Long-Term Evaluation of GPS

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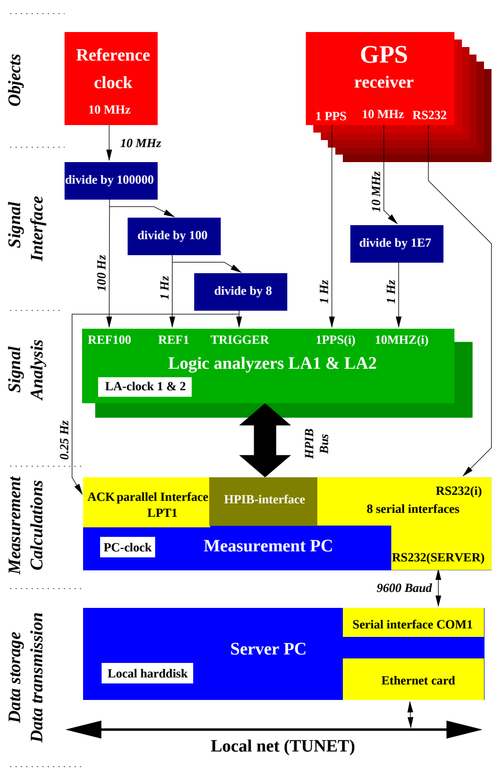
Experimental Setup

- **Reference clock.** The 10 MHz signal of the Ball Efratom FRS-C rubidium clock (placed in a climatic housing) was used to generate a 100 Hz reference signal. This signal was further divided to provide a 8 s period trigger signal to control the sampling and reading of the logic analyzers.
- **Measurement PC.** Apart from being responsible for reading out the memory of the logic analyzers via the HPIB interface, the Measurment PC also provides serial interfaces required for getting time tag and status information from the GPS receivers. It associates the 1 pps data from the LA with the additional information and computes a full reference timestamp by combining the LA clock timestamps with the 100 Hz rubidium pulses. Complete records, including "spurious pulse" data, are eventually sent to the Server PC via a RS-232 interface.
- **Server PC.** The Server PC stores data from the measurment PC on disk and provides access to the campus network for easy acces and backup purposes.



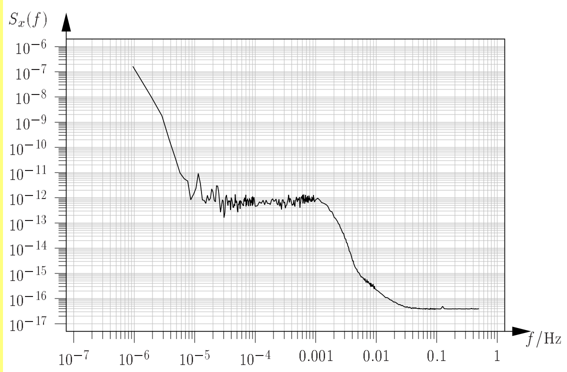
- **Evaluated GPS Receivers.** The 1 PPS and 10 MHz signals of following receivers were measured:

Model	#Chn.	Year/Vers.	US $
Stellar 100 GPS Clock	5	1995	4.500,–
NavSymm NTFR-S	6	1995/2.9	3.500,–
Motorola VP Oncore	6	1994/6.x	300,–
Trimble SVeeSix-CM2	6	1994	750,–
Magellan Brain	5	1993	600,–
Rockwell Microtracker	5	1993	350,–

- **Logic analyzers.** Two HP16500B from Hewlett Packard samples the pulses with a resolution of 8 ns. The analyzers' event trigger mode is used where a timestamp of the internal LA clock is sampled into memory upon occurence of a pulse at any input channel.

  Thereby the leading edge of the 8 s trigger signal initates sampling at LA1 and causes LA2 to be read out whereas the falling edge triggers the sampling at LA2 and read out of LA1. This way, continous measurement in accomplished.

Reference time



Stellar 1 pps versus reference clock

How much does the reference time differ from GPST ?

$$\overline{x(t)} = x_{\mathrm{GPST}}(t) + \underbrace{\overline{z_S^0(t)} + \left(z_R^0(t) - \overline{z_R^0(t)}\right)}_{\text{systematic}} + \underbrace{\overline{\zeta_S(t)} + \left(\zeta_R(t) - \overline{\zeta_R(t)}\right)}_{\text{stochastic}} .$$

	Contribution	Amount
without	$z_S^0(t)$	unknown
average	$\zeta_S(t)$	$\sigma = 38.0$ ns
	$\overline{z_S^0(t)}$	$\approx z_S^0(t)$
with	$\overline{\zeta_S(t)}$	$\sigma = 5.7$ ns
average	$z_R^0(t) - \overline{z_R^0(t)}$	≈ 0 s
	$\zeta_R(t) - \overline{\zeta_R(t)}$	$\sigma = 3.2$ ns

- Starting point of the *Reference Time* is the 1 pps output of the best of the receivers (Stellar). By smoothing the data (double Kalman filtering) we obtain a better approximation of GPS Time.
- Me made following assumptions for the construction of the reference time
  - Noise of reference clock and Stellar 1 pps are independent.
  - The 1 pps output of Stellar has no significant noise for lower frequencies ($< 10^{-5}$)

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