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TEKTRONIX®

465

OSCILLOSCOPE

WITH OPTIONS

(SN B250000 & UP)

SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
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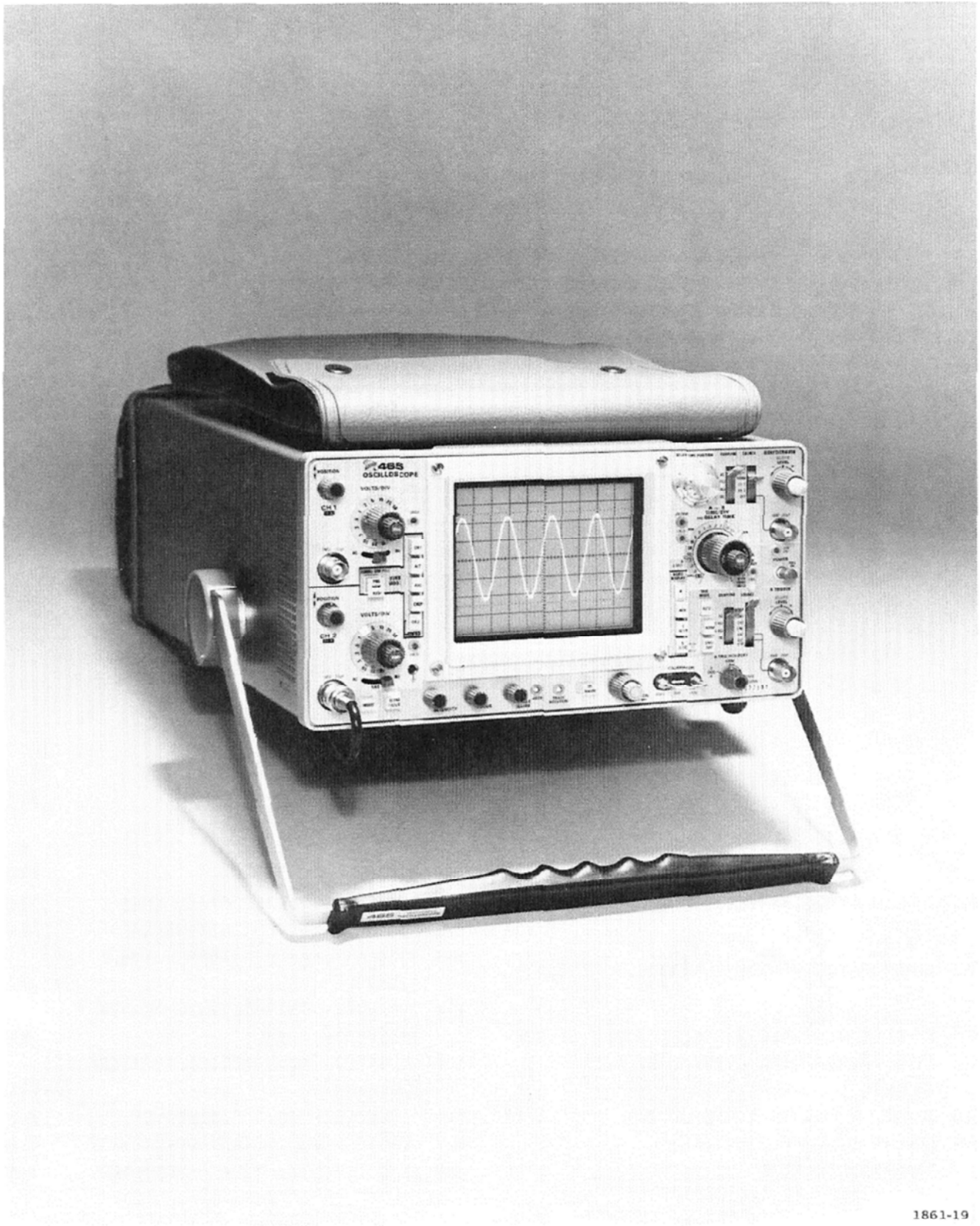


Fig. 1-1. 465 Oscilloscope.

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SPECIFICATIONS

Introduction

The 465 Oscilloscope is a wide-band, portable oscilloscope designed to operate in a wide range of environmental conditions. The instrument is light in weight and compact of design for ease of transportation, yet capable of performance necessary for accurate high-frequency measurements. The dual-channel dc-to-100 megahertz vertical deflection system provides calibrated deflection factors from 5 millivolts to 5 volts/division. The bandwidth limiting switch reduces interference from signals above about 20 megahertz for viewing low-frequency, low-level signals.

The trigger circuits provide stable sweep triggering to beyond the bandwidth of the vertical deflection system. Separate controls are provided to select the desired mode of triggering for the A and B sweeps. The A sweep can be operated in one of three modes: automatic triggering, normal triggering, or single sweep. A variable trigger holdoff control provides the ability for A sweep to trigger stably on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.05 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of 5 nanoseconds/division in the 0.05 μs position. The delayed and mixed sweep features allow the start of the B sweep to be delayed a selected amount from the start of A sweep to provide accurate relative-time measurements. Calibrated X-Y measurements can be made with Channel 2 providing the vertical deflection and Channel 1 providing the horizontal deflection (TIME/DIV switch fully counterclockwise and VERT MODE switch to CH 2). The regulated dc power supplies ensure that instrument performance is not affected by variations in line voltage and frequency. Maximum power consumption of the instrument is approximately 75 watts.

The following instrument specifications apply over an ambient temperature range of −15°C to +55°C unless otherwise specified. Warm-up time for specified accuracies is 20 minutes. The calibration procedure given in section 6, if performed completely, will allow an instrument to meet the electrical characteristics listed below.

VERTICAL DEFLECTION SYSTEM

Deflection Factor

Calibrated range is from 5 millivolts to 5 volts/division in 10 steps in a 1-2-5 sequence. Accuracy is within 3%. Uncalibrated VAR control provides deflection factors continuously variable between the calibrated settings and extends deflection factor to at least 12.5 volts/division in the 5 VOLTS/DIV position.

Frequency Response

Bandwidth in both Channel 1 and Channel 2 is dc to at least 100 megahertz from −15°C to +40°C and dc to at least 85 megahertz from +40°C to +55°C. Risetime is 3.5 nanoseconds or less from 0°C to +40°C and 4.2 nanoseconds or less from +40°C to +55°C. The ac-coupled lower −3 dB point is 10 hertz or less (1 hertz or less when using a 10X probe). Vertical system bandwidth with the BW LIMIT pushbutton pulled is approximately 20 megahertz.

Chopped Mode Repetition Rate

Approximately 250 kilohertz.

Input Resistance And Capacitance

One megohm within 2% paralleled by approximately 20 picofarads.

Maximum Input Voltage

Dc coupled: 250 V (dc + peak ac) or 500 V p-p ac at 1 kHz or less.

Ac coupled: 500 V (dc + peak ac) or 500 V p-p ac at 1 kHz or less.

Cascaded Operation (CH 1 VERT SIGNAL OUT Connected to CH 2 OR Y)

Bandwidth is dc to at least 50 MHz with a sensitivity of at least 1 millivolt/division.

TRIGGERING

Sensitivity

DC Coupled: 0.3 division internal or 50 millivolts external from dc to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz.

AC Coupled: 0.3 division internal or 50 millivolts external from 60 hertz to 25 megahertz, increasing to 1.5 divisions internal or 150 millivolts external at 100 megahertz. Attenuates all signals below about 60 hertz.

LF REJ Coupled: 0.5 division internal or 100 millivolts external from 50 kilohertz to 25 megahertz, increasing to 1.5 divisions internal or 300 millivolts external at

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100 megahertz. Blocks dc and attenuates all signals below about 50 kilohertz.

HF REJ Coupled: 0.5 division internal or 100 millivolts external from 60 hertz to 50 kilohertz. Blocks dc and attenuates all signals below about 60 hertz and above about 50 kilohertz.

Trigger Jitter

0.5 nanosecond or less at 5 nanoseconds/division with 100 megahertz applied (X10 MAG on).

External Trigger Input

Maximum input voltage is 250 volts (dc + peak ac) or 250 volts peak to peak ac (1 kilohertz or less). Input resistance is 1 megohm within 10%.

Level Range

EXT: At least + and −2 volts, 4 volts peak to peak.

EXT ÷10: At least + and −20 volts, 40 volts peak to peak.

HORIZONTAL DEFLECTION SYSTEM

Calibrated Sweep Range

A Sweep: From 0.5 second/division to 0.05 microsecond/division in 22 steps in a 1-2-5 sequence. X10 MAG extends maximum sweep rate to 5 nanoseconds/division.

B Sweep: From 50 milliseconds/division to 0.05 microsecond/division in 19 steps in a 1-2-5 sequence. X10 MAG extends maximum sweep rate to 5 nanoseconds/division.

Calibrated Sweep Accuracy

Unmagnified sweep accuracy is within 2% from +20°C to +30°C (+68°F to +86°F) and within 3% from −15°C to +20°C and +30°C to +55°C (+5°F to +68°F and +86°F to +131°F). For the same temperature ranges, magnified sweep accuracy is within 3% and within 4% respectively. Exclude the first and last 50 nanoseconds of the 5 nanoseconds, 10 nanoseconds, and 20 nanoseconds magnified sweep rates. Accuracy specifications apply over full 10 divisions unless otherwise specified.

Sweep accuracy, over any 2 or less division portion of the sweep, is within 5%. Exclude the first and last magnified divisions of the 5 nanosecond and 10 nanosecond/division magnified sweep rates. Also exclude the first and last 50 nanoseconds of the 5, 10, and 20 nanoseconds/division sweep rates.

Mixed sweep accuracy is within 2% plus the measured A sweep error when viewing the A sweep portion only. The B sweep portion retains its normal accuracy.

A Time/Division Variable Range

Provides continuously variable (Uncalibrated) sweep rates between the calibrated settings of the A TIME/DIV switch. Extends the slowest A sweep rate to at least 1.25 seconds/division.

A Trigger Holdoff

Increases A sweep holdoff time by at least a factor of 10.

Delay Time And Differential Time Measurement Accuracy

	+10°C to +35°C (+50°F to +95°F)	−15°C to +55°C (+5°F to +131°F)
Over 1 Or More Major Dial Division	±1%	±2.5%
Over Less Than 1 Major Dial Division	±0.01 Major Dial Division	±0.03 Major Dial Division

Delay or Differential Time Jitter

Within 0.002% (less than one part in 50,000) of the maximum available delay time when operating on power line frequencies other than 50 hertz.

Within 0.005% (less than one part in 20,000) of the maximum available delay time when operating on 50 hertz power line frequency.

Maximum available delay time is 10 times the setting of the A TIME/DIV switch.

Calibrated Delay Time (A VAR set to calibrated position)

Continuous from 5 seconds to 0.2 microsecond.

X-Y OPERATION

Sensitivity

Same as vertical deflection system.

X Axis deflection accuracy within 4%.

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Variable Range

Same as vertical deflection system.

X-Axis Bandwidth

Dc to at least 4 megahertz.

Y-Axis Bandwidth

Same as vertical deflection system.

Input Resistance

Same as vertical deflection system.

Input Capacitance

Same as vertical deflection system.

Maximum Usable Input Voltage

Same as vertical deflection system.

CALIBRATOR

Output

An approximate 1 kilohertz, 30 milliampere (within 2%), 300 millivolt (within 1%), square-wave signal.

Z AXIS INPUT

Sensitivity

A 5-volt peak to peak signal causes noticeable modulation at normal intensity.

Usable Frequency Range

From dc to 50 megahertz.

SIGNAL OUTPUTS

Ch 1 Vertical

Output voltage is at least 50 millivolts/division into a 1 megohm load (at least 25 millivolts/division into a 50 ohm load).

Bandwidth is from dc to at least 50 megahertz into a 50 ohm load.

Output dc level is approximately zero volts.

A and B +Gate

Output voltage is approximately 5.5 volts, positive-going.

POWER SOURCE

Line Voltages

110, 115, 120, 220, 230, or 240 Volts ac (all within 10%), depending on the settings of the Line Voltage Selector switch and the Regulating Range Selector assembly, with a line frequency of 48 to 440 hertz. Maximum power consumption is 75 watts at 115 volts ac, 60 hertz.

CATHODE-RAY TUBE (CRT)

Graticule Area

Eight by 10 centimeters.

Phosphor

P31 is the standard phosphor with P11 offered as an option.

SUPPLEMENTAL INFORMATION

NOTE

The following supplemental information represents limits that, when met, ensure optimum instrument operation. They are, however, not instrument specifications but are intended to be used only as maintenance or operational aids.

VERTICAL DEFLECTION SYSTEM

Low—Frequency Linearity

There should be no more than 0.1 division of compression or expansion of a 2-division signal, at center screen, when the signal is positioned to the upper and lower extremes of the crt graticule area.

Bandwidth Limiter Switch

The −3 dB point should be between 15 and 25 megahertz with the 20 MHz BW switch pulled (yellow showing).

Step Response Aberrations

Aberrations on a positive going 5 division step should be +3%, −3% or less not to exceed 3% peak-to-peak on

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all ranges except at 5 VOLTS/DIV. Aberrations at 5 VOLTS/DIV should be +4%, −4% or less not to exceed 4% peak-to-peak. Position effect should cause aberrations to be no more than +5%, −5% not to exceed 5% peak-to-peak.

Common-Mode Rejection Ratio (CMRR)

At least 10:1 at 20 megahertz for common mode signals of 6 divisions or less with vertical gain adjusted for best cmrr at 50 kilohertz.

Step Attenuator Balance

Adjustable to 0.2 division or less of trace shift when switching between adjacent deflection factors.

Trace Shift as Variable is Rotated

Adjustable to 1 division or less.

Invert Trace Shift

Two divisions or less when switching from normal to inverted.

Input Gate Current

0.5 nanoampere or less (0.1 division of deflection at 5 millivolts/division) from +20°C to +30°C. Four nanoamperes or less (0.8 division of deflection at 5 millivolts/division) from −15°C to +55°C.

Channel Isolation

At least 100:1 at 25 megahertz.

Position Range

Twelve divisions up and 12 divisions down from graticule center.

TRIGGERING

External Trigger Input Capacitance

Twenty picofarads within 30%.

HORIZONTAL DEFLECTION SYSTEM

A Sweep Length

10.5 to 11.5 divisions.

Magnifier Registration

There should be 0.2 division or less difference at graticule center when switching from MAG on to MAG off.

Position Range

Should be able to position the start of the sweep to the right of graticule center, and the end of the sweep to the left of graticule center.

Phase Difference Between X And Y Axes Amplifiers

Typically 3° or less from dc to 50 kilohertz.

CALIBRATOR

Repetition Rate

Repetition rate accuracy is 1 kilohertz within 25%.

Output Resistance

Approximately 9.4 ohms.

EXTERNAL Z AXIS INPUT

Voltages applied to the EXT Z AXIS INPUT connector should be limited to less than 100 volts (dc + peak ac) or 100 volts peak to peak ac at 1 kilohertz or less.

OUTPUT RESISTANCES

Output resistance of the CH 1 VERT SIG OUT connector is approximately 50 ohms.

Output resistance of A+ and B+ GATE outputs is approximately 500 ohms.

CATHODE-RAY TUBE

Resolution

Typically at least 15 lines/division horizontally and vertically.

Geometry

0.1 division or less of tilt or bowing.

Raster Distortion

0.1 division or less.

Nominal Accelerating Potential

Approximately 18,500 volts.

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