

# **OPERATORS HANDBOOK**

This Operators Handbook supplements the complete Instruction Manual provided for this instrument. For more detailed information, refer to the Instruction Manual.

## **453A OSCILLOSCOPE**

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# 453A OPERATORS HANDBOOK

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# SPECIFICATIONS

## General

The specifications given in this handbook are only a partial list condensed from the specifications listed in Section 1 of the Instruction Manual. These specifications most directly reflect the capabilities of the 453A.

Characteristic	Performance
<b>VERTICAL DEFLECTION SYSTEM</b>	
Deflection Accuracy	Within 3% of indicated deflection. Cascaded deflection factor uncalibrated.
Bandwidth at -3 dB points (with or without P6061 Probe)	
20 mV to 10 VOLTS/DIV	DC to at least 60 megahertz.
10 mV/DIV	DC to at least 50 megahertz.
5 mV/DIV	DC to at least 40 megahertz.
Channels 1 and 2 cascaded	DC to at least 25 megahertz.

Characteristic	Performance
AC Low-Frequency Response (lower -3 dB point)	
Without probe	1.6 hertz or less at all deflection factors.
With P6061 Probe	0.16 hertz or less at all deflection factors.
Maximum Safe Input Voltage	600 volts DC + peak AC (one kilohertz or less).

## TRIGGERING (A AND B SWEEP)

Internal Trigger Sensitivity	
AC	0.3 division of deflection, minimum, 30 hertz to 10 megahertz; increasing to one division at 60 megahertz.
LF REJ	0.3 division of deflection, minimum, 30 kilohertz to 10 megahertz; increasing to one division at 60 megahertz.

Characteristic	Performance
HF REJ	0.3 division of deflection, minimum, 30 hertz to 50 kilohertz.
DC	0.3 division of deflection, minimum, DC to 10 megahertz; increasing to one division at 60 megahertz.
External Trigger Sensitivity	
AC	50 millivolts, minimum, 30 hertz to 10 megahertz; increasing to 200 millivolts at 60 megahertz.
LF REJ	50 millivolts, minimum, 30 kilohertz to 10 megahertz; increasing to 200 millivolts at 60 megahertz.
HF REJ	50 millivolts, minimum, 30 hertz to 50 kilohertz.
DC	50 millivolts, minimum, DC to 10 megahertz; increasing to 200 millivolts at 60 megahertz.

Characteristic	Performance	
<b>HORIZONTAL DEFLECTION SYSTEM</b>		
<b>A and B Sweep Generator</b>		
Sweep Accuracy Over Center Eight Divisions (0°C to +40°C)	Unmagnified	Magnified
	Within 3%	Within 4%
<b>Mixed and Delayed Sweep</b>		
Mixed Sweep Accuracy	Within 2% ± measured A sweep error when viewing A portion only. B portion accuracy is same as stated under Sweep Accuracy.	
Calibrated Delay Range	Continuous from 50 seconds to 0.2 microsecond.	
Delay Accuracy Over Center Eight Divisions (0°C to +40°C)		
	5 s to 0.1 s/DIV	Within 2.5% of indicated delay.
	50 ms to 1 μs/DIV	Within 1.5% of indicated delay.
Delay Time Jitter	Less than 1 part in 20,000 of the maximum available delay time (10 times A TIME/DIV switch setting).	

Characteristic	Performance
<b>External Horizontal Amplifier</b>	
Input to CH 1 OR X Connector	
Accuracy (0°C to +40°C)	Within 5% of indicated deflection.
X Bandwidth at Upper -3 dB Point	Five megahertz or greater.
Phase difference between X and Y amplifiers	3° or less at 50 kilohertz.
Input to EXT TRIG OR X INPUT Connector	
Deflection Factor	B SOURCE switch in EXT; 270 millivolts/division ±15%. B SOURCE switch in EXT ÷ 10; 2.7 volts/division ±20%.
X Bandwidth at Upper -3 dB point	Five megahertz or greater.

Characteristic	Performance
Phase difference between X and Y amplifiers	3° or less at 50 kilohertz.
<b>CALIBRATOR</b>	
Accuracy (0°C to +40°C)	
Voltage	±1%
Current	±1%
Repetition Rate	±0.5%
Risetime	One microsecond or less.
Output Resistance	Approximately 200 ohms in 1 V position. Approximately 20 ohms in 0.1 V position.
<b>Z AXIS INPUT</b>	
Sensitivity	Five volt peak-to-peak signal produces noticeable modulation at normal intensity.
Usable Frequency Range	DC to 50 megahertz or greater.

Characteristic	Performance
<b>POWER SUPPLY</b>	
Line Voltage	115 volts nominal or 230 volts nominal.
Voltage Ranges (AC, RMS)	
115-volts nominal	90 to 110 volts 104 to 126 volts 112 to 136 volts

Characteristic	Performance
230-volts nominal	180 to 220 volts 208 to 252 volts 224 to 272 volts
Line Frequency	48 to 62 hertz
Maximum Power Consumption	92 watts, one ampere at 60 hertz, 115-volt line

# OPERATING INSTRUCTIONS

## OPERATING VOLTAGE



*This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multiphase system, or across the legs of a single-phase three-wire system.*

The 453A can be operated from either a 115-volt or a 230-volt nominal line voltage source. The Line Voltage Selector assembly on the rear panel converts this instrument from one operating voltage to the other. This assembly also includes the fuses that provide protection for the line-input portion of the instrument. To convert from 115-volt to 230-volt nominal line voltage, or vice versa, remove the cover from the Line Voltage Selector assembly. Then, pull out the Selector switch bar and plug it back into the remaining holes. Change the line-cord power plug to match the power-source receptacle or use a 115- to 230-volt adapter. To change regulating ranges, pull out the Range Selector switch bar, slide it to the desired position and plug it back in. Select a range which is centered about the aver-

age line voltage to which the instrument is to be connected. Replace the cover and tighten the two captive screws. Before applying power to the instrument, check that the indicating tabs on the switch bars are protruding through the correct holes for the desired nominal line voltage and regulating range.

## CONTROLS AND CONNECTORS

### Display

INTENSITY	Controls brightness of display.
FOCUS	Provides adjustment for well-defined display.
BEAM FINDER	Compresses display within graticule area, independent of display position or applied signals.

### Vertical (both channels except as noted)

VOLTS/DIV	Selects vertical deflection factor (VAR control must be in calibrated position for indicated deflection factor).
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## Vertical (cont)

VAR	(Variable) Provides continuously variable deflection factors between the calibrated settings of the VOLTS/DIV switch.	STEP ATTEN BAL	(Step Attenuator Balance) Screwdriver adjustment to balance Input Amplifier in the 5, 10, and 20 mV positions of the VOLTS/DIV switch.
UNCAL	(Uncalibrated) Light indicates that the VAR control is not in the calibrated position.	CH 1 OR X and CH 2 OR Y	Input connector for vertical signal.
POSITION	Controls vertical position of trace.	MODE	Selects vertical mode of operation.
GAIN	Screwdriver adjustment to set gain of the Vertical System.		CH 1: The Channel 1 signal is displayed.
Input Coupling (AC-GND-DC)	Selects method of coupling input signal to Vertical Deflection System.  AC: DC component of input signal is blocked. Low frequency limit (−3 dB point) is about 1.6 hertz.  GND: (Ground) Input circuit is grounded (does not ground applied signal).  DC: All components of the input signal are passed to the Vertical Deflection System.		CH 2: The Channel 2 signal is displayed.  ALT: (Alternate) Dual-trace display of signal on both channels. Display switched between channels at end of each sweep.  CHOP: (Chopped) Dual-trace display of signal on both channels. Display switched between channels at a repetition rate of about 500 kilohertz.



ADD: Channel 1 and 2 signals are algebraically added and the algebraic sum is displayed on the CRT.

INVERT  
(CH 2 only)

Inverts the Channel 2 display when pulled out.

INT TRIG

(Internal Trigger) Selects source of internal trigger signal from vertical system. Also selects the source of the X signal for X-Y mode operation.

NORM: Sweep circuits triggered from displayed channel(s). Channel 1 signal available at CH 1 OUT connector.

CH 1 OR X-Y: Sweep circuits triggered only from the signal applied to the CH 1 OR X connector. No signal available at CH 1 OUT connector. CH 1 lights, located beside A and B SOURCE switches, indicate that the INT TRIG switch is in the CH 1 OR X-Y position. For X-Y mode operation, Channel 1 signal is connected to the Horizontal Amplifier.

**A and B Triggering (both where applicable)**

LEVEL

Selects amplitude point on trigger signal at which sweep is triggered.

HF STAB (A  
Triggering Only)

(High Frequency Stability) Decreases display jitter for high-frequency trigger signals. Has negligible effect at lower repetition rates.

SLOPE

Selects slope of trigger signal which starts the sweep.

+: Sweep can be triggered from positive-going portion of trigger signal.

-: Sweep can be triggered from negative-going portion of trigger signal.

COUPLING

Determines method of coupling trigger signal to trigger circuit.

## A and B Triggering (cont)

AC: Rejects DC and attenuates signals below about 30 hertz. Accepts signals between about 30 hertz and 60 megahertz.

LF REJ: (Low Frequency Reject)  
Rejects DC and attenuates signals below about 30 kilohertz. Accepts signals between about 30 kilohertz and 60 megahertz.

HF REJ: (High Frequency Reject)  
Accepts signals between about 30 hertz and 50 kilohertz; rejects DC and attenuates signals outside the above range.

DC: Accepts all trigger signals from DC to 60 megahertz or greater.

### SOURCE

Selects source of trigger signal.

INT: Internal trigger signal obtained from Vertical Deflection System. When CH 1 light is on, trigger signal is obtained only from the Channel 1 input signal;

CH 1

EXT TRIG INPUT

when the light is off, the trigger signal is obtained from the displayed channel(s). Source of internal trigger signal is selected by the INT TRIG switch.

LINE: Trigger signal obtained from a sample of the line voltage applied to this instrument.

EXT: Trigger signal obtained from an external signal applied to the EXT TRIG INPUT connector.

EXT ÷ 10: Attenuates external trigger signals approximately 10 times.

Light indicates that the internal trigger signal is obtained only from the signal connected to the CH 1 OR X connector (see INT TRIG switch).

Input connector for external trigger signal. Connector for B Triggering also serves as external horizontal input for the X signal when HORIZ DISPLAY switch is in X-Y position

and B SOURCE switch is in EXT position.

### A and B Sweep

#### DELAY-TIME MULTIPLIER

Provides variable sweep delay between 0.20 and 10.20 times the delay time indicated by the A TIME/DIV switch.

#### A VAR

sweep rate of B sweep circuit for delayed or mixed sweep operation only. Variable controls must be in calibrated positions for calibrated sweep rates.

(Variable) Provides continuously variable A sweep rate between the calibrated settings selected by the A TIME/DIV switch. A sweep rate is calibrated when control is set fully clockwise to calibrated.

#### A SWEEP TRIG'D

Light indicates that A sweep is triggered and will produce a stable display with correct INTENSITY and POSITION control settings.

#### B SWEEP MODE

Selects B sweep operation mode.

#### UNCAL A OR B

(Uncalibrated) Light indicates that either the A VAR or B VARIABLE control is not in the calibrated position.

#### TRIGGERABLE AFTER DELAY

TIME: B sweep circuit will not produce a sweep until a trigger pulse is received following the delay time selected by the DELAY TIME (A TIME/DIV) switch and the DELAY-TIME MULTIPLIER dial.

#### A and B TIME/DIV and DELAY TIME

A TIME/DIV switch (clear plastic flange) selects the sweep rate of the A sweep circuit for A sweep only operation and selects the basic delay time (to be multiplied by DELAY-TIME MULTIPLIER dial setting) for delayed or mixed sweep operation. B TIME/DIV (DELAYED SWEEP) switch selects

#### B STARTS AFTER DELAY TIME:

B sweep circuit runs immediately following delay time selected by the DELAY TIME switch

## A and B Sweep (cont)

and DELAY-TIME MULTIPLIER dial.

HORIZ DISPLAY Selects horizontal mode of operation.

A: Horizontal deflection provided by A sweep. B sweep inoperative.

A INTEN DURING B: Sweep rate determined by A TIME/DIV switch. An intensified portion appears on the display during the B sweep time. This switch position provides a check of the duration and position of B sweep (delayed sweep) with respect to the delaying sweep (A).

B (DELAYED SWEEP): Sweep rate determined by B TIME/DIV switch with the delay time determined by the setting of the DELAY TIME (A TIME/DIV) switch and the DELAY-TIME MULTIPLIER dial. Sweep mode

MAG

A SWEEP MODE

determined by B SWEEP MODE switch.

MIXED: Both time bases are operating. The sweep rate of the first part of the sweep is determined by the A TIME/DIV switch; the last part is determined by the B TIME/DIV switch. The amount of display allocated to each time base is determined by the setting of the DELAY-TIME MULTIPLIER dial.

X-Y: Horizontal deflection provided by an external signal.

(Magnifier) Increases sweep rate to ten times setting of the A or B TIME/DIV switch by horizontally expanding the center division of the display. Light indicates when magnifier is on (magnifier inoperative in X-Y mode).

Determines the operating mode for A sweep.

**AUTO TRIG:** (Automatic Trigger)  
Sweep Initiated by the applied trigger signal at point selected by the A LEVEL control when the trigger signal repetition rate is above about 20 hertz and within the frequency range selected by the A COUPLING switch. Triggered sweep can be obtained only over the amplitude range of the applied trigger signal. When the A LEVEL control is outside the amplitude range, the trigger repetition rate is below the lower frequency limit (or above upper limit for HF REJ), or the trigger signal is inadequate, the sweep free runs at the sweep rate selected by the TIME/DIV switch to produce a bright reference trace.

**NORM TRIG:** (Normal Trigger)  
Sweep initiated by the applied trigger signal at point selected by the A LEVEL control over the frequency range selected by the A COUPLING switch. Triggered sweep can be obtained only over the amplitude range of the

applied trigger signal. When the A LEVEL control is outside the amplitude range, the trigger repetition rate is outside the frequency range selected by the A COUPLING switch, or the trigger signal is inadequate, there is no trace.

**SINGLE SWEEP:** After a sweep is displayed, further sweeps cannot be presented until the RESET button is pressed. Display is triggered as for NORM operation using the A Triggering controls.

**RESET**

When the RESET button is pressed (SINGLE SWEEP mode), a single display will be presented (with correct triggering) when the next trigger pulse is received. RESET light (inside RESET button) remains on until a trigger is received and the sweep is completed. RESET button must be pressed again before another sweep can be displayed.

**A SWEEP LENGTH**

Adjusts length of A sweep. In the FULL position (clockwise detent),

## A and B Sweep (cont)

the sweep is at least 10 divisions long. As this control is rotated counterclockwise, the length of A sweep is reduced until it is less than four divisions long just before the detent in the fully-counterclockwise position is reached. In the B ENDS A position (counterclockwise detent), the A sweep is reset at the end of the B sweep to provide the fastest possible sweep repetition rate for delayed sweep displays.

POSITION	Controls horizontal position of trace.
FINE	Provides more precise horizontal position adjustment.
1 kHz CAL	(One-kilohertz calibrator) Calibrator output connector.
POWER ON	Light: Indicates that POWER switch is on and the instrument is connected to a line voltage source.

Switch: Controls power to the instrument.

### Side Panel

ASTIG

(Astigmatism) Screwdriver adjustment used in conjunction with the FOCUS control to obtain a well-defined display. Does not require re-adjustment in normal use.

B TIME/DIV  
VARIABLE

Provides continuously variable B sweep rate between the calibrated settings of the B TIME/DIV switch. B sweep rate is calibrated when control is set fully clockwise to CAL.

PROBE LOOP

Current loop providing five-milliampere square-wave current from calibrator circuit.

A GATE

Output connector providing a rectangular 12 volt pulse coincident with A Sweep.

B GATE

Output connector providing a rectangular 12 volt pulse coincident with B Sweep.

CH 1 OUT (Channel 1 Output) Output connector providing a sample of the signal applied to the CH 1 OR X connector when the INT TRIG switch is in the NORM position.

CALIBRATOR Switch selects output voltage of Calibrator. One-volt and 0.1-volt square wave available.

TRACE ROTATION Screwdriver adjustment to align trace with horizontal graticule lines.

### Rear Panel

Z AXIS INPUT Input connector for intensity modulation of the CRT display.

Line Voltage Selector Switching assembly to select the nominal operating voltage and the line voltage range. The assembly also includes the line fuses.

Voltage Selector: Selects nominal operating voltage range (115 V or 230 V).

Range Selector: Selects line voltage range (low, medium, high).

## GENERAL OPERATING INFORMATION

### Simplified Operating Instructions

**General.** The following operating instructions will allow calibrated measurements in most applications. The operator should be familiar with the complete function and operation of the instrument as described in the complete 453A Instruction Manual before using this procedure.

### Normal Sweep Display

1. Set INTENSITY control fully counterclockwise.
2. Set Input Coupling switches to AC, VAR VOLTS/DIV controls to calibrated, and vertical MODE switch to CH 1 (use ALT or CHOP for dual-trace display).
3. Push A SWEEP MODE, A SLOPE, A COUPLING, and A SOURCE switches to the up position.
4. Set A TIME/DIV switch to 1 ms/DIV, A VAR control to calibrated and HORIZ DISPLAY switch to A.
5. Set POWER switch to ON. Allow several minutes warmup.

6. Connect signal to the CH 1 OR X connector.

7. Advance INTENSITY control until display is visible (if display is not visible with INTENSITY control at mid-range, press BEAM FINDER switch and adjust VOLTS/DIV switch until display is reduced in size vertically; then center compressed display with vertical and horizontal POSITION controls; release BEAM FINDER switch). Set FOCUS control for well-defined display.

8. Set VOLTS/DIV switch and vertical POSITION control for display which remains within display area vertically.

9. Set A LEVEL control for stable display.

10. Set A TIME/DIV switch and horizontal POSITION control for display which remains within the display area horizontally.

11. To make a peak-to-peak voltage measurement, use the following procedure:

a. Turn the vertical POSITION control so the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top

of the waveform is within the viewing area. Move the display with the horizontal POSITION control so one of the peaks lies near the center vertical line.

b. Measure the divisions of vertical deflection from peak to peak. Make sure the VAR VOLTS/DIV control is in the calibrated position.

12. To measure the time between two points on a waveform, use the following procedure:

a. Set the A TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the time measurement points.

b. Adjust the vertical POSITION control to move the points, between which the time measurement is made, to the center horizontal graticule line.

c. Adjust the horizontal POSITION control to center the display within the center eight divisions of the graticule.

d. Measure the horizontal distance between the time measurement points. Be sure the A VAR control is set to the calibrated position.

e. Multiply the distance measured in step d by the setting of the TIME/DIV switch.



## Magnified Sweep Display

1. Follow steps 1 – 10 for Normal Sweep Display.
2. Adjust horizontal POSITION control to move area to be magnified within center division of CRT. If necessary, change TIME/DIV switch setting so complete area to be magnified is within center division.
3. Set MAG switch to X10 and adjust horizontal FINE control for precise positioning of magnified display.

## Delayed Sweep Display

1. Follow steps 1 – 10 for Normal Sweep Display.
2. Set B SWEEP MODE switch to B STARTS AFTER DELAY TIME, HORIZ DISPLAY switch to A INTEN DURING B, and A SWEEP LENGTH control to FULL.
3. Pull out DELAYED SWEEP (B TIME/DIV) switch and turn clockwise so intensified zone on display is desired length (intensified zone will be displayed in delayed form). If intensified zone is not visible, change INTENSITY control setting.

4. Adjust DELAY-TIME MULTIPLIER dial to position intensified zone to portion of display to be delayed.

5. Set HORIZ DISPLAY switch to B (DELAYED SWEEP). Delayed sweep rate is shown by dot on DELAYED SWEEP (B TIME/DIV) switch.

6. For delayed display with less jitter, set B SWEEP MODE switch to TRIGGERABLE AFTER DELAY TIME, all B Triggering switches up, and adjust B LEVEL control for stable display.

## Mixed Sweep Display

1. Follow steps 1 – 10 for Normal Sweep Display.
2. Set the B SWEEP MODE switch to B STARTS AFTER DELAY TIME, HORIZ DISPLAY switch to MIXED, and A SWEEP LENGTH to FULL.
3. Pull out DELAYED SWEEP (B TIME/DIV) switch and turn clockwise to obtain the amount of magnification desired.

4. Adjust DELAY-TIME MULTIPLIER dial to vary the amount of delay time before the start of the magnified portion of the display.

5. For mixed sweep display with less jitter, set B SWEEP MODE switch to TRIGGERABLE AFTER DELAY TIME, all B Triggering switches up, and adjust B LEVEL control for stable display.

### **X-Y Display**

1. Set INTENSITY control fully counterclockwise.

2. Set both Input Coupling switches to AC and VAR VOLTS/DIV controls to calibrated.

3. Set INT TRIG switch to CH 1 OR X-Y and HORIZ DISPLAY switch to X-Y.

4. Set POWER switch to ON. Allow several minutes warmup.

5. Connect X (horizontal) signal to CH 1 OR X connector and Y (vertical) signal to CH 2 OR Y connector.

6. Advance INTENSITY control until display is visible (if display is not visible, press BEAM FINDER switch and adjust CH 1 and CH 2 VOLTS/DIV switches until display is reduced in size both vertically and horizontally; then center compressed display with CH 1 and CH 2 POSITION controls; release BEAM FINDER switch). Set FOCUS control for well-defined display.

7. Set CH 1 and CH 2 VOLTS/DIV switches and POSITION controls for display which remains within display area. CH 1 controls affect horizontal deflection and CH 2 controls affect vertical deflection.

# USER'S CALIBRATION

## General

The following procedure provides calibration information for external adjustments of the 453A. See the complete Instruction Manual for detailed calibration instructions.

## Astigmatism

Obtain a display of the calibrator waveform. Adjust ASTIG in conjunction with the FOCUS control for the best definition of the square-wave display.

## Trace Rotation

Obtain a free-running trace. Adjust TRACE ROTATION so the trace aligns with the horizontal lines of the graticule.

## Vertical Gain

Connect the .1 volt calibrator signal to the input connector of either vertical input channel. Set the vertical MODE switch to display that channel and set that channel's deflec-

tion factor to 20 mV/DIV. Adjust the front-panel GAIN adjustment of the channel for exactly 5 divisions of deflection.

The best measurement accuracy when using probes is provided if the GAIN adjustment is made with the probes installed. Connect the one-volt calibrator signal to the probe tip.

## Step Attenuator Balance

Set both Input Coupling switches to GND and obtain a free-running alternate dual-trace display. Adjust the STEP ATTEN BAL control in each input channel for no trace shift when switching the appropriate attenuator switch between the 5, 10, and 20 mV/div positions.

## X Gain Check (X-Y Operation)

Set the HORIZ DISPLAY switch to X-Y and the INT TRIG switch to CH 1 OR X-Y. Set the CH 1 attenuator switch to 20 mV/div and the CH 1 Input Coupling switch to DC. Apply the .1 volt calibrator signal to the CH 1 OR X connector. Check for exactly five divisions of horizontal deflection between the displayed dots.

## Timing Check

Connect the calibrator signal to the input of either vertical channel and set the vertical MODE switch to display this channel. Set the HORIZ DISPLAY switch to display either time base. Adjust the appropriate triggering controls for a

triggered display at a sweep rate of one millisecond/division. Check the display for one complete cycle of the calibrator waveform for each horizontal division. For more precise timing check, refer to the calibration procedure given in the complete Instruction Manual.