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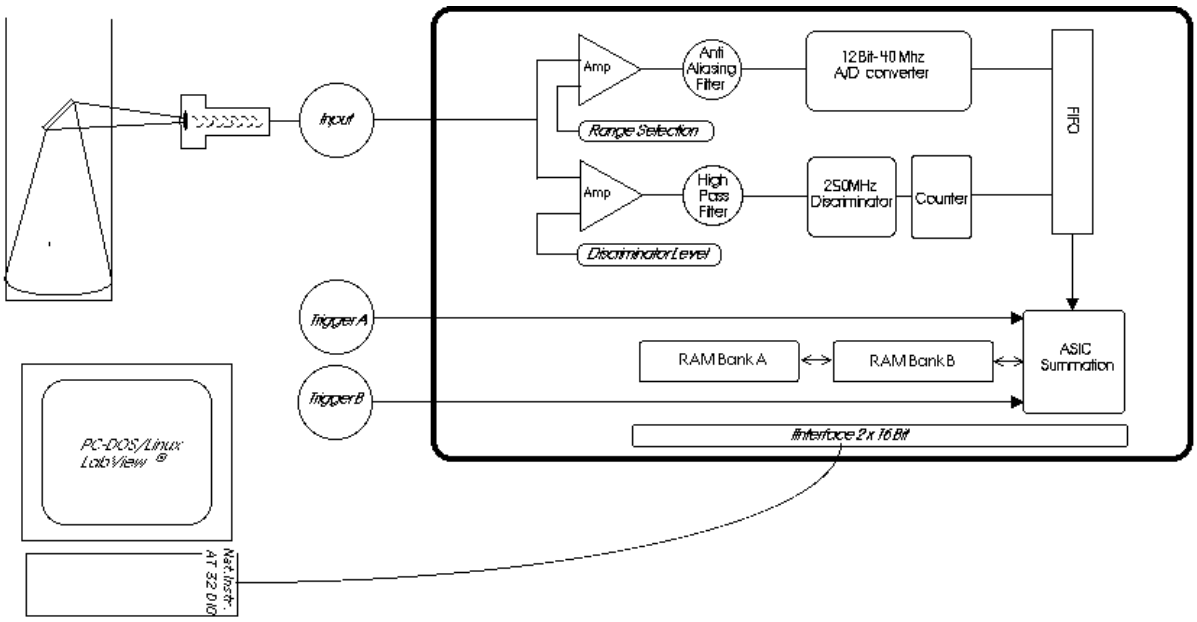
The Licel Transient Recorder

Concept

The Licel transient recorder is a powerful data acquisition system, especially designed for remote sensing applications. To meet the demanding requirements of optical signal detection, a new concept was developed to achieve the best dynamic range together with high temporal resolution at fast signal repetition rates.



For the first time analog detection of the photomultiplier current and single photon counting is combined in one acquisition system. The combination of a powerful A/D converter (12 Bit at 40 MHz) with a 250 MHz fast photon counting system increases the dynamic range of the acquired signal substantially compared to conventional systems. Signal averaging is performed by specially designed ASIC's which outperform any CISC- or RISC-processor based solution. A high-speed data interface to the host computer allows readout of the acquired signal between laser shots. The implementation of this concept makes the Licel transient recorder the state of the art solution for all applications where fast and accurate detection of photomultiplier, photodiode or other electrical signals is required at high repetition rates.

Applications:

- LIDAR (Light Detection and Ranging)
- LIF (Laser induced fluorescence)
- TDLAS (Tunable Diode Laser Absorption Spectroscopy)
- and other pulsed optical signal techniques.

Principle of operation

The Licel transient recorder is comprised of a fast transient digitizer with on-board signal averaging, a discriminator for single photon detection and a multichannel scalar combined with preamplifiers for both systems. For analog detection, the signal is amplified according to the input range selected and digitized by a 12-Bit-20/40 MHz A/D converter. A hardware adder is used to write the summed signal into a 24-Bit wide RAM. Depending on whether trigger A or B is used, the signal is added to RAM A or B, which allows acquisitions of two repetitive channels if these signals can be measured sequentially.

At the same time the signal part in the high frequency domain is amplified and a 250 MHz fast discriminator detects single photon events above the selected threshold voltage. 64 different discriminator levels and 2 different settings of the preamplifier can be selected by using the acquisition software supplied. The photon-counting signal is written to a 16-Bit wide summation RAM that allows averaging of up to 4094 acquisition cycles.

Detection of light signals ranging over 5 orders of magnitude

In remote sensing applications like LIDAR (Laser Radar) a photomultiplier looking at a laser pulse sent out into the atmosphere is driven close to saturation by the backscattered light from the near field, but a few hundred microseconds later it is required to detect single photons returning from a distance of 40 to 80 km. This high dynamic range of up to five orders of magnitude is one of the challenges in the detection of LIDAR signals as well as in other techniques like LIF (Laser Induced Fluorescence) or CARS (Coherent Anti Raman Scattering).

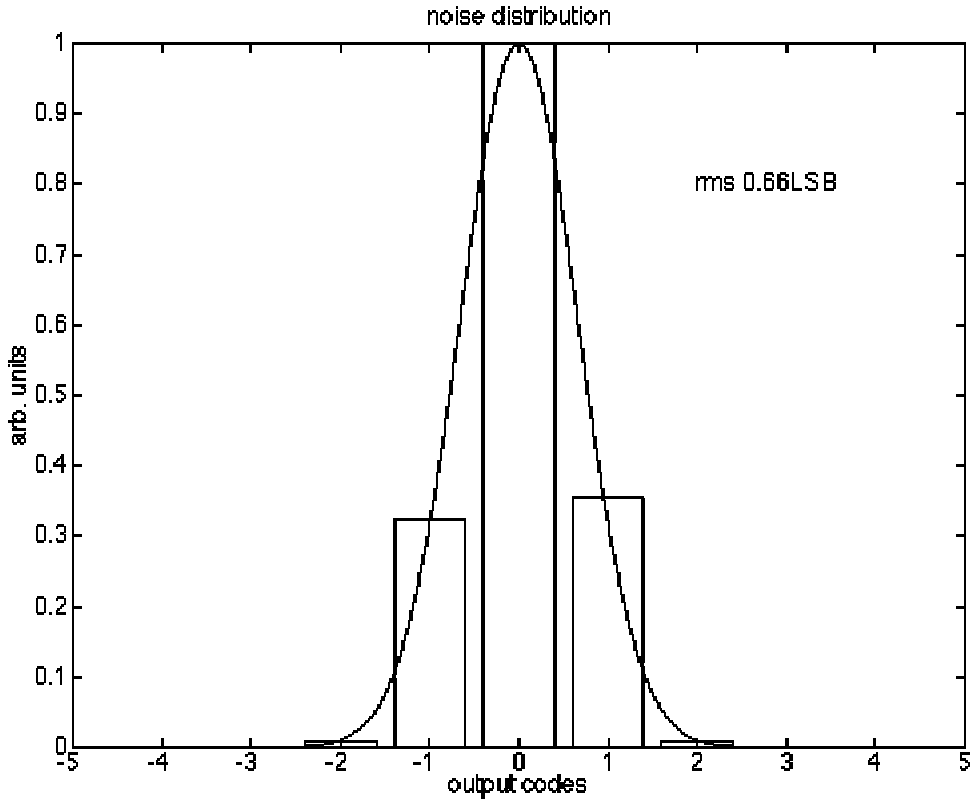
Usually, the detection system is optimized for measuring low-level light intensities using the single photon counting technique, but at higher light levels this approach results in nonlinear signal response. Analog measurement of the photomultiplier current is therefore necessary to increase the dynamic range.

Combined analog and photon counting acquisition

Analog and photon counting detection techniques require different signal conditioning. High speed and high gain amplification is needed for photon counting, whereas a strictly linear amplification below the Nyquist frequency of the A/D converter is necessary for analog measurement. Only the integration of two complete acquisition chains from the preamplifier to the summation memory will therefore enable one to combine both techniques for increased linear dynamic range. This has been done in the Licel transient recorder.

High end analog acquisition

The best 12-Bit A/D converter available at 40 MHz sampling frequency was used to build a high end transient digitizer with a signal to noise ratio greater than 74 dB up to the Nyquist frequency of 20 MHz. Carefully shielded preamplifiers for three different input ranges and a fast hardware adder can average up to 4094 shots of 200 µs or 400 µs (800µs at 20 MHz) signals to attain a maximum resolution of 0.03 µV (500 µV input range). Each sample is checked for overrange to control clipping in the average signal.



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Fast Photon Counting

The photon counting acquisition system includes a fast three-stage preamplifier and a discriminator with 64 threshold levels, controlled by the host computer. With a maximum count rate of 250 MHz, single photon counting is pushed to new limits when the selected photomultipliers are used. A time resolution of 50 ns without any dead time or overlap between two memory bins is reached by using a continuous counter together with a multichannel scalar burnt into the silicon of a custom designed ASIC.

Complete acquisition software

The Licel transient recorder is completely software controlled. Input ranges for analog and photon counting acquisition, discriminator levels and the Number of active bins can be selected. The acquired analog and photon counting signals for both summation memories can be read out separately. Data are transferred via a 2 x 16 Bit interface to a National Instruments DIO-32-HS family (PC) interface card.

Support of NuBus-cards has been discontinued, as they are not listed anymore in the NI catalog. The data transfer rates are 800 KB (PC/486 DX2-66) using DOS and 500 KB using LabVIEW. Up to 16 Transient recorders can be controlled by one interface card. A ready-to-use LabView Interface comes with each Licel transient recorder. It can be run on the PC/Windows platforms. Software drivers and acquisition programs for PC/Linux are supplied.

Specifications

In/Outputs:		Spurious free dynamic range:	74 dB
Signal input:	BNC, 50 Ohm, front panel	S/N single shot:	66 dB@ 100 mV input range (100mV)
Trigger A:	BNC, 50 Ohm, front panel	Memory depth:	8192 or 16 384 bins
Trigger B:	BNC, 50 Ohm, front panel	Summation memory:	2 channels
Host I/O:	50-pol bus, back panel		4094 acquisitions
Indicators:	-Analog input range	Repetition Rate:	150 Hz for 400µms signals,
	-Signal overrange		75 Hz for 800µs signals
	-Trigger and Host I/O	Protection:	Diode clamped
	Environmental:	Input impedance:	50 Ohm
Power:	230V/50 Hz or 110V /60Hz, 12 W per transient recorder.	Coupling:	DC
Operating temperature:	+10º to + 40º C	Trigger Delay and Jitter:	50 ± 12.5 ns
Storage Temperature:	-30º to + 70º C		

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Humidity:	0 to 95%, non-condensing.
Dimensions:	Each transient recorder is mounted in a RF-shielded cassette 50.4x262x232mm. Systems up to 6 channels are mounted in a 448.6x 311.5 x 361mm housing for 19" rack mounting.
Analog acquisition:	
Signal input range:	0... -20, -100, -500 mV
A/D Resolution:	12 Bit
Sampling rate:	20 MSPS/40 MSPS
Lidar spatial resolution:	7.5 m / 3.75 m
Bandwidth:	DC-10/20 MHz
A/D differential nonlinearity:	typ. 0.65 LSB
	max. 1.25 LSB @25º C
A/D integral nonlinearity:	typ. 1 LSB @25º C

Photon Counting Acquisition:

Max. count rate:	250 MHz
Threshold:	0... -20 mV
	0... -100 mV
Discriminator:	64 levels for each input range, software controlled
	4094 acquisitions
Input impedance:	50 Ohm
Bandwidth:	10 MHz - 250 MHz.

no dead time or overlap between bins.

Trigger:

2 Trigger inputs to acquire signals in 2 separate summation memories.

Impedance: 50 Ohm

Threshold and slope 2.5 V, positive

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