E10-GPS

GPS Disciplined

Rubidium Frequency Reference

USER'S HANDBOOK

Quartzlock UK Ltd
Gothic, Plymouth Road, Totnes, Devon TQ9 5LH, England.

Tel:	+44 (0) 1803 862062	Fax:	+44 (0) 1803 867962
Web:	www.quartzlock.com	E-mail:	sales@quartzlock.com

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Contents

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 charger 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.

1.2 Voltage, Frequency and Power Characteristics

1.2.1 Universal Full Range AC Input Power Adaptor

Class II power (no earth)

Overvoltage, short circuit & over temperature protection

GS, UL/cUL & CE approval

Voltage 100 - 240V AC

Frequency 50 - 60Hz

Power characteristics 600mA Max

Output Voltage 15V DC 1.2A

1.2.2 Unit Power Requirements

Input Voltage 12Vdc – 18Vdc

Input Current 1.7A max

1.3 Environmental Conditions

1.3.1 Temperature

Operating (ambient)	-20°C to +50°C
Charging	0°C to +45°C
Storage	-20°C to +40°C

1.3.2 Magnetic Field

Sensitivity	$\leq 2 \times 10^{-11}$/ Gauss
Atmospheric Pressure	-60m to 4000m
	$<1 \times 10^{-13}$/ mbar

1.4 Cleaning Instructions

To ensure long and trouble free 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.

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 Reference

2.1 Rubidium Frequency Reference

A Rubidium frequency reference 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 reference 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 references 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 reference.

The Rubidium frequency reference, 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 reference 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 reference 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 reference. Perhaps more important 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 reference 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 reference. 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 reference 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 reference 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^{-11}.

3 Operating Procedure

3.1 Introduction

The basic E10-GPS unit contains three principal internal units:

1) The Rubidium Atomic Frequency Standard.
2) The Internal GPS Chipset.
3) The Associated External Power Supply.

3.2 Getting Started

Check that the appropriate supply voltage is being used. Connect the external supply to the unit (at the rear) and switch on.

Switch on the unit via the front panel switch, the 'ON' indicator LED will come on and it will remain on.

The 10 MHz output is available from the SMA socket on the unit.

The units' warm time is approximately 7 minutes. Frequency stabilization time is up to 15 minutes depending on the detailed specification of the particular Rubidium fitted.

4 Specification

1. Accuracy

Disciplined to GPS or to EXT. 1PPS

a. Frequency ≤1E-12 (after disciplined for one day, 24 hours average, 25℃)

b. Time ±100ns (relative to GPS or Ext. input, 25℃)

2. Holdover

a. (no GPS) Frequency ≤5E-12/day

b. Time ≤1μs/24 hours

3. Short Term Stability

a. ≤3E-11@1s

b. ≤1E-11@10s

c. ≤3E-12@100s

4. Phase Noise

a. ＜-100dBc@10Hz

b. ＜-130dBc@100Hz

c. ＜-140dBc@1kHz

5. Harmonics

a. ＜-40dBc

6. Spurious

a. ＜-80dBc

7. Temperature Coefficient

a. ±3E-10 over -20℃～+50℃

8. Time to Lock (@25℃)

a. ＜7 min

9. Earth Magnetic Field Sensitivity

a. ≤2E-11

10. Retrace

a. ≤2E-11

11. Output & Input

a. Output 1×10MHz Sine wave (7～13)dBm/50Ω SMA
b. 1×1PPS TTL/50Ω SMA
c. PC channel (RS232) for Time & Locality & Other Data and Frequency Control
d. Input GPS Antenna/50Ω SMA
e. Ext. 1PPS/50Ω BNC
f. Mode of operations
    a. Disciplined to GPS
    b. Disciplined to external 1PPS
    c. Auto Select: first priority to external 1PPS and second to internal GPS receiver.

12. Remote Setting

a. Via Serial Port Software for PC Export UTC time.
b. Export the location of the local place, including longitude, latitude and length.
c. Export the model of the Atomic Oscillator.
d. Export the version number of the software.
e. Adjust the accuracy of 10MHz.

13. Power Supply

a. Input Voltage 12VDC
b. Power Dissipation (25℃) 22W@ Warm-up, 9W@ Steady

14. Dimensions & weight

a. Dimensions $\leq 127^{\pm 0.5} \times 94^{\pm 0.5} \times 38^{\pm 0.5}$
b. Weight <0.6kg

15. Environment

a. Operating Temperature -40℃～+60℃
b. Storage Temperature -40℃～+70℃
c. Humidity ≤90%

16. MTBF

≥100000h

17. Universal Power Adaptor

a. Class II power (no earth)
b. Protection Over voltage, short circuit & over temperature

c. Approvals GS, UL/cUL & CE
d. Voltage 100 to 240V AC
e. Frequency 50 to 60Hz
f. Power characteristics 600mA Max
g. Output Voltage 15V DC 1.7A

18. Warm Time

@ 25°C 5 Minutes to lock

19. Retrace

$\leq \pm 2 \times 10^{-11}$

20. Magnetic Field Sensitivity

$< \pm 2 \times 10^{-11}$

21. Mechanical

a. Size 103 x 55 x 122 mm
b. Weight 500g

22. Warranty

24 months

23. Temperature

a. Operating -20°C to +50°C
b. Storage -20°C to +40°C

24. Temperature Coefficient

a. Ambient 2×10^{-10}

25. MTBF

100,000 hours

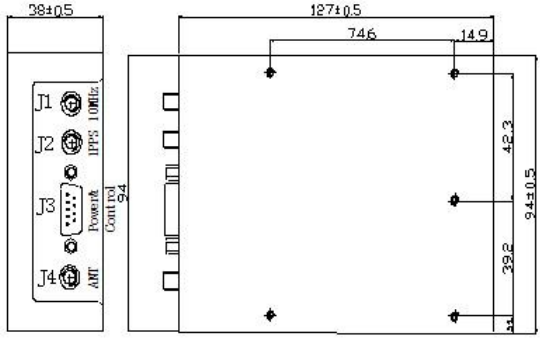
26. Environmental

RoHS

27. EMI

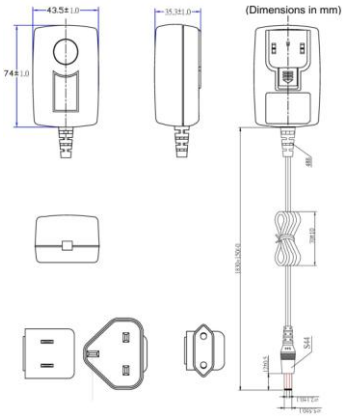
a. Compliant to FCC Part 15 Class B

5 Unit Outline



6 Accessories

6.1 Plug Top Supply



7 Appendix – Connector, Jumper and Link References

J1

(SMA) 10MHz Output

J2

(SMA) 1PPS Output

J3

Pin 1 – +12Vdc
Pin 2 – Ground
Pin 3 – Lock Signal
Pin 4 – 1PPS External Input
Pin 5 – Ground
Pin 6 – RS232 TX
Pin 7 – Lock Tag
Pin 8 – 1PPS Out GPS
Pin 9 – RS232 RX

J4

(SMA) GPS Antenna