PRODUCT DESCRIPTION

INTRODUCTION

The LeCroy 9424 is a wide–bandwidth digital oscilloscope suited to a variety of multi–channel engineering design and test applications. It is used to capture, analyze, display and archive electrical waveforms in fields such as analog and digital engineering, automated test and measurement, telecommunications and electronics research.

ARCHITECTURE

The 9424 features four 100 megasample/second 8–bit Flash ADC systems, with 50K non–volatilememories for waveform acquisition and storage, and four 50K memories for waveform processing, expansion and temporary storage. High–speed internal data transfer and processing are performed using a multi–processor system. The central processor is a powerful Motorola 68020 microprocessor which performs computations and controls the oscilloscope's operation.

All front–panel knobs and buttons are constantly monitored by the internal processor, and front–panel setups are rapidly reconfigured via the unit's internal 16–bit bus. Data are quickly processed according to the selected front–panel setups, and are transferred to the display memory for direct waveform display or stored in the reference memories.

The 68020 controls the unit's GPIB (IEEE–488) remote control port, as well as the RS–232–C port which is used to directly interface the oscilloscope to a digital plotter, printer, remote terminal or other slow–speed device.
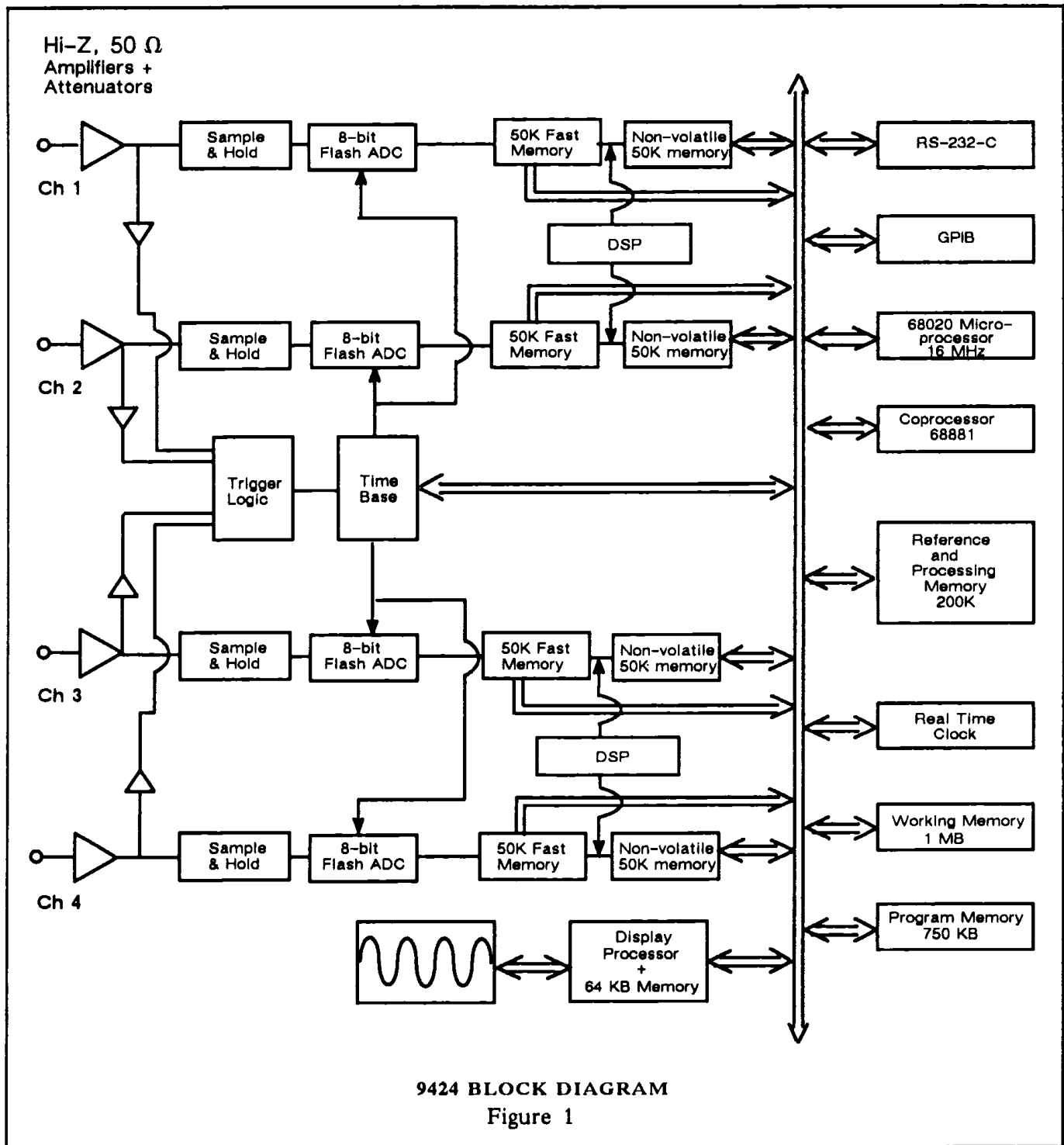
ADCs AND MEMORIES

Each of the oscilloscope's four identical input channels is equipped with a 100 megasample/second, 8–bit ADC and a 50 kiloword acquisition memory (see Figure 1). This quad ADC architecture ensures absolute amplitude and phase correlation, maximum ADC performance for all single– and multi–channel acquisition modes, large record lengths and excellent time resolution.

Four50K acquisition memories simplify transient capture by providing long waveform records that capture waveforms even when trigger timing or signal speed is uncertain. In addition, a special expansion facility magnifies waveforms by up to 1000 times the selected time–base speed.

Repetitive signals can be acquired and stored at a Random Interleaved Sampling (RIS) rate of 10 gigasamples/second. RIS is a high–precision digitizing technique that enables measurement of repetitive signals to a bandwidth of 350 MHz, with an effective sampling interval of 100 psec and measurement resolution of 5 psec.

The 9424 assures precision measurements over its entire range of operation.

Hi-Z, 50 Ω
Amplifiers +
Attenuators

Ch 1	Sample & Hold	8-bit Flash ADC	50K Fast Memory	Non-volatile 50K memory	RS-232-C

DSP

GPIB

| Ch 2 | Sample & Hold | 8-bit Flash ADC | 50K Fast Memory | Non-volatile 50K memory | 68020 Micro-processor 16 MHz |

Coprocessor 68881

Trigger Logic | Time Base

Reference and Processing Memory 200K

| Ch 3 | Sample & Hold | 8-bit Flash ADC | 50K Fast Memory | Non-volatile 50K memory |

Real Time Clock

DSP

Working Memory 1 MB

| Ch 4 | Sample & Hold | 8-bit Flash ADC | 50K Fast Memory | Non-volatile 50K memory |

Program Memory 750 KB

Display Processor + 64 KB Memory

9424 BLOCK DIAGRAM
Figure 1

TRIGGER

The 9424's digitally-controlled trigger system offers an extensive range of trigger capabilities. Front-panel and menu controls let the user choose the appropriate trigger function for the signal.

In the standard trigger mode the front-panel controls are used to select and set parameters such as pre- and post-trigger recording, sequence and roll modes, in addition to the Auto, Normal and Single (Hold) modes. The trigger source can be line, Channel 1, 2 or 4 (Channel 4 is replaced by EXT on the 9424E). The coupling is selected from HF, AC, LF REJect, HF REJect and DC, and the slope from positive and negative.

The SMART trigger facility provides a complete range of sophisticated and versatile trigger features. The following trigger classes and operational modes are available:

Trigger Classes	Operational Modes
Single-source trigger Pattern trigger	Hold-off by time Hold-off by number of events Pulse width > Pulse width < (FASTGLITCH) Interval width > Interval width <
State Qualified trigger Time/Event Qualified trigger	Wait for a given time Wait for a given event count
TV trigger on Channel 3	Trigger on a given line in a chosen field

AUTOMATIC CALIBRATION

The oscilloscope has an automatic calibration facility that ensures overall vertical accuracy of $\pm$ 2% of full scale ($\pm$ 3% for 5mV/div sensitivity) and a time-base interpolator accuracy of $\pm$ 20 psec RMS for the unit's crystal-controlled time base.

The time base is calibrated whenever the time-base control is adjusted to a new Time/div setting; vertical gain and offset calibration take place each time the Volts/div or offset are modified. All channels are calibrated each time the Bandwidth Limit button is pressed. In addition, periodic calibration is performed to ensure long term stability at the current setting.

DISPLAY

The large 12.5 $\times$ 17.5 cm (5 $\times$ 7 inches) screen displays waveforms with enhanced resolution and serves as an interactive, user-friendly interface via a set of pushbuttons located immediately to the left and right of the CRT.

The oscilloscope displays up to four waveforms, while simultaneously reporting the parameters controlling signal acquisition. The screen also presents internal status and measurement results, as well as operational, measurement, and waveform analysis menus.

A hard copy of the screen is available via the unit's front-panel screen dump button. Plotting is done in parallel with normal oscilloscope operation.

MANUAL/REMOTE CONTROL

The front-panel layout and operation will be very familiar to users of analog oscilloscopes. The "analog" feel is emphasized by rapid instrument response and the fact that waveforms are presented instantly on the high-resolution screen.

The oscilloscope has also been designed for remote control operation in automated testing and computer-aided measurement applications. The entire measurement process, including cursor and pulse parameter settings, dynamic modification of front-panel settings, and display organization, can be controlled via the rear-panel GPIB (IEEE-488) and RS-232-C ports.

The 9424 can store up to seven front-panel setups which may be recalled either manually or by remote control, thus ensuring rapid front-panel configuration. When the power is switched off, the current front-panel setting is automatically stored for subsequent recall at the next power on.

SPECIFICATIONS

Vertical Analog Section

Bandwidth (- 3 dB):
@ 50 Ω: DC to 350 MHz.
@ 1 MΩ AC: < 10 Hz to 250 MHz typical at the probe tip.
@ 1 MΩ DC: DC to 250 MHz typical at the probe tip.

Input impedance: 1 MΩ // 30 pF and 50 Ω ± 1%.

Channels: Four independent channels; standard BNC connector inputs.

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

Vertical expansion: up to 5 times (with averaging, up to 10 times or 500 μV/div sensitivity).

Scale factors: Probe attenuation factors of ×1, ×10, ×100, ×1000 or ×10000 may be selected and remotely programmed.

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

DC accuracy: $\leq \pm$ 2%.

Bandwidth limiter: 80 MHz (– 3 dB) typical.

Max input voltage: 250 V (DC + peak AC) at 1 MΩ, $\pm$ 5 V DC (500 mW) or 5 V RMS at 50 Ω.

Vertical Digital Section

ADCs: One per channel, 8–bit Flash.

Conversion rate: Up to 100 megasamples/sec for transients, up to 10 gigasamples/sec for repetitive signals, simultaneously on four channels.

Aperture uncertainty: $\pm$ 10 psec.

Acquisition memories, Channels 1, 2, 3 and 4: 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 blocks.

Reference and Function memories, C, D, E and F: 50K, 16–bit word memories which can store one acquired or processed waveform, or up to 200 waveform segments.

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 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: $\leq \pm$ 0.01%.
Interpolator resolution: 5 psec.
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 20 μsec/div.

Single shot for transient signals and repetitive signals from 50 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: Multi zoom mode allows different signals or different sections of the same signal to be expanded up to 1000 times.

Trigger

Pre–trigger 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.

Rate: Up to 500 MHz using HF trigger coupling.

Timing: Trigger timing (date and time) is listed 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, Chan4, and Line. Chan 1, Chan2 and Chan4 have independent trigger circuits allowing slope, coupling and level to be set individually for each source. (Chan3 is used for the TV trigger).

◆ *Note: On the 9424E oscilloscope with External trigger option, Channel 4 is replaced by EXT. In this case, all references to Channel 4 should be interpreted as referring to EXT.*

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 1,000,000,000 events.

Width–based trigger modes

Pulse width < (FASTGLITCH): Triggers on opposite slopes of pulses narrower than a value in the range 2.5 nsec to 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 logical AND of Chan1, Chan2 and Chan4, 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 at the end (exited) of the specified pattern.

Bi-level: This is a special condition of pattern trigger which allows the oscilloscope 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 oscilloscope to trigger on any source (Chan1, Chan2 or Chan4), while requiring that a certain pattern of the other two channels is present or absent. In addition a delay by time or by number of events can be selected from the moment the pattern is valid.

Time/Event qualified: Allows the oscilloscope to trigger on any source (Chan1, Chan2 or Chan4) 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.

◆ *Note: On the 9424E oscilloscope with External trigger option, Channel 4 is replaced by EXT. In this case all references to Channel 4 should be interpreted as referring to EXT.*

TV trigger operational modes

Allows stable triggering on TV signals that comply with PAL, SECAM or NTSC standards. Selection of both line and field number is possible. Active on Channel 3 only.

Any line: Triggers at the beginning of the front porch of a composite video signal applied to Channel 3.

Line mode: Triggers at the beginning of the front porch of a chosen line of a composite video signal applied to Channel 3.

Field choice: The user can select which field the chosen line should be in. The field can be specified in the range 1 to the total number of fields. This total number of fields can take one of the values 1, 2, 4 or 8. The hardware circuits can distinguish between the odd and even fields for the standard forms of TV signals.

Knowledge of the time interval between triggers allows the oscilloscope to make a "relative" distinction between fields 1, 3, 5, and 7 (or 2, 4, 6, and 8). This is the exclusive "FIELDLOCK" feature. It should be noted that this final field identification is not absolute.

The 9424 offers direct support for the two most common system characteristics 625/50/2:1 and 525/60/2:1. It also supports an extended class with arbitrary line count, 50 or 60 fields/sec, and arbitrary interlace factor.

Display

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

Resolution: 4096 × 4096 points.

Real-time clock: Date, hours, minutes, seconds.

Grid: Internally generated; separate intensity control for grid and waveforms. Single, dual, quad, XY and pulse parameter measurement grid modes.

XY mode: Plots any two sources (Chan1, 2, 3 and 4, Expand A and B, Functions C, D, E and F) against one another. Operates on live waveforms with cursor readout.

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

Graphics: All 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; RS-232-C configuration; hardcopy setup and real-time clock setup; waveform parameters; averaging, and arithmetic.

Cursors

Relative time: Two cursors provide time measurements with a resolution of ± 0.2% of full scale for unexpanded traces; up to ± 10% of the data point sampling interval for expanded traces. The corresponding frequency information is also provided.

Relative voltage: Two horizontal bars measure voltage differences up to ± 0.2% of full scale for each trace in single grid mode.

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

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 display 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 1 sec.

Waveform Processing

Waveform processing routines are called and 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:

Maximum	Period
Minimum	Pulse width
Mean	Risetime
Standard deviation	Falltime
RMS	Delay

Sources: Channel 1, Channel 2, Channel 3, Channel 4, Functions C, D, E or F, Expand A or B. Cursors define the measurement zone. With more than 1 pulse present in the measurement zone, averaged results for period, width, risetime and falltime are given.

Optional Processing

Extra processing power can be added by installing LeCroy's waveform processing options. Option WP01 provides waveform characterization in high resolution mode up to 11 bits, and extended mathematical analysis (integration, differentiation, etc.), as well as averaging and extrema mode for the accumulation of maximum and minimum values. Option WP02 performs spectral analysis (FFT processing).

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.

GPIB port: (IEEE-488). Configured as talker/listener for computer control and fast data transfer. Address switches on rear panel.

Local/remote: Remote control can be interrupted for local (manual) control at any time (except when in remote control with the lock-out state selected) by pushing a button on the front panel.

Probes

Model: Four P9020 ($\times$ 10, 10 MΩ // 3.33 pF) 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, + 5 V DC.

Self Tests

Auto-calibration ensures :
  DC accuracy: $\pm$ 3% full scale at 5mV/div
  $\pm$ 2% full scale > 5mV/div
  Time accuracy: 20 psec RMS.

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.

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

Enclosure: (HWD) 21 x 37 x 50 cm (8½ x 14½ x 20 inches).

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

Warranty: two years.