Operation status of time keeping system of Shanghai Institute of Measurement and Testing Technology

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Abstract

The time keeping system of Shanghai Institute of Measurement and Testing Technology (SIMT) was planned since 2012 and completed in 2015. The system was in trial operation since 2016, and started working normally from 2017. The time keeping data of the first season of 2017 was compared with the National Institute of Metrology (NIM) through GPS common view. The average deviation in the 3-month comparison is 5.6ns, the uncertainty is *U*=1.5ns (*k*=2). This paper introduces the time keeping system of SIMT and its operation status.

1. Introduction

As a participant in keeping China's coordinated time, the time keeping system of SIMT was planned since 2012 and completed in 2015. The time keeping clocks consist of 2 active hydrogen masers (MHM 2010) and 6 high performance cesium clocks (5071A). The cesium clock group and the hydrogen masers group are placed in two thermostatic chambers with two set of high-precision sensors monitoring and recording the temperature and humidity in each chamber. The temperature change stabilizes at ±0.25 ℃ since the system started operating. In the trial operation period from January 1, 2017 to June 30, 2018, the frequency stability of the two hydrogen masers are about 1.1E-15(τ=86400s), while the time keeping system is about 4.0E-15(τ=86400s). In January 1, 2017 to March 31, 2017, the time keeping data was compared with NIM through GPS common view [1], and the average deviation result is 5.6ns, *U*=1.5ns (*k*=2).

2. Operation status of the time keeping system of SIMT

The Allan variance, AVAR, is the most common time domain measure of frequency stability. In terms of phase data, the Allan variance is defined as [1]

$$\sigma_y^2(\tau) = \frac{1}{2(N-2)\tau^2}\sum_{i=1}^{N-2}[x_{i+2} - 2x_{i+1} + x_i]^2. \quad (1)$$

Where x_i is the *i*th of the *N=M+1* phase values spaced by the measurement interval τ. The result is usually expressed as the square root, $\sigma_y(\tau)$, the Allan deviation, ADEV.
The overlapping Allan variance can be expressed as

$$\sigma_y^2(\tau) = \frac{1}{2(N-2m)\tau^2}\sum_{i=1}^{N-2m}[x_{i+2m} - 2x_{i+m} + x_i]^2. \quad (2)$$

A comparison between the two hydrogen masers (denoted as HM1 and HM2) are shown in Figure 1. The overlapping Allan deviation, σ_y(τ=86400s) is calculated for each month duration from January 1, 2017 to June 30, 2018. The overlapping Allan deviations for each month are all better than 1.8E-15, and the average result is about 1.1E-15.

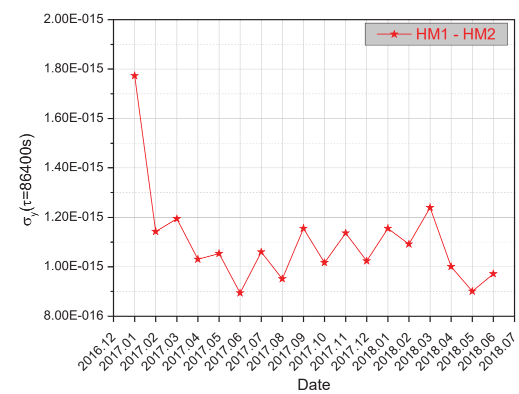


Figure 1. Overlapping Allan deviations,σ_y(τ=86400s), of the comparison between the two hydrogen maser for each month duration.

The daily frequency drifts of the two masers in one month duration are shown in Figure 2. The 1 PPS signals of the masers were compared with the GPS signal, and the phase difference data was record in the database. The frequency drifts are obtained by a least squares quadratic fit to the phase data [1]. The results of April and October 2017 are not shown in Figure 2 because the GPS receiver had some problems in the two periods. Ignoring these two results, other values are very good. The average daily frequency drifts of the two masers are 2.0E-15 and 1.5E-15 respectively.

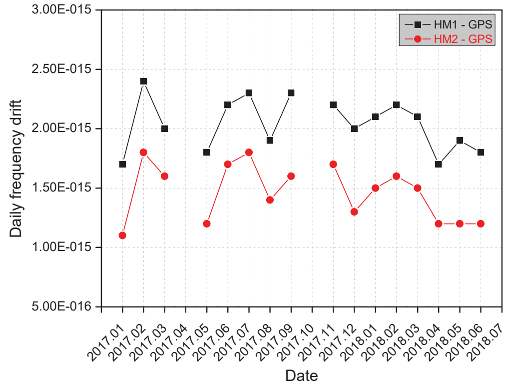


Figure 2. Daily frequency drifts of the two masers in one month duration.

Figure 3 shows the frequency stability of our time keeping system. The HM2 is chose as the reference. The SIMT time keeping system traces regularly to NIM through GPS. In April and October 2017 where there are some problems with the GPS receiver, these two months' stabilities are significantly larger than the others. Ignoring these two results, other values are all below 1.0E-14, the average value is about 4.0E-15.

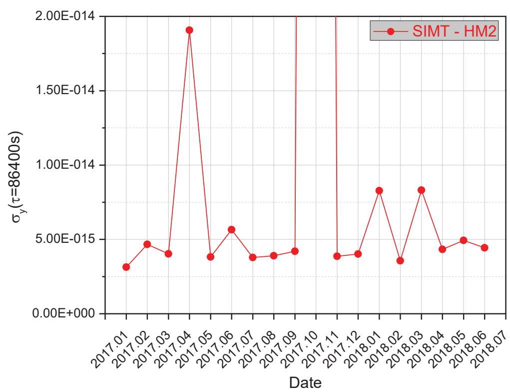


Figure 3. Frequency stability of SIMT time keeping system. $\sigma_y(\tau = 86400s)$ are shown.

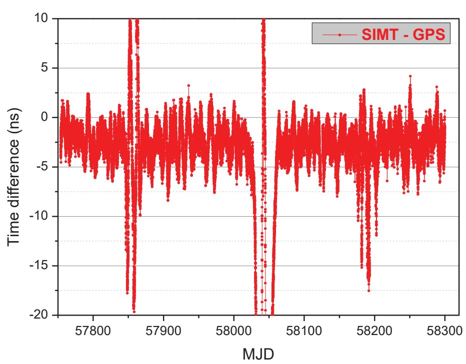
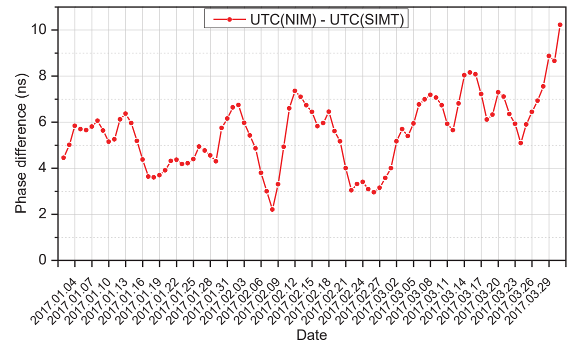


Figure 4. Time difference between the SIMT time keeping system and GPS.

Figure 4 shows the time difference between the SIMT time keeping system and GPS from January 1, 2017 to June 30, 2018. As is shown in Figure 4, the difference in three periods is much larger than the other. This is because the GPS receiver did not work properly in these three periods (April and October 2017, and March 2018). Ignoring the data in these three periods, the time difference between our system and GPS stabilizes in the range -7.5~5ns.

The time keeping data of the first season of 2017 was compared with the National Institute of Metrology (NIM) through GPS common view. Figure 5 shows the result of the comparison. The average deviation in the 3-month comparison is 5.6ns, the uncertainty is U=1.5ns (k=2).



3. Conclusion

The time keeping system of SIMT has been in good condition since 2017 when it started working normally. The average deviation of comparison between NIM and SIMT using GPS common view is 5.6ns, the uncertainty is U=1.5ns (k=2). The time keeping system of SIMT will make contribution to China's coordinated time.

4. References

1. D. Allan and M. Weiss, "Accurate time and frequency transfer during common-view of a GPS satellite," in Proc. 34th Frequency Control Symposium, pp.334-346, May 1980.

2. W. J. Riley, "Handbook of Frequency Stability Analysis," NIST Special Publication 1065 (2008).