AN EVALUATION OF ANTENNA PERFORMANCE AND ASSOCIATED TIMING UNCERTAINTIES BETWEEN IDENTICAL C/A-CODE GPS RECEIVERS

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ABSTRACT

After the de-activation of Selective Availability features in the satellite system, comparisons between two co-located identical off-the-shelf C/A-code GPS receivers indicate a mean timing difference of 10 ns over 1 month with a statistical variation up to 240 ns. Maximum momentary 1 PPS deviations were around 900 ns. Tests showed an achievable uncertainty below 10 ns but only with averaging above 10000 s mainly because of sudden peaks of about 50 - 100 ns and repeating every 10000 s. Observed effects of the atmospheric temperature on the antenna cabling and associated hardware were estimated to have a correlation coefficient near 2 ns/°C which clearly suggests the need of temperature controlled antennas already in sub-arctic environments.

Keywords: Time Transfer, GPS accuracy, Frequency and Time Standards, Time Interval Counter

1. TEST SET-UP

Tests between two identical C/A-code GPS receivers have been carried out after the removal of Selective Availability degradation as a comparison to Refs 1 and 2. Fig. 1 shows the applied system which measures the timing differences of co-located clocks. HP VEE was used for controlling the time interval counters and transferring the recordings into a Matlab-type spreadsheet. An oscilloscope as well as the receivers' software was used to analyse the occasional problems. Software was used to generate artificial problems such as a reduced GPS constellation, loss of signal and for cancelling satellites. Also a physical visibility reduction test was performed by masking sectors around the antenna. Some information on the temperature behaviour was obtained, mainly related to the antennas.

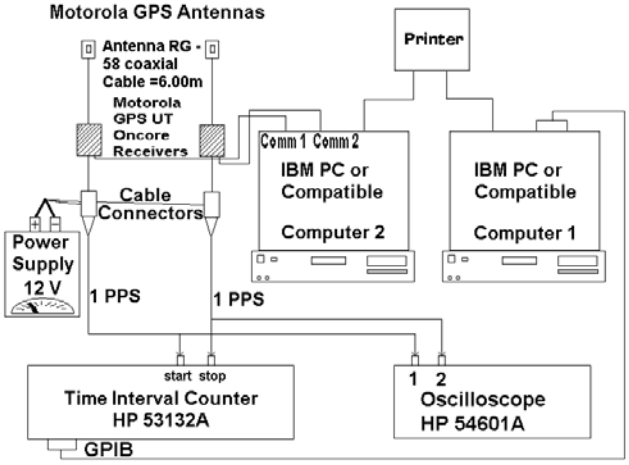

Fig. 1. The set-up uses HP VEE in PC1 to control the time interval counter through IEEE-488. PC2 takes care of the receivers (RS-232) which need only three meters of antenna cable. An uninterrupted power supply was unfortunately not available for the test campaign which seriously hampered the long-term tracing of clock performance

Most GPS receivers have algorithms to set thresholds at which they keep or drop a current or acquire a new satellite, based on the best geometric dilution of precision or on satellites highest in the sky. Some limit the timing solution to one satellite but others can use 12. Two different GPS receivers obtain different results even when connected to same antenna.

2. EXPERIMENTAL RESULTS AND SOME STATISTICS

The tested commercial device (a direct descendant of the type used in Refs 3 and 4) seems to be suitable for

precision timing. The algorithm detected simulated errors and isolated bad satellites. On two occasions RX 2 lost track of all satellites and did not give a 1 PPS output although RX 1 was functioning fully and tracking eight satellites. This all corrected on it own in ten minutes. For up to 10000 s, the uncertainty between the 1 PPS pulses was below 10 ns. By averaging over 500 sample intervals clear peaks were found (every 10000 s) - more distinctive after 700000 samples.

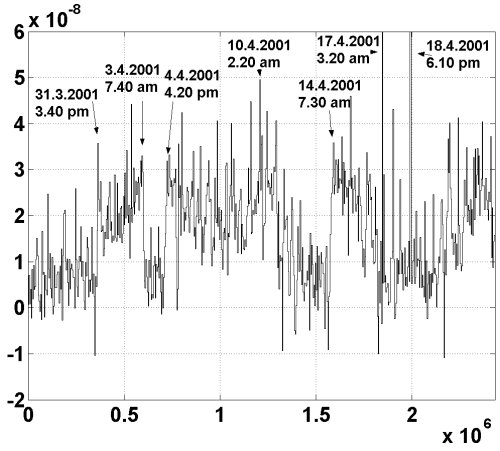

Fig. 2. Averaging over 2000 samples reveals bends at 3.4. - 4.4. and 10.4. -14.4. Vertical scale in seconds.

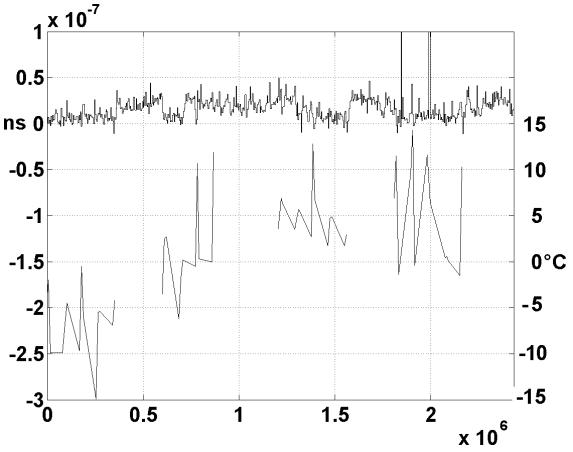

Fig. 3. The effects of outside temperature on the timing difference are estimated as 2 ns/ °C. Vertical scale in sec.

Satellite mask angle was 0° and S/N threshold 20. The antenna site was prepared to mask parts of the sky which gave insight both to a limited field of view and the effects of local multipath. The satellite orbits reached 61°.

Temperature effects, see e.g. Refs 5 or 6, are here estimated as 2 ns/°C, and are illustrated in Fig. 3. It is feasible to assume that averaging over 500-2000 samples is enough to remove excessive system noise for most applications.

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