

# Digital Oscilloscopes

## 9450A Portable, Dual-Channel Digital Oscilloscope

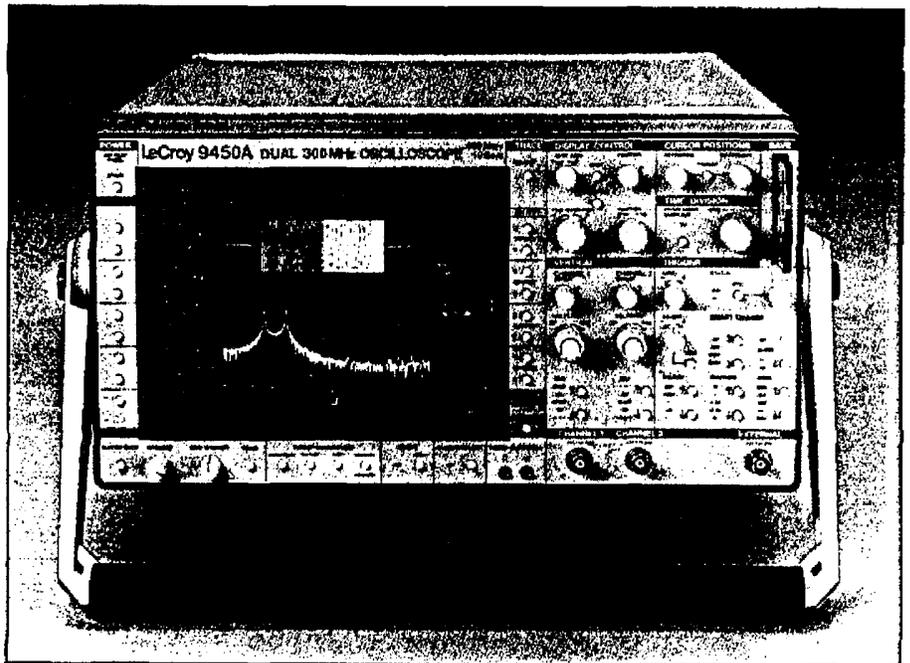
### Main Features

- 50K memory per channel
- Automatic PASS/FAIL testing on templates and parameters
- Segmentable memories with trigger point time stamps
- FASTGLITCH trigger mode
- Signal processing and FFT analysis
- Optional high speed memory card
- Unmatched display quality
- TV trigger and XY display

### The Ultimate Instrument for Design and Test

The LeCroy 9450A combines high bandwidth, fast sampling rates, high fidelity, extensive trigger capabilities and signal processing. Aimed at meeting the demands of researchers and engineers working in fields as diverse as telecommunications, electronic design and test, lasers, computers, NDT, physics and defense, the 9450A will rapidly become an indispensable measurement tool in any laboratory.

Like all LeCroy oscilloscopes, the 9450A is designed to serve as a range of different instruments: oscilloscope, transient recorder, counter/timer, frequency meter, signal averager, data logger and digital voltmeter. It offers the highest performing data acquisition and processing system available in any portable instrument.



The 9450A is shown measuring a frequency shift keyed signal. The FFT of the waveform is shown in the lower trace, indicating peaks at 1 MHz and 1.5 MHz.

### Functional Description

The LeCroy 9450A Dual-channel Digital Oscilloscope is a powerful high-resolution instrument for waveform recording and sophisticated analysis. It provides a bandwidth of 300 MHz, and sampling rates of up to 400 MS/sec for transients and 10 GS/sec for repetitive waveforms. The instrument features high-fidelity, 8-bit ADCs, 50K of non-volatile acquisition memory per channel, 200K of additional waveform storage memory, extensive pulse parameter analysis, and a highly sophisticated trigger system to capture the most complex signals,

including spikes and glitches. It is fully programmable over GPIB or RS-232-C interfaces. Hard copies are made at the touch of a button on a wide range of digital plotters and printers.

### ANALOG FEEL, DIGITAL PRECISION

The 9450A employs Flash technology in its two high-resolution, 8-bit ADCs (one per channel) which digitize waveforms with speed and precision. By combining this technology with ease of use, LeCroy's portable instrument provides the best features of both analog and digital oscilloscopes.

The front-panel controls of the 9450A have been laid out in the style of an analog oscilloscope, making it easy to use from the very first moment. The analog feel is enhanced by the rapid instrument response and the fact that waveforms are presented instantly on a bright high-resolution screen. For automated test applications all the front-panel controls, including cursor positions and internal functions, are fully programmable over RS-232-C or GPIB interfaces.

Capturing and measuring signals has never been easier. For repetitive signals an auto-setup facility finds and displays signals in less than 2 seconds. For one-time phenomena the 9450A's long 50K memories and extensive triggering capabilities enable signals to be captured the very first time, even when signal speed and duration are uncertain.

### **LONG NON-VOLATILE MEMORIES**

Only long memories allow high-fidelity recording over extended periods of time. On equal time-base settings the 9450A, with 50K of memory per channel, will sample waveforms up to 50 times faster than an oscilloscope with only 1K of memory. Faster sampling means better single-shot bandwidth, better time resolution and the power to expand waveforms up to 1000 times to see details that completely elude other digital oscilloscopes. In addition, when segmented, the 9450A's non-volatile acquisition memories can store up to 200 waveforms/channel (complete with date and time stamps).

### **TRIGGER**

Push-button control enables the user to choose the appropriate trigger functions for his signal: standard triggering for basic measurements and advanced triggering to meet highly sophisticated requirements.

The standard trigger facility provides all the conventional trigger functions. Front-panel controls select and adjust parameters such as pre- and post-trigger settings, trigger level, slope, mode and coupling. To help users quickly determine the 9450A's trigger mode and conditions, LeCroy has created a series of illustrative trigger graphics.

SMART triggering offers a solution to even the most intricate triggering problems. For example, FASTGLITCH trigger can be used to locate and reveal glitches and spikes less than 2.5 nsec wide. Time-qualified trigger is ideal for ranging applications and can be used to ignore unwanted signal reflections. Other trigger features include hold-off (by time or number of events), gated triggering and conditional triggering, qualified trigger, and trigger delayed by time or number of events.

### **PASS/FAIL**

The PASS/FAIL routine enables the oscilloscope to compare a source trace against a tolerance mask while simultaneously testing a set of extracted parameters.

For instance, the oscilloscope can be set up to PASS if:

1. The waveform in Channel 1 is contained in the mask in Memory C (all points inside the mask).
2. The frequency in Channel 2 is less than 10 kHz.
3. The maximum value of Function F is more than 1.45 V.
4. The RMS value in Channel 1 is less than 850 mV.

If any of these four conditions is not satisfied, the test will FAIL.

Whether the test PASSES or FAILS, the oscilloscope can, if the user wishes, perform any or all of the following actions:

- Stop the acquisition.
- Make a screen dump.
- Store a trace to Memory D.
- Store the selected traces to the memory card.
- Emit a "beep".
- Send a pulse from the rear-panel accessory port.

The mask envelope can also be generated inside the oscilloscope.

## 9450A Specifications

### VERTICAL ANALOG SECTION

#### Bandwidth (-3 dB):

@ 50  $\Omega$ : DC to 300 MHz.

@ 1 M $\Omega$  DC: DC to 250 MHz typical at the probe tip.

**Input impedance:** 1 M $\Omega$ /15 pF and 50  $\Omega$   $\pm$ 1%.

**Channels:** Two independent channels; standard BNC connector inputs.

**Sensitivity range:** 5 mV/div to 2 V/div; continuously variable from 1 to 2.5 times the fixed setting. Fixed settings range from 5 mV/div to 2 V/div (in a 1, 2, 5 sequence).

**Vertical expansion:** Up to 5 times (with averaging, up to 50 times or 100 mV/div sensitivity).

**Scale factors:** Probe attenuation factors of X1, X10, X100, X1000, X10000 may be selected and are remotely programmable.

**Offset:**  $\pm$ 12 times the fixed sensitivity setting in 0.02 division increments up to  $\pm$ 10 V max.;  $\pm$ 24 div @ 10 mV/div;  $\pm$ 48 div @ 5 mV/div.

**DC accuracy:**  $\leq$   $\pm$ 2%, full scale.

**Bandwidth limiter:** 80 MHz (-3 dB) typical.

**Maximum input voltage:** 250 V (DC + peak AC  $\leq$  10 kHz) at 1 M $\Omega$ ,  $\pm$ 5 V DC (500 mW) or 5 V RMS at 50  $\Omega$ .

### VERTICAL DIGITAL SECTION

**ADCs:** One per channel, 8-bit Flash.

**Conversion rate:** Up to 400 MS/sec for transients, up to 10 GS/sec for repetitive signals, simultaneously on both channels.

**Aperture uncertainty:**  $\pm$ 10 psec.

**Acquisition memories, Channel 1 and 2:** Non-volatile memories (battery backed for a minimum of 2 years) of 50 kilowords per channel can be segmented into 2, 5, 10, 20, 50, 100 or 200 segments.

**Reference memories, C and D:** 50K, 16-bit word memories which can store one acquired and/or processed waveform, or up to 200 waveforms when segmented.

**Function memories E and F:** Two 50K, 16-bit word memories for waveform processing.

### PEAK AND GLITCH DETECTION

Minimum and maximum peaks, as fast as 0.002% of the record length (minimum 2.5 nsec), are captured and displayed with 100% probability. Using LeCroy's new FASTGLITCH trigger technique (see the trigger section below), glitches faster than 2.5 nsec can be detected on all time base settings.

### HORIZONTAL SECTION

#### Time Base

**Range:** 1 nsec/div to 5000 sec/div.

**Clock accuracy:**  $\leq$   $\pm$ 0.002%.

**Interpolator resolution:** 5 psec.

**Interpolator accuracy:** 20 psec RMS.

**Sampling clock output:** BNC connector on rear panel.

**External clock in:** BNC connector on rear panel.

#### Acquisition Modes

##### Random Interleaved Sampling (RIS):

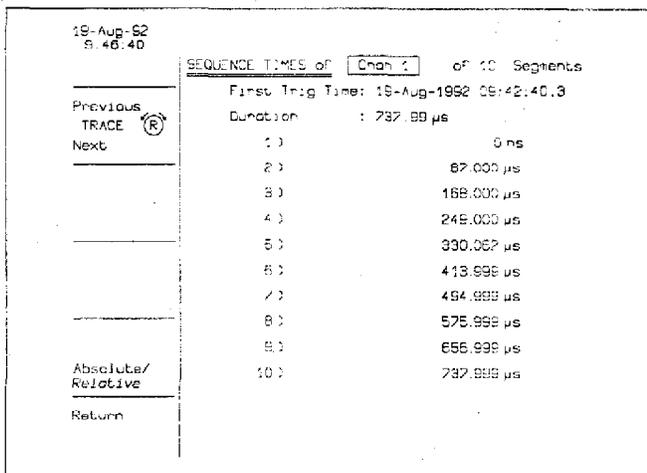
For repetitive signals from 1 nsec/div to 5  $\mu$ sec/div.

**Single shot:** For transient signals and repetitive signals from 10 nsec/div to 200 msec/div.

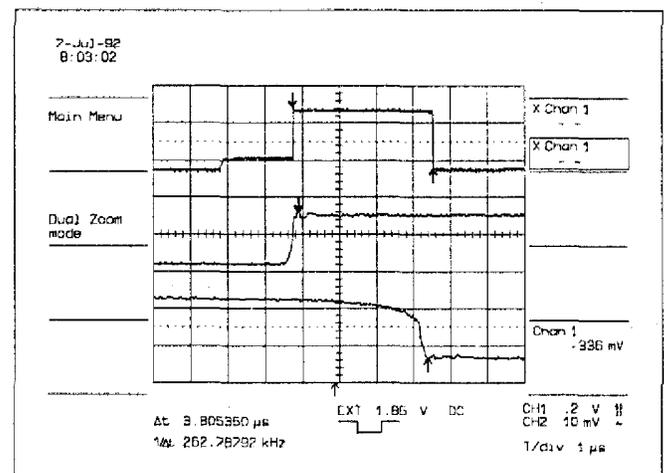
**Roll:** For slowly changing signals from 500 msec/div to 5000 sec/div.

**Sequence mode:** Divides the acquisition memory into 2, 5, 10, 20, 50, 100 or 200 segments.

**Horizontal expansion:** Dual Zoom mode allows two different signals or two different sections of the same signal to be expanded up to 1,000 times.



The 9450A sequence mode collects several segments with very little time (100  $\mu$ sec) between segments.



The display of acquired waveform and expanded views allows precise placement of measurement cursors and full use of the oscilloscope's 0.002% timebase accuracy.

**TRIGGERING**

**Pretrigger recording:** Adjustable in 0.2% increments to 100% of full scale (grid width).

**Post-trigger delay:** Adjustable in 0.02 division increments up to 10,000 divisions.

**External trigger input:** 1 M $\Omega$ , < 20 pF, 250 V max. (DC + peak AC  $\leq$  10 kHz).

**External trigger range:**  $\pm 2$  V in EXT,  $\pm 20$  V in EXT/10.

**Rate:** Up to 500 MHz using HF trigger coupling.

**Timing:** Trigger timing (date and time) is logged in the memory status menu. The timing of subsequent triggers in sequence mode is measured with 0.1 sec absolute resolution, or nanosecond resolution relative to the time of the first trigger.

**Trigger output:** BNC connector on rear panel.

**Trigger veto:** BNC connector on rear panel.

**Standard Trigger**

**Sources:** CHAN1, CHAN2, LINE, EXT, EXT/10. CHAN1, CHAN2 and EXT have independent trigger circuits allowing slope, coupling and level to be set individually for each source.

**Slope:** Positive, negative.

**Coupling:** HF, AC, LF REJ, HF REJ, DC.

**Modes:**

**Auto:** Automatically re-arms after each sweep. If no trigger occurs, one is generated at an appropriate rate.

**Normal:** Re-arms after each sweep. If no trigger occurs after a reasonable length of time, the warning message "NO or SLOW TRIGGER" is displayed.

**Single (hold):** Holds display after a trigger occurs. Re-arms only when the "single" button is pressed again.

**Sequence:** Stores multiple events in segmented acquisition memories.

**SMART Trigger**

**Single-source trigger operational modes:**

**Hold-off by time:** 25 nsec to 20 sec.

**Hold-off by events:** 0 to 10<sup>9</sup> events.

**Width-based trigger modes:**

**Pulse width < (FASTGLITCH):** Triggers on opposite slopes of pulses narrower than a value in the range 2.5 nsec and 20 sec.

**Pulse width >:** Triggers on opposite slopes of pulses wider than a value in the range 2.5 nsec to 20 sec.

**Interval width <:** Triggers on similar slopes of signals narrower than a value in the range 10 nsec to 20 sec.

**Interval width >:** Triggers on similar slopes of signals wider than a value in the range 25 nsec to 20 sec.

**Multi-source trigger operational modes:**

**Pattern:** Triggers on the logic AND of the three sources CHAN1, CHAN2 and EXT, where each source can be defined as high (H), low (L) or don't care (X). The trigger can be selected at the beginning (entered) or the end (exited) of the specified pattern.

**Bi-level:** This is a special condition of pattern trigger which allows the 9450A to trigger on any signal that exceeds a certain preset high or low trigger level. The signal must be connected simultaneously to two channels. The third trigger channel must be set to don't care (X).

**State qualified:** Allows the 9450A to trigger on any source (CHAN1, CHAN2 or EXT), while requiring that a certain pattern of the other two channels is present or absent. A delay by time or by number of events can be selected from the moment the pattern is valid.

**Time/event qualified:** Allows the 9450A to trigger on any source (CHAN1, CHAN2 or EXT), as soon as a certain pattern of the three channels is entered or exited. From the moment of validity, a delay can be defined in terms of time or number of events.

**TV:** Allows stable triggering on TV signals that comply with PAL, SECAM or NTSC standards. Selection of both line (up to 1500) and field number (up to 8) is possible. Active on EXT only.

**DISPLAY**

**CRT:** 12.5 x 17.5 cm (5 x 7 inches); magnetic deflection; vector type.

**Resolution:** 4096 x 4096 points.

**Real-time clock:** Date, hours, minutes, sec.

**Grid:** Internally generated; separate intensity control for grid and waveforms. Single, dual and pulse parameter measurement grid mode.

**Persistence mode:** Plots consecutively acquired traces of up to four sources (CHAN1, CHAN2, Memory C or D, Function E or F and Expansion A or B) on top of each other, allowing waveform trends and history to be examined. The number of sweeps is selectable from 1, 2, 5, 10, 20, 50, 100, 200 or INFINITE. Time and voltage cursor measurements are supported in persistence mode.

**XY mode:** Plots any two sources (CHAN1 and 2, Expansions A and B, Memories C and D and Functions E and F) against one another. Operates on live waveforms with full cursor readout.

**Hard copy:** Single or multi-pen digital plotters as well as printers can be used to make hard copies of the display. Screen dumps are activated by a front-panel push-button or via remote control. Plotters supported are: the HP 7400 and 7500 series, Philips PM 8151, Graphtek FP 5301, and compatible models. Printers supported are: EPSON and the HP ThinkJet, QuietJet and LaserJet. Plotting can be done in parallel with normal 9450A operation.

**Graphics:** Waveforms and display information are presented using vector (linear) graphics. Expanded waveforms use LeCroy's DOT-LINEAR graphics that highlight actual data points and interpolate linearly between them.

**Menus:** Waveform storage; acquisition parameters; memory status; save/recall front-panel configurations; SMART trigger; waveform parameters, RS-232-C configuration; hardcopy setup and real-time clock setup, averaging, arithmetic, and PASS/FAIL.

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## Cursors

**Relative time:** Two cursors provide time measurements with a resolution of  $\pm 0.05\%$  of full scale for unexpanded traces; up to 10% of the sampling interval for expanded traces. The corresponding frequency information is also provided.

**Relative voltage:** Two horizontal bars measure voltage differences to  $\pm 0.2\%$  of full scale for each trace.

**Absolute time:** A cross-hair marker measures absolute voltage versus signal ground, as well as the time relative to the trigger.

**Absolute voltage:** A reference bar measures absolute voltage with respect to ground.

**Pulse parameters:** Two cross-hair cursors are used to define a region of interest for which pulse parameters will be calculated automatically.

## AUTO-SETUP

Pressing the auto-setup button automatically scales the time base, trigger and sensitivity settings to provide a stable display for a wide range of repetitive input signals.

**Type of signals detected:** Repetitive signals with amplitudes between 2 mV and 8 V, frequency above 50 Hz and a duty cycle greater than 0.1%.

**Auto-setup time:** Approximately 2 sec.

## WAVEFORM PROCESSING

Waveform processing routines are set up via menus. These include arithmetic functions (add, subtract and invert), and summation averaging (up to 1000 signals).

**Pulse parameters:** Based on ANSI/IEEE Std. 181-1977 "Standard on Pulse Measurement and Analysis by Objective Techniques". The terminology is derived from IEEE Std. 194-1977 "Standard Pulse Terms and Definitions".

## Automatic measurements determine:

Amplitude	Frequency	Period
Area	Maximum	Pulse Width
Base	Mean	Rise Time
Cycles	Minimum	RMS
Delay	Overshoot Neg	Standard Dev
Duty Cycle	Overshoot Pos	Top
Fall Time	Peak-Peak	

**Sources:** CHAN1, CHAN2, Memory C or D, Function E or F, Expansion A or B. Cursors define the measurement zone. With more than 1 pulse present in the measurement zone, averaged results for period, width, rise time and fall time are presented.

## REMOTE CONTROL

Front-panel controls, including variable gain, offset, position controls and cursors, as well as all internal functions are programmable.

**RS-232-C port:** For computer/terminal control or plotter connection. Asynchronous up to 19200 baud.

**GPIO port:** (IEEE-488). Configured as talker/listener for computer control and fast data transfer.

## PROBES

**Model:** Two P9020 probes supplied.

**Probe calibration:** 1 kHz square wave, 1 V p-p.

**Probe power:** Two rear-panel power outlets for use with active probes provide  $\pm 15$  V,  $\pm 5$  V DC.

## SELF TESTS

**Auto-calibration** ensures specified DC and time accuracy.

## GENERAL

**Temperature:** 5 to 40° C (41 to 104° F) rated; 0 to 50° C (32 to 122° F) operating.

**Humidity:** < 80%.

**Power required:** 110 or 220 V AC, 45 to 440 Hz, 275 W.

**Shock and vibration:** Meets requirements of MIL-STD-810C modified to LeCroy design specifications, and MIL-T-28800C.

**Battery backup:** Lithium batteries maintain front-panel settings and waveform data for 2 years.

**Dimensions:** (HWD) 21 x 37 x 50 cm, (8.5 x 14.5 x 20 inches).

**Weight:** 15 kg (33 lbs) net, 20 kg (44 lb) shipping.

**Warranty:** 2 years.

## ORDERING INFORMATION

### Oscilloscope and Options

Code	Description
9450A	Digital oscilloscope
9450AWP01	Waveform processing option
9450AWP02	FFT processing option
9450AMATE	CIIL/MATE option
9450A-MC01	Memory card reader
9450A-MC02	128K memory card
9450A-MC04	512K memory card
OM9450A	Operator's manual
94XX-FC	Front cover