NATIONAL TIME AND FREQUENCY STANDARD OF KAZAKHSTAN REPUBLIC. FIRST RESULTS

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1. ABSTRACT

The National Time and Frequency Standard (NTFS) of Kazakhstan Republic have been certified for the first time and started up in operational activity since 10 October 2001.

NTFS mainly consists of the ensemble of continuously operating high stable atomic clocks, clocks intercomparison system and GPS time receiver for remote time scales comparison.

The National time scale UTC(KZ) is generated basing on clock intercomparison and time link data between UTC(KZ) and UTC(SU).

As a result type B uncertainty of the NTFS is certified at the level of 1×10^{-13} and $|UTC(KZ)-UTC(SU)|\leq1\mu s$.

2. INTRODUCTION

A set of the National Standards of the main physical units constitute one of the essential component of state sovereignty. These become more and more demanding in modern CISs, especially in such a fast growing as Kazakhstan. It seems not astonishing that one of the first such a National Standard to be found the Time and Frequency Standard. The application area of modern time and frequency measurements is enormous: from simple wrist-watch with daily gained error about few tens seconds to the most sophisticated instruments for scientific application, navigation and communication which need daily error 1 billion part of the second (1ns) or even less.

Trying to satisfy the need of Kazakhstan Republic in such a mean experts from Committee on Standardization, Metrology and Certification made a request to the Institute of Metrology for Time and Space GP “VNIIFTRI” on development, shipping, installation, teaching of personnel, run into operation and certification tests of the National Time and Frequency Standard.

According to requirements of Kazakhstan partners such an apparatus complex has to consist mainly of:

- Two stationary H-masers
- One portable clock
- Automated time and frequency intercomparison system
- Satellite time receiver for remote time scales comparison
- Distributing amplifiers of 5 MHz and 1 pps
- Time signal transmitting system
- UPS and climatization system

Main metrology requirements were as follows:

- Automated time and frequency intercomparison system random uncertainty $\sigma_y(\tau))|\leq5\times10^{-13}/\tau$ for sample time $1\leq\tau\leq100$ and $\sigma_y(\tau))|\leq1\times10^{-15}$ for sample time from 1 hour to 1 day
  $\sigma_x(\tau))|\leq1$ ns for sample time form 1s to 1 day
- Satellite time receiver for remote time scales comparison random uncertainty $\sigma_x(\tau))|\leq20$ ns for sample time 1 day
- The time error gained during portable clock transportation for the period of 12 hours less than 3 ns
- National Time and Frequency Standard type B uncertainty less than 1×10^{-13}
- The National time scale UTC(KZ) possible offset relative to UTC(SU) less than $1\mu s$.

3. REALIZATION

During a period about one and a half year the requested apparatus complex have been developed, shipped, installed and run into test operation by joint effort of the team consisted of experts from Institute of Metrology for Time and Space and Nijny Novgorod Vremya-Ch company. Along with it a group of experts from Kazakhstan headed by leader of laboratory responsible for future National Standard learned a proper theoretical course in Time Metrology in the Institute of Metrology for Time and Space and took a training course first of all in servicing of H-masers and other time measuring instruments.

As a result of this activity the following complex have been created, Fig.1.

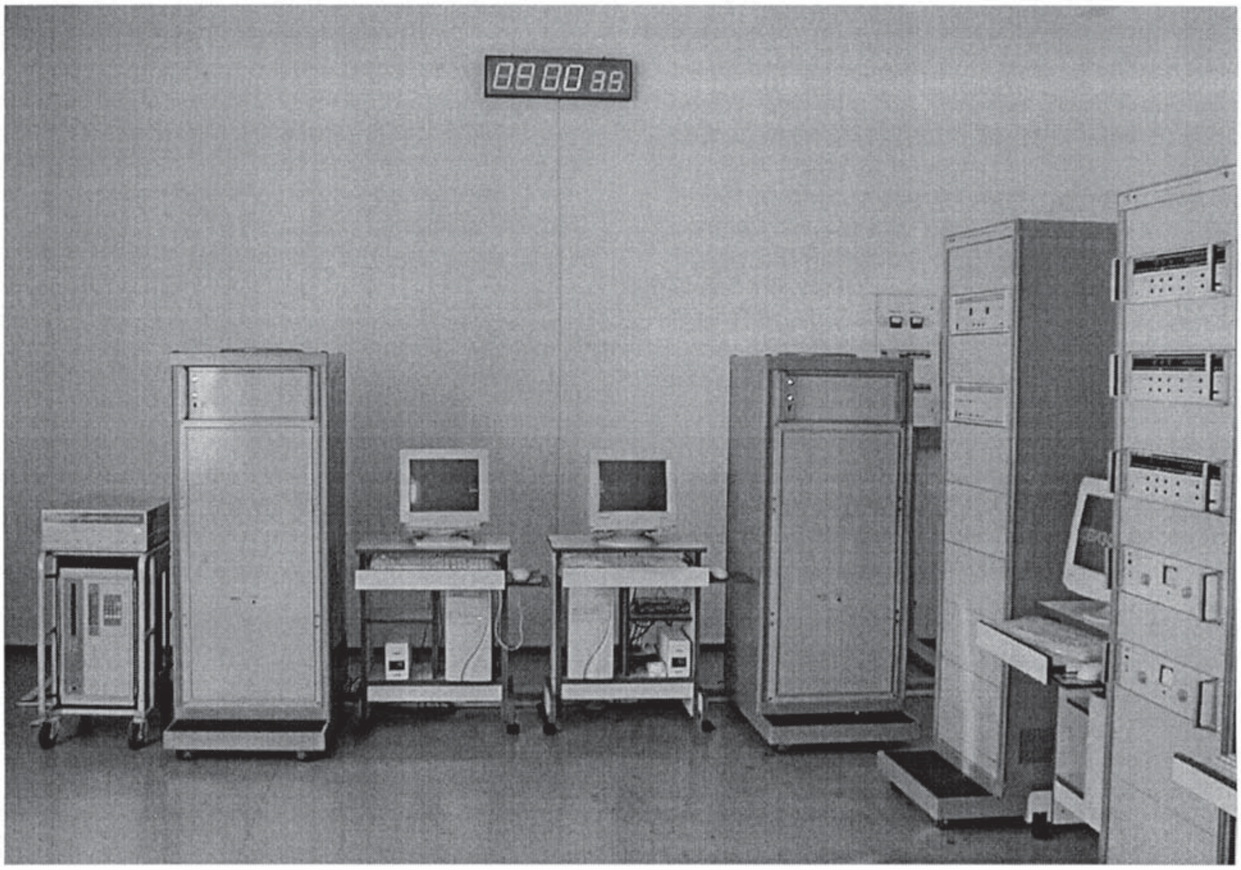

Fig.1

4. PERFORMANCES

During test operation and certification test period main expected performances have been validated.

First we started from automated time and frequency intercomparison system. It consisted of precise time interval meter type of GT 200 preceded by computer controlled multiplexer. The time results of the tests are depicted at Fig.2.

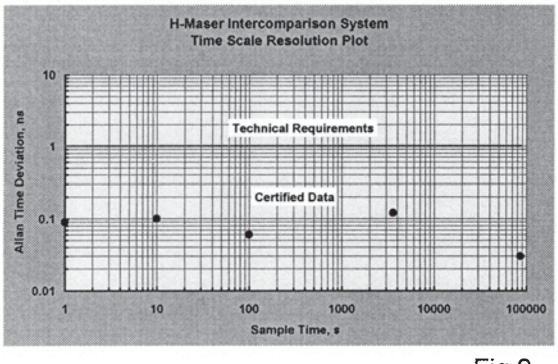

Fig.2

The other part of the frequency measuring system consisted of two channels 5 MHz phase comparator which 1 pps outputs fed above mentioned multiplexer and which, in turn, directed them to time interval meter. Results of its tests are depicted at Fig.3.

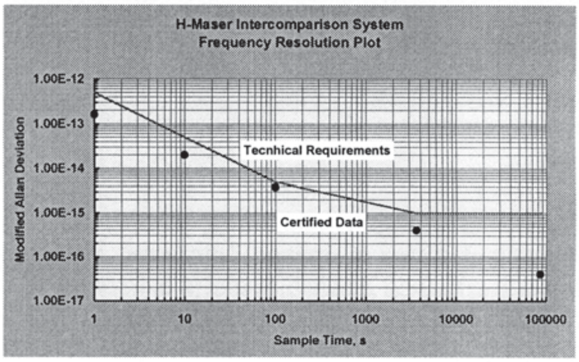

Fig.3

At this stage one has enough means to estimate frequency stability of the main time-keeping instruments – H-masers. Two continuously operating H-masers made by Vremya-Ch company were type of VCH-1005B with expected long term relative frequency instability about 2×10^{-14} for sample time from 1 hour to at least 1 day. Automatic Frequency Control (AFC) loop periodically measured H-maser's cavity frequency detuning and tuned it if necessary. To realise AFC both H-masers in sequence played a role of frequency reference for each other, basing on which one may vary parameters of H-maser under investigation and measure its cavity detuning value. In fact cavity detuning was calculated basing on readings of one the of above mentioned phase comparators fed by both H-masers 5 MHz signals.

The other striking feature provided by H-maser of VCH-1005B type is possibility to monitor all necessary parameters of instrument via RS232 port. One may use such a monitor information for additional investigations or postprocessing needs.

Data for relative frequency instability for both H-masers looks quite similar and are presented at Fig. 4.

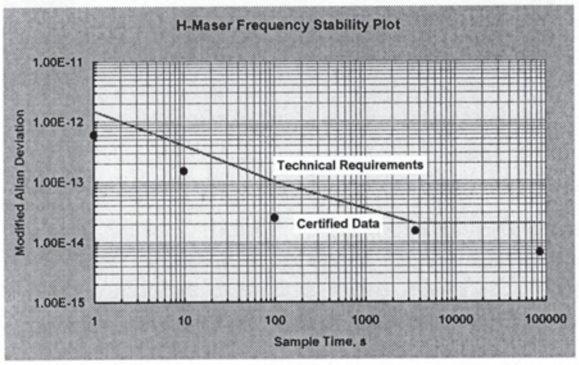

Fig.4

The third time keeping instrument in the ensemble was portable clock based on passive H-maser of VCH-1004A type, presented on Fig.5.

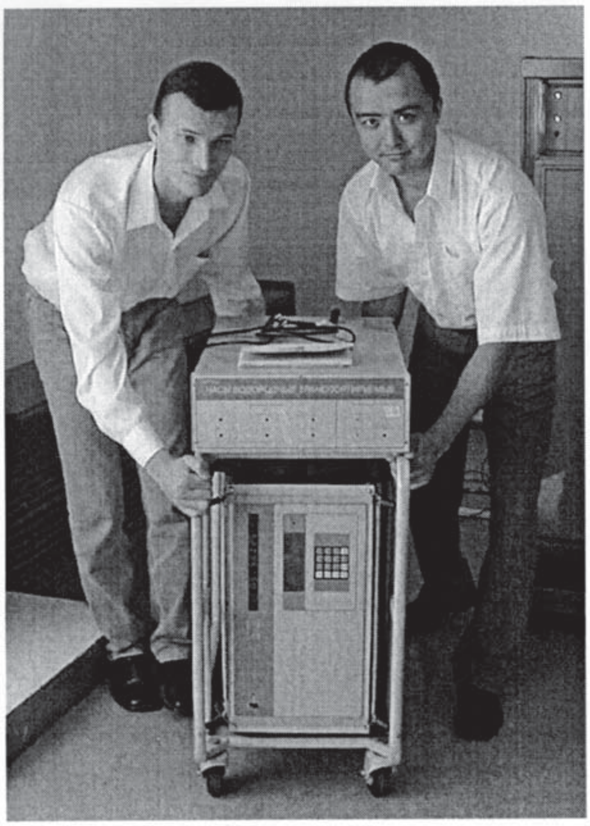

Fig.5

Certified engineers Mr. R. Ismagilov, at the left, and Mr. A. Batanov with portable atomic clock during tests

A portable clock is absolutely essential for calibration needs in country with limited time and frequency infrastructure. Under certification tests during few trips the portable clock demonstrated gained error less than 1 ns for during transportation time from 3 to 4 hours.

The other mean for remote clock time scale comparison was operational one – specially designed GPS time transfer receiver which operated under international tracking schedule. Such a configuration provides world wide time link to any laboratory contributing to TAI and able to track simultaneously signals from the same satellites (common-view mode of operation). The GPS time receiver consists of Motorola VP Oncore 8 channel single frequency module, additional GT 200 time interval meter, control computer and software, Ref.1. Time resolution of the instrument was evaluated, Fig. 6, and internal delay calibrated in Mendeleevo by short base comparing instrument with TTR6 time transfer receiver from Allen Osborne Associate*. Almaty-Mendeleevo time link uncertainty for one day sample time was demonstrated about few ns.

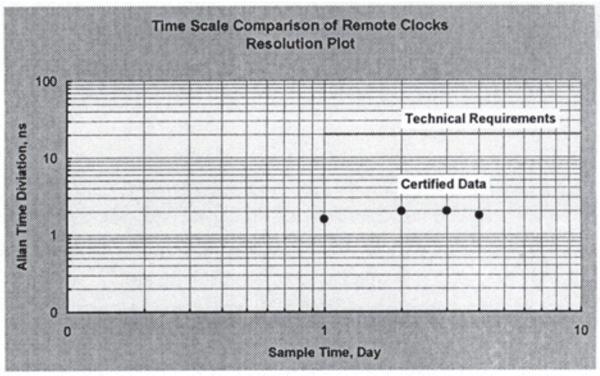

Fig.6

The National time scale UTC(KZ) is steering time scale generated basing on two data streams: clock ensemble intercomparison and time link data between UTC(KZ) and UTC(SU) – National time scale of Russian Federation, and simple time algorithm, Ref. 2. Within period of five days forecast time scale ($UTC(KZ)_{draft}$) is generated basing on the results of H-masers intercomparison and few constants estimated at previous cycle only. Binary weighting procedure applied to the clock. Then, basing on elapsed five days $UTC(KZ)_{draft}$ comparison data relative to UTC(SU), definitive time scale UTC(KZ) generated and necessary constants are calculated for next five days period. Such an arrangement of time scale generation process resulted in data depicted at Figs 7-8.

One may see that for test interval about half a year |UTC(SU) – UTC(KZ)| difference have been

* TTR 6 time transfer receiver operates in IMVP under loan agreement with BIPM.

considerably less than 1 μs that matched all requirements, Fig.7.

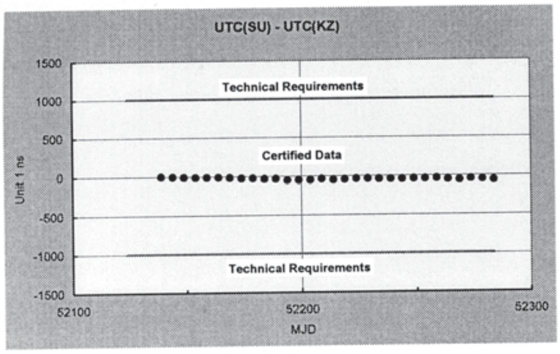

Fig.7

On other hand Fig. 8 demonstrates UTC-UTC(k) difference behavior for the same period and validates that one more member of the world time community have been born in Kazakhstan Republic.

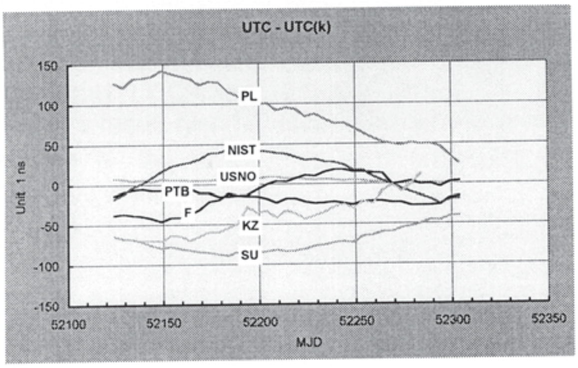

Fig.8

5. REFERENCES

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[2] N.Koshelyaevsky, Yu.Tremsina, H. Zagirova The simple time algorithm and software for steering time scale, Proceedings of the IV Time Scales Algorithms Symposium, Sèvres, 18-19 March, 2002, (to be published).

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