Instruction Manual
for
B+K PRECISION

Model 1540 Dual-Trace
and
Model 1560 Triple-Trace
DUAL TIME BASE
OSCILLOSCOPES

⚠ This symbol on oscilloscope means "refer to instruction manual for further precautionary information". This symbol appears in the manual where the corresponding information is given.

B+K PRECISION DYNASCAN CORPORATION

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FEATURES

HIGH FREQUENCY FEATURES

Wide Bandwidth
Conservatively rated −3 dB bandwidth is dc to 60 MHz for Model 1560; dc to 40 MHz for Model 1540.

Fast Rise Time
Rise time is less than 5.8 ns for Model 1560; 8.8 ns for Model 1540.

Fast Sweep
Maximum sweep speed (with ×10 MAG) of 5 ns/div for Model 1560; 10 ns/div for Model 1540 assures high frequencies and short duration pulses are displayed with high resolution.

Signal Delay Line
Signal is delayed with respect to triggering to give at least 20 ns visible delay. Permits viewing leading edge of high frequency and fast risetime pulses.

DUAL TIME BASE FEATURES

Dual Sweep Generators
A sweep gives normal weveform display, B sweep may be operated at faster sweep speed to expand a portion of the waveform.

5 Modes of Horizontal Display
Choice of A sweep only, B sweep only, A sweep with B sweep portion intensified, alternating A and B sweep (trace separation adjustable), and X-Y.

B Sweep Delay
Start of B sweep selectable from zero delay, triggerable after delay, and continuous delay (starts immediately after delay) modes. Delay adjustable from 0.2 to 10 times A sweep time. Permits expansion of any portion of waveform.

DUAL/TRIPLE TRACE FEATURES

Triple Trace
Model 1560 has three vertical input channels for displaying three waveforms simultaneously. Selectable single trace (either CH 1 or CH 2), dual trace, or triple trace operation. Alternate or chop sweep selectable at all sweep rates.

Dual Trace
Model 1540 has two vertical input channels for displaying two waveforms simultaneously. Selectable single trace (either CH 1 or CH 2) or dual-trace operation. Alternate or chop sweep selectable at all sweep rates.

Sum and Difference Capability
Permits algebraic addition or subtraction of channel 1 and channel 2 waveforms, displayed as a single trace. Useful for differential voltage and distortion measurements.

CRT FEATURES

Rectangular CRT
Rectangular CRT with large 8 × 10 centimeter viewing area. Internal 8 × 10 division graticule eliminates parallax error.

High Brightness
Domed mesh type CRT with post deflection acceleration and high brightness phosphors. High acceleration voltage; 16 kV for Model 1560, 12 kV for Model 1540.

Conveniance
Variable scale illumination for easy viewing in darkened area and for waveform photographs. Trace rotation electrically adjustable from front panel. 0%, 10%, 90%, and 100% markers for rise time measurements.

VERTICAL FEATURES

High Sensitivity
5 mV/div sensitivity for full bandwidth. Selectable 1 mV/div and 2 mV/div sensitivity at reduced bandwidth.

Calibrated Voltage Measurements
Accurate voltage measurements (±3%) on 12 calibrated ranges from 1 mV/div to 5 V/div. Vertical gain fully adjustable between calibrated ranges.

SWEEP FEATURES

Calibrated Time Measurements
Accurate (±3%) time measurements. Model 1560 has 22 calibrated ranges from 0.5 s/div to 0.05 μs/div; Model 1540 has 21 calibrated ranges from 0.5 s/div to 0.1 μs/div. Sweep time fully adjustable between calibrated ranges.

×10 Sweep Magnification
Allows closer examination of waveforms, increases maximum sweep rate to 5 ns/div (Model 1560) or 10 ns/div (Model 1540).

TRIGGERING FEATURES

4 Trigger Modes
Selectable normal (triggered), automatic, FIX, or single sweep modes.

Triggered Sweep
Sweep remains at rest unless adequate trigger signel is applied. Fully adjustable trigger level and (+) or (−) slope.

AUTO Sweep
Selectable AUTO sweep provides sweep without trigger input, automatically reverts to triggered sweep operation when adequate trigger is applied.

FIX Sweep
Same as AUTO sweep except trigger level is automatically fixed at center of waveform. LEVEL control has no effect.

Single Sweep
Permits viewing and photographing onetime events.

5 Trigger Sources
Five trigger source selections, including V.MODE, CH 1, CH 2, CH 3/EXTernal, and LINE (50/60 Hz). In V.MODE, each waveform displayed becomes its own trigger (alternete triggering in ALT dual-trace or triple-trace mode).

5 Trigger Coupling Choices
Selectable AC, DC, high-frequency reject, video frame, or video line trigger coupling.

Video Sync
Selectable FRAME or LINE triggering for observing composite video waveforms.

Variable Holdoff
Trigger inhibit period after end of sweep adjustable. Permits stable observation of complex pulse trains.

OTHER FEATURES

X-Y Operation
Channel 2 can be applied as horizontal deflection (X-axis) while channel 1 provides vertical deflaction (Y-axis).

Z Axis Input
Intensity modulation capability permits time or frequency markers to be added. Trace brightens with 2 V or more positive signal, TTL compatible.

Built-In Probe Adjust Square Wave
A 0.5 V p-p, 1 kHz square wave generator permits probe compensation adjustment.

Channel 1 Output
Buffered 50 Ω output of channel 1 signal available on rear panel for driving frequency counter or other instruments. Output is 50 mV/div into 50 Ω and at full bandwidth rating.

Sweep Gate and Sweep Output
TTL rectangular wave coincident with sweep and 1 V p-p sweep ramp wave outputs for external use.

Auto Focus
Auto focus circuit keeps waveform in focus with changes in intensity (for example, the intensified portion of trace).

SPECIFICATIONS

	MODEL 1560	MODEL 1540
CRT	150HTM31 Rectangular, with internal graticule	150JTM31 Rectangular, with internal graticule
Acceleration Voltage	16 kV	12 kV
Display Area	8×10 div (1 div=10 mm)	
VERTICAL AXIS	CH1 and CH2	
Sensitivity	1 mV/div to 5 V/div, ±3%	
Attenuator	12 steps, 1 mV/div to 5 V/div in 1-2-5 sequence. Vernier control for fully adjustable sensitivity between steps.	
Input Impedance	1 MΩ ±2%, approx 20 pF	
Frequency Response		
5mV/div to 5V/div	DC; DC to 60 MHz, −3 dB AC; 5 Hz to 60 MHz, −3 dB	DC; DC to 40 MHz, −3 dB AC; 5 Hz, to 40 MHz, −3 dB
1 mV/div, 2 mV/div	DC; DC to 20 MHz, −3 dB AC; 5 Hz to 20 MHz, −3 dB	DC; DC to 15 MHz, −3 dB AC; 5 Hz to 15 MHz, −3 dB
Rise Time	5.8 nsec or less (60 MHz) 17.5 nsec or less (20 MHz)	8.8 nsec or less (40 MHz) 23.4 nsec or less (15 MHz)
Signal Delay Time	Approx.20 nsec on the CRT screen	
Cross talk	−40 dB minimum	
Operating Modes	CH1; single trace CH2; single trace ADD; CH1+CH2 added as a single trace DUAL; CH1 and CH2, dual trace TRIPLE; CH1, CH2 and CH3 triple trace ALT; dual trace or triple trace, alternating CHOP; dual or triple trace, chopped	CH1; single trace CH2; single trace ADD; CH1+CH2 added as a single trace DUAL; CH1 and CH2, dual trace ALT; dual trace alternating CHOP; dual trace, chopped
Chop Frequency	Approx. 250 kHz	
Channel Polarity	Normal or inverted, channel 2 only inverted	
⚠ Maximum Input voltage	500 Vp-p or 250 V (dc+ac peak)	
Non-Distorted Maximum Amplitude	More than 8 div (DC to 60 MHz)	More than 8 div (DC to 40 MHz)
VERTICAL AXIS	CH3	
Sensitivity	0.1 V/div and 1 V/div ±3%	
Input Resistance	1 MΩ ±2%	
Input Capacitance	Approx 27pF	
Frequency Response	DC: DC to 60 MHz, −3 dB AC: 5 Hz to 60 MHz, −3 dB	
Rise Time	5.8 nsec or less	
Signal Delay Time	Same as CH1 and CH2	
⚠ Maximum Input Voltage	50 V (dc+ac peak)	
HORIZONTAL AXIS	Input thru CH2, ×10 MAG not included	
Operating Modes	With HORIZ DISPLAY switch, X-Y operation is selectable CH1; Y axis CH2; X axis	
Sensitivity	Same as vertical axis (CH2)	

<table>
<tr><th colspan="2"></th><th colspan="3">MODEL 1560</th><th colspan="3">MODEL 1540</th></tr>
<tr><td colspan="2">Input Impedance</td><td colspan="6">Same as vertical axis (CH2)</td></tr>
<tr><td colspan="2">Frequency Response</td><td colspan="6">DC; DC to 1 MHz, −3 dB
AC; 5 Hz to 1 MHz, −3 dB</td></tr>
<tr><td colspan="2">X-Y Phase Difference</td><td colspan="6">3° or less at 100 kHz</td></tr>
<tr><td colspan="2">⚠ Maximum Input Voltage</td><td colspan="6">Same as vertical axis (CH2)</td></tr>
<tr><td colspan="2">SWEEP</td><td colspan="6"></td></tr>
<tr><td colspan="2">Type</td><td colspan="6">A; A sweep
ALT; A sweep (intensified for duration of B sweep and B sweep (delayed sweep) alternating
INT; Duration of B sweep is displayed as an intensified portion of A sweep.
B; Delayed sweep
X-Y; X-Y oscilloscope</td></tr>
<tr><td>Sweep Time</td><td>A;</td><td colspan="3">0.05 μs/div to 0.5 s/div, ±3% in 22 ranges, in 1-2-5 sequence.
Vernier control provides fully adjustable sweep time between steps.</td><td colspan="3">0.1 μs/div to 0.5 s/div, ±3% in 21 ranges, in 1-2-5 sequence.
Vernier control provides fully adjustable sweep time between steps.</td></tr>
<tr><td></td><td>B;</td><td colspan="3">0.05 μs/div to 50 ms/div in 19 ranges, in 1-2-5 sequence.</td><td colspan="3">0.1 μs/div to 50 ms/div in 18 ranges, in 1-2-5 sequence.</td></tr>
<tr><td colspan="2">Sweep Magnification</td><td colspan="6">×10 (ten times) ±5%</td></tr>
<tr><td colspan="2">Linearity</td><td colspan="6">±3% all ranges,
±5% on 0.05 μs/div to 0.1 μs/div range at ×10 MAG.</td></tr>
<tr><td colspan="2">Holdoff</td><td colspan="6">Continuously variable from NORM to more than ten times (MAX)</td></tr>
<tr><td colspan="2">Trace Separation</td><td colspan="6">B sweep can be separated from A sweep up to 4 divisions, continuously adjustable.</td></tr>
<tr><td colspan="2">Delay Method</td><td colspan="6">Continuous delay (STARTS AFTER DELAY), Trigger delay (TRIG), Zero delay (DELAY TIME=ZERO)</td></tr>
<tr><td colspan="2">Delay Time</td><td colspan="6">From 500 nsec to 0.5 sec. Available delay time is 0.2 to 10 times the A sweep time setting, continuously adjustable.</td></tr>
<tr><td colspan="2">Delay Jitter</td><td colspan="6">1/20000 of ten times of A sweep time setting</td></tr>
<tr><td colspan="2">TRIGGERING</td><td colspan="6"></td></tr>
<tr><td colspan="2">Trigger mode</td><td colspan="6">AUTO, NORM, FIX, SINGLE</td></tr>
<tr><td>Trigger source</td><td>V.MODE
CH1
CH2
CH3/EXT
LINE</td><td colspan="3">Trigger selected by vertical MODE switch.
Triggered by CH1 signal
Triggered by CH2 signal
Triggered by CH3 signal
Triggered by line voltage</td><td colspan="3">Trigger selected by vertical MODE switch.
Triggered by CH1 signal
Triggered by CH2 signal
Triggered by EXT TRIG signal
Triggered by line voltage</td></tr>
<tr><td colspan="2">Coupling</td><td colspan="6">AC, HFrej, DC, VIDEO FRAME, VIDEO LINE</td></tr>
<tr><td colspan="2">Trigger sensitivity</td><td>FREQ.RANGE</td><td>INT</td><td>EXT</td><td>FREQ.RANGE</td><td>INT</td><td>EXT</td></tr>
<tr><td></td><td>DC</td><td>DC −60 MHz</td><td>1 div</td><td>0.1 Vp-p</td><td>DC −40 MHz</td><td>1 div</td><td>0.1VP-P</td></tr>
<tr><td></td><td>AC</td><td colspan="6">Same as for DC but increased minimum level below 10 Hz</td></tr>
<tr><td></td><td>AC, HF rej</td><td colspan="6">Increased minimum level below 10 Hz and above 20 kHz</td></tr>
<tr><td></td><td>VIDEO</td><td>FRAME, LINE</td><td>1 div</td><td>0.1 Vp-p</td><td>FRAME, LINE</td><td>1 div</td><td>0.1 Vp-p</td></tr>
<tr><td colspan="2"></td><td colspan="6">AUTO: Same as above specifications for above 50 Hz.
FIX: Same as above specifications for above 50 Hz.</td></tr>
<tr><td colspan="2">⚠ Maximum External Trigger Voltage</td><td colspan="3">Same as CH3</td><td colspan="3">50 V (dc+ac peak)</td></tr>
</table>

	MODEL 1560	MODEL 1540
CALIBRATING VOLTAGE	0.5 V, ±6%, square wave, positive polarity, approx 1 kHz	
INTENSITY MODULATION		
Sensitivity	TTL compatible positive voltage increases brightness, negative voltage decreases brightness.	
Input Impedance	Approx. 10 kΩ	
Usable Frequency Range	DC to 5 MHz	DC to 3.5 MHz
⚠ Maximum Input Voltage	50 V (dc + ac peak)	
VERTICAL AXIS SIGNAL OUTPUT	CH1 OUTPUT	
Output Voltage	Approx. 50 mV/div into 50 Ω	
Output Impedance	Approx. 50 Ω	
Frequency Response		
5 mV/div to 5 V/div	100 Hz to 60 MHz, −3 dB into 50 Ω	100 Hz to 40 MHz, −3 dB into 50 Ω
1 mV/div, 2 mV/div	100 Hz to 20 MHz, −3 dB into 50 Ω	100 Hz to 15 MHz, −3 dB into 50 Ω
GATE OUTPUT		
Output Voltage	TTL compatible	
Output Impedance	Approx. 220 Ω	
SWEEP OUTPUT		
Output Voltage	1 Vp-p	
Output Impedance	Approx. 1 kΩ	
POWER REQUIREMENT		
Power Supply	100 V/120 V/220 V/240 V ±10%	
Line Frequency	50/60 Hz	
Power Consumption	Approx. 65 W	
DIMENSIONS (W × H × D)	304(346) × 160(173) × 401(461) mm ( ) dimensions include protrusion from basic outline dimensions	
WEIGHT	Approx. 11 kg	
ENVIRONMENTAL		
Within Specifications	10°C to 35°C, 85% max. relative humidity	
Full Operation	0°C to 50°C, 90% max. relative humidity	

PRECAUTIONS

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to prevent electric shock.

1. When the oscilloscope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.

2. Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 16,000 volts (Model 1560) or 12,000 volts (Model 1540) is present when the unit is operating with the case removed.

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

4. Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:

   a. Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.

   b. Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. The power transformer of this instrument may be wired to operate from nominal line voltage of 100, 120, 220, or 240 VAC, 50/60 Hz. Be sure the line voltage selection is correct before applying power. Also, make sure the correct fuse value is used, corresponding to line voltage as follows:

   100 VAC operation - 2 A.
   120 VAC operation - 2 A.
   220 VAC operation - 1 A.
   240 VAC operation - 1 A.

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

3. Do not rest objects on top of the oscilloscope or otherwise obstruct the ventilating holes in the case, as this will increase the internal temperature.

4. Excessive voltage applied to the input jacks may damage the oscilloscope. The maximum ratings of the inputs are as follows:

   CH 1 and CH 2:
   500 V p-p; 250 V (dc + ac peak.)
   CH 3/EXT TRIG and Z AXIS INPUT:
   50 V (dc + ac peak.)

   Never apply external voltage to oscilloscope output jacks.

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

6. The probe ground clips are at oscilloscope ground and should be connected only to the common of the equipment under test. To measure with respect to any point other than the common, use CH 1 - CH 2 subtract

operation (ADD mode and CH 2 INV), with the channel 1 probe to the point of measurement and the channel 2 probe to the point of reference. Use this method even if the reference point is a dc voltage with no signal.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips as undesired signals may be induced.

2. Avoid the following operating conditions:
   a. Direct sunlight.
   b. High temperature and humidity.
   c. Mechanical vibration.
   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, astigmatism, and calibration accuracy of the oscilloscope using the procedures found in this manual.

4. When using 10:1/direct probes, Use 10:1 attenuation whenever possible for minimum circuit loading and improved high frequency response. For example, the frequency response of the PR-40 Probe (which is typical of most 10:1/direct probes) is 100 MHz in X10, compered to 15 MHz in DIRECT. Similarly, circuit loading is 10 MΩ and 18 pF in X10, compared to 1 MΩ and 100 pF in DIRECT.

5. Terminate the output of a signal generator in its characteristic impedance to minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating resistor and connected to the oscilloscope with 50 Ω coaxial cable.

6. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, the the same probe always used with channel 1 and channel 2 respectively. Probe compensation should be readjusted when a probe from a different oscilloscope is used.

CONTROLS AND INDICATORS

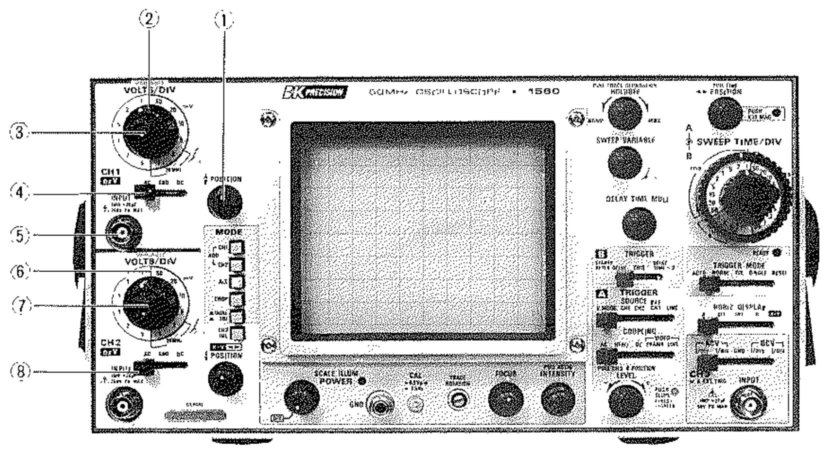


Fig. 1

FRONT PANEL

① ⇕ POSITION

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

② VOLTS/DIV

Vertical attenuator for channel 1; provides step adjustment of vertical sensitivity. When VARIABLE control ③ is set to CAL, vertical sensitivity is calibrated in 12 steps from 5 V/div to 1 mV/div.
For X-Y operation, this control provides step adjustment of vertical sensitivity.

③ VARIABLE Control

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

④ AC-GND-DC

Three-position lever switch which operates as follows:

AC: Blocks dc component of channel 1 input signal.

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

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

⑤ INPUT Jack

Vertical input for channel 1 trace. Vertical input for X-Y operation.

⑥ VOLTS/DIV

Vertical attenuator for channel 2; provides step adjustment of vertical sensitivity. When VARIABLE control ⑦ is set to CAL, vertical sensitivity is calibrated in 12 steps from 5 V/div to 1 mV/div.
In X-Y operation, this control provides step adjustment of horizontal sensitivity.

⑦ VARIABLE Control

Rotation provides fine control of channel 2 vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. In X-Y operation, this control becomes the fine horizontal gain control.

⑧ AC-GND-DC

Three-position lever switch which operates as follows:

AC: Blocks dc component of channel 2 input signal.

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

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

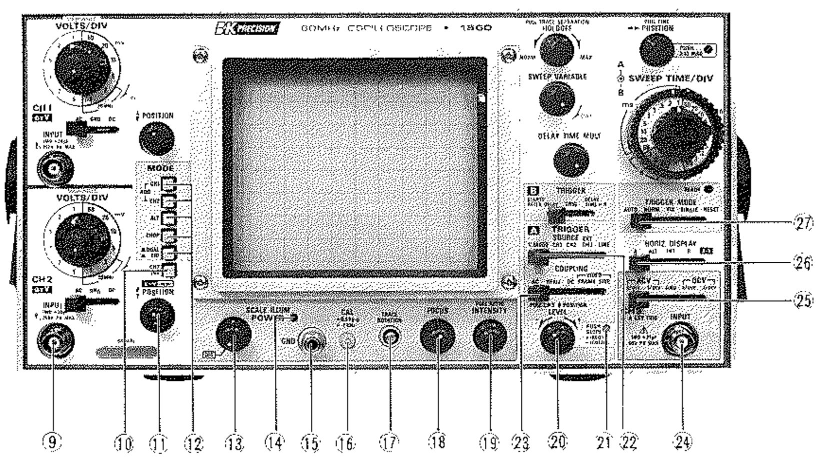


Fig. 2

⑨ **INPUT Jack**
Vertical input for channel 2 trace in normal sweep operation. External horizontal input in X-Y operation.

⑩ **CH2 INV**
In the NORM position (button released), the channel 2 signal is non-inverted. In the INV position (button engaged), the channel 2 signal is inverted.

⑪ **⬍ POSITION, X-Y ◂▸**
Rotation adjusts vertical position of channel 2 trace.
In X-Y operation adjusts horizontal position of display.

⑫ **MODE**
Pushbutton switch assembly; selects the basic operating modes of the oscilloscope.

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

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

ADD: (CH1 + CH2) When both CH1 and CH2 buttons are engaged, the waveforms from channel 1 and channel 2 inputs are added and the sum is displayed as a single trace. When the CH2 INV ⑩ button is engaged, the waveform from channel 2 is subtracted from the channel 1 waveform and the difference is displayed as a single trace.

ALT: Alternate sweep is selected regardless of sweep time as dual trace (CH1 and CH2) [or triple trace (CH1, CH2 and CH3) for Model 1560].

CHOP: Chop sweep is selected regardless of sweep time at approximately 250 kHz as dual trace (CH1 and CH2) [or triple trace (CH1, CH2 and CH3) for Model 1560].

DUAL/TRIPLE: (Model 1560 only) With this button released, allows ALT or CHOP switch to select dual-trace operation. With this button engaged, allows ALT or CHOP switch to select triple-trace operation.

⑬ **POWER, SCALE ILLUM**
Fully counterclockwise rotation of this control (OFF position) turns off oscilloscope. Clockwise rotation turns on oscilloscope. Further clockwise rotation of the control increases the illumination level of scale.

⑭ **PILOT Lamp**
Lights when oscilloscope is turned on.

⑮ **GND terminal/binding post.**
Earth and chassis ground.

⑯ **CAL**
Provides approximately 1 kHz, 0.5 Volt peak-to-peak square wave signal. This is useful for probe compensation adjustment.

⑰ **TRACE ROTATION**

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

⑱ **FOCUS**

Adjusts the trace for optimum focus.

⑲ **INTENSITY/PULL ASTIG**

INTENSITY: Clockwise rotation of this control increases the brightness of the trace.

ASTIG: Pull out and rotate this knob. Astigmatism adjustment provides optimum spot roundness when used in conjunction with FOCUS control.

⑳ **LEVEL/PUSH SLOPE/PULL CH3 ⇕ POSITION**

LEVEL: Trigger level adjustment determines point on waveform where sweep starts. + equals more positive point of triggering and − equals more negative point of triggering.

SLDPE: Push-push switch selects positive or negative slope.

CH3 POSITION:
When pulled out, rotation sdjusts vertical position of channel 3 trace.

㉑ **SLOPE Indicator**

Red LED lights when the sweep is triggered on the positive-going slope of input signal and green LED lights when the sweep is triggered negative-going slope of input signal.

㉒ **SOURCE**

Five-position lever switch; selects triggering source for the sweep, with following positions;

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

- CH1: Channel 1 signal is used as a trigger source.
- CH2: Channel 2 signal is used as a trigger source.
- ADD: The algebraic sum of channel 1 and channel 2 signal is the trigger source. (If CH2 INV engaged, the difference becomes the trigger source.)
- ALT: Display is alternately triggered by CH1 and CH2 (dual-trace operation) or CH1, CH2, and CH3 (triple-trace operation; Model 1560 only).
- CHOP: The display cannot be synchronized with the input signal since the chopping signal becomes the trigger source.

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

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

EXT/CH3: Sweep is triggered by signal applied to EXT TRIG INPUT jack ㉔.

LINE: Sweep is triggered by line voltage (50/60 Hz).

㉓ **COUPLING**

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

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

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

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

VIDEO FRAME: Vertical sync pulses of a composite video signal are selected for triggering.

VIDEO LINE: Horizontal sync pulses of a composite video signal are selected for triggering.

㉔ **CH3 or A EXT TRIG**

Input terminal of external trigger signal of A TRIG. (For Model 1560, also input terminal of channel 3. When vertical MODE is set at TRI, not only channel 1 and channel 2 input signals but channel 3 signal is observable simultaneously.)

㉕ **AC (0.1 V, 1 V)-GND-DC(1 V, 0.1 V) [Model 1560 only]**

Five position lever switch selects channel 3 input coupling and channel 3 vertical attenuator (0.1V/div. 1 V/div).

㉖ **HORIZ. DISPLAY**

Used to select the horizontal display mode.

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

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

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

B: Only delayed B sweep is operative.

X-Y: Channel 1 becomes the Y axis and channel 2 becomes the X axis for X-Y operation. The setting of the vertical MODE and TRIG MODE switches have no effect.

㉗ **TRIG MODE**

Five-position lever switch; selects triggering mode.

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

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

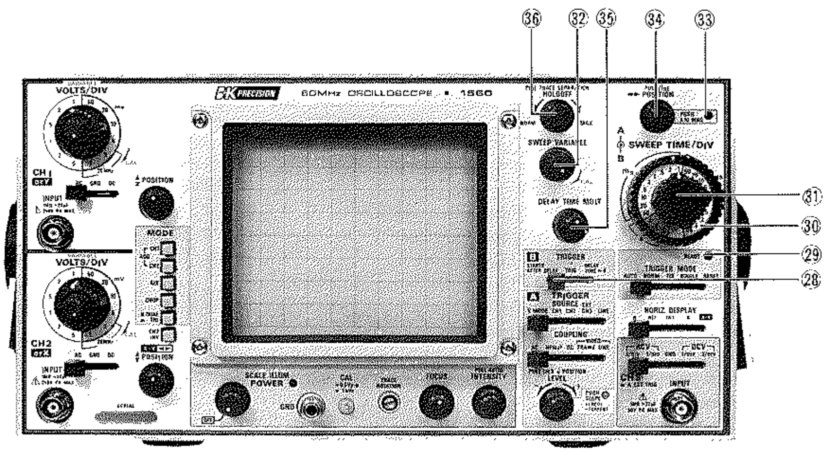


Fig. 3

FIX: Same as automatic mode, automatically generates sweep (free runs) in absence of trigger signal except trigger threshold is automatically fixed at center of trigger signal regardless of setting of LEVEL control.

SINGLE: Single sweep operation. Note that in this mode, simultaneous observation of both the A and B sweeps is not possible.
Note;
For dual or triple trace, single sweep operation, vertical MODE must not be set to ALT. Use the CHOP mode instead.

RESET: This is the reset switch for single sweep operation. Switching the RESET side initiates a single sweep which will begin when the next sync trigger occurs.

(28) B TRIGGER

Used to select delay sweep mode.

STARTS ATER DELAY:
B sweep is triggered immediately after the delay set by A SWEEP TIME/DIV and DELAY TIME MULT controls.

TRIG: "Triggerable After Delay" operation. B Sweep triggering is inhibited during delay period set by A SWEEP TIME/DIV and DELAY TIME MULT controls. B Sweep is triggered by first occurence of proper trigger signal after the delay. In this case the source of the B trigger is the same as the source of the A trigger. Both A and B trigger levels are adjusted by TRIG LEVEL control.

DELAY TIME=ZERO:
A and B sweeps are triggered simultaneously, regardless of DELAY TIME MULT setting. This mode is used to observe the rises of complicated period of pulses with magnification.

(29) Ready Indicator

In SINGLE triggering mode, lights when TRIG MODE switch is set to RESET and goes off when sweep is completed.

(30) A SWEEP TIME/DIV

Horizontal coarse A sweep time selector.
Selects calibrated sweep times of 0.05 μs/div to 0.5 s/div in 22 steps (1540... 0.1 μs/div to 0.5 s/div in 21 steps) when SWEEP VARIABLE control (32) is set to CAL position (fully clockwise).

(31) B SWEEP TIME/DIV

Coarse horizontal/B sweep time selector.
Selects sweep times of 0.05 μs/div to 50 ms/div in 19 steps (1540....0.1 μs/div to 50 ms/div in 18 steps).
No fine adjustment is available for the B sweep time.

(32) SWEEP VARIABLE Control

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

(33) ×10 MAG Indicator

Lights when ×10 sweep magnification is selected.

㉞ ◂▸ POSITION/PUSH × 10 MAG/PULL FINE

Rotation adjusts horizontal position of trace. Rotation becomes fine adjustment of horizontal position of trace when pulled out. Push-push switch alternately turns × 10 MAG on and off (ten times sweep expansion).

㉟ DELAY TIME MULT

Adjusts the start time of the B sweep to some delay time after the start of A sweep. The delay time may be set to values between 0.2 and 10 times the setting of the A SWEEP TIME/DIV control.

㊱ HOLDOFF/PULL TRACE SEPARATION

HOLDOFF: Rotation adjusts holdoff (trigger inhibit period beyond sweep duration). Counter-clockwise rotation increases holdoff period from NORM to more than ten times.

TRACE SEPARATION: Adjusts vertical separation between A sweep and B sweep (control has effect only in the ALT of HORIZ. DISPLAY).
Clockwise rotation increases separation; B sweep moves down with respect to A sweep up to 4 divisions.

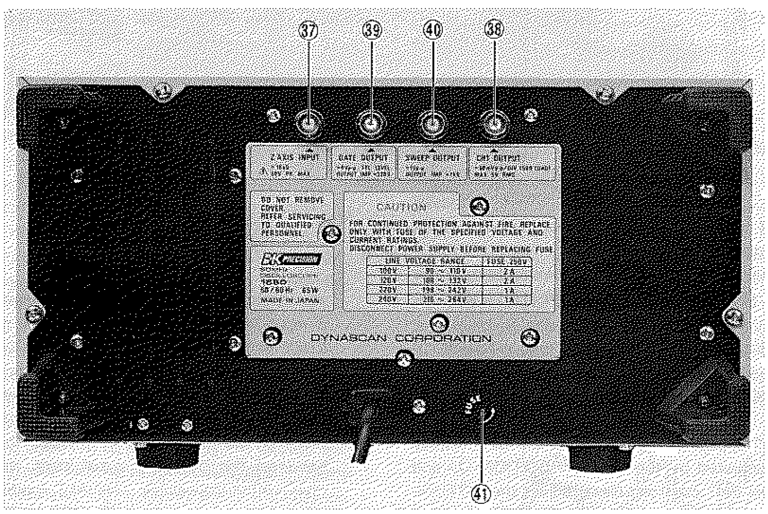


Fig. 4

㊲ Z AXIS INPUT

External intensity modulation input; TTL compatible.
Positive voltage increases brightness, negative voltage decreases brightness.

㊳ CH1 OUTPUT

CH1 vertical output signal connector.
AC coupled output connector.
This connector is used to measure the frequency by connecting the frequency counter. For stable operation, do not connect CH1 OUTPUT to channel 2 input as cascaded operation.

㊴ GATE OUTPUT

Output connector of square wave triggered with A sweep.

㊵ SWEEP OUTPUT

Output connector of saw-tooth wave triggerd with A sweep.

㊶ Fuse Holder

Contains the line fuse. Verify that the proper fuse is installed when replacing the line fuse.
100 V, 120 V ....2 A
220 V, 240 V ....1 A

OPERATION

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the following procedure may be used to standarize the initial setting of controls as a reference point and to obtain trace on the CRT in preparation for waveform observation. When using the probe(s), refer to probe's instructions and "PROBE COMPENSATION" listed in APPLICATION of this manual.

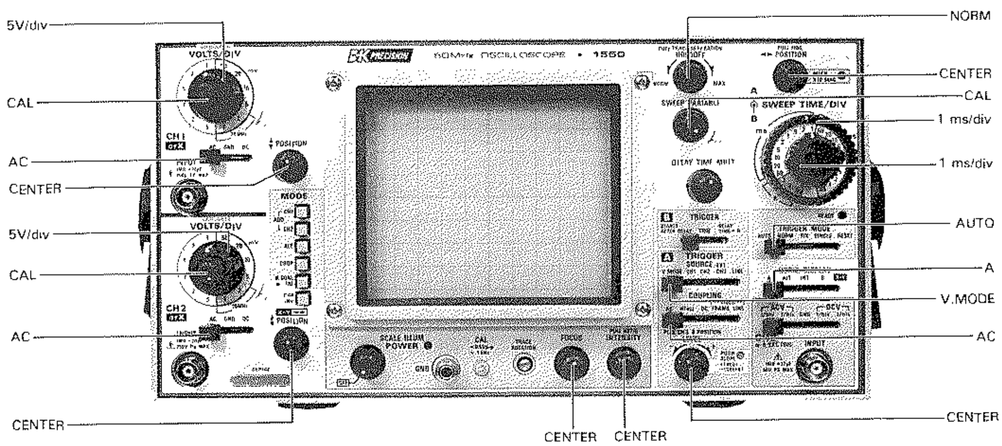


Fig. 5

(1) NORMAL SWEEP DISPLAY OPERATION

1. Turn the POWER control ⑬ clockwise — the power supply will be turned on and the pilot lamp will light.
   Set these modes as follows;
   VERTICAL MODE ⑫ : CH1
   TRIG MODE ㉗ : AUTO
2. The trace will appear in the center of the CRT display and can be adjusted by the CH1 ⇕ POSITION ① and ◄► POSITION ㉞ controls. Next, adjust the INTENSITY ⑲ and, if necessary, the FOCUS ⑱ for ease of observation.
3. Vertical Modes
   With vertical MODE ⑫ set to CH1, apply an input signal to the CH1 INPUT ⑤ jack and adjust the VOLTS/DIV ② control for a suitable size display of the waveform. If the waveform does not appear in the display, adjust the VOLTS/DIV and ⇕ POSITION controls to bring the waveform into the center portion of the CRT display. Operation with a signal applied to the CH2 INPUT ⑨ jack and the vertical MODE set to CH2 is similar to the above procedure.
   In the ADD mode, the algebraic sum of CH1 + CH2 is displayed. If the CH2 INV ⑩ switch has been engaged, the algebraic difference of the two waveforms, CH1 — CH2 is displayed. If both channels are set to the same VOLTS/DIV, the sum or difference can be read directly in VOLTS/DIV from the CRT.
   The DUAL mode allows simultaneous observation of channel 1 and channel 2 waveforms. The TRI mode allows simultaneous viewing of channel 1 thru channel 3 input signals. In the DUAL or TRI mode, either the CHOP or ALT mode applies and must be selected.
   In the CHOP mode, the sweep is chopped at an approximate 250 kHz rate and switched between CH1 and CH2. Note that in the CHOP mode of operation with the SOURCE switch set to V. MODE, the trigger source becomes the chopping signal itself, making waveform observation impossible. Use ALT mode instead in such cases, or select a trigger SOURCE of CH1, CH2 or CH3. If no trace is obtainable, refer to the following TRIGGERING procedures.
4. After setting the SOURCE switch, adjust the LEVEL/SLOPE control ⑳. The display on the screen will probably be unsynchronized. Refer to TRIGGERING procedure below for adjusting synchronization and sweep speed to obtain a stable display showing the desired number of waveform.

TRIGGERING

The input signal must be properly triggered for stable waveform observation. TRIGGERING is possible using the input signal INTernally to create a trigger or with an EXTernally provided signal of timing relationship to the observed signal, appliying such a signal to the EXT TRIG INPUT jack. The SOURCE switch selects the input signal that is to be used to trigger the sweep, with INT sync possibilities (V.MODE, CH1, CH2, LINE) and CH3/EXT sync possibility.

★ **Intemal Sync**

When the SOURCE selection is in INT (V.MODE, CH1, CH2, LINE), the input signal is connected to the internal trigger circuit. In this position, a part of the input signal fed to the INPUT ⑤ or ⑨ jack is applied from the vertical amplifier to the trigger circuit to cause the trigger signal triggered with the input signal to drive the sweep.
When the V.MDDE position is selected, the trigger source is dependent upon the vertical MDDE selection.
When the vertical MDDE switch is selected in ALT and DUAL, the trigger source alternates between channel 1 and channel 2 with each sweep.
When the vertical MDDE switch is selected in ALT and TRI, the trigger source alternates channel 1 thru channel 3 with each sweep.
This is convenient for checking emplitudes, waveshape, or waveform period measurements and even permits simultaneous observation of waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, all traces must be triggered by the same sync signal.
When the SOURCE selection is in CH1, the input signal at the channel 1 INPUT ⑤ jeck becomes trigger regardless of the position of vertical MDDE. When the SDURCE selection is in CH2, the input signal at the channel 2 INPUT ⑨ jeck becomes trigger regardless of the position of vertical MDDE. If the SDURCE switch is set to the LINE position, triggering is derived from the input line voltage (50/60 Hz). This is useful measurements that are releted to line frequency.

★ **Extamal Sync**

When the SOURCE selection is in EXT/CH3, the input signal at the EXT TRIG INPUT ㉔ jack becomes the trigger. This signal must have e time or frequency relationship to the signal being observed to synchronize the display. External sync is prefered for waveform observation in many applications. For example, Fig. 6 shows that the sweep circuit is driven by the gate signal when the gate signal in the burst signal is applied to the EXT TRIG INPUT jack. Fig. 6 also shows the input/output signals, where the burst signal generated from the signal is applied to the instrument under test. Thus, accurate triggering can be achieved without regard to the input signal fed to the INPUT ⑤ or ⑨ jack so that no further triggering is required even when the input signal is varied. When the vertical MDDE is set to TRI, triple-trace display is provided and the signal applied to EXT/CH3 is to be used to trigger the sweep, with INTernal sync possibility.

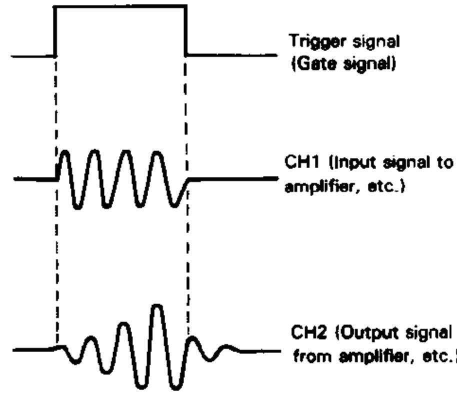


Fig. 6

★ **Coupling**

The CDUPLING switch selects the coupling moda of the trigger signal to the trigger circuit according to tha typa of trigger signal (DC, AC, signal superimposed on dc, signal with high frequency noise.).

AC:
Most commonly used position; permits triggering from 10 Hz to highest frequency observable. Blocks dc component of sync trigger signal.

HFrej.:
Attenuates trigger signal above 100 kHz. Useful to reduce high-frequency noise, and permits triggering from the moduletion envelope of an amplitude moduleted rf signal.

DC:
Permits triggering from dc to over 60 MHz (for 1540, 40 MHz). Couples dc component of sync trigger signal. Useful for triggering from very low frequency signals (below 10 Hz) or ramp waveforms with slow repeeting dc.

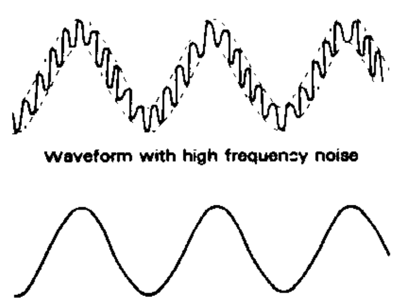


Fig. 7

★ **Triggering Level**

Trigger point on waveform is adjusted by the LEVEL/PUSH SLOPE ㉖ control. Fig. 8 shows the relationship between the SLDPE and LEVEL of the trigger point. Triggering level can be adjusted as necessary.

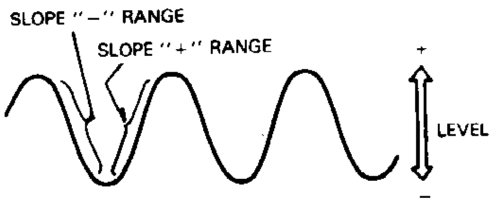


Fig. 8

★ **Auto Trigger**

When the TRIG MDDE ㉗ selection is in AUTD, the sweep circuit becomes free-running as long as there is no trigger signal, permitting a check of GND level. When a trigger signal is present, the trigger point can be determined by the LEVEL control for observation as in the normal trigger signal. When the trigger level exceeds the trigger signal, the trigger circuit also becomes free-running where the waveform starts running. When the TRIG MODE is set to NORM and/or, when the trigger signal is absent or the triggering level exceeds the signal there is no sweep.

★ **Fix**

When the TRIG MDDE ㉗ is set to FIX, triggering is always effected in the center of the waveform, eliminating the need for adjusting the triggering level. As shown in Fig. 9-(a) or (b), when the TRIG MDDE is set to NDRM and the triggering level is adjusted to either side of the signal, the trigger point is deviated as the input signal becomes small which, in turn, stops the sweep operation. By setting the TRIG MDDE to FIX, the triggering level is automatically adjusted to the approximate center of the waveform and the signal is synchronized regardless of the position of LEVEL control as shown in Fig. 9-(c).

When the input signal is suddenly changed from a square waveform to a pulse waveform, the trigger point is shifted extremely toward the "−" side of the waveform unless the triggering level is readjusted as shown in Fig. 10-(a). See Fig. 10-(a)-(2). Also, if the trigger point has been set to the "−" of squarewave (Fig. 10-(b)-(1)) and the input signal is changed to a pluse signal, the trigger point is deviated and the sweep stops. When this happens, set the TRIG MDDE to FIX and the triggering is effected in the approximate center of the waveform, making it possible to observe a stabilized waveform. (Fig. 10-(c))

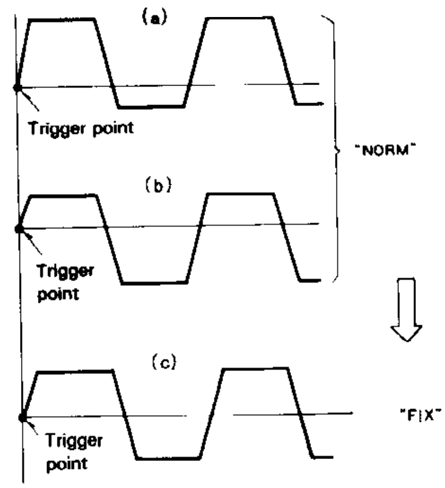


Fig. 9

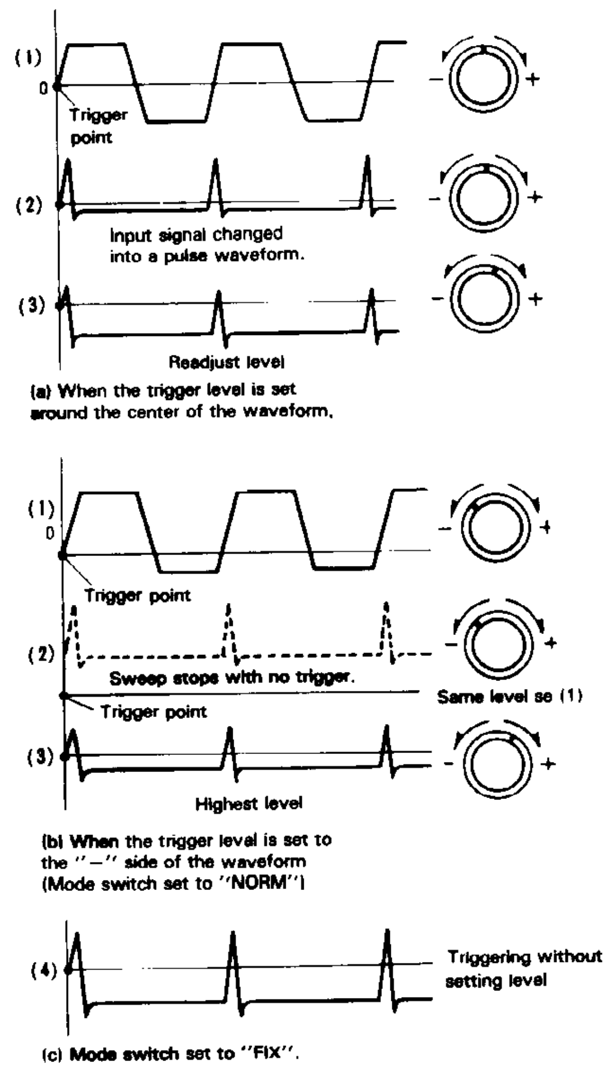


Fig. 10

(2) MAGNIFIED SWEEP OPERATION

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

Using the ◄► PDSITIDN control, adjust the desired portion of waveform to the CRT. Push the PUSH ×10 MAG switch to magnify the display 10 times and ×10 MAG indicator lights. For this type of display the sweep time is the SWEEP TIME/DIV setting divided by 10.

(3) DELAYED SWEEP OPERATION

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

Procedure:

1. First set the HORIZ DISPLAY to A and adjust for a normal waveform display.
2. Set the B sweep in the STARTS AFTER DELAY mode. Set the HORIZ DISPLAY to the INT mode and the B sweep will appear as an intensified portion of the A sweep. The length of the intensified portion is adjusted by the B SWEEP TIME/DIV control. (Fig. 11).
3. Shift the intensified portion of waveform (section to be magnified) along the sweep A sweep by use of the DELAY TIME MULT ㉟ .
4. Set the HORIZ DISPLAY to B to display the INT intensified portion as a magnified B sweep. (Fig. 12).

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

5. For STARTS AFTER DELAY operation, apparent jitter increases as magnification increases. To obtain a jitter free display set the B TRIGGER ㉘ to TRIG. In this "Triggerable After Delay" mode the A trigger signal selected by the SOURCE switch ㉒ becomes the B trigger source.

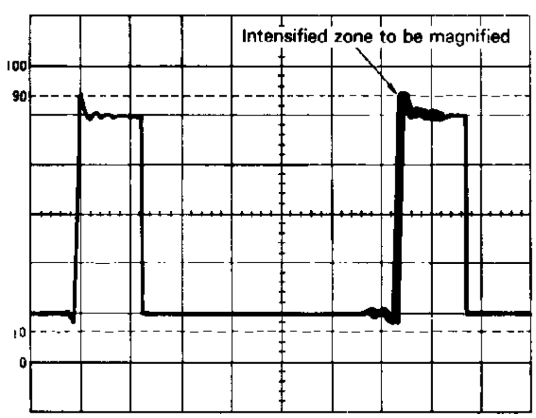


Fig. 11

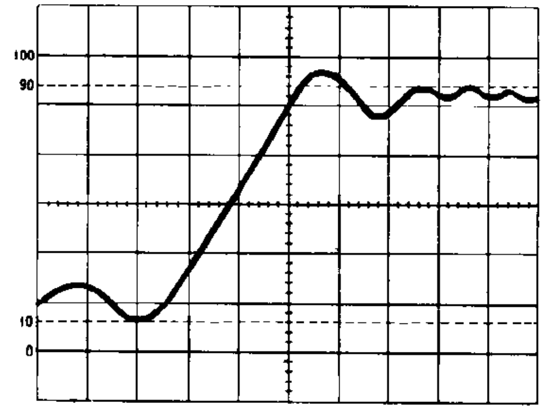


Fig. 12

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

(4) ALTERNATING SWEEP OPERATION

A sweep and B delayed sweep are usable in an alternating fashion making it possible to observe both the normal and magnified waveform simultaneously. (Fig. 13).

Procedure:

1. Set the HORIZ DISPLAY to A and adjust for a normal waveform display.
2. Set the B TRIGGER to STARTS AFTER DELAY and set the HORIZ DISPLAY to ALT. Adjust TRACE SEPATATION ㊱ for easy observation of both the A and B traces. The upper trace is the non-magnified portion of the waveform with the magnified portion super-imposed as an intensified section. The lower waveform is the intensified portion displayed magnified.
3. The DELAY TIME MULT can be used to continuously slide the magnified portion of the waveform across the A sweep period to allow magnification of precisely the desired portion of waveform.
4. Apparent display jitter increases with increased magnification as is the case with delayed sweep discussed above.
   Set the B TRIGGER to TRIG to obtain a jitter free display the same as delayed sweep operation.

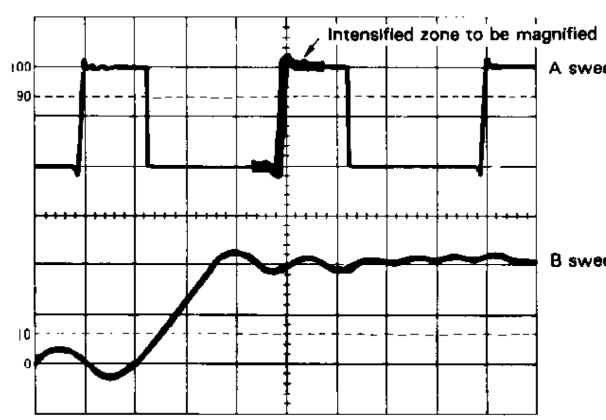


Fig. 13

(5) X-Y OPERATION

For some measurements, an external horizontal deflection signal is required. This is also referred to as an X-Y measurement, where the Y input provides vertical deflection and X input provides horizontal deflection.

X-Y oparation parmits the oscilloscope to parform many types of measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of two voltages such as during phase measurement, or frequency measurement with Lissajous weveforms.

To use an external horizontal input, use the following procedure;

1. Set the HDRIZ DISPLAY switch to X-Y the position.
2. Use the channel 1 probe for the vertical input and the channel 2 probe for the horizontal input.
3. Adjust the amount of horizontal deflection with the CH2 VOLTS/DIV and VARIABLE controls.
4. The CH2 (vertical) PDSITIDN ⑪ control now serves as the horizontal position control, and the ◄► PDSITIDN control is disabled.
5. All sync controls are disconnected and have no effect.

(6) VIDEO SIGNAL OBSERVATION

The VIDED FRAME/LINE switch permits selection of vertical or horizontal sync pulse for sweep triggering when viewing composite video waveforms. In the LINE position, horizontal sync pulses are selected as triggers to parmit viewing of horizontal line of video. In the FRAME position, vertical sync pulses are selected as triggers to permit viewing of vertical fields and frames of video.

At most points of measurement, a composite video signal is of the (−) polarity, that Is, the sync pulses are negative and the video is positive. In this casa, use "−" SLDPE.

If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negstive. In this case, use "+" SLDPE.

(7) SINGLE SWEEP OPERATION

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

Procedure:

1. Set the TRIG MDDE ㉗ to either AUTD or NDRM. Apply a signal of approximately the same amplitude and frequency as the signal that is to be observed as the trigger signal and set the trigger level.
2. Set TRIG MDDE to RESET — observe that the READY indicator LED lights to indicate the reset condition. This LED goes out when the A sweep period is completed.
3. After the above set-up is completed the scope is ready to oparate in the SINGLE sweep mode of operation after resetting the instrument using the RESET switch. Input of the trigger signal results in one and only one sweep and READY indicator LED goes out.

CAUTION:

With the HORIZ DISPLAY set to ALT the simultaneous observation of the A sweep and B sweep waveforms at SINGLE sweep mode is not possible. Also for DUAL or TRI operstion simultaneous observation is not possible using ALT mode. Set the unit to the CHDP mode in this case.

APPLICATIONS

PROBE COMPENSATION

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

1. Connect probe to INPUT jack. Connect ground clip of probe of oscilloscope ground terminal and touch tip of probe to CAL terminal.
2. Select single trace operation of channel 1, then channel 2, for step 3 and 4.
   Set the VOLTS/DIV to 10mV/div and for Model 1540, set the probe for 10:1 attenuation (10× position).
3. Set oscilloscope controls to display 3 or 4 cycles of CAL square wave at 5 or 6 divisions amplitude.
4. Adjust compensation trimmer on probe for optimum square wave waveshape (minimum overshoot, rounding off, and tilt).

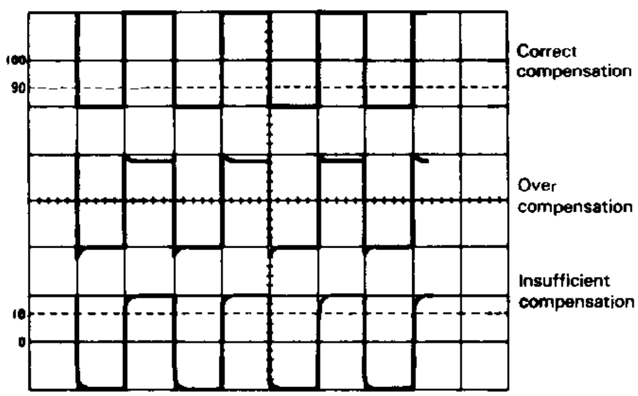


Fig. 14

TRACE ROTATION COMPENSATION

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

DC VOLTAGE MEASUREMENTS

This procedure describes the measurement procedure for waveforms, including the dc component.
Procedure:

1. Connect the signal to be measured to the INPUT jack.Set the vertical MODE to the channel to be used. Set the VOLTS/DIV and SWEEP TIME/DIV switch to obtain a normal display of the waveform to be measured. Set the VARIABLE control to CAL position.
2. Set the TRIG MODE to AUTO and AC-GND-DC to the GND position, which established the zero volt reference. Using the ⇕ POSITION control, adjust the trace position to the desired reference level position, making sura not to disturb this setting once made.
3. Set the AC-GND-DC switch to the DC position to observe the input waveform, including its dc component. If an appropriate reference level or VDLTS/DIV sstting was not made, the waveform may not be visible on the CRT screen at this point. If so, reset VOLTS/DIV and/or the ⇕ POSITION control.
4. Use the ◄► POSITION control to bring the portion of the waveform to be measured to the center vertical graduation line of the CRT screen.
5. Measure the vertical distance from the reference level to the point to be measured, (the reference lavel can be rechecked by setting the AC-GND-DC switch again to GND).
   Multiply the distance measured above by the VOLTS/DIV setting and the probe attenuation ratio as well. Voltages above and below the reference level are positive and negative values respectively.

Using the formula:
DC level = Vertical distance in divisions × (VOLTS/DIV setting) × (probe attenuation ratio).

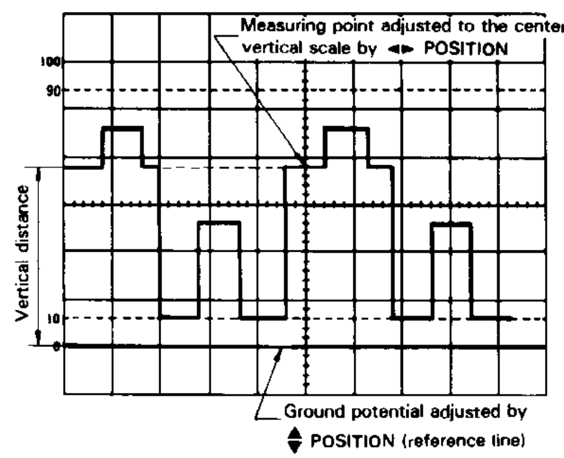


Fig. 15

[EXAMPLE]
For the example, the point being measured is 3.8 divisions from the reference level (ground potential).
If the VOLTS/DIV was set to 0.2 V and a 10:1 probe was used. (See Fig. 15)
Substituting the given values:
DC level = 3.8 (div) × 0.2(V) × 10 = 7.6 V

MEASUREMENT OF THE VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM

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

Procedure:

1. Apply the signal to be measured to the INPUT jack. Set the vertical MODE to the channel to be used. Set the AC-GND-DC to AC, adjusting VDLTS/DIV and SWEEP TIME/DIV for a normal display. Set the VARIABLE control to CAL position.
2. Using the ⬍ PDSITIDN control, adjust the waveform position such that one of the two points falls on a CRT graduation line and that the other is visible on the display screen.
3. Using the ◀▶ PDSITION control, adjust the second point to coincide with the center vertical graduation line.
4. Measure the vertical distance between the two points and multiply this by the setting of the VDLTS/DIV control.
   If a probe is used, further multiply this by the attenuation ratio.

Using the formula:

Volts Peak-to-Peak
= Vertical distance (div) × (VDLTS/DIV setting) × (probe attenuation ratio)

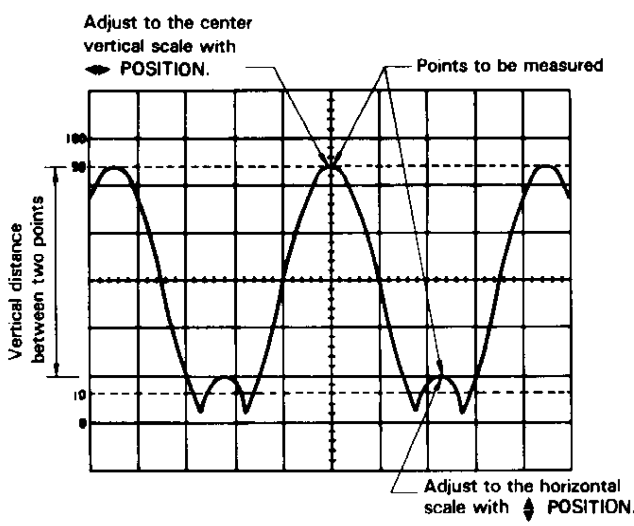


Fig. 16

[EXAMPLE]

For the example, the two points are separated by 4.4 divisions vertically. Set the VOLTS/DIV setting be 0.2 V/div and the probe attenuation be 10:1. (See Fig. 16)

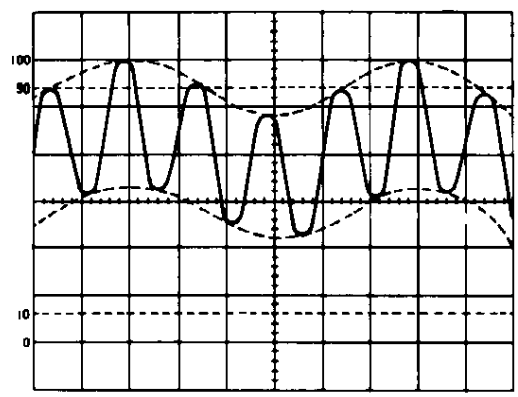
Substituting the given value:
Voltage between two points = 4.4 (div) × 0.2(V) × 10 = 8.8V

ELIMINATION OF UNDESIRED SIGNAL COMPONENTS

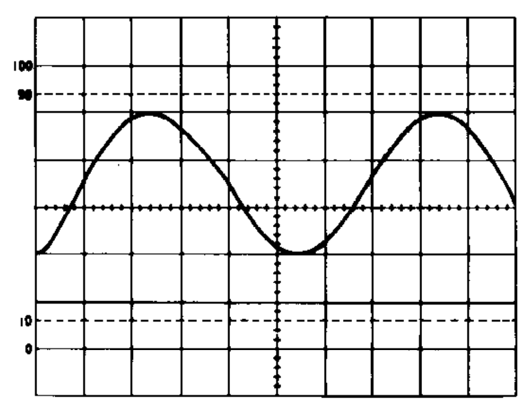
The ADD feature can be conveniently used to cancel out the effect of an undesired signal component which may be superimposed on the signal you wish to observe. (See Fig. 17)

Procedure:

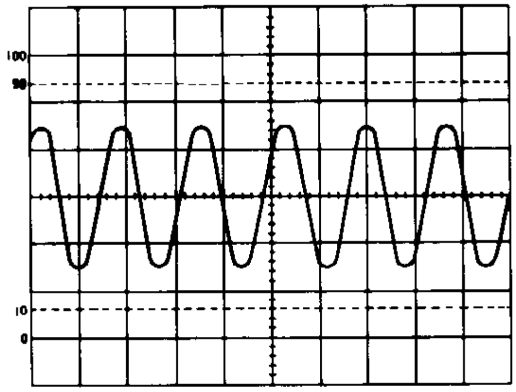
1. Apply the signal containing an undesired component to the CH1 INPUT jack and the undesired signal itself alone to the CH2 INPUT jack.
2. Set the vertical MDDE to DUAL (CHOP) and SDURCE to CH2. Verify that CH2 represents the unwanted signal in reverse polarity. If necessary reverse polarity by setting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



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



Undesired component signal



Signal without undesired component

Fig. 17

TIME MEASUREMENTS

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

Procedure:

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

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

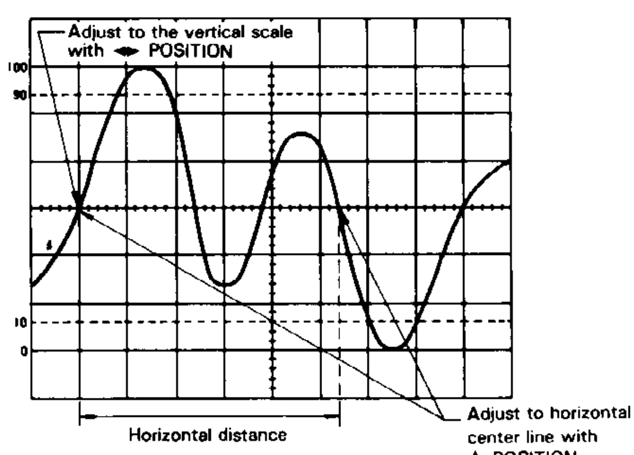


Fig. 18

[EXAMPLE]
For the example, the horizontal distance between the two points is 5.4 divisions.
If the SWEEP TIME/DIV is 0.2 ms/div we calculate. (See Fig. 18)

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

FREQUENCY MEASUREMENTS

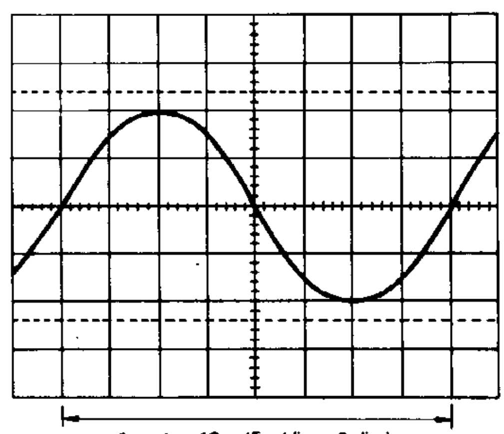
Frequency measurements are made by measuring the period of one cycle of waveform and taking the reciprocal of this time value as the frequency.

Procedure:

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

Using the formula:

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



1 cycle = 40µs (5µs/div. × S div.)

Fig. 19

[EXAMPLE]
A period of 40 µs is observed and measured. (See Fig. 19)

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

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

1. Apply the signal to the INPUT jack. Set the vertical MDDE to the channel to be used and adjusting the various controls for a normal display. Set the VARIABLE control to CAL position.
2. Count the number of cycles of waveform between a chosen set of vertical graduetion lines.
   Using the horizontal distance between the vertical lines used above and the SWEEP TIME/DIV, the time span may be calculeted. Multiply the reciprocal of this value

by the number of cycles present in the given time span. If "×10 MAG" is used multiply this further by 10. Note thet errors will occur for displays heving only a few cycles.

Using the formula:

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

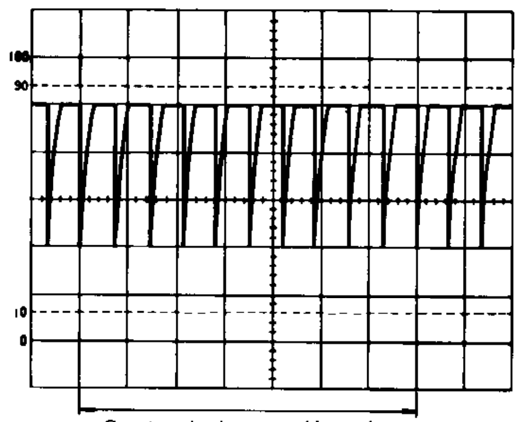


Fig. 20

[EXAMPLE]

For the example, within 7 divisions there are 10 cycles. The SWEEP TIME/DIV is 5 μs. (See Fig. 20)

Substituting the given value:

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

PULSE WIDTH MEASUREMENTS

Procedure:

1. Apply the pulse signal to the INPUT jack. Set the vertical MODE to the channel to be used.
2. Use the VOLTS/DIV, VARIABLE and ⇕ POSITIDN to edjust the waveform such that the pulse is easily observed and such that the centar pulse width coincides with the center horizontal line on the CRT screen.
3. Measure the distance between the intersection of the pulse waveform and the center horizontal line in divisions. Be sure that the VARIABLE control is in the CAL. Multiply this distance by the SWEEP TIME/DIV and by 1/10 is "×10 MAG" mode is being used.

Using tha formula:

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

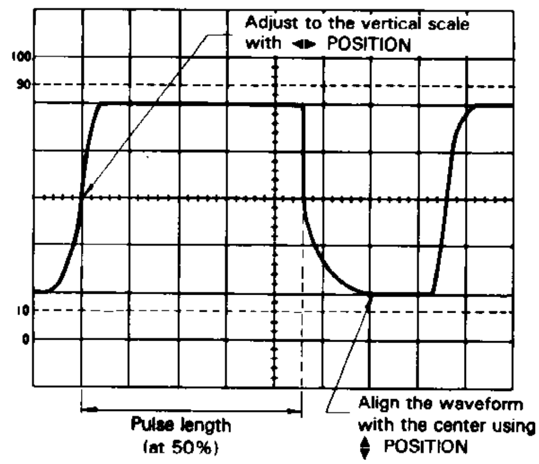


Fig. 21

[EXAMPLE]

For the example, the distance (width) at the center horizontal line is 4.6 divisions and the SWEEP TIME/DIV is 0.2 ms. (See Fig. 21)

Substituting the given value:

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

PULSE RISETIME AND FALLTIME MEASUREMENTS

IMPORTANT See Appendix I

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

Procedure:

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

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

Using the formula:

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

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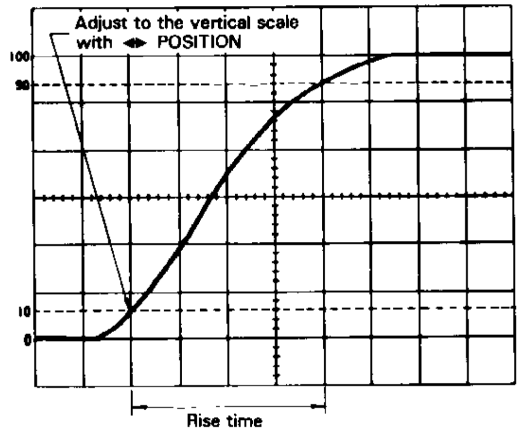


Fig. 22

[EXAMPLE]
For the example, the horizontal distance is 4.0 divisions. The SWEEP TIME/DIV is 2 μs. (See Fig. 22)

Substituting the given value:
Risetime = 4.0 (div) × 2 (μs) = 8μs

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

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

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

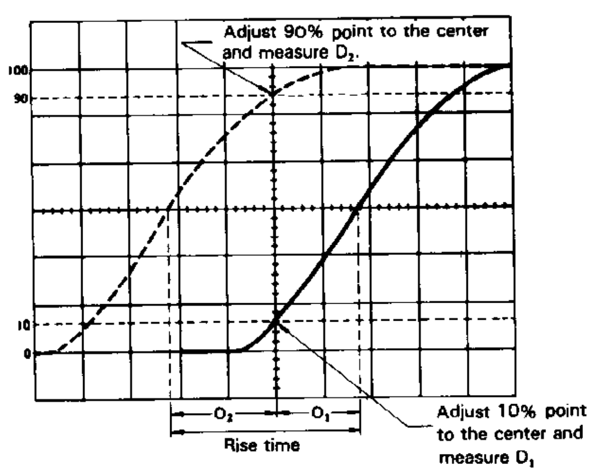


Fig. 23

[EXAMPLE]
For the example, the measured D_1 is 1.8 divisions while D_2 is 2.2 divisions. If SWEEP TIME/DIV is 2 μs we use the following relationship. (See Fig. 23)

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

TIME DIFFERENCE MEASUREMENTS

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

Procedure:

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

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

[EXAMPLE]
For the example, the horizontal distance measured is 4.4 divisions. The SWEEP TIME/DIV is 0.2 ms. (See Fig. 24)

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

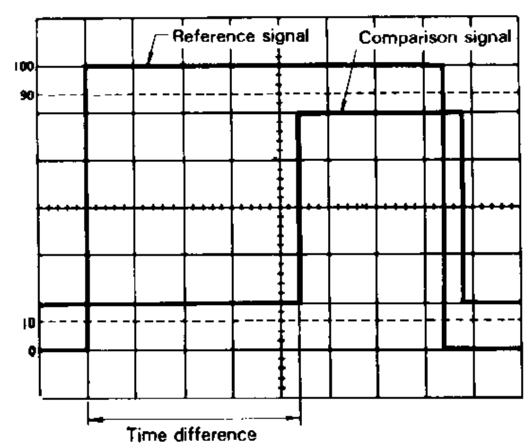


Fig. 24

PHASE DIFFERENCE MEASUREMENTS

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

Procedure:

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

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

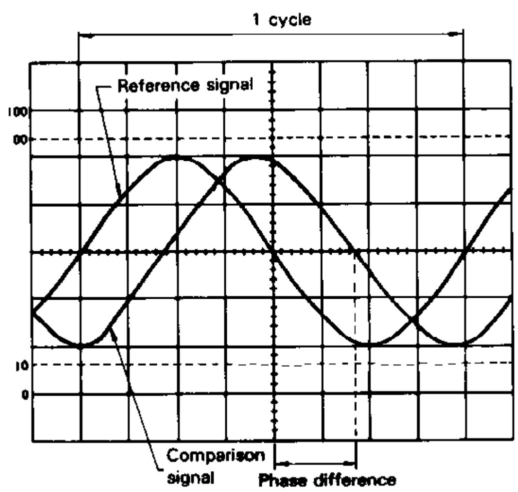


Fig. 25

[EXAMPLE]

For the example, the horizontal distance is 1.7 divisions. (See Fig. 25)

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

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

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

Phase difference = Horizontal distance of new sweep range (div) × 45°/div

$$\times \frac{\text{New SWEEP TIME/DIV setting}}{\text{Original SWEEP TIME/DIV setting}}$$

Another simple method of obtaining more accuracy quickly is to simply use × 10 MAG for a scale of 4.5°/div.

RELATIVE MEASUREMENT

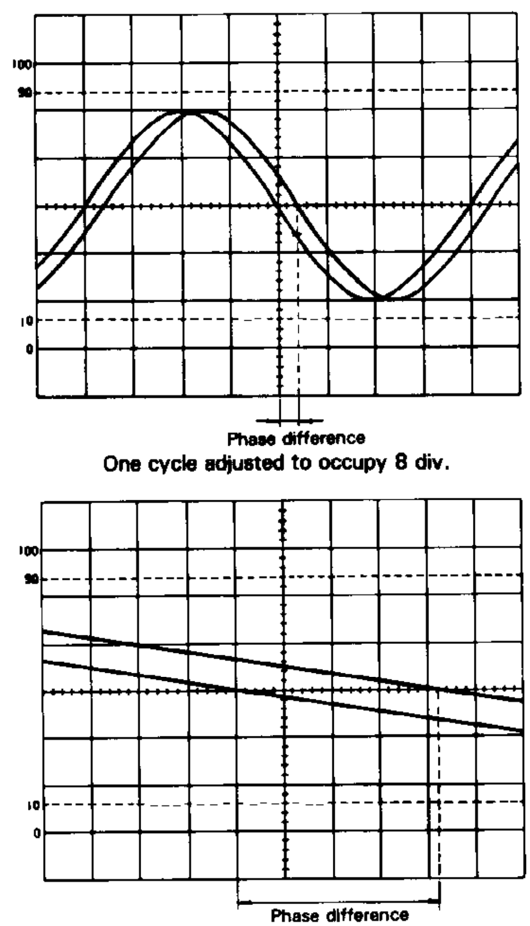
If the frequency and amplitude of some reference signal are known, an unknown signal may be measured for level and frequency without use of the VOLTS/DIV or SWEEP TIME/DIV for calibration.
The measurement is made in units relative to the reference signal.

★ **Vertical Sensitivity**

Setting the relative vertical sensitivity using a reference signal.

Procedure:

1. Apply the reference signal to the INPUT jack and adjust the display for a normal waveform display.
   Adjust the VOLTS/DIV and VARIABLE so that the signal coincides with the CRT face's graduation lines. After adjusting, be sure not to disturb the setting of the VARIABLE control.



One cycle adjusted to occupy 8 div.

Expanded sweep waveform display.

Fig. 26

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

Using the formula:
Vertical coefficient

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

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

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

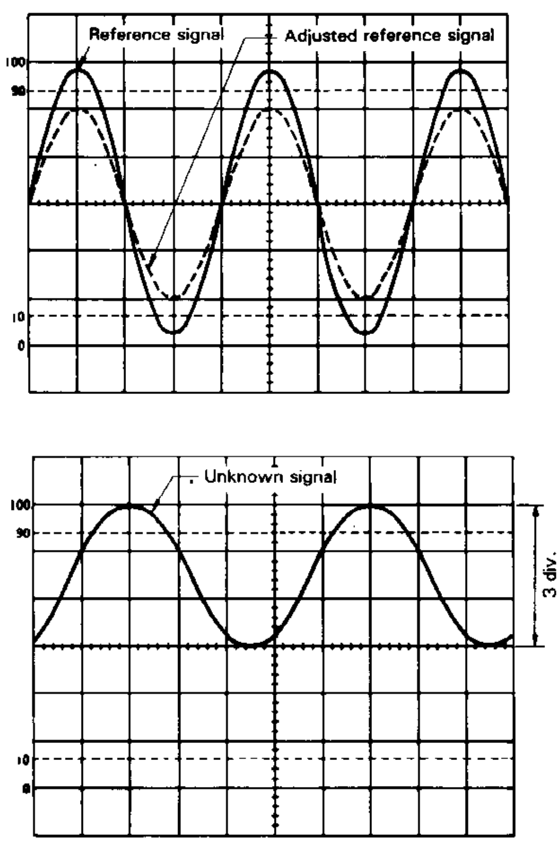


Fig. 27

[EXAMPLE]
For the example, the VOLTS/DIV is 1 V.
The reference signal is 2 Vrms. Using the VARIABLE, adjust so that the amplitude of the reference signal is 4 divisions. (See Fig. 27)

Substituting the given value:

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

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

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

★ Period
Setting the relative sweep coefficient with raspect to a reference frequency signal.

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

   Using the formula:
   Sweep coefficient

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

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

Using the formula:
Period of unknown signal = Width of 1 cycla (div) × swaap coefficiant × SWEEP TIME/DIV setting

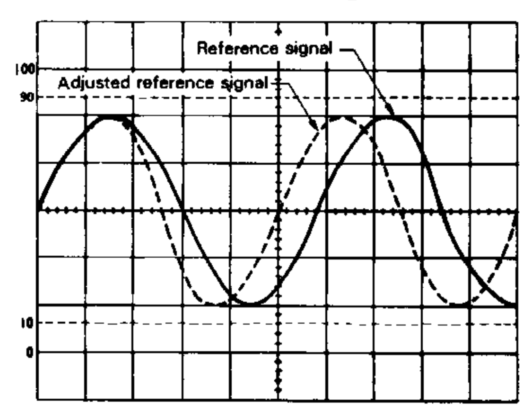


Fig. 28

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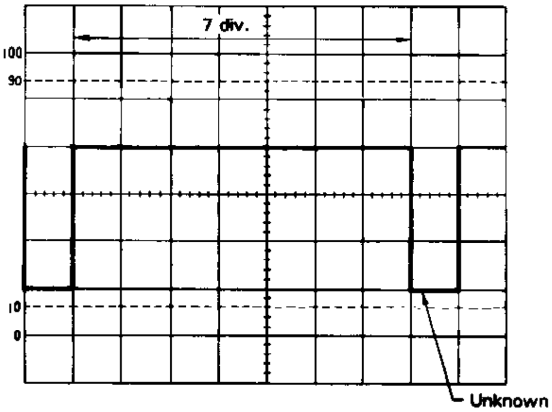

Fig. 29

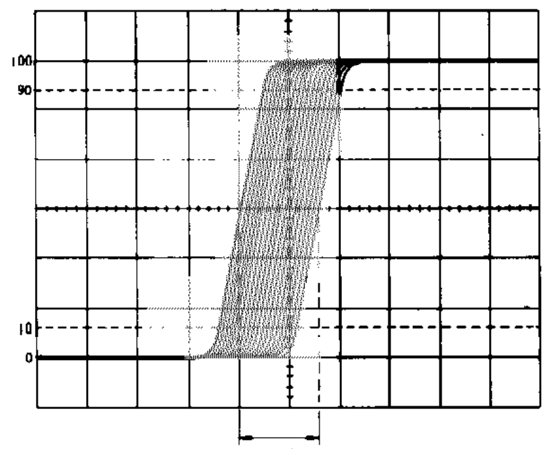

Fig. 30

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

Substituting the given value:

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

Then, SWEEP TIME/DIV is 0.2 ms and horizontal amplitude is 7 divisions. (See Fig. 29)

Substituting the given value:
Pulse width = 7 (div) × t.142 × 0.2 (ms) ≒ 1.6 ms

PULSE JITTER MEASUREMENT

1. Apply the signal to the INPUT jack and set the vertical MODE to the channel to be used.
   Use the VOLTS/DIV to adjust for an easy to observe waveform display. Special care should be taken to adjust the trigger group of controls for e etable display.
   Set the SWEEP VARIABLE to CAL position.
2. Set the HORIZ DISPLAY to INT and B TRIGGER to affect the STARTS AFTER DELAY mode.
   Adjust the DELAY TIME MULT for intensified display of the waveform to be measured.
3. Using the B SWEEP TIME/DIV adjust the display for intensificaion of the entire jitter area of the waveform.
4. Set the HORIZ DISPLAY to B.
   Measure the width of the jitter area.
   The jitter time is this width in division multiplied by the setting of the B SWEEP TIME/DIV control.

Using the formula:
Pulse jitter = Jitter width (div) × B SWEEP TIME/DIV setting

[EXAMPLE]
The example shows a case in which the jitter width was measured at 1.6' divisions wide with the B SWEEP TIME/DIV set et 0.2 μs. (See Fig. 30)
Substituting the given value:
Pulse jitter = 1.6 (div) × 0.2 (μs) = 0.32 μs

SWEEP MULTIPLICATION (MAGNIFICATION)

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

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

Using the formula:

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

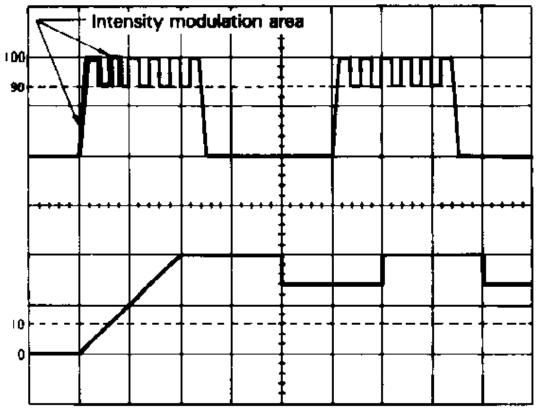

Fig. 31

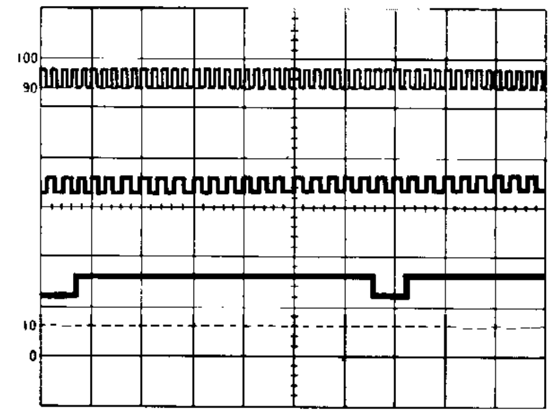

Fig. 32

[EXAMPLE)
In the example, the **A SWEEP TIME is 2 μs** and the B SWEEP TIME is 0.2 μs. **(See Fig. 31)**

Substituting tha given valua:

$$\text{Apparent magnification ratio} = \frac{2\times10^{-6}}{0.2\times10^{-6}} = 10$$

With the above magnification, if tha magnification ratio is increased, delay jitter will occur.
To achieve a stable display, set the B TRIGGER to TRIG and used the triggered mode of operation.

1. Perform the above steps 1 through 3.
2. Set the B TRIGGER to TRIG.
3. Set the HORIZ DISPLAY to aither ALT or B. The apparent magnification will be the same as described above.

TRIPLE-TRACE APPLICATIONS (Model 1560 only)

The sensitivities of channel 1 thru channal 3 are calibrated and each chennel has 60 MHz band width. The trigger signal of channel 3 can be obtained from its preamplifier. This unit can be used not only for external synchronization but also for checking triple-trace at a time.

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

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

Logic signal timing indication
Control setting
Vertical MODE: TRI, ALT
HORIZ DISPLAY: A
SOURCE: CH3

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

In the above application, when the HORIZ DISPLAY control is set to ALT, the main and delay sweep waveforms ara displayed on the CRT at a time. The portion in which the intensity is modulated is enlarged to enable easy checking (Fig. 32)

Main and delay sweep waveforms (magnified by 10 times)
Control setting
Vertical MODE: TRI, ALT
SOURCE: CH3
HORIZ OISPLAY: ALT
B TRIGGER: STARTS AFTER DELAY

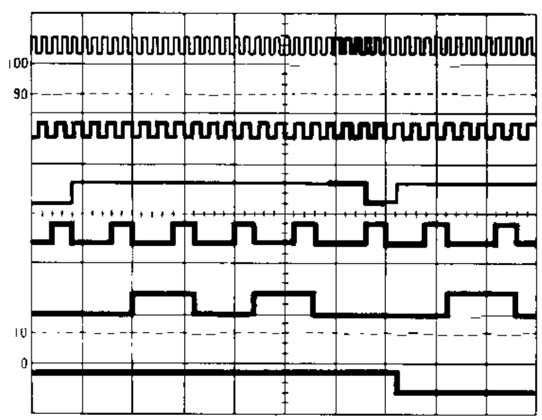

Fig. 33

OBSERVATION OF THE START PORTION OF THE IRREGULAR WAVEFORM

To observe the start portion of the irregular waveform, magnification of the start portion of the waveform can be made with the DELAY TIME = ZERO.

Procedure;

1. Apply the signal to INPUT jack and set the verticel MOOE to the channel to be used and adjusting the various controls for e normal display.

2. Use the A SWEEP TIME/DIV and HOLDDFF controls to adjust the display such that a number of cycles of waveform is observed. Next, set the B TRIGGER to TRIG.
3. Set the HORIZ DISPLAY to ALT or B and use the ⇕ POSITION and TRACE SEPARATION controls to adjust the display such that the display is easily observed.
4. The observation of the start portion of tha waveform can be made to set the B SWEEP TIME/DIV to as fast a setting as possible consistent with observetion.
   For time measurement, calculate from the B SWEEP TIME/DIV setting.

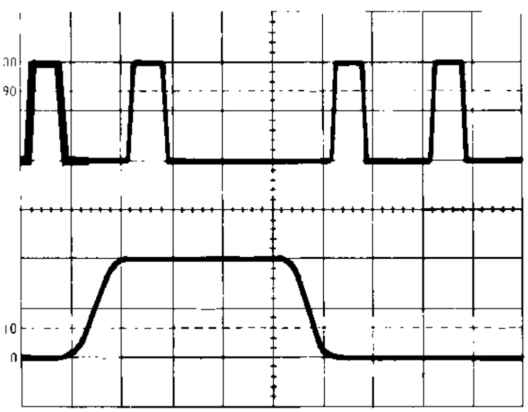

Fig. 34

X-Y APPLICATIONS

★ Phese Shift Measurement

A method of phase measurement requires calculations based on the Lissajous patterns obtained using X-Y operations. Distortion due to non-linear amplification also can be displayed.

A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.

To make phase measurements, use the following procedure.

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.
2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.
3. Connect the channel 2 probe to the output of the test circuit.
4. Select X-Y operation by placing the HORIZ DISPLAY switch in the X-Y position.
5. Connect the channel 1 probe to the input of the test circuit.
   (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reserved.)
6. Adjust the channel 1 and 2 gain controls for a suitable viewing size.
7. Some typical results ara shown in Fig. 36.
   If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is st a 45° angle. A 90° phase sift produces a circular oscilloscope pattern.
   Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 35.

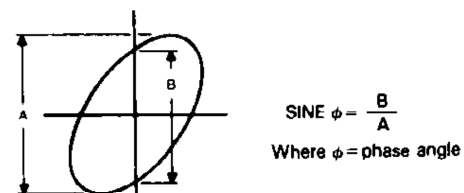

Fig. 35 Phase shift calculation

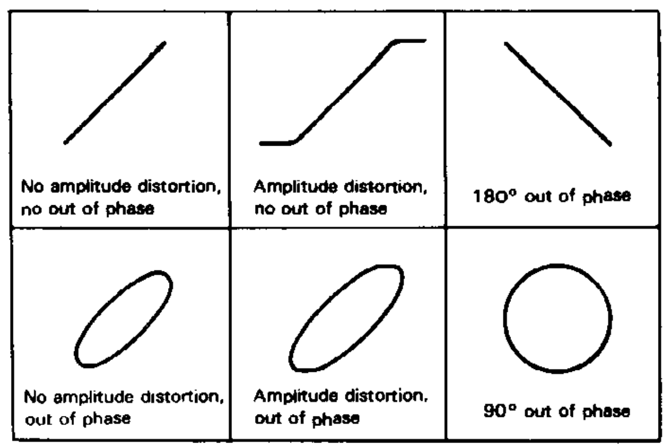

Fig. 36 Typical phase measurement oscilloscope dispisy

★ Frequency Measurement

1. Connect the sine wave of known frequency to the channel 2 INPUT jack of the oscilloscope and selact X–Y operation. This provides external horizontal input.
2. Connect the vertical input probe (CH1 INPUT) to the unknown frequency.
3. Adjust the channel 1 and 2 size controls for convenient, easy-to-read siza of display.
4. The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies.

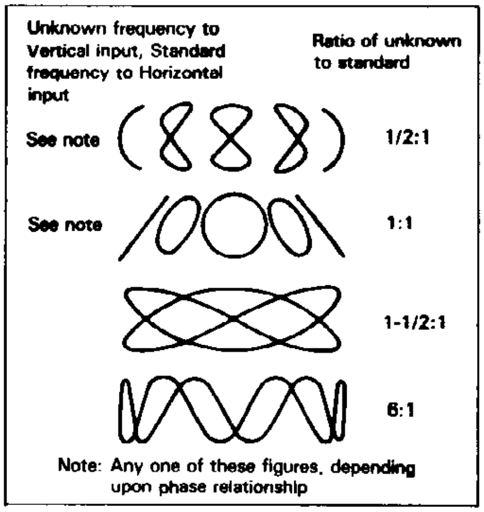

Fig. 37 Lissajous waveforms used for frequency measurement

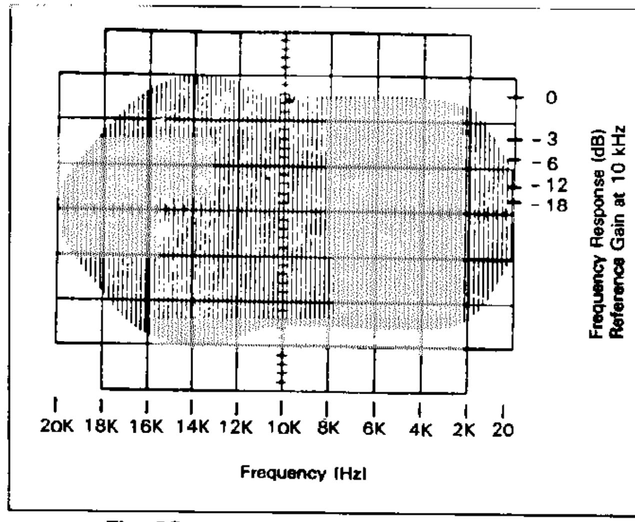

Fig. 38 Frequency Response Measurement, Envelope Response.

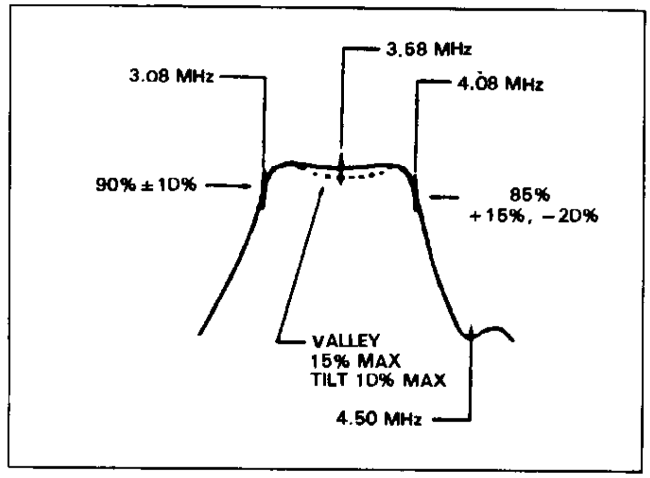

Fig. 39 Frequency Response Measurement, Demodulated Response.

★ **Frequency Response Measurements**

The X-Y mode of this oscilloscope may be used to measure the frequency response of amplifiers, band pass filters, coupling networks, etc. The only additional test equipment needed is a sweep generator, such as the B & **K-Precision** Model 3020, 3025, or 3030 Sweep/Function Generator.

1. Connect the audio or rf output of the sweep generator to the input of the circuit under test. Connect the output of the test circuit to the CH 1 (or Y-axis) input of the oscilloscope. Set the sweep generator to sweep the desired band of frequencies. For a typical audio frequency response measurement, the generator is set to sweep from 20 Hz to 20 kHz.
2. Connect the sweep ramp voltage of the sweep generator to the CH 2 or X-axis input of the oscilloscope.
3. Select the X-Y mode of HORIZ DISPLAY and adjust the CH 1 (vertical) and CH 2 (horizontal) sensitivity for a suitable viewing size.
4. A standard probe will result in an envelope display such as shown in Fig. 38. The example in Fig. 38 results from a negative-going sweep ramp voltage as frequency increases, with the higher frequencies at the left side of the display. If the sweep ramp voltage is positive-going as frequency increases, the higher frequencies are at the right side of the display.
5. A demodulator probe will give a "text book" frequency response display as shown in Fig. 39.

OPTIONAL ACCESSORIES

MODEL LC-150 PROBE POUCH

This soft vinyl pouch attaches to the top side of the oscilloscope housing and provides storage space for two probes and instruction manual. Install the probe pouch as follows:

1. Unsnap probe pouch from retainer plate.
2. Align retainer plate with 4 holes on top side of the case, with 4 snaps at the top.
3. Attach the four corners of retainer plate to oscilloscope case with four nylon rivets supplied.
4. Attach probe pouch to retainer plata using the snap fasteners.

MODEL PR-32 DEMODULATOR PROBE

Permits display of modulation envelope of rf signals to 250 MHz.

MODEL PR-45 10:1 PROBE

Standard replacement probe for Model 1560. Bandwidth is 150 MHz and input capacitance is 18 pF with fixed 10:1 attenuation. Supplied with four tips.

MODEL PR-40 10:1/DIRECT PROBE

Standard replacement probe for Model 1540. At 10:1, −3 dB bandwidth is 100 MHz with circuit loading of 10 MΩ and 18 pF. At direct, bandwidth is 15 MHz with circuit loading of 1 MΩ and 100 pF. Supplied with four tips.

MODEL PR-37 DELUXE 10:1/DIRECT PROBE

Deluxe replacement probe. At 10:1, −3 dB bandwidth is 100 MHz with circuit loading of 10 MΩ and 11.5 pF. At direct, bandwidth is 10 MHz with circuit loading of 1 MΩ and 40 pF. Supplied with four tips.

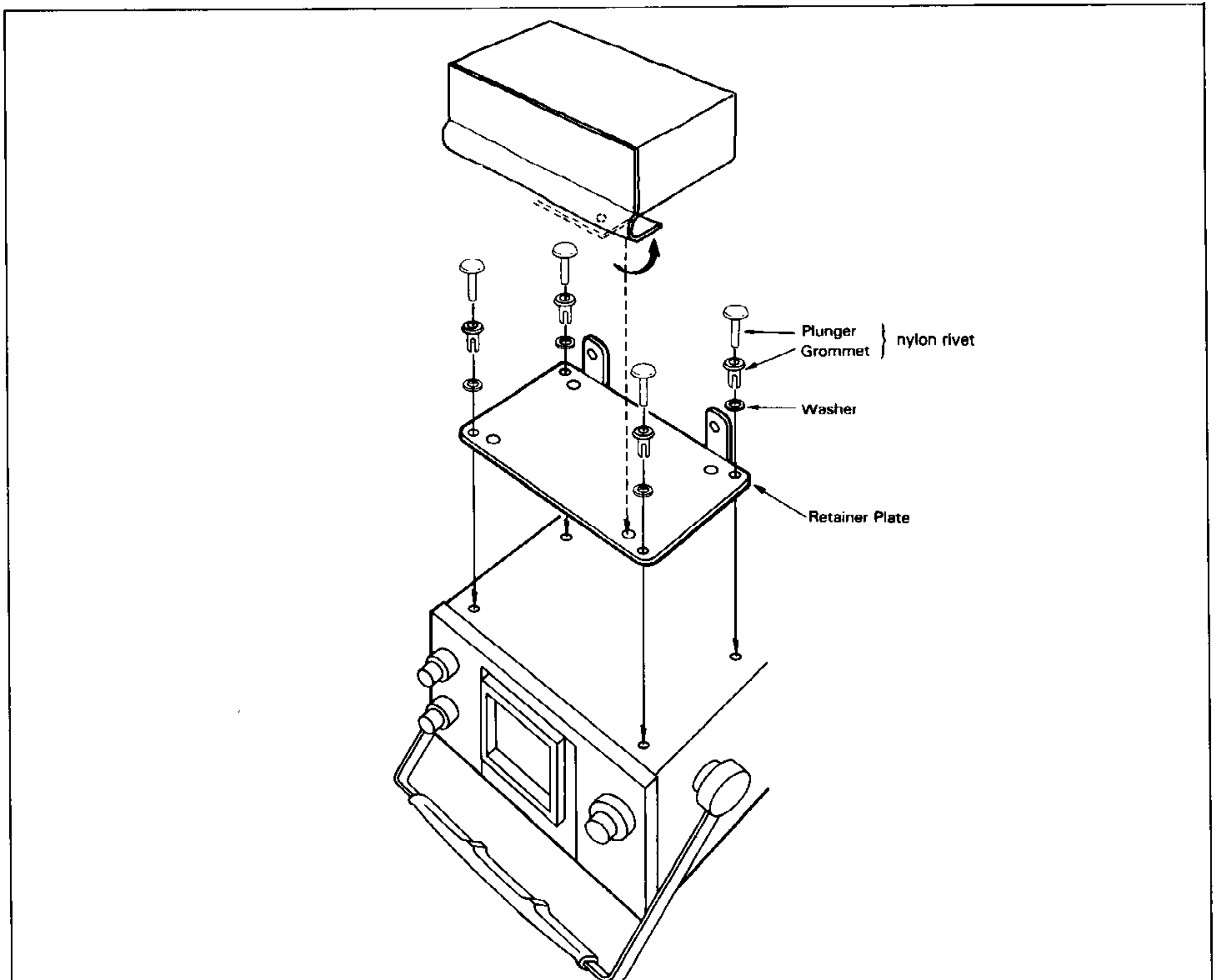

Fig. 40 Installation of LC-150 Probe Pouch.

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MAINTENANCE

WARNING

The following instructions are for use by qualified service personnel only. To evoid electricel shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

High voltage up to 16,000 volts (Model 1560) or 12,000 volts (Model 1540) is present when covers are removed end the unit is operating. Remember that high voltage may be retained indefinitely on high voltage capacitors. Also remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the oscilloscope and discharge high voltage capacitors before performing service procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the oscilloscope will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with a fuse of the proper current rating; 2 amp for 100 or 120 volt operation or 1 amp for 220 or 240 volt operation. The fuse is located on the rear panel.

CASE REMOVAL

To remove the top cover, simply remove the five screws (one from top and two from each side) and lift off the cover. The front of the top cover slides slightly under the lip formad by the front panel bezel. The bottom cover may be similarly removed by removing the bottom screws (plus side panel screws if top cover is not removed) and lifting off the bottom cover.

PERIODIC ADJUSTMENTS

Some adjustments only need to be checked and adjusted periodically. Probe compensation, trace rotation, and astigmatism adjustments are included in this category. Probe compensation and trace rotation adjustment procedures are given in the APPLICATIONS section. The procedure for astigmatism adjustment is given below.

Astigmatism Adjustment

1. Set the TRIG MODE switch to X-Y and both AC-GND-DC switches to GND. This will produce a spot on the screen. *Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may be permanently burned.*
2. With INTENSITY set about mid-range, adjust both the ASTIG and FOCUS controls for the sharpest, roundest spot. Pull out and rotate the PULL ASTIG control to adjust astigmatism. Do not readjust ASTIG after this step.

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the CAL terminal on the screen. This terminal provides a square wave of 0.5 V p-p (within $\pm 6\%$). This signal should produce a displayed waveform amplitude of five divisions at 10 mV/div sensitivity for both channel 1 and 2 (using 10:1 probes). The VARIABLE controls must be set to CAL during this check.

The CAL signal may be used only as a general check of calibration accuracy, not as a signal source for performing recalibration adjustments; a signal source of $\pm 0.5\%$ or better accuracy is required for calibration adjustments.

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of B & **K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTION portion of this manual. There is a nominal charge for instruments out of warranty.

ADDITIONAL SERVICING INFORMATION

A complete service menual will soon be available for the Model 1540 and 1560 Oscilloscopes. Requests for the service manual should be sent to the **B & K-Precision** Service Department address listed in the WARRANTY SERVICE INSTRUCTIONS. Be sure to specify Model 1540 or 1560.

APPENDIX I

IMPORTANT CONSIDERATIONS FOR RISE TIME AND FALL TIME MEASUREMENTS

ERROR IN OBSERVED MEASUREMENT

The "observed" rise time (or fall time) as seen on the CRT is actually the cascaded rise time of the pulse being measured and the oscilloscope's own rise time. The two rise times are combined in square law addition as follows:

$$T_{observed} = \sqrt{(T_{pulse})^2 + (T_{scope})^2}$$

The effect of the oscilloscope's rise time is almost negligible when its rise time is at least 3 times as fast as that of the pulse being measured. Thus, slower rise times may be measured directly from the CRT. However, for faster rise time pulses, an error is introduced that increases progressively as the pulse rise time approaches that of the oscilloscope. Accurate measurements can still be obtained by calculation as described later.

DIRECT MEASUREMENTS

The Model 1560 Oscilloscope has a rated rise time of 5.8 ns at 5 mV/div and higher sensitivity. Thus, pulse rise times of about 18 ns or greater can be measured directly. For Model 1540 with its rated rise time of 8.8 ns, pulse rise times of 27 ns or greater may be measured directly. Most fast rise times are measured at the fastest sweep speed and using ×10 MAG. For Model 1560, this sweep rate is 5 ns/div. A rise time measurement of less than about 4 divisions should be calculated. For Model 1540, the fastest sweep rate is 10 ns/div, and rise time measurements of less than 3 divisions should be calculated.

At 1 mV/div and 2 mV/div sensitivity, the Model 1560's rated rise time is increased to 17.5 ns, and the Model 1540's is increased to 23.4 ns. Pulse rise time must be at least 53 ns or 70 ns respectively for Model 1560 and 1540 for direct measurement on these ranges. Because of this, the 1 mV/div and 2 mV/div ranges should be avoided for rise time measurements if possible.

CALCULATED MEASUREMENTS

For "observed" rise times of less than 18 ns for Model 1560, or 27 ns for Model 1540, the pulse rise time should be calculated to eliminate the error introduced by the cascaded oscilloscope rise time. Calculate pulse rise time as follows:

$$T_{pulse} = \sqrt{(T_{observed})^2 - (T_{scope})^2}$$

LIMITS OF MEASUREMENT

Measurements of pulse rise times that are faster than the scope's rated rise time are not recommended because a very small reading error introduces significant error into the calculation. This limit is reached when the "observed" rise time is about 1.3 greater than the scope's rated rise time; i.e., about 8 ns minimum for Model 1560 and 11 ns minimum for Model 1540.