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PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

2445/2465
OPTION 06 and OPTION 09
COUNTER/TIMER/TRIGGER
and
WORD RECOGNIZER
OPERATORS

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

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Product Group 38

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
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OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply and do not appear in this summary.

Terms in This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms as Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the markings, or a hazard to property, including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols in This Manual

This symbol indicates where applicable cautionary or other information is to be found. For maximum and minimum input voltage see Table 1-2.

Symbols as Marked on Equipment

DANGER — High voltage.

Protective gound (earth) terminal.

ATTENTION — Refer to manual.

Power Source

This product is intended to operate from a power source that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Use the Proper Fuse

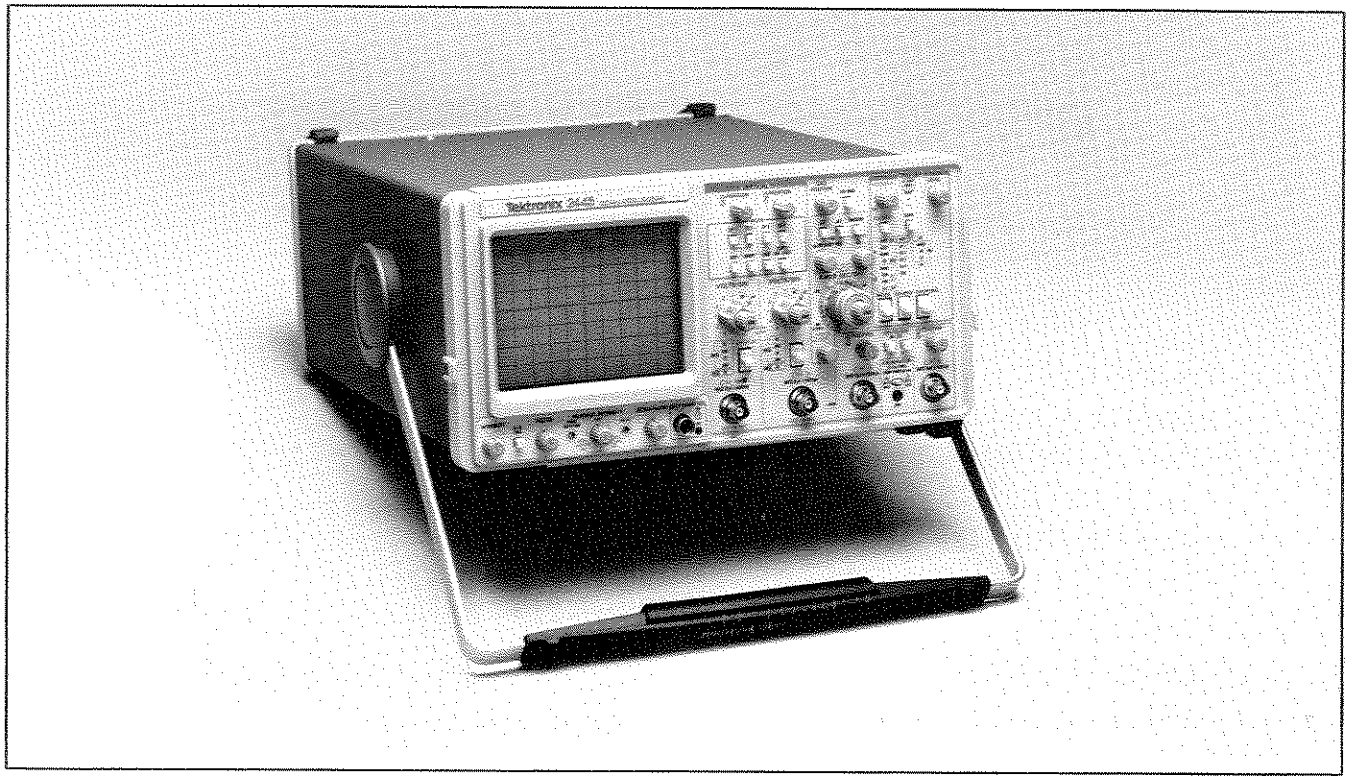
To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your product.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.



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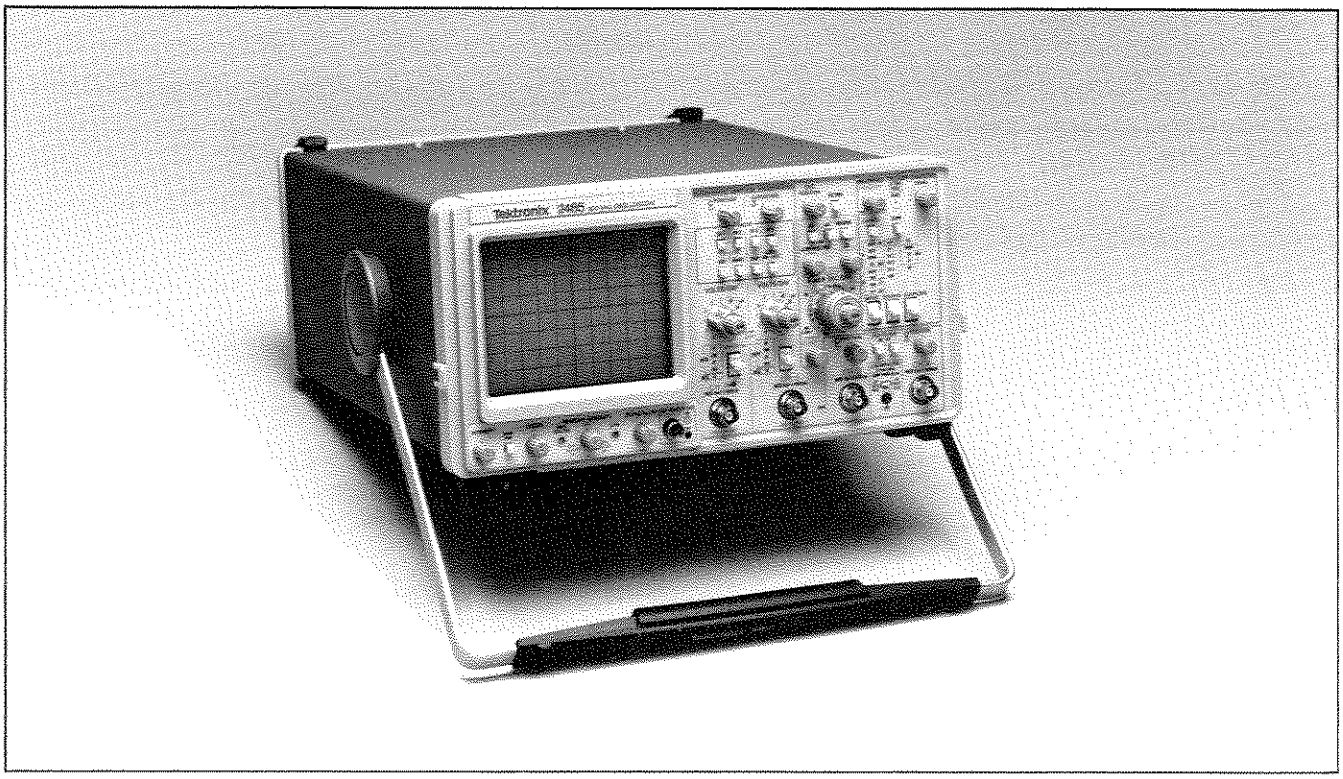
The 2445 Option 06 and Option 09 Oscilloscope.



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The 2465 Option 06 and Option 09 Oscilloscope.

SPECIFICATION

INTRODUCTION

The Counter/Timer/Trigger (Option 06) and Counter/Timer/Trigger with Word Recognizer (Option 09) add the following four capabilities to the TEKTRONIX 2445 and 2465 Oscilloscopes:

1. Precision time-interval measurement.
2. Event and frequency counting.
3. Delay-by-events triggering.
4. Logic triggering.

The 17-bit Word Recognizer probe of Option 09 extends the capabilities of these functions. The functions described in this manual which use the Word Recognizer require the Word Recognizer Option 09 and the 17-bit Word Recognizer probe.

The Counter/Timer/Trigger and Counter/Timer/Trigger with Word Recognizer options use the 2445 and 2465 alphanumeric crt readout to display configuration menus and function results.

The oscilloscope operators manual should be consulted for operating information regarding the 2445 and 2465 instruments. The operation and specifications of functions not described in this manual remain unchanged.

In addition to the standard instrument's standard accessories, the following standard accessories are provided with each instrument containing the 2445/2465 Option 06 Counter/Timer/Trigger:

1 2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Operators Manual.

1 2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Reference Card

1 2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Reference Guide

Each instrument containing the Word Recognizer is provided with the following standard accessories in addition to those mentioned for the Counter/Timer/Trigger:

1 P6407 Word Recognizer Probe package.

The following optional accessory is also available for these options:

1 2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Service Manual

DESCRIPTION OF FUNCTIONS

Precision Time-Interval Measurements

Precision delay and precision delta-time measurements are made possible by a precision timer which directly measures the time interval between the start of the A Sweep and the start of the B Sweep. Direct measurement capability operates when the B Sweep is triggerable after delay as well as in RUN AFT DLY. Direct measurement increases resolution and accuracy.

Only one of the four functions provided by the Counter/Timer/Trigger Option (Precision Time-Interval Measurement, Event Counting, Delay-by-Events Triggering, and Logic Triggering) can be active at a given time with the exception that precision time measurements are available with the Logic Trigger function when the B Sweep is triggered by the Word Recognizer.

When timing measurements are requested while a conflicting Counter/Timer/Trigger (C/T/T) function is operating, the timing measurement is displayed with the accuracy and resolution associated with a 2445/2465 instrument not equipped with the Counter/Timer/Trigger Option. The word **SET** following the time measurement indicates this condition.

Pulse-width measurement is made easier by Alternate Slope (ALT SLP) mode. When this mode is selected, the delayed sweep controlled by the Δ REF OR DLY POS control triggers on the slope indicated by the SLOPE indicator, and the delayed sweep controlled by the Δ control triggers on the opposite slope.

Event Counting (COUNT)

The Event-Counting function has three modes: Frequency, Period, and Totalize. Either the A Trigger events or the 17-bit Word Recognizer (WR) events (if the Option 09 Word Recognizer is present) can be counted.

Delay-by-Events (DLY/EVTS)

The Delay-by-Events function adds the ability to delay a sweep by a number of events, rather than by an absolute time interval. Either the A or the B Sweep can be delayed; the delay period begins when a "Start" event occurs, and the duration of the delay is determined by a number of occurrences of a "Delaying" event. The sweep to be delayed, the "Start" event, the "Delaying" event, and the number of occurrences of the "Delaying" event are all operator selected.

Logic Trigger (LOGIC-TRIG)

This function adds logic-triggering capabilities. The A Sweep can trigger on any of the following:

1. The logical AND of the A and the B triggers going TRUE.
2. The logical OR of the A and the B triggers going TRUE.
3. The occurrence of a word recognized by the Word Recognizer.

The B sweep can trigger on the word recognized by the Word Recognizer.

Word Recognizer

The 17-bit Word Recognizer detects any 17-bit digital word, either synchronously with an external clock or asynchronously. Word occurrences may be counted for frequency, period, or totalize measurements. A word can trigger either the A or B Sweep, or the word can be a delaying event in the Delay-by-Events function. The Word Recognizer probe is shown in Figure 1-1.

PERFORMANCE CONDITIONS

Except as noted in Tables 1-1 through 1-4 of this manual, the electrical, environmental, and mechanical characteristics of Option 06 and 09 instruments are identical to those specified in the respective 2445 and 2465 Oscilloscope Operators manuals.

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

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

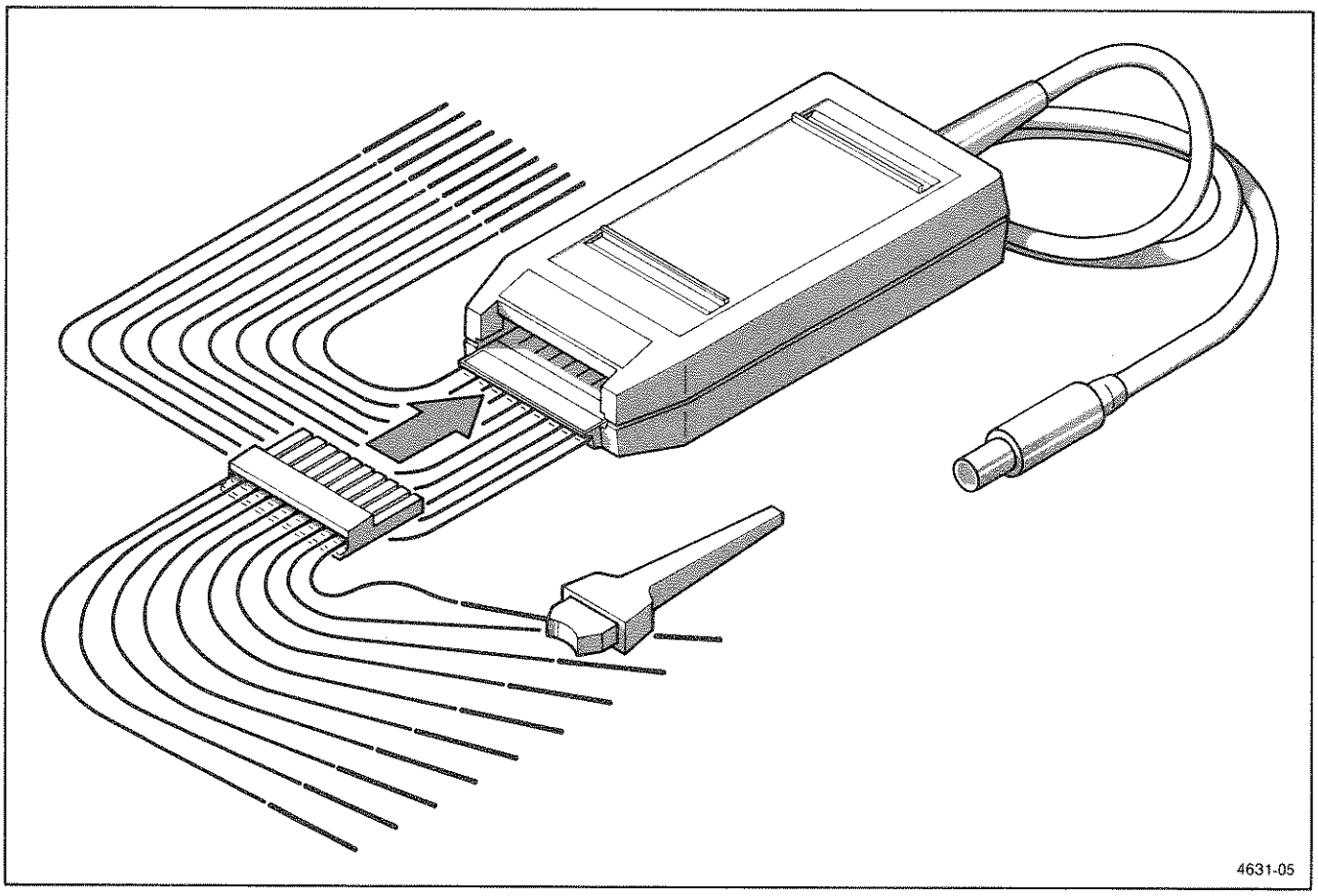


Figure 1-1. The Word Recognizer probe.

Table 1-1

Counter/Timer/Trigger Electrical Characteristics

Characteristics	Performance Requirements
SIGNAL INPUT SPECIFICATIONS FOR COUNT, DELAY-BY-EVENTS, AND LOGIC TRIGGER FUNCTIONS EXCLUDING WORD RECOGNIZER	
Maximum Input Frequency	≥150 MHz.
Minimum Width of High or Low State of Input Signal	<3.3 ns.
Sensitivity	
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[a]** 1 Hz — 100 nHz 10 Hz — 1 uHz 100 Hz — 10 uHz 1 kHz — 100 uHz 10 kHz — 1 mHz 100 kHz — 10 mHz 1 MHz — 100 mHz 10 MHz — 1 Hz 100 MHz — 10 Hz 150 MHz — 100 Hz
Auto Ranging	Upranges at 100% of full scale; downranges at 9% of full scale. 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.
Accuracy	±[Resolution + (Frequency X TBE)] Hz.
Time Base Error (TBE)	10 ppm with less than 5 ppm per year drift.
Resolution	$\frac{1.4 \times \text{Frequency}^2 \times \text{TJE}}{N} + \text{LSD}$
Display Update Rate	Twice per second or twice the period of the input signal, whichever is slower.

[a]Least significant digit.

Table 1-1 (cont)

Characteristics	Performance Requirements
PERIOD	
RANGES	**RANGE** — **LSD** 10 ns — 1 fs 100 ns — 10 fs 1 μs — 100 fs 10 μs — 1 ps 100 μs — 10 ps 1 ms — 100 ps 10 ms — 1 ns 100 ms — 10 ns 1 s — 100 ns 2 s — 1 μs
Minimum Period	<6.7 ns
Auto Ranging	Upranges at 100% of full scale; downranges at 9% of full scale. 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.
Accuracy	± [Resolution + (TBE X Period)].
Resolution	± [LSD + (1.4 X 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 1-1 (cont)

Characteristics	Performance Requirements
DELAY TIME	
Run After Delay Accuracy	LSD[b] + [0.0012 X (A SEC/DIV)] + [0.03 X (B Time/Div)[c] + A Trigger Level Error + 50 ns. 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. **NOTE** *Due to changes in the amount of trace that is visible before the trigger point, caused by changes in intensity and the Z axis, the C/T/T and the base instrument measure Delay Time from different points.*
Maximum Measurable Delay Time	9.95 times the A SEC/DIV setting.
Triggerable After Delay Accuracy	LSD[b]+ [10 ppm X (measured interval)] + TJE + A Trigger Level Error + B Trigger Level Error + 0.5 ns. If the A and B Sweeps are triggered from different channels, then add 0.5 ns for channel-to-channel mismatch. 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. 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 Table 4-2.

[c]B time/div includes SEC/DIV, X10 MAG, and VAR.

Table 1-1 (cont)

Characteristics	Performance Requirements
DELTA TIME	
Run After Delay Accuracy	LSD[b] + [0.0008 X (A SEC/DIV)] + [0.01 X (B Time/Div)[c]] + 83 ps. 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 Superimposed Delta Time	LSD[b] + [0.01 X (B Time/Div)[c]] + [10 ppm X (A SEC/DIV)] + [10 ppm X (measured interval)] + 50 ps + TJE. If CH 3 or CH 4 is one channel of a two-channel measurement, add 0.5 ns for channel-to-channel delay mismatch.
Non-superimposed Delta Time	LSD[b] + $\lvert t_{r_{REF}} - t_{r_{DELT}} \rvert$[d] + TJE + [(0.0005 div) X ($1/SR_{REF}$ + $1/SR_{DELT}$)] + [10 ppm X (A SEC/DIV)] + [10 ppm X (measured interval)] + 50 ps. If A and B sweeps are triggered from different channels, add 0.5 ns for channel-to-channel mismatch + [0.5 div X ($1/SR_{REF}$ + $1/SR_{DELT}$)] for trigger offset.
Minimum Displayable Delta Time	0 s.
Maximum Displayable Delta Time	± 9.95 times the A SEC/DIV setting.
Display Update Rate	In Auto Resolution, twice per second or once for every four sweeps, whichever is slower. 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.
ALTERNATE SLOPE	
Accuracy	Same as DELTA TIME Triggerable After Delay.
Minimum Displayable Width	1 ns.
Maximum Displayable Width	9.95 times the A SEC/DIV setting.

[b] See Table 4-2.

[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 1-1 (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.

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

$t_{r_{DELT}}$ = risetime, 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.

= (Trigger Jitter)/$\sqrt{N}$.

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 = $\sqrt{(\text{Reference Trigger Signal Jitter})^2 + (\text{Delta Trigger Signal Jitter})^2 + (\text{A Sweep Trigger Signal Jitter})^2}$.

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.

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.

Table 1-1 (cont)

Characteristics	Performance Requirements
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 4-2 for Delay or Delta Time. = (measured frequency) X (Measurement Interval) for Frequency or Period. Measurement Interval = 0.5 s or two periods of measured signal, whichever is greater.	

[a]Least significant digit.

[b]See Table 4-2.

[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 1-2

Word Recognizer Electrical Characteristics

Characteristics	Performance Requirements
SYNCHRONOUS MODE	
Data Setup Time W_0—W_{15} and Q	25 ns.
Data Hold Time W_0—W_{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	$\leq$ 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 Coincedence Between Data Inputs (D_0—D_{15} & Q) Without Producing a Trigger	$>$ 20 ns.
Delay from Input Word Coincidence to Word Out	$\leq$ 140 ns.
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.

Table 1-3

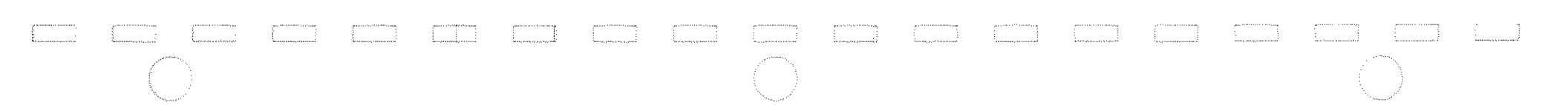
Environmental Characteristics

Characteristics	Performance Requirements
All Items	Same as the 2445 and 2465 Oscilloscopes without the C/T/T Option.

Table 1-4

Mechanical Characteristics

Characteristics	Description
Weight	
With Power Cord, Cover, Pouch, Test Leads, Probes, Operators Manual, and Options, Including Word Recognizer Probe	< 12.0 kg (26.4 lb).
Word Recognizer Probe	0.27 kg (0.6 lb).
Domestic Shipping Weight	< 17.6 kg (38.8 lb).
P6407 Probe Dimensions	
Length	
Body	11.4 cm (4.5 in).
Cable	2 m (6.6 ft).
Width	5.6 cm (2.2 in).
Height	2.21 cm (0.87 in).



PREPARATION FOR USE

OPERATING CONSIDERATIONS

A GATE OUT Termination

To prevent measurement errors, of as much as ±2.0 ns in Precision Delay and ±0.5 ns in Precision Delta Time, the A GATE OUT signal must not be terminated in less than 10 kΩ.

POWER-UP TESTS

Before initially turning on power to the instrument, read Section 2, "Preparation for Use," in the oscilloscope operators manual and follow the safety and precautionary information described there.

The power-up tests, automatically performed each time the oscilloscope is turned on, verify both the oscilloscope circuitry and the option circuitry. Tests, specifically applicable to Option 06 and Option 09, are integrated into the power-up tests of the host oscilloscope, and the tests consist of two main parts: Kernel tests and Confidence tests.

A power-up test failure will either flash the A SWP TRIG'D indicator or display a diagnostic message in the crt readout. Pressing in the A/B/MENU switch (**A/B TRIG** in the crt readout) may place the instrument into a usable mode. Even if the instrument then functions adequately for your particular requirement, it should be referred to a qualified service technician for repair of the problem as soon as possible.

CONTROLS, CONNECTORS, AND INDICATORS

The controls, connectors, and indicators used in the operation of the Option 06 Counter/Timer/Trigger and Option 09 Counter/Timer/Trigger with Word Recognizer are described in this section, along with any controls whose function is affected by these options. For details about the controls used to operate the standard oscilloscope, refer to the respective instrument operators manual. There are no controls added to the front panel to accommodate these options, but the B TRIGGER MODE indicator group has two extra positions, MENU and ALT SLP.

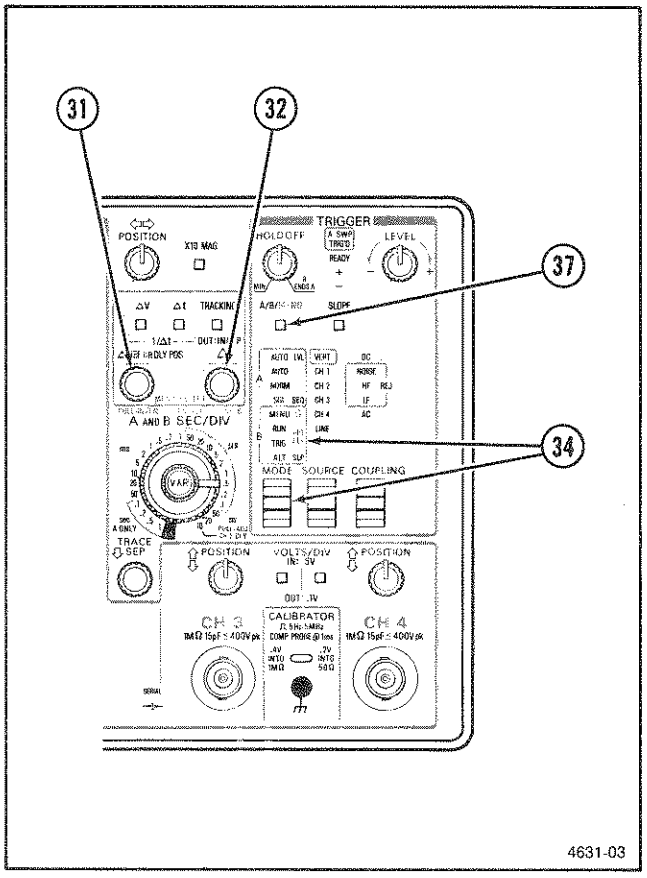


Figure 3-1. Counter/Timer/Trigger and Word Recognizer controls.

Refer to Figure 3-1 for the location of the controls and indicators described in this section. The circled item numbers are the same as the corresponding items discussed in Section 3 of the standard instrument operators manual.

FRONT PANEL CONTROLS

(31) **Δ REF OR DLY POS Control**—This control is used for configuration menu selection and menu-mode configuration (for details see "Menu Mode Function Selection" which follows).

(32) **Δ Control**—This control is used for configuration menu selection and menu-mode configuration (for details see "Menu Mode Function Selection" which follows).

(34) **TRIGGER MODE Switch and Indicators**—The A TRIGGER MODE switch and indicators are the same as in the standard instrument. Two new positions are added to the B TRIGGER MODE switch indicators:

MENU—When this mode is entered, the readout displays various menus which permit Counter/Timer/Trigger and Word Recognizer functions to be selected and configured.

ALT SLP—In this mode, when the A AND B SEC/DIV knobs are unlocked, the instrument makes a precision time-interval measurement between alternate B sweeps which are triggered on opposite slopes of the waveform.

(37) **A/B/MENU Switch**—If an A Trigger indicator is illuminated and the SEC/DIV switches are locked together, pressing the switch activates MENU mode. On instruments that do not contain the Counter/Timer/Trigger, this control is labeled A/B TRIG.

REAR PANEL

The rear panel is identical to that of the standard instrument, except that when the Word Recognizer Option is installed, the Word Recognizer Probe and the WORD RECOG OUT connectors are installed in the same locations used by the Probe Power connectors of Option 11 (see Figure 3-2).

(54) **Word Recognizer Probe Connector**—Connects the 17-Bit Word Recognizer Probe to the instrument.

(55) **Word RECOG OUT Connector**—Provides an LSTTL-compatible, positive-going pulse when the Word Recognizer detects the selected word.

READOUT DISPLAYS

Bottom-Row Readout Displays

The readout displays along the bottom row of the crt are not affected by the Counter/Timer/Trigger and the Word Recognizer except for additions to the Diagnostics menu.

Top-Row Readout Displays

The top row of the crt readout is shared according to the following priority:

1. Menus occupy the entire top row.

2. Delta and Delay displays appear in the right-hand field of the display.

3. Event-Counting (COUNT), Delay-by-Events (DLY/EVTS), and Logic-Trigger (LOGIC TRIG) displays (excluding the WR Logic-Trigger display) appear in the right-hand field if the field is not occupied by a Delta or Delay display; otherwise, the displays appear in the left-hand field.

4. Word-Recognizer displays appear in the left-hand field of the display.

5. The trigger-level readout appears in the left-hand field.

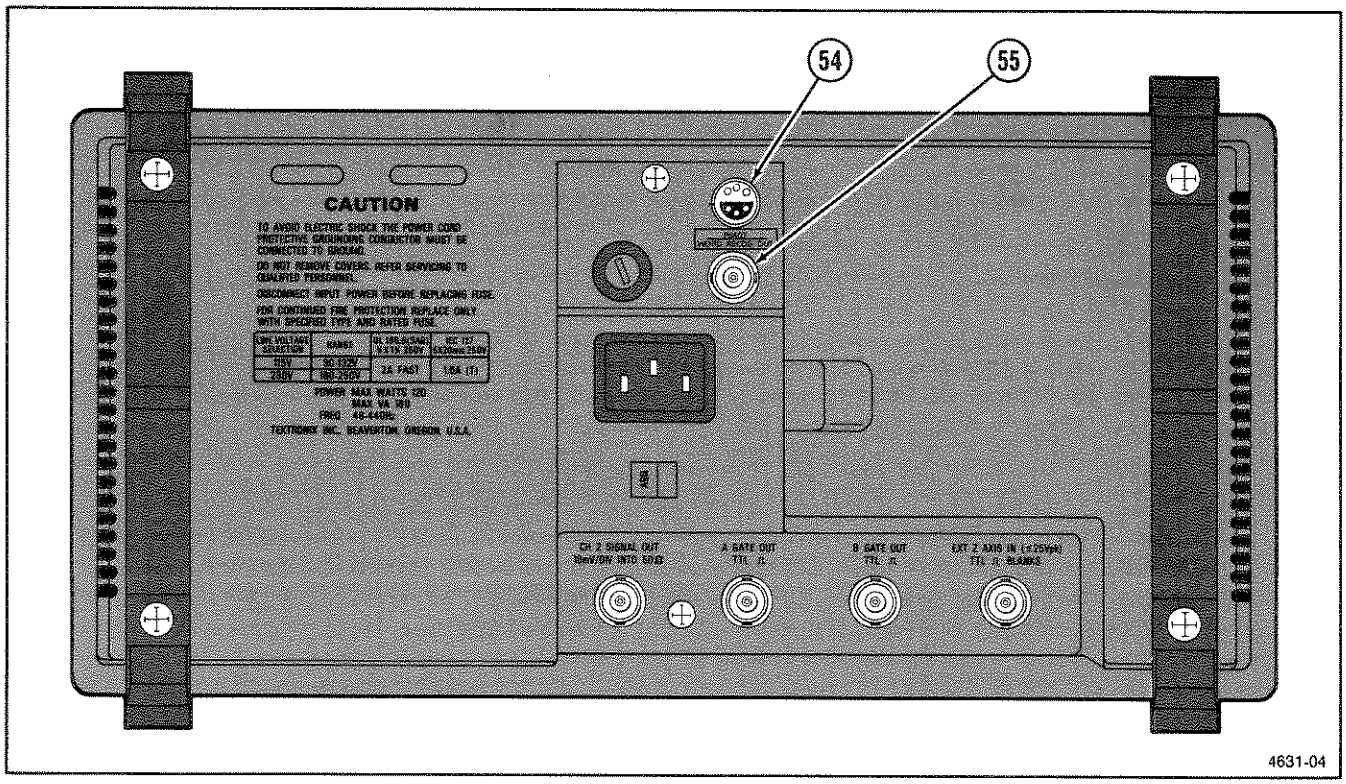


Figure 3-2. Rear Panel Word Recognizer connectors.

OPERATING PROCEDURES

Consult the 2445 and 2465 Operators manuals for basic operating information and techniques that should be considered before attempting to make any measurements with your instrument.

PRECISION TIME-INTERVAL MEASUREMENTS

Time-Interval Measurements

The Counter/Timer/Trigger Option has no effect on cursor measurements except that Δt and $1/\Delta t$ measurements with cursors are available when the B Sweep is delayed by events.

Precision Delay-Time and Precision Delta-Time Operation

Operating procedures for precision delay-time and delta-time functions are the same as the operating procedures for delay-time and delta-time functions in a 2445 or 2465 instrument without the C/T/T Option.

Whenever the display for precision time-interval measurements is updated, the last letter of the units symbol blinks. The displayed resolution is selectable (see "Resolution Selection" in this section).

When a conflicting Counter/Timer/Trigger function (Delay-by-Events or Event Counting) is active, the precision time-interval measurement function is not available, but it is replaced by a time measurement having the resolution and accuracy of a 2445 or 2465 without the Counter/Timer/Trigger Option. In this case, the word **SET** appears following the time-measurement display.

The **SET** display also occurs during precision time measurements any time a control switch or delta control is operated. The **SET** display remains for two seconds, and then the precision time measurement is displayed if it's available; e.g.:

starting display:	**DLY 213.3693ms**
delta control rotated:	**DLY 198.1ms SET**
final display:	**DLY 197.8849ms**

If the measurement is not available, one of the following messages is displayed to indicate why:

AVERAGING	More sweeps are required for the selected measurement resolution.
NO A TRIGGER	No A Trigger event was received.
MISSING B TRIG	At least one A Sweep occurred without a B Trigger event during the A Sweep.

B Triggered After Delay Mode

The C/T/T Option allows precision time measurements even while in the B TRIG AFT DLY mode. The B Trigger controls operate in the same manner with the C/T/T Option as in a 2445 or 2465 not equipped with the option.

An instrument with a C/T/T measures the time from the start of the A Sweep to the start of the B Sweep, whether the B Trigger MODE is RUN AFT DLY or TRIG AFT DLY. The measurement gives delay times directly when B Sweep is operated without delta time.

When B Sweep is used with delta time or 1/delta time, the instrument measures the interval from the start of A Sweep to the start of B Sweep. A measurement is made for each of the two delays controlled by the Δ REF OR DLY POS and Δ controls. The difference between these measurements gives the delta-time result.

If the transition times of the signals being measured are not negligible relative to the measurement, rotate the B SEC/DIV switch to provide a magnified view of the signals.

This magnified view shows the intersection points of the two delayed sweeps. The time interval measured is the time between these points. Adjusting the B TRIGGER LEVEL and the VERTICAL POSITION selects various intersection points. When making a dual-channel delta-time measurement, if the points of interest can not be made to intersect by the LEVEL and POSITION controls, the points can be forced to intersect by reducing the displayed amplitude of the signal that appears later in the display and then readjusting the LEVEL and POSITION controls.

The relative accuracies of delta-time and delay-time measurements using cursors (delta time only), RUN AFT DLY, and TRIG AFT DLY varies as the measured time interval varies. Figure 4-1 shows the relative accuracies for delta-time measurements. Relative accuracies for delay-time measurements are shown in Figure 4-2.

The B Trigger-After-Delay mode is deselected when the Channel 2 Delay-Adjust function is selected.

Alternate Slope Mode Selection

Alternate Slope mode measures the time interval between two points on opposite slopes of a waveform. The delayed sweep controlled by the Δ REF OR DLY POS control triggers on the slope indicated by the SLOPE indicator, while the delayed sweep controlled by the Δ control triggers on the opposite slope.

To select the Alternate Slope mode of Precision Delta Time:

1. Unlock the SEC/DIV knobs.

2. If an A TRIGGER MODE indicator is illuminated, push the A/B/MENU switch.

3. Repeatedly press the B TRIGGER MODE switch down and release it until the ALT SLP MODE indicator is illuminated.

4. Select the desired B Trigger Source and Coupling.

5. Adjust the B TRIGGER LEVEL to the desired trigger point.

6. Rotate the Δ controls until intensified zones appear on the desired slopes.

7. If the transition times of the signal being measured are not negligible to the measurement, rotate the B SEC/DIV control to a faster sweep speed to magnify the view of the signal. The time interval is measured between the points where the two delayed sweeps intersect. Adjusting the B TRIGGER LEVEL moves the area of intersection.

The Alternate Slope function is deselected when the Channel 2 Delay-Adjust function is selected.

MENU MODE FUNCTION SELECTION

Event-Counting, Delay-by-Events, Logic-Trigger functions, and Resolution selection are selected from a menu. To select one of these functions:

1. Enter MENU mode by one of the two following methods:

   a. If an A TRIGGER MODE indicator is illuminated:

      (1) Press the A/B/MENU select switch to illuminate a B TRIGGER MODE indicator.

      (2) If the MENU indicator is not illuminated, push the TRIGGER MODE switch up to select MENU.

   b. If a B TRIGGER MODE indicator is illuminated, push the TRIGGER MODE switch up until MENU is selected.

2. The Main Menu is displayed on the crt:

COUNT DLY/EVTS LOGIC–TRIG RES

3. Turn either the Δ or the Δ REF OR DLY POS control to move the dotted-line cursor under the desired function.

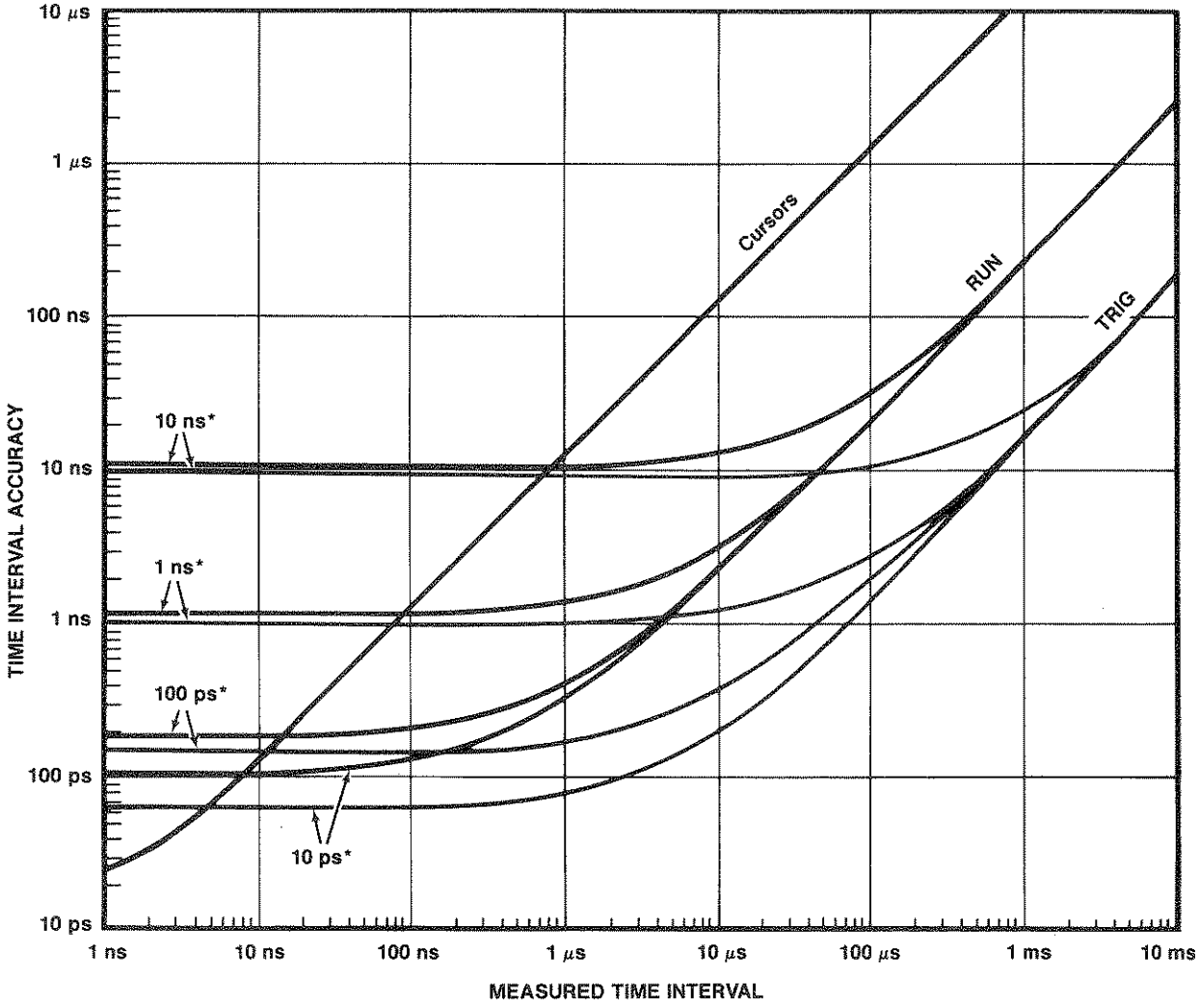
4. Push the TRIGGER MODE switch up to display the Configuration Menu for the selected function.

5. See appropriate function descriptions which follow for further Menu information.

To remove the Menu display without activating a function, press any one of the following controls:

1. TRIGGER MODE switch down.
2. A/B/MENU switch.
3. Δt switch.
4. ΔV switch.

Any MENU function (Event-Counting, Delay-by-Events, or Logic-Trigger) is deselected when the Channel 2 Delay-Adjust function is activated.



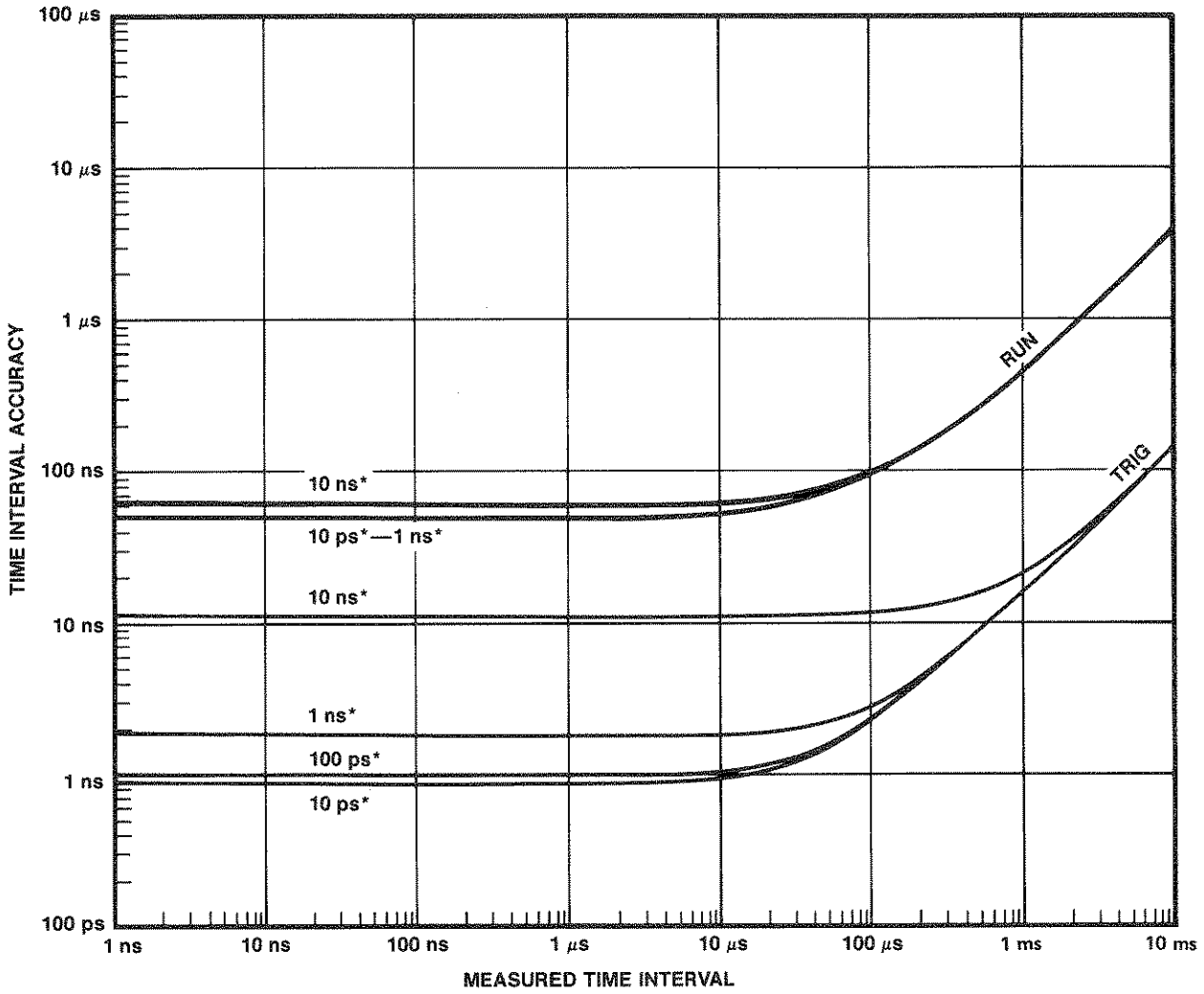
CONDITIONS:

1) Input signal is 5 vertical divisions with a 2 ns risetime.
2) Measured times are 4 horizontal divisions.
3) TJE is negligible for slew rates greater than 0.1 div/ns.
4) For all B Sweep modes, the beginning and end of the measured interval are visually superimposed.

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

4631-06

Figure 4-1. Delta Time relative accuracies.



CONDITIONS:

1) Input signal is 5 vertical divisions with a 2 ns risetime.
2) Measured times are 4 horizontal divisions.
3) TJE is negligible for slew rates greater than 0.1 div/ns.

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

4631-07A

Figure 4-2. Delay Time relative accuracies.

Event Counting (COUNT)

To activate Event Counting from the Main menu:

1. After using a delta control to underline COUNT in the main menu and pushing the TRIGGER MODE switch up, the Count Configure menu is displayed. If the instrument contains the Word Recognizer Option, the Count Configure menu is:

MODE<FREQ PERIOD TOT> EVT<A WR>

The MODE field allows selection of either FREQuency, PERIOD, or TOTalize. The EVT field allows selection of the event that the selected mode operates on. Either the A Trigger events (A) or the Word Recognizer events (WR) can be selected. While counting Word Recognizer events, the A Sweep is triggered by the Word Recognizer event.

If the instrument does not contain the Word Recognizer Option, the Count Configure menu is:

MODE<FREQ PERIOD TOT> EVT=A TRIG

2. Turn the Δ REF OR DLY POS control to underline the field to be configured (i.e., MODE or EVT). Then turn the Δ control to underline the selection for that field. If only one underline is shown, either control may be turned.

3. When the configuration is correct, push the TRIGGER MODE switch up. If Word Recognizer has been selected as the event, the Word Recognizer Configure Menu is displayed (see "Word Recognizer" in this section); otherwise, the function is activated.

NOTE

When counting high-frequency signals, readjustment of the Trigger Level may be required to eliminate jitter of the displayed waveform.

4. If Totalize mode is active, the displayed count is reset by moving any front panel switch.

5. To deselect any function and exit MENU mode:

a. If the MENU indicator is not illuminated, push the A/B/MENU switch.

b. Push the TRIGGER MODE switch down.

Any of the following actions will also deselect an active Count mode:

a. Selecting an A Trigger Source of LINE.

b. Selecting an A Trigger Mode of SGL SEQ.

c. If the Count event is the Word Recognizer, selecting AUTO LVL for the A Trigger Mode (the Main menu will be displayed).

d. If the Totalize mode is active, selecting AUTO or AUTO LVL for the A Trigger Mode (the Main menu will be displayed).

Delay-by-Events (DLY/EVTS)

The Delay-by-Events function allows the selection of the sweep to be delayed, the starting event, and the delaying event. The combinations available are shown in Table 4-1.

To activate the Delay-by-Events function from the Main menu:

1. After using a delta control to underline DLY/EVTS in the Main menu and pushing the TRIGGER MODE switch up, the Delay-by-Events Configure menu will be displayed. If the instrument contains the Word Recognizer Option, the Delay-by-Events Configure menu is:

SWP<A B> START<A WR> DLY BY<B WR>

If the instrument does not contain the Word Recognizer (WR), the Delay-by-Events Configure menu is:

SWP<A B> START=A DLY BY B

The sweep to be delayed, either A or B, is selected from the SWP field. If the B Sweep is selected to be delayed, the START field is limited to only the A Trigger event. The event which will start the delay is selected from the START field. Either the A Trigger event (A) or the Word Recognizer event (WR) can be selected. If the Word Recognizer is selected as the START event, SWP defaults to A. The event counted to give the desired delay is selected from the EVT field. Either the B Trigger event (B) or the Word Recognizer event (WR) can be selected.

2. Turn the Δ REF OR DLY POS control to underline the field to be configured (i.e., SWP, START or EVT). Then turn the Δ control to underline the selection for that field.

Table 4-1
Delay-by-Events Combinations

Sweep to be Delayed	Start Event	Delaying Event	Results
A	A Trigger	B Trigger	Delay begins when the A Trigger event occurs; the A Sweep runs after the selected number of B Trigger events.
A	Word Recognizer	B Trigger	Delay begins when a recognized word occurs; the A Sweep runs after the selected number of B Trigger events.
A	A Trigger	Word Recognizer	Delay begins when the A Trigger event occurs; the A Sweep runs after the selected number of words are recognized.
A	Word Recognizer	Word Recognizer	The A Sweep runs after the selected number of words are recognized.
B	A Trigger	B Trigger	Delay begins when the A Sweep is triggered by the A Trigger event; the B Sweep runs after the selected number of B Trigger events, if the A Sweep has not terminated.
B	A Trigger	Word Reconizer	Delay begins when the A Sweep is triggered by the A Trigger event; the B Sweep runs after the selected number of words are recognized, if the A Sweep has not terminated.

3. When the configuration is correct, push the TRIGGER MODE switch up. If Word Recognizer was selected, the Word Recognizer Configure menu is displayed (see "Word Recognizer" in this section); otherwise, the function is activated.

If B Sweep Delay-by-Events is selected and the SEC/DIV knobs are locked, the message **PULL SEC/DIV** appears instead of the Delay-by-Events display.

While the function is active, the number of occurrences of the Delaying event required to trigger the delayed sweep is displayed along with a letter identifying the sweep being delayed by events; e.g.:

A DBE 1234567

The number of occurrences can be changed if the Delay-by-Events display is on the right side of the crt. The display is on the right side of the crt if no higher priority function such as Δt is also selected.

To change the number of events:

Turn the Δ REF OR DLY POS control to underline a digit of the number. Turn the Δ control to alter the underlined character's value. If a digit is incremented from 9 to 0 (nine to ten), the digit to its left is incremented; if a digit is decremented from 0 to 9 (ten to nine), the digit to its left is decremented. If a digit is incremented to its maximum permissible value and all the digits to its left are at their maximum value, the underline moves to the next digit to the right. If a digit is decremented to 0 and all digits to its left are 0 (displayed as spaces), then the cursor moves to the next digit to the right.

If B Sweep Delay-by-Events is displayed and either Δt or 1/Δt is selected, cursors are also displayed. The word **SET** in the cursor's display is replaced with **BSW** to indicate that the displayed time is referenced to the B Sweep.

4. To deselect any function and exit MENU mode:

a. If the MENU indicator is not illuminated, push the A/B/MENU switch.

b. Push the TRIGGER MODE switch down.

If the A Sweep is delayed by events, selecting AUTO or AUTO LVL Trigger Mode for the A Trigger will deselect Delay-by-Events and display the Main menu.

NOTE

When the time between the start event and the delaying event is less than 4 ns, whether or not the delaying event will be counted is ambiguous. In most cases, the ambiguity can be resolved by choosing appropriate trigger slopes for the start and delaying events.

Logic Trigger

To activate the Logic Trigger function from the Main menu:

1. After using a delta control to underline **LOGIC-TRIG** in the Main menu and pushing the TRIGGER MODE switch up, the Logic-Trigger-Configure menu will be displayed. If the instrument contains the Word Recognizer Option, the Logic-Trigger-Configure menu is:

SWP:TRIG <A:A·B A:A+B A:WR B:WR>

The sweep (SWP) to be triggered and the source (TRIG) of the trigger are both selected from this menu. The selections are:

A:A·B = The A Sweep is triggered when the logical AND of the A and B Triggers becomes TRUE.

A:A+B = The A Sweep is triggered when the logical OR of the A and B Triggers becomes TRUE.

A:WR = The A Sweep is triggered when the Word Recognizer detects the selected word.

B:WR = The B Sweep is triggered when the Word Recognizer detects the selected word.

NOTE

The trigger is TRUE if + SLOPE is selected and the trigger-source voltage is more positive than the trigger level, or if − SLOPE is selected and the trigger-source voltage is more negative than the trigger level.

When the B Sweep is triggered by the Word Recognizer, delay time and delta time are measured by the crystal-controlled timer, but when any other Logic-Trigger function is active, delay-time and delta-time measurements are limited to the capabilities of the 2445 or 2465 without the C/T/T Option.

If the instrument does not contain the Word Recognizer Option, the Logic-Trigger-Configure menu is:

TRIG A SWEEP BY <A·B A+B>

2. Turn either delta control to move the underline cursor to the desired selection.

3. When the configuration is correct, push the TRIGGER MODE switch up. If Word Recognizer has been selected, the Word-Recognizer-Configuration menu is displayed (see "Word Recognizer" in this section); otherwise, the function is activated.

If the Word Recognizer is selected in Logic-Trigger mode, the Word Recognizer display takes the place of the respective trigger-level display.

While a Logic-Trigger function other than WR is active, one of the following Logic-Trigger displays is normally displayed on the right half of the crt readout. It is displayed on the left half of the crt readout if a delta or delay function is also active:

A SWP A·B and **A SWP A+B**

4. To deselect any function and exit MENU mode:

a. If the MENU indicator is not illuminated, push the A/B/MENU switch.

b. Push the TRIGGER MODE switch down.

Selecting AUTO LVL A Trigger Mode while any Logic Trigger function other than B Sweep triggered by the Word Recognizer (B:WR) is active results in the function being deselected and the Main menu being displayed.

Resolution Selection

Four resolutions are available for Delay Time, Delta Time, and 1/Delta Time precision measurements. In AUTO, the display update rate is either every 1/2 second or every time a measurement sample is available, whichever is greater. For 1 ns, 100 ps, and 10 ps resolution, the display is updated only when enough sweeps have occurred to display the indicated resolution. For low sweep repetition rates, the time interval between updates is noticeably long. Table 4-2 lists the displayed resolution for each resolution selection and the number of sweeps (N) required for each measurement.

Table 4-2
Resolution Selections

A SEC/DIV[a]	Selected Resolution	LSD	N
10 ns to 1 s	AUTO	See AUTO RESOLUTION	See AUTO RESOLUTION
10 ns to 5 μs	10 ps	10 ps	$>10^6$
	100 ps	100 ps	$>10^4$
	1 ns	1 ns	>100
10 μs to 50 μs	10 ps or 100 ps	100 ps	$>10^4$
	1 ns	1 ns	>100
100 μs to 500 μs	10 ps to 1 ns	1 ns	>100
1 ms to 5 ms	10 ps to 1 ns	10 ns	>1
10 ms to 50 ms	10 ps to 1 ns	100 ns	>1
100 ms to 500 ms	10 ps to 1 ns	1 μs	>1
1 s	10 ps to 1 ns	10 μs	>1

AUTO RESOLUTION

A SEC/DIV[a]	Trigger Repetition Rate	LSD	N
10 ns to 2 μs	>20kHz	100 ps	$>10^4$
10 ns to 2 μs	200 Hz to 20 kHz	1 ns	>100
5 μs to 200 μs	>200 Hz	1 ns	>100
10 ns to 200 μs	<200 Hz	10 ns	>1
500 μs to 5 ms	Any	10 ns	>1
10 ms to 50 ms	Any	100 ns	>1
100 ms to 500 ms	Any	1 μs	>1
1 s	Any	10 μs	>1

[a]2445 A SEC/DIV settings range from 20 ns to 1 s. 2465 A SEC/DIV settings range from 10 ns to 500 ms.

To activate the Resolution Selection function from the Main menu:

1. After using either delta control to underline **RES** in the Main menu and pushing the TRIGGER MODE switch up, the Resolution Selection menu is displayed:

RESOLUTION <AUTO 1ns 100ps 10ps>

2. Turn either delta control to underline the desired resolution.

3. Push the TRIGGER MODE switch up when the configuration is correct.

Word Recognizer Configuration

The Word-Recognizer-Configuration menu is used to set the Word Recognizer's radix and clock parameters. When Word Recognizer (WR) is selected for use by a menu function and the TRIGGER MODE switch is pushed up to exit the Function-Configuration menu, the Word-Recognizer-Configuration menu is displayed:

RADIX<BIN OCT HEX> CLOCK<↑ ↓ X>

The Word Recognizer's configuration is displayed in the radix selected from the RADIX field. The choices are binary (BIN), octal (OCT), and hexadecimal (HEX).

The clock edge, used to acquire data in the Word Recognizer, is selected from the clock field. The choices are:

↑ = rising edge of clock.

↓ = falling edge of clock.

X = no clock used (asynchronous mode).

To set the Word Recognizer's parameters:

1. Select the Word Recognizer in a Function-Configuration menu.

2. Exit the function's menu by pushing up on the TRIGGER MODE switch. The Word-Recognizer-Configuration menu is then displayed.

3. Turn the Δ REF OR DLY POS control to underline the field to be configured (i.e., RADIX or CLOCK). Turn the Δ control to underline the selection for that field.

4. When the configuration is correct, push the TRIGGER MODE switch up to activate the function.

When a menu function uses the Word Recognizer, the status of the Word Recognizer is displayed in the following format:

tcq word

The t is the trigger selected (A or B); the c is the clock mode, rising (↑) or falling (↓) edge, or asynchronous (X); the q is the qualifier bit; and 'word' is a value displayed in the selected radix.

The Δ REF OR DLY POS control is turned to underline the clock mode, qualifier, or a digit of the word. The Δ control changes the selection for the underlined field.

If some bits of a hexadecimal or octal digit are irrelevant (don't care or 'X') the digit is ambiguous. Ambiguous digits are displayed as question marks; e.g.:

A↑011XX XXX1	A↑0 1?X077	A↑0 ??3F
... 0011 1111	...	...
BIN	OCT	HEX

When the status of the Word Recognizer and the event count for Delay-by-Events are both displayed, the Δ REF OR DLY POS control will move the selection cursor across both fields.

WORD OUT SIGNAL

The WORD OUT signal, at a BNC connector on the rear panel, is high when the selected word is recognized. This signal is valid after the Word Recognizer word has been defined using the C/T/T menu. The signal remains valid even if the menu function is not in use. The relation of the word coincidence relative to other signals can be observed by connecting the WORD OUT signal to one vertical channel and using the remaining vertical channels for the other signals.

The WORD OUT signal is delayed after the clock transition in synchronous mode or after the recognized coincidence in asynchronous mode. Because of this delay, the signal transition which generates the trigger cannot be displayed by the oscilloscope when the oscilloscope is triggered by the Word Recognizer or when the oscilloscope is triggered by the WORD OUT signal.

CONTROLLING INSTRUMENT FUNCTIONS WITH THE GPIB

This information pertains to controlling the 2445 and 2465 Oscilloscopes containing Counter/Timer/Trigger (Option 06), or the Counter/Timer/Trigger with the Word Recognizer (Option 09) via the IEEE-488-1978 digital interface (commonly referred to as the General Purpose Interface Bus, or GPIB). This information applies only if the instrument also contains the GPIB (Option 10) interface.

NOTE

If either the Counter/Timer/Trigger or Word Recognizer option is not contained in the instrument, reference to it in a GPIB command will cause an SRQ error.

The 2445/2465 Option 10 GPIB Operators Manual should be consulted for a complete description of remote control of oscilloscope functions by way of the GPIB.

A complete description of additional commands for controlling the Counter/Timer/Trigger Option and the Counter/Timer/Trigger with the Word Recognizer Option is listed in Table 4-3 and Table 4-4 respectively.

NOTE

*C/T/T measurements are requested with the CTSend command. DELAy? and DTIme? queries, which are common to the 2445/2465 without the C/T/T Option, return settings, **not** measurements.*

Table 4-3
Counter/Timer/Trigger GPIB Commands

C/T/T Measurement Commands

Header	Argument	Argument	Comments
CTRdy?			Query response is 1 if a C/T/T measurement is available, 0 if not. This flag is always valid regardless of the OPC state. If no measurement function is active, or a measurement function is suspended due to another option using the display, an option-not-in-correct-mode SRQ error is sent.
CTSend?	IMMediate WAIt		This command is used to request any one of the following measurements: FREQuency, PERiod, TOTalize, Delay, Delta Time, or 1/Delta Time. The measurement returned is that generated by the currently operating function. The format of the returned measurment is <nr3>. The "?" following CTSend is optional and does not affect the operation of the command. If the currently available measurement is invalid, an error code is returned in place of the normal measurement. The error codes are: 1.0E+99 for a missing B trigger. 1.0E+98 for a missing A trigger. 1.0E+97 when the time being measured in a 1/Δt mode is less than 1% of full scale. 1.0E+96 for Totalize mode overflow. If no measurement function (count, precision delta, or delay) is active, or a measurement function is suspended due to another option using the display, an option-is-not-in-correct-mode SRQ error is sent. Any given measurement is only sent once. The current measurement is always sent immediately if it has not already been sent once. The argument following CTSend controls the manner in which the instrument responds when a measurement is in progress and no current measurement is available to send. CTSend with no argument defaults to WAIt for a measurement. If a measurement is not available and the IMMediate argument is received, a null message (talked with nothing to say) is sent. If a measurement is not available and the IMMediate argument is not received, the instrument will not respond until a new measurement has been acquired.

Table 4-3 (cont)

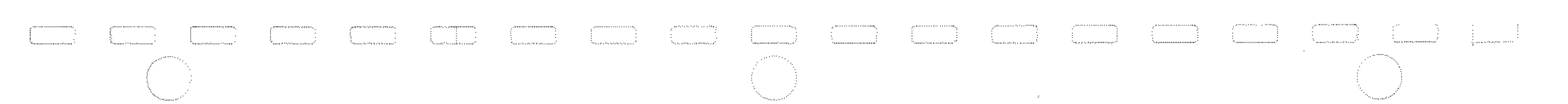
Header	Argument	Argument	Comments
OPC	ON OFF		This is an extension of the main instrument's OPC command. When OPC is ON, an SRQ is generated when a C/T/T measurement is completed. Generation of SRQ can be turned off by the RQS OFF command. The EVENT? query, as described in the 2445/2465 GPIB Operators Manual, may be used to determine the status of the C/T/T Option. The event code, returned through the EVENT? query, may be used to determine if a C/T/T measurement is complete (event code 778) even when RQS is OFF. However, the event code is only available when OPC is ON. Once the event code is generated, to indicate a measurement is available, SRQs and the event code are not generated again on measurement completion until a measurement has been read. The event code is generated only on completion of the next measurement after a measurement is read via the GPIB.
	C/T/T Setup Commands		
BTRigger	MODe:	ALTSlope RUN TRIGGerable	This command is an extension of the BTRigger MODe: command of the Main instrument. RUN and TRIGGerable function the same as in the main instrument. Setting mode to ALTSlope or TRIGGerable will conflict with any Count, Delay-by-Events, or Logic-Trigger mode, and a setting-conflict SRQ error is sent.
BTRigger?	MODe		Query response is identical to the Main instrument BTRigger? response except that MOD: ALTS can be sent.
COUNt	EVEnt: MODe:	ATRigger WREcognizer FREquency TOTal PERIod	This command configures the Count function. If the Word Recognizer Option is not installed and If EVEnt: WRE is received, an option-not-installed SRQ error is sent.
COUNt?	EVEnt MODe		Query response is: COUN MOD: string, EVE: string or COUN arg: string if an argument is given in the query.
CTT	COUNt DBEvents LTRigger OFF RESET		This command will either turn on a C/T/T function or turn off any active C/T/T function. Selecting any function will turn off any other selected function. Functions cannot be active at the same time. B TRIGGER MODE is set to RUN AFT DLY. CTT RESET resets any counter or precision measurement currently in progress.
CTT?			Query response is: CTT string, where "string" is the current C/T/T function.

Table 4-3 (cont)

Header	Argument	Argument	Comments
DBEvents	COUNt:	<nr1>	This command configures the Delay-by-Events function. The format of <nr1> is a positive integer in the range 1-4194303 inclusive. If a number is received that is out of range or noninteger, a numeric-argument SRQ error is sent.
	EVEnt:	BTRigger WREcognizer	If the Word Recognizer Option is not installed and if EVEnt:WREcognizer or STArt: WREcognizer is received, an option-not-installed SRQ error is sent.
	STArt:	ATRigger WREcognizer	Selecting STArt: WREcognizer sets SWEep to ASWeep.
	SWEep:	ASWeep BSWeep	Selecting SWEep: BSWeep sets STArt to ATRigger.
DBEvents:	COUNt EVEnt STArt SWEep		Query response is: DBE SWE: string, STA: string, EVE: string, COUN: <nr1>, or DBE arg: string if an argument is given in the query.
ID?			This query is an extension of the ID? query of the main instrument. Query returns CTT:FVn for the C/T/T's portion of [string:FV<nr1>,] (see 2445/2465 Option 10 GPIB Option Operators Manual); where <nr1> is the version number of the C/T/T Option.
LTRigger	ASWeep:	AANdb AORb WREcognizer	This command configures the Logic-Trigger function If the Word Recognizer Option is not installed and if either the ASW: WRE, or BSW: WRE command is received, then an option-not-installed SRQ error is sent.
	BSWeep:	WREcognizer	
LTRigger?			Query response is: LTR ASW: string or LTR BSW: WRE.
RESolution	AUTO R1Ns R100ps R10Ps		This command sets the resolution of precision measurements.
RESolution?			Query response is : RES string.

Table 4-4
Word Recognizer GPIB Commands

Header	Argument	Argument	Comments
WREcognizer	CLOck:	ASYnch DNClock UPClock	This command configures the Word Recognizer.
	RADix:	BINary HEX OCTal	The RADix: argument only controls the format of the Word Recognizer settings display on the crt.
	WORd:	<ASCII binary data>	The format of ASCII binary data is #Y followed by 17 digits, where each digit may be either 0, 1, or X (don't care). Spaces may be used anywhere to separate groups of digits. The option will accept ASCII binary data command arguments without the #Y prefix. The following are all valid and equivalent: WOR: #Y1 00X01X10 0X0X110X, WOR: #Y100X01X100X0X110X, WOR: 1 00X0 1X10 0X0X 110X, WOR: #Y1 0 0X0 1X1 00X 0X1 10X The order of the digits is: qualifer bit, then a 16-bit wod in most-significant to least-significant bit order. All 17 digits must be sent. If an error is detected in the ASCII binary data argument, a command-argument SRQ error is sent. If the Word Recognizer Option is not installed and any word recognizer command or query is received, an option-not-installed SRQ error is sent.
WREcognizer?	CLOck RADix WORd		Query response is: WRE RAD: string, CLO: string, WOR:<ASCII binary data>. An example of the output format of WRE? WOR is: WOR: #Y1 00X01X10 0X0X110X.



OPERATOR'S CHECKS

INTRODUCTION

To verify the operation and accuracy of your instrument before making measurements, perform the following check procedures. If indications specified in these procedures cannot be obtained, refer the instrument to a qualified service technician.

Before proceeding with these instructions, refer to "Preparation for Use" (Section 2) in both this manual and the standard instrument's Operators manual.

Verify that the POWER switch is OFF (push button out); then plug the power cord into a power outlet.

NOTE

The initial setup, all verifications, and each step within them must be performed in the sequence presented and in their entirety to ensure that control settings are correct for the following step.

INITIAL SETUP

1. Press in the POWER switch button (ON) and allow the instrument to warm up for 20 minutes.

2. If an A TRIGGER MODE indicator is illuminated, push the A/B/MENU switch.

3. Push the TRIGGER MODE switch down to deactivate any MENU selected function.

4. Set instrument controls to obtain a baseline trace as follows:

Vertical

CH 1 POSITION	Midrange
MODE	CH 1
BW LIMIT	Off (button out)
CH 1 VOLTS/DIV	10 mV
CH 1 Input Coupling	1 MΩ DC

Horizontal

A AND B SEC/DIV	Locked together at 50 ms
SEC/DIV VAR	Calibrated detent
POSITION	Midrange
X10 MAG	Off (button out)
Δt and ΔV	Off (press and release until readout display disappears)

Trigger

HOLDOFF	Fully counterclockwise
LEVEL	Midrange
A MODE	AUTO
A and B SOURCE	VERT
A and B COUPLING	DC
A and B SLOPE	+

5. Adjust the INTENSITY, READOUT INTENSITY, and FOCUS controls for desired display and readout brightness and best trace definition.

6. Connect a 10X probe to the CH 1 OR X input connector and connect the probe tip the the CALIBRATOR output.

7. Adjust the Vertical and Horizontal POSITION controls to position the trace within the graticule area.

8. Adjust the A TRIGGER LEVEL to 0.200 V.

FREQUENCY VERIFICATION

1. Enter MENU mode (see "Menu Mode Function Selection" in Section 4).

2. Use the Δ REF OR DLY POS control to underline **COUNT**.

3. Push up on the TRIGGER MODE switch.

4. Use the Δ REF OR DLY POS control to underline **MODE**.

5. Use the Δ control to underline **FREQ**.

6. If the instrument contains the Word Recognizer Option:

a. Use the Δ REF OR DLY POS control to underline **EVT**.

b. Use the Δ control to underline **A**.

7. Push up on the TRIGGER MODE switch.

8. Verify the displayed frequency is between 9.99 Hz and 10.01 Hz.

9. Exit Menu mode (see "Menu Mode Function Selection" in Section 4).

DELAY VERIFICATION

1. Select AUTO Resolution (see "Resolution Selection" in Section 4).

2. Set the A AND B SEC/DIV switches to 0.5 μs.

3. Pull out the B SEC/DIV switch.

4. Set the B TRIGGER MODE to TRIG AFT DLY.

5. Adjust the B TRIGGER LEVEL to 0.200 V.

6. Move the intensified zone as far left as possible using the Δ REF OR DLY POS control.

7. Verify the displayed delay is between 989.5 ns and 1010.5 ns.

DELTA VERIFICATION

1. Select the delta time mode using the Δt switch.

2. Move the intensified zone as far left as possible using the Δ REF OR DLY POS control.

3. Move the second intensified zone two divisions to the right of the first intensified zone using the Δ control.

4. Verify the displayed delta time is between 999.0 ns and 1001.0 ns.

5. Deselect the delta time mode using the Δt switch.

6. Lock together the A AND B SEC/DIV switch.

DELAY-BY-EVENTS

1. Set the A TRIGGER SLOPE to −.

2. Enter Menu mode.

3. Use the Δ REF OR DLY POS control to underline **DLY/EVTS**.

4. Push up on the TRIGGER MODE switch.

5. Use the Δ REF OR DLY POS and Δ controls to select SWP B, START A, DLY BY B (see "Delay-by-Events" in Section 4).

6. Push up on the TRIGGER MODE switch.

7. Pull out the B SEC/DIV switch.

8. Use the Δ REF OR DLY POS and the Δ controls to set the number of delaying events to 1.

9. Verify that the intensified zone moves to each succeeding rising edge as the delaying event count is changed to 2, 3, 4, and 5.

OPTIONS AND ACCESSORIES

INTRODUCTION

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. 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

There are currently no options available for the C/T/T and WR. Also, Option 11 (rear panel probe-power connectors) described in the 2465 manuals and Option 09 (Word Recognizer) described in this manual are not available in the same instrument.

ACCESSORIES

In addition to the base instrument's standard accessories, one each of the following standard accessories is provided with each instrument containing the 2445/2465 Option 06 Counter/Timer/Trigger:

Description	Part Number
2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Operators Manual	070-4631-00
2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Reference Card	070-4181-00
2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Reference Guide	070-5366-00

Each instrument containing the Word Recognizer is provided with the following standard accessories in addition to those mentioned for the Counter/Timer/Trigger:

1	P6407 Word Recognizer Probe multi-lead, with the following accessories:	010-6407-01
2	10-wide comb, 10-inch leads (without grabbers)	012-0747-00
20	Grabber Tips	206-0222-00

In addition to the base instrument's optional accessories, the following optional accessory is available for the Counter/Timer/Trigger or the Counter/Timer/Trigger and Word Recognizer options:

2445/2465 Option 06 and Option 09 Counter/Timer/Trigger and Word Recognizer Service Manual	070-4632-00

APPENDIX A

GPIB COMMAND REFERENCE

Table A-1
Counter/Timer/Trigger GPIB Command Summary

C/T/T Measurement Commands		
Header	**Argument**	**Argument**
CTRdy?		
CTSend?	IMMediate WAIt	
OPC	ON OFF	
C/T/T Setup Commands		
BTRigger	MODe:	ALTSlope RUN TRIGGerable
BTRigger?	MODe	
COUNt	EVent:	ATRigger WREcognizer
	MODe:	FREquency TOTal PERIod
COUNt?	EVEnt MODe	
CTT	COUNt DBEvents LTRigger OFF RESET	
CTT?		
DBEvents	COUNt: EVEnt:	<nr1> BTRigger WREcognizer
	STArt:	ATRigger WREcognizer
	SWEep:	ASWeep BSWeep
DBEvents?	COUNt EVEnt STArt SWEep	

Table A-1 (cont)

Header	Argument	Argument
LTRigger	ASWeep:	AANdb AORb WREcognizer
	BSWeep:	WREcognizer
LTRigger?		
RESolution	AUto R1Ns R100ps R10Ps	
RESolution?		

Table A-2
Word Recognizer GPIB Command Summary

Header	Argument	Argument
WREcognizer	CLOck:	ASYnch DNClock UPClock
	RADix:	BINary HEX OCTal
	WORd:	<ASCII binary data>
WREcognizer?		
	CLOck RADix WORd	

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.