6D7 Real-Time Clock Performance Analysis

Report

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Specialists
at depth

1 Introduction

Precise and accurate timing information is paramount to seismological data. However, providing a stable time-base for periods of 12 months or longer in autonomous ocean bottom instruments is challenging. In 2023 K.U.M. launched a new ocean bottom seismic data logger, the 6D7. Building on K.U.M.'s vast experience in OBS technology, we started from scratch in developing a new seismic data logger that meets the highest standards in power efficiency, energy consumption, reliability, and real-time clock performance over extended time periods.

The 6D7 is equipped with a new real-time clock that promises extremely accurate timing of seismic data. To verify these claims K.U.M. has conducted multiple tests during the development process. In this report we present the analysis results of two lab tests assessing the performance and stability of the real-time clock implemented in the 6D7 data logger.

2 Test A: In Basement with minor Temperature Variations

To verify the accuracy over long time periods, we connected a 6D7 data logger to a GPS signal and simulated a deployment over a period of 16 months. A sample record of the GPS signal is displayed in Figure 1.

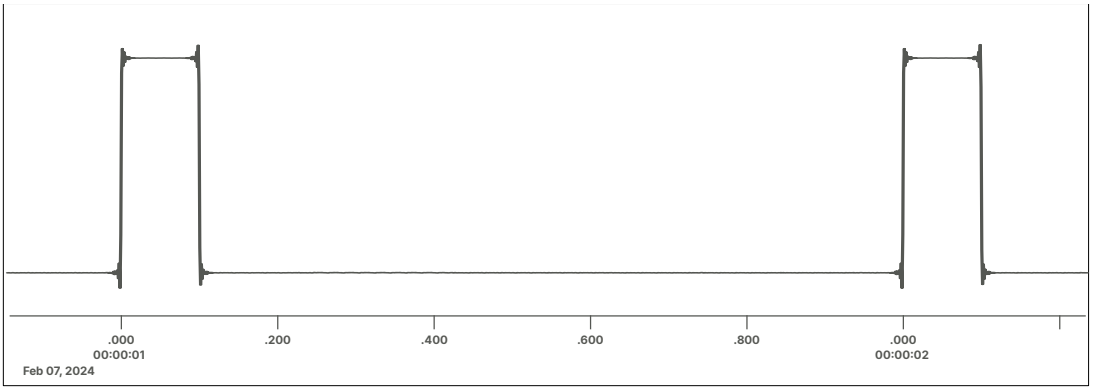

Figure 1: Data snippet with two GPS second pulses recorded by the data logger during Test A.

Recording parameters of Test A, including the linear time-deviation from GPS time (skew) at the time when the recording was stopped, are depicted in Listing 1.

```
 Start Time: 2022-08-18 09:24:24 UTC
   End Time: 2023-12-19 14:33:51 UTC
  Sync Time: 2022-08-18 09:24:16 UTC
  Skew Time: 2023-12-19 14:34:24 UTC
       Skew: 135977µs (0.003ppm)
   Duration: 488d 5h 9m 27s
Sample Rate: 250 SPS
```

Listing 1: Recording parameters of Test A.

Due to the high self-similarity of the recorded GPS second-pulses, an short-term-average versus long-term-average trigger can be used to determine variations between the internal clock and the GPS-timing throughout the experiment to a precision of milliseconds.

The results of this test are displayed in Figure 2. After correction for the linear clock-skew, the maximum non-linear time deviation was **0.018 s** which corresponds to a **relative error of 0.000426 parts per million (ppm)**. This is significantly below the advertised error of 0.020 ppm. Comparing the two graphs in Figure 2, a minor co-variance of temperature and time-deviation can be spotted, at a time period of several months.

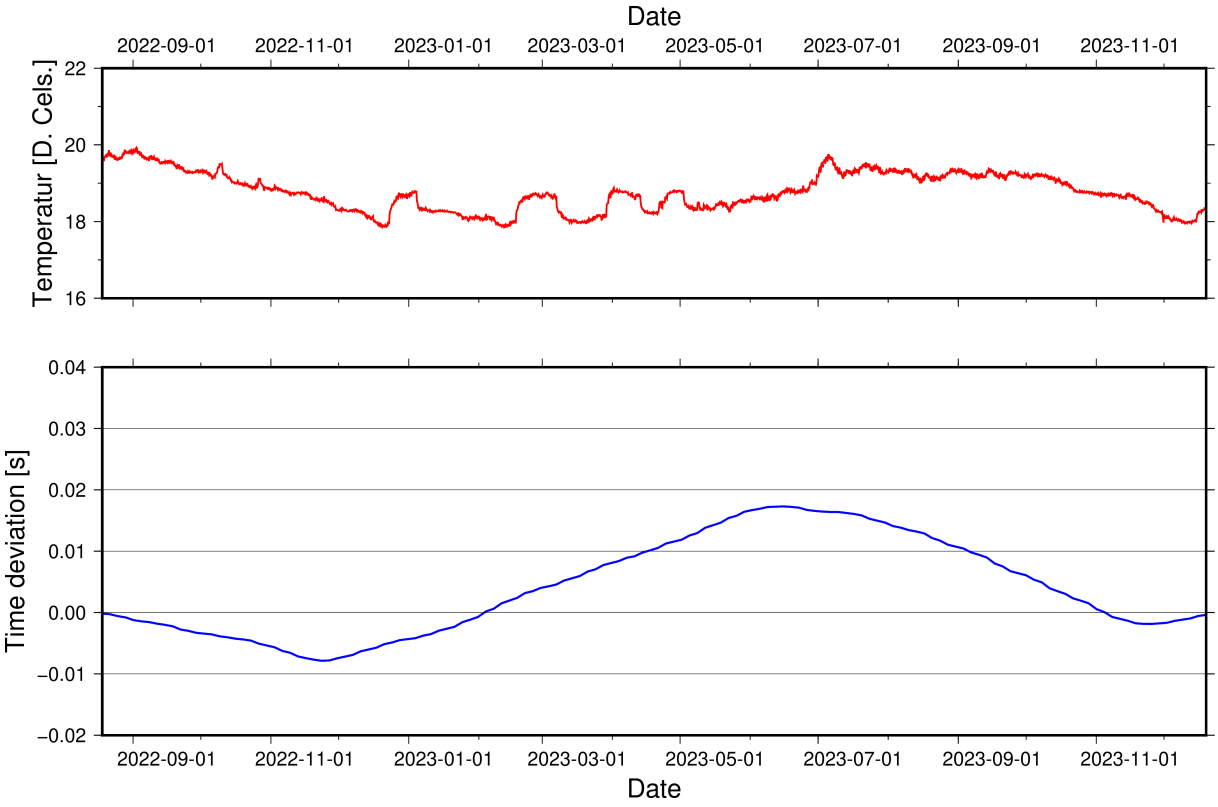

Figure 2: Analysis results of Test A. The upper panel shows temperature recorded inside the data logger housing. The lower panel shows the deviation between the data loggers internal clock and GPS time. The time deviation was measured via picking the onset of the recorded GPS second pulses (see Figure 1).

3 Test B: In Climate Cabinet with strong Temperature Variations

The second test was conducted with the data logger emplaced inside a climate cabinet. During the recording period of 12 months the temperature was alternated multiple times between 4°C and 26°C. Apart from this the test-setup was identical to Test A. The recording parameters are displayed in Listing 2.

```
 Start Time: 2024-02-06 11:06:31 UTC
   End Time: 2025-02-08 22:06:23 UTC
  Sync Time: 2024-02-06 11:04:38 UTC
  Skew Time: 2025-02-28 08:32:29 UTC
       Skew: 85306µs (0.003ppm)
   Duration: 268d 10h 59m 52s
Sample Rate: 1000 SPS
```

Listing 2: Recording parameters of Test B.

The results of this test are displayed in Figure 2. After correcting the linear clock-skew, the maximum non-linear time deviation was **0.037 s** which corresponds to a **relative error of 0.001162 parts per million (ppm)**. This is significantly below the advertised error of 0.020 ppm. There is no co-variance of temperature and time-deviation visible in the results.

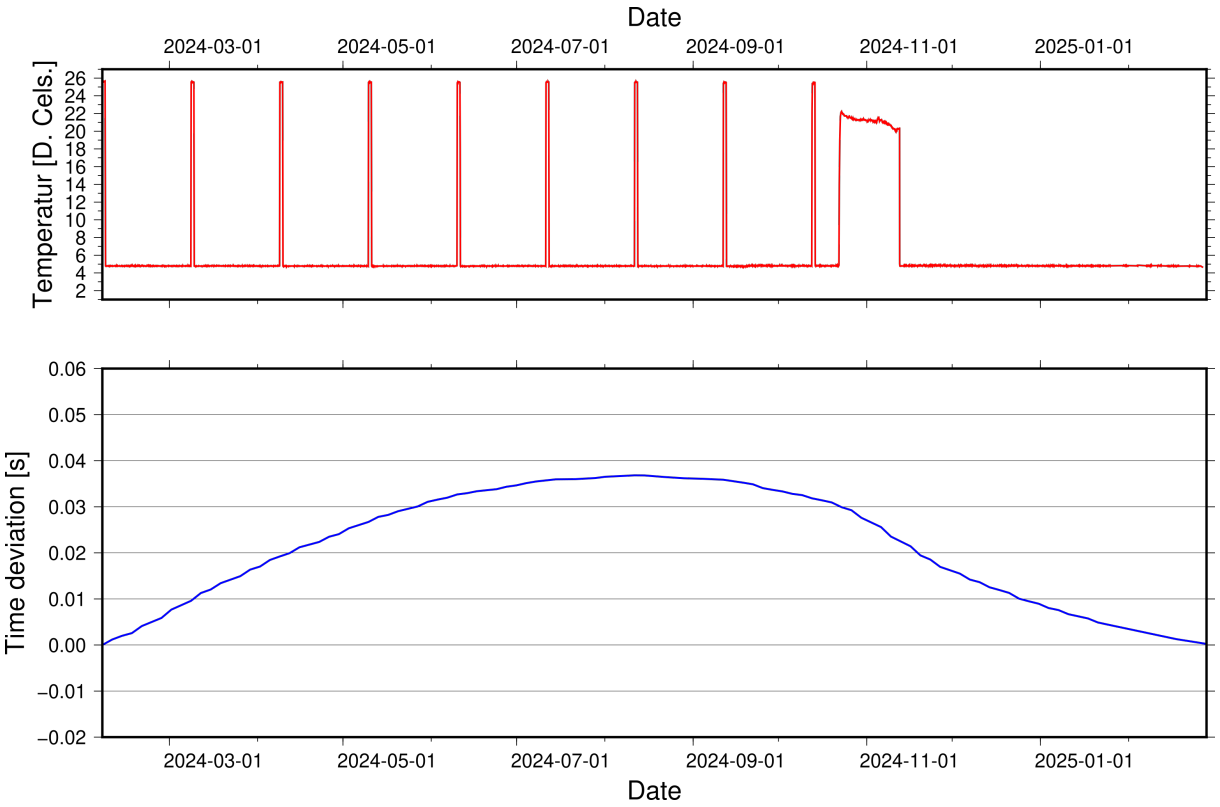

Figure 3: Analysis results of Test B. The upper panel shows temperature recorded inside the data logger housing. The lower panel shows deviation between the data loggers internal clock and GPS time. The time deviation was measured via picking the onset of the recorded GPS second pulses (see Figure 1).

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