The Model A032-ET of Riga Event Timers

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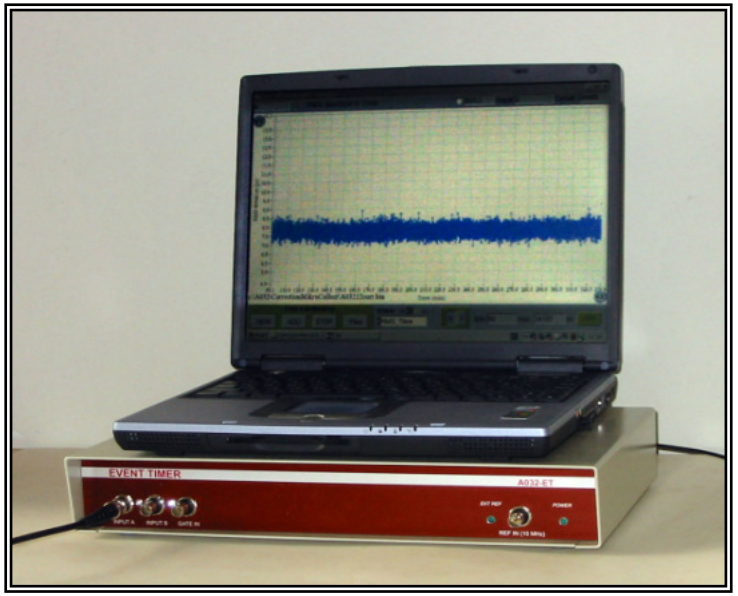


"If we truly wish to have 1mm systems we must migrate away from the interval timers in common use amongst the SLR community and convert to epoch timers. However epoch timers are very expensive and time consuming to build. A viable alternative may well be the Riga timer which is very affordable..."

From "Summary of ILRS Technical Workshop"
(Eastbourne, Great Britain, October 3-7, 2005)

INTRODUCTION

Riga Event Timer A032-ET was designed in 2005 as an advanced version of the previous model A031-ET with the main aim to tailor it to KHz SLR and, in passing, advance its some operating characteristics.

As compared to the previous model, the A032-ET offers:

- Continuous measurement at mean rate up to 10 KHz and burst rate up to 16 MHz
- Client-Server interaction and fully remote control from the Client
- Better single-shot resolution (<10 ps RMS)
- Smaller “dead time” (60 ns)
- Built-in online programmable Stop-pulse gating

At the same time the A032-ET satisfies basic demands of conventional (low-rate) SLR and remains affordable. Thus currently the A032-ET fully replaces the previous model.

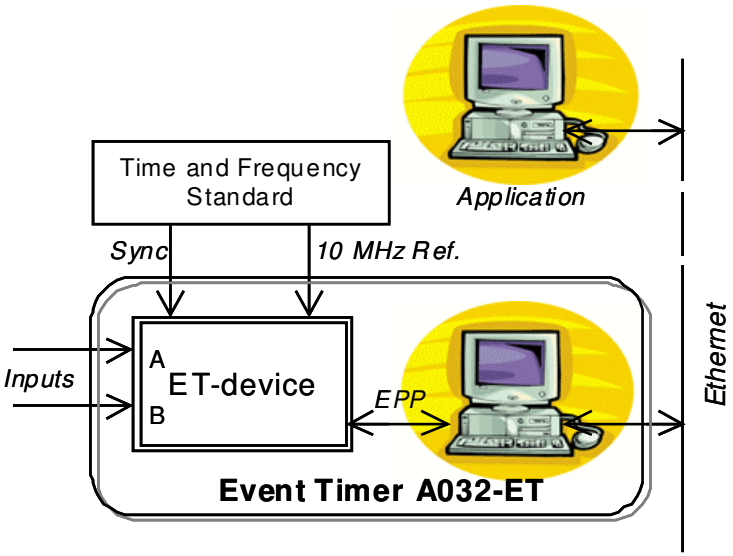
The A032-ET is already known for some part of ILRS partners from private contacts; during last year ten units of this instrument have been delivered for SLR applications. However we still did not inform about it more broadly. For this reason the principles of operation and basic features of the A032-ET are further considered in more details. The consideration is focused on precision characteristics since these are of primary interest for potential users.

A032-ET ARCHITECTURE

The Event Timer A032-ET is a computer-based instrument that precisely measures the times when events (input pulse comings) occur. First and foremost the A032-ET is designed for applications related to SLR, although it can be also well suitable for other applications.

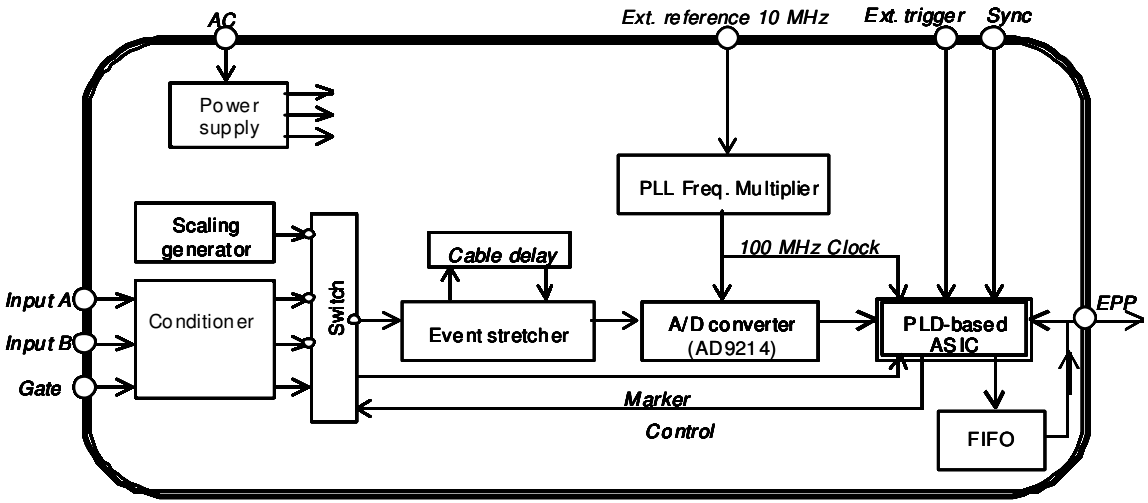
There are two alternative modes of A032-ET operation:

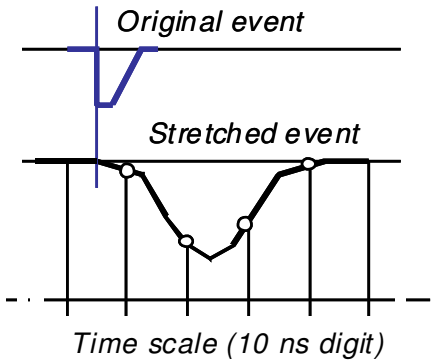
- **"True Timer"** provides continuous (gapless) measurement of events at high (up to 10 KHz) mean measurement rate, allowing bursts of the rate up to 16 MHz. This option is well suitable to measure the overlapped time intervals between Start and Stop events that come at the separate inputs (either *A* or *B*) of the Event Timer in any order.
- **"Multi-Stop Counter"** provides cyclical measurement of events that come at the separate inputs of the ET-device in the strict order: in every cycle at first the Event Timer measures a single Start event coming at the input *A*, and then - a user-defined number of Stop events (up to 12,000) coming at the input *B*. The Stop events can be measured within internal online programmable gate.



The A032-ET interacts with user's application programs via the network, providing overall remote control and remote applications in multi-user mode. As a result the A032-ET combined with user-made or custom-made application program can be used to create various top-quality and reasonably priced timing systems.

Schematic block diagram



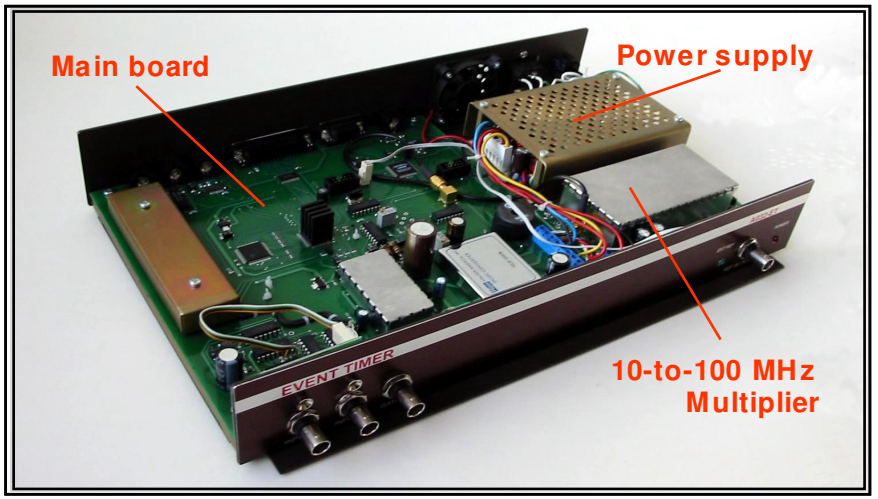


Interpolation measurement is based on so called "Event stretching". It is simply a generation of bell-shaped pulse locked to the input event time. The samples of this pulse define its location on time axis.

Main distinctive features:

- Advanced method of interpolation measurement that provides both high speed (60 ns "dead time") and high resolution (<10 ns RMS)
- Emphasis on commonly available DSP facilities, resulting in compact and inexpensive hardware design

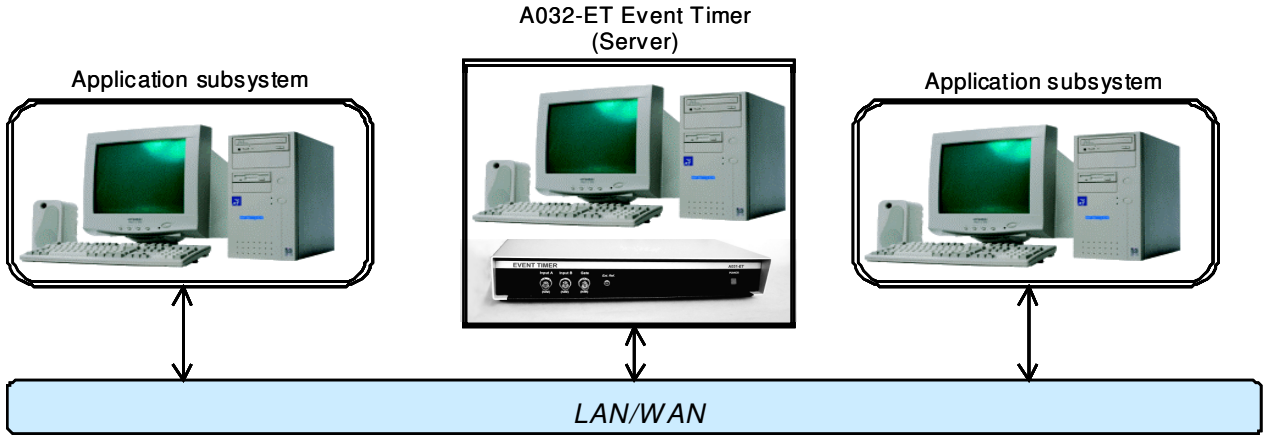
Hardware design



A032-ET SOFTWARE

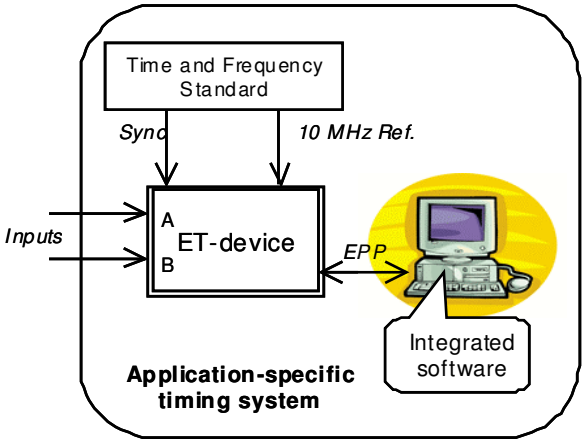
There are two basic kinds of the A032 software:

- Server application A032.1 provides **"True Timer"** for network applications
- Server application A032.2 provides **"Multi-Stop Counter"** for network applications



The DEMO Client software (source code) is added to each above Server software to illustrate the manner in which user can create own specific application

Additionally there is the Sample program (source code in *C*). This program defines device-specific software functions which can be directly built in the user-made software to interact with the A032-ET hardware when user creates own timing system based on integrated software.



Introduction to the tests

The Event Timer A032-ET provides extreme precision, exact determining of which in commonly certified way is impossible or, at least, very difficult. For this reason particular methods have been developed for reliable precision testing of the A032-ET in process of their manufacturing. Details of these methods are available on request.

Although in fact the A032-ET measures the separate events, its precision is specified for time interval between two measured events. In this case the total measurement error Δ_{Tj} for time interval T_j represented by difference of any two time-tags can be expressed as follows:

$$\Delta_{Tj} = B(t) + E(T_j) + \xi_j,$$

where:

$B(t)$ – time-varying offset in measurement;
$E(T_j)$ – non-linearity error that depends on the value of measured time interval;
ξ_j – unbiased random error.

Specific values of these components of measurement error completely specify the A032-ET precision for the most applications and are evaluated for each instrument before its delivering.

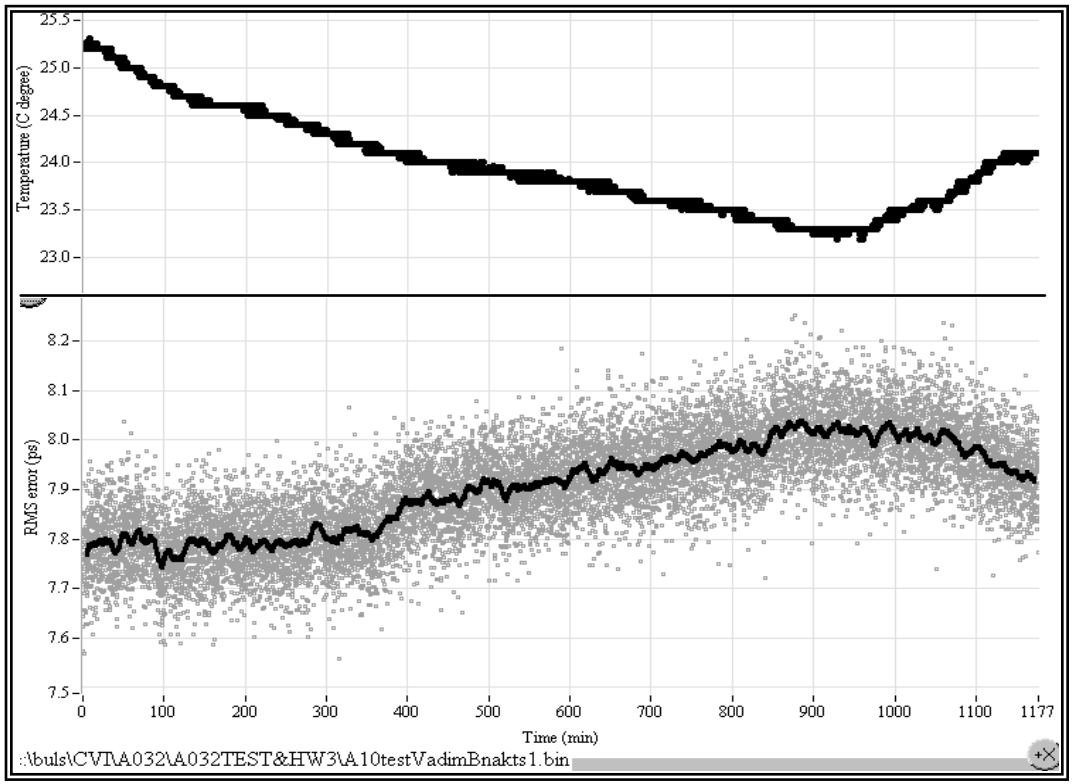
As for the errors caused by the reference frequency instability and the trigger errors, they are beyond the scope of the A032-ET specifications since the A032-ET usually uses an external source of the reference frequency and measures events presented by the normalised pulses.

A032-ET PRECISION CHARACTERISTICS

Single shot RMS resolution

The A032-ET provides measurement results with 1 ps LSD resolution. However the standard deviation of the time interval between measured events (RMS resolution) usually is much greater and characterizes the practicable measurement precision more adequately.

The best resolution is provided directly after calibration; then it can slightly degrade under time-varying temperature conditions.



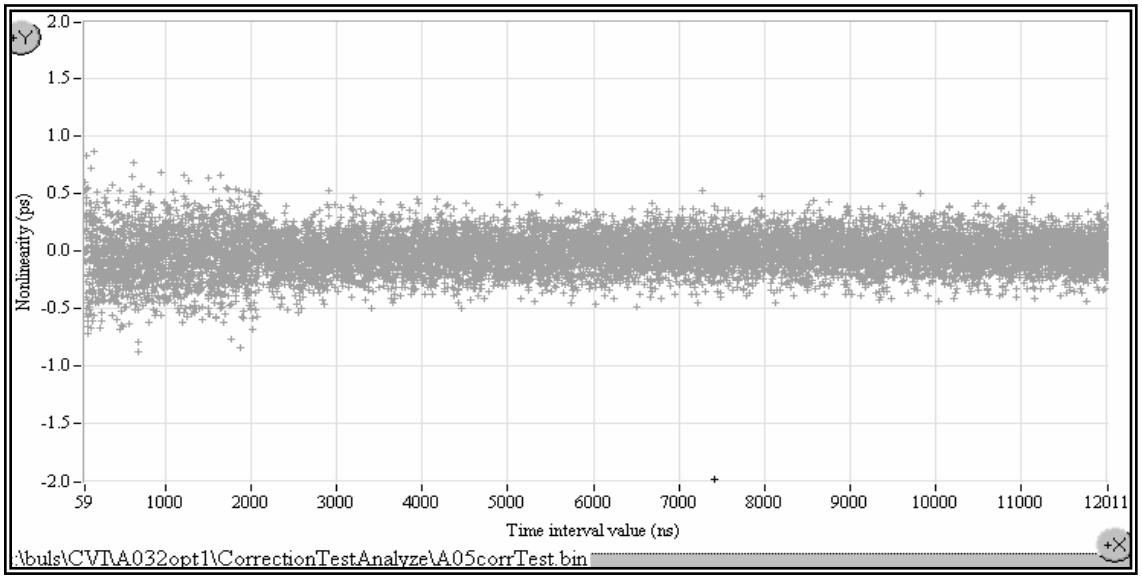
Ambient-temperature and RMS resolution vs. time (12500 sequential readings obtained during 19.6 hours of continuous test)

Directly after initial calibration the RMS resolution is about 7.8 ps and it gradually degrades to 8 ps when the ambient-temperature is changed for 2 ^{0}C. In other words, the temperature stability of RMS resolution is about 0.1ps/1^{0}C.

Linearity

The A032-ET needs about 60 ns for single event measurement. During this “dead time” the next measurement is impossible. But even after “dead time” there is some damping transient in electrical circuits responsible for event measurement. If such transient is not completed before next measurement, the last one will be performed with some error. This error depends on the time interval between previous event and event currently measured, causing non-linearity in event measurement.

The A032-ET provides a special correction of such non-linearity. However it cannot correct initial non-linearity completely, leaving slight, noise-like non-linearity in the time interval range up to 2000 ns. This residual non-linearity appears as errors, which are particular and constant for every 1 ns step of time interval incrementing. In the range exceeding 2000 ns the non-linearity is negligible.



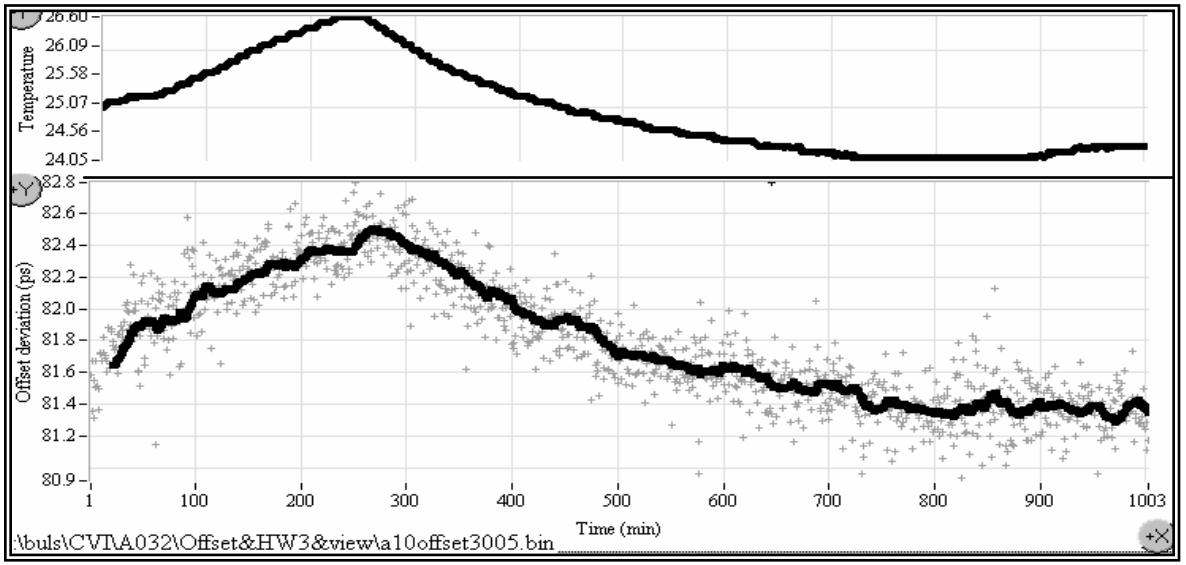
Non-linearity error vs. time interval. Total statistics volume is about 500 millions (more than 9000 initial estimates for each 1 ns increment). Such statistics has been collected during 9.1 hours of continuous test.

The test result shows that the maximum non-linearity does not exceed ±1 ps. However such estimate may be considerably overstated by reason of the evaluation errors.

Offset drift

All events provided by either input of the ET-device are measured sequentially in the same manner and by the same means. Owing to this there is no any noticeable offset in time intervals between measured events when these events come at only one input. However when the events come at the different inputs some offset appears. It is caused by a difference between internal propagation delays of input signals before coming of them to the common measurement unit. These delays slightly vary with the ambient-temperature change, causing certain offset drift and corresponding long-term instability in time interval measurements.

It should be pointed out that this parameter cannot be defined strictly as its value considerably depends on the test conditions which may differ substantially from the actual operating conditions.



Ambient-temperature and offset vs. time.
Duration of the test is about 16.7 hours.

The offset variation is directly related to the temperature changing, indicating the offset temperature stability about 0.48 ps/^{0}C. Generally this parameter value depends on the specific operating conditions.

SUMMARY OF A032-ET SPECIFICATION

Inputs (BNC): INPUT A	NIM pulse (falling edge; >5 ns width)*
INPUT B	NIM pulse (falling edge; >5 ns width)*
GATE IN	NIM pulse (high level)
SYNC IN	TTL pulse (rising edge, 1 pps)
TRIG IN	TTL pulse (rising edge)
REF IN	10 MHz (>0.5 V p-p)
Output (BNC): TEST OUT	NIM pulse indicating the gate delay (the A032.2 option)
Single-shot RMS resolution**	<10 ps
Dead time	60 ns
Non-linearity error	<1 ps (<3-5 ps for time intervals less than 100 ns)
Offset temperature stability	<0.5 ps/^{0}C after warm-up
Warm-up time	2 hours
FIFO depth	12,000 time-tags
Measurement rate***	
A032.1 option	up to 10 KHz continuously
A032.2 option	up to 500 Hz cycle repetition rate
Triggering	external or internal (programmable)
Time-base	commonly external; internal (+/-10 ppm) – for optional use
Stop pulse gating	
A032.1 option	only external
A032.2 option	also internal (10 ns LSD, 60 ns to 167 ms range) online programmable via network
Control	fully remote control from a user program via the network
Application interface	over TCP/IP
Hardware interface	via PC parallel port supporting EPP mode
Software	MS-Windows based
Accessory software	DEMO application software for both of the options
Hardware dimension, weight	375x60x233 mm (desktop); 3.0 kg
Power supply	100-240 VAC

** To support the specified precision it is necessary to provide the falling time < 2 ns/V and the pulse width <50 ns*

*** The resolution is specified for the case of using external high-stable time-base*

**** The actual rate may depend on the PC performance and its extraneous load*