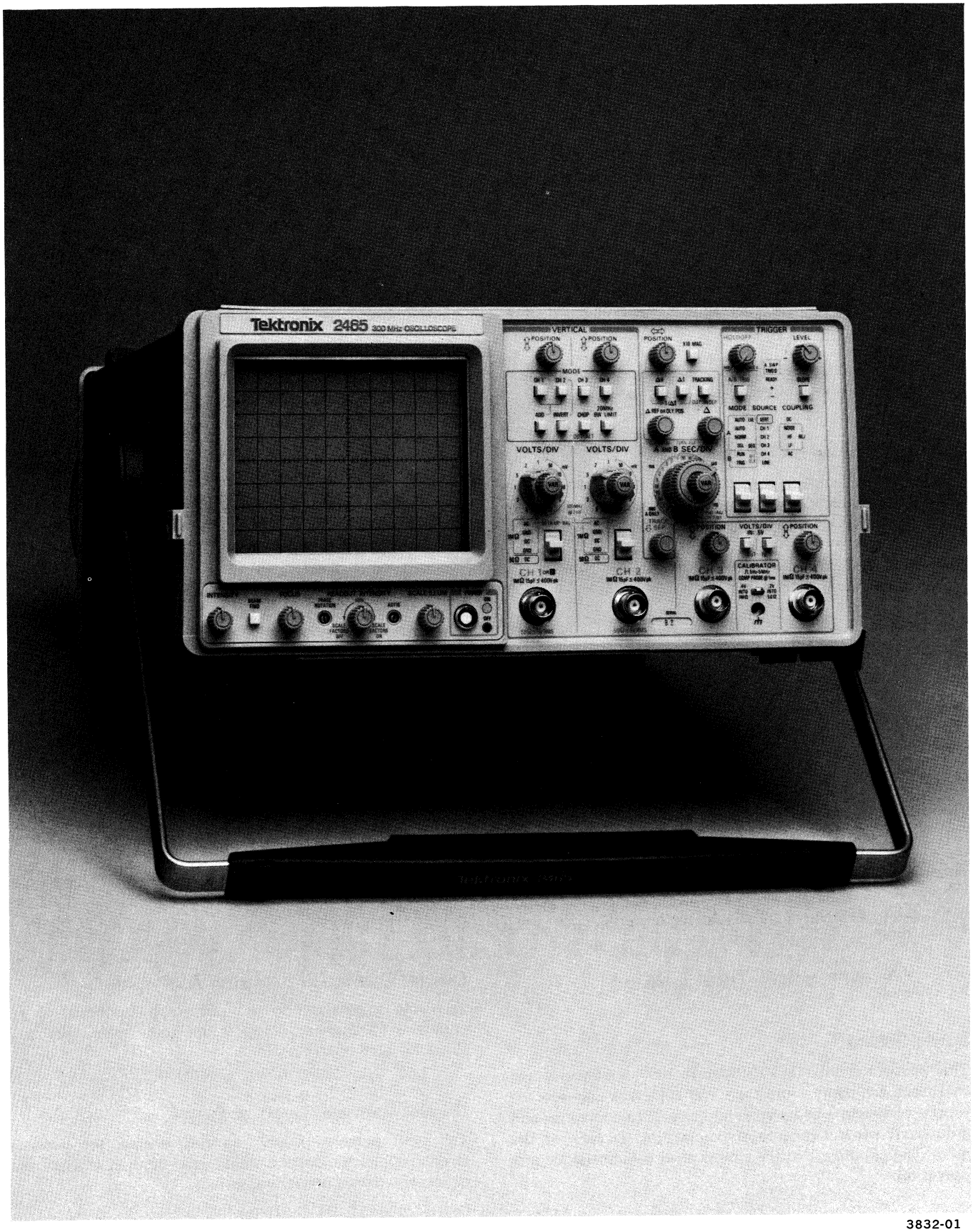


3832-01

The 2465 Oscilloscope.



@

# 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 MΩ in parallel with 15 pF, or 50 Ω internal termination. Input-signal coupling with 1-MΩ 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 MΩ 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 "Options and Accessories" (Section 7) of this manual. Your Tektronix representative or local Tektronix Field Office can also provide accessories information and ordering assistance.

## 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<br>Range | 2 mV per division to 5 V per division in a 1-2-5 sequence of 11 steps. |
| Accuracy<br>+15°C to +35°C | Within ±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)<br>+15°C to +35°C | ± (1.25% of reading + 0.03 division + 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<br>1X Probe | 10 Hz or less. |
| 10X Probe | 1 Hz or less. |
| Step Response<br>Rise Time | 1.17 ns or less for VOLTS/DIV switch settings of 5 mV and up (calculated).<br><br>3.5 ns or less for VOLTS/DIV switch setting of 2 mV (calculated).<br><br>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 MΩ) | |
| Resistance | 1 MΩ ±0.5%. |
| Capacitance | 15 pF ±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 ±1%. |
| VSWR (DC to 300 MHz) | 1.3:1 or less. |
| Maximum Input Votlage (DC Coupling Only) ⚠ | 5 V rms; 0.5 W-seconds during any 1-s interval for instantaneous voltage from 5 V to 50 V.<br>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:<br>Maximum duty factor of applied pulse $= \left(\frac{5\ V}{V_{pulse}}\right)^2$.<br>Maximum duration of applied pulse $= \left(\frac{5\ V}{V_{pulse}}\right)^2$ 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 μV per division ±10%. |

| | |
|---|---|
| **VERTICAL DEFLECTION SYSTEM—CHANNEL 3 AND CHANNEL 4** | |
| Deflection | |
| Values | 0.1 V per division and 0.5 V per division. |
| Accuracy | Within ±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 | DC to 300 MHz |
| +35°C to +55°C | DC to 250 MHz | 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);<br>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<br>+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<br>(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<br>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)<br>A and B Sweep Accuracy, Time Intervals Measured at Vertical Center with SEC/DIV VAR Control in Detent | **Unmagnified**: ±(0.7% of time interval +0.6% of full scale).<br>**Magnified**: ±(1.2% of time interval +0.6% of full scale).<br>0.6% of full scale is 0.06 division. |
| Δt Accuracy, Time Intervals Measured with Cursors, Anywhere on the Graticule (A Sweep Only) | **Unmagnified**: ±(0.5% of time interval +0.3% of full scale).<br>**Magnified**: ±(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 ±0.2% of time interval to all Δt and delay specifications. Add ±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;<br>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 kΩ ±10%. |
| Maximum Input Voltage ⚠ | ±25 V peak; 25 V p-p ac at 10 kHz or less. |

**Table 1-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **SIGNAL OUTPUTS** | |
| CALIBRATOR | |
| Output Voltage and Current | 0.4 V ±1% into a 1-MΩ load, 0.2 V ±1.5% into a 50-Ω load, or 8 mA ±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 | ±0.1%, measured with SGL SEQ A TRIGGER MODE selected. |
| Symmetry | Duration of high portion of output cycle is 50% of output period ± (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 ±10% into 1 MΩ;<br>10 mV per division ±10% into 50 Ω. |
| Offset | ±10 mV into 50 Ω, when dc balance has been performed within ±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 μA 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;<br>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 |
|---|---|
| | 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. |
| Temperature | |
| 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, of 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, Catagory 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. |