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Innovative Technology for Creating High-precision Event Timers

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OUR SPECIALIZATION

As known, Satellite Laser Ranging (SLR) provides observation data sets to satisfy the objectives of a wide range of scientific, engineering, and operational applications.

In many respects the SLR performance depends on the performance of Time-Of-Flight (TOF) measurements. It is generally recognised that the epoch event timers should be used for TOF measurement to reach millimetre precision in range:

> *"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. …"*
>
> *(from Summary of Eastbourne ILRS Workshop, October 2005)*

In view of that, our field of specialization is development and design of high-performance and reasonable priced epoch event timers for SLR and related applications.

Scientific background of such activity is R&D results concerning innovative technologies for high-precision event timing.

WHY ARE WE THE BEST IN THE WORLD

Experience

We conduct R&D activity related with TOF measurement for more than 30 years. As a leader in this field, we were in a number of large-scale projects in the former USSR, (e.g., development of the laser network for the Lunar and satellite ranging). Starting in 2000, this activity is oriented to the demands of SLR community worldwide.

Innovative technology

In the 2000-ties we have invented and applied a new technology for designing event timers which provides top-level performance characteristics, low unit cost and high reliability. This technology is a basis for creating our event timers for SLR.

Recognition worldwide

SLR community represented by a number of its leading specialists highly appreciates our activity and defines the Riga event timers as the best ones for SLR and related applications.

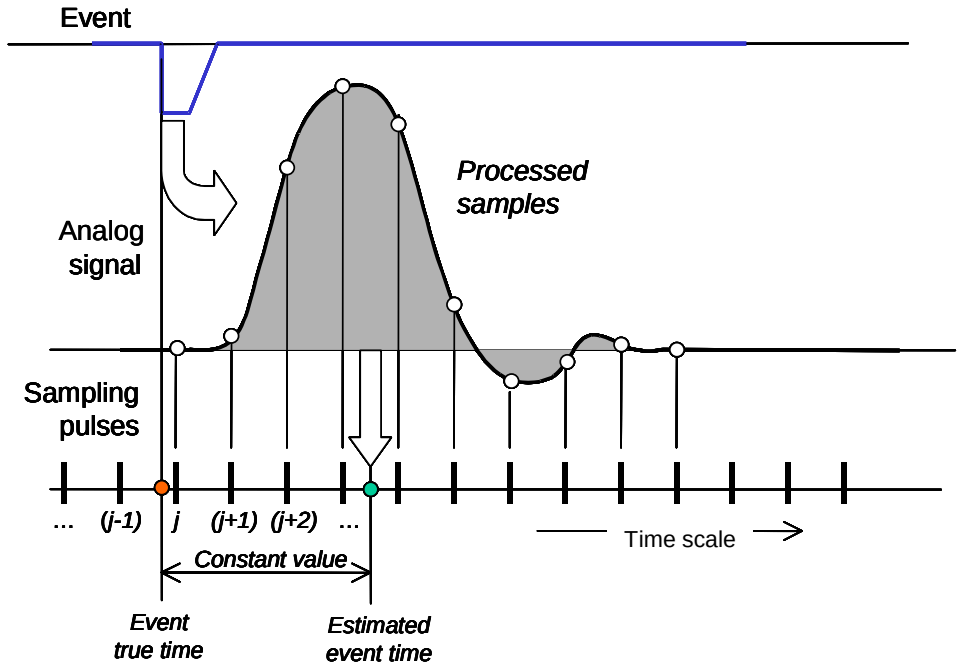
Growing demand

In 2002, the fraction of Riga event timers in ILRS laser network was 8%. Currently it is about 30%. Subsequent growing of this percentage is expected as well as widening the application area of Riga event timers (e.g., on absolute gravimetry).

The innovative event timing technology is based on a new DSP-based method, which has been employed in Riga Event Timers over many years

•Each input event (pulse edge) is converted to an analog signal by generation of such signal at the time instant defined by the respective input event.

• Then the analog signal is digitised using a typical A/D converter and digitally processed by a special algorithm to estimate its position relative to the periodic sampling pulse sequence.



In other words the method represents an interpolation technique – the event position is measured within the interpolation interval, which is the period of the sampling sequence or master clock signal. The shape of the produced analog signal has to be known as accurate as possible – that is done by specific calibration procedures.

PRODUCT DESCRIPTION

To meet different user demands, we have developed and offered the “adaptable-to-application” event timer that allows creating user-defined event timer systems in two basic configurations:

- Networked system (event timer interacts with application via network)
- Integrated system (timer’s software and application software are integrated)

Both systems are based on the same hardware and differ by software.

Main features:

Precision: 3-4 ps RMS
Event rate:
up to 20 MHz (in bursts)
up to 15 KHz continuously

Reasonable unit cost
Short manufacturing cycle
Customizing on user request

The product represents spin-off of our main R&D activity. It is made in the form of prototype available on contract basis. During 2005-2009 years 30 units of such product have been made and delivered for ILRS network.

THE BEST PRACTICE OF APPLICATION

We have a number of ongoing agreements on scientific and technical collaboration with different European and Asian institutions from SLR community. Basically these agreements are aimed for the most efficient applications of Riga event timers.

The best results have been achieved in such collaboration with Chinese SLR stations where the Riga event timers are widely used in various applications, including but not limited to the conventional SLR*.

> As an example, the experiment with time transfer by Laser link was carried out in July 2007 - March 2008 at Chinese SLR stations. The experiment was directed to extremely precise synchronising of terrestrial clocks through Chinese satellite COMPASS-M1. In this experiment Riga event timers were used for onground measurements in parallel with onboard measurements, providing the data for clock comparison.

* *Reference:*
Zhang Zhongping et al., (Shanghai Astronomical Observatory, CAS), Yu. Artyukh (Institute of Electronics and Computer Science, Riga, Latvia). Applications of Riga Event Timer at Shanghai SLR Station // *Proceedings of the 16th International Workshop on Laser Ranging*, Poznan, Poland, 2009, Vol.2, pp. 447- 453.

BUSINESS & APPLICATION DEVELOPMENT

Due to it's high commercial potential, in 2011 Riga event timer technology was noticed by a group of business people from Latvia who agreed to commercialise it together with the Institute of Electronics and Computer Science.

As a result, a new privately held company called "Eventech" was established in December, 2011. The aim of the company is to extend the application of the technology.

The business development has led to several potential new applications for our timing technology:

- **LIDAR industry** (specifically as timing circuitry in Terrestrial 3D laser scanners, Mobile and airbourne LIDAR's and Laser altimeters)
- **Lifetime fluorescence measurements** (specifically as a photon counting timing circuitry in TCSPC)
- **Gravimetry** (specifically measurements of absolute gravitational acceleration)

MAIN DIRECTIONS OF RIGA EVINT TIMER DEVELOPMENT

1. Supporting of stable precision at the level 3 ps RMS in a wide temperature range by means of:

- •temperature compensation,
- •fast and robust calibration.

2. More compact design, more fast operating by means of:

- •integration of all digital functions in one FPGA,
- •higher clock frequency,
- •high-speed PC interfaces: USB2, USB3, PCIe, Ethernet 1G, etc;

3. User interface friendliness:

- •user get the time-stamps directly from hardware, without any additional data processing by PC

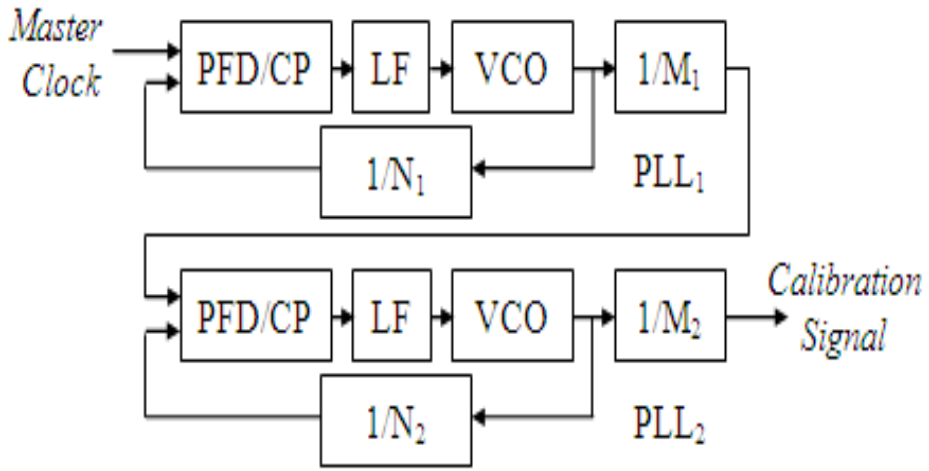
Up to now the first direction is considerably advanced, while other directions are at the beginning stage of development

THE BEST AND STABLE PRECISION – ROBUST CALIBRATION

When ambient temperature is considerable changed, the Riga ET should be re-calibrated. Conventionally we use for calibration a stand-alone crystal clock oscillator with “right” calibration frequency that provides the best ET precision. In this case the temperature drift of the “right” frequency causes sometimes improper quality of calibration and may require a repeating calibration.

The calibration signal should be derived from the master clock, and, hence, calibration signal frequency will not depend on temperature.

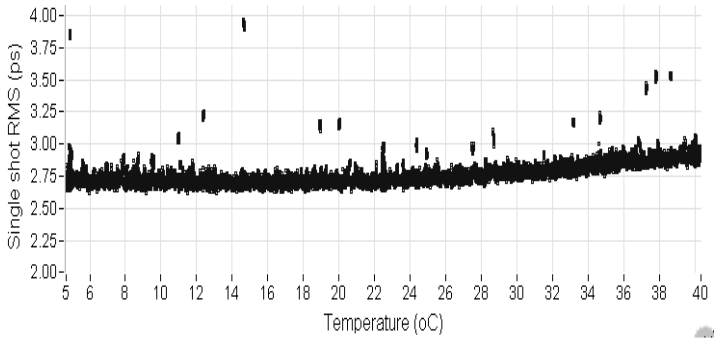
Using two PLLs and prime numbers for coefficients of frequency dividers allow synthesizing frequencies, which result in small steps of covering the interpolation interval.



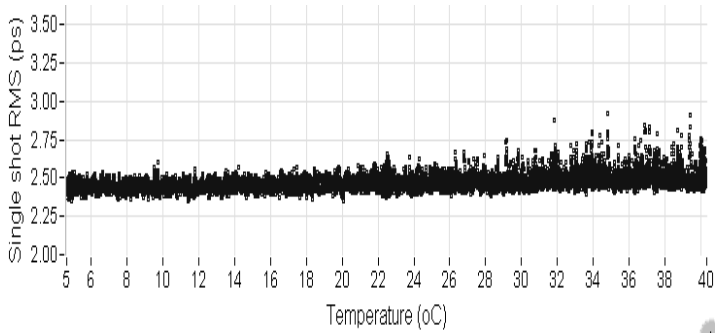
CALIBRATION EXPERIMENTAL RESULTS

Two PLL chips AD9524 have been employed in an experimental calibration signal synthesizer. The experimental studies have been done with the event timer A033-ET.

Single-shot RMS precision vs. temperature for the case of the stand-alone oscillator



Single-shot RMS precision vs. temperature for the case of the PLL circuit



So, the expected timer precision is maintained irrespective of the ambient temperature variations.

CONCLUSIONS

The presented technology has certain potential for further development. Some results have been already achieved such as weakened dependence on temperature, robust calibration that is independent on temperature variation. Now the work on the USB interface is in progress.

NEW FEATURE! – Inputs can be configured for NIM and TTL

NEW INFO! The timer works via Parallel Port under Windows7-32 as it is and Windows7-64 by using an additional driver.

Thank you! :-)