

The PQConsole Program

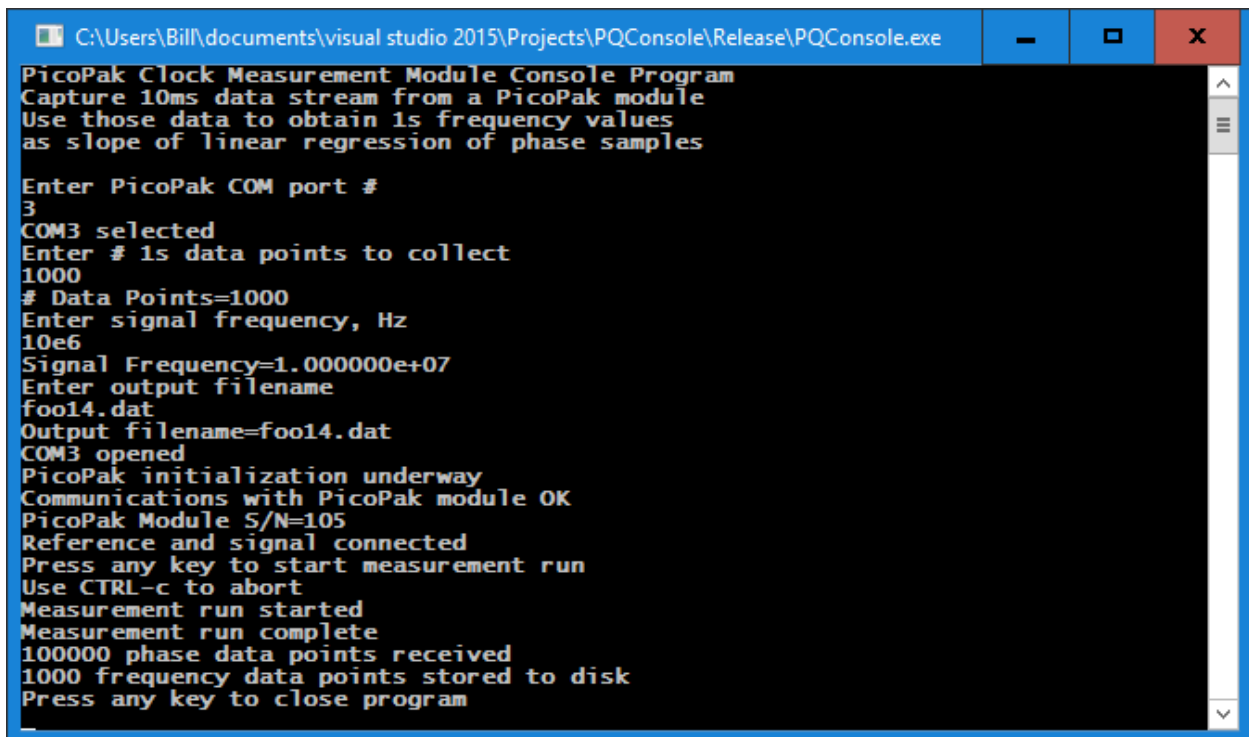
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- **Introduction**

PQConsole is a command line program for the PicoPak clock measurement module [1, 2]. It supports capturing the 10 ms data stream from a PicoPak module and using those data to calculate and output 1 s fractional frequency values. The fractional frequency results are found as the phase slope by performing a linear least-squares regression on successive blocks of 100 10 ms phase samples. When followed by an Allan variance (AVAR) analysis, this is analogous to an Ω counter [3] and the quadratic variance (QVAR) [4, 5], and has the beneficial effect of reducing wideband white PM instrumental noise. The resulting noise floor is white FM noise at a level close to the PicoPak's 6.2 ps resolution at 10 MHz. This measurement methodology is therefore best suited to making short-term measurements.

- **Program Description**

Figure 1 shows the PQConsole screen for a 1000 second measurement run. The user enters the PicoPak COM port, the number of 1-second data points to collect, the nominal signal frequency and the output filename. The PicoPak module is initialized, the measurement is started, and the measurement run starts. At the conclusion of the run, the program reports the results and waits to be closed. A portion of the resulting PQConsole data file is shown in Figure 2.



```
C:\Users\Bill\documents\visual studio 2015\Projects\PQConsole\Release\PQConsole.exe
PicoPak Clock Measurement Module Console Program
Capture 10ms data stream from a PicoPak module
Use those data to obtain 1s frequency values
as slope of linear regression of phase samples

Enter PicoPak COM port #
3
COM3 selected
Enter # 1s data points to collect
1000
# Data Points=1000
Enter signal frequency, Hz
10e6
Signal Frequency=1.000000e+07
Enter output filename
foo14.dat
Output filename=foo14.dat
COM3 opened
PicoPak initialization underway
Communications with PicoPak module OK
PicoPak Module S/N=105
Reference and signal connected
Press any key to start measurement run
Use CTRL-c to abort
Measurement run started
Measurement run complete
100000 phase data points received
1000 frequency data points stored to disk
Press any key to close program
```

Figure 1. PPConsole Screen

```

PQConsole Data File
PicoPak Module S/N 105
Tau: 1.000000e+00
Points: 1000
Start: Thu Jun 22 12:08:33 2017
End: Thu Jun 22 12:25:12 2017
Data are fractional frequency WRT 10.000000 MHz
# Header End
-4.782167e-12
-5.556698e-13
-1.471289e-12
2.205837e-12
3.597578e-12
-3.251252e-12
8.067711e-13
1.094450e-11
1.546591e-12
-1.647088e-12.
.
.

```

Figure 2. PQConsole Data File

It is necessary to manually enter the signal frequency within several pp10⁹, and the corresponding DDS setting will not be adjusted during the measurement run. The phase data are processed and the frequency values written to the file at the end of the run after all phase data are acquired. The file can be read into Stable32 for analysis.

- **PicoPak/PQConsole Noise Floor**

Figure 3 shows PicoPak/PQConsole noise floor with coherent 10 MHz inputs. The 1-second ADEV is about half that of the PicoPak with normal processing (as shown by the green line on the plot), but, because its white FM noise decreases as $\sqrt{\tau}$ rather than τ , it is better only for short averaging times.

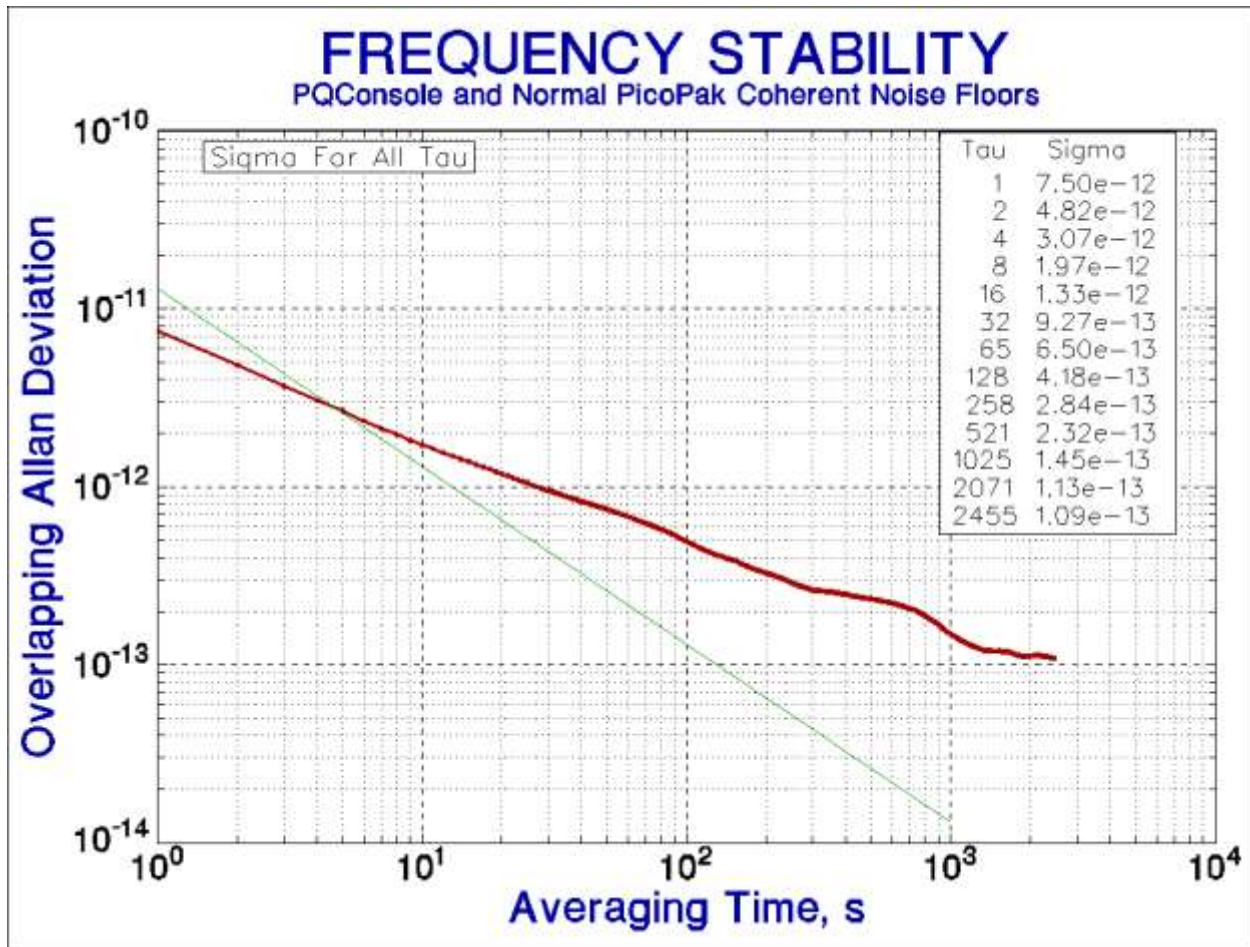


Figure 3. PQConsole and Normal PicoPak Coherent Noise Floors

- **PQConsole Measurement Example**

Figure 4 shows an example of using a PicoPak with the PQConsole software to measure the relative stability of a pair of LPRO rubidium oscillators. The measured white FM noise level is somewhat above the PicoPak/PQConsole noise floor (green line), and the short-term (1 s) stability determination is considerable better than that of a PicoPak using its normal control software.

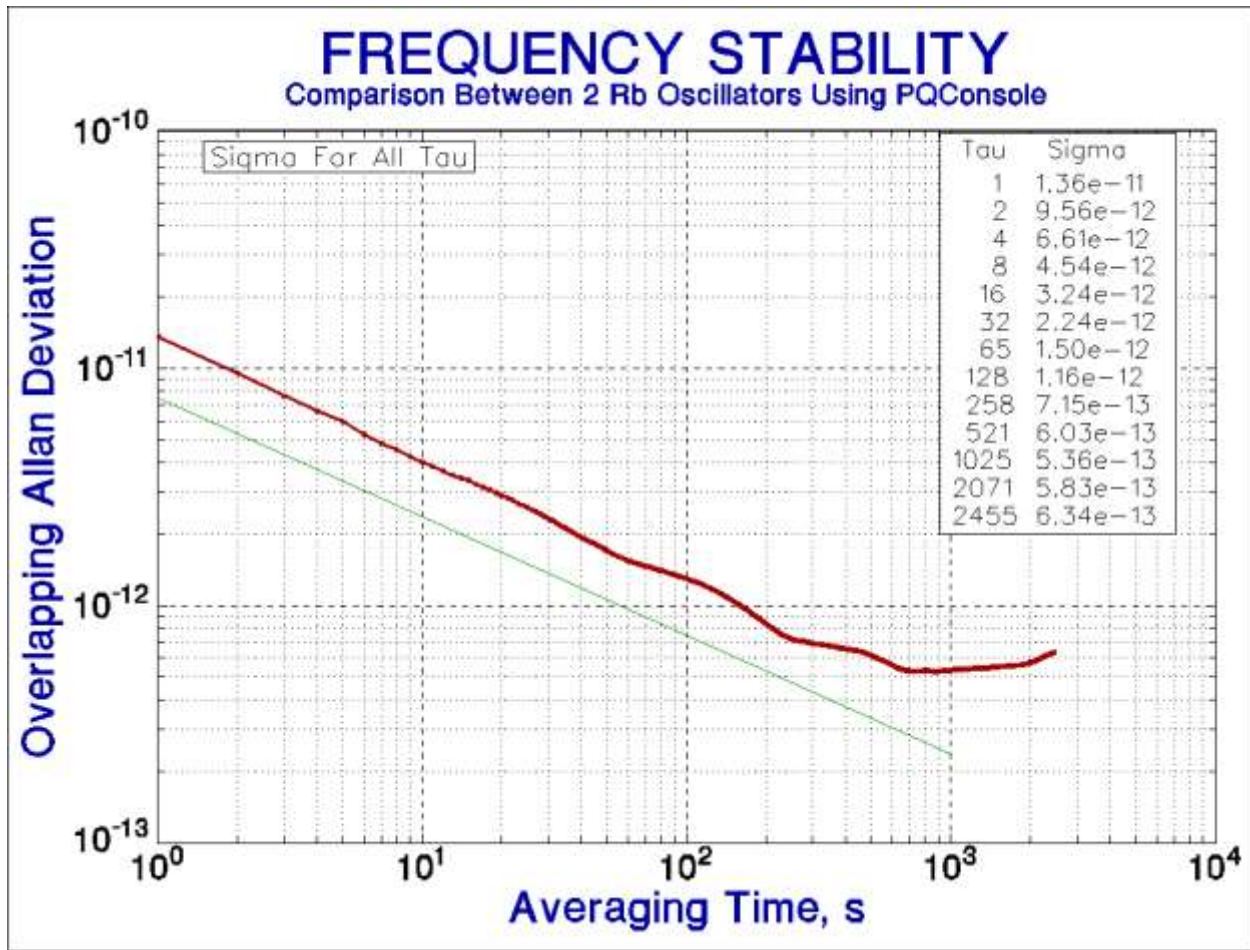


Figure 4. Stability Plot For Two Rb Oscillators Using a PicoPak with PQConsole

- **PQConsole with the PicoPlus**

Figure 5 shows the white FM noise floor of a PicoPlus, a PicoPak with a x10.635 PicoMult Frequency Error Multiplier (FEM) [6]. That unit also benefits from PQConsole processing in the short-term where its 1-second white FM noise floor of about 7×10^{-13} is below the $\approx 2 \times 10^{-12} \tau^{-1}$ white PM noise floor with normal processing at averaging times shorter than about 10 seconds.

The PQConsole program supports PicoPak FEM processing when the entered nominal frequency is exactly 10.25 MHz.

With a PicoPlus and PQConsole processing, the measured 1-second ADEV for the two LPRO Rb oscillators of Figure 4 is slightly better, about 9.7×10^{-12} , indicating that the PQConsole-processed PicoPak noise without an FEM contributes somewhat to the Figure 4 results.

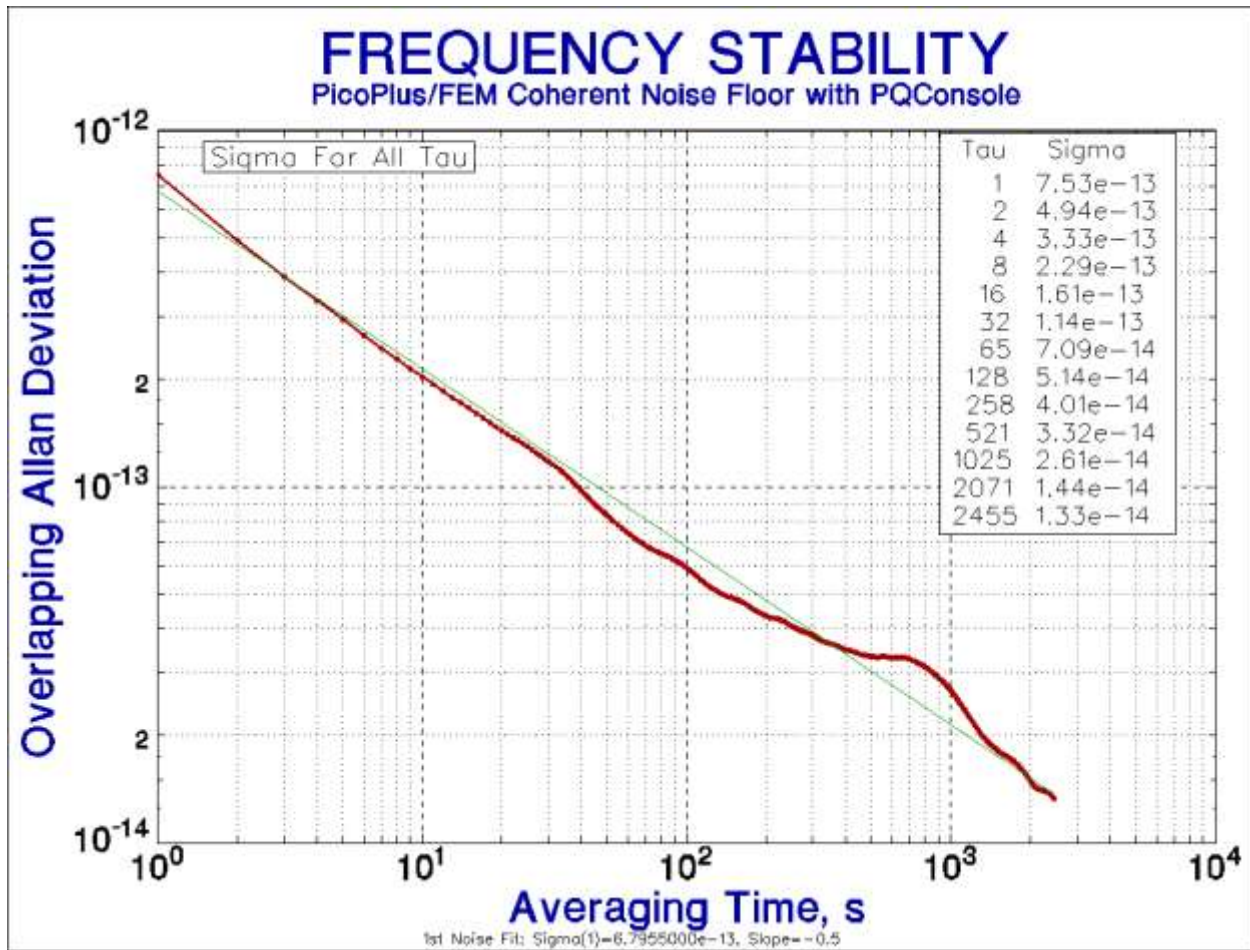


Figure 5. Coherent Noise Floor of a PicoPlus Module with its FEM Using PQConsole Processing

• **References**

1. W.J. Riley, "[The PicoPak Clock Measurement Module](#)", Hamilton Technical Services, Beaufort, SC 29907 USA, March 2015.
2. The PQConsole program was written in C using the Win32 API and Microsoft Visual Studio 2015, and is supplied with the PicoPak clock measurement module hardware.
3. E. Rubiola, et alia, "[The \$\Omega\$ Counter, a Frequency Counter Based on the Linear Regression](#)", *IEEE Trans. UFFC*, Vol. 63, No. 7, July 2016, pp 961-969.
4. F. Vernotte, et alia, "[The Parabolic Variance \(PVAR\): A Wavelet Variance Based on the Least-Square Fit](#)", *IEEE Trans. UFFC*, Vol. 63, No. 4, April 2016, pp. 611-623.
5. F. Vernotte, et alia, "[Least-Square Fit, \$\Omega\$ Counters. And Quadratic Variance](#)", *Proc. IEEE IFCS/EFTF 2015*, April 2015.
6. W.J. Riley, "[The PicoMult Frequency Error Multiplier](#)" ", Hamilton Technical Services, Beaufort, SC 29907 USA, November 2016.

File: The PQConsole Program.doc
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June 23, 2017
Rev A. June 25, 2017