

SPECIFICATION

INTRODUCTION

The TEKTRONIX 2465 Oscilloscope is a portable 300-MHz instrument having a four-channel vertical deflection system. Channel 1 and Channel 2 provide calibrated deflection factors from 2 mV per division to 5 V per division. For each of these channels, input impedance is selectable between two values: either 1 M Ω in parallel with 15 pF, or 50 Ω internal termination. Input-signal coupling with 1-M Ω impedance can be selected as either AC or DC. Channel 3 and Channel 4 have deflection factors of either 0.1 V or 0.5 V per division. Each of these channels has an input impedance of 1 M Ω in parallel with 15 pF, with DC input-signal coupling. Trigger circuits enable stable triggering over the full bandwidth of the vertical system.

The horizontal deflection system provides calibrated sweep speeds from 1.5 s per division to 500 ps per division. Drive for the horizontal deflection system is obtained from a choice of A, B delayed, A alternated with B delayed sweeps, or CH 1 (for the X-Y display mode).

The 2465 incorporates alphanumeric crt readouts of the vertical and horizontal scale factors, the trigger levels, time-difference measurement values, voltage-difference measurement values, and certain auxiliary information.

The 2465 Oscilloscope is shipped with the following standard accessories:

- 2 Probe packages
- 1 Snap-lock accessories pouch
- 1 Zip-lock accessories pouch
- 1 Operators manual
- 1 Power cord (installed)
- 1 2-A, 250-V fuse
- 1 Clear plastic crt filter
- 1 Blue plastic crt filter (installed)
- 1 Front-panel cover
- 1 Operators pocket reference card

For part numbers and further information about both standard and optional accessories, refer to the "Options and Accessories" section (Section 7) of this manual. Your Tektronix representative, local Tektronix Field Office, or Tektronix product catalog can also provide accessories information.

PERFORMANCE CONDITIONS

The following electrical characteristics (Table 1-1) are valid for the 2465 when it has been adjusted at an ambient temperature between +20°C and +30°C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between -15°C and +55°C (unless otherwise noted).

Items listed in the "Performance Requirements" column are verifiable qualitative or quantitative limits that define the measurement capabilities of the instrument.

Environmental characteristics are given in Table 1-2. The 2465 Oscilloscope meets the environmental requirements of MIL-T-28800C for Type III, Class 3, Style C equipment, with the humidity and temperature requirements defined in paragraphs 3.9.2.2, 3.9.2.3, and 3.9.2.4.

Mechanical characteristics of the 2465 are listed in Table 1-3.

Table 1-1
Electrical Characteristics

Characteristics	Performance Requirements		
VERTICAL DEFLECTION SYSTEM—CHANNEL 1 AND CHANNEL 2			
Deflection Factor			
Range	2 mV per division to 5 V per division in a 1-2-5 sequence of 11 steps.		
Accuracy			
+15°C to +35°C	Within $\pm 2\%$ at any VOLTS/DIV setting for a 4- or 5-division signal centered on the screen.		
-15°C to +15°C and +35°C to +55°C	Add 1% to +15°C-to-+35°C specification.		
ΔV Accuracy (using cursors over entire graticule area)			
+15°C to +35°C	$\pm (1.25\% \text{ of reading} + 0.03 \text{ division} + \text{signal aberration})$.		
-15°C to +15°C and +35°C to +55°C	Add 1% of reading to +15°C-to-+35°C specification.		
ΔV Range	± 8 times the VOLTS/DIV switch setting.		
Variable Range	Continuously variable between VOLTS/DIV switch settings. Extends deflection factor of the 5 V per division setting to at least 12.5 V per division.		
Frequency Response	Six-division reference signal from a terminated 50- Ω system, with VAR VOLTS/DIV control in calibrated detent.		
	VOLTS/DIV setting	-3 dB bandwidth with standard-accessory probe or internal 50-Ω termination	-4.7 dB bandwidth with 50-Ω external termination on 1-MΩ input
-15°C to +55°C	2 mV	DC to 100 MHz	DC to 100 MHz
-15°C to +35°C	5 mV or greater	DC to 300 MHz	DC to 300 MHz
+35°C to +55°C	5 mV or greater	DC to 250 MHz	DC to 250 MHz
AC Coupled Lower -3 dB Point			
1X Probe	10 Hz or less.		
10X Probe	1 Hz or less.		
Step Response			
Rise Time	1.17 ns or less for VOLTS/DIV switch settings of 5 mV and up (calculated).		
	3.5 ns or less for VOLTS/DIV switch setting of 2 mV (calculated).		
	Rise time calculated from: bandwidth x rise time = 0.35.		
Common-mode Rejection Ratio (CMRR)	At least 20:1 at 50 MHz for common-mode signals of eight divisions or less, with VAR VOLTS/DIV control adjusted for best CMRR at 50 kHz at VOLTS/DIV switch settings from 5 mV to 5 V. At least 20:1 at 20 MHz for the 2 mV switch setting.		

Table 1-1 (cont)



Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM—CHANNEL 1 AND CHANNEL 2 (cont)	
Channel Isolation	100:1 or greater attenuation of the deselected channel at 100 MHz; 50:1 or greater attenuation at 300 MHz, for an eight-division input signal from 2 mV per division to 500 mV per division, with equal VOLTS/DIV switch settings on both channels.
Displayed Channel 2 Signal Delay with Respect to Channel 1 Signal	Adjustable through a range of at least –500 ps to +500 ps.
Input R and C (1 M Ω)	
Resistance	1 M Ω \pm 0.5%.
Capacitance	15 pF \pm 2 pF.
Maximum Input Voltage 	400 V (dc + peak ac). 800 V p-p ac at 10 kHz or less.
Input R (50 Ω)	
Resistance	50 Ω \pm 1%.
VSWR (DC to 300 MHz)	1.3:1 or less.
Maximum Input Voltage (DC Coupling Only) 	5 V rms; 0.5 W-seconds during any 1-s interval for instantaneous voltage from 5 V to 50 V. Maximum pulse duty factor and maximum pulse duration for a one second interval that produce 0.5 W-seconds into 50 Ω input with a 5 V rms maximum allowable input voltage are determined from the following: Maximum duty factor of applied pulse = $\left(\frac{5 \text{ V}}{V_{\text{pulse}}}\right)^2$. Maximum duration of applied pulse = $\left(\frac{5 \text{ V}}{V_{\text{pulse}}}\right)^2$ sec.
Cascaded Operation	CH 2 SIGNAL OUT into Channel 1 input; DC coupled using a 50- Ω RG-58C/U coaxial cable, terminated in 50 Ω at the Channel 1 input. Channel 1 and Channel 2 VOLTS/DIV switch set to 2 mV.
Bandwidth	Dc to 50 MHz or greater.
Deflection Factor	400 μ V per division \pm 10%.
VERTICAL DEFLECTION SYSTEM—CHANNEL 3 AND CHANNEL 4	
Deflection	
Values	0.1 V per division and 0.5 V per division.
Accuracy	Within \pm 10%.

Table 1-1 (cont)


Characteristics	Performance Requirements	
VERTICAL DEFLECTION SYSTEM—CHANNEL 3 AND CHANNEL 4 (cont)		
Frequency Response (3-dB Bandwidth)	Six-division reference signal, from a terminated 50-Ω system.	
	–3 dB Bandwidth With standard-accessory probe	–4.7 dB Bandwidth With external 50-Ω termination
	–15°C to +35°C	DC to 300 MHz
	+35°C to +55°C	DC to 250 MHz
Step Response		
Rise Time	1.17 ns or less (calculated from bandwidth).	
Channel Isolation	50:1 or greater attenuation of the deselected channel at 100 MHz with an eight-division input signal.	
Input R and C		
Resistance	1 MΩ ± 1%.	
Capacitance	15 pF ± 3 pF.	
Maximum Input Voltage 	400 V (dc + peak ac); 800 V p-p ac at 10 kHz or less.	
VERTICAL DEFLECTION SYSTEM—ALL CHANNELS		
Low-frequency Linearity	0.1 division or less compression or expansion of a two-division, center-screen signal when positioned anywhere within the graticule area.	
Bandwidth Limiter	Reduces upper 3-dB bandpass to a limit of 13 MHz to 24 MHz.	
Vertical Signal Delay	At least 20 ns of the sweep is displayed before the triggering event is displayed.	
Chopped Mode Switching Rate	Vertical display switches sequentially through the selected channels at the chop switching rate. If the B SEC/DIV switch is set to sweep speeds outside the range of 20 μs per division to 2 μs per division, the switching rate is 1 MHz ± 0.2% (dual-channel cycle rate of 500 kHz). If the B SEC/DIV switch is set within the range of 20 μs per division to 2 μs per division, the switching rate is 2.5 MHz ± 0.2% (dual-channel cycle rate of 1.25 MHz). At all sweep speeds, the chop switching rate is desynchronized with the sweep frequency to minimize waveform breaks when viewing repetitive signals.	
TRIGGERING		
Minimum P-P Signal Amplitude for Stable Triggering from Channel 1 or Channel 2 Source		
DC Coupled	0.35 division from dc to 50 MHz, increasing to 1 division at 300 MHz, 1.5 divisions at 500 MHz in ADD MODE.	
NOISE REJ Coupled	1.2 divisions or less from dc to 50 MHz, increasing to 3 divisions at 300 MHz, 4.5 divisions at 500 MHz in ADD MODE.	
AC Coupled	0.35 division from 60 Hz to 50 MHz, increasing to 1 division at 300 MHz, 1.5 divisions at 500 MHz in ADD MODE. Attenuates signals below 60 Hz.	


Table 1-1 (cont)

Characteristics	Performance Requirements
TRIGGERING (cont)	
HF REJ Coupled	0.5 division from dc to 30 kHz.
LF REJ Coupled	0.5 division from 80 kHz to 50 MHz, increasing to 1 division at 300 MHz, 1.5 divisions at 500 MHz in ADD MODE.
Minimum P-P Signal Amplitude for Stable Triggering from Channel 3 or Channel 4 Source	Amplitudes are one-half of Channel 1 or Channel 2 source specification.
Minimum P-P Signal Amplitude for Stable Triggering from Composite, Multiple Channel Source in ALT Vertical Mode	Add 1 division to single-channel source specifications.
Maximum P-P Signal Rejected by NOISE REJ COUPLING for Signals Within the Vertical Bandwidth	
Channel 1 or Channel 2 Source	0.4 division or greater for VOLTS/DIV switch settings of 10 mV and higher.
Channel 3 or Channel 4 Source	0.2 division or greater.
Jitter	Less than 50 ps at 300 MHz with A and B SEC/DIV switch set to 5 ns, X10 MAG on, and 5 divisions of amplitude.
LEVEL Control Range	
Channel 1 or Channel 2 Source	± 18 times the VOLTS/DIV switch setting.
Channel 3 or Channel 4 Source	± 9 times the VOLTS/DIV switch setting.
LEVEL Control Readout Accuracy (for triggering signals with transition times greater than 20 ns)	
Channel 1 or Channel 2 Source	
DC Coupled +15°C to +35°C	Within ± [3% of setting + 3% of p-p signal + 0.2 division + 0.5 mV (0.5 mV x probe attenuation factor)].
-15°C to +55°C (excluding +15°C to +35°C)	Add (1.5 mV x probe attenuation factor) to the specification listed for +15°C to +35°C.
NOISE REJ Coupled	Add ±0.6 division to the DC Coupled specification.
Channel 3 or Channel 4 Source	Within ± [3% of setting + 4% of p-p signal + 0.1 division + (0.5 mV x probe attenuation factor)].
SLOPE Selection	Conforms to trigger-source waveform or ac power-source waveform.
AUTO LVL Mode Maximum Triggering Signal Period	
A SEC/DIV Switch Setting Less than 10 ms	At least 20 ms.
A SEC/DIV Switch Setting from 10 ms to 50 ms	At least four times the A SEC/DIV switch setting.
A SEC/DIV Switch Setting from 100 ms to 500 ms	At least 200 ms.

Table 1-1 (cont)

Characteristics	Performance Requirements	
TRIGGERING (cont)		
AUTO Mode Maximum Triggering Signal Period		
A SEC/DIV Switch Setting Less than 10 ms	At least 80 ms.	
A SEC/DIV Switch Setting from 10 ms to 50 ms	At least 16 times the A SEC/DIV switch setting.	
A SEC/DIV Switch Setting from 100 ms to 500 ms	At least 800 ms.	
AUTO LVL Mode Trigger Acquisition Time	Eight to 100 times the AUTO LVL Mode maximum triggering-signal period, depending on the triggering-signal period and waveform.	
HORIZONTAL DEFLECTION SYSTEM		
A Sweep Time Base Range	0.5 s per division to 5 ns per division in a 1-2-5 sequence of 25 steps. X10 MAG feature extends maximum sweep speed to 0.5 ns per division.	
B Sweep Time Base Range	50 ms per division to 5 ns per division in a 1-2-5 sequence of 22 steps. X10 MAG feature extends maximum sweep speed to 0.5 ns per division.	
SEC/DIV VAR Control	Continuously variable and calibrated between settings of the SEC/DIV switch. Extends slowest A Sweep speed to 1.5 s per division. Operates in conjunction with the A SEC/DIV switch when A and B are locked together; operates in conjunction with the B SEC/DIV switch when A and B are not locked together.	
Timing Accuracy (+15°C to +35°C, SEC/DIV switch set to 0.1 s per division or less) A and B Sweep Accuracy, Time Intervals Measured at Vertical Center with SEC/DIV VAR Control in Detent	Unmagnified	Magnified
	±(0.7% of time interval +0.6% of full scale).	±(1.2% of time interval +0.6% of full scale).
	0.6% of full scale is 0.06 division.	
Δt Accuracy, Time Intervals Measured with Cursors, Anywhere on the Graticule (A Sweep Only)	Unmagnified	Magnified
	±(0.5% of time interval +0.3% of full scale).	±(1% of time interval +0.3% of full scale).
Δt Accuracy, Time Intervals Measured with Delayed B Sweep with Both Delays Set at 1% or More of Full Scale from Minimum Delay (no ? displayed in readout)	± (0.3% of time interval +0.1% of full scale).	
Delay Accuracy, A Sweep Trigger Point to Start of B Sweep	± (0.3% of delay setting + 0.6% of full scale) –25 ns.	
Timing Accuracy (A SEC/DIV switch set to 0.5 s or 0.2 s per division)	Add ±0.5% of time interval to accuracy specifications.	
Timing Accuracy (SEC/DIV VAR control out of detent)	Add 2% of time interval to the A and B Sweep Accuracy specification.	

Table 1-1 (cont)

Characteristics	Performance Requirements
HORIZONTAL DEFLECTION SYSTEM (cont)	
Timing Accuracy (–15°C to +15°C and +35°C to +55°C)	Add $\pm 0.2\%$ of time interval to all Δt and delay specifications. Add $\pm 0.5\%$ of time interval to A and B Sweep accuracy specifications.
Δt Readout Resolution	Greater of either 10 ps or 0.025% of full scale.
Δt Range	± 10 times the A SEC/DIV switch setting.
Delay Pickoff Jitter	Within 0.004% (one part or less in 25,000) of the maximum available delay, plus 100 ps.
Delay Time Position Range	0 to 9.95 times the A SEC/DIV switch setting. Main sweep triggering event is observable on delayed sweep with zero delay setting.
X-Y Operation	
X-Axis Deflection Factor	
Range	Same as Channel 1.
Accuracy	Same as Channel 1.
Variable Range	Same as Channel 1.
X-Axis Bandwidth	Dc to 3 MHz.
Input R and C	Same as Channel 1.
Phase Difference Between X and Y with Normal Bandwidth	1° or less from dc to 1 MHz; 3° or less from 1 MHz to 2 MHz.
X-Axis Low-Frequency Linearity	0.2 division or less compression or expansion of two-division, center-screen signal when positioned within the display area.
CURSOR AND FRONT-PANEL DISPLAY	
Cursor Position Range	
Delta Volts (ΔV)	At least the 7.6 vertical divisions.
Delta Time (Δt)	At least the center 9.6 horizontal divisions.
Minimum Setup Time Required to Maintain Front-panel Settings at Power-down	10 seconds or less.
Z-AXIS INPUT	
Sensitivity	Positive voltage decreases intensity. From dc to 2 MHz, +2 V blanks a maximum-intensity trace; from 2 MHz to 20 MHz, +2 V modulates a normal-intensity trace.
Input Resistance	9 k Ω $\pm 10\%$.
Maximum Input Voltage 	± 25 V peak; 25 V p-p ac at 10 kHz or less.

Specification—2465 Operators

Table 1-1 (cont)

Characteristics	Performance Requirements
SIGNAL OUTPUTS	
CALIBRATOR	
Output Voltage and Current	0.4 V \pm 1% into a 1-M Ω load, 0.2 V \pm 1.5% into a 50- Ω load, or 8 mA \pm 1.5% into a short circuit, with the A SEC/DIV switch set to 1 ms per division.
Repetition Period	Two times the A SEC/DIV switch setting within the range of 200 ns to 200 ms.
Accuracy	\pm 0.1%, measured with SGL SEQ A TRIGGER MODE selected.
Symmetry	Duration of high portion of output cycle is 50% of output period \pm (lesser of 500 ns or 25% of period).
Jitter of Pulse Period or Pulse Width	10 ns or less.
CH 2 SIGNAL OUT	
Output Voltage	20 mV per division \pm 10% into 1 M Ω ; 10 mV per division \pm 10% into 50 Ω .
Offset	\pm 10 mV into 50 Ω , when dc balance has been performed within \pm 5°C of the operating temperature.
A GATE OUT and B GATE OUT	
Output Voltage	2.4 V to 5 V positive-going pulse, starting at 0 V to 0.4 V.
Output Drive	Will supply 400 μ A during HI state; will sink 2 mA during LO state.
CRT	
Display	80 mm x 100 mm.
Standard Phosphor	P31.
Nominal Accelerating Potential	16 kV.
AC POWER SOURCE	
Source Voltage	
Ranges	
115 V	90 V to 132 V.
230 V	180 V to 250 V.
Source Frequency	48 Hz to 440 Hz.
Fuse Rating	2 A; 250 V, AGC/3AG, Fast blow; or 1.6 A, 250 V, 5 x 20 mm, Quick-acting (F).
Power Consumption	
Typical	70 W (140 VA).
Maximum	120 W (180 VA).
Primary Circuit Dielectric Voltage Withstand Test	1500 V rms, 60 Hz for 10 s without breakdown.
Primary Grounding	Type test to 0.1 Ω maximum. Routine test to check grounding continuity between chassis ground and protective earth ground.

Table 1-2
Environmental Characteristics

Characteristics	Performance Requirements
Temperature	The 2465 Oscilloscope meets the environmental requirements of MIL-T-28800C for Type III, Class 3, Style C equipment, with the humidity and temperature requirements defined in paragraphs 3.9.2.2, 3.9.2.3, and 3.9.2.4.
Operating	−15°C to +55°C.
Nonoperating (storage)	−62°C to +85°C.
Altitude	
Operating	To 15,000 ft. Maximum operating temperature decreases 1°C for each 1,000 ft above 5,000 ft.
Nonoperating (storage)	To 50,000 ft.
Humidity (operating and nonoperating)	Stored at 95% relative humidity for five cycles (120 hours) from 30°C to 60°C, with operational performance checks at 30°C and 55°C.
Vibration (operating)	15 minutes along each of three axes at a total displacement of 0.025 inch p-p (4 g at 55 Hz), with frequency varied from 10 Hz to 55 Hz in one-minute sweeps. Held 10 minutes at each major resonance, or if none existed, held 10 minutes at 55 Hz (75 minutes total test time).
Shock (operating and nonoperating)	50 g, half-sine, 11-ms duration, three shocks on each face, for a total of 18 shocks.
Transit Drop (not in shipping package)	12-inch drop on each corner and each face (MIL-T-28800C, para 3.9.5.2 and 4.5.5.4.2).
Bench Handling (with and without cabinet installed)	MIL-STD-810C, Method 516.2, Procedure V (MIL-T-28800C, para 4.5.5.4.3).
EMI (electromagnetic interference)	Meets MIL-T-28800C; MIL-STD-461B, part 4 (CE-03 and CS-02), part 5 (CS-06 and RS-02), and part 7 (CS-01, RE-02, and RE-03—limited to 1 GHz); VDE 0871, Category B; Part 15 of FCC Rules and Regulations, Subpart J, Class A; and Tektronix Standard 062-2866-00.
Topple (operating with cabinet installed)	Set on rear feet and allowed to topple over onto each of four adjacent faces (Tektronix Standard 062-2858-00).
Packaged Transportation Drop	Meets the limits of the National Safe Transit Association test procedure 1A-B-2; 10 drops of 36 inches (Tektronix Standard 062-2858-00).
Packaged Transportation Vibration	Meets the limits of the National Safe Transit Association test procedure 1A-B-1; excursion of 1 inch p-p at 4.63 Hz (1.1 g) for 30 minutes (Tektronix Standard 062-2858-00).

Table 1-3
Mechanical Characteristics

Characteristics	Description
Weight	
With Accessories and Pouch	10.2 kg (22.4 lb).
Without Accessories and Pouch	9.3 kg (20.5 lb).
Domestic Shipping Weight	12.8 kg (28.2 lb).
Height	
With Feet and Accessories Pouch	190 mm (7.5 in).
Without Accessories Pouch	160 mm (6.3 in).
Width (with handle)	330 mm (13.0 in).
Depth	
With Front-Panel Cover	434 mm (17.1 in).
With Handle Extended	505 mm (19.9 in).
Cooling	Forced-air circulation.
Finish	Tektronix Blue vinyl-clad material on aluminum cabinet.
Construction	Aluminum-alloy chassis (sheet metal). Die-cast aluminum front panel. Glass-laminate circuit boards.