CS-2100A

100MHz 4-CHANNEL OSCILLOSCOPE

INSTRUCTION MANUAL

TRIO-KENWOOD CORPORATION

DELAYED SWEEP OSCILLOSCOPE

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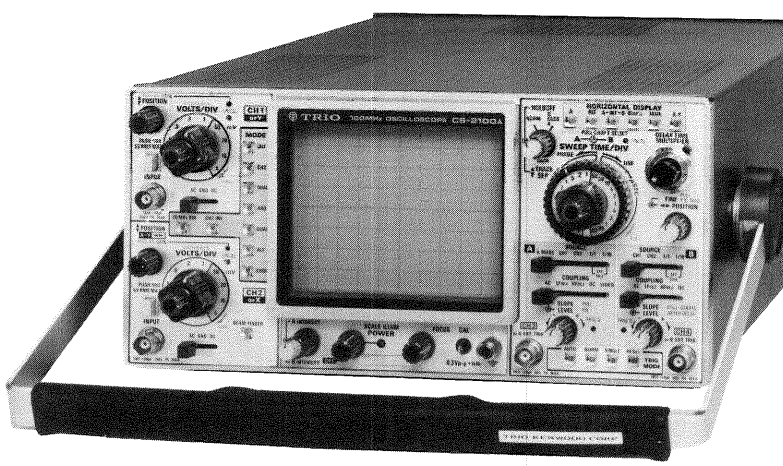


TRIO

CONTENTS

FEATURES

- Small and compact with high 5 mV/div sensitivity and 100 MHz bandwidth (1 mV/div when X5 GAIN function is used and 500 μV/div for cascaded operation, CH1 to CH2).
- Bright 150 mm rectangular CRT with an internal graticule and a 16 kV accelerating potential.
- Vertical axis is capable of single, dual as well as 4-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.
- 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.
- Logic controlled switching with LED lighted pushbutton switches provides easy, reliable switching with setting hold capability when the instrument is switched off.

SPECIFICATIONS

CRT

Model:	150ATM31A
Display area:	8 × 10 div (1 div = 1 cm)
Type:	Rectangular, with internal graticule
Accelerating potential:	16kV

VERTICAL AXIS (Channel 1 and Channel 2 identical specifications)

Sensitivity:	5 mV/div to 5V/div (X1 mode) 1 mV/div to 1V/div (X5 mode) 500 μV/div (Cascaded operation, CH1 to CH2)
Accuracy:	±3% (10 ~ 35°C) ±5% (0 ~ 50°C) ±8% (Cascaded operation, CH1 to CH2)
Attenuator:	5 mV/div to 5V/div in 1-2-5 sequence, all 10 ranges with fine adjustment.
Input resistance:	1 MΩ ±2% (1 MΩ mode) 50Ω ±2% (50Ω mode)
Input capacitance:	Approx. 28pF
Frequency response:	(Include × 5 GAIN mode)
DC:	DC to 100 MHz (−3 dB) DC to 120 MHz (−6 dB) DC to 70 MHz (−3 dB), (Cascaded operation, CH1 to CH2)
AC:	5 Hz to 100 MHz (−3 dB) 5 Hz to 120 MHz (−6 dB) 7 Hz to 70 MHz (−3 dB), (Cascaded operation, CH1, to CH2)
Risetime:	3.5ns
Signal delay time:	Approx 30ns 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, four trace
ALT	Two or four waveforms, alternating
CHOP	Two or four waveforms, chopped
CHOP frequency:	Approx 250 kHz, switchable
Polarity reversal:	CH2 only
Maximum input voltage:	500 Vp-p or 250V (DC + AC peak) in 1 MΩ mode. 5 Vrms or DC ±5V in 50Ω mode.
Maximum undistorted amplitude:	8 division, minimum (DC to 100 MHz)
Bandwidth limiting:	Vertical system bandwidth with the 20 MHz BW pushbutton switch pushed is approximately 20 MHz

VERTICAL AXIS (Channel 3 and Channel 4 common specifications)

Sensitivity:	0.1V/div, 1V/div ±3%
Attenuator:	1/1, 1/10
Input resistance:	1 MΩ ±2%
Input capacitance:	Approx. 28 pF
Input coupling mode:	DC only
Frequency response:	DC to 100 MHz (−3 dB) DC to 120 MHz (−6 dB)
Risetime:	3.5ns
Signal delay time:	Same as CH1 and CH2
Maximum allowable voltage	
DC component:	±0.5V or less (AC + DC) (±5V, 1/10 attenuated)
AC component:	1 Vp-p (10 Vp-p, 1/10 attenuated) or less
Maximum input voltage:	50V (DC + AC peak)

HORIZONTAL AXIS (CH2 input)

Modes:	X-Y mode is switch selectable (HORIZONTAL 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 6 MHz (−6 dB)
AC:	5 Hz to 5 MHz (−3 dB) 5 Hz to 6 MHz (−6 dB)
X-Y phase difference:	Less than 3° at 100 kHz

SWEEP

Modes (switchable with the HORIZONTAL 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	Duration of the B Sweep is displayed as an intensified portion of the A Sweep.
B DLY'D	Delayed B sweep
DUAL	Dual sweep — A and B sweeps, in dependently
X-Y	X-Y display mode

SPECIFICATIONS

A Sweep time: 20ns/div to 0.5s/div in 23 ranges, in 1-2-5 sequence, verninier 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: ±3% (10 ~ 35°C)
±6% (0 ~ 50°C)

Sweep magnification: X10 ±5% (10 ~ 35°C)
±7% (0 ~ 50°C)

Linearity: 20ns/div to 0.5s/div ±3%
(±5% with X10 magnification)

HOLDOFF: Continuously adjustable for A Sweep hold off time from NORM to X5.

Trace separation: B positionable up to 4 divisions separated from A Sweep, continuously adjustable.

Delay method: Continuous delay, SYNC delay

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

Time difference measurement accuracy:
±2% (10 ~ 35 °C)
±4% (0 ~ 50°C)

Delay jitter: 1/20000 of the full scale sweep time.

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

Coupling modes: AC, LF_{REJ}, HF_{REJ}, DC, VIDEO
VIDEO-LINE sync automatically selected at sweep times of 50 μs/div to 20ns/div.
VIDEO-FRAME sync automatically selected at sweep times of 0.5s/div to 0.1ms/div.

Trigger level: ±90° 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, LF_{REJ}, HF_{REJ}, DC

Trigger level: ±90° adjustable

Polarity: +/−

Trigger sensitivity (A and B)

COUPLING	FREQ RANGE	MINIMUM SYNC AMPLITUDE		
		INT	EXT	EXT1 10
DC	DC ~ 20 MHz DC ~ 50 MHz DC ~ 100 MHz	0 5div 1 0div 1 5div	50 mV 100 mV 150 mV	0 5V 1 0V 1 5V
AC	Same as for DC but with increased minimum level for below 20 Hz			
AC HF_{REJ}	Increased minimum level below 20 Hz and above 30 kHz			
AC LF_{REJ}	Increased minimum level below 30 kHz			
VIDEO	FRAME LINE	0 5div	50 mV	0 5V

AUTO: Same as above specifications for above 30 Hz.

FIX: 40 Hz~20 MHz 1.0 div (100 mV)
40 Hz∿80 MHz 1.5 div (150 mV)

Jitter: 0.5ns maximum at 100 MHz at 2ns/div sweep rate (X10 MAG on)

CALIBRATING VOLTAGE AND CURRENT

1 kHz ±3% Positive square wave
0.3V ±1% (10 ~ 35 C)
±2% (0 ~ 50 C)
10 mA ±2% (10 ~ 35 C)
±4% (0 ~ 50 C)

INTENSITY MODULATION

Input signal: TTL level, intensity increasing with more positive levels

Input impedance: Approx. 10 kΩ

Usable frequency range: DC to 10 MHz

Maximum input voltage: 50V (DC + AC peak)

VERTICAL AXIS OUTPUT

Sampled CH1 output

Output voltage: 50 mVp-p/div (into 50Ω load)

Output impedance: Approx. 50Ω

Frequency response: DC to 100 MHz (−3 dB) (into 50Ω load)

GATE OUTPUT (A and B)

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

TRACE ROTATION

Electrical, adjustable

POWER SUPPLY

Line voltage: LOW: 90 ~ 132V
HIGH: 180 ~ 264V

Line frequency: 50/60 Hz

Power consumption: Approx. 56W

DIMENSIONS

Width: 284 mm (328 mm)

Height: 138 mm (150 mm)

Depth: 400 mm (471 mm)

( ) dimensions include protrusions from basic case outline dimensions.

SPECIFICATIONS

WEIGHT 7.4 kg

ACCESSORIES

PC-29 Probes	2
Instruction Manual	1
Hand Book	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 range:	0 ~ 50°C, 90% maximum RH
Storage temperature and humidity range:	−20° ~ 55°C 80% maximum
Altitude:	
Operating:	5000 m
Non-operating:	12000 m

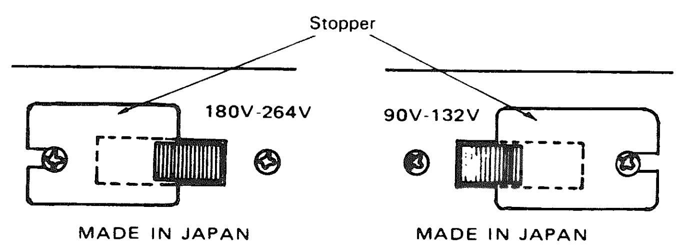
PRECAUTIONS FOR USE

CAUTION:
Before applying power to the CS-2100A be sure that the Line Voltage Switch is set to the proper voltage. If this is not done damage to the CS-2100A could result.
After verifying the setting, connect the AC Power Cord to the line power source.

1) Do not apply input voltage exceeding their maximum rating and never apply external voltage to the input terminals.

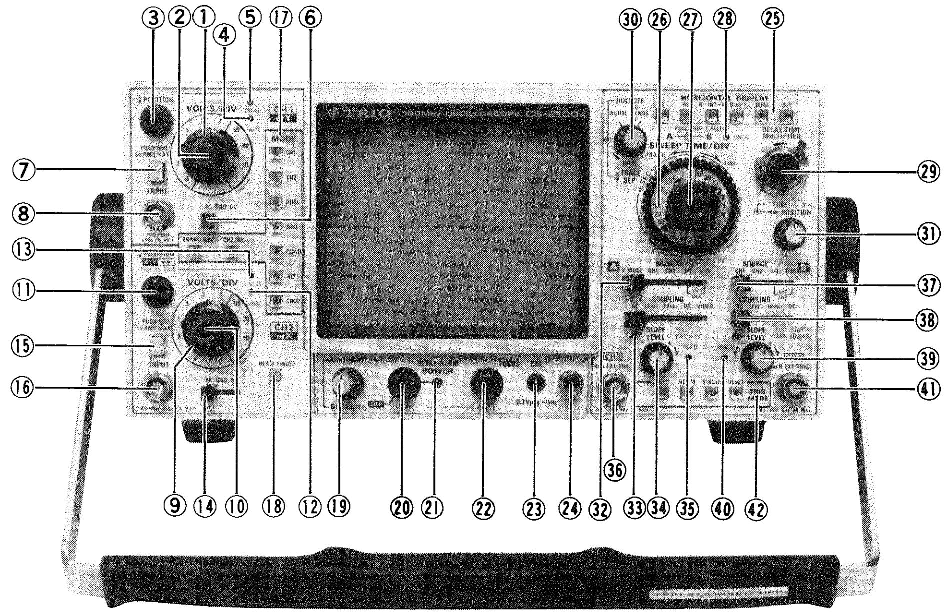
CH1 and CH2:	
1 MΩ:	500Vp-p or 250V (DC + AC peak)
50Ω:	5Vrms or DC ±5V
CH3 and CH4:	50V (DC + AC peak)
Z-axis Input:	50V (DC + AC peak)

2) The following conditions should be avoided:
   (a) Direct sunlight
   (b) High temperatures and humidity
   (c) Mechanical vibration
   (d) Proximity to electrical noise or transient generating machinery.
3) Do not use more than the required beam intensity.
4) Do not leave the beam stationary for long periods.
5) The CS-2100A makes use of internal battery which, if depleted, can cause the panel LED's not to light upon turning the unit ON. If this occurs, refer to the instruction manual for instructions on replacing the battery.
6) To prevent electrical shocks, be sure to connect the GND terminal to an appropriate earth point.
7) Cooling precautions.
   The CS-2100A is provided with a convenient carrying handle which doubles as a stand to adjust the viewing angle. While any arbitrary angle may be set, be sure that no objects are allowed to rest on the top of the unit or that the cooling vents are not blocked, since this will cause an undue temperature rise in the CS-2100A.
8) Since the CS-2100A makes use of high voltage circuitry, if removing the case, refer to the "MAINTENANCE" for removing the case.
9) AC voltage selector switch setting.



1 Remove screw and stopper plate.
2 Switch lever to opposite side.
3 Lock lever by attaching stopper plate to opposite side screw.

CONTROLS AND INDICATORS



FRONT PANEL

VERTICAL AXIS CONTROL

(1) VOLTS/DIV

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

Fine adjustment control CH1 vertical attenuation. This control provides continuous adjustment between the VOLTS/DIV ranges. When set to its extreme clockwise (CAL) position, the attenuator is calibrated. For X-Y operation, this control serves as the Y-axis attenuation fine adjustment. As this fine adjuster uses a variable resistor with a center tap, the amplitude sometimes does not change during rotation.

(3) ⬍ POSITION/PULL X5 GAIN

This is a potentiometer control with an added switch function. It serves as the CH1 vertical position control for normal operation and X-Y operation as well. When pulled out, the VOLTS/DIV setting is multiplied by 5 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.

(4) UNCAL

This LED lights to indicate that CH1 is not calibrated, i.e., that the VARIABLE control is not in the CAL position.

(5) PULL X5 GAIN

This LED lights to indicate that the CH1 ⬍ POSITION control is in the pulled out position, i.e. that the CH1 sensitivity is five times the VOLTS/DIV setting.

(6) AC-GND-DC

This switch is the CH1 vertical axis coupling mode selector, for X-Y operation, the Y-axis coupling mode control.

- AC: AC input coupling, with blocking of any DC signal component.
- GND: Vertical amplifier is disconnected from the input signal and connected to ground. This mode is useful in determining the actual ground potential.
- DC: DC coupling, with both the DC and AC components of the input signal displayed on the CRT.

(7) PUSH 50Ω

This control selects the CH1 input resistance between 50Ω and 1 MΩ. In the depressed position the input resistance is 50Ω.

CAUTIION:

In the 50Ω input mode, the maximum input voltage is 5Vrms or DC ±5V. Care should be taken not to exceed this level as damage to the CS-2100A could result.

CONTROLS AND INDICATORS

(8) INPUT

CH1 vertical input connector; serves also as the Y-axis input connector for X-Y operation.

(9) VOLTS/DIV

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 5 mV/div. For X-Y operation the control provides step adjustment of horizontal sensitivity.

(10) VARIABLE

CH2 vertical attenuation fine adjustment. Operation is similar to that of the CH1 VARIABLE control. For X-Y operation the control serves as the X-axis attenuation fine adjustment.

(11) ▲▼ POSITION X-Y ◀▶/PULL X5 GAIN

Dual control which functions similarly to the corresponding CH1 control. In addition, it serves as the horizontal position control and X-axis sensitivity magnifier for X-Y operation.

(12) UNCAL

UNCAL display for CH2 vertical axis or for the X-axis for X-Y operation when CH2 VARIABLE control is not in CAL position.

(13) PULL X5 GAIN

This display LED indicates that X5 magnification is in effect for the CH2 vertical axis for normal operation or that it is in effect for the X-axis for X-Y operation.

(14) AC-GND-DC

This switch sets the CH2 vertical axis input coupling mode or the X-axis coupling mode for X-Y operation. Its operation is similar to that of the corresponding control for CH1.

(15) PUSH 50Ω

This switch selects the CH2 input resistance between 50Ω and 1 MΩ. It serves to similarly switch the X-axis input resistance for X-Y operation. Operation is the same as for the corresponding CH1 control.

> **CAUTION:**
> The same 5Vrms or DC ±5V limitation applies to the CH2 input when using the 50Ω input resistance mode as discussed above for CH1.

(16) INPUT

CH2 vertical input connector; serves also as the X-axis input connector for X-Y operation.

(17) MODE

Vertical axis mode selection switches.

- CH1 — Display of CH1 input signal only.
- CH2 — Display of CH2 input signal only.
- DUAL — Display of both CH1 and CH2. For this mode either CHOP or ALT mode will be in effect, selected by the similarly named switches.
- ADD — Display of the algebraic sum of CH1 + CH2 or, if CH2 has been inverted, the difference of CH1 − CH2.
- QUAD — Display of CH1 through CH4 input signals. For this mode as well as for DUAL, either the ALT or CHOP mode is applicable and selected by the appropriately named switch.
- ALT — When DUAL or QUAD mode has been selected, 2 or 4 signal inputs are displayed in an alternating fashion.
- CHOP — Similar to ALT but input signals are displayed in a chopped fashion.
- CH2 INV — This switch inverts the polarity of the CH2 input signal.
- 20 MHzBW — This switch when the LED is indicated, limits the vertical bandwidth to approximately 20 MHz.

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

(18) BEAM FINDER

This push switch is used to shrink the CRT display to allow easy location of the beam.

POWER SUPPLY/CRT DISPLAY CONTROLS

(19) A INTENSITY/B INTENSITY

This dual control allows adjustment of the beam intensity for the A Sweep and B Sweep respectively.

A INTENSITY (center control)
Adjusts the beam intensity for the A Sweep and the display intensity for X-Y operation.

B INTENSITY (outer control)
Adjusts the intensity of the B Sweep beam.

(20) POWER/SCALE ILLUM

This control serves as the power supply switch as well as the adjustment for the scale illumination.

(21) LED PILOT LAMP

This lamp indicates that the power supply has been turned ON.

CONTROLS AND INDICATORS

(22) FOCUS

This focus control can be used to adjust the beam for optimum focus.

Auto-Focus circuit automatically focusing, once this control is adjusted it needs not be frequently readjusted.

(23) CAL

This is the calibration voltage output. 0.3 Vp-p at 1 kHz is available in the form of a square wave signal.

(24) GND

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

HORIZONTAL AXIS CONTROLS

(25) HORIZONTAL DISPLAY

This control is 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 waveform 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	CH1 becomes the Y-axis and CH2 the X-axis for X-Y operation. The settings of the vertical MODE and TRIG MODE are ineffective.

(26) A SWEEP TIME/DIV, B SWEEP TIME/DIV

A SWEEP TIME/DIV	This outer control is used to set the A Sweep time in 23 ranges in 1-2-5 sequence from 20ns/div to 0.5s/div.
B SWEEP TIME/DIV	This center control sets the B Sweep time in 20 ranges in 1-2-5 sequence from 20ns/div to 50ms/div. This control is constructed to make it impossible to set the B Sweep time slower than the A Sweep time. No fine adjustment is available for the B Sweep time.

(27) A VAR/PULL CHOP F. SELECT

This control is the innermost control on the SWEEP TIME/DIV control. It is the fine adjustment for the A Sweep time. When it is turned fully clockwise to the CAL position, the A Sweep time is calibrated to the setting of the SWEEP TIME/DIV control.

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 synchronized to the chopping frequency.

(28) UNCAL

This LED lights to indicate that the A VAR control is not set to the CAL position and thus that the A Sweep time is not calibrated.

(29) DELAY TIME MULTIPLIER

This control adjusts the start time of the B Sweep to some delay time after the start of the 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

⬍ TRACE SEP

This outer control allows the adjustment of the B Sweep up to 4 divisions below the A Sweep. turning this control to counterclockwise. This knob is effective when the Horizontal Display is set to ALT. Even when the Horizontal Display is set to DUAL, this knob is effective with the V mode set to CH1, CH2 or ADD.

HOLDOFF

A dual control incorporating a switching function.

As a holdoff adjustment, it allows the adjustment of the time between successive sweeps. Turning the control counterclockwise from the NORM position lengthens the holdoff time until just before the B ENDS A when the holdoff time is more than 10 times the NORM value.

In the B ENDS A position (fully counterclockwise), the A Sweep is reset at the end of the B Sweep.

B ENDS A mode is applicable to the ALT, A-INT-B and B DLY'D modes of HORIZONTAL DISPLAY.

(31) ◂▸ POSITION/FINE PULL X10 MAG

A combination adjustment/switch control.

This control is not used for X-Y operation.

◂▸ POSITION

Horizontal position coarse adjustment.

FINE PULL X10 MAG

Horizontal position fine adjustment. When this control is pulled out, the sweep time is made 10 times shorter.

CONTROLS AND INDICATORS

TRIGGER SOURCE CONTROLS

(32) SOURCE

This control selects the source for the A Sweep Trigger.

V MODE — The trigger source for the A Sweep is determined by the Vertical MODE setting.

CH1	CH1 signal is used as a trigger source
CH2	CH2 signal is used as a trigger source
ADD	The algebraic sum of CH1 and CH2 signals isured a signal source. (if CH2 has been inverted, the difference becomes the source.)
DUAL QUAD (ALT) (CHOP)	For ALT mode the signals for CH1 through CH4 alternate as the trigger source. For the CHOP mode the chopping signal becomes the trigger source.

CAUTION:

1. When the vertical MODE is selected in CHOP, the display cannot be synchronized with the input signal since the chopping signal becomes the trigger source.
2. Triggering is impossible when input signals are not applied to all channels with the vertical axis mode set to DUAL or QUAD.

- CH1 — CH1 signal is the trigger source for the A Sweep.
- CH2 — CH2 signal is the trigger source for the A Sweep.
- 1/1 — CH3 signal is the trigger source for the A Sweep.
- 1/10 — The CH3 signal, attenuated to 1/10 of its true value is the trigger source for the A Sweep.

(33) COUPLING

This control is used to select the SYNC coupling for the A trigger.

- AC — SYNC signal is AC coupled with any DC component blocked.
- LF REJ — SYNC signal is coupled through a high-pass filter to eliminate low frequency components for stable triggering of high frequency signals.
- HF REJ — SYNC signal is coupled through a low-pass filter to eliminate high frequency components for a stable triggering of low frequency signals.
- DC — The SYNC signal is DC coupled for SYNC which includes the effects of DC components.

  For CH3 and CH4, 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 synced. Settings between 0.5s and 0.1ms result in FRAME while those between 50 μs and 20 ns result in LINE sync.

(34) LEVEL/SLOPE PULL FIX

LEVEL

This outer control adjusts the level at which the A trigger causes the A Sweep be started.

SLOPE PULL FIX

This inner control adjusts the slope of the A trigger signal. When the control is pulled out the FIX mode is selected for auto level adjustment, under which circumstances outer TRIG LEVEL control no longer has any effect.

(35) TRIG'D

This green LED lights when the A trigger source signal causes the initiation of a A Sweep. It lights for X-Y operation as well.

(36) CH3 or A EXT TRIG

Input connector for the CH3 signal. It serves also as the external A TRIG input connector. CH3 signal may be observed simultaneously with CH1, 2 and 4 signals when the QUAD mode is selected.

When the SOURCE control is set to either EXT (CH3) 1/1 or 1/10, the trigger source is this input signal.

(37) SOURCE

This control selects the B Sweep trigger source.

- CH1 — CH1 signal is the trigger source for the B Sweep.
- CH2 — CH2 signal is the trigger source for the B Sweep.
- 1/1 — CH4 signal is the trigger source for the B Sweep.
- 1/10 — The CH4 signal, attenuated to 1/10 of its true value is the trigger source for the B Sweep.

(38) COUPLING

This control selects the SYNC coupling for the B trigger group. Operation is similar to that of the corresponding A Sweep trigger coupling select control except that VIDEO is not available.

(39) LEVEL/SLOPE PULL STARTS AFTER DELAY

LEVEL

This outer control adjusts the level at which the B trigger signal causes the start of the B Sweep.

SLOPE PULL STARTS AFTER DELAY

This control selects the slope of the B trigger signal. For B trigger operation it must be set in its pushed in position. When it is pulled out, the B Sweep starts immediately after the delay time selected by the DELAY TIME MULTIPLIER and A SWEEP TIME/DIV control, regardless of the TRIG LEVEL setting. Even when this switch is in position with the TRIG MODE set to AUTO, turning the LEVEL (outer knob) fully clockwise or counterclockwise release the trigger and set the unit to B START AFTER DELAY operation.

CONTROLS AND INDICATORS

(40) TRIG'D

This green LED lights when the B trigger source signal causes the B triggered sweep to be initiated.

(41) CH4 or B EXT TRIG

Input connector for the CH4 signal; serves also as the B TRIG external input connector. CH4 signal may be observed simultaneously with CH1, 2 and 3 signals when the QUAD mode is selected. When the SOURCE select control is set to either EXT (CH4) 1/1, or 1/10, the trigger source is this input signal.

(42) TRIG MODE

This control selects the Trigger Mode. A corresponding LED lights to indicate which mode has been selected.

AUTO — Sweep is initiated in triggered operation but the trace is sweept even in the absence of a trigger signal. When the HORIZONTAL DISPLAY is set to DUAL, the B sweep is set to AUTO.

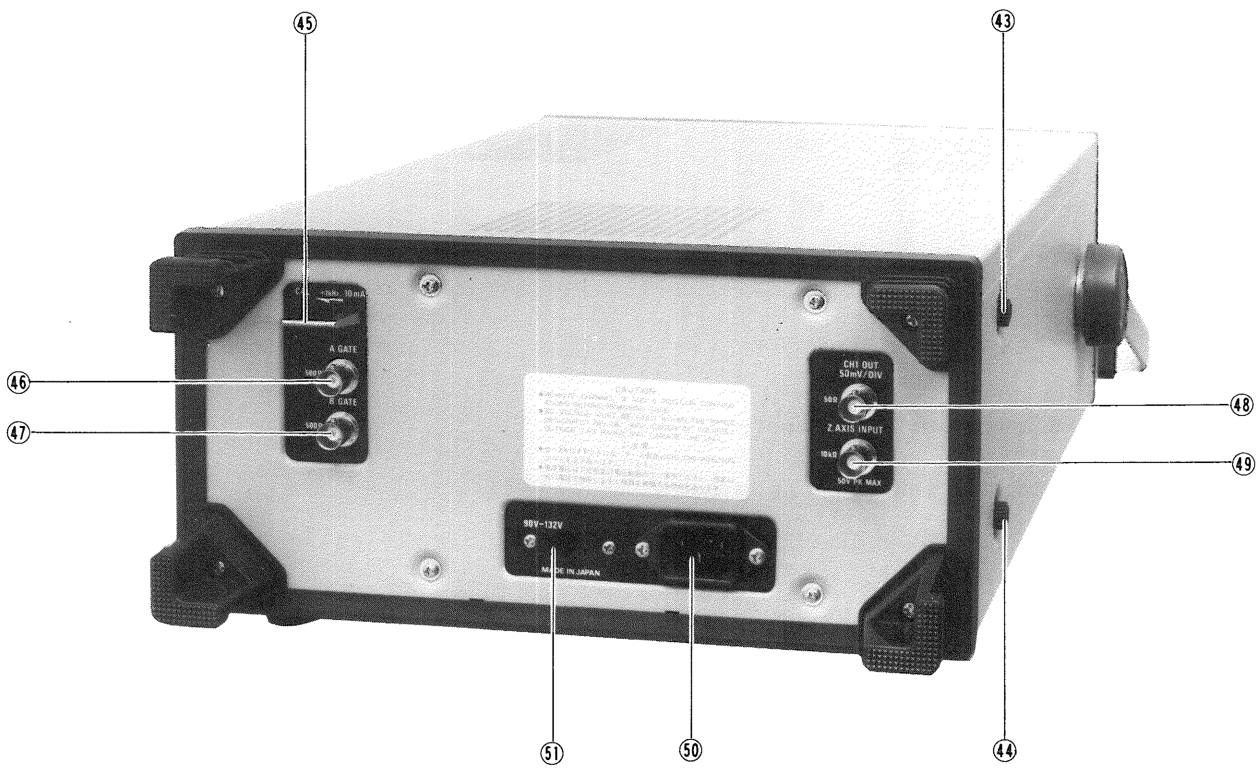
NORM — Triggered operation but no trace is presented when a proper trigger signal is not applied.

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

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

RESET — This is the reset button for single sweep operation. Its LED remains lighted until the main A Sweep ends.

SIDE PANEL AND REAR PANEL CONTROLS



(43) CH3 POSITION

This adjustment controls the vertical position of the CH3 signal on the CRT display.

(44) CH4 POSITION

Similar to the CH3 POSITION control but for CH4.

(45) CAL

Current Probe calibration loop. A 10 mA 1 kHz (approx.) square wave is provided.

(46) A GATE

The output connector for the A Sweep gate, a square wave gate signal.

(47) B GATE

Same as A GATE but for the B Sweep gate.

(48) CH1 OUT

The CH1 vertical output signal connector.
For cascaded operation this output is connected to the CH2 input.

CONTROLS AND INDICATORS

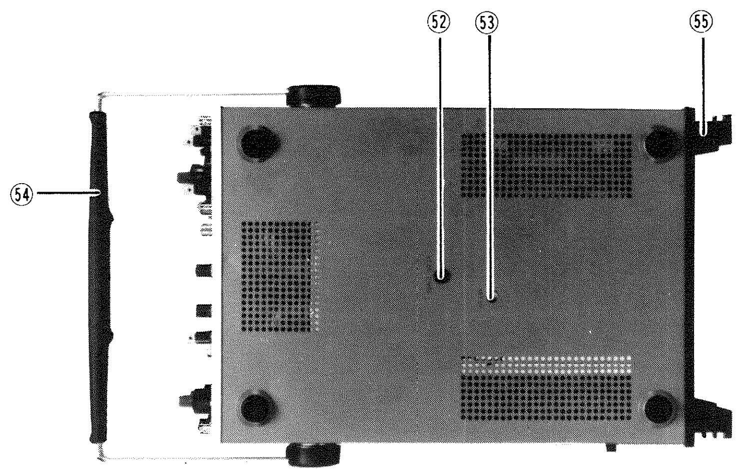
(49) Z. AXIS INPUT
External intensity modulation input connector. TTL level input; intensity increases for increasing positive inputs.

(50) POWER LINE CONNECTOR
The input connector for the AC power cord.

(51) LINE VOLTAGE SWITCH
This switch is used to select the power supply input voltage.

LOW	90 ~ 132VAC
HIGH	180 ~ 264VAC

BOTTOM PANEL



(52) TRACE ROTATION
This control is used to compensate for trace rotation distortion.
Once this control is adjusted it needs not be frequently readjusted.

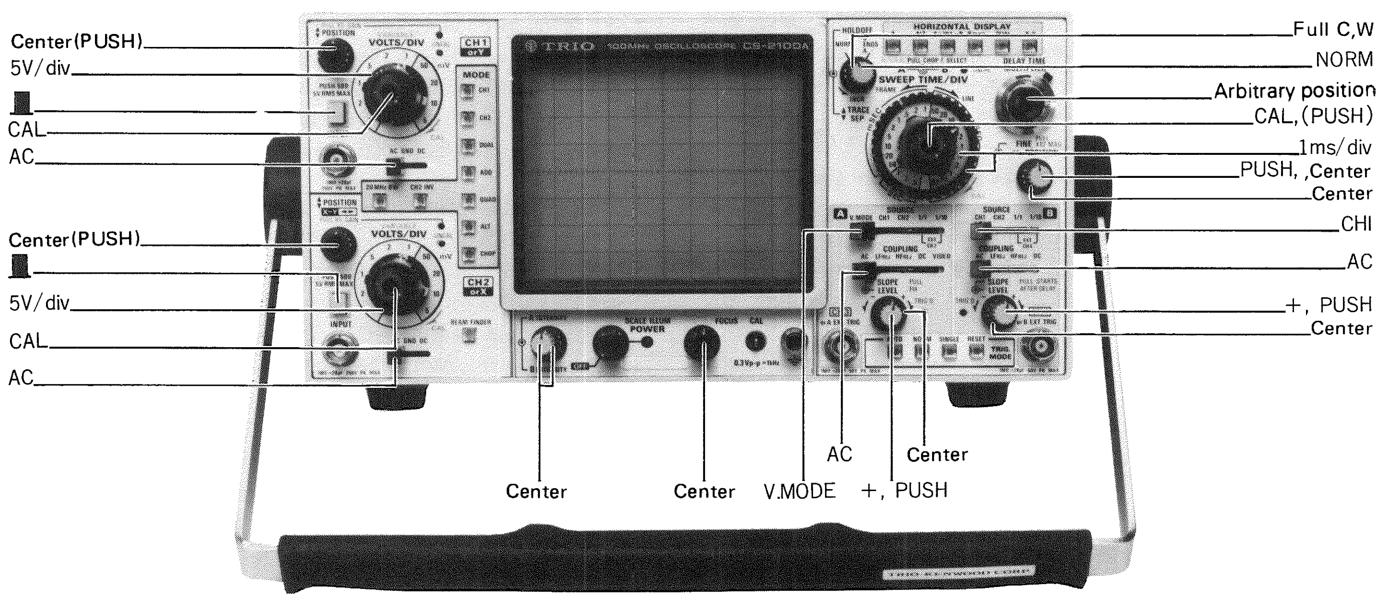
(53) ASTIG
This control is used to compensate for trace or spot astigmatism.
Once this control is adjusted it needs not be frequently readjusted.

(54) Handle
The handle of the CS-2100A can be set to desired angle so that the CS-2100A is inclined for easy operation. The handle turns in 15 degree steps.
The supplied probe holder can be installed in the metal portion of the holder.

(55) Feet
Feet support oscilloscope in vertical position (face up) and serve as cord wrap for storing power cord.

OPERATION

Before turning the CS-2100A 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 (20) clockwise — the power supply will be turned on and the pilot lamp will light with the other LED's for the previously set MODE (17), HORIZONTAL DISPLAY (25) and TRIG MODE (42) also lighting.

   Set these modes as follows:

MODE (17)	: CH1
HORIZONTAL MODE (25)	: A
TRIG MODE (42)	: AUTO

2. The trace will appear in the center of the CRT display and can be adjusted by the CH1 ⬍ POSITION (3) and ◂▸ POSITION (31) controls. Next, adjust the A INTENSITY (19) and, if necessary, the FOCUS (22) for ease of observation.
3. Apply an input signal to CH1 INPUT (8) 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 FINDER (18) to locate the waveform adjust the VOLTS/DIV and ⬍ POSITION to bring the waveform confortably into the center of the CRT display.
   Operation with a signal applied to the CH2 INPUT (16) and the MODE set to CH2 is similar to the above procedure. In the ADD mode the algebraic sum of CH1 + CH2 is displayed. If the CH2 INV switch has been pressed, the algebraic difference of the two waveforms, CH1 — CH2 is displayed. If both channels are set to the same VOLTS/DIV, the difference waveform can be read directly in VOLTS/DIV off of the CRT. DUAL mode allows simultaneous observation of CH1 and CH2 while QUAD provides viewing of CH1 through CH4 simultaneously.
   In the DUAL or QUAD mode one of either CHOP or ALT modes applies and should be selected. In the ALT mode, CH1 and CH2 or CH1 through CH4 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 CH1, CH2 or CH3.

4) To adjust the trigger point to capture elusive waveforms, use the A trigger Control Group.

TRIGGERING Operation

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 input connector.

A Trigger

1) The SOURCE control selects the signal to be used. With the V. MODE the source is determined by the setting of the Vertical MODE.
As mentionned above, if CHOP has been selected, the trigger source is the chopping signal itself, making waveform observation impossible. Use ALT instead in this case. If SOURCE is set to CH1 or CH2, regardless of the setting of MODE, CH1 or CH2 signal provides the trigger source.
If SOURCE is set to EXT (CH3) 1/1, or 1/10, except for QUAD operation, the signal applied to the CH3 or A EXT TRIG input (36) is the trigger source. For QUAD operation this input is taken as the CH3 signal and can be observed as the trigger waveform.

2) After setting SOURCE, adjust the LEVEL/SLOPE (34) control to set the trigger point. Sync is indicated by the green LED lighting.
As necessary to obtain a stable synchronized signal display, adjust HOLDOFF (30) and COUPLING (33).
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.

5. Adjust the A SWEEP TIME/DIV (26) control for an appropriate display of the signal input. If required, use the A VAR (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 ◀▶ POSITION control, adjust the desired portion of waveform to the center of the CRT. Pull out the FINE PULL X10 MAG (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

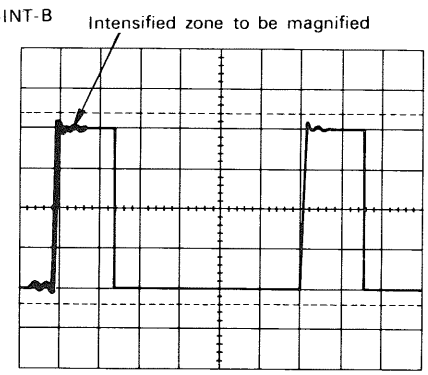
Delayed sweep operation is achieved by use of both the A Sweep and the B Sweep.

Procedure:

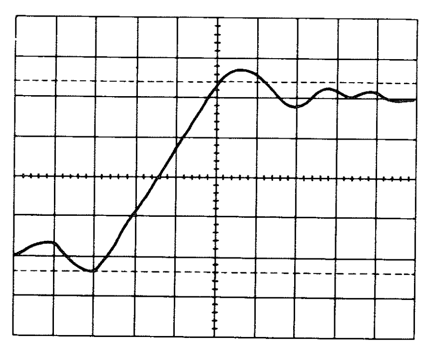
1. First set the HORIZONTAL DISPLAY to A and adjust the CS-2100A for a normal waveform display.
2. Pull out the SLOPE PULL STARTS AFTER DELAY (39) control to set the sweep in the STARTS AFTER DELAY mode.
Set the HORIZONTAL DISPLAY to the A-INT-B mode and a portion of the B Sweep representing the B SWEEP TIME/DIV will appear as an intensified portion of the A Sweep.
The B Sweep intensity is adjusted using the B INTENSITY control (19).
3. Shift the intensified portion of waveform (section to be magnified) along the A Sweep by use of the DELAY TIME MULTIPLIER (29).
4. Set the HORIZONTAL DISPLAY 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 MALTIPLIER setting × 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 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



B DLY'D



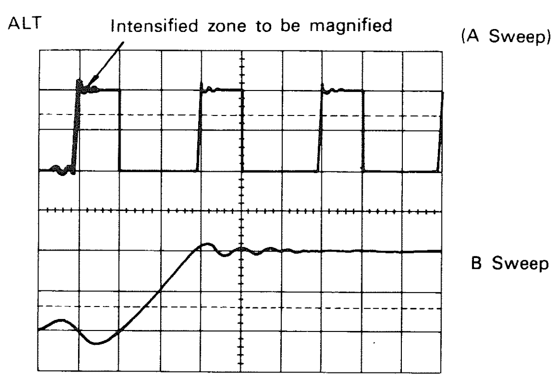
Note that for this type of operation both the DELAY TIME MULTIPLIER and TRIG LEVEL affect the start of the sweep so that the delay time is used as a reference point.

[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. Set the HORIZONTAL DISPLAY to A and adjust the CS-2100A for a normal waveform display.
2. Pull out the SLOPE PULL STARTS AFTER DELAY control and set the HORIZONTAL DISPLAY to ALT. Adjust TRACE SEP (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 MULTIPLIER 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 SLOPE PULL STARTS AFTER DELAY control the B 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 Sweep 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 the 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	
SOURCE	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	CH3	Trigger Source
		CH1	CH2	CH1	CH1+CH2	CH1, CH3 ALT(*4)	CRT Display

B SOURCE (B Sweep)

		MODE					
		CH1	CH2	DUAL	ADD	QUAD	
SOURCE	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	CH1+CH2	CH2, CH4 (*5)	CRT Display
	EXT CH4	CH4	CH4	CH4	CH4	CH4	Trigger Source
		CH1	CH2	CH2	CH1+CH2	CH2, CH4 (*6)	CRT Display

*Note 1: A Sweep is triggered by alternate signals from CH1 and CH2, but only the CH1 signal on the display is triggered.

*Note 2: A Sweep is triggered by alternate signals from CH1 ~ CH4, but only the CH1 and CH3 signals on the display are triggered.

*Note 3: A Sweep is triggered by CH1 signal and CH1 and CH3 signals are displayed.

*Note 4: A Sweep is triggered by CH3 signal and CH1 and CH3 signals are displayed.

*Note 5: B Sweep is triggered by CH2 signal and CH2 and CH4 signals are displayed.

*Note 6: B Sweep is triggered by CH4 signal but CH2 and CH4 signals are displayed.

*Note 7: If there is no time relation between CH1 and CH2 input, triggereing is not possible.

Please bear in mind these relationship when using DUAL mode operation with the CS-2100A.

OPERATION

> **CAUTION:**
> For DUAL operation be sure to set the TRIG MODE control to AUTO to allow sweep of both A and B to be performed.
> When A and B Sweeps are to be used alternately, the CS-2100A must be set up to provide both sweeps.

[6] X-Y OPERATION

Phase difference measurements may be made with the CS-2100A by use of the X-Y display mode.

Procedure:
Set the HORIZONTAL DISPLAY control to the X-Y mode. In this mode the CH1 input becomes the Y-axis input and the CH2 input the X-axis input for X-Y display.
For X-Y operation the X and Y positions are adjusted using the CH2 ⬍ POSITION X-Y ◂▸ and CH1 ⬍ POSITION controls respectively.

X and Y sensitivity is set by using the CH2 and CH1 VARIABLE, VOLTS/DIV controls respectively.
By pulling out the two above mentioned POSITION controls, the sensitivity of both the X and Y axis is magnified by 5 times.
The 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. Set the TRIG MODE to either AUTO or NORM, and the SLOPE PULL FIX to pushed in position.
   Apply a signal of approximately the same amplitude and frequency as the signal that is to be observed to the CS-2100A as the trigger signal and set the trigger level.
2. Set TRIG MODE to SINGLE and press the RESET button — observe that the green 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 CS-2100A is ready to operate in the SINGLE sweep mode of operation after resetting the instrument using the RESET button. Input of the trigger signal results in one and only one sweep.

> **CAUTION:**
> With the HORIZONTAL DISPLAY set 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 unit to the CHOP mode in this case.

[8] DUAL AND QUAD TRACE OPERATION

By setting the MODE to DUAL or QUAD, Dual and Quad trace operation can be achieved. When necessary, setting HORIZONTAL DISPLAY to ALT can in addition turn the CS-2100A into an 8-trace instrument.
Operation of the various controls is for this type of display mode similar to the operaton described above.

[9] CASCADED OPERATION

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

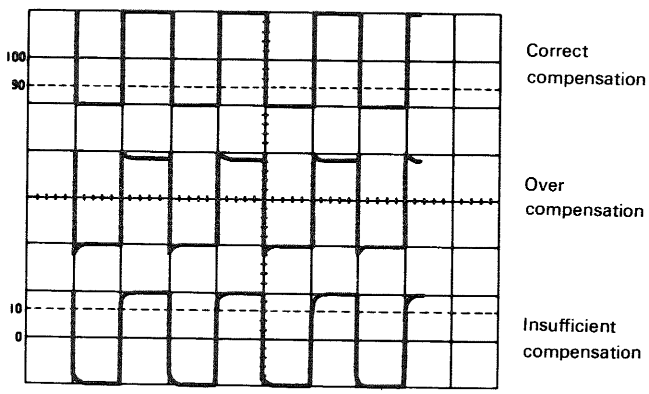
1. Connect the CH1 output to the CH2 input using a BNC cable.
2. For cascade operation depress the CH1 and CH2 × 5 GAIN switches.
3. Push the CH2 50Ω switch and set V MODE to CH2.
4. Set the CH1 and CH2 VOLTS/DIV to 5 mV and input a signal for a sensitivity of 500 μV/div on CH1.

APPLICATION

ADJUSTMENTS REQUIRED BEFORE STARTING MEASUREMENTS
PROBE COMPENSATION

If accurate measurements are to be made, the effect of the probe being used must be properly adjusted output of the measurement system using the internal calibration signal or some other squarewave source.

1. Connect the probe to the channel to be used and set the various controls for a normal A sweep display.
2. Adjust the SWEEP TIME/DIV control display of several cycles of the signal from the calibration output, CAL, terminal.
3. Adjust the probe compensation control for a proper waveform display.
4. The other channels are compensated for in the same way. Note that for CH3 and CH4 the sensitivity is 0.1V/DIV (1/1) so that when using a 10:1 probe sufficient waveform amplitude is not available, so that an alternate squarewave signal generator must be used for the compensating procedure.



TRACE ROTATION COMPENSATION

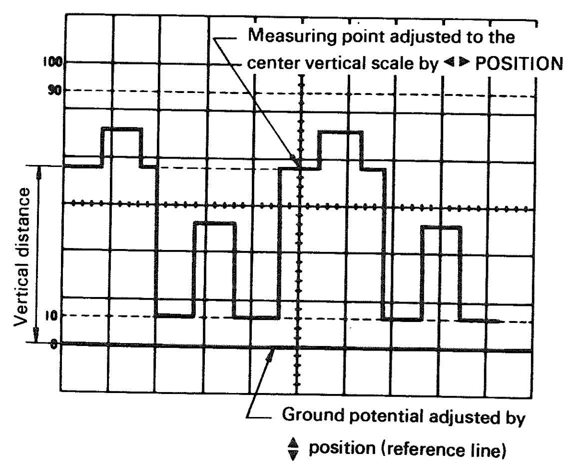
Rotation from a horizontal trace position can be the cause of measurement errors.
Adjust the CS-2100A controls for a normal display. Set the AC-GND-DC switch to GND and TRIG MODE to AUTO. Adjust the ⇕ POSITION control such that the trace is over the center horizontal graduation line.
If the trace appears to be rotated from horizontal, align it with the center graduation line using the TRACE ROTATION control located on the bottom of the instrument.

MEASUREMENTS
DC VOLTAGE MEASUREMENTS

This procedure describes the measurement procedure for DC waveforms.
Procedure:

1. Connect the signal to be measured to the INPUT connector and set the V MODE to the channel to be used. Set the VOLTS/DIV and SWEEP TIME/DIV switch to obtain a normal display of the waveform to be measured. Set the VARIABLE control to the CAL position.
2. Set TRIG MODE to AUTO and AC-GND-DC to the GND position to determine the true ground level. Using the ⇕ POSITION control adjust the trace position to the reference level position, making sure not to disturb this setting once made.
3. Set the AC-GND-DC switch to the DC position to observe the input waveform, including its DC component. If an appropriate reference level or VOLTS/DIV setting was not made, the waveform may not be visible on the CRT screen at this point. If so, press BEAM FINDER to locate it and reset VOLTS/DIV and/or the ⇕ POSITION control.
4. Use the ◂▸ POSITION control to bring the portion of the waveform to be measured to the center vertical graduation line of the CRT screen.
5. Measure the vertical distance from the reference level to the point to be measured, (the reference level can be checked by setting the AC-GND-DC switch again to GND).
   Multiply the distance measured above by the VOLTS/DIV setting and is the probe used is not a 1:1 probe, by the probe attenuation ratio as well. If "×5 GAIN" has been set multiply the value by 1/5 as well. Voltages above and below the reference level are positive and negative values respectively.

Using the formula:
DC level = Vertical distance in divisions × (VOLTS/DIV setting) × (probe attenuation ratio) × "×5 GAIN" value^{-1} (1/5)



[EXAMPLE]

For the example, the point being measured is 3.8 divisions from the reference level (ground potential).
If the VOLTS/DIV was set to 0.2V and a 10:1 probe was used.
Substituting the given values-
DC level = 3.8 (div) × 0.2(V) × 10 = 7.6V

APPLICATION

MEASUREMENT OF THE VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM

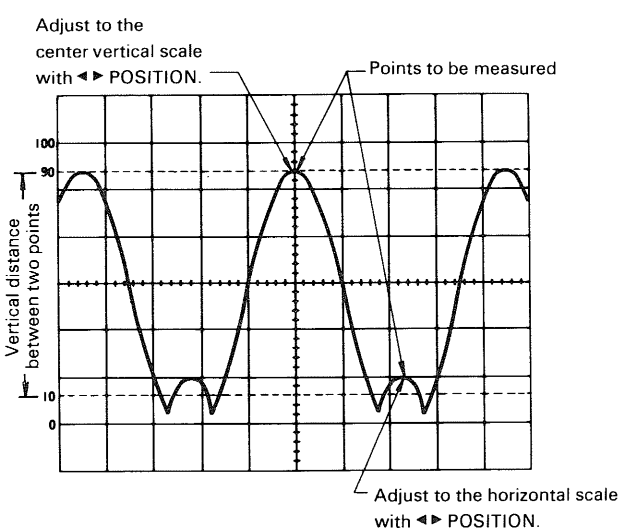
This technique can be used to measure peak-to-peak voltages.

Procedure:

1. Apply the signal to be measured to the INPUT, set the V MODE to the channel to be used and AC-GND-DC to AC, adjusting VOLTS/DIV and SWEEP TIME/DIV for a normal display. Set VARIABLE to the CAL position.
2. Using the ⬍ POSITION control adjust the waveform position such that one of the two points falls on a CRT graduation line and that the other is visible on the display screen.
3. Using the ◄► POSITION control, adjust the second point to coincide with the center vertical graduation line.
4. Measure the vertical distance between the two points and multiply this by the setting of the VOLTS/DIV control.
   If a probe is used, further multiply this by the attenuation ratio, if any and if "×5 GAIN" is used, multiply the value by 1/5 as well.

Using the formula:

Volts Peak-to-Peak
= Vertical distance (div) × (VOLTS/DIV setting)
× (probe attenuation ratio) × "×5 GAIN" value^{-1} (1/5)



[EXAMPLE]

For the example, the two points are separated by 4.4 divisions vertically. Let the VOLTS/DIV setting be 0.2V/div and the probe attenuation be 10:1.

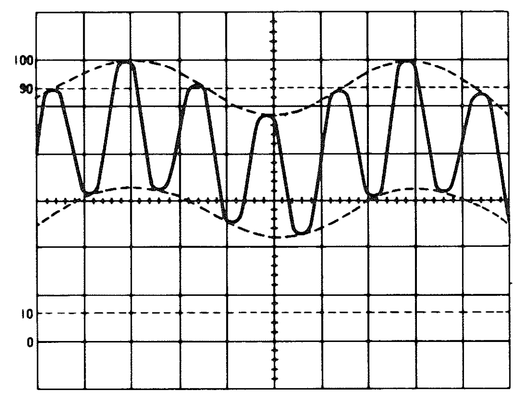
Substituting the given value:
Voltage between two points = 4.4 (div) × 0.2 (V) × 10 = 8.8V

ELIMINATION OF UNDESIRED SIGNAL COMPONENTS

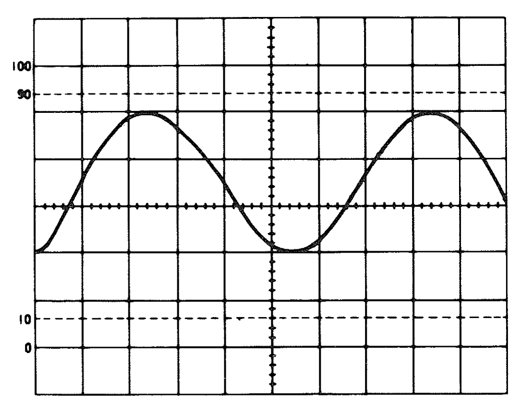
The ADD feature can be conveniently used to cancel out the effect of an undesired signal component which is riding on the back of the signal you wish to observe.

Procedure:

1. Apply the signal containing an undesired component to the CH1 INPUT and the undesired signal itself alone to the CH2 INPUT.
2. Set the V MODE to DUAL (CHOP) and SOURCE to CH2. Verify that CH2 represents the unwanted signal in reverse polarity. If necessary reverse polarity by setting CH2 to INV.
3. Set V MODE to ADD, SOURCE to V MODE and CH2 VOLTS/DIV and VARIABLE so that the undesired signal component is cancelled as much as possible. The remaining signal should be the signal you wish to observe alone and free of the unwanted signal.

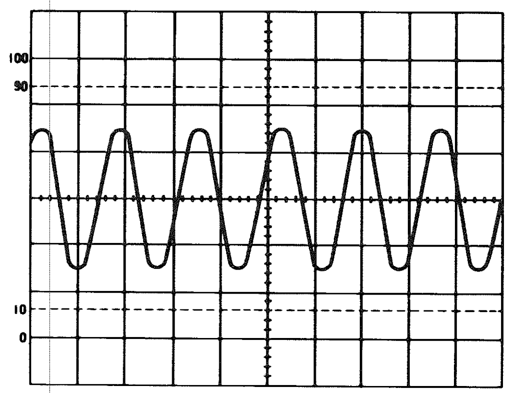


Signal containing undesired component
(Broken lines: undesired component envelope)

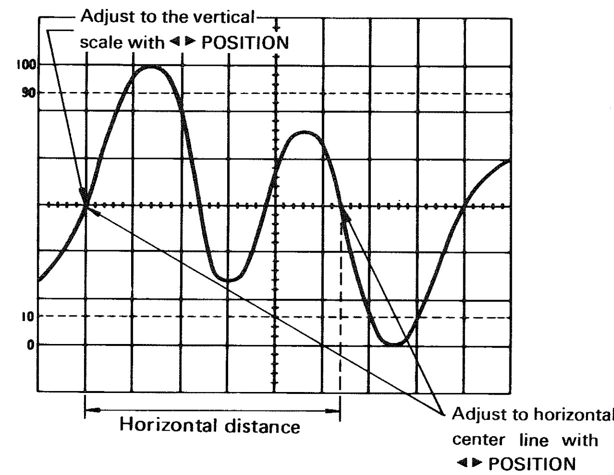


Undesired component signal

APPLICATION



Signal without undesired component



TIME MEASUREMENTS

This is the procedure for making time measurements between two points on a waveform. The combination of the SWEEP TIME/DIV and the horizontal distance in divisions between the two points is used in the calculation.

Procedure:

1. Apply the signal to be measured to the INPUT connector and set the V MODE to the channel to be used. Adjust VOLTS/DIV and SWEEP TIME/DIV for a normal display.
   Be sure that the VARIABLE control is set to CAL.
2. Using the ▲▼ POSITION control set one of the points to be used as a reference to coincide with the horizontal centerline.
   Use the ◄► POSITION control to set this point at the intersection of any vertical graduation line.
3. Measure the horizontal distance between the two points.
   Multiply this by the setting of the A SWEEP TIME/DIV control to obtain the time between the two points. If horizontal "× 10 MAG" is used, multiply this further by 1/10.

Using the formula:
Time = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "× 10 MAG" value^{-1} (1/10)

[EXAMPLE]

For the example, the horizontal distance between the two points is 5.4 divisions.
If the SWEEP TIME/DIV is 0.2ms/div we calculate.

Substituting the given value:
Time = 5.4 (div) × 0.2 (ms) = 1.08ms

FREQUENCY MEASUREMENTS

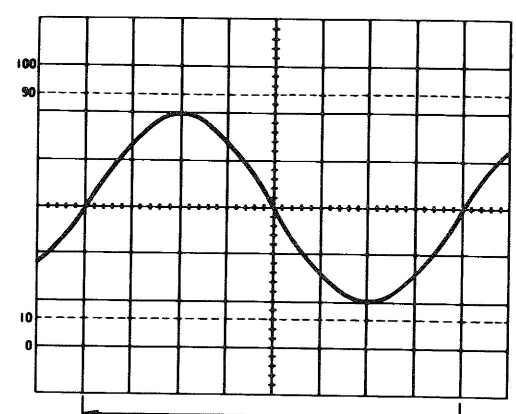
Frequency measurements are made by measuring the period of one cycle of waveform and taking the reciprocal of this time value as the frequency.

Procedure:

1. Set the oscilloscope up to display one cycle of waveform (one period).
2. The frequency is the reciprocal of the period measured.

Using the formula:

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



1 cycle=40μs(5μs/div.×8div.)

[EXAMPLE]

A period of 40μs is observed and measured.

Substituting the given value:
Freq = $1/[40 \times 10^{-6}] = 2.5 \times 10^{4} =$ 25 kHz

While the above method relies on the measurement directly of the period of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Apply the signal to the INPUT, setting the V MODE to the channel to be used and adjusting the various controls for a normal display. Set A VAR to CAL.
2. Count the number of cycles of waveform between a chosen set of vertical graduation lines.
   Using the horizontal distance between the vertical lines used above and the SWEEP TIME/DIV the time span may be calculated. Multiply the reciprocal of this value by the number of cycles present in the given time span. If " × 10 MAG" is used multiply this further by 10.
   Note that errors will occur for displays having only a few cycles.

Using the formula:

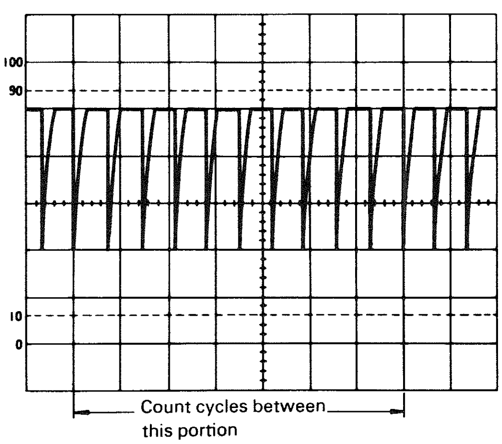
$$\text{Freq} = \frac{\text{\# of cycles} \times \text{" × 10 MAG" value}}{\text{Horizontal distance (div)} \times \text{SWEEP TIME/DIV setting}}$$

[EXAMPLE]

For the example, within 7 divisions there are 10 cycles.
The SWEEP TIME/DIV is 5μs.

Substituting the given value:

$$\text{Freq} = \frac{10}{7 \times 5\ (\mu s)} \doteqdot 285.7\ \text{kHz}$$



PULSE WIDTH MEASUREMENTS

Procedure:

1. Apply the pulse signal to the INPUT and set the V MODE to the channel to be used.
2. Use VOLTS/DIV, VARIABLE and ⬍ POSITION to adjust the waveform such that the pulse is easily observed and such that the center pulse width coincides with the center horizontal line on the CRT screen.
3. Measure the distance between the intersection of the pulse waveform and the center horizontal line in divisions. Be sure that the A VAR is in the CAL position. Multiply this distance by the A SWEEP TIME/DIV and by 1/10 is " × 10 MAG" mode is being used.

Using the formula:

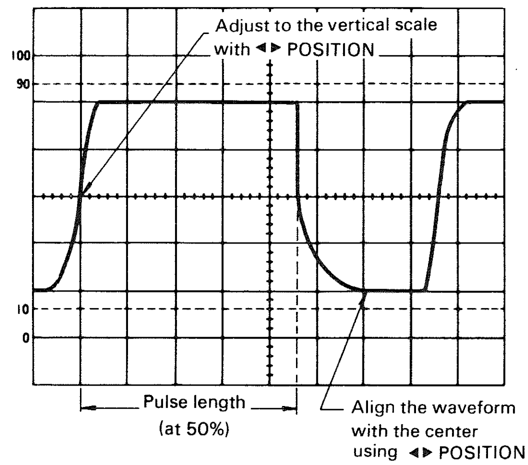
Pulse width = Horizontal distance (div) × (SWEEP TIME/DIV setting) × " × MAG 10" value^{-1} (1/10)

[EXAMPLE]

For the example, the distance (width) at the center horizontal line is 4.6 divisions and the A SWEEP. TIME/DIV is 0.2ms.

Substituting the given value:

Pulse width = 4.6 (div) × 0.2ms = 0.92ms



PULSE RISETIME AND FALLTIME MEASUREMENTS

For risetime and falltime measurements, the 10% and 90% amplitude points are used as starting and ending reference points.

Procedure:

1. Apply a signal to the INPUT and set V MODE to the channel to be used.
   Use VOLTS/DIV and VARIABLE to adjust the waveform peak to peak height to six divisions.
2. Using the ⬍ POSITION control and the other controls, adjust the display such that the waveform is centered vertically in the display. Set the SWEEP TIME/DIV to as fast a setting as possible consistent with observation of both the 10% and 90% points. Set the A VAR to the CAL position.
3. Use the ◀▶ POSITION control to adjust the 10% point to coincide with a vertical graduation line and measure the distance in divisions between the 10% and 90% points on the waveform. Multiply this by the SWEEP TIME/DIV and also by 1/10, if "× 10 MAG" mode was used.

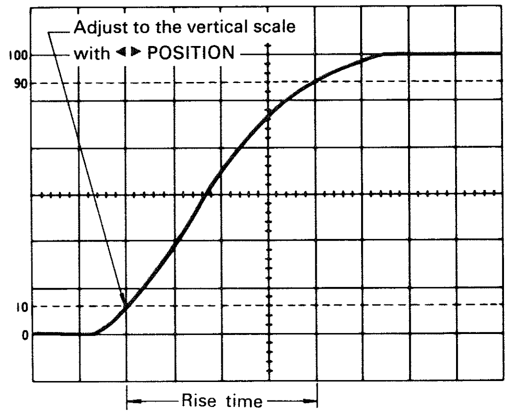
CAUTION

Be sure that the correct 10% and 90% lines are used. For such measurements the 0, 10, 90 and 100% points are marked on the CRT screen.

Using the formula:

Risetime = Horizontal distance (div) × (SWEEP TIME/DIV setting) × " × 10 MAG" value^{-1} (1/10)

APPLICATION



[EXAMPLE]

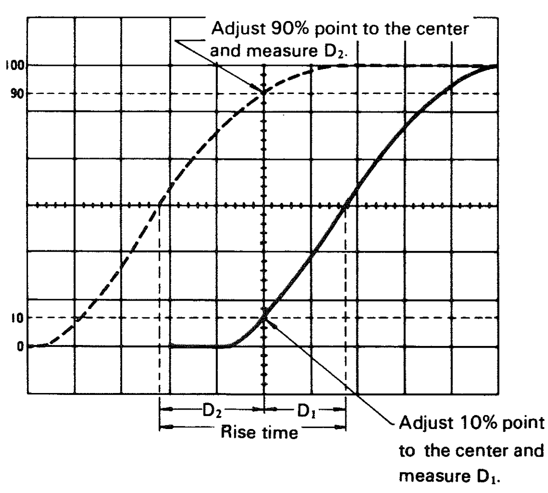
For the example, the horizontal distance is 4.0 divisions. The SWEEP TIME/DIV is $2\mu s$.

Substituting the given value:
Risetime = 4.0 (div) × 2 (μs) = $8\mu s$

Risetime and falltimes can be measured by making use of the alternate step 3′ as described below as well.

4. Use the ◄► POSITION control to set the 10% point to coincide with the center vertical graduation line and measure the horizontal distance to the point of the intersection of the waveform with the center horizontal line. Let this distance be D_1. Next adjust the waveform position such that the 90% point coincides with the vertical centerline and measure the distance from that line to the intersection of the waveform with the horizontal centerline. This distance is D_2 and the total horizontal distance is then D_1 plus D_2 for use in the above relationship in calculating the risetime or falltime.

Using the formula:
Risetime = ($D_1 + D_2$) (div) × (SWEEP TIME/DIV setting) × " × 10 MAG" value^{-1} + 1/10)



[EXAMPLE]

For the example, the measured D_1 is 1.8 divisions while D_2 is 2.2 divisions. If SWEEP TIME/DIV is $2\mu s$ we use the following relationship

Substituting the given value:
Risetime = (1.8 + 2.2) (div) × 2 (μs) = $8\mu s$

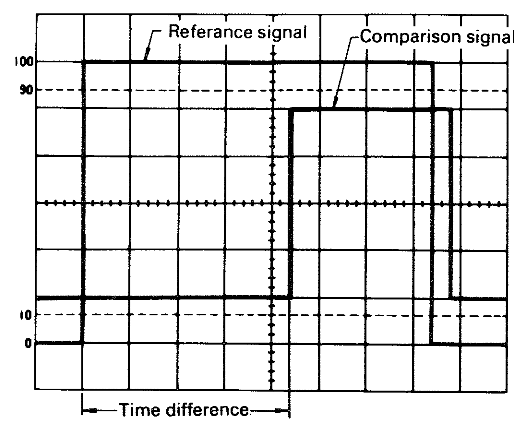
TIME DIFFERENCE MEASUREMENTS

This procedure is useful in measurement of time differences between two signals that are synchronized to one another but skewed in time.

Procedure:

1. Apply the two signals to CH1 and CH2 and set the V MODE to DUAL choosing either ALT or CHOP mode. Generally for low frequency signals CHOP is chosen with ALT used for high frequency signals.
2. Select the faster of the two signals as the SOURCE and use VOLTS/DIV and SWEEP TIME/DIV to obtain an easily observed display.
   Set A VAR to CAL.
3. Using ▲▼ POSITION control set the waveforms to the center of the CRT display and use the ◄► POSITION control to set the reference signal to be coincident with a vertical graduation line.
4. Measure the horizontal distance between the two signals and multiply this distance in divisions by the SWEEP TIME/DIV setting.
   If × 10 MAG is being used multiply this again by 1/10.

   Using the formula:
   Time = Horizontal distance (div) × (SWEEP TIME/DIV setting) × " × 10 MAG" value^{-1} (1/10)



[EXAMPLE]

For the example, the horizontal distance measured is 4.4 divisions. The SWEEP TIME/DIV is 0.2ms.

Substituting the given value:
Time = 4.4 (div) × 0.2(ms) = 0.88ms

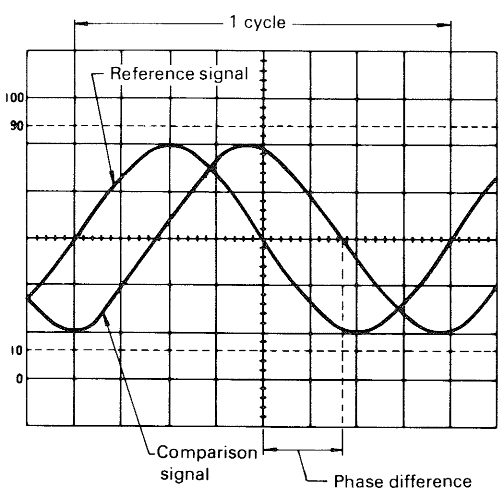
APPLICATION

PHASE DIFFERENCE MEASUREMENTS

This procedure is useful in measuring the phase difference of signals of the same frequency.

1. Apply the two signals to the CH1 and CH2 INPUTS, setting the V MODE to DUAL and choosing either CHOP or ALT mode.
2. Set the SOURCE to the signal which is leading in phase and use VOLTS/DIV to adjust the signals such that they are equal in amplitude. Adjust the other controls for a normal display.
3. Use SWEEP TIME/DIV and A VAR to adjust the display such that one cycle of the signals occupies 8 divisions of horizontal display.
   Use the ⬍ POSITION to bring the signals in the center of the screen.
   Having set up the display as above, one division now represents 45° .in phase.
4. Measure the horizontal distance between corresponding points on the two waveforms.

Using the formula:
Phase difference = horizontal distance (div) × 45°/div



[EXAMPLE]
For the example, the horizontal distance is 1.7 divisions.

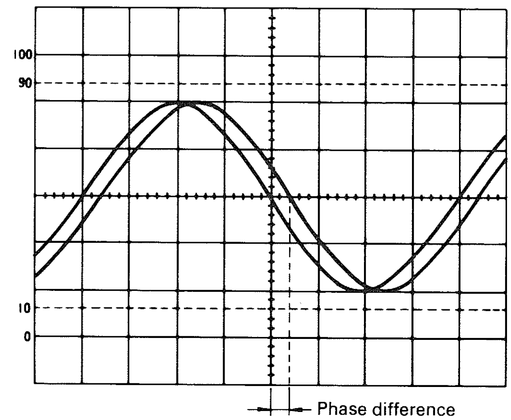
Substituting the given value:
The phase difference = 1.7 (div) × 45°/div = 76.5°

The above setup allows 45° per division but if more accuracy is required the SWEEP TIME/DIV may be changed and magnified without touching the A VAR control and if necessary the trigger level can be readjusted.

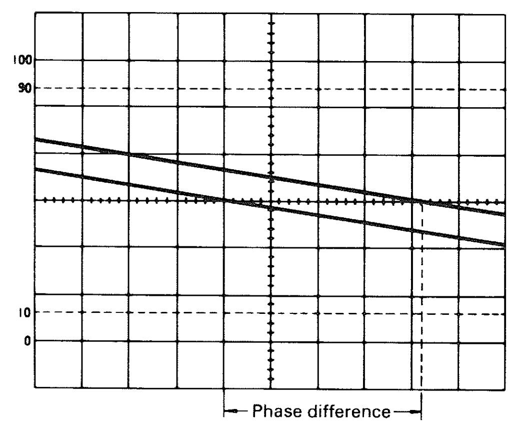
For this type of operation, the relationship of one division to 45° no longer holds. Phase difference is defined by the formula as follow.

$$\text{Phase difference} = \text{horizontal distance of new sweep range (div)} \times 45°/\text{div} \times \frac{\text{New SWEEP TIME/DIV setting}}{\text{Original SWEEP TIME/DIV setting}}$$

Another simple method of obtaining more accuracy quickly is to simply use × 10 MAG for a scale of 1 division = 45°/div



One cycle adjusted to occupy 8 div.



Expanded sweep waveform display.

RELATIVE MEASUREMENTS

If the frequency and amplitude of some reference signal are known, an unknown signal may be measured for level and frequency without use of the VOLTS/DIV or SWEEP TIME/DIV for calibration.
The measurement is made in units relative to the reference signal.

★ Vertical Sensitivity

Setting the relative vertical sensitivity using a reference signal.

1. Apply the reference signal to the INPUT and adjust the display for a normal waveform display.

APPLICATION

Adjust VOLTS/DIV and VARIABLE so that the signal coincides with the CRT face's graduation lines. After adjusting, be sure not to disturb the setting of the VARIABLE control.

2. The vertical calibration coefficient is now the reference signal's amplitude (in volts) divided by the product of the vertical amplitude set in step 1 and the VOLTS/DIV setting.

   Using the formula:

   Vertical coefficient

   $$= \frac{\text{Voltage of the reference signal (V)}}{\text{Vertical amplitude (div)} \times \text{VOLTS/DIV setting}}$$

3. Remove the reference signal and apply the unknown signal to the INPUT, using the VOLTS/DIV control to adjust the display for easy observation. Measure the amplitude of the displayed waveform and use the following relationship to calculate the actual amplitude of the unknown waveform.

   Amplitude of the unknown signal (V)
   = Vertical distance (div) × Vertical coefficient
   × VOLTS/DIV setting

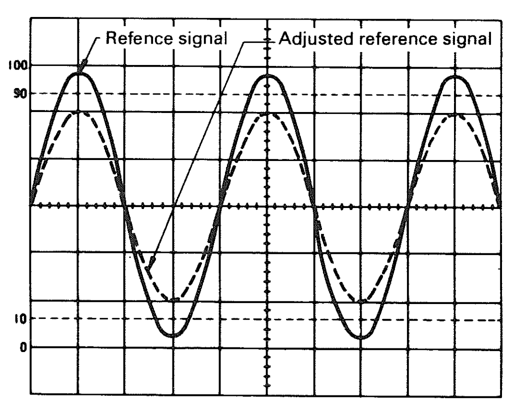
[EXAMPLE]
For the example the VOLTS/DIV is 1V.
The reference signal is 2 Vrms. Using the VARIABLE, adjust so that the amplitude of the reference signal is 4 divisions.

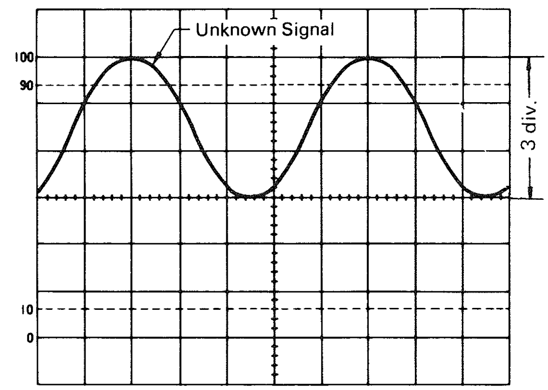
Substituting the given value:

$$\text{Vertical coefficient} = \frac{2\text{ Vrms}}{4\text{ (div)} \times 1\text{ (V)}} = 0.5$$

Then, measure the unknown signal and VOLTS/DIV is 2V and vertical amplitude is 3 divisions.

Substituting the given value:
Effective value of unknown signal = 3 (div) × 0.5 × 5(V)
= 7.5 V rms





★PERIOD

Setting the relative sweep coefficient with respect to a reference frequency signal.

1. Apply the reference signal to the INPUT, using VOLTS/DIV and VARIABLE to obtain an easily observed waveform display.
   Using SWEEP TIME/DIV and VARIABLE adjust one cycle of the reference signal to occupy a fixed number of scale divisions accurately. After this is done be sure not to disturb the setting of the A VAR control.
2. The Sweep (horizontal) calibration coefficient is then the period of the reference signal divided by the product of the number of divisions used in step 1 for setup of the reference and the setting of the SWEEP TIME/DIV control.

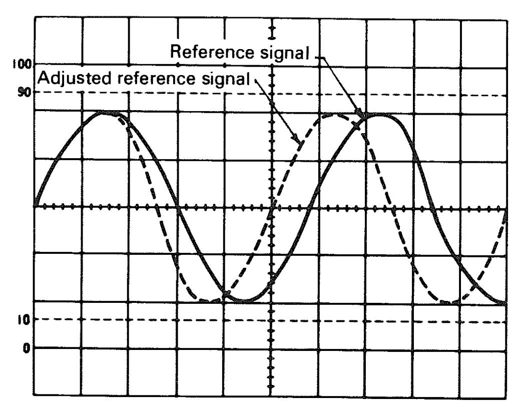
   Using the formula:

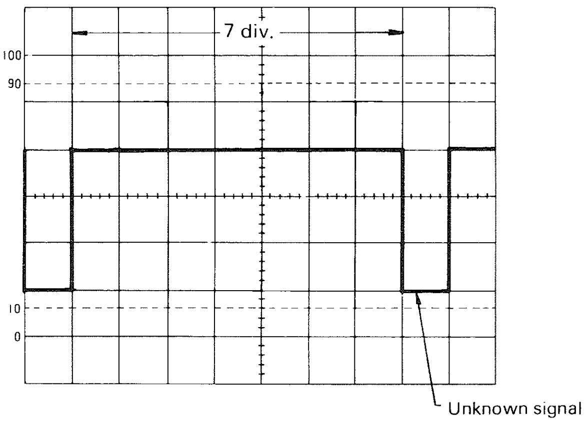
   Sweep coefficient

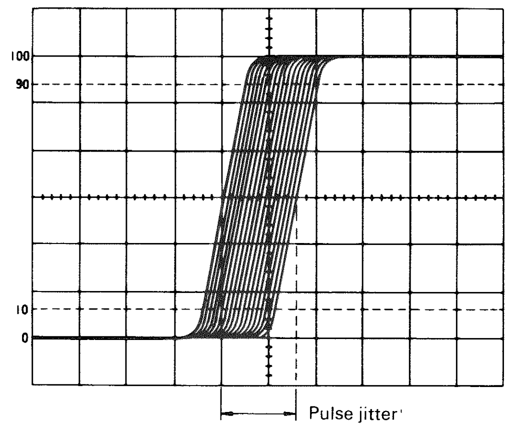
   $$= \frac{\text{Period of the reference signal (sec)}}{\text{Horizontal width (div)} \times \text{SWEEP TIME/DIV setting}}$$

3. Remove the reference signal and input the unknown signal, adjusting the SWEEP TIME/DIV control for easy observation.
   Measure the width of one cycle in divisions and use the following relationship to calculate the actual period.

Using the formula:
Period of unknown signal = Width of 1 cycle (div) × sweep coefficient × SWEEP TIME/DIV setting







[EXAMPLE]

A SWEEP TIME/DIV is 0.1ms and apply 1.75kHz reference signal. Adjust the A VAR so that the distance of one cycle is 5 divisions.

Substituting the given value:

$$\text{Horizontal coefficient} = \frac{1.75\ (\text{kHz})^{-1}}{5 \times 0.1\ (\text{ms})} = 1.142$$

Then, SWEEP TIME/DIV is 0.2ms and horizontal amplitude is 7 divisions.

Substituting the given value:

Pulse width $= 7\ (\text{div}) \times 1.142 \times 0.2\ (\text{ms}) \fallingdotseq 1.6\text{ms}$

PULSE JITTER MEASUREMENTS

1. Apply the signal to the INPUT and set the V MODE to the channel to be used.
   Use VOLTS/DIV to adjust for an easy to observe waveform display. Special care should be taken to adjust the Trigger group of controls for a stable display. Set A VAR to CAL.
2. Set HORIZONTAL DISPLAY to A-INT-B, and pull out the B SLOPE control to affect the STARTS AFTER DELAY mode.
   Adjust the DELAY TIME MULTIPLIER for intensified display of the waveform to be measured.
3. Using the B SWEEP TIME/DIV adjust the display for intensification of the entire jitter area of the waveform.
4. Set the HORIZONTAL DISPLAY to B DLY'D.
   Measure the width of the jitter area.
   The jitter time is this width in divisions multiplied by the setting of the B SWEEP TIME/DIV control.

Using the formula:

Pulse jitter = Jitter width (div) × B SWEEP TIME/DIV setting

[EXAMPLE]

The example shows a case in which the jitter width was measured at 1.6 divisions wide with the B SWEEP TIME/DIV set at 0.2μs.

Substituting the given value:

Pulse jitter $= 1.6 \times 0.2\mu s = 0.32\mu s$

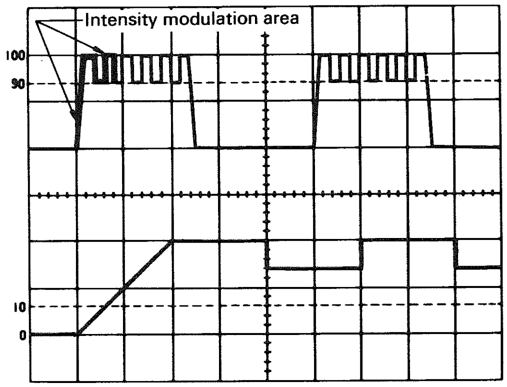
SWEEP MULTIPLICATION (MAGNIFICATION)

The apparent magnification of the delayed sweep is determined by the values set by the A and B SWEEP TIME/DIV controls

1. Apply a signal to the INPUT and set the V MODE to the channel to be used, adjusting VOLTS/DIV for an easily observed display of the waveform and the other controls if necessary.
2. Set the A SWEEP TIME/DIV so that several cycles of the waveform are displayed. Set the B SLOPE to STARTS AFTER DELAY (pull out).
   When HORIZONTAL DISPLAY is set to A-INT-B, the magnified portion of the waveform will appeared intensified on the CRT display.
3. Use the DELAY TIME MULTIPLIER to shift the intensified portion of waveform to correspond with the section to be magnified for observation. Use the B SWEEP TIME/DIV to adjust intensified portion to cover the entire portion to be magnified.
4. Set the HORIZONTAL DISPLAY to either ALT or B DLY'D and use the ⇕ POSITION and ⇕ TRACE SEP controls to adjust the display for easy viewing.
5. Time measurements are performed in the same manner from the B sweep as was described above for A sweep time measurements.
   The apparent magnification of the intensified waveform section is the A SWEEP TIME/DIV divided by the B SWEEP TIME/DIV.

Using the formula:

$$\text{The apparent magniffication of the intensified waveform} = \frac{\text{A SWEEP TIME/DIV setting}}{\text{B SWEEP TIME/DIV setting}}$$



[EXAMPLE]

In the example, the A SWEEP TIME is 2μs and the B SWEEP TIME is 0.2μs.

Substituting the given value:

$$\text{Apparent magnification ratio} = \frac{2 \times 10^{-6}}{0.2 \times 10^{-6}} = 10$$

With the above magnification, if the magnification ratio is increased, delay jitter will occur.
To achieve a stable display, cancel the STARTS AFTER DELAY mode and used the triggered mode of operation.

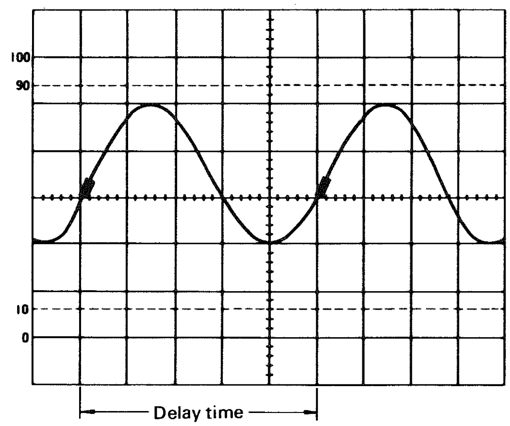
1. Perform the above steps 1 through 3.
2. Press the SLOPE control in to cancel the STARTS AFTER DELAY mode and set the B SOURCE to the same signal as the A trigger source.
3. Set HORIZONTAL DISPLAY to either ALT or B DLY'D. The apparent magnification will be the same as described above.
   If a proper B trigger signal is not applied, intensification may not occur. If this happens, vary the signal level or trigger with an external signal source.

DELAYED SWEEP TIME MEASUREMENTS

Using the B sweep high accuracy time measurements can be made.

1. Apply a signal to INPUT and set the V MODE to the channel to be used. Adjust VOLTS/DIV and the other controls if necessary to obtain an easily observed waveform display.
   Set the A VAR to CAL.
2. Adjust the A SWEEP TIME/DIV to display the portion of waveform to be measured. Pull out the B SLOPE control to set the STARTS AFTER DELAY mode.
   Set HORIZONTAL DISPLAY to A-INT-B and adjust the B SWEEP TIME/DIV for as small as possible an intensified region.
3. Using the ⬍ POSITION control adjust the waveform position so as to intersect with the center horizontal line on the CRT screen. Use the DELAY TIME MULTIPLIER so that the intensified portion of waveform touches the center horizontal line and record the setting of the DELAY TIME MULTIPLIER at this point.
4. Use the DELAY TIME MULTIPLIER to adjust portion of modulation to same point of the second weveform
   The waveform period is the second dial reading minus the first dial reading multiplied by the A SWEEP TIME/DIV setting.

Using the formula:
Period = (2nd dial reading − 1st dial reading)
× Delayed sweep time (A SWEEP TIME/DIV setting)



[EXAMPLE]

For the example the first dial setting is 1.01 and the second is 6.04. The setting of A SWEEP TIME/DIV is 2ms.

Substituting the given value:
Period = (6.04 − 1.01) × 2 (ms) = 10.06ms

PULSE WIDTH MEASUREMENTS USING DELAYED SWEEP

This method is similar to the time measurement method and can be used for high accuracy pulse width measurements.

1. Apply the pulse signal to the INPUT and set the V MODE to the channel to be used.
2. Use the VOLTS/DIV, VARIABLE and ⬍ POSITION controls to adjust the display such that the waveform is easily observable with the center of the pulse width coinciding with the center horizontal graduation line.
   Set A VAR to CAL.
3. Set the A SWEEP TIME/DIV to display the portion of the waveform to be measured, pulling out the B SLOPE control to set up the STARTS AFTER DELAY mode of display.
   Set HORIZONTAL DISPLAY to A-INT-B, and adjust the B SWEEP TIME/DIV for as short as possible an intensified section of waveform.
4. Using the DELAY TIME MULTIPLIER, adjust the display so that the intensified portion touches the center horizontal graduation line of the CRT screen and record the dial setting at this point.

5. Using the DELAY TIME MULTIPLIER adjust the falling edge of the pulse so that it touches the center horizontal graduation line and is intensified.
   The pulse width is the second dial reading minus the first dial reading multiplied by the A SWEEP TIME/DIV setting.

Using the formula:
Pulse width = (2nd dial reading-1st dial reading)
× Delayed sweep time (A SWEEP TIME/DIV setting)

[EXAMPLE]
In the example, the first dial reading is 0.61 and the second is 5.78 with the A SWEEP TIME/DIV setting at 2μs.
Substituting the appropriate values

Pulse width = (5.78−0.61) × 2 (μs) = 10.34μs

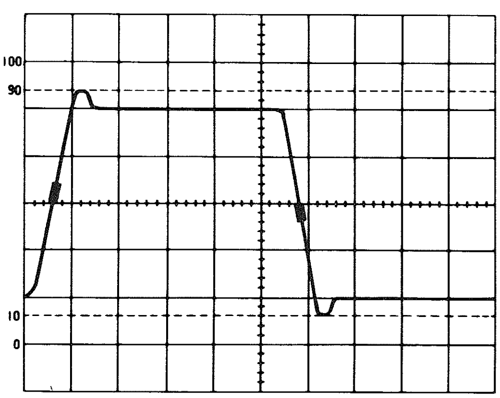
FREQUENCY MEASUREMENTS USING DELAYED SWEEP

The frequency is obtained as the reciprocal of the period of one cycle.

1. Measure the period of the waveform using the procedure described above for time measurement.
2. The frequency is then the reciprocal of the period measured.

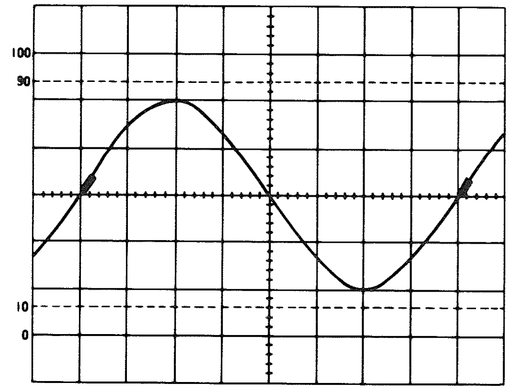
Using the formula:

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



[EXAMPLE]
For the example, the period measured is 40.2μs, making the frequency simply.

Substituting the given value:
Freq = $1/(40.2 \times 10^{-6}) \fallingdotseq 24.88$ kHz

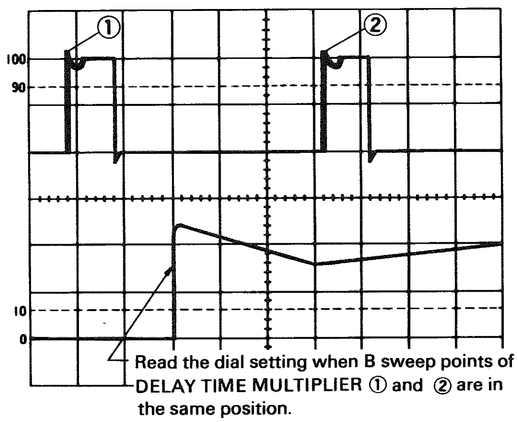


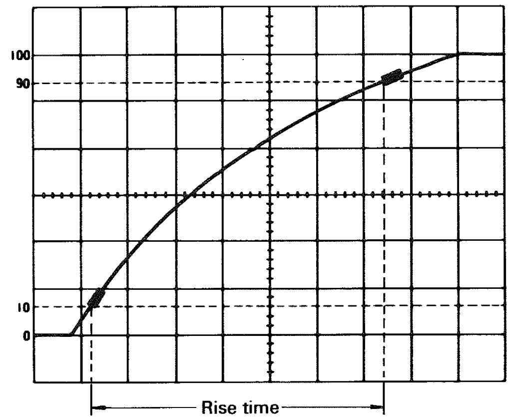
PULSE REPETITION TIME

Using the delayed sweep feature, reliable time measurements can be made.

1. Apply a signal to the INPUT and set the V MODE to the channel to be used.
   Adjust VOLTS/DIV to obtain a normal easy to view display of the waveform.
2. Adjust the A SWEEP TIME/DIV so that at least two cycles of the waveform are displayed.
   Set the HORIZONTAL DISPLAY to A-INT-B and pull out the B SLOPE control to affect the STARTS AFTER DELAY mode of operation.
   Set the B SWEEP TIME/DIV as fast a sweep speed as possible.
3. Using the DELAY TIME MULTIPLIER, adjust the intensified portion to coincide with the first pulse.
   Set the HORIZONTAL DISPLAY to ALT and use ⬍ TRACE SEP to adjust the waveforms for easy viewing.
4. Using the DELAY TIME MULTIPLIER, set the pulse to coincide with one of the vertical graduation lines and record the dial setting at this point.
5. Again using the DELAY TIME MULTIPLIER, adjust the second pulse in the same manner to the vertical line used in step 4, recording this dial setting as well. The pulse repetition time is the second dial reading minus the first dial reading multiplied by the A SWEEP TIME/DIV control setting.

Using the formula:
Pulse repetition time = (2nd dial reading−1st dial reading) × Delayed sweep time (A SWEEP TIME/DIV setting)





[EXAMPLE]

For the example, the first dial reading is 0.76 and the second is 6.22 with the A SWEEP TIME/DIV set at 2μs.
We have, substituting the appropriate values

Pulse repetition time = (6.22-0.76) × 2 (μs) = 10.92μs

USING DELAYED SWEEP FOR MEASUREMENT OF RISETIMES AND FALLTIMES

Risetimes and falltimes are generally measured by using the 10% and 90% amplitude points as reference starting and ending points for the rise or fall.

1. Apply the signal to the INPUT and set the V MODE to the channel to be used.
   Use VOLTS/DIV and VARIABLE to obtain a normal 6 division high waveform display.
   Using the ⬍ POSITION control, set the waveform position in the central area of the screen vertically, that it to coincide with the 100% and 0% lines on the CRT screen.
   Set the SWEEP TIME/DIV to as high a speed as possible.
   Set A VAR to the CAL position.
3. Pull out the B SLOPE control to initiate the STARTS AFTER DELAY mode of operation and adjust the B SWEEP TIME/DIV for as short as possible an intensified section of waveform.
4. Using the DELAY TIME MULTIPLIER, adjust the waveform such that the 10% point is intensified and record the dial reading.
5. Similarly, using the DELAY TIME MULTIPLIER adjust the 90% point so that it is intensified and record that dial reading as well.
   The pulse risetime (or falltime) is simply the difference between the two dial settings times the A SWEEP TIME/DIV control setting.

Using the formula
Risetime = (2nd dial reading − 1st dial reading) × Delayed sweep time (A SWEEP TIME/DIV setting)

[EXAMPLE]

For the example, the first dial reading is 1.20 (10% point) and the second is 7.38 (90% point) with the A SWEEP TIME/DIV set at 2μs.

Substituting the given value:

Risetime = (7.38 − 1.20) × 2 (μs) = 12.36μs

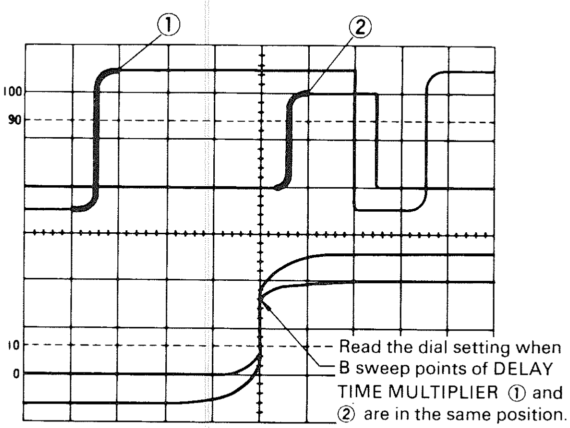
TIME DIFFERENCE MEASUREMENTS USING DELAYED SWEEP

Synchronized waveforms which are skewed in time can be accurately measured using the delayed sweep.

1. Apply the two signals to the CH1 and CH2 INPUTs, setting the V MODE to DUAL and selecting either ALT or CHOP display.
2. Set the SOURCE to the signal that is leading in phase and adjust VOLTS/DIV and SWEEP TIME/DIV for easy waveform observation.
   Set the A VAR control to CAL.
3. Pull out the B SLOPE control to initiate the STARTS AFTER DELAY mode of operation. Set HORIZONTAL DISPLAY to A-INT-B and adjust the B SWEEP TIME/DIV and DELAY TIME MULTIPLIER to make the intensified portion coincide with the rising edge or falling edge of the waveform that is to be used as the reference.
4. Set the HORIZONTAL DISPLAY to ALT and use the ⬍ TRACE SEP control to adjust the B sweep for easy observation.
5. Using the DELAY TIME MULTIPLIER adjust the pulse to any convenient vertical graduation line and record the dial reading at that point.
6. Using the DELAY TIME MULTIPLIER adjust the corresponding point on the second signal to the same vertical line and record the reading of the dial at this point as well. The time difference or skew of the two waveforms is then the second dial reading minus the first dial reading multiplied by the A SWEEP TIME/DIV control setting.

Using the formula:

Time difference = (2nd dial reading − 1st dial reading) × Delayed sweep time (A SWEEP TIME/DIV setting)



[EXAMPLE]

The reference signal dial reading is 1.00 while the second dial reading is 5.34 with an A SWEEP TIME/DIV setting of 2μs.

Substituting the value:

Time difference = (5.34 − 1.00) × 2(μs) = 8.68 μs

X-Y OPERATION

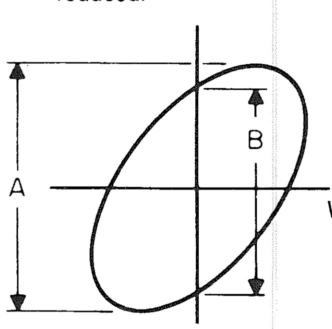
PHASE MEASUREMENT

Phase measurements may be made with X-Y operation. Typical applications are in circuits designed to produce a specific phase shift, and measurement of phase shift distortion in audio amplifiers or other audio networks.

Distortion of amplitude is also displayed in the oscilloscope waveform.

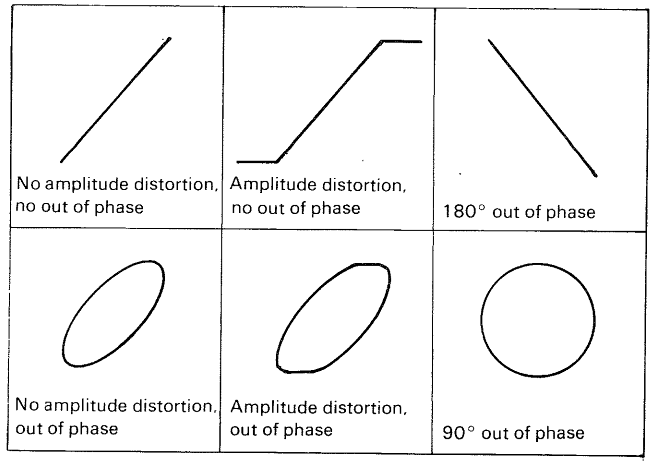
To make phase measurements, use the following procedure

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.
2. Set the signal generator output for the normal operating level of the ciruict being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.



SINE $\phi = \frac{B}{A}$

WHERE ϕ = PHASE ANGLE



3. Connect the Channel 1 probe to the output of the test circuit.
4. Set the H. DISPLAY to X-Y.
5. Connect the Channel 2 INPUT probe to the input of the test circuit.
6. Adjust the Channel 1 and 2 gain controls for a suitable viewing size.
7. Some typical results are shown above. If the two signals are in phase, the lissajous' pettern is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle.

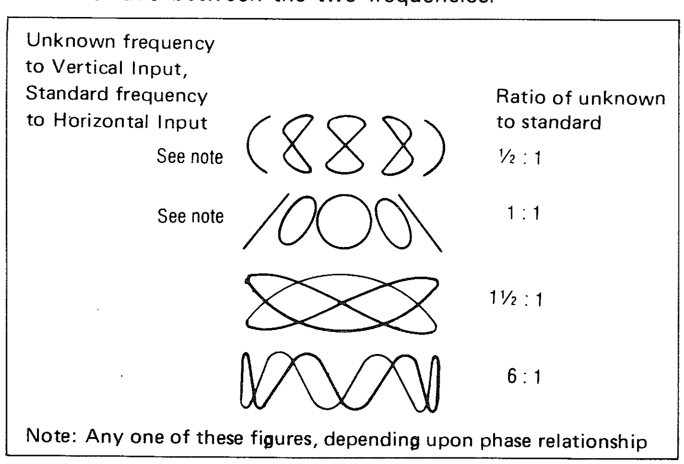
A 90° phase shift produces a circuilar Lissajours' pattern. Phase shift of less (or more) than 90° produces an elliptical Lissajous' pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown left below.

FREQUENCY MEASUREMENT

Frequency measurement may be mode with the Lissajous' pattern, as phase measurement.

Procedure:

1. Connect the sine wave of known frequency to the CH 2 INPUT of the oscilloscope and set the H. DISPLAY to X-Y.
2. Connect the vertical input probe (CH 1 INPUT) to the unknown frequency.
3. Adjust the Channel 1 and 2 gain controls for a convenient, easy-to-read display.
4. The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies.



APPLICATION

4-CHANNEL APPLICATION

The sensitivities of CH1 to CH4 are calibrated and each channel has 100 MHz band width. The trigger signals of CH3 and CH4 can be obtained from each preamplifiers. This unit can be used not only for external synchronization but also for checking 4-Channel at a time.

Application

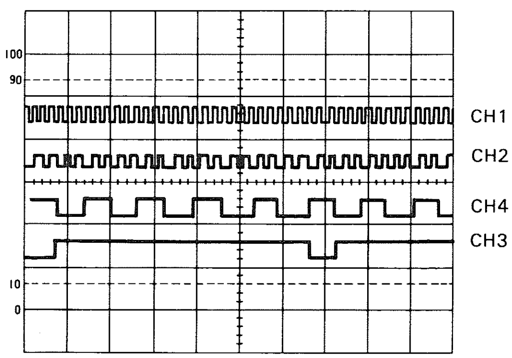
1. Checking logic signal timing
2. Monitoring video signal
3. Measuring audio signal gain and phase characteristics

The details of the logic signal timing checking are described below.

Logic signal timing indication

Control setting
V. MODE: QUAD, ALT A. SOURCE: CH3
H. DISPLAY: A

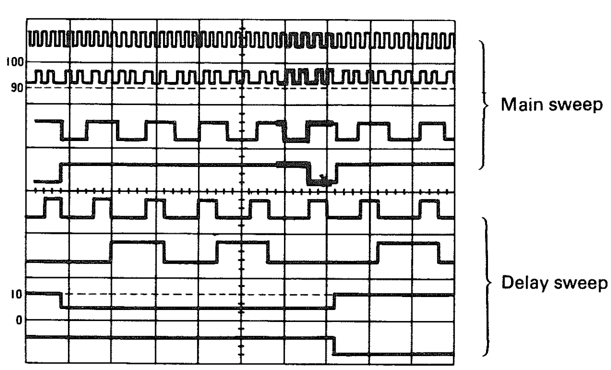
To obtain stable synchronization, synchronize with the longest period channel (in this case, CH3).



In the above application, when the H. DISPLAY control is set to ALT, the main and delay sweep waveforms are displayed on the CRT at a time. The portion in which the intensity is modulated is enlarged to enable easy checking.

Main and delay sweep waveforms (Magnified by 10 times)

Control setting
V. MODE: QUAD, ALT
A. SOURCE: CH3
H. DISPLAY: ALT
STARTS AFTER DELAY: PULL (ON)



DUAL SWEEP APPLICATION

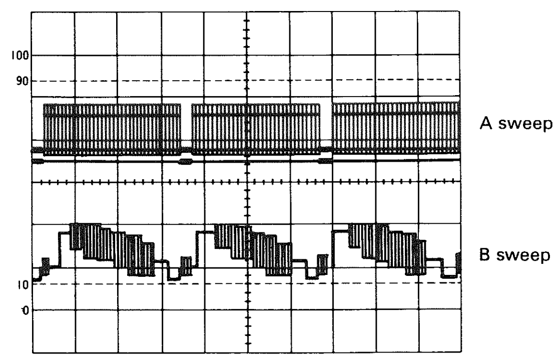
In this mode, two trigger sweep circuit systems can display different period signals without intensity difference.

Video FRAME and LINE signal waveforms

Control setting

Input signal:	CH1	V. MODE:	CH1
H. DISPLAY:	DUAL	A. TRIG SOURCE:	CH1
A. COUPLING:	VIDEO	B. TRIG SOURCE:	CH1
B. COUPLING:	AC	A SWEEP TIME/DIV:	5ms
B. SWEEP TIME/DIV:	20μs		

In one waveform display mode, the A and B. TRIG. SOURCE control operation is as described in the front panel. For two or four waveform display mode, refer to the next item.

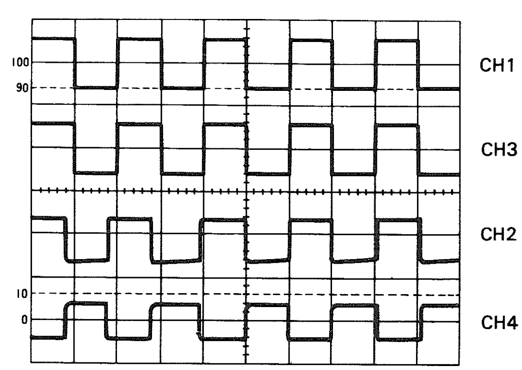


Divider circuit waveforms

Control setting
V. MODE: QUAD, ALT H. DISPLAY: DUAL
A. SOURCE: CH1, B. SOURCE: CH2
A. SWEEP TIME/DIV: 5ms
B. SWEEP TIME/DIV: 0.5μs
CH1 and CH3: 100 Hz signal input
CH2 and CH4: 1 MHz signal input

With this method, when the sweep ratio is set to 10,000 times, the intensity does not change and different period waveform can be synchronized.

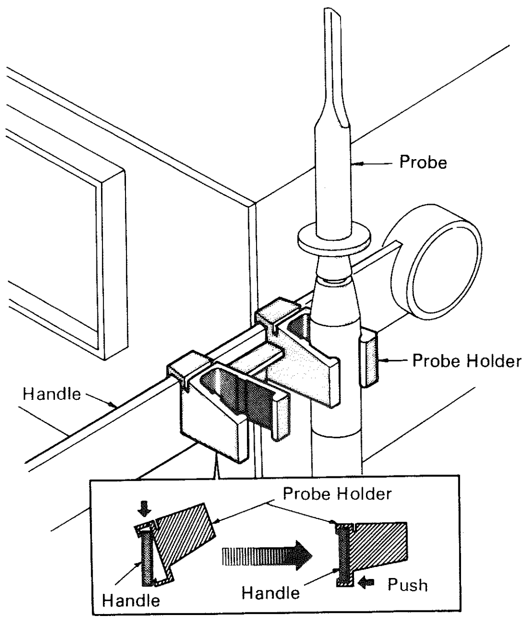
When H. DISPLAY control is set to DUAL and two or four waveforms are displayed, the CH1 and CH3 waveforms are displayed in A sweep mode and CH2 and CH4 waveforms are displayed in B sweep mode. Therefore, adjust the A and B. TRIG SOURCE control accordingly.



ACCESSORY, OPTION

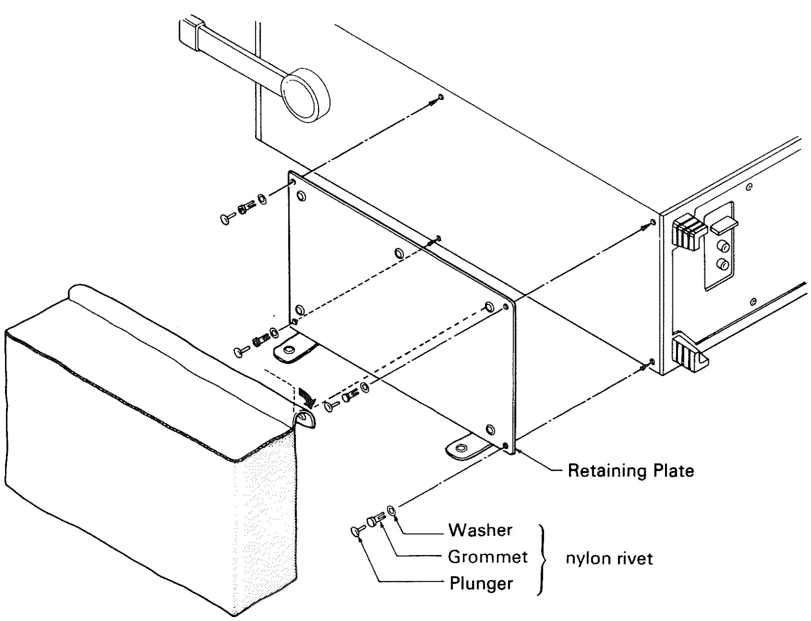
INSTALLING PROBE HOLDER

1. The probe holder is installed in the metal portion of the handle and catches the probe shaft.
2. To install the probe holder, engage the upper two claws with the handle and then engage the lower claw.
3. According to the probe shaft thickness, the probe can be attached as shown below.
4. To remove the probe holder, disengage the lower claw first.



INSTALLING ACCESSORY BAG (OPTION)

1. Detach the hock and separate the accessory bag and retaining plate.
2. When viewed from the front, align the four case right side holes with those of the retaining plate and fix the retaining plate with 4 nylon rivets and 4 washers.
   At this time, confirm that the retaining plate is installed grommet and insert the plunger.
   To remove the nylon rivet, wrench out the plunger with a ⊖ screwdriver.
3. Then mount the accessory bag to the retaining plate with hook.



CIRCUIT DESCRIPTION

VERTICAL ATTENUATOR

The CS-2100A input attenuator consists of two stages of attenuation having 1/2, 1/4 and 1/10 steps and the other having either 1/10 or 1/100 attenuation to form an overall ten point attenuator in 1-2-5 sequence.
The signal from the attenuator is passed to a dual FET impedance conversion circuit (Q1). Its output is sent to IC12.
Variable gain is achieved by varying the emitter resistance of IC12.
The output of IC12 is sent to the vertical pre-amp.
The arrangement for CH2 is the same as for CH1.
Each channel has a 50Ω termination that can be switch selected.

VERTICAL MODE LOGIC CIRCUIT

Instead of the usual mechanical switches used on other instruments the CS-2100A makes use of electronic switching. The switches themselves generate a single pulse output when operated so that the various combinations of switches and holding of selected modes must be done with external logic circuitry. The circuit that accomplishes this is the Vertical Mode Logic Circuit. The pulses generated when the switches are operated are shaped by a schmitt trigger circuit and sent to the rest of the circuitry. IC6 is a latch used to hold a single pulse. The input signal, passing through the circuit formed by D5-D11 and IC3, IC2 and IC7 is a delayed pulse which acts as the trigger for IC6. In this way IC6 holds the data that represents the fact that a switch has been depressed. IC4 acts as a logical single pole double throw switch to select one of DUAL/QUAD and ALT/CHOP. CH2 inverter and 20MHz BW switching functions are managed (ON-OFF) by IC10 which acts as a SPST switch. The output of IC4 is also latched into IC6. The output of IC6 is used to drive the vertical mode LED's through IC8, IC11, IC5 and IC9.

VERTICAL PRE-AMP CIRCUIT

The CS-2100A has four pre-amp circuits to allow 4-channel operation. The output of the vertical attenuator is fed to IC1, an amplifier.
For CH2 an inverting stage, IC2, is provided to allow switched inversion of that channel only. Q2 and Q3 form the CH1 position circuit.
Q50 and Q51 form the CH2 position circuit which operates in a similar fashion to the circuit for CH1. Q4 and Q5 are x1 amplifier stages (for CH1) and Q6, Q7 are x5 amplifier stages. The circuit formed by Q8 and Q9 is used to switch between × 1 and × 5 gain for CH1. For CH2, Q52/Q53 and Q54/Q55 along with Q56 and Q57 have the same functions. Q10/Q11 and Q19/Q20 for a cascoded amplifier.
Q18 and Q21 in combination with Q19 and Q20 form a switching circuit. This circuit is used to turn the CH1 signal on and off.
Q12 and Q13 form the trigger amplifier. The trigger signal passes through the buffer output amplifier formed by Q14 and Q15, being converted to 50Ω impedance and is sent to the A trigger switch circuit. For channel 1 only, the vertical signal passes through the stage formed by Q16 and Q17 to the rear panel connector for CH1 output. The circuit configuration for CH2, CH3 and CH4 is similar except that the CH3 and CH4 position adjustment is accomplished by means of PCB mounted trimmers VR1 and VR2.
The CH1 through CH4 signals are amplified by the output amplifier formed at the base side of the emitter follower formed by Q42 and Q43. This amplifer consists of Q44 and Q45 whose output is sent to the delay line.
Q38/Q39 and Q40/Q41 for the trigger amplifier which sends the signal of the output amplifier to the A trigger switch circuit and acts as the V MODE trigger source. Q37 acts as the load resistance switch for the ADD mode. Q33-Q36 form the 20MHz bandwidth circuit which limit the vertical bandwidth to −3dB down at 20MHz.
CH1 through CH4 signals are switched by the logic circuit formed by IC3 - IC7 in accordance with the vertical mode and horizontal mode selected.

VERTICAL OUTPUT AMPLIFIER

The signal from the delay line is sent to the vertical output amplifier. Q1, Q2, Q3 and Q4 form a cascoded differential input amplifier. Q11 forms a bias current stabilization circuit which in conjuction with Q12 forms the beam finder circuit.
Q7 −Q10 form the final output stage.
Q5 forms the trace separation circuit.

A TRIGGER SWITCH CIRCUIT

The CH1-CH4, V MODE signals are sent to the A trigger switch circuit. S1 is the trigger source switch with S2 acting as the trigger coupling selection switch. Q1 and Q2 form the FIX synchronization circuit, which detects the peak value of the signal and acts as an automatic trigger level control.
Q3 and Q4 form the VIDEO sync circuit which detects the trigger signal of the TV picture signal for stable display.
Q6 and Q7 form an impedance converting emitter follower circuit to lower the output impedance to drive the next stage. Q8 and Q9 form a circuit which is used to improve the CMRR. This circuit is a feedback amplifier. IC1 is a cascode amplifier used as the polarity reversal (inversion) circuit for the trigger signal. Q10 forms an impedance conversion stage used to convert the output of the IC1 stage to 50Ω for output to the horizontal sweep unit.

B TRIGGER SWITCH CIRCUIT

Basically this circuit operates as does the A trigger switch circuit. Q1 accepts the CH2 trigger input and uses this signal to form the X signal for X-Y operation. Other aspects of operation are the same as the A trigger switch circuit.

CIRCUIT DESCRIPTION

SWEEP ROTARY CIRCUIT

This circuit is a part of the sweep circuit, but is located on a separate board. It is composed of a rotary switch to select the sweep time and resistors of the HOLDOFF circuit.

HORIZONTAL SWEEP CIRCUIT

This sweep circuit uses a constant current integrated circuit to obtain sawtooth waveform by charging capacitor with constant current.

Q14, Q16, Q18 form the circuit that switches the sweep time capacitors for A sweep.

For the B sweep, this function is managed by Q43, Q45, Q47 in the same manner.

Q13, Q15 and Q17 form the circuit that switches HOLDOFF capacitor for the A sweep, and in the case of B sweep the same operation is carried out by transistors Q42, Q44 and Q46. The voltage supplied by the constant voltage circuit is converted to a constant current source by the voltage setting circuit comprised of IC3a and transistor Q8 and the resistor which is selected by the rotary switch.

This current is used to charge the sweep time capacitor, and result in a rise voltage at the capacitor terminals. This voltage is sent to a high impedance buffer amplifier composed of Q19 and Q20.

When the output of this amplifier reaches a constant voltage value, IC7d is switched on and IC2b flip-flop is reset. At the same time IC2a is set.

The output of IC2a turns on Q7 and enshorts the sweep time capacitor. The terminal output voltage of the capacitor falls.

At the same time the constant current circuit which is composed of Q22 changes one of the following HOLDOFF capacitors; C13, C19, or C23.

The terminal voltage of the capacitor increases step by step. When this terminal voltage goes beyond the threshold level Q23 is turned on. The output of Q23 turns on the SCHMIDT trigger circuit which is composed of IC2b. The output of IC2b cancels the set condition of IC2a and sweep is once again started. The trigger signal sychronizes IC2a through IC1a, IC1b. It cancels the set of the flip-flop when it is in the set state and starts the sweep which is synchronized to the trigger signal.

The SCHMIDT trigger circuit is composed of IC1a and IC1b. The trigger signal which is smoothed by IC1a and IC1b is supplied to IC1c, Q3 and Q4. When there is a trigger signal, IC1d gate is closed and IC2a operates as the master slave flip-flop.

When there is no trigger signal IC2a opens the gate of IC1d and operates R-S flip-flop. This is the auto free run circuit.

Q24 to Q26 form the delay sweep level detection circuit.

When the voltage level increases as set by DELAY TIME MULTIPLIER, Q24 is turned on and triggers IC8a gate, IC8a and IC10b compose the logic differential circuit. It makes constant width pulse which activates IC5b and starts B sweep circuit is approximately the same as A sweep circuit, but it does not have 3 low speed ranges. IC4d gate is selected from master slave flip-flop using B START AFTER DELAY switch, and has trigger priority to R-S flip-flop.

The sweep can be started from the voltage level set by the DELAY TIME MULTIPLIER. A sweep horizontal position adjustment is carried out by Q53, and B sweep by Q54. The selection of HORIZONTAL DISPLAY is carried out by Q55 to Q58. A and B sweep waveform is synthesized by Q55 and Q58 collectors and X-Y signal is also sythesized at this point by Q59.

The signal through Q60 enhances CMRR and is sent to next stage by Q62 and Q63. Q64 and Q65, and Q66 and Q67 are selected times one and times ten (x1 and x10) by Q69 and Q68 respectively. The impedance is converted to 50 ohms and is sent to the horizontal output amplifier by Q70 and Q71.

The trace SEP circuit is composed of Q78 to Q80 and two different bias voltages are sent to the vertical output amplifier by the A and B sweep signals. IC8d is the reset-pulse generator circuit in the case of signal sweep operation and also produces the blanking control signal when it is necessary to produce horizontal display using IC13a, IC14a and IC14e.

This circuit combines the sweep and chop signal using IC11a, IC11b, IC11c, IC11d and IC12d. The impedance is converted in Q72 to Q75.

This signal becomes the input signal of the blanking circuit.

The signal in the case of DUAL or QUAD setting of the vertical axis mode produced in IC12a, IC12b, IC13b, IC14c, IC14d, IC15a, IC15b, IC15c and IC15d and D48 to D50.

IC12a and IC12b comprise the chop oscillator. The vertical mode logic and horizontal mode logic signal switch this oscillator on and off. In the case of oscillation stopping this oscillator produces an alternate signal output.

On receiving a signal from IC14e, the output of IC12a and IC12b is turned off in the case of vertical axis single trace operation by IC15d.

However this output can be supplied in another case. The output of Q77 is supplied to the vertical amplifier and the output is separated into chop and alternate signals.

HORIZONTAL MODE CONTROL CIRCUIT

The switch states are latched by IC4 and IC7 which effectively makes these non-locking switches into locking types functionally.

For horizontal display D1-D9 and IC1d—IC1f are used to hold 3 bits of coded status information. Waveform shaping is used in the IC1 circuit to prevent misoperation. Diodes D10—D12 and IC2c—IC2e and IC3d form a circuit that is used to detect what switch of the horizontal group has been depressed.

The detected switch data is entered into the register IC4 which then holds the switch status. IC5 is a tri-state buffer. IC6 is used to restore the encoded switches status information on a one to one basis for all functions. Switch status held until a particular switch is pressed for a second time.

CIRCUIT DESCRIPTION

The output of IC6 is used to drive an LED and as a control signal for blanking and sweep switching. The operation of the trigger mode switch input is the same as for the horizontal display switch group. Diodes D13-D16 and IC1a and IC1b are used to encode 2 bits of switch status information for this switch group after pulse shaping is done. D17, D18 IC2a, IC2b, IC2f and IC3a determine whether an input is present, writing into the register IC7a and IC7b the appropriate status information.
This register holds the switch status encoded information until IC8 is used to cancel, or return the status information based on alternate operation of the switches. Similar to the horizontal display switch group, once depressed a switch mode is maintained until the switch is depressed once more. IC5a, IC5b, and IC5c are tri-state buffers. IC9a, IC9b, and IC9d−IC9f along with Q1−Q3 form buffers for the switch LED's and sweep circuit. The output from the trigger mode reset switch is pulse shaped and sent to the trigger sweep circuit.
This circuit holds data even when the instrument's power supply switch is turned OFF. That control is performed by Q4, D19, D20, IC3 and IC8a.

D19 and D20 form a power supply based on the internal lithium battery for memory backup. IC3b and IC3c detect the power OFF condition and generate a memory save signal. The output of the above circuit forms the set of control signals used to control the vertical mode logic circuitry.

CALIBRATING VOLTAGE CIRCUIT

Q11 and Q12 form a multivibrator circuit which generates a signal which is subsequently converted to a low impedance by means of Q10 for output as the calibration signal. It is also used for creation of a current calibration signal by means of R70 and R71. The current calibration signal is output via a rear panel terminal. IC17 is used to regulate the voltage generated by this calibration circuit.

CH3 and CH4 INPUT CIRCUITS

These circuits consist of an attenuator and buffer amplifier. Q16 drives a relay to switch the attenuation between 1/1 and 1/10. The signal from the attenuator is impedance converted with the circuit formed by Q13a, Q13b, Q14 and Q15 and sent to the vertical pre-amplifier. The operation and configuration of the CH4 circuit is similar to the CH3 circuit.

HORIZONTAL OUTPUT AMPLIFIER

The signal from the horizontal sweep circuit is amplified by the differential amplifier formed by Q1 and Q2. The output signal of this circuit is then passed to the emitter follower circuit formed by Q5 and Q6 for impedance conversion to enable driving the circuit formed by Q7 and Q8. Q9 and Q10 form a voltage regulation circuit which serves as the DC load for Q7 and Q8 respectively with AC peaking performed by means of C15 and C16. Q11 and Q12 form an auto-bias circuit which automatically controls the operating point of the output stage. It also serves as the beam finder circuit such that when the base of Q13 is grounded the operating point of the output stage is lowered, resulting in a shrunken display.

SWITCHING POWER SUPPLY UNIT

Although the CS-2100A is light and compact, and make use of a switching regulator type power supply.
Input of either 100V of 200V is rectified and a smoothing capacitor is used to generate a smooth DC output of approximately 200V.
Next, a power transistor is used to convert this output to an AC voltage which is used to drive a compact type converter transformer. The transformer used has 6 bifilar windings which create six separate outputs which are then rectified and smoothed to provide the supply for the blanking unit directly. One of the outputs is compared with a reference voltage to form an error voltage used for regulation. The error voltage is sent to the error voltage amplifier, the output of which is used to control the base of the power transistor. This output is isolated from the primary by means of a photocoupler.

POWER BLANKING UNIT

The five remaining outputs from the switching regulator power supply are further regulated using a series regulation method. This accomplished with Q1, Q3−Q6. IC1a, IC1b, IC2a and IC2b are error voltage amplifiers. The +20V derived by use of a resistance voltage divider. A conventional high voltage DC-DC converter is used. Q25−Q27 are error voltage amplifiers with Q29 acting as a control transistor. The CS-2100A provides independent A and B sweep intensity controls. This function is implemented by means of the circuit formed by Q13−Q15. Q16 forms the beam finder circuit which allows the beam to be seen even if the intensity control has been inadvertently turned to minimum. Q17 forms the external intensity (Z-axis) modulation circuit which accepts an input and results in brighter displays for increasing inputs.
The signals from these circuits are combined at the base of Q18 to drive Q19. Q20 forms the DC load for Q19 with C25 acting to provide AC peaking for this circuit. Q21 and Q22 form the auto-focus circuit which apply a signal to the focus electrodes of a reverse phase from the blanking signal. Q23 and Q24 act to restore the DC component of the blanking and auto-focus circuits by using differential amplifiers for isolation. Q8 controls scale illumination with Q9 and Q10 controlling the adjustment of trace rotation. Q11 and Q12 are used to adjust perpendicularity.

CIRCUIT DESCRIPTION

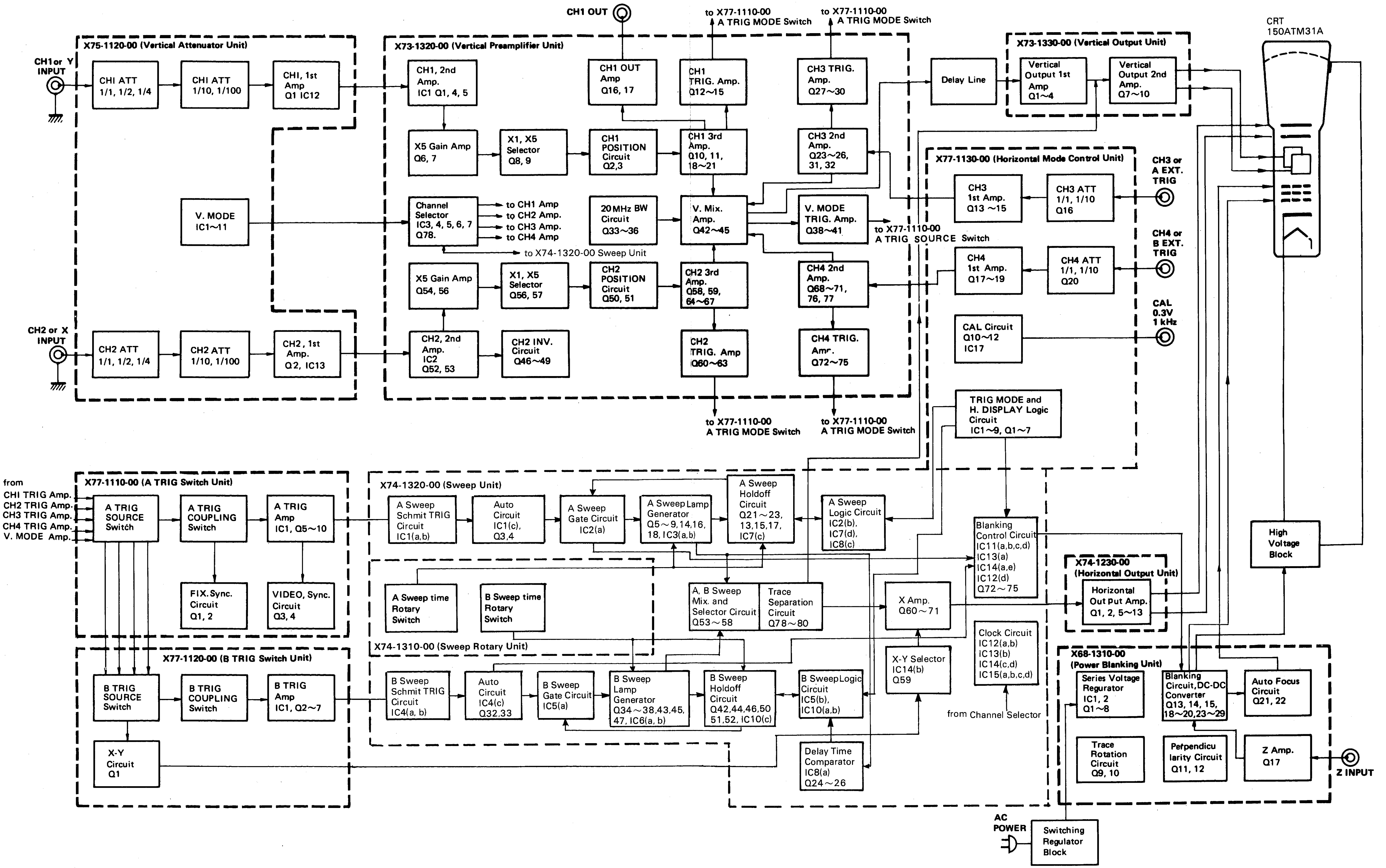
HIGH VOLTAGE UNIT

The post-acceleration voltage of the CS-2100A is 16kV requiring the high voltage unit to be protected from the hands of the user if safety is to be maintained.

This protection also is required to prevent leakage.

To achieve this goal, the high voltage unit of the CS-2100A has been encapsulated in resin to form a high voltage "block". In the block are the high voltage DC to DC converter as well as the 1.75kV cathode voltage supplies rectifier. In addition to the anode cap which makes available 14kV, the block has 1.75kV DC and 6.3V AC outputs.

BLOCK DIAGRAM

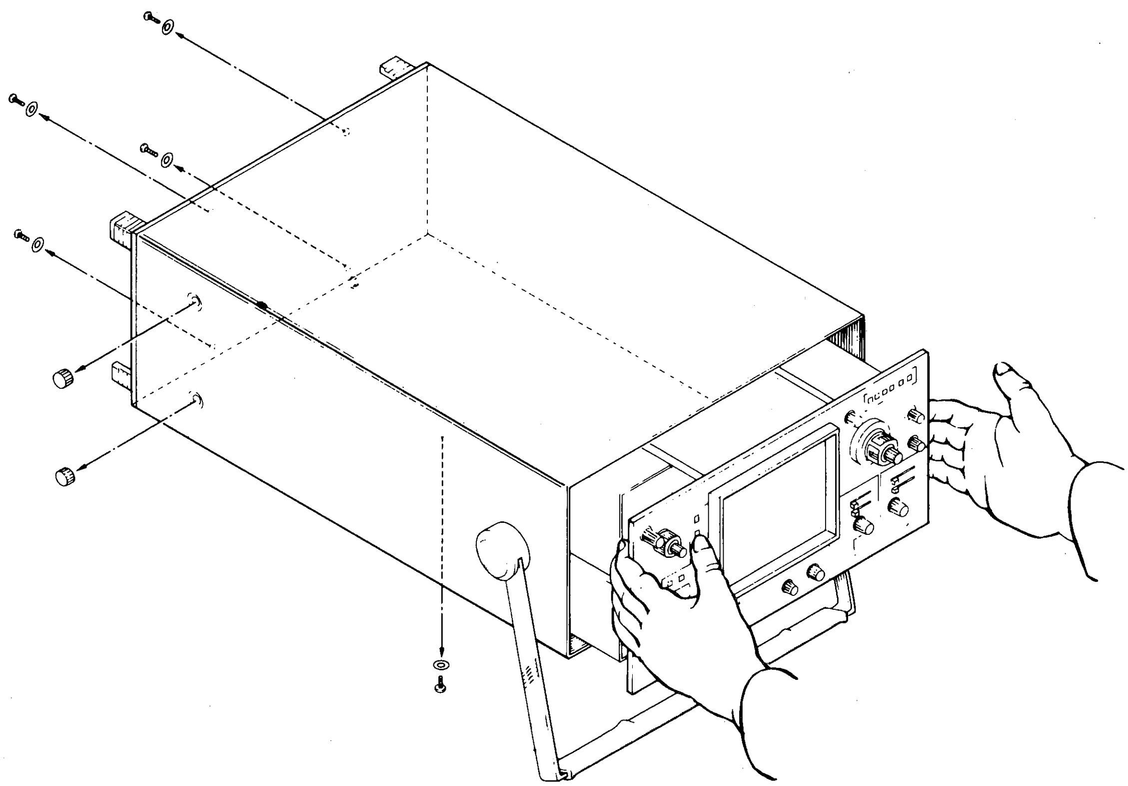


MAINTENANCE

REMOVAL OF CASE

1. Pull out CH3 and CH4 POSITION knobs.
2. Remove the 4 screws located at the rear of the case and the 1 located at bottom with a ⊕ screwdriver. Carefully slide the body forward from the case.
3. To install the body in the case, place the case horizontally and slide the body into the case using the rails located at the bottom of the case. Then, place the body vertically and engage the case front edge into the front panel groove.
4. Temporarily insert the case retaining screws and then tighten them evenly.
5. Install the CH3 and CH4 POSITION knobs.

CAUTION:
A voltage of 16kV is applied to the CRT socket and anode cap. Before removing the case, turn the power off and pull out the power plug. After removing the case, take care not to touch them.



REMOVING/INSTALLING CRT

1. When servicing CRT, do not loosen the CRT band. Only remove the CRT retaining screws, then slide the CRT backward and raise the socket. The CRT can be removed easily.
2. Insert the CRT from the socket side until the CRT comes in contact with the shield plate and tighten the CRT band retaining screws.
3. As slots are provided in the CRT bracket, the CRT can be moved right and left, and back and force.
   As the bracket is inclined by 45°, the CRT can be positioned in an arbitrary position. To fix the CRT, fix the CRT band, then fix the bracket.

CAUTION:
A high tension voltage is remained at the anode of the CRT. Before removing the CRT, connect the anode to the ground via a 100 kΩ load for 5 seconds to discharge the voltage.

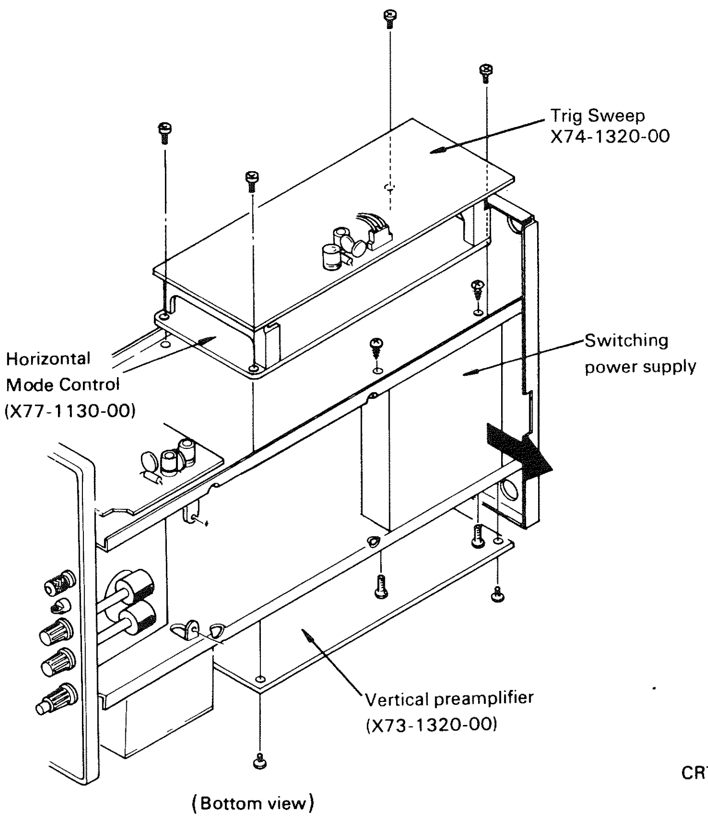
TROUBLESHOOTING

1. Confirm that the voltage selector is set to the correct position.
2. If one of the mode LEDs does not light, the unit will not operate correctly. When using the unit, confirm that the LED lights up.
3. To service the unit effectively, isolate the failure first. Then, remove the case and check the wiring, P.C.B, pattern and parts.
4. A low voltage power supply will affect the circuitry. Do not use the low voltage power supply for checking.

MAINTENANCE

REPLACING SWITCHING POWER SUPPLY

The switching power supply is housed in the shield case located at the rear. To remove the switching power supply, remove the horizontal logic circuitry (right) and vertical preamplifier (left) and remove the retaining screws which fix the shield case to the frame.



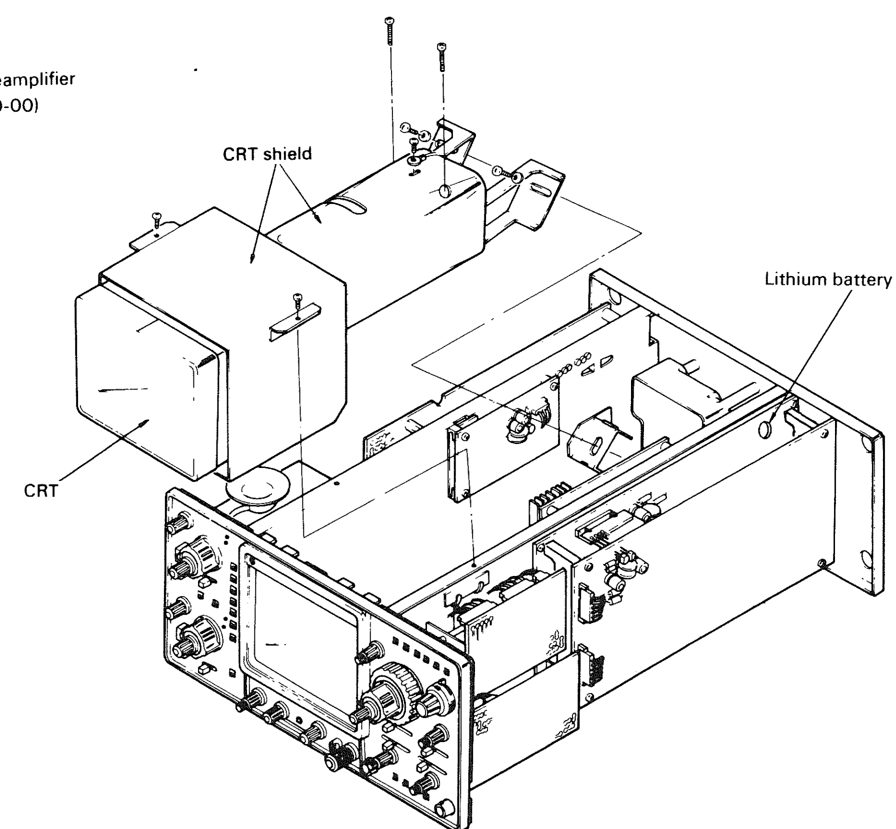
Replacing switching power supply

REPLACING BATTERY

A disc type Lithium battery is installed in the horizontal mode control unit (X77-1130-00). The voltage of the battery is 2.7V. When the voltage drops to 2.0V, replace the battery.

Before replacing the battery, set the unit to the operation mode and confirm that each switch with built-in LED is set correctly.

To remove or install the battery, apply a soldering iron to the parts side of the P.C.B. When installing the battery, observe the polarity. The polarity is indicated on the parts side of the P.C.B.



Removing/installing CRT

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