Using TimeLab with the Tiny PFA

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Tiny PFA

- Two input device which can measure very precise frequency and phase differences between the signals applied to both inputs.
- Input frequency can be between 1 MHz and 300 MHz.
- Typical use is to measure differences between two 10 MHz clocks.
- Can display phase and frequency difference, show measurement in graph versus time form, store measurements on SD card or send phase measurements over USB to a PC running TimeLab.
- Phase and frequency measurement accuracy is better than 1e-12 divided by measurement time in seconds with decimation = 1.
- Maximum frequency difference that can be measured depends on measurement time and is approximately 200 Hz/Tau in seconds so for Tau=1 second it is effectively 200 Hz as a maximum diff.

External influences

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Guidelines for input signal connections

Although the N-F and SMA-F input jacks offer superior mechanical stability, BNC-N coax adapters are also supplied with the 53100A for operator convenience. Regardless of your choice of coax fittings, double-shielded cables such as RG223 or RG400 are recommended for low-level measurements that may be affected by crosstalk and environmental interference. **Use of RG58, RG174 and other common single-shielded cables can cause artifacts in stability and noise plots**, particularly with longer cables.

Working with dual reference sources

Two OCXOs running from the same power supply, for instance, may not be as independent as they look. They may even injection-lock to each other through their power supply connections if decoupling isn't adequate. When working with dual references, consider enclosing each of them in its own RF-tight box or other sealed metal container. Use high-quality DC feedthrough capacitors rather than conventional power jacks or connectors. These precautions are always a good idea, but they're absolutely mandatory with OCXOs whose output signals are obtained from discrete pins or SMT pads rather than coaxial outputs.

- Timelab reference: PhaseStation_53100A_user_manual.pdf

Measurement setup part 1

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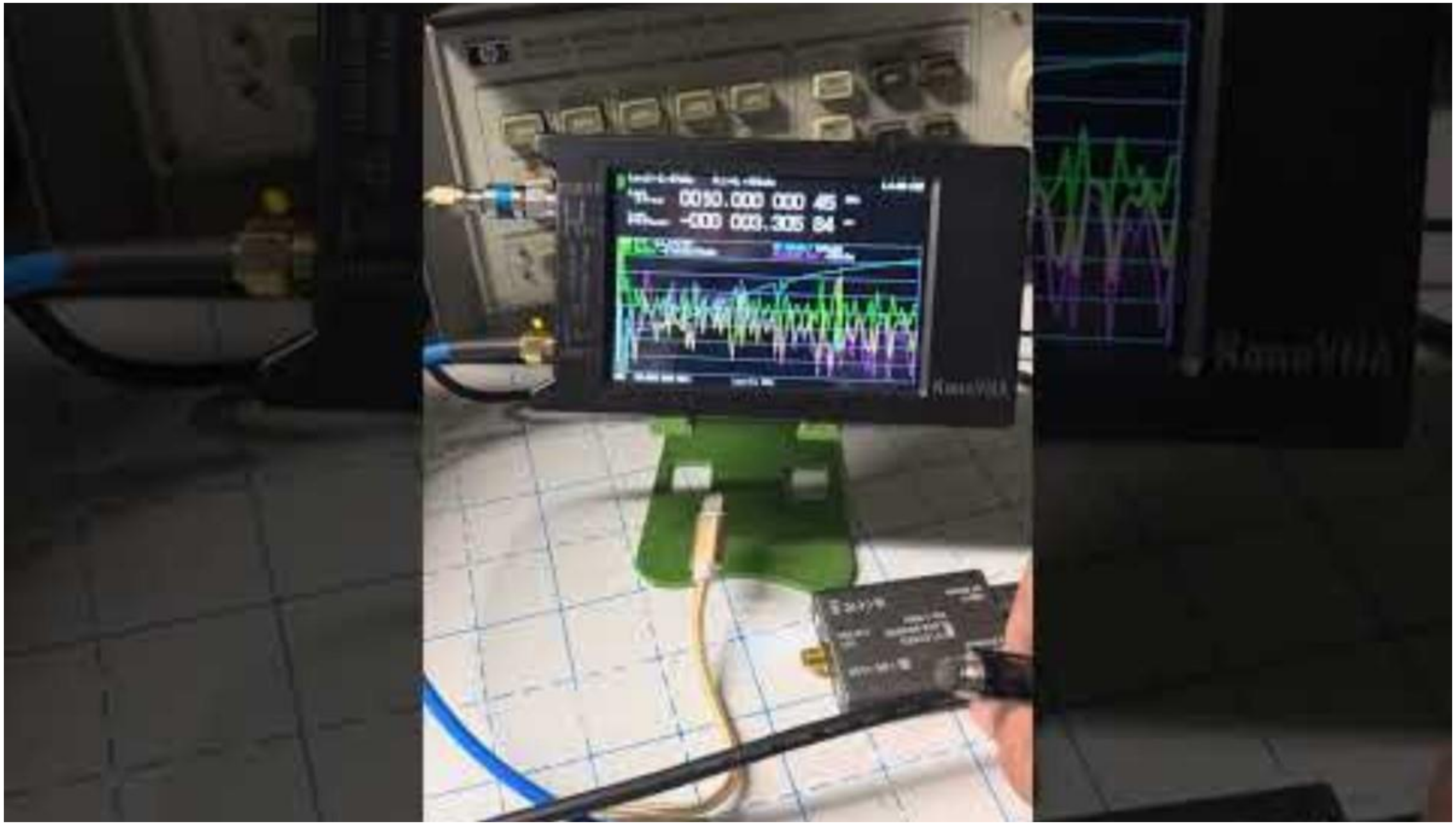
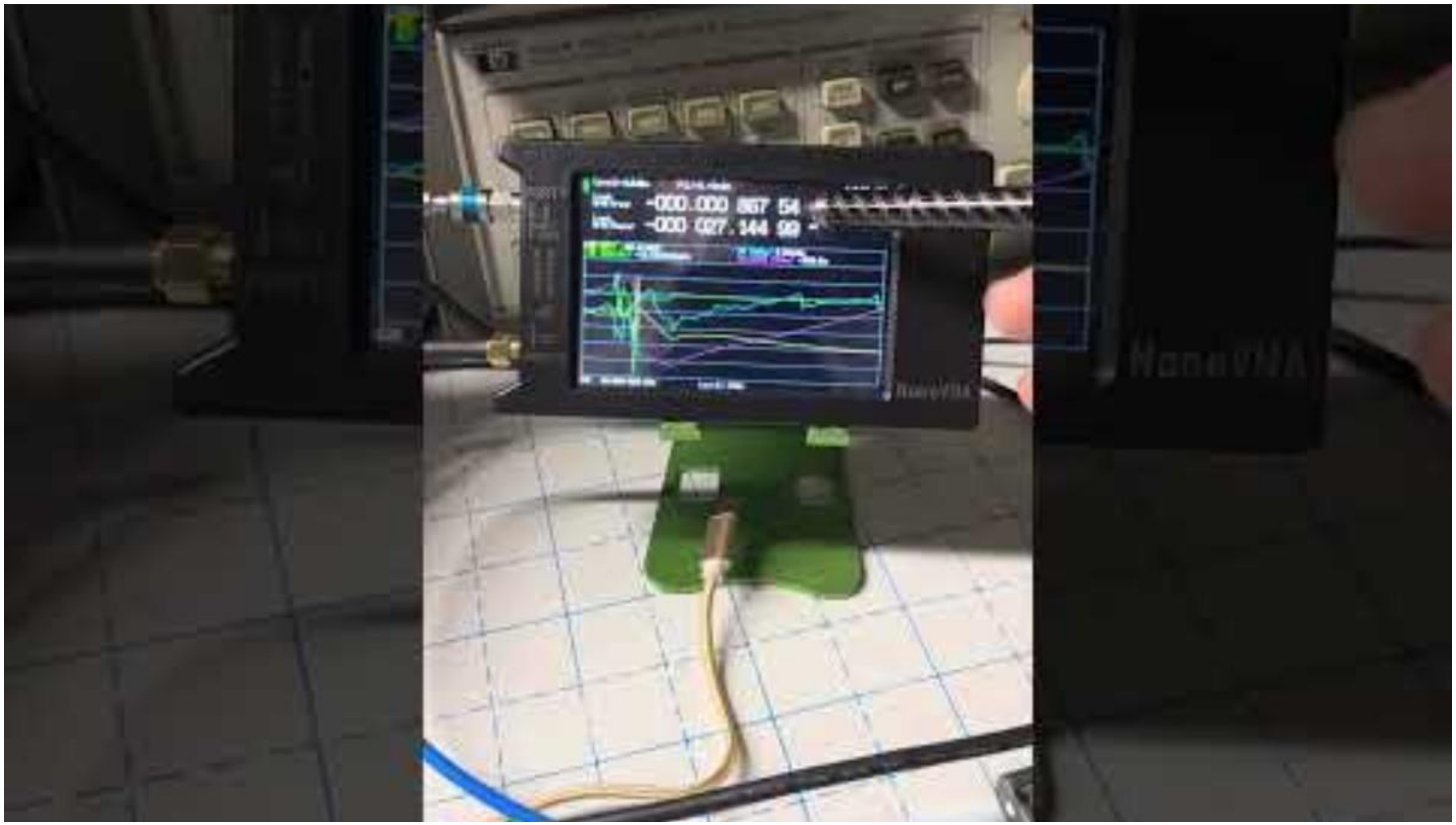


Measurement setup part 2



Measurement setup part 3

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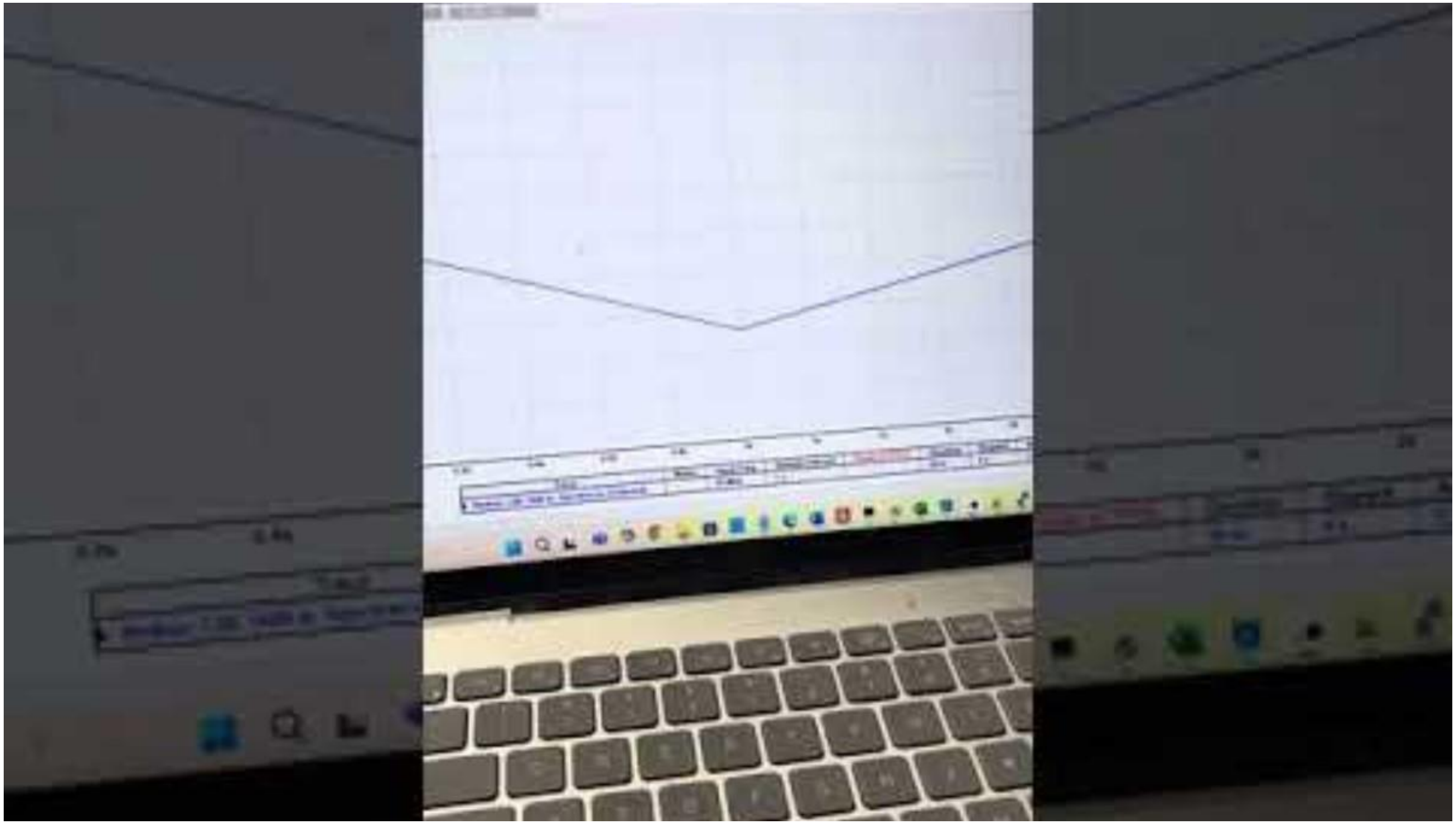

Timelab Frequency Measurement

How does TimeLab measure frequency?

But what exactly is this "input frequency?" Where does it come from, and how accurate is it? When acquiring data with a frequency counter, it's easy enough to determine the nominal input frequency for the measurement: we simply use the first reading. All subsequent data points in the phase record are computed using the difference between the incoming frequency readings and the first one recorded... and all of these readings can be assumed to carry the same accuracy and precision.

When a time-interval counter (TIC) is used, however, TimeLab sees only a series of START-to-STOP interval times. It's impossible to infer the input frequency automatically. Instead, you must enter it into the appropriate field of the acquisition dialog, specifying at least as much precision as you expect to obtain when viewing the frequency count chart.

- Timelab reference: PhaseStation_53100A_user_manual.pdf

Spectracom vs Bodnar

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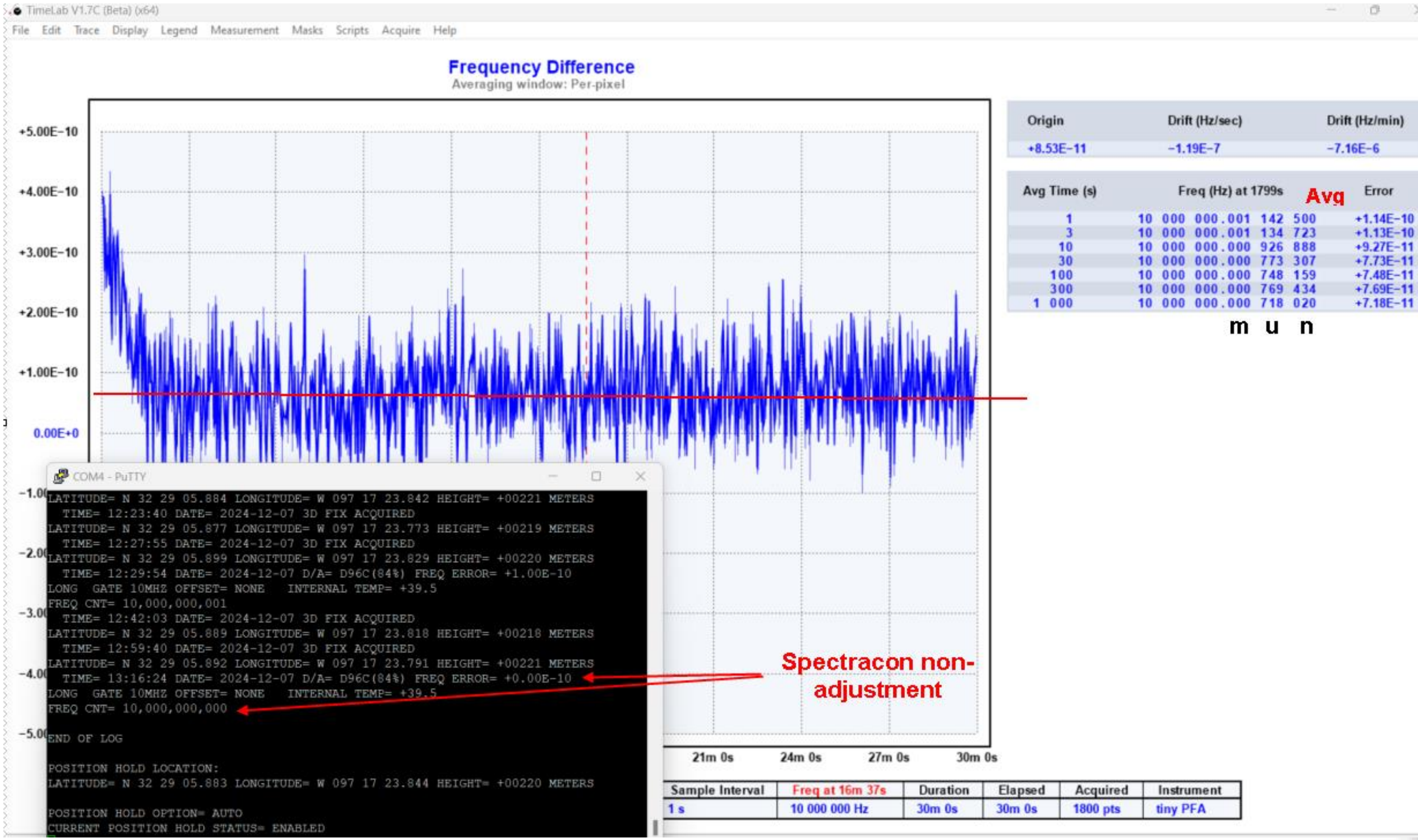
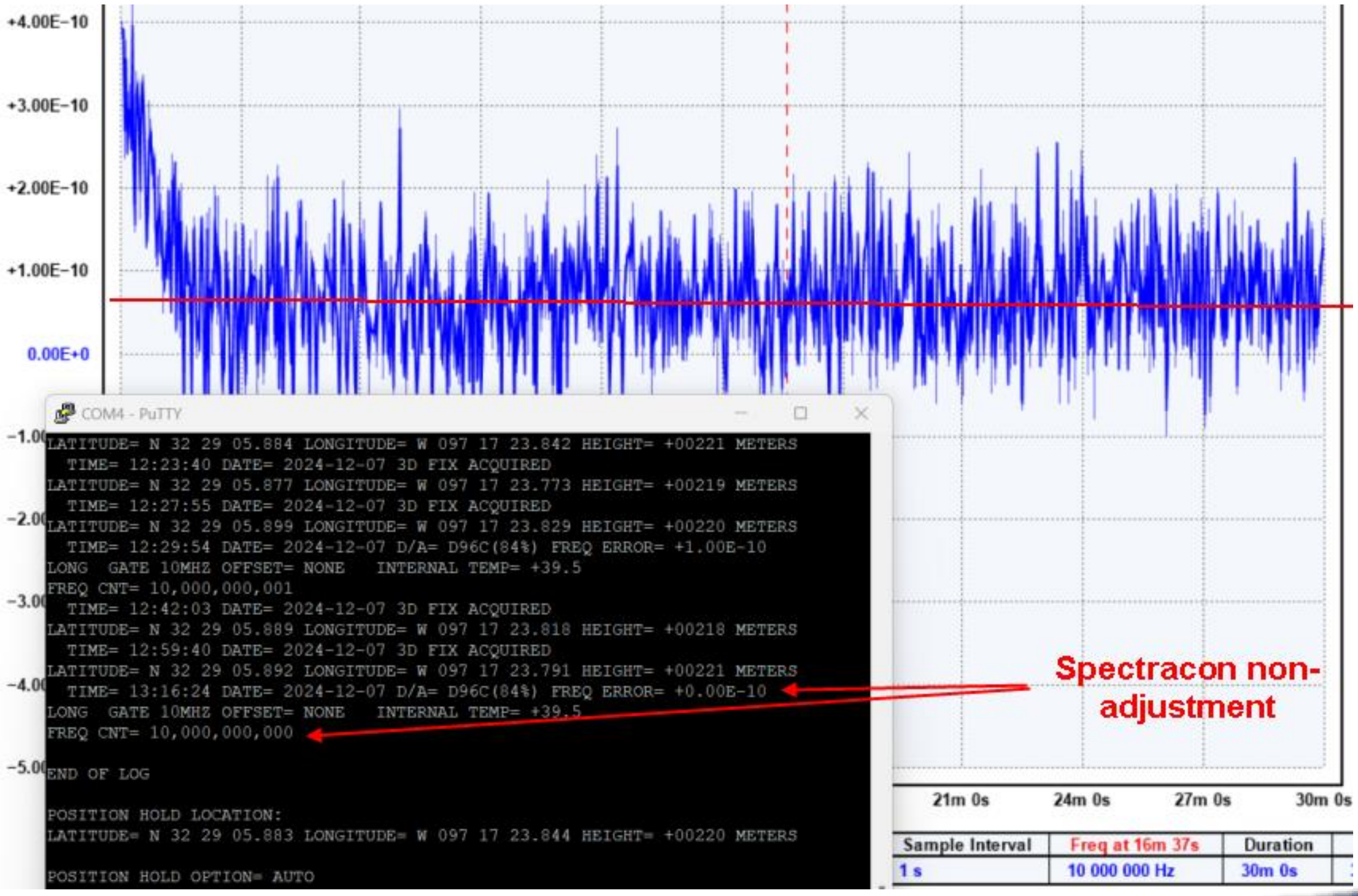


Timelab graph



Timelab counter

Averages

Origin	Drift (Hz/sec)	Drift (Hz/min)
+8.53E−11	−1.19E−7	−7.16E−6

Avg Time (s)	Freq (Hz) at 1799s	Error
1	10 000 000.001 142 500	+1.14E−10
3	10 000 000.001 134 723	+1.13E−10
10	10 000 000.000 926 888	+9.27E−11
30	10 000 000.000 773 307	+7.73E−11
100	10 000 000.000 748 159	+7.48E−11
300	10 000 000.000 769 434	+7.69E−11
1 000	10 000 000.000 718 020	+7.18E−11
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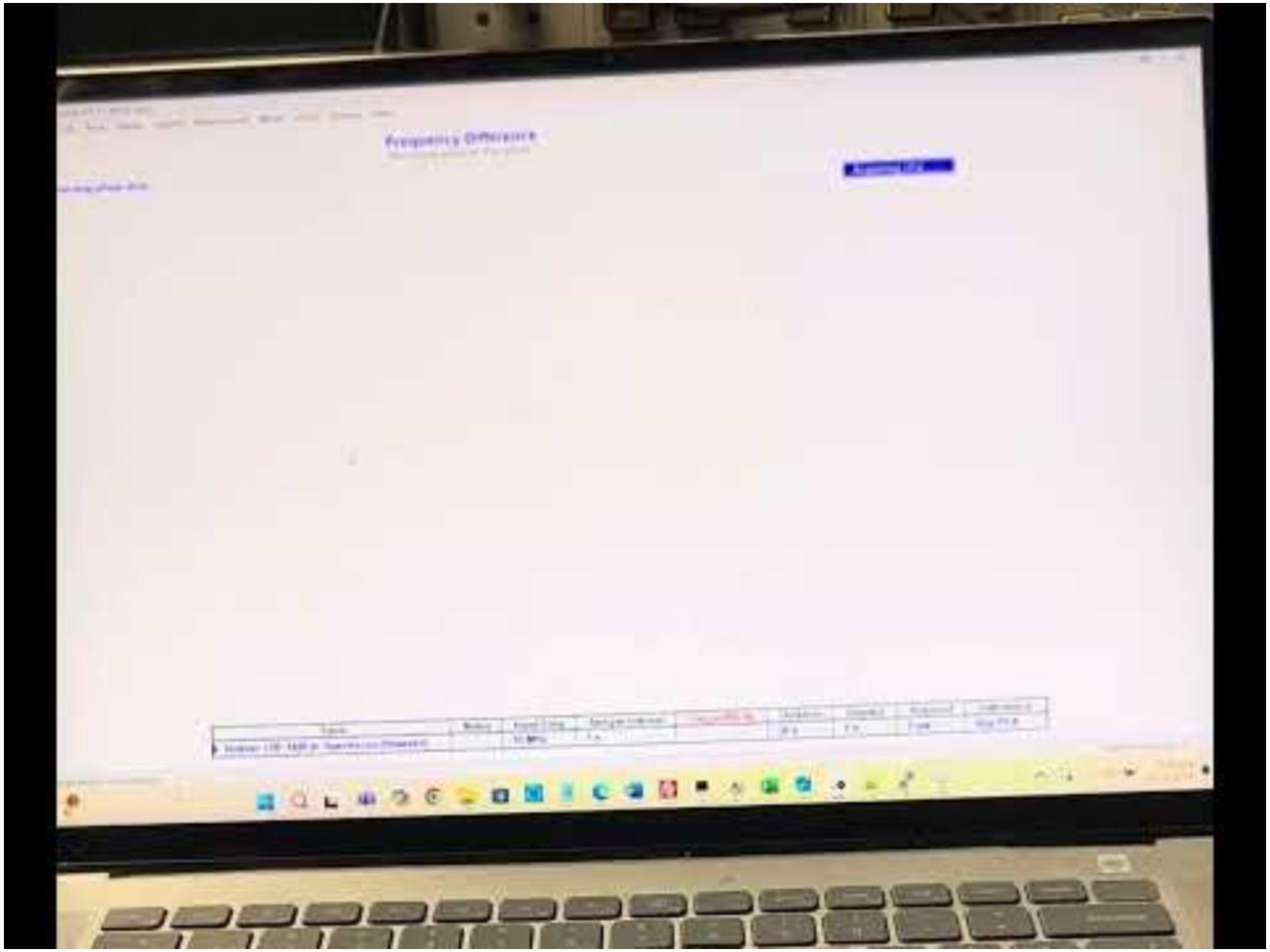
30 second sample



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30 second sample

TimeLab V1.7C (Beta) (x64)

File Edit Trace Display Legend Measurement Masks Scripts Acquire Help

Frequency Difference

Averaging window: Per-pixel

Origin	Drift (Hz/sec)	Drift (Hz/min)
-2.74E-11	+1.15E-5	+6.89E-4

Avg Time (s)	Freq (Hz) at 29s	Error
1	9 999 999.998 729 572	-1.27E-10
3	9 999 999.999 425 417	-5.75E-11
10	9 999 999.999 835 430	-1.65E-11

Trace	Notes	Input Freq	Sample Interval	Freq at 8m 0s	Duration	Elapsed	Acquired	Instrument
Bodnar LBE-1420 to Spectracon (Unsaved)		10 MHz	1 s		30 s	30 s	30 pts	tiny PFA

30 second sample

Sample	Frequency	Sample	Frequency
0	1.0000000000000000E+07	15	1.0000000000434205E+07
1	1.0000000000569284E+07	16	1.0000000000295490E+07
2	9.9999999991354942E+06	17	1.0000000001627833E+07
3	9.9999999995963871E+06	18	1.0000000001467526E+07
4	9.9999999997335225E+06	19	9.9999999998856485E+06
5	9.9999999992461354E+06	20	9.9999999996116906E+06
6	9.9999999994176328E+06	21	1.0000000000501558E+07
7	9.9999999990510195E+06	22	9.9999999995321780E+06
8	1.0000000000525832E+07	23	9.9999999986701459E+06
9	1.0000000000401348E+07	24	9.9999999998835176E+06
10	1.0000000000125349E+07	25	1.0000000000378609E+07
11	9.9999999989569634E+06	26	1.0000000001500353E+07
12	9.9999999993007332E+06	27	1.0000000000457600E+07
13	9.9999999988362342E+06	28	9.9999999990890771E+06
14	9.9999999997489154E+06	29	9.9999999987295717E+06

Set spot cursor

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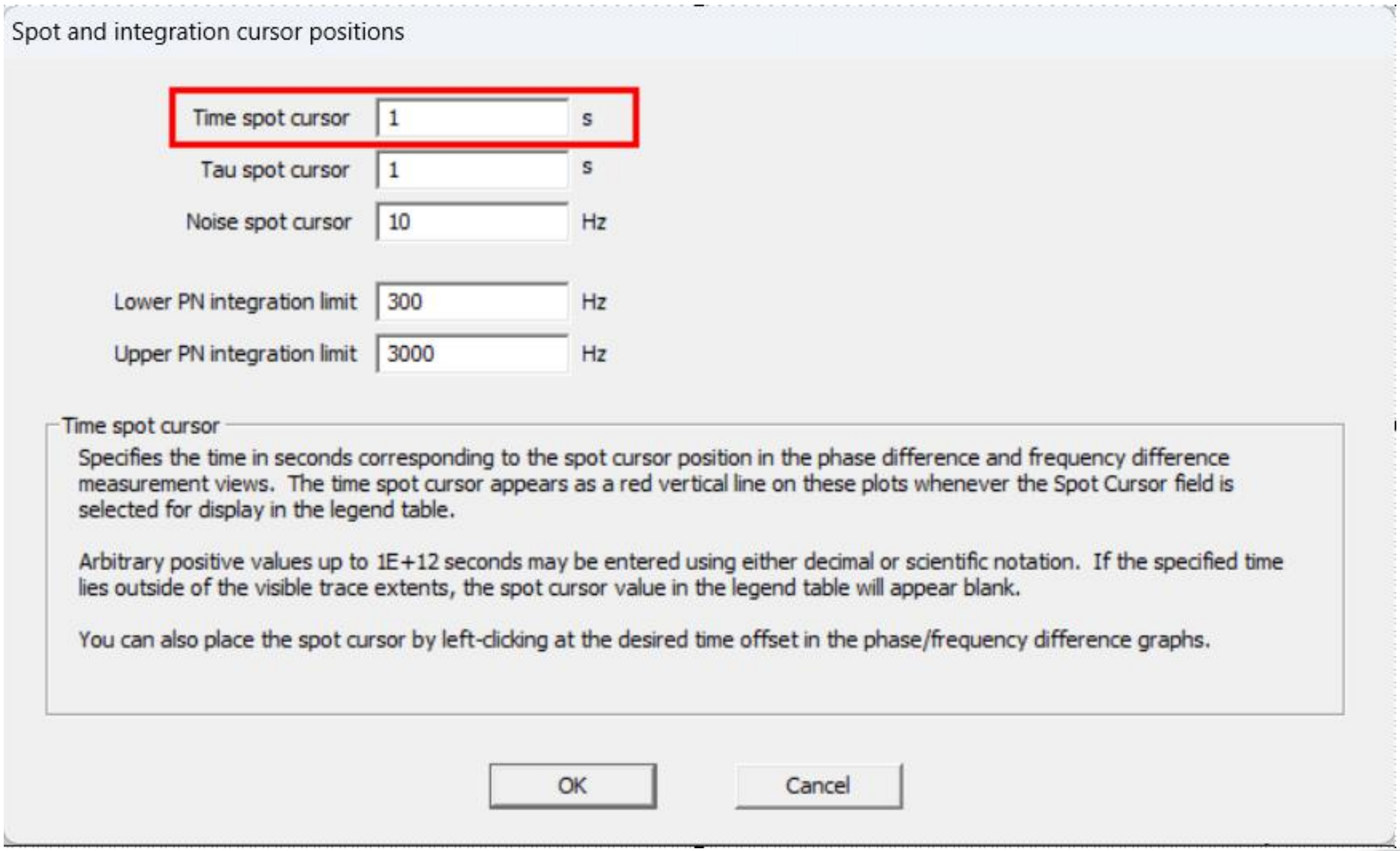
Display→Set spot cursor positions (j)



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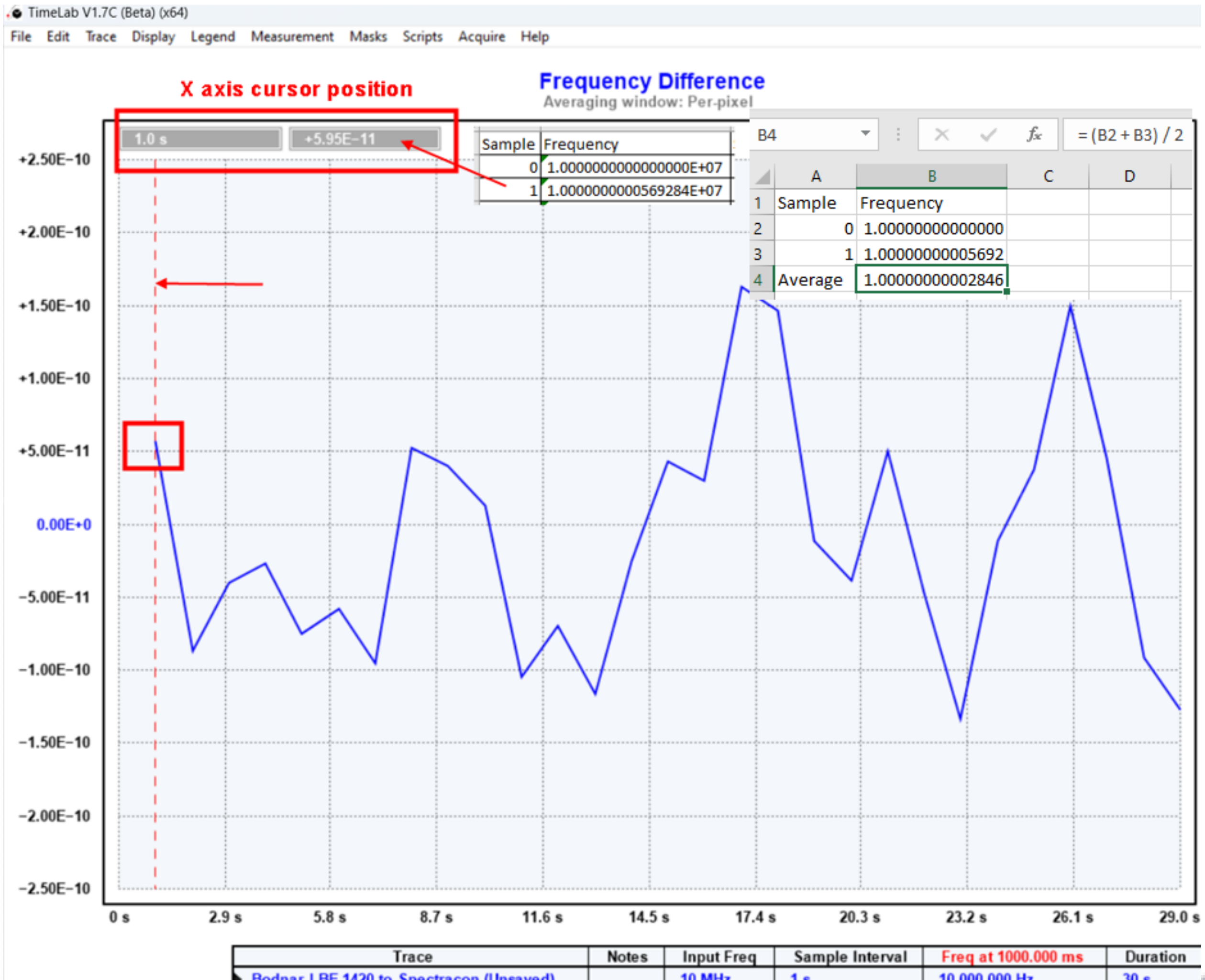
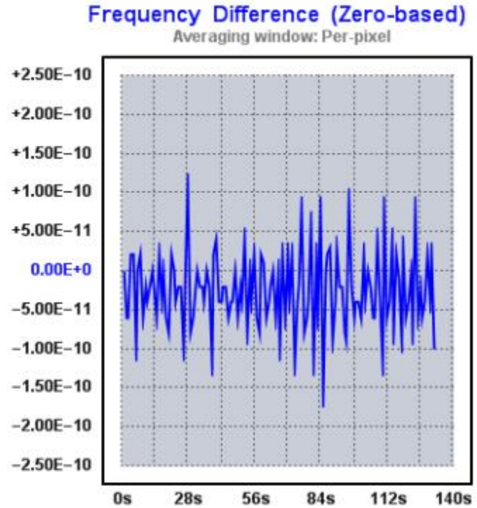
Set spot cursor



n - 1

Frequency difference (f)



Origin	Drift (Hz/sec)	Drift (Hz/min)
−2.57E−11	−8.04E−8	−4.82E−6

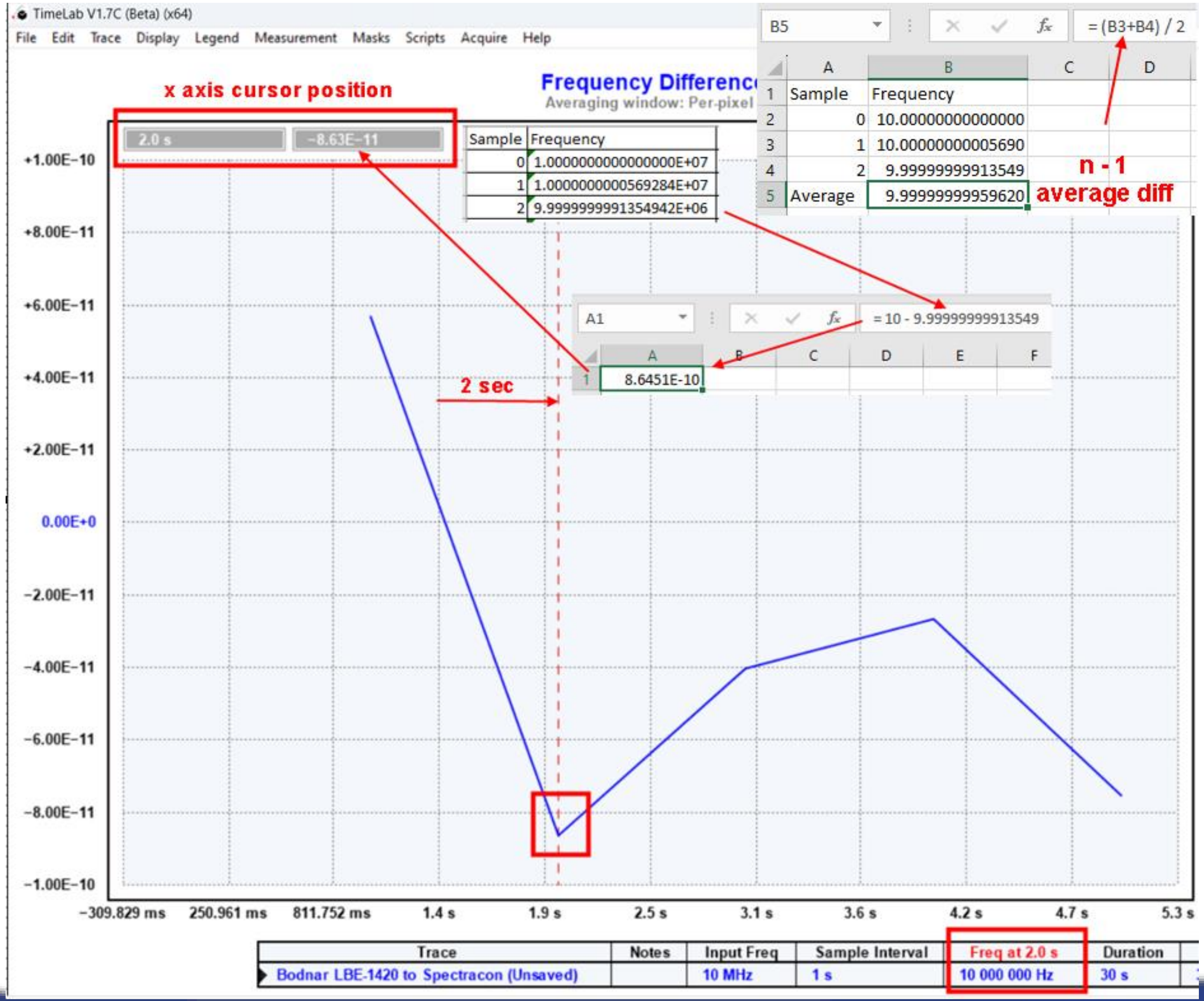
Avg Time (s)	Freq (Hz) at 132s	Error
1	9 999 999.961 900 000	−3.81E−9
3	9 999 999.962 500 000	−3.75E−9
10	9 999 999.962 619 999	−3.74E−9
30	9 999 999.962 636 666	−3.74E−9
100	9 999 999.962 634 999	−3.74E−9

Trace	Notes	Input Freq	Sample Interval	Instrument
HP 10811A	Trimble Thunderbolt	10 MHz	1.00 s	HP 5370A/B

Figure 19: Frequency difference measurement view with count chart

Shown above is a third way to view the phase data from the earlier example. Each point on the Measurement→Frequency difference (f) trace is calculated by dividing the difference between successive pairs of phase-difference samples by the sample rate. Taking the time derivative of *n* adjacent phase-difference points in this manner yields a stream of *n-1* frequency-difference points.

Set spot cursor



Summary

- TinyPFA is a two input device which can measure very precise frequency and phase differences between the signals applied to both inputs.
- Typical use is to measure differences between two 10 MHz clocks.
- TimeLab PC software (free) may be used with a connected TinyPFA to map/graph measurements
- TimLab software can display ADEV, Time Deviation, Phase and Frequency difference.

Reference

- Timelab home page: TimeLab
- Timelab reference manual: PhaseStation_53100A_user_manual.pdf

Questions?

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