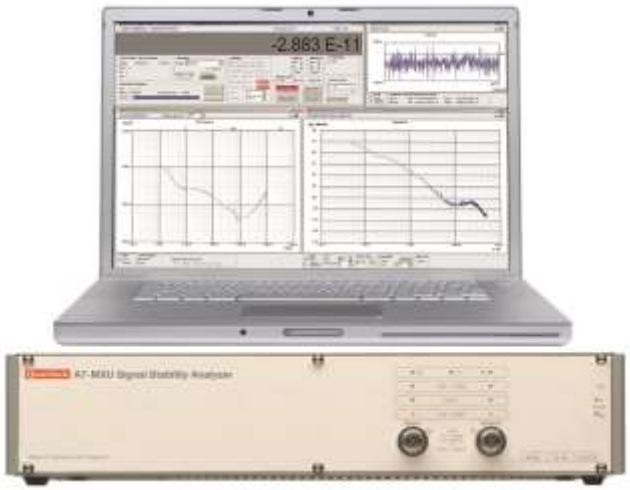
Quartzlock A7-MXU

# Signal Stability Analyser

- Real Time Phase or Frequency Display
- Real Time Data, Allan Variance and Phase Noise Plots
- 1MHz to 65MHz medium resolution (12.5ps)
- 5MHz and 10MHz high resolution (50fs)
- < $10^{-16}$ Allan Variance Floor




The A7-MXU is the latest substantially enhanced successor to Quartzlock's long line of phase/frequency comparators. The A7-MXU is invaluable in the design of low noise oscillators, atomic frequency standards and passive devices where close in phase noise, freedom from spurii, and phase stability are essential design objectives.

## Features

- 5MHz or 10MHz external reference
- 50fs resolution
- Scalable graphs
- Graphs updated in real time

## Benefits

- Fast sample rate (1000 s/s)
- Block storage or continuous logging
- Clear and flexible PC interface

## Applications

- Stability analysis of all frequency references
- Close-in phase noise analysis
- Spurii analysis
- Atomic frequency standard calibration
- Active & passive component phase stability measurement

# Quartzlock A7-MXU

| Specification | Narrow Band | Broad Band |
|---|---|---|
| **Type** | **A7-MXU** | |
| **Inputs** | | |
| Type | N, Front panel | |
| Impedance | 50Ω | |
| Reference | 5 or 10MHz ±50x10$^{-6}$ | |
| Measurement | 5 or 10MHz ±50x10$^{-6}$ | 1 to 65MHz |
| level | 0 to +13dBm | |
| 1MHz to 50MHz | | -10 to +15dBm |
| 50MHz to 65MHz | | 0 to +15dBm |
| Maximum level | +20dBm | |
| Max frequency Difference Filter off | | |
| Low resolution | ±10x10$^{-6}$ | |
| High resolution | ±100x10$^{-9}$ | |
| **Outputs** | | |
| A (Measurement IF) | 100kHz CMOS/TTL | |
| B (Reference IF) | 100kHz CMOS/TTL | |
| C (Reference out) | 10MHz CMOS/TTL | |
| **Filter** | | |
| Analogue | | |
| 200Hz | 3dB bandwidth | |
| 60Hz | 3dB bandwidth | |
| 10Hz | 3dB bandwidth | |
| Digital | 1/(2tau)/Hz bandwidth | |
| **Dither Mode** reduces internal spurii with higher noise floor | +10dB | |
| **Fractional Frequency Multiplication** | | |
| High resolution | $10^5$ | |
| Low resolution | $10^3$ | |
| **Measurement Resolution** | | |
| Frequency difference mode | | |
| High resolution | 1x10$^{-13}$ / gate time | |
| Low resolution | 1x10$^{-12}$ / gate time | 11 digits/second of gate time (Digital filter on) |
| Phase difference mode | | |
| RMS resolution (single measurement) | 50fs (measured 1.024s) | |
| **Short Term Stability** high res, filter 200Hz, digital filter off, dither off, 10MHz | | |
| 1ms | <5x10$^{-11}$ | |
| 10ms | <5x10$^{-12}$ | |
| 100ms | <5x10$^{-13}$ | <2x10$^{-9}$ |
| 1s | <5x10$^{-14}$ | <2x10$^{-10}$ |
| 10s | | <2x10$^{-11}$ |
| high res, filter 200Hz, digital filter on, dither on, 10MHz, sample rate 1/s | | |
| 10ms | | <2x10$^{-11}$ |
| 100ms | | <6x10$^{-12}$ |
| 1s | <3x10$^{-14}$ | <2x10$^{-12}$ |
| 10s | <5x10$^{-15}$ | |
| 100s | <1x10$^{-15}$ | |
| 1000s | <3x10$^{-16}$ | |
| 10000s | <1x10$^{-16}$ | |
| **Sampling Interval (tau) or Gate Time** | | |
| 1ms to 2000s | 1, 2, 5 steps | |
| **Drift** (after 24 hour warm up) | | |
| Ambient | <1ps/Hour | |
| (Constant ambient temperature) | <5ps/Day | |
| With temperature | <2ps/°C | |
| **Measurement Error** | | |
| Input referred self generated spurii | | |
| $10^3$ multiplication | <-90dBc | |
| $10^5$ multiplication | <-100dBc | |
| Corresponding peak phase modulation | | |
| $10^3$ multiplication | <1ps | |
| $10^5$ multiplication | <0.3ps | |
| Maximum error in Allen variance (due to each spur) divided by average interval (tau) | | |
| $10^3$ multiplication | 1x10$^{-12}$ | |
| $10^5$ multiplication | 3x10$^{-13}$ | |
| **Power Supply** | | |
| AC | 90 - 240Vac | |
| DC | External Input Option | |
| **Power Consumption @ 25°C** | 50W | |
| **Temperature** | | |
| Operating | -20°C to +50°C | |
| Storage | -40°C to +70°C | |
| Humidity | 90% (Non Condensing) | |
| **Mechanical** | | |
| Colour | Grey/Cream | |
| Dimension | 88 x 483 x 240mm | |
| Dimension Packed | 640 x 540 x 290mm | |
| Weight | 9kg | |

The A7-MXU is a bench or rack mount instrument which interfaces with most notebook or desktop PCs, using an RS232, USB, or LAN interface.

The General User Interface (GUI) controls all the functions of the A7-MXU, and displays all measurement results.

## Inputs

There are two inputs on the front panel. One of these is for the phase/frequency reference which will often be an atomic frequency standard. The reference frequency can be 5 or 10MHz with automatic switching. The input impedance is 50 ohms, and the required level is 0dBm to 13dBm.

The other input is for the measurement signal, 1MHz to 65MHz. If the measurement frequency is 5MHz or 10MHz within limits of about 50ppm, then the instrument will work in high resolution mode. The mode is selected from the virtual control panel.

There are indicator lights to confirm that the reference and measurement inputs are at the required level, and that the internal phase locked multipliers are locked. These indicators are repeated on the virtual control panel.

On the rear panel are outputs to an external timer/counter, the PC interface connectors, and an input for the optional 24V DC battery backup.

## Modes

The instrument has two main modes, i) narrowband, high resolution, and ii) broadband. The selection between these modes is made on the PC virtual control panel.

In narrowband, high resolution mode, the measured signal must be at 5 or 10MHz. In this mode the instrument uses multiply and mix techniques to increase the fractional frequency difference (or phase difference) between the measured input and the reference. This improves the resolution of the digital phase comparator, and results in a theoretical phase resolution of 0.125fs. The actual resolution is noise limited to about 50fs. The corresponding fractional frequency resolution is 1x10$^{-13}$ in one second of measurement time.

In broadband mode the multiply and mix is not used. The digital phase comparator makes direct phase measurements with a resolution of 12.5ps. This is comparable to the fastest frequency counters and gives a fractional frequency resolution of 3x10$^{-11}$ in one second of measurement time, or 2x10$^{-12}$ with the digital filter switched on.

## Displays

When connected to a PC, the GUI provides four scalable windows. One of these is the virtual panel and digital display. The other three are data graph,

Allan variance graph, and phase spectral density (phase noise) graph. All the graphical displays have manual or automatic scaling, statistics, and averaging where appropriate.

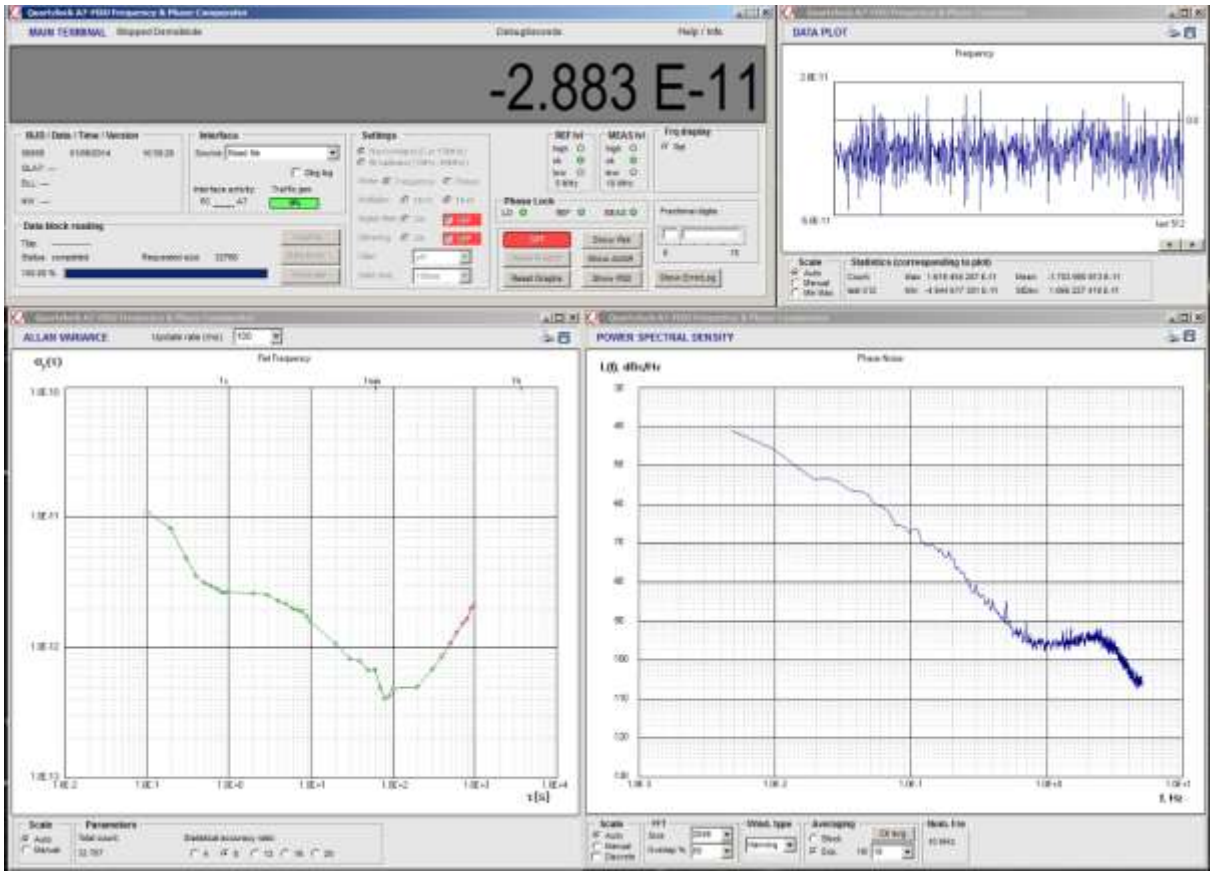
*The data window* shows real time accumulation of the data as a graph. The last 8 to 32768 data points may be shown on the graph. A statistics display shows max, min, mean, and standard deviation for the data shown on the graph. The scaling of the y axis may be auto, manual, or max/min.

*The Allan variance window* shows calculated Allan variance for all data accumulated since the start of a run. The part of the trace in green shows that a selected number of averages have been applied to the data. The red part of the trace shows that fewer than the selected number of averages have been used. The Allan variance graph automatically scales to longer averaging times as more data is accumulated.

*The Phase Spectral Density (PSD) window* shows phase noise as a graph of L(f) in units of dBc against offset frequency on a log scale. Various window functions and averaging modes are provided. The routines are identical to those used in the industry standard software "Stable32".

The user can select the basic length of the FFT, and also the degree of overlap. As data is accumulated, new FFTs are performed on a mix of old and new data depending on the overlap parameter. Each FFT result can either replace the last graph, be added to a block average, or be used in a continuous or exponential average. All FFTs are correctly normalised for bin bandwidth, window ENBW, window coherent gain, and nominal frequency. Frequency data always has a fixed offset removed before being used for the FFT calculation. Phase data has a fixed slope ramp removed by linear regression. This avoids a large component in the lower frequency bins which will distort the result, even when windowing is used.

A mode is provided for the measurement of discrete components (spurii). In this mode the scale is changed from L(f), dBc/Hz to Power, dBc. Corrections for bin bandwidth and window ENBW are removed. A flat top window is provided for measurement of discretes, with scallop loss of only 0.01dB.



## Virtual Control Panel

The virtual control panel provides control of all A7-MXU functions. It also monitors hardware status. The virtual control panel functions are described here in more detail:

### Phase/Frequency mode

In high resolution mode (5MHz or 10MHz) the digital display and the data graph may be switched between phase and fractional frequency (high resolution mode). In broadband mode, only frequency is available, however this can be either absolute frequency or fractional frequency difference from a manually entered nominal frequency. The Allan variance and PSD modes operate exactly the same in either phase or frequency mode. In phase mode relative phase not absolute phase is measured. The phase may be zeroed at the start of a run.

### Multiplier

In high resolution mode the multiplier may be switched between $10^3$ and $10^5$. The low multiplier is suitable for measuring lower stability oscillators as the maximum frequency difference allowed between the reference and the Device Under Test (DUT) is much greater. The high multiplier is suitable for stable sources where the maximum frequency offset is less than 1ppm.

### Filter

This selects an analogue filter which limits the bandwidth of the IF signal before the digital phase meter.

### Tau

This is the sampling rate used to calculate the Allen variance and PSD.

### Dither

Dither selects a low internal spurious mode with increased noise floor

### Digital Filter

This selects a digital filter which filters the basic phase difference data after the digital phase meter. Its bandwidth is linked to the selected sampling rate (tau). For more details on the correct use of the filters and dither, see the operating manual.

### Acquisition control

There are three acquisition modes, free run, data block, or continuous logging.

*Free Run*: A run may be started at any time without storing the data using the on/off button. The graphs can be reset if desired.

*Data Block*: A block of data up to 32768 samples is stored in a selected file. This data is backed up in the A7-MXU and can be reloaded if the PC crashes.

*Continuous logging*: The data is stored continuously in a selected file. There is no limit to the length of the run.

### Interface

This selects the interface to the PC. It also allows an existing stored file to be read back into the GUI. All relevant instrument settings are stored in a file header, and will be used to preset the indicators on the GUI to the settings that were actually used when the file was generated.

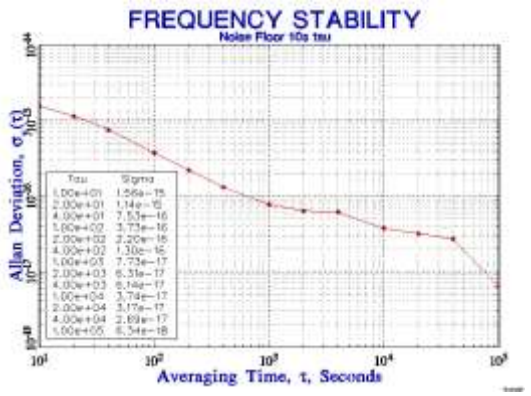



*Figure 1 Narrow Band Noise Floor 10s tau long term drift*


*Figure 2 Narrow Band Noise Floor Phase Data 10s tau long term drift*

Note: - The long term drift results shown were taken in an uncontrolled temperature environment and therefore users should experience significant improvements using a constant temperature controlled environment.

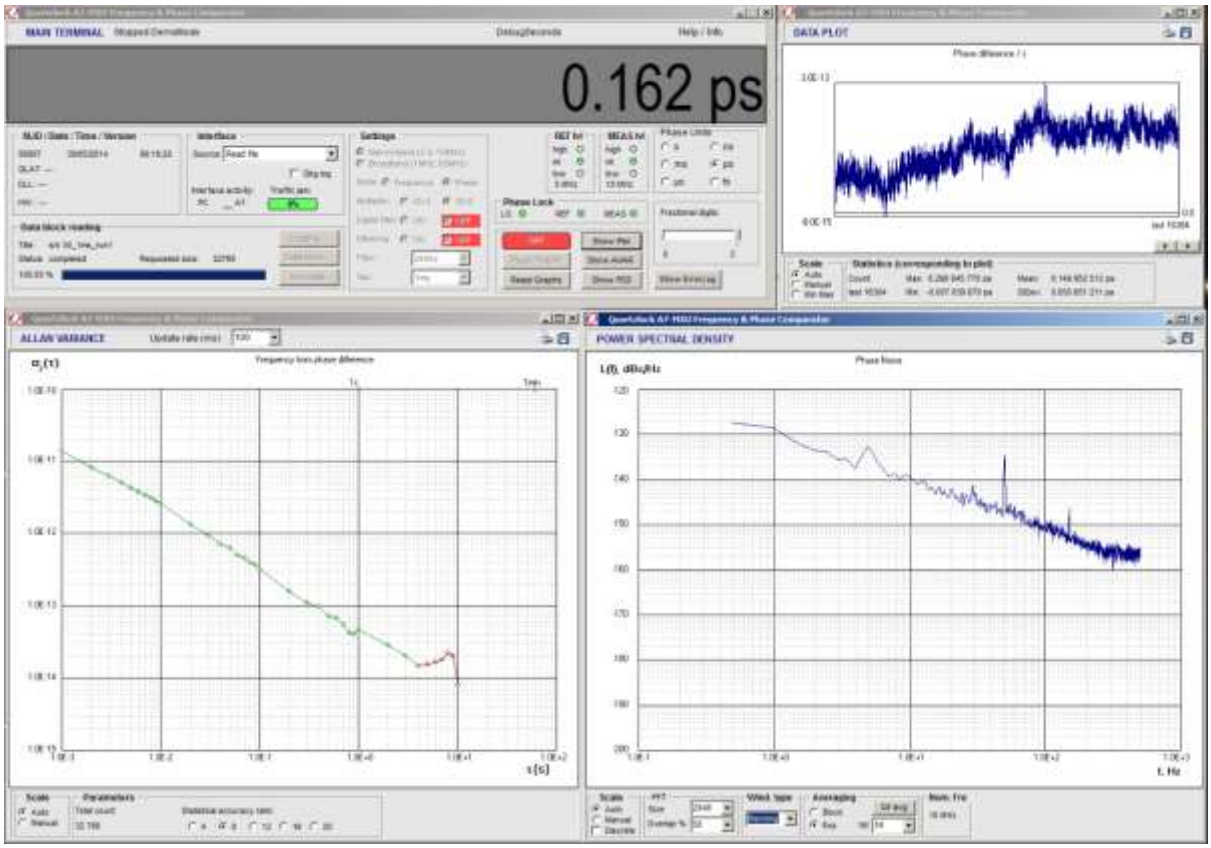



*Figure 3 Noise Floor 1ms*

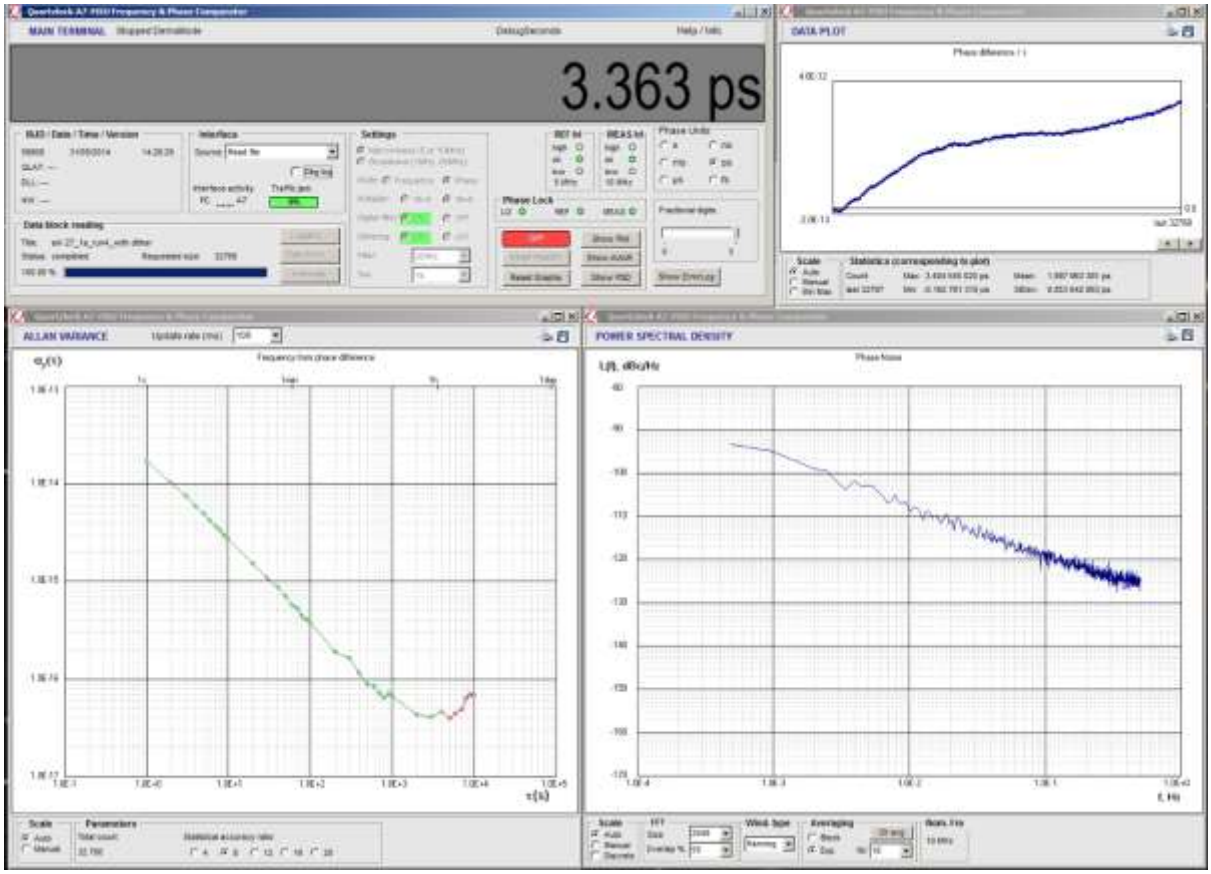



*Figure 4 Noise Floor 1s*

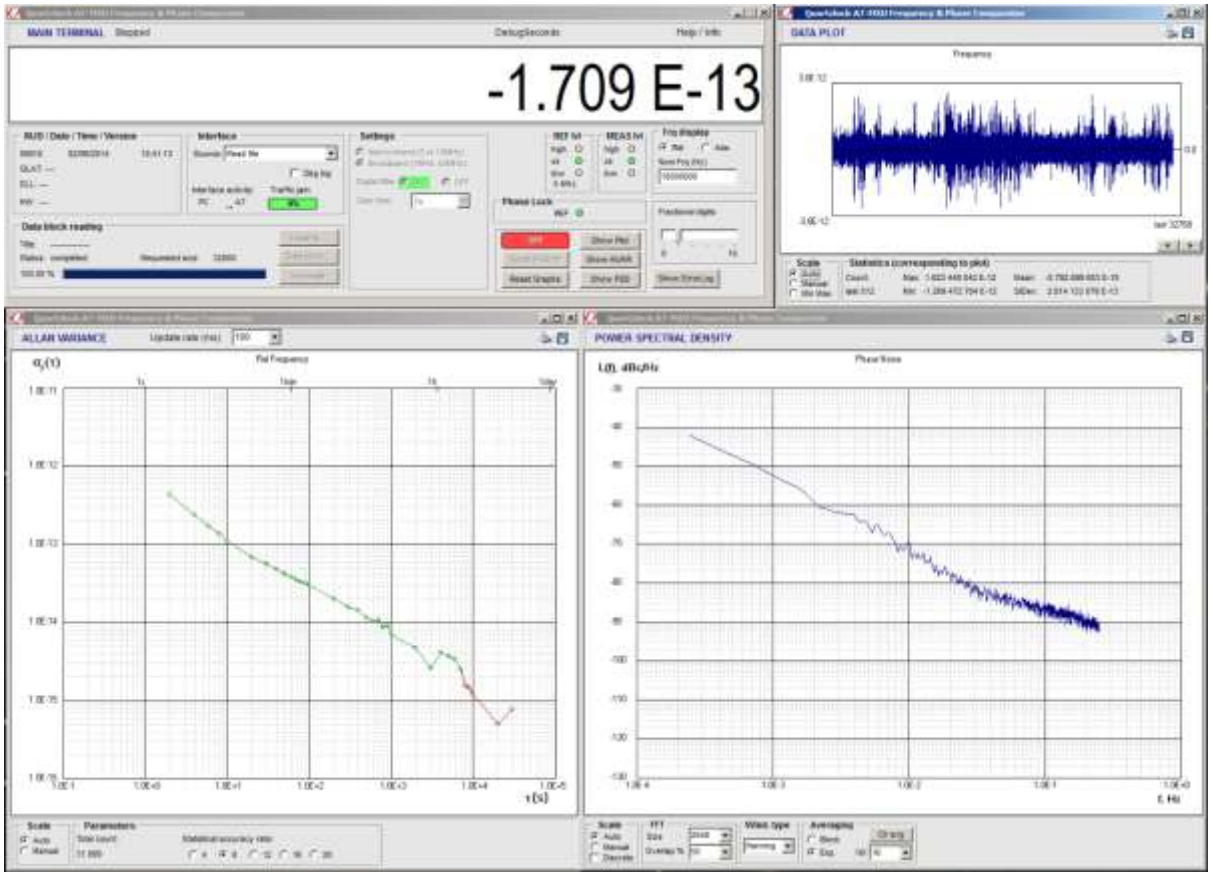



*Figure 5 Noise Floor Broadband 2s*

## *Ordering information*

| | |
|---|---|
| A7-MXU | Signal Stability Analyser |

## *Options*

| | |
|---|---|
| 0 | Seamless Battery Back-up Switch |
| 18 | Add Additional 1 to 5 Years Warranty (18.1 = 1 Year … 18.5 = 5 Years) |
| 32 | Stable 32 Analysis Software |
| 36 | Training |