Quartzlock

A10

4x10-13
Stability

Rubidium Time and Frequency Standards

instruments & components

APPLICATIONS

- Frequency calibration
- Telecom network synchronisation
- Cellular phone base stations
- Satellite navigation and GPS receivers
- TV Broadcasting
- Radio transmitters

BENCH

1U RACK

2U RACK

BENEFITS

- Space saving
- Low cost
- Ideal for mobile applications
- Low power consumption
- Sync with gps
- Environmentaly tolerant

FEATURES

- Stability: $4x10^{-13}$/100s (HSRO)
- Outputs: 1...13 of 1, 5, 10MHz & 1pps
- Inputs: GPS sync lock, 1pps sync
- Phase Noise: -155dBc/Hz @ 10kHz
- Aging: $1x10^{-10}$/ year
- Warm time to $5x10^{-10}$: 5mins
- Options: HSRO, 13MHz, 10.24MHz, E1, T1, BBU
- Physical: Bench mount, 1U & 2U 19" rack mount

INTRODUCTION

A Rubidium frequency standard owes its outstanding accuracy and superb stability to a unique frequency control mechanism. The resonant transition frequency of the Rb87 atom (6,834,682,614 Hz) is used as a reference against which an OCXO output is compared. The OCXO output is multiplied to the resonance frequency and is used to drive the microwave cavity where the atomic transition is detected by Electro-optical means. The detector is used to lock the OCXO output ensuring its medium and long-term stability.

The first realised Rb frequency standard arose out of the work of carpenter (Carpenter et al 1960) and Arditi (Arditi 1960). It was a few years until the first commercial devices came onto the market and this was primarily due to the work of Packard and Schwartz who had been strongly influenced by the work of Arditi a few years before on Alkali atoms (of which Rb87 is one). Unlike much of the research done into frequency standards at that time, practical realisation of a rubidium maser was high on the researchers agenda. This was mainly due to an understanding that such a device would have extremely good short-term stability relative to size and price. In 1964, Davidovits brought such research to fruition, with the first operational rubidium frequency standard.

The rubidium frequency standard, like its more expensive cousin, the hydrogen maser, may be operated either as a passive or as an active device. The passive rubidium frequency standard has proved the most useful, as it may be reduced to the smallest size whilst retaining excellent frequency stability. The applications for such a device abound in the communication, space and navigation fields.

The rubidium frequency standard may be thought of as consisting of a cell containing the rubidium in its vapour state, placed into a microwave cavity resonant at the hyperfine frequency of the ground state. Optical pumping ensures state selection. The cell contains a buffer gas primarily to inhibit wall relaxation and Doppler broadening. The Rubidium frequency standard essentially consists of a voltage controlled crystal oscillator, which is locked to a highly stable atomic transition in the ground state of the Rb87 atom.

There are several reasons why Rb has an important role to play as a frequency standard. Perhaps most significantly is its accuracy and stability. Accuracy is comparable with that of the standard caesium with an operating life approximately 5 times that of Cs. Furthermore, the cost of a replacement physics package is only about $50 or in some cases free. Moreover the stability of a Rb frequency standard over short time-scales -100s of seconds- betters that of Cs (Cs are more stable over longer time periods, in the regions of hours to years). After 100s the frequency stability of the best performing Quartzlock Rb is 3.10-13, better than the HP standard caesium beam tube. The phase noise of the Quartzlock Rb is -150 dBc/Hz @ 10 kHz from the carrier, identical to the HP5071 which provides 80 % of the UTC weighting.

There are, however, a few drawbacks to the use of Rb as a frequency standard. In the past, these included the limited life of the Rb lamp (since improved to >10years), The Caesium is affected to a greater degree than this, whilst the H-maser operates differently and is not affected. The thermal stability of Rb is inferior to that of Cs or H-Masers, and the Rb previously required frequency access to a primary reference signal or synchronisation source to maintain long-term Cs level accuracy. The cost of a rubidium frequency standard at around $5000 is significantly cheaper than a Cs, with a much reduced size and weight (The HP5071 weighs about 30kg). Due to its small size, low weight and environmental tolerance the Rb frequency standard is ideal for mobile applications. Indeed, Rb atomic clocks are being used in the new generation of GPS satellites. This is in part due to the extended life of the Rb physics package c.f. Cs. The Rb is also extremely quick to reach operational performance, within 5mins reaching $5x10^{-10}$.

The Quartzlock A10-B is the only rubidium frequency standard providing the user with 1MHz, 5MHz and 10 MHz sinewave and squarewave outputs from the front panel. Also included on the front panel is a 1pps output, enabling the user to turn the Rb frequency standard into a clock. At the rear of the device, six 10MHz highly buffered outputs are provided. Although the rear panel outputs are factory set at 10MHz, simple alterations made inside the unit (easily performed by even the novice) can turn this into either 5MHz or 1MHz. The flexibility afforded by the A10-B is unsurpassed. Due to Quartzlock's wide range of products and expertise, a further improvement is possible using the Quartzlock A8 carrier phase tracking GPS. By inputting a 1pps signal from the A8 GPS to the rear of the unit, the A-10-B may be transformed into an extremely accurate and stable GPS disciplined Rubidium.

Recently Quartzlock have been awarded a major European research and development award. The CRAFT project will, amongst other things, enable further research and development of the company's Rb frequency standard. Already an entirely new electronics package has been developed in Falmouth. It is hoped that Quartzlock's production of Rubidium will expand rapidly within the UK from 60 units/year to over 1000/year. This will enable it to become one of only three companies serving the world market for Rb standards (at present worth ~$100 million).

Naturally, the applications for such a low cost, small size device with excellent short-term accuracy are many. It may be used in frequency calibration, telecom network synchronisation, cellular phone base stations, satellite navigation and GPS receivers, TV broadcasting, radio transmitters, ground and satellite communications, time base and calibration, secure communications and spread spectrum techniques and radio navigation.

STANDARD SPECIFICATIONS

Core Output	10MHz
Adjustment Mechanical Range Electrical Range Stability Factory Setting	 $2x10^{-9}$min $2x10^{-9}$min $2x10^{-11}$ $\pm5x10^{-11}$
Frequency Stability 1s 10s 100s 1day	 $3x10^{-11}$ $1x10^{-11}$ $3x10^{-11}$ $1x10^{-11}$
Aging 1 month 1 year	 $4x10^{-11}$ $5x10^{-10}$
Phase Noise 1Hz 10Hz 100Hz 1000Hz 10000Hz	 - 100dBc 130dBc 140dBc 145dBc
Harmonics	<40dBc
Spurious	<80dBc
Warm time to $1x10^{-9}$	5min
Retrace after 24h off & 1h on, same temp	 $<2x10^{-11}$
Power at Warm Up Power at steady state at 25ºC Freq offset over output voltage range	 10W $<2x10^{-11}$
Temperature Operating Storage Freq offset over operating temperature range	 -10ºC to +55ºC (-65 to +65 op) -40ºC to +85ºC $<3x10^{-10}$
Magnetic Field Sensitivity Atmospheric Pressure Approx MTBF, Stationary	 $<2x10^{-11}$/Gauss -60m to 4000m $<1x10^{-13}$/mbar 50,000Hrs

A10-B

Bench Mount Rb
1, 5, 10MHz Sinewave @ +13dBm
1, 5, 10MHz Squarewave @ <2V ttl
6x10MHz Sinewave at rear
1pps output
1pps input + GPS Sync input
LPRO/ FRS Rb

Options:

10.24MHz, 13MHz, E1, T1, BBU

A10-R

1U 19" Rack Mount Rb
10MHz output
LPRO Rb

Options:

10.24MHz, 13MHz, E1, T1,
1pps, GPS sync, BBU

A10-M *(old 10A-R)*

2U 19" Rack Mount Rb
10MHz output
LPRO/ FRS Rb

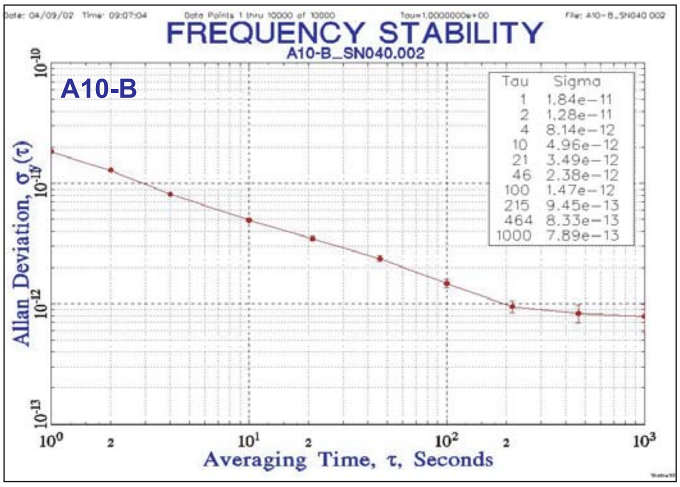
Options:

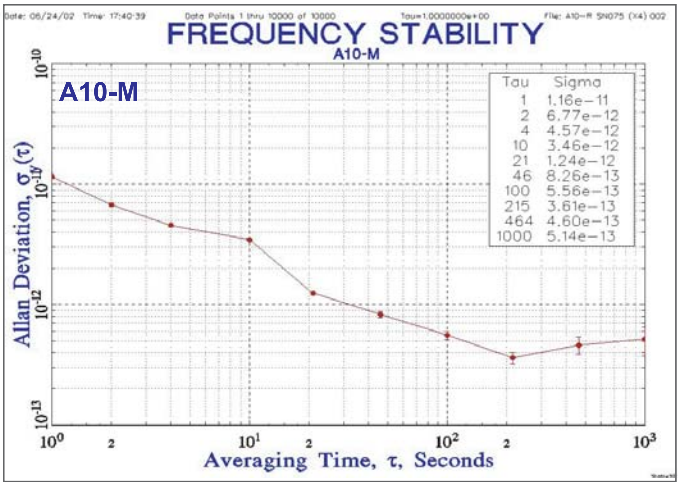
1MHz, 5MHz, 10.24MHz, 13MHz,
E1, T1, 1pps, GPS sync, BBU,
multiple 1, 5, 10MHz,
HPRO A/B/C/D Rb,
HSRO

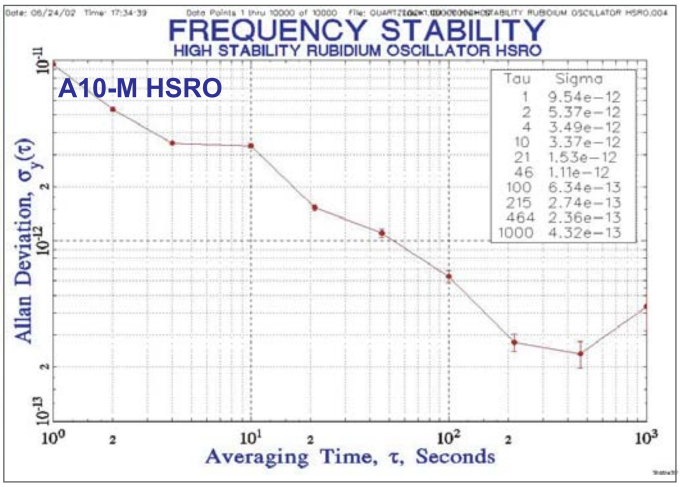
RUBIDIUM SPECIFICATIONS

Rubidium Spec	**HPRO**				**HSRO**	**LPRO/ FRS**
	A	**B**	**C**	**D**		
Drift 1 month 1 year	 $1x10^{-11}$ $2x10^{-10}$	 $4x10^{-11}$ $5x10^{-10}$	 $1x10^{-10}$ $5x10^{-10}$	 $1x10^{-10}$ $5x10^{-10}$	 $2x10^{-11}$ $5x10^{-10}$	 $4x10^{-11}$ $5x10^{-10}$
Frequency Stability 1s 10s 100s	 $3x10^{-11}$ $1x10^{-11}$ $3x10^{-12}$	 $3x10^{-11}$ $1x10^{-10}$ $3x10^{-12}$	 $1x10^{-10}$ $3x10^{-11}$ $1x10^{-11}$	 $1x10^{-10}$ $3x10^{-11}$ $1x10^{-11}$	 $3x10^{-12}$ $1x10^{-12}$ $4x10^{-13}$	 $3x10^{-11}$ $1x10^{-11}$ $3x10^{-11}$
Offset Over Temp Range	$3x10^{-10}$	$3x10^{-10}$	$5x10^{-10}$	$5x10^{-10}$	$5x10^{-11}$	$3x10^{-10}$
Operating Temerature ºC	-10..+55	-10..+55	-10..+55	-10..+55	-10..+55	-10..+55
Phase Noise 10Hz 100Hz 1kHz 10kHz	 -100 -130 -140 -145	 -100 -130 -140 -145	 -100 -130 -140 -155	 -100 -130 -140 -145	 n/a -135 -145 -155	 -100 -130 -140 -145

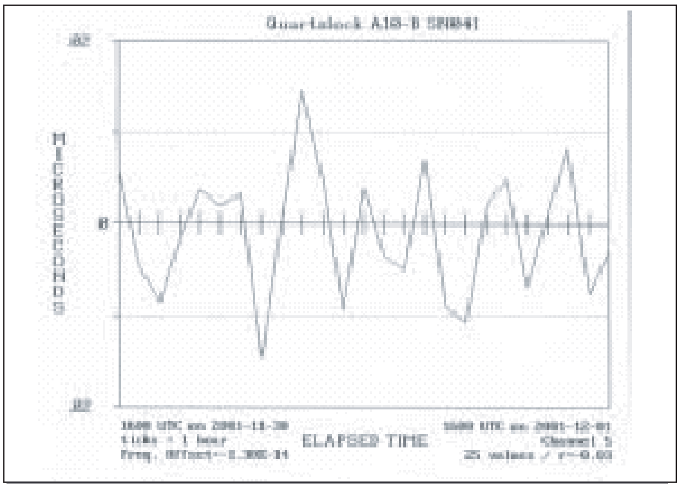
TEST RESULTS WITH A7-M

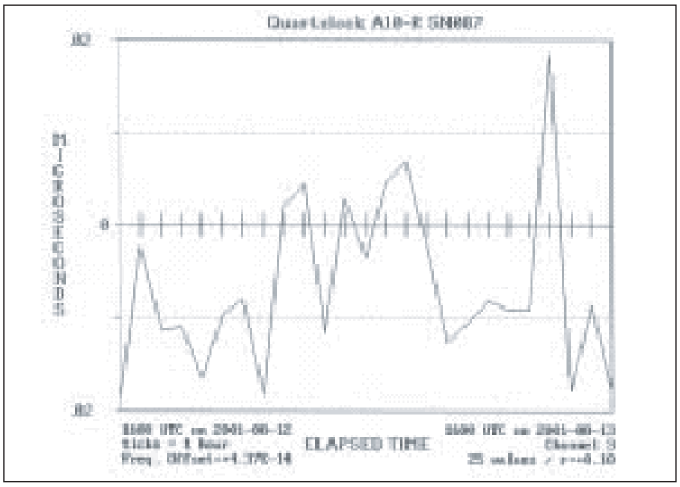


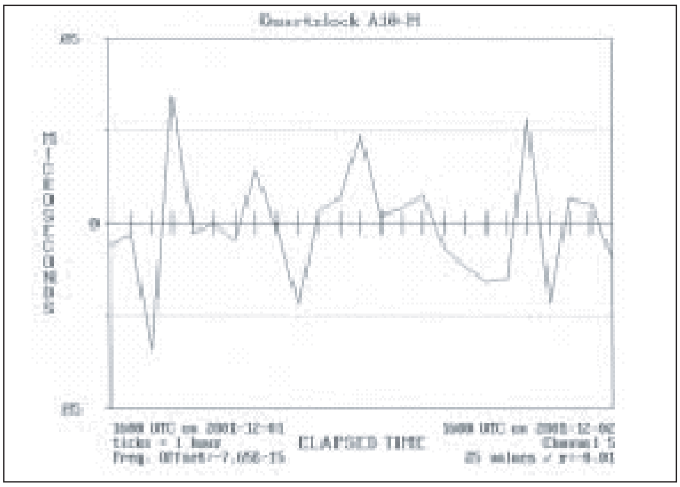




TEST RESULTS WITH NIST FMAS







Quartzlock (UK) Ltd
Gothic, Plymouth Road,
Totnes, Devon TQ9 5LH, England
Tel: +44 (0) 1803 862 062
Fax: +44 (0) 1803 867 962

Web: www.quartzlock.com
E-mail: quartzlock@quartzlock.com

Quartzlock (USA)
P.O. Box 6094, Astoria, NY 11106, USA
Sales
Tel: 718 614 8672
jrm1950@yahoo.com
Technical Service
Tel: 719 228 0540
Fax: 719 228 9009