A10-M

Rubidium Time & Frequency Standard

USER'S HANDBOOK

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1 Safety Considerations

1.1 General

This product and related documentation must be reviewed for familiarisation before operation. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired.

1.1.1 Before Applying Power

Verify that the product is set to match the available line voltage and the correct fuse is installed.

1.1.2 Before Cleaning

Disconnect the product from operating power before cleaning.

WARNING

Bodily injury or death may result from failure to heed a warning. Do not proceed beyond a warning until the indicated conditions are fully understood and met.

CAUTION

Damage to equipment, or incorrect measurement data, may result from failure to heed a caution. Do not proceed beyond a caution until the indicated conditions are fully understood and met.

1.1.3 This equipment must be earthed

An uninterruptible safety earth ground must be maintained from the mains power source to the product's ground circuitry.

WARNING

When measuring power line signals, be extremely careful and use a step down isolation transformer whose output is compatible with the input measurement capabilities of this product. The product's front and rear panels are typically at earth ground. Thus, never try to measure AC power line signals without an isolation transformer.

WARNING

Instructions for adjustments when covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform such adjustments or servicing unless qualified to do so.

WARNING

Any interruption of the protective grounding conductor (inside or outside the instrument) or disconnecting of the protective earth terminal will cause a potential shock hazard that could result in personal injury. Grounding one conductor of a two conductor out-let is not sufficient protection.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If the instrument is to be energised via an autotransformer (for voltage reduction) make sure the common terminal is connected to the earthed pole terminal (neutral) of the power source.

Instructions for adjustments while the covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform such adjustments or servicing unless qualified to do so.

For continued protections against fire, replace the line fuse(s) with fuses of the same current rating and type (for example, normal blow time delay). Do not use repaired fuses of short-circuited fuse holders.

1.2 Voltage, Frequency and Power Characteristics

Voltage 220-240V AC

Frequency 40-50Hz

Power characteristics 500mA Max

1.3 Environmental Conditions

1.3.1 Temperature

Operating (ambient)	-10°C to +55°C (-65 to +65 op)
Storage	-40°C to +85°C

1.3.2 Magnetic Field

Sensitivity	$\leq 2x10^{-11}$/ Gauss
Atmospheric Pressure	-60m to 4000m
	$<1x10^{-13}$/ mbar

1.4 Replaceable Fusing Characteristics

800mA time-lag HBC

1.5 Cleaning Instructions

To ensure long and trouble operation, keep the unit free from dust and use care with liquids around the unit.

Be careful not to spill liquids onto the unit. If the unit does get wet, turn the power off immediately and let the unit dry completely before turning it on again.

Clean with a damp (with water) cloth.

Never spray cleaner directly onto the unit or let liquid run into any part of it. Never use harsh or caustic products to clean the unit.

2 Rubidium Frequency Standard A10-M

2.1 Rubidium Frequency Standards

A Rubidium frequency standard owes its outstanding accuracy and superb stability to a unique frequency control mechanism. The resonant transition frequency of the Rb 87 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 Rubidium 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 Rb 87 is one). Unlike much of the research done into frequency standards at that time, practical realization 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 Rb 87 atom.

There are several reasons why Rubidium has an important role to play as a frequency standard. Perhaps most importantly is its accuracy and stability.

Accuracy is comparable with that of the standard Caesium with an operating life approximately 5 times that of Caesium. Moreover the stability of a Rubidium frequency standard over short time-scales -100s of seconds-betters that of Caesium (Caesium is more stable over longer time periods, in the regions of hours to years).

There are, however, a few drawbacks to the use of Rubidium as a frequency standard. In the past, these included the limited life of the Rubidium lamp (since improved to >10 years), The Caesium is affected to a greater degree than this, whilst the Hydrogen Maser operates differently and is not affected. The thermal stability of Rubidium is inferior to that of Caesium or Hydrogen Masers, and the Rubidium previously required frequency access to a primary reference signal or synchronization source to maintain long-term Caesium level accuracy.

The cost of a Rubidium frequency standard is significantly cheaper than a Caesium, with a much reduced size and weight. Due to its small size, low weight and environmental tolerance the Rubidium frequency standard is ideal for mobile applications. Indeed, Rubidium atomic clocks are beginning to be implemented into the new generation of GPS satellites. This is in part due to the extended life of the Rubidium physics package compared to that of Caesium. The Rubidium is also extremely quick to reach operational performance, within 10 minutes reaching 5 parts in 10.

3 Operating Procedure

3.1 Introduction

The basic A10-M unit contains two principal internal units:

1) The Rubidium Atomic Frequency Standard
2) The Associated power supply.

Additionally a small indicator board is fitted to the front panel to monitor performance of the Rubidium.

Other options may also be fitted to suit customer requirement, for example:

a) Sine-TTL conversion board
b) Universal Output Board
c) 2048kHz generator board
d) A5-12 (10 output) or A5-4 (4 output)

3.2 Getting Started

Check that the AC mains voltage selector is appropriate to the supply voltage being used. (This is normally set to 240V on leaving the Company).

Connect the mains supply to the unit (at the rear) and switch on.

The 'AC', 'DC unreg' and 'DC reg' indicator LEDs' will come on immediately the power is switched on, and they will remain on.

During the first 10 to 20 minutes, the VCO PLL, Bit, and Rb indicator LED's will flicker until the unit has stabilised and then will remain on indicating that the internal frequency control loops are locked.

The 10 MHz (or option) is available from the appropriately labelled BNC socket(s) at the rear of the unit.

The units' warm time is approximately 20 minutes. Frequency stabilization time is up to 45 minutes depending on the detailed specification of the particular Rubidium fitted.

All outputs are fed to the rear mounted BNC sockets, which are appropriately labelled.

In addition to the 10 MHz (or other) outputs, there are two BNC sockets, labelled 'GPS SYNC/LOCK' and 'lock', on the rear panel. These are for use with GPS (Navstar) systems where further accuracy enhancement is desired. Quartzlock are able to supply such instruments in 1u high units. Specifications are available upon request.

As an alternative to the mains supply, an external 24V supply (@ 2.5 A) may be used. Connection is made via the rear-mounted XLR socket if the BBU is fitted. This external power supply and the internal mains supply are isolated from each other to prevent mutual damage. If this external supply is set so that no current is drawn when the unit is driven from the mains, an effective uninterruptible power supply to the rubidium is achieved.

4 Specification

1. No of outputs:

a.	10MHz	1, 2, 4 or 10 (Option dependant)
b.	Lock	1 (Option)

2. No of inputs:

a.	GPS SYNC/LOCK	1 (Option)

3. Input Characteristics:

a.	Level:	From GPS (Navstar) System. (Option)

4. Output Characteristics:

a.	Impedance:	50 Ω nominal
b.	Level:	+8 dBm ±2 dBm into 50 Ω
c.	Output SWR:	<1.2:1

5. Short Term Stability:

a.	1s	3x10-11
b.	10s	1x10-11
c.	100s	2x10-12
d.	1 day	1x10-11

6. Aging

a.	1 month	4x10-11
b.	1 year	5x10-10

7. Phase Noise

a.	1Hz	-
b.	10Hz	100dBc
c.	100Hz	130dBc
d.	1kHz	140dBc
e.	10kHz	145dBc

8. Harmonics:

a.	Second harmonic	< -40dBc

9. Spurious Outputs:

< -80 dBc