

THE NBS ATOMIC TIME SCALE SYSTEM: AT(NBS), SAT(NBS), AND UTC(NBS)

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Summary

The Atomic Time Scale at NBS Boulder has its rate determined by periodic calibration with the NBS primary frequency standard, currently NBS III. Because of the increased demand for accurate and precise timing, a study was made of the clock ensemble which generates the time scale AT(NBS) to determine the precision and accuracy with which time and frequency may be generated.

The accuracy involved both the 5 part in  $10^{13}$  uncertainty in NBS III and the frequency dispersion of the ensemble after calibration. To determine the precision capabilities, noise models were established for the time dispersion characteristics of each clock in the ensemble. Some theoretical considerations based on these models yielded very encouraging predictions on both how to process the time data from each clock and on the precision capabilities of the ensemble.

A computer program incorporating the above ideas was written with the capability to self-optimize the statistical weight given to each clock in the ensemble. The program also determined the clock time, frequency, and precision of each member of the ensemble. Reasonable agreement was achieved between the predicted results and those measured.

The accuracy of the second used for AT(NBS) time scale is estimated to be within 9 parts in  $10^{13}$  (1 sigma limit) of the internationally agreed upon definition employing the cesium atom. The internal estimate of the precision capabilities of the AT(NBS) time scale gives the following equation for the time dispersion:

$$\epsilon_{\text{rms}} = [k_1 \tau + k_2 \tau^2]^{1/2}$$

where  $k_1 = 5.3 \times 10^{-22}$  seconds,  $k_2 = 3 \times 10^{-27}$ , and where  $\epsilon_{\text{rms}}$  and  $\tau$  are the possible root-mean-square time error accumulation (1 sigma limit) in seconds and the elapsed time in seconds respectively.

SAT(NBS) and UTC(NBS) are coordinated time scales, i. e., controlled by international regulation. In addition a cooperative effort between the United States Naval Observatory and the National Bureau of Standards has led to a synchronization of the times of the UTC(USNO) and UTC(NBS) time scales to within 5 microseconds.

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