Quartzlock Rubidium range

Over the past 5 years Quartzlock have been steadily improving and extending their range of Rubidium atomic frequency standards. At present Quartzlock supply about 60 units per years to customers from all over the world. However, with the recent awarding of a European research and development award (CRAFT), improvements in the Rb electronics and lifetime of the Rb lamp will enable Quartzlock to begin extending production to over 1000/year. This will enable it to become one of only three companies accommodating the Rubidium market. This article is intended to shed light on the companies' extensive range of Rb frequency standards and thereby help potential customers chose the right standard for the application

Rubidium atomic frequency standards are generally operated in the passive mode, since this ensures size minimisation coupled with excellent short-term stability. At 100s averaging time a high quality Rb oscillator will outperform the HP Cesium beam 5071B, despite being only a fraction of the size, weight and cost.

Quartzlock have developed a range of Rubidium components and also complete instruments. One of the advantages conferred to the user is the ability to be able to mix and match component with instrument, ensuring the correct quality oscillator is married into a suitably sized instrument, with the appropriate number of outputs.

The range of components manufactured under license for Quartzlock has been extended in the last year. The backbone to the companies Rb line has been provided for many years by the CH1-84. This is a Rb reference oscillator with optical pumping. The crystal oscillator frequency tuning is provided by the automatic frequency control (AFC) unit to the value determined by the quantum discriminator atomic line frequency. The ensures that the crystal oscillator frequency stability is comparable to the stability of Rb^{87} alkali metal isotope atomic resonance frequency used in Rb frequency standard quantum discriminator. The volume of the unit is a little over 1050cc with a weight not exceeding 1.5 kg. This is the largest of the Rb reference oscillators manufactured by Quartzlock. Whilst this determines the size, volume and weight of the unit, the user is afforded flexibility in choosing the quality of the oscillator. Four options are available.

i) The standard option, D, has the lowest frequency stability of the 4, with a stability $\sigma(2,\tau)$ of $1E\text{-}10/\tau^{1/2}$ as specification. Typical test results often exceed this. The latest batch of CH1-84-D has $\sigma(2,\tau)$ up to ten times this. The relative frequency accuracy (commonly called offset) at an ambient temperature of 25 °C is 2E-11. When compared with the 30 times more expensive HP-5071-B, which has an accuracy (bearing in mind that accuracy is the ability to produce a frequency which is a near as possible to the SI defined second and is based on the Cesium atom) of 2E-12, this is extremely good. This frequency has a reproducibility between switching of 5E-11 and a systematic relative frequency drift per month (after 72h of continuous operation) of 5E-11.

ii) The medium performance option, B, has an improved stability $\sigma(2,\tau)$ of $3E\text{-}11/\tau^{1/2}$ as specification. Whilst the relative frequency accuracy is identical to the 'D' option, ability to reproduce this is improved by 500% to 1E-11, with the systematic frequency drift improved by 20% to 4E-11 per month.

iii) The high performance option, A, has an excellent short-term stability specification $\sigma(2,\tau)$ of $1E\text{-}11/\tau^{1/2}$, with systematic frequency drift per month reduced to 1E-11. The latest test results have indicated $\sigma(2,\tau)$ of 5.7E-13 at $\tau = 100s$ and frequency drift reduced to 7.7E-12. The major difference between the different options is the drift and short term stability, with improvements resulting in increased cost of oscillator. All options work on the same principle, but variations in the final product, result in a few oscillators from every batch being deemed of sufficient quality to be A or B class.

If Rubidium oscillators are to be used as reference in calibration of other frequency standards, a test uncertainty ratio of 10:1 between the DUT and the reference oscillator must be maintained at all times for the results to be reliable and unambiguous. Smaller ratios than this may be used, but longer run times are to be expected. Therefore a very high quality A class rubidium could be used to test other rubidium frequency standards, with this TUR being maintained at all times. This could save the calibration laboratory huge amounts of money, where normally a costly Cesium beam or Hydrogen maser would have to be employed.

The new Quartzlock P-Line standards are intended to move the CH1-84 into the next century.

The P1000 replaces the CH1-84 and incorporates the latest 1999 electronics. It includes a temperature compensation option, which reduces the frequency deviation (or offset) to 1E-11 over a temperature range of +/- 65 °C. This improves the environmental stability of the P-1000 and enables it to compete favourably with the HP-5071. The P-1000 is available in four options: the existing A, B and D options mentioned above, but also a top of the range high stability option has been introduced (HSRO). This was primarily due to the realisation that for precision telecommunications applications, where very narrow frequency/time tolerances are permissible in large digital networks, a high performance device would be necessary, whilst maintaining the advantageous size, weight and cost of Rb. Short term stability of the HSRO, $\sigma(2,\tau)$ is specified at 3E-12 $/\tau^{1/2}$. Frequency drift and retrace are similar to the A class option. Another advantage is the choice of both 5 and 10 MHz output options as standard.

The P-Line includes 2 other basic sizes, the FRS (frequency reference standard) comparable rubidium oscillator, which comes in a 320cc and 400cc volumes, and the LPRO (low profile rubidium oscillator) which comes in 380cc and 450cc volumes. An advantage of the LPRO is that it may be employed in the 1U rack mount option, attractive to telecommunications due to its slim size and easy operation.

A cost effective option is also available, the LCRO (low cost rubidium oscillator), with a frequency stability $\sigma(2,\tau)$ specified at 1E-10 $/\tau^{1/2}$. This may be a desirable option for times when a greater frequency tolerance is acceptable and cost is a primary factor between choosing say an OCXO or a Rb. This allows rubidium technology to be available to even the most limited of budgets. Drift is no worse than 5E-11 per month. Over 1 year the LCRO, drifts 5E-10, no worse than its more expensive cousins

Quartzlock offer maximum flexibility in its Rubidium Frequency Standard output frequencies. Standard options include 2048 kHz for use in telecommunications and 13 MHz, which are utilised in GSM base station technology.

Whilst the Quartzlock Rubidium components are available separately, Quartzlock have developed 2 instruments that take full advantage of the extensive Rubidium range.

The first of the two to be developed was the 10A-R. This is a 19" x 2U or 1U rack mount rubidium reference. This has one core 10 MHz +7 dBm sine wave output frequency at the rear of the unit, with 1 MHz, 5 MHz, 10 MHz, 2048 kHz, 13 MHz and 60 MHz options available if requested. Multiple outputs of the same frequency @ 13 dBm are possible using the Quartzlock A5-4, low noise, high isolation distribution amplifier. If desired the unit may be fitted with a temperature control option, limiting the sensitivity of the unit with regard to temperature. A clear front panel contains no user operable controls or outputs, making the unit ideal where user intervention may interrupt valuable measurements. However, the front panel has 6 yellow LED's, indicating the functionality of the Rubidium (VCO PLL, BIT and Rb lamp) and the power supply (AC, DC UNREG and DC REG). The user is thus indicated of failure or malfunction of critical elements by these lights being not unlit in the system (positive logic). To assist in maintaining long term stability of the unit, the 10 MHz output may be applied to a GPS system and any errors in frequency will be indicated. The GPS signal may then be fed back into the 'C' field GPS sync lock input at the rear of the device, which will enable any error to be calibrated out of the device. This ensures that the Rubidium gives excellent performance in both the short and long term. Commonly the 10A-R is fitted with the larger Rubidium oscillators, like the Ch1-84 and the new P-1000. Different quality oscillators will dictate the price of the overall unit. It is the reference oscillator, which ultimately determines the stability of the signal output from the unit

Recently, Quartzlock realised that a rack mount option did not appeal to some people and so developed the far smaller compact bench mount A10-B rubidium reference standard. Unlike its rack mount cousin, the A10-B offers 14 outputs as standard. At the front of the device there are 1 MHz, 5 MHz and 10 MHz sine (+12 dBm into 50Ω) and square (> 2V ttl hcmos into 50Ω). There is also a very precise 1pps output (which is used extensively in astronomy and for clock generation). In common with the 10A-R, the A10-B has a sync lock option into GPS, enabling error correction and precise long-term stability maintenance. At the rear of the device, the user is offered the option of 6 x any single frequency. Whilst this is factory set to 10 MHz, simple internal adjustment can be made to any other standard frequency. . Red LEDS being lit indicate failure of the BIT lock or the lamp (negative logic). Such flexibility is unique in the rubidium market. The reference oscillators commonly used in the A10-B are the FRS and LPRO. Again, the user may decide which option oscillator he requires.

The Quartzlock Rubidium technology has even found its way into the companies' range of time and frequency dedicated GPS receivers. Traditionally, GPS receiver stability is dictated in the short term by the quality of crystals oscillator fitted in the unit and in the long term by the GPS signal. This means that over long averaging times the GPS system is excellent, but falls down at averaging time of between 1s and 100s, where stabilities are of the order of 1E-10. This can be improved dramatically by the implementation of temperature controlled Rubidium as the local frequency source, to which the GPS signal locks. This does not affect the receiver long-term stability, but enables the GPS to provide both excellent short and long-term stability. When an HSRO is put into the A8-Rb, stabilities, σ (2,τ), of 4E-13 at τ = 100s are achieved, whilst over 100,000 seconds stability is still parts in E-13. Long term average offset with reference to GPS is held to below 5E-14, only an 10 times poorer than a hydrogen maser This is essential f they are to be used as calibration devices in laboratories or in telecom network synchronisation.