Frequency Combining System for Atomic Clock Ensembles

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High frequency and 1PPS output signals of atomic clock ensembles are produced by single atomic clock usually, which is to be the most reliable and possesses the best signal quality. Signal of the best atomic clock (master clock) can be steered by means of external auxiliary crystal oscillator (phase/frequency stepper). It allows implementing time scale algorithms for long-term stability improvement of real signal and adjusting phase and frequency to UTC. In case of master clock failure, switching to another atomic clock and adjusting of output signal is required. To avoid output signal loss and phase/frequency jumps it is possible to use more complicated scheme for auxiliary oscillator synchronization. This scheme assumes simultaneous measuring of frequency differences between controlled oscillator and several atomic clocks, analysis of frequency differences and forming control code to synchronize slave oscillator. Slave oscillator frequency can be stabilized by weighted average frequency of the ensemble or by master clock frequency (master clock weight is 1, the other has weight 0). This approach allows detecting clock failures and preventing output signal from frequency and phase jumps. Moreover, quality of output signal can be improved due to averaging. To our knowledge, this effect has not been clearly demonstrated in experiments with atomic clock ensembles and such frequency combining systems. Fig. 1 illustrates improvement of frequency stability of signal produced by atomic clock combiner VCH-317, which is synchronized to the average frequency of four active hydrogen masers VCH-1003M. Details of the measurement method and additional experimental results are described and discussed in the report. Simple modification of frequency control algorithm – quasi-optimal atomic clock frequency combining algorithm[1] is described also. The algorithm allows combining atomic clocks of different types, which have different frequency stability characteristics on different averaging times.

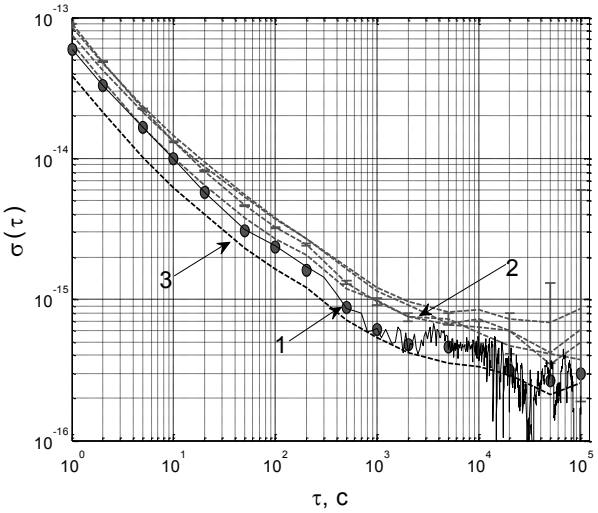

Fig. 1: 1 – Allan deviation of VCH-317 output signal, 2 – Allan deviations of four VCH-1003M, 3 – estimation of the minimal Allan deviation of the group signal (possible for this group of input signals)

[1] K.G. Mishagin S.D. Podogova, I.N. Chernyshev, S.Yu. Medvedev, "Algorithm for Generating the Output Signal of a Group Frequency Reference", Measurement Techniques, vol. 56, p. 887-893, 2013.