- **CH 1 - CH 4 Scale Factors** - Numerical deflection factors and supplementary symbols. CH 3 and CH 4 deflection factors are shown in volts. The supplementary symbols for CH 1 and CH 2 are as follows:

  > Variable out of detent

  ⏚ Input grounded

  V Dc coupling

  ~V Ac coupling

- **Indicators** - Symbolic indicators of oscilloscope modes.

  \+ ADD vertical mode

  ↓ CH 2 INVERT mode

  BW 20 MHz BW Limit

  HO HOLDOFF is not set at minimum

  50Ω OVERLOAD CH 1 or CH 2 input power limit has been exceeded

- **A and B SWP RATES** - Calibrated A and B SEC/DIV scale factors. With the SEC/DIV switches unlocked (INTENS, ALT, or B display), only the B sweep rate is affected by the SEC/DIV VARiable control.

TRIGGER OPERATION

- **Trigger Mode Buttons** - When held in, automatically increment (move up or down) the associated trigger mode.

Trigger Modes

AUTO LVL - Range of TRIGGER LEVEL control is limited within signal peaks. Range limits are reestablished when:

- triggering ceases,
- the TRIGGER LEVEL control is moved to either extreme,

or

- Upper MODE button is pushed when Mode is AUTO LVL

The initially established level is near the midpoint between signal peaks except as follows:

- If the LEVEL control is set near the CCW limit, the trigger level is set just above the negative signal peak.
- If the control is set near the CW limit, the level is set just below the positive peak.

AUTO - Sweep freeruns in absence of trigger signal. Trigger level changes only when LEVEL control is moved.

NORM - Sweep runs when trigger requirements are met. With input coupling of the selected trigger source at GND, sweep freeruns.

SGL SEQ - Sweep is triggerable once for each selected trace. READY is illuminated until final trace is completed, then readout and scale-illumination flash.

ACCURACY ASSURANCE TECHNIQUES

- **DC Balance** - Minimizes trace shift when changing VOLTS/DIV, and maintains trigger level readout accuracy.

  1. Set both CH 1 and CH 2 input coupling to AC.
  2. Push both CH 1 and CH 2 upper input coupling buttons.

- **Vertical Amplitude Verification**

  1. With A and B SEC/DIV set at 1 ms (knobs locked), use the Δ V cursors to measure the amplitude of the CALIBRATOR signal on each of the four vertical channels. CH 1 and CH 2 should measure between 388 mV and 412 mV, while CH 3 and CH 4 should be between 360 mV and 440 mV.

- **Timing Verification**

  1. With the CALIBRATOR signal displayed on CH 1, set the VOLTS/DIV control to 100 mV.
  2. Verify Horizontal Timing using table below.

HORIZONTAL TIMING

SEC/DIV	Display
1 ms w/X10 MAG	1/2 cycle/10 div
100 ms - 100 ns	5 cycles/10 div
50 ns	2 cycles/8 div
20 ns	1 cycle/10 div
10 ns	proportional stretching of CALIBRATOR signal
5 ns (2465B only)	

  3. Using the Δ t cursors and the B Delayed displays, verify that the measured intervals defined by the center four cycles of CALIBRATOR display (from 100 ms/div - 100 ns/div) are respectively within 0.6% and 0.4% of the graticule measurement.

- **Probe Compensation**

  1. Obtain a four-division, 1 kHz CALIBRATOR display on both CH 1 and CH 2 using the probes to be compensated (VOLTS/DIV = 100 mV, A and B SEC/DIV = 1 ms).
  2. Adjust the probe-compensation caps for optimum (flat) front corner.
  3. Probes used on CH 3 or CH 4 should be compensated on CH 1 or CH 2, then moved to channel of use.

- **CH 2 Delay Adjust** - Match vertical delays, including probes.

  1. Connect both CH 1 and CH 2 inputs to a fast-rise pulse generator. Use the probes that will be used for measurements.
  2. Set A and B SEC/DIV controls to 5 ns (10 ns for 2445B).
  3. With both channels displayed, vertically superimpose the signals.
  4. Pull out the B SEC/DIV knob and push in the X10 MAG button.
  5. Adjust the Δ control until the two signals are superimposed horizontally.

AUTOMATIC MEASUREMENT ACCURACY FACTORS

Signals without narrow peaks or spikes and without noise will be measured more accurately than their counterparts with high overshoot, fast spikes or glitches, and significant noise present. Jitter (time variations among cycles) also makes accurate measurements more difficult. Noise degrades the accuracy of any measurement.

Pulse-width measurements between identical amplitudes on opposite slopes are less accurate than Frequency measurements.

Rise- and fall-time measurements tend to be less accurate and to have more variation due to small variations in the triggering points. Rise and fall times are measured on a peak-to-peak basis; therefore any overshoot or undershoot tends to change the measurement result. Fast overshoot or undershoot will not be accurately measured by the measurement system, so results will differ from those obtained manually.

Example of Best-Case Measurement

Frequency measurement depends on signal peaks and their consistent amplitude. The fact that signal peaks may be of lower amplitude at 500 MHz than they were at 300 MHz is not particularly significant as long as the instrument can detect them. Frequency can be measured with about 0.5% accuracy using automatic measurements.

Voltage Measurements are accurate to 1 MHz.

Example of Worst-Case Measurement

Imagine *a triangle wave* of 2 V amplitude pk-to-pk, 1 MHZ frequency, with 0.2 V of noise present. This signal has a 1 µsec period. With 0.2 V of noise, jitter could be 0.2 V/(2V/0.5 µsec) = 50 ns per transition, or 100 ns total per cycle. In this case, frequency measurement accuracy could not be better than 10% even before considering the measurement system.

ACCURACY SPECIFICATIONS FOR AUTOMATIC MEASUREMENTS (+15°C to +35°C)

Period
0.9% + 500 ps.

Volts
(5% + 5 mV + 1 LSD) to 1 MHz.

Rise Time, Fall Time
5% + 3 ns (for transition times greater than 10 ns). These rise and fall times are based on measurements at 20% and 80% extrapolated to 10% and 90%. Pulse overshoot, undershoot <5% of peak-to-peak signal.

Time A-B (from % to %)
0.5% + 3 ns (add 0.5 ns if measuring from Ch 1 to Ch 2) + 5% of start event and 5% of stop event transition times.

Time A-B (between two Voltages)
0.5% + 3 ns (add 0.5 ns if measuring from Ch 1 to Ch 2) + 5% of start event and 5% of stop event transition times. Voltages must not be within 10% of either peak.

Pulse Width
0.9% + 1 ns (transition times <10% of measured interval).

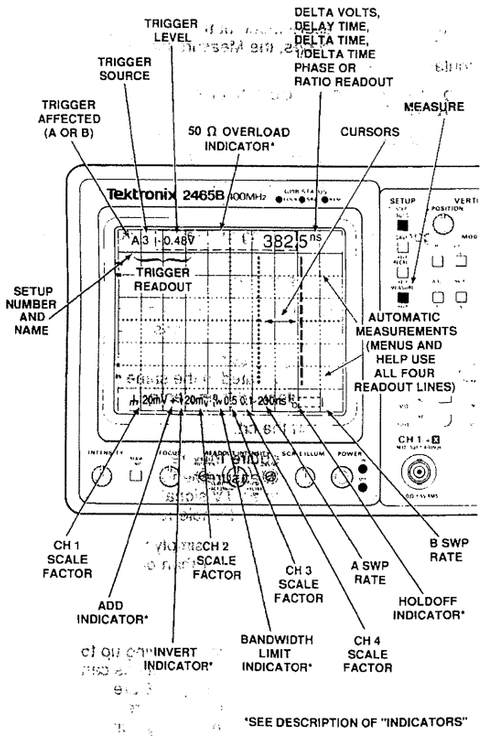
Specifications above based on noise less than 0.5% of Peak-to-Peak input signal.

Reference

Tektronix

2445B, 2465B & 2467B Oscilloscopes

070-7148-00



*SEE DESCRIPTION OF "INDICATORS"

AUTO SETUP

The Auto Setup feature presents a clear signal display. Auto Setup saves time and is easy to use.

To use Auto Setup, just connect a signal to an input, turn on that input channel, set the input coupling as desired, and press the AUTO SETUP button. The oscilloscope does the rest.

Automatically set displays vary depending on the number of channels turned on. When only one channel is turned on, Auto Setup centers the zero-volt level, and displays between two and five vertical divisions. When displaying multiple channels, Auto Setup sets the zero-volt levels of Channels 1, 2, 3, and 4 to +2, 0, -2, and -3 divisions, respectively, and sizes the displays to minimize overlap.

Auto Setup places SEC/DIV at a value, from 20 ns to 2 ms, that will present two to five cycles of the signal on the lowest-numbered channel.

Triggering is set to Auto Level mode, Vertical source, 50% level, DC coupling, and Minimum holdoff. If the input is a pulse whose width is less than 5% of its period, the sweep is expanded to show the pulse itself instead of two to five cycles.

AUTOMATIC MEASUREMENTS

At the press of a button, a 2467B, 2465B, or 2445B will measure any of six waveform parameters: frequency, volts, rise time, fall time, pulse width, and time between events.

To make a measurement:

- Press the MEASURE button. The oscilloscope will display the Measure menu at the top of the crt. On non-CTT scopes, the Measure menu contains these entries:

FREQ VOLTS RISE-t CONFIGURE
WIDTH TIME FALL-t

If your scope has the CTT (Option 06 or 09), the Measure menu contains different entries:

FREQ VOLTS RISE-t COUNTER
WIDTH TIME FALL-t <MORE>

As suggested by the following message at the bottom of the crt,

PRESS 1-7 TO SELECT FUNCTION

the menu entries are arranged in a pattern resembling the VERTICAL MODE buttons.

- Select a measurement by pressing the VERTICAL MODE button located in the same relative position as the desired menu entry.

The result is displayed on the crt.

Automatic measurements require truly repetitive signals for reliable results. Measurements on one-shot or irregular signals such as TV signals or pulse-burst signals will produce unpredictable results.

You can remove the Measure menu simply by pressing any front-panel button other than one of the eight VERTICAL MODE buttons.

SAVE/RECALL

The Save/Recall feature offers a way of saving up to 30 different front-panel settings. Saved settings can be recalled for use at any time. Settings 1-8 are saved and recalled through a direct procedure; settings 9-30 are saved and recalled through an extended process.

Direct Save (Setups 1-8)

- Set the scope to present the desired display.
- Press the SAVE button.

SAVE 1-8 DIRECTLY NAME: . . . . . .

will be displayed at the top of the crt, and

PUSH ANY OF 1-8 TO SAVE SETUP

will be displayed in the lower part of the crt.

- To assign or change the name for the setup, turn the Δ control to define characters. Then adjust ΔREF to the next character location, and use Δ to define subsequent characters. Repeat as needed.
- Press one of the 1-8 VERTICAL MODE buttons to save the **front-panel** setup.

To perform a measurement as a step in a sequence, proceed as follows:

- Press SAVE.
- Press MEASURE. The readout MEAS:°FREQ will appear at the top right of the CRT.
- Use the Δ knob to select a measurement. (Turning Δ will present different measurements; FREQ, WIDTH, RISE-t, FALL-t, TIME, and VOLTS are available.)
- Press one of the VERTICAL MODE buttons to save the measurement.

Extended Save (Setups 9-30)

To save more than eight setups:

- Set the scope to present a display.
- Press SAVE.
- Press STEP/AUTO.
- Turn Δ to select step number.
- Use the ΔREF and Δ controls to name the setup.
- Press STEP/AUTO to save the setup.

Direct Recall (Setups 1-8)

- Press RECALL.
- Press the desired 1-8 VERTICAL MODE button to select the setup.

Extended Recall (Setups 9-30)

- Press RECALL.
- Turn the Δ control counterclockwise until the desired setup number is displayed at the top left of the crt screen.
- Press STEP/AUTO.

SEQUENCING

After setups are saved, they can be performed in sequence as follows:

- Press the RECALL button,
- Press the STEP button. The scope now displays the name of the first step of each sequence (up to four) it contains. You must now choose one of these sequences. To do so:
- Press the VERTICAL MODE button (1, 2, 3, or 4) that represents the sequence you want. The scope immediately performs the first step of the sequence you chose. To advance the scope through the test sequence you chose:
- Press the STEP button, or any switch connected to the STEP/AUTO EXT SWITCH connector on the instrument rear panel.

For more detail refer to the Operator's manual.

THE CONFIGURE MENU

The Configure menu allows you to change the internal parameters the scope uses for various functions. To access the Configure menu, press the MEASURE button, then select the Configure menu by pressing VERTICAL MODE button 4 (CONFIGURE). (Instruments with the CTT have more Measure entries than will fit in one menu. On CTT models, press VERTICAL MODE button 8 <MORE> to call the rest of the menu, which contains the CONFIGURE entry.)

The AUTO entry lets you perform an automatic measurement when an Auto Setup takes place.

The TIME entry lets you assign channel, polarity, and triggering level of points between which time will be measured with the TIME automatic measurement.

The MINFREQ entry lets you choose the minimum frequency at which automatic measurements will work: 50 Hz or 10 Hz. Choosing 10 Hz will result in longer measurement times.

The RESOLUTION entry lets you select Auto, 1 ns, 100 ps, or 10 ps resolution for the scope's optional Counter/Timer/Trigger (CTT, Option 06 or CTT with Word Recognizer, Option 09).

The WR-RADIX entry lets you select binary, octal, or hex for the optional Word Recognizer (Option 09).

HOW TO ASSIGN A MEASUREMENT TO THE AUTO BUTTON

The oscilloscope can be set to perform a measurement when the AUTO button is pressed. To select a measurement:

1. Press the MEASURE button.
2. If your scope has the CTT (Option 06), select the MORE menu entry. Otherwise, go to Step 3. If you selected MORE on a CTT scope, the CTT menu appears:

DLY-BY-EVENTS LOGIC TRIGGER
CONFIGURE OFF <HOME>

3. Select the CONFIGURE entry.
4. Select AUTO entry.
5. Select a measurement from the menu using the appropriate VERTICAL MODE button.

When a measurement is assigned to the AUTO button, the oscilloscope does two operations when you press the AUTO button: 1. an Auto Setup, and 2. the automatic measurement you assigned.

THE PROBE IDENTIFICATION (ID) BUTTON

The button on the P6137 probe offers convenient trace identification: to identify the trace with signal you're displaying, just push the button. The trace will move upward about half a division and the letters ID will replace the sensitivity readout.

Auto Setup is also available via the probe ID button; two pushes of the ID button within 0.5 second will initiate an Auto Setup.

If the oscilloscope is configured to perform a automatic measurement via Auto Setup, pushing the ID button will initiate that measurement.

For more information, refer to the Operator's manual.

CRT READOUT

NOTE: All readouts except V, t, 1/ t, RATIO, PHASE, and 50 Ω OVERLOAD are turned off when READOUT INTENSITY is CCW from center.

- **Trigger Readout** - Indicates that a single, dc-coupled trigger source is selected with VOLTS/DIV VARIABLE in detent and with DC or NOISE REJ COUPLING.
- **Trigger Affected** - Trigger controls affect only the indicated trigger.

  A - If SEC/DIV knobs are locked.

  B - If SEC/DIV knobs are unlocked and B TRIGGER MODE is TRIG AFT DLY.

The A/B TRIG button momentarily directs control to the opposite trigger.

With B TRIGGER MODE set to RUN AFT DLY and SEC/DIV knobs unlocked, the A/B TRIG button alternately directs control to the A and B triggers. No B readout is present in RUN AFT DLY mode

- **Trigger Source** - Indicates CH 1 - CH 4.
- **Trigger Level** - Signal voltage required to initiate sweep.
- **Cursor Measurement Readouts** - Values of the Delay Time, Δ Time, 1/ Δ Time, Δ Volts, Phase, and Ratio measurements. To turn off a measurement/readout, push the button(s) indicated in the readout.