Tests of the Cross-Correlation ADEV Using Two PicoPak Clock Measurement Modules

Tests were conducted of the cross-correlation Allan deviation technique using two PicoPak clock measurement modules (S/N 103 and 107) to determine its effectiveness in reducing their noise floor. Two Efratom/Datum LPRO Rb oscillators (Rb1 and Rb2) were measured with each PicoPak module by using an RF power splitter on their 10 MHz outputs and driving the two PicoPak reference and signal inputs identically. The measurements were started at nearly the same fractional second. That was done manually by first starting one module (S/N 103) and noting the fractional second of its first data timetag, and then starting the second module several times until its first timetag had a fractional second nearly the same. The actual timetag difference was 0.090 second (modulo 1 second). At the end of the overnight (around 12½-hour) run, the other PicoPak module (S/N 107) was stopped first. Before performing the stability analysis, 30 data points (27 at the start, 3 at the end) were removed from the S/N 103 data to provide an equal number (44771) of closely-aligned data points from each module. Stable32 was then used to perform conventional and cross-correlation stability analyses of these near-simultaneous data, as shown in the following stability plots.

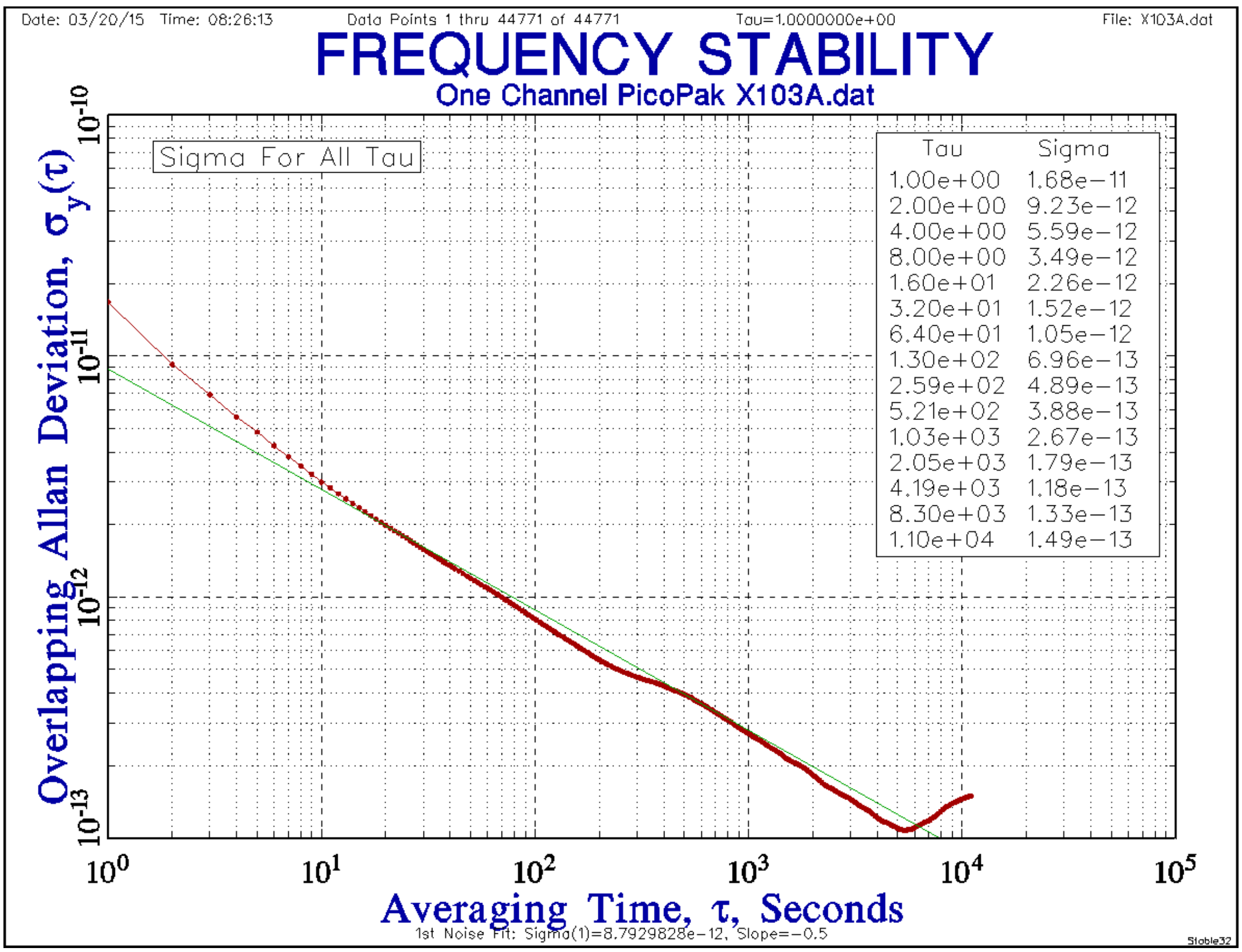

Figure 1. One Channel PicoPak S/N 103 ADEV Stability Plot

The noise is white FM at about $8.8 \times 10^{-12}\tau^{-1/2}$ except for excess PicoPak white PM quantization noise at short tau. The stability "flickers out" at about $1\text{-}2 \times 10^{-13}$. This is the typical stability of a pair of LPRO Rb oscillators. The single PicoPak has a white PM noise level of about $1.3 \times 10^{-11}\tau^{-1}$ and is able to measure these sources for averaging times longer that about 10 seconds.

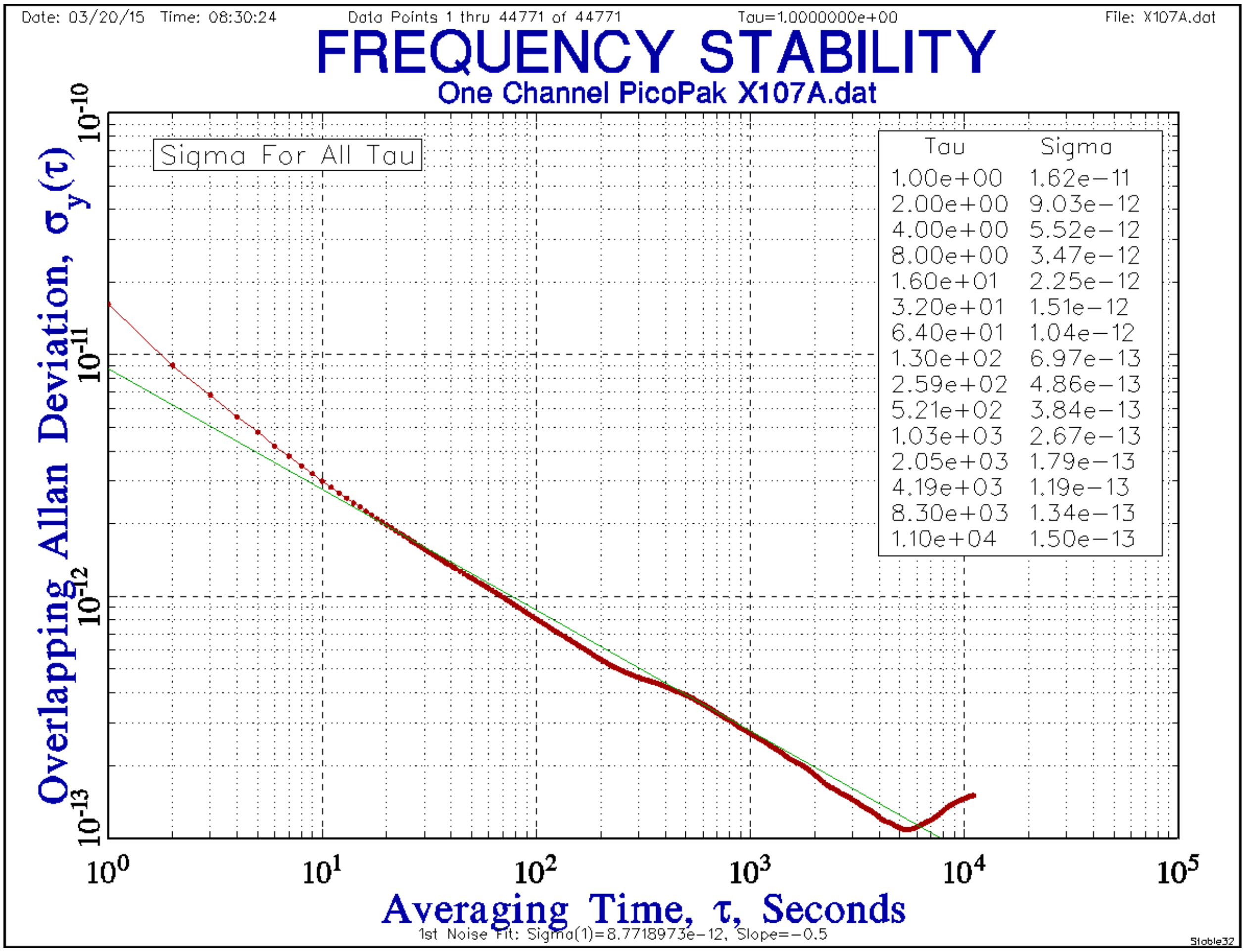

Figure 2. One Channel PicoPak S/N 107 ADEV Stability Plot

The noise is also white FM at about $8.8 \times 10^{-12}\tau^{-1/2}$ except for excess PicoPak white PM quantization noise at short tau. The stability "flickers out" at about $1\text{-}2 \times 10^{-13}$. This is the typical stability of a pair of LPRO Rb oscillators. The single PicoPak has a white PM noise level of about $1.3 \times 10^{-11}\tau^{-1}$ and is able to measure these sources for averaging times longer that about 10 seconds.

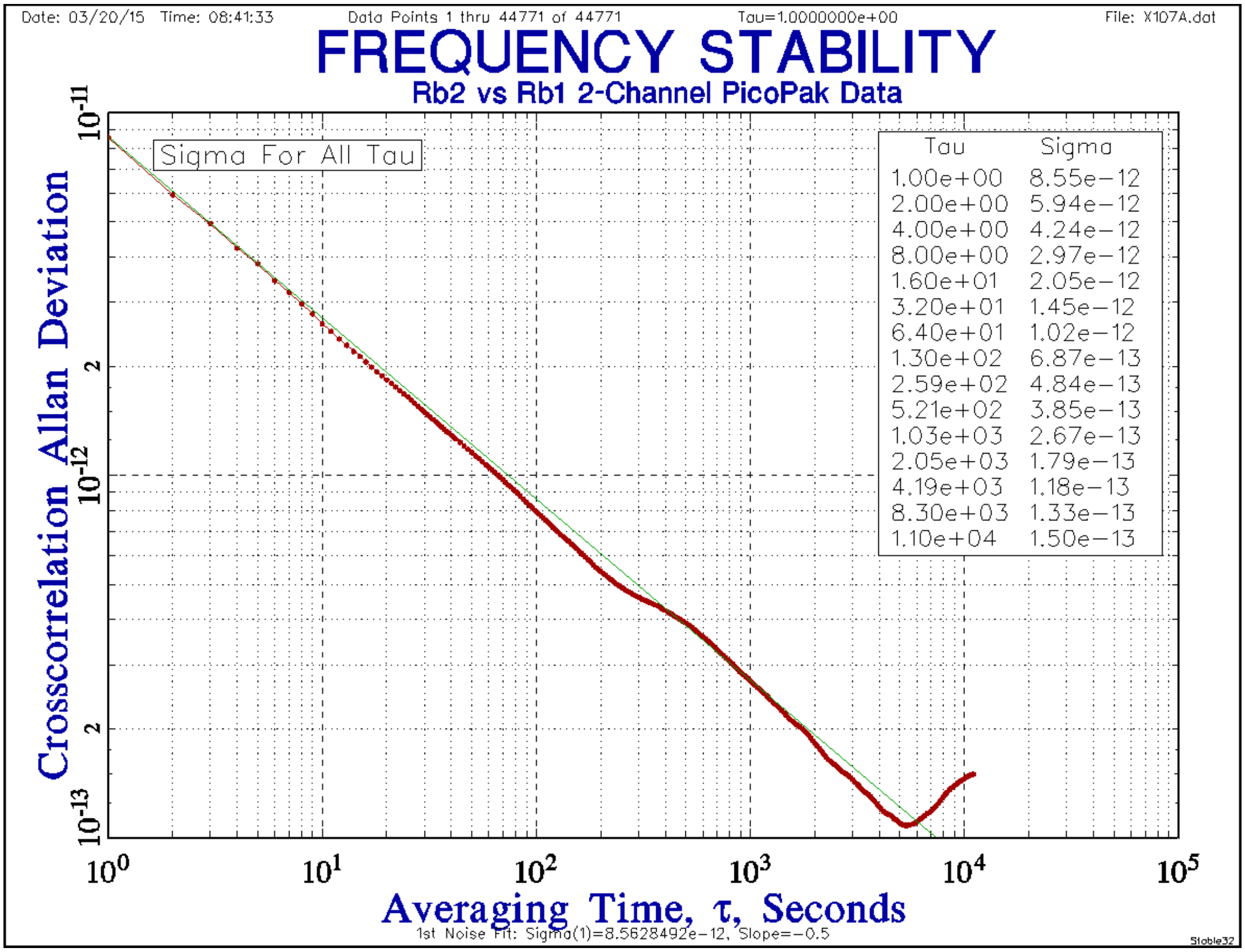

Figure 3. Crosscorrelation ADEV Stability Plot

The noise is white FM at about $8.6x10^{-12}\tau^{-1/2}$ even at short tau. The stability "flickers out" at about $1\text{-}2x10^{-13}$. This is the typical stability of a pair of LPRO Rb oscillators. The pair of PicoPak clock measurement modules is able to measure the stability of these sources down to an averaging time of 1 second by using the cross-correlation technique.

The amount of noise floor reduction provided by the cross-correlation technique can be measured by a fully-coherent run with the same 10 MHz signal applied to the reference and signal inputs of both PicoPak modules as shown in Figure 4.

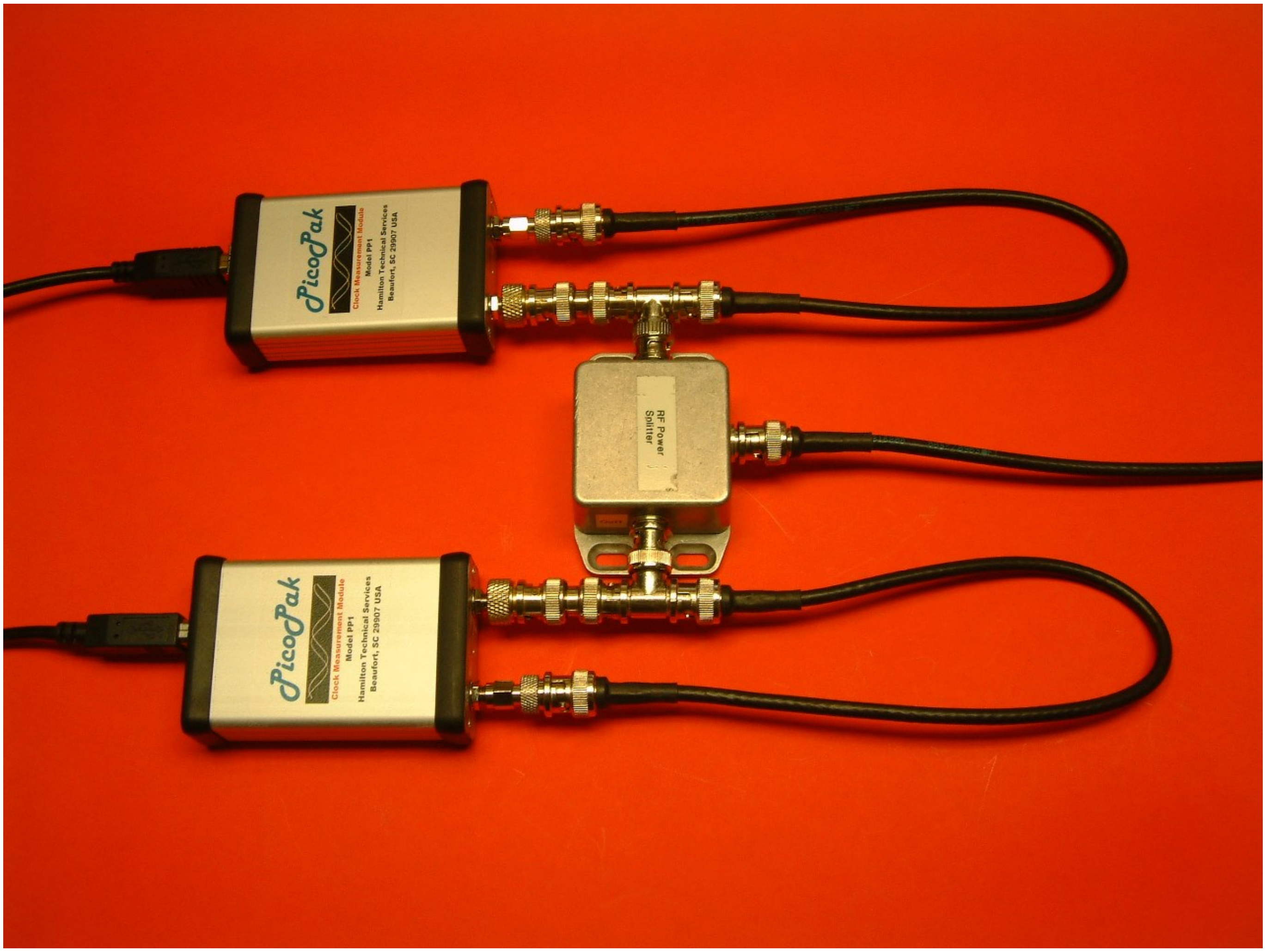

Figure 4. Fully-Coherent Coherent Cross-Correlation Noise Floor Test Setup

Stability plots for the two individual and cross-correlation noise floors are shown in Figures 5-7 below. During this test, the timetags of the two modules were synchronized to within 0.016 second.

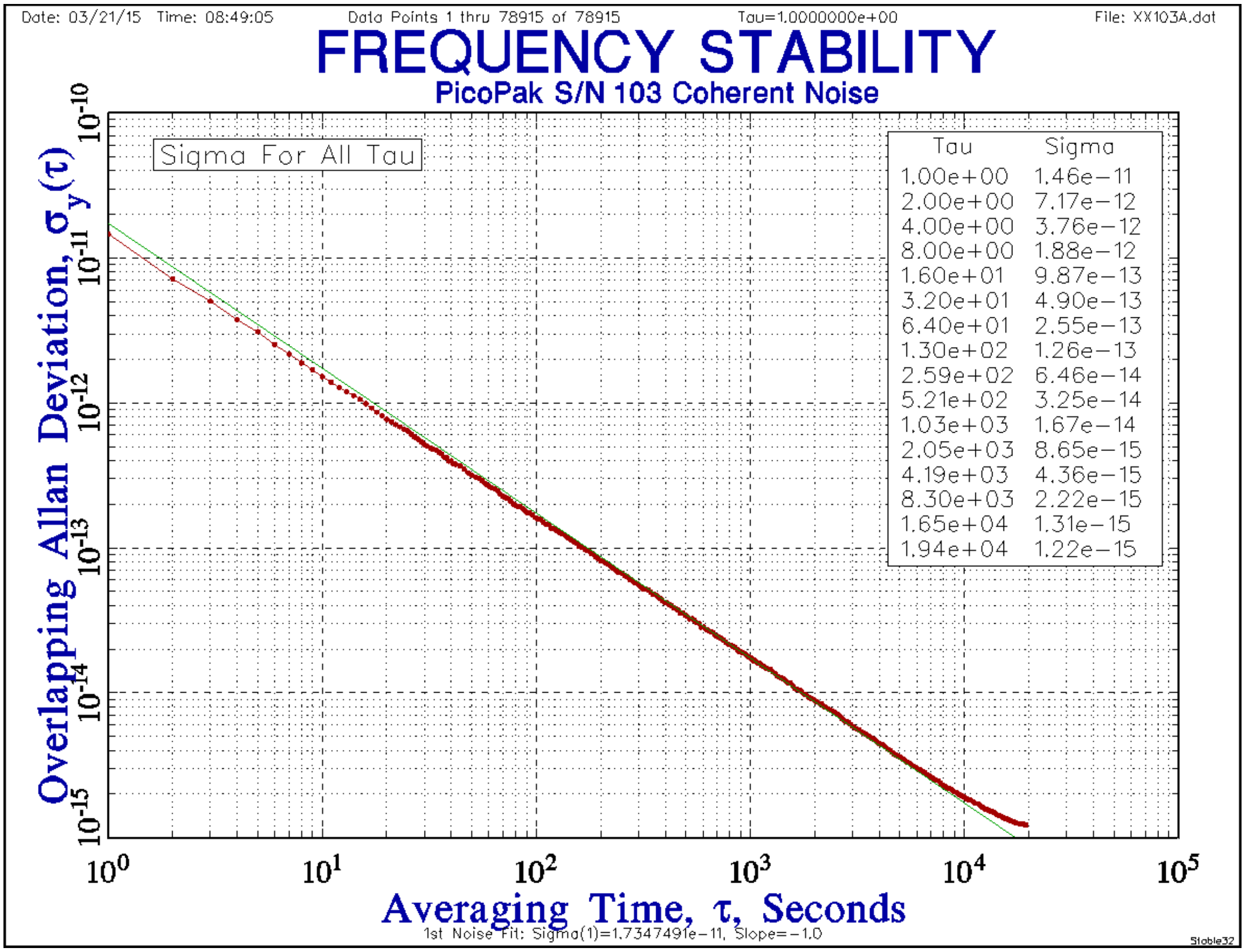

Figure 5. PiciPak Module S/N 103 Coherent Noise Floor.

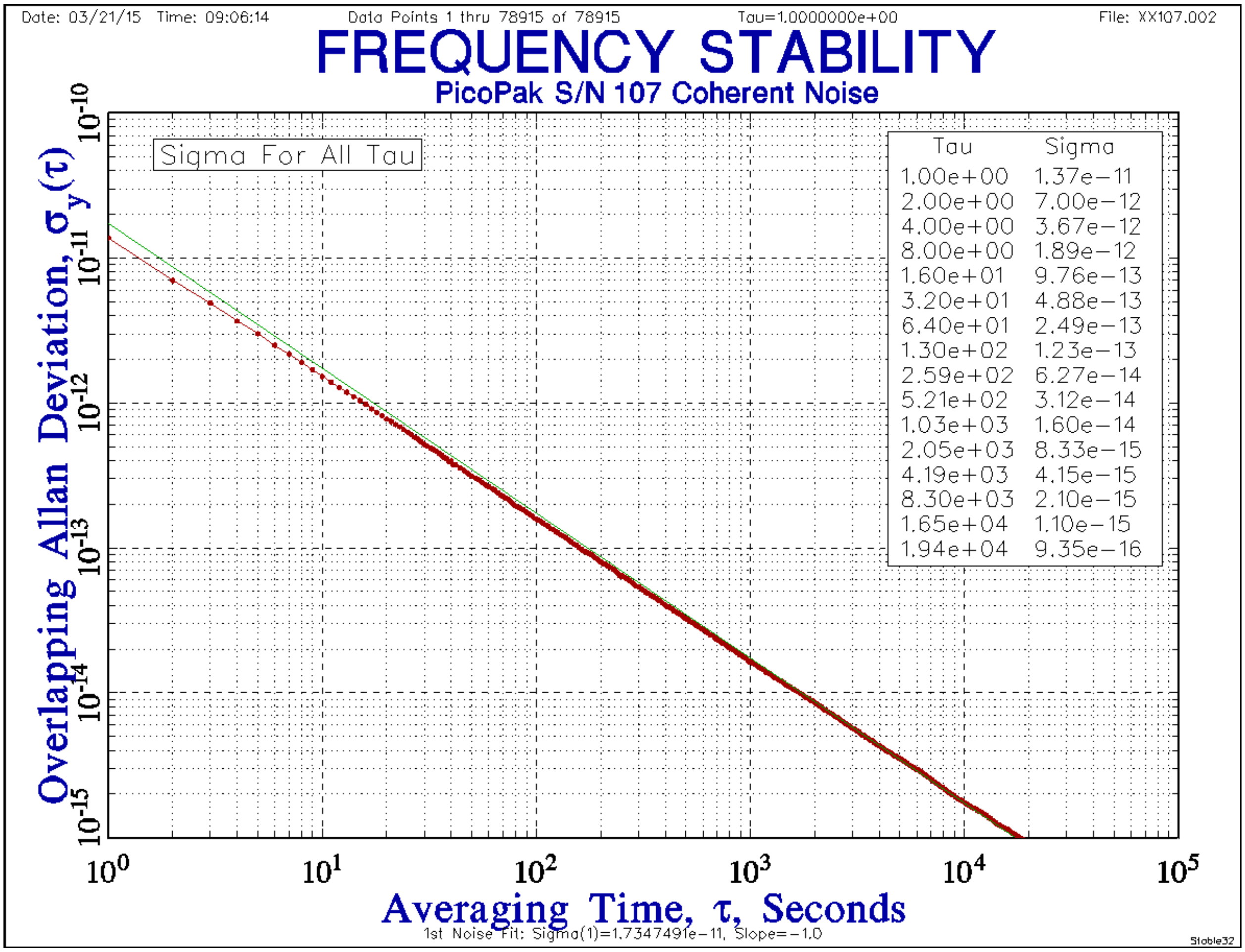

Figure 5. PiciPak Module S/N 107 Coherent Noise Floor.

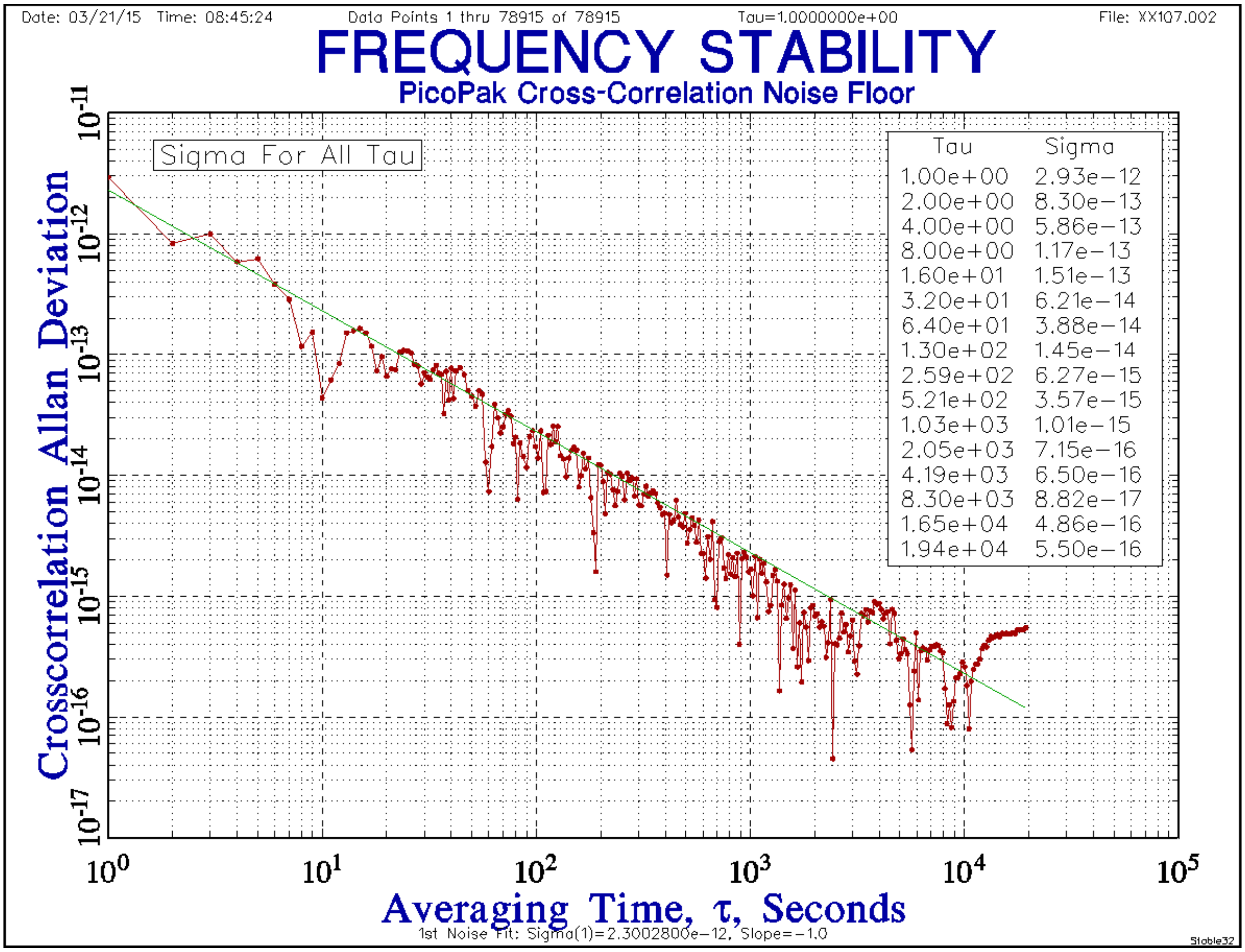

Figure 5. PiciPak Module Cross-Correlation Coherent Noise Floor.

The individual 1-second coherent noise floors were 1.47×10^{-11} and 1.37×10^{-11} for PicoPak modules S/N 103 and 107 respectively. Using cross-correlation, the 1-second white PM noise floor is reduced by a factor of about x5 to 2.93×10^{-12}. The latter is well below the value for the two Rb oscillators, thus validating their measurement.

We conclude that the cross-correlation technique is an effective means to reduce the instrumental noise of the PicoPak clock measuring module.

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