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TECHNICAL DATA

LeCroy

2228A HIGH PRECISION TIME-TO-DIGITAL CONVERTER
2229 HIGH PRECISION TDC, ECL INPUTS
4204 MULTISOURCE TDC, SINGLE CHANNEL
4208 MULTIHIT TDC, WIDE RANGE

- **Full Scale Ranges from 100 nsec to 167 msec**
- **LSB from 30 psec to 2.56 µsec**
- **Single and Multiple Input Digitizers**
- **Single Hit, Multihit and Multisource Devices**
- **No (Real Time) or Very Low Conversion Time**
- **NIM, TTL and ECL Signal Level Compatibility**

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FLEXIBLE CONFIGURATIONS FOR PRECISE MEASUREMENTS

LeCroy time digitizers offer precise, fast measurements of time intervals in a large variety of industrial, government laboratory and university research environments. Applications for LeCroy time digitizers include time-of-flight spectroscopy, particle beam accelerator monitoring, Muon Spin Rotation measurements, laser induced chemical studies and digital signal analysis.

Electronic time interval measurement involves digitizing the time between two or more pulses. The first pulse is usually called START and the latter called STOP. For many devices a single COMMON input is used, against which INDIVIDUAL inputs are timed. Other configurations may also be employed. A MULTIHIT digitizer accepts a COMMON input, then digitizes several INDIVIDUAL pulses which arrive on the same cable. A second variation is called MULTISOURCE, where many inputs are present but only the first to arrive is digitized.

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Model 2228A and Model 2229 Octal Time Digitizers

The LeCroy Models 2228A and 2229 are Octal Time Digitizers packaged in single-width CAMAC modules. Internally, the 2228A and 2229 are identical. They differ only in that the 2228A accepts NIM level inputs while the 2229 requires complementary ECL (Emitter Coupled Logic) logic levels.

The Models 2228A and 2229 have eight independent channels, each of which measures the time from the leading edge of a common START pulse to the leading edge of its individual STOP pulse. Each channel disregards any STOP pulses received before a START signal and will accept only one STOP for every START.

Conversion begins upon receipt of the START signal and proceeds until one of the following: a STOP signal is received; the cycle is terminated by the application of a front-panel CLEAR signal; or the digitizer reaches full scale.

The 2228A or 2229 converts the measured time intervals into 11-bit digital numbers using a 20 MHz internal clock for a full-scale digitizing time of 100 µsec. Rear-panel control of full scale and conversion slope permits digitization to fewer bits and correspondingly shorter conversion time if desired. The conversion clock is started in phase with the TDC start signal to assure synchronization and eliminate the inaccuracy introduced by the free-running oscillators in conventional designs. A CAMAC LAM (Look-At-Me), if enabled, is generated at the end of the conversion interval to signal readout.

Three switch-selectable full-scale time ranges, 100, 200 and 500 nsec, are digitized to 95% of 11 bits (2048 counts) and provide 50, 100 and 250 psec resolutions respectively. Longer time ranges (up to 10 µsec) may be provided on request at slight expense of stability and accuracy.

On-line testing is facilitated by either a front-panel COMMON STOP input or by a CAMAC command. A signal at the COMMON STOP input generates simultaneous stops for each channel, permitting accurate testing of the module.

Excessive system dead time due to false starts may be eliminated through use of the FAST CLEAR input. Accepting NIM level signals, this input allows the digitizer to be cleared at any point in its conversion cycle without the necessity for CAMAC operations.

Model 4204 Multi-source, Time Interval Meter

The Model 4204 Time Interval Meter is a general purpose time measurement instrument designed for research and industrial monitoring applications requiring fast encoding or conversion times, high precision, and long time ranges.

In less than a microsecond, the 4204 encodes the measured time interval into a 32-bit word. By selecting the required resolution (down to 156.2 psec), a specific subset of 24 bits of the data word may be read. Several overflow options are included and both the designated overflow and an overall data offset can be set via CAMAC control.

An externally controlled fast routing system permits the acquisition of data in a time-resolved environment. The acquired data may be accumulated with a preprogrammed offset and then shifted by a fixed amount each time the externally triggered router is pulsed. A total of 256 time slices may be accumulated.

The 4204 may accept up to 16 different sources of STOP (or START) to make one time interval measurement. The 16 sources are OR'd together inside the module and an OR front-panel output is provided. This OR output may be used to STOP (or START) the digitizer. The pattern of the sources providing the STOP (or START) within a given time window is stored in the 4204 and is CAMAC readable. When more than one source is present within the time window, an overflow may be generated to reset the unit. Finally, the channel number of the active input may drive the router, permitting the acquisition of separate spectra for each input. This instrument is widely used in Muon Spin Rotation experiments.

The 1 MHz data throughput rate may be achieved, even without a fast data acquisition system, via a LeCroy Histogramming Memory Module (Model 3588) that can be connected via a front-panel auxiliary bus. The histogramming memories may then be read out at lower speeds via CAMAC or through the LeCroy Model 8901A, GPIB (IEEE-488) Interface. Data loaded into the histogramming memory units retain all the above features including programmable offset and router.

Model 4208 Wide Range, Octal Time Digitizer

The LeCroy Model 4208 Time Digitizer is designed to cover applications where time measurements must be performed in real time, and which require wide dynamic range with high resolution.

The 4208 has eight independent channels, each one measures the time from the leading edge of a COMMON input to the leading edge of its INDIVIDUAL input pulse.

Due to the design, Common Start Input Mode as well as Common Stop Input Mode can be used. The digitizer will encode input pulses preceding the COMMON input as negative times and input pulses arriving after the COMMON input as positive times.

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The 4208 also may operate as a single input, 8-hit time digitizer. In this strap-selectable mode, all eight inputs are cascaded. As each input is hit, it enables the next one. The unit also may be configured as a dual input 4-hit time digitizer, a quad double-hit time digitizer, or several other combinations of multihit.

The 4208 converts the measured time intervals into a 23-bit digital word plus a 24th sign bit. The sign bit indicates whether or not the COMMON input has preceded or followed the INDIVIDUAL input. This corresponds to a dynamic range of ±8.3 msec (which can be expanded with an external clock and appropriate logic circuits). See LeCroy Application Note AN-4002.

The module is equipped with a high stability crystal-controlled 125 MHz clock. The 1 nsec resolution is achieved by digital interpolation between two clock pulses. Dead time after an event has occurred is negligible and data readout can occur immediately after the event. An external clock input is provided to permit synchronous operation of several modules with an external 125 MHz time base.

Note that two other TDCs are available from LeCroy. The first is the Model 2277, 16-channel multihit and the other is the Model 4300B, 16-channel ADC in combination with a time-to-charge converter (Model 3420 or 4303). Please see separate data sheets for details.

SPECIFICATIONS

Model 2228A and 2229

2228A INPUTS

Stop Inputs: 8, one per channel, 50 Ω impedance; Lemo-type connectors; direct-coupled; input amplitude > -450 mV; ineffective unless preceded by a "Start" input. Can be cascaded by factory modification for multihit operation.
Common Start Input: One, common to all channels, 50 Ω impedance; Lemo-type connector; input amplitude > -450 mV.
Common Stop Input: One, common to all channels, 50 Ω impedance; Lemo-type connector; input amplitude > -450 mV; functions identical to individual "Stop Inputs" above; used for on-line testing.
Fast Clear: One input, common to all channels; Lemo-type connector; 50 Ω impedance; -450 mV or greater clears; minimum duration 50 nsec. Requires 1.4 µsec after start of clear signal to settle to 1 ±1 counts. (However, if the unit is always cleared at a fixed time before each start, it will settle to a constant offset with a small uncertainty, effectively permitting fast reset times on the order of 500 nsec.)

2229 INPUTS

Stop Inputs: 8, using a 2 x 8 pin connector (mates with LeCroy 403211016 or 3M 3452-6016 or equivalent); accepts differential ECL input levels; 110 Ω input impedance pin-to-pin; direct-coupled; inputs ignored unless preceded by a "Start" input.
Common Start Input: One, common to all channels, using a pin pair on the control group, 2 x 8 pin connector (mates with LeCroy 403211016 or 3M 3452-6016 or equivalent); accepts differential ECL input levels; 112 Ω input impedance pin-to-pin; direct-coupled; 5 nsec minimum width.
Common Stop Input: One, common to all channels, input characteristics identical to Common Start. Functions identical to the individual "Stop Inputs" above, used for on-line testing.
Fast Clear: One input, common to all channels; input characteristics identical to Common Stop except 50 nsec minimum width. Requires 1.4 µsec after start of clear signal to settle to 1 ±1 counts. (However, if the unit is always cleared at a fixed time before each start, it will settle to a constant offset with a small uncertainty, effectively permitting fast reset times on the order of 500 nsec.)

2228A AND 2229 GENERAL

Full Scale Time Range: 11-bit binary output corresponds to 100, 200, and 500 nsec nominal, switch-selectable (with longest range field-adjustable up to 1 µsec). Larger full scales possible by factory option up to 10 µsec (specify MOD200 for 1, 2, & 5 µsec full scale). Shorter range of 60 nsec is available as a factory option (2229/400). Both the full scale value and conversion slope are rear-panel adjustable, permitting faster conversion at the expense of range.
Integral Non-linearity: <±2 counts (20 nsec to full scale).
Differential Non-linearity: Channel widths vary by <±10% (10 nsec to full scale); <±30% for long-range option.
Time Resolution: 50 psec on 100 nsec range; 100 psec on 200 nsec range; 250 psec on 500 nsec range. Internal adjustments allow 500 psec resolution with 1 µsec full scale. A 30 psec resolution is available as factory option 2229/400.
Temperature Coefficient: Typically (±0.02% of full scale ±0.01% of reading) per degree C.
Digitizing Time: Approximately 100 µsec for 11 bits; rear-panel adjustable for fewer bits, shorter conversion time.
Readout Time: Readout may proceed at the fastest rate permitted by the CAMAC standard after digitizing is complete.
Test Functions: An internal start/stop is generated with approximately 80% of full scale time in response to an F(25) command. On-line testing and calibrations can be done with common start and common stop above.

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Data: The proper CAMAC function and address command gates the binary data of the selected channel onto the R(1) to R(11) (2^0 to 2^{10}) dataway bus lines. The full scale number of bits, and thus the conversion time, can be selected by a rear-panel pot and test point. (Conversion curve provided with unit.) The overflow flag is always presented on R(12).
Q and LAM Suppression: A module receiving no stop inputs will produce no Q response or LAM and appears during readout as an empty CAMAC slot, thus reducing readout time. A Command Accepted response is still generated. The Q and LAM suppress features can be disabled with side-panel switches.
Packaging: In conformance with CAMAC standard for nuclear modules. (ESONE Report EUR4100 or IEEE Report #583.) RF-shielded CAMAC #1 module.
Power Requirements: 25 mA at +24 V; 140 mA at -24 V; 600 mA at +6 V; 600 mA at -6 V.

Model 4204

INPUTS

Multi-Source Input: 16 in a rear panel, 34-pin connector; accepts complementary ECL pulses, 100 Ω input impedance; ECLine compatible; minimum pulse width 10 nsec; receives signals from 16 possible sources of STOPS (or STARTS). The leading edges of the inputs occurring during the gate time (GATE/INCR) will be registered. The channel number of the first hit is also recorded. This channel will be the one generating the time encoded into the TDC when the OR output is connected to the START or STOP input (see below). The channel number of the first hit also directs the internal router so the time data may be accumulated in separate histograms for each input source. If the router increment (see description of CAMAC function F(17)) has been set to 0, only one histogram is generated.
Start/Stop: Two paralleled Lemo-type connectors per function, for cascading START/STOP pulses; high input impedance (>50 kΩ), unused inputs must be terminated; independent threshold START and STOP input, adjustable by front-panel potentiometers, in a range -1.5 V to +1.5 V; threshold precision ±20 mV; two front-panel test points allow a 10 x threshold monitor; minimum pulse width 1 nsec. A side-panel switch permits selection of differential drive of the START and/or the STOP inputs. In this case each of the input connectors receives one pulse of the differential pair; input impedance 50 Ω AC each input to ground, 100 Ω DC between the two inputs; common mode swing ±2.5 V; fixed threshold ±10 mV; suitable for complementary ECL pulses. A second side-panel switch selects as START/STOP either the leading or trailing edges of the input pulses.
Gate Start, Gate Stop, Clear, Reset, Gate/INCR: Two paralleled Lemo-type connectors for each; high input impedance; accept positive or negative pulses, in particular NIM or TTL; threshold -0.4 V for negative, +1.4 V for positive pulses.
Gate Start: Applies a time window to the START pulse; a side-panel switch permits use of this input as a veto; minimum pulse width is 10 nsec.
Gate Stop: Applies a time window to the STOP pulse; a side-panel switch permits use of this input as a veto; minimum pulse width is 10 nsec.
Clear: A 10 nsec minimum width pulse, applicable at any time, permits the clearing of only the last event either being processed or already processed; clear time < 500 nsec.
Reset: Sets the router register to zero; in multi-source mode, clears the hit pattern word, and clears only the last event either being processed or already processed; clear time < 500 nsec minimum pulse width 10 nsec.
Gate/INCR: Increment the router register by a quantity fixed by the router increment register; minimum pulse width 10 nsec. When multi-source mode is used, acts as the GATE for the rear panel inputs; minimum pulse width 15 nsec.

OUTPUTS

OR: One Lemo-type connector producing NIM levels when terminated in 50 Ω; provides the logical OR of the 16 rear-panel multi-source inputs; must be connected to either STOP or START for multi-source operation. The time jitter of the OR output is less than 100 psec.
BUSY: Two paralleled Lemo-type connectors provide either 32 mA NIM outputs or 20 mA TTL outputs; side-panel switch selectable; the busy output changes state as soon as either a START or STOP input pulse arrives, and stays on until the conversion is finished; 8 nsec delay between input and busy signals. A front-panel BUSY LED monitor is provided. A side-panel switch permits selection of the BUSY interval to run from the START (STOP) to the STOP (START) time only.
Data Ready: Two paralleled Lemo-type connectors provide either 32 mA NIM outputs or 20 mA TTL outputs; side-panel switch selectable; the DATA READY output changes state as soon as data is ready to be read; the DATA READY is generated when both the GATE/INCR signal has ended and the conversion is finished. A front-panel DATA READY LED monitor is provided.
TIME OVF: Two paralleled Lemo-type connectors provide either 32 mA NIM outputs or 20 mA TTL outputs; side-panel switch selectable; the overflow output generates a pulse when the time has reached the preset overflow; also set in multi-source mode when more than one input has occurred on rear-panel connector. (See F(17) description.)

GENERAL

Time Range: ±167 msec maximum. Defined by 32-bit coding; any subset may be read out by appropriate CAMAC command to redefine the maximum time range. Circuit symmetry relative to START and STOP times permits negative time measurements.
Time Resolution: 156.2 psec minimum; 15 resolution ranges controlled via CAMAC, LSB ranging from 156.2 psec to 2560 nsec.
Precision: σ < 0.8 counts for 156.2 psec resolution. 10^{-6} long-term stability.

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