Tektronix®

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475 OSCILLOSCOPE AND DM44 DIGITAL MULTIMETER OPERATORS

INSTRUCTION MANUAL

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

070-2039-00

Serial Number _____ First Printing JULY 1976

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BEFORE OPERATING

INTRODUCTION

The Tektronix 475 Oscilloscope is a dual-channel portable instrument. The dual-channel dc-to-200 MHz vertical system provides calibrated deflection factors from 2 millivolts to 5 volts/division. The sweep trigger circuits are capable of stable triggering over the full bandwidth capabilities of the vertical deflection system. The horizontal deflection system provides calibrated sweep rates from 0.5 second to 0.01 microsecond/division along with delayed sweep features for accurate relative-time measurements. A X10 magnifier extends the calibrated sweep rate to 1 nanosecond/division. The instrument operates over a wide variation of line voltages and frequencies. Maximum power consumption is about 100 watts.

The Tektronix DM44 Digital Multimeter measures 0 ohm to 20 megohms, 0 dc volt to 1200 dc volts (+ or −), or (using the temperature probe) −55°C to +150°C. The measurement is displayed on a 3-1/2 digital display while the oscilloscope operates normally.

The digital multimeter and oscilloscope combine to provide a digital readout of the time between any two points on the oscilloscope display. Both time measurement points are displayed on the crt at the same time. The 1/TIME function can provide direct measurement of frequency.

SAFETY INFORMATION

The instrument is designed to operate from a single-phase power source with one of the current-carrying conductors (the Neutral Conductor) at ground (earth) potential. Operation from power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a three-wire system) is not recommended, since only the Line Conductor has over-current (fuse) protection within the instrument.

The instrument has a three-wire power cord with a three-terminal polarized plug for connection to the power source and safety-earth. The ground (earth) terminal of the plug is directly connected to the instrument frame. For electric-shock protection, insert this plug only in a mating outlet with a safety-earth contact.

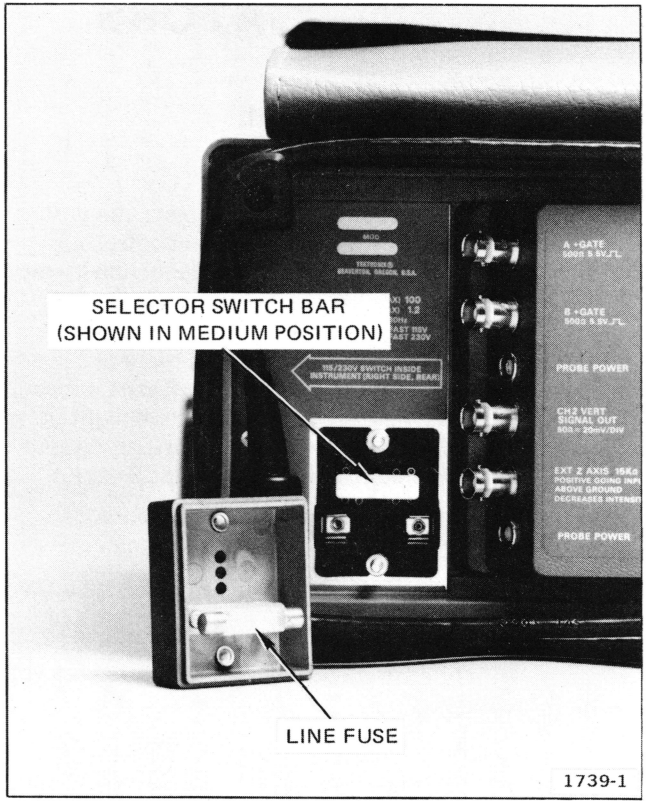

Fig. 1. Regulating range selector and line fuse.

OPTIONS

Options are available to alter oscilloscope performance to meet particular applications. A number in either MOD slot (see Item 53, Controls, Connectors, and Indicators) indicates a modified oscilloscope.

5. POSITION—Positions the display vertically. In the X-Y mode, the CH 1 POSITION control positions on the X axis (horizontally) and the CH 2 POSITION control positions on the Y-axis (vertically).

6. CH 1 OR X and CH 2 OR Y—Input connectors for application of external signals to the inputs of the vertical amplifier. In the X-Y mode of operation, the signal connected to the CH 1 OR X connector provides horizontal deflection and the signal connected to the CH 2 OR Y connector provides vertical deflection.

7. AC-GND-DC—Selects the method used to couple a signal to the input of the vertical amplifier. In the AC position, signals are capacitively coupled to the vertical amplifier. The dc component of the input signal is blocked. In the GND position, the input of the vertical amplifier is disconnected from the input connector and grounded to allow the input coupling capacitor to precharge. In the DC position, all components of the input signal are passed to the input amplifier.

8. VERT MODE—Selects mode of operation for vertical amplifier system.

CH 1: Channel 1 only is displayed.

ALT: Provides dual-trace display of the signals of both channels. Display is switched between channels at the end of each sweep. Useful at sweep rates faster than about 50 microseconds/division.

ADD: Signals applied to the CH 1 and CH 2 input connectors are algebraically added, and the algebraic sum is displayed on the crt. The INVERT switch in Channel 2 allows the display to be CH 1 plus CH 2 or CH 1 minus CH 2. Useful for common-mode rejection to remove an undesired signal or for dc offset.

CHOP: Provides dual-trace display of the signals of both channels. Display is switched between channels at a repetition rate of approximately 250 kHz. Useful at sweep rates slower than about 50 microseconds/division, or when a dual-trace, single-sweep display is required.

CH 2: Channel 2 only is displayed. It must be selected in X-Y operation.

9. 100 OR 20 MHz BW/TRIG VIEW—Three-purpose switch that limits the bandwidth of the vertical amplifier system to approximately 100 MHz (first detent) or 20 MHz (second detent) when pulled, or when pressed, causes the signal applied to A Trigger Generator to be displayed on the crt.

10. INVERT—Channel 2 display is inverted in the INVERT (button in) position.

DISPLAY

11. Internal Graticule—Eliminates parallax. Risetime, amplitude and measurement points are indicated at the left-hand graticule edge.

12. BEAM FINDER—Compresses the display to within the graticule area independently of display position or applied signals and provides a visible viewing level.

13. INTENSITY—Controls brightness of the crt display.

14. FOCUS—Adjusts for optimum display definition.

15. SCALE ILLUM—Controls graticule illumination.

16. ASTIG—Used in conjunction with the FOCUS control to obtain a well-defined display. It does not require readjustment in normal use.

17. TRACE ROTATION—Adjusts trace to align with the horizontal graticule lines.

DM44

18. Input Connectors—Two banana jacks provide + (red) and COM (black) inputs for voltage and resistance only.

19. Probe Connector—Input connector for the temperature probe.

20. Readout—Negative polarity indication is automatic for negative dc voltage and temperature with no polarity indication for positive measurement. A blinking display indicates overrange. The decimal point is positioned by the FUNCTION and RANGE controls for multimeter operation and by the oscilloscope A TIME/DIV switch in the TIME or 1/TIME modes.

21. RANGE—Selects from .2 V to 1.2 kV dc in 5 ranges (1200 volts is the maximum safe input in the 1.2 kV dc mode); from 200 ohms to 20 megohms in 6 ranges.

22. FUNCTION—Selects VOLTS, OHMS, TEMP (°C), 1/TIME, or TIME functions of the DM44.

23. Scale Factor Lamps—Two lamps.

In the TIME function, the Readout and Scale Factor Lamps indicate the time difference between the two intensified zones on the crt display. One lamp or the other will light to indicate ms or μs. No lamp lit indicates seconds.

In the 1/TIME function the Readout and Scale Factor Lamps indicate the number of measured intervals per unit of time. One lamp or the other will light to indicate intervals per ms (1/ms lamp) or intervals per μs (1/μs lamp). No

NORM: Sweep is initiated by the applied trigger signal. In the absence of an adequate trigger signal, there is no trace. When the trigger rate is too low for AUTO use NORM.

SINGL SWP: When this pushbutton is pushed, the A Sweep operates in the single sweep mode. After a single sweep is displayed, further sweeps cannot be presented until the SINGLE SWP button is again pushed. It is useful when the signal to be displayed is not repetitive or varies in amplitude, shape or time causing an unstable conventional display. It can also be used to photograph a nonrepetitive signal.

26. READY Lamp—Indicates A Sweep is "armed" and, upon receipt of an adequate trigger signal, will present a single-sweep display.

27. TRIG Lamp—Indicates that A Sweep is triggered and will produce a stable display. It is useful for setting up the trigger circuits when a trigger signal is available without a display on the crt (for example, when using external triggers).

28. A TRIG HOLDOFF—Provides continuous control of time between sweeps. Allows triggering on aperiodic signals (such as complex digital words). In the fully clockwise position (B ENDS A), A sweep is reset at the end of B sweep to provide the fastest possible sweep repetition rate for delayed-sweep presentations and low-repetition rate signals. Use the A trigger controls for the best possible display before using the A TRIG HOLDOFF control.

29. COUPLING—Determines method used to couple signals to the trigger generator circuit.

AC: Signals are capacitively coupled to the input of the trigger generator. Dc is rejected and signals below about 60 Hz are attenuated.

LF REJ: Signals are capacitively coupled to the input of the trigger circuit. Dc is rejected and signals below about 50 kHz are attenuated. It is useful for providing a stable display of the high-frequency components of a complex waveform.

HF REJ: Signals are capacitively coupled to the input of the trigger circuit. Dc is rejected and signals below about 60 Hz and above about 50 kHz are attenuated. It is useful for providing a stable display of the low-frequency components of a complex waveform.

DC: All components of a trigger signal are coupled to the input of the trigger circuit. It is useful for providing a stable display of low-frequency or low-repetition rate signals, except the combination of the ALT (dual trace) mode with the trigger SOURCE switch in NORM.

32. SOURCE—Determines the source of the trigger signal coupled to the input of the trigger circuit.

NORM: Trigger source is displayed signal(s). It does not indicate time relationship between CH 1 and CH 2 signals. However, stable triggering of non-time-related signals usually can be obtained by setting VERT MODE to ALT, SOURCE to NORM and COUPLING to LF REJ. Carefully adjust LEVEL for a stable display.

CH 1: A sample of the signal available in Channel 1 is used as a trigger signal. CH 2 signal is unstable if it is not time-related.

CH 2: A sample of the signal available in Channel 2 is used as a trigger signal. CH 1 signal is unstable if it is not time-related.

LINE (A Trigger circuit only): A sample of the power-line frequency is used as a trigger signal. It is useful when the input signal is time-related (multiple or submultiple) to the line frequency or when it is desirable to provide a stable display of a line-frequency component in a complex waveform.

EXT: Signals connected to the External Trigger Input connectors are used for triggering. External signals must be time-related to the displayed signal for a stable display. It is useful when the internal signal is too small or contains undesired signals that could cause unstable triggering. It is useful when operating in CHOP mode.

EXT ÷ 10 (A Trigger circuit only): External trigger signal is attenuated by a factor of 10.

STARTS AFTER DELAY (B Trigger circuit only): B Sweep runs immediately after the delay time selected by the DELAY-TIME POSITION control. When making differential time measurements you must use this mode to obtain valid measurements. On instruments equipped with a DM44 you must use this mode to obtain valid measurements when using the TIME or 1/TIME functions.

33. External Trigger Inputs—Input connectors for external trigger signals.

37. VAR—Provides continuously variable sweep rates between the calibrated settings of the A TIME/DIV switch. It extends the slowest A Sweep rate to at least 1.25 seconds/division. The A Sweep rate is calibrated when the control is set fully clockwise to the calibrated detent. Must be in the detent position to make accurate differential time measurements. On instruments equipped with a DM44 the VAR control must be in the detent position to make accurate measurements in the TIME and 1/TIME functions.

38. UNCAL Lamp—Indicates the A Sweep rate is uncalibrated (VAR control out of the calibrated detent).

39. X10 MAG Lamp—Indicates that the X10 magnifier is on.

40a. DELAY TIME POSITION—Provides variable sweep delay to more than 10 times the delay time indicated by the A TIME/DIV switch.

40b. DM44 DELAY TIME POSITION—Operates in the same manner as 41a. Also, when the DM44 is in the TIME or 1/TIME function, this control operates in conjunction with the Δ TIME control. The DELAY TIME POSITION control moves both the reference point and the time-measurement point. The Δ TIME control moves only the time-measurement point. With the time-measurement point to the left of the reference point the Readout indicates a negative time difference.

NOTE

You can modify your instrument to make the DELAY TIME POSITION control move only the reference point. The procedure for making this modification is located in the Operating Information section of the DM44 Service manual.

41. CALIBRATOR—A combination current loop/square-wave voltage output that permits the operator to compensate voltage probes and check vertical gain, current probes and oscilloscope operation. It is not intended to verify time-base calibration.

42. POWER—Turns instrument power on and off.

43. LOW LINE Lamp—Indicates that the applied line voltage is below the lower limit of the regulating range selected by the Regulating Range Selector.

44. HORIZ DISPLAY—Determines the mode of operation for the horizontal deflection system.

A: Horizontal deflection provided by A Sweep at a sweep rate determined by the setting of the A TIME/DIV switch. B sweep is inoperative.

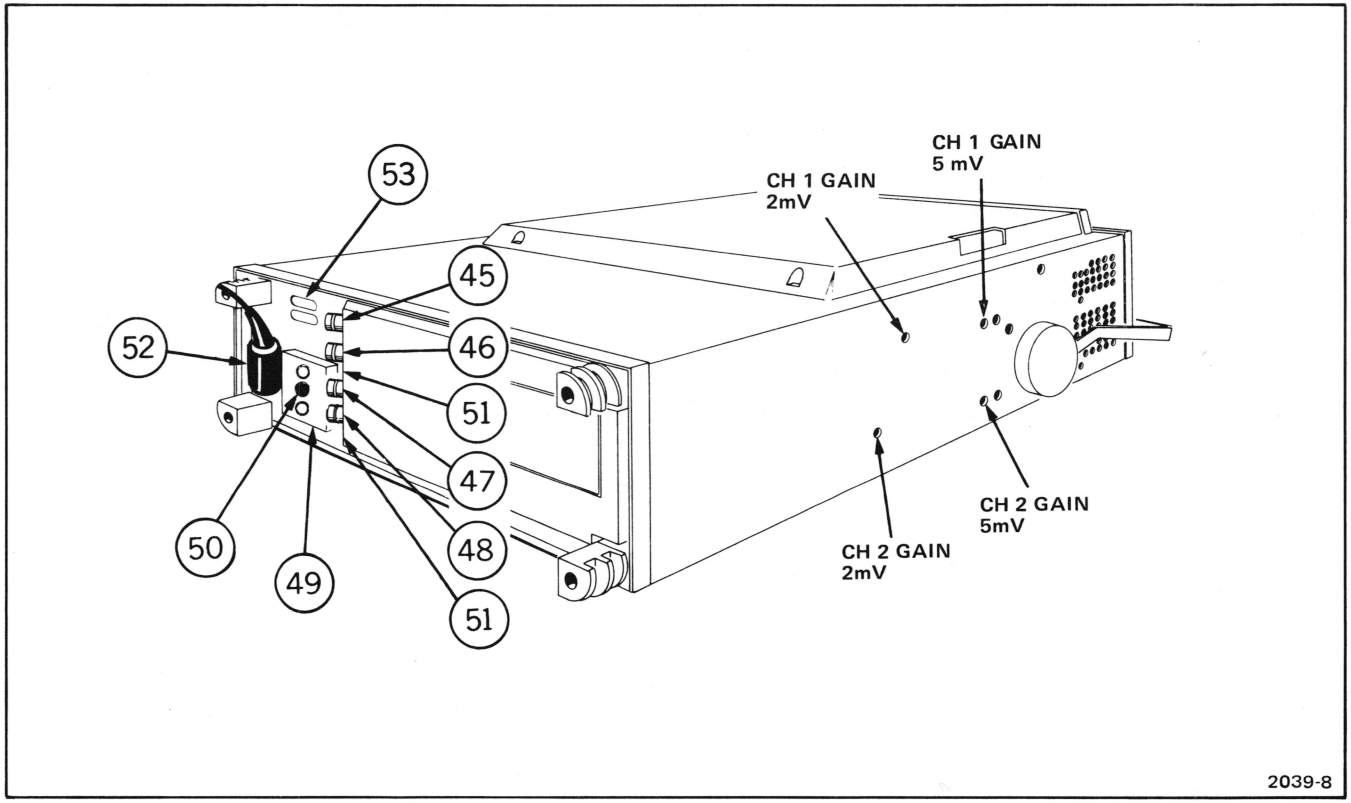

Fig. 7. Rear panel and left side panel controls, connectors, and indicators.

4. Set the CH 1 VOLTS/DIV switch and vertical POSITION control to locate the display within the display area.

5. Adjust the A Trigger LEVEL control for a stable display.

6. Set the A TIME/DIV switch and the horizontal POSITION control to locate the display within the display area. Then adjust the FOCUS control as needed.

MAGNIFIED SWEEP DISPLAY

1. Obtain a Normal Sweep Display.

2. Adjust the horizontal POSITION control to move the area to be magnified to within the center graticule division (0.5 division on each side of the center vertical graticule line). It may be necessary to change the TIME/DIV switch setting.

3. Push the X10 MAG switch (on) and adjust the horizontal POSITION control for precise positioning of the magnified display. Divide the TIME/DIV setting by 10 to determine the magnified sweep rate.

DELAYED SWEEP DISPLAY

NOTE

Differential time measurements and measurements using the TIME or 1/TIME functions of the DM44 are invalid when the B Trigger SOURCE switch is not set to STARTS AFTER DELAY.

1. Obtain a Normal Sweep Display.

2. Set the HORIZ DISPLAY switch to A INTEN and the B Trigger SOURCE switch to STARTS AFTER DELAY.

3. Pull out on the B TIME/DIV knob and turn cw until the intensified zone is the desired length. Adjust the INTENSITY control as needed to make the intensified zone distinguishable from the rest of the display. If your instrument is equipped with a DM44, set the FUNCTION switch to a function other than TIME or 1/TIME for a single delayed sweep. Dual delayed displays are discussed in step 6.

2. Set the TIME/DIV switches to X-Y and the VERT MODE switch to CH 2. Apply the vertical signal to the CH 2 OR Y input connector and the horizontal signal to the CH 1 OR X input connector.

3. Advance the INTENSITY control until the display is visible. If the display is not visible with the INTENSITY control at midrange, press the BEAM FINDER pushbutton and adjust the CH 1 and CH 2 VOLTS/DIV switches until the display is reduced in size, both vertically and horizontally. Center the compressed display with the POSITION controls (CH 2 POSITION vertically, CH 1 POSITION horizontally); release the BEAM FINDER pushbutton. Adjust the FOCUS control for a well-defined display.

SINGLE SWEEP DISPLAY

1. Obtain a Normal Sweep Display. For random signals, set the trigger circuit to trigger on a signal that is approximately the same amplitude and frequency as the random signal.

2. Push the SINGL SWP button on the A TRIG MODE switch. The next trigger pulse starts the sweep and displays a single trace. If no triggers are present, the READY lamp lights, indicating the A Sweep Generator circuit is set and waiting to be triggered.

3. After the sweep is complete, the circuit is "locked out" and the READY lamp is out. Press the SINGL SWP button to prepare the circuit for another single-sweep display.

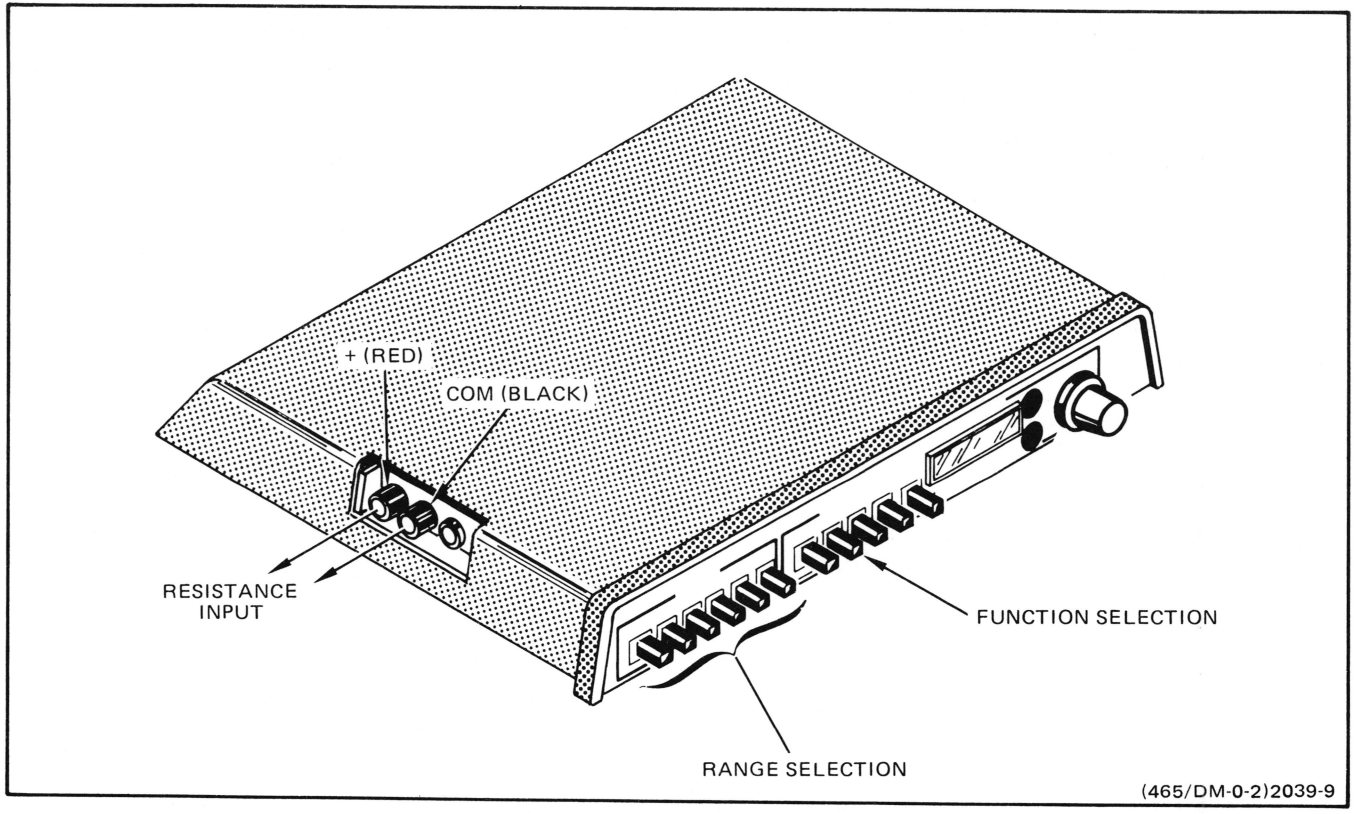

Fig. 8. Resistance.

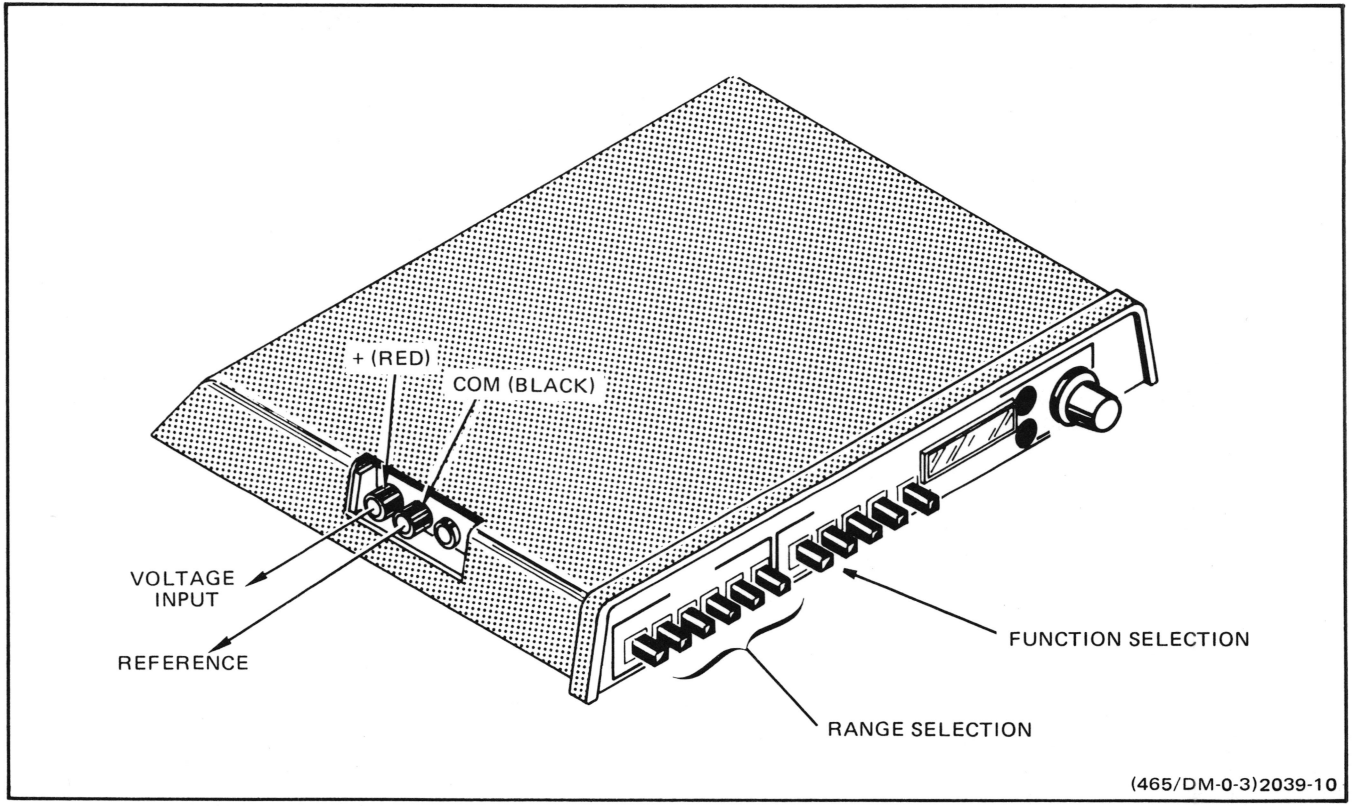

Fig. 9. Volts.

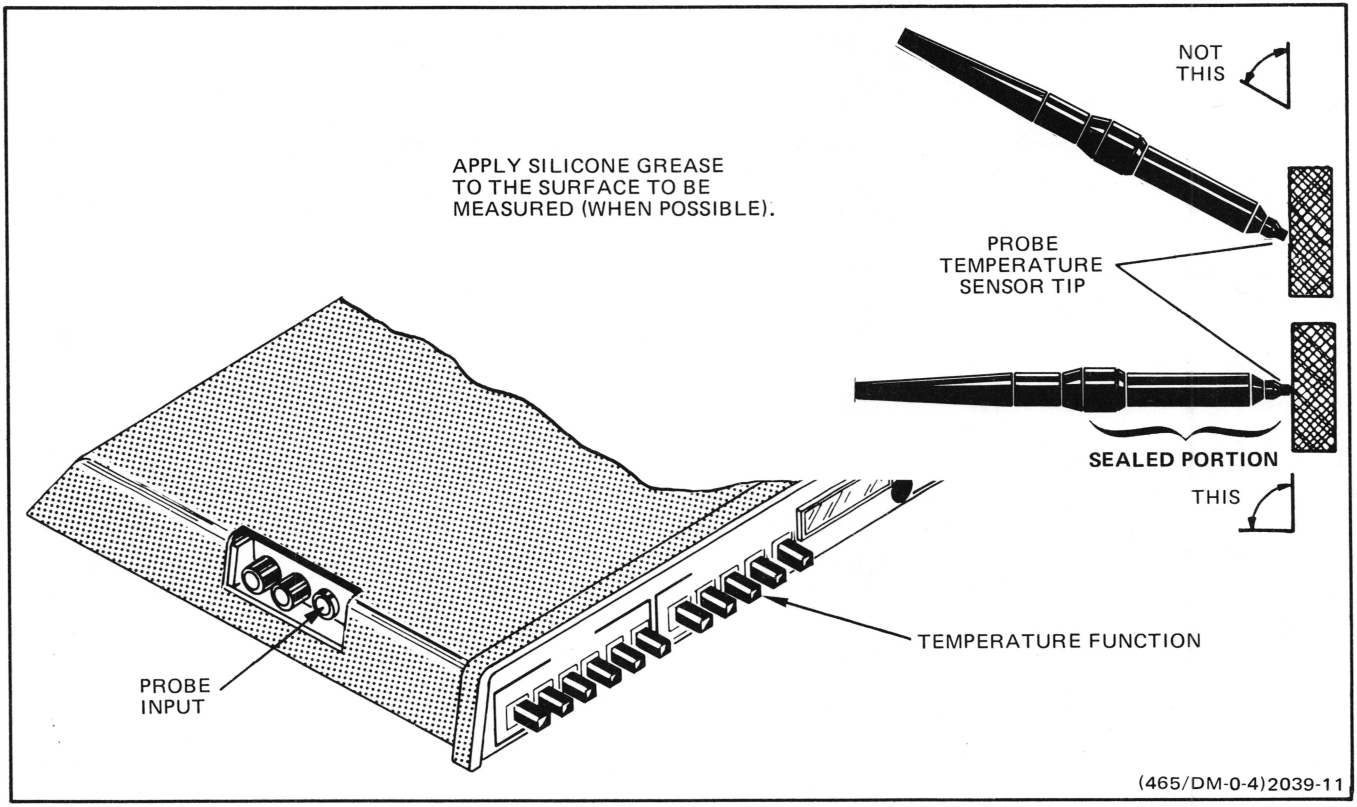

Fig. 10. Temperature.

CAUTION

To prevent possible probe damage, be sure only the sealed portion of the probe is immersed (see Fig. 10).

Put the probe tip into the water, avoiding the side or bottom of the container. Wait for the readout to stabilize, indicating the probe has reached the water temperature.

The readout should be −2° C to 2° C. There should be ice remaining after the test to verify that inserting the probe did not raise the water temperature.

High Temperature

Bring water to a slow boil (to prevent splattering). Put the probe tip into the water, avoiding the side or bottom of the container. Wait for the readout to stabilize, indicating the probe has reached the water temperature.

The readout should be between 98° C and 102° C for clean water at sea level.

TIME AND 1/TIME

See DM44 DELAYED OR MIXED SWEEP TIME MEASUREMENTS in this manual.

OPERATOR'S ADJUSTMENTS AND CHECKS

To verify measurement accuracy, perform the following checks and adjustments before making a measurement. See the Calibration section of the Service manual for calibration information.

Trace Rotation Adjustment

Normally not required. Obtain a Normal Sweep Display using only steps 1 through 3. Set the CH 1 input Coupling switch to GND to display a free-running trace with no vertical deflection. Adjust the TRACE ROTATION (screwdriver adjustment located below the crt graticule) to align the trace with the center horizontal graticule line.

Probe Compensation

Miscompensation is one of the greatest sources of operator error. Most attenuator probes are equipped with adjustments to ensure optimum measurement accuracy. Probe compensation is accomplished as follows:

Obtain a Normal Sweep Display presentation of the calibrator square-wave voltage. Set the appropriate VOLTS/DIV switch to .1 V position and the Input coupling to DC. Check the waveform presentation for overshoot or rolloff, and if necessary, readjust compensation for flat tops on the waveforms. See Fig. 11. Refer to probe manual for method of compensating the probe being used.

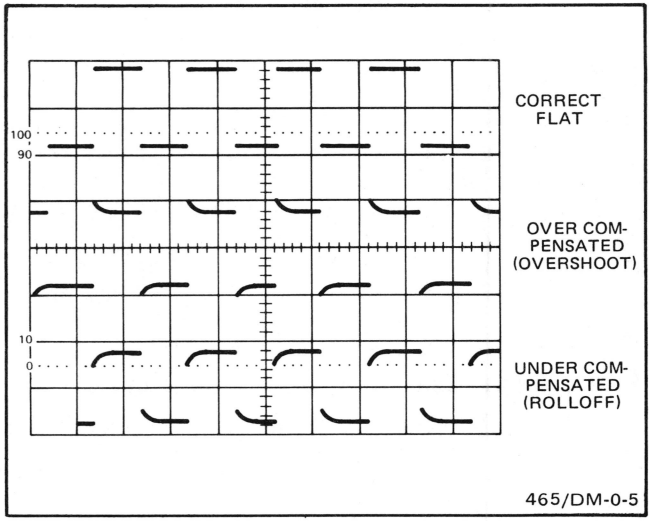

Fig. 11. Probe compensation.

Push the TRIG VIEW button and hold it in. Use the DELAY TIME POSITION control to move the reference point to the center horizontal graticule line (see Fig. 13, Point A). Use the ALT DELAY control to move the time-measurement point to the center horizontal graticule line on the next cycle (see Fig. 13, Point B). Verify the readout is 16.49 to 16.84 and the ms lamp is lit.

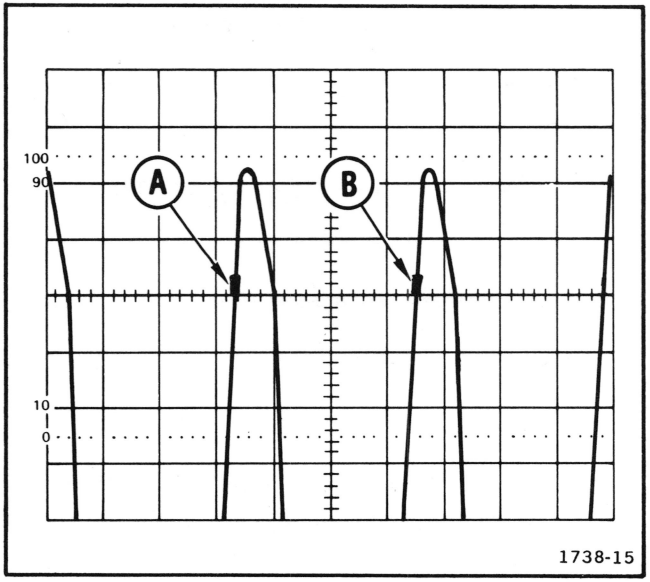

Fig. 13. DM44 timing check.

External Horizontal Gain Check

(If X-Y operation is to be used.) Use steps 1 through 3 of the Basic Oscilloscope Displays procedure for obtaining a Normal Sweep Display of the calibrator square-wave voltage waveform; then, set the TIME/DIV switch to X-Y. With the calibrator signal connected to the CH 1 OR X input connector and the CH 1 VOLTS/DIV switch set to 50 mV, the crt display should be two dots separated horizontally by 5.75 to 6.25 divisions.

PEAK-TO-PEAK VOLTAGE MEASUREMENTS—AC

Obtain a Normal Display. Make sure the VAR VOLTS/DIV control is in the calibrated detent. Vertically position the display so the lower portion coincides with a horizontal graticule line (see Fig. 14, Point A). Horizontally position the display so one of the upper peaks coincides with the center vertical graticule line (see Fig. 14, Point B). Measure the vertical deflection from peak-to-peak (Point A to Point B).

To determine the polarity of the voltage to be measured, set the input coupling switch to GND and vertically position the baseline to the center of the crt. Set the input coupling switch to DC. If the waveform moves to above the center of the crt, the voltage is positive. If the waveform moves to below the center of the crt, the voltage is negative.

Set the input coupling switch to GND and position the baseline to a convenient reference line. For example, if the voltage to be measured is positive, then position the baseline to the bottom graticule line.

Switch the Input Coupling Switch to DC. Measure the divisions of vertical deflection between the reference line and the desired point on the waveform (see Fig. 15). Multiply the veritcal deflection by the VOLTS/DIV switch setting. Include the attenuation factor of the probe if the probe does not have a scale-factor switching connector.

EXAMPLE: The vertical distance measured is 4.6 divisions (see Fig. 15), the waveform is above the reference line, and the VOLTS/DIV switch is set to 2.

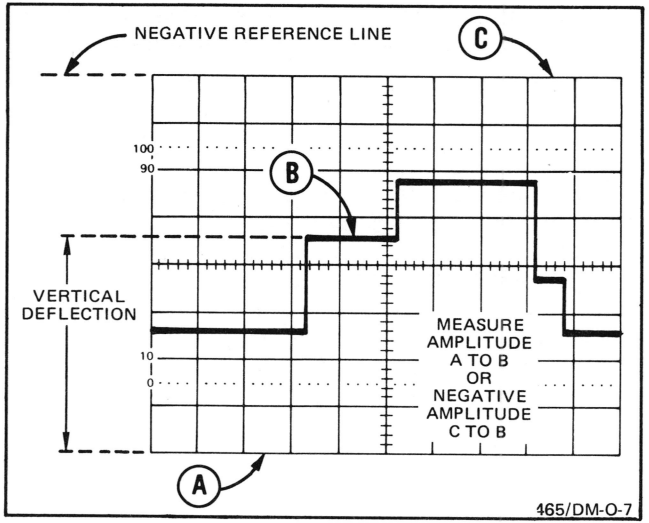

Fig. 15. Instantaneous voltage measurement.

Using the formula:

Instantaneous Voltage	=	vertical distance (divisions)	X	polarity	X	VOLTS/DIV setting

Substituting: = 4.6 X (+1) X 2 V = 9.2 volts.

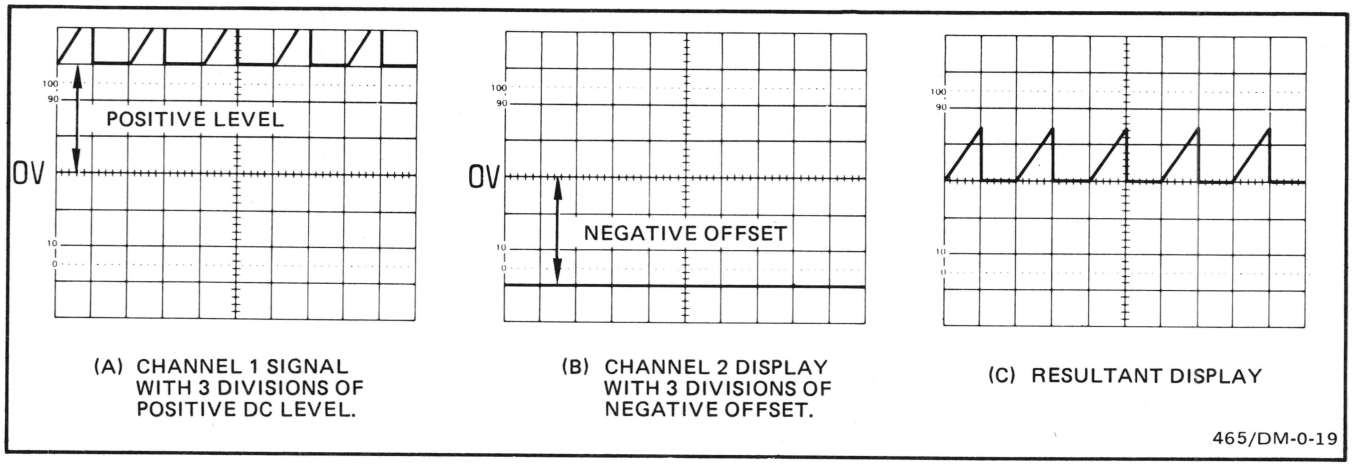

Fig. 16. Algebraic addition.

COMMON-MODE REJECTION

The ADD mode can be used to display signals that contain undesirable components. These undesirable components can be eliminated through common mode rejection. The precautions given under algebraic addition should be observed.

EXAMPLE: The signal applied to the CH 1 input contains unwanted line frequency components (see Fig. 17A). To remove the undesired components use the following procedure.

1. Connect a line frequency signal to the CH 2 input.

2. Set the VERT MODE switch to ALT and the CH 2 INVERT switch to on (button in). Adjust the CH 2

Determine the vertical conversion factor using this formula:

$$\text{Vertical Conversion Factor} = \frac{\text{reference signal amplitude (volt)}}{\text{vertical deflection (divisions)} \times \text{VOLTS/DIV switch setting}}$$

Determine the arbitrary deflection factor using the formula:

$$\text{Arbitrary Deflection Factor} = \text{Vertical Conversion Factor} \times \text{VOLTS/DIV switch setting}$$

To measure the amplitude of an unknown signal, set the VOLTS/DIV switch to a setting that provides sufficient vertical deflection to make an accurate measurement. Do not readjust the VAR VOLTS/DIV control. Measure the vertical deflection in divisions and calculate the amplitude of the unknown signal using the following formula:

$$\text{Signal Amplitude} = \text{Arbitrary deflection factor} \times \text{Vertical deflection (divisions)}$$

or

$$\text{Signal Amplitude} = \text{Vertical Conversion Factor} \times \text{VOLTS/DIV switch setting} \times \text{Vertical deflection (divisions)}$$

EXAMPLE: The reference signal amplitude measured is 30 volts with a VOLTS/DIV switch setting of 5 and the VAR VOLTS/DIV control adjusted to provide a vertical deflection of 4 divisions.

Substituting these values in the vertical conversion factor formula:

$$\text{Vertical Conversion Factor} = \frac{30}{4 \times 5} = 1.5$$

Then with a VOLTS/DIV switch setting of 1, the peak-to-peak amplitude of an unknown signal, 5 divisions high can be determined by using the signal amplitude formula:

Signal Amplitude: = 1 V X 1.5 X 5 = 7.5 volts.

TIME-DURATION MEASUREMENTS

Obtain a Normal Sweep display. Be sure the VAR TIME/DIV control is set to the calibrated detent. Set the TIME/DIV switch for a single event and position the display to place the time measurement points to the center horizontal graticule line (see Fig. 18).

RISETIME MEASUREMENTS

Risetime measurements use the same methods as time-duration measurements, except the measurements are made between the 10% and 90% points of the waveform. Falltime is measured between the 90% and 10% points on the trailing edge of the waveform.

Obtain a Normal Sweep Display. Set A SLOPE to +. Use a sweep speed setting that displays several cycles or events (if possible) and be sure the VAR TIME/DIV control is in the calibrated detent. Set the VOLTS/DIV switch and VAR control (or signal amplitude) for exactly a five/division display. Set vertical positioning so the display bottom touches the 0% graticule line and the display top touches the 100% graticule line.

Set the TIME/DIV switch for a single-event display with the risetime spread horizontally as much as possible. Horizontally position the display so the 10% point on the waveform intersects the second vertical graticule line (see Fig. 19).

Measure the horizontal distance between the 10% and 90% points and multiply the distance measured by the setting of the TIME/DIV switch.

EXAMPLE: The horizontal distance between the 10% and 90% points is 5 divisions (see Fig. 19) and the TIME/DIV switch is set to 1 μs.

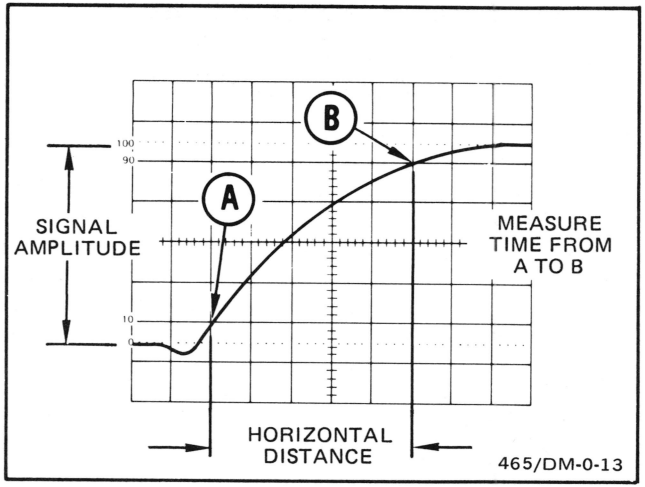

Fig. 19. Risetime.

Using the time duration formula to find risetime:

Time Duration (risetime)	=	horizontal distance (divisions)	X	TIME/DIV setting

Substituting the given values:

Risetime = 5 X 1 μs = 5 microseconds.

TIME COMPARISON MEASUREMENTS

If comparisons of an unknown signal with a reference signal are repetitious (e.g., on assembly line test) it is possible to obtain more accurate, easily read measurements if the VAR TIME/DIV control is adjusted to set the reference signal to an exact number of divisions. The unknown signal can then be quickly and easily compared with, or adjusted to, an exact number of divisions.

Other unknown signals may be measured without disturbing the setting of the VAR TIME/DIV control by establishing a horizontal conversion factor and an arbitrary deflection factor. The time duration of the reference signal must be known before a horizontal conversion factor can be established.

Determine the horizontal conversion factor using the formula:

$$\text{Horizontal Conversion Factor} = \frac{\text{reference signal time duration (seconds)}}{\text{Horizontal deflection (divisions)} \times \text{TIME/DIV switch setting}}$$

Determine the arbitrary deflection factor using this formula:

$$\text{Arbitrary Deflection Factor} = \text{horizontal conversion factor} \times \text{TIME/DIV switch setting}$$

To measure the time duration of an unknown signal, set the TIME/DIV switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the VAR TIME/DIV control. Measure the horizontal deflection in divisions and calculate the time duration using the formula:

$$\text{Time Duration} = \text{arbitrary deflection factor} \times \text{horizontal deflection (divisions)}$$

or

$$\text{Time Duration} = \text{horizontal conversion factor} \times \text{TIME/DIV switch setting} \times \text{horizontal deflection (divisions)}$$

EXAMPLE: The reference signal frequency measured is 455 hertz (time duration: 2.19 milliseconds) with a TIME/DIV switch setting of .2 ms, and the VAR TIME/DIV control adjusted to provide a horizontal deflection of eight

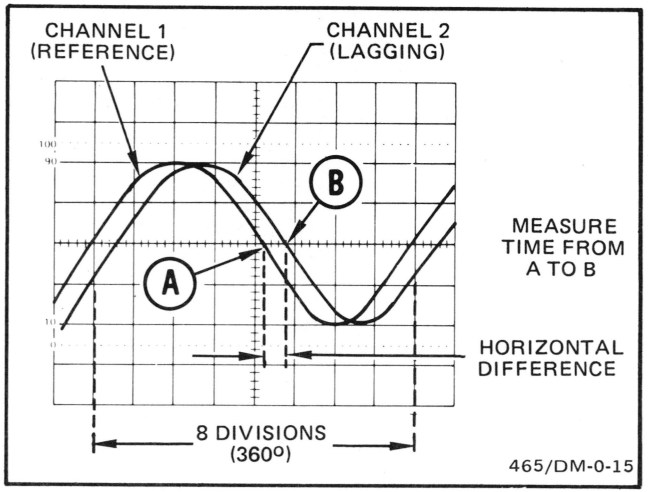

Fig. 21. Phase difference.

Using the formula:

$$\text{Phase Difference} = \text{horizontal difference divisions} \times \text{sweep rate (degrees/div)}$$

Substituting the given values:

Phase Difference = 0.6 X 45° = 27°.

HIGH RESOLUTION PHASE DIFFERENCE MEASUREMENTS

Make more accurate phase measurements by increasing the sweep rate (without changing the A VAR TIME/DIV control) by using the X10 MAG mode. Delayed sweep magnification may also be used (see Fig. 22).

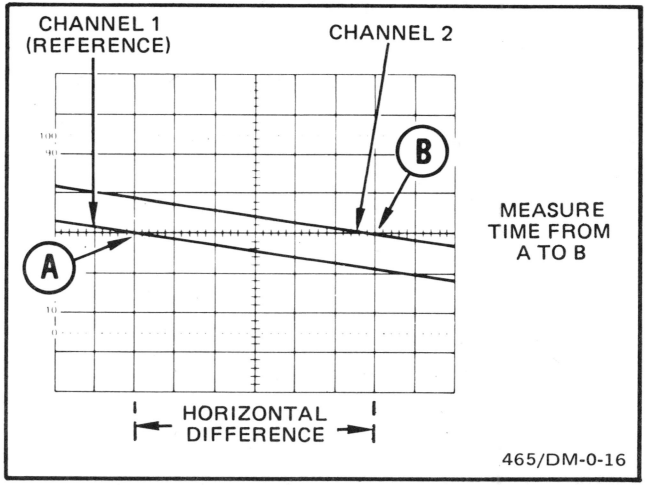

Fig. 22. High-resolution phase difference.

DELAYED OR MIXED SWEEP MAGNIFICATION

The delayed sweep features of the 475 can be used to provide higher apparent magnification than is provided by the X10 MAG switch. The sweep rate of the delayed sweep (B sweep) is not actually increased; the apparent magnification is the result of delaying the B sweep an amount of time selected by the A TIME/DIV switch and the DELAY-TIME POSITION control before the display is presented at the sweep rate selected by the B TIME/DIV switch. The following method uses the STARTS AFTER DELAY position of the B Trigger SOURCE switch to allow the delayed portion to be positioned with the DELAY-TIME POSITION control. If there is too much jitter in the delayed display, use the Triggered B Sweep mode of operation.

Magnified Sweep Starts After Delay

1. Connect the signal to either input connector. Set the VERT MODE switch to display the channel used.

2. Set the VOLTS/DIV switch to produce a display about four divisions in amplitude.

3. Set the A TIME/DIV switch to a sweep rate which displays the complete waveform.

4. Set the HORIZ DISPLAY switch to A INT and the B Trigger SOURCE switch to STARTS AFTER DELAY. Instrument equipped with DM44. Verify that the FUNCTION switch is not set to TIME or 1/TIME.

5. Position the start of the intensified zone with the DELAY-TIME POSITION control to the part of the display to be magnified.

6. Set the B TIME/DIV switch to a setting which intensifies the full portion to be magnified. The start of the intensified zone remains as positioned above (see Fig. 24).

7. Set the HORIZ DISPLAY switch to B DLY'D to magnify the portion of A sweep that is intensified (see Fig. 24).

8. Time measurements can be made from the display in the conventional manner. The sweep rate is determined by the setting of the B TIME/DIV switch.

9. The apparent sweep magnification can be calculated by dividing the A TIME/DIV switch setting by the B TIME/DIV switch setting.

1. Set up the display as given in steps 1 through 6 under "Magnified Sweep Starts After Delay."

2. Set the B Trigger SOURCE switch to the same position as the A Trigger SOURCE switch.

3. Adjust the B LEVEL control so the intensified zone on the trace is stable. (If an intensified zone cannot be obtained, see step 4.)

4. Inability to intensify the desired portion indicates that the signal does not meet the triggering requirements. If the condition cannot be remedied with the B Triggering controls or by increasing the display amplitude (lower VOLTS/DIV setting), trigger B Sweep externally.

5. When the correct portion is intensified, set the HORIZ DISPLAY switch to B DLY'D. Slight readjustment of the B LEVEL control may be necessary for a stable display.

6. Measurements are made and magnification factors are calculated as in the STARTS AFTER DELAY mode previously given.

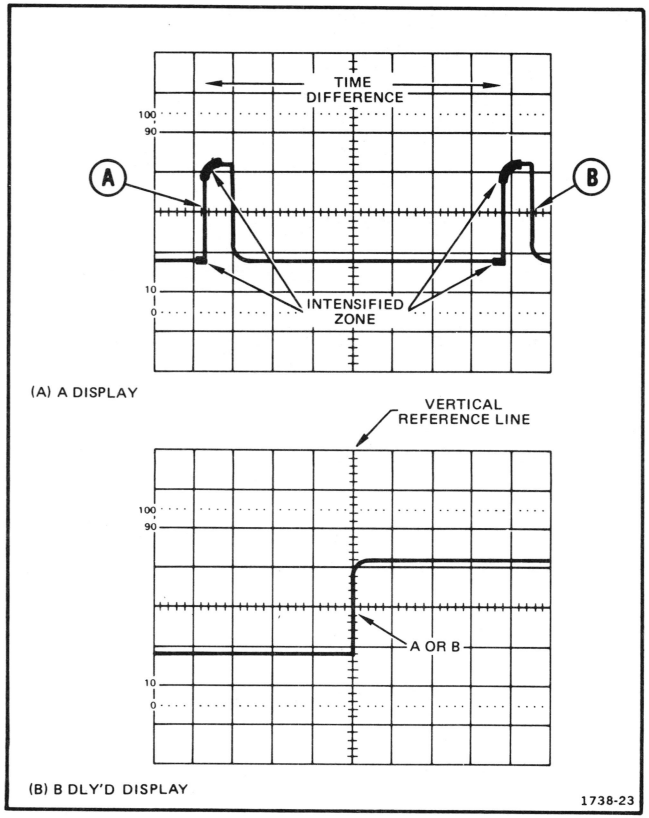

Fig. 25. Time difference between repetitive pulses.

Substituting the given values:

Time Difference = (8.81 − 1.31) X 0.2 μs.

The time difference is 1.5 microseconds.

TIME DURATION MEASUREMENTS (BASIC 475)

Obtain a Delayed Sweep Display. Set the A TIME/DIV switch to display a single event. Be sure the VAR TIME/DIV control is in the calibrated detent. For the most accurate measurement, set the B TIME/DIV switch to the fastest sweep speed that gives a usable (visible) intensified zone. Vertically position the display to place the time measurement points to the center horizontal graticule line (see Fig. 26).

Use the DELAY TIME POSITION dial to move the start (left-hand edge) of the intensified zone to just touch the intersection of the signal and the center horizontal graticule line (see Fig. 26, Point A). Note the DELAY TIME POSITION dial setting.

Use the DELAY TIME POSITION dial to move the start of the intensified zone to the second time measurement point (see Fig. 26, Point B). Note the DELAY TIME POSITION dial setting.

TIME DIFFERENCE BETWEEN TWO PULSES FROM DIFFERENT SOURCES (BASIC 475)

Make sure the VAR TIME/DIV control is in the calibrated detent. Set the A Trigger SOURCE switch to CH 1. Connect the reference signal to CH 1 and the comparison signal to CH 2. Connect the signals to the input connectors using probes or cables with equal time delay.

Set the VERT MODE switch to either CHOP or ALT. In general, CHOP is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals. Center each of the displays vertically (see Fig. 27A).

Set the HORIZ DISPLAY switch to A INT and the B Trigger SOURCE to STARTS AFTER DELAY. Set the B TIME/DIV switch 20 times faster than the A TIME/DIV switch (when possible).

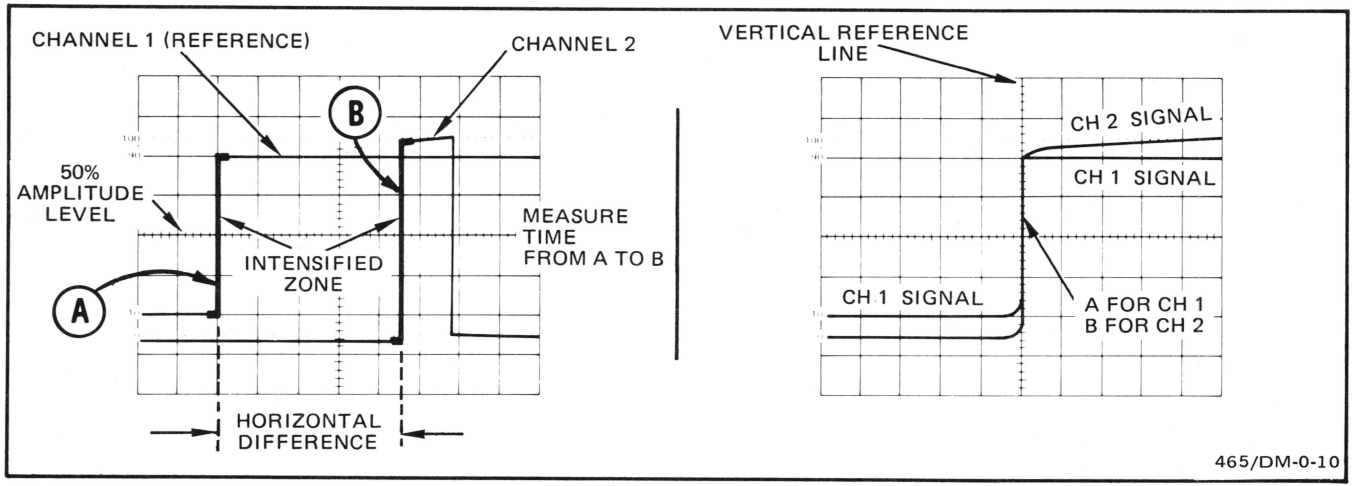

Fig. 27. Time difference between two pulses from different sources.

Fig. 28, Point A). Note the DELAY TIME POSITION dial setting.

Use the DELAY TIME POSITION dial to move the start of the intensified zone to just touch the intersection of the signal and the 190% graticule line (see Fig. 28, Point B). Note the DELAY TIME POSITION dial setting.

Substitute the DELAY TIME POSITION dial settings in the time difference formula to find the risetime.

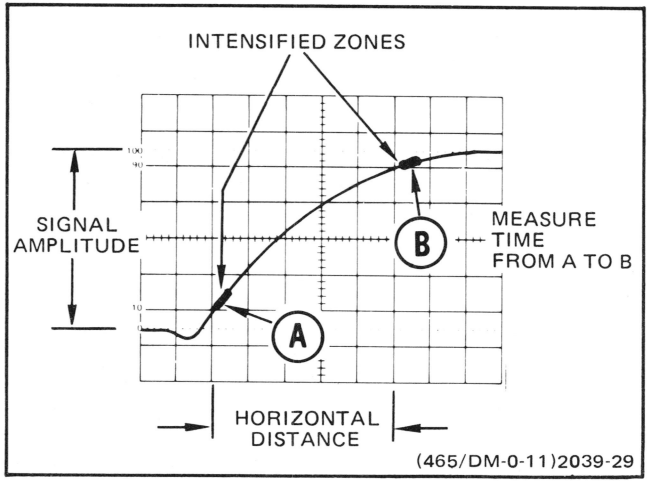

Fig. 28. Risetime.

EXAMPLE: The A TIME/DIV switch is set to 1 μs. The DELAY TIME POSITION dial setting at point A (Fig. 28) is 2.50 The DELAY TIME POSITION dial setting at point B (Fig. 28) is 7.50. To find the risetime use the formula:

$$\begin{matrix}\text{Time} \\ \text{Difference}\end{matrix} = \text{Risetime} = \left[\begin{matrix}\text{second} \\ \text{dial} \\ \text{setting}\end{matrix} - \begin{matrix}\text{first} \\ \text{dial} \\ \text{setting}\end{matrix}\right] \times \begin{matrix}\text{delay time} \\ \text{(A TIME/DIV} \\ \text{setting)}\end{matrix}$$

Substituting the given values:

Risetime = (7.50 − 2.50) X 1 μs = 5 ms.

MIX (BASIC 475)

For the MIX mode of operation, the same general procedures can be used. With the first part of the display at a sweep rate set by the A TIME/DIV switch and the second part of the display at a sweep rate set by the B TIME/DIV switch, it is not necessary to switch display modes to ensure location of the correct pulse.

However, inaccuracies are introduced into the measurement by the transition from A to B sweeps. The B DLY'D mode is the most accurate and therefore recommended mode of making differential time measurements.

TABLE 5 (cont)
DM44 Delayed Sweep Displays

DM44 FUNCTION	HORIZ DISPLAY	VERT MODE	DISPLAY OBTAINED
TIME OR 1/TIME	A INT[2]	CH 1, CH 2 OR ADD	Two intensified zones. DELAY TIME POSITION moves both intensified zones. Δ TIME moves only one intensified zone.
		ALT	Two intensified zones. Reference point appears on CH 1 display. Measurement point appears on CH 2 display. DELAY TIME POSITION moves both intensified zones. Δ TIME moves only the measurement point (on the CH 2 display).
	MIX	CHOP	Two pairs of intensified zones, one pair on each channel display. The pairs are coincident in time with each other. DELAY TIME POSITION moves all four intensified zones. Δ TIME moves two intensified zones.
		CH 1, CH 2, OR ADD	Two mixed displays, one on each channel display. DELAY TIME POSITION moves transition point of both displays. Δ TIME moves transition point of CH 2 display only.
		ALT	Two mixed displays, one on each channel display. DELAY TIME POSITION moves transition point of both displays. ALT DELAY moves transition point of CH 2 display only.
		CHOP	Four mixed displays, two on each channel display. Not generally used since mixed displays overlap.

[2]**Your instrument may be modified to make the DELAY TIME POSITION and Δ TIME controls operate independently. The instructions for making this modification are located in the Maintenance section of the DM44 Service manual.**

To find the pulse repetition rate, superimpose the waveforms as above and set the FUNCTION switch to 1/TIME. The Readout and Scale Factor Lamps now indicate the repetition rate.

TIME DURATION MEASUREMENTS (DM44)

Set controls as follows:

FUNCTION	TIME
HORIZ DISPLAY	A INTEN
B SOURCE	STARTS AFTER DELAY
A TIME/DIV	To display a single event.
B TIME/DIV	3 or 4 positions more cw than A TIME/DIV
Δ TIME	To move the time-measurement point to the right of the reference point.
VAR TIME/DIV	Detent position

Use the DELAY TIME POSITION control to move the reference point to a horizontal graticule line (see Fig. 30A, Point A). Use the Δ TIME control to move the time-

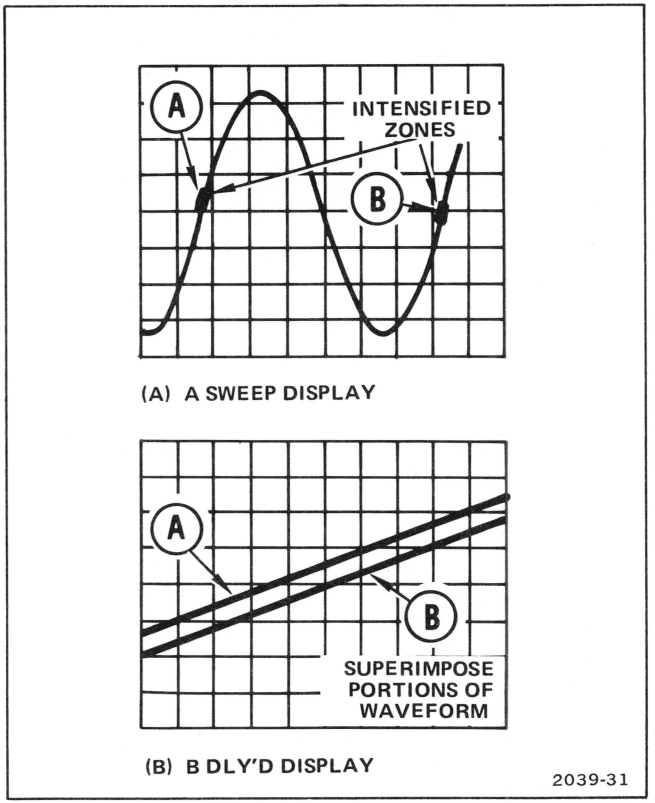

Fig. 30. Time duration and frequency measurements.

Connect the reference signal to the CH 1 input and the comparison signal to the CH 2 input. Connect the signals to the inputs with cables or probes having equal time delays.

Adjust the DELAY TIME POSITION control to move the reference point to the desired spot on the reference (CH 1) display (see Fig. 31A, Point A). In the ALT vertical mode the reference point appears on the CH 1 display while the time-measurement point appears on the CH 2 display.

Adjust the Δ TIME control to move the time-measurement point to the desired spot on the CH 2 display (see Fig. 31A, Point B).

Set the HORIZ DISPLAY switch to B DLY'D. Slightly readjust the DELAY TIME POSITION and Δ TIME controls to superimpose the waveforms (see Fig. 31B). The Readout and Scale Factor Lamps indicate the time difference.

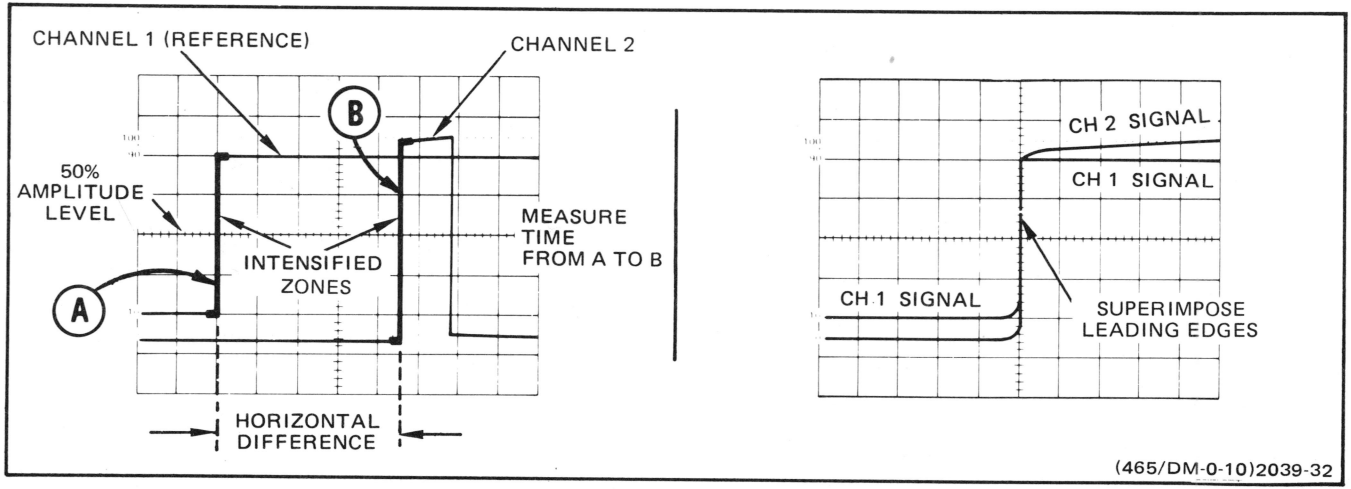

Fig. 31. Time difference between two pulses from different sources.

MIX (DM44)

For the MIX mode of operation, the same general procedures can be used. With the first part of the display at a sweep rate set by the A TIME/DIV switch, and the second part of the display at a sweep rate set by the B TIME/DIV switch, it is not necessary to switch display modes to ensure location of the correct pulse.

However, inaccuracies are introduced into the measurement by the transition from A to B sweeps. The B DLY'D mode is the most accurate and therefore the recommended mode of making differential time measurements.

50 MHz, with CH 2 OUT connected to CH 1 input. AC-coupled, using a 50 Ω, 42-inch BNC cable, terminated in 50 Ω at CH 2 Input.

TRIGGERING

Sensitivity

Ac Coupled Signal: 0.3 div internal or 50 mV external, from 60 Hz to 25 MHz; increasing to 1.5 div, internal or 150 mV external at 100 MHz.

LF REJ Coupled Signal: 0.5 div internal or 100 mV external, from 50 kHz to 25 MHz; increasing to 1.5 div internal or 300 mV external at 100 MHz. Attenuates signals below about 50 kHz.

HF REJ Coupled Signal: 0.5 div internal or 50 mV external, from 60 Hz to 50 kHz. Attenuates signals below about 50 Hz and above about 50 kHz.

DC Coupled Signal: 0.3 div internal or 50 mV external, from dc to 25 MHz; increasing to 1.5 div internal or 150 mV external at 100 MHz.

EXT ÷ 10 Signal: Amplitude requirements are multiplied by 10.

External Trigger Input

Maximum Input Voltage: 250 V (dc + peak ac) or 250 V p-p ac (1 kHz or less).

Level Control Range in Ext

At least + and −2 V, 4 V p-p; EXT ÷ 10 is at least + and −20 V, 40 V p-p.

Trigger View

Deflection Factor: About 50 mV/div in EXT and about 500 mV/div in EXT ÷ 10.

Risetime: 5 ns or less.

Trigger Centering Point: Within 1.0 division of screen center.

DIFFERENTIAL TIME MEASUREMENT (BASIC 475)

Accuracy for Measurements Greater than One Major Dial Division: Within ±1% from +15°C to +35°C. Within +1.5% from −15°C to +55°C.

Z AXIS INPUT

Sensitivity: Noticeable intensity modulation, at normal intensity settings, by a 5 V p-p signal. A positive-going signal decreases intensity.

Frequency Range (Usable): Dc to 50 MHz.

Maximum Input Voltage: 100 V (dc plus peak ac) or 100 V p-p ac at 1 kHz or less.

OUTPUTS

CH 2 Out

Output Voltage: At least 50 mV/div into 1 MΩ; to at least 25 mV/div into 50 ohms.

Bandwidth: Dc to at least 50 MHz into 50 ohms.

DC Level: About 0 volts.

A+ and B+ Gates

Output Voltage: About 5.5 V of positive-going pulse.

Output Resistance: About 500 ohms.

AC POWER SOURCE

Regulating Ranges:

	115 V	230 V
Low	99 V to 121 V	198 V to 242 V
Medium	104 V to 126 V	207 V to 253 V
High	108 V to 132 V	216 V to 264 V

Line Frequency: From 48 Hz to 440 Hz.

Maximum Power Consumption: 100 watts at 115 V, 60 Hz, medium range.

ENVIRONMENTAL

Operating Temperature: −15°C to +55°C.

Operating Altitude: To 15,000 feet. Maximum operating temperature decreases 1°C/1,000 feet, above 5,000 feet.

Humidity (Operating and Storage): 5 cycles (120 hours) referenced to MIL-E-16400F.

DC Voltage Accuracy: Within 0.1% of reading, ±1 count.

Temperature Dependence: 44 ppm/°C.

Resolution: 100 μV.

Recycle Time: At least 3 measurements/second.

Response Time: Within 0.5 second.

Normal/Common Mode Rejection Ratio:

Normal Mode—At least 60 dB at 50 Hz and 60 Hz.

Common Mode—At least 100 dB at dc; 80 dB at 50 Hz and 60 Hz.

Input Impedance: 10 MΩ.

OPTIONS

Your instrument may contain the following options:

OPTION 1

Deletes the temperature probe from the DM 44.

OPTION 4

The instrument is modified to meet certain specifications on radiated interference requirements. There is no change in operating instructions.

OPTION 7

At the time of this writing, instruments having the DM44 do not have the Option 7 available.

Option 7 permits operation on 12 or 24 Vdc with no performance deterioration. Circuitry is provided to protect against damage due to connection of 24 V when in the 12 V mode of operation. The 24-volt external input permits use with conventional dc power (marine and aircraft).