). The TRIG'D light indicates that the sweep is triggered.

When the trigger repetition rate is outside the frequency range selected by the COUPLING switch or the trigger signal amplitude is inadequate, the sweep free runs at the rate indicated by the TIME/DIV control (TRIG'D indicator will be off). An adequate trigger signal ends the free-running condition and a triggered display will be presented. The sweep also free runs at the rate indicated by the TIME/DIV control when the LEVEL/SENSITIVITY control is at a setting outside the amplitude range of the trigger signal. This type of free-running display is useful when it is desired to measure only the peak-to-peak amplitude of a signal without observing the waveshape (such as bandwidth measurements). The triggering circuit will not operate in AUTO mode below about 25 hertz. To trigger effectively below about 25 hertz, use the NORMal triggering mode.

Normal

The NORM MODE provides a triggered display with the correct settings of the LEVEL/SENSITIVITY control whenever an adequate trigger signal is applied. The TRIG'D light indicates that the sweep is triggered.

The normal trigger mode must be used to produce triggered displays with trigger repetition rates below about 25 hertz. When no trace is displayed, the TRIG'D light is off.

Single Sweep

When the signal to be displayed is not repetitive or varies in amplitude, waveshape, or repetition rate, a conventional repetitive type sweep may produce an unstable display. Under these circumstances, a useful display can often be obtained by using the single-sweep feature.

To demonstrate a single-sweep display of a repetitive signal, first connect the mainframe calibrator signal to the vertical amplifier and obtain the best possible display in the NORM MODE. Then, without changing the other TRIGGERING controls, remove the calibrator signal and press the SINGLE SWEEP RESET button. The SINGLE SWEEP READY indicator should light. Reconnect the calibrator signal to the vertical amplifier. A single sweep of the calibrator signal should occur. Further sweeps cannot take place until the SINGLE SWEEP RESET button is pressed again. If the displayed signal is a complex waveform composed of varying amplitude pulses, successive single-sweep displays may not start at the same point on the waveform. At fast sweep rates, it may be difficult to view the single-sweep display. The apparent trace intensity can be increased by reducing the ambient light level or by using a viewing hood as recommended in the mainframe instruction manual.

When using the single-sweep mode to photograph waveforms, the graticule may have to be photographed separately in the normal manner to prevent overexposing the film. Be sure the camera system is well protected against stray light, or operate the system in a darkened room. For repetitive waveforms, press the SINGLE SWEEP RESET button only once for each waveform unless the signal is completely symmetrical. Otherwise, multiple waveforms may appear on the film. For random signals, the lens can be left open until the signal triggers the 5B25N. Further information on photographic techniques is given in the appropriate camera instruction manual.

TRIGGERING COUPLING

The TRIGGERING COUPLING pushbuttons select the method of coupling the trigger signal to the trigger circuits.

AC

AC COUPLING blocks the dc component of the trigger signal. Signals with components below about 30 hertz are attenuated. AC coupling can be used for most applications. However, if the sweep is to be triggered at a low repetition rate or by a dc level, DC coupling will provide a better display.

DC

DC COUPLING can be used to provide stable triggering from low-frequency signals which would be attenuated in the AC COUPLING control position. The DC COUPLING control position can be used to trigger the sweep when the trigger signal reaches a dc level set by the LEVEL/SENSITIVITY control.

TRIGGERING SOURCE

The TRIGGERING SOURCE pushbuttons select the source of the trigger signal which is connected to the trigger circuits. When the TIME/DIV control is set to AMPL, they select the source of the signal to be applied to the horizontal deflection channel.

Left, Right

The LEFT and RIGHT positions connect trigger signals from the vertical plug-in units. Further selection of the internal trigger signal may be provided by a vertical plug-in unit; see the instruction manuals for these instruments for more information. For most applications, the internal source can be used. However, some applications require special triggering which cannot be obtained internally. In such cases, the LINE or EXT positions of the SOURCE switches must be used.

Line

The LINE position connects a sample of the power-line voltage from the mainframe to the trigger circuit. Line triggering is useful when the input signal is time-related (multiple or submultiple) to the line frequency. It is also useful for providing a stable display of a line-frequency component in a complex waveform.

External

The EXT position connects the signal from the EXT INPUT connector to the trigger circuit. The external signal must be time-related to the displayed waveform for a stable display. An external trigger signal can be used to provide a triggered display when the internal signal is either too low in amplitude for correct triggering or contains signal components on which triggering is not desired. External triggering is also useful when signal tracing in amplifiers, phase-shift networks, wave-shaping circuits, etc. The signal from a single point in the circuit can be connected to the EXT INPUT connector through a probe or cable. The sweep is then triggered by the same signal at all times and allows amplitude, time relationship, or waveshape changes of signals at various points in the circuit to be examined without resetting the TRIGGERING controls.

When the TIME/DIV control is in the AMPL position and the EXT SOURCE switch is pressed in, a signal applied to the EXT INPUT connector will be displayed horizontally on the mainframe crt. The sensitivity is 50 mV/div. Other sources of horizontal deflection voltage may also be selected, i.e., LEFT, RIGHT, or LINE.

TRIGGERING SLOPE

In the + or − positions, the TRIGGERING SLOPE control (concentric with the TRIGGERING LEVEL/SENSITIVITY control) determines whether the trigger circuit responds on the positive- or negative-going portion of the trigger signal. When the SLOPE switch is in the + (positive-going) position, the display starts on the positive-going portion of the waveform (see Fig. 2-4). When several cycles of a signal appear on the display the setting of the SLOPE switch is often unimportant. However, if only a certain portion of a cycle is to be displayed, correct setting of the SLOPE switch is important to provide a display that starts on the desired slope of the input signal.

Setting the SLOPE switch to the ± position activates the dual or bislope function of the time base. Bislope triggering allows capture (and storage using a 5223 mainframe) of a signal which exceeds, either positive or negative, a particular level. This level is adjustable over a wide range by varying the LEVEL/SENSITIVITY control; in this case, the control adjusts the sensitivity of the trigger circuits.

TRIGGERING LEVEL/SENSITIVITY

The TRIGGERING LEVEL/SENSITIVITY control has two functions that depend on the setting of the SLOPE selector.

When the SLOPE selector is set to + or −, the LEVEL/SENSITIVITY control functions as a LEVEL control. Turning the LEVEL control clockwise selects a more positive part of the input signal as the trigger point. Conversely, counterclockwise rotation selects a more negative part of the signal as the trigger point.

When the SLOPE selector is set to ± (bislope), the LEVEL/SENSITIVITY control functions as a SENSITIVITY control. The counterclockwise extreme is MAXimum sensitivity, and the clockwise extreme is MINimum sensitivity.

The LEVEL/SENSITIVITY control adjusts the sensitivity threshold when the SLOPE switch is in the ± position. Adjusting the sensitivity threshold allows the operator to view a signal (or signals) which exceed a selected positive or negative level.

To set the LEVEL control, first select the TRIGGERING MODE, COUPLING, SOURCE, and SLOPE. Then set the LEVEL/SENSITIVITY control fully counterclockwise and rotate it clockwise until the display starts at the desired point.

To set the SENSITIVITY control, first select the TRIGGERING MODE, COUPLING, SOURCE and SLOPE. Then set the SENSITIVITY control fully counterclockwise to MAX. If the input signal is of sufficient amplitude (see Specification in Section 1), the trigger circuit will start the sweep. Turning the SENSITIVITY control clockwise, from its MAX sensitivity position, moves the + and − trigger threshold levels away from their maximum sensitivity levels. The + level becomes more positive and the − level becomes more negative, and the trigger circuit will require a larger input signal to operate. The trigger circuit will start the sweep when the input crosses either + or − threshold level.

The bislope feature is useful for detecting low-level, randomly occurring events and storing them for continuous viewing in the 5223 mainframe.

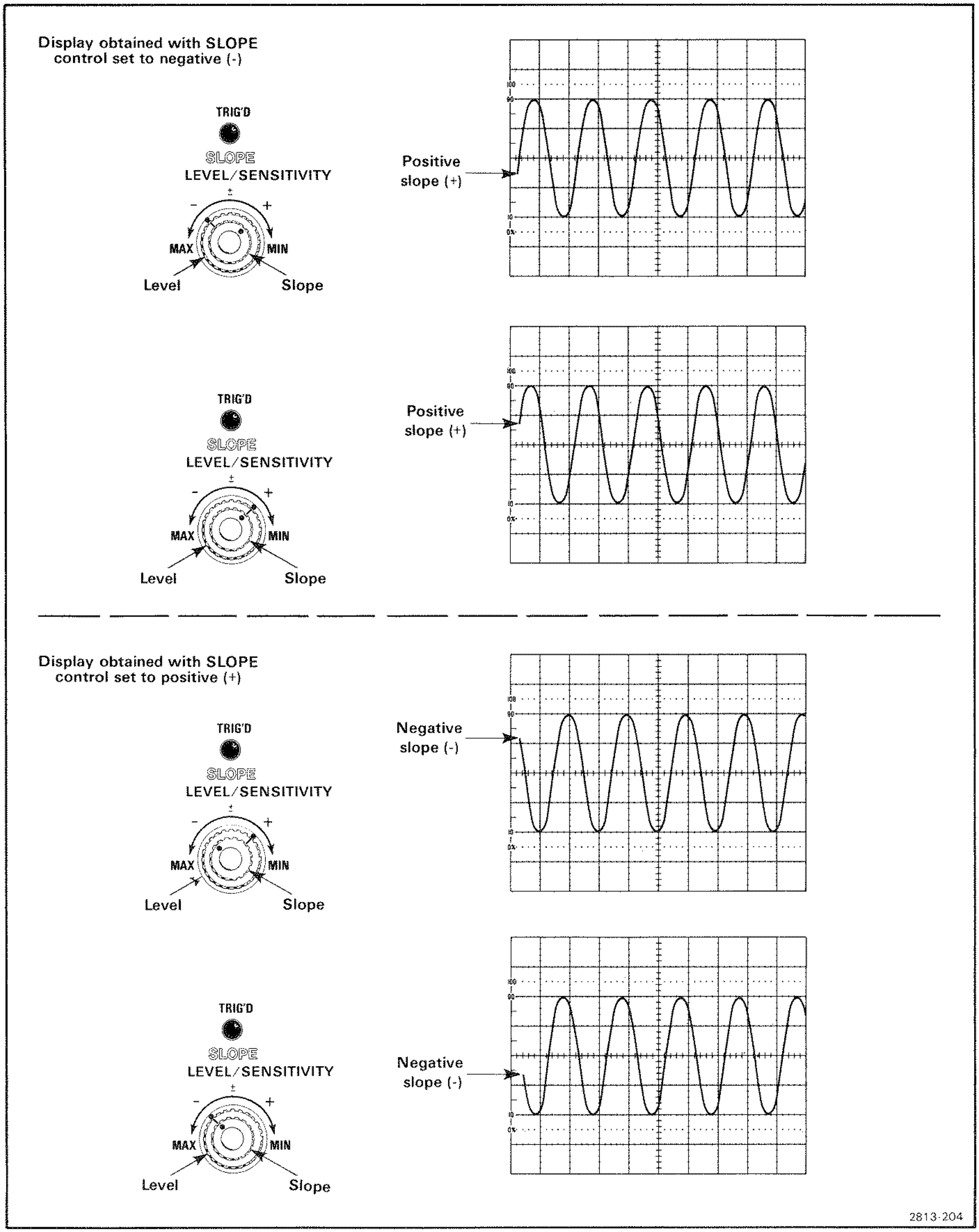

Figure 2-4. Effect of LEVEL/SENSITIVITY and SLOPE controls on crt display.

SWEEP RATES

The TIME/DIV control provides calibrated sweep rates from 5 seconds/division to 0.2 microseconds/division in a 1-2-5 sequence. The CAL control must be in its calibrated position and the X10 SWP MAG button set to X1 to obtain the sweep rate indicated by the TIME/DIV control.

The CAL control has a detent to indicate if the sweep rate is calibrated or uncalibrated. When the CAL control is in the detent position, the sweep rate is calibrated. When out of detent the CAL control provides for uncalibrated sweep rates, to at least the sweep rate of the next slower position.

Alternate and Chopped Operation

The pushbutton labeled CHOP in the blue DISPLAY area of the front panel selects the switching mode for dual-channel vertical plug-ins or dual vertical-channel mainframes. With the button out and the 5B25N in a 5223 mainframe, the switching is in the alternate mode, i.e., one vertical channel is displayed for two sweeps, then the other channel is displayed for two sweeps (except for the 5A14, which will alternate at one sweep per channel). When the 5B25N is in a 5400-series mainframe, alternate operation causes one sweep per channel. This will be apparent at sweep speeds of 10 ms/div and slower.

Pushing the CHOP button in selects the CHOP mode. Use the chopped mode for viewing slower dual-trace displays and the alternate mode for viewing faster displays. In the 5223 mainframe, only alternate display is available at sweep speeds of 50 μs/div and faster.

DIGITIZER FUNCTIONS

When the 5B25N is installed in a 5223 Digitizing Oscilloscope and the TIME/DIV control is in one of the 0.1 ms to 5 s positions, the following functions are activated:

Pretrigger Viewing

The PRETRIGGER control adjusts the amount of information, preceding the trigger, to be stored in the 5223 memory when the 5B25N operates in the real-time sampling mode (0.1 ms to 5 s/division). Rotating the control from 0% (fully clockwise) to 100% (fully counterclockwise) varies the point at which the mainframe memory stops recording data. Thus, any point up to 10.24 divisions (100%) preceding the trigger may be viewed by adjusting the PRETRIGGER control accordingly.

Possible Undersampling

The POSSIBLE UNDERSAMPLING indicator lights when eight or fewer pulses are sent to the 5223 per trigger event, i.e., per cycle of repetitive input signal. This indicator alerts the operator to many combinations of sweep speed and signal frequency which could produce misleading stored information.

When the TIME/DIV control is set to the shaded REPETITIVE STORE ONLY area, the 5B25N operates in equivalent-time sampling mode. In this mode the PRETRIGGER, POSSIBLE UNDERSAMPLING, and DISPLAY functions are disabled. The display is locked in alternate mode.

NOTE

The 5223 stored waveform may not be a replica of the real-time waveform when the 5B25N is in the ± SLOPE TRIGGERING mode, the TIME/DIV switch is in one of the shaded REPETITIVE STORE ONLY positions, and the 5223's Vector Mode button is pressed in.

TIME MEASUREMENTS

When making time measurements from the graticule, the area of the crt between the second and tenth vertical lines of the graticule provides the most linear measurements (see Fig. 2-5). Position the start of the timing area to the second vertical line and set the TIME/DIV control so that the end of the timing area falls between the second and tenth vertical lines.

SWEEP MAGNIFICATION

The sweep magnifier can be used to expand the display by a factor of 10. The part of the unmagnified display that is at horizontal center will be on screen when the X10 MAG button is pressed (see Fig. 2-6). The equivalent length of the magnified sweep is more than 100 divisions; any 10-division portion can be viewed by adjusting the POSITION control to bring the desired portion into the viewing area. When the X10 SWP MAG switch is set to the X10 position (in), the equivalent magnified sweep rate can be determined by dividing the TIME/DIV setting by 10.

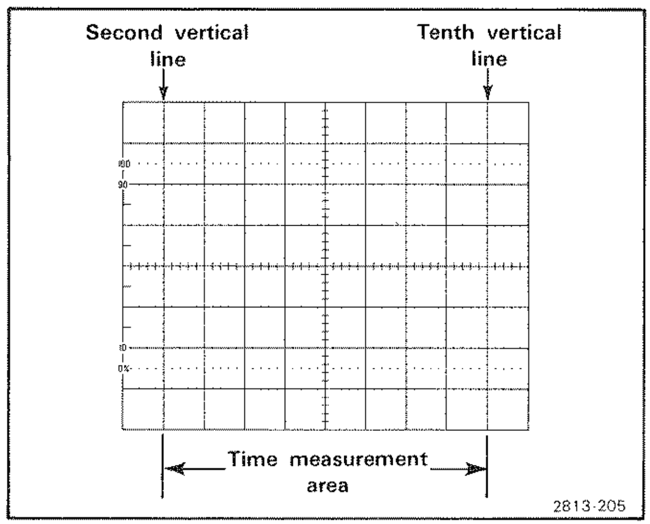

Figure 2-5. Area of graticule where crt is most accurate.

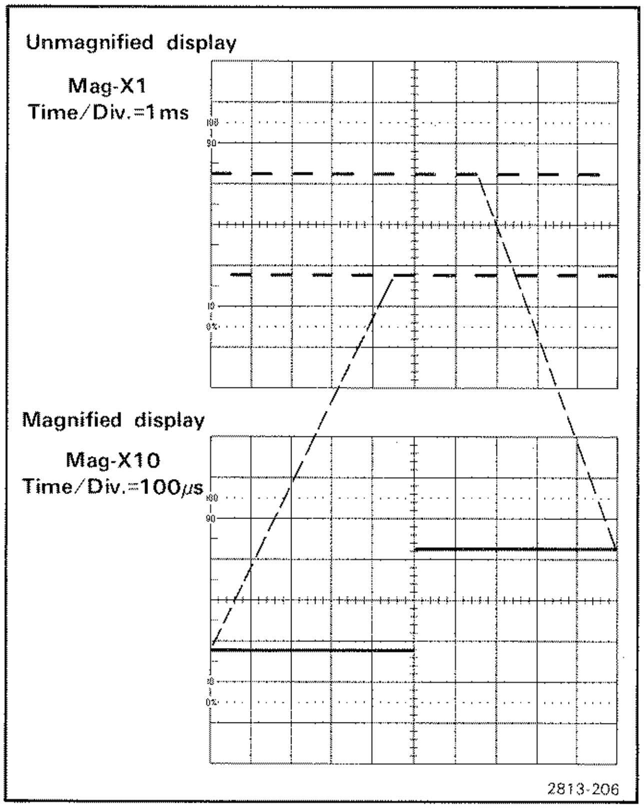

Figure 2-6. Operation of sweep magnifier.

MAINFRAME OPERATING MODES

The 5B25N can operate as an independent time base in any Tektronix 5400-series oscilloscope mainframe, or as a digitizer time base in the 5223 mainframe. Refer to the mainframe instruction manual for additional information.

APPLICATIONS

The following information describes procedures and techniques for making basic time measurements with the 5B25N in a Tektronix 5223 or a 5400-series oscilloscope mainframe. These procedures provide enough detail to enable the operator to adapt them to other related time measurements. Contact your Tektronix Field Office or representative for assistance in making other measurements.

TIME-INTERVAL MEASUREMENTS

Because displayed time is a function of the sweep rate and the horizontal distance (in divisions) that the sweep travels across the graticule in a calibrated-sweep oscilloscope system, the time interval between any two points on a waveform can be accurately measured. The following procedures provide methods to measure some of the more common time-related characteristics of a waveform such as period, frequency, rise time, fall time, and pulse width. For greatest accuracy, make time-interval measurements in the center eight divisions of the crt graticule.

Period And Frequency

Use this procedure to measure the period and determine the frequency of a displayed waveform:

1. Install the 5B25N in the mainframe horizontal compartment.

2. Connect the signal to be measured to the vertical amplifier input.

3. Set the display controls to display the time base and vertical units. (Check that the CAL control is fully clockwise—in its detent.)

4. Set the TRIGGERING and LEVEL/SENSITIVITY controls for a stable display (see General Operating Information for selecting proper triggering).

5. Set the vertical deflection factor and position control for about a five-division display, vertically centered on the graticule.

6. Set the TIME/DIV and POSITION controls for a complete cycle displayed within the center eight graticule divisions as shown in Figure 2-7.

7. Measure the horizontal distance in divisions over one complete cycle of the displayed waveform.

8. Multiply the horizontal distance measured in step 7 by the TIME/DIV control setting. (Divide the answer by 10 if sweep magnification is used.)

Example: Assume that the horizontal distance over one complete cycle is seven divisions, and the TIME/DIV control setting is 0.1 ms (see Fig. 2-7).

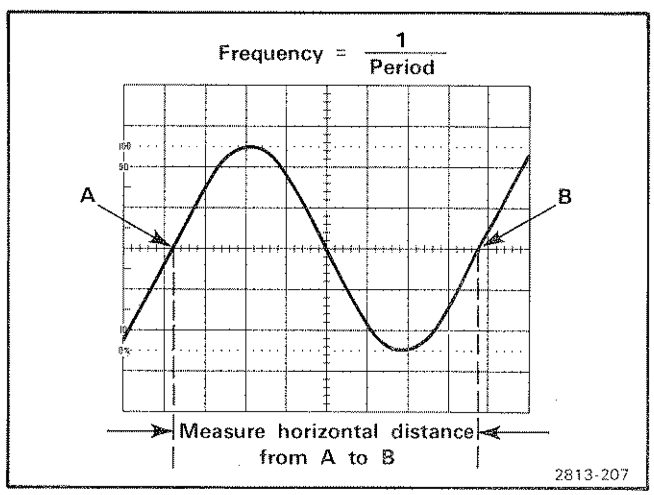

Figure 2-7. Measuring the period and calculating the frequency of a displayed waveform.

Using the formula:

$$\text{Period} = \frac{\text{Horizontal}}{\text{Distance}} \times \frac{\text{TIME/DIV setting}}{\text{magnification}}$$

Substituting values:

$$\text{Period} = 7 \times 0.1 \text{ ms} \div 1 = 0.7 \text{ millisecond}$$

9. Determine the frequency of the displayed waveform obtained in steps 1 through 8 by taking the reciprocal of the period of 1 cycle.

EXAMPLE: Assume that the period of the displayed waveform is 0.7 millisecond.

Using the formula:

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

Substituting values:

$$\text{Frequency} = \frac{1}{0.7 \text{ ms}} = 1.43 \text{ kilohertz}$$

Rise Time And Fall Time

Use this procedure to measure the rise time and fall time of a displayed waveform:

1. Install the 5B25N in the mainframe horizontal compartment.

2. Connect the signal to be measured to the vertical amplifier input.

3. Press the Display button on the vertical amplifier. (Check that the CAL control is fully clockwise—in its detent.)

4. Set the TRIGGERING controls for a stable display (see General Operating Information for selecting proper triggering).

5. Set the vertical deflection factor and position controls for a vertically centered display with a whole number of divisions of amplitude.

6. Set the TIME/DIV and POSITION controls to display the rising or falling portion of the waveform within the center eight graticule divisions as shown in Figure 2-8 (see General Operating Information in this manual for discussion of timing measurement accuracy).

7. Determine rise time or fall time by measuring the horizontal distance in divisions between the point on the rising or falling portion of the waveform that is 10% and the point that is 90% of the total display amplitude (see Fig. 2-8).

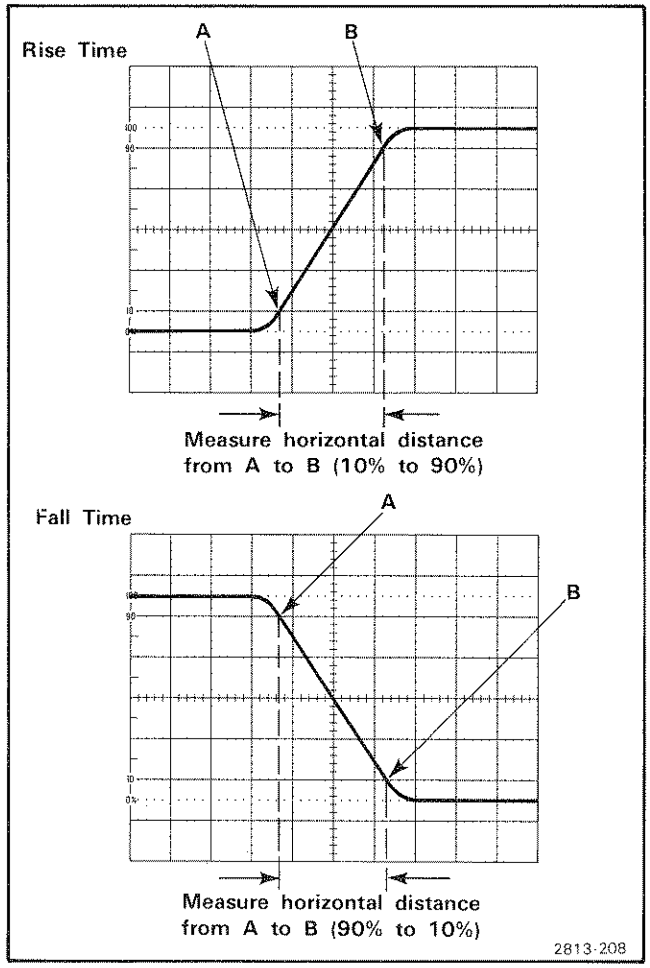

Figure 2-8. Measuring the rise time and fall time of a pulse.

NOTE

The oscilloscope graticule is scribed with 0, 10, 90, and 100% lines, labeled at the left edge of the screen, for convenience when measuring rise time or fall time. To use this feature, adjust the vertical deflection factor and position controls to fit the display between the 0 and 100% graticule lines. Then measure the horizontal distance between the points where the waveform crosses the 10% and 90% graticule lines.

8. Multiply the horizontal distance measured in step 7 by the TIME/DIV setting. (Divide the answer by 10 if sweep magnification is used.)

EXAMPLE: Assume that the horizontal distance between the 10% and 90% amplitude points is 2.5 divisions, and the TIME/DIV setting is 0.1 μs (see Fig. 2-8).

Using the formula:

$$\text{Rise Time} = \frac{\text{Horizontal distance}}{\text{(divisions)}} \times \frac{\text{TIME/DIV setting}}{\text{magnification}}$$

Substituting values:

Rise time = 2.5 × 0.1 μs ÷ 1 = 0.25 microsecond

Pulse-Width

Use this procedure to measure the width of a pulse:

1. Install the 5B25N in the mainframe horizontal compartment.

2. Connect the signal to be measured to the vertical amplifier input.

3. Set the display switches to display the time base and vertical amplifier. (Check that the CAL control is fully clockwise—in its detent.)

4. Set the TRIGGERING controls for a stable display (see General Operating information for selecting proper triggering).

5. Set the vertical deflection factor and position controls for about a five-division pulse vertically centered on the graticule.

6. Set the TIME/DIV and POSITION controls for one complete pulse displayed within the center eight graticule divisions as shown in Figure 2-9.

7. Measure the horizontal distance in divisions between the 50% amplitude points of the displayed pulse (see Fig. 2-9).

8. Multiply the horizontal distance measured in step 7 by the TIME/DIV control setting. (Divide the answer by 10 if sweep magnification is used.)

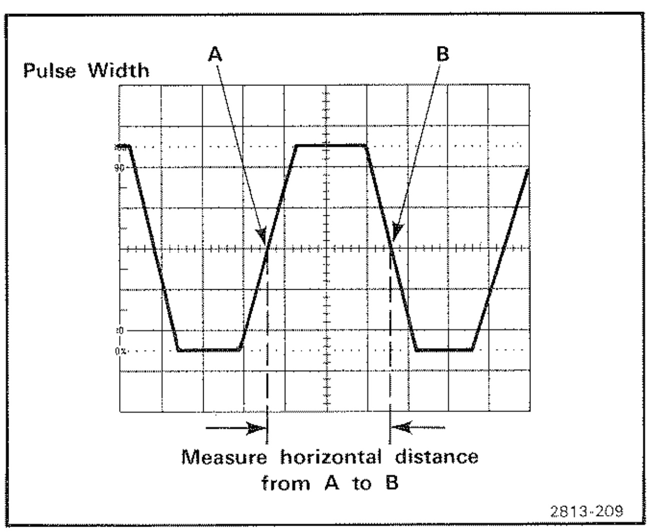

Figure 2-9. Measuring the width of a pulse.

EXAMPLE: Assume that the horizontal distance between the 50% amplitude points is three divisions, and the TIME/DIV control setting is 0.1 ms (see Fig. 2-9).

Using the formula:

$$\text{Pulse Width} = \frac{\text{Horizontal}}{\text{Distance}} \times \frac{\text{TIME/DIV setting}}{\text{magnification}}$$

Substituting values:

Pulse width = 3 × 0.1 ms ÷ 1 = 0.3 millisecond

DIGITIZER APPLICATION

Pretrigger Viewing

In applications where it is desired to view a response to a stimulus, it may be desirable to view the time-window where the stimulus occurred. With conventional triggering methods, the only recourse is to provide an electrical trigger signal coincident with the beginning of the stimulus. This is sometimes impractical with nonelectrical stimuli.

The pretrigger viewing feature lets you observe up to one full digitized sweep length prior to the trigger event. For example, if the sweep rate were set to 100 ms/division, events occurring up to 1 second (10 crt divisions) prior to the trigger point could be observed. Figure 2-10 shows an event viewed at 50% pretrigger. The 50% pretrigger setting puts the trigger point at the horizontal center of the graticule, with pretrigger events as the first half of the display and post-trigger events as the second half.

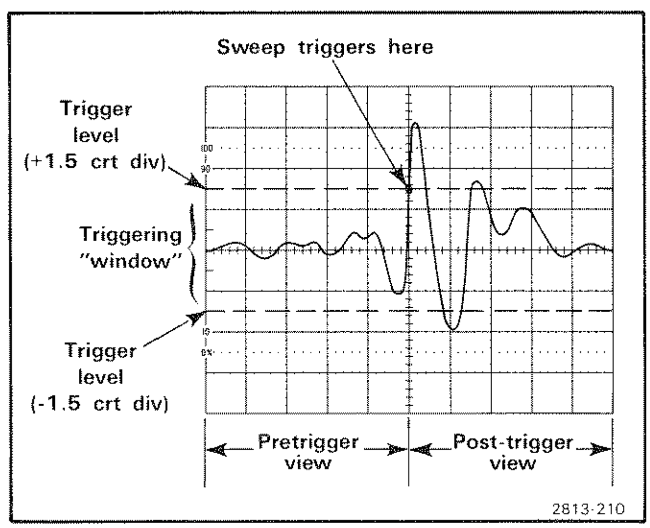

Figure 2-10. Display of signal with bislope triggering, TRIGGERING LEVEL/SENSITIVITY at + and −1.5 crt divisions, and PRETRIGGER set to 50%.

One application for the PRETRIGGER control when the time base is installed in the 5223 Digitizing Oscilloscope is to view small transitions in a power supply output prior to loss of that output. Figure 2-11 illustrates how the PRETRIGGER control can be used to locate and study possible fault indications in the output of the supply under test. Triggering on the supply shutdown transition allows the operator to view events prior to shutdown as the PRETRIGGER control is varied from 0% to 100% (up to one full digitized sweep length before the trigger point).

5223 Memory Save

The 5223 Memory Save mode may be used to hold and to horizontally and vertically expand the desired portion of the waveform for detailed examination. See the Operating Instructions section of the 5223 Digitizing Oscilloscope manual for more information.

Bislope Triggering and Capturing Transients of Unknown Polarity

The polarity of an electric signal is not always known in advance. For example, a transient on a power line or the output of a strain gage used for mechanical shock studies could be of either polarity.

If it is important to trigger an oscilloscope (without bislope triggering) on the first major transition, it is necessary to know the polarity of that first transition so the slope and trigger level controls can be set correctly. A wrong setting could cause a lost display. Figure 2-12 shows how a conventional trigger circuit can miss a display if the signal originates with a polarity opposite to the expected polarity.

In the example of Figure 2-12, + slope and a level of +3 crt divisions were the trigger settings. However, the actual signal started out negative-going (solid line) and never reached +3 crt divisions, so the sweep was not triggered and the input was not displayed.

If the trigger level had been set at +1.5 crt divisions, the signal would have triggered the sweep when it reached point 2 in Figure 2-12, but the preceding portion of the waveform would have been lost.

Bislope Triggering

The 5B25N Digitizer Time Base/Amplifier incorporates bislope triggering, as well as conventional triggering. Bislope triggering guarantees the capture of transient waveforms of unknown polarity by triggering on the first available transition within an adjustable triggering window. Figure 2-13 shows the operation of bislope triggering and a 3.0 division triggering window (+ and −1.5 crt divisions) on the same waveform shown in Figure 2-12.

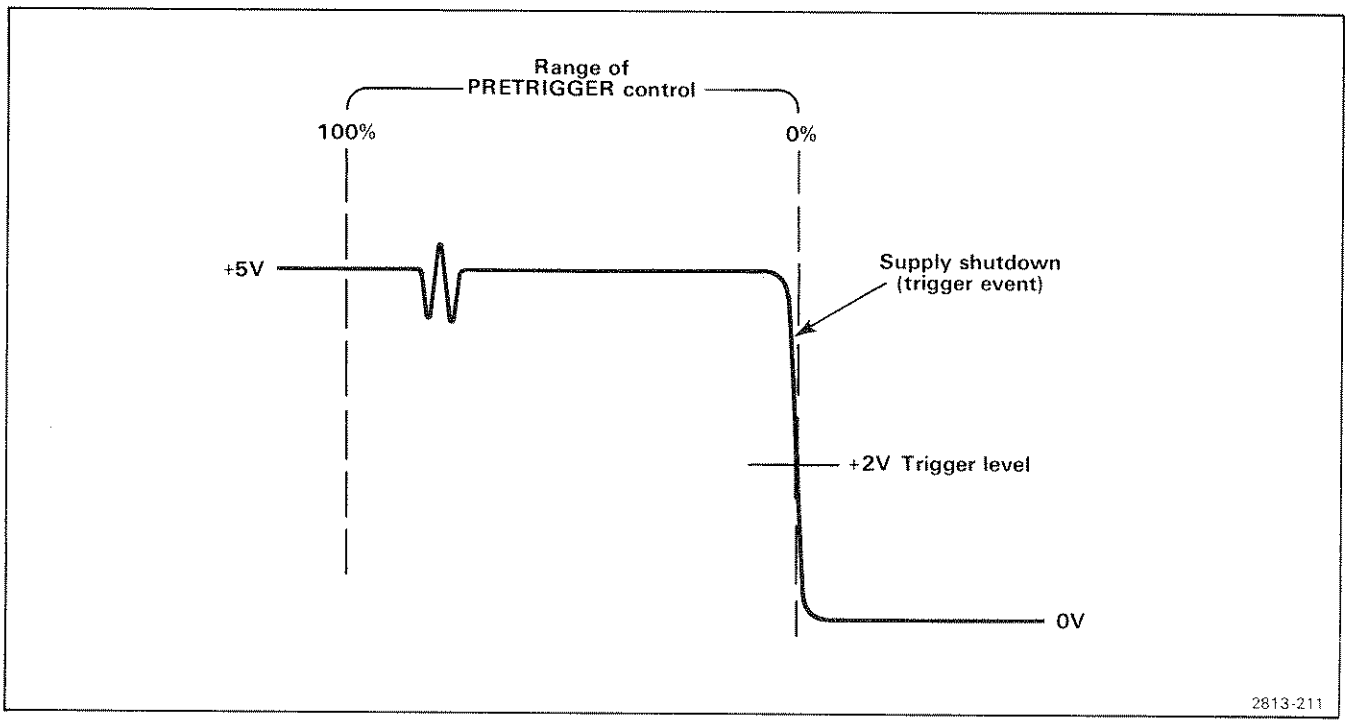

Figure 2-11. Observing power supply variations using the PRETRIGGER control.

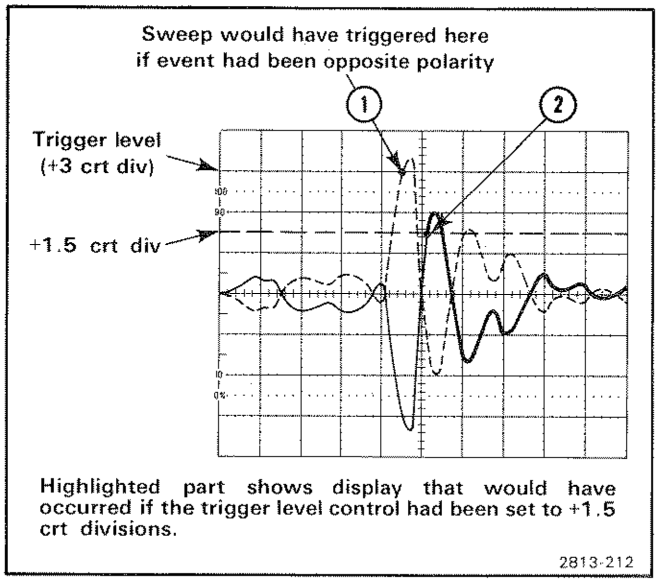

Figure 2-12. Effect of wrong choice of trigger polarity and level for event of random polarity.

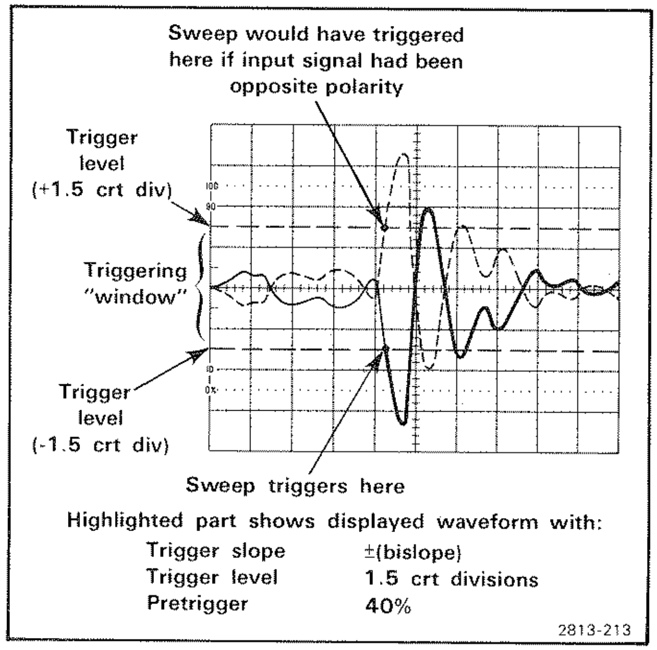

Figure 2-13. Display of same signal using bislope triggering and three-crt-division trigger "window."

Combined Bislope Triggering & Pretrigger Viewing

The most convenient, reliable way to capture transients of unknown polarity is to use bislope triggering and pretrigger viewing. This ensures that you will see the entire chain of events, regardless of trigger polarity. The actual trigger window is set by the the LEVEL/SENSITIVITY control on the 5B25N. Maximum sensitivity (minimum trigger window) is 1.0 major crt division. The PRETRIGGER control facilitates observation of the leading edge of a waveform at sweep speeds from 5 s to 0.1 ms/division.

THEORY OF OPERATION

This section of the manual describes the circuitry in the 5B25N Digitizer Time Base/Amplifier. The description begins with a discussion of the instrument, using the block diagram shown in Figure 3-1, and then continues in detail, showing the relationships between the stages in each major circuit. Schematics of all major circuits are given in Section 8, Diagrams and Circuit Board Illustrations. Stages are outlined on the schematics with wide shaded lines; the stage names are in shaded boxes. Refer to the appropriate diagram along with the Troubleshooting Chart in section 8 throughout the following discussion.

BLOCK DIAGRAM

The following discussion presents the overall concept of the 5B25N before the individual circuits are discussed in detail. A basic block diagram of the 5B25N is shown in Figure 3-1. Each major circuit within the instrument is given a block. The numbered diamond in each block refers to the corresponding circuit diagram at the rear of this manual.

DESCRIPTION

TRIGGER GENERATOR

The Trigger Generator ensures a stable display by starting each sweep at the same point on the waveform. Circuitry is included for selection of the triggering mode, coupling, and source. The output of the Trigger Generator is a fast-rise pulse which enables the Sweep Generator. The trigger source signal is also fed from the Trigger Generator to the Horizontal Amplifier.

SWEEP CONTROL

The Sweep Control circuitry controls the 5B25N mode of operation. The Holdoff, Z-Axis, Alternate Drive, and A Gate signals are generated in this block. Holdoff is initiated upon receipt of a Swp End gate from the Sweep Generator. In the NORMAL and SINGLE SWEEP modes Z-Axis, Alternate Drive, and A Gate signals are produced when appropriate trigger gates are present at the Sweep Control inputs. In the AUTO mode these signals occur after a prescribed delay following each sweep, provided no trigger signals are received during the delay.

SWEEP GENERATOR

The Swp ramp signal starts when the Trigger Generator Gate is applied, via the Sweep Control, to the Sweep Generator. The rate of change (slope) of the ramp is determined by the TIME/DIV control setting. The ramp signal provides horizontal deflection for the oscilloscope mainframe . The Sweep Generator also generates a Swp End gate which initiates holdoff in the Sweep Control block, and a reference voltage for the Clock Generator and Undersampling circuit.

HORIZONTAL AMPLIFIER

The Horizontal Amplifier has two modes of operation: time-base mode and amplifier mode. In time-base mode, the Horizontal Amplifier changes the sweep ramp to a differential signal for use in the oscilloscope mainframe. In amplifier mode, the external X Signal is fed through the Horizontal Amplifier to the + Plug-In Signal connector. The POSITION and SWP MAG control functions are also provided in this block.

CLOCK GENERATOR AND UNDERSAMPLING

The circuitry in this block is active only at sweep speeds of 0.1 ms/division and slower. One of the two oscillator outputs is selected and frequency-divided to produce the Real-Time Sample Pulse. The Real-Time Sample Pulse commands the digitizing circuit in the 5223 oscilloscope mainframe to perform an A/D conversion. The POSSIBLE UNDERSAMPLING indicator lights when a logic circuit detects fewer than eight sample pulses between trigger pulses.

LOGIC

The Logic circuitry generates the Sample Pulse and Load Stop signals. Depending on the operating mode of the 5223 oscilloscope mainframe, the Sample Pulse originates either in the Logic or the Clock Generator and Undersampling block and is fed through the Logic circuitry. The Logic circuit also generates the Sweep Rate signal, which notifies the 5223 which group of sweep speeds is selected and that the time base is a 5B25N.

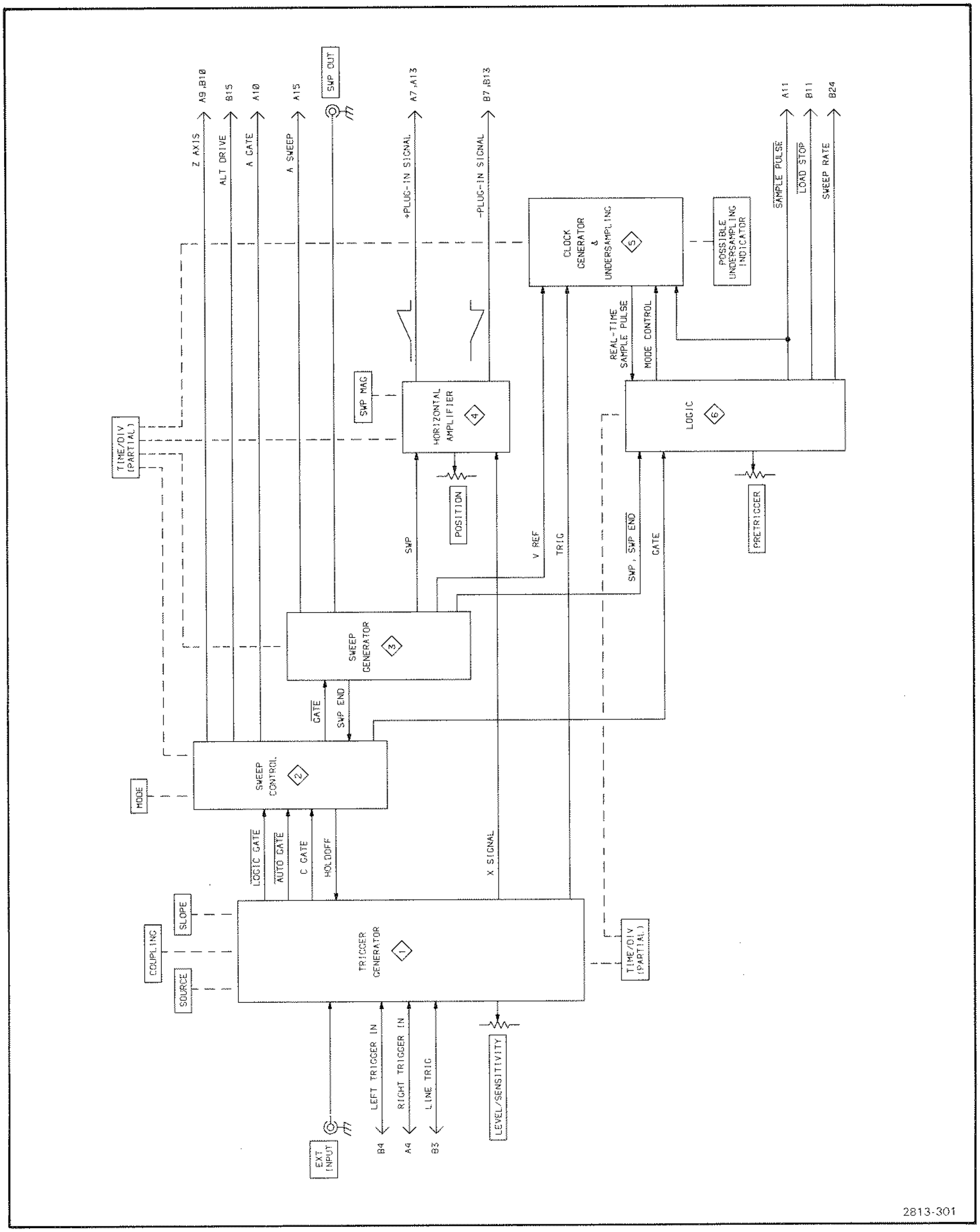

Figure 3-1. Block diagram of the 5B25N Digitizer Time Base/Amplifier.

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DETAILED CIRCUIT OPERATION

Complete schematic diagrams are provided in Section 8, Diagrams and Circuit Board Illustrations. The number inside the diamond preceeding a heading in the following discussions refers to the schematic diagram for that circuit. The schematic diagrams contain wide shaded borders around the major stages of the circuit to conveniently locate the components mentioned in the following discussions. The name of each stage is given in a shaded box on the diagram, and appears as a subheading in the discussion of that schematic diagram.

All logic functions are described using the positive logic convention. Positive logic is a system of notation where the more positive of two levels (HI) is called the true or 1state; the more negative level (LO) is called the false of 0-state. The HI-LO method of notation is used in this logic description. The specific voltages that constitute a HI or LO state vary between individual devices. Whenever possible, the input and output lines are named to indicate the function that they perform when in the HI (true) state.

1 TRIGGER

The Trigger Generator provides a stable crt display by starting the Sweep Generator (diagram 3) at a selected point on the input waveform. The triggering point can be varied with the LEVEL/SENSITIVITY control and may be on either the positive- or negative-going portion of the waveform, or both. The triggering source signal may be either the signal being displayed (LEFT, RIGHT), a signal from an external source (EXT), or a sample of the power line voltage (LINE).

INPUT BUFFER AMPLIFIER

Trigger signals from the left and right vertical compartments in the oscilloscope mainframe pass through the appropriate sections of the TRIGGERING SOURCE switch (S5) to the input of Q20A. Resistors R1 and R3 combine with resistors in the oscilloscope mainframe to provide a signal level of 50 mV/division for the trigger lines. Resistors R5 and R7 are dividers for the sample of ac line voltage used in the line trigger mode. Capacitor C7 acts as a low-pass filter, preventing noise from affecting the triggering. The external input is applied through a compensated attenuator (R9, R10, C10, R16, C16, and C17) to the gate of Q20A when the EXT TRIGGERING SOURCE button is pressed.

Switch S13 provides ac coupling by connecting C12 and C14 to the gate of Q20A in the AC COUPLING control position. The ±Slope Bal control, R29, provides adjustment for zero dc offset through the Input Buffer Amplifier circuit. Field-effect transistor (FET) Q20B is a current source for Q20A.

Diode CR22 protects the gate of FET Q20A from large negative signal excursions. Light-emitting diodes (LED) DS24, DS25 and diodes CR24, CR25 provide over-voltage protection for level comparators U72 and U79. Transistors Q27 and Q32 are thermally coupled (with a common heat sink) to compensate for Q32's base-emitter drop. Emitter-follower Q32 furnishes low-impedance drive to the level comparators and the X Signal input to the Horizontal Amplifier circuit (diagram 4).

LEVEL COMPARATOR AND SLOPE SELECTOR

Integrated circuits U72 and U79 are voltage comparators which provide signals for use in the Gate Generator circuitry. When the SLOPE control (S11) is in the ± (bislope) position, both comparators are enabled, allowing complementary level comparison to take place. The incoming trigger signal from Q32 is applied to the noninverting and inverting inputs, respectively, of U72 and U79. The opposite input of U72 receives a positive voltage from U62B and the other input of U79 receives a negative voltage from U62A. This arrangement permits complementary voltage control of the comparators with one LEVEL/SENSITIVITY control (R10). Figure 3-2 shows how comparators U72 and U79 respond to a sine-wave trigger signal to help understand the following: The output of U72 goes low when the trigger signal level exceeds the positive threshold level determined by the LEVEL/SENSITIVITY control. Conversely, the output of U79 goes low when the trigger signal level becomes more negative than the threshold level from U62A. Each output goes to a high-logic level again as the trigger signal level recrosses the appropriate threshold levels from U62A and B. Thus, when the sine-wave signal exceeds the positive and negative Sensitivity Threshold levels, the comparators generate output signals. Diodes CR75 and CR82 combine the two signals whose negative-going leading edges are used in the Gate Generator circuit.

The LEVEL/SENSITIVITY control varies the trigger sensitivity threshold in the ± SLOPE mode by shifting the input voltage to U62A and B between about 0 V and a positive level. The input voltage is prevented from reaching exactly 0 volts by R39. If the voltage level reached zero, the threshold level at the comparators would be zero, and the outputs of the comparators would be complements. The complementary signals would cancel each other and produce a steady level at pin 13 of U95 instead of the negative-going edge required by U95. When the TRIGGERING SLOPE switch is set to ± (bislope), Q52 is turned off. The output of Q52 turns off Q47, which produces a high level that turns on switch U45. Integrated circuit U45 holds the junction of R39, R41, and R42 at ground by paralleling FET sections (U45B and D) and injecting a positive offset voltage (U45C).

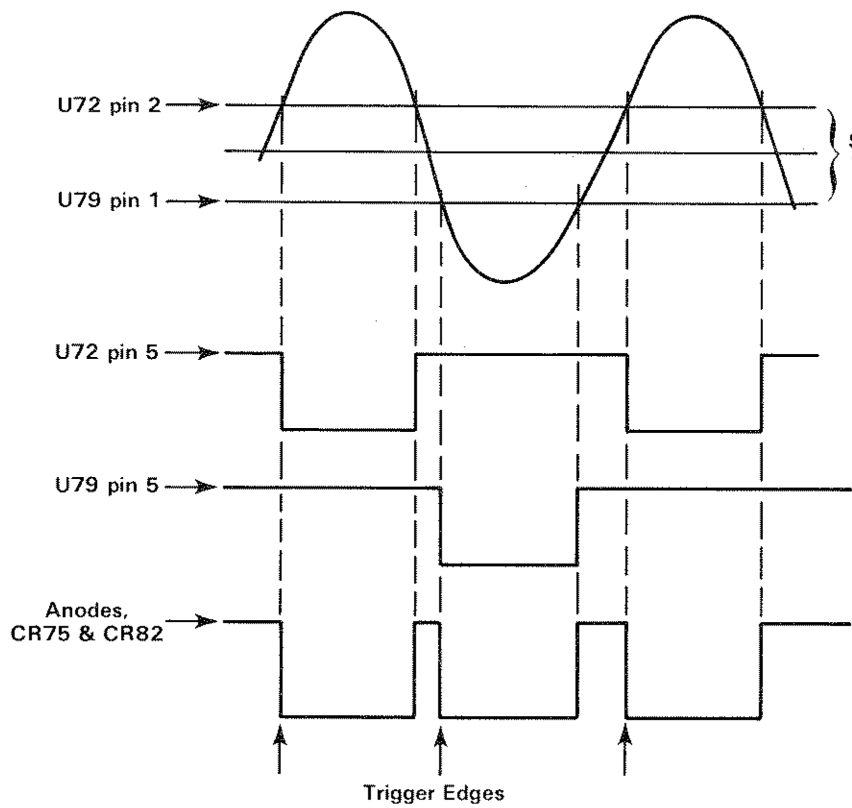

Figure 3-2. Timing of signals from level comparator with SLOPE in ± (bislope) position.

Thus, the LEVEL/SENSITIVITY control acts as a unipolar voltage source in the bislope mode only. In the + or − SLOPE control positions U45A, B, C, and D are off, allowing the LEVEL/SENSITIVITY control to function as a bipolar voltage source providing both negative and positive voltage drive to U62.

Setting the SLOPE switch to + or − will disable either U79 or U72 which allows the signal to be triggered on the appropriate slope. When the SLOPE switch is in the − position, U79 produces a trigger signal only when its input goes more negative than the threshold level determined by the LEVEL/SENSITIVITY control. In the + SLOPE position, U72 produces a trigger signal only when its input goes more positive than the threshold level from the LEVEL/SENSITIVITY control. Both U72 and U79 are disabled when the TIME/DIV switch is in the AMPL position. This allows the X Signal from Q32 to drive Q280 (diagram 4) without being affected by the voltage comparators.

Integrated circuit U62A is a unity-gain inverting or noninverting amplifier as selected by U45A. When the SLOPE switch is in the − position, U45A opens and lets U62A operate in its noninverting mode. This allows the trigger level at U79 to become more positive as the LEVEL/SENSITIVITY control is turned clockwise.

GATE GENERATOR

Integrated circuit U95 receives trigger signals from the level comparators and processes them into gate output signals. It operates like a set-reset flip-flop (FF) by changing its output states (pins 3, 4) every time its input (pin 13) is toggled by a negative-going edge. When pins 6 and 10 go high, the outputs are reset to their original states. Thus, when a trigger signal is present, sweep gating is initiated by U95 and terminated when pins 6 and 10 go high.

Transistors Q95 and Q97 are gate signal comparators which provide level shifting and drive to buffers U98A and B and succeeding circuitry. The gate signal is inverted by U98A and B for use by U135 on diagram 2.

⟨2⟩ SWEEP CONTROL

The Sweep Control circuitry provides control of the time base in the AUTO, NORM and SINGLE SWEEP modes depending upon the front-panel control settings. It also provides Holdoff, Z Axis, Alternate Drive, Single-Sweep Mode and A Gate signals for the time base and the oscilloscope mainframe.

Integrated circuit U135 produces an A Gate pulse at pin 7 which is used to start the sweep (diagram 3). In AUTO mode, U135 waits for an interval determined by the RC time constant of C130 and R130 and if no trigger gates are received at pins 5 and 6, it generates an A Gate. Holdoff control is also accomplished by U135. Holdoff starts when a sweep Lockout signal from pins A16 or A17, or a Swp End signal from Q269 (diagram 3), produces a high-logic level at pin 12 of U135. The next Swp Gate is generated after the holdoff interval determined by components at pins 10 and 11.

The pin 7 output of U135 activates U120A, and U98E inverts the U120A output to form the Z Axis signal. The Z Axis signal causes the mainframe to turn off the crt beam during retrace and to turn on the crt beam during the sweep. Figure 3-3 shows these signals, their timing and relation to the crt beam.

When the SINGLE SWEEP RESET button is pressed, the AUTO and NORM modes are disabled. Pushing the RESET button produces a low-logic level at pin 2 of U135, causing U135 to generate a single A Gate pulse if the $\overline{\text{Logic Gate}}$ and $\overline{\text{Auto Gate}}$ lines are at low-logic levels. OR gate U120B directs the A Gate (as $\overline{\text{Gate}}$) from U135 to the Sweep Generator (diagram 3) and other circuitry in the instrument. Gate U120B also couples the fast leading edge of C Gate from Q97 (diagram 1) around U135 to compensate for the slower reaction time required by U135 to generate the A Gate. The fast leading edge of the Swp End pulse from Q269 (diagram 3) is inverted by U98D and combined with the A Gate at U135 pin 7 to speed up its negative-going transition.

3

SWEEP GENERATOR

When gated by the Sweep Control circuit (diagram 2), the Sweep Generator produces a linear ramp signal (Swp) for the oscilloscope mainframe. The ramp is fed to the interface connector, the front panel SWP OUT connector, the Horizontal Amplifier (diagram 4), and the Logic circuitry (diagram 6). The Sweep Generator also produces the Swp $\overline{\text{End}}$ gate for the Sweep Control (diagram 2) and Logic (diagram 6) circuitry.

The linear Swp signal is produced by charging a capacitor from a constant-current source. The slope of the ramp determines the sweep rate of the display.

TIMING CURRENT SOURCE

The Timing Current Source circuitry generates a constant current for the Ramp Generator stage. Integrated circuit U175 establishes a reference voltage (V_{REF}) for the timing-current resistors, and for the Clock Generator and the Undersampling circuitry (diagram 5). The Variable TIME/DIV control, R170, varies V_{REF} over a range of greater than 2.5 to 1, providing full control over each sweep speed. Applying V_{REF} to the timing resistors (those connected to U200 pin 2) produces the timing current. Integrated circuit U200 and Q202 form a precision constant-current source. The current entering the summing node at pin 2 of U200 appears at the emitter of Q202. Practically the same current appears at the collector because the alpha of Q202 is very close to unity. The constant timing current is fed to the Ramp Generator stage.

RAMP GENERATOR

The Ramp Generator stage produces a linear positive-going ramp signal which drives output transistors Q245, Q249 and the Sweep End Comparator stage.

A low-logic level on the $\overline{\text{Gate}}$ line turns off Q214 and Q204, and allows the precision current from Q202 to charge the timing capacitors. Constant current for Q223 and VR233 comes from Q229 and Q241. (The drain of Q223 connects to the emitter of Q260 to provide a constant voltage between its gate and drain and thereby reduce the effects of leakage.)

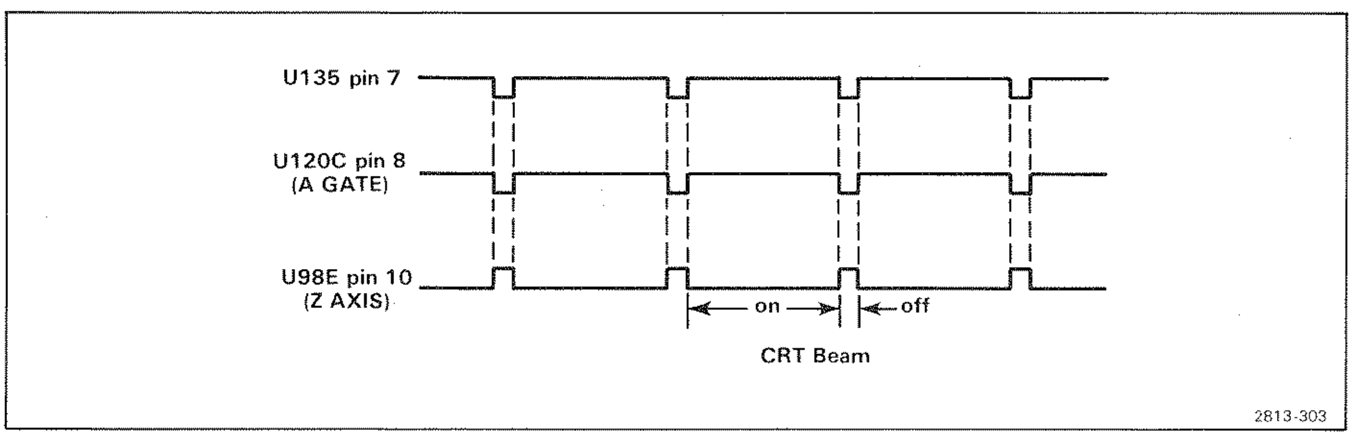

Figure 3-3. Timing of Z AXIS (beam control) signal.

When the sweep ends, the $\overline{Gate}$ goes to a HI logic level which turns on Q214 and Q204 and discharges the timing capacitors. After the capacitors are discharged, Q204 provides just enough current to offset the current drain into Q202 which results in current equilibrium and stable voltage between sweep ramps (zero volts at the emitter of Q260). Any deviation from this level is detected and compensated by the baseline-stabilization loop comprised of Q223, Q260, Q218, Q214, and Q204. Loop stability is maintained because the bases of Q214 and Q218 attempt to stay close to zero volts. Transistor Q209 and its emitter voltage divider samples a small amount of timing current to compensate for inherent offsets in the stabilization loop. Output emitter-follower stages Q245, Q249, and Q260 isolate the Ramp Generator from, and provide low impedance drive to, the mainframe and succeeding circuitry.

SWEEP-END COMPARATOR

Transistors Q265 and Q269 form a bistable Schmitt trigger which generates the Swp End pulse. When the sweep ramp reaches about +12 volts, Q265 turns off and Q269 conducts, producing a positive-going pulse at its collector. Inverter U98C sends the pulse, $\overline{\text{Swp End}}$, to the Sweep Control (diagram 2) and to the Logic circuitry (diagram 6).

⟨4⟩

HORIZONTAL AMPLIFIER

The Horizontal Amplifier performs four functions: It provides differential sweep signal drive to the plus and minus horizontal oscilloscope mainframe inputs, it amplifies the X Signal from Q32 (diagram 1), it will magnify the sweep rate by 10, and it controls the position of the sweep and X signals.

When the TIME/DIV control is set to any position between 5 s and 0.2 μs, differential-amplifier pair Q308 and Q338 are active. The amplifier provides differential drive from a single-ended source (Q260, diagram 3) which drives the base of Q338. The overall gain is less than unity. When the X10 SWP MAG button is pressed in, the gain is increased 10 times because R320 and R321 are paralleled with R323 and R325. Transistor Q314 is the current source for Q308 and Q338. Positioning current is applied to the base of Q308 from POSITION control R23.

Setting the TIME/DIV control to the AMPL position disables the sweep-signal differential amplifier and enables the X Signal amplifier. The X signal amplifier is a feedback amplifier. The feedback path is from the collector of Q280 to the collector of Q285, then via R287 to the base of Q295. The output signal at the collector of Q285 is coupled through R309 to the + Plug-In Signal connector. Positioning of the X Signal is provided by the POSITION control via R300.

⟨5⟩

CLOCK GENERATOR AND UNDERSAMPLING

The Clock Generator and Undersampling diagram has four distinct groups of circuitry; a crystal oscillator, a voltage-controlled oscillator, a frequency-divider circuit, and a logic circuit that detects possible undersampling. These circuits are active only at sweep speeds of 0.1 ms and slower.

The two oscillators generate pulses which form the Real-Time Sample Pulse when the 5223 is in the real-time sampling mode, i.e., when the 5B25N is set to 0.1 ms/div or a slower sweep speed. (The Real-Time Sample Pulse commands the 5223 Oscilloscope mainframe digitizing circuit to make an A/D conversion.)

The frequency-divider circuit furnishes 100 Real-Time Sample Pulses to the 5223 for each division of unmagnified sweep.

The undersampling detection logic circuit monitors the trigger pulses and sample pulses. When fewer than eight sample pulses occur between trigger pulses, the undersampling detection logic turns on the front-panel POSSIBLE UNDERSAMPLING indicator.

VOLTAGE-CONTROLLED OSCILLATOR (VCO)

When the variable TIME/DIV control is moved out of the CAL (calibrated) position, the VCO operates and the Crystal Oscillator stops. Both the Crystal Oscillator and the VCO stages are controlled by the Var Gnd line; a low-logic level on the Var Gnd line stops the Crystal Oscillator and allows the VCO to operate and vice versa. The voltage on the V_{REF} line controls the frequency of the VCO. (V_{REF} comes from the variable TIME/DIV control, R170, on diagram 3.)

The VCO is a collector-to-base coupled astable multivibrator. Transistors Q40 and Q43 are the active elements. Two current sources, controlled by V_{REF} via U22, provide charging current for the timing capacitors to set the operating frequency of the VCO. The voltage on the V_{REF} line controls the magnitude of the currents supplied by the current sources, thus controlling the frequency of the VCO.

Because the VCO has no dc feedback paths, Q40 and Q43 could possibly turn on at once. If they did, the VCO would not start. Diodes CR36 and CR37 form an OR gate that senses the voltages at the collectors of Q40 and Q43. As long as the VCO is operating, the OR gate is activated and Q34 is turned on. The output of Q34 is an input to U22, the voltage-control amplifier. If the VCO should stop, the OR gate would be disabled and Q34 would be turned off. The positive voltage at the collector of Q34 would forward-bias CR31 and cause a high-logic level at the + input of U22. Amplifier U22 would respond by turning off the current sources Q25 and Q28, which would cause Q40 and Q43 to stop conducting. This would generate voltage transients that would start the oscillator.

The output of the VCO goes (via common-base and emitter-follower transistors Q52 and Q54) to U5C, the input of the Frequency-Divider stage.

CRYSTAL OSCILLATOR

The A and D sections of gate U5, 2 MHz crystal Y8, and associated parts compose the Crystal Oscillator stage. When the variable TIME/DIV control is in its detent (calibrated) position, the Crystal Oscillator operates. Otherwise, the Crystal Oscillator stops because of the low-logic level on the Var Gnd line, and the VCO operates.

The output of the oscillator goes to U5C, the input to the Frequency-Divider stage.

FREQUENCY DIVIDER

The Frequency Divider stage divides the output of the oscillator to form pulses to trigger the A/D converter on the 5223 Oscilloscope digitizer board. The Frequency Divider stage consists of counter U68, U5C, U88B, U75A & B and related parts.

The oscillator signal reaches counter U68 via U5C. Counter U68 divides its input by 1, 10, 100, 1,000, or 10,000 as determined by the 1, 2, and 3 sections of the TIME/DIV control, S20. Via U88B, the output of U68 reaches FF U75A and B and sections 14, 15 and 16 of S20. Depending up on the setting of S20, the output of counter U68 can be sent directly out, divided by two, or divided by four.

UNDERSAMPLING DETECTOR

The circuitry on the lower part of diagram 5 lights the front-panel POSSIBLE UNDERSAMPLING indicator when fewer than eight sample pulses occur between successive Trig pulses. The Undersampling Detector circuit consists of U83A, U88A, U86, U90A and Q93.

Sample Pulses from the frequency-divider stage clock the counter, U86. Trig pulses trigger one-shot U83A, whose Q output resets U86 and clocks FF U90A. If a Trig pulse occurs after only two Sample Pulses, the output of one-shot U83A will clock FF U90A and reset counter U86. Flip-flop U90A then applies a HI-logic level to the base of Q93, which conducts current that turns on the POSSIBLE UNDERSAMPLING indicator. If nine Sample Pulses occur without a Trig pulse, the ninth Sample Pulse causes U86 to assert a HI-logic level at its pin 11 output. The HI-logic level from U86 pin 11 has two effects, as follows: 1) It activates U88A, whose LO-logic level output holds FF U90A reset. Now, Trig pulses cannot cause U90A to turn on the POSSIBLE UNDERSAMPLING light. 2) It activates an AND gate in U86 which locks the U86 pin 11 output at a HI-logic level. Counter U86 stays "locked" until a Trig pulse resets it, and it resumes counting.

When the 5B25N is operating in equivalent-time sampling mode (50 μs/division and faster), the Mode Control line will be at a HI-logic level, activating U88A, holding the U90A reset input at a LO-logic level, and keeping the POSSIBLE UNDERSAMPLING indicator off. When the 5B25N is in the real-time sampling mode (0.1 ms/division and slower), the Mode Control line will be at a LO-logic level, permitting U88A to respond to the output of U86.

6

LOGIC

The circuitry on the Logic diagram generates Sample Pulse and Load Stop signals. The Logic circuit consists of a counter, U103, U105, and U107; a D/A converter, U109; a comparator, U142 and U70D; multiplexers, U155A and B; a one-shot multivibrator, U83B; and associated circuitry.

NOTE

The Logic circuit operation is more easily described by discussing how it produces its output signals, rather than by discussing individual stages. For this reason the Logic circuit description subheadings are given signal names rather than stage names.

SAMPLE PULSE

Equivalent-Time Sampling (50 μs/division and faster)

In this mode comparator U142 produces an output (which becomes the Sample Pulse) when the combined voltage of the sweep and the output of D/A converter U109 crosses zero volts. The output of U142 increments counter U103, U105 and U107, which then presents a higher number to U109. D/A converter U109 then produces a slightly higher output voltage, which combines with the next sweep to cause the next Sample Pulse at a later time. Because only one Sample Pulse occurs per sweep, 1024 sweeps must occur to sample an entire display. Each time the sweep triggers comparator U142, U70D activates U70B. The output of U70B reaches the inputs of multiplexer U155B via U101C, S20 section 24, and S29. It reaches one input (U155B pins 9 and 10) directly and the other (U155B pin 12) via a differentiator. The Mode Control line, and its complement, control the two input gates in U155B. Switch S20 section 13 establishes the voltage on the Mode Control line—it will be a HI-logic level when the TIME/DIV control is set to 50 μs or faster (equivalent-time sampling), and a LO-logic level when the TIME/DIV control is at 0.1 ms or slower (real-time sampling). When the Mode Control line is at a HI-logic level it enables U155B at its pin 11 input, and the direct input from U70B activates U155B to produce the Sample Pulse. The Sample Pulse starts when the sweep triggers U142 and ends at the end of the sweep when U142 resets.

Real-Time Sampling (.1 ms/division and slower)

When the 5223 Oscilloscope mainframe is operating in the real-time sampling mode and the SAMPLE CLK SOURCE button is in NORMAL position (pressed in), Sample Pulses are caused by the Real Time Sample Pulse from the frequency-divider circuit shown on diagram 5. Real Time Sample Pulses reach multiplexer U155B via section 23 of S20, and S170B. In the real-time sampling mode, section 24 of S20 disconnects the counter, the D/A converter and comparator circuits from multiplexer U155. A LO-logic level on the Mode Control line disables U155B pin 11; its complement enables U155B pins 1 and 13. Capacitor C77 and the combination of R78 and R79 differentiate the Real Time Sample Pulse. The resulting positive spike activates U155B to produce a short (between 50 and 100 ns) Sample Pulse. Table 3-1 shows the relation between the TIME/DIV control setting and the SAMPLE PULSE.

TABLE 3-1
Relationship of TIME/DIV Control, Counter U68, and SAMPLE PULSE in Real-Time Sampling Mode

TIME/DIV	Output of Counter U68	SAMPLE PULSE Frequency	SAMPLE PULSE Period
5 s	20 Hz	20 Hz	50 ms
2 s		50 Hz	20 ms
1 s	200 Hz	100 Hz	10 ms
.5 s		200 Hz	5 ms
.2 s		500 Hz	2 ms
.1 s	2 kHz	1 kHz	1 ms
50 ms		2 kHz	.5 ms
20 ms		5 kHz	.2 ms
10 ms	20 kHz	10 kHz	.1 ms
5 ms		20 kHz	50 μs
2 ms		50 kHz	20 μs
1 ms	200 kHz	100 kHz	10 μs
.5 ms		200 kHz	5 μs
.2 ms	2 MHz	500 kHz	2 μs
.1 ms	2 MHz	1 MHz	1 μs

LOAD STOP

Equivalent-Time Sampling (50 μs/division and faster)

In equivalent-time sampling mode U83B generates one Load Stop pulse for every 1024 Sample Pulses. A HI-logic level on the Mode Control line enables the gate on U155A pin 4. A LO-logic level activates the gate on U155A pin 2. The pin 8 output of counter U107 is at a LO-logic level from sweeps zero to 511, and at a HI-logic level from sweeps 512 to 1023. Multiplexer U155A inverts this signal and appies it to the D input (pin 12) of FF U90B. At sweep 1023 the D input of FF U90B receives a HI-logic level and the clock input receives the inverted Sample Pulse via U88C. Flip-flop U90B produces a positive-going output that triggers one-shot U83B to produce the Load Stop pulse. Figure 3-4 shows the timing of these events.

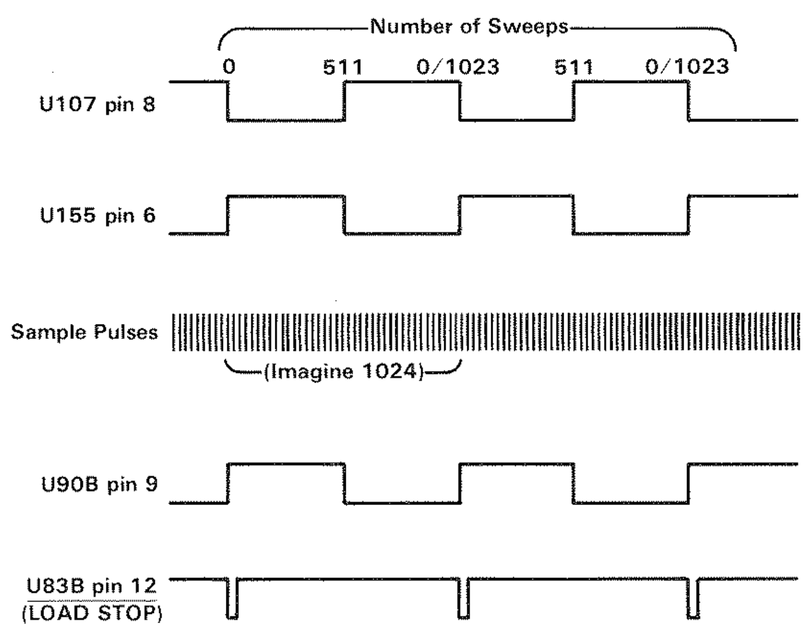

Figure 3-4. Timing of LOAD STOP pulse.

In the equivalent-time sampling mode, if U142 does not generate a sample pulse during the sweep due to improper adjustment of the Sample Zero or Sample FS controls (R133 or R115), U70B will produce one when it receives a Swp End pulse.

Real-Time Sampling (.1 ms/division and slower)

In real-time sampling mode, comparator U142 produces a pulse (which becomes Load Stop) when the combined voltage of the sweep and the output of Q123 crosses zero volts. The setting of the PRETRIGGER control, R341, sets the conduction of Q123. This permits the operator to set the Load Stop pulse anywhere in the sweep. When U142 is triggered it activates U70D, whose output activates U70B. Gate U70B activates U88D, which applies a LO-logic level to pin 3 of multiplexer U155A. In real-time sampling mode a HI-logic level on pin 2 enables U155A, and U88D's output activates U155A. The HI-logic level output of U155A is connected to the D input (pin 12) of FF U90B. The next Sample Pulse clocks FF U90B (via U88C) and the U90B output triggers one-shot U83B. One-shot U83B produces the Load Stop pulse, which is about 1 μs in duration. The Gate line controls comparator U142 and U70D—a HI-logic level enables them during the sweep, and a LO-logic level disables them during holdoff time.

If the PRETRIGGER control is set for the display to end more than 1024 samples after the sweep start, the trigger event would be off screen when viewing the stored display, and no Load Stop pulse would occur. To ensure that this doesn't happen, the Q_D output of U107 is connected to U88D. This connection causes multiplexer U155A to generate a Load Stop pulse 1024 samples after the beginning of the sweep if U142 has not previously done so. If the PRETRIGGER control is set to a level that means "before sweep start," U142 will be held off by the Gate signal until sweep start, when it will change states.

When the TIME/DIV control is in the AMPL position, the 5B25N operates as an amplifier. To notify the 5223 mainframe of this, S20 contact 4 opens and allows the Sweep Rate line to float.