

DELAYED SWEEP OSCILLOSCOPE

HIGH STABILITY

CS-2110

100 MHz QUAD-TRACE

OSCILLOSCOPE

HANDBOOK

TRIO

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SAFETY

Symbol in This Manual



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

Power Source

This equipment operates from a power source that does not apply more than 250V 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.

Grounding the Product

This equipment 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 equipment input or output terminals.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use the Proper Fuse

To avoid fire hazard, use a fuse of the correct type.

Do not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere.

Do not Remove cover or Panel

To avoid personal injury, do not remove the cover or panel. Refer servicing to qualified personnel.

FEATURES

- Small and compact with high 1 mV/div sensitivity and 100 MHz bandwidth (1 mV/div when X5 GAIN function is used and 500 μ V/div for cascaded operation, channel 1 to channel 2).
- Bright 150 mm rectangular CRT with an internal graticule and a 20 kV accelerating potential.
- Vertical axis is capable of single, dual as well as quad-trace display.
- Dual sweep with independent A and B sweeps is provided in addition to single sweep. X10 magnification, delayed sweep and alternating sweep capability.
- Fast 20ns/div sweep speed (2ns/div with X10 magnification).
- A switching type power supply provides stable operation with varying power sources (90V – 264V).
- A convenient channel 1 sampling output is provided.
- Gate signal outputs for both A sweep and B sweep are provided for use in synchronizing peripheral equipment to these sweeps.
- A convenient beam finder allows you to quickly locate elusive traces.
- CPU controlled switching with LED lighted pushbutton switches provides easy, reliable switching with setting hold capability when the scope is switched off.
- The 20 MHz bandwidth limiter incorporated eliminates high-frequency noises and stabilizes signal waveforms displayed.
- LED indicators provided for the vertical axis, X5 GAIN, UNCAL, horizontal axis, A/B trigger prevent erroneous operations.
- The circuit which varies chop frequency permits to easily observe waveform whose frequency is equal to the chop frequency multiplied or divided by an integer.
- The dual intensity control circuit permits to vary intensities separately for A and B sweeps.
- The VIDEO synchronization circuit permits to observe video signal easily.
- When waveform amplitude varies, the FIX circuit stabilizes triggering automatically so that the operator is free from complicated synchronizing operations.
- Accuracies of vertical axis and horizontal sweeping are as high as $\pm 2\%$ at 10 – 35°C.
- The current CAL terminal (10 mA_{p-p}, 1 kHz) permits to calibrate the current probe.

SPECIFICATIONS

CRT

Model:	150KTM31
Type:	Rectangular, with internal graticule
Accelerating potential:	20kV
Display area:	8 div × 10 div (1 div = 1 cm)

VERTICAL AXIS (Channel 1 and Channel 2 identical specifications)

Sensitivity	5mV/div to 5V/div (X1 mode) 1 mV/div to 1V/div (X5 mode) 500 μ V/div (Cascaded operation, CH1 to CH2)
Accuracy:	$\pm 2\%$ (10 ~ 35°C) $\pm 4\%$ (0 ~ 50°C) $\pm 7\%$ (Cascaded operation, CH1 to CH2)
Attenuator:	5mV/div to 5V/div in 1-2-5 sequence, all 10 ranges with fine adjustment between steps.
Input resistance:	1 M Ω \pm 1%
Input capacitance:	Approx 22pF
Frequency response	
DC:	DC to 100 MHz (-3 dB) DC to 140 MHz (-6 dB) (unapplied × 5 GAIN mode)

AC:	5 Hz to 100 MHz (-3 dB) 5 Hz to 140 MHz (-6 dB) (unapplied × 5 GAIN mode) 7 Hz to 70 MHz (-3 dB), (Cascaded operation, CH1 to CH2)
Risetime:	3.5ns
Signal delay time:	Approx 10ns as displayed on CRT screen
Crosstalk:	-40 dB minimum
Operating modes:	
CH1	CH1, single trace
CH2	CH2, single trace
DUAL	CH1 and CH2, dual trace
ADD	CH1 + CH2 (added) display
QUAD	CH1 ~ CH4, quad trace
ALT	Dual or quad trace alternating
CHOP	Dual or quad trace chopped
CHOP frequency:	Approx 250 kHz, adjustable
Channel polarity:	Normal or inverted, CH2 only inverted

Δ Maximum input voltage: 800 Vp-p or 400V (dc + ac peak)

Maximum undistorted amplitude:	8 divisions, minimum (DC to 100 MHz)
Bandwidth limiting:	Vertical system bandwidth with the 20 MHz BW pushbutton switch pushed is approximately 20 MHz
Delay time difference:	
CH1 to CH2:	Less than 0.5ns
CH1, CH2 to CH3, CH4:	Less than 1ns

VERTICAL AXIS (Channel 3 and Channel 4 common specifications)

Sensitivity	0.1V/div, 1V/div $\pm 2\%$
Attenuator:	1/1, 1/10
Input resistance:	1 M Ω $\pm 1\%$
Input capacitance:	Approx. 22 pF
Input coupling mode:	DC only
Frequency response:	DC to 100 MHz (-3 dB) DC to 140 MHz (-6 dB) (unapplied x 5 GAIN mode)
Risetime:	3.5ns
Signal delay time:	Same as CH1 and CH2
Maximum allowable voltage	
DC component:	$\pm 0.5V$ or less (ac + dc) ($\pm 5V$, 1/10 attenuated)
AC component:	1 Vp-p (10 Vp-p, 1/10 attenuated) or less

△ Maximum input voltage: 400V (dc + ac peak)

HORIZONTAL AXIS (Channel 2 input)

Modes:	X-Y mode is switch selectable (HORIZ DISPLAY)
X-Y mode:	CH1: Y-axis CH2: X-axis
Sensitivity:	Same as CH2
Accuracy:	Same as CH2
Input resistance:	Same as CH2
Input capacitance:	Same as CH2
Frequency response:	
DC:	DC to 5 MHz (-3 dB) DC to 7 MHz (-6 dB)
AC:	5 Hz to 5 MHz (-3 dB) 5 Hz to 7 MHz (-6 dB)
X-Y phase difference:	Less than 3° at 100 kHz

SWEEP

Modes	(Switchable with the HORIZ DISPLAY switch):
A	A sweep
ALT	B sweep waveform is displayed as an intensified portion of the A sweep and B sweep alternating
A-INT-B	B sweep waveform is displayed as an intensified portion of the A sweep.
B DLY'D	Delayed B sweep

SPECIFICATIONS

DUAL

Dual sweep – A and B sweeps, independently

X-Y

X-Y display mode

A sweep time:

20 ns/div to 0.5s/div in 23 ranges, in 1-2-5 sequence, vernier control provides fully adjustable sweep time between steps.

B sweep time:

20ns/div to 50ms/div in 20 ranges, in 1-2-5 sequence.

Accuracy:

$\pm 2\%$ (10 35°C)
 $\pm 4\%$ (0 50°C)

Sweep magnification:

X10 $\pm 5\%$ (10 35°C)
 $\pm 6\%$ (0 50°C)

Linearity:

20ns/div to 0.5s, $\pm 3\%$ ($\pm 5\%$ with X10 magnification)

HOLDOFF:

Continuously adjustable for A sweep from NORM to X5

Trace separation:

B positionable up to 4 divisions separated from A sweep, continuously adjustable.

Delay method:

Continuous delay, Trigger delay

Delay time:

0.2 to 10 times the sweep time from 200ns to 0.5s, continuously adjustable.

Time difference measurement accuracy:

$\pm 1\%$ of measurement + 0.1% of full scale (10 ~ 35°C)
 $\pm 4\%$ (0 ~ 50°C)
1/20000 of the full scale sweep time.

Delay jitter:

TRIGGERING

A TRIG

A trigger modes:

AUTO, NORM, SINGLE, FIX: at the center of the waveform

Trigger source:

V MODE, CH1, CH2, (EXT) CH3 1/1 and 1/10, LINE

Coupling modes:

AC, LFREJ, HFREJ, DC, VIDEO VIDEO-LINE sync automatically selected at sweep times of 50 μ s/div to 20ns/div. VIDEO-FRAME sync automatically selected at sweep times of 0.5s/div to 0.1ms/div.

Trigger level:

$\pm 90^\circ$ adjustable

Polarity:

+/-

B TRIG

B trigger modes:

STARTS AFTER DELAY, TRIGGERABLE AFTER DELAY

Trigger source:

CH1, CH2, (EXT) CH4 1/1 and 1/10

Coupling modes: AC, LFREJ, HFREJ, DC
 Trigger level: $\pm 90^\circ$ adjustable
 Polarity: +/-

TRIGGER SENSITIVITY (A AND B)

COUPLING	FREQ RANGE	MINIMUM SYNC AMPLITUDE		
		INT	EXT	EXT 1/10
DC	DC ~ 20 MHz	0.5 div	50 mV	0.5V
	DC ~ 50 MHz	1.0 div	100 mV	1.0V
	DC ~ 100 MHz	1.5 div	210 mV	2.1V
AC	Same as for DC but with increased minimum level for below 20 Hz.			
AC HFREJ	Increased minimum level below 20 Hz and above 30 kHz.			
AC LFREJ	Increased minimum level below 30 kHz.			
VIDEO	FRAME/LINE	0.5 div	50 mV	0.5V

AUTO: Same as above specifications for above 50 Hz.
 FIX: 40 Hz ~ 20 MHz 1.0 div (100 mV)
 40 Hz ~ 100 MHz 1.5 div (210 mV)
 Jitter: 0.5ns maximum at 100 MHz,
 2ns/div sweep rate (X10 MAG on)

CALIBRATING VOLTAGE AND CURRENT

1 kHz $\pm 3\%$ Positive square wave
 1V $\pm 1\%$ (10 ~ 35°C)
 $\pm 2\%$ (0 ~ 50°C)
 10 mA $\pm 2\%$ (10 ~ 35°C)
 $\pm 4\%$ (0 ~ 50°C)

INTENSITY MODULATION

Input signal: TTL level, intensity decreasing with more positive levels
 Input impedance: Approx. 10 k Ω
 Usable frequency range: DC to 10 MHz

Δ Maximum input voltage: 50V (dc + ac peak)

VERTICAL AXIS OUTPUT

Output voltage: Sampled CH1 output
 50 mVp-p/div (into 50 Ω load)
 Output impedance: Approx. 50 Ω
 Frequency response: DC to 100 MHz (-3 dB)
 (into 50 Ω load)

GATE OUTPUT (A and B)

Output voltage: Approx. 1.5V positive gate
 (into 500 Ω load)

TRACE ROTATION

Electrical, adjustable

POWER SUPPLY

Line voltage: 90 ~ 264V
 Line frequency: 45 ~ 400 Hz
 Power consumption: Approx. 55W (at 100V, 50 Hz)

DIMENSIONS

Width: 284 mm (328 mm)
 Height: 138 mm (150 mm)

SPECIFICATIONS AND PREPARATION FOR USE

Depth: 400 mm(471 mm)
() dimensions include protrusions from basic case outline dimensions.

WEIGHT

7.4 kg

ACCESSORIES

PC-29 Probes 2
Instruction manual..... 1
Handbook 1
AC power cord 1
Panel cover 1
Probe holder 1

OPTION

Accessory bag (MC-78)

ENVIRONMENT

Operating temperature and humidity for guaranteed specifications: 10 ~ 35°C, 85% maximum RH
Full operating temperature and humidity range: 0 ~ 50°C, 90% maximum RH
Storage temperature and humidity range: -20 ~ +70°C, 80% maximum
Altitude:
Operating: 5000 m
Non-operating: 12000 m

- Circuit and ratings are subject to change without notice due to developments in technology.

PREPARATION FOR USE

SAFETY

Before connecting the instrument to a power source, carefully read the following information, and verify that the proper power cord is used and the proper line fuse is installed for power source. If the power source is not applied to your product, contact your dealer. If the power cord is not applied for specified voltage, there is always a certain amount of danger from electric shock.

Line voltage

This instrument operates using ac-power input voltages that 90V to 264V at frequencies from 45 Hz to 400 Hz.

Power cord

The ground wire of the 3-wire ac power plug places the chassis and housing of the oscilloscope at earth ground. Do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.

Line fuse

The fuse holder is located on the rear panel and contains the line fuse. Verify that the proper fuse is installed by replacing the line fuse.

EQUIPMENT PROTECTION

1. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur only when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, switch back to normal sweep operation when no signal is applied, or set up the scope for spot blanking.

2. Never cover the ventilating holes on the top of the oscilloscope, as this will increase the operating temperature inside the case.

3. Never apply more than the maximum rating to the oscilloscope input jacks.

CH1, CH2 INPUT jacks: 800 Vp-p or 400V (dc + ac peak)

CH3, CH4 INPUT jacks: 400 V (dc + ac peak)

Z axis INPUT jack: 50V (dc + ac peak)

Never apply external voltage to the oscilloscope output terminals.

4. Always connect a cable from the earth ground (GND) jack of the oscilloscope to the chassis of the equipment under test. Without this caution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

5. Always use the probe ground clips for best results. Do not use an external ground wire in lieu of the probe ground clips, as undesired signals may be introduced.
6. Operation adjacent to equipment which produces strong ac magnetic fields should be avoided where possible. This includes such devices as large power supplies, transformers, electric motors, etc., that are often found in an industrial environment. Strong magnetic shields can exceed the practical CRT magnetic shielding limits and result interference and distortion.
7. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation of probe should be adjusted initially, then the same probe always used with the input of scope. Probe compensation should be readjusted whenever a probe from a different scope is used.
8. When power is off, the position of each switch where it was set immediately before power-off is held in memory, backed up by battery. If the battery is dead, the LEDs of the switches indicate as follows when supplying power starts.

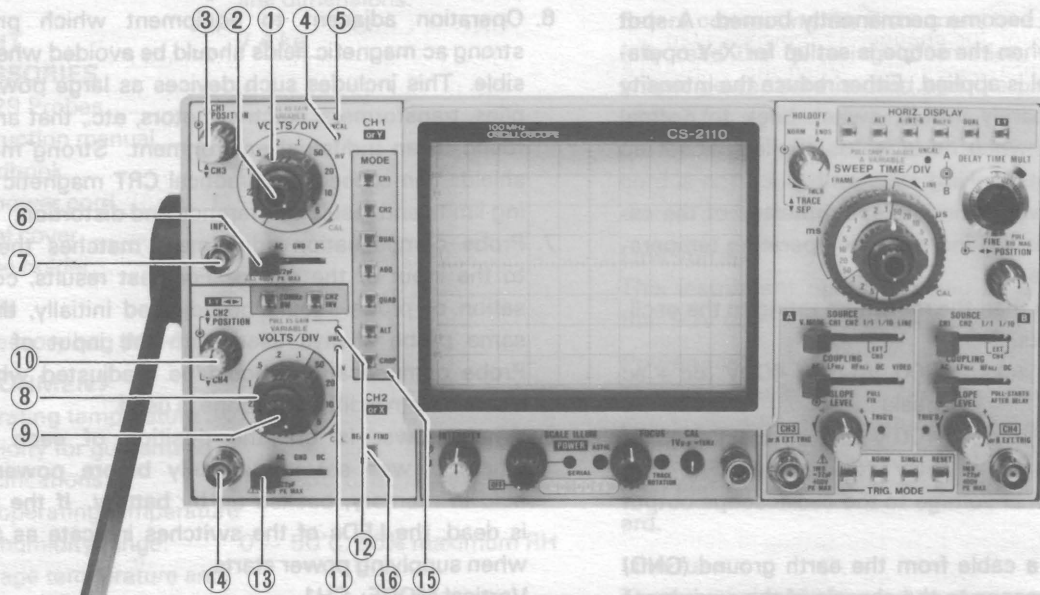
Vertical MODE: CH1,

HORIZ DISPLAY: A

TRIG MODE: AUTO

VERTICAL AXIS CONTROLS

CONTROLS AND INDICATORS



FRONT PANEL

VERTICAL AXIS CONTROL

① VOLTS/DIV Control

Vertical attenuator for channel 1; provides step adjustment of vertical sensitivity. When the VARIABLE control is turned to the CAL position, the vertical sensitivity is calibrated in 10 steps from 5V/div to 5 mV/div.

For X-Y operation this control provides step adjustment of vertical sensitivity.

② VARIABLE, PULL X5 GAIN Controls VARIABLE;

Rotation provides fine control of channel 1 vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. For X-Y operation, this control serves as the Y axis attenuation fine adjustment.

PULL X5 GAIN;

When pulled out, the VOLTS/DIV setting is multiplied by five and for X-Y operation the Y-axis sensitivity is multiplied accordingly. In X5 GAIN mode, the vertical gain is increased and the trace becomes thickness.

③ \blacktriangle CH1 POSITION, \blacktriangle CH3 Controls

\blacktriangle CH1 POSITION;

Rotation adjusts vertical position of channel 1 trace. In X-Y operation, rotation adjusts vertical position of display.

\blacktriangle CH3;

Rotation adjusts vertical position of channel 3 trace on the screen.

④ UNCAL Lamp

Glowes when channel 1 VARIABLE control ② is not set to CAL position. Reminds user that channel 1 measurements are not calibrated.

⑤ PULL X5 GAIN Indicator

Indicate that the channel 1 VARIABLE control is in the pulled out position, i.e. that the channel 1 sensitivity is five times the VOLTS/DIV setting.

⑥ AC-GND-DC switch

Three-position lever switch which operates as follows:

AC: Blocks dc component of channel 1 input signal.

GND: Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.

DC: Direct input of ac and dc component of channel 1 input signal.

⑦ INPUT Jack

Vertical input for channel 1 trace in normal sweep operation. Vertical input for X-Y operation.

VERTICAL AXIS CONTROLS

⑧ VOLTS/DIV Control

Vertical attenuator for channel 2; provides step adjustment of vertical sensitivity, VARIABLE control is turned to the CAL position, the vertical sensitivity calibrated in 10 steps from 5V/div to 5mV/div. For X-Y operation the control provides step adjustment of horizontal sensitivity.

⑨ VARIABLE, PULL X5 GAIN Controls

VARIABLE;

Rotation provides fine control of channel 2 vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. For X-Y operation, this control serves as the X axis attenuation fine adjustment.

PULL X5 GAIN;

When pulled out, the VOLTS/DIV setting is multiplied by five and for X-Y operation the X-axis sensitivity is multiplied accordingly. In X5 GAIN mode, the vertical gain is increased and the trace becomes thickness.

⑩ CH2 \blacktriangleleft POSITION X-Y \blacktriangleright , \blacktriangle CH4 Controls

\blacktriangle CH2 POSITION;

Rotation adjusts vertical position of channel 2 trace. In X-Y operation adjusts horizontal position of display.

\blacktriangleleft CH4;

Rotation adjusts vertical position of channel 4 trace on the screen.

⑪ UNCAL Lamp

Glows when channel 2 VARIABLE control ⑨ is not set to CAL position. Reminds user that channel 2 measurements are not calibrated.

⑫ PULL X5 GAIN Indicator

Indicates that the channel 2 VARIABLE control is in the pulled out position, i.e. that the channel 2 sensitivity is five times the VOLTS/DIV setting.

⑬ AC-GND-DC Switch

Three-position lever switch which operates as follows:

AC: Blocks dc component of channel 2 input signal.

GND: Opens signal path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.

DC: Direct input of ac and dc component of channel 2 input signal.

⑭ INPUT Jack

Vertical input for channel 2 trace in normal sweep operation. Horizontal input in X-Y operation.

15 MODE Switch Assembly

Used to select the basic operating modes of the oscilloscope. LED's indicate what mode has been selected.

CH1: Only the input signal to channel 1 is displayed as a single trace.

CH2: Only the input signal to channel 2 is displayed as a single trace.

DUAL: When engaged this button, if either ALT or CHOP switch is pushed in, dual trace mode presents traces of channel 1, channel 2 input waveforms.

ADD: Channel 1 and channel 2 input signals are added and the sum is displayed as a single trace. When the CH2 INV button is engaged, the waveform from channel 2 is subtracted from the channel 1 waveform and the difference is displayed as a single trace.

QUAD: When engaged this button, if either ALT or CHOP switch is pushed in, quad trace mode presents traces of channel 1 through channel 4 input waveforms

ALT: Alternate sweep is selected regardless of sweep time as dual trace (channel 1 and channel 2) or quad trace (channel 1 through channel 4)

CHOP: Chop sweep is selected regardless of sweep time at approximately 250 kHz as dual trace (channel 1 and channel 2) or quad trace (channel 1 through channel 4).

CH2 INV: In the NORM position (button released), the channel 2 signal is non-inverted. In the INV position (button engaged), the channel 2 signal is inverted.

20 MHzBW: Limits the vertical bandwidth to approximately 20 MHz when engaged this button.

NOTE:

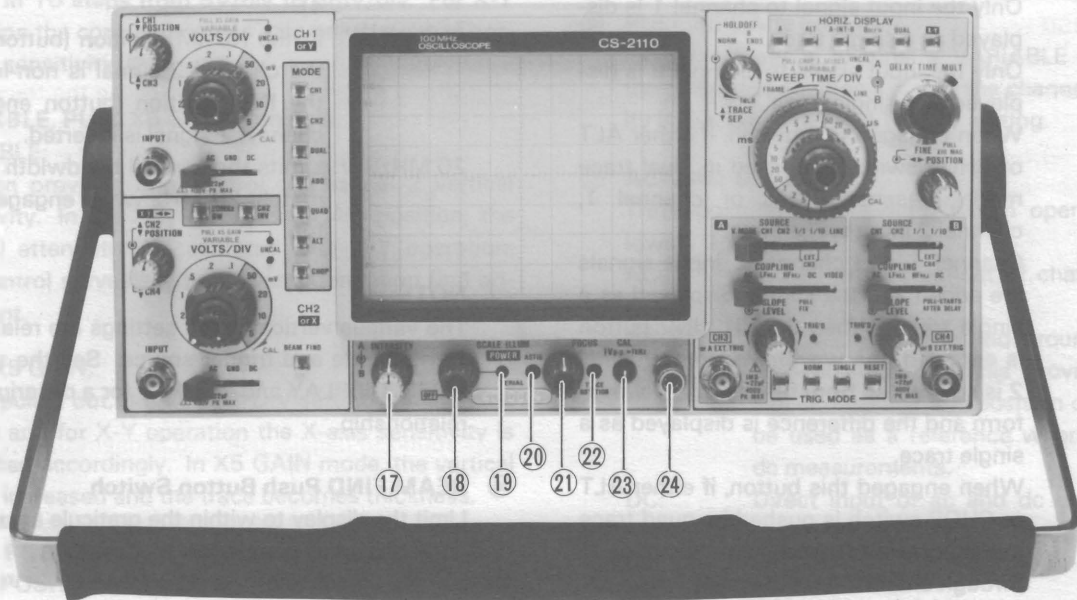
The various vertical mode settings are related to horizontal mode and trigger source. See the sections on HORIZ DISPLAY and SOURCE for a description of this relationship.

16 BEAM FIND Push Button Switch

Limit the display to within the graticule area, independently of display position.

POWER SUPPLY/CRT DISPLAY CONTROLS

POWER SUPPLY/CRT DISPLAY CONTROLS



POWER SUPPLY/CRT DISPLAY CONTROLS

⑰ **A INTENSITY, B INTENSITY Controls**

Allows adjustment of intensity for the A sweep and B sweep respectively.

A INTENSITY;

Adjusts the trace intensity for the A sweep and the display intensity for X-Y operation.

B INTENSITY;

Adjusts the intensity of the B sweep.

⑱ **POWER, SCALE ILLUM Controls**

Fully counterclockwise rotation (off position) turns off oscilloscope. Clockwise rotation turns on oscilloscope. Further clockwise rotation of the control increases the illumination level of scale.

⑲ **LED Pilot Lamp**

Indicates that the power supply has been turned on.

⑳ **ASTIG Control**

Astigmatism adjustment provides optimum spot roundness when used in conjunction with FOCUS control regardless intensity control.

㉑ **FOCUS Control**

Used to adjust the trace for optimum focus.

Auto-focus circuit keeps waveform in focus with changes in intensity.

㉒ **TRACE ROTATION Control**

Electrically rotates trace to horizontal position. Strong magnetic fields may cause the trace to be tilted. The degree of tilt may vary as the scope is moved from one location to another. In these cases, adjust this control.

㉓ **CAL, 1Vp-p, \approx 1 kHz Terminal**

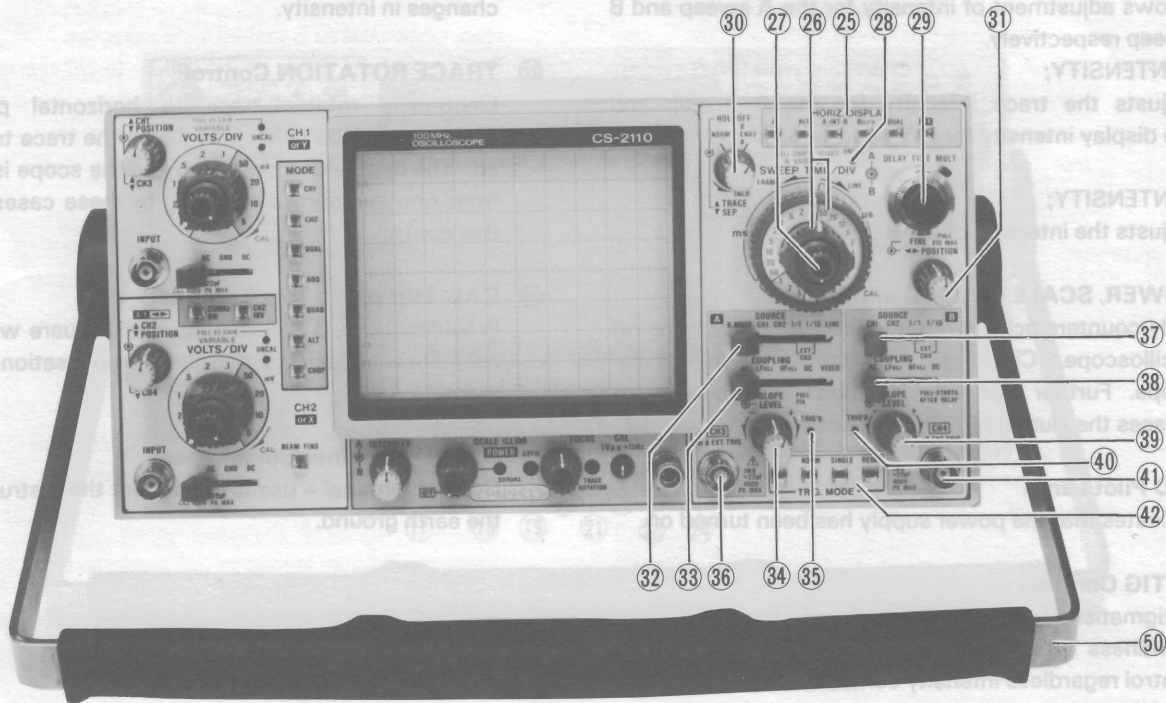
Provides 1kHz, 1Volt peak-to-peak square wave signal. This is useful for probe compensation adjustment.

㉔ **\perp GND Terminal/Binding post.**

Ground terminal – use it to connect the instrument to the earth ground.

HORIZONTAL AXIS CONTROLS AND TRIGGER SOURCE CONTROLS

HORIZONTAL AXIS CONTROLS AND TRIGGER SOURCE CONTROLS



HORIZONTAL AXIS CONTROLS

25 HORIZ DISPLAY Switch assembly

Used to select the horizontal display mode. LED's indicate what mode has been selected.

A: Only A sweep is operative with the B sweep dormant.

ALT: A sweep alternates with the B sweep. For this mode of operation, the B sweep appears as an intensified section on the A sweep.

A-INT-B: Duration of the B sweep appears as an intensified section on the A sweep.

B DLY'D: Only delayed B sweep is operative.

DUAL: A sweep and B sweep operate independently. For this mode the two sweeps are triggered by the A trigger source and B trigger source respectively.

X-Y: Channel 1 becomes the Y-axis and channel 2 becomes the X-axis for X-Y operation.

The settings of the vertical MODE and TRIG MODE switches have no effect.

26 A SWEEP TIME/DIV, B SWEEP TIME/DIV Controls

A SWEEP TIME/DIV:

Horizontal coarse A sweep time selector.

Selects calibrated sweep times of 20 ns/div to 0.5

s/div in 23 steps when A VARIABLE control 27 is set to CAL position (fully clockwise).

B SWEEP TIME/DIV;

Horizontal coarse B sweep time selector.

Selects sweep times of 20 ns/div to 50 ms/div in 20 steps. B sweep time selector is constructed to make it possible to set the B sweep time slower than A sweep time. No fine adjustment is available for the B sweep time.

27 A VARIABLE, PULL CHOP F. SELECT Controls

A VARIABLE;

Fine A sweep time adjustment. In the fully clockwise (CAL) position, the A sweep time is calibrated.

PULL CHOP F. SELECT

The chopping frequency may be changed by pulling this control outward. This is useful in cases where the input signal is triggered to the chopping frequency.

28 UNCAL Lamp

Grows when the A VARIABLE control is not set to the CAL position. Reminds user that the A sweep time is not calibrated.

HORIZONTAL AXIS CONTROLS AND TRIGGER SOURCE CONTROLS

29 DELAY TIME MULT Control

Adjusts the start time of the B sweep to some delay time after the start of the A sweep.

The delay time may be set to values between 0.2 and 10 times the setting of the A SWEEP TIME/DIV control.

30 ▲ TRACE SEP, HOLDOFF Controls

▲ TRACE SEP

Adjusts vertical separation between A sweep and B sweep (control has effect only in the ALT of HORIZ DISPLAY).

Clockwise rotation increases separation; B sweep moves down with respect to A sweep up to 4 divisions.

In this case, HOLDOFF control has no effect. This control is effective when the HORIZ DISPLAY switch is selected to ALT. Even when the HORIZ DISPLAY switch is selected to DUAL, this control is effective with the vertical MODE switch set to CH1, CH2 or ADD position.

HOLDOFF

Rotation adjusts holdoff (trigger inhibit period beyond sweep duration). Counterclockwise rotation increases holdoff period from NORM to max more than five times before the B ENDS A position.

In the B ENDS A position (fully counterclockwise), the

A sweep is reset at the end of the B sweep. And therefore intensity of B sweep increases. B ENDS A mode is applicable to the ALT, A-INT-B and B DLY'D modes of HORIZ DISPLAY.

31 ◀◀ POSITION, FINE, PULL X10 MAG Controls

◀◀ POSITION

Rotation adjusts horizontal position of trace.

FINE, PULL X10 MAG

Rotation becomes fine adjustment of horizontal position of trace. Selects ×10 sweep magnification (PULL ×10 MAG) when pulled out.

Do not use ×10 MAG during X-Y operation.

TRIGGER SOURCE CONTROLS

32 SOURCE Switch

Six-position lever switch; selects triggering source for the A sweep, with following positions:

V. MODE: The trigger source for A sweep is determined by vertical MODE selection.

CH1: Channel 1 signal is used as a trigger source.

CH2: Channel 2 signal is used as a trigger source.

ADD: The algebraic sum of channel 1 and channel 2 signal is the trigger source. (If CH2 INV engaged, the difference becomes the trigger source.)

DUAL: For ALT mode the signals for CH1 through CH4 alternate as the trigger source. For the CHOP mode the chop-
(ALT) ping signal becomes the trigger source.
(CHOP)

NOTE:

1. When the vertical MODE switch is selected to CHOP position, the display cannot be observed with the input since the chopping signal becomes the trigger source.
2. Synchronization is impossible when input signals are not applied to all channels with the vertical MODE switch set to DUAL or QUAD position.

CH1: A sweep is triggered by channel 1 signal regardless of vertical MODE selection.

CH2: A sweep is triggered by channel 2 signal regardless of vertical MODE selection.

1/1: A sweep is triggered by channel 3 signal.

1/10: A sweep is triggered by channel 3 signal attenuated to 1/10.

LINE: A sweep is triggered by line voltage.

③③ **COUPLING Switch**

Five-position lever switch; selects coupling for A trigger signal.

AC: Trigger is ac coupled. Blocks dc component of input signal; most commonly used position.

LFREJ: Trigger is coupled through a high-pass filter to eliminate low frequency components for stable triggering of high frequency signals.

HFREJ: Trigger is coupled through a low-pass filter to eliminate high frequency components for a stable triggering of low frequency signals.

DC: Trigger is dc coupled for sync which includes the effects of dc components. For channel 3 and channel 4, the vertical position adjustment has no effect on the trigger point.

VIDEO: For synchronization of video signals. The position of the A SWEEP TIME/DIV control determines whether FRAME or LINE is to be synchronized. Settings between 0.5s and 0.1ms result in FRAME while those between 50 μ s and 20ns result in LINE sync.

HORIZONTAL AXIS CONTROLS AND TRIGGER SOURCE CONTROLS

34 LEVEL, SLOPE, PULL FIX Controls

LEVEL: Rotation adjusts point on waveform where A sweep starts. When COUPLING switch is selected in VIDEO, the trigger level adjustment has no effect.

SLOPE, PULL FIX:

Adjusts the slope of the A trigger signal.
+equals most positive point of triggering and
-equals most negative point of triggering.
When the control is pulled out the FIX mode is selected for auto level adjustment, under which circumstances outer Trigger LEVEL control no longer has any effect.

35 TRIG'D Lamp

Green LED lights for duration of triggered A sweep; shows when trigger LEVEL control is properly set to obtain triggering.

36 CH3 or A EXT TRIG Jack

Input terminal of channel 3 signal or A external trigger signal. Channel 3 signal may be observed simultaneously with channel 1, 2 and 4 signals when the vertical MODE switch is selected in QUAD.

When the SOURCE switch is set to either EXT (CH3) 1/1 or 1/10, sweep is triggered by this input signal.

37 SOURCE Switch

Four-position lever switch; selects the triggering

source for the B sweep, with following positions;

CH1: B sweep is triggered by channel 1 signal.

CH2: B sweep is triggered by channel 2 signal.

1/1: B sweep is triggered by channel 4 signal.

1/10: B sweep is triggered by channel 4 signal attenuated to 1/10.

38 COUPLING Switch

Four-position lever switch; selects coupling for B trigger signal.

AC: Trigger is ac coupled. Blocks dc component of input signal.

LFREJ: Trigger is coupled through a high-pass filter to eliminate low frequency components for stable triggering of high frequency signals.

HFREJ: Trigger is coupled through a low-pass filter to eliminate high frequency components for stable triggering of low frequency signals.

DC: Trigger is dc coupled for sync which includes the effects of dc components.

39 LEVEL, SLOPE, PULL STARTS AFTER DELAY Controls

LEVEL: Rotation adjusts point on waveform where B sweep starts.

SLOPE: Adjust the slope of the B trigger signal, +equals most positive point of triggering and -equals most negative point of trigger-

ing. For B trigger operation it must be set in its pushed-in position.

PULL STARTS AFTER DELAY:

When it is pulled out, the B sweep starts immediately after the delay time selected by the DELAY TIME MULT and A SWEEP TIME/DIV control, regardless of the trigger LEVEL setting. Even when this switch is in position with the TRIG MODE switch set to AUTO, turning the trigger LEVEL clockwise or counterclockwise release the trigger and set the scope to B STARTS AFTER DELAY operation.

40 TRIG'D Lamp

Green LED lights for duration of triggered B sweep; shows when trigger LEVEL control is properly set to obtain triggering.

41 CH4 or B EXT TRIG Jack

Input terminal for the channel 4 signal or B external trigger signal. Channel 4 signal may be observed simultaneously with channel 1, 2 and 3 signals when the vertical MODE switch is selected in QUAD.

When the SOURCE switch is set to either EXT (CH4) 1/1, or 1/10, sweep is triggered by this input signal.

42 TRIG MODE Switch

Push button switch assembly; selects triggering mode.

AUTO: Triggered sweep operation. When trigger signal is present, automatically generates sweep (free runs in absence of trigger signal.)

NORM: Normal triggered sweep operation. No trace is presented when a proper trigger signal is not applied.

SINGLE: Single sweep operation. Note that in this mode, simultaneous observation of both the A and B sweeps is not possible.

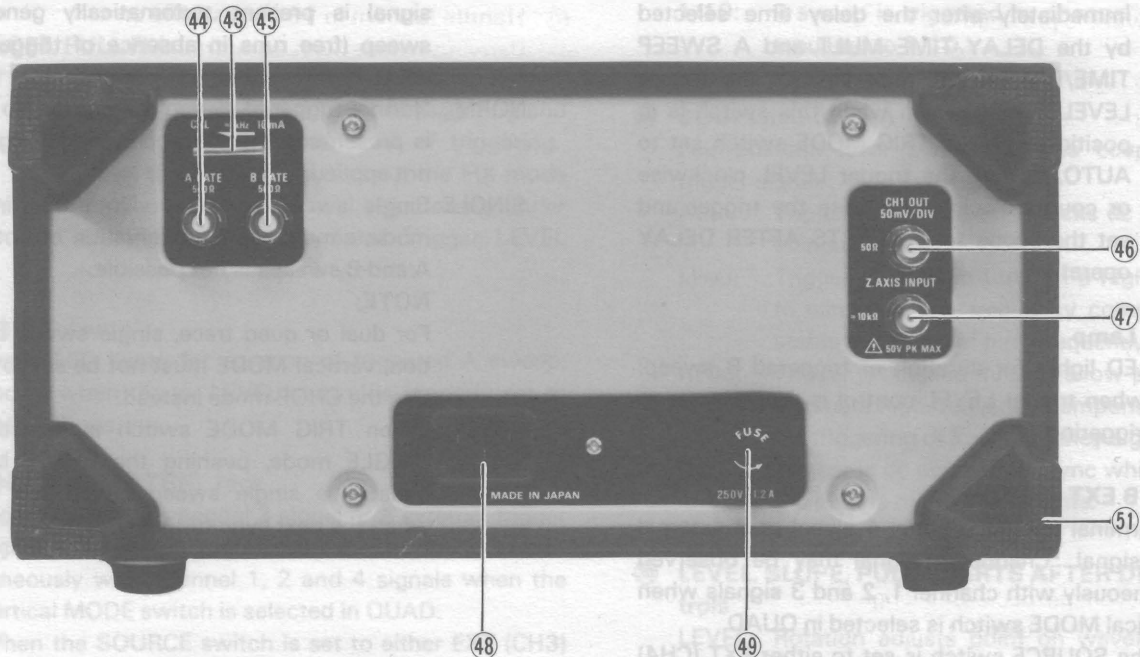
NOTE;

For dual or quad trace, single sweep operation, vertical MODE must not be set to ALT. Use the CHOP mode instead.

RESET: When TRIG MODE switch is selected to SINGLE mode, pushing the RESET button initiates a single sweep which will begin when the next sync trigger occurs.

REAR PANEL CONNECTORS

REAR PANEL CONTROLS AND CONNECTORS



⑤ SOURCE Switch

Four-position lever switch selects the triggering

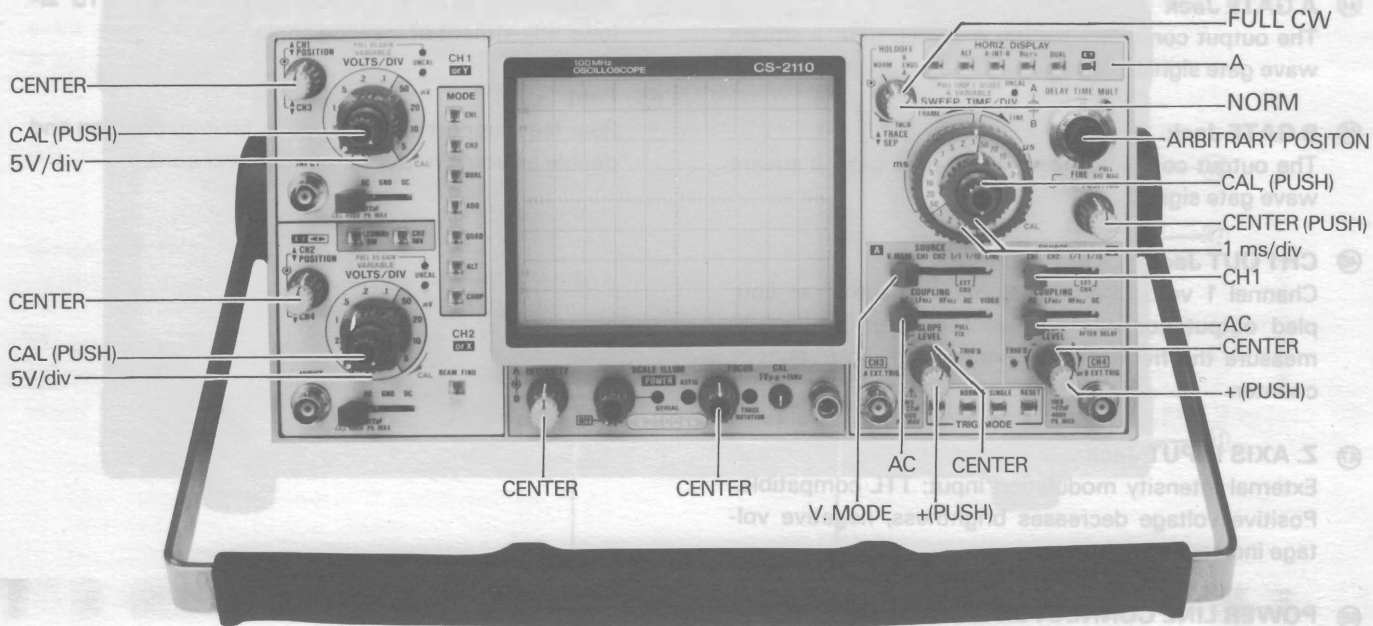
REAR PANEL

- ④③ **CAL Loop**
Current Probe calibration loop. A 10 mA, 1 kHz square wave is provided.
- ④④ **A GATE Jack**
The output connector for the A sweep gate, a square wave gate signal.
- ④⑤ **B GATE Jack**
The output connector for the B sweep gate, a square wave gate signal.
- ④⑥ **CH1 OUT Jack**
Channel 1 vertical output signal connector. ac coupled output connector. This connector is used to measure the frequency by connecting the frequency counter.
- ④⑦ **Z. AXIS INPUT Jack**
External intensity modulation input; TTL compatible. Positive voltage decreases brightness, negative voltage increases brightness.
- ④⑧ **POWER LINE CONNECTOR**
The input connector for the ac power cord.
- ④⑨ **FUSE HOLDER**
Contain the line fuse. Verify that the proper fuse is installed (1.2A).
- ⑤① **Handle (shown in 16 pages)**
Carrying handle with comfortable molded finger grip also doubles as tilt stand. Locking detent each 15° allows adjustment of viewing angle.
- ⑤② **Feet**
Rear feet support oscilloscope in face-up position and double as cord wrap for storing power cord.

OPERATION

OPERATION

Before turning the scope on, set the front panel controls as follows, referring to the section on front panel in this manual.



[1] NORMAL SWEEP DISPLAY OPERATION

1. Turn the POWER control (18) clockwise – the power supply will be turned on and the pilot lamp will light with the other LED's for the previously set vertical MODE (15), HORIZ DISPLAY (25) and TRIG MODE (42) also lighting.

Set these modes as follows:

Vertical MODE (15) : CH1

HORIZ DISPLAY (25) : A

TRIG MODE (42) : AUTO

2. The trace will appear in the center of the CRT display and can be adjusted by the channel 1 \blacklozenge POSITION (3) and $\blacktriangleleft\blacktriangleright$ POSITION (31) controls. Next, adjust the A INTENSITY (17) and, if necessary, the FOCUS (21) for ease of observation.
3. Vertical MODE

Apply an input signal to channel 1 INPUT jack (7) and adjust VOLTS/DIV (1) for a suitable size display of the waveform. If the waveform does not appear in the display, use the BEAM FIND (16) to locate the waveform adjust the VOLTS/DIV and \blacklozenge POSITION to bring the waveform comfortably into the center of the CRT display.

Operation with a signal applied to the channel 2 INPUT jack (14) and the vertical MODE set to CH2 is similar to the above procedure. In the ADD mode the algebraic sum of channel 1 + channel 2 is displayed as a single trace. If the CH2 INV switch has been pressed, the

algebraic difference of the two waveforms, channel 1 – channel 2 displayed as a single trace. If both channels are set to the same VOLTS/DIV, the difference waveform can be read directly in VOLTS/DIV on the CRT. DUAL mode allows simultaneous observation of channel 1 and channel 2 while QUAD provides viewing of channel 1 through channel 4 simultaneously.

In the DUAL or QUAD mode one of either CHOP or ALT mode applies and should be selected. In the ALT mode, channel 1 and channel 2 or channel 1 through channel 4 are displayed in an alternating fashion.

Note that in the CHOP mode of operation with the SOURCE (32) set to V.MODE, the trigger source is the chopping signal itself, making waveform observation impossible. Use ALT mode instead in such cases. SOURCE must be set to one of CH 1, CH 2 or CH 3.

4. After setting the SOURCE switch, adjust the LEVEL/SLOPE control (34). The display on the screen will probably be unsynchronized. Refer to TRIGGERING procedure below for adjusting synchronization and sweep speed to obtain a stable display showing the desired number of waveform.

TRIGGERING

The input signal must be properly triggered for stable waveform observation. Triggering is possible the input signal internally to create a trigger or with an externally provided signal of fixed timing relationship to the observed signal, applying such a signal to the EXT TRIG jack (36).

A TRIGGER

- (1) The SOURCE switch selects the signal to be used as the sync trigger. When the V. MODE position is selected, the trigger source is dependent upon the vertical MODE selection. In this manner, each waveform being observed becomes its own trigger signal; e.g., when the vertical MODE is changed from CH 1 to CH 2, the source signal is also changed from channel 1 to channel 2. This also permits synchronization of waveforms (even without a timing relationship) in the DUAL and QUAD modes. However, when phase or timing comparison is desired in DUAL and QUAD modes, all waveforms must be triggered by the same source, and the V. MODE position is unsuitable. Also, as explained previously, CHOP cannot be used in conjunction with V. MODE in DUAL or QUAD mode. If the SOURCE switch is set to the CH 1 (or CH 2) position, the channel 1 (or CH 2) input signal is the trigger source, regardless of the vertical mode. CH 1 (or CH 2) is often used as the trigger source when timing comparison is desired. If the SOURCE switch is set to the CH 3 position, the signal applied to the CH 3 or A EXT TRIG jack becomes the trigger source. This signal must have a timing relationship to the displayed waveforms for a synchronized display. In QUAD mode, the signal applied to the CH 3 or A EXT TRIG jack becomes both the trigger source and the displayed channel 3 signal. If the SOURCE switch is set to LINE position, triggering is derived from the input

line voltage. This is useful measurements that are related to line frequency.

- (2) After setting SOURCE, adjust the trigger LEVEL control to set the trigger point. Triggering is indicated by the green LED lighting.

As necessary to obtain a stable synchronized signal display, adjust HOLDOFF $\text{\textcircled{30}}$ and COUPLING $\text{\textcircled{33}}$ controls.

If the SLOPE control is pulled out, the trigger level is put into the FIX mode with the trigger point at the center of the waveform.

- (3) Adjust the A SWEEP TIME/DIV $\text{\textcircled{26}}$ control for an appropriate display of the signal input. If required, use the A VARIABLE $\text{\textcircled{27}}$ control as well.

This completes the adjustment procedure for normal A sweep display operation.

[2] MAGNIFIED SWEEP OPERATION

Since merely shortening the sweep time to magnify a portion of an observed waveform can result in the desired portion disappearing off the screen, such magnified display should be performed using the MAGNIFIED SWEEP.

Procedure:

Using the \blacktriangleleft POSITION control, adjust the desired portion of waveform to the center of the CRT. Pull out the FINE PULL X10 MAG $\text{\textcircled{31}}$ control to magnify the display 10 times. For this type of display the sweep time is the SWEEP TIME/DIV setting divided by 10.

[3] DELAYED SWEEP OPERATION

Delayed sweep operation is achieved by use of both the A sweep and the B sweep.

Procedure:

1. First select the HORIZ DISPLAY switch to A and adjust the scope for a normal waveform display.
2. Pull out the, PULL STARTS AFTER DELAY (38) control to set the sweep in the STARTS AFTER DELAY mode. Select the HORIZ DISPLAY to the A-INT-B mode and a portion of the B sweep representing the B SWEEP TIME/DIV will appear as an intensified portion of the A sweep. The B sweep intensity is adjusted using the B INTENSITY control (17).
3. Shift the intensified portion of waveform (section to be magnified) along the A sweep by use of the DELAY TIME MULT (28).
4. Select the HORIZ DISPLAY switch to B DLY'D to display the A-INT-B intensified portion as a magnified B DLY'D sweep.

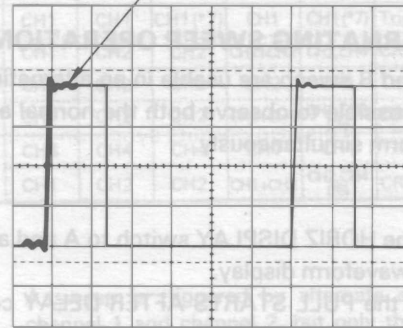
Delay Time (magnified portion) = DELAY TIME MULT setting \times A SWEEP TIME/DIV setting.

5. For STARTS AFTER DELAY operation, apparent jitter increases as magnification increases. To obtain a jitter free display, push in the SLOPE, PULL STARTS AFTER DELAY control. In this mode the signal selected by the B SOURCE switch (37) becomes the B trigger source, making use of the B trigger LEVEL (39) control to set the trigger point. B SOURCE, COUPLING and LEVEL

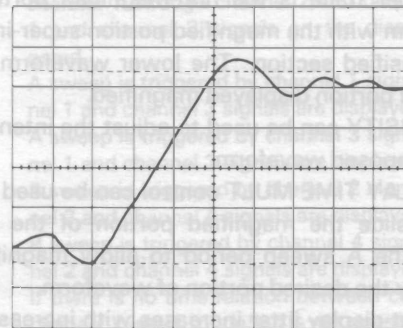
SLOPE are set in a manner similar to that of the corresponding controls for A sweep.

A-INT-B

Intensified zone to be magnified.



B DLY'D



OPERATION

Note that for type of operation both the DELAY TIME MULT and trigger LEVEL affect the start of the B sweep so that the delay time is used as a reference point.

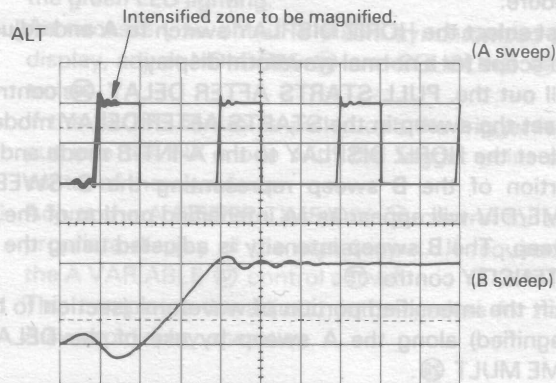
[4] ALTERNATING SWEEP OPERATION

A sweep and B sweep are usable in an alternating fashion making it possible to observe both the normal and magnified waveform simultaneously.

Procedure:

1. Select the HORIZ DISPLAY switch to A and adjust for a normal waveform display.
2. Pull out the PULL STARTS AFTER DELAY control and select the HORIZ DISPLAY to ALT. Adjust \blacktriangledown TRACE SEP $\text{\textcircled{30}}$ for easy observation of both the A and B traces. The upper trace is the non-magnified portion of the waveform with the magnified portion super-imposed as an intensified section. The lower waveform is the intensified portion displayed magnified. B INTENSITY can be used to adjust the intensity of the super-imposed waveform.
3. The DELAY TIME MULT control can be used to continuously slide the magnified portion of the waveform across the A sweep period to allow magnification of precisely the desired portion of waveform.
4. Apparent display jitter increases with increased magnification as is the case with delayed sweep discussed above. By cancelling the magnified operating mode by

pushing in the PULL STARTS AFTER DELAY control, B trigger LEVEL control can be used to set the trigger point.



[5] DUAL SWEEP OPERATION

Up until now we have discussed using the B sweep to display only a Delayed sweep of the A sweep signal. In the DUAL mode A and B sweeps are performed independently so that two non time-related signals can be observed at one time.

Procedure:

The A sweep and B sweep are controlled by A trigger and B trigger controls respectively.

While triggering of A and B sweeps independently using the input signals themselves is quite simple and presents no particular problems, use of a common trigger source or use of A to trigger B and vice versa can result in some impossible triggering conditions for signals that are not related to each other in a timing sense.

For DUAL operation the A and B sweeps alternate regardless of the setting of the ALT and CHOP switches.

This A sweep/B sweep/Trigger source/Vertical MODE relationships are outlined in the following tables.

A SOURCE (A sweep)

		MODE					
		CH1	CH2	DUAL	ADD	QUAD	
S O U R C E	V. MODE	CH1	CH2	CH1, CH2 ALT (*1)	CH1+CH2	CH1, CH4 ALT (*2)	Trigger Source
		CH1	CH2	CH1	CH1+CH2	CH1, CH3	CRT Display
	CH1	CH1	CH1	CH1	CH1	CH1	Trigger Source
		CH1	CH2	CH1	CH1+CH2	CH1, CH3 ALT (*3)	CRT Display
	CH2	CH2	CH2	CH2(*7)	CH2	CH2(*7)	Trigger Source
		CH1	CH2	CH1	CH1+CH2	CH1, CH3 ALT	CRT Display
	EXT	CH3	CH3	CH3	CH3	CH3	Trigger Source
	CH3	CH1	CH2	CH1	CH1+CH2	CH1, CH2 ALT (*4)	CRT Display

B SOURCE (B sweep)

		MODE					
		CH1	CH2	DUAL	ADD	QUAD	
S O U R C E	CH1	CH1	CH1	CH1(*7)	CH1	CH1(*7)	Trigger Source
		CH1	CH2	CH2	CH1+CH2	CH2, CH4	CRT Display
	CH2	CH2	CH2	CH2	CH2	CH2	Trigger Source
		CH1	CH2	CH2	CH2+CH4	CH1, CH3 (*5)	CRT Display
	EXT	CH4	CH4	CH4	CH4	CH4	Trigger Source
		CH4	CH1	CH2	CH2	CH1+CH2	CH2, CH4 (*6)

- *Note 1: A sweep is triggered by alternate signals from channel 1 and channel 2, but only the channel 1 signal on the display is triggered.
- *Note 2: A sweep is triggered by alternate signals from channel 1 through channel 2, but only the channel 1 and channel 3 signals on the display are triggered.
- *Note 3: A sweep is triggered by channel 1 signal and channel 1 and channel 3 signals are displayed.
- *Note 4: A sweep is triggered by channel 3 signal and channel 1 and channel 3 signals are displayed.
- *Note 5: B sweep is triggered by channel 2 signal and channel 2 and channel 4 signals are displayed.
- *Note 6: B sweep is triggered by channel 4 signal but channel 2 and channel 4 signals are displayed.
- *Note 7: If there is no time relation between channel 1 and channel 2 input, triggering is not possible.

Please bear in mind these relationship when using DUAL mode operation.

OPERATION

NOTE:

For DUAL operation be sure to select the TRIG MODE switch to AUTO to allow sweep of both A and B to be performed.

When A and B sweeps are to be used alternately, set up the scope to provide both sweeps.

[6] X-Y OPERATION

Phase difference measurements may be made by use of the X-Y display mode.

Procedure:

Select the HORIZ DISPLAY switch to the X-Y mode. In this mode the channel 1 input becomes the Y-axis input and the channel 2 input the X-axis input for X-Y display.

For X-Y operation the X and Y positions are adjusted using the channel 2 \blacklozenge POSITION, X-Y \blacktriangleleft and channel 1 \blacklozenge POSITION controls respectively.

X and Y sensitivity are set by using the channel 2 and channel 1 VARIABLE, VOLTS/DIV controls respectively.

By pulling out the two above mentioned VARIABLE controls, the sensitivities of both the X and Y axis are magnified by 5 times. A INTENSITY control is used to adjust the intensity of the display during X-Y operation.

[7] SINGLE SWEEP OPERATION

This mode of display is useful for looking at non-synchronous or one time events.

Procedure:

1. Select the TRIG MODE to either AUTO or NORM, and the SLOPE PULL FIX control to pushed-in position. Apply a signal of approximately the same amplitude and frequency as the signal that is to be observed as the trigger signal and set the trigger LEVEL.
2. Select TRIG MODE to SINGLE and press the RESET button – observe that the red LED lights to indicate the reset condition. This LED goes out when the A sweep period is completed.
3. After the above set-up is completed the scope is ready to operate in the SINGLE sweep mode of operation after resetting the scope using the RESET button. Input of the trigger signal results in one and only one sweep.

NOTE:

With the HORIZ DISPLAY select to ALT or DUAL, the simultaneous observation of the A sweep and B sweep waveforms at SINGLE sweep mode is not possible. Also for DUAL or QUAD operation simultaneous observation is not possible using ALT mode. Set the scope to the CHOP mode in this case.

[8] DUAL AND QUAD TRACE OPERATION

By setting the vertical MODE to DUAL or QUAD, Dual and Quad trace operations can be achieved. Additionally selecting the HORIZ DISPLAY to ALT produces up to an 8 trace.

Operation of the various controls is for this type of display mode similar to the operation described above for Alternating sweep operation.

[9] CASCADED OPERATION

This mode of operation is used when sensitivity greater than 1 mV/div is required.

Procedure:

1. Connect the CH 1 OUT jack to the channel 2 input jack using a BNC cable through the 50 Ω termination.
2. For cascade operation do not pull the channel 1 and channel 2 X5 GAIN switches toward you.
3. Select vertical MODE to CH 2.
4. Set the channel 1 and channel 2 VOLTS/DIV to 5mV and input a signal for a sensitivity of 500 μ V/div on channel 1.

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