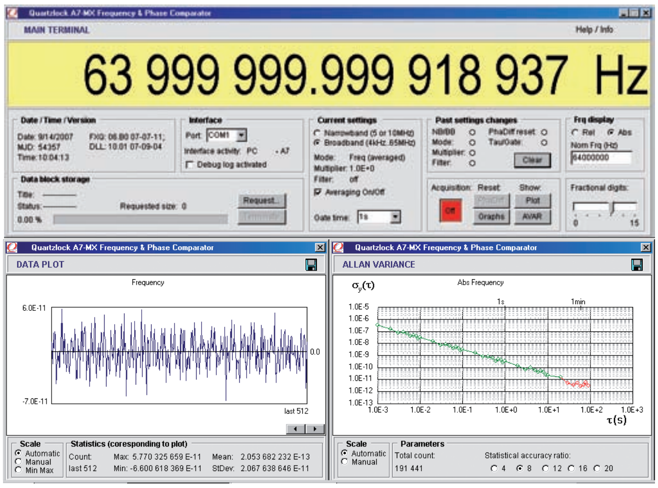
PROVISIONAL

Quartzlock **A7-MX** broadband with ADS* & Plot Print

Frequency & Phase Analyser

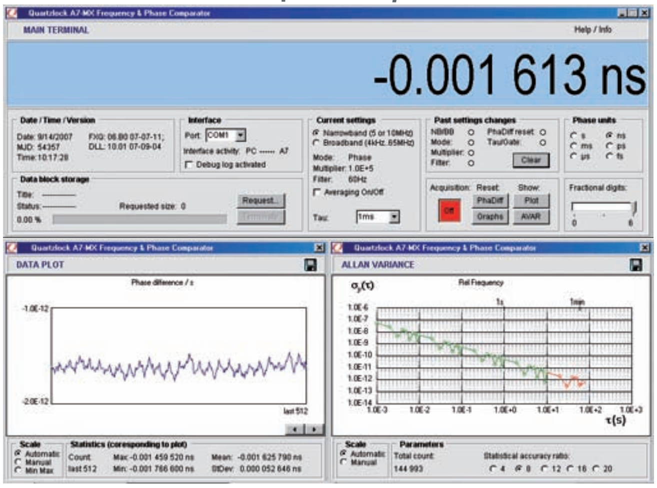
with Relative & Absolute High Resolution Counter
50kHz....65MHz Bandwidth

Absolute Frequency



Absolute Frequency — Absolute Frequency 'AVAR' stability

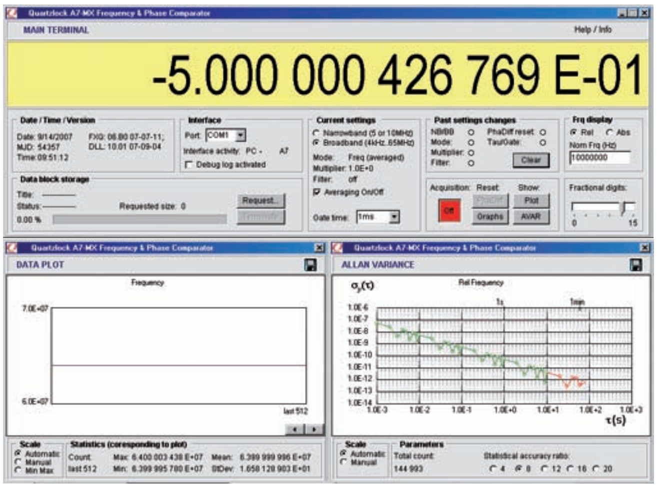
Phase Difference fs · ps · ns · µs · ms · s



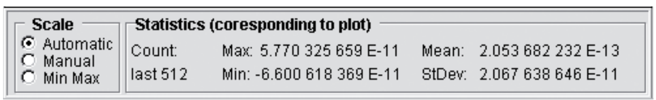
Phase Difference — Relative Frequency 'AVAR' stability

Frequency Difference

Relative Frequency Difference



Frequency Difference — Relative Frequency 'AVAR' stability



Statistics: Max · Min · Mean · Standard Deviation

Save 40% of Oscillator Development & Production Test Time

New 2008

- Broadband 50kHz - 65MHz input
- Large digital display of ΔØ or Δf
- Large digital display of phase / relative & absolute frequency
- Plot print function

Features

- Measurement error fully specified
- Industry Best Phase Stability
- Very high resolution: 50fs single shot
- Very low noise: 1s <5x10^{-14}
- Sample rate: 1000 readings/second
- Selectable filters, resolutions & tau's
- * Averaging, Dithering & Scrambling for even lower noise

Applications from Metrology to Production Test

- Stability analysis of both Frequency & Phase
- Phase noise analysis
- ADEV, Modified ADEV, TVAR, MTIE etc
- Relative & Absolute counter display of Frequency & Phase difference

Benefits

- Unequaled performance
- External PC enables low cost 2-3 year upgrades
- "National Measurement" level metrology & analysis with production test ease of use

SPECIFICATIONS

Inputs				
a) Reference	5 or 10MHz sine wave	$\pm5\times10^{-5}$	50 PPM	50×10^{-6}
b) Measurement (3 measurement inputs - see non standard options = A7-MY)	5 or 10MHz sine wave	$\pm5\times10^{-5}$	50 PPM	50×10^{-6}
c) Input levels:	+0dBm to +13dBm into 50Ω			
d) Max Freq difference (Filter off):	Low resolution	$\pm1\times10^{-5}$	10 PPM	10×10^{-6}
	High resolution	$\pm1\times10^{-7}$	10 PPB	10×10^{-8}

Outputs	
a) Counter A channel	100kHz square wave CMOS/TTL (frequency mode)
	10us pulse CMOS/TTL (phase difference mode)
b) Counter B channel	10us pulse CMOS/TTL (phase difference mode)
c) Counter external reference	10MHz CMOS/TTL
Filter	Selectable bandwidth IF filter reduces measurement noise
Nominal 3dB Bandwidths	200Hz, 60Hz, 10Hz

Fractional frequency multiplication			A7-A Analogue Meter Version. *Note option 2 delete internal phase meter.
Selectable	High resolution 10^5 Low resolution 10^3		
Measurement resolution	A7-MX	A7-A + Ext TIC	Analogue meter resolution manually selected from 6 ranges
Relative frequency difference mode	Using internal phase/freq. meter (TIC) and Windows software	Using external frequency/time interval counter with 1ns or better time interval resolution	
RMS resolution (filter 200Hz)			
High resolution	1×10^{-13}/gate time	1×10^{-13}/gate time	
Low resolution	1×10^{-12}/gate time	1×10^{-12}/gate time	
Meter			
Full scale ranges (decade steps)	$\pm1\times10^{-7}$ to $\pm1\times10^{-12}$	$\pm1\times10^{-7}$ to $\pm1\times10^{-12}$	$\pm1\times10^{-7}$ to $\pm1\times10^{-12}$
Time constant (linked to range)	20ms to 10 Sec	20ms to 10 Sec	20ms to 10 Sec
Time constant multiplier	x 1, x3, x10	x 1, x3, x10	x 1, x3, x10
Displayed Noise	$<2\times10^{-13}$ peak	$<2\times10^{-13}$ peak	$<2\times10^{-13}$ peak
Zero drift	$<2\times10^{-13}$/hour	$<2\times10^{-13}$/hour	$<2\times10^{-13}$/hour
Phase difference mode			10ps....1µs/div
(High resolution, Filter 200Hz)			
RMS resolution (single measurement)	50fs*1	50fs*1	
Meter			
Full scale ranges (decade steps)	±10us to ±100ps	±10us to ±100ps	±10us to ±100ps
Displayed noise	<1ps peak	<1ps peak	<1ps peak
Zero drift	<1ps/hour	<1ps/hour	<1ps/hour

A7-A analogue meter ranges:

Δf/f	Phase
1×10^{-8}	1µs
1×10^{-9}	100ns
1×10^{-10}	10ns
1×10^{-11}	1ns
1×10^{-12}	100ps
1×10^{-13}	10ps

Short-term stability	**Allan variance**	
Tau		
1ms	$<5\times10^{-11}$	$<5\times10^{-11}$
10ms	$<5\times10^{-12}$	$<5\times10^{-12}$
100ms	$<5\times10^{-13}$	$<5\times10^{-13}$
1s	$<5\times10^{-14}$	$<5\times10^{-14}$
10s	$<1\times10^{-14}$	$<1\times10^{-14}$
100s	$<2\times10^{-15}$	$<2\times10^{-15}$
1000s	$<5\times10^{-16}$	$<5\times10^{-16}$
10000s	$<1\times10^{-16}$	$<1\times10^{-16}$
Sampling interval	1ms to 2000s 1, 2, 5 Steps	1ms to 1000s Decade Steps
Drift		
Hour	<1ps typical	<1ps typical at constant ambient temperature
Day	<5ps typical	<5ps typical at constant ambient temperature
Temperature	<2ps/°C	<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
Allen Variance Error (due to each spur)*3	
10^3 multiplication	10^{-12} divided by averaging interval (tau)
10^5 multiplication	3×10^{-13} divided by averaging interval (tau)
MECHANICAL	2U 19" rack unit WxHxD(max) 450(483)x88(96)x345(370) <9kg
POWER SUPPLY	120/ 240V AC line 50W max 24V DC battery backup with automatic switching. Current consumption 1Amp max. With option 1 add 1Amp

Note: phase modulation spurii will be present at multiples of the input frequency difference.

1 Measured as the standard deviation of 1024 phase difference measurements/1.024s
2 Measured as the standard deviation of 1000 phase difference measurements/1s
3 Phase modulation spurii will be present at multiples of the input frequency difference

SPECIFICATIONS

Addendum: Broadband Input
Note 5 or 10MHz reference must be present at reference (front panel) input of A7-MX bb

Input

Type	BNC, rear panel
Impedance	1Mohm
Input levels	
50kHz to 1MHz	224mV rms (0dBm) to 2V rms (+19dBm)
1MHz to 50MHz	70.7mV rms (-10dBm) to 2V rms (+19dBm)
50MHz to 65MHz	224mV rms (0dBm) to 2V rms (+19dBm)

Resolution (nominal)

11 digits /second of gate time (averaging on)

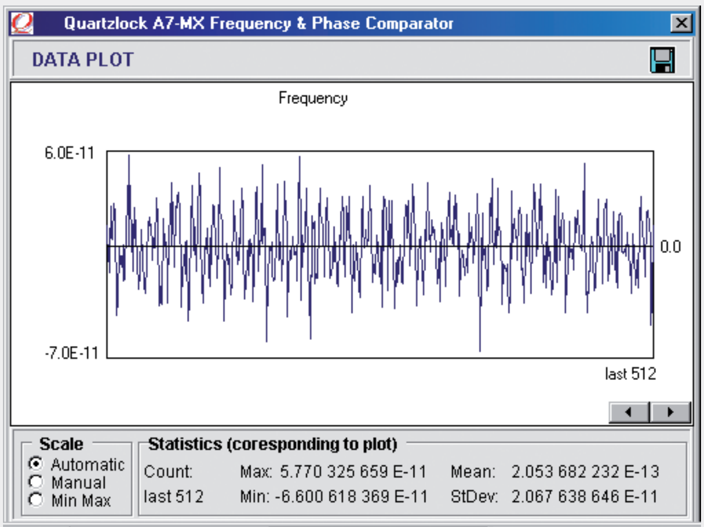
Noise Floor (allen variance) (measured at 10MHz, 10dBm input)

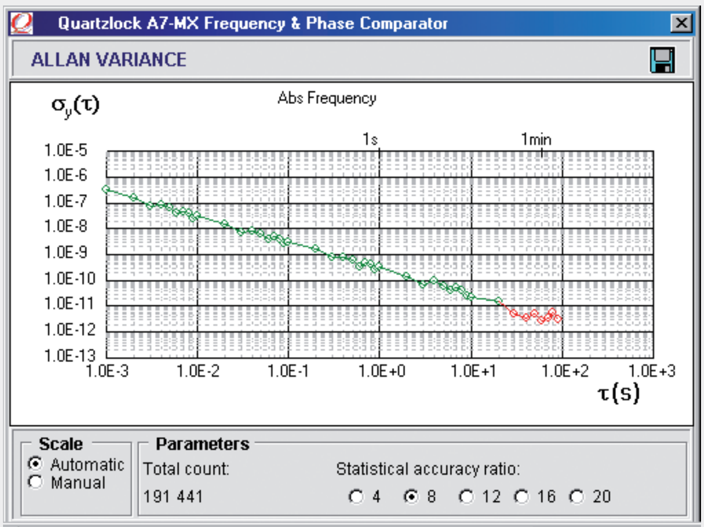
Averaging off	All gate times	$< 2\times10^{-9}$	100ms
		$< 2\times10^{-10}$	1s
		$< 2\times10^{-11}$	10s
Averaging on	gate time		
	10ms	$< 2\times10^{-11}$	1s
	100ms	$< 6\times10^{-12}$	1s
	1s	$< 2\times10^{-12}$	1s

Virtual Front Panel

Absolute or relative (normalised) frequency display
User entered normalisation frequency
Allen Variance graph
Frequency data graph
Block storage of phase on frequency data

Instant plot print function enables hard copy of Phase, Frequency or Allan Variance





The A7-MX is the 2008 substantially enhanced successor to Quartzlock's industry leading A7 line. The A7-MX can save 40% of Oscillator Research, Development and Production Test Time.

The A7-MX includes major additional facilities: Relative & Absolute counting of the input frequency over a broadband of input frequencies with comprehensive input conditioning.

Innovative Averaging, Dithering & Scrambling noise reduction techniques are used in the Stroboscopic Phasemeter, Phase Comparator & "time interval counter". Temperature Stabilisation of the Comparator & Error Multiplier enable close to zero thermal impedance between components. Averaging also reduces passive component noise.

Scrambling reduces noise to 3 x 10-13/s in the stroboscopoic phase meter.

The new virtual front panel enables selection of Averaging, (which auto selects Scrambling) at gate times of >50ms.

Averaging & Scrambling optimisation with gate time gives the best estimate of phase measurement available & improves further with longer gate times.

New for 2008

- Broadband 50kHz - 65MHz input
- Large digital display of ΔØ or Δf
- Large digital display of phase / relative & absolute frequency
- Data stored in A7-MX
- RS232 & USB connect to PC
- 32000 data point storage
- Crash proof with 24Vdc Battery Back Up
- On screen plot in real time
- Measurement error fully specified
- Plot print

Features

- Industry Best Phase Stability
- Very high resolution: <50fs single shot
- Very low noise: 1s $<5x10^{-14}$ (200Hz bandwidth)
- Ultra fast measurement time
- Sample rate: 1000 readings/second
- A7-A (Analogue): simple to use E-13 resolution
- A7-M (Metrology): best available E-16 resolution
- Selectable filters, resolutions & tau's
- Phase/frequency meter extremely useful

Applications from Metrology to Production Test

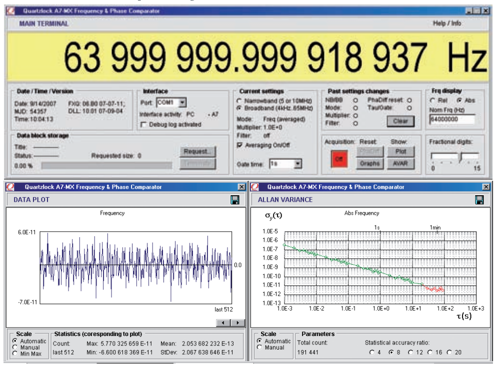
- Stability analysis of both Frequency & Phase
- Phase noise analysis
- Atomic frequency standard calibration
- Active & passive component stability measurement
- ADEV, Modified ADEV, TVAR, MTIE etc
- Temperature & Phase testing
- Relative & Absolute counter display of Frequency & Phase difference
- Precision product characterisation
- "National Measurement" level metrology & analysis

Benefits

- Unskilled operation
- Unequaled performance
- External PC enables low cost 2-3 year upgrades

Frequency Difference

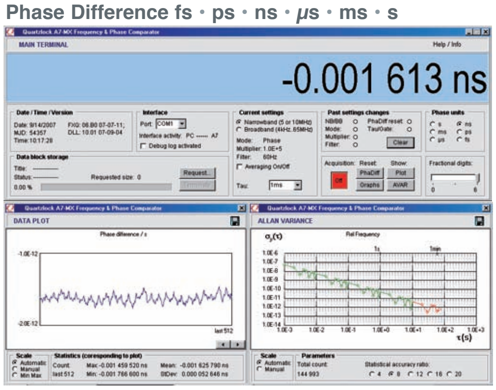
Absolute Frequency



Absolute Frequency

Absolute Frequency 'AVAR' stability

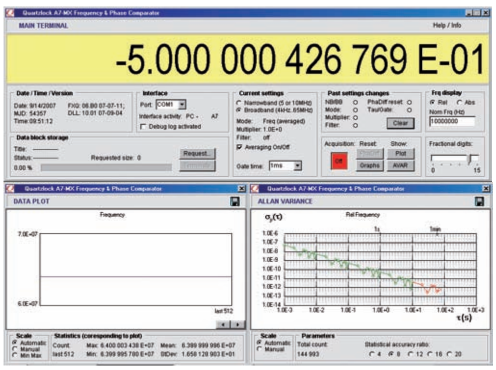
Phase Difference fs · ps · ns · μs · ms · s



Phase Difference

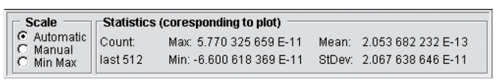
Relative Frequency 'AVAR' stability

Relative Frequency Difference



Frequency Difference

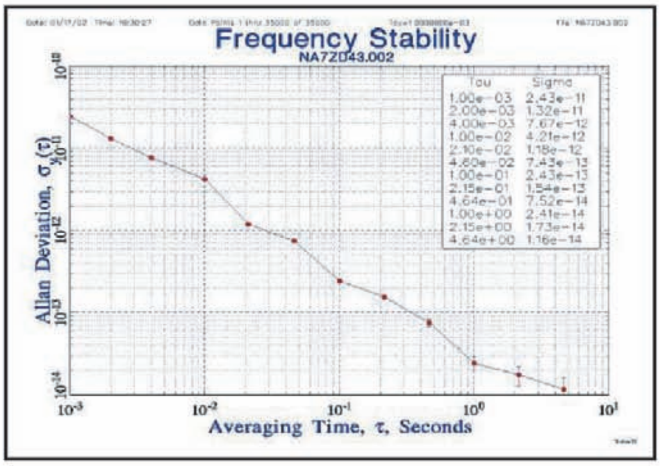
Relative Frequency 'AVAR' stability

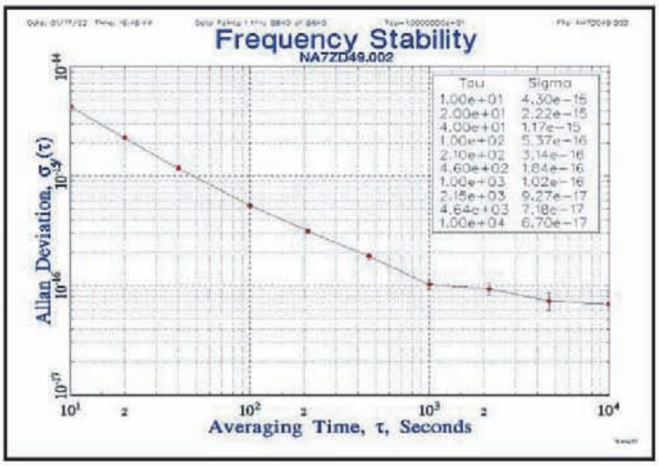


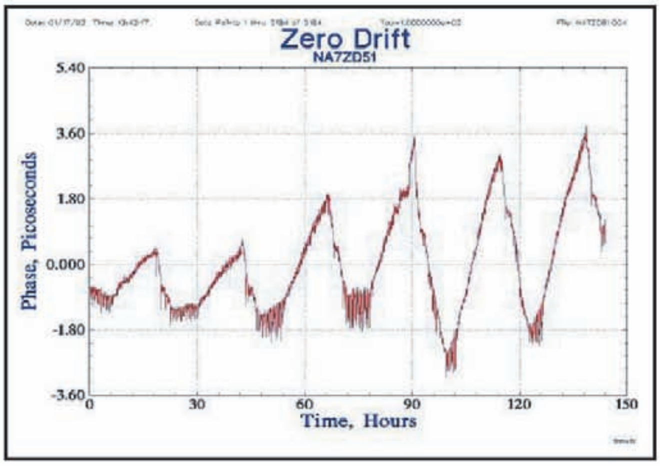
Statistics: Max · Min · Mean · Standard Deviation

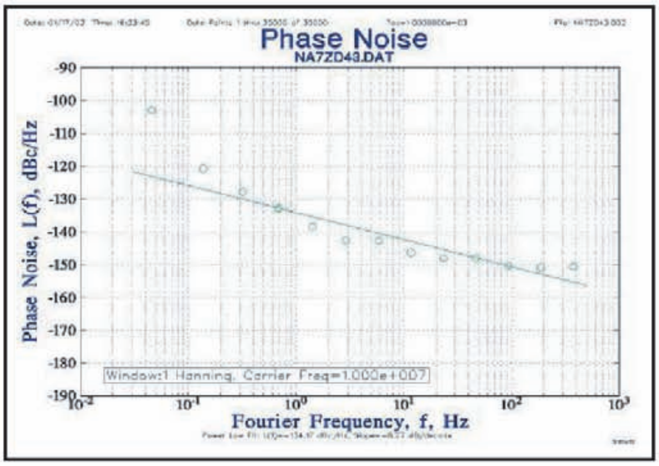
Quartzlock Frequency & Phase Analyser A7-MX

Typical performance plots









ORDERING INFORMATION - A7-MX OPTIONS

0	Seamless Battery Back-up Switch & 24V dc input
1	Distribution Card 1 Input 4 Outputs (for reference outputs)
2	Delete internal phasemeter and software = A7-A
17	Add A10-LPRO High Performance Rubidium Oscillator (STD Version)
18	Add Additional 1 to 5 Years Warranty (18.1 = 1 Year ... 18.5 = 5 years)
26	Change to LPRO HS High Stability Rubidium Oscillator from LPRO = A10-Y
27	Change to LPRO LN Low Phase Noise Rubidium Oscillator from LPRO -160dBc/Hz = A10-Y
32	Stable 32 Analysis Software also enables phase noise calc.
36	Training

Options 17, 26 and 27 are internal rubidium oscillator refernces. It may be preffered that an external reference be supplied in light of Quartzlock 2007 rubidium product line - ask Quartzlock, costs are similar.

Non standard options - ask Quartzlock
- Automatic Close-in Phase Noise Calculation display
- User specified input range up to microwave frequencies i.e. 12 GHz
- Isolated inputs • ATE version (remote filter select) • Cable set
- Lower related noise (5 & 10MHz input) • Zero drift input splitter • 100MHz input
- A7-MZ multi channel inputs

Option 2 A7-A as A7-MX but less Internal Phase Meter, Computer Control and Quartzlock Analysis Software

The 2008 A7-MX now includes options listed in previous issues as standard fittings.

Technical Description

What it does

The A7 revision 6 frequency/phase difference comparator is an improved version of the previous model A7 Quartzlock product for measuring a wide range of frequency standards, isolation amplifiers, frequency multipliers and dividers, and passive devices such as cables. The instrument is self contained with an internal phasemeter and needs no external counter. A PC running most operating systems with one RS232 port provides a sophisticated user interface with immediate calculation and graphing of Allan variance. A digital display of phase or fractional frequency offset is provided. Tau values from 1ms to 2000 seconds may be used. A unique RS232 interface protocol has been designed which prevents Windows from losing data. The phasemeter has a 32k buffer which provides complete protection to the data if the computer fails during a measurement run. Data blocks with up to 32k readings may be stored to disk for analysis with an external program such as Stable 32.

Analogue or digital display

The instrument includes a moving coil meter for rapid, unambiguous display of fractional frequency difference or relative phase difference between two sources. Outputs are also provided for an external counter to connect to existing logging equipment if required. The instrument combines the production oriented capability of rapidly adjusting a source to within a certain tolerance using the panel meter, along with the metrology capability of a full time domain analysis of a source or passive component using data acquisition from the internal phasemeter or external counter.

Noise & drift - very low

The A7 comparator has state of the art noise floor and drift characteristics. Its technique of frequency multiplication followed by down conversion provides lower noise floors than the simpler dual mix downconvert system. The very low drift is achieved by providing identical multiplier/mixing chains for the reference and measurement channels. When the multiplied signals are finally mixed together (subtracted), any drift in the multiplier chains is cancelled.

BBU

The automatic battery backup facility fitted as standard enables very long measurement runs to be undertaken without concerns over line power failures. An external 24V battery will power the instrument for at least 24 hours.

Reference

A Rubidium frequency standard may be fitted internally or externally (Option) along with a 4 output distribution amplifier with very low phase noise (Option).

How it works

Measurements are made in the time domain and consist of time difference measurements between a reference source and a measurement source. Measurements may be made on passive devices such as amplifiers by splitting a source output and comparing the time delay through the item under test with the direct path. In this way the time or phase stability of the amplifier may be measured. Unlike a general purpose time interval meter the inputs must be substantially sine wave and at either 5MHz or 10MHz. The resolution is much better than even the fastest counters, being around 50fs for a single measurement.

2007 - new features

The A7 is a completely new design using phase locked multipliers as opposed to the harmonic multipliers used in previous Quartzlock phase/frequency comparators. Several new features have been added. The frequency input range is much wider, enabling measurements on VCXOs and OCXOs. Two resolutions are provided, with multiplication factors of 10^3 and 10^5. This optimises measurement on very stable sources such as Rubidium and Caesium oscillators and Hydrogen Masers, as well as lower stability sources. A variable band width IF filter has been added. This essentially sets the measuring bandwidth and allows sources with considerable phase noise to be filtered.

2007 - new features cont.

This has particular advantages in frequency mode where the apparent jitter of a real time frequency readout can be reduced. A Rubidium frequency standard can be adjusted using 100ms sampling time to an accuracy of $1x10^{12}$. The phasemeter may be set to sample at the maximum rate of 1ms, with averaging to generate samples at the requested lower sampling rate. This digital averaging provides lower noise with some sources. **The phase meter takes stroboscopic phase readings of a single input at regular intervals without any dead time.**

Input spec.

The comparator will operate at either 5MHz or 10MHz with automatic switching. The inputs are 50ohm impedance, and a level of between 0dBm and 13dBm is required at both inputs. The absolute accuracy of both reference and measurement inputs should be less than ±50 in 10^6. The maximum frequency difference should be less than ±10 in 10^6 in low resolution mode and less than ±100 in 10^9 in high resolution mode. The inputs are provided with level indicators.

FREQUENCY - Modes, ranges and resolution

The comparator has two modes of operation, frequency measurement mode and phase difference mode. In frequency mode the moving coil meter indicates fractional frequency difference and the phasemeter is configured as a frequency counter. Meter full scale ranges are selectable from the front panel in the range $\pm10^{-7}$ to $\pm10^{-12}$. The internal phasemeter is configured as a frequency counter with gate times selected on the PC virtual panel as usual for a frequency measurement. The digital display shows fractional frequency with selectable number of digits displayed. The RMS resolution is typically better than 5 parts in 10^{14} for a 1 second gate. The Allen variance is calculated automatically and continuously as the samples are accumulated, and the graph is updated.

PHASE

In phase mode, the moving coil meter is configured to read phase difference between the reference and the measurement inputs. The full scale range is selectable between ±10us to ±100ps. An extended range phase detector is used so phase roll over will be between +10 and 0 on the meter if the frequency is increasing, and between -10 and 0 on the meter if the frequency is decreasing. The meter shows relative phase difference between the reference and measurement inputs. Because of the multiplication process in the comparator, the absolute phase difference is not available. A phase reset key is provided that zeros the indicated phase to within ±100ps.

The internal phasemeter is configured as a time interval meter and measures the time difference between the measurement and reference channels. The sampling rate is set on the PC virtual panel. The phase may be reset to zero on the virtual panel. Allen variance is calculated continuously from the phase data. The single shot time resolution (measured as the standard deviation of 1024 readings accumulated over 1.024 seconds) is less than 50fs.

Data

In both frequency and phase mode blocks of data may be accumulated and stored to disk. The block size may be up to 32k readings. The data is stored internally in the phase meter so that a failure of the computer or slow operation of the RS232 interface cannot lose any data. The computer may be used for other applications with the A7 application minimised without any concerns.

Software

A sophisticated software package is available for analysis of data (Option). This is Stable 32 supplied by Hamilton Technical Services. It supports every possible type of time domain stability analysis, as well as conversion to the frequency domain for close in phase noise analysis.

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