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## Event Timing System for Riga SLR Station



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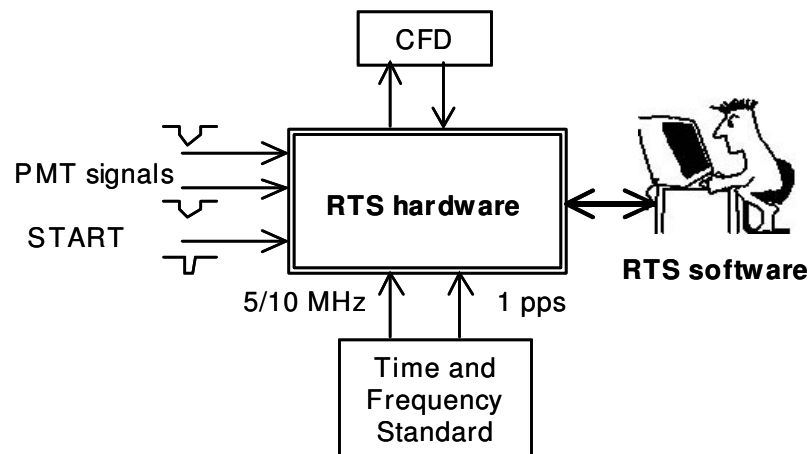
## COMMON DATA

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The Riga Timing System (RTS) is designed and built in 2006 for SLR station Riga-1884 to improve its measurement equipment in precision, functionality and reliability in operation.

The main lines of the design:

- New platform for timing measurement
- Hardware integration
- New software implementation
- Functionality extension



The RTS is a multimode instrument supporting:

- Satellite Ranging at 10 Hz repetition rate with parallel measurement of PMT-pulse amplitudes for range-bias correction. There is a special measurement mode when the satellite range overlaps the repetition period (100 ms)
- SLR system calibration in the target range from 9 to 375 m with parallel measurement of PMT-pulse amplitudes
- Integrated mode when the above system calibration and satellite ranging are performed simultaneously
- Measurement of PMT pulse noises

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The RTS supports millimetre accuracy of SLR although the overall system accuracy is currently limited by the performance of other equipment of Riga SLR station.

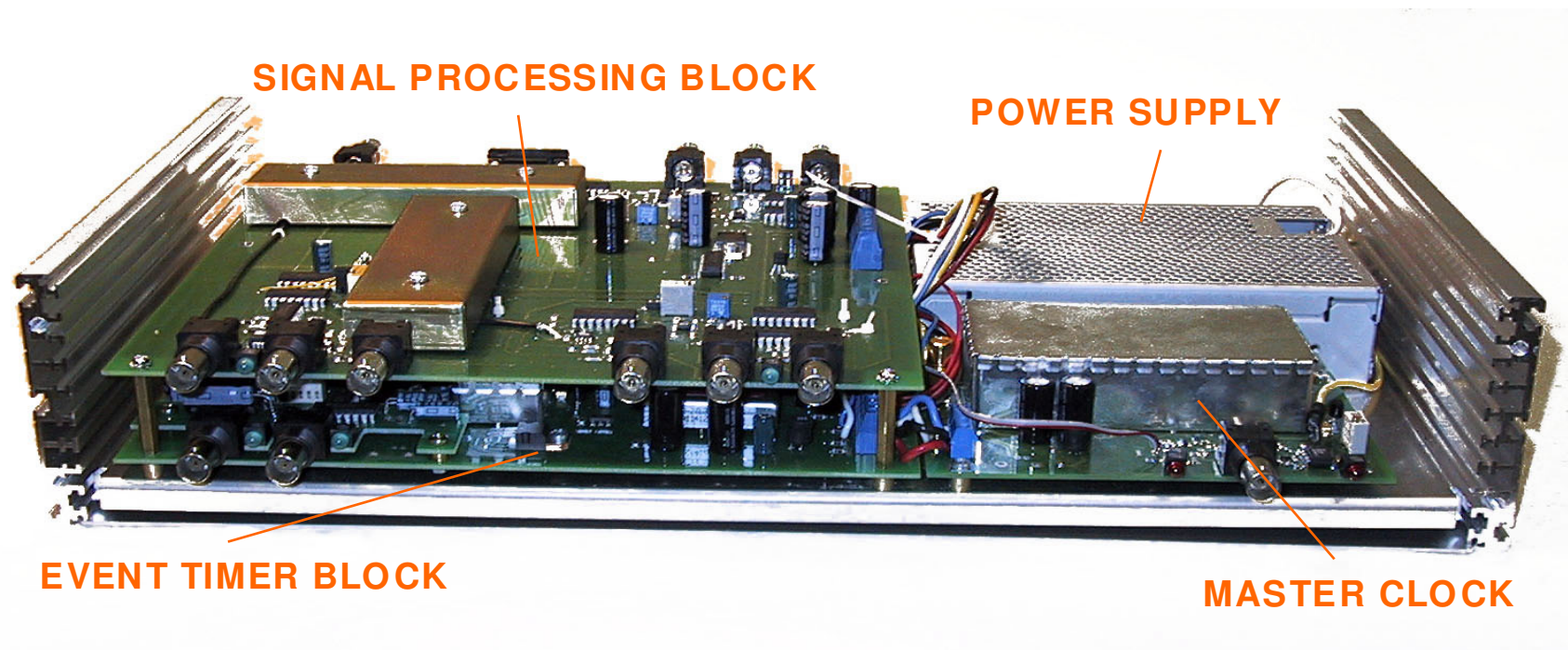
## RTS HARDWARE

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The RTS hardware is a stand-alone device containing three functional units:

- Event Timer Block
- Signal Processing Block
- Master Clock (PPL based low-jitter frequency converter 5/10 to 100 MHz)

Each block is implemented as a separate board. These boards and power supply are housed in 19" 2U rack module.



## RTS HARDWARE. Event Timer Block

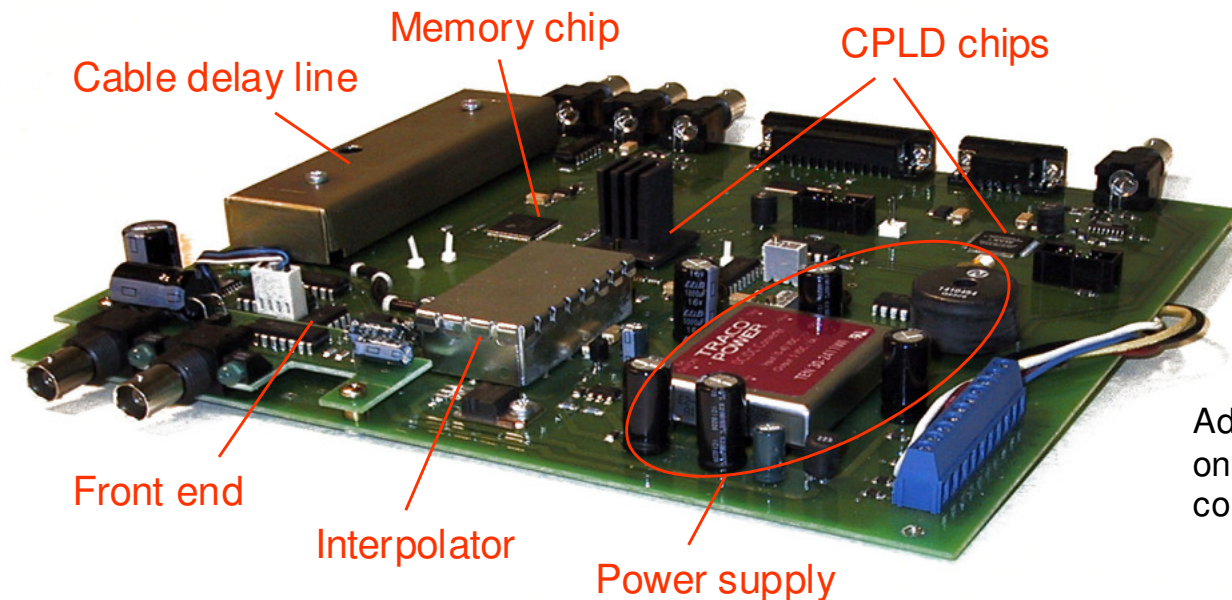
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The Event Timer Block is the same as for the latest model A032-ET of Riga Event Timers [1] and provides the similar performance of timing measurement:

- Single-shot RMS resolution    8 ps
- Dead time                            60 ns
- Non-linearity                        <1 ps
- FIFO depth                          12 000 time-tags
- Epoch time-tags, multi-stop measurement, built-in online programmable gating with 10 ns LSD resolution

References:

The Model A032-ET of Riga Event Timers.  
Presented at this Workshop



Advanced technique of event timing provides not only high-performance characteristics but compact implementation as well.

## RTS HARDWARE. Signal Processing Block

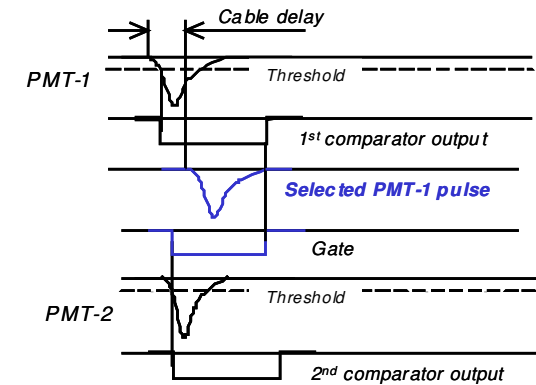
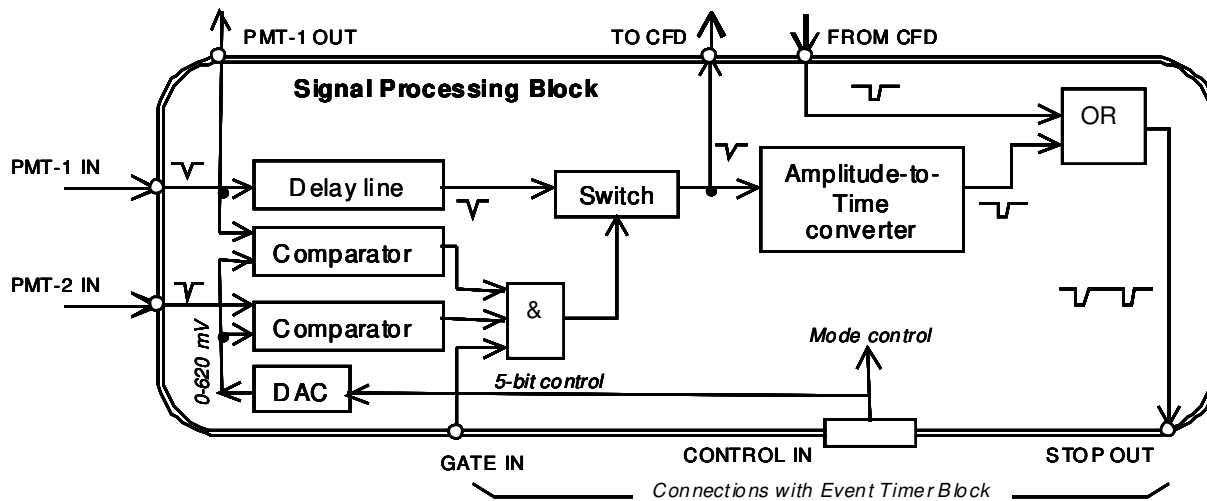
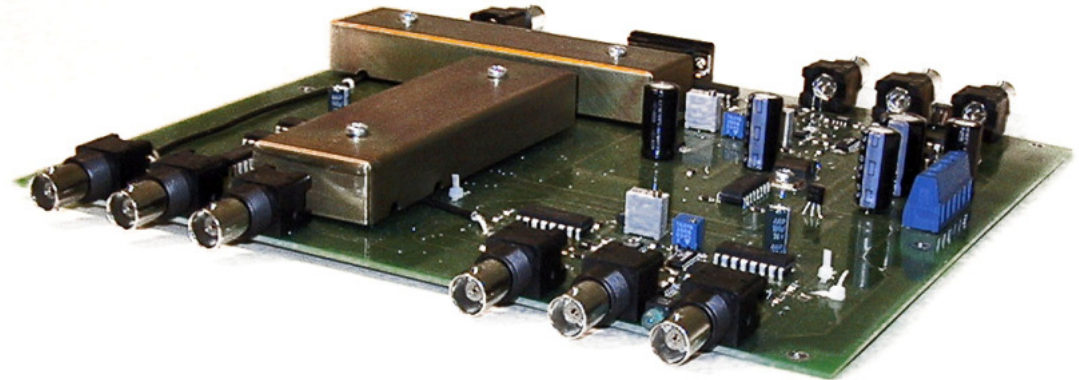
The Signal Processing Block provides:

- Selection of PMT pulses from doubled receiver (the PMT pulses overlap only when the true returned laser pulse is being received) [1]
- Conversion of PMT pulse amplitude into time event to measure it by the Event Timing Block (in parallel with basic measurement) for further range bias correction [2]

References:

[1] ILRS 2003-2004 Annual Report, p. B-38.

[2] PMT signals caused range-bias correction at the SLR Station Riga-1884. Proceedings of the 12th International Workshop on Laser Ranging.



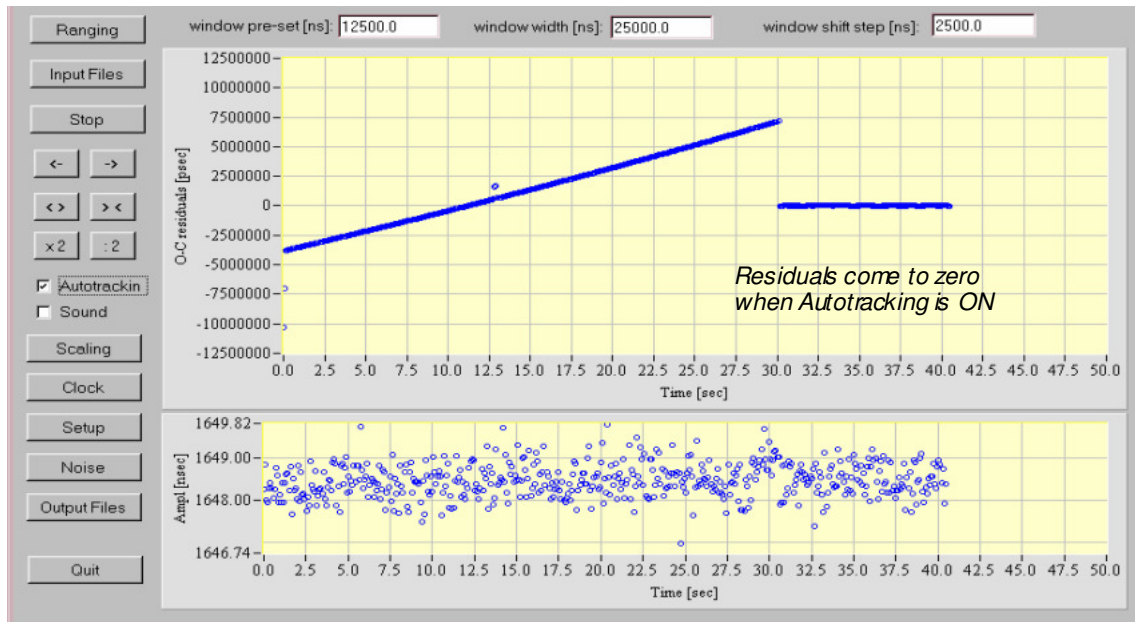
**Primary PMT pulse selection.** There is an adjustable limit for allow able mismatch of paired PMT pulses to perform reliable selection of the true return.



# RTS SOFTWARE

The real-time RTS software is a 32-bit application written in C language for LabWindows/CVI ver.6.0. The software executes under MS-Windows XP using PC with 1GHz or faster processor and at least 512MB of RAM. The software is able to support the repetition rate of reliable RTS operation up to 50 Hz.

The RTS graphical user interface provides system control and displaying the measurement results in form of residuals and Stop pulse amplitudes.



There is a real-time correction of gate delay (autotracking). It is based on the median selection of current residuals to exclude their possible abnormal values and on continuous generation of a piecewise-linear correction function. Every piece of this function is determined using regression analysis of the current fraction of residuals.

## Summary specifications

Inputs (BNC):	PMT-1 IN	PMT pulse (negative; 3 to 7 ns FWHM; 0.1 to 3 V amplitude)	
	PMT-2 IN	PMT pulse (negative; 3 to 7 ns FWHM; 0.1 to 3 V amplitude)	
	START IN	NIM pulse (falling edge; falling time <2 ns; >5 ns width)	
	FROM CFD	NIM pulse (falling edge; falling time <2 ns; >5 ns width)	
	1pps TTL pulses (rising edge)		
	REF IN	5/10 MHz (>0.5 V p-p)	
Output (BNC):	TO CFD	PMT pulse (negative; 3 to 7 ns FWHM; 0.2 to 6 V amplitude)	
	PMT-1 OUT	PMT pulse (negative; 3 to 7 ns FWHM; 0.1 to 3 V amplitude)	
Single-shot RMS resolution of NIM pulse measurement:	8 ps		
Dead time:	60 ns		
Non-linearity error:	<1 ps		
Offset temperature stability:	1ps/°C		
Resolution of PMT pulse amplitude measurement:	9 bits		
Warm-up period:	3 hours		
Measurement rate:	10 Hz		
Time-base:	external - either 5 or 10 MHz (selectable)		
Stop pulse gating:	online programmable (10 ns LSD, 60 ns to 167 ms range)		
Special features:	a) preliminary selection of PMT pulses b) auto-tracking the Satellite in range after its acquisition c) range bias correction based on PMT pulse amplitude measurement		
Input/Output data:	data files in specific formats		
User's system control:	via PC graphical interface		
Hardware interface:	via PC parallel port supporting EPP mode		
Software:	MS-Windows based		
Hardware dimension, weight:	19" 2U rack module; 4.0 kg		
Hardware power supply:	100-240 VAC		

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## **Conclusion**

As compared to the previous version of Riga timing system, the RTS offers considerably better performance in terms of accuracy, functionality, and reliability in operation and provides a good basis for further advancing the Riga SLR Station as a whole.

Currently the RTS is under trial operation and software debugging; the first series of successful SLR results has already been obtained.