Frequency Evaluation of the Primary Frequency Standard NIM5

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I. SUMMARY

The primary frequency standard NIM5 was used to measure the average fractional frequency difference of the H-maser H271, identified by the clock code 1404871, during an evaluation campaign over 20 days in April 2015. The results are given in table 1, together with the uncertainties of NIM5 and of the link between NIM5 to maser H271.

Table 1 Summary of the frequency measurements of H-maser H271 (1404871)

Period	MJD 57119.0 to 57139.0
$y_{(\mathrm{NIM5\text{-}H271})}$ [$\times 10^{-15}$]	2874.4
Duty cycle [%]	95.6%
u_A [$\times 10^{-15}$]	0.6
u_B [$\times 10^{-15}$]	1.4
$u_{link/lab}$ [$\times 10^{-15}$]	0.2
u_{total} [$\times 10^{-15}$]	1.54

The combined total uncertainty u_{total} is the square sum of the three uncertainties as following:

$$u_{total} = \sqrt{(u_A)^2 + (u_B)^2 + (u_{link/lab})^2} \quad (1)$$

Type A uncertainty u_A is the statistical uncertainty on the frequency measurement, u_B is the Type B uncertainty from bias evaluations of NIM5, and $u_{link/lab}$ is the uncertainty induced by the link between NIM5 fountain clock and the H-maser H271, which includes the dead time and the phase noise of the link between NIM5 and H271. All the above uncertainties are calculated at 1σ.

II. Measurement methods

No change to the NIM5 system has been made since the previously reported evaluation. The C-field has been remapped to check the center Ramsey fringe position of the magnetic field sensitive transition. During the evaluation period, NIM5 was operated at low and high densities alternatively. The collision-free frequency at zero density is:

$$f_0 = \frac{k\bar{f}_{\mathrm{L}} - \bar{f}_{\mathrm{H}}}{k-1} \tag{1}$$

Here k is the ratio between high and low densities, and f_H and f_L are the measured frequencies at high and low densities respectively. The uncertainty in eliminating the collisional frequency shift is derived from equation (1) as:

$$\sigma_0^2 = \left(\frac{k}{k-1}\right)^2 \sigma_{\mathrm{L}}{}^2(\tau_{\mathrm{L}}) + \left(\frac{1}{k-1}\right)^2 \sigma_{\mathrm{H}}{}^2(\tau_{\mathrm{H}}) + \left(\frac{\bar{f}_{\mathrm{L}} - \bar{f}_{\mathrm{H}}}{(k-1)^2}\right)^2 \sigma_k{}^2 \tag{2}$$

Here, the first two terms are related to the respective statistical frequency uncertainties (σ_L, σ_H for the low and high densities). The high and low density instability values of 0.21×10^{-15} and 0.23×10^{-15} are obtained respectively for these 20 day period. The combined type-A uncertainty is calculated from equation (2) to be 0.6×10^{-15}.

The combined relative Type B uncertainty is similar to what has been given in the previous report, and is 1.4×10^{-15}. The dead time distribution during this report period is shown in figure 1:

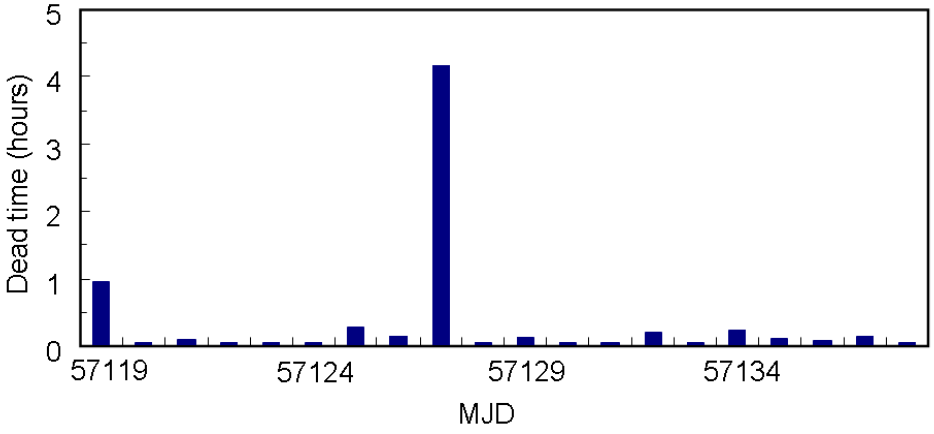

Figure 1 Dead time distributions in April, 2015 report period.