

SPECIFICATION

Introduction

The 475 Oscilloscope is a wide bandwidth, 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-200 megahertz vertical deflection system provides calibrated deflection factors from 2 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 in a stable manner on aperiodic signals or complex digital

words. The horizontal deflection system has calibrated sweep rates from .5 second to .01 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of one nanosecond/division in the .01 μ s position. The delayed and mixed sweep features allow the start of 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 100 watts.

The following instrument specifications apply over an ambient temperature range of -15°C to $+55^{\circ}\text{C}$ unless otherwise specified. Warm-up time for specified accuracies is 20 minutes. The calibration procedure given in section 5, if performed completely, will allow an instrument to meet the electrical characteristics listed below.

VERTICAL DEFLECTION SYSTEM

Deflection Factor

Calibrated range is from 2 millivolts to 5 volts per division in 11 steps in a 1-2-5 sequence. Accuracy is within 3%. Uncalibrated VAR control provides deflection factors continuously variable between the calibrated settings. Extends deflection factor to at least 12.5 volts per division in the 5 volts/div position.

Frequency Response

Bandwidth in both Channel 1 and Channel 2 is DC to at least 200 megahertz. Risetime is 1.75 nanoseconds or less¹. 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 one megahertz.

Input Resistance And Capacitance

One megohm within 2%, paralleled by approximately 20 picofarads.

¹Risetime (in nanoseconds) is calculated from the formula 0.35 divided by bandwidth (in megahertz).

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 2 VERTICAL SIGNAL OUT connected to CH 1 OR X)

Bandwidth is DC to at least 50 MHz with a sensitivity of approximately 400 μ V/division.

TRIGGERING

Sensitivity

DC Coupled: 0.3 division internal or 50 millivolts external from DC to 40 megahertz, increasing to 1.5 divisions internal or 250 millivolts external at 200 megahertz.

AC Coupled: 0.3 division internal or 50 millivolts external from 60 hertz to 40 megahertz, increasing to 1.5 divisions internal or 250 millivolts external at 200 megahertz. Attenuates all signals below about 60 hertz.

Specification—475

LF REJ Coupled: 0.3 division internal or 100 millivolts external from 50 kilohertz to 40 megahertz, increasing to 1.5 divisions internal or 500 millivolts external at 200 megahertz. Blocks DC and attenuates all signals below about 50 kilohertz.

HF REJ Coupled: 0.3 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

0.2 nanosecond or less at 200 megahertz at 1 nanosecond/division (X10 MAG on).

External Trigger Input

Maximum input voltage is 250 V DC + peak AC or 250 V P-P AC (1 kilohertz or less). Input impedance is 1 megohm within 10%, paralleled by approximately 20 picofarads.

LEVEL Control Range

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

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

Exclude the LF REJ coupling mode.

Trigger View Deflection Factor

Approximately 50 millivolts/division.

HORIZONTAL DEFLECTION SYSTEM

Calibrated Sweep Range

A Sweep or B DLYD Sweep: from 0.5 second/division to 0.01 microsecond/division in 24 steps in a 1-2-5 sequence. X10 MAG extends maximum sweep rate to 1 nanosecond/division.

A Delaying Sweep: from 0.5 second/division to 0.05 microsecond/division in 22 steps in a 1-2-5 sequence.

Calibrated Sweep Accuracy (Over full ten horizontal divisions)

	X1 MAG	X10 MAG
+20°C to +30°C		
A or B DLYD Sweep		
5 ms/div to 0.01 μs/div	±1%	±2%
.5 s/div to 10 ms/div	±2%	±3%
A INT Sweep		
All rates	±2%	±3%
-15°C to +55°C		
All Sweeps, All Rates	±3%	±4%

X10 Magnified Sweep Accuracy

Within 5% over any two-division interval.

Mixed Sweep Accuracy

Within 3%

Variable Time/Division Control Range

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

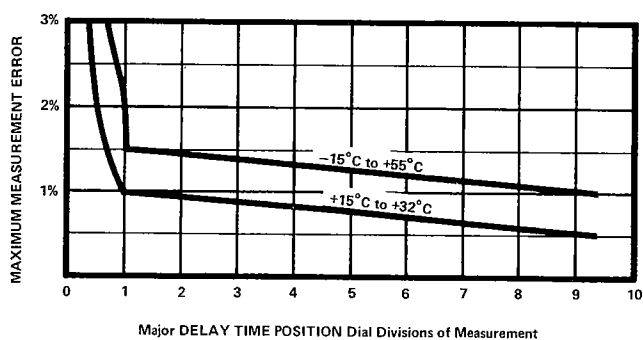
A Trigger Holdoff

Increases A sweep holdoff time to at least nine times the TIME/DIV switch setting.

Delay Time And Differential Time Measurement Accuracy (Simplified)

	+15°C to +35°C (+60°F to +95°F)	-15°C to +55°C (+5°F to +131°F)
Over One Or More Major Dial Divisions Over Less Than One Major Dial Division	±1%	±1.5%
	±0.01 Major Dial Division	±0.02 Major Dial Division

Delay Time And Differential Time Measurement Accuracy (Detailed)



Delay Pickoff Jitter

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

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

Delay Range

From 0.05 microsecond or less to at least 5 seconds after the start of the delaying (A) sweep.

X-Y OPERATION

Sensitivity

Same as vertical deflection system.

Deflection Accuracy

Same as vertical deflection system.

Variable Range

Same as vertical deflection system.

X-Axis Bandwidth

DC to 3 MHz.

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 repetition rate, 30 milliamperes ($\pm 2\%$), 300 millivolt ($\pm 1\%$) 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 2 VERT SIGNAL OUT

Output voltage is approximately 20 millivolts/division into a 1 megohm load (approximately 10 millivolts/division into 50 ohm load).

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

Output DC level is approximately zero volts.

A and B +GATE Outputs

Output voltage is approximately 5 volts positive-going.

POWER SOURCE

Line Voltages

110, 115, 120, 220, 230, or 240 VAC (all $\pm 10\%$) depending on the settings of the Line Voltage Selector switch and the Regulating Range Selector assembly, with a

Specification—475

line frequency of 48 to 440 hertz. Maximum power consumption is 100 watts at 115 VAC, 60 hertz.

CATHODE-RAY TUBE

Graticule Area

Eight by ten centimeters.

Phosphor

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

ENVIRONMENTAL

Temperature

Operating: -15°C to $+55^{\circ}\text{C}$; Storage: -55°C to $+75^{\circ}\text{C}$.

Altitude

Operating: to 15,000 feet. Maximum operating temperature decreased $1^{\circ}\text{C}/1,000$ feet above 5,000 feet.

Storage: to 50,000 feet.

Humidity (Operating and Storage)

5 cycles (120 hours) referenced to MIL-E-16400F.

Vibration

15 minutes along each of three major axes at a total displacement of 0.025" peak to peak (4 g's at 55 hertz) with frequency varied from 10 hertz to 55 hertz to 10 hertz in one minute sweeps. After sweep vibration in each axis, hold the frequency steady at each major resonance for 3 minutes, or if no such resonances are found, hold at 55 hertz for 3 minutes.

Shock (Operating and Nonoperating)

30 g's 1/2 sine, 11 milliseconds duration, 2 shocks per axis each direction for a total of 12 shocks.

Transportation

Tested to National Safe Transit Committee Procedure 1A, with a 30-inch drop.

SUPPLEMENTAL INFORMATION

The supplemental information listed here 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 two-division signal (at center screen) positioned to the upper and lower extremes of the graticule area.

Bandwidth Limiter Bandwidth

The -3 dB point should be between 15 and 25 megahertz.

Step Response Aberrations

There should be less than +4%, -4% , or a total of 4% peak to peak aberration on a positive-going step in the 5 mV/DIV position of the VOLTS/DIV switch. Add 3% when checking a negative-going step or when checking for aberrations while operating in the added mode.

Common-Mode Rejection Ratio

At least 20:1 at 1 kilohertz for common-mode signals of 8 divisions or less.

Trace Shift As Variable Is Rotated

Adjustable to 2 divisions or less.

INVERT Trace Shift

One division or less when switching from normal to inverted.

Input Gate Current

1 nanoampere or less (0.2 division at 5 mV/division) from $+20^{\circ}\text{C}$ to $+30^{\circ}\text{C}$. Four nanoamperes or less (0.8 division at 5 mV/division) from -15°C to $+55^{\circ}\text{C}$.

Channel Isolation

At least 100:1 at 50 megahertz.

POSITION Control Range

At least +12 and -12 divisions from graticule center.

Signal Delay Between Channel 1 and Channel 2

± 0.25 nanosecond at 5 mV/DIV.

Input R and C Time Constant

Aberrations should be 2% or less using a one megohm, 20 picofarad input time-constant normalizer.

TRIGGERING**External Trigger Input Capacitance**

Twenty picofarads within 30%.

TRIG VIEW Deflection Factor

50 mV/div $\pm 20\%$. Exclude LF REJ and HF REJ trigger coupling modes.

TRIG VIEW Risetime

≤ 3.5 nanoseconds over the 10% to 90% part of the fast rise portion.

TRIG VIEW Delay Difference

≤ 2 nanoseconds with 5 division signal having 1 nanosecond or less risetime from 25 ohm source, centered vertically with equal cable length from signal source to vertical channel and external trigger inputs, each terminated in 50 ohms.

TRIG VIEW Centering of Trigger Point

Adjustable to within one division of center screen.

HORIZONTAL DEFLECTION SYSTEM**Sweep Accuracy**

Exclude the first 25 nanoseconds or 2 divisions (whichever is greater) and all beyond the 100th division of the sweep when checking 1 ns through 500 ns/division magnified sweep rates.

Mixed Sweep Accuracy

Exclude the first 0.5 division after the display start, and the first 0.2 division or 0.1 microsecond (whichever is greater) after the transition of A to B.

Differential Time Measurement Accuracy

Exclude DELAY TIME POSITION dial settings of 0.00 through 0.50 for 0.5 second through 1.0 microsecond/division delaying sweep rates.

Exclude DELAY TIME POSITION dial settings of 0.00 through 1.00 for 0.5 microsecond through 0.05 microsecond/division delaying sweep rates.

Sweep Length (A Only)

At least 10.1 divisions.

Magnifier Registration

Within 0.5 division from graticule center at 1 millisecond/division.

POSITION Control Range

Start of sweep must position to right of graticule center. End of sweep must position to left of graticule center. Check made at 1 millisecond/Division sweep rate.

Phase Difference between X and Y Axes Amplifiers

Within 1° from DC to 1 megahertz. Within 3° from 1 megahertz to 2 megahertz.

X Axis Low Frequency Linearity

0.2 division or less compression or expansion of a 2 division signal (at center screen) positioned to both horizontal extremes of the display area.

CALIBRATOR**Repetition Rate**

Repetition Rate accuracy is typically within 25%.

Output Resistance

Approximately 9.4 ohms.

EXTERNAL Z AXIS INPUT**Maximum Input Voltage**

Voltages applied to the EXT Z AXIS INPUT connector should be limited to less than 100 volts DC plus peak AC or 100 volts peak to peak AC at 1 kilohertz or less.

Specification—475

OUTPUT SIGNALS

Output Resistance

Output resistance of the CH 2 VERT SIGNAL 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 per 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 18,000 volts.