INSTRUCTION MANUAL FOR

OSCILLOSCOPE

MODEL 5515

KIKUSUI ELECTRONICS CORPORATION

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is ________ VAC,
and the voltage range is ________ to ________ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is ________A, ________VAC, and ________.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

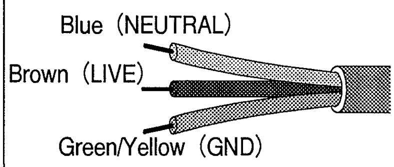
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

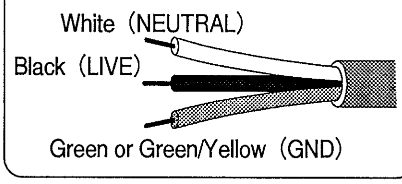
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

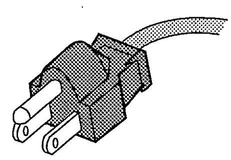
☐ Without a power plug



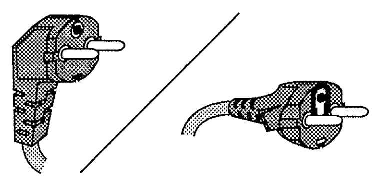
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable ________________________________

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KIKUSUI

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1. GENERAL DESCRIPTION AND FEATURES

1.1 General

Kikusui Model 5515 is a portable dual-channel oscilloscope of excellent measuring performance, high operation reliability, and good cost performance. The 5515 incorporates wide band vertical amplifiers which cover frequencies for DC - 15 MHz and sensitivities up to 5 mV/cm and which also can be switched over (with pushbuttons) to another operation mode of sensitivities up to 1 mV/cm and AC frequencies up to 6 MHz ("AC ONLY 6 MHz" mode). The maximum sweep time is 0.5 μs/cm plus sweep magnification with a factor of 5 ("5X MAG"). The 5515 employs a 5-inch post-acceleration CRT.

The 5515 is widely used not only for research and developments of analog and digital electronic equipment but also for monitoring, inspection, maintenance and service of production lines.

1.2 Features

o Controllability:

The 5515 provides an excellent controllability by the use of pushbutton switches, which simplify control actions, at many points where switching actions are frequently made.

o Cost performance:

High performance and low cost are mutually contradictory. The 5515 has realized the highest cost performance through the best possible use of the-state-of-the-art.

- CRT:

The 5515 employs a 5-inch post-acceleration CRT which provides a wide display screen and bright and sharp traces. For better life expectancy of the CRT, the acceleration voltage is selected at a lower voltage of 3.3 kV with an ample allowance, yet providing sufficient trace brightness.

- FET's and IC's:

The 5515 operates stably immediately after its power is turned on. It employs dual FET's in its vertical input circuits and regulated IC power supply, reducing to the possible minimum the drifts caused by external disturbances and temperature.

As for the power on-off indicator, a LED indicator which has a semi-permanent life is used. Since solid-state circuits are employed throughout, the oscilloscope operates very stably immediately after its power is turned on.

- High-sensitivity wide-band vertical amplifier:

The vertical amplifier has a high sensitivity of 5 mV/cm and covers a wide frequency range of DC to 15 MHz (-3 dB). It also provides another operation state of sensitivity 1 mV/cm and frequency AC ONLY 6MHz (-3 dB). The highest sensitivity of 1 mV/cm is advantageous in measurements of low level signals. Having excellent temperature characteristics, the amplifier ensures stable observation and measurement of signals.

- Automatic CHOP/ALT switching:

Switching between CHOP mode and ALT mode is linked with the TIME/CM switch of the time axis. When the oscilloscope is operated in the DUAL mode, the two traces are displayed in the CHOP mode when the sweep time is slower than 1 msec but in the ALT mode when the sweep time is 1 msec or faster. This is another one of the operation simplification features of the oscilloscope.

- Maximum sweep speed 0.1 μs/cm (with 5X MAG)

  When the sweep magnification with a factor of 5 is effected, as fast sweep speed as 0.1 μs/cm is obtained. This high speed, together with the excellent performance of the trigger circuit, provides a powerful means for observation and measurement of high speed pulse signals.

- External sweep amplifier for X-Y display:

  When the TIME/CM switch is turned to the X-Y position, CH_1 is connected to the X (horizontal) axis and CH_2 to the Y (vertical) axis, simultaneously. Identical 11-step attenuators can be used for both X and Y axes, making the sensitivities of both X and Y axes equal.

- Wide band Z-axis amplifier:

  The oscilloscope provides intensity modulation with an input signal of DC - 1 MHz, 3 Vp-p.

- Bright traces at high sweep speed:

  The 5515 is incorporated with such a feature that if the GND button of the AC/DC/GND selector is pressed when the oscilloscope is operating at a high sweep speed with no input signal under the AUTO mode, a bright base trace line is displayed on the screen. This feature can be effectively used when checking inclination of trace lines when measuring waveforms which must be analyzed with respect to the zero volt level.

o CH_1/CH_2 IDEN button:

When the CH_1 or CH_2 button is pressed, the waveform of the corresponding channel disappears from the CRT screen providing a means of channel identification.

1.3 Construction

The oscilloscope consists of the main unit and accessories as follows:

Main Unit 1

Accessories

- Probes (955 BNC) 2
- Terminal adaptor, Type 942 1
- Hex. wrench, 3 mm 1
- Fuse 1
- Short bar 1
- Instruction manual 1

1.4 Specifications

Vertical Deflection Circuit

Item	Specification	Remarks
Sensitivity	5 mV/cm ~ 10 V/cm, 11 ranges	1-2-5 step
Sensitivity accuracy	Within ±3% of panel indicated value, with VARIABLE knob in CAL'D position.	Sensitivity calibrated at 5 mV/cm range

PUSH 1 mV (AC ONLY)	1 mV/cm ~ 2 V/cm (CH_2)	5 Hz ~ 6 MHz, within -3 dB; 50 kHz, 4 cm as reference
Maximum noise voltage	Less than 2 mm	At PUSH 1 mV (AC)
Frequency bandwidth	DC: DC ~ 15 MHz AC: 3 Hz ~ 15 MHz	Within -3 dB; 50 kHz, 4 cm as reference
Continuous sensitivity adjustment	Adjustable by 2.5 times or over of panel indicated value.	
Rise time	Approx. 23.3 ns	Calculated value
Input impedance	1 MΩ ±2%, 38 pF ±2 pF	Parallel
Input terminal	BNC type receptacle	
Maximum allowable input voltages	400 V at 5 mV, 10 mV, and 20 mV ranges. 600 V at other ranges.	DC + AC peak value. 1 kHz or below for AC.
Input coupling	AC and DC	
Shift of base line caused by DC offset	Less than 2 mm at 5 mV/cm range	When switching for DC, GND is made.
Shift of base line caused by range switching	Less than 10 mm for switching at 5 mV/cm, 10 mV/cm, and 20 mV/cm ranges	When AC/DC/GND selector is set at GND state.

Linearity	When 4 cm signal displayed in CRT center is moved fully in effective vertical area, variation of signal in vertical amplitude is within ±2 mm.			For signal frequency of less than 100 kHz; including CRT linearity.
Common mode rejection ratio	100:1 or over, at 50 kHz			When sensitivities of CH_1 and CH_2 are exactly equal.
Interference between channels	1000:1 or over; as measured at 100 kHz, amplitude 8 cm.			Both CH_1 and CH_2 are set at 5 mV/cm range, in DUAL mode. Signal corresponding to full effective area is applied to one channel; input of the other channel is terminated with 50 Ω.
Operation modes of vertical channels	CH_1	Operation with independent CH_1 alone		
	CH_2	Operation with independent CH_2 alone		
	DUAL (automatic switching)	ALT	CH_1 and CH_2 are alternately swept.	ALT sweep for 0.5 ms ~ 0.5 µs
		CHOP	CH_1 and CH_2 are switched at approx. 100 kHz.	CHOP switching for 0.5 s ~ 1 ms. Linked with TIME/CM switch.
	ADD ($CH_1 \pm CH_2$)			

PUSH INV	Polarity of CH_2 alone is inverted.	
CH_1-CH_2 IDEN	Trace corresponding to pressed IDEN button disappears from CRT screen, when operated in DUAL mode.	

Horizontal Deflection Circuit

Item	Specification	Remarks
Sweep time	0.5 μs/cm ~ 0.5 s/cm, 19 ranges	1-2-5 step
Sweep time accuracy	Within ±3%	When VARIABLE knob set in CAL'D position.
Continuous sweep time adjustment	Adjustable by 2.5 times or over of panel indicated value.	
Sweep magnification	5 times	
Magnification errors	±3% for 0.5 s ~ 2 μs. ±5% for 1 μs ~ 0.5 μs.	In addition to sweep time errors.
Position shift caused by magnification	Within ±5 mm at CRT center.	

Trigger Circuit

Item	Specification		Remarks
Trigger signal source	NORM	Triggered with CH_1 or CH_2 signal.	
	CH_1	Triggered with CH_1 signal alone.	
	EXT	Triggered with external signal.	
Coupling	AC HF REJ		
Polarity	"+" and "-"		
Internal trigger sensitivity AC HF REJ	 5 Hz ~ 15 MHz: 15 mm 5 Hz ~ 50 kHz: 15 mm		In terms of deflection amplitude on CRT screen.
External trigger sensitivity AC HF REJ	 5 Hz ~ 15 MHz: 200 mVp-p 5 Hz ~ 50 kHz: 1 Vp-p		
AUTO	Satisfies the trigger sensitivity specification for signals of 50 Hz and over.		
External trigger input impedance	Approx. 50 kΩ, with 40 pF or less capacitance in parallel.		
Input terminal	BNC receptacle		
Maximum allowable input voltage	100 V (DC + AC peak)		Below 1 kHz for AC.

External Sweep Amplifier (X-Y)

Item	Specification	Remarks
System	X-Y system: CH_1 for X CH_2 for Y	Horizontal axis Vertical axis
Sensitivity (X)	5 mV ~ 10 V/cm, 11 ranges	1-2-5 step. VARIABLE knob idle.
Frequency range	DC ~ 1 MHz	Within -3 dB
Input impedance	1 MΩ ±2%, 38 pF	Parallel
Maximum allowable input voltage	400 V at 5 mV, 10 mV, and 20 mV ranges. 600 V at other ranges.	DC + AC peak value. Below 1 kHz for AC.
Input terminal	BNC receptacle	X letter indication

Calibration Voltage

Item	Specification	Remarks
Waveform	Square wave	
Polarity	Positive; 0 V (zero volts) reference.	
Output voltage	50 mVp-p, 2 Vp-p	Two outputs
Output voltage accuracy	Better than ±3%	
Frequency	1 kHz ±25%	

Duty ratio	48:52 or over	
Rise time	Approx. 1 μs	
Output terminal	Jack	

CRT

Item	Specification	Remarks
Type	Post-acceleration round cathode-ray tube	
Fluorescent material	B31	
Acceleration voltage	Approx. 3300 V	Between cathode and Anode electrode
Effective screen size	8 cm x 10 cm	
Raster distortion	3.7%	
Trace and graticule alignment	Mechanical adjustment	
Blanking	With G_1	
Illumination	Continuously adjustable	

Z-axis Amplifier

Item	Specification	Remarks
Intensity modulation	Trace intensity is varied (discernible) with input signal of 3 Vp-p. Trace is darkened with positive input and brightened with negative input.	
Frequency range	DC ~ 1 MHz	Intensity modulation discernible
Input resistance	Approx. 10 kΩ	
Input terminal	Binding post	

Power Supply

Item	Specification	Remarks
Line voltage range	_ _ _ _ _V	±10%
Frequency range	50 Hz ~ 60 Hz	
Power consumption	Approx. 52 VA	

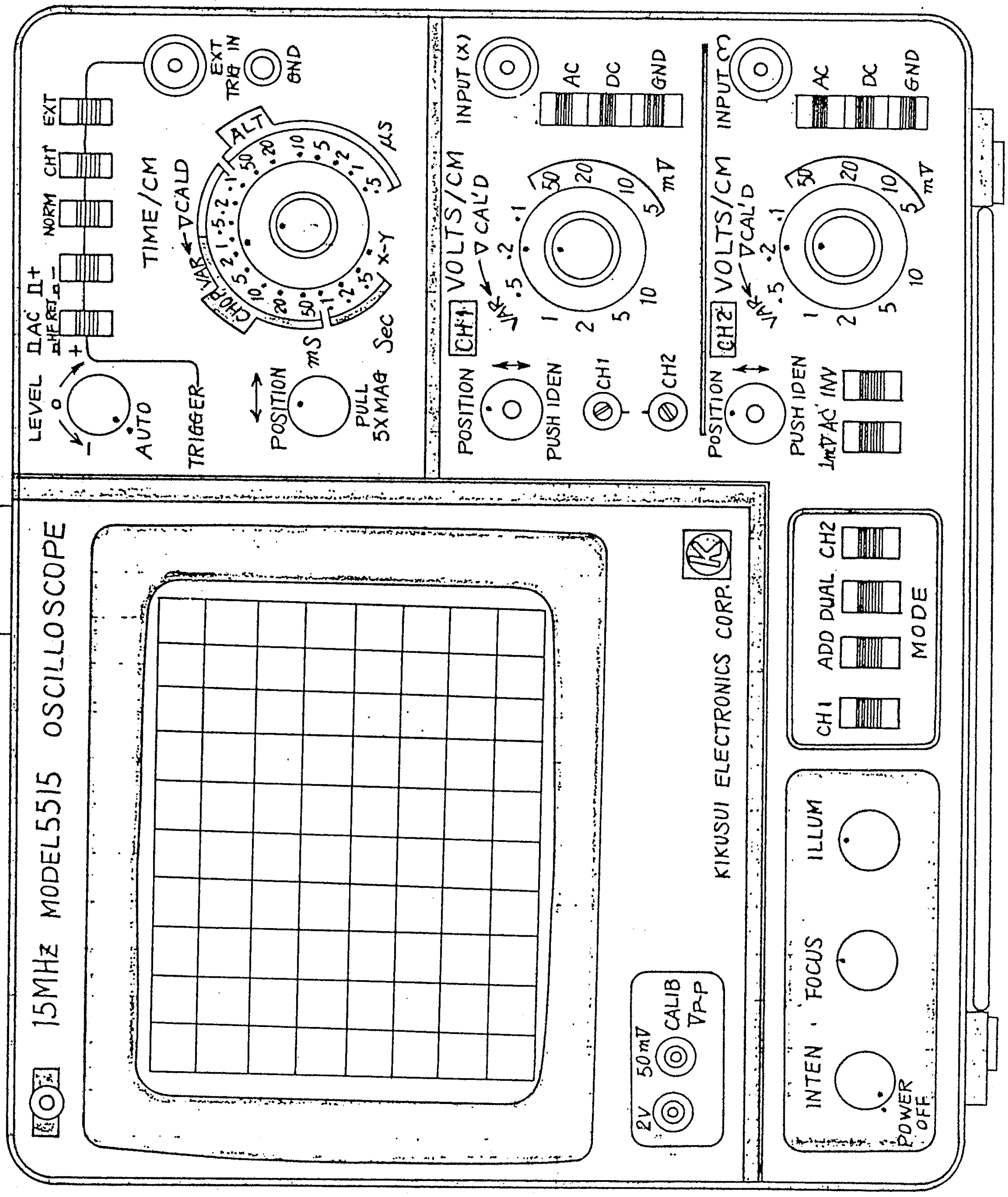
Cabinet

Item	Specification	Remarks
External dimensions	245 W x 210 H x 447 D mm	Maximum dimensions
	243 W x 190 H x 395 D mm	Cabinet dimensions
Weight	Approx. 7.7 kg	

Accessories

955 BNC type probes (10:1 low capacitance)	2
942 type terminal adaptor	1
Slow blow fuse, 1 A	1
Hex. wrench (3 mm)	1
Short bar	1
Instruction manual	1

Front Panel


15MHz MODEL5515 OSCILLOSCOPE
KIKUSUI ELECTRONICS CORP.
LEVEL
AUTO
TRIGGER
NORM
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EXT TRIG IN
GND
TIME/CM
ALT
CHOP
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ADD
DUAL
MODE
INTEN
FOCUS
ILLUM
POWER OFF
2V
50mV
CALIB Vp-p

2. PANEL DESCRIPTION

2.1 Explanation of Front Panel

Functions of the knobs and terminals of the front panel (and rear panel) are explained in this section. Regarding the double-knobs, the functions of the grey knobs are displayed with black letters and those of the red knobs with red letters.

POWER OFF	This knob is used in common for both mains power on-off control and trace intensity control. The extremely counterclockwise position is the power-off position.
INTEN	Used in common for mains power on-off. Trace intensity increases as this knob is turned clockwise and vice-versa.
FOCUS	In conjunction with ASTIG control (semi-fixed resistor on the rear panel), this knob should be so adjusted that the spot or trace displayed on CRT screen is made sharpest.
ILLUM	For control of illumination of CRT screen graticule. Clockwise rotation is for brightening, and vice-versa.
CALIB	Provides a signal for sensitivity calibration and probe phase adjustment. The signal is a zero-volt-referenced positive-going square wave, at a frequency of approximately 1 kHz and voltages at 50 mVp-p and 2Vp-p. The signal is available at the jack terminal on the front panel.

Vertical Deflection Circuit

(CH_1)	The functions of controls and terminals of CH_1 and CH_2 are identical. The explanation on CH_1 is directly applicable to CH_2 also.

INPUT	BNC-type receptacle terminal for connection of input signal. This terminal is used also when the probe is used.
AC/DC/GND	Pushbutton switches for selection of input coupling of vertical input signal. The AC button is for AC coupling: if the input signal includes a DC component, it is cut off and the AC component alone is measured. The DC button is for DC coupling: overall input signal including DC component is measured. When GND button is depressed, the input signal is disconnected from the vertical amplifier at the INPUT terminal (BNC-type terminal) and the amplifier input is connected to the ground. By depressing the GND button, the zero volt level of the trace displayed on the CRT screen can be readily checked.
VOLTS/CM	The grey knob is for selection of vertical deflection sensitivity, covering 5 mV/cm to 10 V/cm in 11 ranges. The value of each switch position indicates the voltage sensitivity per 1 cm of vertical deflection on CRT screen with the VARIABLE knob turned to the extremely clockwise position (CAL'D position).
VARIABLE	The red knob is for continuously variable attenuation of the input signal. When the knob is turned to the extremely counterclockwise position, the signal is attenuated to approximately 1/2.5. With this knob, sensitivity between two adjoining ranges can be continuously covered.
POSITION	For vertical positioning of the spot or trace displayed on the CRT screen, clockwise rotation for upward movement and counterclockwise for downward.
IDEN	These two pushbuttons in the center of two POSITION knobs are for identification of channel number of the displayed waveforms, under the DUAL mode. The waveform of the

signal corresponding to the channel of the depressed button disappears from the CRT screen.

RANGE BAL — Semi-fixed resistor which should be so adjusted that the shift of the base trace line caused by switching the VOLTS/CM switch is made minimum.

GND — The GND terminal is electrically shorted to the panel, chassis, and main unit.

CH_2 INV — This pushbutton switch is for 180° phase inversion of input signal of CH_2.

CH_2 1mV AC — When this button is depressed, the maximum deflection sensitivity of CH_2 is increased to 1 mV/cm. This feature is applicable to 1 mV ~ 2 V/cm ranges (11 ranges) of VOLTS/CM switch. Under the AC ONLY mode, however, the frequency becomes 5 Hz ~ 6 MHz, -3 dB.

The above-explained items, excluding the CH_2 INV and CH_2 PUSH 1mV, are identical for both CH_1 and CH_2.

MODE — This switch selects the operating modes of amplifiers of CH_1 and CH_2 as below.

- CH_1 — The oscilloscope operates as a single-channel instrument, with CH_1 amplifier alone.
- CH_2 — The oscilloscope operates as a single-channel instrument, with CH_2 amplifier alone.
- DUAL — Switching between ALT and CHOP is automatically made being linked with turning of TIME/CM switch. The sweep circuit operates in the ALT mode for ranges from 0.5 ms/cm to 0.5 μs/cm and in the CHOP mode for ranges from 0.5 s/cm to 1 ms/cm.

ADD — Both CH_1 and CH_2 simultaneously operate and the mathematic sum or difference of the signals of the two channels is displayed on the CRT screen.

$CH_1 + CH_2$

For subtraction or $CH_1 - CH_2$, the CH_2 INV button must be depressed.

Horizontal Deflection Circuit

POSITION — For horizontal positioning of the spot or trace displayed on the CRT screen, with clockwise turning for rightward movement and counterclockwise turning for leftward movement.

PULL 5X MAG — The POSITION knob is used in common for this function also. As the knob is pulled out, the horizontal amplitude of the trace is magnified by a factor of 5.

EXT TRIG IN — BNC-type receptacle terminal to accept external trigger signal.

TIME/CM — For selection of sweep time. The value of each position indicates the sweep time per 1 cm of horizontal sweep under the state that the VARIABLE knob is turned to the extremely clockwise position (CAL'D position).

X-Y — When the TIME/CM switch is set in the X-Y position, the oscilloscope operates in the X-Y mode -- with CH_1 for X axis (horizontal axis) and CH_2 for Y axis (vertical axis). The frequency range of X axis is DC ~ 1 MHz, -3 dB.

Trigger Circuit

LEVEL — Selects a point on the trigger signal waveform, at where the sweep starts. When no measured signal is being applied, the trigger circuit is in a stand-by state and no sweep operation is made by the time axis.

AUTO

When the LEVEL knob is turned to the extremely counter-clockwise position, the time axis operates in the AUTO sweep mode. Without requiring any measured signal, the base trace line is displayed on the CRT screen, and triggering is effected when a measured signal of a frequency of 50 Hz or over and of an amplitude of 15 mm or over as displayed on the CRT screen is applied.

±

This pushbutton selects the triggering point either on a positive-going slope (when set in the "+" state) or on a negative-going slope (when set in the "-" state).

(AC
HF REJ

Selects the coupling state of trigger signal as below.

AC

AC coupling which cuts off the DC component so that triggering is made with the AC component alone.

HF REJ

This button is used to reject the high frequency component for observation of compound waveform or noise-superimposed waveform, or observation of waveforms in the CHOP range under the DUAL channel mode. This feature is also is effective for observation of noise-superimposed waveform under the 1 mV AC mode.

NORM
CH_1
EXT

These pushbuttons select the type of trigger signal source as below.

NORM

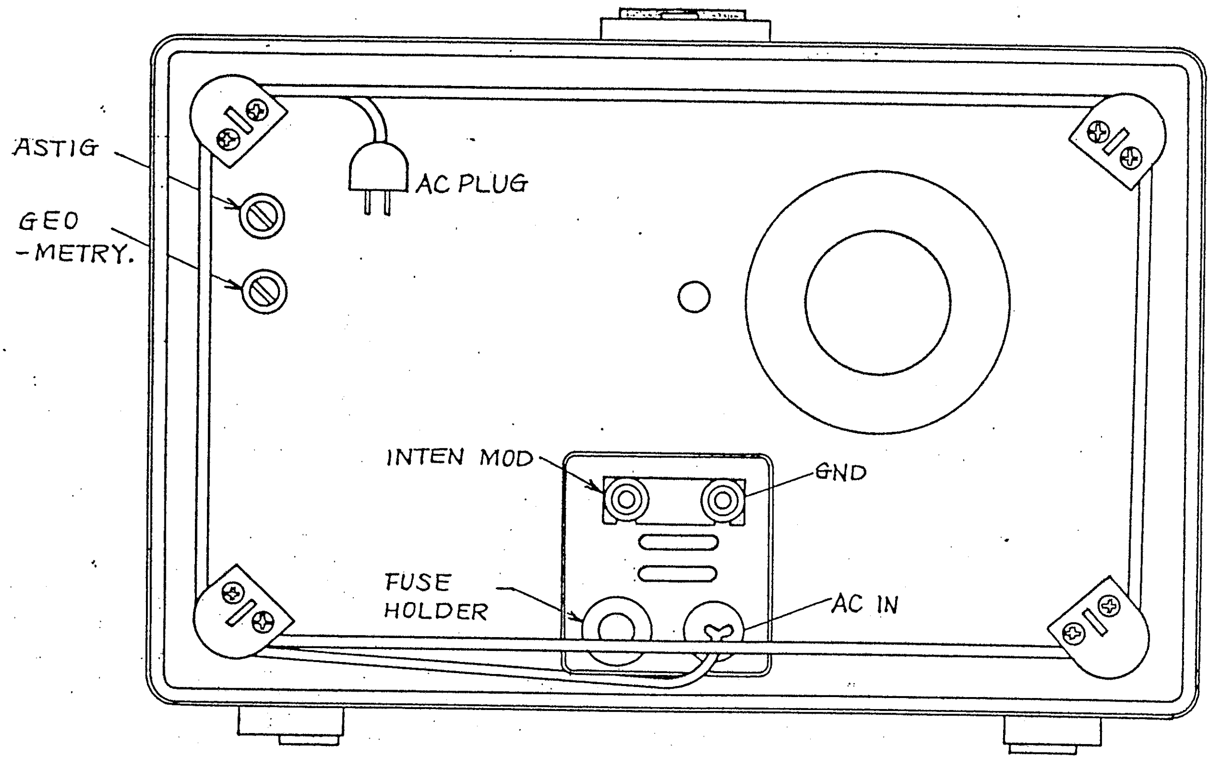
The measured signals which are displayed on the CRT screen are used as the trigger signals, that is, the input signals of CH_1 and CH_2 are used as trigger signals.

CH$_1$ The measured signal of CH$_1$ alone is used as the trigger signal.

EXT An external signal applied through the EXT TRIG IN terminal is used as the trigger signal.

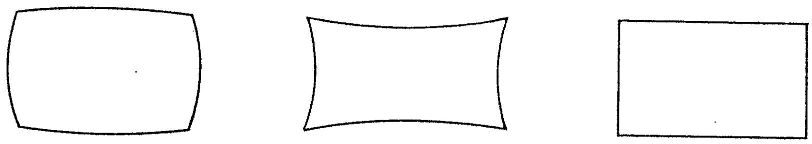
2.2 Explanation of Rear Panel

Mounted on the rear panel are the semi-fixed resistors for ASTIG and GEOMETRY adjustments, INTEN MOD terminal (external intensity modulation terminal), power fuse holder, and AC IN (mains input cord). These items are identified with letters on the panel.



ASTIG — In conjunction with FOCUS control on the front panel, this semi-fixed resistor should be so adjusted that the spot or trace displayed on CRT screen is made sharpest.

GEOMETRY — This semi-fixed resistor is used to compensate for distortion of rectangular raster area displayed on CRT screen.



Distorted Distorted Normal

FUSE HOLDER — Mains power fuse holder. The fuse is 1 ampere, slow blow type, and is removable by turning the cap counterclockwise.

AC IN — Power cord to be connected to AC mains power receptacle.

INTEN MOD — Intensity modulation signal is applied between INTEN MOD terminal and GND terminal. When no intensity modulation is made, the two terminals must be shorted with the jumper bar.

2.3 Precautions

Mains voltage:

The 5515 normally operates on an AC line of rated voltage ±10%. If the oscilloscope is operated with a mains voltage which is not within this range, mal-functioning or damage may result. If the AC line voltage is not within the above range, provide an appropriate means to make the voltage within the above range.

Ambient temperature:

The ambient temperature range for normal operation of the 5515 is $0^{\circ}C \sim +40^{\circ}C$.

Environments:

If the oscilloscope is operated for long periods in high temperature and high humidity, troubles may be caused and the life may be shortened.

Strong magnetic field or electromagnetic field also affects adversely the measurement with the oscilloscope.

Allowable maximum voltages of input terminals:

The allowable maximum voltages of the input terminals and probes are as shown in the below table. Note that the oscilloscope may be damaged if a voltage exceeding the specified value is applied.

Input terminals of CH_1 and CH_2	
5 mV, 10 mV, and 20 mV ranges of VOLTS/CM	400 V (DC + AC peak)
Other ranges of VOLTS/CM	600 V (DC + AC peak)
Probe (955 BNC)	600 V (DC + AC peak)
EXT TRING IN terminal	100 V (DC + AC peak)
INTEN MOD terminal	100 V (DC + AC peak)

The above voltages are for signals of maximum frequency 1 kHz.

Protection of CRT screen:

In order to protect the fluorescent screen of the CRT, do not make the trace excessively bright or do not leave a stationary spot for long period on the screen. Note that the CRT is of a post-acceleration type and employs a high acceleration, making it susceptible to the above damage.

3. OPERATION METHOD

Before turning on the power, set the controls on the front panel as follows:

INTEN, POWER OFF:	Extremely counterclockwise position
FOCUS:	Mid-position
MODE:	Depress CH_1 button.
TRIGGER AUTO:	Extremely counterclockwise position. Depress "+" button. Depress AC button. Depress NORM button.
CH_1 POSITION:	Mid-position
VOLTS/CM (CH_1):	10 mV
AC/DC/GND (CH_1):	Depress GND button.
HORIZONTAL POSITION:	Mid-position
TIME/CM:	0.2 ms

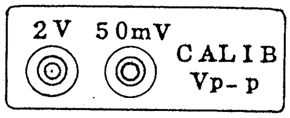
Connect the power cord to an AC line receptacle of correct voltage. Turn clockwise the INTEN knob from the POWER OFF position, when the power switch clicks and the power is supplied to the oscilloscope and the LED (light emitting diode) indicator located on the upper left of the front panel of the oscilloscope turns on. In some ten seconds later, turn further the INTEN knob clockwise until the trace is displayed with an appropriate brightness.

Focus Adjustment

Move the trace to the center of the CRT screen by adjusting the CH_1 POSITION and HORIZONTAL POSITION knobs. Adjust the FOCUS knob so that the trace is made sharpest. If sufficient sharpness cannot be obtained by means of the FOCUS control alone, adjust the ASTIG control (semi-fixed resistor) on the rear panel also.

3.1 Display of Calibration Signal Waveform

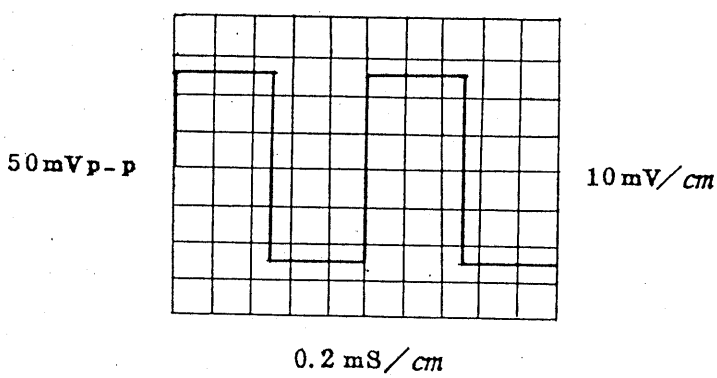
Display on the CRT screen the square wave calibration signal of the oscilloscope (CALIB signal) by connecting the BNC terminal adaptor (supplied) to the input terminal of CH_1 and using as short lead cable as possible.



Set the controls of the front panel as follows:

AC/DC/GND (CH_1):	Depress DC button.
VOLTS/CM (CH_1) knob:	10 mV
VARIABLE (CH_1):	CAL'D
CALIB:	50 mVp-p terminal
TIME/CM knob:	0.2 ms
VARIABLE:	CAL'D
TRIGGER:	AUTO

When the above setting is made, the square wave with an amplitude of 5 cm is displayed on the CRT screen.



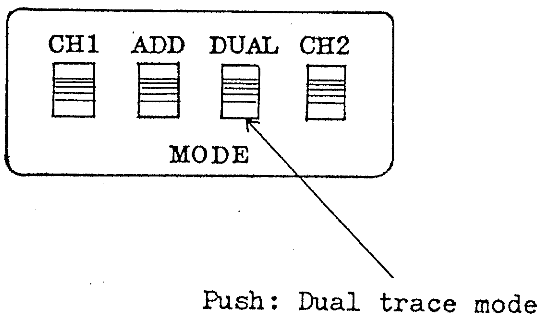
Turn the VOLTS/CM knob step by step, checking that the vertical amplitude of the displayed waveform is reduced correspondingly. Also check that the amplitude is continuously reduced as the VARIABLE knob is turned counterclockwise. Thus the functions of the VOLTS/CM switch and VARIABLE control on the input signal can be ensured.

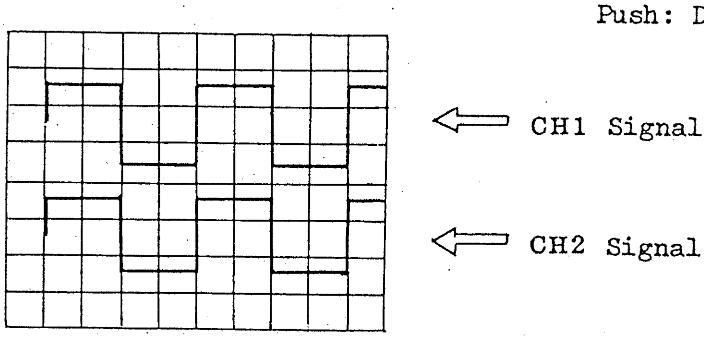
3.2 Dual Channel Mode and ADD Mode

Dual Channel Mode

Set the MODE switch in the DUAL state. In the above operating state, the calibration voltage was applied to CH_1 but not to CH_2. Now, apply the calibration voltage to CH_2 also.

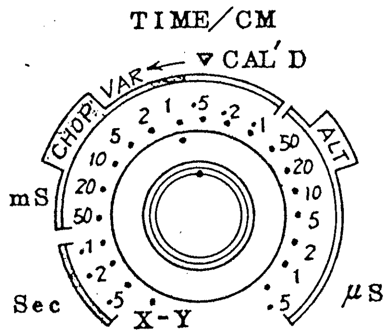
When the oscilloscope is operated in the DUAL mode, triggering must always be made with the signal applied to CH_1.





If CH_2 signal is synchronizable with respect to CH_1 signal, both signals are displayed as stationary waveforms on the CRT screen.

The 5515 has no individual pushbuttons for CHOP and ALT but has the DUAL button only. Actually, the chop and alternate sweep modes are selected being linked with the TIME/CM switch -- in the CHOP mode for the 0.5 s ~ 1 ms/cm and in the ALT mode for the 0.5 ms ~ 0.5 µs/cm ranges.



The HF REJ button is provided to eliminate undesirable high frequency components higher than 50 kHz from the trigger signal. This feature can be effectively utilized in such a case that the oscilloscope is operated in the CHOP range and the CH_1 signal level is low and its S/N ratio is poor and triggering is unstable.

ADD Mode

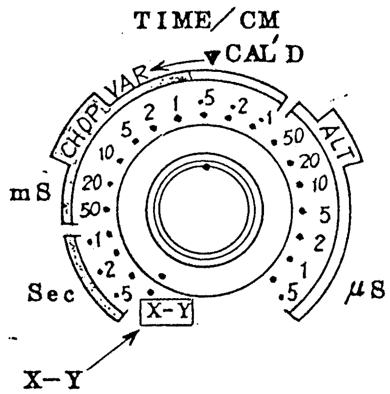
When the ADD button of the MODE selector is pressed, the result of addition or subtraction of the CH_1 and CH_2 signals is displayed on the CRT screen.

$$CH_1 \pm CH_2 = \text{ADD signal}$$

To observe the result of subtraction or the difference between the two signals, the INV button must be pressed. When this is done, the phase of the CH_2 signal is varied by 180° or the signal polarity is inverted, thereby providing a state of (CH_1 - CH_2) = (displayed waveform). The INV button is reset when it is pressed gain.

3.3 X-Y Mode

The extremely counterclockwise position of the TIME/CM switch is for the X-Y mode. Simply by turning the switch to this position, the operation mode of the oscilloscope is turned into the X-Y mode -- CH_1 for X-axis and CH_2 for Y-axis.



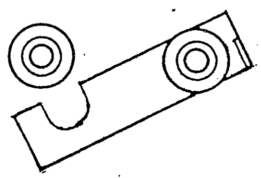
The electrical performance of the Y-axis in this case is the same with that of CH_2. That of the X-axis, however, becomes such that the frequency range is DC ~ 1 MHz for -3 dB and the VARIABLE control, POSITION control, and CH_1 IDEN button are idle. Positioning control on the X-axis can be made with the HORIZONTAL POSITION control. The sweep operation in the X-Y operation becomes sharper than the case of the normal operation. Other electrical performance is the same with that of CH_1.

Apply the calibration voltage signal to both X and Y axes. Adjust the VOLTS/CM switches of both channels so that appropriate amplitude is obtained and two spots are displayed on the diagonal line of the CRT screen. When this is done, a Lissajou's figure for frequency ratio 1:1 and phase angle difference zero or almost zero is displayed on the screen.

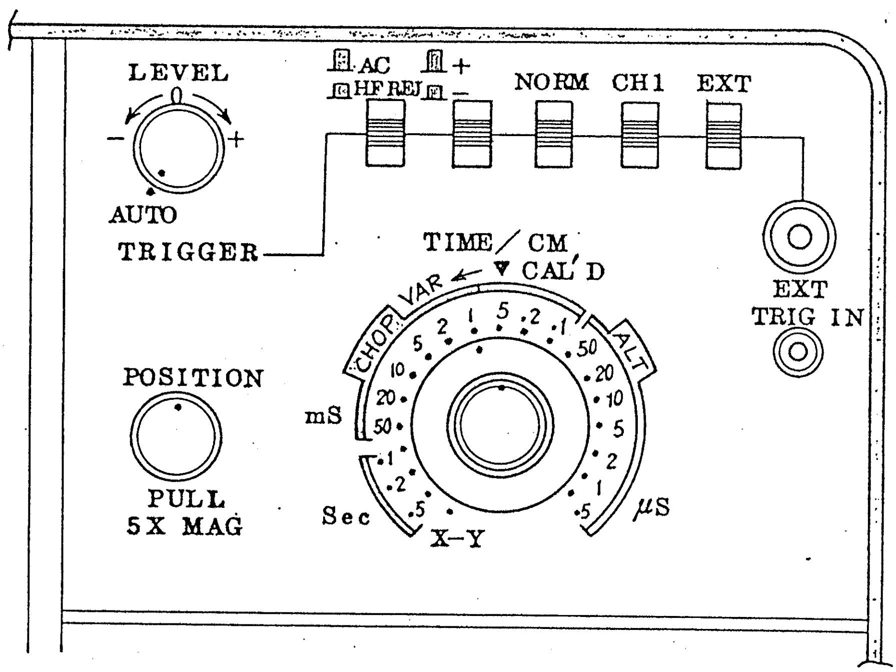
Under the X-Y mode also, the indicated sensitivity values of the VOLTS/CM switch of the X-axis is for an accuracy of ±3%. The 5X MAG function (which in the normal operation is effected by pulling to this side the knob) remains idle.

3.4 INTEN MOD

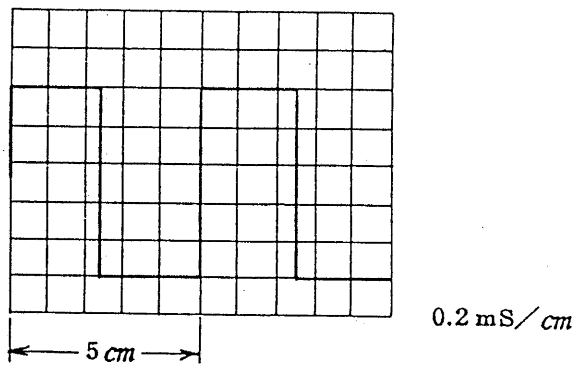
The INTEN MOD terminals which accept an external intensity modulation signal is located on the rear panel. For intensity modulation, remove the short bar from between red terminal and black terminal (GND) and apply the signal. When no intensity modulation is made, the two terminals must be connected with the short bar.



3.5 Trigger and Time Axis



This calibration voltage signal is a square wave of approximately 1 kHz. When the TIME/CM switch is set in the 0.2 ms position, one repetition of the square is displayed with a horizontal amplitude of approximately 5 cm.

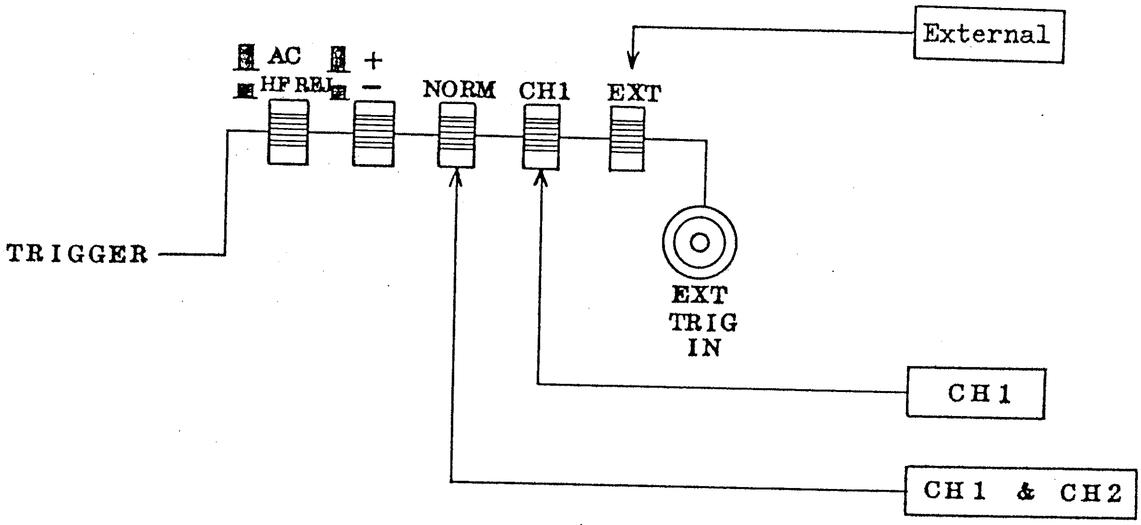


As the TIME/CM switch is turned clockwise, the sweep time becomes faster and vice versa. The sweep time is continuously adjustable with the VARIABLE knob.

3.6 Types of Trigger Signal Sources

To display the measured signal as a stationary waveform on the CRT screen, a trigger signal which is synchronized with the measured signal must be applied to the trigger circuit so that the sweeps of the time axis are initiated in synchronization with the measured signal.

There are three types of trigger signal sources applicable to the oscilloscope, namely, NORM, CH_1, and EXT. Under the NORM mode, the measured signals of CH_1 and CH_2 within the oscilloscope is used as the trigger signal; under the CH_1 mode, the measured signal of CH_1 is used as the trigger signal. Under the EXT mode, an external signal applied through the EXT TRIG IN terminal is used as the trigger signal.



3.6.1 Internal Trigger (NORM and CH_1)

Under the internal trigger, the measured input signal is picked off as a trigger signal at a certain point in the vertical amplifier within the oscilloscope. Under the NORM mode, both CH_1 and CH_2 signals are used as trigger signals. Under the CH_1 mode, the CH_1 signal alone is used as the trigger signal.

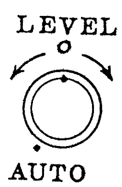
Under the internal trigger mode, stable trigging can be realized even with a low level input signal because the signal is amplified to an appropriate level by the vertical amplifier before applied to the trigger circuit.

3.6.2 External Trigger (EXT)

Under the EXT trigger mode, the trigger circuit can be directly driven eliminating adverse effects which could be caused by the vertical amplifier. For example, under the internal trigger mode, when the VOLTS/CM switch or the VERTICAL POSITION knob is turned, the voltage applied to the trigger circuit is affected and the triggering may become unstable for some input signal waveforms.

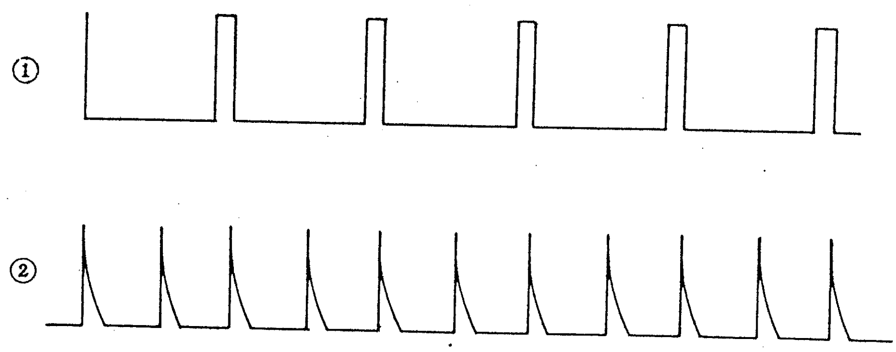
Under the external trigger mode, the trigger circuit is stably driven irrespective of turning of any controls of the vertical amplifier circuit so far as they do not affect the external trigger circuit. As for the external trigger signal, a signal of less than approximately 4 Vp-p must be used.

3.7 LEVEL Knob Operation and AUTO



When the TRIGGER knob is turned clockwise from the AUTO position (extremely counterclockwise position mentioned on the initial page of Section 3 "OPERATION METHOD") gradually into the AUTO area, triggering is effected when the knob is turned to its mid-position of the turning range and a stable waveform is displayed on the screen.

For measurement of a low level signal (displayed waveform amplitude is less than 15 mm) or a pulse signal of a very large duty cycle, turn the knob from the AUTO position into the LEVEL area to a point where stable triggering is effected.



Waveforms (1) and (2) are examples of pulse signal waveforms of large duty cycle ratios. The duty cycle ratio is calculated as follows:

Duty cycle ratio (%) = Pulse width (sec) x pulse repetition frequency (Hz) x 100

Under the LEVEL state, the time axis is in the stand-by state and the trace disappears from the CRT screen when no trigger signal is being applied, when the input signal level is less than 200 mVp-p, or when the LEVEL knob is turned exceeding the triggering point.

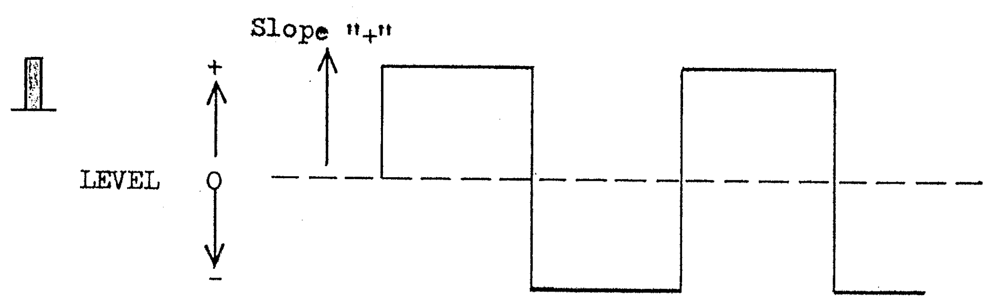
3.8 AUTO Mode

Under the AUTO mode, the time axis is automatically swept even when no trigger input signal is being applied. A bright trace is displayed even at fast sweep ranges and the zero level can be readily checked.

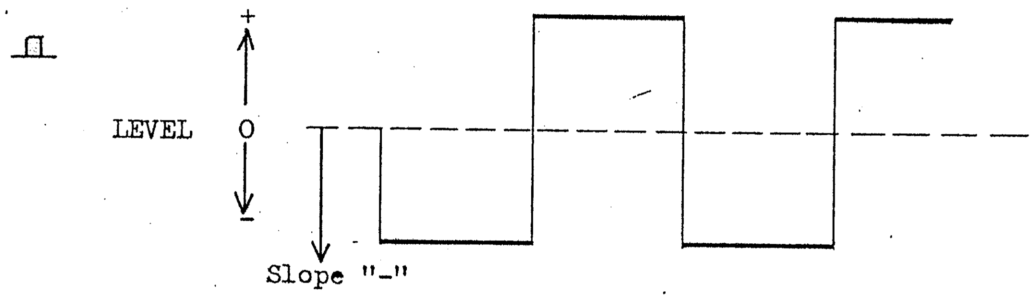
Note, however, that, under the AUTO mode, triggering is not affected with an input signal of which repetition frequency is less than 50 Hz. The AUTO mode is suitable for observation of pulse wave signals of which displayed amplitude is 15 mm or over and of which duty cycles are almost equal.

3.9 Triggering Slope ("+" and "-")

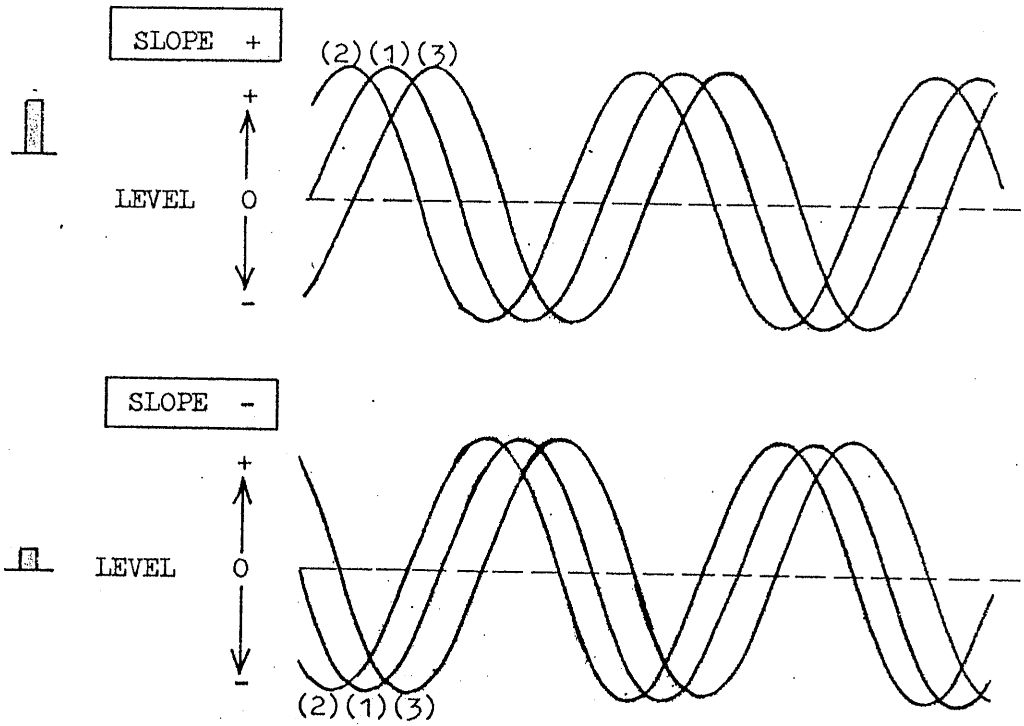
Referring to the initial page of Section 3 "OPERATION METHOD," the SLOPE button is set in the "+" state. In addition, since the calibration voltage signal is being applied as the input signal, a waveform as illustrated below is displayed on the CRT screen.



When the SLOPE button is set in the "-" state, a waveform as illustrated below is displayed.

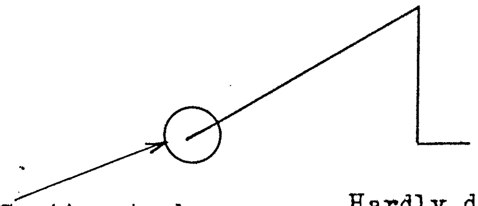


When a sine wave is used, triggering is made as below.

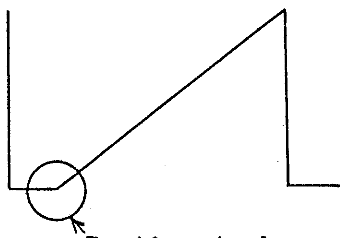


Under the AUTO mode of operation, waveform (1) is displayed normally. Under the LEVEL mode of operation, the triggering level can be varied so that waveforms (1), (2), or (3) is displayed.

The SLOPE button is switched to the "+" or "-" state for such case as below, for example.

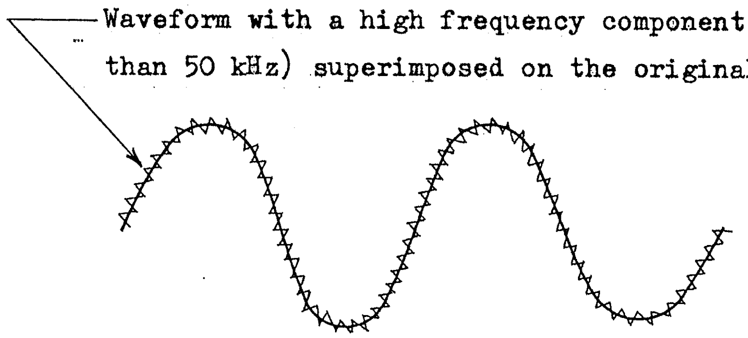


By changing the SLOPE button into the "-" state, the measurement can be easily made.

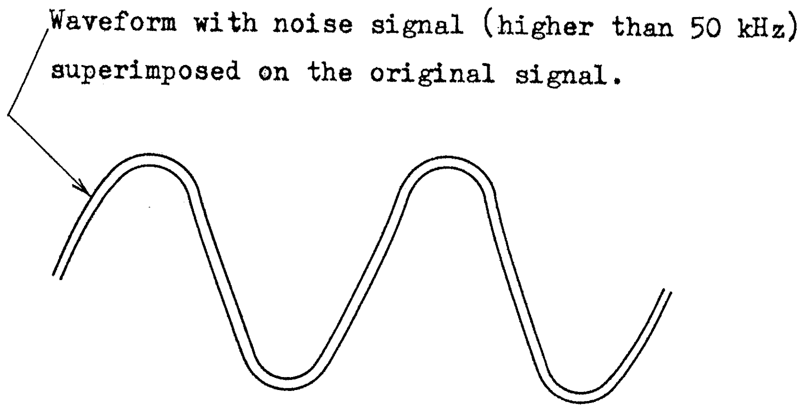


3.10 HF REJ

Under the HF REJ mode, frequency components higher than approximately 50 kHz are rejected with a low pass filter in order that triggering is stably made without being interfered by noise or other undesirable high frequency components which are superimposed on the original trigger signal.

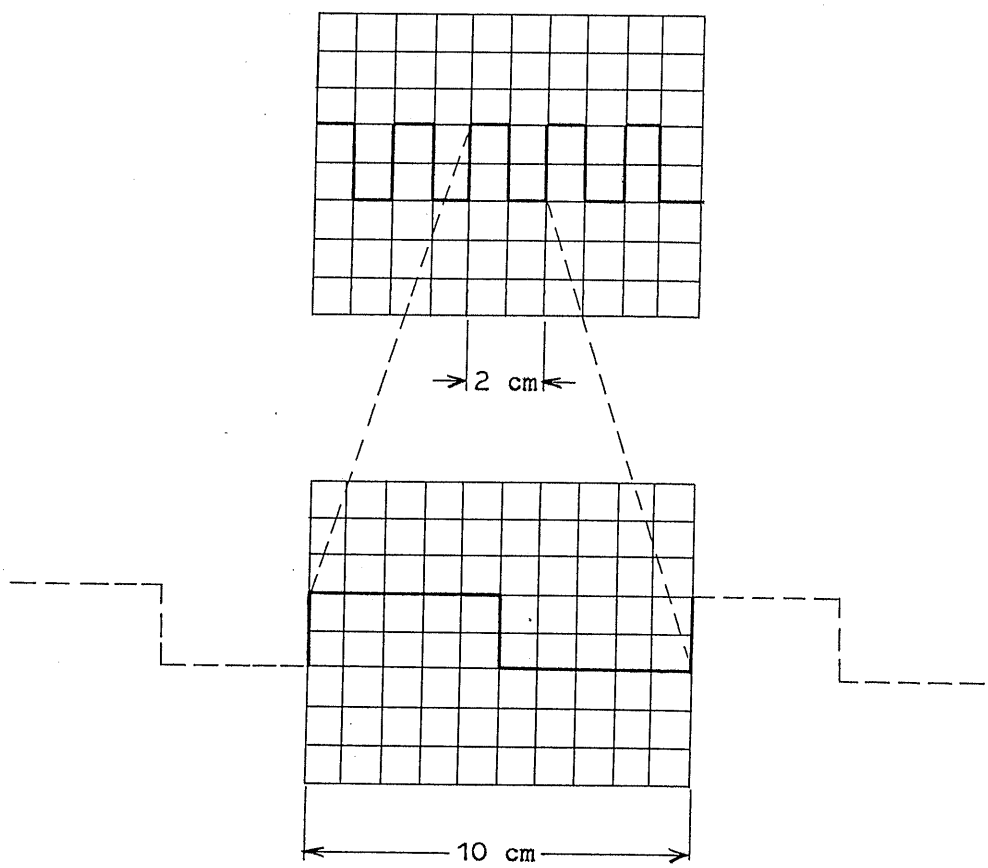


The HF REJ feature is effective also for observation of a signal of which S/N ratio is poor.



The HF REJ feature also is effective when the CH2 is set in the highest sensitivity state (1 mV AC) and when the oscilloscope is operated in the CHOP range under the DUAL mode.

3.11 Sweep Magnification (PULL 5X MAG)



When a particular section of the input signal is required to be expanded for detailed observation, the requirement may be met by using a fast sweep speed. However, if the required section is located apart from the starting point of the sweep, the required section may run out of the viewing screen. In such a case, move the required section to the screen center by turning the HORIZONTAL POSITION knob and, then, pull out the knob (set in the 5X MAG state). When this is done, the required section is horizontally expanded by a factor of 5 from the screen center.

When the 5X MAG function is effected, the sweep time becomes as below.

(TIME/CM indication) x 1/5

Thus, a sweep speed faster by 5 times than the maximum sweep speed indicated by the TIME/CM switch is attainable with this function as below.

0.5 μsec/cm x 1/5 = 0.1 μsec/cm

When the sweep is magnified, the trace intensity is reduced. The use of the sweep magnification should recommendably be limited to the below cases:

(1) When a particular section which is located apart from the sweep start point is required to be magnified for observation of details.

(2) When a sweep time of faster than 0.5 μs/cm is required.

3.12 Application Method of Vertical Input Signal

3.12.1 With Covered Wires

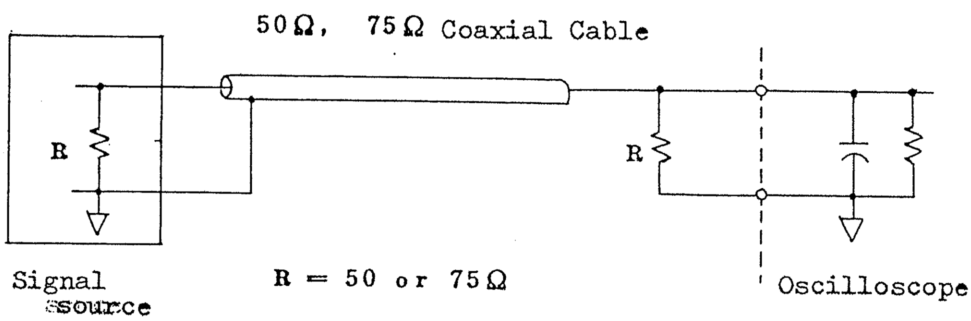
Attach the BNC terminal adaptor (supplied) to the vertical input terminal, connect the covered wires to the adaptor, and apply the input signal. Note, however, that measurement under this method may be unstable because the input wires are susceptible to induction noise interference when they are long or when the input signal source impedance is high and also because the stray capacitance with respect to the ground is large. As compared with the case the 10:1 probe is used, this method is susceptible to mutual interference with the measured circuit and other undesirable effects.

3.12.2 With Shielded Cable

By the use of a shielded cable, external noise introduced in the input connection can be eliminated. However, the use of a shielded cable is disadvantageous in that the capacitance between signal source and ground becomes large (50 pF ~ 100 pF/m) and, therefore, the use is not suitable for input connection when the signal source impedance is substantially high or when a signal which include higher frequency components is to be measured.

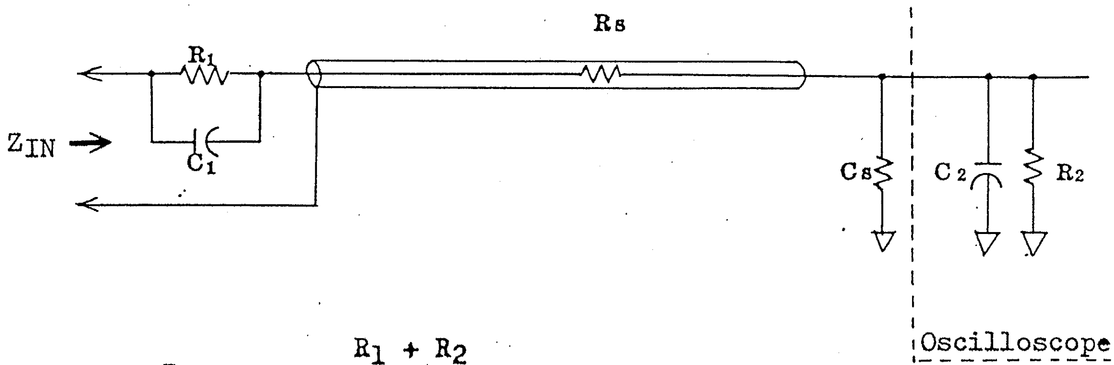
3.12.3 With Coaxial Cable

When the signal source impedance is 50 Ω or 75 Ω, a coaxial cable of the matched impedance may be used for input signal connection. When an impedance-matched coaxial cable is used, the input signal can be connected without attenuation for higher frequency components also. Impedance matching can be accomplished by connecting a pure resistance (R) of 50 Ω or 75 Ω corresponding to the characteristic impedance of the cable, in the input side of the oscilloscope as illustrated below.



3.12.4 Use of Probe

The input signal can be applied through the 10:1 probe which is supplied as an accessory of the oscilloscope. The probe provides electrical shielding from the oscilloscope to the probe, eliminating external noise.



$$Z_{IN} = \frac{R_1 + R_2}{W\ C\ (R_1 + R_2) + 1}$$

$$C = \frac{C_1 \times (C_2 + C_S)}{C_1 + C_2 + C_S}$$

RS: Series resistance of cable

C_S: (Stray capacitance) + (Cable capacitance)

Attenuation resistor (R_1) and its parallel capacitor (C_1) make up a wide-band attenuator which minimizes the loading effect on the measured signal source when the signal source impedance is high and which is suitable for measurement of signals which include higher frequency components. The attenuation ratio is 10:1 as expressed by the below equation. The purpose of the circuit is not to divide the voltage level to 1/10 but is to reduce the loading effect on the measured signal source.

Attenuation ratio: $$\frac{R_2}{R_1 + R_2} = \frac{1\ M\Omega}{9\ M\Omega + 1\ M\Omega} = \frac{1}{10}$$

3.12.5 Precautions in Using the Probe

(1) The specified maximum allowable input voltage must not be exceeded.

(2) The ground wires must be connected when the oscilloscope is used at a high sensitivity for a wide frequency range. They must be connected also when the oscilloscope is used in the dual channel mode.

(3) The phase of the probe must be accurately calibrated. The probe supplied as an accessory of the 5515 must be used.

(4) The probe must be protected against abnormally large mechanical shock, vibration, bent, and pull.

(5) The main body and tip of the probe is not highly heat resistant. Do not make soldering near the probe under the state that the lead wire is being connected to the probe.

3.13 Voltage Measurement

3.13.1 DC Voltage Measurement

(1) Set the triggering in the AUTO mode and the time axis in the free running mode, and display a trace by setting the TIME/CM switch at a position approximately 1 ms/cm.

(2) Set the AC/DC/GND selector of the vertical input in the GND state. The trace position under this state is corresponding to 0 V (zero volt) level. By turning the POSITION knob, move the trace to a position where is convenient for waveform observation.

(3) Set the AC/DC/GND selector in the DC state. Apply the measured voltage to the vertical input terminal, and determine the movement of the trace on the CRT screen.

(4) If the trace is deflected off the CRT screen when the measured voltage is applied to the input terminal, turn the VOLTS/CM switch counterclockwise to a position where an appropriate deflection on the CRT screen in response to application of the measured signal is obtained.

(5) If the trace is moved upward, the polarity of the measured signal is positive; if the trace is moved downward, the polarity of the measured signal is negative.

(6) The measurement may be made with the VARIABLE knob turned to the extremely clockwise position (CAL'D position) where the voltage sensitivity per 1 cm on graticule is calibrated and quantitative measurement of the measured signal voltage (V) can be easily made as below.

o When the measured signal is directly applied to the input terminal:

V = (VOLTS/CM indication) x (deflection amplitude in cm)

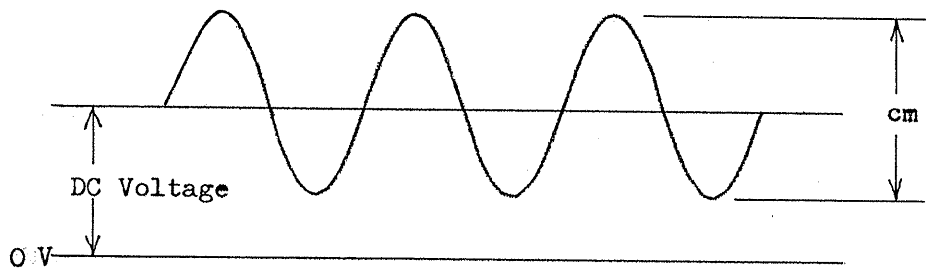
o When the 10:1 probe is used:

V = (VOLTS/CM indication) x (deflection amplitude in cm) x 10

3.13.2 AC Voltage Measurement

Regarding measurement of an AC component superimposed on a DC component, if measurement is made with the AC/DC/GND selector set in the DC state and if the DC component is sufficiently large as compared with the AC component, the trace will be deflected off the CRT screen and the AC component will disappear. It may be possible to move the trace of the AC component back onto the CRT screen by turning the VERTICAL POSITION control. Another method of bringing the waveform of the AC component onto the CRT screen is to turn the VOLTS/CM switch to a lower sensitivity position.

The most effective and generally practiced method, however, is to set the AC/DC/GND selector in the AC state so that the DC component is cut off and the AC component alone is displayed with an appropriate amplitude on the CRT screen.



In the AC measurement, the voltage (Vp-p) is calculated as below.

Vp-p = (VOLTS/CM indication) x (deflection amplitude in cm)

When the 10:1 probe is used, the voltage (Vp-p) is calculated as below.

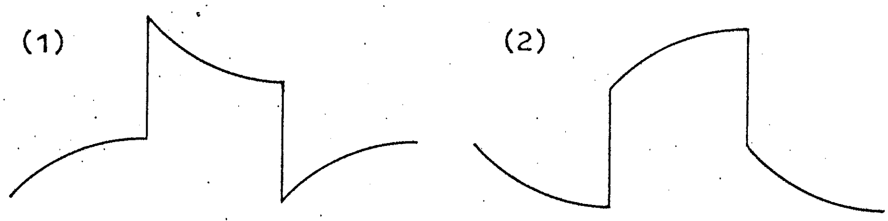
Vp-p = (VOLTS/CM indication) x (deflection amplitude in cm) x 10

The r.m.s. value can be calculated from the peak-to-peak value as below.

$$V\ r.m.s. = \frac{Vp\text{-}p}{2\sqrt{2}}$$

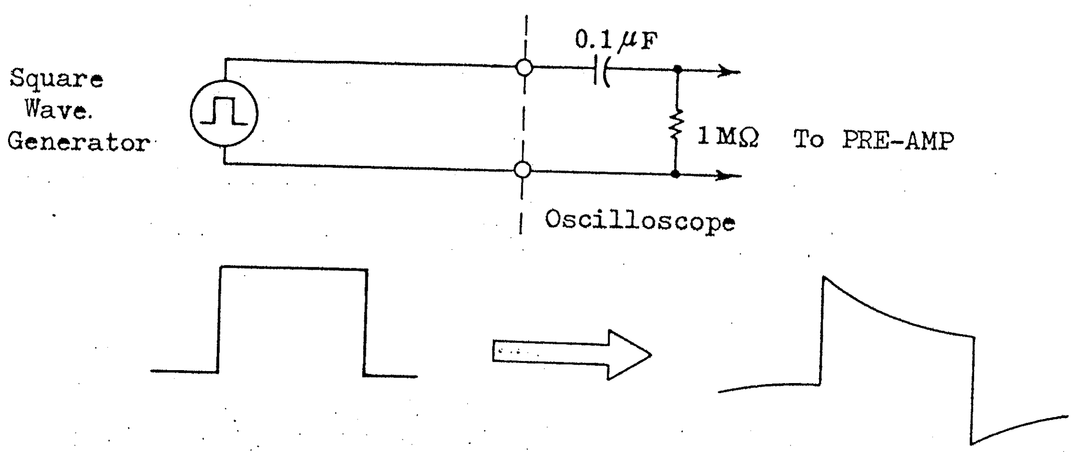
3.13.3 AC Coupling

As explained in the above, an AC voltage superimposed on a DC voltage is measured in the AC coupling mode. With the AC coupling, however, when the frequency of the measured signal is less than 1 kHz, attention must be paid to phase lead and lag and to amplitude reduction. Especially in the case of a square wave of repetition frequency of less than 1 kHz, the waveform may be distorted with sag as illustrated below.

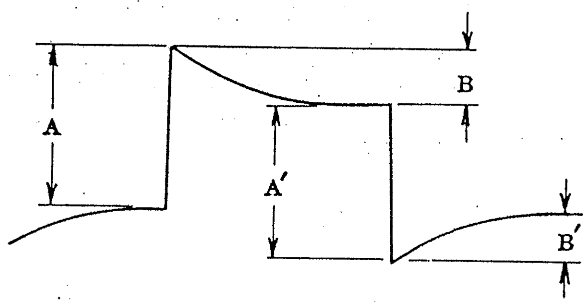


Waveform (1) indicates typical sag which is caused when the phase is leading and the amplitude is attenuated. Waveform (2) indicates typical sag which is caused when the phase is lagging and the amplitude is attenuated. From the viewpoint of waveform fidelity, the DC coupling is dieal because it causes no variations either in phase or amplitude.

The input impedance of the oscilloscope is 1 MΩ, with a coupling capacitor of 0.1 μF. When a low frequency square wave of a stepwise voltage is applied, sag similar to that indicated with waveform (1) is caused.



The percentage of sag is calculated as below.



A: Basic amplitude

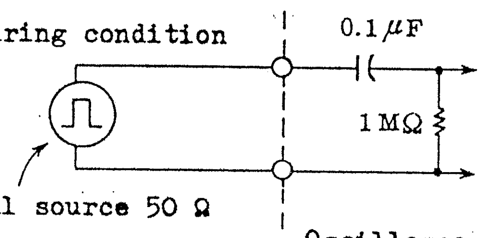
B: Sag

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

The degree of sag of the oscilloscope is tabulated below.

Repetition frequency	Sag (%)
10 Hz	26
50 Hz	4
100 Hz	2
500 Hz	0.6

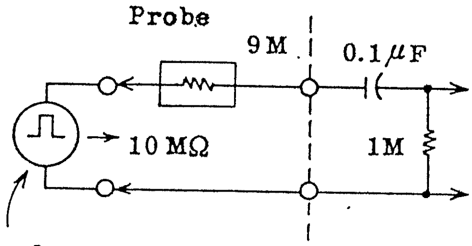
Measuring condition



The degree of sag when the 10:1 probe is used is as tabulated below.

Repetition frequency	Sag (%)
10 Hz	2.6
50 Hz	0.4
100 Hz	0.2
500 Hz	0.06

Measuring condition



As can be seen in the above tables, the degree of sag is reduced to approximately 1/10 when the 10:1 probe is used as compared with the case the input is directly applied to the oscilloscope of which input impedance is 1 MΩ. It must be noted, however, that the input signal voltage is reduced to 1/10 when the probe is used. The 10:1 probe can be effectively used when the DC coupling cannot be used and yet observation of waveform with minimum sag is required.

CH_2 1 mV AC

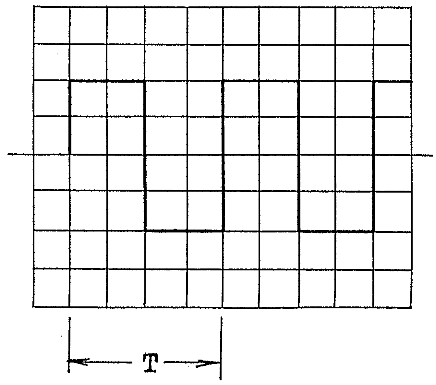
When this button is depressed, the sensitivity is increased to 1 mV/cm. The internal connection is made in the AC coupling mode. The degree of sag also depends upon whether the input connection is made in the DC coupling or AC coupling and whether the 10:1 probe is used or not. Typical degrees (percentage) of sag are listed below.

Repetition frequency	Sag (%)		
	DC	AC	10:1 probe
10 Hz	50	70	62.5
50 Hz	10	16.3	12.5
100 Hz	5	6.3	6.3
500 Hz	0.63	1.3	1.3

4. MEASUREMENTS

4.1 Time Interval Measurement

The time interval between two points on the displayed waveform can be measured by reading value of T referring to the TIME/CM indication with the VARIABLE knob of the TIME/CM switch turned to the CAL'D position.



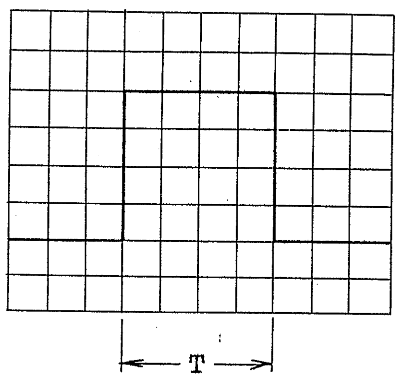
Time T (sec) = TIME/CM (sec) x Read distance (cm)

x Magnification factor ..... (A)

The factor of the magnifier is 1 when it is idle and is 1/5 = 0.2 when it is effected.

4.2 Pulse Width Measurement

Set the measured pulse signal in the center of the screen, with an easily readable horizontal amplitude of 2 ~ 4 cm.



Turn the VARIABLE knob of the TIME/CM switch to the CAL'D position. When the pulse width is narrow, effect the 5X MAG function as required. Determine the distance of T and calculate the time interval using equation (A).

4.3 Measurement of Pulse Rise Time and Fall Time

In a similar manner as pulse width measurement, determine the distance (T) and calculate the rise or fall time using equation (A). When the rise or fall time of the measured signal is sufficiently slow as compared with that of the oscilloscope itself (23.3 ns), the value can be directly read. When that of the measured signal is fast, the measured value must be corrected employing the below formula.

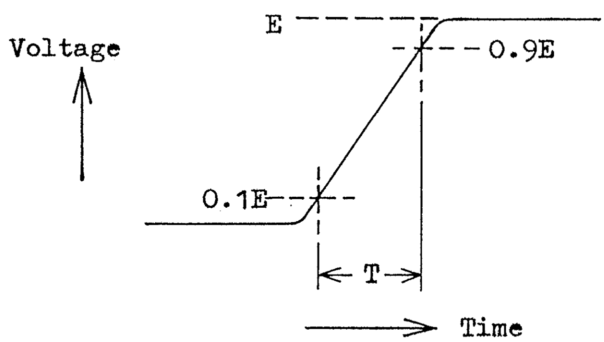
$$Tu = \sqrt{T^2 - To^2 - T_G^2}$$

Tu: True value

T: Measured value

To: Rise time of oscilloscope, 23.3 ns (calculated value)

T_G: Rise time of square wave generator



4.4 Frequency Measurement

There are three frequency measuring methods as below.

(1) The period per one cycle of waveform is calculated employing equation (A) upon determining the time interval T, and the frequency is calculated as the reciprocal of the period.

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

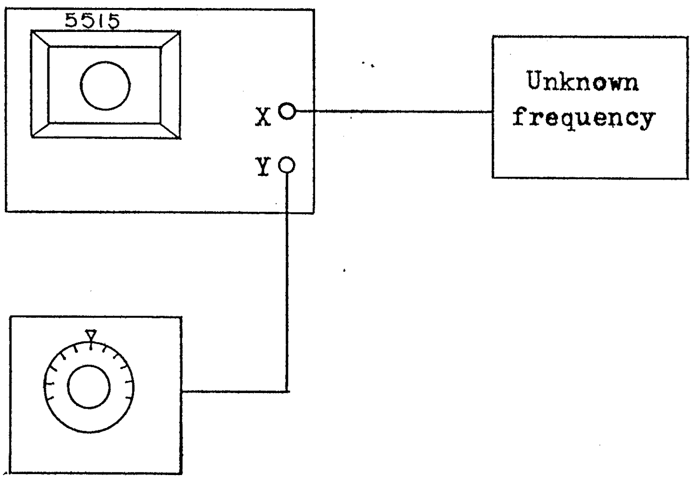
(2) The time interval per 10 ~ 20 cycles is determined, the number cycles per 10 cm of graticule is counted, and the frequency is calculated with the below formula.

$$\text{Frequency} \quad f\ (\text{Hz}) = \frac{N}{\text{TIME/CM indication (sec)} \times 10}$$

This method is advantageous over method (1) in that measuring errors are reduced as the number (N) of cycles is increased.

(3)

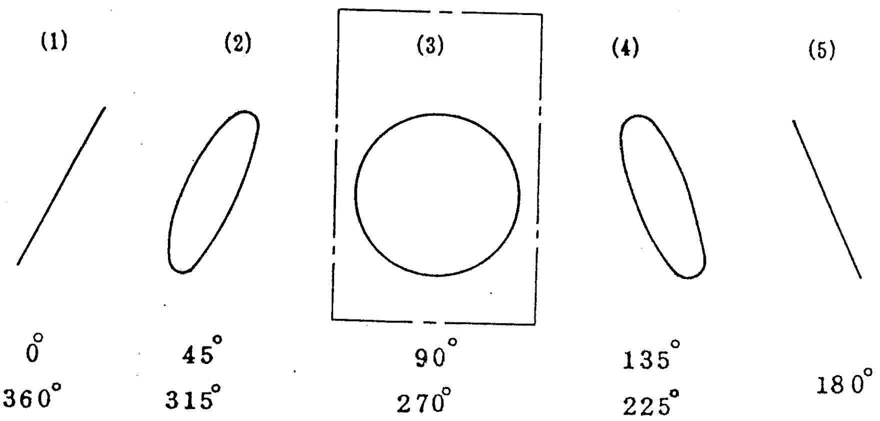
Measuring setup



Known frequency

In the above two methods, the frequency is measured through measuring the period. When the signal is less than 10 kHz and is of a sine or other simple waveform, frequency measurement can be efficiently made by displaying a Lissajou's figure operating the oscilloscope in the X-Y mode. For the operation method, refer to Par. 3.3 "X-Y Mode."

Adjust the sensitivities with the VOLTS/CM switch and VARIABLE control in accordance with the levels of the signals applied to the X-axis and Y-axis, so that the amplitudes are made almost equal for both axes. As signal of the known frequency source is varied, a Lissajou's figure representing 1:1 as illustrated below is displayed on the CRT screen.



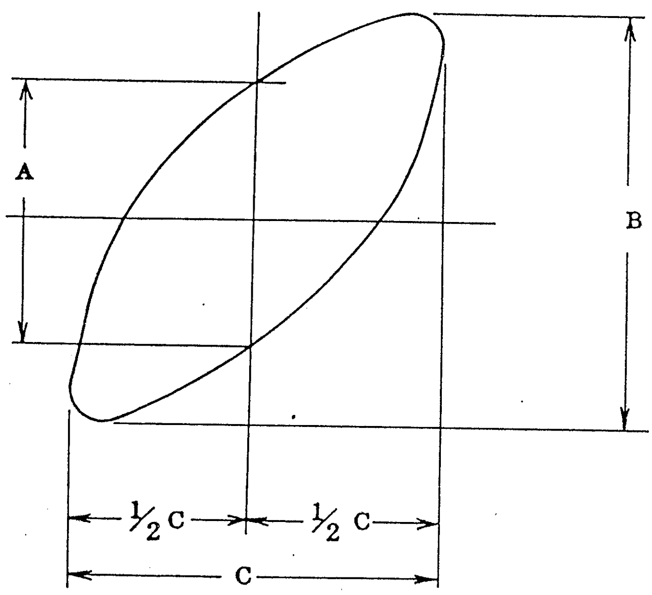
The Lissajou's figure which represents the frequency ratio of 1:1 is either a circle, an ellipse, or a line. When the frequency ratio approaches 1:1, the figure continuously rotates in the order of (1) (5) (1). As the frequency ratio approaches still closer to 1:1, the rotation becomes slower and, ultimately, when the two signal frequencies have become exactly equal, the Lissajou's figure becomes stationary. Now the unknown frequency is determined to be the same with the known frequency. This is the most simple but accurate method of frequency measurement, provided a continuously variable wide-range reliable signal generator is available.

4.5 Phase Difference Measurement

(1) Phase Difference Measurement with Lissajou's Figure

Operate the oscilloscope in the X-Y mode and display a Lissajou's figure are described in the paragraphs for frequency measurement. In this case, the both X-axis and Y-axis amplifiers should be operated at their maximum sensitivities. Adjust the output of the signal source so that the amplitude of the displayed waveform is made more than 50% in the center of the CRT screen. Determine the distances A and B on the graticule, and calculate the phase difference employing the below formula.

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



Disadvantages of phase difference measurement with Lissajou's figure are as follows:

(1) With a conventional oscilloscope, the frequency response of X-axis is not sufficiently wide and substantial phase shift is caused within the oscilloscope.

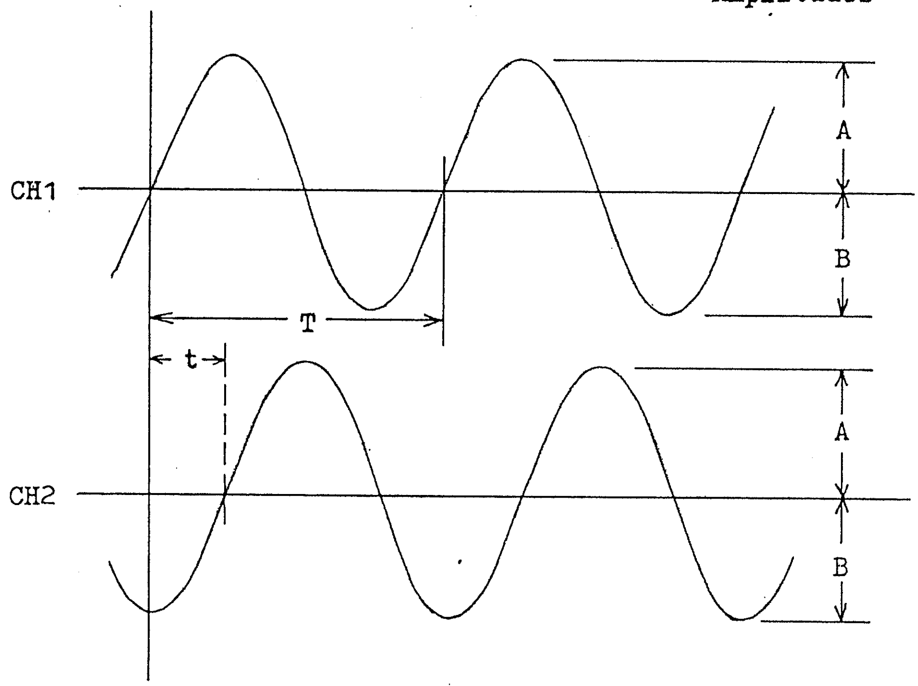
(2) The measuring accuracy of phase difference is not very high.

For the above reasons, the below-described dual channel method is recommended for accurate measurement of phase difference (θ).

(2) Phase Difference Measurement in Dual Channel Method

Set the MODE selector of the vertical axis in the DUAL state, and depress the CH_1 button of the TRIGGER selector. Apply signals to CH_1 and CH_2 channels (the reference signal to CH_1), and display waveforms as illustrated below.

Amplitudes A = B



Phase difference $\theta = \frac{t}{T} \times 360^\circ$

Measure the phase difference with large amplitudes of displayed waveforms, by increasing the voltages of the signals applied to CH_1 and CH_2 or by increasing the sensitivities of both channels.

As for the center lines of waveforms, set both CH_1 and CH_2 in amplitudes A = B.

When probes are to be used for measurement, use them for both channels and accurately adjust their phase characteristics employing the CALIB signal.

The dual-channel phase measuring method is advantageous in that even very small phase difference (t) can be measured and the leading or lagging state can be known at a glance.

5. CALIBRATION

5.1 General

The oscilloscope should be calibrated periodically. The calibration should recommendably cover all items. However, calibration on special items may be made instead, for examples, the time axis may be calibrated especially carefully if the use of the oscilloscope is primarily for time measurement or the vertical sensitivity may be calibrated with extra attention is the routine measurements require accurate vertical sensitivity.

The overall performance items must be calibrated after the oscilloscope has been subjected to repair which affects the essential performance of the oscilloscope or after the low-voltage regulated power supply or high-voltage power supply has been adjusted or repaired.

For reliable calibration, please contact Kikusui's agent in your area.

Calibration points and methods which can be made comparatively easily are explained below.

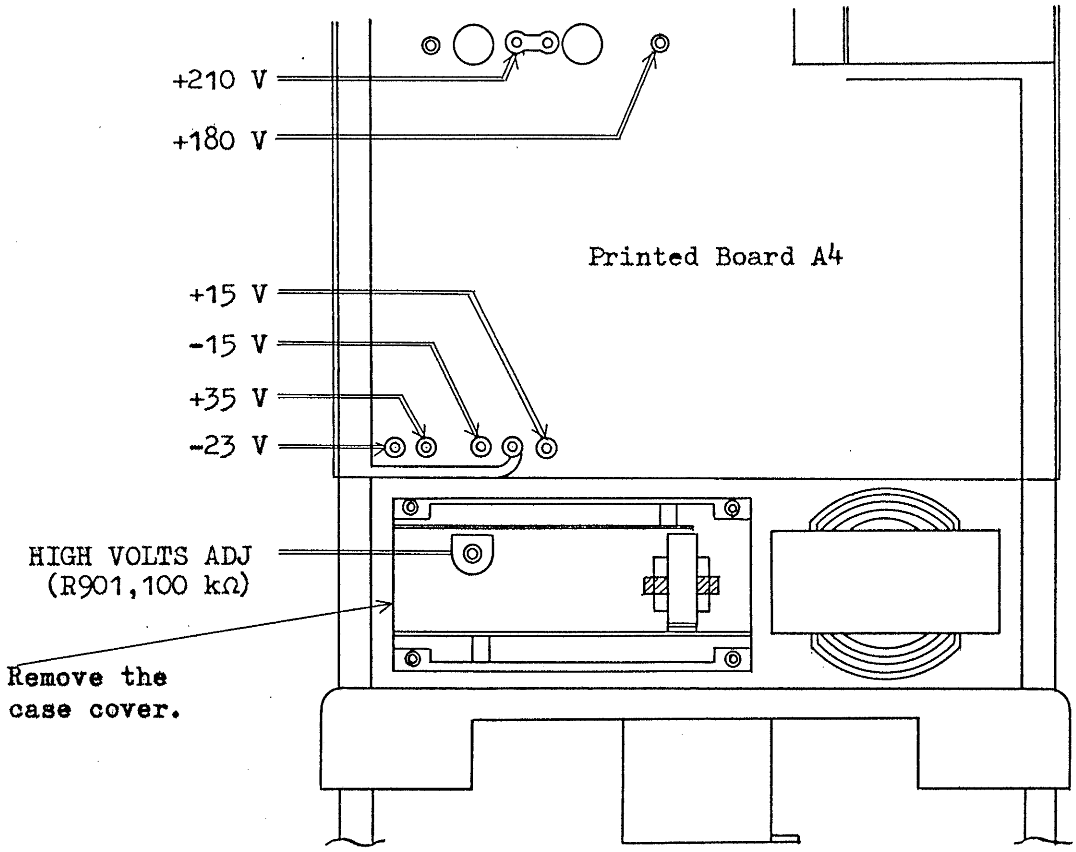
5.2 Low Voltage Supply

Before calibrating the oscilloscope, the low voltage supply must be inspected and adjusted. An accurately calibrated digital voltmeter is required for the inspection and adjustment. The voltages and semi-fixed resistors for adjustments are listed in the below table and the locations of these components are shown in the below drawings.

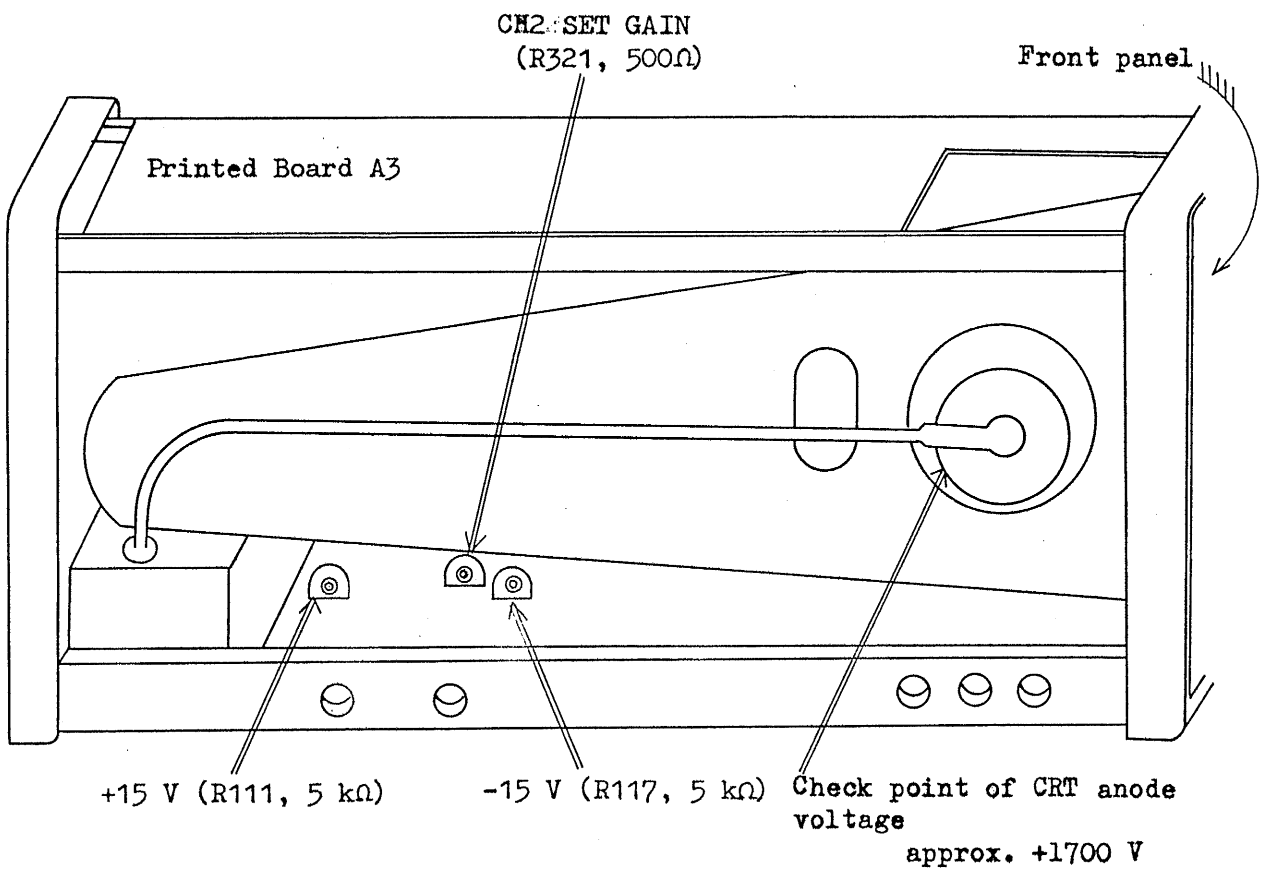
Each voltage must be measured between the check point and the ground. The input power voltage in this case must be maintained within ±5% of the primary supply.

Low voltage supply	Type	Tolerance	Resistor	Remarks
-15 V	Regulated	-14.9 ~ -15.1 V	R117, 5 kΩ	⊘
+15 V	Regulated	+14.9 ~ +15.1 V	R111, 5 kΩ	⊘
+35 V	Non-regulated	±20%	-	-
-23 V	Non-regulated	±20%	-	-
+180 V	Non-regulated	±20%	-	-
+210 V	Non-regulated	±20%	-	-

⊘ mark denotes a semi-fixed resistor.



+210 V
+180 V
Printed Board A4
+15 V
-15 V
+35 V
-23 V
HIGH VOLTS ADJ
(R901,100 kΩ)
Remove the
case cover.



CH2 SET GAIN
(R321, 500Ω)
Front panel
Printed Board A3
+15 V (R111, 5 kΩ)
-15 V (R117, 5 kΩ)
Check point of CRT anode
voltage
approx. +1700 V

5.3 High Voltage Supply

The high voltage supply is for the CRT circuit. These voltage must be carefully checked because they largely affect the trace intensity, and the vertical and horizontal deflection sensitivities. The voltages are shown in the below table and the locations of the check point and adjusting components are shown in the drawing.

High voltage supply	Specification	Remarks
Supply voltage for CRT cathode	-1500 V ±1%	Regulated
Supply voltage for CRT anode	Approx. +1700 V	Non-regulated

The voltages are accurately factory-adjusted employing electrostatic voltmeters before shipment. In measuring these high voltages, attention must be paid to the fact that the internal resistance of the voltmeter affects the measuring accuracy. Especially for measurement of the voltage of the anode voltage supply circuit of which internal impedance is very high, a special voltmeter such as electrostatic voltmeter which does not impose substantial loading effect on the power supply circuit is required. The -1500V ±1% supply voltage is adjustable by means of the HIGH VOLTS ADJ (R901, 100 kΩ) semi-fixed resistor. The check point is between CRT pin # 1 and ground.

5.4 Vertical Deflection Sensitivity

Prepare a square wave generator which has an output voltage accuracy of better than 0.5%. Apply the output signal of the generator, at 1 kHz, 20 mVp-p, to the vertical input terminal. With the VOLTS/CM switch set in the 5 mV position, adjust the displayed square wave amplitude accurately at 4 cm on the graticule, by means of the SET GAIN (R369 500 Ω or R321 500 Ω). At each range of VOLTS/CM, apply an input voltage corresponding to twice of the value indicated by the VOLTS/CM switch, and measure the amplitude of the displayed square wave. At any range, the measured value must be within ±3% of the value indicated by the VOLTS/CM switch.

SET GAIN R369 500 Ω ⟶ CH_1

SET GAIN R321 500 Ω ⟶ CH_2

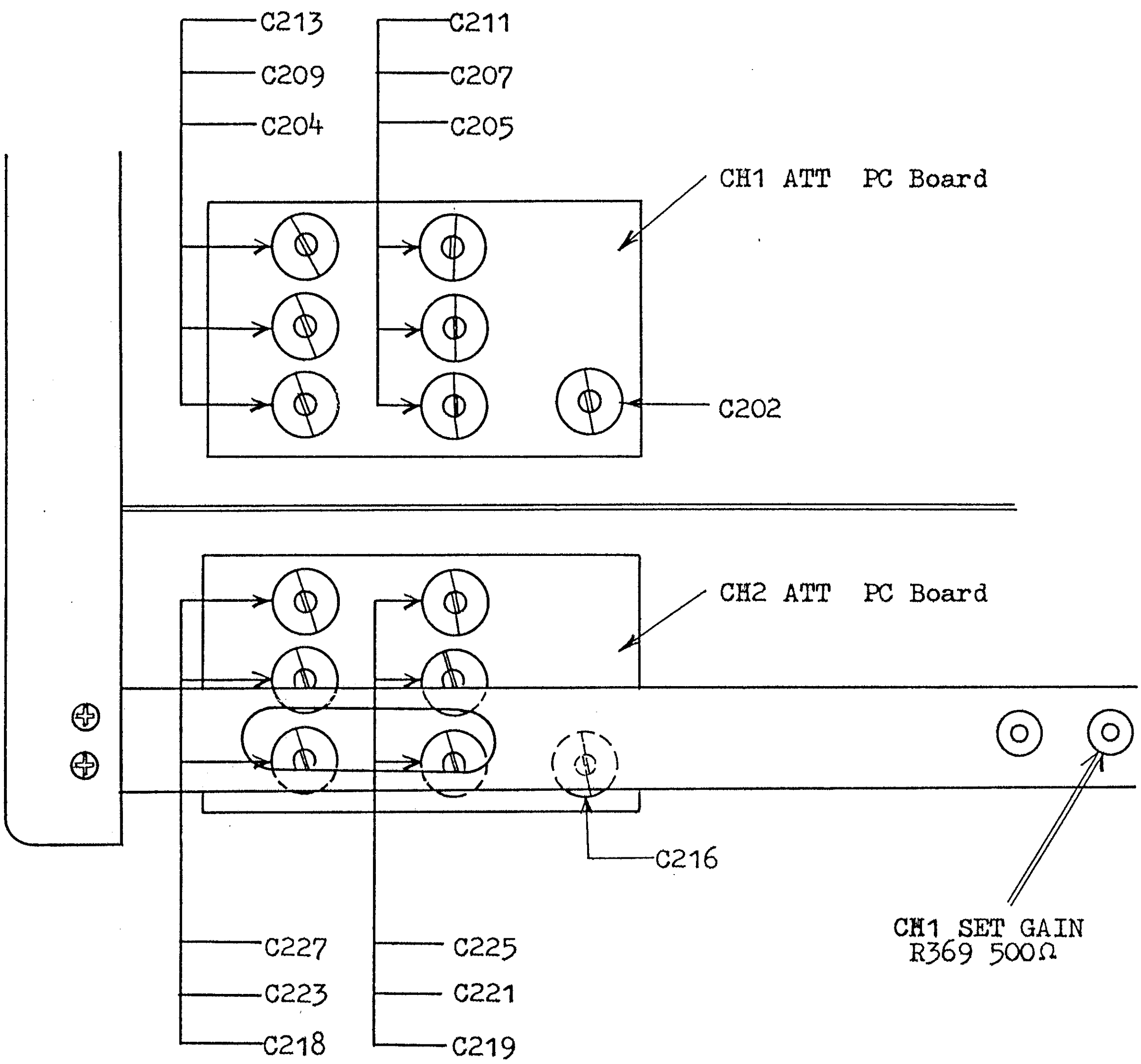
5.5 VOLTS/CM Input Capacitance and Phase Characteristics Compensation

Unless the phase characteristics of each range of the VOLTS/CM switch is correctly adjusted, the waveform displayed on the CRT screen may be distorted and the frequency response may become abnormal. Adjustment of the phase characteristics is made by adjusting the input capacitor and the compensation capacitor. For this adjustment, a capacitance meter which is capable of measurement of the input capacitance (38 pF) and a highly reliable square wave generator which is capable of providing a quality square wave of a repetition frequency of approximately 1 kHz are required.

As for the capacitance meter, conventional bridge-type meter is inadequate. A low-capacitance C meter should be used. As for the 1 kHz square wave generator, the internal generator of the oscilloscope which provides the CALIB signal for the probes can be used. If an external square wave generator is to be used, the generator must be capable of delivering a signal of quality waveform with minimum overshoot and sag and with rise time of less than 1 μs. The adjusting points are tabulated below.

	VOLTS/CM switch range	Variable capacitor for calibration	
		Input capacitor	High frequency compensation
	5 mV	C202	-
	10 mV	C202	-
	20 mV	C202	-
	50 mV	C204	C205
	0.1 V	C204	C205
CH_1	0.2 V	C204	C205
	0.5 V	C209	C207
	1 V	C209	C207
	2 V	C209	C207
	5 V	C213	C211
	10 V	C213	C211

	VOLTS/CM switch range	Variable capacitor for calibration	
		Input capacitor	High frequency compensation
	5 mV	C216	-
	10 mV	C216	-
	20 mV	C216	-
	50 mV	C218	C219
CH_2	0.1 V	C218	C219
	0.2 V	C218	C219
	0.5 V	C223	C221
	1 V	C223	C221
	2 V	C223	C221
	5 V	C227	C225
	10 V	C227	C225



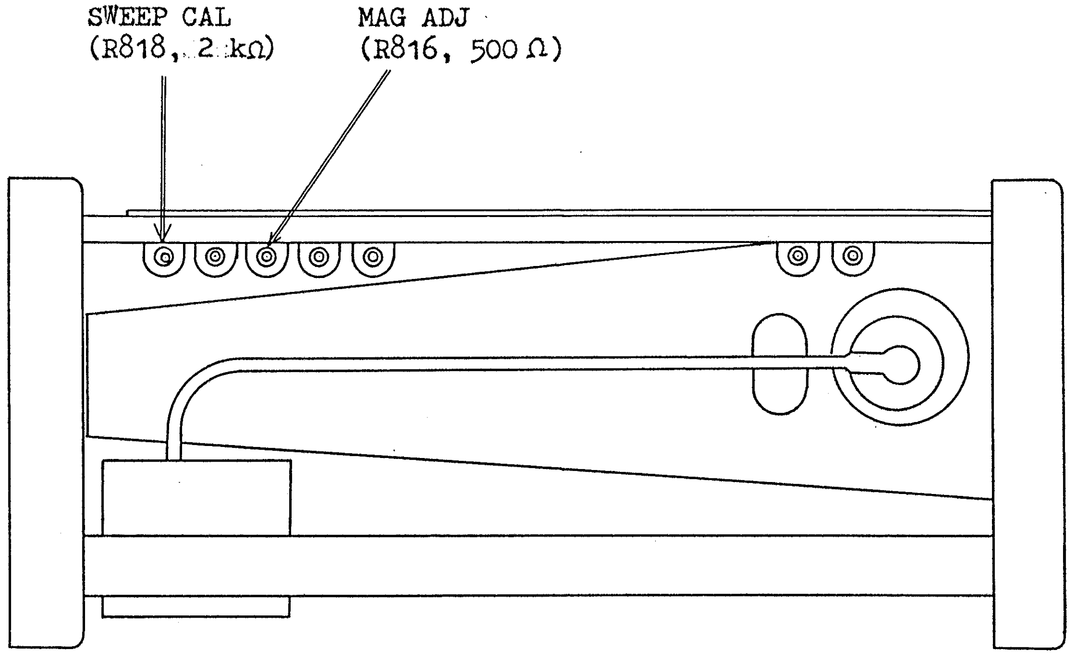
5.6 Sweep Time

Set the knobs on the panel as below. Apply to the vertical input an accurate 1-ms-interval time marker signal or an accurate 1 kHz signal.

TRIGGER: AUTO

TIME/CM: 1 ms

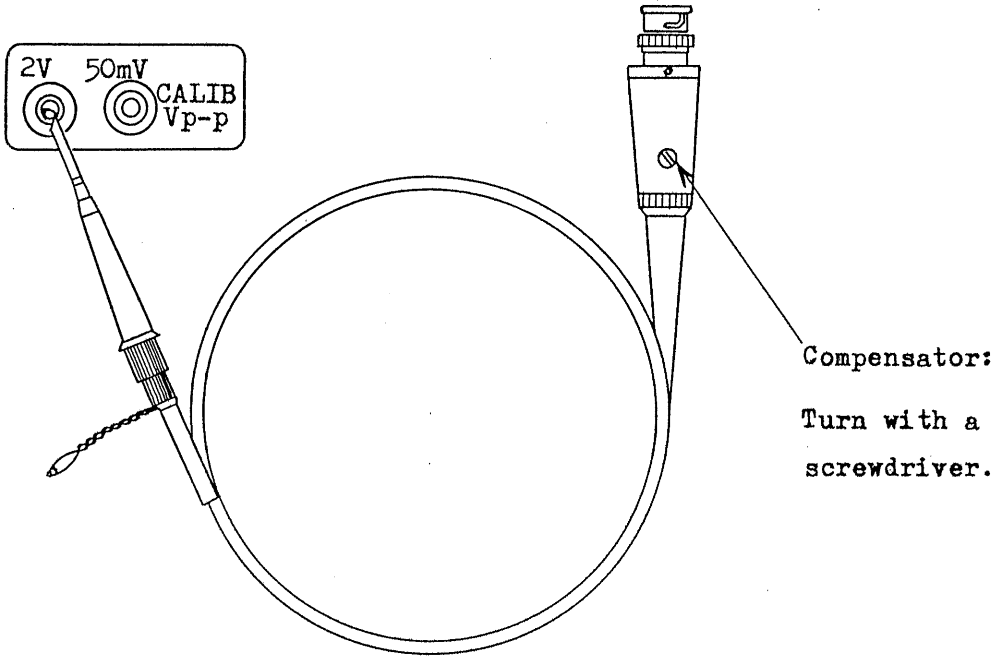
The specified accuracy of sweep time is within ±3% of the value indicated by the TIME/CM switch. The 1 ms range is the reference range for all other ranges and, therefore, this range must be calibrated especially accurately. Adjust the SWEEP CAL (R818, 2 kΩ) semi-fixed resistor so that the calibration is made to an accuracy of ±1%. In this case, calibrate also to an accuracy of ±1% the 5X MAG mode of operation by means of the MAG ADJ (R816, 500 Ω) semi-fixed resistor.

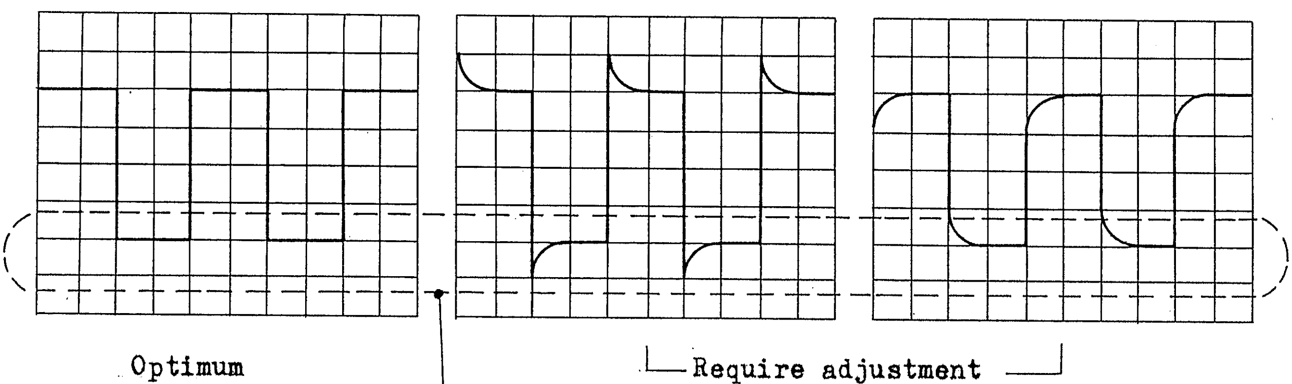


5.7 Calibration of Probe

To calibrate the probe, use the calibration signal of 1 kHz, 50 mVp-p or 2 Vp-p available on the calibration voltage terminal on the front panel of the oscilloscope.

Connect the probe to the CH_1 or CH_2 input terminal. Set the range at 50 mV. When the probe tip is contacted to the calibration voltage terminal where 2 Vp-p voltage is being delivered, a square wave with an amplitude of approximately 4 cm should be displayed on the CRT screen. Turn the compensator with a screwdriver so an optimum waveform as illustrated below is obtained.





Make adjustment with the bottom side (zero volt side) of the waveform as reference.

Block Diagram of Model 5515 Oscilloscope