Estimation of Electronics Component Contribution in the Overall Measurement Error at SLR Station Riga

Poster 1987

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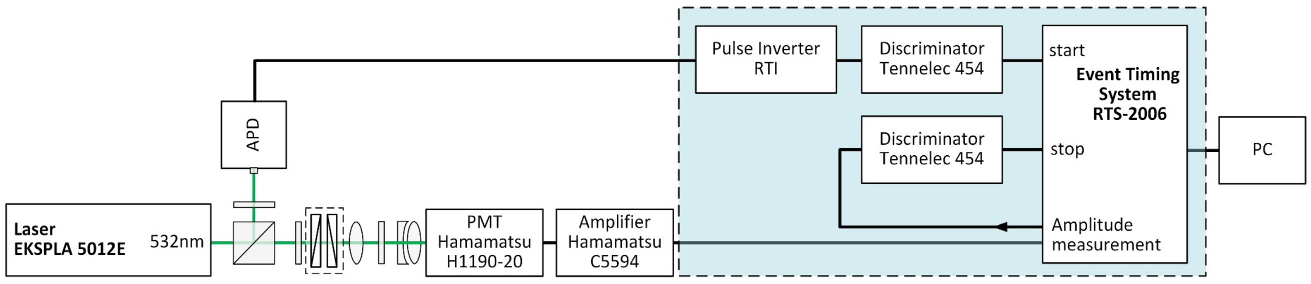
Introduction:

The electronic part of the satellite ranging system consists of a number of devices, each of which contributes an error in the total system error result.

High-precision electronics needs accurate adjustment and regular checking.
In order to look for the ways to improving the precision of the measuring system, it is necessary to estimate the precision of all its components.

The usual calibration mode will not allow to individually test each device.
In this poster, we show the way we used at the 1884 Riga SLR station for the estimation of errors on each of the devices of the electronic part of the measuring system.

The estimation errors are based on the simulation of highly stable time intervals, and the accurate simulation of the input signals shapes and amplitudes.



Experiment:

The total error of an electronic measuring system **ΔD,** is defined as the sum of the errors squared of all the devices in the system:

$$\Delta D = \sqrt{(ET^2 + Inv^2 + CFD_{start}^2 + CFD_{stop}^2 + ET_{ampl}^2)}$$

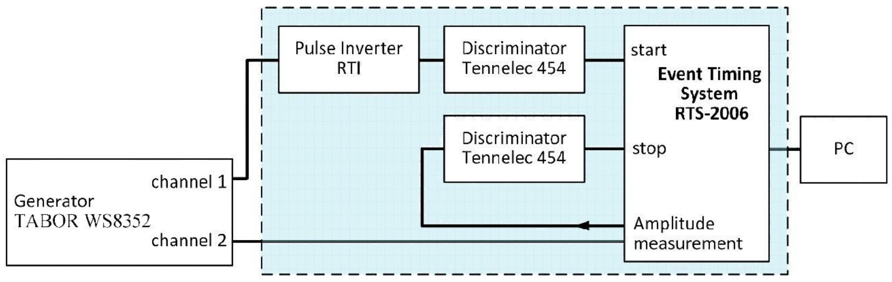
Where:
ET Event Timer RTS-2006
CFD$_{start}$ Constant Fraction Discriminator en the start channel
CFD$_{stop}$ Constant Fraction Discriminator en the stop channel
ET$_{ampl}$ Amplitude Measurement Block on the Event Timer RTS-2006

In order to estimate each device error, we carried out a series of measurements in order to evaluate the individual device error.
The optical part of the measuring system was replaced by the emulator-generator **TABOR WS8352**, which not only generates very stable time intervals but also emulates with high accuracy the APD and PMT output pulses.
The PMT pulses were emulated in two versions:

For a weak Lageos light flux we used 400 mV pulses.
For strong Ajisai returns we used pulses of 2V.

The devices were sequentially connected to the Event timer and the measurements errors were logged.
The first set was only with the Event Timer + TABOR WS8352, then we added the CFD*start* and so on, as shown in the table.
About 5·10³ measurements were done for each device combination.
The Error distribution agrees with the normal distribution.
The experimental results are shown on the "**ΔD**" column of the table.
Using the formula above we calculated the error of each device, shown on the table bottom line.

The greatest error source is the start channel discriminator.



Inv	CFD start	Gen start	ET	Gen stop	CFD stop	ET Ampl	ΔD
			+				8ps
		+	+	+			10ps
	+	+	+	+			16ps
+	+	+	+	+			18ps
		+	+	2V	+		11ps
		+	+	400mV	+		12ps
		+	+	2V	+	+	11.5ps
		+	+	400mV	+	+	12.3ps
+	+	+	+	2V	+	+	19.7ps
+	+	+	+	400mV	+	+	22.1ps
8.2ps	**12.5ps**	**4.2ps**	**8ps**	**4.2ps**	**4.6/6.6ps**	**3.5/2.7ps**	

The order of the devices sets used in experiment.
The results of measurements and calculation.

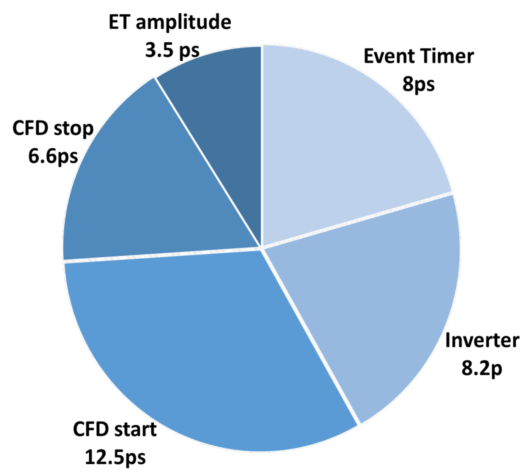
Estimation:

The diagram shows the contribution of each electronic device in the total measurement error.

It is clear that the greatest contribution is from the start discriminator. This result indicates the system component that requires further study.

Indeed, it appeared that the APD detector in the start channel is sensitive to the laser pulse energy value.
A slight decrease in the laser energy occurs with prolonged usage of the flash pumping lamps. This turned out to cause instability of the start discriminator.
When this cause of the greatest error was eliminated the start discriminator error decreased to a value of 6ps.
With the proposed method of identify the weak link in the electronic devices used, the calibration error of the measuring systems at the SLR station Riga is decreased from 75ps to 65ps.

Earlier, by the same way, it was identified the incorrect operation of the discriminator's power supply which made a significant error about 90ps.



Assumptions:

Provided that each event is independent, the determination of the standard deviation is produced by the formula mentioned above.
In this case, the electronic devices are located in the general chain of measurements that obviously makes them interdependent.
Therefore, the total error which is measured is different from the sum which is calculated.
However, for the purposes of this method, this approach is quite acceptable as the result indicates the device(s) with the maximum value of error.
More precisely, in order to determine the jitter of each device is possible when there is a couple of Event Timers

(V. Bespal'ko, E. Boole, and J. Savarovskiy. *An Instability Estimation of Precision Time Intervals.* Instruments and Experimental Techniques, 2012, Vol. 55, No. 3, pp. 377-382)

Conclusions:

- It is proposed as a way to estimate the precision contribution of each individual device.
- It is a quite simple method to use in any system diagnostic.
- Can be used to estimate the error distribution, and to check for anomalies.
- It is a powerful tool to identify the system precision limit.

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