

SPECIFICATION

Introduction

The 475 Oscilloscope is a 200 megahertz bandwidth portable instrument designed to operate in a wide range of environmental conditions. The lightweight, compact design combines accurate high-frequency measurement capability and ease of transportation.

The dual-channel, DC-to-200 megahertz vertical deflection system provides calibrated deflection factors from 2 millivolts to 5 volts/division. A BW/TRIG VIEW switch permits limiting the bandwidth of the vertical system to reduce interference from high-frequency signals when viewing lower-frequency, low-level signals. The switch also permits displaying of the signal applied to the 'A' Trigger Generator on the CRT.

The trigger circuits provide stable sweep triggering to beyond the 200 megahertz 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 permits the A

sweep to trigger in a stable manner on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.01 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of one nanosecond per 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). Regulated DC power supplies provide stable instrument performance over a wide range of line voltages and frequencies. Maximum power consumption of the instrument is approximately 100 watts.

Characteristics

The following instrument specifications apply over an ambient temperature range of -15°C to $+55^{\circ}\text{C}$ unless otherwise specified. Warmup time for specified accuracies is 20 minutes. The calibration procedure given in Section 6, if performed completely, will ensure the instrument meets the electrical characteristics listed in this section.

TABLE 1-1
ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
VERTICAL DEFLECTION SYSTEM (CH 1 and CH 2)		
Deflection Factor Calibrated Range	2 mV to 5 V/DIV in 11 steps; 1-2-5 sequence.	
Cascaded Operation (CH 2 VERT SIGNAL OUT Connected to CH 1)	Deflection Factor to Approximately 400 μ V/div. Bandwidth: DC to \geq 50 MHz.	CH 2 VERT SIGNAL OUT into CH 1 input. DC coupled using a 50 Ω , 42" RG58A/U cable terminated in 50 Ω at CH 1 input.
Uncalibrated (VAR VOLTS/DIV) Range	Provides continuously variable deflection factors between the calibrated steps. Extends maximum uncalibrated deflection factor to at least 12.5 volts per division in the 5 V/DIV position.	At least 2.5:1.
Low Frequency Linearity		0.1 division or less compression or expansion of 2 division signal at center screen positioned to the upper and lower extremes of the graticule area.
Deflection Factor Accuracy	Within 3% of indicated deflection.	With GAIN set at 5 mV/DIV.
Bandwidth		5 div reference signal from a 25 Ω source with the VAR V/DIV control in calibrated detent with or without a P6075 or P6106 probe.
–15°C to +40°C	DC to 200 MHz.	
+40°C to +55°C	DC to 175 MHz.	
Risetime		
–15°C to +40°C	1.75 ns or less (Calculated) ¹ .	
+40°C to +55°C	2.0 ns or less (Calculated) ¹ .	
AC Coupled Lower –3 dB Point	10 Hz or less with 1X probe.	1 Hz or less with 10X probe.
Bandwidth with 100 or 20 MHz BW Switch in 20 MHz Position	Approximately 20 MHz.	–3 dB point between 15 MHz and 20 MHz.
Bandwidth with 100 or 20 MHz BW Switch in 100 MHz Position	Approximately 100 MHz.	–3 dB point between 75 MHz and 125 MHz.
Input Resistance and Capacitance	1 M Ω within 2% paralleled by approximately 20 pF.	

¹Risetime is calculated from the formula:

$$\frac{0.35}{\text{Bandwidth}}$$

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
VERTICAL DEFLECTION SYSTEM (cont)		
Step Response Positive-Going Step Aberrations (0°C to 40°C) At 5 mV/DIV		+4%, -4%, 4% P-P.
Negative-Going Step		Add 3% to positive-going step aberrations.
Added Mode		Add 3% to positive-going step aberrations.
Common-Mode Rejection Ratio (ADD Mode with CH 2 inverted)		20:1 at 1 kHz for common-mode signals of 8 divisions or less.
Trace Shift as VAR is Rotated		Adjusts to 2 divisions or less.
INVERT Trace Shift		Within 1 division from center screen when switching from normal to inverted.
Channel Isolation		At least 100:1 at 50 MHz.
Position Range		At least +12 and -12 divisions from graticule center.
Signal Delay Between CH 1 and CH 2		0.25 ns or less at 5 mV/DIV.
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.	
Chopped Mode Repetition Rate	Approximately 1 MHz.	-20%, +30%.

Specification—475 Service (SN B250000 & up)

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
TRIGGER SYSTEM		
Sensitivity		
DC Coupled	0.3 div internal or 50 mV external from DC to 40 MHz, increasing to 1.5 div internal or 250 mV external at 200 MHz.	
AC Coupled	0.3 div internal or 50 mV external from 60 Hz to 40 MHz, increasing to 1.5 div internal or 250 mV external at 200 MHz. Attenuates signals below about 60 Hz.	
HF REJ Coupled	0.5 div internal or 100 mV external from 60 Hz to 50 kHz. Attenuates signals below about 60 Hz and above about 50 kHz.	
LF REJ Coupled	0.5 div internal or 100 mV external from 50 kHz to 40 MHz, increasing to 1.5 div internal or 500 mV external at 200 MHz. Attenuates signals below about 50 kHz.	
Trigger Jitter	0.2 ns or less at 200 MHz at 1 ns/DIV sweep rate (X10 MAG on).	
External Trigger Input		
Maximum Input Voltage	250 V DC + peak AC or 250 V P-P AC (1 kHz or less).	
Input Resistance and Capacitance	1 M Ω within 10%, paralleled by approximately 20 pF.	

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
TRIGGER SYSTEM (cont)		
LEVEL Control Range		
EXT	At least + and -2 V, 4 V P-P.	
EXT $\div 10$	At least + and -20 V, 40 V P-P. Exclude LF REJ coupling mode.	
Trigger View		
Deflection Factor	Approximately 50 mV/DIV.	$\pm 20\%$. Exclude LF REJ and HF REJ trigger coupling modes.
Risetime		≤ 4.0 ns over the 10% to 90% part of the fast-rise portion.
Delay Difference		≤ 2.5 ns with a 5 division signal having 1 ns or less risetime from a $25\ \Omega$ source, centered vertically with equal cable length from signal source to vertical channel and external trigger inputs, each terminated in $50\ \Omega$.
Centering of Trigger Point		Adjustable to within 1.0 division of center screen.
HORIZONTAL DEFLECTION SYSTEM		
Calibrated Sweep Range		
A Sweep or B DLY'D Sweep	0.5 s/DIV to $0.01\ \mu\text{s/DIV}$ in 24 steps; 1-2-5 sequence. X10 MAG extends maximum sweep rate to 1 ns/DIV.	
A Delaying Sweep (or A INTEN)	0.5 s/DIV to $0.05\ \mu\text{s/DIV}$ in 22 steps; 1-2-5 sequence.	

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements		Supplemental Information
HORIZONTAL DEFLECTION SYSTEM (cont)			
Calibrated Sweep Accuracy	UNMAGNIFIED	MAGNIFIED	Accuracy specification applies over the full 10 divisions of deflection unless otherwise specified. For all sweeps; exclude the first 25 ns when checking 0.01 and 0.02 $\mu\text{s}/\text{div}$ unmagnified sweep rates. For all sweeps except B; exclude the first 25 ns or 2 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking magnified sweep rates. For B sweep; exclude the first 25 ns or 5 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking B magnified sweep rates.
+20°C to +30°C			
A or B DLY'D Sweep			
5 ms/DIV to 0.01 $\mu\text{s}/\text{DIV}$	$\pm 1\%$	$\pm 2\%$	
.5 s/DIV to 10 ms/DIV	$\pm 2\%$	$\pm 3\%$	
A INTEN Sweeps (or A Delaying)			
0.5 s/DIV to 0.05 $\mu\text{s}/\text{DIV}$	$\pm 2\%$	$\pm 3\%$	
−15°C to +55°C			
All Sweeps	$\pm 3\%$	$\pm 4\%$	
X10 Magnified Sweep Accuracy	Within 5% over any 2 division interval.		
Mixed Sweep Accuracy	Within 3%		Accuracy applies over 8 divisions of deflection. B sweep must be at least 1 TIME/DIV setting faster than A Sweep on all ranges. When checking A TIME/DIV accuracy, exclude the first 0.5 division after the display start; when checking B TIME/DIV accuracy, exclude the first 0.2 division or 0.1 μs (whichever is greater) after the transition of A to B.
VAR TIME/DIV Control Range	Continuously variable between calibrated settings. Extends the slowest A sweep rate to at least 1.25 seconds per division.		At least 2.5:1.
Sweep Length (A Only)			At least 10.1 divisions.
A Trigger Holdoff	Increases sweep holdoff time to at least 9 times the TIME/DIV switch setting.		

TABLE 1-1 (cont)

ELECTRICAL

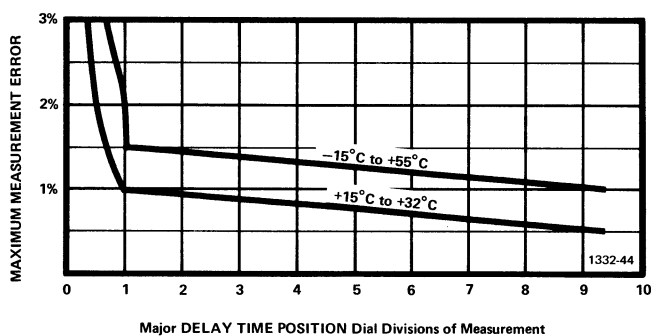
Characteristics	Performance Requirements		Supplemental Information
HORIZONTAL DEFLECTION SYSTEM (cont)			
Magnified Registration			Within 0.5 division from graticule center at 1 ms/DIV when switching X10 magnifier from on to off.
POSITION Control Range			Start of sweep must position to right of graticule center. End of sweep must position to left of graticule center. Check made at 1 ms/DIV.
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)	Exclude dial settings of 0.00 thru 0.50 for 0.5 sec through 1 μs/DIV delaying sweep rates. Exclude dial settings of 0.00 thru 1.00 for .5 μs thru .05 μs/DIV delaying sweep rates.
Over One or More Major Dial Divisions	±1%	±1.5%	
Over Less Than One Major Dial Division	±0.01 Major Dial Division	±0.02 Major Dial Division	
Delay Time and Differential Time Measurement Accuracy (see Fig. 1-2)	<div></div> <p>Fig. 1-2. Detailed Delay Time and Differential Time Measurement accuracy.</p>		
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 above 52 Hz, decreasing to 0.005% (less than one part in 20,000) on power line frequencies of 48 to 52 Hz.		
Delay Range	From 0.05 μs or less to at least 5 seconds after the start of the delaying (A) sweep. Maximum available delay time is ten times the setting of the A TIME/DIV switch.		

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
X-Y OPERATION		
Sensitivity	Same as vertical deflection system.	Extreme counterclockwise position of TIME/DIV switch. CH 2 OR X-Y button of VERT MODE switch must be pushed.
Deflection Accuracy	Same as vertical deflection system.	
Variable Range	Same as vertical deflection system.	
X-Axis Bandwidth	DC to 3 MHz.	
Input Capacitance	Same as vertical deflection system.	
Input Resistance	Same as vertical deflection system.	
Maximum Input Voltage	Same as vertical deflection system.	
Phase Difference Between X and Y Axis Amplifiers		Within 1° from DC to 1 MHz. Within 3° from 1 MHz to 2 MHz.
X Axis Low Frequency Linearity		0.2 div or less compression or expansion of a 2 div signal at center screen, positioned to horizontal extremes of display area.
CALIBRATOR		
Output Voltage		Adjusted to within 0.5% at 25° C, ±5° C
0° C to +40° C	300 mV within 1.0%.	
-15° C to +55° C		300 mV within 1.5%.
Repetition Rate	Approximately 1 kHz.	Within 25%.
Output Resistance		Approximately 9.4 Ω.
Output Current		
+20° C to +30° C	30 mA within 2%.	
-15° C to +55° C		30 mA within 2.5%
Z AXIS INPUT		
Sensitivity	5 V P-P signal causes noticeable modulation at normal intensity.	Positive-going signal from ground decreases intensity.
Useable Frequency Range	DC to 50 MHz.	
Maximum Input Voltage		100 V (DC plus peak AC). 100 V P-P AC at 1 kHz or less.

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
SIGNAL OUTPUTS		
CH 2 VERT SIGNAL OUT	One division of deflection gives approximately 20 mV into 1 M Ω load.	
Output Voltage	One division of deflection gives approximately 10 mV into 50 Ω load.	
Output Resistance		Approximately 50 Ω .
Bandwidth	DC to at least 50 MHz into 50 Ω .	
Output DC Level	Approximately 0 V.	
A and B + GATE Outputs		
Output Voltage	Approximately 5 V positive-going.	
Output Resistance		Approximately 500 Ω .
POWER SOURCE		
Line Voltage Ranges (AC, RMS)		
115 V		
Low	110 V, $\pm 10\%$.	99 V to 121 V.
Medium	115 V, $\pm 10\%$.	103.5 V to 126.5 V.
High	120 V, $\pm 10\%$.	108 V to 132 V.
230 V		
Low	220 V, $\pm 10\%$.	198 V to 242 V.
Medium	230 V, $\pm 10\%$.	207 V to 253 V.
High	240 V, $\pm 10\%$.	216 V to 264 V.
Line Frequency	48 Hz to 440 Hz.	
Maximum Power Consumption	100 watts at 115 V, 60 Hz.	

Specification—475 Service (SN B250000 & up)

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
CATHODE-RAY TUBE		
Horizontal Resolution		At least 15 lines/division
Vertical Resolution		At least 15 lines/division.
Display Area	8 x 10 cm.	
Geometry		0.1 division or less of tilt or bowing.
Raster Distortion		0.1 division or less.
Normal Accelerating Potential		Approximately 18,000 V.
Trace Rotation Range		Adequate to align trace with horizontal center line.
Standard Phosphor	P31.	
Optional Phosphor	P11.	

TABLE 1-2
ENVIRONMENTAL

Characteristics	Performance Requirements	Supplemental Information
Temperature		
Operating (AC)	−15°C to +55°C.	
Storage	−55°C to +75°C.	
Altitude		
Operating	To 15,000 feet. Maximum operating temperature decreased 1°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 (Operating)	15 minutes along each of three major axes at a total displacement of 0.025 inch P-P (4 g's at 55 Hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one minute sweeps. After sweep vibration in each axis, hold frequency steady at each major resonance for 3 minutes, or if no such resonances are found, hold at 55 Hz for three minutes.	
Shock (Operating and Non-operating)	30 g's, 1/2 sine, 11 ms duration, 2 shocks per axis each direction for a total of 12 shocks.	
Transportation	Meets the limits of National Safe Transit Committee test procedure 1A with a 30-inch drop.	

TABLE 1-3
PHYSICAL

Characteristics	Information
Construction	
Chassis	Aluminum alloy.
Panel	Aluminum alloy with anodized finish.
Cabinet	Blue vinyl-coated aluminum alloy.
Circuit Boards	Glass laminate etched-wiring.
Overall Dimension	
Height	
With Feet and Pouch	7.5 inches (19.1 cm).
Without Pouch	6.2 inches (15.7 cm).
Width	
With Handle	12.9 inches (32.8 cm).
Without Handle	11.5 inches (29.2 cm).
Depth	
Including Panel Cover	18.1 inches (46 cm).
Handle Extended	20.3 inches (51.5 cm).
Weight	
With Panel Cover, Accessories, and Accessory Pouch	25.3 pounds (11.5 kg).
Without Panel Cover, Accessories, and Accessory Pouch.	22.8 pounds (10.3 kg).
Domestic Shipping Weight	32.7 pounds (14.8 kg).
Export Shipping Weight	Approximately 48.0 pounds (21.8 kg).

Standard Accessories

Standard accessories supplied with the 475 are listed in the Mechanical Parts List, in this Service manual. For optional accessories available for use with the 475, see the Tektronix, Inc., catalog.