Application Note: CNT-91 + PicoTime

pendulum

Improvement of frequency measurement resolution using PicoTime along with the CNT-91

Background

Certain tasks, such as characterization of quartz crystal oscillators, atomic clocks or frequency distribution systems, among others, require performing measurements with a very high accuracy.

PicoTime is a small but powerful device that in combination with the Pendulum CNT-91, constitute the perfect set of instruments to measure a wide range of frequencies with an excellent resolution.

PicoTime is based on a two-step heterodyne down-converter mixer, which lower the frequency-under-test down to 1kHz, where all the measurements are easily performed by the CNT-91.

Using this method, signal frequency including the frequency error, are magnified by the factor FUT/1KHz (FUT = Frequency under test), which is the same factor that is to be used to find out the error in the FUT, after being measured in the 1kHz signal.

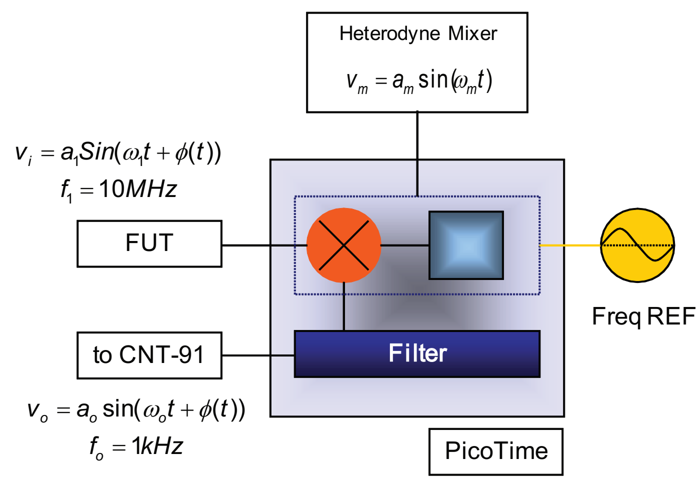

Figure 1. Basic block diagram of PicoTime as a front-end.

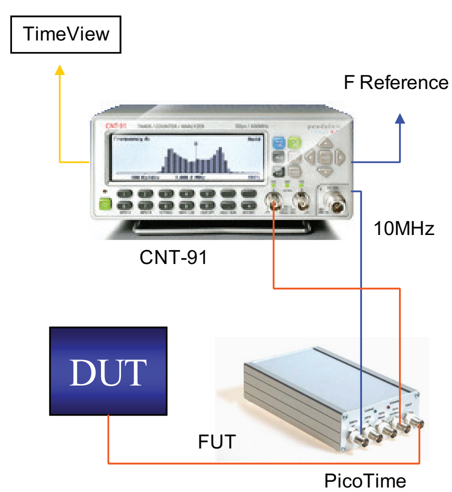

Figure 2. Basic implementation.

Typical Setup

Let us suppose that the aim of the setup is to measure the short time stability of a 10 MHz frequency clock with a resolution of few ps.

For this purpose, we can improve the resolution of the CNT-91, by adding the PicoTime as a RF front-end to the measurement system. Thereby, we get a signal of 1kHz with the behaviour of the original signal of 10 MHz. It is possible to say, that we have magnified the signal to measure, with a factor of 10^4, and therefore the error measured in the 1kHz signal is equivalent to 10^4 times the error on the original signal. In this way we have an ideal improvement of resolution of our measurement by this factor.

The CNT-91, in its turn, can be connected to TimeView, where there are a bunch of tools available, which may be used, to make a more comprehensive analysis to the signal under-measurement.

It is possible to perform a simple test, if you use your signal reference as a signal-under-test. Then, your measurement is simply limited by the resolution of the instruments. For didactical purposes, the results in TimeView are shown in figure 3.

It shows two screen shots. The one above shows the result of a measurement of a 10 MHz signal directly with the CNT-91, taking 12 800 samples with a measurement time of 1ms.

The second graph shows the result of the measurement of same signal magnified to 1kHz, taking the same number of samples and same measurement time.

On the statistic parameters on the left hand side, in every one of the graphs, it is easy to distinguish the improvement of the resolution of the measurement, by comparing the values in the ADEV in each of the cases. Here, the measurement is limited by the resolution of the instruments. The direct 10 MHz shows a resolution per timestamp of 33 ps, whereas the down-converted 1kHz measurement shows a resolution of only 1,9 ps.

ADEV Measurements

Consequently, due to the improvement of resolution/noise floor, the use of PicoTime also gives an important enhancement in the ADEV calculation, mainly in a short term, up to 10 s.

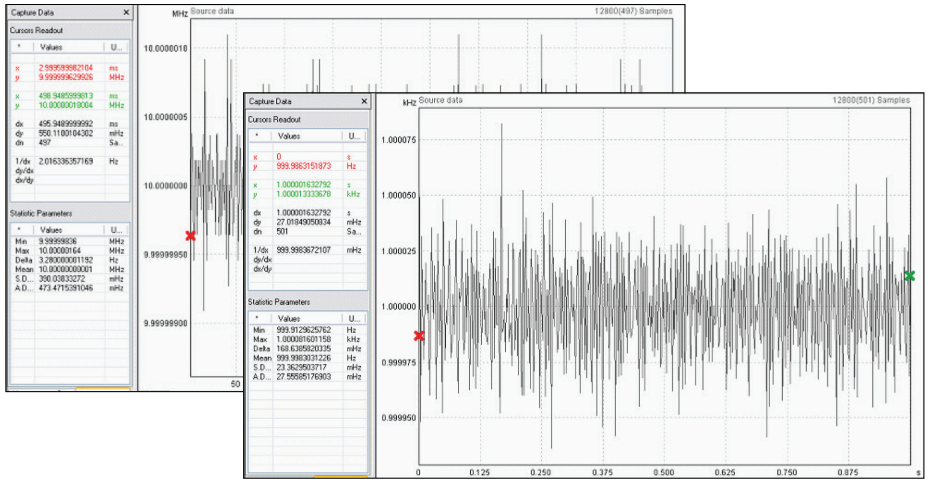

Figure 3. TimeView result of 2 back-to-back frequency measurements.

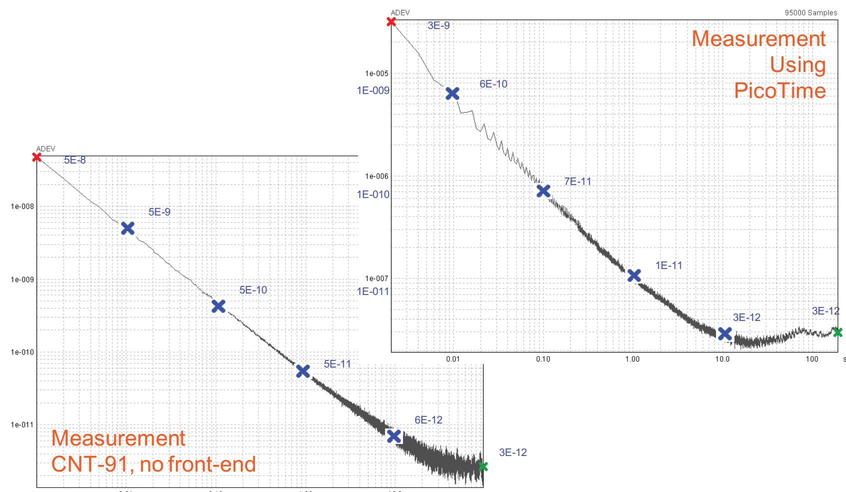

Figure 4. TimeView ADEV graphs of the same signal. One using PicoTime and the other one only with the CNT-91.

Comparison on resolution improvement

Model	CNT-91 alone	PicoTime alone	PicoTime and CNT-91
ADEV floor at 1s averaging time	5x10^{-11}	2x10^{-12}	2x10^{-12}
ADEV range (τ)	From 4μs	From 1s	From 1s
Frequency sample speed	250 kSa/s	1Sa/s	1kSa/s
Frequency measurements Resolution @ 1s meas. time	5x10^{-12}	3x10^{-12}	3x10^{-12} no post-processing 2x10^{-13} post-processing
Frequency range	DC to 20 GHz	1 to 30 MHz	1 to 30 MHz
TIE measurements	Yes	Yes	Yes