# 6
# Performance Characteristics

# Performance Characteristics

The following electrical characteristics (Tables 6-1 through 6-6) are valid for the instrument 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). As a general rule, this instrument should be adjusted every 2,000 hours of operation or once a year if used infrequently.

Items listed in the "Performance Requirements" column define the measurement capabilities of the instruments. Supplementary measurement conditions may also be listed in the "Performance Requirement" column.

Mechanical characteristics are listed in Table 6-7.

Environmental characteristics are given in Table 6-8. The 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.

**Table 6-1**
**2465B/2455B/2445B Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| **VERTICAL DEFLECTION SYSTEM—CHANNEL 1 AND CHANNEL 2** | |
| Deflection Factor | |
| Range | 2 mV/division to 5 V/division in a 1-2-5 sequence of 11 steps. |
| Accuracy | 1 MΩ input, noninverted. |
| +15°C to +35°C | |
| On-Graticule Accuracy | Within ±2% at any VOLTS/DIV setting for a four or five-division signal centered on the screen. |
| ΔV Accuracy (using cursors over entire graticule area) | ±(1.25% of reading +0.03 div + signal aberrations). |
| −15°C to +15°C and +35°C to +55°C | Add ±2% of reading. |
| 50 Ω Coupling | Add ±1% of reading. |
| CH 2 Inverted | Add ±1% of reading. |
| ΔV Range | ±8 × VOLTS/DIV setting. |
| V/DIV VARiable, noninverted | Continuously variable between VOLTS/DIV settings. Extends deflection factor to >12.5 V/division. |
| Frequency Response | Bandwidth is measured with a leveled, low distortion, 50-Ω source, sine-wave generator, terminated in 50 Ω. The reference signal amplitude is set at the lesser of 6 divisions or the maximum leveled amplitude.<br><br>Bandwidth with probe is checked using a BNC-to-probe-tip (013-0227-00) termination adapter.<br><br>Bandwidth with external termination is checked using a BNC 50-Ω feed through terminator (011-0049-01). |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| −3 dB Bandwidth | Using standard accessory probe or internal 50-Ω termination. |
| 2465B | |
| +15°C to +35°C | ⩾5 mV/DIV:Dc to 400 MHz.[a]<br>2 mV/DIV:Dc to 350 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | ⩾5 mV/DIV: Dc to 350 MHz.<br>2 mV/DIV: Dc to 300 MHz. |
| 2455B | |
| +15°C to +35°C | Dc to 250 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | Dc to 200 MHz. |
| 2445B | Dc to 150 MHz. |
| −4.7 dB Bandwidth | Using 50-Ω external termination on 1-MΩ input. |
| 2465B | |
| −15°C to +35°C | ⩾5 mV/DIV: Dc to 400 MHz.[a]<br>2 mV/DIV: Dc to 350 MHz.[a] |
| +35°C to +55°C | Dc to 300 MHz. |
| 2455B | |
| −15°C to +35°C | Dc to 250 MHz.[a] |
| +35°C to +55°C | Dc to 200 MHz. |
| 2445B | Dc to 150 MHz. |
| AC Coupled, Lower −3 dB Frequency | 10 Hz or less. |
| With Standard Accessory Probe | 1 Hz or less. |
| Step Response Rise Time | Calculated from $T_r = 0.35/BW$. |
| 2465B | ⩾5 mV/DIV: ⩽.875 ns.<br>2 mV/DIV: ⩽1 ns. |
| 2455B | ⩽1.4 ns. |
| 2445B | ⩽2.33 ns. |

**[a]If instrument is subjected to "greater than" 85% relative humidity, bandwidth is reduced by 50 MHz. After instrument is subjected to "greater than" 85% relative humidity, it requires more than 50 hours of operation at "less than" 60% relative humidity before full bandwidth is restored.**

Table 6-1 (cont)

| Characteristics | Performance Requirement |
|---|---|
| Channel Isolation | ≥ 100:1 attenuation of deselected channel at 100 MHz; ≥ 50:1 at 400 MHz, for an eight-division input signal from 5 mV per division to 500 mV per division, with equal VOLTS/DIV 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 DC, AC, or GND Coupled ⚠ | 400 V (dc + peak ac). 800 V p-p ac at 10 kHz or less. |
| Input R (50 Ω) | |
| Resistance | 50Ω ±1%. |
| VSWR | |
| 2465B | |
| Dc to 400 MHz | ≤ 1.5:1. |
| 2455B, 2445B | ≤1.3:1 for dc to Nominal Bandwidth |
| Maximum Input Voltage ⚠ | 5 V rms, averaged for 1 second; ±50 V peak. |
| Cascaded Operation | Channel 2 Vertical Signal Output into Channel 1 input; DC coupled using 50-Ω RG-58C/U coaxial, 1 MΩ DC or 1 MΩ AC Channel 1 input coupling; Channel 1 and Channel 2 VOLTS/DIV set at 2 mV; 20 MHz bandwidth limit on. |
| Deflection Factor | 200 μV per division ±10%. |
| CMRR (ADD Mode with Channel 2 inverted) | 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 any VOLTS/DIV setting. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **VERTICAL DEFLECTION SYSTEM—CHANNEL 3 AND CHANNEL 4** | |
| Deflection Factors | |
| Values | 100 mV and 500 mV per division. |
| Accuracy | Within ±10%. |
| Frequency Response | Bandwidth is measured with a leveled, low distortion, 50-Ω source, sine-wave generator, terminated in 50 Ω. The reference signal amplitude is set at the lesser of 6 divisions or the maximum leveled amplitude. Bandwidth with external termination is checked with a 4 division reference signal amplitude.<br>Bandwidth with probe is checked using a BNC-to-probe-tip (013-0227-00) termination adapter.<br>Bandwidth with external termination is checked using a BNC 50-Ω feed through terminator (011-0049-01). |
| – 3 dB Bandwidth | Using standard accessory probe. |
| 2465B | |
| +15°C to +35°C | Dc to 400 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | Dc to 350 MHz. |
| 2455B | |
| +15°C to +35°C | Dc to 250 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | Dc to 200 MHz. |
| 2445B | Dc to 150 MHz. |

**[a]If instrument is subjected to "greater than" 85% relative humidity, bandwidth is reduced by 50 MHz. After instrument is subjected to "greater than" 85% relative humidity, it requires 50 hours of operation at "less than" 60% relative humidity before full bandwidth is restored.**

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| −4.7 dB Bandwidth | Using 50-Ω external termination. |
| 2465B | |
| +15°C to +35°C | Dc to 400 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | Dc to 350 MHz. |
| 2455B | |
| +15°C to +35°C | Dc to 250 MHz.[a] |
| −15°C to +15°C and +35°C to +55°C | Dc to 200 MHz. |
| 2445B | Dc to 150 MHz. |
| Step Response Rise Time | Calculated from $T_r = 0.35/BW$. |
| 2465B | ≤.875 ns. |
| 2455B | ≤1.4 ns. |
| 2445B | ≤2.33 ns. |
| Channel Isolation | ≥50:1 attenuation of deselected channel at 100 MHz with an 8-division input signal. |
| Signal Delay Between Channel 1 and Either Channel 3 or Channel 4 | Within ±1.0 ns, measured at the 50% points. |
| Input Resistance | 1 MΩ ±1%. |
| Input 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. |

**[a]If instrument is subjected to "greater than" 85% relative humidity, bandwidth is reduced by 50 MHz. After instrument is subjected to "greater than" 85% relative humidity, it requires more than 50 hours of operation at "less than" 60% relative humidity before full bandwidth is restored.**

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| Vertical Signal Delay | At least 30 ns of the sweep is displayed before the triggering event is displayed at any SEC/DIV ≥10 ns/div. At 5 ns/div, at least 10 ns of the sweep is displayed before the triggering event. |
| Chopped Mode Switching Rate | With displayed SEC/DIV in the 20 μs to 2 μs/div range, the switching rate is 2.5 MHz ±0.2%. Otherwise, the switching rate is 1 MHz ±0.2%. The display cycle rate equals the chop switching rate divided by the number of channels displayed. The chop switching rate is modulated slightly to minimize waveform breaks with repetitive signals. |
| **TRIGGERING** | |
| Minimum P-P Signal Amplitude for Stable Triggering from Channel 1 or Channel 2 Source | |
| 2465B and 2455B | |
| DC Coupled | 0.35 division from dc to 50 MHz; increasing to 1.0 division at 300 MHz and 1.5 divisions at 500 MHz. |
| NOISE REJ Coupled | ≤1.2 divisions from dc to 50 MHz; increasing to 3 divisions at 300 MHz and 4.5 divisions at 500 MHz. |
| AC Coupled | 0.35 division from 60 Hz to 50 MHz; increasing to 1.0 division at 300 MHz and 1.5 divisions at 500 MHz. Attenuates signals below 60 Hz. |
| 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 1.0 division at 300 MHz and 1.5 divisions at 500 MHz. |
| 2445B | |
| DC Coupled | 0.35 division from dc to 50 MHz; increasing to 1.5 divisions at 250 MHz. |
| NOISE REJ Coupled | ≤1.2 divisions from dc to 50 MHz; increasing to 4.5 divisions at 250 MHz. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| AC Coupled | 0.35 division from 60 Hz to 50 MHz; increasing to 1.5 divisions at 250 MHz. Attenuates signals below 60 Hz. |
| HF REJ Coupled | 0.5 division from dc to 30 kHz. |
| LF REJ Coupled | 0.50 division from 80 kHz to 50 MHz; increasing to 1.5 divisions at 250 MHz. |
| Minimum P-P Signal Amplitude for Stable Triggering from ADD Source | Add 0.5 division to CH 1 or CH 2 requirement at 300 MHz and 500 MHz for 2465B and 2455B. |
| Minimum P-P Signal Amplitude for Stable Triggering from CH 3 or CH 4 Source | 0.5 × CH 1 or CH 2 requirement. |
| Minimum P-P Signal Amplitude for Stable Triggering from Composite, Multiple Channel Source, ALT Vertical Mode | Add 1 division to the single-channel source specification.<br><br>Checked at 50 mV per division. |
| Maximum P-P Signal Rejected by NOISE REJ COUPLING Signals Within the Vertical Bandwidth | |
| CH 1 or CH 2 SOURCE | ≥0.4 division for VOLTS/DIV settings of 10 mV/div and higher.<br><br>Maximum noise amplitude rejected is reduced at 2 mV/div and 5 mV/div. |
| CH 3 or CH 4 SOURCE | ≥0.2 division. |
| Jitter | |
| 2465B | ≤50 ps with 5 divisions of 300 MHz at 500 ps/division. |
| 2455B | ≤50 ps with 5 divisions of 250 MHz at 1 ns/division. |
| 2445B | ≤100 ps with 5 divisions of 150 MHz at 1 ns/division. |
| LEVEL Control Range | |
| CH I or CH 2 SOURCE | ±18 × VOLTS/DIV setting. |
| CH 3 or CH 4 SOURCE | ±9 × VOLTS/DIV setting. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| LEVEL Readout Accuracy | For triggering signals with transition times greater than 20 ns. |
| CH 1 or CH 2 SOURCE | |
| +15°C to +35°C | Within ±[3% of reading + 3% of p-p signal + 0.2 division + 0.5 mV + (0.5 mV × probe attenuation factor)] with Vertical Input at 1 MΩ DC, CH 2 Source Not Inverted, and Trigger DC Coupled. |
| −15°C to +35°C and +35°C to +55°C | Add 1.5 mV × probe attenuation to +15°C to +35°C specification. |
| 50 Ω Input | Add ±1% to 1 MΩ input specification. |
| CH 2 Inverted | Add ±1% of reading to non-inverted specification. |
| NOISE REJ Coupled | Add ±0.6 division to DC Coupled specifications. |
| CH 3 or CH 4 SOURCE | Within ±[3% of reading + 4% of p-p signal + 0.1 division + (0.5 mV × probe attenuation factor)] and Trigger DC Coupled. |
| NOISE REJ Coupled | Add ±0.3 division to the DC Coupled specification. |
| AUTO LVL Mode Maximum Triggering Signal Period | |
| A SEC/DIV Setting | |
| <10 ms | At least 20 ms. |
| 10 ms to 50 ms | At least four times the A-SEC/DIV setting. |
| >50 ms | At least 200 ms. |
| AUTO Mode Maximum Triggering Signal Period | |
| A-SEC/DIV Setting | |
| <10 ms | At least 80 ms. |
| 10 ms to 50 ms | At least 16 times the A-SEC/DIV setting. |
| >50 ms | At least 800 ms. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| 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. |
| Trigger Holdoff | |
| Minimum | The greater of the A-SEC/DIV setting value or 2 μs, within +33% to −10%, except 1 μs at 5 ns/div. |
| Variable | Increases trigger holdoff time to 10 to 25 times the minimum holdoff. |
| SLOPE Selection | Conforms to trigger-source waveform or ac power-source waveform. |
| **HORIZONTAL DEFLECTION SYSTEM** | |
| A Sweep Time Base Range | |
| 2465B | 500 ms/div to 5 ns/div in a 1-2-5 sequence of 25 steps. X10 MAG extends maximum sweep rate to 500 ps/div. |
| 2455B and 2445B | 500 ms/div to 10 ns/div in a 1-2-5 sequence of 24 steps. X10 MAG extends maximum sweep rate to 1 ns/div. |
| B Sweep Time Base Range | |
| 2465B | 50 ms/div to 5 ns/div in a 1-2-5 sequence of 22 steps. X10 MAG extends maximum sweep rate to 500 ps/div. |
| 2455B and 2445B | 50 ms/div to 10 ns/div in a 1-2-5 sequence of 21 steps. X10 MAG extends maximum sweep rate to 1 ns/div. |
| Timing Accuracy | +15°C to +35°C, A Sweep, with SEC/DIV at 100 ms/div or faster. |
| Sweep Accuracy Unmagnified | ±(0.7% of time interval + 0.6% of full scale). |
| Δt Accuracy With Cursors, Unmagnified | ±(0.5% of time interval + 0.3% of full scale). |
| Δt Accuracy with Sweep Delay | ±(0.3% of time interval + 0.1% of full scale + 200 ps). |
| Delay Accuracy, A Sweep Trigger to Start of B Sweep | ±(0.3% of delay setting + 0.6% of full scale) +0 to −25 ns. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| B-Sweep Accuracy and Δt Accuracy with Cursors on B Sweep | Add ±0.3% of time interval to A-Sweep specifications. |
| X10 MAG Accuracy | Add ±0.5% of time interval to unmagnified Sweep and Δt Cursors specifications. Exclude the first 0.5 division after the sweep starts (the first 0.5% of the full 100 division sweep). |
| 500 ms or 200 ms/div Timing Accuracy (A Sweep only) | Add ±0.5% of interval to specifications for A SEC/DIV at 100 ms or faster. |
| SEC/DIV VAR Timing Accuracy | Add 2% of time interval to sweep accuracy specifications when VAR is out of detent. |
| 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 interval to sweep accuracy specification. |
| Δt Readout Resolution | |
| 2465B | Greater of either 10 ps or 0.025% of full scale. |
| 2455B, 2445B | Greater of either 20 ps or 0.25% of full scale. |
| Δt Range | ±10 times A-SEC/DIV setting with Cursors, ±9.95 times A-SEC/DIV setting with Sweep Delay. |
| Sweep Delay Range | 0 to 9.95 times the A SEC/DIV setting, from 500 ms to 10 ns with 2465B, or 500 ms to 20 ns with the 2455B and 2445B. A-Sweep triggering event is observable on B Sweep with zero delay setting for A SEC/DIV settings 10 μs or faster. |
| Delay Jitter | Within 0.004% (one part or less in 25,000) of the maximum available delay, plus 50 ps. |
| X10 MAG Registration | Within 0.5 division from graticule center at 1 ms SEC/DIV setting (X10 MAG on to X10 MAG off). |
| Horizontal POSITION Range | Start of 1 ms per division sweep can be positioned from right of graticule center to at least 10 divisions left of graticule center. Some portion of 1 ms per division sweep is always visible with X10 MAG off. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **HORIZONTAL DEFLECTION SYSTEM (cont)** | |
| X-Y Operation | |
| X-Axis Deflection Factor Range, Variable, and Input Characteristics | Same as Channel 1. |
| Deflection Factor Accuracy | Same as Channel 1. |
| X-Axis Bandwidth | Dc to 3 MHz. |
| Phase Difference Between X and Y with BW Limit Off | ≤1° from dc to 1 MHz; ≤3° from 1 MHz to 2 MHz. |
| X-Axis Low-frequency Linearity | 0.1 division or less compression or expansion of a two-division, center-screen signal when positioned within the graticule area. |
| **DISPLAY** | |
| Cursor Position Range | |
| Delta Volts (ΔV) | At least the center 7.6 vertical divisions. |
| Delta Time (Δt) | At least the center 9.6 horizontal divisions. |
| Graticule | |
| Size | 80 mm X 100 mm. |
| Markings | 8 major divisions vertically and 10 major divisions horizontally, with auxiliary markings. |
| Trace Rotation Range | Adequate to align trace with the center horizontal graticule line. |

Table 6-1 (cont)

| Characteristics | Performance Requirement |
|---|---|
| **Z-AXIS INPUT** | |
| Sensitivity | |
| Dc to 2 MHz | Positive voltage decreases intensity: +2 V blanks a maximum intensity trace. |
| 2 MHz to 20 MHz | +2 V modulates a normal intensity trace. |
| Input Impedance | 10 kΩ ±10%. |
| Maximum Input Voltage ⚠ | ± 25 V peak; 25 V p-p ac at 10 kHz or less. |
| **SIGNAL OUTPUTS** | |
| CALIBRATOR | With A SEC/DIV set to 1 ms. |
| 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. |
| Repetition Period | Two times the A SEC/DIV setting for SEC/DIV from 100 ns to 100 ms. |
| Accuracy | ± 0.1%, during sweep time. |
| CH 2 SIGNAL OUT | |
| Output Voltage | 20 mV/division ± 10% into 1 MΩ, 10 mV/division ±10% into 50 Ω. |
| Offset | ±20 mV into 1 MΩ, 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 400 mV. |
| Output Drive | Will supply 400 μA during HI state; will sink 2 mA during LO state. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **AC POWER SOURCE** | |
| Source Voltage<br>Nominal Ranges<br>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 × 20 mm Quick-acting. |
| Maximum Power Consumption (fully optioned instrument) | 120 watts (180 VA). |
| Primary Circuit Dielectric Voltage Withstand Test | 1500 V rms, 60 Hz for 10 seconds 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 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **PARAMETRIC MEASUREMENTS** | |
| Period | |
| Accuracy | |
| +15°C to +35°C | 0.9% + 0.5 ns + Jitter Error. |
| −15 to +15°C and +35°C to +55°C | Add 0.3%. |
| Minimum Period | ⩽ 2 ns. |
| Maximum Period | ⩾100 ms (MINFREQ=10Hz). |
| Minimum Signal Amplitude | ⩽ (60 mV * probe attenuation factor) p-p.<br>If DC coupling is used, the DC offset voltage must meet the following criteria:<br>At a VOLTS/DIV setting which gives a p-p signal ⩾ 4 divisions, the peak signal + offset must be ⩽12 divisions. |
| Frequency | Calculated as 1/period. |
| Volts | |
| +Peak, −Peak, Peak-to-Peak, and Average | |
| Accuracy | |
| +15°C to +35°C | 5% of reading + 5 mV + (0.5 mV * probe attenuation) + signal aberrations + 1 Least Significant Digit (LSD). |
| −15°C to +15°C and +35°C to +55°C | Add (1.5 mV * probe attenuation). |
| Minimum Width at Peak Amplitude | ⩽ 10 ns. |
| Maximum Sine Wave Frequency | |
| +15°C to +35°C | ⩾ 1 MHz. |
| −15°C to +15°C and +35°C to +55°C | Add 2%.<br>Volts measurements depend on peak signal measurements. Noise on the input signal, even if at a low repetition rate that makes it difficult to see, will be detected and will affect the measurements. |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements | |
|---|---|---|
| **PARAMETRIC MEASUREMENTS (cont)** | | |
| Pulse Width (High or Low)<br>Accuracy<br>+15°C to +35°C | 0.9% of reading + 1.0 ns + jitter error + 2 × offset error. | |
| −15°C to +15°C and 35°C to +55°C | Add 0.3%. | |
| Minimum Pulse Width | ≤ 5 ns. | |
| Minimum Repetition Rate | ≤ 10 Hz (with MINFREQ = 10 Hz). | |
| Duty Cycle | Calculated from Pulse Width and Period. | |
| Rise Time, Fall Time, and Time Interval<br>Accuracy<br>+15°C to +35°C | **Rise/Fall Time** | **Time Interval** |
| | 5% of reading + 3.0 ns + jitter error + offset error. | 0.5% of reading + 5% of start event transition time + 5% of stop event transition time + 3.0 ns + jitter error + offset error. |
| | Add 0.5 ns if measurement is made between CH1 and CH2.<br><br>Rise and Fall time measurement is made at 20% and 80% points of transition and linearly extrapolated to the 10% and 90% points.<br><br>Accuracy is relative to time interval as measured on screen using cursors. Measurement is made using peak-to-peak transition for measurement points in percent. | |
| −15 to +15°C and 35°C to +55°C | Add 2%. | |
| Minimum Time | ≤ 5 ns. | |
| Minimum Repetition Rate | ≤ 10 Hz (with MINFREQ = 10 Hz). | |

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **PARAMETRIC MEASUREMENTS (cont)** | |
| Jitter Error | Noise on the input signal causes jitter which introduces errors in the measurements. The amount of jitter depends on the noise amplitude and the slew rate of the input signals.<br><br>The amount of jitter can be calculated as:<br><br>$\text{jitter} = \frac{\text{input noise amplitude (peak)}}{\text{input slew rate in div/sec}}$<br><br>Input slew rate should be measured at 2 Volts/div settings more sensitive than the setting at the end of the measurements or at 5 mV/div, whichever is less sensitive.<br><br>The slew rate must be measured at the same points at which the measurement will be taken. The points for the various measurements are: |

**Measurement Points**

| Measurement | First Measurement point | Second Measurement point |
|---|---|---|
| Frequency | 50% amplitude | 50% amplitude |
| Width | 50% amplitude | 50% amplitude |
| Rise, Fall Time | 10% amplitude | 90% amplitude |
| Time interval | Specified by Time Interval Configuration | Specified by Time Interval Configuration |

The algorithms used for the measurements result in the following equation for the total jitter error that must be applied to the accuracy specifications.

Jitter Error = 2 * first point jitter
+ 2 * second point jitter.

**Table 6-1 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **PARAMETRIC MEASUREMENTS (cont)** | |
| Offset Error | Offset error is introduced when the trigger level is not set exactly at the expected points. This misplacement of the trigger level applied to any non-infinite slew rate produces a timing error. The magnitude of the error is given by:<br><br>$$\text{Offset Error} = \frac{\text{offset}}{\text{input slew rate}}$$<br><br>Frequency measurements do not suffer from offset errors since measurements are made with the same trigger level and slope, so no offset is introduced.<br><br>All other timing measurements suffer from offset errors.<br><br>The slew rates used to calculate offset errors must be measured at the first and second measurement points given in the Measurement Points table.<br><br>Offset error is calculated as:<br><br>$$\text{Offset Error} = \frac{0.2\ \text{div}}{\text{First Point slew rate}} + \frac{0.2\ \text{div}}{\text{Second Point slew rate}}$$<br><br>If a time interval measurement is made using Volts mode, the offset at each measurement point is:<br><br>0.2 div + 5% of measurement point voltage converted to divisions. |

**Table 6-2**
**Option 01 (DMM) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| **DC VOLTS** | |
| Accuracies by Range | |
| +18°C to +28°C | |
| 200 mV to 200 V | ±(0.03% of reading + 0.01% of full scale). |
| 500 V | ±(0.3% of reading + 0.04% of full scale). |
| −15°C to +18°C and +28°C to +55°C | |
| 200 mV to 200 V | Add ±(0.003% of reading + 0.001% of full scale)/°C below 18°C or above 28°C. |
| 500 V | Add ±(0.003% of reading + 0.004% of full scale)/°C below 18°C or above 28°C. |
| Common Mode Rejection Ratio | >100 dB at dc: >80 dB at 50 and 60 Hz, with 1 kΩ imbalance. |
| Normal Mode Rejection Ratio | >60 dB at 50 and 60 Hz. |
| Resolution | 1 part in 20,000 of full scale except 0.1 V on 500 V range. |
| Step Response Time | |
| Manual Range | Less than 1 second. |
| Auto Range | Less than 2 seconds. |
| Input Resistance | |
| 200 mV and 2 V Ranges | >1 GΩ or 10 MΩ, ±1%. |
| 20 V to 500 V Ranges | 10 MΩ ±1%. |
| Input Bias Current at 23°C Ambient Temperature | Less than 10 pA. |
| Reading Rate | Approximately 3 per second. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **AC VOLTS** | |
| Accuracies by Range | Crest Factor ≤4. |
| +18°C to +28°C | |
| 200 mV to 200 V | Input signal between 5% and 100% of full scale. |
| 40 Hz to 10 kHz | ±(0.6% of reading + 0.1% of full scale). |
| 20 Hz to 40 Hz and 10 kHz to 20 kHz | ±(1% of reading + 0.1% of full scale). |
| 20 kHz to 100 kHz | ±(5% of reading + 0.1% of full scale). |
| 500 V | Input signal between 100 V and 500 V. |
| 40 Hz to 10 kHz | ±(0.6% of reading + 0.2% of full scale). |
| 20 Hz to 40 Hz and 10 kHz to 20 kHz | ±(1% of reading + 0.2% of full scale). |
| 20 kHz to 100 kHz | ±(5% of reading + 0.2% of full scale). |
| −15°C to +18°C and +28°C to +55°C | |
| 200 mV to 200 V | Input signal between 5% and 100% of full scale. |
| 40 Hz to 10 kHz | ±(0.8% of reading + 0.1% of full scale). |
| 20 Hz to 40 Hz and 10 kHz to 20 kHz | ±(1.3% of reading + 0.1% of full scale). |
| 20 kHz to 10 kHz | ±(6% of reading + 0.1% of full scale). |
| 500 V | Input signal greater than 100 V and less than 500 V. |
| 40 Hz to 10 kHz | ±(0.8% of reading + 0.3% of full scale). |
| 20 Hz to 40 Hz and 10 kHz to 20 kHz | ±(1.3% of reading + 0.3% of full scale). |
| 20 kHz to 100 kHz | ±(6% of reading + 0.3% of full scale). |
| Common Mode Rejection Ratio | >60 dB from dc to 60 Hz, with 1 kΩ imbalance. |
| Resolution | 1 part in 20,000 of full scale except 0.1 V on 500 V range. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **AC VOLTS (cont)** | |
| Response Time | |
| Manual Range | Less than 2 seconds. |
| Auto Range | Less than 3 seconds. |
| Input Impedance | 1 MΩ ±1% in parallel with less than 100 pF. |
| dBV, dBm | |
| Accuracy | dB readings are calculated from AC VOLTS measurements. |
| Resolution | 0.01 dB. |
| **HI OHMS** | |
| Accuracies by Range | |
| +18°C to +28°C | |
| 2 kΩ to 2 MΩ | ±(0.1% of reading + 0.01% of full scale). |
| 20 MΩ | ±(0.5% of reading + 0.01% of full scale). |
| −15° C to +18°C and +28°C to +55°C | |
| 2 kΩ to 200 kΩ | Add ±(0.01% of reading + 0.001% of full scale)/°C above 28°C or below 18°C. |
| 2 MΩ | Add ±(0.01% of reading + 0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity. |
| 20 MΩ | Add ±(0.05% of reading + 0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity. |
| Voltage at Full Scale | Approximately 2 V. |
| Maximum Open Circuit Voltage | Less than 6 V. |
| Resolution | One part in 20,000 of full scale. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **HI OHMS (cont)** | |
| Measuring Current by Range | |
| 2 kΩ | Approximately 1 mA. |
| 20 kΩ | Approximately 0.1 mA. |
| 200 kΩ | Approximately 10 μA. |
| 2 MΩ | Approximately 1 μA. |
| 20 MΩ | Approximately 0.1 μA. |
| Response Time | |
| 2 kΩ to 2 MΩ | |
| Manual Range | Less than 1 second. |
| Auto Range | Less than 2 seconds. |
| 20 MΩ Range | Less than 5 seconds. |
| Reading Rate by Range | |
| 2 kΩ to 2 MΩ | Approximately 3 per second. |
| 20 MΩ | Approximately 1.5 per second. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **LO OHMS** | |
| Accuracies by Range | |
| +18°C to +28°C | |
| 200 Ω | ±(0.1% of reading + 0.1% of full scale). |
| 2 kΩ to 200 kΩ | ±(0.1% of reading + 0.01% of full scale). |
| 2 MΩ | ±(0.25% of reading + 0.01% of full scale). |
| −15°C to +18°C and +28°C to +55°C | |
| 200 Ω to 20 kΩ | Add ±(0.01% of reading + 0.001% of full scale)/°C above 28°C or below 18°C. |
| 200 kΩ | Add ±(0.01% of reading + 0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity. |
| 2 MΩ | Add ±(0.025% of reading + 0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity. |
| Voltage at Full Scale | Approximately 0.2 V. |
| Maximum Open Circuit Voltage | Less than 6 V. |
| Measuring Current by Range | |
| 200 Ω | Approximately 1 mA. |
| 2 kΩ | Approximately 0.1 mA. |
| 20 kΩ | Approximately 10 μA. |
| 200 kΩ | Approximately 1 μA. |
| 2 MΩ | Approximately 0.1 μA. |
| Resolution | 1 part in 20,000 of full scale. |
| Response Time | |
| Manual Range | Less than 1 second. |
| Auto Range | Less than 2 seconds. |
| Reading Rate | Approximately 3 per second. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirement |
|---|---|
| **AMPS** | |
| DC Accuracy | |
| +18oC to +28oC | ±(0.1% of reading + 0.02% of full scale). |
| −15oC to +18oC and +28oC to +55oC | ±(0.15% of reading + 0.06% of full scale). |
| AC Accuracy | |
| 20 Hz to 5 kHz sinewave | |
| +18oC to +28oC | ±(0.6% of reading + 0.1% of full scale). |
| −15oC to +18oC and +28oC to +55oC | ±(0.7% of reading + 0.15% of full scale). |
| 5 kHz to 10 kHz sinewave | |
| +18oC to +28oC | ±(2.5% of reading + 0.1% of full scale). |
| −15oC to +18oC and +28oC to +55oC | ±(2.6% of reading + 0.15% of full scale). |
| Response Time | |
| Manual Range | Less than 1 second. |
| Auto Range | Less than 2 seconds. |
| Input Resistance by Range | |
| 100 μA | Approximately 1.0 kΩ. |
| 1 mA | Approximately 100.0 Ω. |
| 10 mA | Approximately 10.5 Ω. |
| 100 mA | Approximately 1.5 Ω. |
| 1 A (1000 mA) | Approximately 0.5 Ω. |
| Maximum Input Current | 1 A. |
| Resolution | 1 part in 10,000 of full scale. |

**Table 6-2 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **CONTINUITY** | |
| Response Time | Approximately 0.1 second. |
| Threshold Resistance | 10 Ω ±1 Ω. |
| **TEMPERATURE** | |
| Accuracy | |
| +18°C to +28°C Ambient Temperature | ±(2% of reading + 1.5°C). |
| −15°C to +18°C and +28°C to +55°C Ambient Temperature | ±(2% of reading + 2.0°C). |
| Probe Tip Measurement Range | −62°C to +230°C in one range. |
| Resolution | 0.1°C or 0.1°F. |
| **ADDITIONAL CHARACTERISTICS** | |
| Warmup time to Meet Electrical Specification | 45 minutes. |
| Maximum Voltage between Inputs from either Input to Ground | |
| DC to 20 kHz | 500 V rms; 700 V peak. |
| Above 20 kHz | $10^7$ V*Hz. |

*NOTE*

*For AMPS modes, maximum voltage between inputs is limited by maximum input current.*

**Table 6-3**
**Option 05 (TV) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| **VERTICAL DEFLECTION SYSTEM—CHANNEL 1 AND CHANNEL 2** | |
| Frequency Response | For VOLTS/DIV settings between 5 mV and 0.2 V with VAR control in calibrated detent. Five-division, 50-kHz reference signal from a 50-Ω system. With external 50-Ω termination on 1 MΩ input. |
| Full Bandwidth | |
| 50 kHz to 5 MHz | Within ±1%. |
| >5 MHz to 10 MHz | Within +1%, −2%. |
| >10 MHz to 30 MHz | Within +2%, −3%. |
| Bandwidth Limit | |
| 50 kHz to 5 MHz | Within +1%, −4%. |
| Square Wave Flatness | With fast-rise step (rise time ≤1 ns), 1 MΩ dc input coupling, an external 50 Ω termination, and VAR VOLTS/DIV control in calibrated detent. Exclude the first 50 ns following the step transition. For signals with rise times ≤10 ns, add 2% p-p between 155 ns and 165 ns after step transition. |
| Field Rate | |
| 5 mV/div to 10 mV/div | 1.5% p-p at 60 Hz with input signal of 0.1 V. |
| 20 mV/div | 1% p-p at 60 Hz with input signal of 0.1 V. |
| 50 mV/div | 1% p-p at 60 Hz with input signal of 1.0 V. |
| Line Rate | |
| 5 mV/div to 10 mV/div | 1.5% p-p at 15 kHz with input signal of 0.1 V. |
| 20 mV/div | 1% p-p at 15 kHz with input signal of 0.1 V. |
| 50 mV/div | 1% p-p at 15 kHz with input signal of 1.0 V. |

**Table 6-3 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| TV (Back-Porch) Clamp (CH 2 only) | For VOLTS/DIV settings between 5 mV and 0.2 V with VAR control in calibrated detent. Six-division reference signal. |
| 60 Hz Attenuation | ⩾18 dB. |
| Back-Porch Reference | Within 1.0 division of ground reference. |
| **TRIGGERING** | |
| Sync Separation | Stable video rejection and sync separation from sync-positive or sync-negative composite video, 525 to 1280 lines, 50 Hz or 60 Hz, interlaced or noninterlaced systems.<br>For noninterlaced scan systems, the video signal source must start and end with full lines of video for correct line identification in the field trigger modes. |
| Line Selection Range in FLD1, FLD2, or Both Coupling Modes | The lesser of 1280 or the number of lines in the field. |
| Input Signal Amplitude for Stable Triggering | |
| Channel 1 or Channel 2 | Minimum sync-pulse amplitude within 18 divisions of input ground reference. |
| Composite Video | 1 division. |
| Composite Sync | 0.3 division. |
| Channel 3 or Channel 4 | Minimum sync-pulse amplitude within 9 divisions of input ground reference. |
| Composite Video | 0.5 division. |
| Composite Sync | 0.25 division. |

**Table 6-4**
**Option 06 (C/T/T) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| **SIGNAL INPUT** | |
| | With DC Coupling of A Trigger and B Trigger. |
| Maximum Input Frequency for Count and Delay by Events | ⩾150 MHz. |
| Minimum Width of High or Low State of Input Signal for Count and Delay by Events | ⩽3.3 ns. |
| Sensitivity | For Count, Delay by Events, and Logic Trigger Functions Excluding Word Recognizer. |
| Dc to 50 MHz (0.5 Hz to 50 MHz for Frequency and Period) | |
| CH 1 and CH 2 | 1.5 divisions. |
| CH 3 and CH 4 | 0.75 division. |
| 50 MHz to 150 MHz | |
| CH 1 and CH 2 | 4.0 divisions. |
| CH 3 and CH 4 | 2.0 divisions. |
| **FREQUENCY** | |
| Ranges | **RANGE** / **LSD INTERNAL REFERENCE** / **LSD EXTERNAL REFERENCE[a]**<br>1 Hz / 100 nHz / 10 nHz<br>10 Hz / 1 μHz / 100 nHz<br>100 Hz / 10 μHz / 1 μHz<br>1 kHz / 100 μHz / 10 μHz<br>10 kHz / 1 mHz / 100 μHz<br>100 kHz / 10 mHz / 1 mHz<br>1 MHz / 100 mHz / 10 mHz<br>10 MHz / 1 Hz / 100 mHz<br>100 MHz / 10 Hz / 1 Hz<br>150 MHz / 100 Hz / 10 Hz |
| Automatic Ranging | Upranges at 100% of full scale; downranges at 9% of full scale. Downrange occurs at 90 MHz on 150 MHz range. Full scale corresponds to the value given in the Range column. Maximum displayed value for any range is Range value LSD value.[a] |

[a]Refers to LSD reading with Option 1E installed.

**Table 6-4 (cont)**
**Option 06 (C/T/T) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| Accuracy | ±[Resolution + (Frequency × TBE)] Hz. |
| Time Base Error (TBE) | |
| Internal Reference | 10 ppm with less than 5 ppm per year drift. |
| External Reference[a] | Determined by external reference. |
| Resolution | $\frac{1.4 \times \text{Frequency}^2 \times \text{TJE}}{N}$ + LSD. |
| Display Update Rate | |
| Internal Reference | Twice per second or twice the period of the input signal, whichever is slower. |
| External Reference[a] | Twice per 1.5 seconds or twice the period of the input signal, whichever is slower. |
| **PERIOD** | |
| Ranges | **RANGE** / **LSD**<br>10 ns / 1 fs<br>100 ns / 10 fs<br>1 µs / 100 fs<br>10 µs / 1 ps<br>100 µs / 10 ps<br>1 ms / 100 ps<br>10 ms / 1 ns<br>100 ms / 10 ns<br>1 s / 100 ns<br>2 s / 1 µs |
| Minimum Period | ≤6.7 ns. |
| Automatic Ranging | Upranges at 100% of full scale; downranges at 9% of full scale.<br>Full scale corresponds to the value given in the Range column. The maximum displayed value for any range is the Range value minus the LSD value.[a] |

**[a]Refers to instruments with Option 1E installed.**

**Table 6-4 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **PERIOD (cont)** | |
| Accuracy | ± [Resolution + (TBE × Period)]. |
| Resolution | ±[LSD + (1.4 × TJE)/N]. |
| Display Update Rate | Twice per second or twice the period of the input signal, whichever is slower. |
| **TOTALIZE** | |
| Maximum Count | 9999999. |
| Display Update Rate | Twice per second or once per event, whichever is slower. |
| **DELAY BY EVENTS** | |
| Maximum Event Count | 4194303. |
| Minimum Time from Start Signal to Any Delay Event | 4 ns. |
| **LOGIC TRIGGER** | |
| Minimum Function-True Time | 4 ns. |
| Minimum Function-False Time | 4 ns. |

**Table 6-4 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **ADDED DELAY TIME CHARACTERISTICS WITH C/T/T** | |
| Run After Delay | |
| Accuracy | LSD[b] + [0.0012 × (A SEC/DIV)] + [0.03 × (B Time/Div)[c]] + A Trigger Level Error + 50 ns.<br><br>When the A Sweep is triggered by the Word Recognizer in synchronous mode, add 100 ns for probe delay; in asynchronous mode, add 200 ns for probe delay. |
| Triggerable After Delay | |
| Accuracy | For intervals within 70 ns to 10 times the A-SEC/DIV Setting. |
| | LSD[b] + [10 ppm × (measured interval)] + TJE + A-Trigger Level Error + B-Trigger Level Error + 0.5 ns.<br><br>If the A and B Sweeps are triggered from different channels, add 0.5 ns for channel-to-channel mismatch.<br><br>When the A Sweep is triggered by the Word Recognizer in synchronous mode, add 100 ns for probe delay; in asynchronous mode, add 200 ns for probe delay. |
| Minimum Measurable Delay Time | ≤70 ns. |
| Display Update Rate | In Auto Resolution, twice per second or once for every sweep, whichever is slower.<br><br>In 1 ns, 100 ps, and 10 ps resolution modes, the update rate depends on the A SEC/DIV setting and the trigger repetition rate. |

[b]**See Tables 2-1 and 2-2.**

[c]**B Time/Div includes SEC/DIV, X10 MAG, and VAR.**

**Table 6-4 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **ADDED DELTA-DELAY-TIME CHARACTERISTICS WITH C/T/T** | |
| Run After Delay | |
| Accuracy | LSD[b] + [0.0008 × (A SEC/DIV)] + [0.01 × (B Time/Div[c])] + 83 ps.<br><br>When the A Sweep is triggered by the Word Recognizer in synchronous mode, add 1 ns for probe jitter; in asynchronous mode, add 20 ns for probe jitter. |
| Triggerable After Delay | |
| Accuracy | Both delays are within 70 ns to 10 times the A-SEC/DIV setting. |
| Superimposed Delta Time | LSD[b] + [0.01 × (B Time/Div[c])] + [10 ppm × (A SEC/DIV)] + [10 ppm × (measured interval)] + 50 ps + TJE.<br><br>If CH 3 or CH 4 is one channel of a two-channel measurement, add 0.5 ns for channel-to-channel delay mismatch. |
| Nonsuperimposed Delta Time | LSD[b] + $\lvert t_{r_{REF}} - t_{r_{DELT}} \rvert$[d] + TJE + [(0.0005 div) × ($1/SR_{REF}$ + $1/SR_{DELT}$)] + [10 ppm × (A SEC/DIV)] + [10 ppm × (measured interval)] + 50 ps.<br><br>If A and B sweeps are triggered from different channels, add 0.5 ns for channel-to-channel mismatch + [0.5 div × ($1/SR_{REF}$ + $1/SR_{DELT}$)] for trigger offset. |
| Display Update Rate | In Auto Resolution, twice per second or once for every four sweeps, whichever is slower.<br><br>In 1 ns, 100 ps, and 10 ps resolution modes, the update rate depends on the A SEC/DIV setting and the trigger repetition rate. |

[b]**See Tables 2-1 and 2-2.**

[c]**B Time/Div includes SEC/DIV, X10 MAG, and VAR.**

[d]**This term assumes the trigger points are between the 10% and 90% points of the waveforms. Fall time is expressed as a negative risetime.**

**Table 6-4 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **DEFINITIONS** | |

A Trigger Level Error = (A Trigger Level Readout Error)/$SR_A$.

B Trigger Level Error = (B Trigger Level Readout Error)/$SR_B$.

$t_{r_{REF}}$ = rise time, reference trigger signal.

$t_{r_{DELT}}$ = rise time, delta trigger signal.

$SR_A$ = slew rate at trigger point, A Sweep trigger signal in div/sec.

$SR_B$ = slew rate at trigger point, B Sweep trigger signal in div/sec.

$SR_{REF}$ = slew rate at trigger point, reference trigger signal in div/sec.

$SR_{DELT}$ = slew rate at trigger point, delta trigger signal in div/sec.

TJE = trigger jitter error.

For delay or delta time, disregarding noise in the signal, this term contributes <1 LSD if the slew rate is greater than 0.03 vertical div/ns or if the slew rate is greater than 30000 vertical div/horizontal div.

Trigger Jitter = $[(\text{Reference Trigger Signal Jitter})^2 + (\text{Delta Trigger Signal Jitter})^2 + (\text{A Sweep Trigger Signal Jitter})^2]^{1/2}$.

Reference Trigger Signal Jitter = $(e_{n_S} + e_{n_{REF}})/SR_{REF}$.

= 0 for Frequency mode.

$e_{n_S}$ = scope noise in div.

= 0.05 div for HF REJ trigger coupling.

= 0.1 div for DC trigger coupling, 5 mV to 5 V sensitivity.

= 0.15 div for DC trigger coupling, 2 mV sensitivity.

$e_{n_{REF}}$ = reference signal rms noise in div.

**Table 6-4 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **DEFINITIONS (cont)** | |

Delta Trigger Signal Jitter = $(e_{n_S} + e_{n_{DELT}})/SR_{DELT}$.

= 0 for Frequency or Delay mode.

$e_{n_{DELT}}$ = delta signal rms noise in div.

A Trigger Signal Sweep Jitter = $(e_{n_S} + e_{n_A})/SR_A$.

$e_{n_A}$ = A sweep trigger signal rms noise in div.

When the Word Recognizer supplies a trigger in synchronous mode, the trigger jitter of the associated trigger signal is <1 ns; in asynchronous mode, the associated trigger signal jitter is <20 ns.

N = number of averages during measurement interval.

= see Table 2-1 for Delay or Delta Time.

= (measured frequency) × (measurement interval) for Frequency or Period.

Measurement Interval = 0.5 s or two periods of measured signal, whichever is greater.

**Table 6-5**
**Option 09 (WR) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| **SYNCHRONOUS MODE** | |
| Data Setup Time $D_0$—$D_{15}$ and Q | 25 ns. |
| Data Hold Time $D_0$—$D_{15}$ and Q | 0 ns. |
| Minimum Clock Pulse Width | |
| High | 20 ns. |
| Low | 20 ns. |
| Minimum Clock Period | 50 ns. |
| Delay from Selected Clock Edge to Word Out from C/T/T | ≤55 ns. |
| **ASYNCHRONOUS MODE** | |
| Maximum Trigger Frequency | 10 MHz. |
| Minimum Coincidence Between Data Inputs ($D_0$—$D_{15}$ & Q) Resulting in a Trigger | <85 ns. |
| Maximum Coincidence Between Data Inputs ($D_0$—$D_{15}$ & Q) Without Producing a Trigger | >20 ns. |
| Delay from Input Word Coincidence to Word Out | ≤140 ns. |

**Table 6-5 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| **INPUTS AND OUTPUTS** | |
| Input Voltages | |
| Minimum Input Voltage ⚠ | −0.5 V. |
| Maximum Input Voltage ⚠ | 5.5 V. |
| Maximum Input Low Voltage | 0.6 V. |
| Minimum Input High Voltage | 2.0 V. |
| WORD RECOG OUT | |
| High | > 2.5 V LSTTL output. |
| Low | < 0.5 V LSTTL output. |
| Input High Current | ≤20 μA. |
| Input Low Current | ≥ −0.6 mA source. |

**Table 6-5**
**Option 10 (GPIB) Electrical Characteristics**

| Characteristics | Performance Requirements |
|---|---|
| Vertical Position Accuracy | Position accuracy is only valid when:<br>1. Positioning occurs after a BALance command is invoked at the ambient temperature in which the instrument is operating.<br>2. The VOLTS/DIV VAR control is in the calibrated detent. |
| CH 1, CH 2 (noninverted) | |
| +15°C to +35°C | ±(0.3 div + 3% of distance from center screen in div + 0.5 mV/V/DIV setting.) |
| CH 2 Inverted | Add 0.2 div. |
| −15°C to +15°C and +35°C to +55°C | Add 1.5 mV/V/DIV setting. |
| CH 3 and CH 4 | ±(0.7 div + 3% of distance from center screen in div.) |
| IEEE 488 Outputs | |
| Volts Out for True ($I_{OT}$=48 mA) | Max 0.5 V. |
| Volts Out for False ($I_{OF}$=−5.2 mA) | Min 2.5 V. |
| Volts Out with Output Disabled | Max 3.7 V, Min 2.5 V. |
| Output Leakage Current with Power OFF (0 V <$V_{IN}$<2.5 V) | Max 40 μA. |
| IEEE 488 Inputs | |
| Volts In for True | Max 0.8 V, Min 0 V. |
| Volts In for False | Max 5.5 V, Min 2.0 V. |
| Current In for True ($V_{IT}$=0.5 V) | Max −0.1 mA. |
| Current In for False ($V_{IT}$=2.7 V) | Max 20 μA. |

**Table 6-7**
**Mechanical Characteristics**

| Characteristics | Description |
|---|---|
| Weight | |
| With Accessories and Pouch | 10.2 kg (22.4 lb). |
| With Option 05, 06 and 09, or 10 | 12.0 kg (26.44 lb). |
| With Option 01 | 13.1 kg (28.8 lb). |
| Without Accessories and Pouch | 9.3 kg (20.5 lb). |
| Domestic Shipping Weight | |
| 2465B, 2455B, 2445B | 12.8 kg (28.2 lb). |
| With Option 05, 06 and 09, or 10 | 17.6 kg (38.8 lb). |
| With Option 01 | 19.2 kg (42.2 lb). |
| Height | |
| Without Accessories Pouch | |
| 2465B, 2455B, 2445B with or without Options 05, 06 and 09, and 10 | 160 mm (6.29 in). |
| 2465B, 2455B, 2445B with Option 01 | 202 mm (7.96 in). |
| With Feet and Accessories Pouch | |
| 2465B, 2455B, 2445B with or without Options 05, 06 and 09, and 10 | 202 mm ± 25.4 mm (7.94 in ± 1.0 in). |
| 2465B, 2455B, 2445B with Option 01 | 243 mm ± 25.4 mm (9.56 in ± 1.0 in). |
| Width (with handle) | 338 mm (13.31 in). |
| Depth | |
| With Front Panel Cover | 434 mm (17.1 in). |
| With Handle Extended | 508 mm (20.0 in). |
| Cooling | Forced-air circulation. |
| Finish | Tek Blue vinyl clad material on aluminum cabinet. |
| Construction | Aluminum-alloy chassis (sheet metal). Plastic-laminate front panel. Glass-laminate circuit boards. |

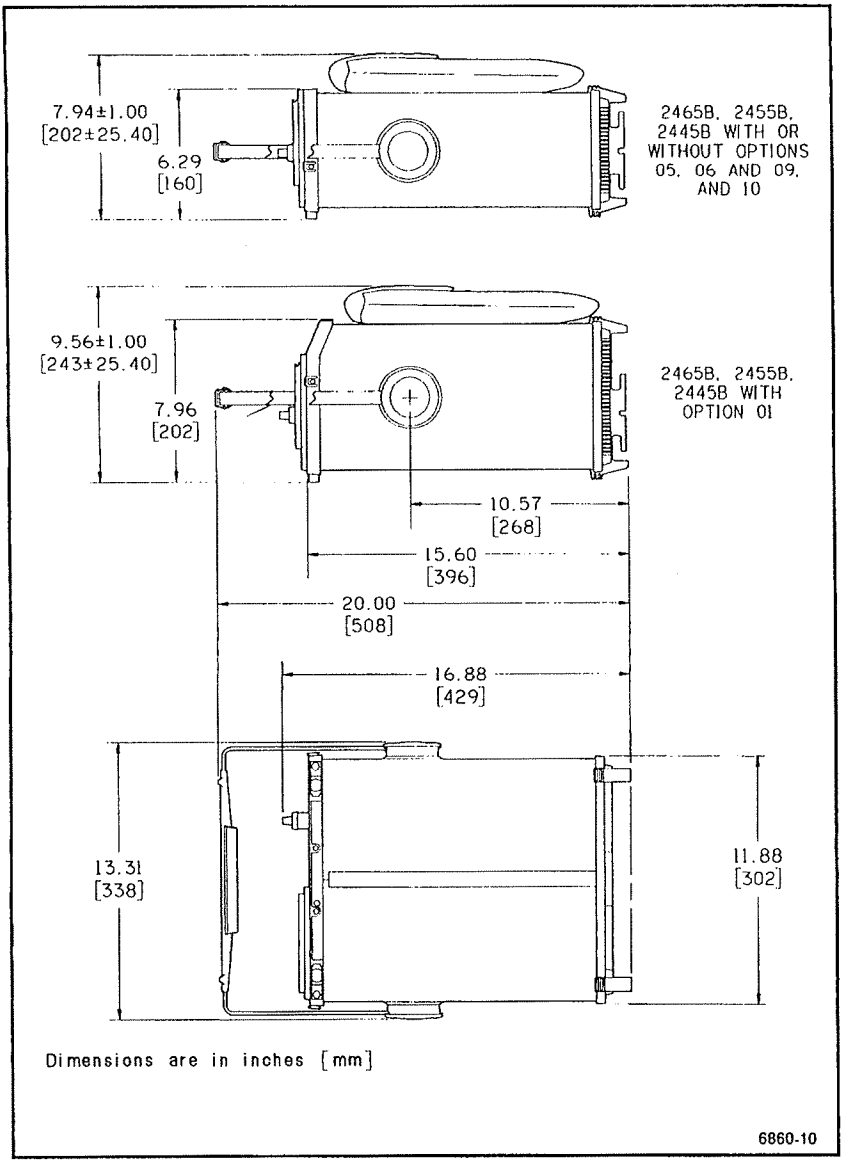



**Figure 6-1. Dimensional drawing.**

**Table 6-8**
**Environmental Requirements**

| Characteristics | Performance Requirements |
|---|---|
| | Environmmental requirements qualify the electrical and mechanical specifications. When not rack mounted, the instrument 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. Rack mounting changes the temperature, vibration, and shock capabilities. The rack mounted instruments meet or exceed the requirements of MIL-T-28800C with respect to Type III, Class 5, Style C equipment with the rack-mounting rear-support kit installed. Rack mounted instruments will be capable of meeting or exceeding the requirements of Tektronix Standard 062-2853-00, class 5. |
| Temperature | |
| Operating | −15°C to +55°C. |
| | For a rack mounted instrument, ambient temperature should be measured at the instrument's air inlet. Fan exhaust temperature should not exceed +65°C. |
| Nonoperating (Storage) | −62°C to +85°C. |
| Altitude | |
| Operating | To 15,000 feet. Maximum operating temperature decreases 1°C for each 1000 feet above 5000 feet. |
| Nonoperating (Storage) | To 50,000 feet. |
| Humidity | |
| Operating and Storage | 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) | |
| Not Rack Mounted | 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. Hold 10 minutes at each major resonance or, if none exists, hold 10 minutes at 55 Hz (75 minutes total test time). |
| Rack Mounted | Change displacement to 0.015 inch p-p (2.3 g at 55 Hz). |

**Table 6-8 (cont)**

| Characteristics | Performance Requirements |
|---|---|
| Shock (operating and nonoperating) | |
| Not Rack Mounted | 50 g, half sine, 11 ms duration, three shocks on each face, for a total of 18 shocks. |
| Rack Mounted | 30 g. |
| Transit Drop (not in shipping package) | 8-inch drop on each corner and each face (MIL-T-28800C, para. 4.5.5.4.2). |
| Bench Handling (cabinet on and cabinet off) | MIL-STD-810C, Method 516.2, Procedure V (MIL-T-28800C, para. 4.5.5.4.3). |
| Topple (operating with cabinet installed) | Set on rear feet and allow 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 Assn., 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 Assn., 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). |
| EMI (Electro-magnetic 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 RS-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. |
| Electrostatic Discharge Susceptibility | Meets Tektronix Standard 062-2862-00. The instrument will not change control states with discharges of less than 10 kV. |
| X-Ray Radiation | Meets requirements of Tektronix Standard 062-1860-00. |

# 7
# Options and Accessories

# Options and Accessories

This section contains a general description of instrument options available at the time of publication of this manual. Also included is a complete list (with Tektronix part numbers) of standard accessories included with each instrument and a partial list of optional accessories. Additional information about instrument options, option availability, and other accessories can be obtained either by consulting the current Tektronix Product Catalog or by contacting your local Tektronix Field Office or representative.

Options 01, 05, 06 and 09, and 10 are discussed throughout this manual.

## Option 11

Option 11 provides two probe-power connectors on the rear panel of the instrument. Voltages supplied at these connectors meet the power requirements of standard Tektronix active oscilloscope probes.

## Option 1R

When the oscilloscope is ordered with Option 1R, it is shipped in a configuration that permits easy installation into a 19-inch-wide electronic-equipment rack.

When rackmounting the instrument, the rear-support kit enables the rackmounted instrument to meet appropriate electrical and environmental specifications.

Connector-mounting holes are provided in the front panel of the rackmounted instrument. These enable convenient accessing of the four bnc connectors (CH 2 SIGNAL OUT, A GATE OUT, B GATE OUT, and EXT Z AXIS IN) and the two PROBE POWER connectors located on the rear panel. Additional cabling and connectors required to implement any front-panel access to the rear-panel connectors are supplied by the user; however, these items can be separately ordered from Tektronix.

Complete rackmounting instructions are provided in a separate document shipped with Option 1R. These instructions also contain appropriate procedures to convert a standard instrument into the Option 1R configuration by using the rackmounting conversion kit.

# Power Cord Options

Instruments are shipped with the detachable power-cord configuration ordered by the customer. Descriptive information about the international power-cord options is provided in Section 1, "Preparation for Use." The following list identifies the Tektronix part numbers for the available power cords and associated fuses.

**Universal Euro** - OPTION A1

| | |
|---|---|
| Power cord (2.5 m) | 161-0104-06 |
| Fuse (1.6 A, 250 V, 5 x 20 mm, Quick-acting) | 159-0098-00 |

**UK** - OPTION A2

| | |
|---|---|
| Power cord (2.5 m) | 161-0104-07 |
| Fuse (1.6 A, 250 V, 5 x 20 mm, Quick-acting) | 159-0098-00 |

**Australian** - OPTION A3

| | |
|---|---|
| Power Cord (2.5 m) | 161-0104-05 |
| Fuse (1.6 A, 250V, 5 x 20 mm, Quick-acting) | 159-0098-00 |

**North American** - OPTION A4

| | |
|---|---|
| Power Cord (2.5 m) | 161-0104-08 |
| Fuse (2 A, 250 V, AGC/3AG, Fast-blow) | 159-0021-00 |

**Switzerland** - OPTION A5

| | |
|---|---|
| Power Cord (2.5 m) | 161-0167-00 |
| Fuse (1.6 A, 250 V, 5 x 20 mm, Quick-acting) | 159-0098-00 |

# *Standard Accessories*

The following standard accessories are provided with each instrument:

| Qty | Description | Part Number |
|---|---|---|
| 2 | Probes (10X, 1.3 m) with Accessories (2465B and 2455B) | P6137 |
| 2 | Probes (10X, 2 m) with Accessories (2445B) | P6133 Opt. 25 |
| 1 | Banana Plug/ Binding Post Adaptor | 134-0016-01 |
| 1 | Accessory Pouch, Snap Fastener | 016-0692-00 |
| 1 | Accessory Pouch, Zip-lock Fastener | 016-0537-00 |
| 1 | Operators Manual | 070-6860-00 |
| 1 | Fuse (2 A, 250 V) | 159-0021-00 |
| 1 | CRT Filter, Blue Plastic (installed) | 378-0199-03 |
| 1 | CRT Filter, Clear Plastic | 378-0208-00 |
| 1 | Front Cover | 200-3199-01 |
| 1 | U.S. Power Cord | Option A0 |

The following standard accessories are provided with instruments containing Option 01 (DMM):

| Qty | Description | Part Number |
|---|---|---|
| 1 | Probe Set | 012-0941-01 |
| 1 | Accessories to Probe Set | 020-0087-00 |
| 1 | P6602 Temperature Probe | 010-6602-00 |

The following standard accessories are provided with instruments containing Option 05 (TV):

| Qty | Description | Part Number |
|---|---|---|
| 1 | CCIR Graticule | 378-0199-04 |
| 1 | NTSC Graticule | 378-0199-05 |
| 1 | Polarized Viewing Hood | 016-0180-00 |

The following standard accessories are provided with instruments containing Option 09 (WR):

| Qty | Description | Part Number |
|---|---|---|
| 1 | P6407 Word Recognizer Probe | 010-6407-01 |
| 2 | 10-wide comb, 10-inch leads (without grabbers) | 012-0747-00 |
| 20 | Grabber Tips | 206-0222-01 |

## Optional Accessories

The following optional accessories are recommended for use with the instrument:

| Description | Part Number |
|---|---|
| Protective Cover, Waterproof, Blue Vinyl | 016-0720-00 |
| Probe Package (2465B and 2455B) | P6137 |
| Probe Package (2445B) | P6133 Opt. 25 |
| Rackmounting Conversion Kit | 016-0825-01 |
| Polarized Collapsible Viewing Hood | 016-0180-00 |
| Folding Viewing Hood, Light-shielding | 016-0592-00 |
| Collapsible Viewing Hood, Binocular | 016-0566-00 |
| Oscilloscope Camera | See C30BP Option 1 |
| SCOPE-MOBILE Cart | K212 |
| Carrying Strap | 346-0199-00 |
| 2455B/2445B Service Manual | 070-6862-00 |
| 2467B/2465B Service Manual | 070-6863-00 |
| 24X5B/2467B Options Service Manual (SN B050000 and Above) [covers Option 05 (TV), Option 5H (HDTV), Option 06 (CTT), Option 09 (WR), and Option 10 (GPIB)] | 070-6864-02 |
| 24X5B/2467B Options Service Manual (SN B049999 and Below) [covers Option 05 (TV), Option 06 (CTT), Option 09 (WR), and Option 10 (GPIB)] | 070-6864-00 |

# A
# Appendix

# Extended Functions with Diagnostic Exercisers

Diagnostic exercisers provide access to an operating-time log and they control instrument setup modes and the viewing-time display. The available GPIB interface adds exercisers to establish system parameters of the instrument and to transfer the set of thirty saved setups from one instrument to one or more other instruments. With the available Television/Video *(TV)* enhancement, added exercisers control video line numbering. The available *DMM* also adds an exerciser, DM EXER 72. The Service Manual describes other exercisers which are used only for instrument testing and troubleshooting.

| | |
|---|---|
| **EXER 05** | Display Operating Time and Power Cycle Count |
| **EXER 06** | Select Setup to Use at Power Up |
| **EXER 07** | Enable/Disable Setup SAVE and Sequence Definition |
| **EXER 08** | Initialize Setups |
| **GP EXER 11** | Program GPIB Address |
| **GP EXER 12** | Program GPIB Message Terminator and Talk/Listen |
| **GP EXER 13** | Receive-Setups Mode |
| **GP EXER 14** | Send-Setups Mode |
| **TV EXER 61** | Select TV system-M or non-system-M |
| **TV EXER 62** | Select TV line numbering format |
| **TV EXER 63** | Select TV sync polarity default |
| **DM EXER 72** | Select DMM Continuity Tone and Input Resistance |

To operate these features:

1. Enter the Diagnostic Monitor mode by pressing and holding both ΔV and Δt, then pressing Trigger SLOPE while holding ΔV and Δt. The readout will display "DIAGNSTIC. PUSH A/B TRIG TO EXIT," indicating the Diagnostic Monitor mode.
2. Repeatedly press the upper or lower Trigger MODE button to sequence through the TEST and EXER routine labels and select the one you want to run.
3. Press the upper Trigger COUPLING button to execute the selected Exerciser. In all listed exercisers except EXER 05, the GP EXER's, and DM EXER 72, repeatedly pressing the upper Trigger COUPLING button cycles through the available selections.
4. To exit an exerciser, press the lower Trigger COUPLING button.
5. To return to normal instrument operation, press A/B/TRIG.

In the descriptions below, the lines marked with ">" show what is displayed in the top row of the readout.

**EXER 05** Display Operating Time and Power Cycle Count

> HRS ON nnnn OFF/ON CYCLES mmmm

nnnn = Accumulated Number of Hours with Power Applied
mmmm = Accumulated Number of Power Cycles

**EXER 06** Select Setup to Use at Power Up

> POWER UP TO POWER DOWN SETUP

Instrument will power up with the setup in effect at power down.

> POWER UP TO SETUP 1

Instrument will power up with the setup stored as setup 1.

**EXER 07** Enable/Disable Setup SAVE and Sequence Definition

> ENABLE SAVE AND SEQUENCE-CHANGE

All Save and Sequence functions are enabled.

> DISABLE SAVE AND SEQUENCE-CHANGE

All Save and Sequence-definition functions are disabled.

> ENABLE SAVE 1 - 8, NO SEQ-CHANGE

Only setups 1 through 8 can be changed. BEGIN/STEP/END attributes cannot be changed for any setup.

**EXER 08** Initialize Setups

> COUPLING UP CLEARS SAVED SETUPS

Press upper Trigger COUPLING to clear all saved setups.
Press lower Trigger COUPLING to retain saved setups.

**GP EXER 11** Program GPIB Address

> GPIB ADDRESS nn

nn = a primary address within 0 to 31. Turn the Δ control to select the appropriate address. With address 31, bus data has no effect on the instrument and is unaffected by the instrument.

**GP EXER 12** Program GPIB Message Terminator and Talk/Listen

Press the upper MODE button to select EOI or LF as message terminator. Press the upper SOURCE button to select TALK/LISTEN or LISTEN operation.

> TERMINATOR EOI MODE TALK LISTEN

The instrument accepts only the EOI bus message as the end of a string of received bytes. The instrument asserts EOI at the end of a string of transmitted bytes. The instrument can be addressed as a talker to send settings and readings.

> TERMINATOR LF MODE TALK LISTEN

The instrument accepts either the EOI bus message or an LF (line feed) character as the end of a string of received bytes. The instrument asserts CR (carriage return) then LF with EOI at the end of a string of transmitted bytes.

> TERMINATOR EOI MODE LISTEN ONLY

The instrument will not operate as a bus talker.

> TERMINATOR LF MODE LISTEN ONLY

**GP EXER 13** Receive-Setups Mode

> READY TO RECEIVE SETUPS

1. Connect the instrument to another instrument of the same model and with the same options by a GPIB cable. If the instrument is a different model in the following list: 2445B, 2455B, 2465B, 2465B CT, 2465B DM, 2465B DV, and 2467B, or one with a different set of options, most setups will be valid, but some will give unpredictable results.
2. Select GP EXER 14 in the other instrument.

> RECEIVING SETUPS

When the transfer is complete, the instrument will exit EXER 13 automatically.

**GP EXER 14** Send-Setups Mode

Before executing this exerciser, make sure the instrument is connected to another by a GPIB cable and be sure the other instrument is in the "READY TO RECEIVE SETUPS" state initiated by GP EXER 13.

> SENDING SETUPS

When the transfer is complete, the instrument will exit EXER 14 automatically.

**TV EXER 61** Select TV system-M or non-system-M

> LINE 1 OCCURS PRIOR TO FLD SYNC

System-M protocol is selected and the line count begins three lines before the field-sync pulse.

> LINE 1 COINCIDENT WITH FLD SYNC

Non-system-M protocol is selected and the line count begins coincident with the field-sync pulse.

**TV EXER 62** Select TV line numbering format

> LINE NO RESETS ON EACH FIELD

Line numbering begins with the first line of both field 1 and field 2.

> LINE NO RESETS ON FLD 1 ONLY

Line numbering begins at the first line of field 1 and continues through field 2.

**TV EXER 63** Select TV sync polarity default

> TVSYNC:SLOPE DEFAULT

Trigger Slope, which corresponds to sync polarity, does not change when LINES Coupling is selected.

> TVSYNC:POSITIVE

Trigger Slope is initialized to + when Coupling is changed from AC to LINES.

> TVSYNC:NEGATIVE

Trigger Slope is initialized to − when Coupling is changed from AC to LINES.

**DM EXER 72** Select DMM Continuity Tone and Input Resistance

> MOVE SOURCE FOR CONTINUITY TONE

Short the test leads together and press the upper SOURCE button to increase the pitch of the continuity tone or press the lower button to lower the pitch.

Press the upper COUPLING button to exit the continuity tone mode and press it again as required to select the desired input resistance.

> INPUT Z ON 0.2VDC 2VDC = 10 MΩ

Input resistance on all DCV ranges = 10 MΩ

> INPUT Z ON 0.2VDC 2VDC > 100G Ω

The input approaches an open circuit on the two lowest DCV ranges and equals 10 MΩ on all other DCV ranges.

# B
# Appendix

# C
# Appendix

# *Sequence Programming and Operation*

As many as thirty stored setups can be organized into one or more sequences to be sequentially recalled by the STEP/AUTO button. Unless otherwise defined, all thirty setups can be recalled in one sequence.

A sequence is defined as a contiguous group of saved setups, where the first setup includes the BEGIN attribute and the last setup includes the END attribute. The Sequence-Save mode provides access to the BEGIN/END attributes and provides sequence editing facilities to REPLACE, INSERT, and DELETE setups.

Pressing SAVE establishes the Direct-Save mode, as described in the "Operation" section. Pressing STEP then establishes the Sequence-Save mode. The readout shows a definition mode, a step attribute, a setup number, the "NAME:" prompt, and the name argument in the top row and a HELP message in the bottom row. (If the Direct-Save mode displays "SAVE FUNCTIONS DISABLED" or if the Sequence-Save mode displays "SEQUENCE DEFINITION DISABLED," refer to EXER 07, described in Appendix A.)

| | | | |
|---|---|---|---|
| Top Row | -- | REPLACE STEP :nn | NAME:xxxxxxx |
| or | -- | REPLACE BEGIN :nn | NAME:xxxxxxx |
| or | -- | REPLACE END :nn | NAME:xxxxxxx |
| Bottom Rows | -- | PUSH STEP TO REPLACE SETUP.<br>PUSH SAVE FOR HELP. | |

Δ REF moves a cursor to the definition mode field, the step attribute field, the setup number field, or any character in the NAME argument. The Δ control selects a definition mode, REPLACE, INSERT, or DELETE; a step attribute, STEP, BEGIN, or END; a setup number, 1-30; or a character for each position of the setup name.

The initial definition mode is REPLACE. Initial values of the step attribute and setup NAME are the values previously stored at the selected setup number, unless NAME was changed in the Direct-Save mode. The initial value of the setup number is one more than the previously defined or selected setup. The cursor initially remains in the NAME argument, as it was in the Direct-Save mode.

When STEP is pressed in the REPLACE definition mode, the current instrument setup, with the displayed step attribute and the displayed NAME, if the NAME has been changed, replaces setup "nn."

A step with the BEGIN attribute begins a sequence of setups. END defines a step that ends a sequence.

While REPLACE is selected, repeated operation of SAVE presents this cycle of HELP messages in the bottom rows.

| | | |
|---|---|---|
| Top Row | -- | REPLACE STEP :nn NAME:xxxxxxx |
| or | -- | REPLACE BEGIN :nn NAME:xxxxxxx |
| or | -- | REPLACE END :nn NAME:xxxxxxx |
| Bottom Rows | -- | PUSH STEP TO REPLACE SETUP. |
| | | PUSH SAVE FOR HELP. |
| or | -- | TURN Δ REF TO FIELD, THEN--- |
| | | TURN Δ TO DESIRED SETTING. |
| or | -- | PUSH MEASURE TO SAVE A MEASUREMENT. |
| | | PUSH RECALL TO CANCEL THIS MODE. |

When STEP is pressed in the INSERT definition mode, the numbers attached to the currently selected setup and each higher-numbered setup are increased by one and setup 30 is discarded. The current instrument setup, the displayed step attribute, and the displayed NAME are then stored in the selected memory location.

While INSERT is selected, repeated operation of SAVE presents this cycle of HELP messages in the bottom rows.

| | | |
|---|---|---|
| Top Row | -- | INSERT STEP :nn NAME:xxxxxxx |
| or | -- | INSERT BEGIN :nn NAME:xxxxxxx |
| or | -- | INSERT END :nn NAME:xxxxxxx |
| Bottom Rows | -- | INSERT WILL DESTROY STEP 30. |
| | | PUSH SAVE FOR HELP. |
| or | -- | PUSH STEP TO INSERT SETUP. |
| | | PUSH MEASURE TO SAVE A MEASUREMENT. |
| or | -- | TURN Δ REF TO FIELD, THEN--- |
| | | TURN Δ TO DESIRED SETTING. |
| or | -- | PUSH RECALL TO CANCEL THIS MODE. |

In the DELETE definition mode, the attribute and NAME fields cannot be changed. When STEP is pressed, the currently selected setup is moved to step 30 and the numbers associated with each higher-numbered setup decreases by one.

While DELETE is selected, repeated operation of SAVE presents this cycle of HELP messages in the bottom rows.

| | | |
|---|---|---|
| Top Row | -- | DELETE STEP :nn NAME:xxxxxxx |
| or | -- | DELETE BEGIN :nn NAME:xxxxxxx |
| or | -- | DELETE END :nn NAME:xxxxxxx |
| Bottom Rows | -- | PUSH STEP TO DELETE SETUP (or MEASSUREMENT). |
| | | PUSH SAVE FOR HELP. |
| or | -- | TURN Δ REF TO FIELD, THEN--- |
| | | TURN Δ TO DESIRED SETTING. |
| or | -- | PUSH RECALL TO CANCEL THIS MODE. |

# *Executing Sequences*

Pressing RECALL establishes the Direct-Recall mode, as described in the Operation section. Then pressing STEP in the Direct-Recall mode enables the Sequence-Recall mode. The top row of the readout shows the names of the first four defined BEGIN steps. If no BEGIN steps are defined, step 1 is the beginning of a sequence, by default. Pressing a setup-number button initiates the corresponding sequence and illuminates the STEP indicator. The position of each button among the others corresponds to the position of a sequence name among the others on the screen. Pressing STEP initiates the first defined sequence and illuminates the STEP indicator.

Repeatedly pressing RECALL presents this cycle of HELP messages. In message 1, "–n" is blank, "–2," "–3," or "–4," depending on how many sequences are defined.

| | | |
|---|---|---|
| Bottom Rows | -- | PUSH 1 – n OR STEP TO START SEQ. |
| | | PUSH RECALL FOR HELP. |
| or | -- | TURN Δ TO SELECT ANY STEP. |
| | | PUSH SAVE TO CANCEL THIS MODE. |

Turning Δ REF or Δ while in the Sequence-Recall mode allows access to any setup.

STEP recalls any selected setup, initiates sequential setups, and illuminates the STEP indicator. If the step number is decremented below 1, the Direct-Recall mode is reestablished.

| | | |
|---|---|---|
| Top Row | -- | nn xxxxxxx TURN Δ TO SELECT. |
| Bottom Rows | -- | PUSH STEP TO BEGIN SEQ HERE. |
| | | PUSH SAVE TO CANCEL THIS MODE. |

Repeated operation of STEP/AUTO sequentially steps through the sequentially stored setups. When an END step or step 30 is encountered, the sequence reverts to the previous BEGIN step, or to step 1, if no previous BEGIN step exists.

# *Power-Up Tests*

Power-up tests are automatically performed each time the instrument is turned on. These tests provide the user with the highest possible confidence that the instrument is operational. They include a Kernel test and Confidence tests.

## *Kernel Test*

A Kernel test failure is considered "fatal" to the operation of the instrument. A Kernel test failure causes the TRIG'D indicator to flash and displays a binary code pattern on other front panel indicators. If a Kernel test fails, the user can attempt to operate the instrument normally by pressing the A/B TRIG button. Operation is unpredictable; it depends on the nature of the failure.

## *Confidence Tests*

Confidence tests are performed after the processor kernel has been found operational. These tests check a portion of the instrument for correct operation.

If a Confidence test fails, the readout will indicate the nature of the failure by a coded message in this format:

**TEST XX FAIL YY**

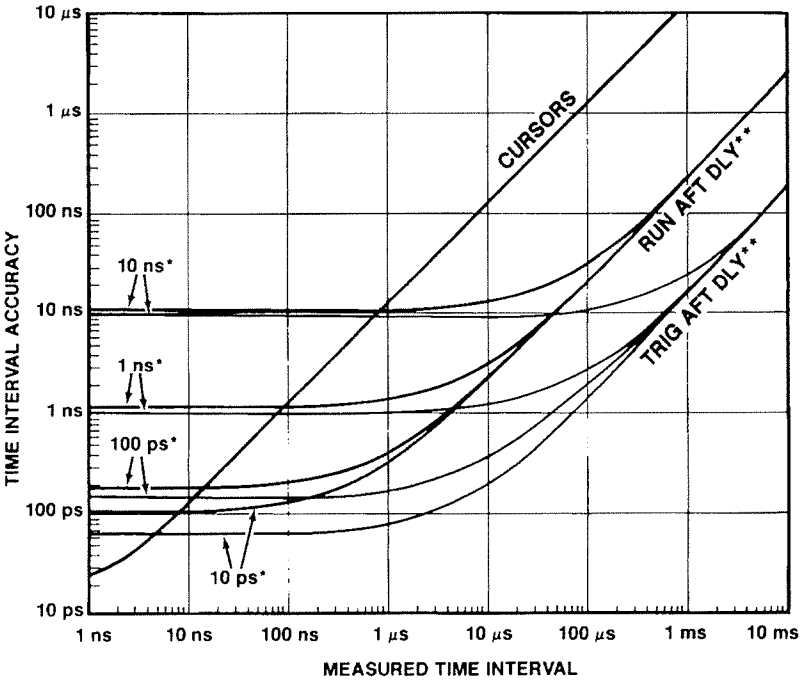
where XX is a two-digit test number and YY is a failure code. Table C-1 shows the function affected by detected failures.

**Table C-1**
**Confidence Test Numbers and Affected Functions**

| Test Number | Description |
|---|---|
| 01 | Controller Timing Signal Missing or Wrong Period |
| 02 | Momentary Switch Stuck |
| 03 | Readout Interface or Memory Failure |
| 04 | Calibration Data Parity or Checksum Error |
| 05 | Main Board Failure Detected by Auto Level Trigger on LINE Source |
| 06 | Memory-Battery Voltage Too High or Too Low |
| GP 11 | GPIB Interface Failure Detected |
| DM 76 | Digital Multimeter Failure Detected |
| CT 81 - 87 | Counter-Timer-Trigger Failure Detected |

# D
# Appendix

## *Delta-Time and Delta-Delay-Time Accuracy under Noted Conditions for the C/T/T Option*



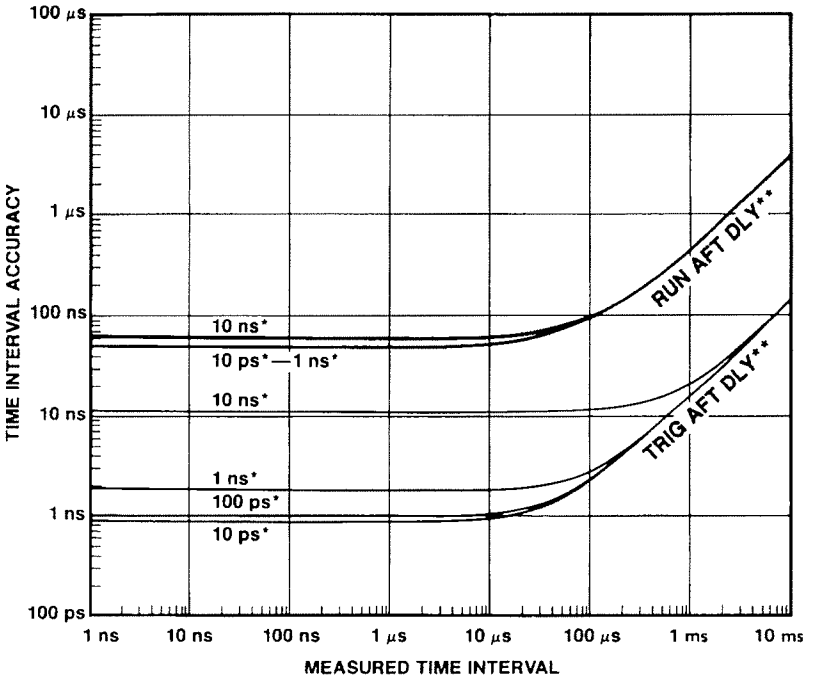

**CONDITIONS:**

1) Input signal is 5 vertical divisions with a 2 ns rise time.
2) Measured times are 4 horizontal divisions.
3) TJE is negligible for slew rates greater than 0.1/div ns.
4) For all B-Trigger modes, the beginning and end of the measured interval are visually superimposed.
5) RUN and TRIG accuracies are with RUN AFT DLY and TRIG AFT DLY B-Trigger Modes.

* Selected resolution. See "Resolution Selections" table for resolutions corresponding to trigger rates with AUTO resolution.

**B-Trigger Modes

## *Delay-Time Accuracy under Noted Conditions for the C/T/T Option*




**CONDITIONS:**
1) Input signal is 5 vertical divisions with a 2 ns rise time.
2) Measured times are 4 horizontal divisions.
3) TJE is negligible for slew rates greater than 0.1 div/ns.
4) RUN and TRIG accuracies are with RUN AFT DLY and TRIG AFT DLY B-Trigger Modes.

* Selected resolution. See "Resolution Selections" table for resolutions corresponding to trigger rates with AUTO resolution.

**B-Trigger Modes

# Index

Tektronix®

# REVISION INFORMATION

**Manual Part No.** 070-6860-00 **First Printing** MAY 1988

**Product:** 2445B/2455B/2465B Operators **Revised** Oct 1993

## Manual Insert Status

| Date | Change Reference | Status |
|---|---|---|
| JUL 90 | M73008 | Effective |

Tektronix
COMMITTED TO EXCELLENCE

# MANUAL CHANGE INFORMATION

Date: 07-05-90 Change Reference: M73008

Product: 2465B/2455B/2445B Operators Manual Part Number: 070-6860-00

**DESCRIPTION** Product Group 38

## EFFECTIVE SERIAL NUMBERS: 2445B B0600000

**PAGE I**

**Change the first and second paragraphs to:**

The TEKTRONIX 2465B, 2455B, and 2445B portable oscilloscopes have four vertical channels with DC to 400 MHz, 250 MHz, and 200 MHz bandwidths. . .

The trigger systems work automatically for most signals. They operate in various modes, from any channel, with couplings for a wide range of signals. The 2445B triggers from DC to 300 MHz. The 2455B and 2465B trigger from DC to 500 MHz.

**PAGE 6-3, 6-5, and 6-6**

**Change the 2445B Vertical Deflection System— Channel 1 and Channel 2, and Vertical Deflection System— Channel 3 and Channel 4 specifications to:**

| | | |
|---|---|---|
| −3 dB Bandwidth | | |
| | 2445B | |
| | +15°C to +35°C | DC to 200 MHz.[a] |
| | −15°C to +15°C and +35°C to +55°C | DC to 175 MHz. |
| −4.7 dB Bandwidth | | |
| | 2445B | |
| | +15°C to +35°C | DC to 200 MHz.[a] |
| | −15°C to +15°C and +35°C to +55°C | DC to 175 MHz. |
| Step Response Rise Time | | |
| | 2445B | ≤1.75 ns. |

Product: 2465B/2455B/2445B Oper Date: 07–05–90 Change Reference: M73008

**PAGE 6–7 and 6–8**

**Change the 2445B Triggering specifications to:**

Minimum P–P Signal Amplitude for Stable Triggering from Channel 1 or Channel 2 Source

2445B

| | |
|---|---|
| DC Coupled | 0.35 division from dc to 50 MHz; increasing to 1.0 division at 200 MHz and 1.5 divisions at 300 MHz. |
| NOISE REJ Coupled | ≤1.2 divisions from dc to 50 MHz; increasing to 3.0 divisions at 200 MHz and 4.5 divisions at 300 MHz. |
| AC Coupled | 0.35 division from 60 Hz to 50 MHz; increasing to 1.0 division at 200 MHz and 1.5 divisions at 300 MHz. Attenuates signals below 60 Hz. |
| LF REJ Coupled | 0.50 division from 80 kHz to 50 MHz; increasing to 1.0 division at 200 MHz and 1.5 divisions at 300 MHz. |

Jitter

| | |
|---|---|
| 2445B | ≤100 ps with 5 divisions of 200 MHz at 1 ns/division. |

**PAGE 7–3**

**Change the 2445B Standard Accessories to:**

| | | |
|---|---|---|
| 2 | Probes (10X, 1.3m) with Accessories | P6137 |

**PAGE 7–5**

**Change the 2445B Standard Accessories to:**

| | |
|---|---|
| Probe Package | P6137 |