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Federal Office of Metrology METAS

CCTF 2012 report from METAS (CH)
Report to the 19th session of the Consultative Committee for Time & Frequency (CCTF), 13-14 September 2012

1 Clocks for TAI

1.1 Commercial clocks

The situation has remained almost the same at METAS as reported in 2009. We are currently operating 4 cesium standards and 1 hydrogen maser, which all contribute to the realization of the local time scales and to the computation of TAI.

1.2 Primary Cs continuous beam frequency standard

Diaphragm

coupler
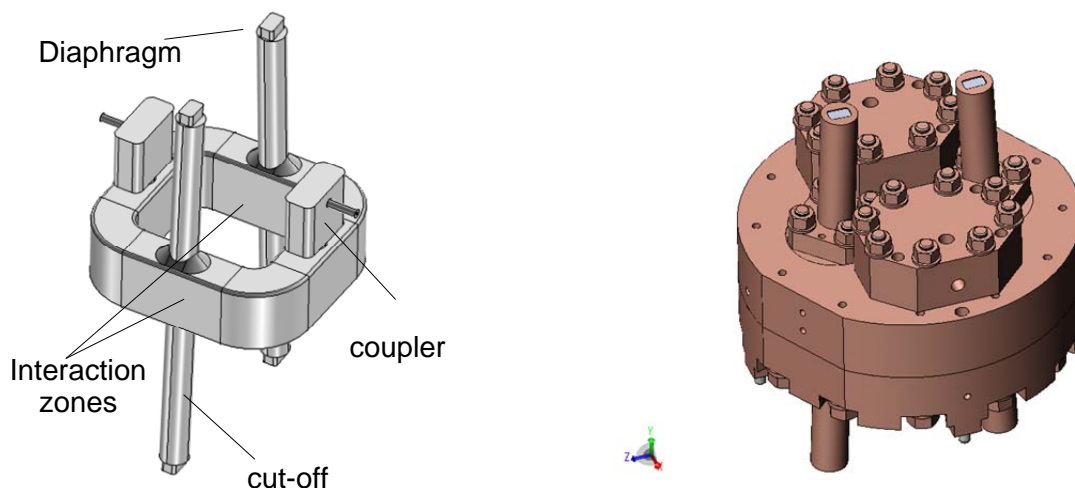
Interaction zones

cut-off

Figure 1 inner structure and mechanical design of the new FOCS-2 microwave cavity.

METAS is still working on the development of its continuous Cs fountain clock FOCS-2 in close collaboration with the University of Neuchâtel [02, 03, 04, 10]. An extensive analysis of the different biases has been carried out in order to assess the uncertainty budget of the primary standard [03]. Currently the main source of uncertainty is the large phase gradient across the openings of the microwave cavity. We have recently demonstrated that the origin of this phase gradient is the superposition of a non-resonant higher order mode with the resonant TE_{021} mode in the cylindrical microwave cavity. This led us to design a completely new resonator, which is based on a rectangular resonant structure with rounded angles. The geometry of the cavity is optimized to excite only the TE_{105} mode and the resonance is excited by means of two symmetrically positioned microwave couplers. This new resonator was de-

signed and optimized by using finite elements analysis, and a reduction of the phase gradient from 350 μrad/mm (original design) to less than 3.4 μrad/mm (new design) is expected. A validation of the microwave design was successfully carried out, jointly with CERN in Geneva. Figure 1 shows the hollow inner part of the resonator (left) and the final realization of the new cavity (right).

 The new microwave cavity is currently under construction and the first measurements with the modified FOCS-2 primary standard are scheduled for October 2012, with the main objective to finalize the bias analysis of the uncertainty budget in the next few months and to contribute to TAI as soon as possible. With the new microwave cavity we expect an uncertainty close to 1×10^{-15}.
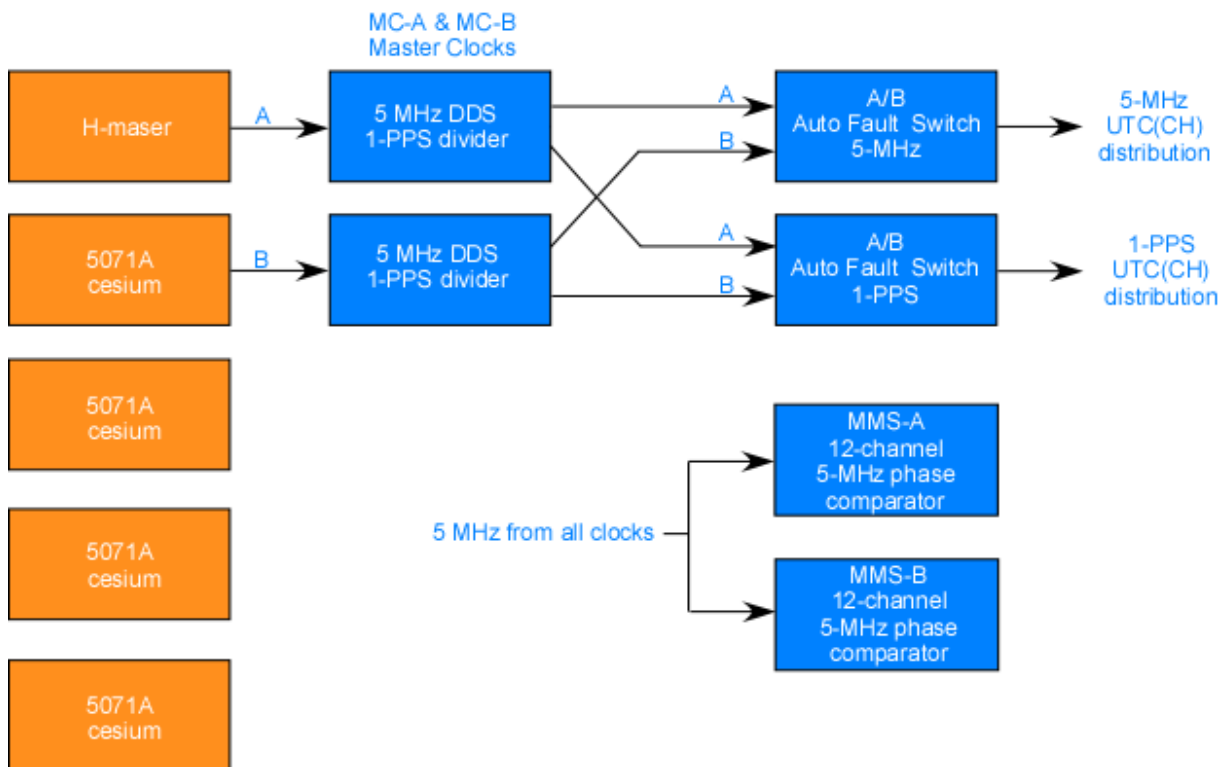
2 Timescales generation

Figure 2 hardware architecture of the ART time scale generation system

The new ART (Autotime Real Time) time scale generation system was commissioned in 2011 after several years of development [06]. With the new ART system, all local comparisons are consistent within 100 ps and the global uncertainty on the measurements traceable to UTC is 1 ns, limited by the accuracy of the TWSTFT TAI link with the pivot laboratory located at PTB.

The original *Autotime* system was developed at the federal office of metrology during the period 1992-1994. *Autotime* was based on a paper clock definition of UTC(CH) and was running on a single computer under the HP-UX operating system. In 2002 we started experimenting with master clock steering algorithms and with time scale algorithm simulations with the goal of developing a new system.

In 2006-2007 a prototype ART (*Autotime Real Time*) system was designed and tested. The ART prototype was a hybrid combining the original *Autotime* system for the computation of the time scales with additional software and hardware for the generation and steering of a pair of redundant master clocks steered to the paper time scale. At the end of 2007 the official definition of UTC(CH) was changed from a paper time scale to a master clock hardware signal.

In 2011 the prototype ART system was replaced by the final production system.

The ART system has three levels of redundancy that allow the maintenance of any part of the system without interruption of service. At the first level there are two master clocks and five atomic clocks in the ensemble which allows the replacement of any clock or master clock. At the second level there are two independent clock comparison systems which allow data substitution, in case of missing data, and continuous consistency checking and reporting of the clock data. At the third level there are two redundant control computers which perform independent calculations of the paper time scale, of the clock states and of the master clock steering parameters. Any system outputs inconsistency between the control computers is automatically detected and reported. The real time control software can be upgraded and the control computers can be rebooted or replaced without interruption of service.

Figure 2 shows the hardware architecture of the ART system. Note the redundancy of the master clocks (MCA and MCB) and the redundancy of the 5 MHz phase comparison systems (MMS-A and MMS-B). The redundant real time controllers are not shown on the figure. Figure 3 illustrates the progress made in the generation of UTC(CH) since 1998.
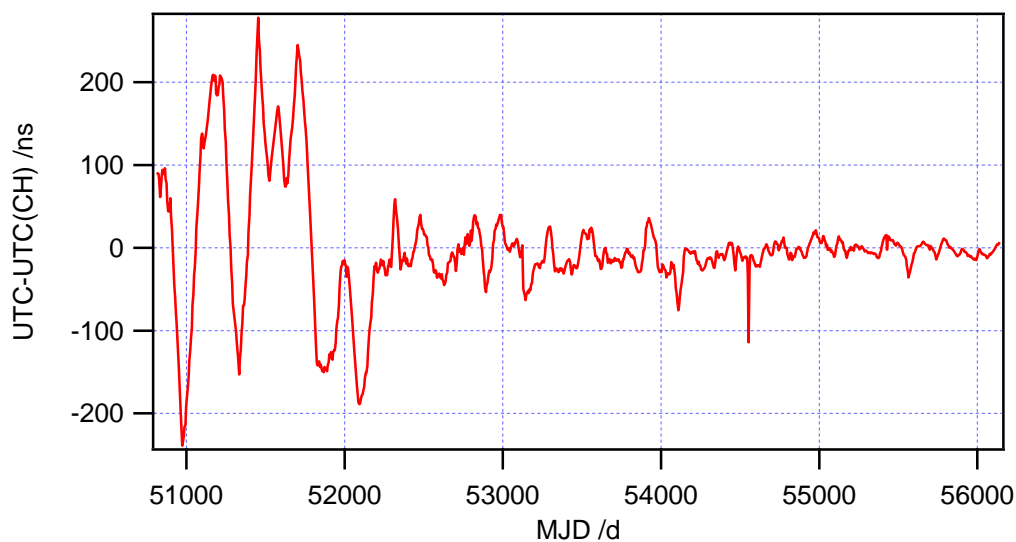

Figure 3 UTC-UTC(CH) as reported by BIPM since January 1998

3   Remote comparisons

The official link for the TAI international comparisons is a TWSTFT station [01]. The TWSTFT link was last calibrated in August 2008 by means of the mobile TWSTFT station of TUG (Technical University Grätz). More details are reported in [01]. In 2009 we have participated to a verification of the calibration of the METAS-PTB comparison links, including the TWSTFT link, by means of a traveling GPS receiver [08].

METAS also operates 3 GPS receivers. Station CH00 (location WAB1) has a Septentrio PolaRx2 receiver. Station CH01 (location WAB2) has an Ashtech Z-XII-T receiver and is an official IGS station. Station CH02 (location WAB3) has a Septentrio PolaRx3 receiver. The GPS receivers are used as backups for the TWSTFT TAI link. The very good stability and accuracy of the METAS time & frequency comparison links is at the origin of several collaborations with other laboratories involving the comparison between different international links [07, 08, 11].

4   Time dissemination

The Swiss time code transmitter HBG was decommissioned at the end of 2011 after decades of continuous operation. The Swiss government decided in 2009 that HBG would cease its operation because the estimated costs of refurbishing of the antenna, built in 1932, were too expensive in regard to the number of users of the HBG time service.

5   References

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