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MODEL COS6100M

OSCILLOSCOPE

841002KK21

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1. GENERAL INFORMATIONS

1.1 Equipment Description

The COS6100M is a solid state, five channel, twelve trace, 100 MHz bandwidth, general purpose oscilloscope. Vertical mode switching enables any combination of five channels to be displayed simultaneously. Channels 1 (CH1) and 2 (CH2) each has ten calibrated deflection factors from 5 millivolts/division to 5 volts/division selected in a 1-2-5 sequence. The horizontal deflection system has calibrated sweep rates of 20 nanoseconds/division to 0.5 seconds/division in 23 steps. A ten times magnifier expands each horizontal sweep to maximum of 2 nanoseconds/division. An X-Y display mode is provided via an X-Y selector switch.

1.2 Features

The features of the COS6100M Oscilloscope can be summarized as follows:

(1) Ease of use:

Light torque lever switches and pushbutton switches are used. These and other controls are laid out in the most convenient locations making the oscilloscope extremely easy to operate.

(2) Clear waveform observation:

The cathode-ray tube is a 6-inch large-screen rectangular type CRT with a red internal graticule of 80 mm × 100 mm (3.15 in. × 3.94 in.) The red graticule produces a high resolution background for easy waveform viewing.

(3) High acceleration voltage (20 kV):

The high acceleration voltage of the CRT ensures a bright trace for observation and photography.

(4) High sensitivity and wide frequency bandwidth:

The maximum vertical sensitivity is 1 mV/DIV (with ×5 MAG) and the frequency response is 100 MHz or greater (-3 dB).

(5) High input impedance:

The input impedance of CH1, CH2, CH3, CH4 and CH5 (EXT TRIG) is 1 MΩ ±1%, 20 pF ±2 pF, allowing the use of 10× Probes.

(6) 5-channel simultaneous display:

The COS6100M employs a new type of vertical mode switching circuit which enables display of any combination of CH1, ADD (CH1 ± CH2), CH2, CH3, and TRIG VIEW (CH4 and CH5). Up to five channels can be displayed simultaneously; up to twelve traces can be displayed when in the alternate sweep mode.

(7) Trigger level lock:

A new trigger level lock circuit eliminates the requirement of triggering adjustments on most signals. (Manual control is still available for triggering on complex waveforms.)

(8) Stable alternate triggering function:

When in the alternate triggering mode, stable triggering can be attained even when the signals of CH1, CH2 and CH3 are not time releated. (patent pending)

(9) B END'S A switch separated from holdoff control knob:

The B END'S A switch is installed separately from the holdoff control switch. Holdoff control can be used while in the B END'S A mode.

(10) Maximum sweep time 2 nsec/DIV with ×10 MAG function:

With the ×10 MAG function, the highest sweep speed of 20 nsec/DIV can be multiplied by a factor of 10 to attain a maximum sweep speed of 2 nsec/DIV.

(11) Alternate sweep:

The A sweep and the delayed sweep can be viewed simultaneously in the alternate mode.

(12) Linear focus:

Once the beam focus is adjusted, it is automatically maintained in this state regardless of changes in intensity.

(13) Multiple-channel X-Y operation:

By using the CH3 HOR channel as the X-axis input and all other channels as the Y-axis inputs, up to four channels of X-Y operation can be viewed.

2. SPECIFICATIONS

Leading Paticulars.

Table 2-1 through 2-3 list the electrical, environmental, and physical characteristics of the COS6100M. The electrical characteristics are valid under these conditions:

(1) The instrument has been calibrated (adjusted) as described in Section 7 at an ambient temperature between +10°C and +35°C (+50 to +95°F).

(2) The instrument is operating in an ambient temperature between 0 and +55°C (+32 to +131°F).

(3) The instrument has warmed up for 5 minites.

Table 2-1. Electrical Characteristics

VERTICAL AXIS

ITEM	CHARACTERISTIC	REMARKS
CH1 and CH2		
Sensitivity	5 mV/DIV - 5 V/DIV 1 mV/DIV - 1 V/DIV (when x5 MAG)	1-2-5 sequence, 10 ranges
Sensitivity accuracy	±2% ±3% ±4% (when x5 MAG)	0 - 40°C 40 - 55°C 10 - 35°C
Variable vertical sensitivity	To 1/2.5 or less of panel-indicated value	

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTIC	REMARKS
Frequency bandwidth	DC - 100 MHz (-3 dB) DC - 10 MHz (-3 dB), when x5 MAG AC coupling: Low limit frequency 10 Hz	Whith reference to 50 kHz, 8 DIV. Except when in bandwidth limit mode
Input coupling	AC, DC, GND	
Input impedance	1 MΩ ±1%, 20 pF ±2 pF	
Allowable input voltage	±250 V (DC + AC peak) at 20 kHz ±10 V (DC + AC peak) at 1 MHz	
Square wave characteristics	Overshoot: Not greater than 3% Other distortions: Not greater than 3% (except for 2 V, 5 V/DIV ranges)	10 to 35°C (50 to 95°F) VARIABLE knob is CAL'D position.
CH3 (HOR)		
Sensitivity	0.1 V, 1 V/DIV	
Sensitivity accuracy	±3%	10 to 35°C (50 to 95°F)
Frequency bandwidth	DC - 100 MHz (-3 dB) AC coupling: Low limit frequency 10 Hz	
Input coupling	AC, DC, GND	
Input impedance	1 MΩ ±1%, 20 pF ±2 pF	
Allowable	±250 V (DC + AC peak) at 20 kHz ±10 V (DC + AC peak) at 1 MHz	
Square wave characteristics	Overshoot: Not greater than 5% Other distortions: Not greater than 3%	10 to 35°C (50 to 95°F)
CH4 and CH5	CH4: A TRIG EXT input CH5: B TRIG EXT input	
Sensitivity	0.1 V, 1 V/DIV	
Sensitivity accuracy	±3%	

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTIC	REMARK
Frequency bandwidth	DC - 100 MHz (-3 dB) AC coupling: Low limit frequency 10 Hz	With reference to 50 kHz, 4 DIV
Input coupling	CH4: AC, HF REJ, LF REJ, DC CH5: AC, HF REJ, LF REJ, DC	Selectable with the coupling switch
Input impedance	1 MΩ ±1%, 20 pF ±2 pF	
Allowable input voltage	±50 V (DC + AC peak)	Frequency 1 kHz or lower
Square wave characteristics	Overshoot: Not greater than 10% Other distortions: Not greater than 5%	10 to 35°C (50 to 95°C)
Rise time	3.5 nsec or less (Approx. 35 nsec when x5 MAG)	
Signal delay time	Approx. 40 nsec (with delay cable of approx. 100 nsec)	The displayed portion preceding the triggering point
Polarity change	CH2 only	
DC balance shift	0.2 DIV, when changes calibrated vertical deflection range	
DC drift	CH1 and CH2: Not more than 0.1 division/hour	
Display modes	Simultaneous displays of CH1, ADD (CH1 + CH2), CH2, CH3, and TRIG VIEW (CH4 and CH5) are possible in any combination. Single X-Y (CH1 for X-axis and CH2 for Y-axis) also is possible.	
Chopping repetition frequency	1 MHz/(number of displayed channels) ±40%	
Common mode rejection ratio	25:1 to 10 MHz, sinusoidal wave 10:1 10 - 50 MHz	When sensitivities of CH1 and CH2 are set equal

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTICS	REMARKS
Isolation between channels	At least: 100:1 to 10 MHz 50:1 10 - 20 MHz 25:1 20 - 50 MHz 15:1 50 - 100 MHz	At 5 mV/DIV range
Bandwidth limit	With filter for approx. 3 dB attenuation at 20 MHz ±5 MHz	
CH1 signal output		
Output voltage	Approx. 10 mV per 1 DIV deflection amplitude on screen	50-ohm termination
Frequency bandwidth	DC - 100 MHz (-6 dB)	
Output resistance	Approx. 50 ohms	

TRIGGERING

ITEM	CHARACTERISTICS	REMARKS
Internal trigger section (INT TRIG switch)	CH1, CH2, CH3, ALT (When in ALT mode, a trigger source is selected depending on the vertical operation mode.)	When in ADD, the CH1 input signal is used as the trigger source signal.
A trigger		
Signal source	INT, LINE, EXT, EXT/10	
Coupling	AC, HF REJ, LF REJ, DC	
Polarity	+ or -	
Sensitivity	DC - 0.3 DIV internal or 50 mV p-p external From DC to 25 MHz 1.0 DIV internal or 150 mV p-p external From 25 MHz to 100 MHz AC - 0.3 DIV internal or 50 mV p-p external From 30 Hz to 25 MHz 1.0 DIV internal or 150 mV p-p external From 25 MHz to 100 MHz	

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTIC	REMARKS
A trigger (Continued) Sensitivity (Continued)	LF REJ - 0.3 DIV internal or 50 mV p-p external From 15 kHz to 25 MHz 1.0 DIV internal or 150 mV p-p external From 25 MHz to 100 MHz HF REJ - 0.3 DIV internal or 50 mV p-p external From 30 Hz to 50 kHz	
B trigger		
Signal source	INT, EXT, EXT/10	
Coupling	AC, HF REJ, LF REJ, DC	
Polarity	+ or -	
Sensitivity	Same as A trigger	
EXT trigger input	CH4 and CH5 input terminals used in common	
Input impedance	1 MΩ ±2%, 20 pF ±2 pF	
Maximum allowable input voltage	±50 V (DC + AC peak)	Frequency 1 kHz or lower
AUTO mode	Satisfies the A trigger sensitivity specification for signal repetition frequency of 40 Hz or over.	
LEVEL LOCK	Satisfies the value of the above trigger sensitivity plus 0.5 DIV (0.05 V) for signal of duty cycle 20:80 and repetition frequency 50 Hz - 80 MHz.	
TRIGGER LEVEL control range		
EXT	At least ±1 V or 2 V p-p	
EXT ÷ 10	At least ±10 V or 20 V p-p	
Trigger jitter	0.5 nsec or less (at 5 nsec/DIV sweep rate)	

Table 2-1. Electrical Characteristics (Continued)

HORIZONTAL AXIS/TIME BASE

ITEM	CHARACTERISTIC	REMARKS
Horizontal axis display	A, A INT, ALT, B (DLY'D)	
A sweep		
Sweep mode	AUTO, NORM, SINGLE	
Sweep time	20 nsec/DIV - 0.5 sec/DIV 2 nsec/DIV - 50 msec/DIV (when in "x10 MAG")	1-2-5 sequence, 23 ranges
Sweep time accuracy	±3%	0 to 55°C (32 to 131°F)
Variable sweep time	To 1/2.5 or slower of panel-indicated value	
Holdoff time	Continuously varible to 2 times or over of sweep time/DIV at 20 nsec/DIV - 0.1 sec/DIV ranges	
B sweep		
Delay system	Continuous delay or triggering delay	
Sweep time	20 nsec/DIV - 0.5 sec/DIV 2 nsec/DIV - 50 msec/DIV (when in "x10 MAG")	1-2-5 sequence, 23 ranges
Sweep time accuracy	±3%	0 to 55°C (32 to 131°F)
Delay time	0.2 µsec - 5 sec	Depends on A sweep rate
Horizontal position drift	Not more than 0.1 DIV/hour	
Differential time measurement	1% + 0.1% of full scale for two or more major dial divisions for 15 - 35°C plus 1% for 0 - 15°C, 35 - 55°C	Excluding between 0.0 and 0.1 and 50, 20 nsec/DIV setting

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTIC	REMARKS
Delay jitter	1/20,000 or less $\frac{\text{B sweep time}}{\text{A sweep time}} \times \frac{\text{jitter width}}{\text{10 DIV}}$	Jiter width 0.5 DIV or less at A: 1 msec/DIV B: 1 μsec/DIV
Sweep magnification	10 times (maximum sweep time 2 nsec/DIV)	Both A and B
Magnified sweep time accuracy	50 nsec/DIV - 0.5 sec/DIV ranges: ±5% 20 nsec/DIV range: ±8%	0 to 55°C (32 to 131°F)
Linearity (unmagnified)	Within 0.25 minor (0.5 mm) divisions	
Magnifier position shift	Within 2.5 dvisions	
CH3 sweep (CH3 HOR)	CH3 input signal is used as sweep signal. For vertical axes, any combination of CH1, ADD (CH1 + CH2), CH2, and TRIG VIEW can be simultaneously displayed in CHOP mode.	
Sensitivity	0.1 V, 1 V/DIV	Same as CH3
Sensitivity accuracy	±3%	Same as CH3
Frequency bandwidth	DC - 5 MHz (-3 dB) AC coupling: Low limit frequency 10 Hz	With reference to 50 kHz, 10 DIV
Phase difference between vertical axes	Not greater than 3° at DC - 100 kHz	
X-Y mode	X-axis: CH1 input signal Y-axis: CH2 input signal	
Sensitivity	5 mV - 5 V/DIV Both axis	Same as CH1, CH2
X-axis sensitivity accuracy	±3% ±5% (when in "x5 MAG")	

Table 2-1. Electrical Characteristics (Continued)

ITEM	CHARACTERISTIC	REMARKS
X-axis frequency bandwidth	DC - 5 MHz (-3 dB) AC coupling: Low limit frequency 10 Hz (Y-axis) Same as CH2	With reference to 50 kHz, 10 DIV
X-Y phase difference	Not greater than 3° at DC - 100 kHz	
Main sweep Gate output	Main sweep gate signal	
Output voltage	At least 0.5 volts positive pulse	Zo ≒ 100Ω
Delay sweep gate output	Delayed sweep gate signal	
Output voltage	At least 1 volt positive pulse	Zo ≒ 120Ω

Z AXIS

ITEM	CHARACTERISTIC	REMARKS
Sensitivity	3 Vp-p (Trace becomes brighter with negative input.)	
Frequency bandwidth	DC - 15 MHz	
Input resistance	5 kΩ ±10%	
Allowable input voltage	±25 V (DC + AC peak)	AC: 1 kHz or less

Table 2-1. Electrical Characteristics (Continued)

CALIBRATOR

ITEM	CHARACTERISTIC	REMARKS
Waveform	Positive-going square wave	
Frequency	1 kHz ±10%	
Duty ratio	Within 25%	
Output voltage	1 V, 200 mV ±1%	0 to 55°C (32 to 131°F)
Rise time	Less than 1 µsec	
Output resistance	1 V: Approx. 1 kΩ 200 mV: Approx. 200Ω	

CRT

ITEM	CHARACTERISTIC	REMARKS
Type	6-inch rectangular type, internal graticule	
Fluorescent screen	P31 phosphor	
Acceleration voltage	Approx. 20 kV	
Effective screen size	8 x 10 DIV	1 DIV = 10 mm (0.39 in.)
Graticule	Internal graticule, continuously adjustable illumination	Red

Table 2-1. Electrical Characteristics (Continued)

POWER REQUIREMENTS

ITEM	CHARACTERISTIC	REMARKS
Line voltage range	A 90 to 110 V RMS (100 V ±10%) B 104 to 126 V RMS (115 V ±10%) C 194 to 236 V RMS (215 V ±10%) D 207 to 253 V RMS (230 V ±10%)	Selectable by connector change
Line frequency	48 to 440 Hz	
Power consumption	Approx. 56 watts	

PROBE

ITEM	CHARACTERISTIC	REMARKS
P100-S		
1:1	ATTENUATION 1X Input resistance 1 Megohm Input capacitance 200 pF or less Bandwidth (-3 dB) DC - 3 MHz Maximum input voltage ±250 V (DC + AC peak)	
10:1	ATTENUATION 10X Input resistance 10 Megohm Input capacitance 14 pF ±10% Bandwidth (-3 dB) DC - 100 MHz Maximum input voltage ±600 V (DC + AC peak)	

The COS6100M is designed to satisfy the rigid standards of MIL-T-28800A, type II, class 4, style C, and conform to following Enviromental Caracteristics as listed.

Table 2-2. Environmental Characteristics

TYPICAL ITEMS	CHARACTERISTIC
Temperature	Operating 0 to +55°C (+32 to +131°F) Storage -62 to +85°C (-79.6 to 185°F)
Humidity (Operating and storage	Five cycle (120 hours to 95% R.H. reference to MIL-28800A)
Altitude	Operating 10,000 feet Non-operating 50,000 feet
Vibration (Operating and non-operating)	Along each of the three major axis 5 Hz to 25 Hz 0.025 inches amplitude 25 Hz to 55 Hz 0.020 inches amplitude
Shock (Operating and non-operating)	Along each of the three major axis 30gs, 11 milliseconds duration 3 shocks each direction
Transit drop (non-operating	Drop unboxed instrument 8 inches an each corner and face for a total of 14 drops
Drip proof (Front cover on, non-operating)	Spray from 3 feet above instrument with instrument lifted 15° away from the horizontal plane in each of 4 horizontal directions
Bench handling	Edge lifts and drops on workbench on bottom and rear face, total of 8 drops. (The instrument will be operating when it is in the transit case and non-operating when removed).

Table 2-2. Environmental Characteristics (Continued)

TYPICAL ITEMS	CHARACTERISTIC	
EMI Test As per MIL-STD-462 performed by MIL-STD-461A	CE-01 30 Hz to 20 kHz	Power lead emission
	CE-03 20 kHz to 50 kHz	Power lead emission
	CS-01 30 Hz to 50 kHz	Power lead, radiation sus.
	CS-02 50 kHz to 400 MHz	Power lead, radiation sus.
	CS-06 Spike Test	Power lead, spike sus.
	RE-01 30 Hz to 30 kHz	Instrument radiation, mag.
	RE-02 14 kHz to 1 GHz	Instrument radiation, elec.
	RS-01 30 Hz to 30 kHz	Instrument sus. mag.
	RS-03 14 kHz to 1 GHz	Instrument sus. elec.

Table 2-3. Physical Characteristics

ITEM	CHARACTERISTIC
Weight Without protectiv front cover	Approx. 9.7 kg (21.3 lbs)
With protective front cover and accessories	Approx. 10.8 kg (24.0 lbs)
Hight (with feet)	165 mm (6.5 in)
Width With handle	365 mm (14.4 in.)
Without handle	325 mm (12.8 in.)
Depth With protectiv front cover	510 mm (20.0 in.)
Without protective front cover	475 mm (18.8 in.)
Handle extended	555 mm (22.0 in.)
Probe length P100-S	1500 mm (59 in.)

ACCESSORIES

P100-S probes (10:1, 1:1) ..... 2 sets

Hook tip x1	x1	(Probe accessories with each probe)
Marker tip x2	x2	
GND lead x1	x1	
Earth attachment	x1	
IC tip x1	x1	

Adapter Banana ..... (89-05-0000) 2

Alligator clip ..... (89-05-0010) 2

IC tip ..... (89-05-0020) 2

BNC plug to M jack ..... (83-90-0220) 2

BNC jack to M plug ..... (89-90-0230) 2

T, BNC to BNC ..... (89-90-0240) 2

Slow blow fuse 0.5 A 1

1 A 1

943 terminal adapter ..... (W4-962-401) 1

Power cord 1

Protective front cover (PFC-3) 1

Mash filter 1

Clear filter 1

Instruction manual 1

3. PRECAUTIONS BEFORE OPERATING THE OSCILLOSCOPE

3.1 Unpacking the Oscilloscope

The oscilloscope is shipped from the factory fully inspected and tested. Upon receipt of the instrument, please unpack and inspect it for any damage which might have been sustained during transportation. If any sign of damage is found, please notify the bearer and/or the dealer.

3.2 Checking the Line Voltage

The oscilloscope can operate on any one of the line voltages shown in the below table. Insert the line voltage selector plug in the corresponding position on the rear panel. Before connecting the power plug to an AC line outlet, be sure to check that the voltage selector plug is set in the position corresponding to the correct line voltage. Note that the oscilloscope may not operate properly or may be damaged if it is connected to a wrong voltage AC line.

When line voltages are changed, replace fuses as required.

Selector plug position	Nominal voltage	Voltage tolerance	Fuse
A	100 V	90 - 110 V	1 A, slow blow
B	115 V	104 - 126 V	
C	215 V	194 - 236 V	0.5 A, slow blow
D	230 V	207 - 253 V	

3.3 Environments

The normal ambient temperature range of this instrument is 0 to +55°C (+32 to +131°F). Operation of the instrument outside of this temperature range may cause damage to the circuit.

Do not use the instrument in a place where a strong magnectic or electric field exists. Such fields may disturb the measurement.

3.4 CRT Intensity

In order to prevent permanent damage to the CRT, do not make the CRT trace excessively bright or leave the spot stationary for an unreasonably long time.

3.5 Maximum Voltages of Input Terminals

The maximum voltages of the instrument input terminals and probe input terminals are as shown in the following table. Do not apply voltages higher than these limits.

Input terminal	Maximum allowable input voltage
CH1, CH2, CH3 inputs	±250 V (DC + AC peak) at 20 kHz
EXT TRIG (CH4, CH5) inputs	±50 V (DC + AC peak) at 1 kHz or lower
Probe input (10:1)	±600 V (DC + AC peak) at 1 kHz or lower
Z AXIS input	±25 V (DC + AC peak) at 1 kHz or lower

4. OPERATION METHOD

4.1 Explanation of Front Panel (See Figure 4-1.)

o CRT circuits:

POWER ..... (1) Main power switch of the instrument. When this switch is turned on, the LED (2) above the switch is also turned on.

INTEN ..... (7) Controls the brightness of the spot or trace.

(PUSH BEAM FIND) Even when the beam is outside of the screen, it can be located by pressing this beam finder button.

B INTEN ..... (6) Potentiometer for adjusting trace intensity when in B sweep mode.

FOCUS ..... (5) Focusing the trace to the sharpest image.

ILLUM ..... (3) Graticule illumination adjustment.

TRACE ROTATION ..... (4) Potentiometer for aligning the horizontal trace in parallel with graticule lines.

Bezel ..... (27) For installing a camera mount

Filter ..... (28) Blue filter for ease of waveform observation. Can be removed.

o Vertical axis:

CH1 (X) input ..... (21) Vertical input terminal of CH1. When in X-Y operation, X-axis input terminal.

CH2 (Y) input ..... (14) Vertical input terminal of CH2. When in X-Y operation, Y-axis input terminal.

CH3 (HOR) input ..... (12) Vertical input terminal for CH3. When TIME/DIV switch (39) is set in the [CH3|HOR] position, this terminal becomes the horizontal axis input terminal.

AC-GND-DC ..... (13) (20) Switch for selecting connection mode between input signal and vertical amplifier.

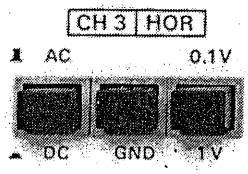


AC: AC coupling

GND: Vertical amplifier input is grounded and input terminals are disconnected.

DC: DC coupling

..... (9) (10) (11) Select input coupling and sensitivity of CH3.



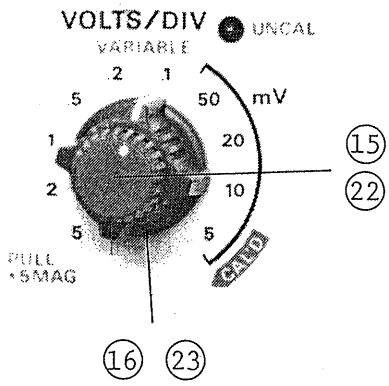
AC/DC: Selects coupling of input signal to CH3 amplifier between AC coupling and DC coupling.

GND: Grounds CH3 amplifier input signal and opens the input terminal.

0.1 V/1V: Selects CH3 amplifier sensitivity between 0.1 V/DIV and 1 V/DIV.

VOLTS/DIV ..... (16) (23) Select the vertical axis sensitivity, from 5 mV/DIV to 5 V/DIV with 10 ranges.

VARIABLE ..... (15) (22) Fine adjustment of sensitivity, with a factor of 1/2,5 or over of panel-indicated value. When in the CAL'D position, sensitivity is calibrated to panel-indicated value. When not in the CAL'D position, the UNCAL lamp (18) or (25) turns on.



When this knob is pulled out, the amplifier sensitivity is multiplied by 5 times.

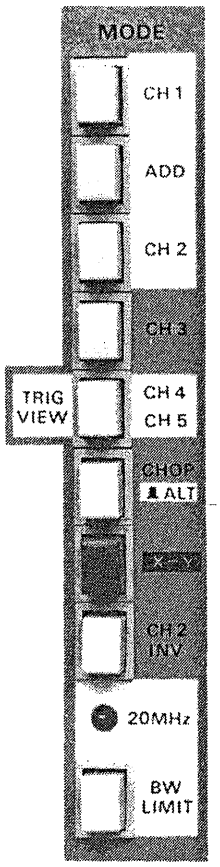
POSITION ..... (17) (24) Vertical positioning control of trace or spot.

When in X-Y operation, knob (24) is for horizontal positioning.

MODE ..... (26) Select vertical axis operation modes and frequency bandwidth limit function. Any combination of CH1, ADD (CH1 + CH2), CH2, CH3 and TRIG VIEW can be simultaneously displayed. The functions of the buttons as they are depressed are as follows:

CH1: CH1 signal is displayed.

ADD: Sum signal (CH1 + CH2) is displayed.



CH2: CH2 signal is displayed.

CH3: CH3 signal is displayed.

TRIG VIEW (CH4, CH5): By depressing the TRIG VIEW button it is possible to look at either A TRIG VIEW (CH4) or B TRIG VIEW (CH5). Both TRIG VIEW A and TRIG VIEW B can be viewed at the same time if the B TRIG SOURCE switch is set in the INT or EXT (÷10) position.

CHOP ALT: Selects switching mode when in multichannel operation.

: Alternate mode

: Chopping mode

X-Y: Oscilloscope operates as an X-Y scope, with CH1 for X-axis and CH2 for Y-axis. This button has the highest priority over all other buttons.

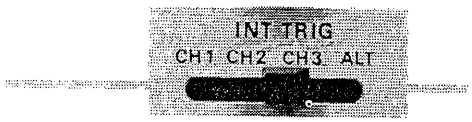
CH2: Polarity of CH2 signal is inverted.

INV: The up state is for normal polarity and the depressed state is for inverted polarity.

BW LIMIT: Limits the bandwidth of the vertical amplifier to approximately 20 MHz, cutting off the frequency components higher than this limit.

o Triggering

INT TRIG ..... (19)



Selects the internal trigger signal source. The signal selected by this switch is fed to the A trigger circuit if SOURCE switch (35) is set in the INT state or to the B trigger circuit if SOURCE switch (48) on rear panel is set in the INT state.

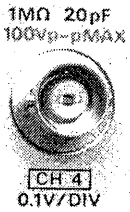
CH1: Input signal of CH1 is used as trigger signal.

CH2: Input signal of CH2 is used as trigger signal.

CH3: Input signal of CH3 is used as trigger signal.

ALT: Asynchronous signals on CH1, CH2 and CH3 may be viewed simultaneously using the INT TRIG ALT mode. (For details, see Subsection 4.6.)

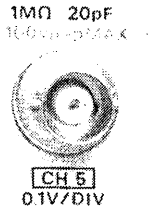
External trigger (CH4).. (36)
Input terminal



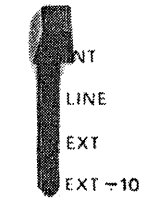
This terminal is used for both the CH4 input signal and the external trigger signal for the A trigger circuit. For the external trigger operation, set the SOURCE switch (33) in the EXT or the EXT ÷ 10 position.

External trigger (CH5) .. (46) This terminal is used for both the CH5 input signal and the external trigger signal for the B trigger circuit. For the external trigger operation, set the SOURCE switch (48) in the EXT or the EXT ÷ 10 position.

Input terminal



SOURCE ..... (35) This switch is used to select the trigger signal source for the A trigger circuit. The signal selected by this switch is used directly as the input signal of the TRIG VIEW (CH4).



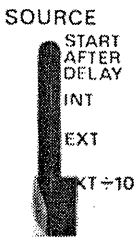
INT: Internal signal selected by INT TRIG switch (19) is used as trigger signal.

LINE: AC line signal is used as trigger signal.

EXT: Input signal of external trigger (CH4) input terminal (36) is used as trigger signal.

EXT ÷ 10: Input signal of external trigger (CH4) input terminal (36) is attenuated to 1/10 and used as trigger signal.

SOURCE ..... (48) Selects between continuous delay and triggered delay; selects the trigger signal source for the B trigger circuit.



START AFTER DELAY:

Selects the continuous delay mode independent of the B trigger signal.

The B sweep starts immediately after the period determened by DELAY TIME switch (39) and DELAY TIME MULTI switch (47) has elapsed.

If this switch is set in any other position, the B sweep operates in the triggered delay mode, and it starts when the sweep delay time has elapsed after the B trigger signal has been applied.

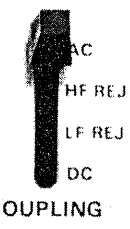
INT: Internal trigger signal selected by INT TRIG switch (19) is used as trigger signal.

EXT: Input signal of external trigger (CH5) input terminal (46) is used as trigger signal.

EXT ÷ 10: Input signal of external trigger (CH5) input terminal (46) is attenuated to 1/10 and used as trigger signal.

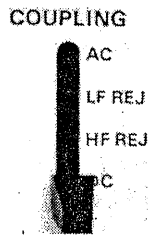
COUPLING ..... (34) (49) Select coupling modes between trigger signal sources and trigger circuits;

(34)



COUPLING

(49)



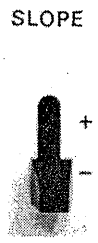
AC: AC coupling

LF REJ: AC coupling, with components lower than 50 kHz rejected.

HF REJ: AC coupling, with components higher than 50 kHz rejected.

DC: DC coupling

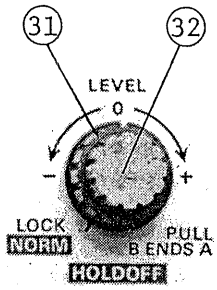
SLOPE ..... (33) (50) Selects the triggering slope.



"+": Triggering occurs when the trigger signal crosses the trigger level in positive-going direction.

"–": Triggering occurs when the trigger signal crosses the trigger level in negative-going direction.

HOLDOFF ..... (31)
LEVEL ..... (32)



These double-knob controls are for holdoff time adjustment and trigger level adjustment. The pulled out position of the LEVEL knob is for the B END'S A mode.

The HOLDOFF time control is used when the signal waveform is complex and stable triggering cannot be attained with LEVEL knob (32) alone.

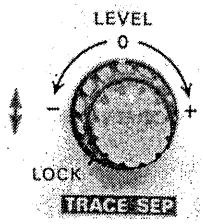
The LEVEL knob is for displaying a synchronized stationary waveform and setting a start point for the waveform.

As this knob is turned in "→+" direction, the trigger level moves upward on the displayed waveform; as the knob is turned "-←", the level moves downward.

When set in the LOCK position, the trigger level is automatically maintained at an optimal value irrespective of the signal amplitude and for most signals requires no manual adjustment of the trigger level. When the signal level is at the trigger level, the TRIG'D LED (37) turns on.

When in the B END'S A mode, the A sweep ends at the same time the B sweep ends. With this function, degradation of brightness can be minimized when in the delayed sweep mode with large magnification of waveform in the horizontal direction.

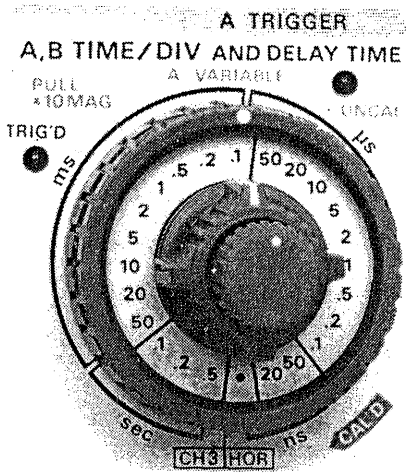
LEVEL..... (51)
TRACE SEP ..... (52)



These double-knob controls are for level adjustment and trace separation adjustment. The functions of the LEVEL knob (51) are the same as those of the LEVEL knob (32). The function of the TRACE SEP knob is to control the vertical distance between A sweep and B sweep when in the ALT sweep mode.

o Time Base

A, B TIME/DIV ..... (39)
AND DELAY TIME (40)



The large knob (39) is for A TIME/DIV and DELAY TIME, and the medium knob (40) is for B TIME/DIV.

The A TIME/DIV knob sets the A sweep rate; the DELAY TIME knob sets the delayed sweep rate.

The B TIME/DIV switch sets the delayed sweep (B sweep) time.

When the TIME/DIV switch is set in the DH3 HOR position, the oscilloscope operates as a multichannel X-Y scope with CH3 channel as the X axis and other channels as the Y axis. (For details, see page 49.)

A VARIABLE ..... (41)
PULL ×10 MAG

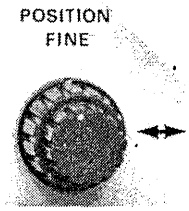
For continuously variable adjustment of A sweep rate and for ×10 MAG function.

The value indicated by A TIME/DIV switch can be reduced by a factor of 2.5 or more. When set in the CAL'D position, the sweep speed is calibrated to the value indicated by the A TIME/DIV switch. When not in the CAL'D position, the UNCAL lamp (38) turns on.

When the knob is pulled out, the A or B sweep is expanded by 10 times.

POSITION ..... (44)

FINE (45)



For horizontal positioning of spot or trace. The larger knob is for coase adjustment and the smaller for fine adjustment.

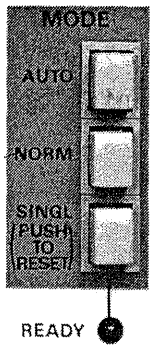
DELAY TIME ..... (47)

MULTI

Multi-turn potentiometer for continuously variable adjustment of the delay time indicated by the A sweep knob (39) in order to select the section to be expanded of the A sweep.

SWEEP MODE ..... (30)

Selects the desired sweep mode.



AUTO: When no triggering signal is applied or when triggering signal frequency is less than 50 Hz, sweep runs in the free mode.

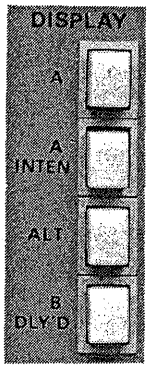
NORM: When no triggering signal is applied, sweep is in a ready state and the trace is blanked out. Used primarily for observation of signals of 50 Hz or lower.

SINGLE: PUSH TO RESET — Used for single sweep operation (one-shot sweep operation) in conjunction with the reset switch.

When the three buttons are in the pushed out state, the circuit is in the single sweep mode. The circuit is reset as

this button is pressed. When the circuit is reset, the READY lamp (42) turns on. The lamp goes off when the single sweep operation is over.

DISPLAY ..... (29) Selects A and B sweep mode as follows:



A: Main sweep (A sweep) mode for general waveform observation.

A INTEN: This sweep mode is used when selecting the section of the A sweep to be magnified for delayed sweep. The B sweep section (delayed sweep) is displayed with high brightness.

ALT: A INTEN sweep and B sweep (delayed sweep) are displayed alternately. (The A, B TRACE SEPARATION control (52) adjusts the distance between these traces.)

B: Displays the delayed sweep (B sweep) alone.

o Others

CAL (Vp-p) ..... (43) These terminals deliver the calibration voltage of approximately 1 kHz, positive square wave.



200 mV: Delivers 200 mVp-p signal. Output resistance approximately 200 Ω.

1 V: Delivers 2 Vp-p signal. Output resistance is approximately 1 kΩ.

 ..... (53) Ground terminal of oscilloscope mainframe.

4.2 Explanation of Rear Panel (See Figure 4-2.)

o Z Axis

A AXIS INPUT ..... (54) Input terminals for external intensity modulation signal.

o Output Terminals

CH1 SIGNAL OUTPUT ... (55) Delivers the CH1 signal with a voltage of approximately 10 mV per 1 DIV on screen (when terminated with 50 ohms). May be used for frequency counting, etc.

GATE OUTPUT ..... (56) (57) Delivers the A, B gate signal. Output resistance is approximately 100 Ω.

o Vertical Axes

CH4 POSITION ..... (59) Vertical positioning of the spot or trace of CH4 (A TRIG VIEW).

CH5 POSITION ..... (60) Vertical positioning of the spot or trace of CH5 (B TRIG VIEW).

o AC Power Input Circuit

AC power input connector ..... (61)
Input connector of the AC power of the instrument. Connect the AC power cord (supplied) to this connector.

FUSE ..... (62) Fuse in the primary circuit of the power transformer. Fuse rating is as shown in Table (63)

AC voltage selecting connector ..... (64)
For selecting the AC voltage of the instrument.

AC voltage selector plug ..... (65)
For selecting the AC voltage of the instrument by aligning its arrowhead mark in the corresponding position as shown in Table (63)

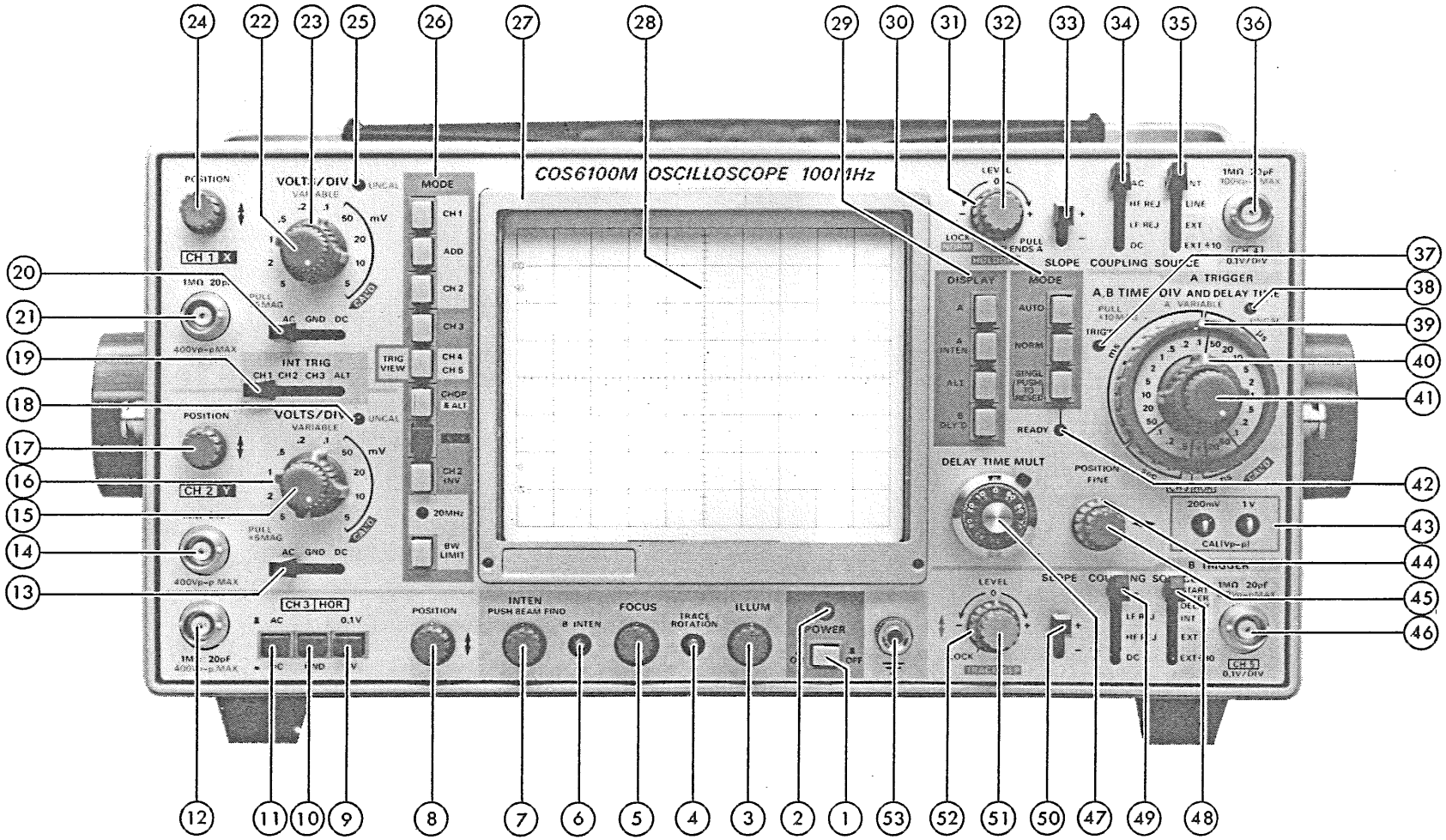

COS6100M OSCILLOSCOPE 100MHz
POSITION
VOLTS/DIV
VARIABLE
UNCAL
MODE
CH 1 X
CH 2 Y
CH 3 HOR
INT TRIG
CH1 CH2 CH3 ALT
AC GND DC
TRIG VIEW
CH1
ADD
CH2
CH3
CH4
CH5
CHOP & ALT
CH2 INV
20MHz
BW LIMIT
INTEN
PUSH BEAM FIND
B INTEN
FOCUS
TRACE ROTATION
ILLUM
POWER
DISPLAY
A
A INTEN
ALT
B DLY'D
LEVEL
SLOPE
COUPLING
SOURCE
A TRIGGER
A,B TIME/DIV AND DELAY TIME
DELAY TIME MULT
POSITION FINE
READY
CALIBRATOR
200mV
1V
B TRIGGER
1MΩ 20pF
0.1V/DIV

Figure 4-1

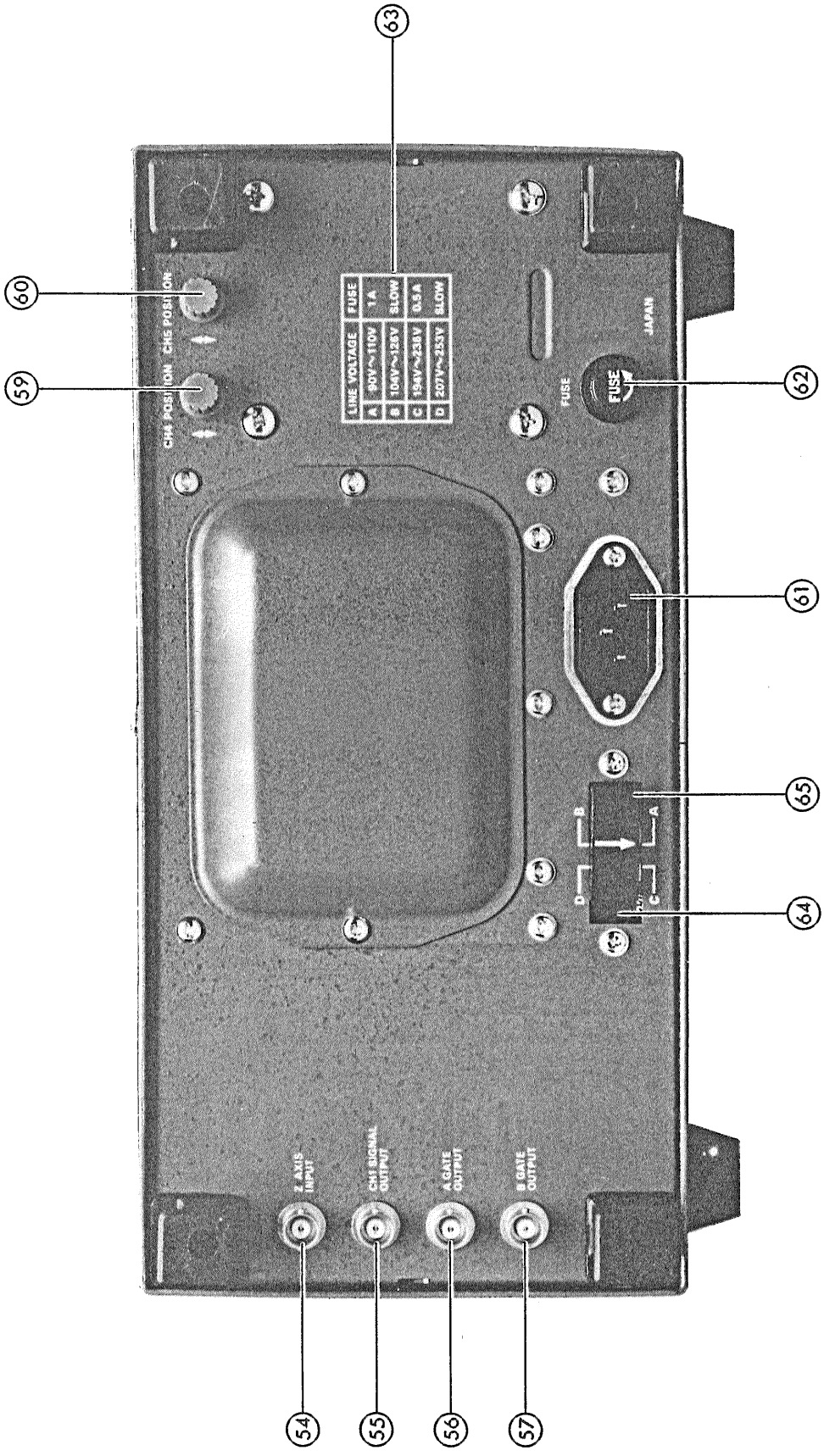

63
60
59
62
61
65
64
54
55
56
57
CH1 POSITION
CH2 POSITION
LINE VOLTAGE
FUSE
A
90V~110V
1A
SLOW
B
104V~128V
C
194V~238V
0.5A
D
207V~253V
SLOW
JAPAN
FUSE
B
A
D
C
Z AXIS INPUT
CH1 SIGNAL OUTPUT
A GATE OUTPUT
B GATE OUTPUT

Figure 4-2

4.3 Basic Operation

Before connecting the power cord to an AC line outlet, check that the AC line voltage selector plug on the rear panel of the instrument is correctly set for the AC line voltage. After ensuring the voltage setting, set the switches and controls of the instrument as shown in the following table.

Item	No.	Setting
POWER	①	⊓ OFF position
INTEN	⑦	Clockwise (3-o'clock position)
FOCUS	⑤	Mid-position
ILLUM	③	Counterclockwise position
MODE (VERT)	㉖	All buttons in ⊓ state
↕ POSITION	⑧ ⑰ ㉔ ㊾ ㊿	Mid-position Mid-position (on rear panel)
VOLTS/DIV	⑯ ㉓	50 mV
VARIABLE (×5 MAG)	⑮ ㉒	CAL'D (clockwise position) Depressed state
AC-GND-DC	⑬ ⑳	GND
AC/DC /GND	⑪ ⑩	⊓ AC ⊓ ON
0.1V/1V	⑨	⊓ 0.1V
INT TRIG	⑲	ALT
SOURCE	㉟ ㊽	INT START AFTER DELAY
COUPLING	㉞ ㊾	AC
SLOPE	㉝ ㊿	+
LEVEL	㉜ ㊶	LOCK (counterclockwise)

Item	No.	Setting
HOLDOFF	㉛	NORM (counterclockwise)
↕ TRACE SEP	㊷	Mid-position
MODE (SWEEP)	㉚	AUTO
DISPLAY	㉙	A
A, B TIME/DIV	㊴ ㊵	0.5 msec
VARIABLE ×10 MAG	㊶	CAL'D (clockwise position) Depressed state
↔ POSITION	㊹	Mid-position
(FINE)	㊺	Mid-position

After setting the switches and controls as above, connect the power cord to the AC line outlet and, then, proceed as follows:

1) Turn-ON the POWER switch and make sure that the power pilot LED above is turned on. In about 20 seconds, a trace will appear on the CRT screen. If no trace appears in about 60 seconds,verify the switch and control settings as shown in the above table.

2) Adjust the trace to an appropriate brightness and sharpest image with the INTEN control and FOCUS control.

3) Align the trace with the horizontal center line of graticule by adjusting the CH1 POSITION control and TRACE ROTATION control (screwdriver adjust).

4) Connect the 10:1 probe (supplied) to the CH1 INPUT terminal, and apply the 200 mVp-p CALIBRATOR signal to the probe tip.

5) Set the AC-GND-DC switch in the AC state. A waveform as shown in Figure 4-3 will be displayed on the CRT screen.

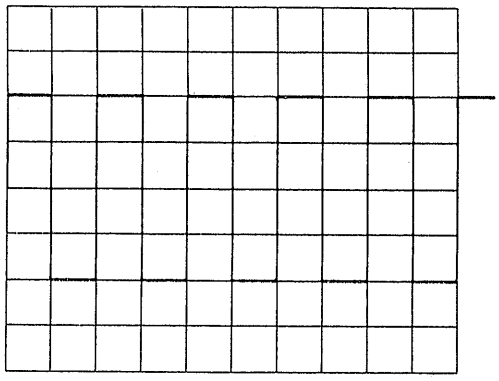


Figure 4-3

6) Adjust the FOCUS control so that the trace image becomes sharpest. No re-adjustment will be necessary as the linear focus circuit will automatically maintain the image in this best focussed state.

7) For signal observation, set the VOLTS/DIV switch and TIME/DIV switch in appropriate positions so that the signal waveform is displayed with an appropriate amplitude and an appropriate number of peaks.

8) Adjust the ↕ POSITION and ↔ POSITION controls in appropriate positions so that the displayed waveform is aligned with the graticule and the voltage (Vp-p) and period (T) can be read conveniently.

The above is the basic operating procedure of the oscilloscope. Further operation methods are explained in the subsequent paragraphs.

4.4 Vertical Mode Switches

The vertical mode switches of the oscilloscope are comprised of five types of mode selector switches as shown in the following:

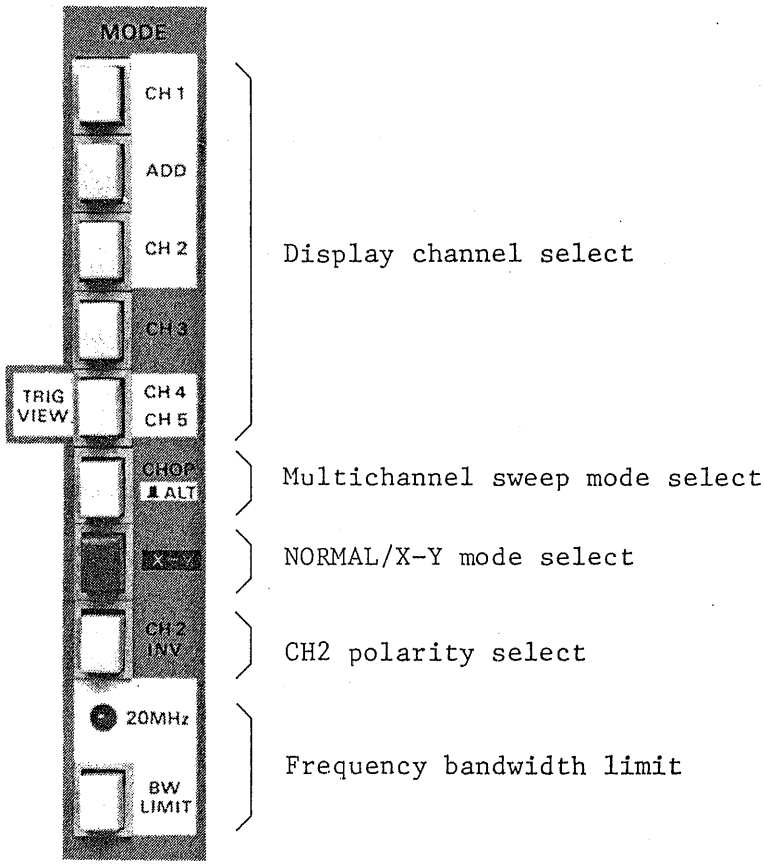


Figure 4-4

These mode switches can be set in any combination.

(1) Single-channel operation

For the signal-channel operation, depress one of the display channel buttons (⊓) and leave the remaining display channel buttons extended (Ⅱ). If none of the display channel buttons are depressed (Ⅱ), CH1 signal is displayed.

Note: Either CH1, ADD (CH1 + CH2), CH2, CH3, or TRIG VIEW (CH4) can be viewed independently of each other. TRIG VIEW (CH5) may not be viewed independently of CH4.

(2) Multichannel operation

For multichannel operation, depress only the required display channel buttons and leave all other vertical mode buttons extended. Set the CHOP/ALT button in the CHOP or ALT mode as required.

When in the CHOP mode, the channel signals are chopped in sequence at a rate of about 1 μsec (1 MHz). Multichannel traces are simultaneously displayed in a time-slicing method. When signal frequencies are high, the waveforms may be displayed with dotted lines. In such cases the ALT mode should be used.

When in the ALT mode, one channel is displayed for an entire sweep, then the next channel is displayed for an entire sweep. This mode is used primarily for display of high frequency signals at fast sweep speeds. At very low sweep speeds, signals are displayed alternately. In such cases the CHOP mode should be used.

Note: The multichannel operation can be done with any combinations of CH1, ADD (CH1 + CH2), CH2, CH3, and TRIG VIEW (CH4 and CH5). The last item means that the CH5 channel can be displayed only when the CH4 (TRIG VIEW) display is selected. The CH5 channel is displayed when the SOURCE switch (48) is set in the INT, EXT, or EXT (÷10) position.

(3) X-Y operation

Simply by depressing the [X-Y] button, the oscilloscope operates as an X-Y scope. This button has the highest priority over all other vertical mode selector buttons. The X-Y operation is with CH1 as X axis and CH2 as Y axis. The bandwidth of the X axis is DC to 5 MHz (-3 dB) and the CH1 POSITION control (24) is used as the X axis (↔) POSITION control. Other electrical performances remain the same as when the circuit is used as the CH1 vertical channel. The Y axis operates with the same electrical performances as when the circuit is used as the CH2 vertical channel, and its operation method remains the same.

When the calibration voltage signal is applied to the input terminals of both X and Y axis with the 10 : 1 probes (supplied) and the corresponding VOLTS/DIV switches are properly adjusted, a Lissajous figure as shown in Figure 4-5 will be displayed.

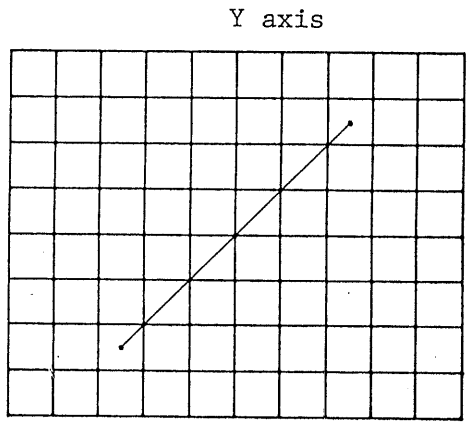


Figure 4-5

Note: When high frequency signals are displayed in the X-Y operation, pay attention to the frequency bandwidths of and phase difference between X and Y axes.

(4) ADD operation

An algebraic sum of the CH1 and CH2 signals can be displayed on the screen by depressing the ADD switch. The displayed signal is the difference between CH1 and CH2 signals if the CH2 POLARITY switch is set in the INV (⊓) state.

For accurate addition or subtraction, it is a prerequisite that the sensitivities of the two channels are adjusted accurately to the same value. Vertical positioning can be done with the ↕ POSITION knob of either channel. In view of the linearities of the vertical amplifiers, it is most advantageous to set them in their mid-positions.

(5) BW LIMIT mode

When the BW LIMIT button is depressed (⊓), a bandpass filter of approximately 20 MHz is inserted in the vertical amplifier. When in this mode of operation, higher frequency components and noise components are eliminated from the displayed signal. Another advantage of this mode is that the internal noise components are eliminated and consequently a clear waveform is displayed. This mode is suitable for use at lower frequencies.

4.5 CH3 HOR Operation

When the A TIME/DIV switch is set in the CH3 HOR position, the oscilloscope operates as a multichannel X-Y scope with the channels (except CH3) selected by the vertical mode switches as the Y axis and CH3 as the X axis. The bandwidth of the X axis becomes DC - 5 MHz (-3 dB). The vertical (↕) POSITION knob (8) can be used as the horizontal (↔) POSITION knob. Other electrical performances are the same as CH3. Regarding the Y axis, the channels selected by the vertical mode switches are displayed in the CHOP mode, with the electrical performances and the operation method remaining the same.

4.6 Triggering

Proper triggering is essential for efficient operation of an oscilloscope. The user of the oscilloscope must make himself thoroughly familiar with the triggering functions and procedures.

(1) Functions of INT TRIG (internal trigger) switch:

The signals applied to the input terminals of CH1, CH2 and CH3 are picked off from respective preamplifiers in order to be used as internal trigger signals. The INT TRIG switch selects these signals. The selected signals are sent to the A trigger circuit or the B trigger circuit through the SOURCE switch. The relationships of these circuits are shown in the block diagram of Figure 4-6.

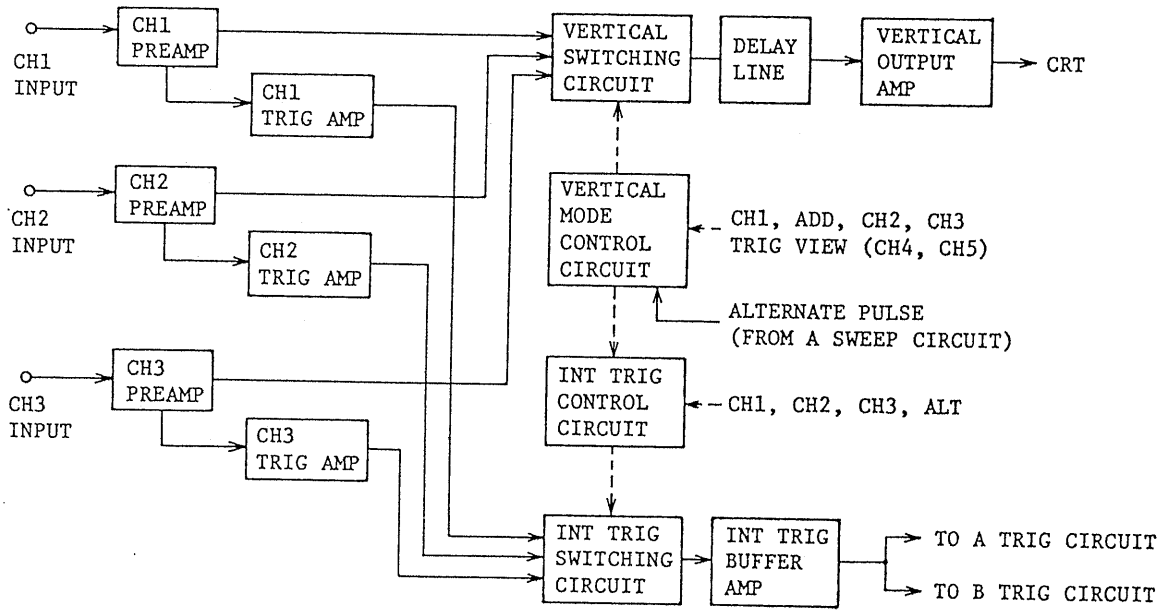


Figure 4-6

With the INT TRIG switch the internal trigger signal can be selected as follows.

CH1: Input signal of CH1
CH2: Input signal of CH2
CH3: Input signal of CH3
ALT: All signals being displayed on screen

As can be seen in the block diagram, the triggering circuits are designed with certain relationships to the vertical mode selector switches. These relationships are shown in the following table.

INT TRIG \ MODE	CH1	ADD	CH2	CH3	TRIG VIEW	
					CH4	CH5
CH1	Trig by CH1					
CH2	Trig by CH2					
CH3	Trig by CH3					
ALT	Trig by CH1	Trig by CH1	Trig by CH2	Trig by CH3	(Trig by CH1)	(Trig by CH1)

The items enclosed in the parentheses are for the TRIG VIEW (INT TRIG) mode.

Notes: 1. When in the ALT mode, two or more signals of CH1, CH2 and CH3 use the same trigger circuit alternately. Therefore, These signals must cross the same trigger level. Pay attention to the DC components of these signals. It is necessary to use TRIG LEVEL knob (21) and DC coupling mode for best triggering.

2. Note that jitter may be produced when the sweep speed is slow if the SOURCE switch is set for AC coupling.
3. The ALT trigger function for vertical modes is effective only when in the single-channel operation and when in the ALT-mode multichannel operation. It is not effective when in the CHOP mode.
4. 3 cycles or more on the C.R.T must be displayed to obtain observation of complete triggering signal.

(2) Function of SOURCE Switch:

To display a stationary pattern on the CRT screen, the displayed signal itself or a trigger signal which has a time relationship with the displayed signal is required to be applied to the trigger circuit. The SOURCE switch selects such a trigger source.

INT: This internal trigger method is used most commonly. The signal applied to the vertical input terminal (the measured signal) is branched off from a point in the amplifier circuit and is fed to the trigger circuit through the INT TRIG switch. Since the trigger signal is the measured signal itself, a very stable waveform can be readily displayed on the CRT screen.

LINE: The AC power line frequency signal is used as the trigger signal. This method is effective when the measured signal has a relationship with the AC line frequency, especially for measurements of low level AC noise of audio circuits, thyristor circuits, etc.

EXT: The sweep is triggered with an external signal applied to the external trigger input terminal (CH4 or CH5). An external signal which has a periodic relationship with respect to the measured signal is used. Since the measured signal (vertical input signal) is not used as the trigger signal, the waveform display can be done independent of the measured signal. (Select CH4 or CH5 input signal.)

EXT ÷ 10: The external trigger signal applied to the external trigger input terminal is attenuated into 1/10 before being applied to the trigger circuit. Operation is the same with those of the EXT trigger mode. This mode is used when the external trigger signal level is too high.

START AFTER DELAY: This position is for continuous sweep delay (B sweep) mode. When in other position (INT or INT ÷ 10), the sweep runs in the triggered delay mode. (When in the START AFTER DELAY position, the CH5 signal is not displayed if the vertical mode selector switch is set in the TRIG VIEW position.)

(3) Functions of COUPLING switch:

This switch is used to select the coupling of the trigger signal to the trigger circuit in accordance with the characteristics of the measured signal.

AC: This coupling is for AC triggering which is used most commonly. As the trigger signal is applied to the trigger circuit through an AC coupling circuit, stable triggering can be attained without being affected by the DC component of the input signal. The low-range cut off frequency is 3 Hz (-3 dB).

When the ALT trigger mode is used and the sweep speed is slow, jitter may be produced. In such a case, use the DC mode.

LF REJ: The trigger signal is fed to the trigger circuit through an AC coupling circuit and a high pass filter (approximately 50 kHz, -3 dB). The DC component, AC noise and other low frequency components are rejected. Only the higher frequency components of the trigger signal are applied to the trigger circuit.

HF REJ: The trigger signal is fed to the trigger circuit through an AC coupling circuit and a low pass filter (approximately 50 kHz, -3 dB). The higher frequency components of the trigger signal are rejected. Only the lower frequency components of the trigger signal are applied to the trigger circuit.

DC: The trigger signal is DC-coupled to the trigger circuit. This mode is used when triggering on a DC component of a signal or when triggering on very low frequency signals.

(4) Functions of SLOPE switch:

This switch selects the slope (polarity) of the trigger signal.

"+": When set in the "+" state, triggering occurs as the trigger signal crosses the trigger level in the positive-going direction.

"-": When set in the "-" state, triggering occurs as the trigger signal crosses the trigger level in the negative-going direction.

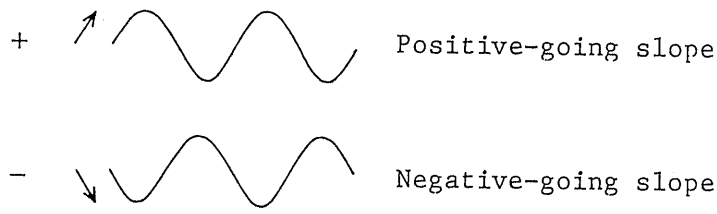


Figure 4-8

(5) Functions of LEVEL (LOCK) control:

The function of this control is to adjust the trigger level and display a stationary image. At the instant the trigger signal has crossed the trigger level set by this control, the sweep is triggered and a waveform is displayed on the screen.

The trigger level changes in the positive direction (upward) as this control knob is turned clockwise and it changes in the negative direction (downward) as the knob is turned counterclockwise. The rate of change is set as shown in Figure 4-9.

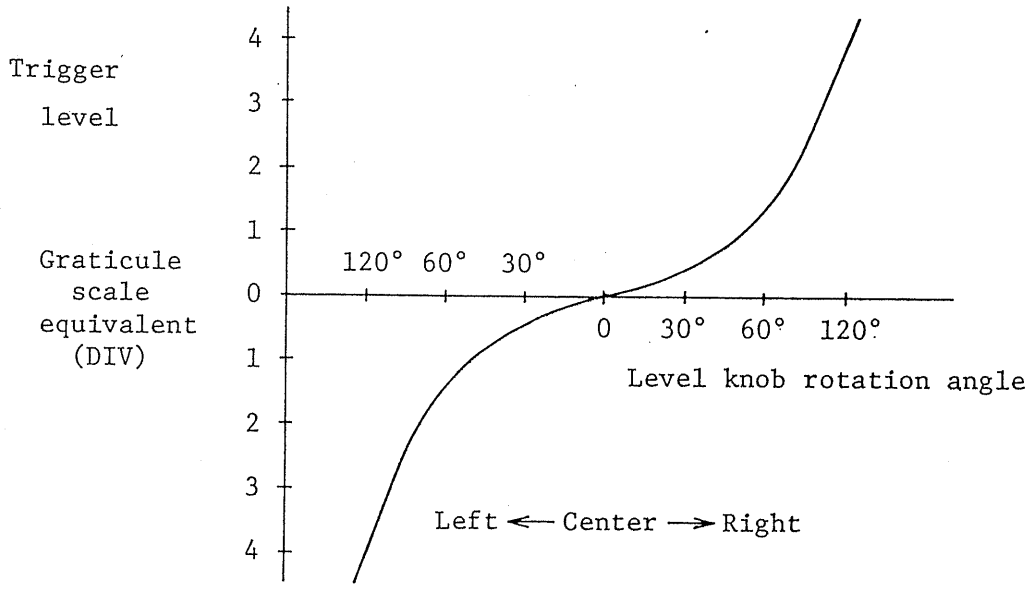


Figure 4-9

o LEVEL LOCK

When the LEVEL knob is set in the LEVEL LOCK position, the trigger level is automatically maintained within the amplitude of the trigger signal and stable triggering can be done without requiring level adjustment (although jitter may not be suppressed when in the ALT mode). This automatic level lock function is effective when the signal amplitude on the screen or the external trigger input voltage is within the following range:

50 Hz - 25 MHz: 0.8 DIV (0.1 V) or less
50 Hz - 80 MHz: 1.5 DIV (0.2 V) or less

(6) Functions of A HOLD OFF control:

When the measured signal is a complex waveform with two or more repetition frequencies (periods), triggering with the above-mentioned LEVEL control alone may not be sufficient

for attaining a stable waveform display. In such a case, the sweep can be stably synchronized to the measured signal waveform by adjusting the HOLD OFF time (sweep pause time) of the sweep waveform. The control covers at least the time of one full sweep, for sweeps faster than 0.2 sec/DIV.

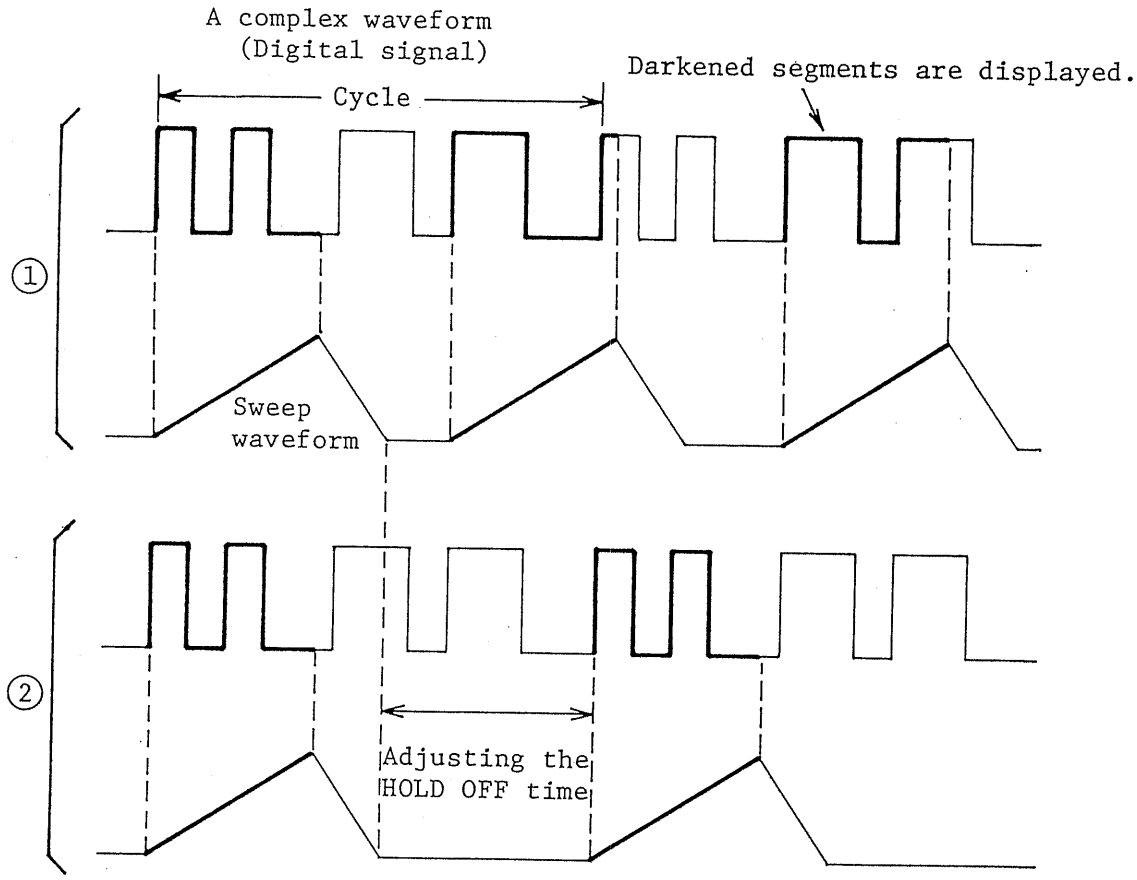


Figure 4-10

Figure 4-10 ① shows a case where the HOLD OFF knob is in the NORM state and various different waveforms are overlapped on the screen, making the signal observation unsuccessful.

Figure 4-10 ② shows a case where the undesirable portion of the signal is with held and the same waveforms are displayed on the screen.

4.7 Single-sweep Operation

Non-repetitive signals and one-shot transiential signals can hardly be observed on the screen. Such signals can be measured by displaying them in the single-sweep mode on the screen and photographing them.

- Measurement of non-repetitive signal:

  (1) Set the DISPLAY in the "A" state and the SWEEP MODE in the NORM state.

  (2) Apply the measured signal to the vertical input terminal and adjust the trigger level.

  (3) Set the SWEEP MODE in the SINGLE state (the three push-button switches are up).

  (4) Press the RESET button. The sweep will run only for one cycle and the measured signal will be displayed only once on the screen.

- Measurement of one-shot signal:

  (1) Set the DISPLAY in the "A" state and the SWEEP MODE in the NORM state.

  (2) Apply the calibration output signal to the vertical input terminal, and adjust the trigger level to a value corresponding to the predicted amplitude of the measured signal.

  (3) Set the SWEEP MODE in the SINGLE state. Apply the measured signal instead of the calibration signal to the vertical input terminal.

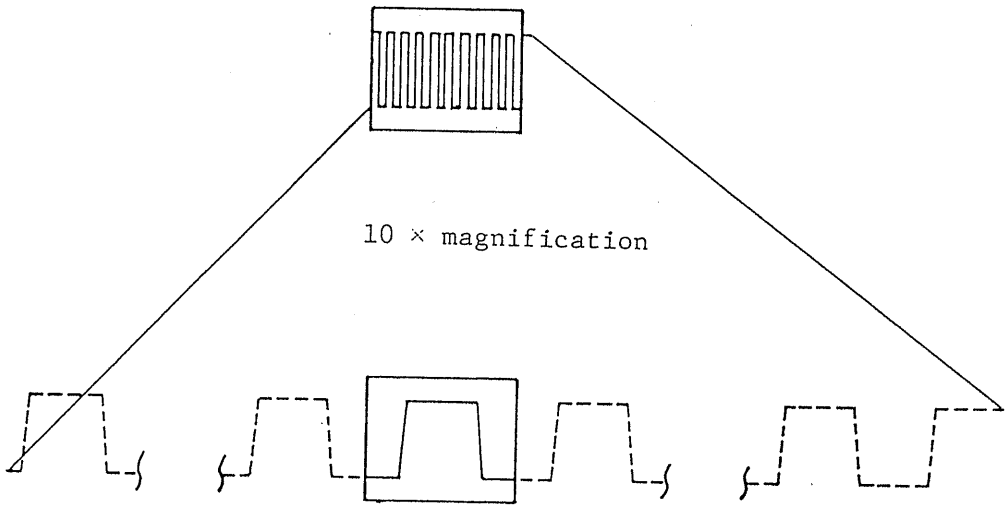
  (4) Depress the RESET button. The sweep circuit will become the ready state and the READY lamp will turn on.

(5) As the one-shot signal occurs in the input circuit, the sweep runs only for one cycle and the one-shot signal is displayed on the CRT screen.

The single-sweep operation can be done also with A INTEN B sweep. However, it cannot be done in the multichannel ALT mode operation. For multichannel one-sweep operation, use the CHOP mode.

4.8 Sweep Magnification

When a certain part of the displayed waveform needs to be magnified, a faster sweep speed (MAG) may be used. In such a case, pull out the sweep VARIABLE knob (41) (set in the ×10 MAG state). When this is done, the displayed waveform is expanded by 10 times. The center of the waveform will be displayed. Any part can be covered by means of POSITION control.



Any part can be covered by means of POSITION control.

Figure 4-11

When the sweep is magnified and the sweep speed has become faster than 20 nsec/DIV, the trace intensity may be reduced. In such a case, the displayed waveform should be expanded in the B sweep mode explained in the subsequent paragraphs.

4.9 Waveform Magnification with Delayed Sweep

With sweep magnification (described above), the magnification ratio is limited to 10×. With the delayed sweep method, the sweep can be expanded for a wide range of from several times to several thousand times depending on ratio between A sweep time and B sweep time.

As the measured signal frequency becomes high and the A sweep range for the non-expanded signal becomes higher, the available expansion ratio becomes smaller. Furthermore, as the magnification ratio becomes larger, the trace intensity becomes lower and the delay jitter increases. To cope with this situation, a triggered delay circuit and a B ENDS A circuit are provided.

(1) Continuous delay:

Set the DISPLAY switch to A and display the signal waveform with the A sweep in the regular operation method.

Next, set the B TIME/DIV switch to a position faster than that of the A TIME/DIV switch.

After ensuring that the SOURCE switch (48) is set in the START AFTER DELAY state, turn the DISPLAY switch to the A INTEN position. A part of the displayed waveform will be accentuated as shown in Figure 4-12, indicating the state ready for delayed sweep. The intensified portion denotes the section corresponding to the B sweep time (DELAYED SWEEP).

The period from the start of the A sweep to the beginning of B sweep (the accentuated portion of the trace) is called "SWEEP DELAY TIME". This period is continuously variable by means of the DELAY TIME MULTI dial.

Next, change the DISPLAY switch to the B position. The B sweep time will be expanded to a full sweep (10 cm) as shown in Figure 4-13.

The B sweep time is set by the B TIME/DIV switch and the magnification ratio becomes as follows:

$$\text{Magnification ratio} = \frac{\text{A TIME/DIV indication}}{\text{B TIME/DIV indication}}$$

The sweep delay time can be read on the CRT screen. For more accurate determination, the DELAY TIME MULTI dial should be used.

$$\text{Sweep delay time} = \text{A TIME/DIV indication} \times \text{DELAY TIME MULTI dial setting}$$

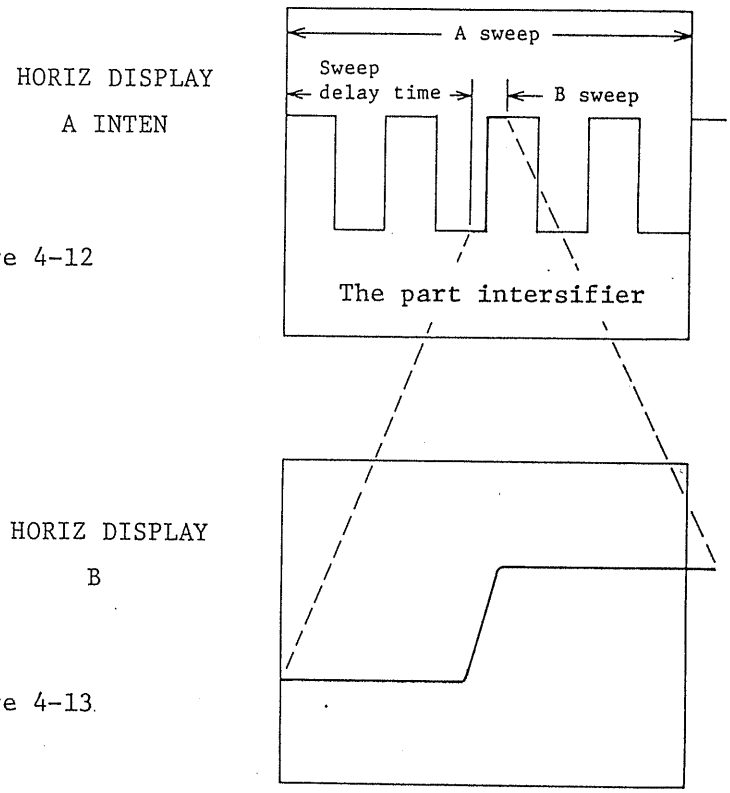


Figure 4-12

Figure 4-13

(2) Triggered delay:

When the displayed waveform is magnified by 100 times or more by the continuous delay method, delay jitter is produced. To suppress the jitter, a triggered delay method may be used.

For this operation, the B trigger circuit operates when the SOURCE switch (48) is set in the INT state and the B sweep is triggered by the B trigger pulse. Therefore, even when the delay time is continuously varied by rotating the DELAY TIME MULTI dial, the starting point does not vary continuously but varies intermittently. This operation when in the A INTEN mode can be observed as the intensified section jumps from trigger point to trigger point on the A sweep waveform.

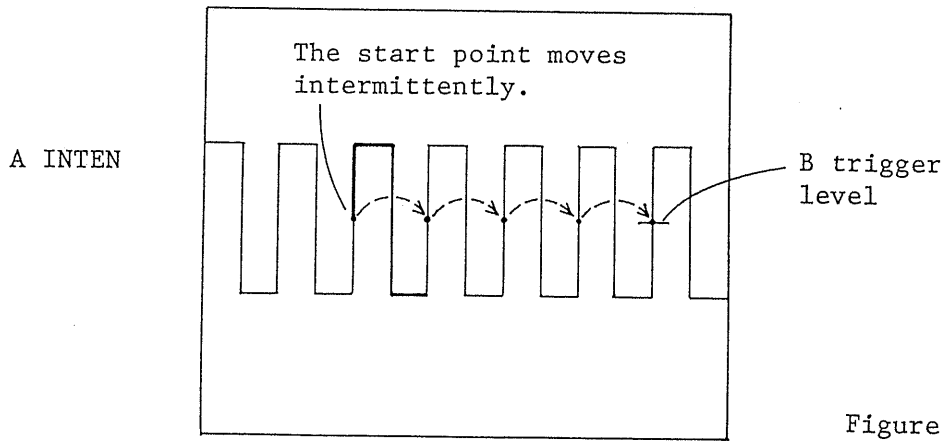


Figure 4-14

4.10 Delayed ALT Sweep

When in the Delayed ALT sweep mode, the A sweep and B sweep (delayed sweep) are displayed alternately on the screen, enabling you to observe at the same time the unmagnified waveform and magnified section.

To prevent the two waveforms from overlapping and to display them separately, adjusted the TRACE SEP control (52).

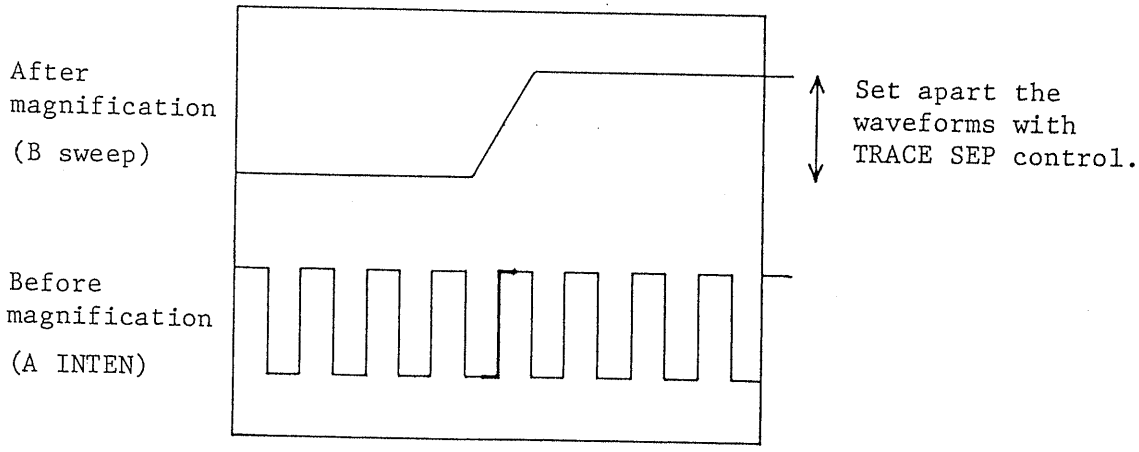


Figure 4-15

Note: The delayed ALT sweep mode can be used in combination with the multichannel mode (CHOP or ALT) of the vertical axes.

4.11 B ENDS A Mode

When the trace is magnified by a large ratio with the delayed sweep, the magnified trace may become dim and hardly discernible. By ending the A sweep at the minimum required point, the display time for the B sweep is increased so that the trace does not become dim. The B ENDS A mode should be used.

The operating method is the same as that of Subsections 4.9 and 4.10. Pull out the LEVEL knob (32) to set it in the B END A state, and a bright magnified trace shown in Figure 4-16 will be displayed.

Turn the A HOLD OFF knob (31) to the extreme clockwise position (B ENDS A position). A bright magnified trace as shown in Figure 4-16 will be displayed.

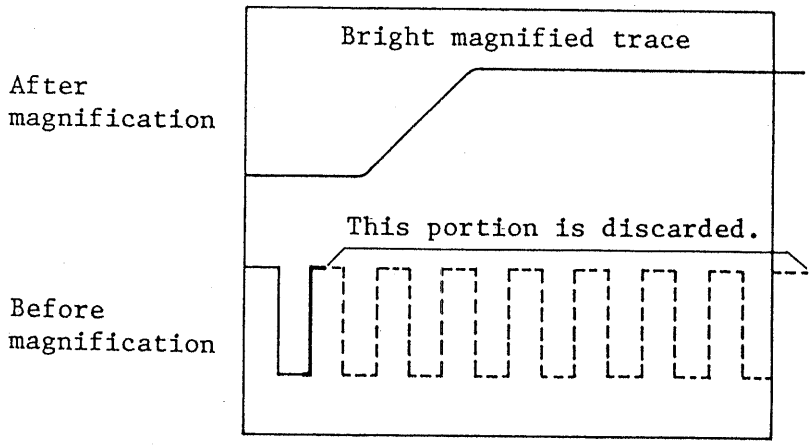

Bright magnified trace
After magnification
This portion is discarded.
Before magnification

Figure 4-16

5. MEASURING METHODS

5.1 Connection Method of Input Signal

The input impedance of the oscilloscope as viewed from the vertical input terminal is 1 MΩ with capacitance approximately 20 pF in parallel. When the probe 10:1 is used, the impedance increases to resistance 10 MΩ with capacitance approximately 14 pF in parallel.

There are various methods of connecting the signal sources to the oscilloscope. The most popular methods are with regular covered wires, with shielded wires, with a probe, or with a coaxial cable. The following factors should be considered.

Output impedance of input signal source
Level and frequency of input signal
External induction
Distance between the input signal source and the oscilloscope

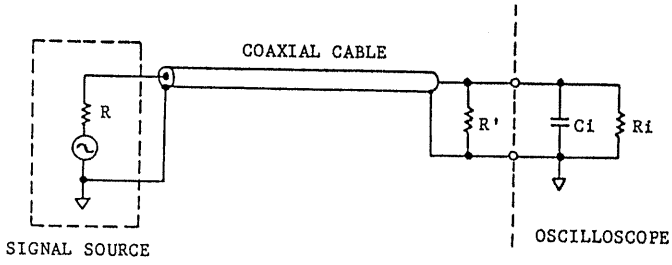
Types of input signals and connection methods are tabulated in the following:

Type of input signal \ Connection method			Probe	Coaxial cable
Low frequency	Low impedance	Near	○	○
		Far		○
	High impedance	Near	○	◍
		Far		◍
High frequency	Low impedance	Near	○	○
		Far		○
	High impedance	Near	○	◍
		Far		

(○: Good, ◍: Fair)

o Connection with coaxial cable:

When the output impedance of the signal source is 50Ω or 75Ω, the input signal can be fed without attenuation by using a coaxial cable which enables impedance matching.
For impedance matching, terminate the coaxial cable with a 50Ω or 75Ω pure-resistive resistor corresponding to the characteristic impedance of coaxial cable, as shown in Figure 5-1.



R = R'

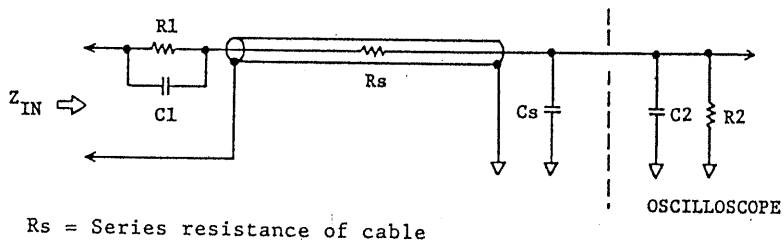
When R = 50 Ω, use a 50 Ω coaxial cable.

When R = 75 Ω, use a 75 Ω coaxial cable.

Figure 5-1

o Connection with probe:

Two probes with an attenuation ratio of 10:1 are supplied. The probe circuit and probe cable are shielded to prevent induction noise. The probe circuit makes up a wide-range attenuator in conjunction with the input circuit of the oscilloscope, thereby enabling a distortionless connection from DC to high frequencies. When the probe is used, although the signal level is attenuated to 1/10, the input impedance becomes very high (resistance 10 MΩ, capacitance approx. 14 pF) and the loading effect on the measured signal source is greatly reduced as explained in the following.



Rs = Series resistance of cable

Cs = Stray capacitance plus cable capacitance

Figure 5-2

The probe makes up an attenuator with resistor R1, in the probe, and the input resistor R2, in the oscilloscope. Capacitor C1 compensates for input capacitor C2 in the oscilloscope and stray capacitance (Cs) in the cable. The input impedance Z_{IN} is expressed as follows:

$$Z_{IN} = \frac{R1 + R2}{\omega C (R1 + R2) + 1}$$

$$C = \frac{C1 \times (C2 + Cs)}{C1 + C2 + Cs}$$

Attenuation ratio A is expressed as follows:

$$A = \frac{R2}{R1 + R2} \quad \left(= \frac{1\ M\Omega}{9\ M\Omega + 1\ M\Omega} = \frac{1}{10} \right)$$

The terms enclosed in the parentheses are for the factor when the probe is used:

Precautions:

- o Observe the maximum allowable input voltages mentioned in Section 3.5.
- o Do not fail to use the ground lead supplied.
- o Before taking measurement, accurately adjust the frequency compensation of the probe without fail.
- o Do not apply large mechanical shocks or vibration to the probe. Do not sharply bend or strongly pull the probe cable.
- o The probe unit and tip are not highly heat resistant. Do not apply a soldering iron to a circuit close to the point where the probe is attached.

5.2 Voltage Measurement

To measure the AC portion of a signal which has DC superimposed on the AC component, set the vertical input AC/DC selector switches (13) and (20) in the AC position. To measure the DC component of a signal, set the switch in the DC position.

Before commencing voltage measurement, set the VARIABLE attenuator knobs (15) and (22) at the CAL'D position and calibrate the sensitivity to the value indicated by the VOLTS/DIV selector switches (16) and (23).

Apply the signal to be measured, display the signal with an appropriate amplitude on the screen, and determine the amplitude on the graticule. For DC voltage measurement, determine the shifted distance of the trace. The voltage can be determined as follows:

(1) When measured signal is directly applied to input terminal:

Voltage (V) = Deflection amplitude (DIV) × VOLTS/DIV

(2) When the 10:1 probe is used:

Voltage (V) = Deflection amplitude (DIV) × VOLTS/DIV × 10

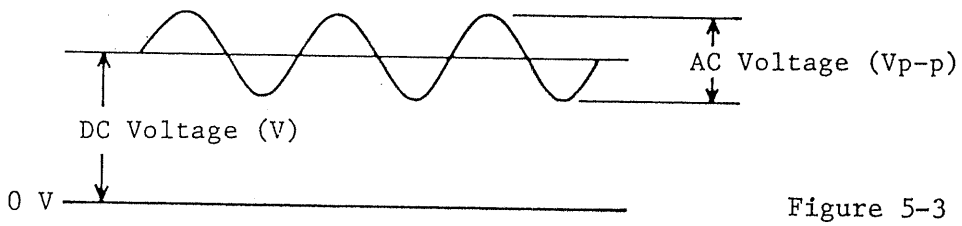


Figure 5-3

5.3 Current Measument (voltage drop method)

Connect a small resistor (R) in series in the circuit in which the current (I) to be measured flows and measure the voltage drop across the resistor with the oscilloscope. The current is known from Ohm's law as follows:

$$I = \frac{E}{R} \quad (A)$$

The resistance should be as small so possible it does not cause change to the measured signal source.

In the above method, currents from DC to high frequencies can be measured quite accurately. Note that the accuracy of the resistor reflects upon the measuring accuracy.

5.4 Time Measurement

Measurement of time interval

The time interval between any two points on the displayed waveform can be measured by setting the TIME/DIV VARIABLE knob (41) in the CAL'D position and referring to the indication of the TIME/DIV switch (39) .

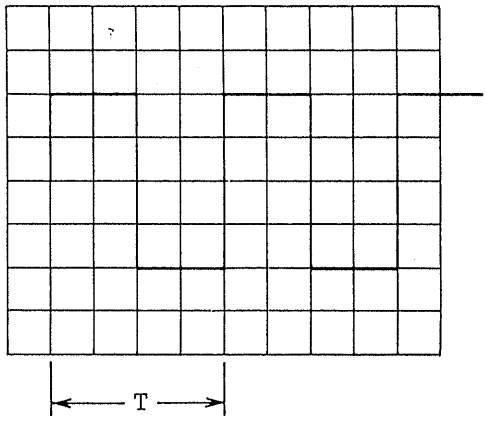


Figure 5-4

Time T (sec) = Indication of TIME DIV × Horizontal span (DIV)

When the sweep is magnified (×10 MAG (41) pulled), the time is 1/10 of the value determined as above.

5.5 Frequency Measurement

- Frequency measurement by determining time (T) per one cycle of the displayed waveform:

  Time T (period) is measured as explained in section 5.4 and the frequency is known by using the following formula.

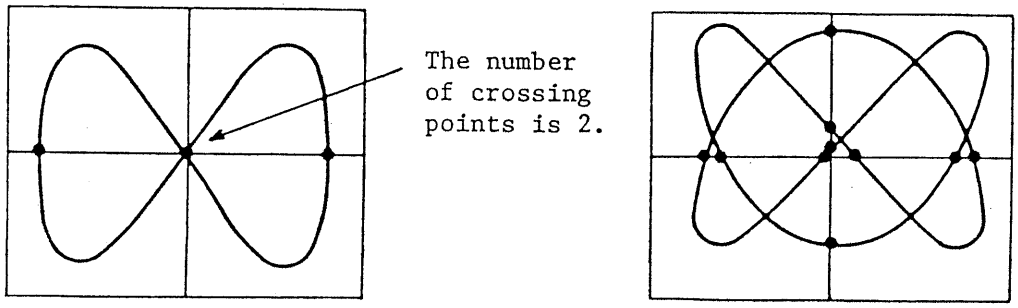
$$\text{Frequency } f \text{ (Hz)} = \frac{1}{\text{Period } T \text{ (sec)}}$$

- Frequency measurement with Lissajous figure (See Figure 5-5 and 5-6):

  Set the MODE switch (21) in the X-Y state so that the oscilloscope operates in the X-Y mode.

Apply to the X-axis a known frequency from a signal genetator (SG) and to the Y-axis the frequency to be measured. Adjust the required controls so that a pattern is displayed on the full surface of the CRT screen. Then adjust the frequency of the signal generator so that the displayed pattern becomes stationary as shown in Figure 5-4. From the displayed waveform, the unknown frequency can be calculated as follows:

$$\text{Unknown Frequency (Hz)} = \frac{\text{The number of crossing points over horizontal scale line}}{\text{The number of crossing points over vertical scale line}} \times \text{Frequency of signal generator (Hz)}$$



$\frac{4}{2} = \frac{2\ (H)}{1\ (V)}$ $\qquad\qquad$ $\frac{6}{4} = \frac{3\ (H)}{2\ (V)}$

Figure 5-5

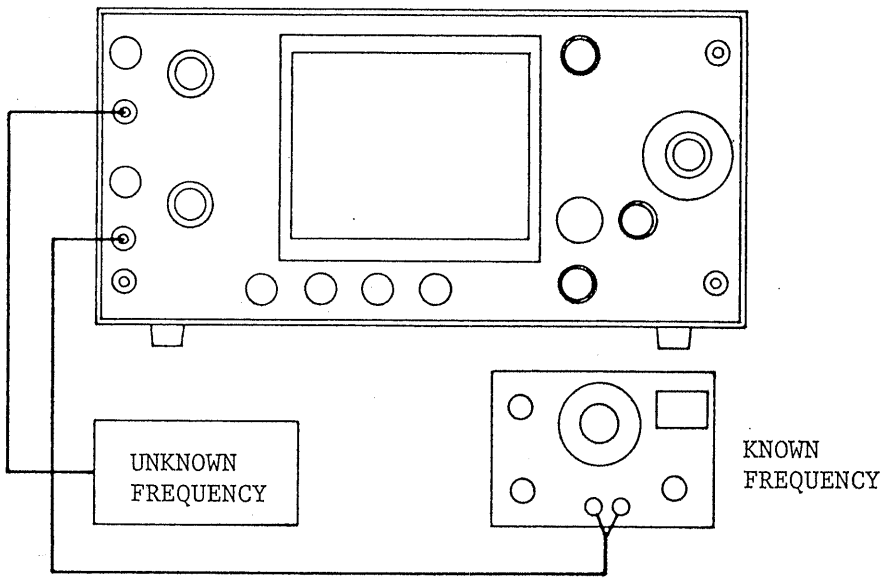


Figure 5-6

5.6 Measurement of Phase Difference

o Measurement of phase difference with Lissajous figure (See Figures 5-6, 5-7 and 5-8):

Operate the oscilloscope in the X-Y mode as explained in the paragraph for frequency measurement, and apply two signals of the same frequency (such as stereophonic signals) to the X and Y axes so that a Lissajous figure is displayed on the CRT screen. The phase difference between the two signals can be known by measuring the displayed waveform and employing the following equation:

$$\text{Phase difference } \theta = \sin^{-1} \frac{B}{A}$$

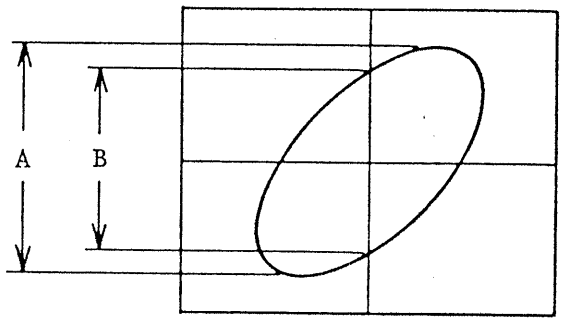


Figure 5-7

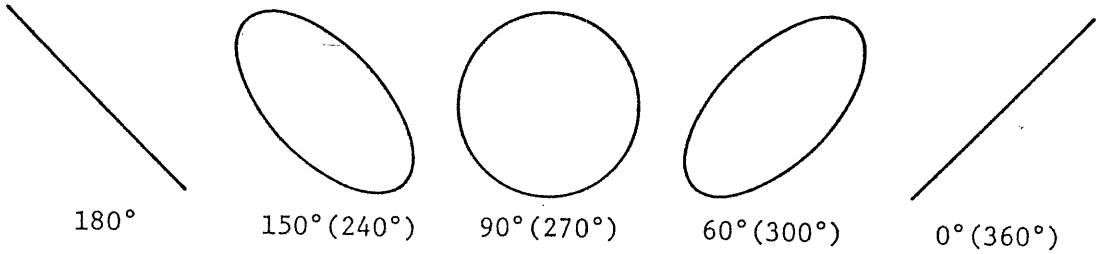


Figure 5-8

5.7 Characteristics of Pulse Waveform

A theoretically ideal pulse waveform is such that the signal changes instantaneously from one level to another, held in this level for a period of time and returns instantaneously to the original level. However, actual pulse waves are distorted. Nomenclature of distortions is given in Figure 5-9.

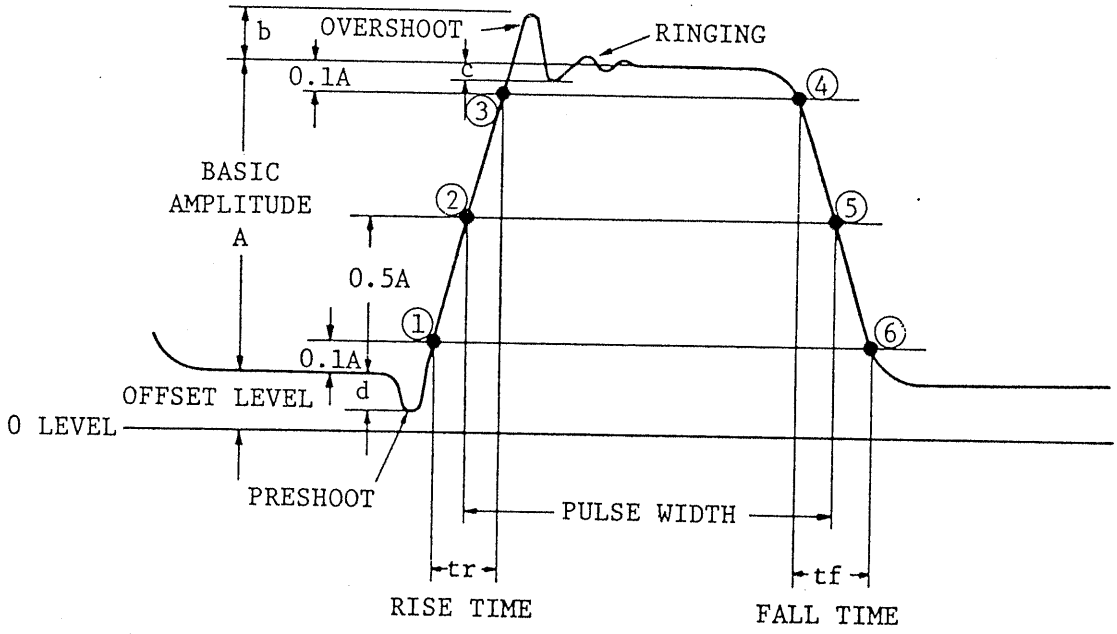


Figure 5-9

Pulse amplitude: Basic amplitude (A) of pulse

Pulse width: Time between points ② and ⑤ where signal amplitude is 50% of basic amplitude

Rise time: Time between 10% basic amplitude point ① and 90% basic amplitude point ③

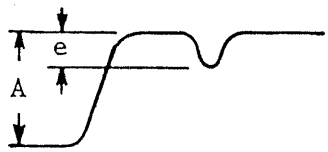
Fall time: Time between 90% basic amplitude point ④ and 10% basic amplitude point ⑥

Overshoot: Amplitude of the first maximum excursion beyond basic amplitude. Expressed in terms of b/A × 100 (%)

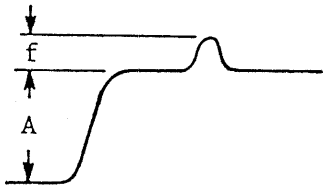
Ringing: Oscillation which follows the first maximum excursion. Expressed in terms of c/A × 100 (%)

Preshoot: Amplitude change (rise or fall) which precedes rise up of main pulse. Expressed in terms of d/A × 10 (%)

Hole: Amplitude fall that occurs after rise up of main pulse. Expressed in terms of e/A × 100 (%)



Bump: Amplitude rise that occurs after rise up of main pulse. Expressed in terms of f/A × 100 (%)



(Refer to EIAJ MEA-27A or IEC PUB. 351-1.)

o Measurement of rise time:

The rise time of a pulse can be known by determining the value of t_r on the CRT screen in the method of "Time Measurement." It must be noted that t_r determined on the CRT screen includes the rise time of the oscilloscope itself. The closer the rise time of the oscilloscope (t_o) to the rise time of the measured pulse (t_n), the larger is the error introduced. To eliminate this error, calculation should be done as follows:

True rise time $t_n = \sqrt{(t_r)^2 - (t_o)^2}$

where, t_r: Rise time measured on CRT screen

t_o: Rise time of oscilloscope itself (approx. 3.5 nsec)

For example, when a pulse wave with a rise time of 10 nsec (about 3 times that of the oscilloscope) is measured on the CRT screen, the error is approximately 6%.

o Measurement of Sag

Pulse waveforms may have slanted sections as shown in Figure 5-10, in addition to those distortions mentioned in Figure 5-9. Slants are caused when the signal is amplified with an amplifier which has poor low-frequency characteristics, resulting from attenuation of low frequency components. The slanted section (d or d') is called "sag" and is calculated as follows:

$$\text{Sag} = \frac{d}{A} \quad (\text{or} \quad \frac{d'}{A'}) \times 100 \ (\%)$$

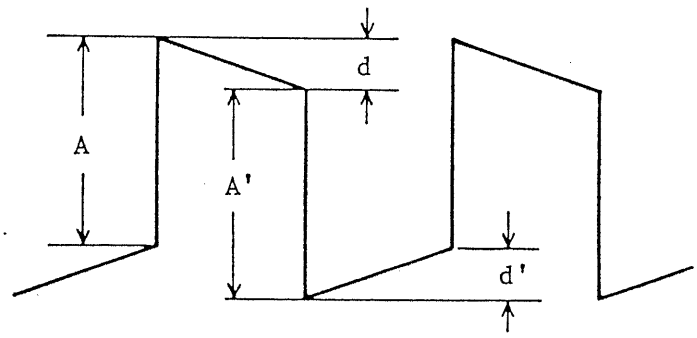


Figure 5-10

Note: If the AC-coupling mode is used for measurement of a low frequency pulse, sag is caused. For measurement of low frequency pulses, use always the DC-coupling mode.

5.8 10:1 Probe Compensation

Each time the 10:1 probes are used with the instrument, probe compensation should be checked and adjusted if necessary. A low capacitance screwdriver should be used. Use the following procedure for adjusting 10:1 probe compensation:

a. Connect the 10:1 probe to CH1 input (Figure 4-1 (21)).

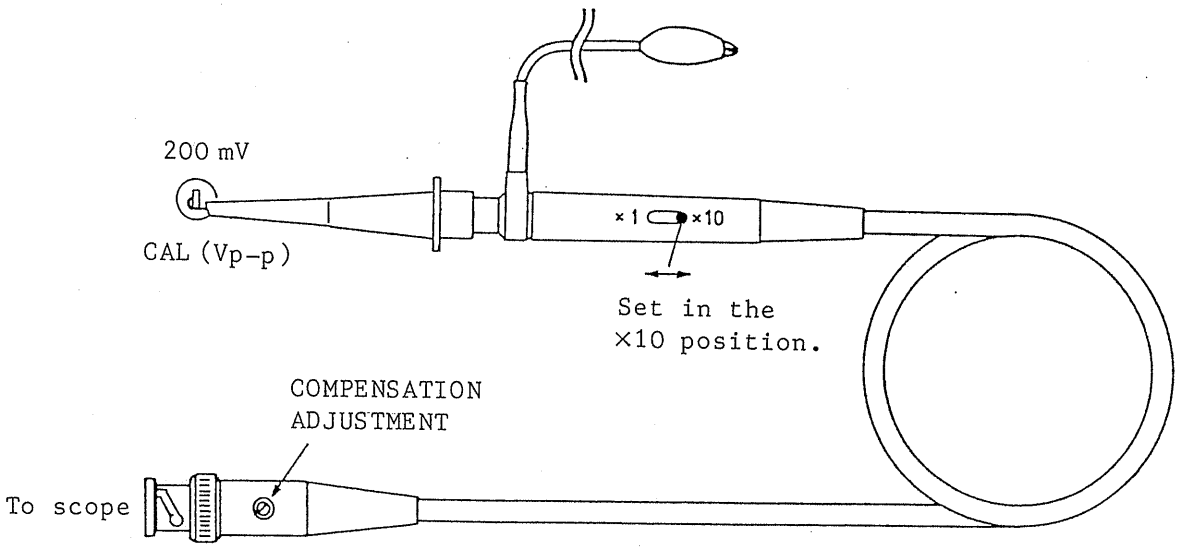
b. Set the instrument controls as follows:

CH1 VOLTS/DIV	Figure 4-1 (23)	5 mV
A, B TIME/DIV	Figure 4-1 (39)	0.5 ms
CH1 input coupling	Figure 4-1 (20)	AC
Vertical MODE	Figure 4-1 (26)	CH1 depressed
COUPLING	Figure 4-1 (34)	AC
SOURCE	Figure 4-1 (35)	INT

c. Connect the 10:1 probe pickup to 200mV CAL(Vp-p) output (Figure 4-1 (43)).

d. Adjust CH1 POSITION (Figure 4-1 (24)) and HORIZ. POSITION (Figure 4-1 (44)) to display the top of at least complete positive pulse.

e. Adjust probe compensation (through hole in compensation box) for best flat top display. Refer to Figure 5-11.



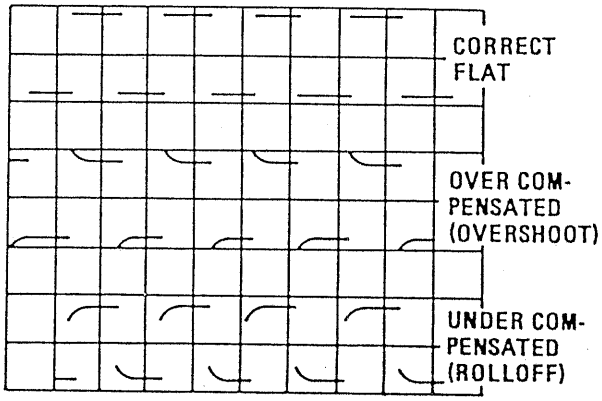


Figure 5-11. PROBE COMPENSATION

6. CIRCUIT DESCRIPTION

6.1 General

The overall circuit structure of the oscilloscope is as depicted with a block diagram in Figure 6-1. It is comprised of a vertical deflection circuit for moving the beam spot in the Y-axis direction on the CRT screen, a horizontal deflection circuit for moving the beam spot in the X-axis direction, a CRT circuit for operating the cathode-ray tube, a calibrator circuit for calibrating the instrument probe, and a power supply circuit for supplying powers to the various circuits of the instrument.

The vertical amplifier circuit has three mutually independent preamplifiers (CH1, CH2 and CH3), a vertical switching circuit, a delay line, and a vertical output amplifier.

Each of the preamplifiers amplifies or attenuates its input signal of several millivolts to several hundreds volts into a level suitable for handling by the subsequent stage. The conditioned vertical signals are sent to the vertical switching circuit. The trigger signals also are picked off at this stage.

The vertical switching circuit electronically switches the vertical signals received from the CH1, CH2 and CH3 preamplifiers and the CH4 and CH5 signals received from the A & B trigger generators. The switched signal is fed via the horizontal switching circuit and delay line circuit to the vertical output amplifier. The trigger signals also are switched and fed as internal trigger signals to the A & B trigger generators.

The vertical output amplifier amplifies the vertical signal, which is received through the delay line circuit, into a level of several volts to several tens volts for vertically deflecting the beam spot on the CRT screen.

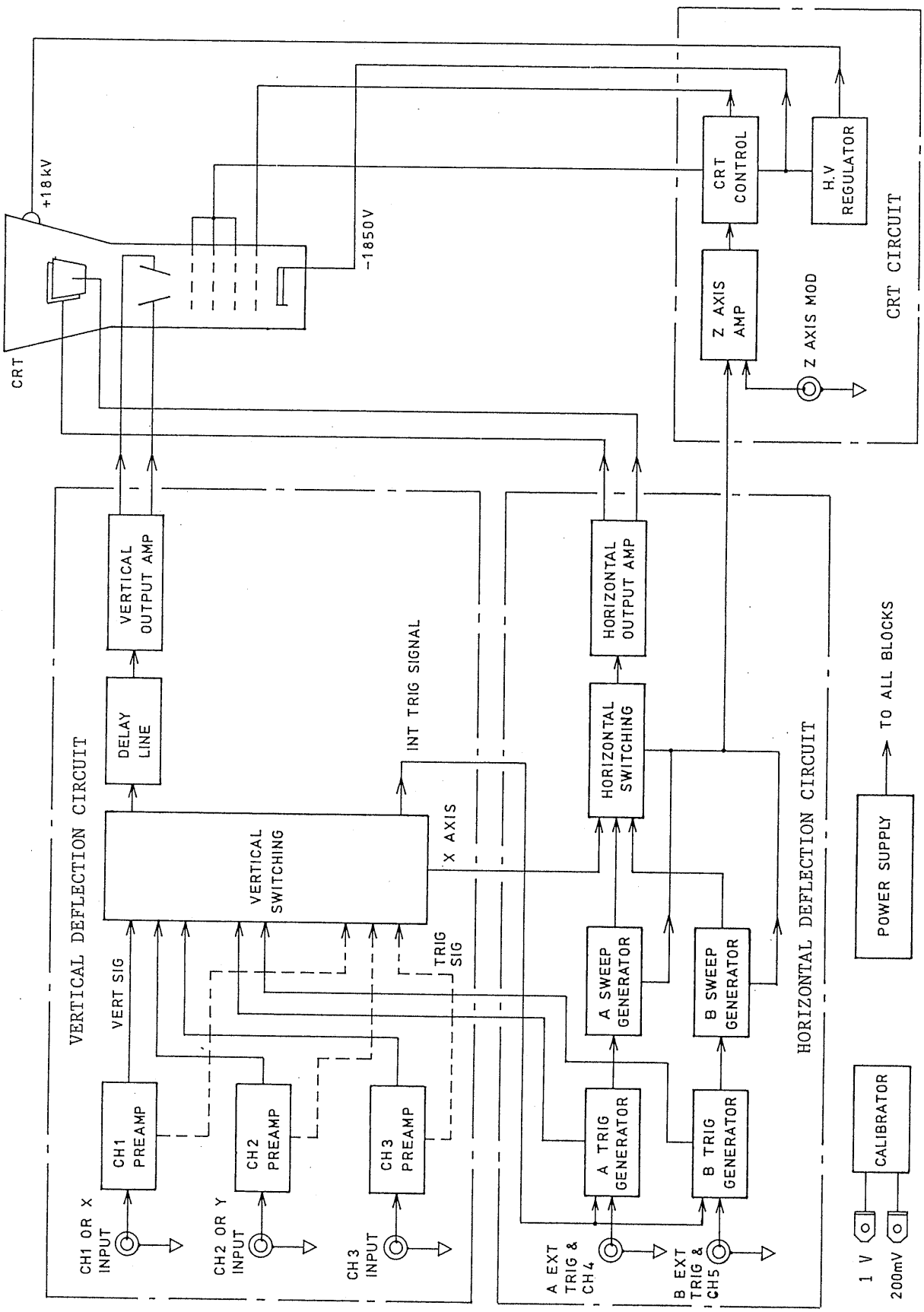

CRT
+18kV
-1850V
CRT CONTROL
H.V REGULATOR
Z AXIS AMP
Z AXIS MOD
CRT CIRCUIT
VERTICAL OUTPUT AMP
HORIZONTAL OUTPUT AMP
DELAY LINE
HORIZONTAL SWITCHING
INT TRIG SIGNAL
VERTICAL SWITCHING
X AXIS
TRIG SIG
VERT SIG
VERTICAL DEFLECTION CIRCUIT
HORIZONTAL DEFLECTION CIRCUIT
POWER SUPPLY
TO ALL BLOCKS
A SWEEP GENERATOR
B SWEEP GENERATOR
A TRIG GENERATOR
B TRIG GENERATOR
CH1 PREAMP
CH2 PREAMP
CH3 PREAMP
CH1 OR X INPUT
CH2 OR Y INPUT
CH3 INPUT
A EXT TRIG & CH4
B EXT TRIG & CH5
CALIBRATOR
1 V
200mV

Figure 6-1

The horizontal deflection circuit has mutually independent A and B trigger generators and sweep generators, a horizontal switching circuit, and a horizontal output amplifier.

The trigger generator receives the internal trigger signal from the vertical switching circuit or an external trigger signal from the EXT TRIG or CH4 or CH5 INPUT terminal and amplifies the signal and generates a trigger pulse signal.

The A sweep generator is driven by the trigger pulse signal of the A trigger generator and produces the A sawtooth signal. The sweep generator produces a sawtooth signal even when no trigger pulse is applied to it (the AUTO mode).

The B sweep generator produces the B sawtooth signal, being driven by the delayed sweep start signal produced with respect to the A sawtooth signal when in the delayed sweep mode. The B sweep generator can also be driven by the trigger pulse signal of the B trigger generator which follows the above delayed sweep start signal (the B TRIG'D mode).

The horizontal switching circuit electronically switches the sawtooth signals received from the A and B sweep generators and the CH1 & CH2 HOR signal received from the vertical switching circuit, and sends the resultant signal to the horizontal output amplifier.

The horizontal output amplifier amplifies the output signal of the horizontal switching circuit to a level of several volts to several tens volts in order to drive horizontally the beam spot on the CRT screen.

The CRT circuit is comprised of a high voltage generator (the HV regulator) to accelerate the electron beam emitted from the CRT cathode, a Z-axis amplifier to amplify the signal to blank out the return traces, and a CRT control circuit to operate the CRT tube in its optimal state.

The HV regulator provides a -1.8 kV voltage which is applied to the CRT cathode to accelerate the electrons emitted by it and a 18 kV voltage which is used as a post-acceleration voltage to accelerate further the electrons after passing the vertical and horizontal deflection plates.

The Z-axis amplifier amplifies the unblanking signals received from the A and B sweep generators and the trace intensity control signal to a level of several tens volts in order to be applied to the 1st grid (control grid) of the CRT via the CRT circuit.

The CRT circuit provides the various voltages for the CRT electrodes so that the CRT operates in an optimal state, displaying sharply-focussed less-distorted signal waveforms. It also conditions the signals received from the Z-axis amplifier and other circuit into levels suitable for application to the CRT.

6.2 Preamplifiers

The CH1 and CH2 preamplifiers amplify the signals of the CH1 (X-axis) and CH2 (Y-axis) input terminals, respectively. The CH3 preamplifier amplifies the signal applied to the CH3 or HOR input terminal. A detailed block diagram is shown in Figure 6-2.

- Input coupling switch:

The input coupling switch (S101, S201, S301-1, or S301-2) selects the input coupling mode for AC, GND, or DC. When the GND state is selected, the preamplifier input is isolated from the input terminal and is grounded so that the base line (0 level) on the CRT screen can be checked.

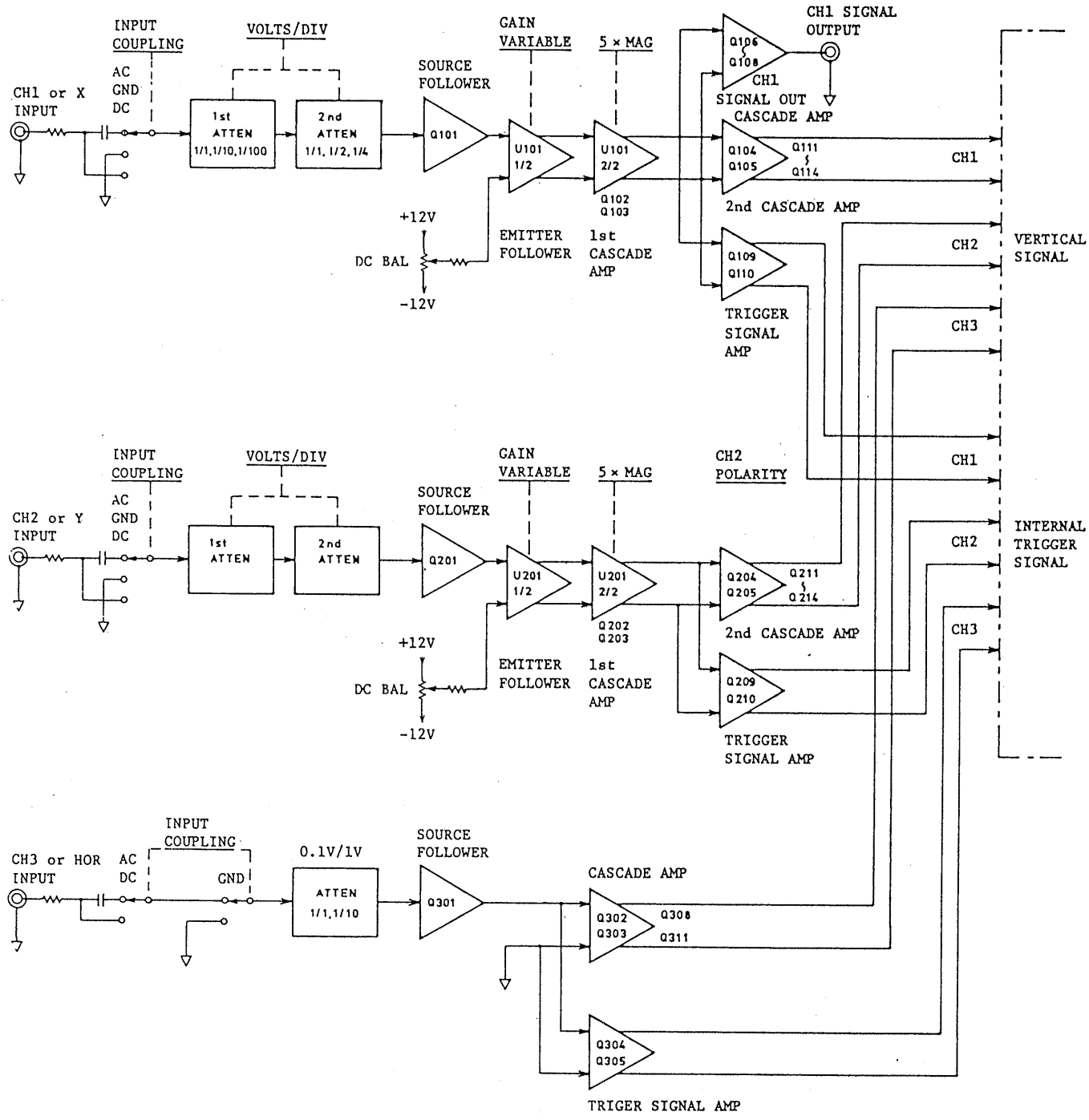

INPUT COUPLING
AC
GND
DC
CH1 or X INPUT
VOLTS/DIV
1st ATTEN 1/1,1/10,1/100
2nd ATTEN 1/1, 1/2, 1/4
SOURCE FOLLOWER
Q101
GAIN VARIABLE
U101 1/2
5 × MAG
U101 2/2
Q102 Q103
+12V
DC BAL
-12V
EMITTER FOLLOWER
1st CASCADE AMP
Q106 Q108
CH1 SIGNAL OUTPUT
CH1 SIGNAL OUT CASCADE AMP
Q104 Q105
Q111 Q114
CH1
2nd CASCADE AMP
Q109 Q110
CH2
TRIGGER SIGNAL AMP
CH3
VERTICAL SIGNAL
CH2 or Y INPUT
CH2 POLARITY
Q201
U201 1/2
U201 2/2
Q202 Q203
Q204 Q205
Q211 Q214
Q209 Q210
INTERNAL TRIGGER SIGNAL
CH3 or HOR INPUT
0.1V/1V
ATTEN 1/1,1/10
Q301
CASCADE AMP
Q302 Q303
Q308 Q311
Q304 Q305
TRIGER SIGNAL AMP

Figure 6-2

o Attenuators:

The CH1 or CH2 attenuator circuit consists of two attenuators: The 1st attenuator for 1/1, 1/10 and 1/100, and the 2nd attenuator for 1/1, 1/2, 1/4 and 1/10. By switching these attenuators with the VOLTS/DIV switch (SW102/202), the signal can be attenuated for a total range of 1/1 to 1/400 in 10 steps. The attenuator circuit is so designed that its input impedance remains constant at 1 MΩ, 20 pF (±2 pF) even when combinations are changed.

The CH3 attenuator provides an attenuation ratio of 1/10, thereby providing two ranges of 0.1 V/DIV and 1 V/DIV.

o Impedance converter:

The impedance converter presents with its source follower (Q101/Q201/Q203) a high input impedance to prevent the loading effect on the high-impedance attenuator circuit and provides a low output impedance with its emitter follower (CH1 and CH2) to drive the 1st differential cascade amplifier of the next stage. In order to guard against thermal drift, the source follower employs a dual-FET package which houses two thermally-coupled elements for thermal drift compensation and the emitter follower employs two premium-grade thermally-coupled transistors.

o 1st differential cascade amplifier:

The 1st differential cascade amplifier is comprised of an emitter-connected differential current amplifier (U101-2/2, U202-2/2) and a current-to-voltage converter (Q102, 103/Q202, 203) which converts the differential collector output current of the differential current amplifier into a voltage signal. This amplifier also has the VARIABLE circuit for continuously-variable adjustment of the sensitivity between two adjoining vertical deflection sensitivity ranges selected by the VOLTS/DIV switch and the 5 × MAG switch for magnifying the vertical sensitivity by 5 times to realize the 1 mV/DIV sensitivity.

o VARIABLE circuit:

The VARIABLE circuit continuously-variably adjusts the vertical sensitivity by shunting with potentiometer RV103/RV203 a part of the collector current amplified by U101-2/2 or U201-2/2. Adjustment (attenuation) can be done with a ratio of 1/2.5 or over.

o 5 × MAG circuit:

The 5 × MAG function is to increase the vertical sensitivity by 5 times by switching the output load resistor of the 1st differential cascade amplifier to the value of 5 times of that when in the normal mode.

o Buffer emitter follower:

The buffer (U101-1/2 or U201-2/2) has a function of sending, with less loading effects, the output signal of the preceding 1st differential cascade amplifier to the subsequent 2nd differential cascade amplifier, trigger signal pickoff amplifier, and CH1 SIGNAL OUTPUT amplifier (CH1 only).

o 2nd differential cascade amplifier:

The 2nd differential cascade amplifier (Q104, 105, 111, 114, or Q204, 205, 211 - 214) amplifies the output of the emitter follower to a sufficient level for driving the vertical switching circuit. The grounded-base stage (Q111, 114/211 - 214) of this cascade amplifier has a function of preventing the switching signal of the vertical switching circuit from being returned to the preceding stage and mixed into the trigger signal or the signal of the CH1 signal output amplifier. For the CH2 signal, this amplifier also has a function of inverting its polarity. This polarity inverting function is accomplished by switching with the INV switch (S351-8) the base grounding stages of Q211/214 and Q212/213 to which the collector currents which have been current-amplified by Q204 and Q205 are fed in a crossing manner.

Different from the case of the 1st differential cascade amplifier, the output signal of the 2nd differential cascade amplifier is fed directly in the form of the current signal to the diode gate of the vertical switching circuit. The current signal for vertical positioning of the trace on the CRT screen is added to the output current signal of the 2nd differential cascade amplifier, being controlled by potentiometer RV108/208 of the positioning circuit.

- o CH1 signal output amplifier (CH1 only):

  The CH1 signal output amplifier (Q106, 107, 108) amplifies the input signal of the CH1 (X INPUT) terminal by approximately 5 times (2.5 times when terminated with 50 ohms). The amplified signal is fed to the output terminal (J12) on the instrument rear panel in order to be monitored with a frequency counter or other measuring instrument.

6.3 Vertical Switching Circuit

The vertical switching circuit is comprised of a vertical signal switching circuit which electronically switches the vertical signals received from the CH1, CH2 and CH3 preamplifiers and the CH4 and CH5 signals received from the A & B TRIG generators, an internal trigger signal switching circuit which electronically switches the trigger signals, and a switching logic circuit which controls these switching circuits.

The vertical signal switching circuit is, as shown in Figure 6-3, comprised of a diode gate circuit, an ADD BAL and buffer circuit which switches the vertical signals with the signal received from the switching logic circuit, and a switching buffer circuit which receives the signal from the diode gate.

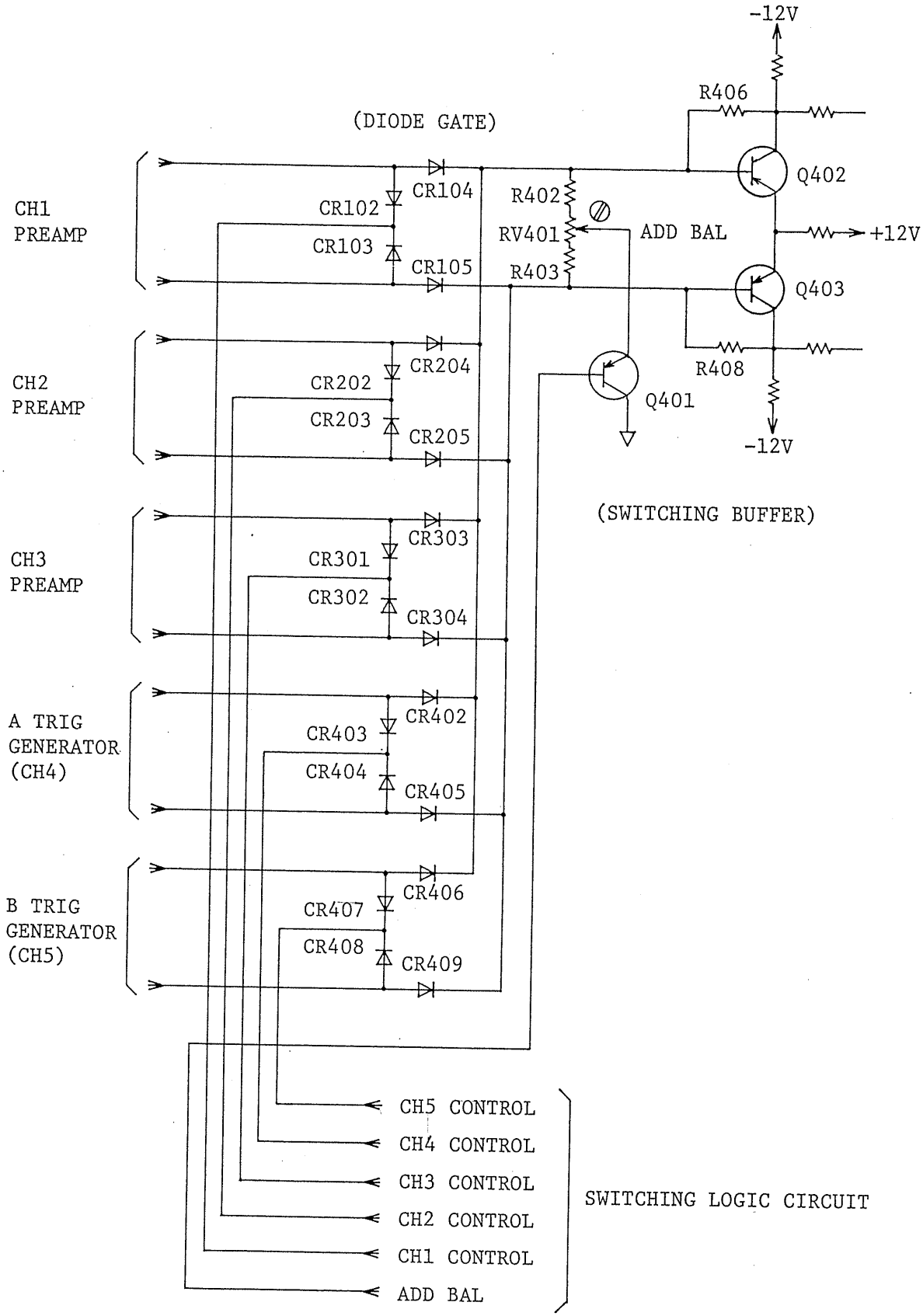

-12V
R406
(DIODE GATE)
Q402
CR104
R402
CH1
PREAMP
CR102
RV401
ADD BAL
+12V
CR103
CR105
R403
Q403
CR204
R408
CH2
PREAMP
CR202
Q401
CR203
CR205
-12V
(SWITCHING BUFFER)
CR303
CH3
PREAMP
CR301
CR302
CR304
CR402
A TRIG
GENERATOR
(CH4)
CR403
CR404
CR405
CR406
B TRIG
GENERATOR
(CH5)
CR407
CR408
CR409
CH5 CONTROL
CH4 CONTROL
CH3 CONTROL
CH2 CONTROL
CH1 CONTROL
ADD BAL
SWITCHING LOGIC CIRCUIT

Figure 6-3

o Diode gate circuit:

The diode gate circuit (CR102 - 105, CR202 - 205, CR301 - 304, CR402 - 409) selects the CH1 - CH5 signals being controlled by the signal of the switching logic circuit according to the mode selected by the VERT MODE switch (S351).

For example, when the VERT MODE switch is set at CH1, the CH1 control signal becomes the Hi state and the CH2 to CH5 control signals become Lo state. Consequently the output signal of the CH1 preamplifier is fed through CR104 and CR105 to the switching buffer circuit consisting of Q402 and Q403. The signals of the other channels are fed through respective diodes CR202/203, CR301/302, CR403/404 and CR407/408 to the control circuit. Thus, the signal of CH1 alone is fed to the switching buffer circuit and the signals of the remaining channels are blocked.

o ADD BAL circuit:

When the ADD mode is selected by the VERT MODE switch, the control signals of both CH1 and CH2 becomes the Hi state, the signals of the CH1 and CH2 preamplifiers are fed through CR104/105 and CR204/205 to the switching buffer circuit, and the two signals are fed as their sum signal to the output circuit. The function of the ADD BAL circuit is to compensate for the DC balance shift caused by the above addition operation, with its ADD BAL control (semi-fixed potentiometer RV401).

o Internal trigger switching circuit:

The internal trigger switching circuit directly controls, with the control signal from the switching logic circuit, the diode gate circuit (CR351 - 362) which is similar to the vertical signal switching circuit. It receives with its switching buffer (Q351/352) the trigger signal which has passed the diode gate circuit and feeds the signal to the internal trigger output amplifier. The internal trigger output amplifier (Q353/354)

coverts the output signal of the switching circuit into a low impedance signal which is delivered as the internal trigger signal via connector P-31.

o Switching logic circuit:

The switching logic circuit is comprised of a vertical switching logic circuit which controls the vertical switching circuit and an internal trigger switching logic circuit which controls the internal trigger switching circuit.

The vertical switching logic circuit is comprised of a ring counter which is consisting of three flip-flops (U307, U309-2/2) with preset/clear terminals and a code converter (U304, U305) which receives the ring counter output and generates control signals for individual channels. Switching can be done for any combination of channels by turning on and off the preset/reset terminals of the ring counter. The code-converted control signal is fed to the internal trigger switching logic circuit.

The internal trigger switching logic circuit controls the internal trigger switching circuit by switching with IC U301 the control signal selected by the INT TRIG switch (S301) and the control signal received from the vertical switching logic circuit. This relationship is shown in the following table.

MODE / INT TRIG	CH1	ADD	CH2	CH3	TRIG VIEW	
					CH4	CH5
CH1	Triggered by CH1					
CH2	Triggered by CH2					
CH3	Triggered by CH3					
ALT	Trig'd by CH1	Trig'd by CH1	Trig'd by CH2	Trig'd by CH3	(Trig'd by CH1)	(Trig'd by CH1)

The items enclosed in the parentheses are for the case of TRIG VIEW (INT TRIG).

6.4 Delay Line Circuit

The vertical input signal is fed via the vertical switching circuit to the bandwidth filter circuit and then to the delay line drive circuit.

The bandwidth filter circuit consists of a CR filter (R412/C405 and R414/C406) and a transistor (Q404) which turns on and off the filter. With the control signal of the BW LIMIT switch (S351-9), bandwidth can be selected between 20 MHz and full band.

The vertical signal which has passed the bandwidth filter is amplified by the delay line drive circuit (Q405, Q406). The delay line drive circuit drives the delay line, with a matched output impedance.

The delay line is used to prevent the trigger point of the signal from being lost from being displayed on the screen due to time lag in the horizontal deflection circuits or the Z-axis amplifier circuits. For the delay line, this oscilloscope employs a delay cable which provides a delay time of approximately 90 nanoseconds. The vertical signal which has passed the delay line is fed to the vertical output amplifier.

6.5 Vertical Output Amplifier

The vertical output amplifier is comprised of a delay line receiver which receives the output signal of the delay line with a matched impedance, an A & B trace separation circuit which positions the B sweep waveform when in the ALT mode, an emitter follower circuit which converts the output of the delay line receiver into a sufficiently low impedance to drive the final cascade amplifier which drives the vertical deflection plates of the CRT, and an X-Y alignment circuit which adjusts the right-angle feature of the displayed axes. A schematic diagram of the vertical output amplifier is shown in Figure 6-4.

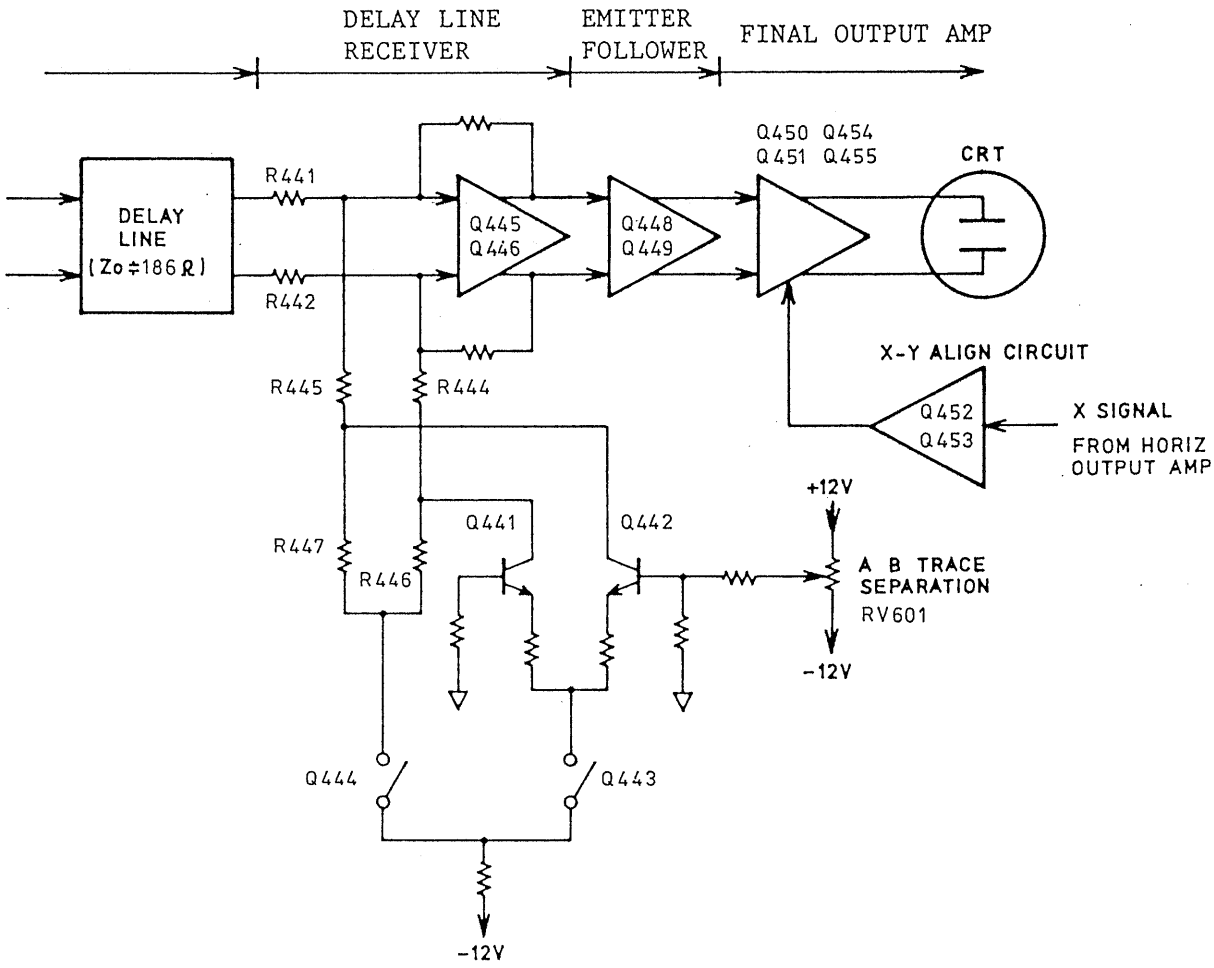

DELAY LINE RECEIVER
EMITTER FOLLOWER
FINAL OUTPUT AMP
DELAY LINE (Zo≒186Ω)
R441
R442
Q445 Q446
Q448 Q449
Q450 Q454 Q451 Q455
CRT
X-Y ALIGN CIRCUIT
Q452 Q453
X SIGNAL FROM HORIZ OUTPUT AMP
R445
R444
R447
R446
Q441
Q442
+12V
A B TRACE SEPARATION RV601
-12V
Q444
Q443
-12V

Figure 6-4

o Delay line receiver circuit:

The delay line receiver circuit (Q445, 446) is a low input impedance negative feedback amplifier which, with its input resistors R441 and R442, provides impedance matching with the characteristic impedance (Zo ≒ 186 ohms) of the delay line. With this low input impedance, the A & B trace separation circuit is connected in parallel.

o A & B trace separation circuit:

The A & B trace separation circuit vertically positions the trace by varying the currents which flow through resistors R444 and R445 from the input of the delay line receiver, as shown in Figure 6-4. In order to prevent intrusion of switching pulses, this circuit has a balanced current circuit (R446 and R447) and an unbalanced current circuit (Q441 and Q442), and these circuits are switched by the transistor switching circuit (Q443, 444). Balancing of the currents which flow in Q441 and Q442 is adjustable with the A & B TRACE SEPARATION potentiometer (RV601).

o Emitter follower:

The emitter follower (Q448, 449) converts the output signal of the delay line receiver into a low impedance to drive the final cascade amplifier. In order to suppress parasitic oscillations, the signal is fed from the emitters of Q448 and Q449 to the bases of Q450 and Q451 through R465 and R468.

o Final cascade amplifier:

The final cascade amplifier is a differential cascade amplifier comprising of a current amplification stage (Q450, 451) which has a high f_T in order to provide a sufficient output voltage to drive the vertical deflection plates of the CRT, and a voltage converter stage (Q454, 455) which employs high-voltage-type high-frequency transistors.

The right-angle compensation current signal of the X-Y alignment circuit is added to the output of the above current amplifier in order to maintain the perpendicularity of the axes on the CRT screen.

o X-Y alignment circuit:

The X-Y alignment circuit (Q452, 453) is a differential amplifier which provides a current signal to compensate for right-angle error of the axes on the CRT screen. This amplifier receives part of the horizontal deflection signal from the horizontal output amplifier and converts it into a perpendicularity compensation current signal, which is applied to the emitters of Q454 and Q455. The polarity and amount of the perpendicularity compensation current signal are adjustable with the X-Y ALIGN potentiometer (RV455).

6.6 A and B Trigger Generators

The A trigger generator is comprised of a trigger pulse generator circuit which produces a trigger pulse signal for driving the A (main) sweep generator and an AUTO circuit which produces a free-run signal for automatic sweep operation when the trigger signal is asynchronized or no trigger signal is applied. The B trigger generator produces a trigger pulse for driving the B (delayed) sweep generator when in the B TRIG'D mode.

A Trigger Generator:

As shown in Figure 6-5, the trigger pulse generator circuit of the A trigger generator is comprised of a source switch which selects a trigger signal source, a coupling switch which selects a coupling mode in conformity with the nature of the trigger signal source, an impedance converter circuit which converts the high-impedance trigger source signal into a low-impedance signal with which to drive the level comparator circuit which controls

the start point (triggered point) of the signal waveform displayed on the CRT screen, a TV synchronization separator circuit which picks off the synchronization signal from the TV video signal, and Schmitt trigger circuits which convert the output signals of the level comparator circuit and TV synchronization signal separator circuit into TTL level signals.

o Source switch:

The source switch (S501) selects the internal trigger signal fed from P-69, the line trigger signal fed from R1212, the the external trigger signal fed from J4, or the signal fed from F-4 and attenuated by a factor of 1/10 into the EXT ÷ TRIG signal. The selected signal is fed to the coupling switch.

o Coupling switch:

The coupling switch (S502) selects the coupling mode. Switch S502-2 selects the DC mode for direct coupling of the signal fed from S501, the AC mode for discarding the DC component, or the HF REJ mode for coupling via a low-pass filter. and the LF REJ mode for coupling via a high-pass filter.

o Impedance converter:

The impedance converter is a temperature-compensated-type cathode follower (Q501) with dual FETs. It converts the trigger signal selected by the source switch and coupling switch into a low-impedance signal. The impedance is lowered further by the emitter follower of U501 and then the signal is fed to drive the level comparator circuit.

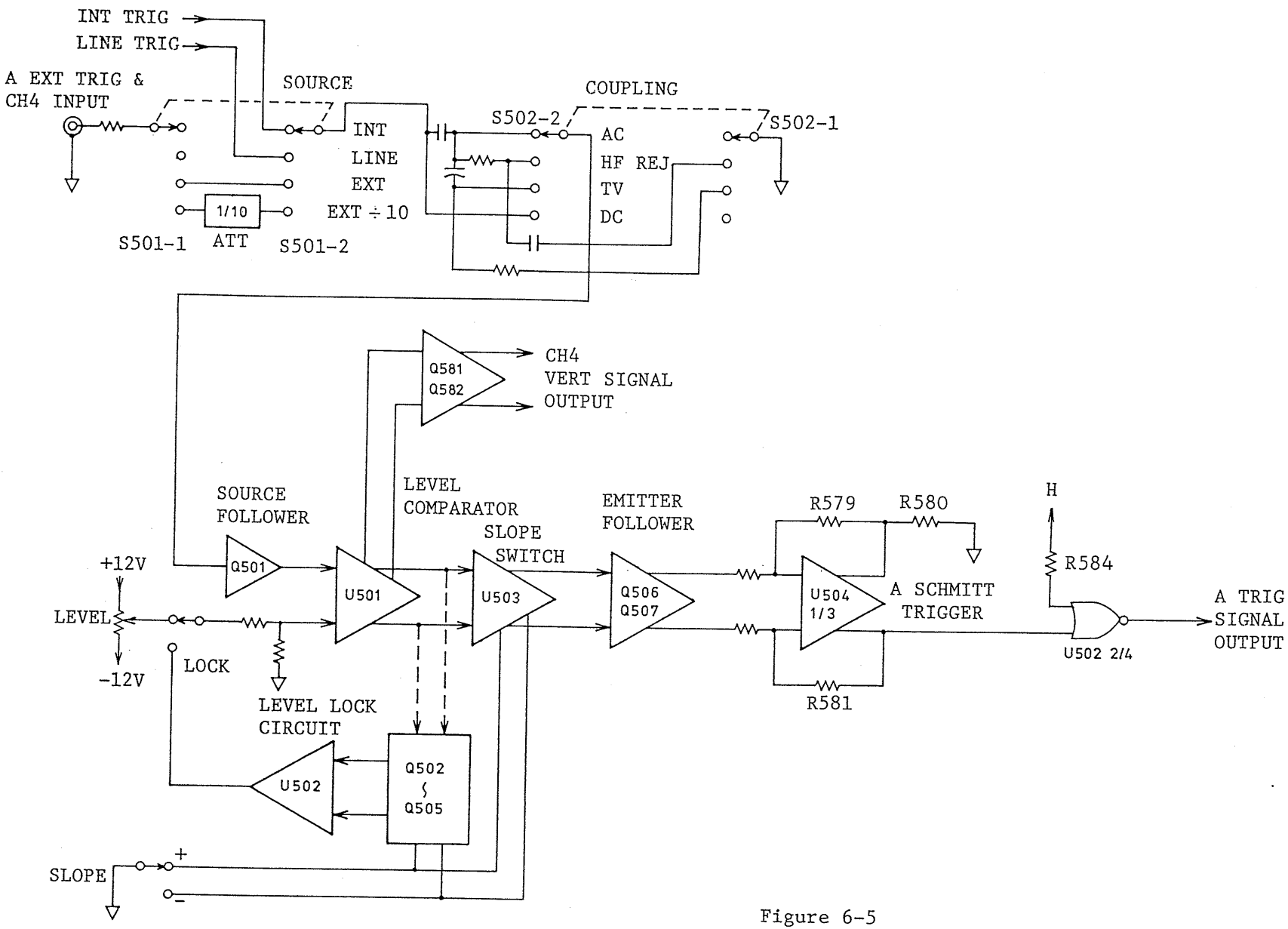

INT TRIG
LINE TRIG
A EXT TRIG &
CH4 INPUT
SOURCE
INT
LINE
EXT
EXT ÷ 10
1/10
ATT
S501-1
S501-2
COUPLING
S502-2
S502-1
AC
HF REJ
TV
DC
Q581
Q582
CH4
VERT SIGNAL
OUTPUT
SOURCE
FOLLOWER
LEVEL
COMPARATOR
SLOPE
SWITCH
EMITTER
FOLLOWER
R579
R580
H
R584
+12V
LEVEL
-12V
Q501
U501
U503
Q506
Q507
U504
1/3
A SCHMITT
TRIGGER
A TRIG
SIGNAL
OUTPUT
U502 2/4
LOCK
R581
LEVEL LOCK
CIRCUIT
U502
Q502
~
Q505
SLOPE
+
-

Figure 6-5

o Level comparator:

The level comparator is a differential cascade amplifier (U501, U503) which adjusts the rise up portion (or the fall down portion) of the comparator output signal by applying to U501 No. 9 of the current amplifier stage the trigger source signal from the impedance converter circuit and adding to U501 No. 8 the comparator level signal from the LEVEL control potentiometer (R501). In this case, if switch S503 which is linked to the LEVEL control potentiometer is locked, the comarator level signal is applied to U501 No. 8 from the level lock circuit and the trigger point is fixed at the center amplitude of the trigger source signal. The level lock circuit amplifies with its error amplifier the error signal detected by Q502 - Q505 and feeds back the signal so that the center level of the comparator output signal becomes the Schmitt level of the Schmitt trigger circuit.

The SLOPE switch (S505) selects a slope by switching the voltage converter stage of the cascade amplifier by changing polarity of U503.

The output signal of the cascade amplifier is fed via the impedance converter (Q506, 507) to the TV synchronization signal separator circuit and the regular (non-TV) Schmitt circuits.

o A TRIG Schmitt circuit:

The A TRIG Schmitt circuit is a differential type circuit which generates a hysteresis voltage by applying a feedback signal with R579/581 to the ECL line receiver of U504 1/3. The output of the Schmitt circuit drives the A SWEEP generator and AUTO circuit via the NORM/TV switching circuit.

o AUTO circuit:

The AUTO circuit converts with its pulse converter (U505 2/4, 4/4, Q573) the high-speed pulse signal of the trigger pulse generator into a low-speed pulse signal which is applied to the CH1, CH2 and CH3 stable multivibrators (702 1/2, 2/2, U701 2/2) to generate the CH1, CH2 and CH3 AUTO signals. With the AUTO switching pulse signal received from the vertical switching circuit, the CH1, CH2 and CH3 signals are switched by the AUTO signal switching circuit (U703). The switched AUTO signal is conditioned for waveform-shaping by the Schmitt circuit (U504 3/3) to drive the A sweep generator and the TRIG'D LED lamp.

B Trigger Generator

The B trigger generator is identical with the A trigger generator except that the former has no AUTO circuit since no such circuit is required for its operation.

6.7 A and B Sweep Generators

The A sweep generator produces the sawtooth signal for the main sweep (A sweep) of this oscilloscope. The B sweep generator produces the sawtooth signal for magnification in the time axis direction the waveform displayed on the main sweep or for display with a certain time delay (delayed sweep or B sweep).

The A sweep generator consists of the A sweep gate circuit which receives the trigger signal from the A trigger generator and produces the sweep gate signal for starting sweeps, the sweep start comparator which maintains stably the sweep start point, the A sawtooth sweep generator which produces a sawtooth wave in conformity with the time constant selected by the TIME/DIV switch, the sweep length circuit which controls the length of sweeps, the hold off circuit which controls the sweep return period and pause period, and the A sweep gate enable circuit which controls the sweep gate circuit in conformity with the AUTO, NORM or SINGLE mode as selected by the MODE switch for the signals of the above control circuits.

o A sweep gate:

The A sweep gate circuit employs a flip-flop ECL IC with reset/clear function. The trigger pulse of the A trigger generator is applied to the CLOCK (No. 11) terminal, the enable signal of the A sweep gate enable circuit to the SET (No. 12) terminal, and the enable signal and AUTO signal of the AUTO circuit to the RESET (No. 13) terminal through the NOR gate circuit. The Q (No. 14) terminal output is applied as the unblanking signal to the Z-axis amplifier and the $\overline{Q}$ (No. 15) terminal output is fed to the sweep start comparator circuit and becomes the A sweep gate signal. Even when no trigger pulse signal is applied to the CLOCK terminal, the $\overline{Q}$ output can be made the low state with the AUTO signal of the RESET terminal so that the A sweep gate signal is generated and the circuit operates in the free-run mode.

o B sweep gate:

The basic structure of the B sweep gate is identical with that of the A sweep gate.

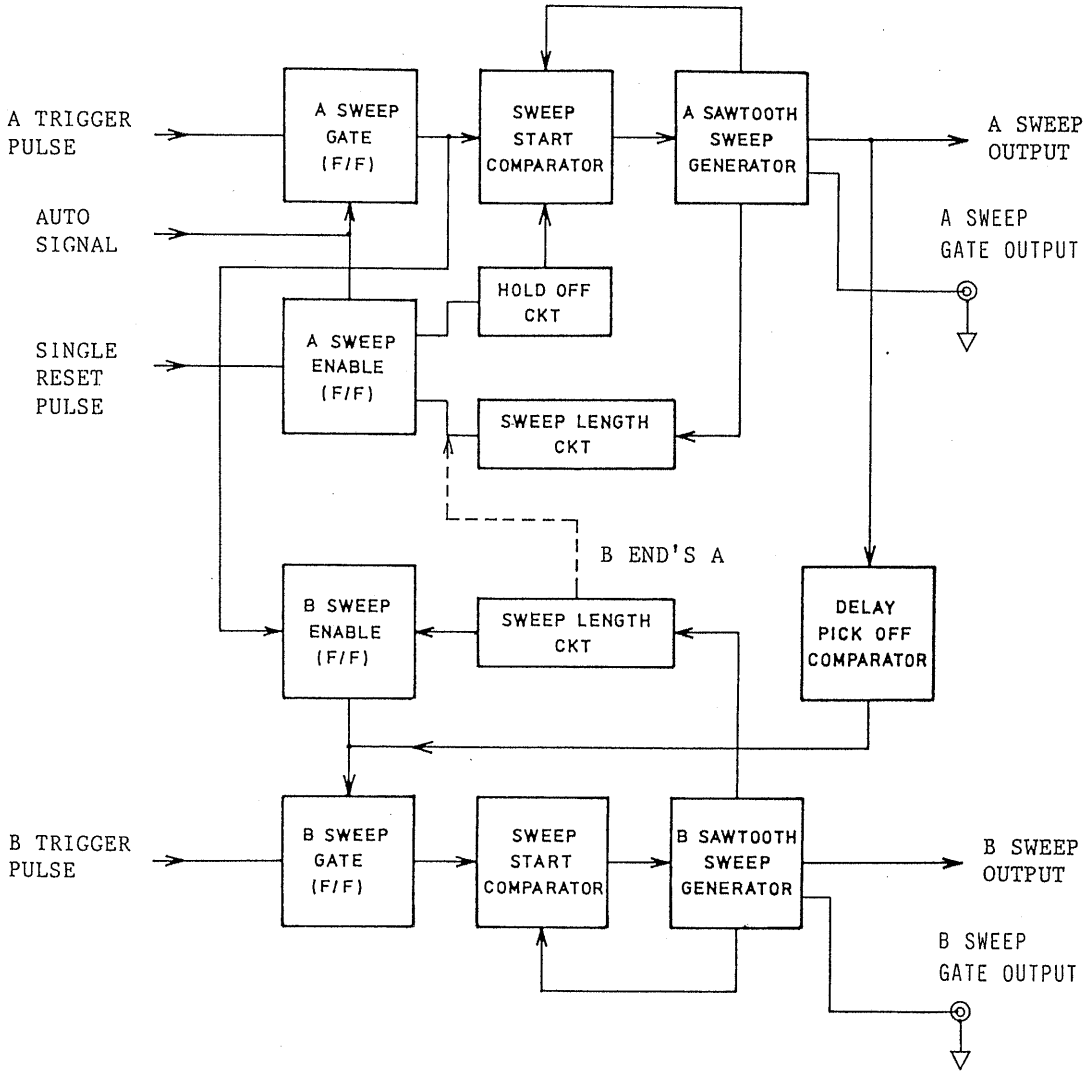


Figure 6-6

o Sweep start comparator:

The sweep start comparator (Q802, 803) is a differential amplifier which lets the sweep gate signal pass and maintains constant the sweep start level. A start reference level identical with the B sweep start level is applied to one of the inputs, the Miller integrator output signal is applied to the other input, and the difference between the two signals is compensated for.

o A sawtooth generator:

The A sawtooth generator is comprised of a gate transistor amplifier, a Miller integrator, an integration time constant switching circuit, and a logic circuit which controls the switching circuit. The gate transistor amplifier (Q810) controls the Miller integrator circuit in such manner that the start level control signal and sweep gate signal of the sweep start comparator do not affect the integration time constant. The Miller integrator (Q809, Q811, 812) produces a sawtooth signal with the time constant selected by the integration time constant selector circuit. The integration time constant selector circuit selects integration capacitor C811/C812 with U802 1/4, 2/4. For integration current, R833 - 836 are selected by Q818 - 821 and R828 - 830 by CR811 - 813. The logic circuit selects an integration capacitor and a resistor in conformity with the range selected by the TIME/DIV switch (S801) in order to control the integration time constant selector circuit.

o Sweep length circuit:

The sweep length circuit divides with its voltage divider (R731, RV701, R732) the output of the A sweep generator, shapes the waveform with its Schmitt circuit (U706 2/3), and produces the length signal. The B END A signal is added to the signal of No. 5 pin of U704.

o Holdoff circuit:

The holdoff circuit generates a holdoff (pause) time signal proportional to the sweep time by producing a triangular wave with the Miller integrator (Q807) and making use of the fall time of the triangular wave. The integrator, with its Q805 and Q806, selects the time constant in accordance with the integration output voltage in order to cover a wide time range. The output signal of the Miller integrator is detected by Q804 and shaped by the Schmitt circuit (U706 3/3) into a holdoff signal. The trigger pulse is fed to the reference input of the Schmitt circuit via C708 in order to suppress jitter which could be produced when in high speed sweep.

o A sweep gate enable circuit:

The A sweep gate enable circuit employs the flip-flop IC (U704 1/2) which makes up a pair with the A sweep gate circuit. The holdoff signal is applied to the RESET (No. 4) terminal, the length signal is applied to the SET (No. 5) terminal, and the enable signal is delivered from the Q (No. 2) terminal. This enable signal resets or sets the A sweep gate circuit. When in the NORM sweep mode, the output signal of the AUTO circuit is blocked and, if no trigger signal is applied, the circuit is in the ready state. When in the SINGLE sweep mode, the holdoff circuit remains idle and a one-shot sweep is effected by the reset signal applied from the CLOCK (No. 6) terminal.

The basic structure of the B sweep generator is identical with that of the A sweep generator. It consists of the B sweep gate, sweep start comparator, B sawtooth generator, sweep length circuit, B sweep enable circuit, and delay pickoff comparator. The B sweep generator requires no holdoff circuit because it operates only during the period the A sweep generator is in the sweep operation. Instead of the holdoff signal, the A sweep gate signal sets the B sweep enable circuit to the enable state.

o Delay pickoff comparator:

The delay pickoff comparator (Q704 - 707) employs a dual FET (Q706) to obtain a certain time relationship as set by the delay time multiplication potentiometer (RV705) with respect to the A sweep signal. The comparator compares the A sweep output signal (sawtooth waveform) with the voltage set by RV705, generates a delayed sweep start signal, and sets the B sweep gate circuit to start the B sweep signal. When in the B TRIG'D mode, the B sweep gate circuit is not set directly with this delayed sweep start signal but the RESET (No. 13) terminal is set in the low state and the B sweep signal is started as driven by the trigger pulse of the B trigger generator.

6.8 Horizontal Switching Circuit

The horizontal switching circuit is comprised of a switching buffer circuit which prevents switching distortion from being sent to the sweep circuit of the preceding stage, a display switching circuit which electronically switches the A and B sweep signals, a 10 × MAG circuit which magnifies the sweep signal by 10 times, and a horizontal mode switching circuit which selects either CH1 or CH3 signal for the horizontal axis.

o Switching buffer circuit:

The switching buffer circuit is of a grounded-base-type amplifier. Transistor Q1001 is for buffer-amplification of the A sweep signal, transistor Q1002 for the B sweep signal.

o Display switching circuit:

The display switch circuit has a diode switching circuit (CR1002, 1003) which turns on and off the A and B sweep signals by controlling the emitter currents of transistors Q1003 and Q1004. The on-off actions of diodes CR1002 and CR1003 are controlled by U1002 1/2 IC as dictated by the DISPLAY switch (S1001). U1002 2/2 IC generates

the vertical ALT switching pulse signal. The switched sweep signal is fed to the ×10 MAG circuit, which is used also to drive the horizontal mode switching circuit.

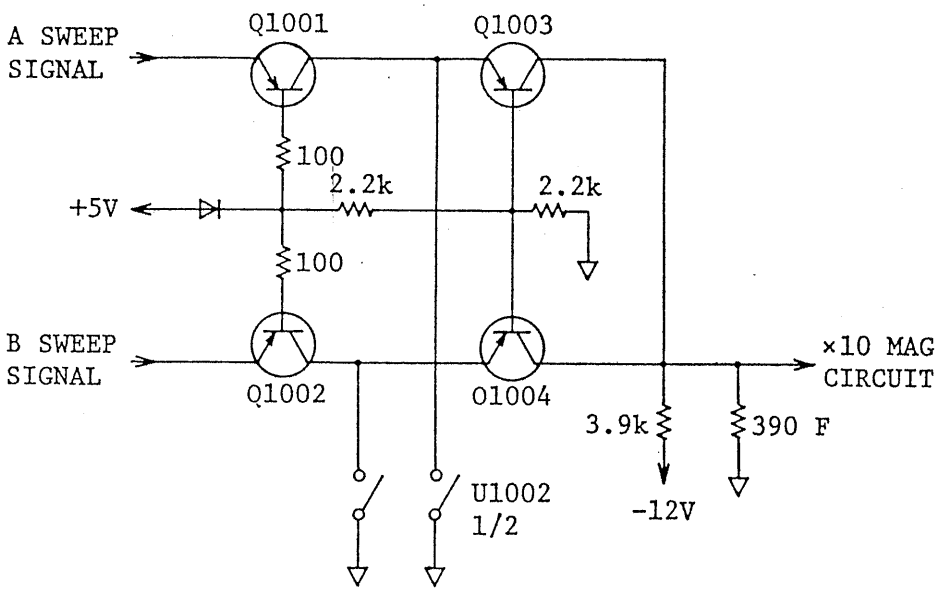


Figure 6-7

o ×10 MAG circuit:

The ×10 MAG circuit converts the sweep signal selected by the display switching circuit into a balanced signal with its transistors Q1008 and Q1009, and it also synthesizes the ↔ POSITION signal.

The ×10 MAG circuit magnifies the gain by 10 times by selecting the emitter coupling resistors of Q1008 and Q1009 with switching transistors Q1006 and Q1007.

o Horizontal mode switching circuit:

The horizontal mode switching circuit (Q1010 - 1013) is a solid-state switching circuit made up of transistors with their collectors connected together. Transistors Q1010 and Q1011 switches

the sweep signal received from the ×10 MAG circuit; transistors Q1012 and Q1013 switches the CH3 HORIZONTAL signal received from P-57.

6.9 Horizontal Output Amplifier

The horizontal output amplifier consists of a drive amplifier which converts and conditions the above signal into a balanced signal and drives the output amplifier, and an output amplifier which drives the horizontal deflection plates of the CRT.

- o Drive amplifier:

The drive amplifier (Q1051 - 1054) limits the amplitude of the horizontal signal received from the horizontal switching circuit and drives the output amplifier via the diode limiter. Also, it delivers the signal as an X-Y alignment signal of the collector of Q1052 to the vertical output amplifier.

- o Output amplifier:

The output amplifier (Q1057 - 1064) is comprised of feedback-type SEPP amplifiers symmetrical for right and left which provide sufficient speed and output voltage for driving the horizontal deflection plates of the CRT. The signal current-amplified by Q1057/1059 and Q1058/1060 is converted into a voltage signal by Q1061/1063 and Q1062/1064 to obtain a sufficiently high gain and a sufficiently low output impedance. By means of negative feedback resistor R1077/R1080 a stable gain and wide and flat frequency response are attained.

6.10 Z-axis Amplifier

The Z-axis amplifier is comprised of an input circuit and an output amplifier. The input circuit merges the unblanking signals of the A and B sweep generators, the external intensity modulation signal applied through the Z-axis input terminal, the

B intensity control signal, and the overall intensity control signal. The output amplifier amplifies the merged signal into a sufficient level for driving the G1 grid of CRT.

o Input circuit:

The input circuit produces the main unblanking signal by merging through the gate circuit (U708 3/4 4/4) the unblanking signals of the A and B sweep generators and the A intensity gate signal of the horizontal switching circuit. The input circuit also adds to the above merged signal, as selected by the display switch (S1001) and the vertical mode switch (S351), the B intensity control signal, the chopped blanking signal, the external intensity modulation signal applied via the X-axis input terminal, and the overall intensity control signal. The resultant compound signal is fed to the output amplifier.

o Output amplifier:

The output amplifier amplifies the above compound signal to several tens volts. It is of a feedback-type SEPP circuit (Q1149 - 1156) similar to that of the horizontal output amplifier. This amplifier also generates a linear focus signal which is in the inverted phase of the unblanking signal. The amplified unblanking output signal and linear focus signal are fed to the G1 and P1 of the cathode-ray tube through the CRT circuit to drive the intensity and focus of the displayed waveform.

6.11 CRT Control Circuit

The CRT control circuit is comprised of a DC regeneration circuit which converts the linear focus signal and the unblanking output signal of the Z-axis amplifier into the operating-voltage signals of the CRT in order to be applied to the focus electrode and G1 electrode of the CRT, semi-fixed potentiometers HALATION (RV1104), ASTIG (RV1103), GEOMETRY (RV1105) and SUB-FOCUS (RV1102), a trace rotation circuit for adjusting the trace direction in parallel

with the horizontal graticule lines, and an illumination circuit for illuminating the graticule.

- o DC regeneration circuit:

  The DC regeneration circuit converts the linear focus signal and unblanking signal of several tens to several hundreds volts into AC signals with the switching signal of the DC-DC converter circuit, and then converts them back into DC signals with respects to the cathode voltage and focus reference voltage of the sub-focus potentiometer in order to provide a focus signal and an unblanking signal of the operating voltages of the CRT.

6.12 HV Regulator (High Voltage Generator)

The high voltage generator produces an acceleration voltage (-1850 V) applied to the CRT cathode and a post-acceleration voltage (approximately +18 kV) applied to the CRT anode to accelerate the electrons beam which have passed the X and Y deflection plates and mesh electrode. The high voltage of approximately 3700 Vp-p generated by the blocking oscillator is 10-times voltage-multiplication rectified by a Cockcroft circuit into a positive voltage of approximately 18 kV and it is half-wave rectified into a negative voltage of -1850 V.

This DC-DC converter feeds the negative voltage of -1850 V via a high resistance circuit (R1114, R1115) to the control circuit (Q1101 - 1103) to obtain a stabilized acceleration voltage. It also is fed through a capacitor-coupling circuit to the DC regeneration circuit in order to be used as the switching signal.

6.13 Power Supply Circuit

The power supply circuit steps up or down with its power transformer the AC line voltage into various voltages and rectifies them to DC supply voltages for the various circuits of the oscilloscope. The primary winding of the power transformer is of a split type, in order that the oscilloscope can be operated on various AC line voltages by connecting the transformer taps in series or parallel as required by means of the line voltage selector plug (P-89). Regarding the secondary circuit, the transformer has one 6.3 V winding for the CRT heater and four windings of different voltages for different circuits of the CRT. The AC voltages of these four windings are rectifies and supplied as non-regulated +21 V power and regulated +150 V, +55 V, +12 V, +5 V, and -12 V powers.

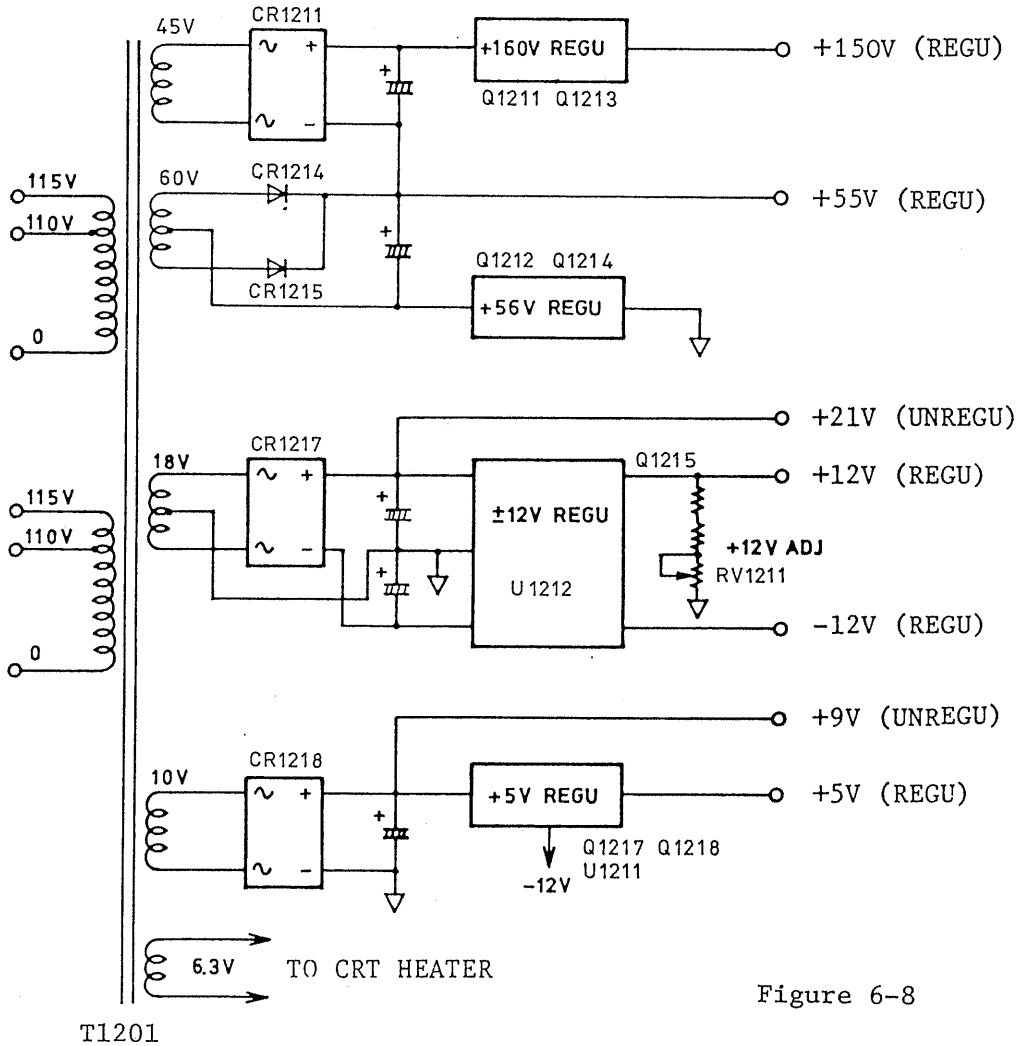


Figure 6-8

6.14 Calibrator Circuit

The calibrator circuit provides square-wave calibration voltage signals of 1 Vp-p and 200 mVp-p which are used for calibration of the probe and the amplifiers when they are operated in the non-calibrated mode. The voltage accuracy of the calibration signals is 2% or better. The calibration signals are produced by generating a signal with the multibrator of CMOS IC (U1101 1/4, 2/4), shaping the waveform with the Schmitt circuit of CMOS IC (U1101 3/4, 4/4), and dividing the voltage signal with resistors.

7. CALIBRATION

7.1 General

After the oscilloscope has been used for a period of time, it should be calibrated. Although calibration of overall performances is recommended, partial calibration may serve the purpose as that the time axis alone is calibrated when the time measuring accuracy is especially important or that the vertical axis alone is calibrated when the vertical sensitivity accuracy is of prime importance. After the oscilloscope has been repaired, overall calibration is suggested although it depends on the type of repair. For accurate calibration service, contact your Kikusui agent.

7.2 Removing the Case

To remove the case, remove the six screws (Figure 7-1) and pull out the chassis forward.

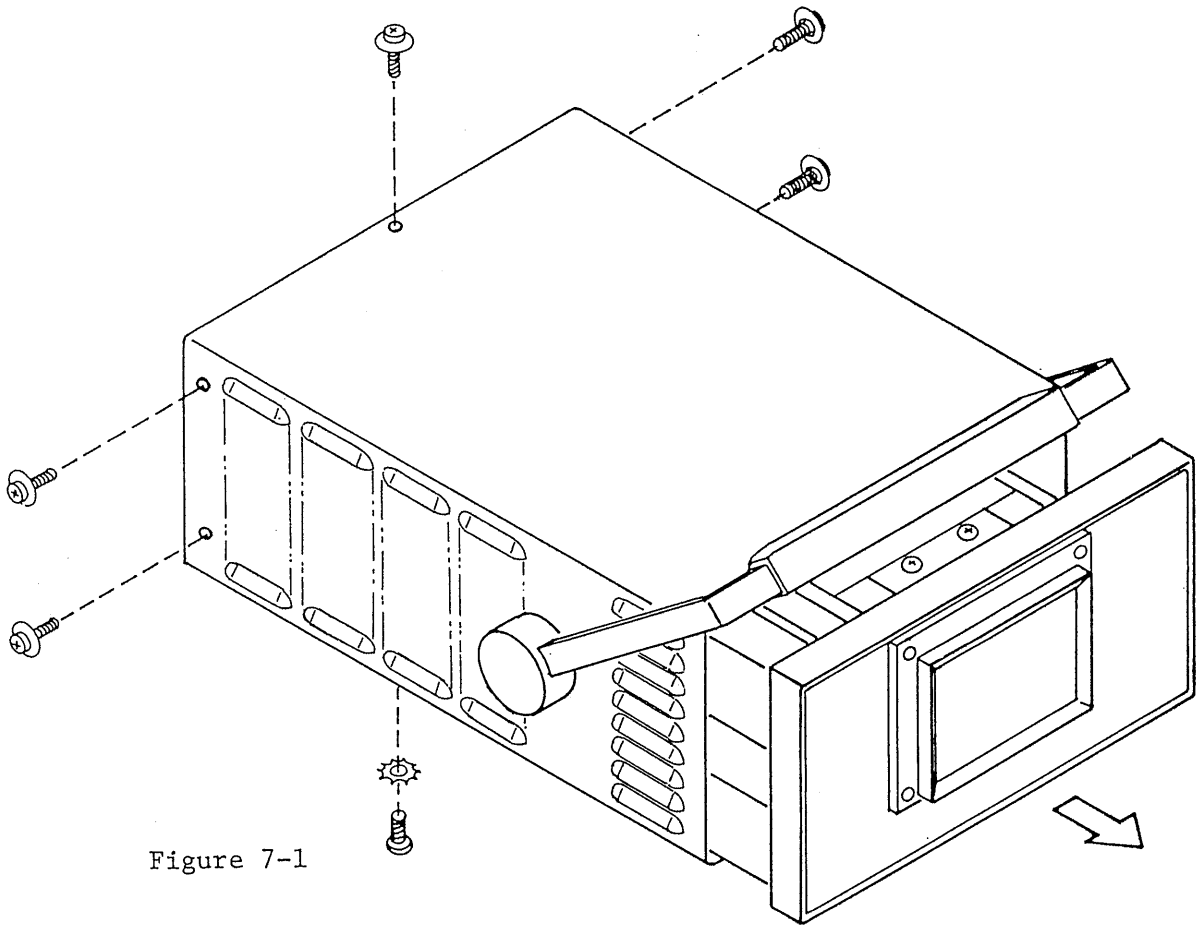


Figure 7-1

7.3 Check and Adjustment of DC Supply Voltages

Before calibrating the oscilloscope, its DC supply voltages should be checked and adjusted. Check and adjust the +12V supply voltage first and the other supply voltages next. The supply voltages shown in the following table and the check and adjustment points are indicated in Figures 7-2, 7-8 and 7-9.

Nominal voltage	Voltage range	Check and adjustment points
+ 5 V	+4.75 - 5.25 V	TP-2
+12 V	+11.95 - 12.05 V	TP-3 RV1211
-12 V	-11.80 - 12.20 V	TP-1
+55 V	+54 - 60 V	TP-4
+150 V	+150 - 160 V	TP-5
-1850 V	-1840 - -1860 V	TP-6 RV1101

For voltage check, measure the voltage between check point and ground using precision digital voltmeter. The +12V supply must be especially carefully adjusted because it provides a reference for other supplies. To mreasure the -1850V supply of which internal impedance is high, use a voltmeter which has a sufficiently high input impedance (10 MΩ or over).

Because adjustments of supply voltages largely affects vertical sensitivity and horizontal sweep time, the oscilloscope must be re-calibrated as explained in the subsequent paragraphs.

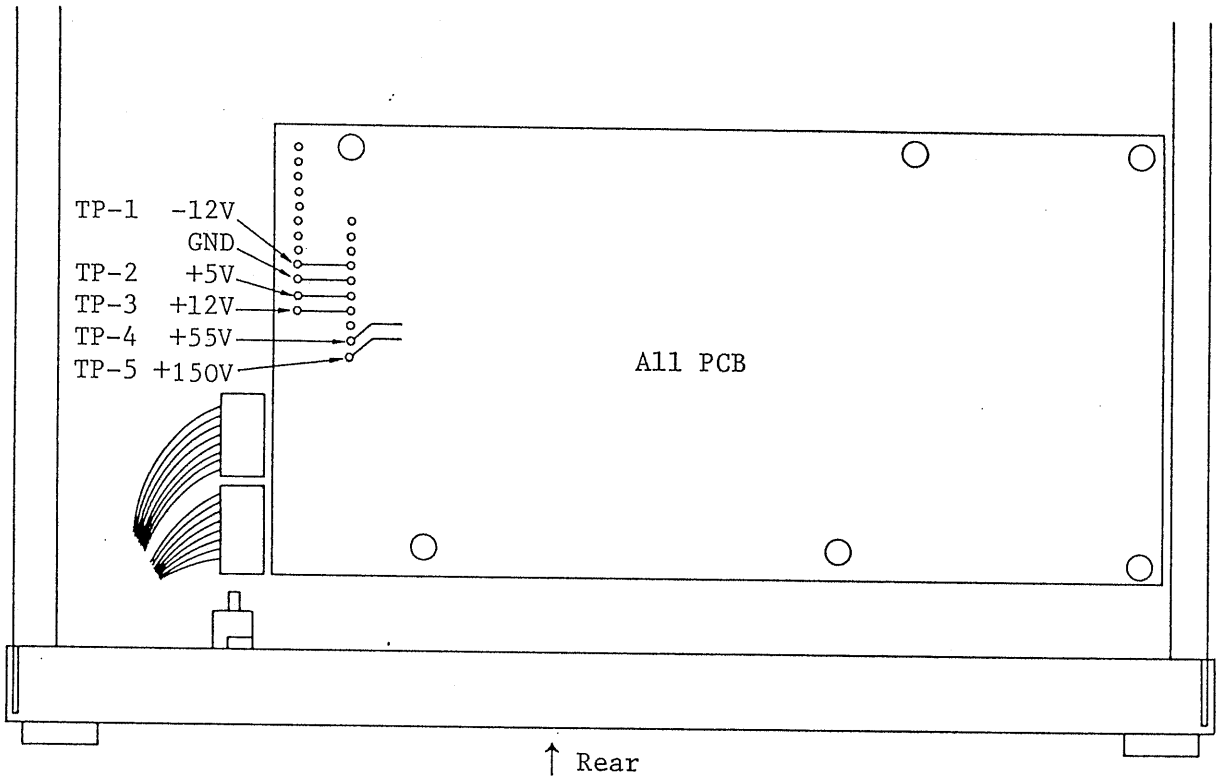


Figure 7-2 (Bottom view)

7.4 Adjustment of CRT Circuits

Some adjustments of the CRT circuits directly affect the CRT deflection sensitivity as is the case of "Check and Adjustment of DC Supply Voltages" of the preceding section. After the GEOMETRY, HALATION and HORIZ LIMIT are adjusted, the vertical sensitivity and sweep time must be calibrated.

- Adjustment of SUB INTEN:

  This control is for adjusting the trace intensity and the operating position of the INTEN knob (7).

(1) Set the TIME/DIV switch (39) at 1 mS and display a single-line horizontal trace on the screen.

(2) Set the white mark of the INTEN knob at the 10 o'clock position and so adjust the SUB INTEN control (Figure 7-9, RV1141) that the trace is displayed on the screen with a barely discernible intensity.

o Adjustment of GEOMETRY:

This control is for reducing geometrical distortions (pincushion distortions or barrel distortions) of the pattern displayed on the screen.

(1) Apply a sinusoidal signal of approximately 50 kHz to vertical input terminal and display the signal with an amplitude of 8 DIV and with approximately 50 peaks.

(2) So adjust the GEOMETRY control (Figure 7-9, RV1105) that the displayed pattern becomes as (b) in Figure 7-3.

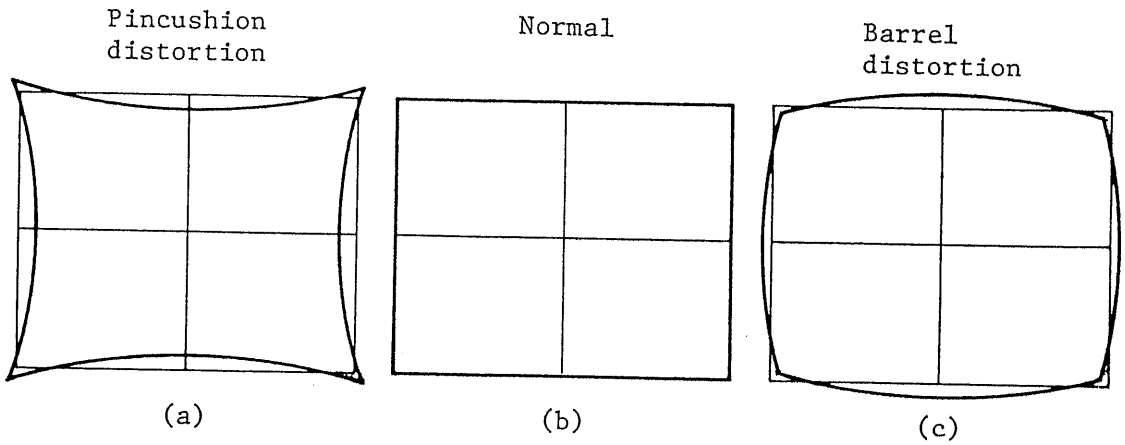


Figure 7-3

o Adjustment of HALATION:

This control is used to reduce halation on the screen to improve the contrast of the displayed waveform.
So adjust the HALATION control (Figure 7-9, RV1104) that the best focus is obtained with the ASTIG voltage set at +70 to +80 volts.

o Adjustment of SUB-FOCUS:

This control is for adjusting the control range position of the FOCUS knob (5). With the FOCUS knob set with its white dot positioned upright (noon position), so adjust the SUB-FOCUS control (Figure 7-9, RV1102) that the best focus is obtained.

o Adjustment of HORIZ LIMIT:

This control is used to suppress halation (caused by the electron beam reflected and scattered in the cathode-ray tube) resulting from change in the horizontal POSITION adjustment and × 10 MAG operation.

(1) Apply the CAL (43) signal to the vertical input terminals and display a waveforms with amplitude 4 DIV and 10 peaks.

(2) Pull out the ×10 MAG switch (41). Turn the HORIZ LIMIT control (Figure 7-8, RV1051) from the extremely counter-clockwise position gradually to clockwise position and stop at the position where halation on the screen is reduced. This is the normal position for the HORIZ LIMIT control.

o Adjustment of Y AXIS ALIGN:

This control is for adjustment of the perpendicularity (90°) between horizontal trace (sweep) and vertical trace.

(1) Ground CH1. Apply to CH2 the output of a sine wave signal generator and display the signal with an amplitude of 8 DIV on the screen.

(2) Set the VERT MODE switch (26) in the X-Y mode and so adjust the TRACE ROTATION control (4) that the vertical trace becomes parallel with the graticule scale.

(3) Next, change the VERT MODE switch to CH1 and so adjust the X-Y AXIS ALIGN (Figure 7-8, RV445) that the horizontal trace becomes parallel with the horizontal scale of the graticule.

By the above procedure, the horizontal trace and vertical trace are adjusted mutually perpendicular.

7.5 Adjustment of Vertical Axis

o Adjustment of STEP BAL:

This control is for minimizing the shift of trace when the VOLTS/DIV switch (16) or (23) is turned from the 5 mV position to the 10 mV position.

(1) Set the AC-GND-DC switch (13) or (20) and display the trace on the CRT screen.

(2) Turning the VOLTS/DIV switch between 5 mV and 10 mV positions, so adjust the STEP BAL control (Figure 7-11, RV101 or RV201) that the shift of trace becomes minimum.

o Adjustment of VAR BAL:

This control is for minimizing the shift of the trace when the VARIABLE KNOB (15) or (22) is turned.

(1) Set the AC-GND-DC switch (13) or (20) in the GND stage and display the trace on the CRT screen.

(2) Turning the VARIABLE knob, so adjust the VAR BAL control that the shift of the trace becomes minimum. (Figure 7-11, RV102 and RV202)

o Adjustment of × 5 MAG BAL:

This control is for minimizing the shift of trace when the × 5 MAG switch (15) or (22) is changed.

(1) Set the AC-GND-DC switch (13) or (20) in the GND state and display a trace on the screen.

(2) Turning on and off the × 5 MAG switch, so adjust the × 5 BAL (Figure 7-11, RV104 or RV204) that the shift of trace becomes minimum.

o Sensitivity calibration of CH1 and CH2:

Calibrate the sensitivity of the vertical amplifier to the value indicated by the VOLTS/DIV switch (16) or (23). For this adjustment, use a square wave generator with an output voltage setting accuracy of 0.3% or better, at 1 kHz.

(1) Set the signal generator output at 50 mVp-p and apply the signal to the vertical input terminal (14) or (21).

(2) Set the VARIABLE knob (15) or (22) at the CAL'D position and set the VOLTS/DIV switch at the 10 mV range.

(3) So adjust the CH1 or CH2, ×1 GAIN control (Figure 7-11, RV109 or RV209) that the amplitude of the displayed waveform becomes 5 DIV.

By the above procedure, other ranges also are calibrated to an accuracy of ±2% or better.

o Sensitivity calibration of CH3:

In a similar manner as for sensitivity calibration of CH1 and CH2, calibrate the sensitivity of the CH3 vertical amplifier.

(1) Set the signal generator output at 500 mVp-p and apply the signal to CH3 input terminal (12). Next, set the CH3 input ATT switch (9) to the 0.1 V state (⊓ state).

(2) So adjust the CH3 GAIN control (Figure 7-10, RV303) that the amplitude of the displayed waveform becomes 5 DIV.

o Sensitivity calibration of CH4 and CH5:

In a similar manner as for sensitivity calibration of CH1 and CH2, calibrate the sensitivities of CH4 and CH5 vertical amplifiers.

(1) Set the signal generator output at 400 mVp-p and apply the signal to CH4 input terminal (36) or CH5 input terminal (46).

(2) Change the source selector switch (35) or (48) to the EXT state and display a signal waveform on the screen. So adjust the CH4 or CH5 GAIN control (RV503 or RV661 in Figure 7-12 or Figure 7-10) that the signal is displayed with an amplitude of 4 DIV on the screen.

o Adjustment of VERT CENTER:

This adjustment is to make zero the shift of trace at the center of the screen when the CH2 INV switch is changed.

(1) Set the AC-GND-DC switch (13) in the GND state and display the trace on the screen.

(2) Turning ON (⊓) and OFF (⊔) the CH2 INV switch (26) , so adjust the POSITION knob (17) that the shift of trace becomes zero.

(3) Under the above state, so adjusted the VERT CENTER control (Figure 7-11, RV446) that the trace is positioned at the center of the screen.

o Adjustment of ADD BAL:

With both CH1 and CH2 channels operating in a single-line horizontal trace mode at the center of the screen, so adjust this control that the traces do not shift even when the VERT MODE switch is changed to the ADD mode.

(1) Set the AC-GND-DC switches (13) and (20) in the GND state and display the traces of the two channels overlapped at the center of the screen.

(2) Change the VERT MODE switch to the ADD state and so adjust the ADD BAL control (Figure 7-11, RV401) that the traces are positioned at the center of the screen.

o Adjustment of square wave characteristics of vertical amplifiers:

This adjustment is to adjust the square wave characteristics of the vertical amplifiers and to make their frequency response flat. This adjustment should be done at a range which does not use the input attenuator (5 mV/DIV range), using two or more square waves of different frequencies.

Adjustment should be done using a quality square wave with a rise time of 1.0 nsec or faster, in the order of low, middle, and high ranges, repeating adjustment for a few times.

(1) Adjustment for low frequency range:

Set the VOLTS/DIV switch at 10 mV/DIV and the TIME/DIV switch at 20 μS/DIV. Apply to the vertical input terminal a square wave of 10 kHz and so adjust the signal generator output that the waveform is displayed with an amplitude of 6 DIV.

Next, so adjust RV444 (Figure 7-8) that the displayed waveform becomes as (b) in Figure 7-4.

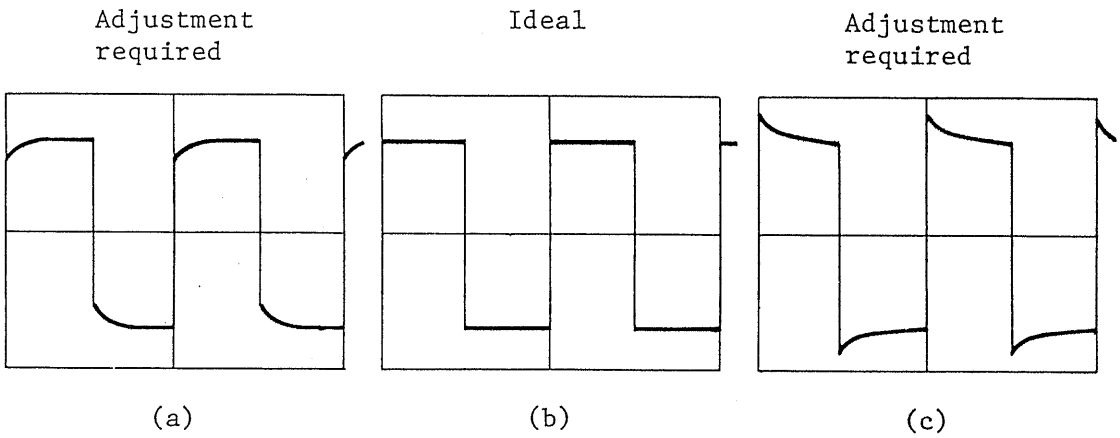


Figure 7-4

(2) Adjustment for middle frequency range:

Change the input pulse signal frequency to 1 MHz and set the TIME/DIV switch at 0.2 μS/DIV. Next, so adjust RV443 (Figure 7-8) that a square wave as shown in (b) of Figure 7-5 is displayed. Also, so adjust RV442 and C446 that the square wave characteristics at the front edge of the waveform becomes flat. For this adjustment, set at first R442 at an appropriate position and then adjust C446 so that a waveform as close to that of (d) as possible is obtained. Repeat this procedure for a few times so that a waveform as shown in (d) is obtained.

(3) Adjustment for high frequency range:

This adjustment is to make still more sharp the leading edge and reduce ringing at the leading edge of the pulse waveform which has been adjusted in step (2).

For this adjustment, adjust at first CH1 and CH2 to the same characteristics and adjust CH3, CH4 and CH5 next.

Change the TIME/DIV switch to the 20 mV/DIV position and expand the front edge of the pulse waveform which has been adjusted in step (2) "Adjustment for middle frequency range." First, adjust RV441 and C446 so that ringing becomes smaller and uniform. Next, adjust C445 so that ringing is eliminated.

Next, adjust RV402 and C410, and RV106 and C141 (RV206 and C241 in the case of CH2) so that the front edge of the displayed waveform becomes flat. Also adjust C407 and C142 (C242 in the case of CH2) so that the leading edge becomes sharp.

Repeat the above adjustment so that flat square wave characteristics with sharp leading edge is obtained and the difference between CH1 and CH2 becomes minimal.

Next, change the channels to CH3, CH4 and CH5, and adjust the HF COMPEN controls of these channels.

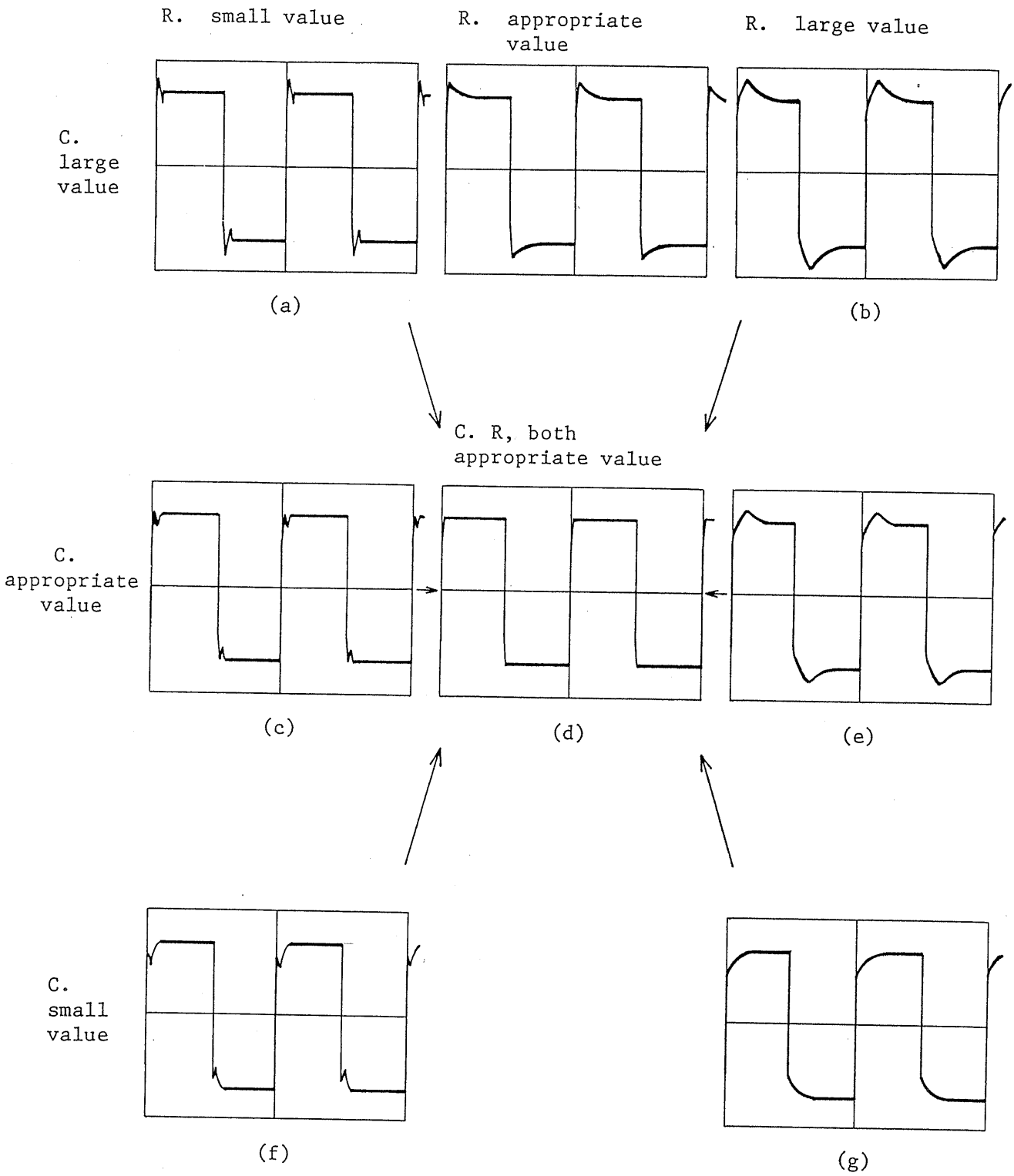

R. small value
R. appropriate value
R. large value
C. large value
(a)
(b)
C. R, both appropriate value
C. appropriate value
(c)
(d)
(e)
C. small value
(f)
(g)

Figure 7-5

	HF COMPEN
CH3	RV302 C316
CH4	C582
CH5	C662

After the above adjustment is done, check again that the frequency response characteristics of all channels are satisfactory.

o Adjustment of input ATT of CH1 and CH2:

The VOLTS/DIV switch selects the oscilloscope sensitivity by switching the attenuator circuit consisting of pre-stage attenuator (1/10-steps) and post-stage attenuator (1/1, 1/2, and 1/5-steps). This procedure is for phase compensation and input capacitance adjustment of the attenuators. Adjustments should be done in the order of phase compensation and input capacitance adjustment for the post-stage attenuator and then phase compensation and input capacitance adjustment of the pre-stage attenuator.

(1) Adjustment of post-stage attenuator:

Use a square wave signal generator which provides a quality square wave of rise time 1 μsec or faster, without sags or overshoots. Apply the signal for each of the ranges (20 mV, 50 mV) and display a waveform with an amplitude of 6 DIV. So adjust the phase compensation capacitors shown in the following table that an ideal waveform is displayed. Next, connect a low-capacitance C-meter to the input terminal and so adjust the input-capacitance compensation capacitor that the input capacitance at each range becomes 20 pF ±2 pF.

Compensation capacitor / Range	CH1		CH2	
	Phase compen-sation	Input capacitor	Phase compen-sation	Input capacitor
20 mV (1/2)	C112	C113	C212	C213
50 mV (1/5)	C114	C115	C214	C215

(2) Adjustment of pre-stage attenuator:

In a similar manner as in the case of step (1), adjust at each of 0.1 V and 1 V ranges the phase compensation capacitors and input capacitance compensation capacitors as shown in the following table.

Compensation capacitor / Range	CH1		CH2	
	Phase compen-sation	Input capacitor	Phase compen-sation	Input capacitor
0.1 V (1/10)	C104	C105	C204	C205
1 V (1/100)	C107	C108	C207	C208

When the above adjustment is done, all other ranges also are automatically adjusted.

o Adjustment of input ATT of CH3:

In a similar manner as is the case for "Adjustment of input ATT of CH1 and CH2," adjust C305 so that the 1/1 input capacitance becomes 20 pF ±2 pF. Next, adjust input capacitance compensation capacitor C303 and phase compensation capacitor C302 of 1/10 ATT. (See Figure 7-10.)

Adjustment of input ATT of CH4 and CH5:

In a similar manner as above, adjust input capacitance compensation capacitors C502 (CH4) and C612 (CH5) and phase compensation capacitors C503 (CH4) and C611 (CH5) of 1/10 ATT. (See Figure 7-12 and 7-10.)

o Adjustment of DC offset CH1 signal output:

This adjustment is to make zero the DC offset of the CH1 signal output.

(1) Apply the CH1 signal output to the CH2 input terminal.

(2) Display the CH2 input signal on the screen and set the VOLTS/DIV switch at the 10 mV range.

(3) Changing the CH2 input coupling switch between GND and DC, so adjust the CH1 SIGNAL OUTPUT DC OFFSET control RV110 (Figure 7-11) that shift of the trace becomes zero.

7.6 Adjustment of Trigger Circuit

o Adjustment of CH1 TRIG DC OFFSET:

This adjustment is for offsetting to zero the DC-component displacement of the CH1 internal trigger output.

(1) Apply a sinusoidal signal of approximately 1 kHz to the CH1 input terminal and set the AC-GND-DC switch at AC.

(2) Set the VERT MODE switch at CH1, set the INT TRIG switch at CH1 or ALT, and display the signal with an amplitude of 8 DIV on the screen.

(3) Set the COUPLING switch at AC and so adjust the LEVEL knob that the trigger point is brought to the center of the displayed waveform amplitude.

(4) Change the COUPLING switch to DC and so adjust the CH1 TRIG DC OFFSET (Figure 7-11, RV107) that the trigger point is brought to the center of the displayed waveform amplitude.

o Adjustment of CH2 TRIG DC OFFSET:

This adjustment is for offsetting to zero the DC-component displacement of the CH2 internal trigger output.

For this adjustment, adjust CH2 TRIG DC OFFSET (Figure 7-11, RV207) in a similar manner as is the case for "Adjustment of CH1 TRIG DC OFFSET."

o Adjustment of CH3 TRIG DC OFFSET:

This adjustment is for offsetting to zero the DC-component displacement of the CH3 internal trigger output.

For this adjustment, adjust CH3 TRIG DC OFFSET (Figure 7-10, RV304) in a similar manner as is the case for "Adjustment of CH1 TRIG DC OFFSET."

7.7 Adjustment of Time Base

o Calibration of A sweep time:

This adjustment is for calibrating the sweep time to the values indicated by the TIME/DIV switch (39). For this adjustment, use time marker signals of accurate time intervals of 0.1 sec, 1 msec and 10 μsec or use signals of accurate frequencies of 10 Hz, 1 kHz and 100 kHz.

(1) Apply to the vertical input terminal a time marker signal of 0.1 sec or a signal of 10 Hz, and deflect the signal with an appropriate amplitude on the screen.

(2) Set the VARIABLE knob (41) in the CAL'D position. Set the TIME/DIV switch (39) at 0.1 sec.

(3) So adjust the 0.1S ADJ (Figure 7-9, RV802) that the displayed waveform conforms with scale divisions of the graticule.

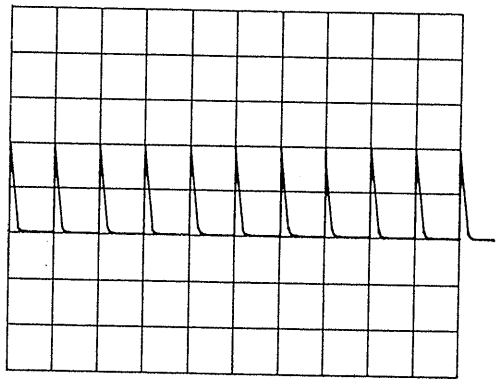
(4) Change the input signal to a time marker signal of 1 msec or sinusoidal wave signal of 1 kHz and change the TIME/DIV switch (39) to 1 msec.

(5) So adjust the 1mS CAL (Figure 7-9, RV801) that the displayed signal waveform conforms with scale divisions of the graticule.

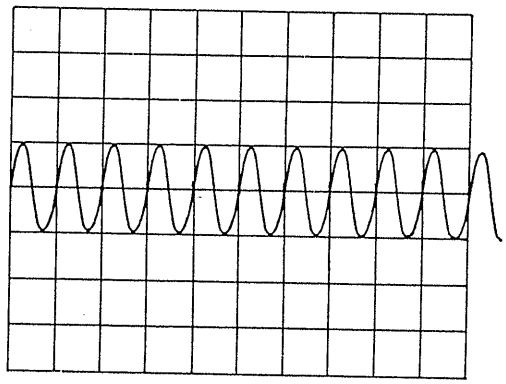
(6) Next, change the input signal to a 10-μsec time marker signal or a 100-kHz repetitive frequency signal and change the TIME/DIV switch indication to 10μS.

(7) So adjust C814 (Figure 7-9) that the displayed signal waveform conform with scale divisions of the graticule.

When the above calibration is complete, the sweep speeds of the remaining ranges of the TIME/DIV switch (39) also are calibrated at an accuracy of ±3%.



Time marker signal



Sinusoidal wave signal

Figure 7-6

o Calibration of B sweep time:

Calibrate the sweep time to the indicated values of the TIME/DIV switch (40). Adjust 0.1S and 1mS (Figure 7-9, RV902 and 901) and C904 (Figure 7-9) in a similar manner as that for the case of "Calibration of A sweep time."

o Adjustment of SWEEP LENGTH:

This adjustment is for setting the lengths of the A and B sweeps at 11 DIV. Set the TIME/DIV switches (39) and (40) at 1 mS and apply a time marker signal of 1 msec or a signal of repetition frequency 1 kHz, and so adjust the A SWEEP LENGTH (Figure 7-9, RV701) and B SWEEP LENGTH (Figure 7-9, RV702) that the sweep length become 11 DIV.

o Adjustment of sweep start point:

This adjustment is for attaining such state that, when the horizontal POSITION knobs (44) and (45) are set with their white dots in the noon positions, their sweeps start at the left hand end of the graticule.

(1) Set the TIME/DIV switches (39) and (40) at 1 mS, set the DISPLAY switch (29) at ALT, and display both A and B sweeps on the screen.

(2) So set the horizontal POSITION knobs (44) and (45) that their white dots are positioned upward (noon position). So adjust the A SWEEP START (Figure 7-9, RV1003) that the start point of the A sweep is brought to the left hand end of the graticule.

(3) Next, with the B SWEEP START (Figure 7-9, RV1004), bring the start point of the B trace to left hand end of the graticule.

o Adjustment of × 10 MAG:

This adjustment is for calibration of the sweep time when the × 10 MAG switch (41) is turned on (pulled out). Before performing this adjustment, make sure that the adjustment for "Calibration of the A sweep time" has been done.

(1) Apply to the vertical input terminal a time marker signal of 0.1 mS or a signal of 10 kHz and display the signal with an appropriate amplitude on the screen.

(2) Set the VARIABLE knob (41) in the CAL'D position and the TIME/DIV switch (39) at 1 mS.

(3) Turn on the × 10 MAG switch and so adjust the × 10 MAG GAIN ADJ (Figure 7-9, RV1005) that the displayed waveform conforms with scale divisions of the graticule.

o Calibration of DELAY TIME MULTI:

This calibration is for calibrating the dial value of the DELAY TIME MULTI to the sweep time. Before performing this calibration, make sure that the adjustment for "Calibration for A sweep time" has been done.

(1) Apply to the vertical input terminal a time marker signal of 1 mS and display the waveform with an appropriate amplitude on the screen.

(2) Set the VARIABLE knob (41) in the CAL'D position, set the TIME/DIV switch (39) at 1 mS, set the TIME/DIV switch (40) at 10 μS, and change the DISPLAY switch (29) to the A INTEN state.

(3) Set the dial indication of the DELAY TIME MULTI at 1.00 and align the displayed waveform with the graticule.

(4) So adjust the DT START (Figure 7-9, RV704) that the accentuated portion of the waveform is aligned to the initial pulse as shown in Figure 7-7.

(5) Set the dial indication of the DELAY TIME MULTI at 10.00.

(6) So adjust the DT END (Figure 7-9, RV703) that the accentuated portion of the waveform is aligned to the 10th pulse.

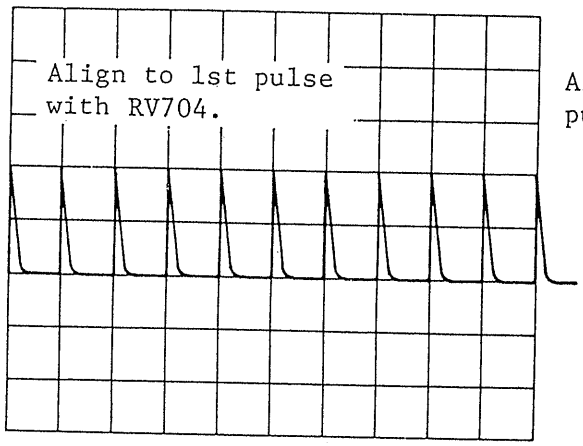


Figure 7-7

7.8 Adjustment of Horizontal Axis (X-axis)

o Calibration of horizontal sensitivity:

This adjustment is for calibration of the X-axis or CH3 HOR sensitivity for X-Y operation.

(1) Set at 100 mVp-p the output of the signal generator used for "Calibration of sensitivity" of section 7.5, and apply the output to the CH1 (X-axis) input terminal.

(2) Set the VERT MODE switch (26) in the X-Y state. Set the AC-GND-DC switch (13) of CH2 (Y-axis) at GND.

(3) Set the VARIABLE knob (22) at CAL'D and the VOLTS/DIV switch (23) at 10 mV.

(4) So adjust the CH1 & CH3 HOR GAIN (Figure 7-11, RV307) that the trace length becomes 10 DIV.

When this adjustment is done, the CH3 HOR sensitivity also is calibrated at the same time.

o Adjustment of CH1 & CH3 HOR POSITION:

This adjustment is to minimize the difference of trace positions between vertical-axis operation and horizontal-axis operation as controlled with the CH1 & CH3 POSITION controls (24) and (8).

(1) Set the VERT MODE switch (26) at CH1 and the AC-GND-DC switches (13) and (20) at GND.

(2) Move the trace to the center of the screen with the POSITION control knob (24).

(3) Next, turn the VERT MODE switch (26) to the X-Y position, and so adjust the CH1 & CH3 HOR POSITION CENT control (Figure 7-11, RV306) that the spot is placed in the center from the right and left ends.

7.9 Adjustment of Calibration Voltage

o Adjustment of repetition frequency:

This adjustment is for calibrating the repetition frequency of the calibration signal at 1 kHz.

(1) Connect the CALIB output (43) to a frequency counter.

(2) So adjust the CAL 1 kHz ADJ (Figure 7-10, RV1181) that the frequency counter 1 kHz.

o Calibration of the output voltage:

This adjustment is for calibrating the output voltage of the calibration signal in a substitution method.

(1) Set at 200 mVp-p the signal of the generator used for "calibration of sensitivity" of Section 7.5. Apply this signal to the CH1 input terminal.

(2) Display the signal on the screen with an amplitude of 8 DIV by adjusting the VOLTS/DIV switch (23) and VARIABLE knob (22).

(3) Apply the 200 mV CALIB output to the CH1 input terminal. So adjust the CAL OUTPUT LEVEL (Figure 7-10, RV1182) that the signal is displayed with an amplitude of 8 DIV on the screen in the same manner as step (2) above.

This completes the CAL voltage adjustment procedure.

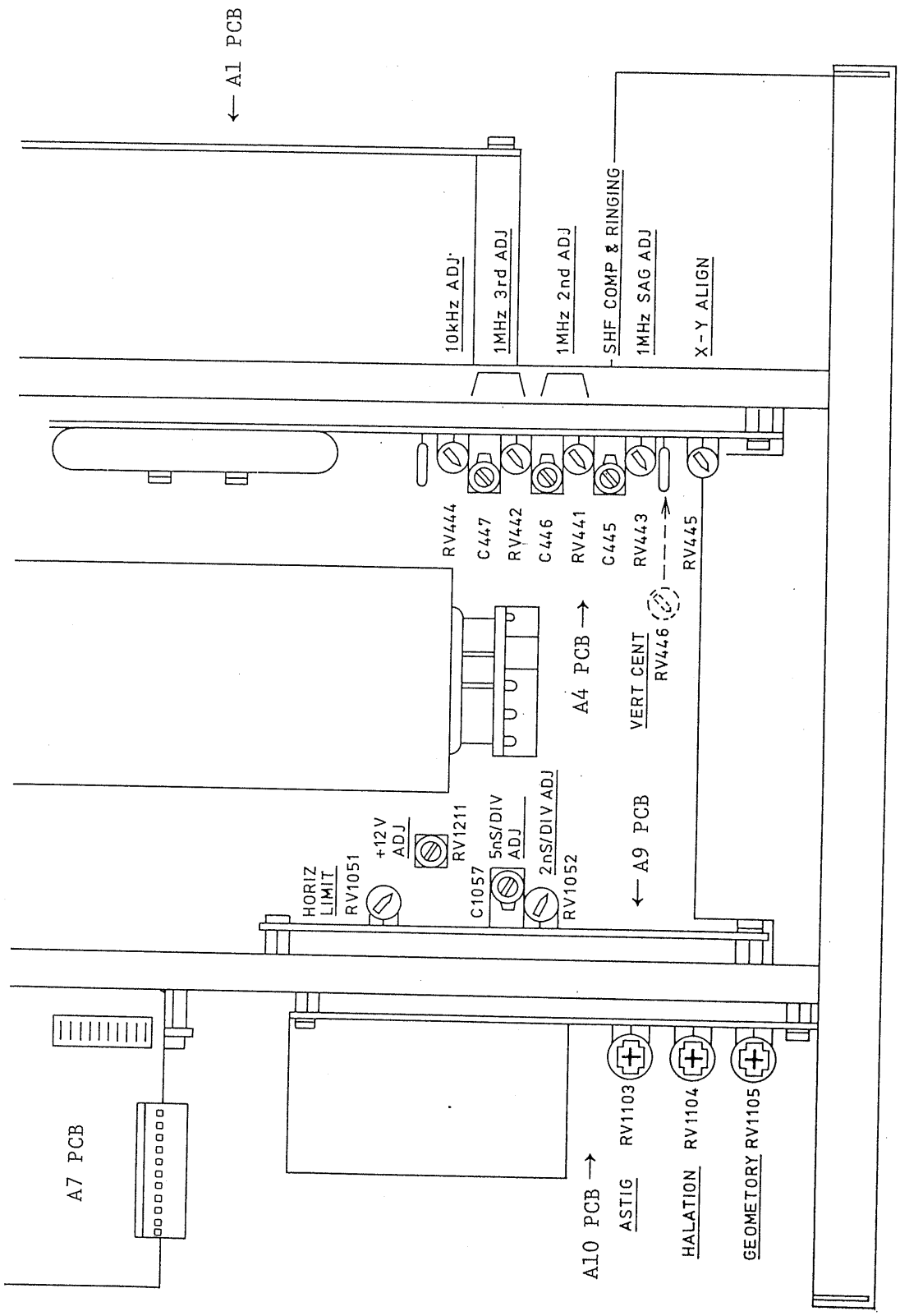


Figure 7-8 (Top view)

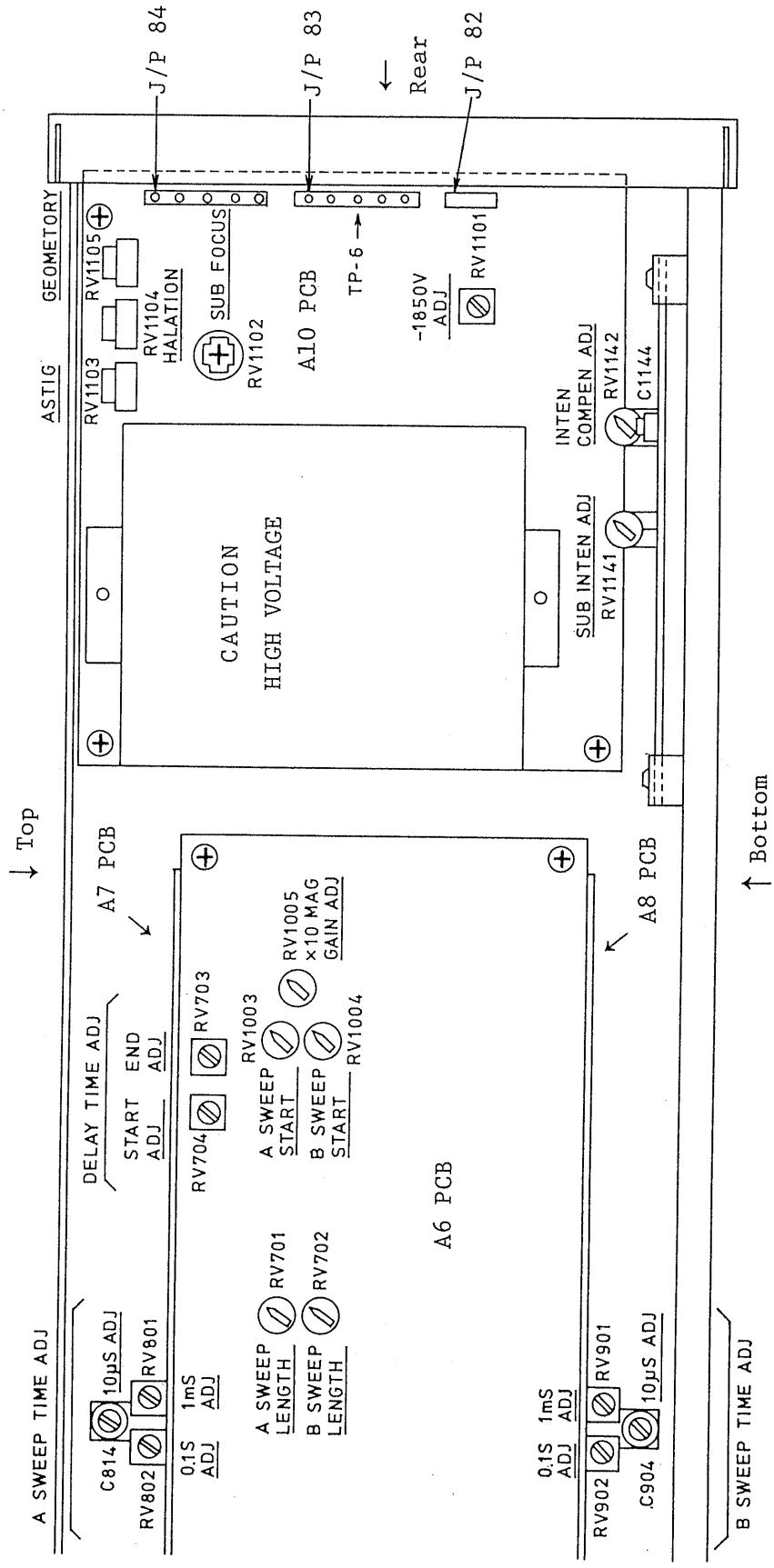


Figure 7-9 (Right hand side view)

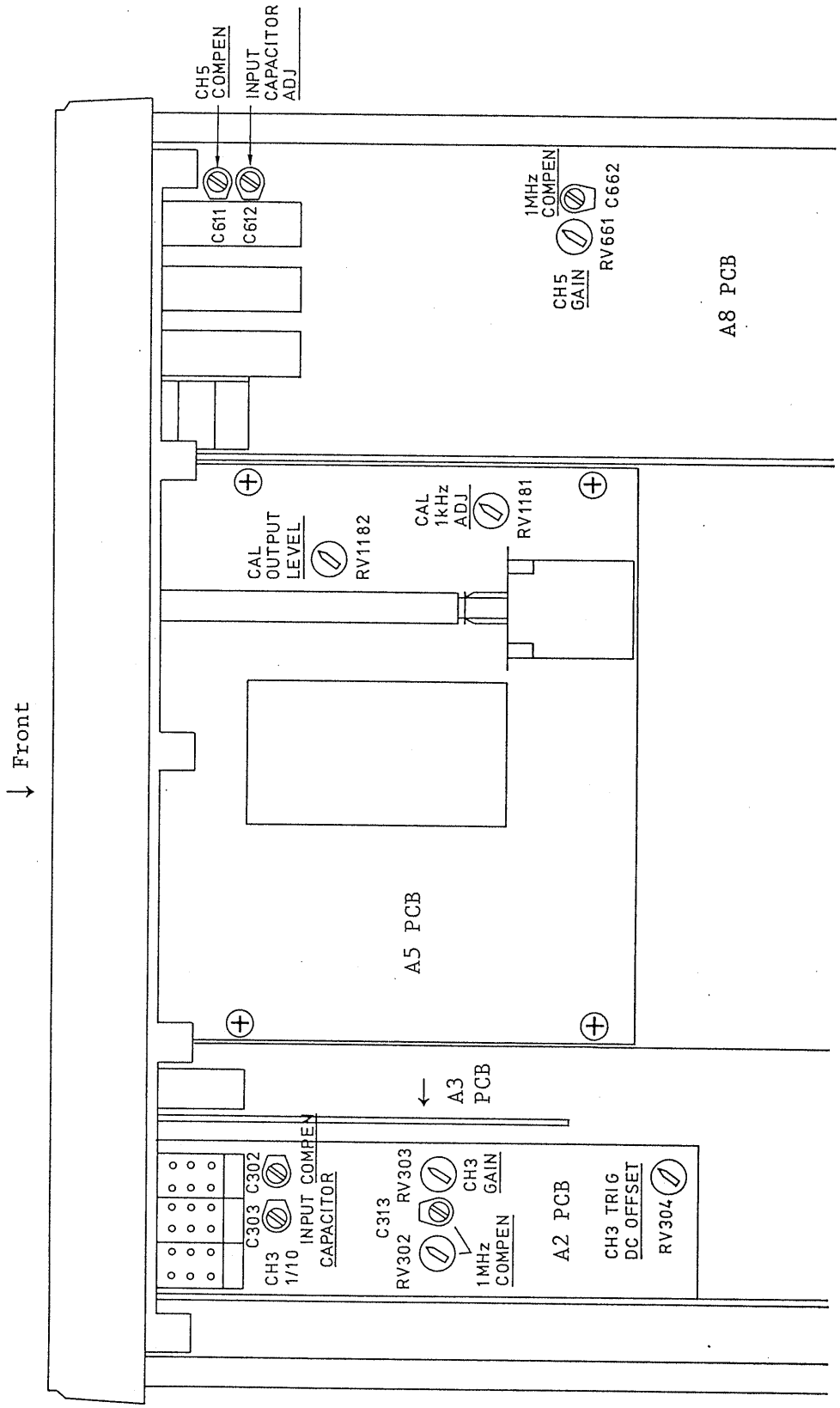


Figure 7-10 (Bottom view)

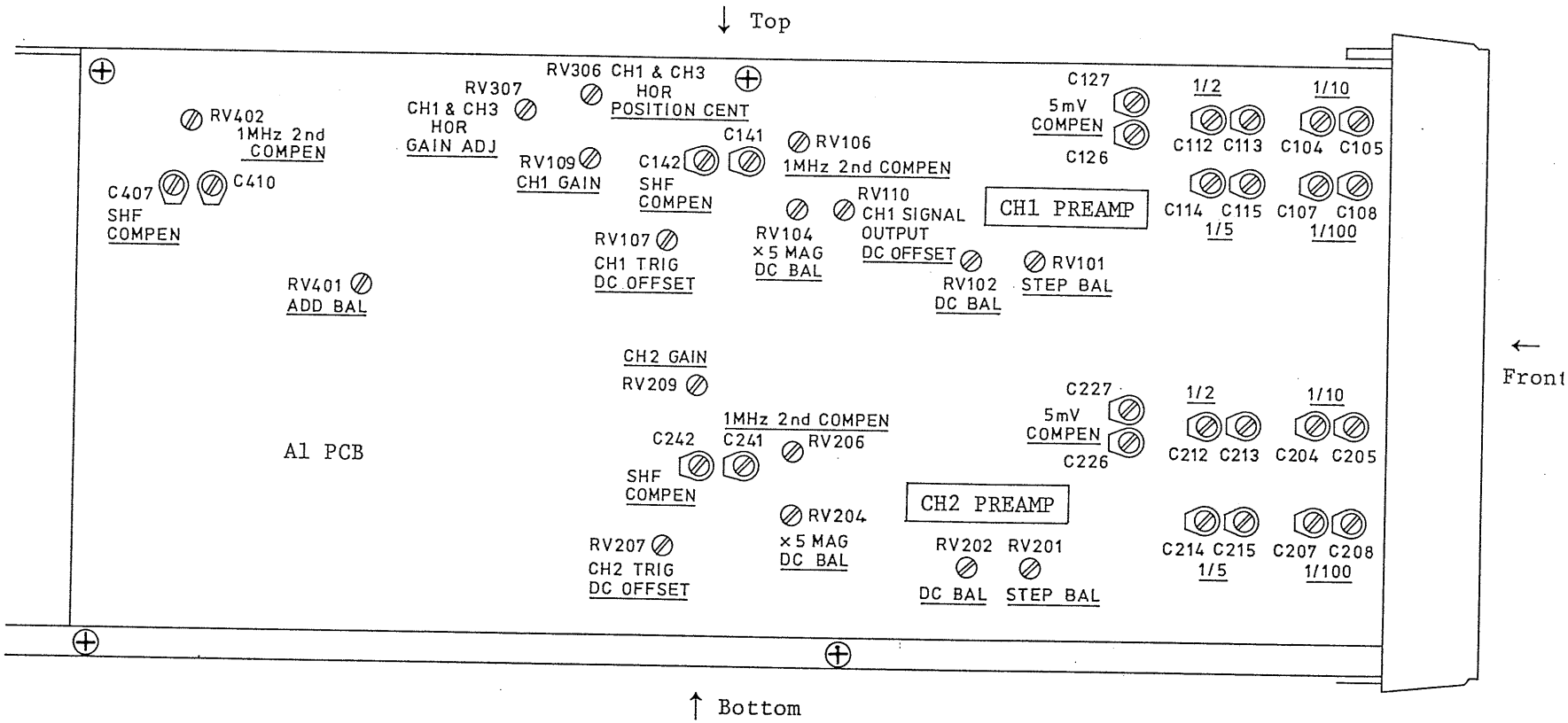


Figure 7-11 (Left hand side view)

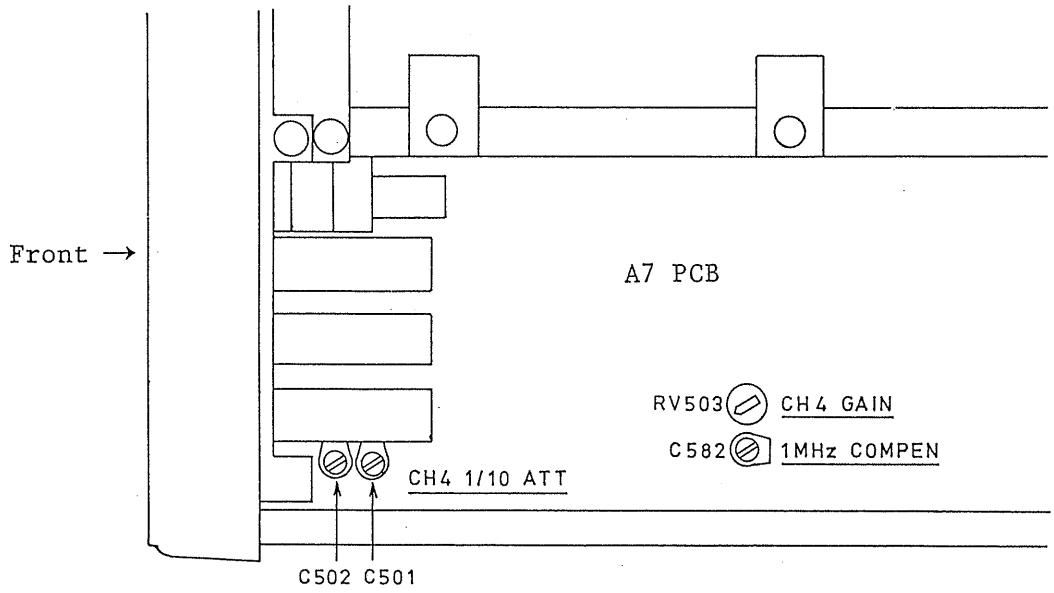


Figure 7-12 (Bottom view)

Table 8-1. Internal Inspection Checklist

ITEM	INSPECT FOR	REPAIR ACTION
Circuit boards	Loose, broken, or corroded solder connections. Burned circuit boards, burned, or cracked circuit run plating	Clean solder corrosion with an eraser and flush with isopropyl alcohol. Resolder connections. Determine cause of burned items, and repair. Repair damaged circuit runs.
Chassis	Dents, deformation, and damaged hardware.	Straighten, repair, or replace damaged hardware.
Resistors	Burned, cracked, broken, or blistered.	Replace damaged resistors.
Solder Connections	Cold solder or rosin joints.	Resolder and clean joint with isopropyl alcohol.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed.	Firmly seat connectors. Repair or replace damaged wire or cables.
Capacitors	Damaged or leaking cases. Corroded solder on terminals or leads.	Replace capacitors with damaged or leaking cases. Clean solder connections and flush with isopropyl alcohol.
Semiconductors	Loosely inserted in sockets. Bent pins.	Remove items with bent pins, carefully straighten the pins with long-nose pliers, and reinsert firmly (be sure that the straightening action hasn't cracked the pin such that it will break easily). Firmly seat all loose semiconductors.
Push-button controls	Binding controls. Missing push buttons.	Determine cause of binding control, and repair. Replace push buttons.

8.1 Troubleshooting

The following information is provided for troubleshooting the instrument. An understanding of the Operation Method in Section 4 may be helpful in location of troubles.

a. Troubleshooting Aids.

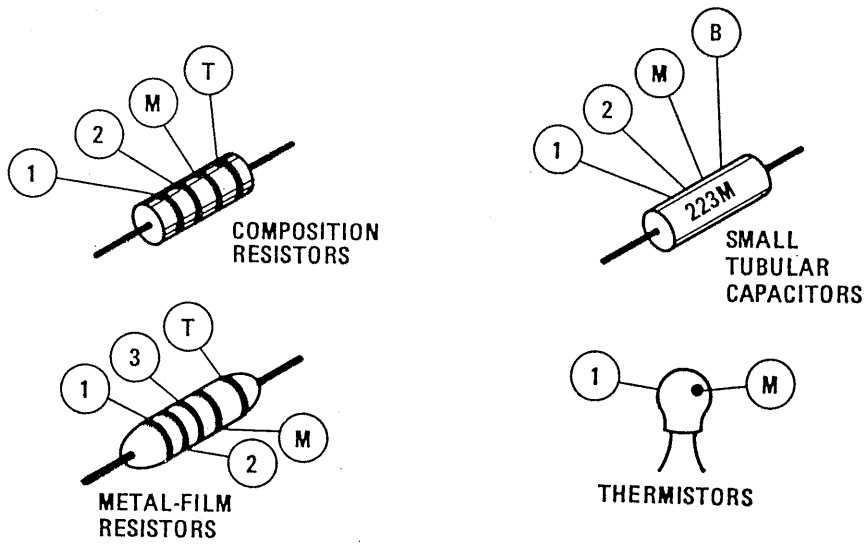
(1) Diagrams. Complete circuit diagrams are contained on foldout pages in Section 9, Diagrams. The portions of the circuit mounted on circuit boards are enclosed with heavy lines. The component numbers and electrical value of each component in this instrument are shown on the diagrams (see the Diagrams section for symbols used on diagrams). Each main circuit is assigned a series of component numbers to assist in identifying their circuit location.

(2) Circuit Board Illustrations. Each circuit diagram has an associated circuit board illustration located preceeding the circuit diagram.

(3) Component Value Identification. Values of capacitors, diodes and resistors used in this instrument are identified by direct numerical values or by a color code scheme. Figure 8-1 shows the color code and numerical value schemes used.

(4) Troubleshooting Chart. A troubleshooting chart, Figure 8-2, is provided to aid in locating problem areas.

(5) Semiconductor Lead Configurations. Typical semiconductor lead configurations are shown in Figure 8-3.



(1) (2) and (3) 1ST, 2ND, AND 3RD SIGNIFICANT FIGS. (B) TOLERANCE; F=±1%, J=5%, K=10%, M=20%

(M) MULTIPLIER (T) TOLERANCE (T) AND/OR (TC) COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS

COLOR	SIGNIFICANT FIGURES	RESISTORS (Ω)		CAPACITORS (pF)		
		MULTIPLIER	TOLERANCE	MULTIPLIER	TOLERANCE	
					over 10 pF	under 10 pF
BLACK	0	1	---	1	±20%	±2 pF
BROWN	1	10	±1%	10	±1%	±0.1 pF
RED	2	10^2 or 100	±2%	10^2 or 100	±2%	---
ORANGE	3	10^3 or 1 K	±3%	10^3 or 1000	±3%	---
YELLOW	4	10^4 or 10 K	±4%	10^4 or 10,000	+100% –9%	---
GREEN	5	10^5 or 100 K	±½%	10^5 or 100,000	±5%	±0.5 pF
BLUE	6	10^6 or 1 M	±¼%	10^6 or 1,000,000	---	---
VIOLET	7	---	±1/10%	---	---	---
GRAY	8	---	---	10^{-2} or 0.01	+80% –20%	±0.25 pF
WHITE	9	---	---	10^{-1} or 0.1	±10%	±1 pF
GOLD	–	10^{-1} or 0.1	±5%	---	---	---
SILVER	–	10^{-2} or 0.01	±10%	---	---	---
NONE	–	---	±20%	---	±10%	±1 pF

Figure 8-1. COMPONENT VALUE IDENTIFICATION

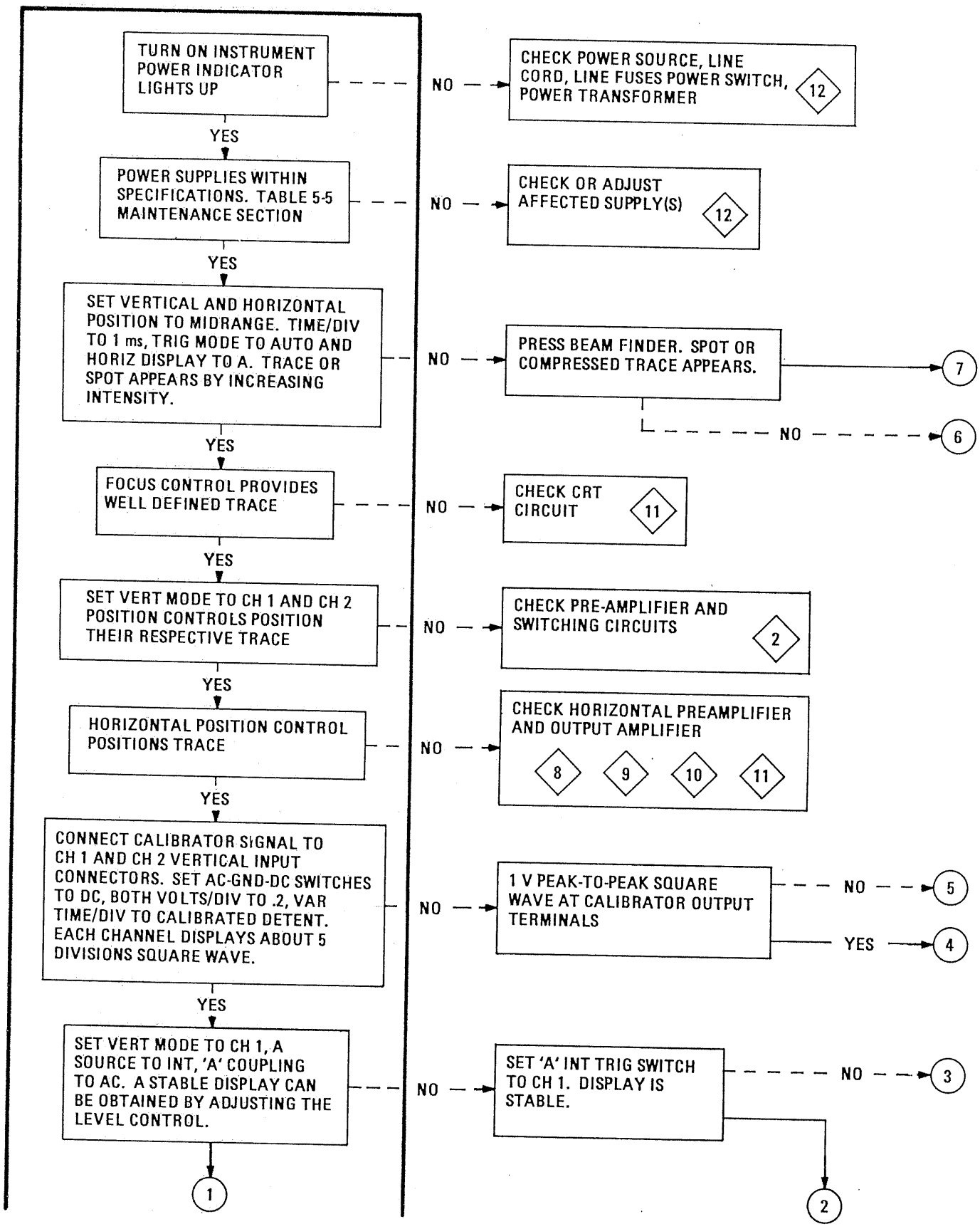


Figure 8-2. TROUBLESHOOTING CHART (SHEET 1 OF 4)

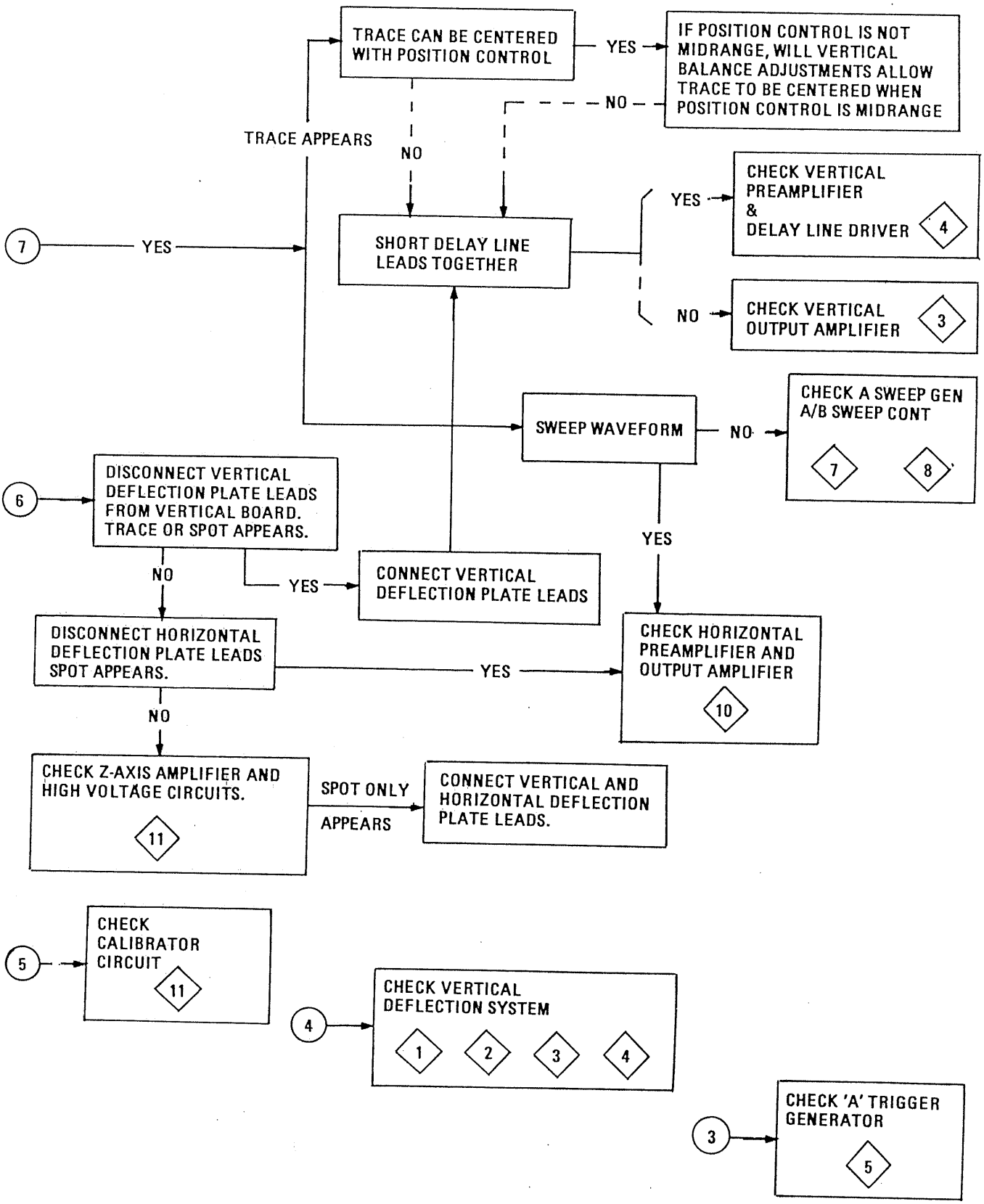


Figure 8-2. TROUBLESHOOTING CHART (SHEET 2 OF 4)

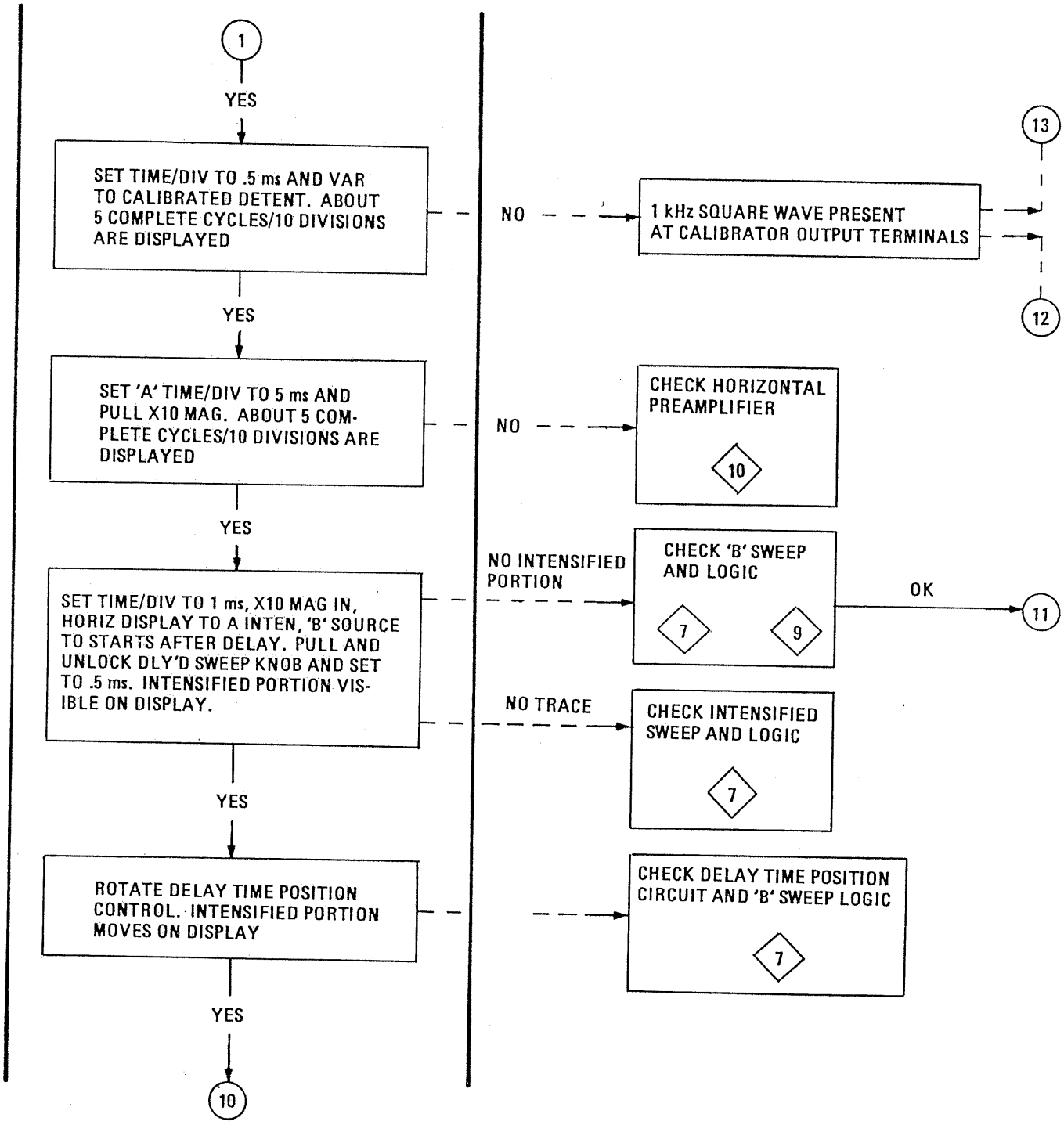


Figure 8-2. TROUBLESHOOTING CHART (SHEET 3 OF 4)

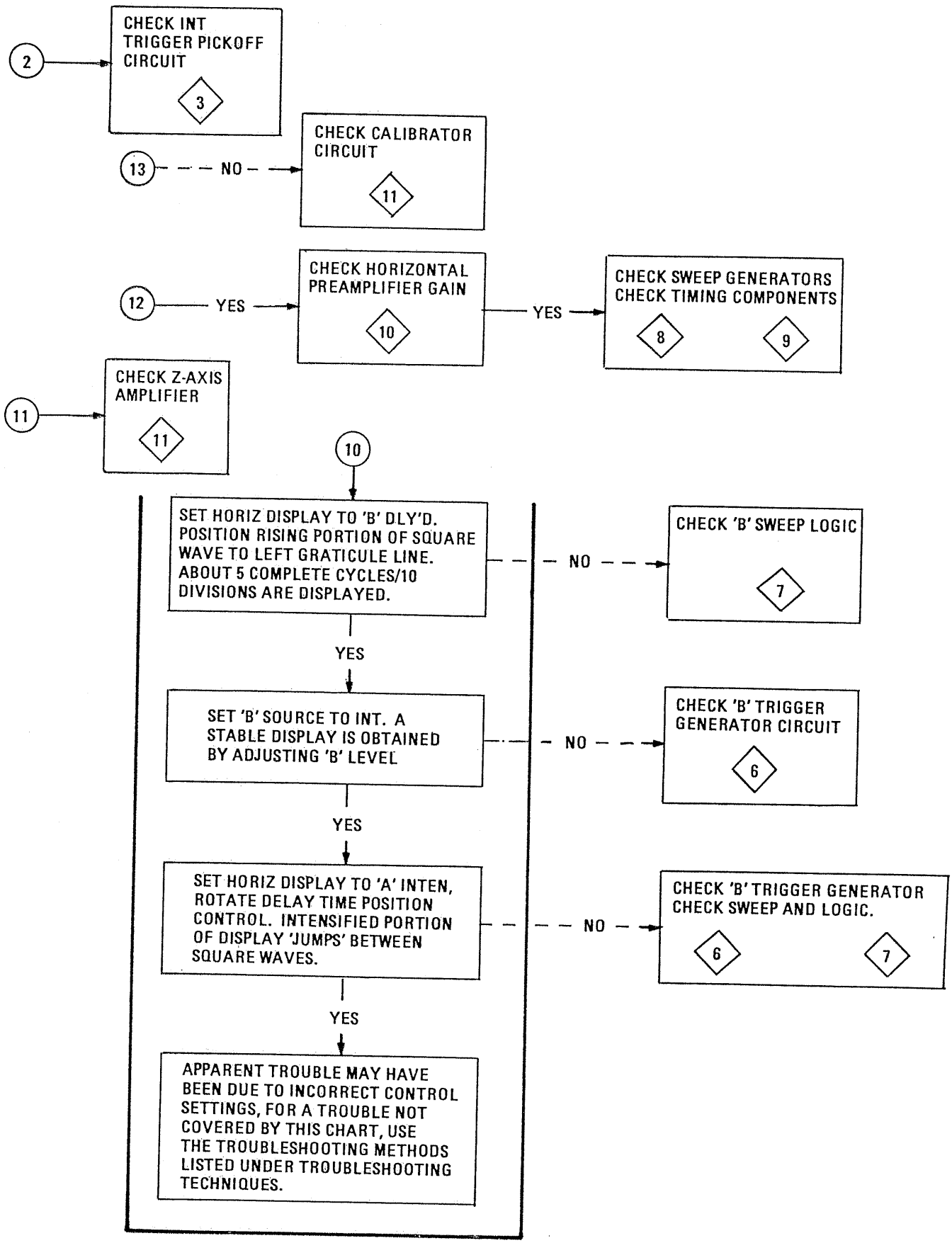


Figure 8-2. TROUBLESHOOTING CHART (SHEET 4 OF 4)

b. Troubleshooting Techniques. The following procedures are arranged in an order that checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining checks should aid in locating the defective component.

(1) Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operation Instructions section.

(2) Check Associated Equipment. Before proceeding with troubleshooting, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

(3) Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble exists in one circuit. The apparent trouble may only be misadjustment that can be corrected by calibration.

(4) Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, and damaged components.

(5) Isolate Trouble to a Circuit. Using the troubleshooting chart, Figure 8-2. isolate trouble to a particular circuit. The symptom often identifies the

defective circuit. Trouble appearing in more than one circuit can indicate possible power supply problems. Power supply tolerance and ripple limits can be checked using Table 8-2.

Table 8-2. Power Supply Voltages and Check Points

VOLTAGE	TOLERANCE	CHECK AND ADJUSTMENT POINT
+5V	+4.74 - 5.25V	TP-2
+12V	+11.95 - 12.05V	TP-3/RV1211
-12V	-11.8 - 12.1V	TP-1
+56V	+54 - 60V	TP-4
+155V	+150 - 160V	TP-5
-1850V	-1840 - -1860V	TP-6/RV1101

(6) Check Circuit Board Interconnections. After the trouble has been isolated to a particular circuit, check for loose or broken connections, improperly seated transistors and heat damaged components.

(7) Check Individual Components. The following procedures describe methods of checking individual components. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

WARNING

The Power switch must be turned off before removing or replacing components to prevent electrical shock or circuit damage.

(a) Semiconductors. A good check of transistor operation is actual performance under operating conditions. A transistor can be most effectively checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static

type testers are not recommended, since they do not check operation under simulated operating conditions.

1 When troubleshooting transistors in the circuit with a voltmeter, measure the emitter to base and emitter to collector voltages to determine if the voltages are consistent with normal circuit voltages. Voltages across a transistor vary with the type of device and its circuit function. Some of these voltages are predictable. The emitter to base voltage of a conducting silicon transistor will normally be 0.6 to 0.8 volts. The emitter to collector voltages of a saturated transistor is about 0.2 volts. Because these values are small, the best way to check them is by connecting the voltmeter across the junction and using a sensitive voltmeter setting, rather than by comparing 2 voltages taken with respect to ground (both leads of the voltmeter must be isolated from ground if this method is used). If values less than these are obtained, either the device is short-circuited or no current is flowing in the circuit. If values are in excess of the base emitter values given, the junction is back biased or the device is defective. Values in excess of those given for emitter collector could indicate either a nonsaturated device operating normally, or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across resistances in series with it; if it is open, no voltage will be developed across resistances in series with it unless current is being supplied by a parallel path.

2 When troubleshooting field effect transistors, the voltages across its elements can be checked in the same manner as transistors. However, it should be remembered that normal depletion mode operation has the gate to source junction reverse biased, while the enhanced mode has the junction forward biased.

3 IC's (integrated circuits) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential to troubleshooting circuits using IC's. Use care when checking voltages and waveforms around the IC's so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin IC's is with an IC test clip. This device also doubles as an extraction tool.

(b) Diodes. A diode can be checked for an open or for a short circuit by measuring the resistance between terminals with an ohmmeter set to the R X 1 kilohm scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents can damage diodes. Check diodes in the same manner as transistor emitter to base junctions. Silicon diodes should have 0.6 to 0.8 volts across the junction when conducting. Higher readings indicate that they are either back biased or defective, depending on polarity.

(c) Resistors. Check the resistors with an ohmmeter. Check the parts list for tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies considerably from the specified value.

(d) Inductors. Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit.

(e) Capacitors. A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

SEMICONDUCTOR LEAD CONFIGURATIONS

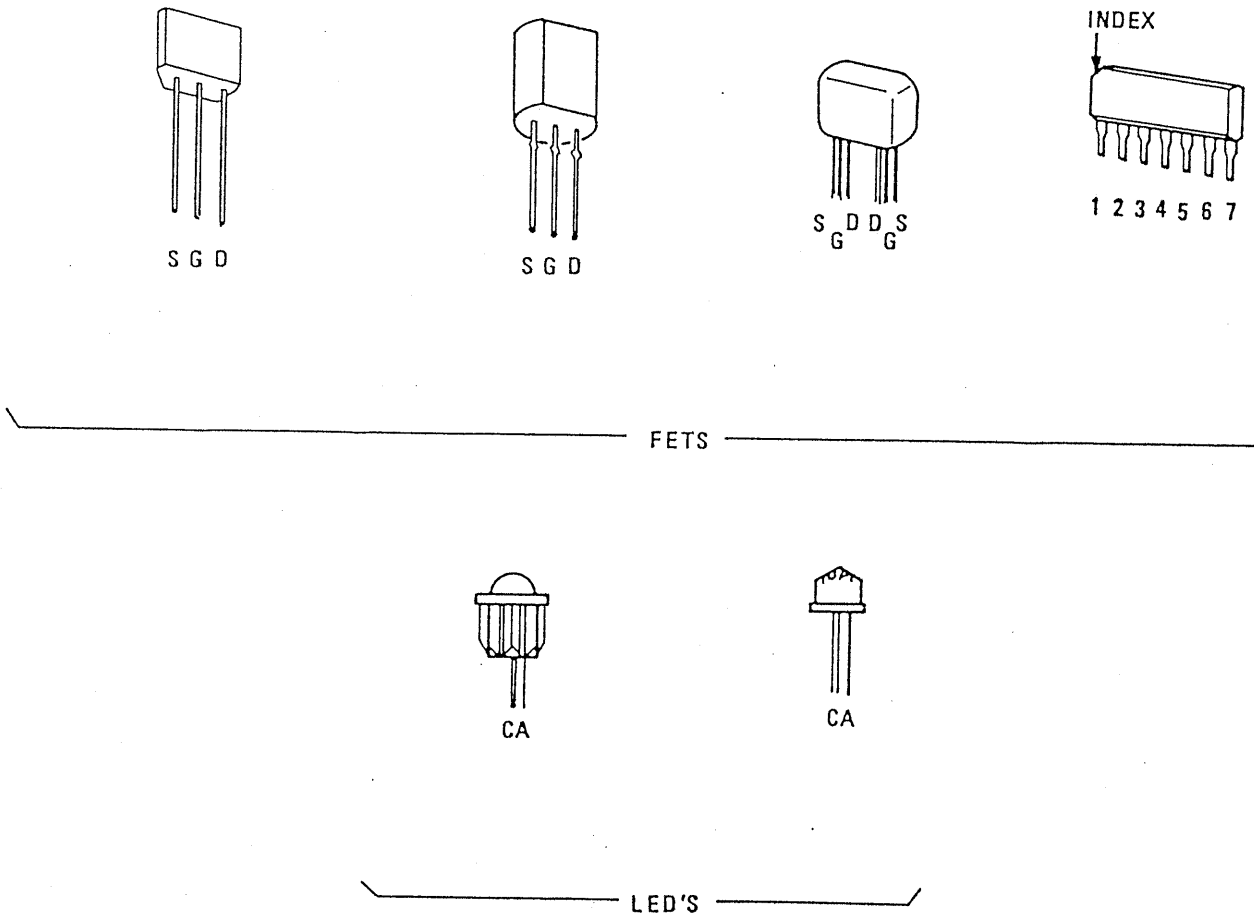


Figure 8-3. SEMICONDUCTOR LEAD CONFIGURATIONS (SHEET 1 OF 2)

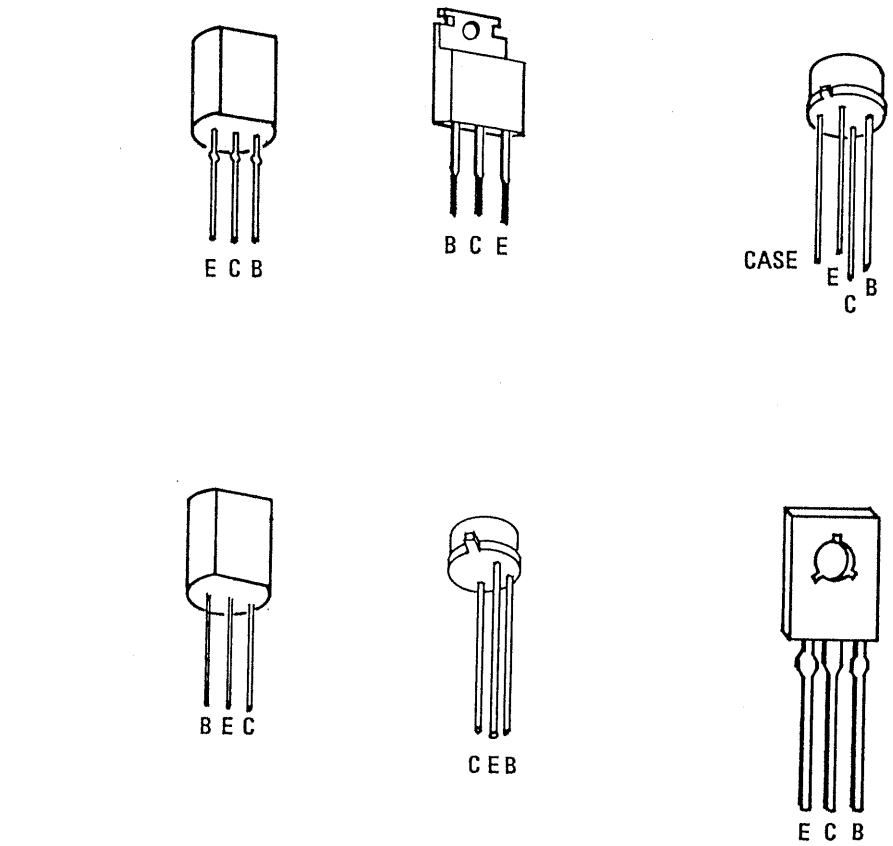


Figure 8-3. SEMICONDUCTOR LEAD CONFIGURATIONS (SHEET 2 OF 2)

9. DIAGRAMS

9.1 Introduction.

This section contains diagrams and associated data for maintaining the instrument.

9.2 Arrangement.

a. Schematic Diagrams. Schematic diagrams are drawn to group circuit functions; therefore, any one diagram may include portions of any number of circuit boards or assemblies. To aid in tracing circuits from one diagram to another, each diagram is identified with a name and a number in a diamond shaped box. Circuits going from one diagram to another identify the destination component and destination diagram number.

b. Symbols and Reference Designators.

(1) Electrical components shown on the diagrams are in the following units unless noted otherwise.

Capacitors	Values are in farads.
Resistors	Ohms (Ω).

* Optimum value factory sected. Average value shown (parts may be omitted).

△ Metal film resistors.

(2) Table 9-1 is a partial listing of prefix letters used as reference designators. These are used to identify components or assemblies on the diagrams.

Table 9-1. Reference Designators

REFERENCE DESIGNATOR	DESCRIPTION	REFERENCE DESIGNATOR	DESCRIPTION
A	Assembly, separable or repairable (circuit board, etc.)	R	Resistor, fixed
		RV	Resistor, variable
C	Capacitor, fixed or variable	S	Switch
CR	Diode	T	Transformer
DL	Delay line	TP	Test point
F	Fuse	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
FL	Filter		
J	Connector, movable portion		
L	Inductor, fixed or variable	V	Electron tube
	Connector, stationary	VR	Voltage regulator
P	Connector, stationary portion		
Q	Transistor or silicone-controlled rectifier		

Diagrams

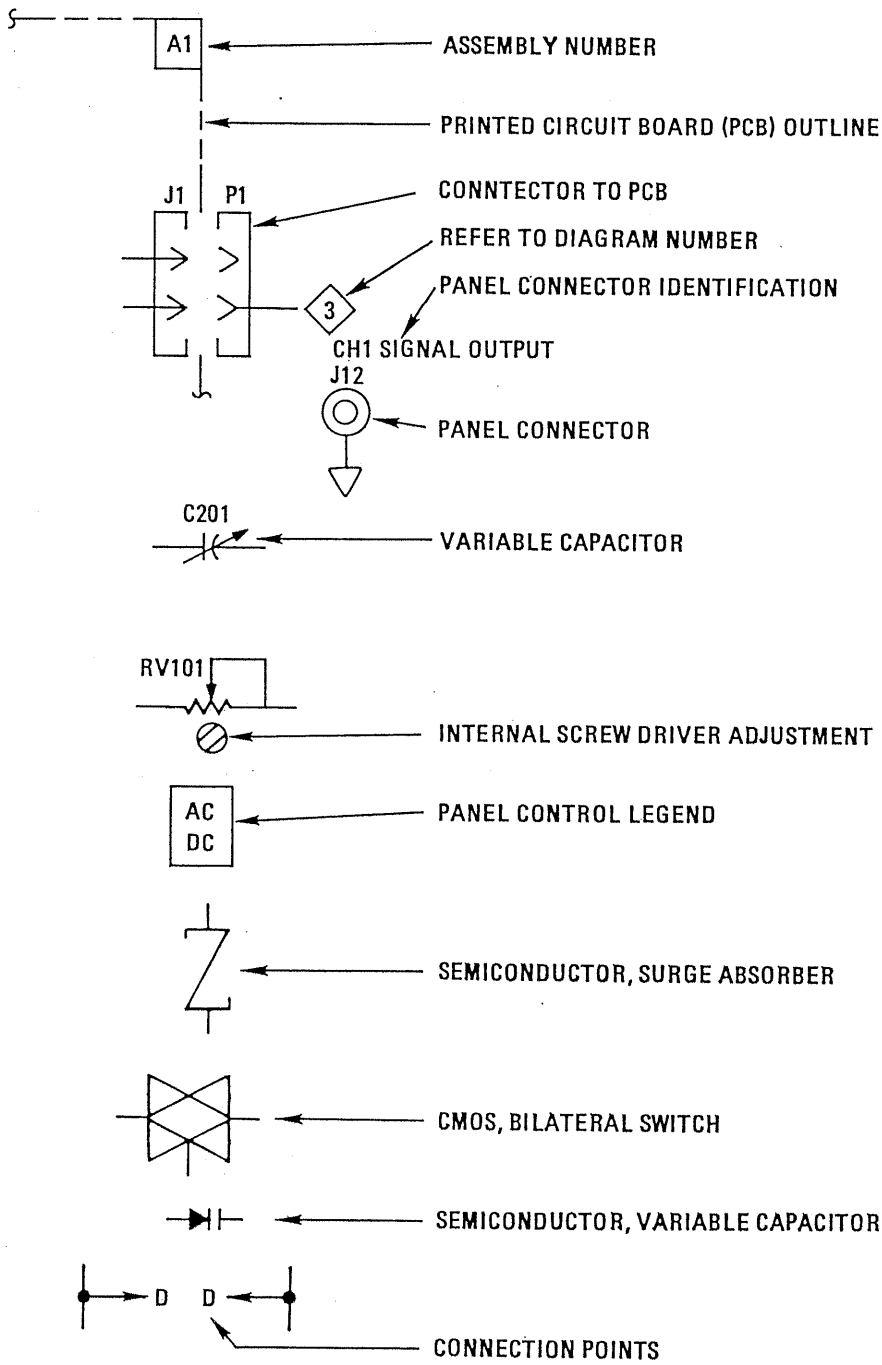


Figure 9-1. SCHEMATIC SYMBOLS

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