Tektronix®
COMMITTED TO EXCELLENCE

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

434 OSCILLOSCOPE

OPERATORS

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

070-1142-01
Product Group 40

INSTRUCTION MANUAL

Serial Number ____________

First Printing AUG 1971
Revised MAR 1984

Copyright © 1971, 1975 Tektronix, Inc. All rights reserved. Contents of this publication may not be reproduced in any form without the written permission of Tektronix, Inc.

Products of Tektronix, Inc. and its subsidiaries are covered by U.S. and foreign patents and/or pending patents.

TEKTRONIX, TEK, SCOPE-MOBILE, and ® are registered trademarks of Tektronix, Inc. TELEQUIPMENT is a registered trademark of Tektronix U.K. Limited.

Printed in U.S.A. Specification and price change priviledges are reserved.

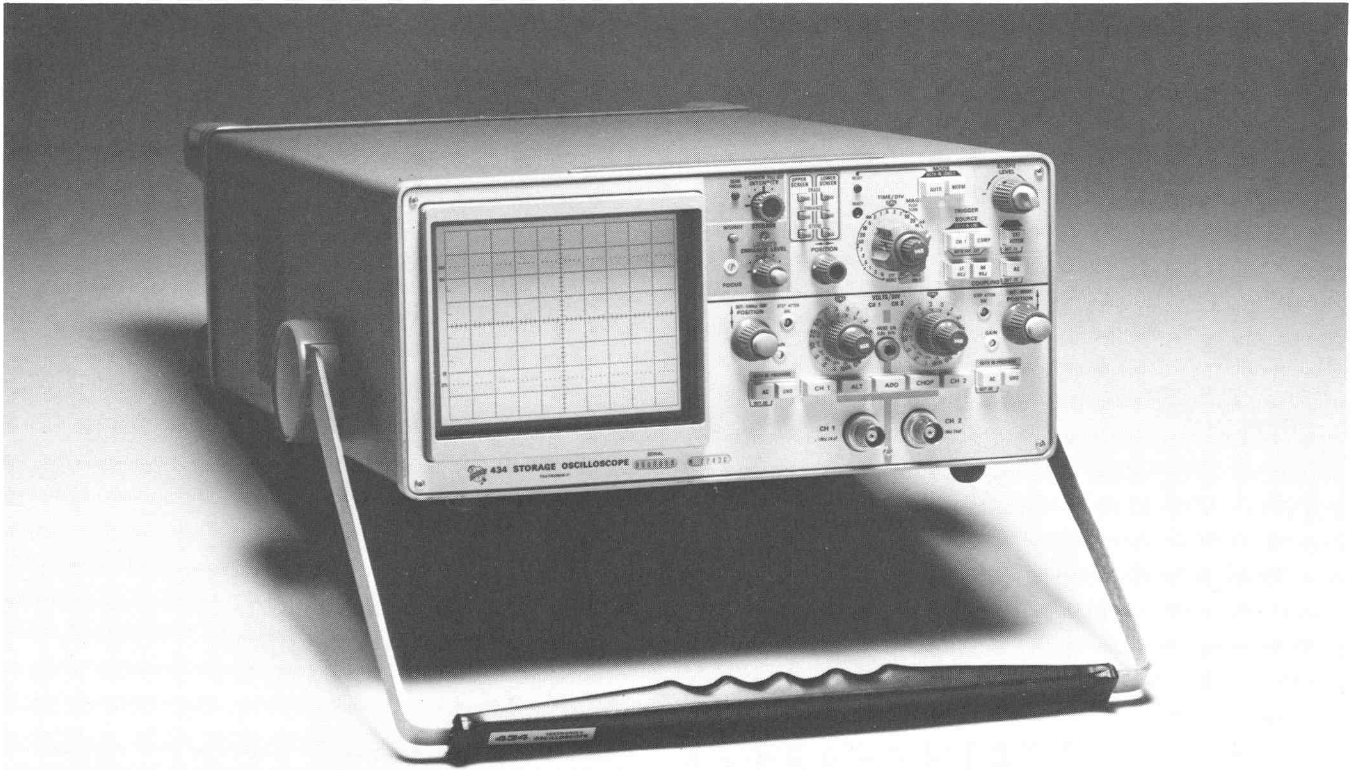
INSTRUMENT SERIAL NUMBERS

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
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

TABLE OF CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 'Standard Symbols for Units', MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.



1142-16

434 OSCILLOSCOPE

INTRODUCTION

General

The Tektronix 434 Oscilloscope is a solid-state portable instrument that combines small size and light weight with the ability to make precision waveform measurements. It is designed for general-purpose applications where display storage is desired along with conventional (non-store) operation. The instrument contains two vertical signal inputs, both of which are capable of 25-megahertz bandwidth, trigger circuitry to permit obtaining stable CRT displays, a horizontal deflection system that provides calibrated (unmagnified) sweep rates from 5 seconds to 0.2 microsecond/division (20 nanoseconds/division magnified), and storage circuitry to allow retention of a displayed event on the CRT screen.

To effectively use the 434 Oscilloscope, the operation and capabilities of the instrument must be known. This Operator's Handbook is intended to give the necessary information to allow a user to become familiar with the instrument's power requirements, functions of controls and connectors, and methods of making several different measurements of electrical phenomena. Also included is a rudimentary procedure for checking basic instrument calibration.

Operating Voltage

For SN B500000 and up, the 434 can be operated from a nominal line voltage of either 115 volts AC or 230 volts AC, 50 to 400 Hz. Set the LINE SELECTOR switch (on the rear panel) for the available nominal line voltage.

For SN below B500000, the 434 can be operated on all nominal line voltages from 100 volts to 240 volts AC, 50 to 400 Hertz. It can also be operated from a 105 volts to 250 volts DC power source. No range switching or selection is necessary.

CAUTION

This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multiphase system, or across the legs of a single-phase, three-wire system.

The 434 is designed to be used with a three-wire AC power system. If a three- to two-wire adapter is used to connect this instrument to a two-wire AC power system, be sure to connect the ground lead of the adapter to earth (ground). Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

Operating Temperature

The 434 requires very little air circulation for proper operation. A thermal cutout in the instrument provides thermal protection and disconnects the instrument power if the internal temperature exceeds a safe operating level. Power is automatically restored when the temperature returns to a safe level.

The 434 can be operated where the ambient temperature is between −15°C and +55°C. The maximum operating temperature must be derated 1°C for each 1000 feet of altitude above 5000 feet. This instrument can be stored in ambient temperatures between −55°C and +75°C. After storage at temperatures beyond the operating limits, allow the chassis temperature to come within the operating limits before power is applied.

NOTE

The crt performance may be degraded if a continuously stored display is maintained for over four hours at ambient temperatures below +40° C or for over one hour at ambient temperatures greater than +40° C.

Operating Position

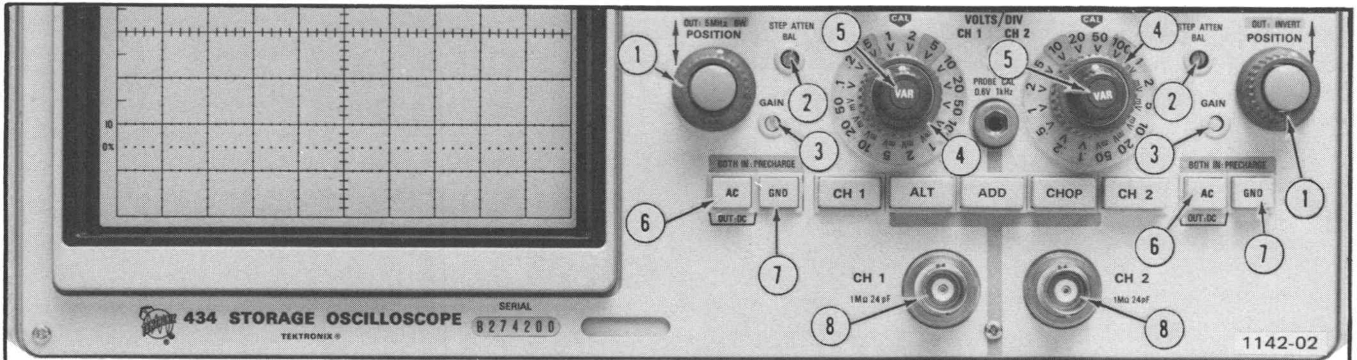
The handle of the 434 can be positioned for carrying or as a tilt-stand for the instrument. To position the handle, press in at both pivot points and turn the handle to the desired position. Fourteen positions are provided for convenient carrying or viewing. The instrument can also be set on the rear feet for operation or storage.

CONTROLS AND CONNECTORS

General

The major controls and connectors for operation of the 434 are located on the front panel of the instrument. Several auxiliary functions are provided on the rear panel. To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each of these controls and connectors. A brief description of each control and connector is given here. Some of the more important instrument specifications are included here also.

434's with SN B191820 and above contain a front panel FOCUS control located below the INTEGRATE button. Two types of CRT graticules have been used in the 434, one has the 0% and 100% risetime references separated by 6 divisions, the other by 5 divisions. Illustrations in this manual show the 5 division version.



1. POSITION—positions the display vertically.

2. STEP ATTEN BAL—balances the input amplifier in the 1 mV, 2 mV, 5 mV, and 10 mV positions of the VOLTS/DIV switch.

3. GAIN—sets the gain of the input amplifier.

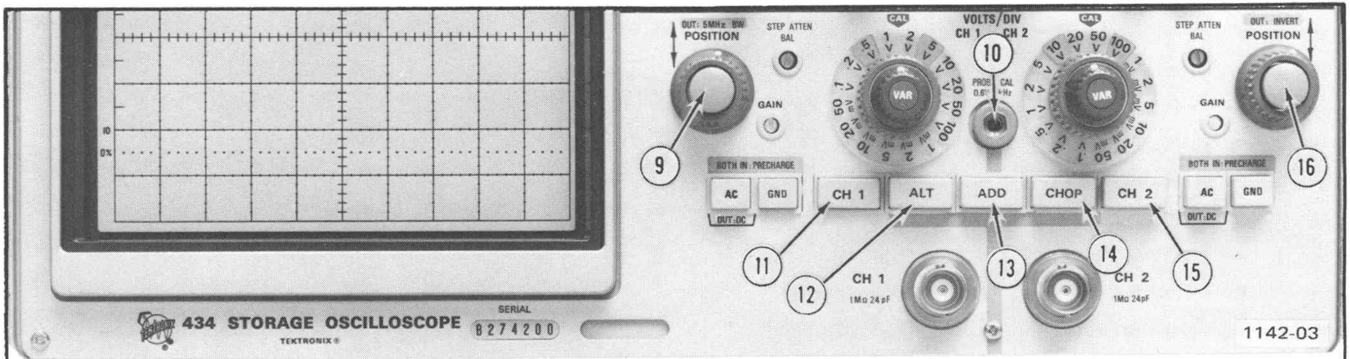
4. VOLTS/DIV—selects vertical deflection factor in a 1-2-5 sequence (variable control must be in the CAL position for indicated deflection). Calibrated position accuracy within 3%.

5. Variable—provides continuously variable uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV switch.

6. AC/DC—in the AC position (button in) of this push-push switch, signals are capacitively coupled to the vertical amplifier. The DC component of the input signal is blocked. Low frequency −3 dB point is about 10 hertz. In the DC position (button out), all components of the input signal are passed to the input amplifier.

7. GND—in the GND position (button in) of this push-push switch, the input of the vertical amplifier is disconnected from the input connector and grounded. Allows precharging of the input coupling capacitor. When the button is out coupling is determined by the AC-DC button.

8. CH 1 and CH 2—input connectors for application of external signals to the inputs of the vertical amplifier. Input impedance is 1 megohm paralleled by approximately 24 picofarads. Bandwidth: 16 to 25 MHz depending on VOLTS/DIV setting and operating temperature.



9. 5 MHz BW—in the out position of this push-push switch, the bandwidth of the complete vertical amplifier system is limited to approximately 5 megahertz.

10. PROBE CAL 0.6 V 1 kHz—provides a 0.6 volt calibrator signal to permit probe compensation, adjustment of amplifier gain, and checking basic horizontal timing.

Vertical Mode Switch

11. CH 1—Channel 1 only is displayed.

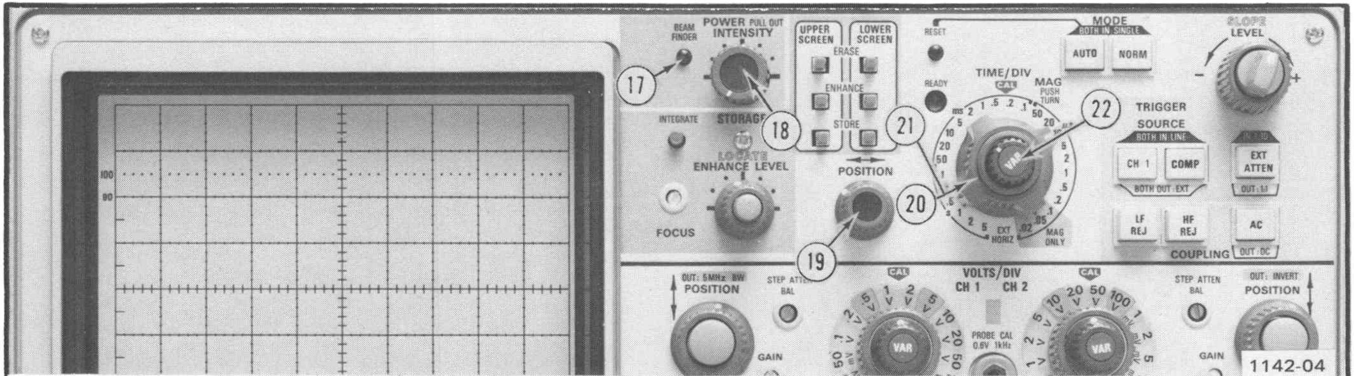
12. ALTernate—dual-trace display of signals of both channels. Display switched between channels at the end of each sweep.

13. 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.

14. CHOP—dual-trace display of signals on both channels. Display is switched at a repetition rate of approximately 100 kilohertz.

15. CH 2—Channel 2 only is displayed.

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



17. BEAM FINDER—compresses an overscanned display to within the graticule area, independently of display position or applied signals.

18. POWER/INTENSITY—a combination control that turns on instrument power when pulled, and controls brightness of the display when rotated.

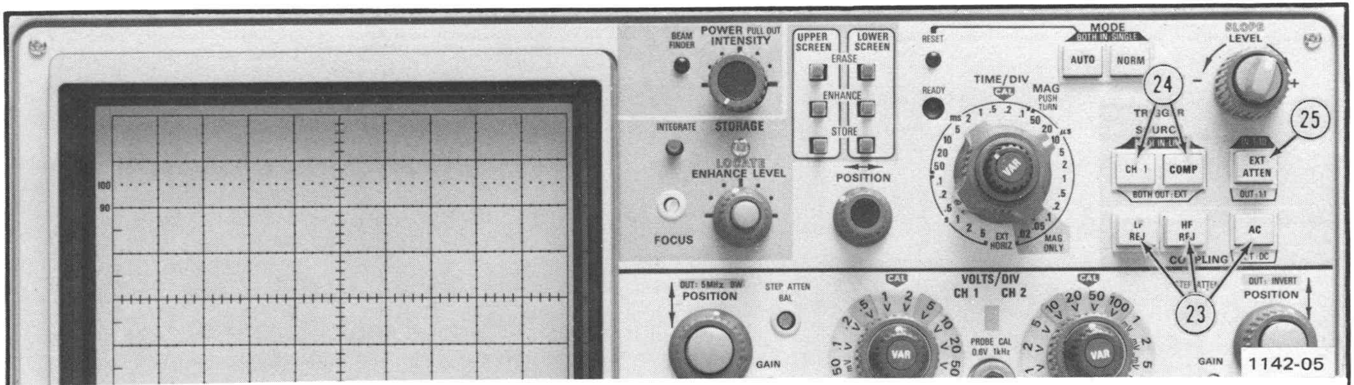
19. POSITION—controls horizontal position of the display (reversing direction of rotation provides vernier action).

20. TIME/DIVision—selects the sweep rate of the sweep generator (variable control must be in the CAL position for indicated sweep rate). Calibrated position accuracy within 3%.

The extreme counterclockwise position of the switch selects External Horizontal mode of operation.

21. MAGnifier—a six-position, push-to-turn switch, which is concentric with the TIME/DIV switch. Provides five positions of magnification (X2, X5, X10, X20, and X50) when TIME/DIV switch is pushed in and rotated clockwise, except for the 5 fastest TIME/DIV settings, where the number of magnified ranges is limited by the TIME/DIV positions remaining in the clockwise direction of rotation.

22. Variable—provides uncalibrated sweep rates between the calibrated settings selected by the TIME/DIV switch. The sweep rate in each TIME/DIV switch position can be reduced to at least the sweep rate of the next adjacent position to provide continuously variable sweep rates.



23. COUPLING—determines method of coupling trigger signal to trigger circuit.

AC—in the in position of this push-push switch, DC is rejected and signals below about 20 hertz are attenuated. Accepts signals between about 20 hertz and 25 megahertz.

DC—when both the AC and the LF REJ push-push switches are in the out position, signals are directly coupled to the trigger circuit. Accepts all signals from DC to 25 megahertz.

LF REJ—rejects DC and attenuates signals below approximately 150 kilohertz. Accepts signals between about 150 kilohertz and 25 megahertz.

HF REJ—attenuates signal above approximately 15 kilohertz. Accepts signals between DC and approximately 15 kilohertz.

24. SOURCE—selects source of trigger signal.

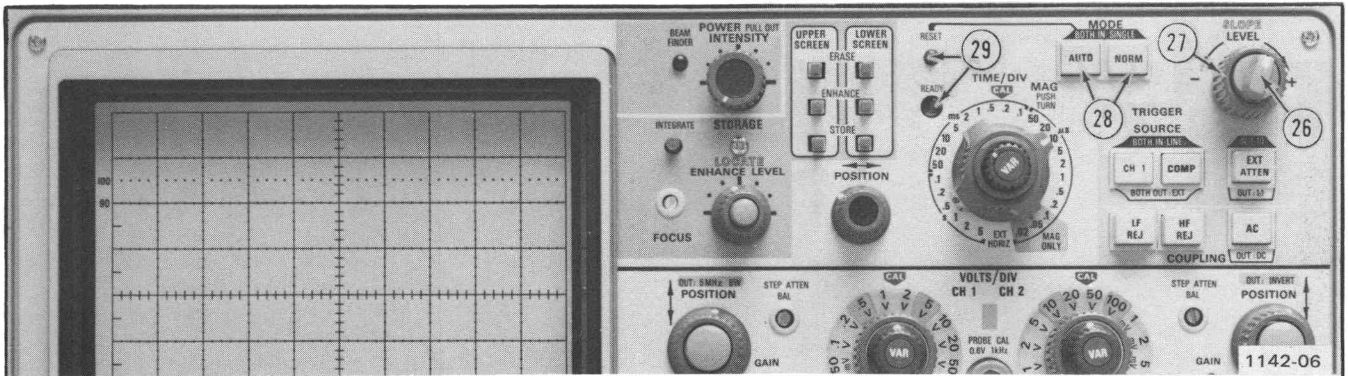
CH 1—A push-push switch that in the CH 1 position (button in) selects Channel 1 as an internal trigger source.

COMPosite—a push-push switch that in the COMP position (button in) allows the internal trigger source to be determined by the vertical mode of operation.

LINE—when both the CH 1 and COMP switches are pushed in, a portion of the line frequency is used as a trigger signal.

EXTernal—when the CH 1 and COMP switches are both out, signals applied to the EXT TRIG input connector are used for triggering.

25. EXT ATTENuator—in the 1:10 position (button in) of this push-push switch, external trigger signals are attenuated by a factor of ten. In the 1:1 position (button out) of this switch, external trigger signals are not attenuated.



26. SLOPE—selects slope of trigger signal which starts the sweep.

   + —sweep can be triggered from positive-going portion of trigger signal.

   – —sweep can be triggered from negative-going portion of trigger signal.

27. LEVEL—selects the amplitude point on the trigger signal at which the sweep is triggered.

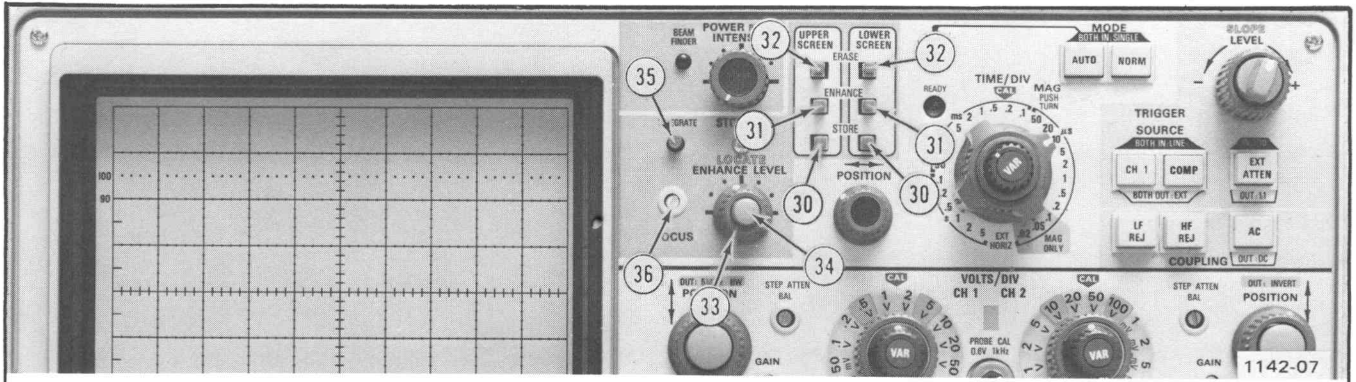
28. MODE—determines the operating mode for the sweep generator.

   AUTOmatic—in the AUTO position (button in) of this pushbutton switch, the sweep is initiated by the applied trigger signal. In the absence of an adequate trigger signal, the sweep free runs and provides a bright reference trace.

   NORMal—in the NORM position (button in) of this pushbutton switch, the sweep is initiated by the applied trigger signal. In the absence of an adequate trigger signal, there is no trace.

   BOTH IN: SINGLE sweep—when both the AUTO and NORM switches are pushed in, the sweep operates in the Single Sweep Mode. After a sweep is displayed, further sweeps cannot be presented until the RESET button is pressed.

29. RESET—when the RESET button is pressed (in the SINGLE SWEEP mode), a single display will be presented (with correct triggering). After the sweep is completed, the RESET button must be pressed again before another sweep can be displayed. If there is not an adequate trigger signal present when the RESET button is pressed, the sweep generator circuit will remain armed as indicated by the READY light.



1142-07

30. STORE (Upper and Lower)—in the STORE position (button in), the CRT operates in the storage mode. In the Non-Store position (button out), the CRT operates in the conventional mode.

31. ENHANCE (Upper and Lower)—in the ENHANCE position (button in), the writing rate for single-sweep displays is increased (using the ENHANCE LEVEL control).

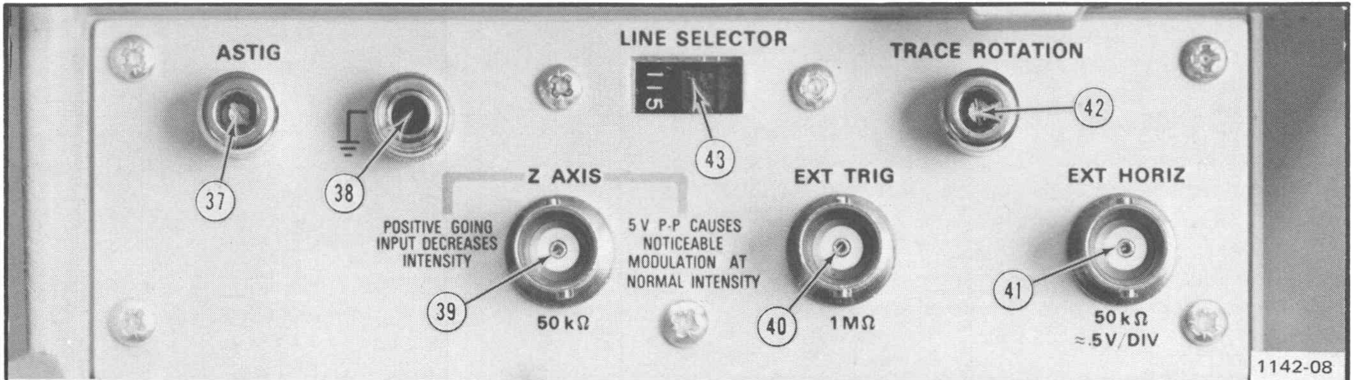
32. ERASE (Upper and Lower)—a momentary contact switch that, when pushed, erases a stored display from the CRT.

33. ENHANCE LEVEL—provides a selectable increase in writing speed capability for single-sweep displays. Effective only when either or both ENHANCE buttons are depressed.

34. LOCATE—a pushbutton switch that unblanks the CRT and provides a visible indication of the position of the display signal while the sweep is held off. This permits the display to be positioned before storing.

35. INTEGRATE—a pushbutton switch that permits storage of very fast repetitive signals by allowing the writing-gun beam to accumulate charges on the target while the flood-gun beams are turned off.

36. FOCUS—screwdriver adjustment (located below INTEGRATE button for SN B191820 and up) used in conjunction with the rear panel ASTIG control to provide optimum display definition.



1142-08

37. ASTIGmatism—adjusts CRT beam for optimum display definition.

38. Ground Post—connects to oscilloscope chassis. Provides a common ground return for signal source to insure measurement reliability.

39. Z AXIS—input connector for external blanking signals. A five volt peak to peak signal will cause noticeable modulation at normal intensity. A positive-going signal decreases intensity.

40. EXTernal TRIGger—input connector for external trigger signals. Nominal input signal level required for correct trigger operation is 50 millivolts at frequencies below five megahertz, increasing to 175 millivolts at 25 megahertz.

41. EXTernal HORIZontal—input connector for external horizontal signal when TIME/DIV switch is set to EXT HORIZ. Input impedance is approximately 50 kilohms with a sensitivity of approximately 0.5 volt/division.

42. TRACE ROTATION—adjusts trace to align with horizontal graticule lines.

43. LINE SELECTOR—(located on rear panel of 434 SN B500000 & up) sets 434 to operate from either a 115 volt or a 230 volt AC nominal line voltage.

BASIC OPERATION

General

The following procedure is given as a method of obtaining a basic display on the CRT of the 434. Calibrated measurements can be made in most applications using this procedure. Specific techniques required to make more involved measurements are given in the Applications section. The following procedure is intended for use until the user becomes familiar with instrument operation.

Non-Store Display

1. Set the instrument controls as follows:

POWER/INTENSITY	Pushed in and rotated fully counterclockwise.
POSITION (horizontal and vertical)	Set to mid-range
Sweep MODE	AUTO
TIME/DIV	1 ms (unmagnified)
VAR (TIME/DIV)	Detent (calibrated)
TRIGGER SOURCE	COMP
TRIGGER COUPLING	AC
SLOPE	+
LEVEL	Mid-range
Vertical Mode	CH 1
Input Coupling	DC
VOLTS/DIV	.1 V
VAR (VOLTS/DIV)	Detent (calibrated)

All remaining pushbuttons should be out.

2. Connect the instrument to a power source that meets the requirements of the instrument (see Operating Voltage section).

3. Turn on the instrument power and allow several minutes warmup.

4. Advance the INTENSITY control until the free-running trace is visible at the desired viewing level.

5. Connect the signal to be observed to the CH 1 input connector. (Use PROBE CAL 0.6 V, 1 KHz signal, if desired.)

6. If display is not visible with the INTENSITY control at mid-range, press the BEAM FINDER pushbutton and adjust the VOLTS/DIV switch until display is reduced in size vertically; then center the compressed display with the vertical and horizontal POSITION controls; release the BEAM FINDER pushbutton.

7. Set the VOLTS/DIV switch and vertical POSITION controls for a display which remains within the display area vertically.

8. Set the LEVEL control for a stable display.

9. Set the TIME/DIV and horizontal POSITION controls for a display that remains within the display area horizontally.

Magnified Sweep Display

1. Follow steps 1 through 9 of Non-Store Display.

2. Adjust the horizontal POSITION control to center the area to be magnified to around the center vertical division of the graticule. There should be equal amounts of the area of interest on either side of the center graticule line. If necessary, change the setting of the TIME/DIV switch and the POSITION control to obtain the desired display.

3. Push in and turn the TIME/DIV knob clockwise to achieve the desired amount of magnification (X2, X5, X10, X20, or X50, except for the five fastest TIME/DIV settings, where the number of magnified ranges is limited by the TIME/DIV positions remaining in the clockwise direction of rotation). Adjust the INTENSITY control for a visible display. The position of the TIME/DIV knob directly indicates the magnified time/div. Adjust the horizontal POSITION control to position the magnified display, or to observe the beginning or end of the magnified sweep. (To obtain fine positioning, use the vernier action of the control by reversing the direction of knob rotation.) Disconnect the signal from the CH 1 input connector.

External Horizontal Display

1. Set the INTENSITY control fully counterclockwise.

2. Set the TIME/DIV switch to EXT HORIZ and the Vertical Mode switch to CH 1.

3. Set the POWER switch to the on position and allow several minutes warmup.

4. Connect the X (horizontal) signal, not greater than 6 V P-P, to the EXT HORIZ input connector on the instrument rear panel.

5. Advance the INTENSITY control until the display is visible. If the display is not visible, push the BEAM FINDER button, center the compressed display with the CH 1 and horizontal POSITION controls, then release the BEAM FINDER button. Note that with the BEAM FINDER button released, the horizontal deflection is unaffected by other 434 controls when the TIME/DIV switch is set at EXT HORIZ; this is affected only by the amplitude of the signal applied to the EXT HORIZ input connector. With a square wave signal applied, the display should consist of two dots separated horizontally by an amount approximately equal to the amplitude of the applied signal (in volts) divided by 0.5 (sensitivity).

Normal Storage Display

1. Center an unmagnified waveform display vertically on the CRT screen so that part of the waveform is above the horizontal centerline and part of it is below the centerline.

2. Set INTENSITY, LEVEL, and TIME/DIV for a stable, visible, triggered display.

3. Press in both STORE pushbuttons, then press in both ERASE pushbuttons (pressing the ERASE button will ensure proper target preparation and achieve uniform storage over the entire target area), then press the STORE buttons again.

4. A stored display should remain on both upper and lower storage screens after the input signal is removed. Increase INTENSITY setting, erase, and re-store, as necessary to achieve a uniform stored display.

5. Erase the stored display by pressing both ERASE pushbuttons. Each half of the display area may be erased or stored independently if so desired.

Single-Sweep Storage

1. Set up a display of the PROBE CAL 0.6 V 1 kHz waveform in the manner described in "Non-Store Display".

2. Set the Sweep MODE to SINGLE SWEEP.

3. Press in both STORE buttons.

4. Apply a single sweep of the trace by pressing the RESET pushbutton. A stored display of the calibrator waveform should remain on the storage screen. If it does not, repeat the demonstration with the display intensity increased slightly.

5. During single-sweep operation, the LOCATE pushbutton can be used to locate the trace or display while the sweep is held off. Pressing the LOCATE button unblanks the CRT and allows the display to be positioned before storing. This shifts the start of the sweep approximately 0.2 division to the left. For instrument operation in Single-Sweep and Store modes simultaneously, when the sweep start is positioned at the graticule edge, the locate spot is shifted into the non-storing locate zone to allow vertical positioning of the trace without storing.

Integrated Fast-Rise Waveforms

The INTEGRATE pushbutton permits storage of waveforms at relatively fast sweep speeds with relatively low repetition rates. Waveforms which would be difficult to see because of the low duty cycle of the sweep, or have poor resolution due to required high setting of the INTENSITY control, can often be stored using the Integrate method to produce higher brightness or better resolution. For a demonstration on how to store the rising edge of the PROBE CAL 0.6 volt 1 kHz signal, proceed as follows:

1. Set up a display of the PROBE CAL waveform in the manner described in "Non-Store Display". Use + Slope, and trigger on the rising portion of the waveform. Set the sweep to 0.05 μsec/DIV, turn the INTENSITY control nearly fully clockwise in order to find the start of the waveform, and position the rising portion of the waveform on screen. Reduce the intensity to midrange.

2. Press in both STORE buttons. The normal storage-mode background light will be present on the CRT.

3. Advancing the INTENSITY control in the clockwise direction will not produce a stored display of the rising portion of the waveform. Reduce the intensity to midrange and press both ERASE buttons to clear the screen if necessary.

4. Press the INTEGRATE button momentarily. A fraction of a second to several seconds is reasonable.

The lower the intensity, the longer the integration period required to store the trace. If the trace does not fully store on the first attempt, repeat the integration for a somewhat longer period, or with somewhat higher intensity. Using lower intensity and longer integration produces better resolution on jitter-free signals.

CAUTION

Do not attempt to store extremely fast-rising or fast-falling portions of waveforms viewed at relatively slow sweep rates. The high trace intensity required (due to the intensity difference between the horizontal and the vertical segments) could cause storage target damage.

Fast Single-Sweep Enhancement

The Enhance mode provides a method of storing single-sweep displays that exceed the normal writing speed of the instrument. This mode is not normally used for repetitive sweeps.

1. Apply a 30 kHz (350 kHz for Option 1 CRT) sine-wave signal for a CRT display of approximately 3.2 divisions P-P amplitude to one of the vertical input connectors.

2. Set up a normal-intensity non-stored display of the signal in the manner given in "Non-Store Display".

3. Set the Sweep MODE to SINGLE SWEEP.

4. Press in both STORE buttons.

5. With the TIME/DIV switch set to 10 μs (2 μs for Option 1 CRT), apply a single sweep of the trace by pressing the RESET button. Note that a complete stored display cannot be obtained for any setting of the INTENSITY control.

6. Depress both ENHANCE buttons, then simultaneously press both ERASE buttons to clear the storage screens.

7. While repeatedly erasing and applying single sweeps, adjust the ENHANCE LEVEL control (starting from the counterclockwise end of rotation) sufficiently clockwise to completely store the display without fading up the target excessively.

8. For instruments equipped with the option 1 CRT, if portions of the CRT target become faded up and cannot be erased in the normal manner due to inadvertent operation in Repetitive Sweep and Enhanced modes simultaneously, proceed as follows:

Store the entire target by using a repetitive sweep at approximately 1 ms/DIV with Intensity at mid-range. Slowly position the trace from top to bottom to store the entire target area. Switch to Single-Sweep (or non-enhanced storage mode) and erase. The target is now ready for normal storage or single-sweep enhanced storage operation.

NOTE for OPTION ONE instruments

After sustained use (6 hours or more) of the Option One instrument in the Non-Store mode or in Store mode with nothing written, the writing speed may be improved by leaving the CRT target fully stored for five to fifteen minutes. This procedure may be repeated every few hours to refresh the target in applications requiring maximum stored writing rate in a usage where the target is stored a small percentage of the time.

USER'S CALIBRATION

General

To insure measurement accuracy, certain portions of the instrument calibration should be checked before making the measurement. The following is a procedure for checking the basic measurement capabilities of the 434. See the Calibration section of the Instruction Manual for more detailed calibration information.

Trace Rotation

Use steps 1-4 of the Basic Operation procedure to obtain a free-running trace. Adjust the TRACE ROTATION adjustment (located on the rear panel) to align the trace with the horizontal graticule lines.

STEP ATTENuator BALance

Use steps 1-4 of the Basic Operation procedure to obtain a vertically centered free-running trace. Rotate the Channel 1 VOLTS/DIV switch from 10 mV to 1 mV (CH 1 vertical mode of operation). Adjust the Channel 1 STEP ATTEN BAL adjustment (located on front panel) for no trace shift when switching from 10 mV to 1 mV. Repeat this procedure for Channel 2.

Probe Compensation

Variations in total input capacitance and resistance occur with different combinations of oscilloscopes and probes. Therefore, most attenuator probes are equipped with adjustments to insure optimum measurement accuracy. Probe compensation is accomplished as follows:

Connect the probe to one of the oscilloscope's input connectors. Use steps 1-9 of the Basic Operation procedure to obtain a display about three divisions in amplitude with one cycle of the calibrator signal displayed each two divisions. Check the waveform presentation for overshoot or rolloff, and readjust compensation for flat tops on the waveforms if necessary. See Fig. 1.

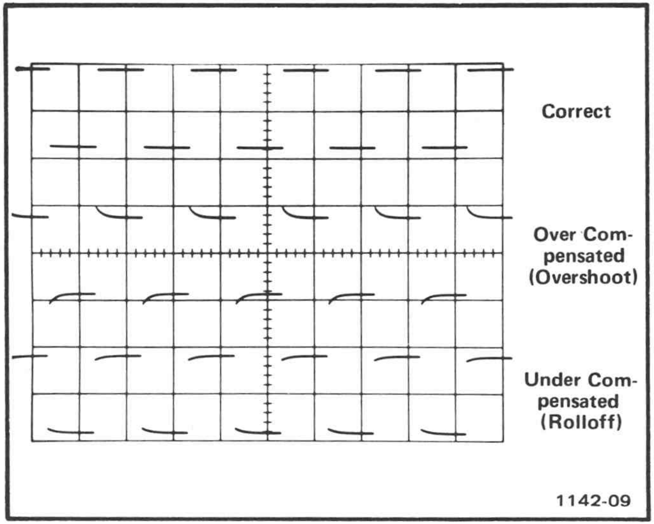


Fig. 1. Probe compensation.

Vertical GAIN

Use steps 1-4 of the Basic Operation procedure to obtain a free-running trace. Connect the PROBE CAL 0.6 V 1 kHz output signal to the CH 1 input connector (if the signal is connected through a 10X probe that does not have a scale factor switching connector, reduce the setting of the VOLTS/DIV switch from .1 V to 10 mV). Adjust the Channel 1 GAIN adjustment (located on front panel) for exactly 6 divisions of vertical deflection. Repeat this procedure for Channel 2.

ASTIGmatism and FOCUS

Use steps 1-9 of the Basic Operation procedure to obtain a stable display of the calibrator waveform. Set the INTENSITY control for normal brightness of the display (approximately mid-range). Adjust the ASTIG adjustment (located on rear panel) and the front panel FOCUS control (SN B191820 and up) so the vertical and horizontal portions of the calibrator waveform are equally focused.

Basic Timing

Use steps 1-9 of the Basic Operation procedure to obtain a stable display of the calibrator waveform. Set the TIME/DIV switch to .5 ms/div. Check the display for one cycle of calibrator waveform for each two horizontal divisions. For a more complete timing check, refer to the calibration procedure given in the Instruction Manual.

APPLICATIONS

General

The following information describes the procedures and techniques for making basic measurements with a 434

Oscilloscope. These applications are not described in detail, since each application must be adapted to the requirements of the individual measurements. This instrument can also be used for many applications which are not described in this handbook. Contact your local Tektronix Field Office or representative for assistance in making specific measurements with this instrument.

DC Voltage Level Measurement

To measure a DC voltage level, use the following procedure:

1. Connect the voltage source to either input connector.

2. Set the instrument for the vertical mode that will display the channel being used.

3. Set the VOLTS/DIV switch to display about five or six divisions of deflection if possible.

4. Set the input coupling to GND.

5. Set the Sweep MODE switch to AUTO.

6. Position the trace to the bottom line of the graticule or other reference line. If the voltage to be measured is negative with respect to ground, position the trace to the top line of the graticule. Do not move the vertical POSITION control after this reference has been established.

NOTE

To measure a voltage level with respect to another voltage rather than ground, make the following changes in step 6: Set the input coupling to DC and apply the reference voltage to the input connector. Then position the trace to this reference line.

7. Set the input coupling to DC. The ground reference line can be checked at any time by switching the input coupling to GND.

8. Measure the distance in divisions between the reference line and the free-running trace.

NOTE

This technique can also be used to make instantaneous DC voltage level measurements on a waveform, rather than fixed DC levels.

9. Establish the polarity of the voltage. If the trace is above the reference line, the voltage is positive; below the line, negative (when the INVERT switch is pushed in if using Channel 2).

10. Multiply the distance measured in step 8 by the VOLTS/DIV switch setting. Also multiply by the attenuation factor of the probe, if any, when using a probe that does not have a scale factor switching connector.

Example. Assume that the vertical distance measured is 5.2 divisions, the trace is above the reference line, with a VOLTS/DIV switch setting of 50 mV.

Using the formula:

$$\text{DC Voltage} = \begin{matrix}\text{vertical}\\ \text{distance}\\ \text{(divisions)}\end{matrix} \times \text{polarity} \times \begin{matrix}\text{VOLTS/DIV}\\ \text{setting}\end{matrix}$$

substitute the given values:

DC Voltage = 5.2 X +1 X .05

The DC voltage is +.26 volts.

Peak-To-Peak Voltage Measurements – AC

To make a peak-to-peak voltage measurement, use the following procedure:

1. Connect the signal to either input connector.

2. Set the vertical mode to display the channel being used.

3. Set the VOLTS/DIV switch to display about five divisions of the waveform.

4. Set the Input Coupling to AC.

NOTE

For low-frequency signals below about 10 hertz, use DC coupling.

5. Set the Triggering controls to obtain a stable display. Set the TIME/DIV switch to a position that displays several cycles of the waveform.

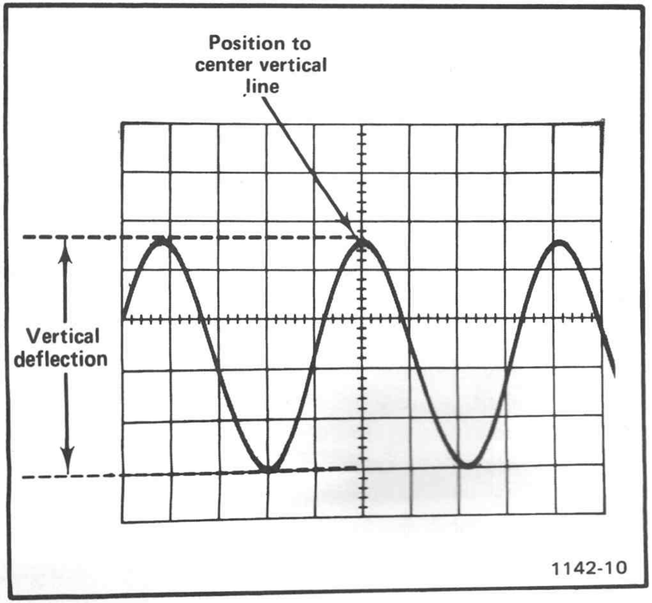


Fig. 2. Measuring peak-to-peak voltage of a waveform.

6. Turn the vertical POSITION control so the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top of the waveform is on the viewing area. Move the display with the horizontal POSITION control, so one of the upper peaks lies near the center vertical line (see Fig. 2).

7. Measure the divisions of vertical deflection from peak to peak. Make sure the Variable VOLTS/DIV control is in the CAL position.

NOTE

This technique may also be used to make measurements between two points on the waveform rather than peak to peak.

8. Multiply the distance measured in step 7 by the VOLTS/DIV switch setting. Also multiply by the attenuation factor of the probe, if any, when using a probe that does not have a scale factor switching connector.

Example. Assume a peak-to-peak vertical deflection of 4.6 divisions (see Fig. 2) and a VOLTS/DIV switch setting of .5 V.

Using the formula:

$$\text{Volts Peak to Peak} = \text{vertical deflection (divisions)} \times \text{VOLTS/DIV setting}$$

substitute the given values:

Volts Peak to Peak = 4.6 X 0.5

The peak-to-peak voltage is 2.3 volts.

Comparison Measurements

In some applications it may be desirable to establish arbitrary units of measurement other than those indicated by the VOLTS/DIV switch or TIME/DIV switch. This is particularly useful when comparing unknown signals to a reference amplitude or repetition rate. One use for the comparison-measurement technique is to facilitate calibration of equipment (e.g., on an assembly-line test) where the desired amplitude or repetition rate does not produce an exact number of divisions of deflection. The adjustment will be easier and more accurate if arbitrary units of measurement are established so that correct adjustment is indicated by an exact number of divisions of deflection. Arbitrary sweep rates can be useful for comparing harmonic signals to a fundamental frequency, or for comparing the repetition rate of the input and output pulses in a digital count-down circuit. The following procedure describes how to establish arbitrary units of measure for comparison measurements. Although the procedure for establishing vertical and horizontal arbitrary units of measurement is much the same, both processes are described in detail.

Vertical Deflection Factor. To establish an arbitrary vertical deflection factor based upon a specific reference amplitude, proceed as follows:

1. Connect the reference signal to the input connector. Set the TIME/DIV switch to display several cycles of the signal.

2. Set the VOLTS/DIV switch and the Variable VOLTS/DIV control to produce a display an exact number of graticule divisions in amplitude. Do not change the Variable VOLTS/DIV control after obtaining the desired deflection. This display can be used as a reference for amplitude comparison measurements.

3. To establish an arbitrary vertical deflection factor so the amplitude of an unknown signal can be measured accurately at any setting of the VOLTS/DIV switch, the amplitude of the reference signal must be known. If it is not known, it can be measured before the Variable VOLTS/DIV control is set in step 2.

4. Divide the amplitude of the reference signal (volts) by the product of the vertical deflection established in step 2 (divisions) and the setting of the VOLTS/DIV switch. This is the vertical conversion factor.

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

5. To measure the amplitude of an unknown signal, disconnect the reference signal and connect the unknown signal to the input connector. Set the VOLTS/DIV switch to a setting that provides sufficient vertical deflection to make an accurate measurement. Do not readjust the Variable VOLTS/DIV control.

6. Measure the vertical deflection in divisions and calculate the amplitude of the unknown signal, using the following formula.

$$\text{Signal Amplitude} = \text{VOLTS/DIV switch setting} \times \text{vertical conversion factor} \times \text{vertical deflection (divisions)}$$

Example. Assume a reference signal amplitude of 30 volts, a VOLTS/DIV switch setting of 5, and the Variable VOLTS/DIV control is adjusted to provide a vertical deflection of four divisions.

Substituting these values in the vertical conversion factor formula (step 4);

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

Then with a VOLTS/DIV switch setting of 1, the peak-to-peak amplitude of an unknown signal which produces a vertical deflection of five divisions can be determined by using the signal amplitude formula (step 6):

$$\text{Signal Amplitude} = 1\text{ V} \times 1.5 \times 5 = 7.5\text{ volts}$$

Sweep Rates. To establish an arbitrary horizontal sweep rate based upon a specific reference frequency, proceed as follows:

1. Connect the reference signal to the input connector. Set the VOLTS/DIV switch for four or five divisions of vertical deflection.

2. Set the TIME/DIV switch and the Variable TIME/DIV control so one cycle of the signal covers an exact number of horizontal divisions. Do not change the Variable TIME/DIV control after obtaining the desired deflection. This display can be used as a reference for frequency comparison measurements.

3. To establish an arbitrary sweep rate so the repetition rate of an unknown signal can be measured accurately at any setting of the TIME/DIV switch, the repetition rate of the reference signal must be known. If it is not known, it

can be measured before the Variable TIME/DIV switch is set in step 2.

4. Divide the repetition rate of the reference signal (seconds) by the product of the horizontal deflection established in step 2 (divisions) and the setting of the TIME/DIV switch. This is the horizontal conversion factor:

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

5. To measure the repetition rate of an unknown signal, disconnect the reference signal and connect the unknown signal to the input connector. Set the TIME/DIV switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the Variable TIME/DIV control.

6. Measure the horizontal deflection in divisions and calculate the repetition rate of the unknown signal using the following formula:

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

Example. Assume a reference signal frequency of 455 hertz (repetition rate 2.19 milliseconds), and a TIME/DIV switch setting of .2 ms, with the Variable TIME/DIV control adjusted to provide a horizontal deflection of eight divisions. Substituting these values in the horizontal conversion factor formula (step 4):

$$\text{Horizontal Conversion Factor} = \frac{2.19\ \text{ms}}{0.2\ \text{ms} \times 8} = 1.37$$

Then, with a TIME/DIV switch setting of 50 μs, the repetition rate of an unknown signal which completes one cycle in seven horizontal divisions can be determined by using the repetition rate formula (step 6):

$$\text{Repetition Rate} = 50\ \mu\text{s} \times 1.37 \times 7 = 480\ \mu\text{s}$$

This answer can be converted to frequency by taking the reciprocal of the repetition rate (see applications on Determining Frequency).

Time-Duration Measurements

To measure time between two points on a waveform, use the following procedure:

1. Connect the signal to either input connector.

2. Set the vertical mode of operation to display the channel used.

3. Set the VOLTS/DIV switch to display about five divisions of the waveform.

4. Set the Triggering controls to obtain a stable display.

5. Set the TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the time measurement points (see Fig. 3).

6. Adjust the vertical POSITION control to move the points between which the time measurement is made to the center horizontal line.

7. Adjust the horizontal POSITION control to center the display within the center eight divisions of the graticule.

8. Measure the horizontal distance between the time measurement points. Be sure the Variable TIME/DIV control is set to CAL.

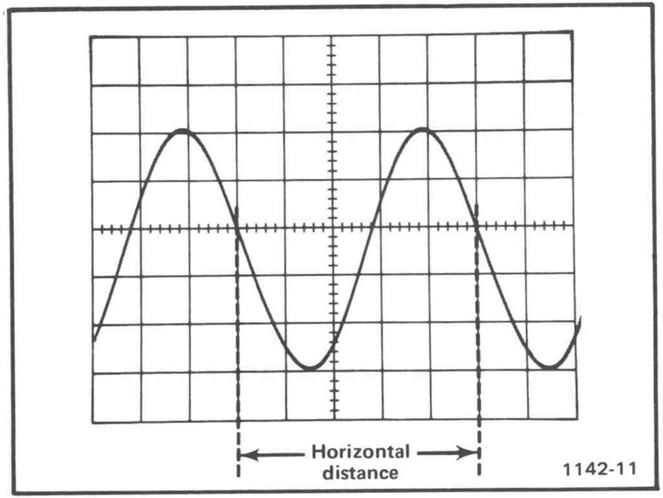


Fig. 3. Measuring the time duration between points on a waveform.

9. Multiply the distance measured in step 8 by the setting of the TIME/DIV switch.

Example. Assume that the distance between the time measurement points is five divisions (see Fig. 3) and the TIME/DIV switch is set to .1 ms.

Using the formula:

$$\text{Time Duration} = \begin{matrix}\text{horizontal}\\ \text{distance}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{TIME/DIV}\\ \text{setting}\end{matrix}$$

Substitute the given values:

$$\text{Time Duration} = 5 \times 0.1 \text{ ms}$$

The time duration is 0.5 millisecond.

Frequency Measurement

The time measurement technique can also be used to determine the frequency of a signal. The frequency of a periodically recurrent signal is the reciprocal of the time duration (period) of one cycle.

Use the following procedure:

1. Measure the time duration of one cycle of the waveform as described in the previous application.

2. Take the reciprocal of the time duration to determine the frequency.

Example. The frequency of the signal shown in Fig. 3 which has a time duration of 0.5 millisecond is:

$$\text{Frequency} = \frac{1}{\text{time duration}} = \frac{1}{0.5 \text{ ms}} = 2 \text{ kHz}$$

Risetime Measurements

Risetime measurements employ basically the same techniques as time-duration measurements. The main difference is the points between which the measurement is made. The following procedure gives the basic method of measuring risetime between the 10% and 90% points of the waveform. Falltime can be measured in the same manner on the trailing edge of the waveform.

1. Connect the signal to either input connector.

2. Set the vertical mode of operation to display the channel used.

3. Set the VOLTS/DIV switch and the Variable control to produce a display amplitude to correspond with the 0% and 100% graticule markings.

NOTE

In earlier instruments, the graticule 0% and 100% risetime measurement points were separated by 6 graticule divisions. Later instruments provided 0% and 100% risetime measurement points separated by 5 graticule divisions. The photos in this manual show the later version.

4. Center the display about the center horizontal graticule line. See Fig. 4.

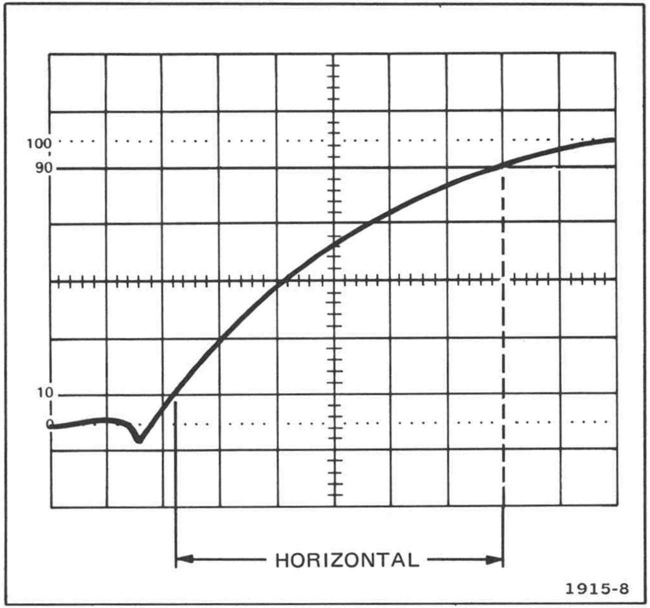


Fig. 4. Measuring risetime.

5. Set the TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the 10% and 90% points on the waveform.

6. Adjust the horizontal POSITION control to move the 10% point of the waveform to the first graticule line. See Fig. 4.

7. Measure the horizontal distance between the 10% and 90% points. Be sure the Variable control is set to CAL.

8. Multiply the distance measured in step 8 by the setting of the TIME/DIV switch.

Example. Assume that the horizontal distance between the 10% and 90% points is four divisions (see Fig. 4) and the TIME/DIV switch is set to 1 μs.

$$\text{Risetime (Time Duration)} = \text{horizontal distance (divisions)} \times \text{TIME/DIV setting}$$

Substituting the given values:

$$\text{Risetime} = 4 \times 1\ \mu\text{s}$$

The risetime is 4 microseconds.

Time-Difference Measurements

The calibrated sweep rate and dual-trace features of the 434 allow measurement of time difference between two separate events. To measure time difference, use the following procedure:

1. Set the Input Coupling switches to the desired coupling positions.

2. Set the vertical mode of operation 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.

3. Set the TRIGGER SOURCE to CH 1.

4. Connect the reference signal to CH 1 input and the comparison signal to CH 2 input. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the input connectors.

5. If the signals are of opposite polarity, set the INVERT switch out to invert the Channel 2 display (signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation).

6. Set the VOLTS/DIV switches to produce four- or five-division displays.

7. Set the LEVEL control for a stable display.

8. If possible, set the TIME/DIV switch for a sweep rate which shows three or more divisions between the two waveforms.

9. Adjust the vertical POSITION control to center each waveform (or the points on the display between which the measurement is made) in relation to the center horizontal line.

10. Adjust the horizontal POSITION control so the Channel 1 (reference) waveform crosses the center horizontal line at a vertical graticule line.

11. Measure the horizontal difference between the Channel 1 waveform and the Channel 2 waveform (see Fig. 5).

12. Multiply the measured difference by the setting of the TIME/DIV switch.

Example. Assume that the TIME/DIV switch is set to 50 μs and the horizontal difference between waveforms is 4.5 divisions (see Fig. 5).

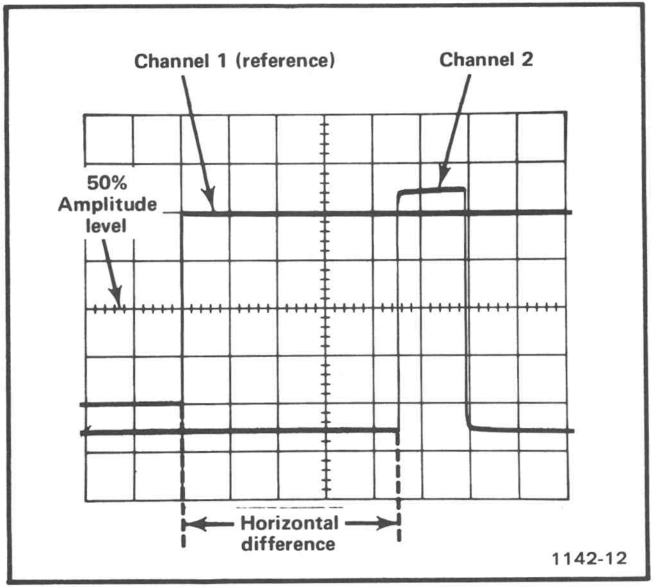


Fig. 5. Measuring time difference between two pulses.

Using the formula:

$$\text{Time Delay} = \frac{\text{TIME/DIV}}{\text{setting}} \times \begin{matrix}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{matrix}$$

Substituting the given values:

$$\text{Time Delay} = 50\ \mu s \times 4.5$$

The time delay is 225 microseconds.

Multi-Trace Phase Difference Measurements

Phase comparison between two signals of the same frequency can be made using the dual-trace feature of the 434. This method of phase difference measurement can be used up to the frequency limit of the vertical system. To make the comparison, use the following procedure.

1. Set the Input Coupling switches to the same position, depending on the type of coupling desired.

2. Set the vertical mode of operation 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.

3. Set the TRIGGER SOURCE to CH 1.

4. Connect the reference signal to the CH 1 input connector and the comparison signal to the CH 2 input

connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the input connectors.

5. If the signals are of opposite polarity, set the INVERT switch out to invert the Channel 2 display. (Signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation.)

6. Set the CH 1 and CH 2 VOLTS/DIV switches and the CH 1 and CH 2 Variable controls so the displays are equal and about five divisions in amplitude.

7. Set the Triggering controls to obtain a stable display.

8. Set the TIME/DIV switch to a sweep rate which displays about one cycle of the waveform.

9. Move the waveforms to the center of the graticule with the CH 1 and CH 2 POSITION controls.

10. Turn the VARIABLE TIME/DIV control until one cycle of the reference signal (Channel 1) occupies exactly eight divisions between the first and ninth graticule lines (see Fig. 6). Each division of the graticule represents 45° of the cycle (360° ÷ 8 divisions = 45°/division). The sweep rate can be stated in terms of degrees as 45°/division.

11. Measure the horizontal difference between corresponding points on the waveforms.

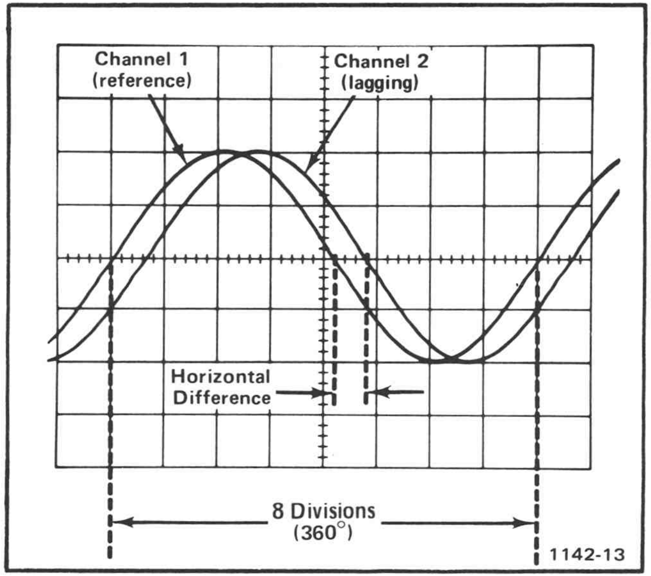


Fig. 6. Measuring phase difference.

12. Multiply the measured distance (in divisions) by 45°/division (sweep rate) to obtain the exact amount of phase difference.

Example. Assume a horizontal difference of 0.6 division with a sweep rate of 45°/division as shown in Fig. 6.

Using the formula:

$$\text{Phase Difference} = \begin{array}{c}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{array} \times \begin{array}{c}\text{sweep rate}\\ \text{(degrees/division)}\end{array}$$

Substituting the given values:

$$\text{Phase Difference} = 0.6 \times 45^\circ$$

The phase difference is 27°

X-Y Phase Measurement

The X-Y phase measurement method can be used to measure the phase difference between two signals of the same frequency. This method provides an alternative method of measurement for signal frequencies up to approximately 50 kilohertz. However, above this frequency the inherent phase difference between the vertical and horizontal system makes accurate phase measurement difficult. In this mode, one of the sine-wave signals provides the horizontal deflection (X) while the other signal provides the vertical deflection (Y). The phase angle between the two signals can be determined from the lissajous pattern as follows:

1. Connect one of the sine-wave signals to the CH 1 input connector and the other signal to the EXT HORIZ input connector.

2. Set the TIME/DIV switch to EXT HORIZ and the Sweep MODE to AUTO.

3. Position the display to the center of the screen and adjust the CH 1 VOLTS/DIV switch to produce a display less than six divisions vertically (Y). Reduce the horizontal (X) deflection to less than 10 divisions by reducing the amplitude of signal applied to the EXT HORIZ input connector.

4. Center the display in relation to the center graticule lines. Measure the distance A and B as shown in Fig. 7. Distance A is the horizontal measurement between the two points where the trace crosses the center horizontal line. Distance B is the maximum horizontal width of the display.

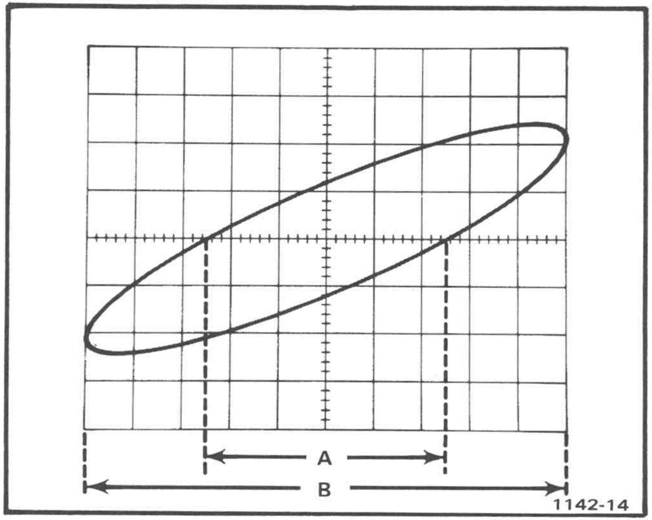


Fig. 7. Phase-difference measurement from an X-Y display.

5. Divide A by B to obtain the sine of the phase angle (Φ) between the two signals. The angle can then be obtained from a trigonometric table.

6. If the display appears as a diagonal straight line, the two signals are either in phase (tilted upper right to lower left) or 180° out of phase (tilted upper left to lower right). If the display is a circle, the signals are 90° out of phase.

Example. To measure the phase of the display shown in Fig. 7 where A is 5 divisions and B is 10 divisions, use the formula:

$$\text{Sine } \Phi = \frac{A}{B}$$

Substituting the given values:

$$\text{Sine } \Phi = \frac{5}{10} = 0.5$$

From the trigonometric tables:

$$\Phi = 30^\circ$$

Common-Mode Rejection

The ADD feature of the 434 can be used to display signals which contain undesirable components. These undesirable components can be eliminated through common-mode rejection.

1. Connect the signal containing both the desired and undesired information to the CH 1 input connector.

2. Connect a signal similar to the unwanted portion of the Channel 1 signal to the CH 2 input connector.

3. Set both Input Coupling switches to DC (AC if DC component of input signal is too large).

4. Set the vertical mode of operation to ALT. Set the VOLTS/DIV switches so the signals are about equal in amplitude.

5. Set the TRIGGER SOURCE to COMP.

6. Set the vertical mode of operation to ADD. Invert the Channel 2 display (INVERT button out) so the common-mode signals are of opposite polarity.

7. Adjust the CH 2 VOLTS/DIV switch and CH 2 Variable control for maximum cancellation of the common-mode signal.

8. The signal which remains should be only the desired portion of the Channel 1 signal. The undesired signal is cancelled out.

Example. An example of this mode of operation is shown in Fig. 8. The signal applied to Channel 1 contains unwanted line-frequency components (see Fig. 8A). A corresponding line-frequency signal is connected to Channel 2 (see Fig. 8B). Fig. 8C shows the desired portion of the signal as displayed when common-mode rejection is used.

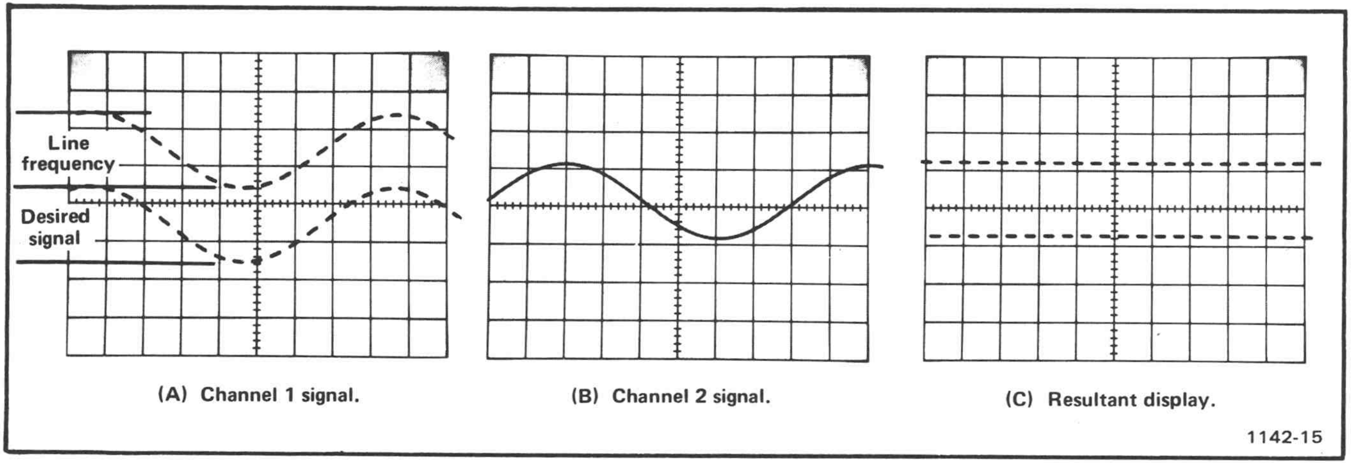


Fig. 8. Using the ADD feature for common-mode rejection. (A) Channel 1 signal contains desired information along with line-frequency component. (B) Channel 2 signal contains line-frequency only, (C) CRT display using common-mode rejection.