TEK 150 MHz to 350 MHz FOUR CHANNEL OSCILLOSCOPES

2400 SERIES

## See, Measure, Automate at the Touch of a Button

## *NEW* 2465A/2445A

GPIB IEEE-488

The 2465A/2445A Option 10, 2465A CT, 2465A DM and 2465A DV comply with IEEE Standard 488-1978 and with Tektronix *Standard Codes and Formats*.

## *NEW* 2465A CT/ 2465A DM/2465A DV

**Special Editions**

**The Tek 2467/2465A/2445A Family: High Performance Capabilities to Match Your Tough Assignments**

Start with the standard setting performance of Tek's top portable analog scopes. Add new productivity enhancing features for fast operation. Increase the probe tip bandwidth to 350 MHz. The result: six new four channel, dual time base oscilloscopes that bring unprecedented efficiency to your design lab, production line or field service site.

**Built on High Performance That Set the Industry Standard**

New preamplifier circuits make possible the increased bandwidth—350 MHz in the 2465A, even at 2 mV/div sensitivity. New probes take the full bandwidth to the probe tip—where you need it.

Timing measurements are possible with 20 ps resolution at sweep speeds to 500 ps/div in the 2467/2465A and to 1 ns/div in the 2445A. Trigger on signals to at least 500 MHz with the 2467/2465A and to at least 250 MHz with the 2445A, which extends the usefulness of each scope well beyond its vertical bandwidth.

Trigger from any one of the four input channels or on four asynchronous signals. Tek's Auto-Level Trigger mode keeps your scope triggered even as the input signal changes. You can choose to trigger at the 10, 50, or 90% level of the signal. On-screen trigger level readout eliminates trial-and-error triggering, saving you time and frustration.

CRT readout of the vertical scale factors and input coupling, sweep speeds, trigger level and source, and indicators such as Bandwidth Limit and Holdoff give you complete status information at a glance. These settings are recorded on film in your waveform photos.

Dual, delaying time bases, each with an independent trigger system, allow for precise measurements on details embedded in complex waveforms.

**Time and Voltage Cursors With CRT *Readout for Immediate, Effortless Measurements of Waveform Parameters***

Use the cursors to obtain quick readouts of voltage, time, frequency, ratio and phase with no interpretation or CRT linearity errors. Readouts are in units of volts, time, percent and degrees.

And now the cursors can even be applied to delayed sweep displays, improving timing measurement flexibility.

**Tailor Your 2467/2465A/2445A for Special Needs, or Choose a Specially Configured Measurement Package**

To fit specialized performance requirements, the 2467/2465A/2445A Family offers five integral and combinable enhancements: GPIB Interface, Digital Multimeter, Counter/Timer functions with Enhanced Triggering, 17-bit Word Recognition, and Video Measurement capabilities.

You can also select one of three 2465A Special Editions. As packages, they are offered at a significant savings over the separately ordered measurement options.

The Tek 2465A CT is designed especially for use with communications, office and computer related equipment. The 2465A DM adds a digital multimeter for applications in government/military electronics, avionics and ATE stations. Finally there's the fully optioned 2465A DV for even more extensive applications including the design, manufacture and service of raster scan devices and high resolution video equipment. Easily the most powerful portable available.

**New Auto Setup, Instant Recall, Set-Up Sequencing: For Easy Answers Fast!**

Now you can attach up to four probes to signal points, press AUTO-SETUP, and within seconds a stable, automatically triggered display of the probed waveforms appears on screen for quick viewing or advanced parametric characterization. With AUTO-SETUP, users of any experience level gain increased speed and ease of use in making day-to-day waveform observations and measurements.

Digital design and test personnel are sure to appreciate Tek's proprietary Pulse Mode for viewing narrow pulses in detail. AUTO-SETUP calculates the duty factor and properly displays either the low duty cycle pulse or several cycles of symmetrical waveforms. Input channel selection is also sensed, and display positioning adjusted for up to four waveforms with appropriate scaling.

**Measure Signal Parameters Quickly, With Instant Access to Complex Setups**
For closer examination of your signals and for more specialized setups, such as delayed sweep displays or ones using the extended measurement options, front panel controls are still necessary. But now you only need to create these setups once. Nonvolatile memory for 30 setups stores *all* front panel information, including cursor locations and control settings for the extended measurement options.

The SAVE/RECALL utility is a tremendous time-saver for designers, evaluators and production test operators who need several setups for measurements at multiple test points in a circuit or system. Switching between measurements is fast, just two buttons for a complete setup. And operator attention is focused on answers, not on control adjustments.

Measurements are highly reliable as well as efficient. Vertical and horizontal accuracy are tightly specified for a wide range of environmental conditions. Pulse response is optimized for flatness and speed so the waveform measurement is a true representation of the signal. With the advanced feature set, including waveform cursors, the 2467/2465A/2445A Family minimizes errors and maximizes your confidence in measurement results.

**Automate Repetitive Measurement Sequences Without an External Controller**
Now systematic verification procedures for engineering prototypes, final production test or field service can easily be set up, stored and sequenced without a computer. Step through up to 30 of the stored setups in the order you choose. Just press the STEP button once for each sequence step. Or plug a foot switch into the rear panel audio jack for hands-free operation.

As a further aid, seven-character alphanumeric labels can be stored with each setup. The labels can be test titles or operator prompts for test point connections. You can protect the saved setups and sequences by write-protecting the memory.

Built-in sequencing and screen message capabilities are standard throughout the 2467/2465A/2445A Family. With a single, standalone portable oscilloscope you can implement extensive automated or semiautomated procedures. This provides an excellent, price-competitive entry into automated testing. The 2467/2465A/2445A family offers complete upward mobility from the 2445A through the 2467 and its options.

Add the GPIB option and take advantage of no-controller setup and sequence transfers, too. Create or modify stored setups on one scope, for example, then update the other scopes in a production test area with a simple transfer procedure.

*The GPIB option opens even more possibilities* for automating measurement procedures. All front panel controls on the 2467/2465A/2445A scopes are programmable and can be set up by an external controller. It also can send messages to the operator for semiautomated tests and read back measurement results for storage and analysis.

**Personal Computers Assist Hardware Development and Evaluation Taskwork**
For many single-step and multistep tests during product development, characterization and evaluation, the 2467/2465A/2445A's internal sequencer provides all the automation you need.

Further automation is accomplished by simply linking the scope with a PC, or other controller, via the GPIB. Use this configuration to debug prototypes, efficiently manage experiments, and record measurement results for documentation or analysis.

Test program generators such as EZ-TEK 2400 PC are designed so that developing your procedures involves little more than setting the scope's front panel controls and making selections from a screen menu. *You* don't need to write code.

Decrease a product's time to market by using the same scope/controller system and software throughout the development cycle. Tests that were designed during the engineering phase can be used for evaluation, then adapted for production. Consistency will be maintained in methods and results.

**Ideal for Production Test Systems**
Configuring 2467/2465A/2445A oscilloscopes for semiautomated operation takes advantage of the strengths of both humans and computers. The controller can record measurement results, make arithmetic-based pass/fail decisions, set the scope for each step of the procedure, and write prompting messages on the CRT. The operator's time is used efficiently to adjust cursors to the signal, compare waveforms against references marked by the controller with the cursors, and decide whether the visual criteria for each test has been met.

Combining the DMM, Video Measurement and CTT options with a 2467/2465A/2445A oscilloscope provides multi-instrument capabilities while reducing rack space, equipment cost and programming complexity. The self-diagnostic capabilities and self-calibration functions of the 2467/2465A/2445A scopes make them excellent candidates for installation in large and small test systems. A built-in run time counter assists in recordkeeping for preventative maintenance and calibration. The 2400 Series instruments offer proven reliability and are all backed by Tek's three year warranty.

**A Powerful Yet Portable System**
A GPIB- and DMM-equipped 2467/2465A/2445A, plus a 4041 controller are all a service technician needs to carry into the field for maintenance or troubleshooting. The controller leads the technician through the steps of a diagnostic test or calibration procedure. Measurement results are recorded on magnetic tape for later analysis or use in statistical recordkeeping.

**The 2467/2465A/2445A Family—Portable and Rugged**
The 2467/2465A/2445A and Special Editions are easy to carry to any field service site. And when you get there, they perform—even in extreme conditions—with environmental characteristics including a low EMI profile and rugged construction per MIL-T-28800C, Type III, Class 3, Style C.

Channels 1 and 2 vertical input couplings can be independently selected as ac, dc or ground. Or terminate your circuit outputs and controlled impedance transmission lines into 50 Ω. To protect against overload while using the internal 50 Ω terminations, the scopes automatically switch to 1 MΩ coupling when an overload is detected, and a readout indicates the change.

**The Assurance of Error-Free Operation is Backed by Tek's Three Year Warranty**
The warranty includes the CRT and can be easily extended to five years (in most countries) through a variety of optional service plans.

This, plus Tek quality and proven reliability, means you can expect outstanding value and long life from your oscilloscope investment. With new productivity-enhancing features to minimize training and operating time, the 2467/2465A/2445A Family offers economical solutions to your needs in waveform observation, measurement and automation. High performance at its affordable best.

## CHARACTERISTICS

Characteristics are common to the 2467, 2465A, 2455A, 2445A and 2465A Special Editions except where indicated.

### VERTICAL SYSTEM

**Display Modes** — CH 1, CH 2, CH 3, CH 4, Add (CH 1 + CH 2); Invert (CH 2 only); Alternating and Chopped display switching for all channels, and 20 MHz bandwidth limiting.

#### CHANNEL 1 AND CHANNEL 2

**Deflection Factor** — 2 mV/div to 5 V/div in a 1-2-5 sequence of 11 steps.

**Deflection Factor Basic Accuracy** — ±2%. Measured at a volts/div setting with a four or five division signal centered on screen.

**ΔV Accuracy** — ±(1.25% of reading + 0.03 div + signal aberrations). Basic accuracies apply for temperatures from +15°C to +35°C. Add ±2% of reading for temperatures from −15°C to +15°C and from +35°C to +55°C. Add 1% of reading when 50 Ω input coupling is used. Add 1% of Channel 2 reading when inverted. Measured with cursors anywhere on the graticule.

**ΔV Range** — ±8 times the Volts/div switch setting.

**Variable Range** — Continuously variable between Volts/div switch settings. Extends deflection factor to at least 12.5 V/div.

**Frequency Response (−3 dB Bandwidth)**

| Instrument | +15°C to +35°C | −15°C to +15°C +35°C to +55°C |
|---|---|---|
| 2467/2465A | 350 MHz | 300 MHz |
| 2455A | 250 MHz | 200 MHz |
| 2445A | 150 MHz | 150 MHz |

*All responses measured with standard accessory probe or internal 50 Ω termination.*

**Ac Coupled Lower −3 dB Point** — With 1X Probe: 10 Hz or less. With 10X Probe: 1 Hz or less.

**Step Response** — 2467/2465A: ≤1 ns. 2455A: ≤1.4 ns. 2445A: ≤2.33 ns. Rise times calculated from $t_r = 0.35/BW$.

**Common-Mode Rejection Ratio (Add Mode With Channel 2 Inverted)** — At least 20:1 at 50 MHz for common-mode signals of 8 div or less, with Var Volts/div control adjusted for best CMRR at 50 kHz at any Volts/div setting ≥5 mV.

**Channel Isolation** — ≥100:1 attenuation of deselected channel at 100 MHz; ≥50:1 at nominal bandwidth. Measured with an eight-division input signal and equal Volts/div switch settings on both channels from 2 mV/div to 500 mV/div.

**Displayed CH 2 Signal Delay With Respect to CH 1 Signal** — Adjustable through a range of at least ±500 ps.

**Input Z (1 MΩ)** — 1 MΩ ±0.5% shunted by 15 pF, ±2 pF. Maximum Input Voltage: 400 V (dc + peak ac); 800 V p-p ac at 10 kHz or less, for ac, dc, and ground-coupled signals.

**Input Z (50 Ω)** — 50 Ω ±1%. VSWR (2467/2465A): ≤1.3:1 from dc to 300 MHz; ≤1.5:1 from 300 MHz to 350 MHz. VSWR (2455A/2445A): ≤1.3:1 from dc to nominal bandwidth. Maximum Input Voltage: 5 VRMS, averaged for 1 s; ±50 V peak.

**Cascaded Operation** — Deflection Factor: 200 μV/div ±10%. For 200 μV/div sensitivity, use 20 MHz bandwidth limit.

#### CHANNEL 3 AND CHANNEL 4

**Deflection Factor** — 100 mV/div and 500 mV/div ±10%.

**Frequency Response** — Same as Channel 1 and Channel 2. Responses measured only with standard probe.

**Step Response** — Same as Channel 1 and Channel 2.

**Signal Delay Between Channel 1 and Either Channel 3 or Channel 4** — ±0.5 ns. Measured at 50% points.

**Input Z** — 1 MΩ ±1%, shunted by 15 pF ±3 pF. Maximum Input Voltage: 400 V (dc + peak ac); 800 V p-p ac at 10 kHz or less.

**Channel Isolation** — ≥50:1 attenuation of the deselected channel at 100 MHz. Measured with an 8 div input signal.

#### ALL CHANNELS

**Low Frequency Linearity** — 0.1 div or less compression or expansion of a 2 div, 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 30 ns of sweep is displayed before triggering event is displayed with Sec/div settings ≥10 ns/div. At least 10 ns of sweep is displayed before triggering event is displayed with Sec/div settings at 5 ns.

**CHOP Mode Switching Rate** — 2.5 MHz ±0.2% for sweep speeds ranging from 20 μs/div to 2 μs/div. 1 MHz ±0.2% for all other sweep speeds. The complete display cycle rate equals the CHOP mode switching rate divided by the number of channels displayed. The CHOP mode switching rate is modulated slightly to minimize waveform breaks with repetitive signals.

### HORIZONTAL SYSTEM

**Display Modes** — A (main sweep), A INTENSified, ALTernate A Intensified with B (delayed sweep), and B. In X-Y mode, Channel 1 provides X-axis (horizontal) deflection.

**A Sweep Time Base Range** — 2467/2465A: 500 ms/div to 5 ns/div in a 1-2-5 sequence of 25 steps. X10 magnification extends fastest sweep rate to 500 ps/div. 2455A and 2445A: 500 ms/div to 10 ns/div in a 1-2-5 sequence of 24 steps. X10 magnification extends fastest sweep rate to 1 ns/div.

**B Sweep Time Base Range** — 2467/2465A: 50 ms/div to 5 ns/div in a 1-2-5 sequence of 22 steps. X10 magnification extends fastest sweep rate to 500 ps/div. 2455A/2445A: 50 ms/div to 10 ns/div in a 1-2-5 sequence of 21 steps. X10 magnification extends fastest sweep rate to 1 ns/div.

**Variable Timing Control** — Continuously variable and calibrated between Sec/div settings. Extends slowest A sweep speed to 1.5 s/div. Affects the A Sec/div setting with the A display mode; affects the B Sec/div setting with INTEN, ALT, and B modes. The VAR control sets one signal cycle to five divisions for RATIO and PHASE measurements with cursors.

**Timing Accuracy**

| Parameter | For 100 ms/Div and Faster Settings: +15°C to +35°C | For 100 ms/Div and Faster Settings: −15°C to +15°C +35°C to +55°C |
|---|---|---|
| **Unmagnified** | | |
| A Sweep*1 | ±(0.7% of time interval +0.6% of full scale) | ±(1.2% of time interval +0.6% of full scale) |
| ΔT Using Cursors*2 | ±(0.5% of time interval +0.3% of full scale) | ±(0.7% of time interval +0.3% of full scale) |
| ΔT Using Sweep Delay*3 | ±(0.3% of time interval +0.1% of full scale) | ±(0.5% of time interval +0.1% of full scale) |
| Delay*4 | ±(0.3% of delay setting +0.6% of full scale) +(0 to −25 ns) | ±(0.5% of delay setting +0.6% of full scale) +(0 to −25 ns) |
| **Magnified** | | |
| A Sweep*5 | ±(1.2% of time interval +0.6% of full scale) | ±(1.7% of time interval +0.6% of full scale) |
| ΔT Using Cursors*5 | ±(1.0% of time interval +0.3% of full scale) | ±(1.2% of time interval +0.3% of full scale) |

*For the A Sec/div settings of 200 ms and 500 ms, add ±0.5% of time interval or delay setting to preceding specifications.*

**1 Intervals are measured on center horizontal graticule line, and 0.6% of full scale is 0.06 division.*

**2 Intervals are measured anywhere on the graticule.*

**3 Intervals are measured with both delays at 1% or more of full scale from minimum delay (no ? displayed in readout).*

**4 Delay is from A Sweep trigger point to start of B Sweep.*

**5 Exclude the first 0.5 division after sweep starts (first 0.5% of the full 100 division sweep).*

*B Sweep Timing Accuracy—Add ±0.3% of time interval to the A Sweep Timing accuracy specifications for Sweep and for ΔT Using Cursors.*

*Variable Timing Accuracy—Add 2% of time interval to Timing Accuracy specifications for sweep when VAR control is out of detent.*

**ΔT Readout Resolution** — 2467/2465A: Either 10 ps or 0.025% of full scale, whichever is greater. 2455A/2445A: Either 20 ps or 0.025% of full scale, whichever is greater.

**ΔT Range** — With Cursors: ±10 times the A Sec/div setting. With Sweep Delay: ±9.95 times the A Sec/div setting.

**Sweep Delay Range** — 0 to 9.95 times the A Sec/div setting, for settings from 500 ms/div to 10 ns/div (2467/2465A) or from 500 ms/div to 20 ns/div (2455A/2445A). With A Sec/div settings of 50 μs and faster, the A Sweep triggering event is observable on the B Sweep with zero delay setting.

**Delay Jitter** — 2467: Within 0.01% (one part or less in 10,000) of maximum available delay, plus 100 ps. 2465A/2455A/2445A: Within 0.004% (one part or less in 25,000) of maximum available delay, plus 50 ps.

**Position Control Range** — Start of the 1 ms/div sweep can be positioned from right of graticule center to at least 10 division left of graticule center. Some portion of the sweep is always visible with X10 magnification off.

NEW

GPIB

## TRIGGERING

**Trigger Sensitivity From CH 1 or CH 2 Source — Dc Coupled:** 0.35 div. **Noise Reject Coupled:** ≤1.2 div. **HF Reject Coupled:** 0.5 div from dc to 30 kHz. **LF Reject Coupled:** 0.5 div from 80 kHz. **Ac Coupled:** 0.35 div from 60 Hz.

Above 50 MHz, triggering signal requirement increases to 1.5 div at 500 mHz (for 2467, 2465A, and 2455A) and at 250 MHz (for 2445A) with dc, LF Reject, and ac coupling. For Noise Reject coupling above 50 MHz, triggering signal requirement increases to 4.5 div at 500 MHz (for 2467, 2465A, and 2455A) and at 250 MHz (for 2445A).

**Trigger Sensitivity From ADD Source — 2467/2465A/2455A:** Add 0.5 div to CH 1 or CH 2 source requirements at 500 MHz.

**Trigger Sensitivity From CH 3 or CH 4 Source — 2467/2465A/2455A:** One-half the CH 1 or CH 2 source requirements.

**Trigger Sensitivity From Multiple-Channel Composite Source — 2467/2465A/2455A:** Add 1.0 div to CH 1 or CH 2 source requirements.

**Maximum P-P Signal Rejected by Noise Reject Coupling Within Vertical Bandwidth — CH 1 or CH 2 Source:** ≥0.4 div with Volts/div settings of 10 mV/div and higher. Maximum noise amplitude rejected is reduced at 2 mV/div and 5 mV/div settings. **CH 3 or CH 4 Source:** ≥0.2 div.

**Jitter — 2467/2465A:** ≤100 ps with 5 div of 300 MHz at 500 ps/div. **2455A/2445A:** ≤100 ps with 5 div of nominal bandwidth at 1 ns/div.

**Level Control Range** — CH 1 or CH 2: ±18 times the Volts/div setting. CH 3 or CH 4: ±9 times the Volts/div setting.

**Level Readout Basic Accuracy — CH 1 or CH 2 Source:** ±[3% of Level setting +3% of p-p signal +0.2 div + 0.5 mV + (0.5 mV x probe attenuation factor)]. **CH 3 or CH 4 Source:** ±[3% of setting +4% of p-p signal +0.1 div +(0.5 mV x probe attenuation factor)].

Basic accuracies apply from +15°C to +35°C and are measured with triggering signals having transition times greater than 20 ns and dc trigger coupling. Add (1.5 mV x probe attenuation factor) for temperatures from −15°C to +15°C and from +35°C to +55°C. Add ±1% of setting from 50 Ω input coupling. Add ±1% of setting with Channel 2 Inverted. Add ±0.6 div for CH 1 or CH 2 Source with Noise Reject trigger coupling. Add ±0.3 div for CH 3 or CH 4 Source with Noise Reject trigger coupling.

**Maximum Triggering Signal Period**

| A Sec/div Setting | AUTO LVL Mode | AUTO Mode |
|---|---|---|
| <10 ms | ≥20 ms | ≥80 ms |
| 10 ms to 50 ms | ≥4 times A Sec/div | ≥16 times A Sec/div |
| >50 ms | ≥200 ms | ≥800 ms |

## X-Y OPERATION

**X-Axis Deflection Factor Range, Variable Range, and Accuracy** — Same as Channel 1.

**X-Axis Bandwidth** — Dc to 3 MHz.

**Input Z** — Same as Channel 1.

**Phase Difference Between X and Y (With Bandwidth Limiting Off)** — ≤1° from dc to 1 MHz. ≤3° from 1 MHz to 2 MHz.

**X-Axis Low Frequency Linearity** — 0.1 div or less compression or expansion of a 2 div, center-screen signal when positioned within the graticule area.

## CURSOR AND FRONT PANEL DISPLAY

**Cursor Position Range** — ΔVolts: At least the center 7.6 vertical divisions. ΔTime: At least the center 9.6 horizontal divisions.

## Z-AXIS INPUT

**Sensitivity** — From Dc to 2 MHz: Positive voltage decreases intensity. +2 V blanks a maximum intensity trace. 2 MHz to 20 MHz: +2 V p-p 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.

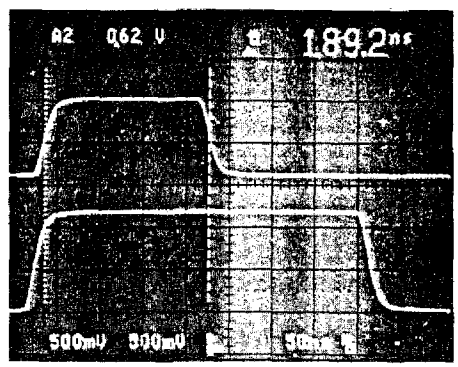
## SIGNAL OUTPUTS

**Calibrator** — Measured with the Sec/div setting at 1 ms/div. **Voltage Into 1 MΩ Load:** 400 mV ±1%. **Voltage Into 50 Ω Load:** 200 mV ±1.5%. **Short Circuit Load Current:** 8 mA ±1.5%. **Repetition Period and Accuracy:** Two times the A Sec/div switch setting for settings from 100 ns/div to 100 ms/div ±0.1%, during the sweep time.

**CH 2 Signal Out** — **Voltage:** 20 mV/div ±10% into 1 MΩ. 10 mV/div ±10% into 50 Ω. **Offset:** ±10 mV into 50 Ω after dc balancing within ±5°C of the operating temperature.

**A Gate Out and B Gate Out** — **Voltage:** 2.4 V to 5 V positive going pulse, starting at 0 V to 400 mV. **Drive:** Supplies 400 μA during HI state; sinks 2 mA during LO state.

## CRT READOUT AND WAVEFORM INFORMATION




*Your eyes never have to leave the screen to obtain front panel settings and measurement results. In the CRT example above, the top area of the display provides trigger source, trigger voltage level, and Δtime results. The lower area displays the selected volts/div and seconds/div scale factors and that bandwidth limit and holdoff are activated.*

## CRT AND DISPLAY FEATURES

**Standard CRT** — 2467: 68 mm x 85 mm. **2465A/2455A/2445A:** 80 mm x 100 mm (8 cm x 10 cm). Markings: Eight major div vertically and 10 major div horizontally, with auxiliary markings.

**Trace Rotation Range** — Adequate to align trace with center horizontal graticule line.

**Standard Phosphor** — GH (P31).

**Visual Writing Speed** — (2467) With 20 ft-cd. Illumination Normal to CRT Faceplate (typical room light): ≥4 div/ns at maximum INTENSITY control setting. No more than five bright spots will be visible at maximum INTENSITY control setting. Additional bright spots may be visible after displaying a high intensity trace. These spots will extinguish when INTENSITY control is set to minimum.

**Photographic Writing Speed — (2467)** ≥10 div/ns with C-30 Series camera and ISO 3000 film, without prefogging. A single-shot trace of instrument rise time at 500 ps/div is recorded with high contrast at f/1.9.

**Display Intensity Limitation — (2467)** Display intensity is automatically reduced and eventually extinguished after periods of no front panel control activity. The time elapsed before intensity reduction is shortened by high intensity settings and high duty factor/sweep speed/trigger rate combinations. Operating any switch or the INTENSITY control restores the selected intensity setting.

## POWER REQUIREMENTS

**Line Voltage Ranges** — 115 V: 90 V to 132 V ac. 230 V: 180 V to 250 V ac.

**Line Frequency** — 48 Hz to 440 Hz.

**Maximum Power Consumption** — 120 W (180 V ac) for fully optioned instrument.

**Fuse Rating** — Either 2 A, 250 V, AGC/3AG, fast-blow or 1.6 A, 250 V, 5 x 20 mm, quick-acting. Each fuse type requires a different cap.

**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.

## ENVIRONMENTAL AND SAFETY

Environmental 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 humidity and temperature requirements defined in paragraphs 3.9.2.2, 3.9.2.3, and 3.9.2.4.

**Ambient Temperature** — Operating: −15°C to +55°C. Nonoperating: −62°C to +85°C.

**Altitude** — Operating: To 4600 m (15,000 ft). Maximum operating temperature decreases 1°C for each 1,000 ft above 1500 m (5,000 ft). Nonoperating: To 15 000 m (50,000 ft).

**Vibration** — Operating: 15 minutes along each of three axes at a total displacement of 0.025 inch p-p (4 g's at 55 Hz), with frequency varied from 10 Hz to 55 Hz in one-minute sweeps. Held 10 minutes at each major resonance, or if none existed, held 10 minutes at 55 Hz (75 minutes total test time).

**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 per Tektronix Standard 062-2858-00.

**Humidity** — Operating and Nonoperating: Stored at 95% relative humidity for 5 cycles (120 hours) from +30°C to +60°C, with operational performance checks at +30°C and +55°C.

**Shock** — Operating and Nonoperating: 50 g's, half-sine, 11 ms duration, three shocks on each face, for a total of 18 shocks.

**Electromagnetic Compatibility** — Meets requirements of the following standards: 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; FCC Rules and Regulations Part 15, Subpart J, Class A; and Tektronix Standard 062-2866-00.

**Electrostatic Discharge Susceptibility** — Instrument does not change control states with discharges of less than 10 kV. Meets requirements of Tektronix Standard 062-2862-00.

**Radiation** — Meets requirements of Tektronix Standard 062-1860-00.

**Safety** — UL listed (UL 1244) and CSA certified (CSA 556B).

**Drip Proof** — With Cover On: Meets MIL-T-28800C para 4.5.5.5.3.

**Transit Drop** — Not In Shipping Package: 12-inch drop on each corner and each face (MIL-T-28800C, para 4.5.5.4.2).

**Packaged Transportation Drop** — Meets the limits of the National Safe Transit Association Test Procedure 1A-B-2; 10 drops of 36 inches per Tektronix Standard 062-2858-00.

**Bench Handling** — With and Without Cabinet Installed: MIL-STD-810C, Method 516.2, Procedure V (MIL-T-28800C, para 4.5.5.4.3).

**Topple** — Operating and Cabinet Installed: Set on rear feet and allowed to topple over onto each of four adjacent faces per Tektronix Standard 062-2858-00.

### PHYSICAL CHARACTERISTICS

| | 2465A/2467 | | 2455A/2445A | | Rackmount | |
|---|---|---|---|---|---|---|
| **Dimensions** | **mm** | **in** | **mm** | **in** | **mm** | **in** |
| Width | | | | | | |
| With handle | 330 | 13.0 | 338 | 13.3 | 483 | 19.0 |
| Height | | | | | | |
| With feet, pouch | 190 | 7.5 | 190 | 7.5 | 178 | 7.0 |
| Without pouch | 165 | 6.5 | 180 | 6.3 | | |
| Depth | | | | | | |
| With front cover | 467 | 18.4 | 434 | 17.1 | 419 | 16.5 |
| handle extended | 533 | 21.0 | 505 | 19.9 | | |
| **Weights≈** | **kg** | **lb** | **kg** | **lb** | **kg** | **lb** |
| Net | | | | | | |
| With accessories and pouch | 10.9 | 24.0 | 10.2 | 22.2 | 4.0*1 | 8.8*1 |
| Without accessories and pouch | 9.7 | 21.3 | 9.3 | 20.5 | | |
| Shipping | 14.6 | 32.1 | 12.8 | 28.2 | 6.3*1 | 13.8*1 |

*1 *Weight of conversion kit only. Rear support kit weight is an additional 6.3 kg (13.8 lb).*

**Cooling** — Forced air circulation.

**Construction** — Sheet aluminum-alloy chassis; plastic-laminate front panel; glass-laminate circuit boards.

**Ordering Information** — See page 289.

## CHARACTERISTICS (OPTION 09)

The set of characteristics is the same as specified for standard 2467/2445A/2465A oscilloscopes and includes the following additions:

**Sensitivity** — Signal input requirements for Frequency, Period, Totalize, Delay-by-Events and Logic Trigger.

| Input | Displayed Signal | Frequency Range |
|---|---|---|
| CH 1, CH 2 | 1.5 div | Dc (0.5 Hz for Frequency and Period) to 50 MHz |
| CH 3, CH 4 | 0.75 div | |
| CH 1, CH 2 | 4.0 div | 50 MHz to ≥150 MHz |
| CH 3, CH 4 | 2.0 div | |

**Source** — A trigger or word recognizer for Frequency, Period, and Totalize.

### FREQUENCY

**Range** — Autoranging over input frequency from 0.5 Hz to 150 MHz.

**Resolution** — $\pm\left[LSD + 1.4 \times \frac{TJE}{N} \times (F)^2\right]$

**Display** — Seven digits, updates twice per second or every two periods, whichever is slower.

**Accuracy** — Resolution ±0.001% of reading over entire temperature range of −15°C to +55°C.

### PERIOD

**Range** — Autoranging over an input period from 6.666667 ns to 2 s.

**Resolution** — $\pm\left(LSD + 1.4 \times \frac{TJE}{N}\right)$

**Display** — Seven digits, updates twice per second or every two periods, whichever is slower.

**Accuracy** — Resolution ±0.001% of reading over entire temperature range of −15°C to +55°C.

### ACCURACY AND RESOLUTION DEFINITIONS

**F**=Input Frequency in Hz

**LSD**=Least Significant Digit (0.1 ppm of full scale)

**TJE**=Trigger Jitter Error

**N**=Number of cycles of measured frequency during measurement interval (0.5 s or 1 period of the input signal, whichever is greater)

**TJE (Trigger Jitter Error)**=

$$\sqrt{\frac{(en1)^2 + (en2)^2}{\text{Input Slew Rate}}}$$

Where: en1=RMS noise of vertical system in div on screen

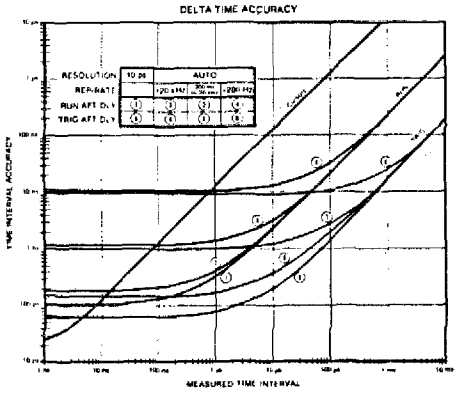
en2=RMS noise voltage of input signal in divs

| Volts/div | en1 | |
|---|---|---|
| | Trigger Coupling Dc and Noise Rej | Trigger Coupling HF Reject |
| 2 mV | 0.15 div | 0.05 div |
| 5 mV to 5 V | 0.1 div | 0.05 div |

### ΔTIME, 1/ΔTIME

**TRIG AFT DLY Accuracy** — ±(LSD +0.01 x B Time/div) + (0.001% x A Sec/div +0.001% of reading +50 ps). Measured with visually superimposed signal transitions, >0.1 div/ns trigger-signal slew rates, and with channel-to-channel delay mismatch corrected by the CH 2 DLY match adjustment from the front panel. Independent SLOPE and LEVEL settings for ΔREF and ΔB triggers allow visual superposition of any pair of points within the center 80% of transitions having at least 5 div amplitude.

**RUN AFT DLY Accuracy** — ±(LSD +0.0008 x A Sec/div) + (0.01 x B Time/div + 83 ps). B Time/div includes 10X mag.




*Notes: Input Signal is five vertical div with a 2 ns rise time.*

*Measured times are four horizontal div.*

*TJE is negligible for Slew Rates >0.1 div/ns.*

*ΔTime TRIG AFT DLY assumes visual superposition.*

**Display Update Rate** — Auto resolution, twice per second or every four sweeps, whichever is slower. Depends on trigger and sweep rates with selectable resolution.

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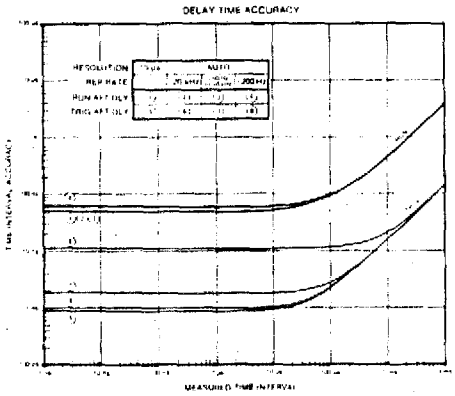
### DELAY TIME

**TRIG AFT DLY Accuracy** — ±(LSD +0.001% of reading +0.5 ns +A trigger slew error +B trigger slew error). Add 0.5 ns for dual channel measurements.

Where: Trigger slew error equals trigger level control readout accuracy ÷ trigger signal slew rate at the trigger point.

**RUN AFT DLY Accuracy** — ±(LSD +0.0012 x A Sec/div +0.03 x B Time/div +50 ns). (B Time/div includes 10X mag.)

**TRIG AFT DLY and RUN AFT DLY Accuracies Using Word Recognizer on the B Trigger** — Add 100 ns, if using external clock. Add 200 ns, if not using external clock.




*Notes: Input Signal is five vertical div with a 2 ns rise time.*

*Measured times are four horizontal div.*

*TJE is negligible for Slew Rates >0.1 div/ns.*

*ΔTime TRIG AFT DLY assumes visual superposition.*

**Display Update Rate** — Auto, twice per second or once for each sweep, whichever is slower. Depends on trigger and sweep rate for selectable resolution.

**Selectable Resolution**

| A Sec/Div | Selected Resolution | LSD |
|---|---|---|
| 10 ns to 1 s | AUTO | See Auto Resolution below |
| 10 ns to 5 μs | 10 ps<br>100 ps<br>1 ns | 10 ps<br>100 ps<br>1 ns |
| 10 μs to 50 μs | 10 ps or 100 ps<br>1 ns | 100 ps<br>1 ns |
| 100 μs to 500 μs | 10 ps to 1 ns | 1 ns |
| 1 ms to 5 ms | 10 ps to 1 ns | 10 ns |
| 10 ms to 50 ms | 10 ps to 1 ns | 100 ns |
| 100 ms to 500 ms | 10 ps to 1 ns | 1 μs |
| 1 s | 10 ps to 1 ns | 10 μs |

**Auto Resolution**

| A Sec/Div | Trigger Repetition Rate | LSD |
|---|---|---|
| 10 ns to 2 μs | >20 kHz | 100 ps |
| 10 ns to 2 μs | 200 Hz to 20 kHz | 1 ns |
| 5 μs to 200 μs | >200 Hz | 1 ns |
| 10 ns to 200 μs | <200 Hz | 10 ns |
| 500 μs to 5 ms | Any | 10 ns |
| 10 ms to 50 ms | Any | 100 ns |
| 100 ms to 500 ms | Any | 1 μs |
| 1 s | Any | 10 μs |

*Note: 2445A Sec/div settings range from 20 ns to 1 s.*
*2465A Sec/div settings range from 10 ns to 500 ms.*

### TOTALIZE

**Maximum Count** — To 9,999,999 events.

### DELAY BY EVENTS

**A or B Sweep** — The A trigger or 17-bit word recognizer defines start events. The B trigger or 17-bit word recognizer defines delay events. With A sweep in the delayed by events mode, the B sweep is delayable by time.

**Maximum Delay Count** — Up to 4,194,303.

**Minimum Time From Start Event to Any Delay Event** — ≥4 ns.

**Minimum Pulse Width** — ≥3.3 ns.

### LOGIC TRIGGER

**Combination Trigger** — A sweep can be triggered from logical combinations of A and B triggers (A and B) or (A or B), or the word recognizer. B sweep can be triggered from the word recognizer.

**Minimum Time to Satisfy Logic Combinations** — ≥4 ns.

### WORD RECOGNIZER

**Input** — P6407 Word Recognizer Probe, 17 bits plus clock. (No CRT display from P6407.)

| All Inputs | Threshold | Load | Safe Limit |
|---|---|---|---|
| High | <2.0 V | <20 μA | 5.5 V |
| Low | >0.6 V | >−0.6 mA | −0.5 V |

**Display Radix** — Hexadecimal, octal, binary.

**Data Rate** — 0 MHz to ≥20 MHz with clock, 0 MHz to ≥10 MHz without clock.

**Data Set-Up Time** — 25 ns.

**Data Hold Time** — 0 ns.

**GPIB Compatibility for Semiautomatic Measurement Systems** — When combined with Option 10 the CTT/WR (Option 09) Oscilloscope combination is fully programmable. Complies with Tektronix *Standard Codes and Formats.*

**Ordering Information** — See page 289.

## CHARACTERISTICS (OPTION 05)

The set of characteristics is the same as specified for standard 2467/2445A/2465A oscilloscopes and includes the following additions:

### VERTICAL SYSTEM (CHANNEL 1 AND CHANNEL 2)

**Frequency Response** — Applicable for volt/div settings between 5 mV and 0.2 V with Var volt/div control in calibrated detent and using a 5 div, 50 kHz reference signal from a 50 Ω or 75 Ω system.

| Range | With Full BW | With BW Limiting |
|---|---|---|
| 50 kHz to 5 MHz | ±1% | +1%, −4% |
| >5 MHz to 10 MHz | +1%, −2% | *1 |
| >10 MHz to 30 MHz | +2%, −3% | *1 |
| >30 MHz | *1 | *1 |

**1 Same as basic instrument.*

**Squarewave Flatness** — 1% p-p for both 60 Hz and 15 kHz squarewaves, from a 50 Ω or 75 Ω system using a 1.0 V input with a 50 mV/div setting and using a 0.1 V input at 20 mV/div setting. 1.5% p-p using a 0.1 V input with 5 mV/div and 10 mV/div settings. Exclude first 50 ns following step transition. For signals with rise times ≤10 ns, add 2% p-p between 155 ns and 165 ns after step transition.

**Television Blanking-Level Clamp (Back-Porch) 60 Hz Rejection (Channel 2 Only)** — ≥18 dB at 60 Hz; with calibrated Volt/div settings between 5 mV and 0.2 V, and a 6 div reference signal.

**Television Blanking-Level Clamp (Back-Porch) Reference** — Within 1.0 div of ground reference.

### TRIGGERING

**Sync Separation** — Stable sync separation from sync-positive or sync-negative composite video on systems with 525 to 1280 lines/frame, 50 Hz or 60 Hz field rate, interlaced or noninterlaced scan.

**Trigger Modes** — LINES, FLD 1, FLD 2, and ALT (FLD 1–FLD 2).

**Input Signal Amplitude for Stable Triggering** — Channel 1 and Channel 2: 1.0 div for composite video and 0.3 div for composite sync signals (dc + peak video-signal amplitude must be within 18 div of input ground reference).

Channel 3 and Channel 4: 0.5 div for composite video and 0.25 div for composite sync signals (dc peak video-signal amplitude must be within 9 div of input ground reference).

**GPIB Compatibility for Semiautomatic Measurement Systems** — When combined with Option 10, the TV Waveform Measurement Systems (Option 05)/oscilloscope combination is fully programmable. Complies with Tektronix *Standard Codes and Formats.*

**Ordering Information** — See page 289.

PORTABLE OSCILLOSCOPES