What the LSA1000 Does and How

The LSA1000 is an ideal instrument for capturing, digitizing and analyzing high-speed electronic signals. Moreover, it has been optimized for system-integration applications with high throughput, ease of use and reliability. The host computer can easily control and retrieve data from the LSA1000 via a 10/100Base-T Ethernet interface. The LSA1000 is an intelligent digitizer that will save valuable development time by acquiring and analyzing complex, high-speed signals. *This chapter covers basic digital concepts and the benefits of using the instrument.*

Overview

The LSA1000 has 1 GHz analog bandwidth. It has two channels, and a 1 GS/s, eight-bit flash Analog-to-Digital Converter (ADC) for each channel. Faster sampling rates can be achieved by combining channels — up to a maximum of 2 GS/s on one channel. The waveform acquisition memory capacity is 100 000 data points per channel in the standard configuration, 500 000 with *Option M1*, 1 million points with *Option M2*, 2 million points with *Option M4*, and 4 million points with option *M*8. Acquisition memory can also be doubled by combining channels — to as much as 8 million data points.

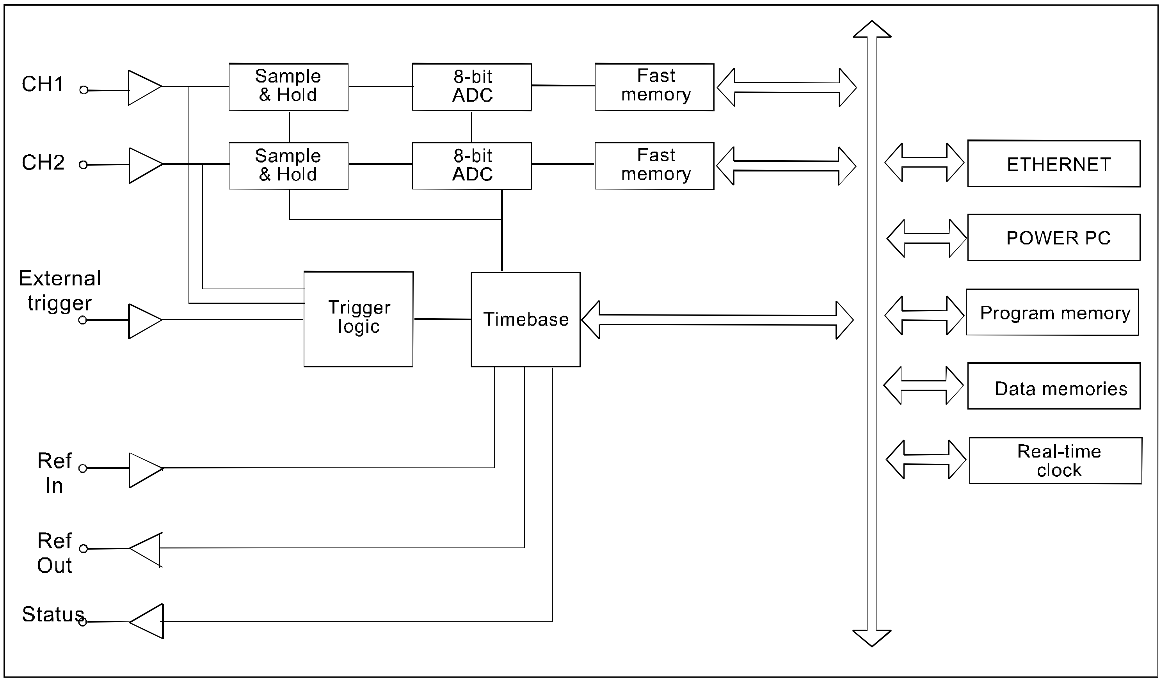
The instrument's central processor is a Motorola PowerPC 603e microprocessor, which performs waveform processing and controls the LSA1000's operation.

A 10/100Base-T Ethernet port is used to directly interface the LSA1000 to the computer for remote control and data transfer.

The LSA1000's entire functionality is via remote control commands, which are fully described in a separate, enclosed manual (*see Remote Control Manual*). Software tools are also provided for application-specific program development and integration. They are explained in the following chapters of the present manual.

Block Diagram

➢ LSA1000 *Signalyst*

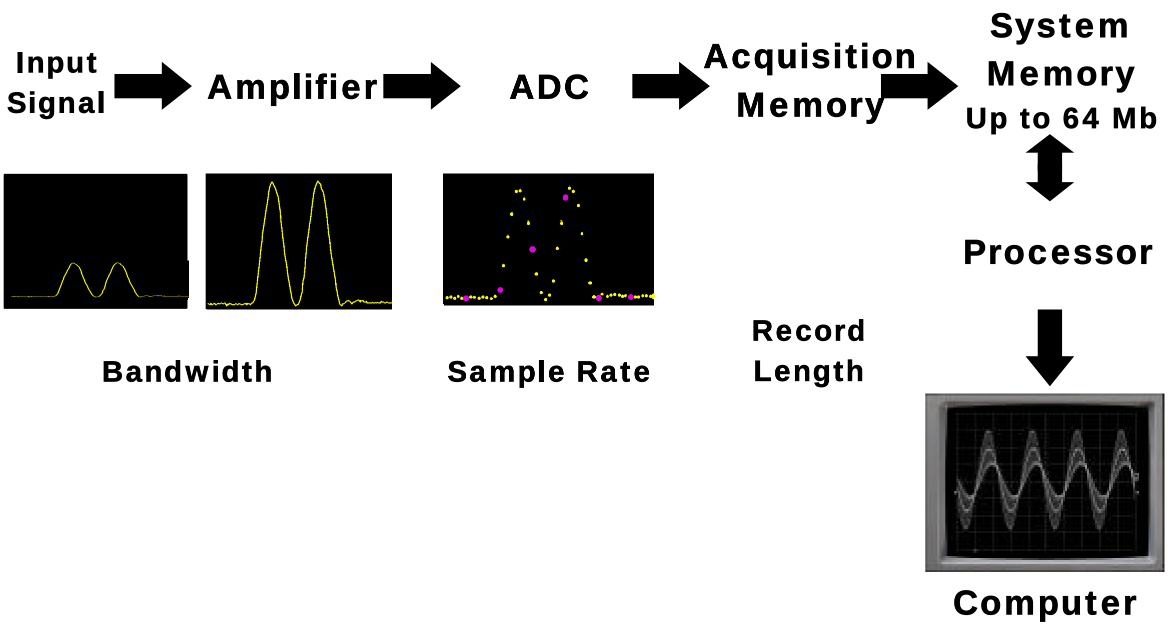


What Can it Do?

The LSA1000 delivers the same powerful performance as a high-end LeCroy DSO (Digital Storage Oscilloscope) in a design optimized for system integration, with:

- ***Capture of one-off (single-shot) events, stored in memory***
- ***On-board analysis of signals, and precise measurement results***
- ***Fast data transfer via Ethernet; remote control of all major functions.***

See this chapter's "Capture", "Measure", "Analyze" and "Transfer" sections for more…



Basic Elements

These are the basic elements that make up the LSA1000:

- **Amplifier** — amplifies and conditions the input signal so that it can be measured most effectively
- **Analog-to-Digital Converter (ADC)** — converts the analog signal into digital form by translating it into a series of sample points that are then measured and transformed into digital codes representing the signal samples. Multiple ADC architecture ensures absolute amplitude and phase correlation, maximum ADC performance for multi-channel acquisitions, large record lengths and excellent time resolution.
- **Acquisition Memory System** — stores resulting digital data from ADCs. Standard 100K points per channel simplify transient capture by producing long waveform records that capture even when trigger-timing or signal-speed is uncertain. Combining two channels doubles the acquisition memory length. There are four memories for temporary storage, and four more for waveform zooming and processing.
- **System RAM Memory** of 16 Mbytes as standard. 64 Mbyte optional.

- **Processor** — a PowerPC 603e microprocessor controls the entire system and performs computations and special monitoring.
- **Interfaces** — Ethernet port transfers processed data to the host computer and receives remote control instructions.

Finding the "Right Fit"

For optimum results there must first be a good "fit" between the character of the signals under analysis and the primary specifications of the LSA1000. In assessing the overall signal representation, particular consideration needs to be given to these three cardinal parameters:

- **Bandwidth:** The bandwidth specification of an LSA1000 indicates the ability of its front-end amplifier to faithfully track an incoming signal. The LSA1000's bandwidth is defined as the frequency at which a sinusoidal input signal has been attenuated to about 70 % of its real amplitude. This point, at which the vertical amplitude error is about 30 %, is called the –3 dB point.
- **Sample Rate:** The higher the sample rate the better the signal resolution. This is particularly important for single-shot waveform capture and measurement. The danger with low sample rates is that important information may be lost between samples. A sample rate of at least twice the highest frequency component of the signal is required to avoid aliasing. A sample rate of at least five times is advisable for accurate waveform capture.
- **Memory Length:** Acquisition memory length determines the number of input signal samples that can be stored. The greater the capacity for stored samples, the faster the possible sample rate for a given waveform duration. The signal captured with a long-memory LSA1000 has a greater resolution, whereas in the case of other short-memory instruments, such high sample rates are only available on short waveform-capture time settings. Long-memory LSA1000s allow operation at the highest possible sample rate, and over a far longer capture time.

The LSA1000's fidelity in reconstructing the input signal is affected mainly by these three parameters. The bandwidth must be sufficient to allow all the signal components to pass through the signal-conditioning system. And the sample rate has to be high enough to provide a good definition of the signal. Long memory maintains the sample rate for large time windows.

Capture

In addition to the primary specifications and three parameters described above, capture techniques, the triggering system, channels and ADC specification all impact on LSA1000 performance.

Acquisition Technique

Single-shot acquisition is the LSA1000's basic acquisition technique, which makes the instrument very suitable for the study of signal phenomena that have a low-repetition rate or are not repeated — hence *single*-shot.

An acquired waveform consists of a series of measured voltage values sampled at a uniform rate on the input signal. The acquisition is typically stopped at a fixed time after the arrival of a trigger event as determined by the trigger delay. The acquisition consists of a single series of measured data values associated with one trigger event. The time of the trigger event is measured using the timebase clock. The timing information of a waveform is determined using the trigger event as the definition of time 0. Since each channel has its own ADC, the voltage on each of the input channels is sampled and measured at the same instant. This allows extremely reliable time measurements between channels.

Trigger delay can be selected anywhere within a range that allows the waveform to be sampled from well before the trigger event up to the moment it occurs (100% pretrigger), or at a time starting at the equivalent of 1,000 times of the memory size after the trigger.

The captured input data signal is transferred to memory for measurement and analysis.

Analog–Digital Conversion

High-speed LSA1000 performance is made possible by the use of advanced flash ADCs whose vertical resolution guarantee a clear representation of the signal. These ADCs measure the voltage level at evenly spaced intervals and store the digitized value in high-speed dedicated memory. The shorter the intervals, the faster the digitizing rate — and the finer the time structure able to be seen. The higher the resolution of the ADC, the better its sensitivity to small voltage changes. And the greater its memory capacity, the longer the recording time available.

Channels

The LSA1000 offers two channels for signal input. There are four additional BNC connectors for an external trigger channel, external reference clock in, external reference clock out and acquisition status output. The LSA1000 can be "stacked" to provide more channels and parallel processing with multiple units. And multiple units can be synchronized using external reference clock connections.

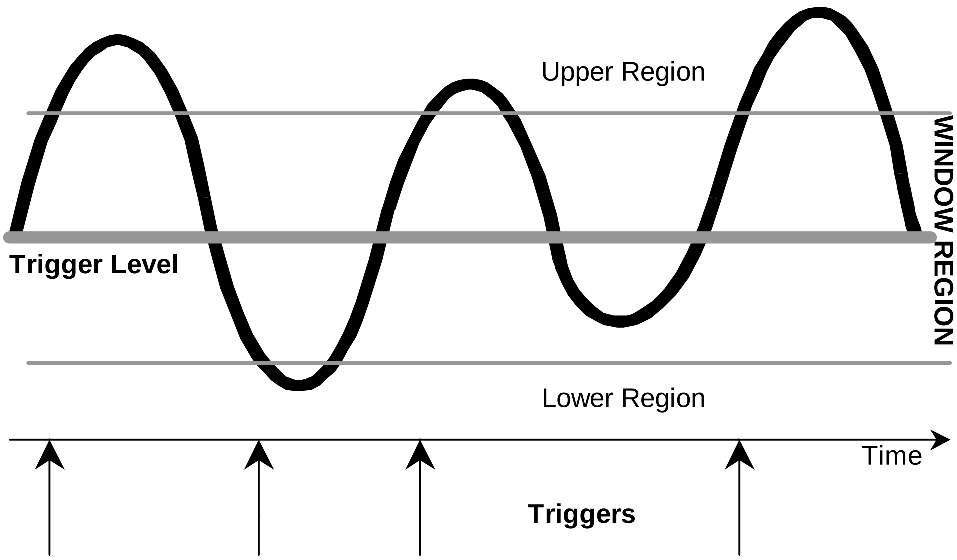
Triggering

Trigger rates of up to 1 GHz are possible with the LSA1000. Single Edge triggers are described by a source, coupling, slope, and level condition.

- **Source** is selected from:
  - CH1, CH2: the acquisition channel signal conditioned for the overall voltage gain, coupling, and bandwidth
  - EXT: the signal applied to the EXT TRIG IN BNC connector. It can be used to trigger the LSA1000 with an ECL signal level. The input impedance is 50 Ω, terminated to –2V. Optionally, this input can be configured to accept a TTL level signal. This configuration must be specified at time of purchase.
- **Coupling** refers to the type of signal coupling at the input of the trigger circuit. LSA1000 supports *DC* coupling on all sources, where all the signal's frequency components are allowed to pass through to the trigger circuit. This coupling mode is used for high-frequency bursts.
- **Slope** selects the direction of the trigger voltage transition that generates a trigger event. In addition to the two traditional choices of *Positive* and *Negative*, the *Window* mode is also included. In Window mode two trigger levels (one upper, one lower) are defined with the window region in between. Triggering occurs when the signal leaves the window region in either direction, *as shown in the diagram on the next page*.
- **Level** defines the source voltage at which the trigger circuit will generate an event (a change in the input signal that satisfies the trigger conditions). The selected level is associated with a trigger source in the same way as the coupling. Note that the trigger level is specified in volts and is normally unchanged when the vertical gain or offset is modified.

The amplitude and range of trigger signals and levels are limited as follows:

- ECL or TTL threshold crossing with EXT as trigger source.



Edge Window Trigger: trigger when the signal leaves the window region.

- With Ch1 or Ch2 as trigger ± 4 divisions. The trigger threshold on a channel is always normalized to the screen and is therefore affected by offset and Vrange. For default configuration of 1V FSR (125mV/div) and 0V offset, the achievable trigger levels are ± 0.5V.

Trigger Modes	
STOP	This command halts the acquisition in any of the three *re-arming* modes: Auto, Normal or Single. Issuing the STOP command prevents the LSA1000 acquiring a new signal. Issue STOP while a single-shot acquisition is under way and the last acquired signal will be kept.
AUTO	In Auto Mode: the LSA1000 automatically captures the signal without waiting for a trigger.
NORM	In Normal Mode, the LSA1000 will continuously capture the signal as long as a valid trigger is present. If not, the last signal is preserved.
SNGL	In Single-Shot Mode, the LSA1000 waits for a single trigger to occur, then captures the signal and stops acquiring.
DELAY	Used to adjust the pre- or post-trigger delay. Pre-trigger adjustment is available from zero to 100 % of the full time-scale in steps of 1 %. The pre-trigger delay is illustrated by the vertical arrow symbol at the bottom of the grid. Post-trigger adjustment is available from 0 to 10 000 divisions in increments of 0.1 of a division.
TIME/DIV	Selects the time per division. Each acquisition has ten divisions.
LEVEL	Adjusts the trigger threshold. The amplitude of trigger signals and the range of trigger levels is limited: ± 4 screen divisions with a channel as trigger source; the full scale range is divided into 8 divisions. Inactive with EXT as trigger source. The trigger sensitivity is better than a third-of-a-screen division.

Measure

Measuring signal characteristics and analyzing performance is at the heart of all test and measurement systems. Some instruments can measure parameters, but analyzing their statistics can be a time-consuming chore. LeCroy's parameter measurements and statistics allow worst-case analysis of performance and make the process much faster.

Parameters

The LSA1000 can determine certain signal properties automatically, using signal parameters. For common measurements on a signal, parameters can be measured in either in the amplitude or time domain. Most users measure the same waveform parameters, such as risetime, falltime, pulse width, overshoot, undershoot, peak voltage, peak-to-peak voltage, maximum, minimum, standard deviation, rms value, frequency, and period. The LSA1000's standard parameters are listed and described in Appendix C of this manual*.

Waveform Math

Waveform mathematics can yield final answers instead of raw data. For example, inputs from voltage and current transformers can be multiplied together to calculate power. An important LeCroy LSA1000 feature is the ability to 'daisy-chain' math functions: a power trace can be integrated to calculate energy, for instance.

* A wide range of additional parameters are available in the specialized software packages, such as WP03, described in those packages' Operator's Manuals.

Analyze

The LSA1000 has the added ability to process and analyze data *on-board*. Once the analog signal has been converted into digital data, the data can be analyzed either by the LSA1000's internal digitizer processor or by an external computer. Most current digitizers have a wide analysis spectrum built-in. Depending on its options, LeCroy LSA1000s offer a selection of the following analytical features.

Time Domain

The optional time domain waveform analysis package — includes summed averaging of up to one million sweeps, derivatives, logarithm, square root, absolute value, ratio, six digital filters and standard arithmetic operations.

Frequency Domain

Spectrum analysis greatly extends the LSA1000's processing power and offers two clear advantages over FFT (Fast Fourier Transform) analyzers: higher frequency components, and the ability to monitor both time and frequency information. Fourier transform converts sampled waveform information into a unique set of sine wave components. The data is usually plotted as amplitude vs frequency, exposing information not easily visible in the time domain (amplitude vs time). Ideally, it can be used for such analyses as measuring frequency components of communication signals and monitoring drift in an oscillator. The frequency resolution of an FFT is directly proportional to the number of time-domain points the FFT algorithm can handle.

Statistical Domain

The existence of measured waveforms in digital representations permits convenient use of the data inherent in those measurements. As well as analysis of signals in the frequency domain and the ability to perform mathematical operations and signal averaging on data, trends can be determined and *histograms* of the data analyzed.

The histogram is a graph of the distribution of values of a measured parameter. For example, when measuring the risetime of a repetitive signal for which all the measurements are equal, the histogram will be a straight vertical line without breadth. However, variations in risetimes create a plot with some horizontal structure, implying variations in the measurements. Your LeCroy LSA1000 is able not only to create such histograms, but also to allow measurement of their characteristics. This is extremely useful when analyzing pulse amplitudes, widths or timing jitter.

Other LeCroy analysis software packages include *JTA (Jitter and Timing Analysis)* and the specialized testing for magnetic media applications, *DDM (Disk Drive Measurements)*, *PRML (Partial Response Maximum Likelihood)* and *ORM (Optical Recording Measurements)*.

Transfer, Remote Control and Software

A 10/100Base-T Ethernet port is provided for control and transfer of data to and from the LeCroy LSA1000. Remote Control is via a subset of the standard LeCroy DSO remote commands with enhancements specific to the LSA1000. TCP/IP protocol is used for Ethernet communication. See the *Remote Control Manual*.

LeCroy's Versatile Instrument Control Protocol (VICP) allows much of the behavior of GPIB to be emulated using Ethernet.

Users can exercise the full functionality of LSA1000 from the host PC using the following easy-to-use software tools. These tools also simplify users' programming development for own specific applications.

An ActiveX control provides the basic connectivity interface to allow Windows to be able to send remote commands from a PC to the LSA1000 in its native form. Application programs such as Microsoft Excel may use the ActiveX controls to control and retrieve waveform data from the LSA1000 with minimal coding.

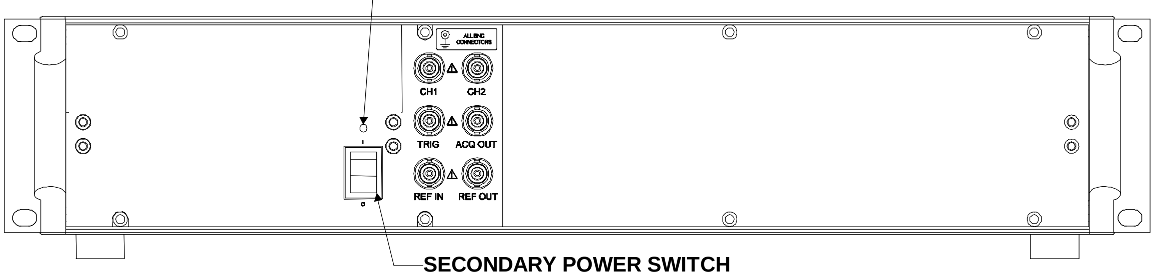
Remote LSA program provides a scope-like user interface with live waveform display on a PC. This familiar user interface makes initial performance verification of LSA1000 simple, even for first-time users.

The LSA1000 — Front and Back

Front Panel

- **CH 1 and CH 2:** signal input channels
- **LED Power Indicator:** indicates power on/off status
- **Secondary Power Switch:** power on/off switching
- **External Reference Clock In:** allows the instrument to be synchronized to an external 10 MHz reference.
- **External Reference Clock Out:** can be used to synchronize multiple units of LSA1000.
- **External Trigger In:** ECL or TTL swing level external trigger input
- **Acquisition Status Indication:** indicates the state of the acquisition system in binary format. On receipt of a trigger, the output goes to the HIGH state until the acquisition is complete at which time it will go LOW.

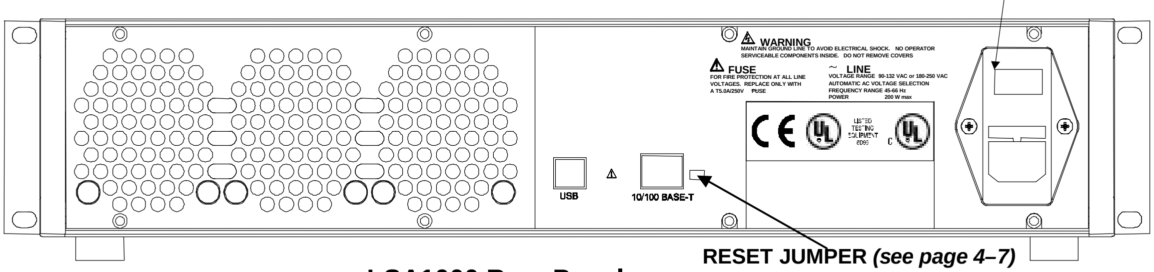
LED POWER INDICATOR



SECONDARY POWER SWITCH

LSA1000 Front Panel

MAIN POWER SWITCH



RESET JUMPER *(see page 4–7)*

LSA1000 Rear Panel

Rear Panel

- **Ethernet Interface Port:** to transfer data and to receive remote commands from the host computer
- **Main Power Switch**: power on/off switching
- **USB port:** Currently disabled. Provision for future enhancement.

***Note:** All six BNC connections may be located on the LSA1000 rear, rather than front, panel, depending on the instrument's mechanical configuration.*