Riga Event Timers: principles of operation and performance characteristics

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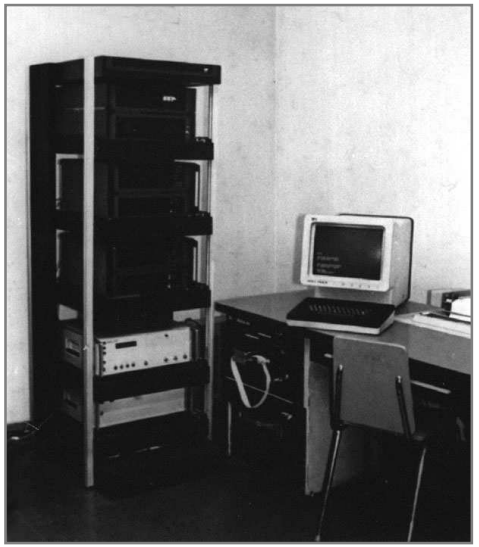
~6.36 ms Time of Light Flight from Grasse to Riga

First Riga Event Timer

The 1st Riga Event Timer has been developed 25 years ago in the framework of creating the Soviet network “Crimea” for the Moon and satellite laser ranging*. The Event Timer concept has been chosen as only one way to provide the Moon ranging at 10 Hz repetition rate.

3 independent channel
100 ps single shot RMS resolution
Built-in range gate generator
10 Hz measurement rate
Controllable laser firing
System controller: computer “Electronika-60” (LSI-11)



Event Timer of the “Crimea-1” station

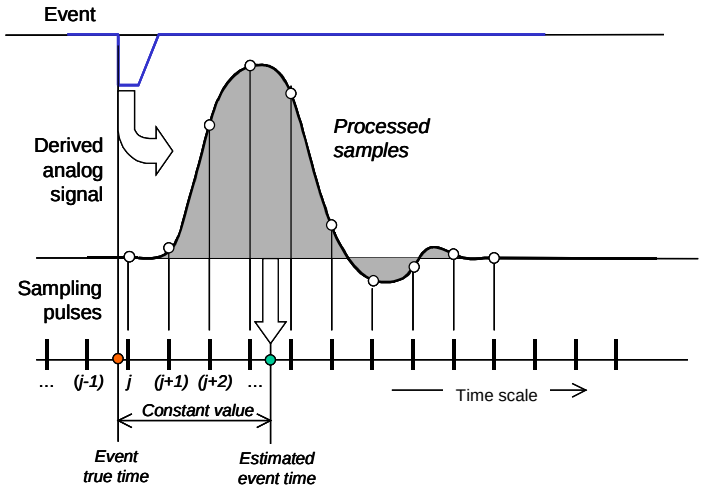
* Reference:

Abalakin N.K., Abele M.K., Artyukh Y.N., Basov N.G. et al. Laser network designed for the Moon and artificial Earth satellite ranging // Proceedings of International Conference on Earth Rotation and Terrestrial Reference Frame. - Columbus (USA), 1985. - Vol.1, part II.- p.246-256.

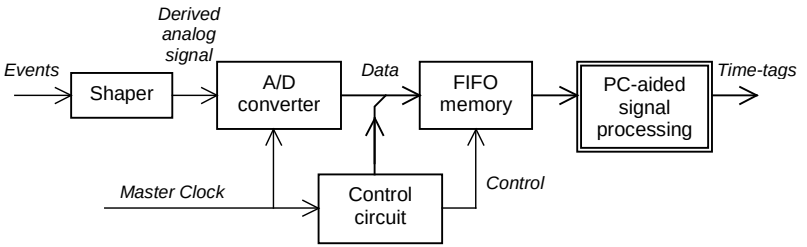
In view of high complexity (and cost) of the event timer systems built on the basis of the available conventional techniques, in the beginning of 1990ies we have developed and applied a new EET-method for event timing to create the event timers which has much simpler hardware and could provide good performance characteristics at reasonable price.

EET-method for Event Timing

According to the EET-method (i.e., Enhanced Event Timing), each input event (pulse edge) is converted to a derived analog signal. Actually this simply is generation of such a signal at the time instant defined by the respective input event. Then this signal is digitised using a typical A/D converter and digitally processed to estimate its position relative to the periodic sampling pulse sequence. For example, this can be an estimation of the gravity center of the derived signal.



Time diagram of the EET-method



Block diagram of the EET-method realisation

Advantages:

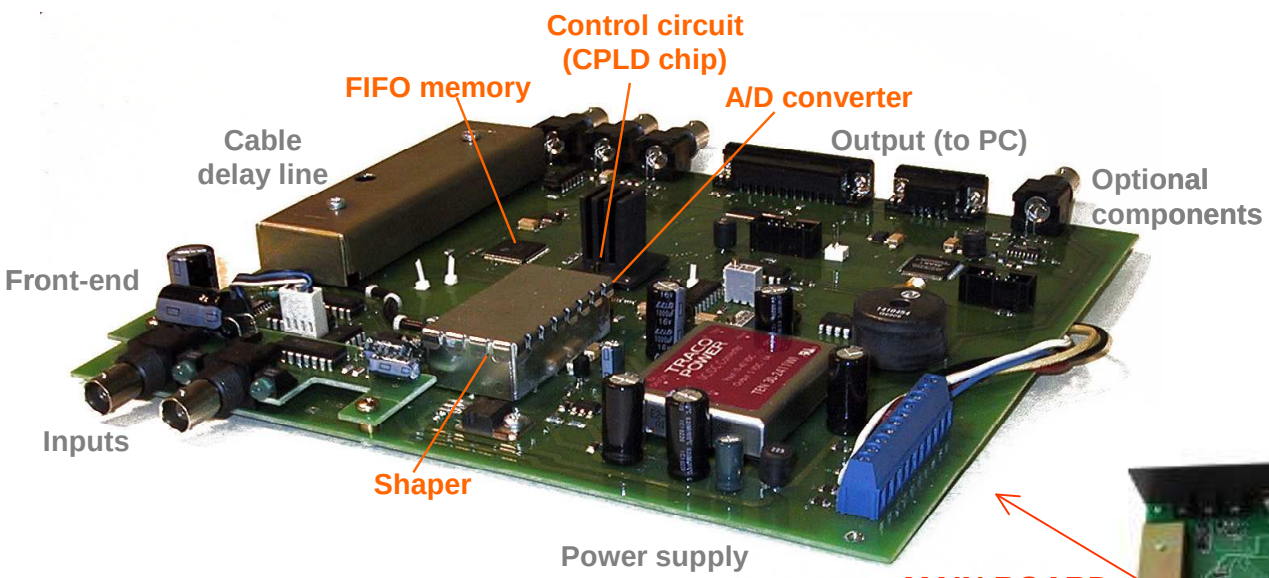
Good performance characteristics are combined with hardware simplicity where highly specialized circuits are almost fully replaced by typical DSP facilities.

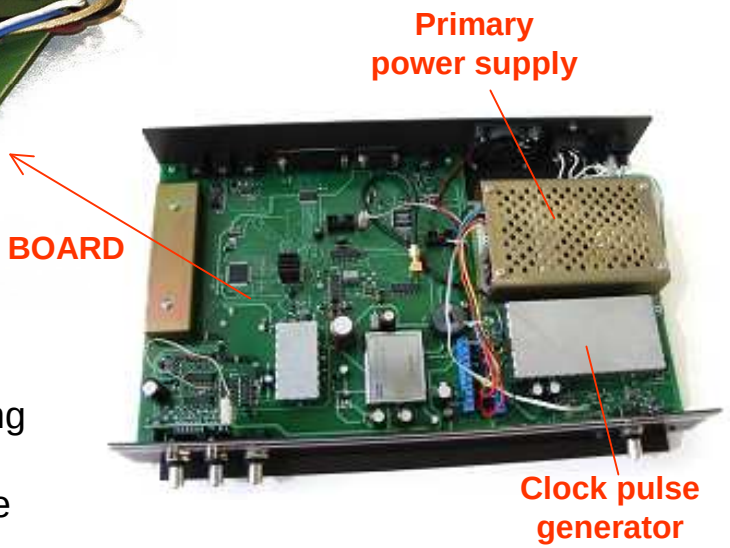
Limitations:

Certain computing facilities have to be used for practical realisation of the method.

The basic principle of the EET-method seems to be simple. However there are many essential realisation details with so as to achieve the good final result. Specifically, it is important to choose correctly the shape and basic parameters of the derived analog signal; it has to be well matched to the algorithm used for involved processing.

Example of hardware implementation (A032-ET model)

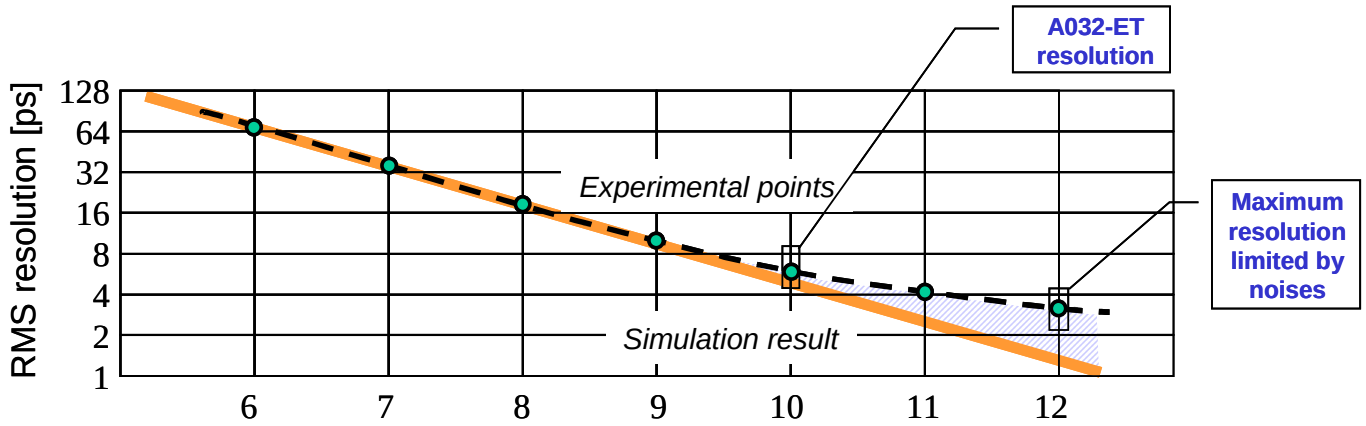




The main board of the A032-ET Event Timer is built on the basis of commonly used integral digital components, including Complex Programmable Logic Devices (CPLD) applied for integral implementation of the control circuit. Operation of the shaper is based on the well-known principle of capacitor's charge/discharge; an ordinary cable delay line is used for stabilization of the derived signal duration. On the whole that results in compact and relatively simple hardware

Performance characteristics of the Riga Event Timers

Timing Resolution: the standard deviation of the difference between two time-tags. It depends on the resolution of AD-converter and internal noises (such as interferences, clock jitter, residual non-linearity and the like). The last ones limit the maximum timing resolution down to 3-4 ps.



Dead time: the time after each recorded event in which the event timer is not able to record another event if it happens. It is defined by the derived signal duration. Typically the dead time for the Riga event timers is about 5-6 periods of clock pulses providing the signal sampling (60 ns for the A032-ET).

Maximum Burst Rate: the maximum measurement rate for a specified amount of sequential events. It is limited by the dead time (the A032-ET provides 15-17 MHz for 12,000 events).

Maximum Average Rate: the maximum rate of long-term continuous event timing. It is limited mainly by the available speed of data transfer to PC (10-15 KHz for the A032-ET via PC parallel port).

About specification of promising Event Timer for SLR applications

Seemingly the Riga Event Timer A032-ET corresponds to the current demands of SLR applications. Specifically, more than ten units of it have been ordered and already delivered to ILRS partners during last few years.

However there are real possibilities to achieve the better performance characteristics (resolution, measurement rate, etc) for the next model of Riga event timers.

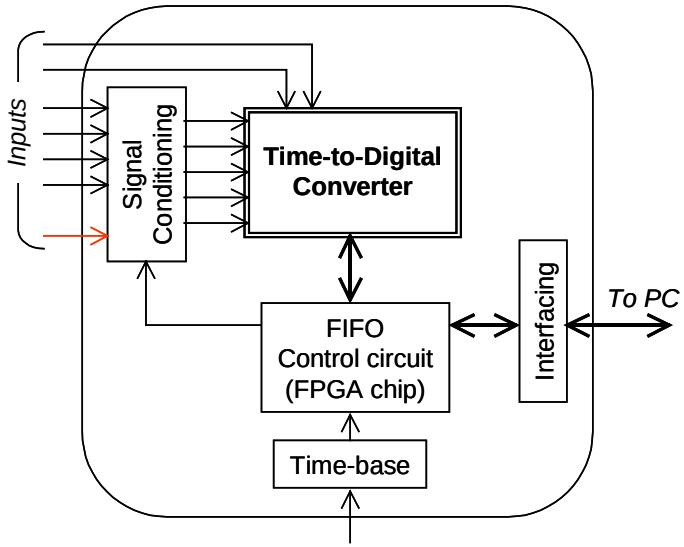
Is it possible to define some typical specification of promising Riga Event Timer that could be the most-used one for SLR applications in the future?

	A032-ET	A0XX-ET
Number of inputs	2	?
Input signal specification	NIM pulses	?
Resolution	7-8 ps	?
Dead time	60 ns	?
Maximum average rate	10-15 KHz	?
Interfacing	PC parallel port	?
Operating modes	True timer & Time Interval	?
Housing	Desktop	?
Other features (such as gate delay generation, internal time-base, etc)	Gate delay generation	?
Unit price	<10,000 EUR	?

If “YES”, we’ll be ready to allow for these demands in our further activity.

High-speed Riga Event Timers

Currently available integral high-performance Time-to-Digital Converters (e.g. TDC-GPX from «Acam-messelectronic gmbh») provide good basis for creating of high-speed multi-channel event timers. This is an additional direction to designing of Riga event timers which could be offered in the nearest future.



Preliminary specification of TDC-based event timer

	A071-ET
Number of inputs	1 (start) + 6 (stops)
Signal conditioning	Controllable threshold for 5 inputs
Resolution	90 ps
Dead time	6.5 ns for each input
FIFO depth	2560 events
Maximum average rate	3.5 MHz
Operating modes	True timer & Time Interval
Gate delay generation	25 ns LSB
Fire/Stimulus generator	1Hz - 100KHz
Interfacing	USB (high-speed)
Housing	Desktop (160x220x50 mm)
Preliminary unit price	<5,000 EUR