U.S. Department of Commerce
National Institute of Standards and Technology
325 Broadway
Boulder, CO 80305
USA

REPORT OF CALIBRATION

Report Number 274681-07

TEST 76120S
May 25, 2007

Instrument being characterized:
Timing Solutions Corporation GPS Receiver
Model TSC 2214.
Serial Number SP00191

Test performed for:
Timing Solutions Corp.
Division of Symmetricom
4775 Walnut St. Suite 1B
Boulder, CO 80301-2579
USA

I TEST CONDITIONS

The Timing Solutions Corporation GPS Receiver, Serial # SP00191, (we will refer to the instrument as the TSCGPS) was operated in a laboratory environment (room 4016 in Building 1) at the National Institute of Standards and Technology (NIST) in Boulder, CO, USA for 10.6 days from May 7, 2007 through May 18, 2007 at 14:10 UTC. The laboratory temperature was stable at the ± 2.0°C level around 22.3°C over this period. The TSCGPS was supplied with 110 VAC power from an uninterruptible power supply. The GPS antenna was mounted on the roof of the NIST building using the supplied cable. The coordinates of the antenna were N 39deg 59min 44.6004sec, E 254deg 44min 16.4739sec, 1645.4m. The TSCGPS was set up by Tim Erickson of Timing Solutions Corp. and was left untouched throughout the course of the testing. The start of data recording was at MJD 54227.962 (May 7, 2007). However, only data after MJD 54229.0 were used for analysis, in order to allow the TSCGPS to settle in. Data were collected until MJD 54238.590 (May 18, 2007).

The 1 PPS output data were recorded every second using a Guide Technology GT200 Time Interval Counter (TIC) with 10 MHz from UTCNIST as the time base reference. UTC(NIST) is generated from an ensemble of active hydrogen masers and is traceable to UTC. The start pulse for the TIC came from the TSCGPS with a short cable delay of 4.2 +/-0.1ns and the stop pulse came from UTC(NIST) with a cable delay of 678.9 +/-0.1ns.

The trigger level for the TIC was 0.52V and the input impedance was 50 ohms. The time interval measured by the TIC, Δt, is given by Eq. 1,

$$\Delta t = \text{UTC(USNO via GPS)} - \text{UTC(NIST)} - \text{Rcd} - d_1 + d_2 \quad (1)$$

where Rcd is the receiver delay, $d_1 = 4.2$ ns and $d_2 = 678.9$ ns. Thus the receiver delay is

$$\text{Rcd} = 674.7 \text{ ns} - \Delta t - [\text{UTC(NIST)} - \text{UTC(USNO)}] \quad (2)$$

All of the data analysis was performed with Stable32(v1.46) from Hamilton Technical Services or an analysis package developed at NIST called PCWORK. The statistics calculated are the Allan (Total) deviation and the Time deviation.

II TEST RESULTS

Figure 1 shows Δt at 1 second intervals over the entire 10.6 day test period (901,661 data points). On MJD 54230 about 4.5 hours of data are missing do to a disk drive problem. Figure 2 shows 100 second averages of Δt for the interval MJD 54229.0 to 54238.590 for which the analysis was performed. The time deviation for the 1 second data over the interval in Fig. 2 is shown in Fig. 3. The Allan (Total) deviation is in Fig. 4. The internal noise of the TIC and the noise of UTC(NIST) are both well below the noise of the TSCGPS at all τ values shown. Figure 5 shows 1 day averages of the receiver delay, Rcd, from Eq. 2 but without correcting for [UTC(NIST) – UTC(USNO)]. Any presence of a daily cycle is quite small.

The time reference for GPS is UTC(USNO), so to determine the exact receiver delay we also need to know the time difference between UTC(NIST) and UTC(USNO). This was obtained from the GPS common-view receivers at NIST and USNO. The IGS ionosphere maps were used to correct for ionospheric delay rather than the broadcast ionospheric delays in order to achieve the best estimate of UTC(NIST) – UTC(USNO). Figure 6 shows one day averages of UTC(NIST) – UTC(USNO) for the interval MJD 54228 to 54239, as determined from GPS common-view with IGS ionospheric data. The uncertainty on UTC(NIST) – UTC(USNO) is +/- 5 ns. The data in Fig. 6 were subtracted from that of Fig. 5 in order to obtain the final receiver delay. The results are shown in Fig. 7. Over the course of the 9.5 day test Rcd varied from a low of about 64 ns to a high of 73 ns. For any given day the uncertainty of the Rcd is +/- 5 ns

For the Director,

Thomas E. Parker and Victor Zhang
Atomic Frequency Standards Group
Time and Frequency Division

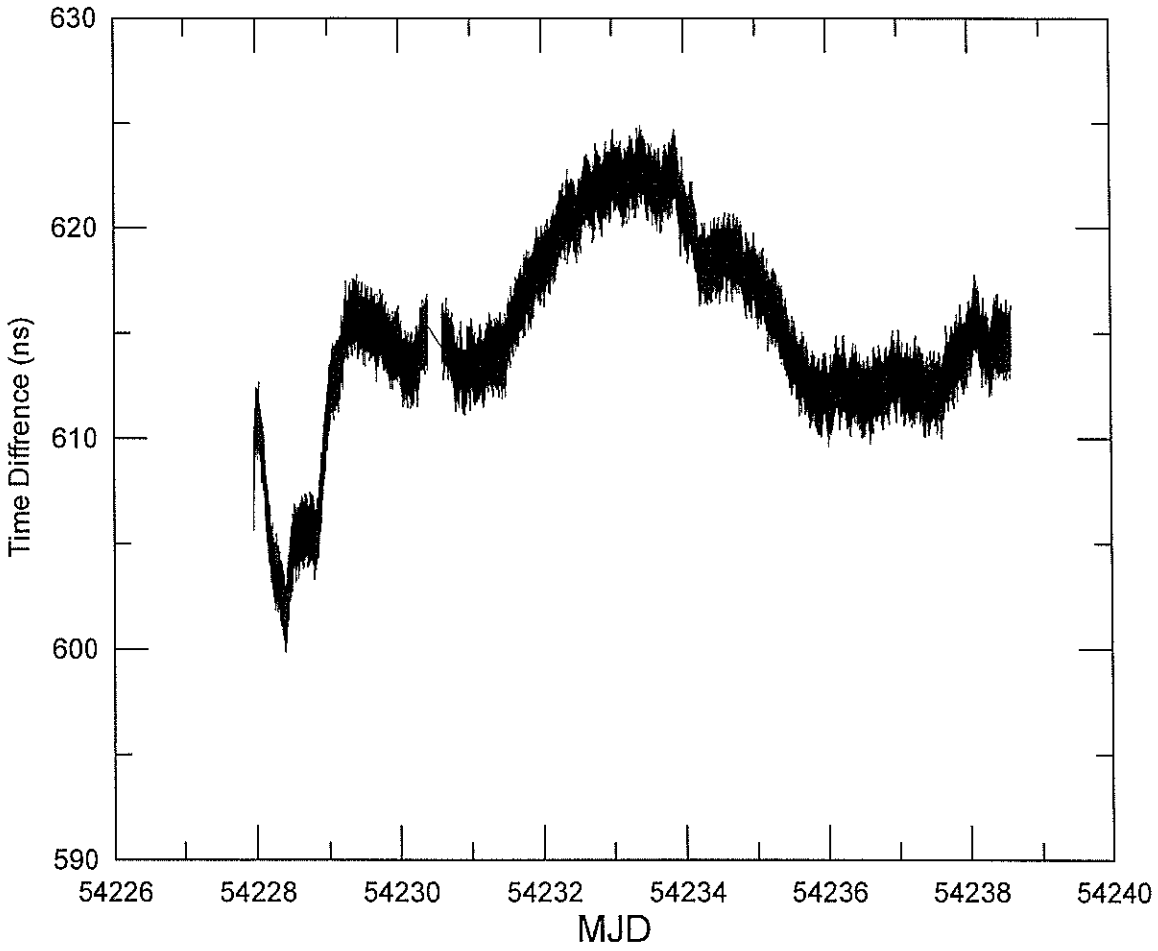

Figure 1. All of the Δt recorded at 1 second intervals from the TSCGPS.

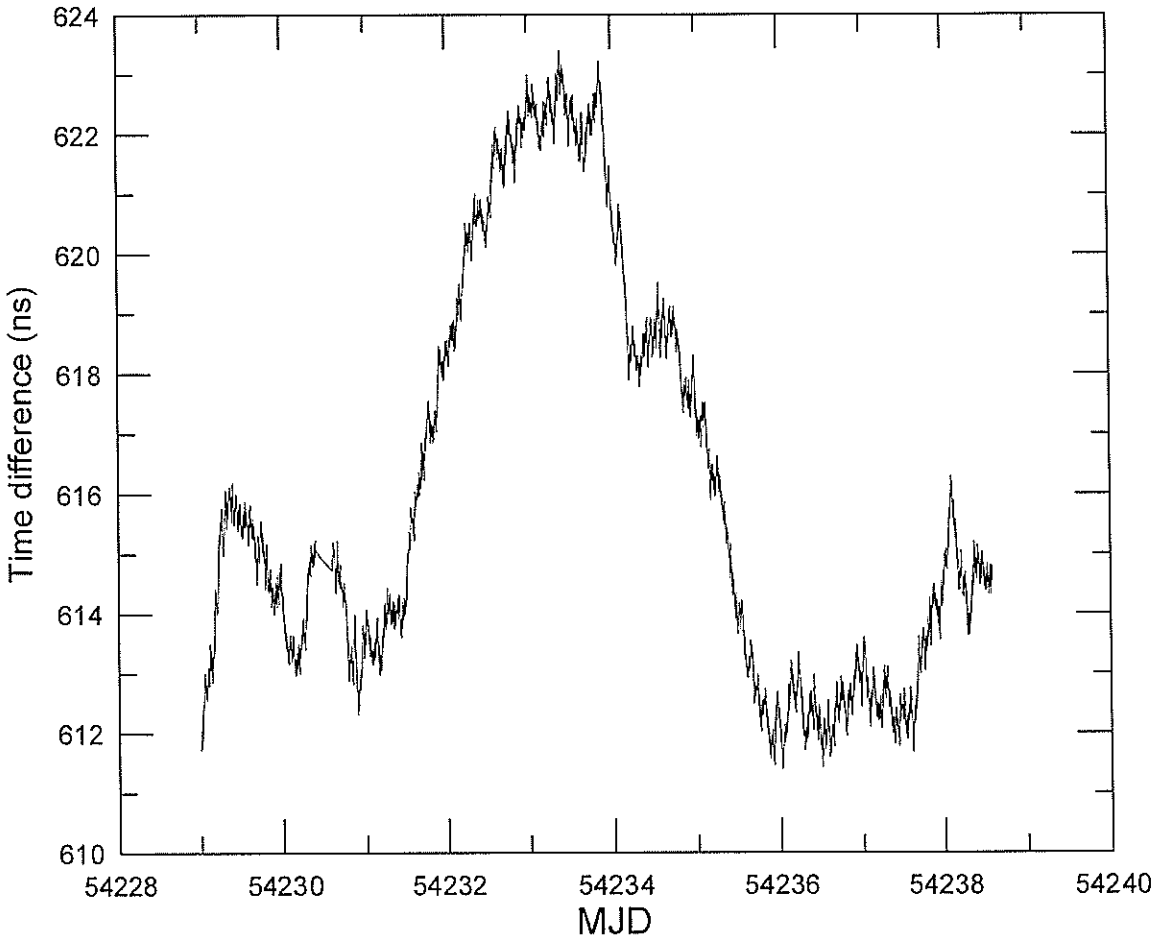

Figure 2. 100 second averages of Δt only over the range of MJD 54229 to 54238.590 for which the analysis was performed.

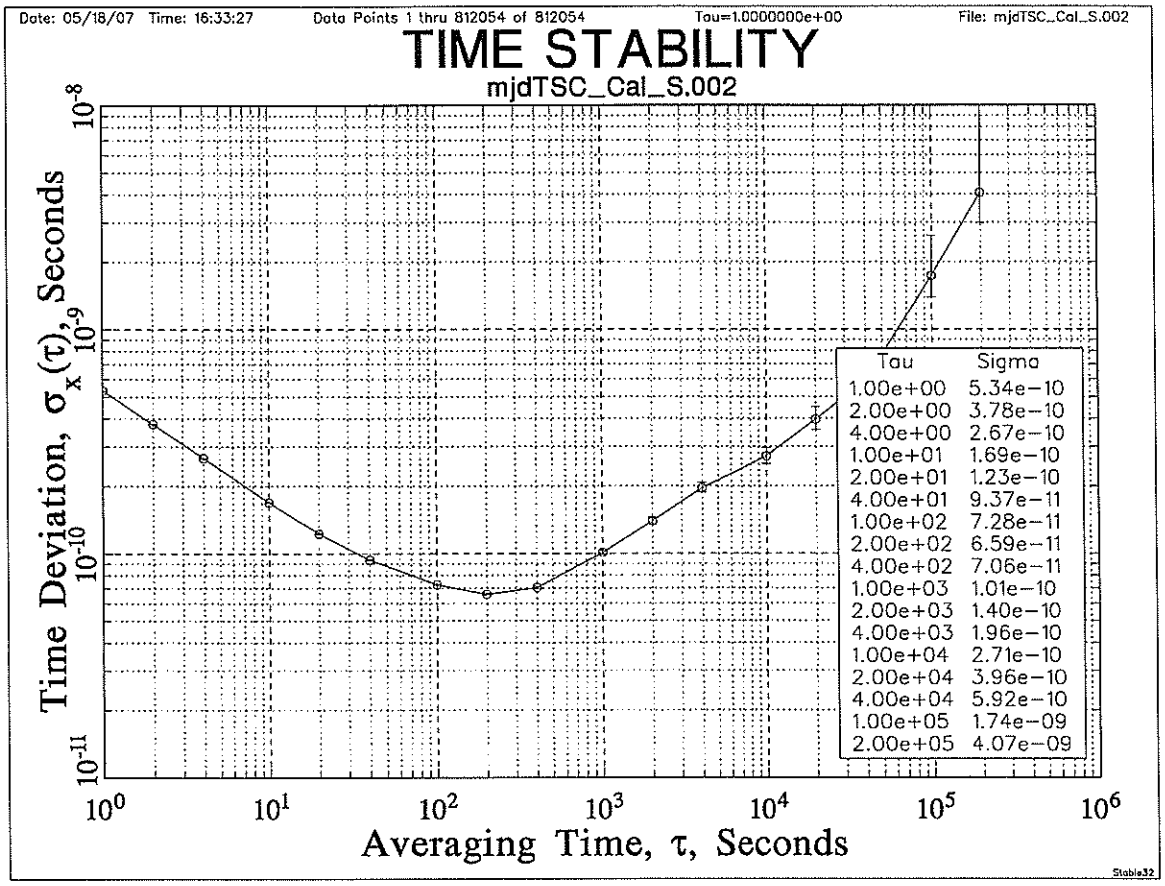

Figure 3. Time deviation for the 1 second data in the interval of Fig. 2.

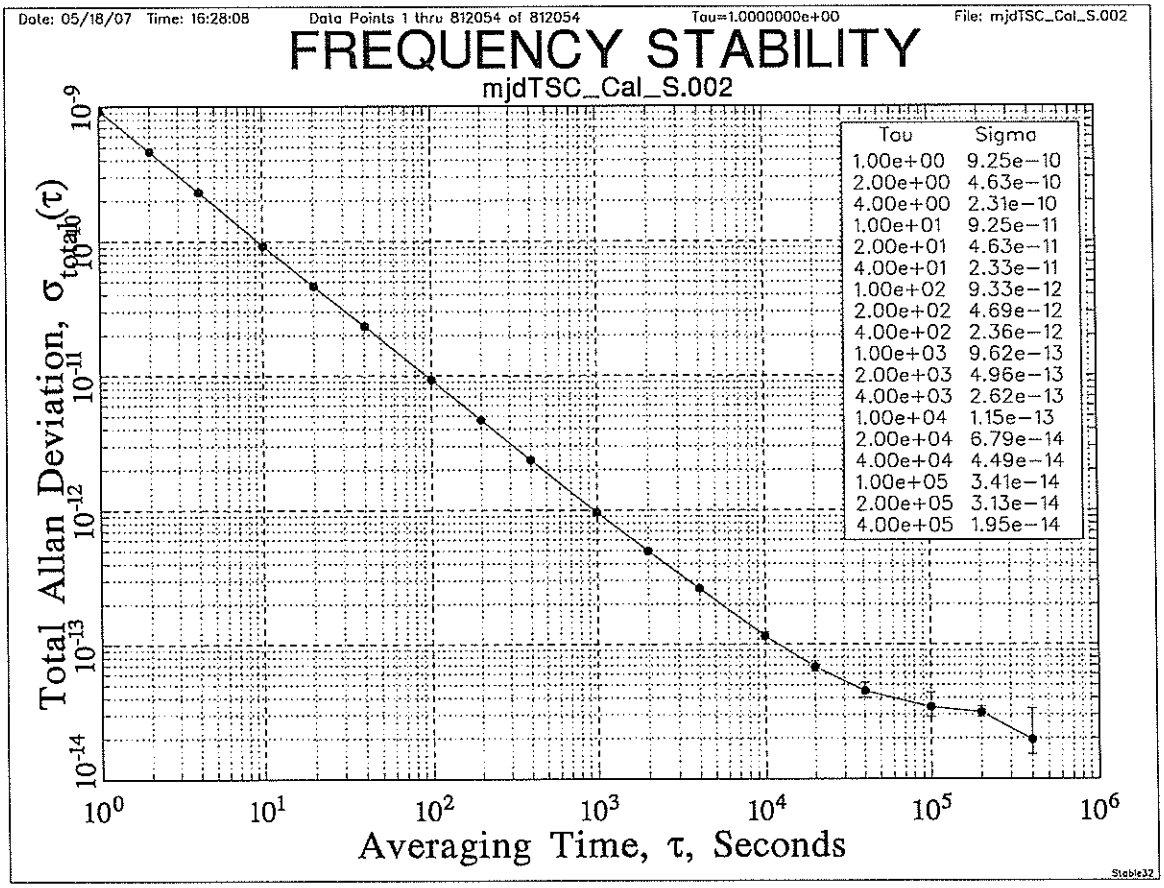

Figure 4. Allan (Total) deviation for the 1 second data in the interval of Fig. 2.

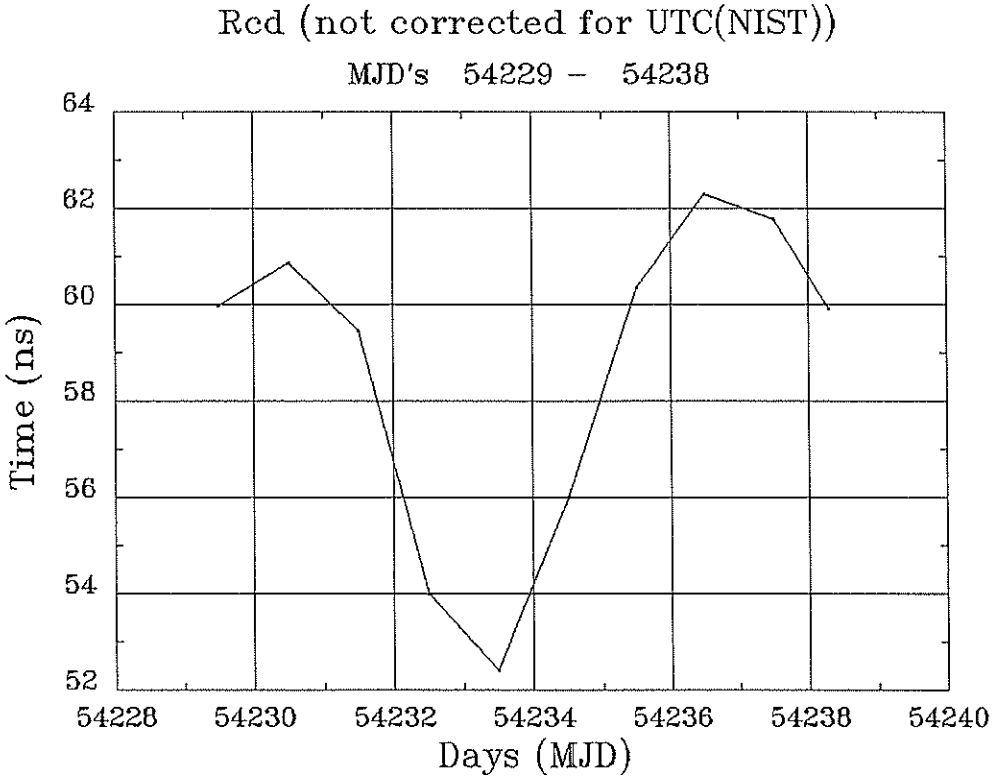

Figure 5. Daily averages of the receiver delay corrected for cable delays, but not for the difference between UTC(NIST) and UTC(USNO).

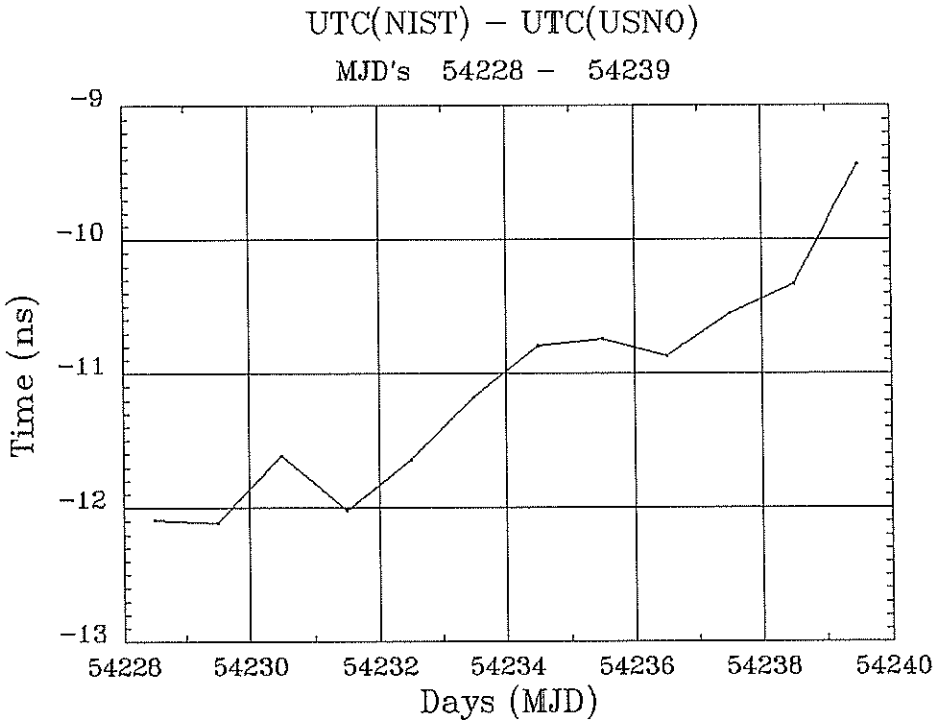

Figure 6. 1 day averages of UTC(NIST) – UTC(USNO) from GPS common view.

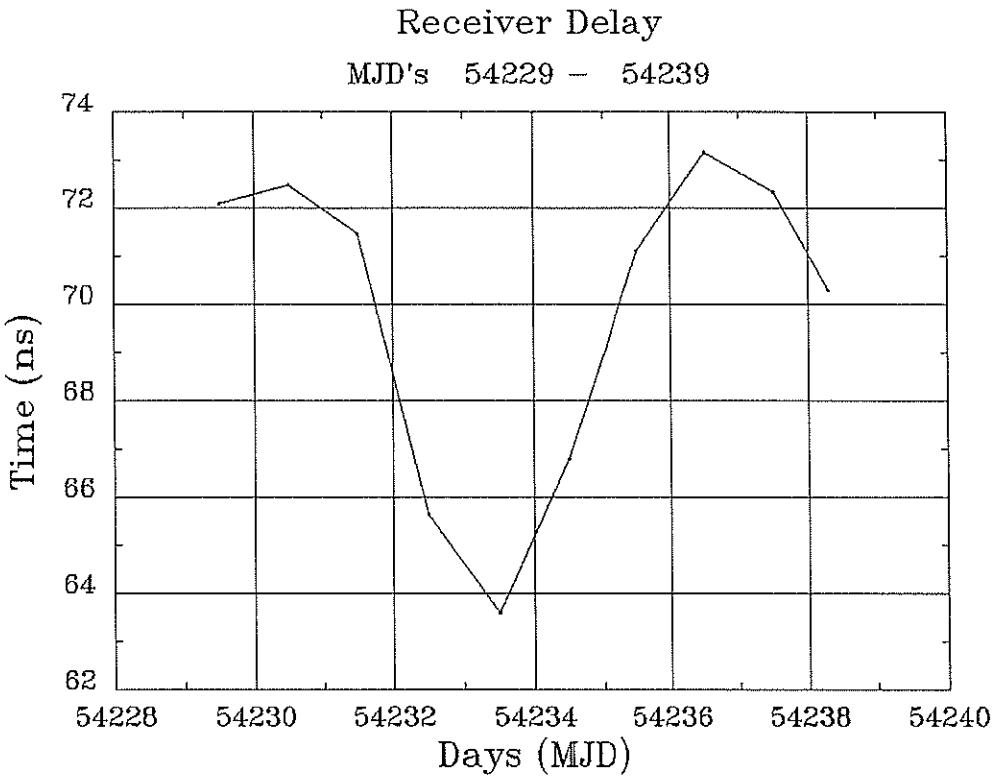

Figure 7. 1 day averages of the receiver delay, Rdc.