



orolia RBSOURCE-1600-DUAL High-Performance Rubidium Reference Dual Source User Manual

[Home](#) » [orolia](#) » orolia RBSOURCE-1600-DUAL High-Performance Rubidium Reference Dual Source User Manual 

Contents

- 1 orolia RBSOURCE-1600-DUAL High-Performance Rubidium Reference Dual Source
- 2 Introduction
- 3 Revision list
- 4 Definitions
- 5 Getting Started
- 6 Installation Procedure
 - 6.1 Software Monitoring
- 7 System Operations
- 8 System Description
- 9 System Communication
- 10 System I/O Interfaces
- 11 Lock indicator
- 12 GLOSSARY
- 13 Documents / Resources
- 14 Related Posts



orolia RBSOURCE-1600-DUAL High-Performance Rubidium Reference Dual Source



Introduction

- The RbSource-1600-dual has been specifically designed for telecom infrastructure, requiring extremely stable and precise timing or frequency source and low phase noise.
- The RbSource-1600-dual integrates two smart GPS-disciplinable SRO-5680 Rubidium clocks and distributes multiple output signals, either phase or frequency aligned depending on the operating modes.

Revision list

Software Revision :			Hardware Revision :
Date	Version	Comment	
11 Jun 2002	1.01	Internal Correction	
09 Jul 2002	1.02	Now commands PW and TC store data in EEPROM	
23 Jul 2002	1.03	Internal Correction	
19 sep 2002	1.04	New command "MCsdd" for interfacing with GPS receiver	
27 Sep 2002	1.05	Internal Correction	
07 Feb 2003	1.06	New command DT, Date. New command COsddd, time comparator offset	
11 Mar 2003			New low power version <17 W
19 Aug 2003	1.07	Improved behavior at the start of tracking. Frequency save (FSx) improved. Command MCsdd extended. New commands VS, view PPSRef stability, VT, view time constant. Internal corrections	
23 Sep 2003	1.08	New command RAsddd. Internal corrections.	
25 Feb 2004	1.09	Back to simple start of tracking. GPS messages for Jupiter-Pico, SuperStar II. NMEA messages.	
05 Sep 2007	1.095	Other initial settings	
01 Apr 2014	1.096	<ul style="list-style-type: none"> – The display of a missing PPSREF in the answer of beating commands: BT1, BT3, BTA, is now "?????? ?". (Was "9999999" before.) – Command DE???????, the answer can be "???? ???" – Command FC: possible cancel of the writing in eeprom – Beating command BTB: the 3rd frequency (aaaa) is now the frequency stored in eeprom – Correction of minor software issues reported since version 1.095 	
7 Sep 2016	1.097	<ul style="list-style-type: none"> – New command.GFdyyyy: Set and activate the go fast mode during the beginning of tracking. – Correction of minor software issues reported since version 1.096 	

Definitions

This is a list of words and related definitions used in this manual to help the user understand the content:

Words Definitions

- RbSource-1600-dual Unit or product
- Unit RbSource-1600-dual
- System RbSource-1600-dual and its integrated modules
- Rb Rubidium
- Rubidium clock Refers to the smart SRO-5680 model
- Rubidium Rubidium clock
- SRO Rubidium clock, model SRO-100 or SRO-5680
- Track mode Frequency alignment between a reference and an output signal, regardless of the relative phase position of the two signals. Also known as “syntonization”
- Sync mode Phase alignment between a reference and an output signal. Also know as synchronization”
- Free-run mode Rubidium clock not locked to any reference, including GPS
- Holdover mode Rubidium clock that was previously locked to a GPS reference but lost it or is no longer present

Getting Started

Unpacking

Unpack and carefully inspect the unit. Check for physical damage. If physical damage is observed, please immediately contact us.

Unit Supplies

- 1x RbSource-1600-dual unit
- 2x Cables SUB-D male/female for PC serial COM
- 2x Power cable
- 2x 19” rack mountable ears or tabletop feet
- 1x Operating Manual + Specifications

Safety

Use proper ESD precautions Ensure that all cables are properly connected

- The equipment contains small quantities of rubidium metal hermetically sealed inside the glass lamp and cell assemblies, hence, any dangers arising from ionizing radiation are caused for human health (exemption set in article 3 to Council directive 96/29/Euratom).
- For further information, ask for the «rubidium product data sheet».
- Handling the product in reasonably foreseeable conditions does not cause any risk to human health, exposure to the SVHC (substances of very high concern) would require grinding the component up.

Environmental Responsibility

- The equipment contains materials, which can be either re-used or recycled.
- Do not deposit the equipment as unsorted municipal waste. Leave it at an authorized local WEEE collection point or return to Orolia Switzerland SA to ensure proper disposal.

- To return the appliance, begin with a support ticket

Navigate to <https://www.rolia.com/support/> and choose option 2, “I’d like to log a Support Ticket”. Complete and submit the You will be contacted with instructions to return the product as soon as possible

Installation Procedure

Connections



1. Connect power 100-240V 50-60Hz to J5 & J6 or at least one J5 or J6 (redundant power modules)
2. Connect a COM cable between J2 (or J4) and one COM available on your computer for RS232 commands and monitoring (if required).
3. Switch On the system S1 or S2 or booth

Software Monitoring

iSyncMgr Application

RbSource-1600-dual operates independently. However, the smart integrated rubidium clock can be monitored through the iSyncMgr application. The latest version can be downloaded from <https://www.rolia.com/support-documents/>. To start the application, please follow the procedure below:

- Start the application with Internet Explorer. By default, the serial port is COM1. If a warning window pops up before the application iSyncMgr starts, the COM1 is not free and another port has to be selected. How? Go to the “Serial Port \ PortNo” menu, then select another available port.
- Once the serial port number is properly working, click on the “Refresh” button. The Identification, Serial Number, and Status of the smart SRO rubidium clock inside the RbSource-1600-dual should be displayed as



Notes

- iSyncMgr gives full monitoring access to the smart SRO rubidium clock
- Changes through these commands should be avoided: TCdddddd or MCsxx...

Monitoring Through RS232 Terminal Communication Interface

The user can also use a serial communication RS232 to monitor the parameters of the SRO rubidium clock or to send specific commands. For example, hyper terminal communication can be used as follows:

RS232 protocol is:

- 9600 bits/s
- 8 data bits
- No parity
- 1 stop bit
- No handshake

Notes:

1. See the RS-232 Application Note at <https://www.oriala.com/support-documents/> for different configurations (tip: keyword search “RS-232”)
2. See chapter 5 for the list of commands

System Operations

Operating Modes

The RbSource-1600-dual integrates a smart SRO rubidium clock and a GPS receiver. It provides 4 basic modes of operation as follows:

1. **Free Run:** When the Rubidium clock is not locked to a GPS reference and, thus, is free running
2. **Track:** When the GPS reference is used to perform frequency alignment applications. It uses the PPS_GPS as a reference (PPSREF) to align the frequency of the Rubidium clock, but the phase is not aligned.
3. **Sync:** When the GPS reference is used to perform phase alignment applications. The PPSOUT of the RbSource-1600-dual is aligned in phase with the GPS PPSREF input through the internal PPSINT reference signal, which uses the SmarTiming+™ algorithm to 1) compare the PPSOUT against the PPSREF signal at 1ns resolution within a +/-500ns dynamic range and 2) auto-adaptively align them.
4. **Holdover:** When the GPS signal is not present (NO PPSREF). The last averaged frequency value is used for performance enhancement by the SmarTiming+™ algorithm

Note a) See Chapter 4.4.1 for a more detailed description

Operating Mode Setup

The user can set up the operating mode in 2 ways:

- Hardware: There is no hardware selector available on the RbClock-1600-dual
- Software: Select desired operation mode through the iSyncMgr application or send RS-232 commands.

Note a) See Chapter 5 for a list of supported RS-232 commands

Alarm Indicators Description

(only Rb Lock alarm & power LED are connected on RbSource-1600-dual)

Operation modes	LED status				Switch 2 positions			Troubleshooting Actions
	Power	Sync /Track	Rb Lock (red)	GPS Mark	free run	Sync	Track	
Free Run	—	—	—	—	—	—	—	Check power supply
	√	—	√	—	√	—	—	Wait for 15 minutes, if I5 is still red then send back the RbSource-1600-dual to factory
	√	—	—	—	√	—	—	Bad installation of GPS antenna
	√	—	—	Blinking	√	—	—	Normal free run situation
Track/Sync	√	—	—	√		√	—	Wait 10 minutes, if I4 still not green, maybe a bad configuration, please contact us
	√	—	—	√			√	Wait 10 minutes, if I4 still not green, maybe a bad configuration, please contact us

	√	green	—			√	(√)	Normal Sync/Track situation
Holdover	√	—		—		√		In holdover mode. No GPS signal detected. If the signal comes back, I6 should blink again and I4 will become green. It doesn't mean that the holdover time was too long. In such case, set the Switch S2 in Free-Run and then back in Sync or Track
	√	—		—			√	

System Description

The RbSource-1600-dual unit consists of a GPS receiver disciplined to a smart rubidium clock (model SRO-100).

Principle of Operation

The Rubidium atomic clock essentially consists of a voltage-controlled crystal oscillator (VCXO) which is locked to a highly stable atomic transition in the ground state of the Rb87 isotope. While the VCXO is oscillating at a convenient frequency of 60 MHz, the Rb clock frequency is at 6.834...GHz in the microwave range. The link between the two frequencies is done through a phase-stabilized frequency multiplication scheme whereby a synthesized frequency is admixed to enable exact matching.

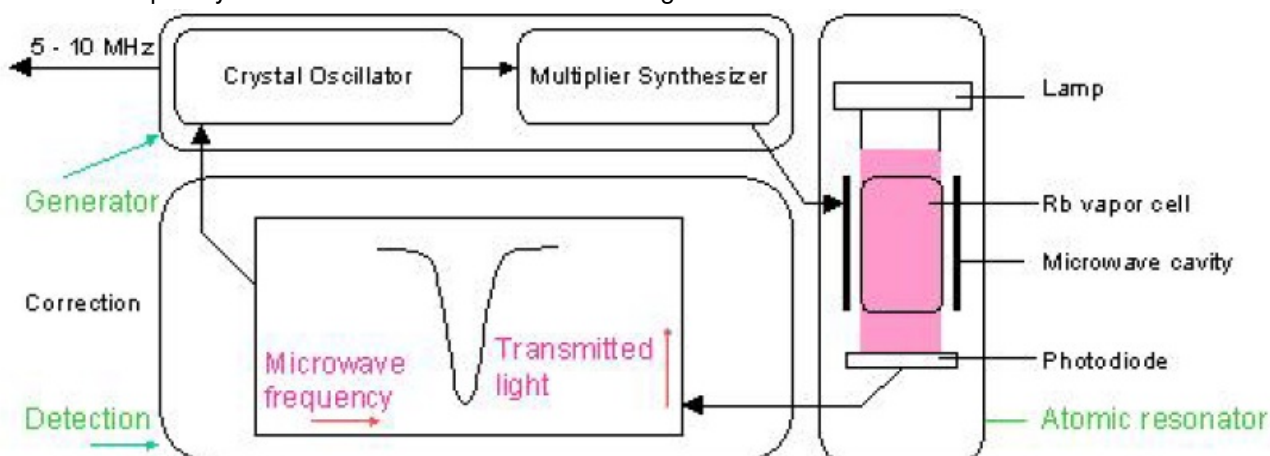


Figure 2 - Rubidium atomic clock block diagram.

Physics Package

The main design characteristics of the physics package are its low power consumption, small size, and mass,

along with minimal environmental sensitivities and mechanical ruggedness.

Other design features contributing to the compact design are:

- Use of the integrated filter technique (IFT)
- Use of a magnetron-type microwave resonator

The integrated filter technique combining the optical filtering and pumping in one cell contributes also to the reliability, the configuration is simplified and the number of components is reduced. The thermal capacitance of the cell assembly is relatively low. Thus, the necessary power during warm-up is greatly reduced. The magnetron resonator is a cylindrical cavity loaded with a concentric capacitive-inductive structure (annular metal electrodes). It allows smaller cavity dimensions and concentrates the microwave field in the right region of the cell. The Rb lamp is an electrode-less RF-discharge lamp, a heated glass bulb, containing Rb and a starter gas surrounded by an RF coil.

Electronics Package

- The clock transition of a Rubidium (Rb) resonator is a microwave transition at 6.834 GHz.
- The microwave resonance occurs as a dip in the optical signal – i.e. in the Rb lamp light which, after transiting the cell, is detected by a photodiode.
- The basic purpose of the electronics package is to synchronize the entering microwave frequency, derived from a quartz crystal oscillator, to this absorption dip. This is achieved by tuning the microwave frequency to maximum optical absorption.
- The clock microwave frequency of the Rb atoms in the vapor cell has a nominal value of 6834.684 MHz. This frequency is generated from a voltage-controlled quartz oscillator (VCXO) oscillating at 60 MHz.
- A serial interface connection, monitoring and tuning the internal parameters and the PPS facilities, is provided to the user.
- The correct operation of the unit can be checked by an output signal called “lock monitor”. This lock monitor information is generated by the micro-controller and is a function of the following parameters:
 - Light level intensity
 - Rb signal level (detected signal)
 - Heaters supply voltages
- The different alarm threshold levels, corresponding to the different internal electronics and physics parameters, are programmed during the automatic adjustment procedure at the factory.

Timing & Tracking System

The reference module includes an extended PPS (Pulse Per Second) facility. The hardware of the PPS facility consists of two modules as follows:

- The first module is a timer clocked at 7.5 MHz. This timer tags the PPSREF connected to the GPS receiver and generates two other PPS. The first one is called PPSINT and is used internally. The second one is called PPSOUT and appears on the back and faceplate.
- The second module is a phase comparator with 1ns resolution and 1μs range. This module compares the phase between PPSREF and PPSINT. The phase information is used for the perfect tracking of a low noise PPSREF and for computing the noise of this PPSREF.
- The computation is used to adjust the time constant of the tracking loop. This way, the GPS antenna can be

directly connected to the system without hardware and software adjustments

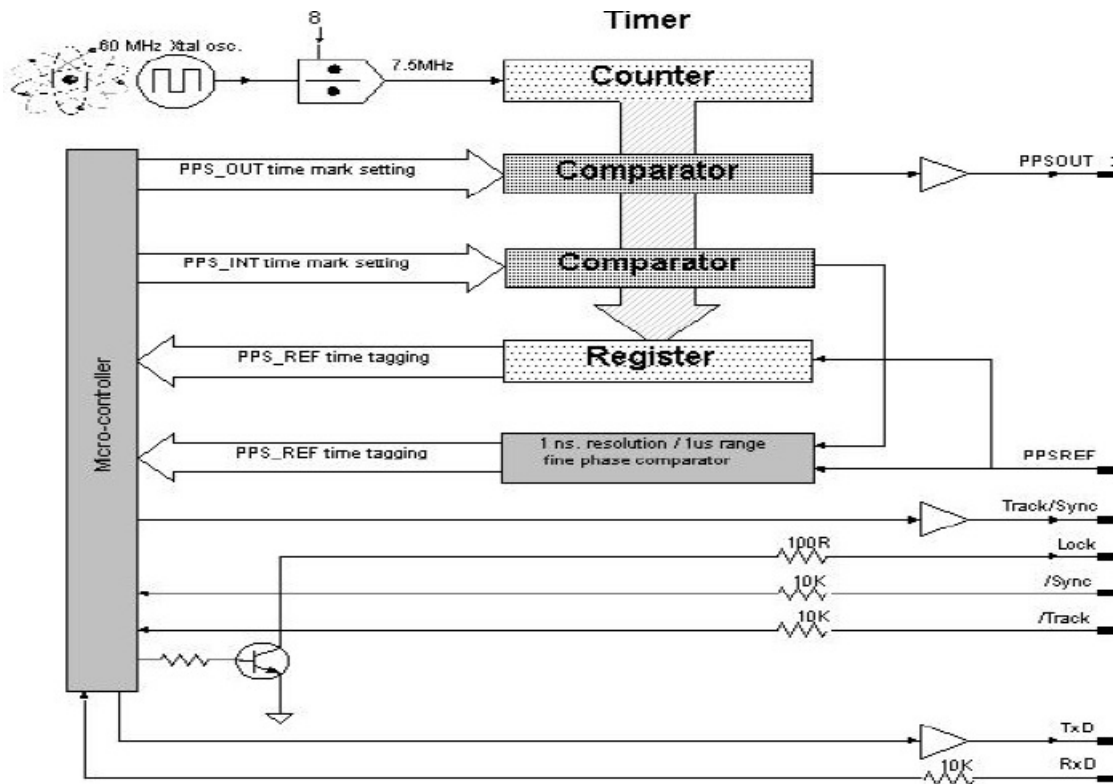


Figure 3 - Timing System

Free Run, Track & Sync Modes

The reference module has 3 basic modes of operation:

- Free Run
- Track
- Sync

When the first mode, Free Run, is set up, the Rubidium clock is not locked to a reference. When the second mode, Track, is set up, the PPSINT is aligned to the PPSREF within 133ns. Then the phase comparator starts its mid-term frequency stability analysis of the PPSREF. The tracking loop time constant is auto-adaptively adjusted accordingly, and the unit starts to track the PPSREF. During this process, the position of the PPSOUT is not changed. The PPSREF timer works in an independent way. Thus the PPSOUT will not suddenly jump when the module starts to track a PPSREF.

When the third mode, Sync, is set up, the PPSOUT is aligned to PPSINT. The Sync mode can only be set up when the unit is already successfully tracking a PPSREF. If the Sync mode is set up just after the unit starts to track a PPSREF, the phase-time difference between PPSOUT and PPSREF can be as big as 133ns. However, the tracking loop will reduce this difference and will bring it nearly to zero if the noise of the PPSREF is low.

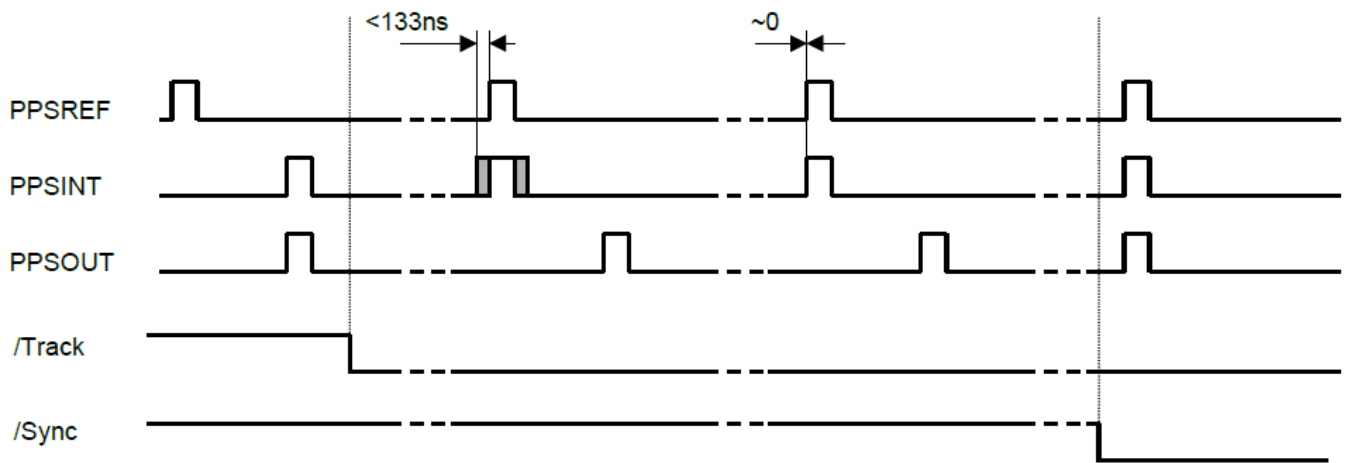


Figure 6 – Track vs. Sync Mode

The Frequency Learning

When the unit is tracking the PPSREF of a GPS, it aligns to the frequency of the GPS. The learning process is simply the memorization of the GPS frequency from time to time to use it after a reset or Power-On. By default, when the unit is continuously and successfully tracking a PPSREF, the average value of the frequency is saved in EEPROM every 24 hours. Through the command FSx<CR>, a user can cancel the learning process or immediately save the average value of the frequency.

The Frequency in Use

With the PPSREF facility, a different frequency can be in use in different situations. Let's assume that the frequency currently in use is located in a single register, and that this register can be read by a user. The command to read this register is: FC+99999<CR>. Through the serial interface, a user can follow the evolution of the tracking through the instructions given below.

The frequency or frequency correction in use in different situations is the following:

- After a Reset or Power-On, the frequency correction is copied from the EEPROM to the RAM and then is used
- After the start of tracking, the internal frequency correction is the one of the EEPROM
- During tracking, the frequency correction in use changes continuously to align as close as possible the PPSINT to the PPSREF. By default, the average value is saved in EEPROM every 24 hours
- If the unit is stopped in its tracking, and put in FREE RUN mode by a user, with the command TR0 for example, the frequency correction in EEPROM is retrieved and loaded in RAM to be used
- If the tracking is stopped because the PPSREF signal disappears suddenly or is strongly degraded, the integral part value of the regulation loop becomes active. This is to avoid a frequency jump in case the PPSREF signal comes back again. This mode of operation is called holdover.

User Frequency Correction

This correction is only possible in Free Run mode and is performed with the command FCsxxxxx. The command has 2 effects as follows:

- Memorization of the asked frequency in EEPROM
- Immediate use of the new frequency

The PPS Tracking Loop

Note: PPSREF is not connected on RbSource-1600-dual.

The unit is equipped with a numerical PI regulation loop to track the PPSREF. The time constant of the tracking loop is either set automatically or forced by a user with the command TCxxxxxx.

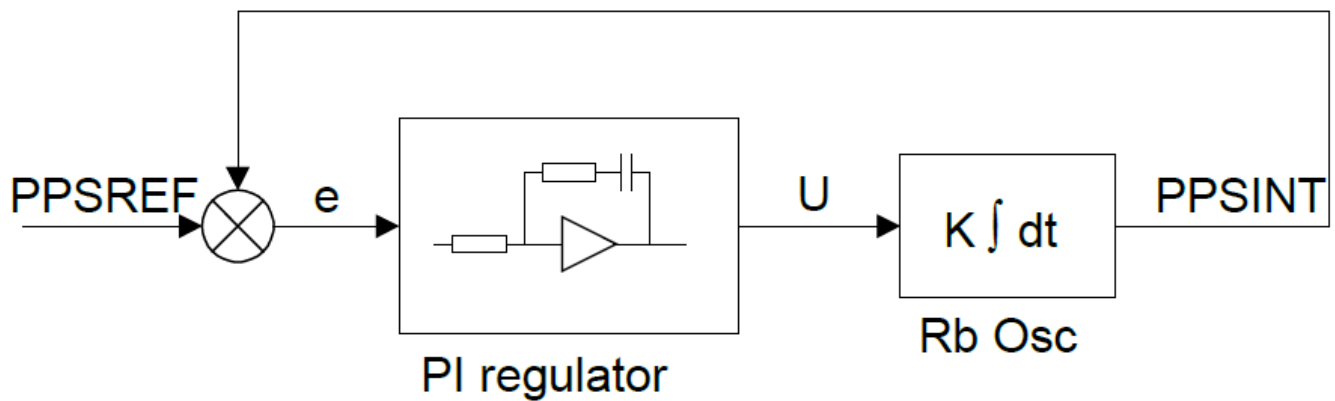


Figure 5 - Schematic of the PPSREF Regulation Loop

By default, the optimum loop time constant is computed by the unit from information such as the PPSREF noise and temperature fluctuations. In this case, if the fine phase comparator cannot give valid information, the time constant is forced to 1000s. But the loop time constant can also be forced by a user to a fixed value. In this case, the time constant is the one manually set by a user. The command to do this is TCxxxxx<CR>.

Tracking Limits & Alarms

If the frequency between the unit and a GPS to track is too large after a while, the phase time error between PPSINT and PPSREF can become too large for some applications. Thus there are two limits as follows:

If the phase time error becomes bigger than the first limit, an alarm is issued, but the tracking continues. This first limit is called the “no alarm” window. If the phase time error becomes bigger than the second limit, then the tracking stops. This second limit is called the “tracking” window. The half value of the “no alarm” window can be changed by a user with the command AWxxx. By default, its value is set to 015 counter steps or $\sim \pm 2\mu\text{s}$. The half value of the “tracking” window can also be changed by a user with the command TWxxx. By default, its value is set to 015 counter steps or $\sim \pm 2\mu\text{s}$. For more details, see chapter “TIMING AND TRACKING COMMANDS”.

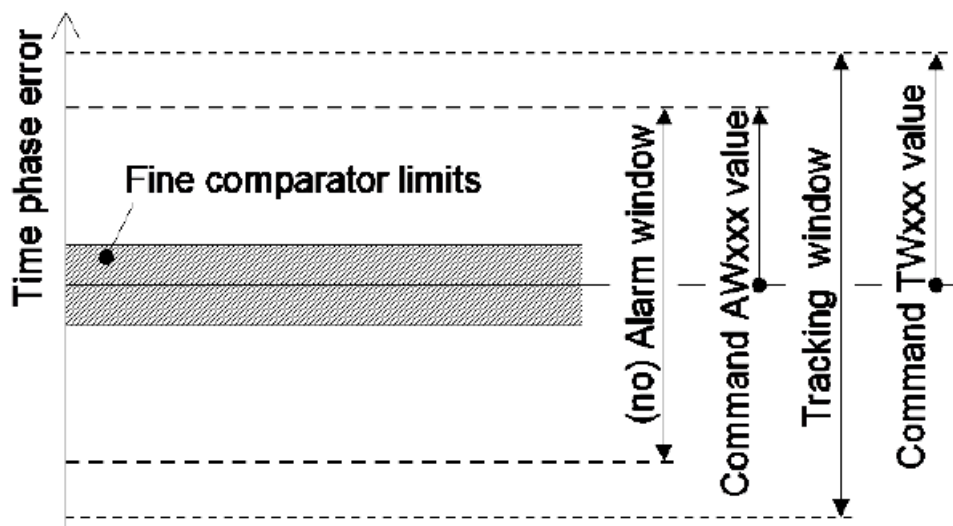


Figure 6 - Tracking Limits

Frequency Fluctuations while Tracking

To track a PPSREF the unit has to change its frequency. The allowed frequency variations are limited by the factory to $\pm 1\text{E-}8$. This means the variations of the register DDSUSER are limited to ± 19531 during tracking or in Hexa to $\pm \$4\text{C4B}$. However, this value can be changed by factory setting to any other value upon request. The limitations are simply the limits of the signed integer DDSUSER. In other words, $+32767$ to -32768 or $\pm 1.6\cdot\text{E-}8$ in relative frequency. If during the tracking of a PPSREF, the unit reaches the frequency limit, its frequency will be limited to the frequency limit and no error will be issued as long the phase time error is staying in the “no alarm” window. If the unit is connected to a terminal through the serial port, a user can read the actual frequency

limitation in use by typing R14<CR>, R15<CR>. The returned values are the MSB and the LSB of a signed integer coded on 2 bytes, representing the allowed frequency variations in 5.12E-13 steps. A user can also check if the DDSUSER is actually limited by typing R4F<CR>. If there is an issue, bit 1 and bit 2 of the register will not be set to 0.

Fine Phase Comparator Offset

This fine offset adjustment can be used in the case of precise phase calibration. The range of the offset is +127/ – 128 steps of the fine phase comparator. Since the fine comparator is analog, a step corresponds to approx. 1ns. The command to set the offset is COsddd <CR>

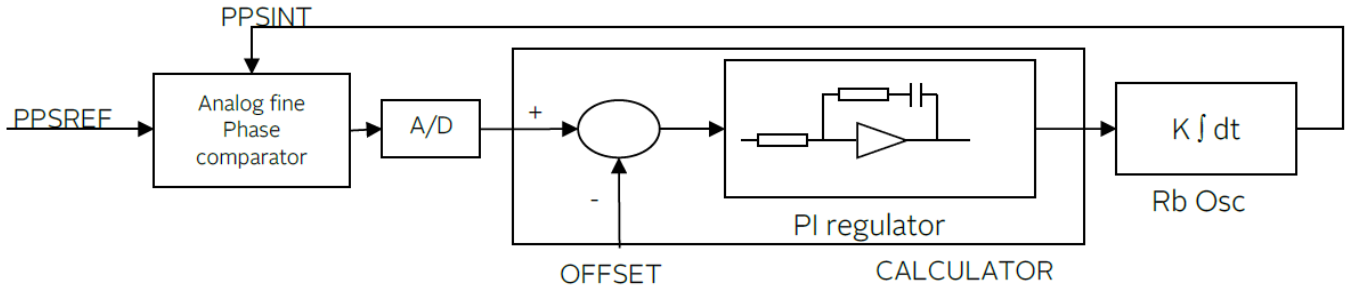


Figure 7 - Schematic of the Analog Fine Phase Comparator Regulation Loop

System Communication

Users can monitor the internal parameters such as identification, status, and parameters by sending a command followed by a carriage return character through the serial interface

Identification

ID<CR>[<LF>] : Identification

- Answer: TNTSRO-aaa/rr/s.ss<CR><LF> 100 if SRO-100, 075 if SRO-75 as Rb clock revision number : software version
 - Example: ID<CR>, answer: TNTSRO-100/01/1.00<CR><LF> SN<CR>[<LF>] : Serial number
- Answer: xxxxxx<CR><LF> xxxxxx: 6 digits serial number of integrated SRO-100 in RbSource-1600-dual
 - Example: SN<CR>, answer: 000098<CR><LF>

General status of Rb clock module

ST<CR>[<LF>] : General Status

Answer: s<CR><LF>

1. status
2. warming up
3. tracking set-up
4. track to PPSREF
5. sync to PPSREF
6. Free Run. Track OFF
7. Free Run .PSREF unstable
8. Free Run. No PPSREF
9. factory used
10. factory used

11. Fault or Rubidium out off lock

Example: ST<CR>, answer: 4<CR><LF> (Free Run. No tracking)

The module can send through the serial port once per second or upon request its general internal status. The meaning of this status is:

1. Warming up. This happens when the system is just powered on and the temperature of the cells is not high enough.
2. Tracking set-up: The system is in this state when it goes from free-run status to the tracking status after a track set-up. The duration of this state should not exceed 3 minutes.
3. Track to PPSREF. PPSINT is aligned to PPSREF.
4. Sync to PPSREF. PPSINT and PPSOUT are aligned to PPSREF.
5. Free Run. Track off.
6. Free Run / Holdover. PPSREF unstable. The stability of the PPSREF is too low to be tracked.
7. Free Run / Holdover. No PPSREF was detected.
8. Factory used.
9. Factory used.
10. Fault or Rb Out Of Lock. This happens when the VCXO is scanning to find the Rb line.

• **Monitoring of internal parameters**

The internal parameters monitoring is made via the serial interface and with the use of the single command "M" followed by a carriage return character. M<CR>[<LF>] The module will respond to this single character command with an eight ASCII / HEX coded string, such as HH GG FF EE DD CC BB AA <CR><LF> Where each returned byte is an ASCII-coded hexadecimal value, separated by a <Space> character. All parameters are coded at full scale.

- HH: Read-back of the frequency adjustment voltage (0 to 5V)
- GG: reserved
- FF: peak voltage of Rb-signal (0 to 5V)
- EE: DC-Voltage of the photocell (5V to 0)
- DD: varactor control voltage (0 to 5V)
- CC: Rb-lamp heating current (Imax to 0)
- BB: Rb-cell heating current (Imax to 0)
- AA: reserved

• **DC-Frequency adjustment voltage.**

HH: o/p frequency adj. voltage (0 to 5V for \$00 to \$FF) This parameter corresponds to the frequency adjustment voltage.

• **Reserved GG:**

• **Rb signal level.**

FF: Peak voltage of Rb signal level (0 to 5V for \$00 to \$FF) This signal monitors the rectified value of the AC signal produced by the interrogation process of the Rb dip absorption. During the warm-up time, this signal is approximately 0V, and after it stabilizes to a nominal value of 1 to 5V. As long as this signal is too low the internal control unit sweeps the Xtal frequency in order to find the Rb absorption dip.

• **DC-Voltage of the photocell.**

EE: DC-Voltage of the photocell (5V to 0 for \$FF to \$00) This signal corresponds to the transmitted Rb light

level. This is the light of the Rb lamp which is partly absorbed by the Rb cell. The nominal photocell voltage is in the range of 2.0 to 3.5 V but must stay stable after the warm-up time. The photocell voltage is related to the internal reference 5 V voltage. The full scale corresponds to the coded value \$00 and the zero (no light) corresponds to the coded value \$FF

- **Frequency adjustment voltage.**

DD: VCXO control voltage (0 to 5V for \$00 to \$FF) This parameter corresponds to the voltage applied to the varicap of the internal VCXO. In normal operation, this voltage is mainly temperature dependent in the range of 2 to 3V in order to compensate for the frequency versus temperature characteristic of the crystal resonator. During warm-up, the control unit generates a ramp of this parameter from 0.3 to 5V and from 5V to 0.3V until the Rb dip absorption is found.

- **Rb lamp heating limiting current.**

CC: Rb lamp heating limiting current (Imax to 0 for \$00 to \$FF) This parameter corresponds to the heating limiting current applied to the lamp heating resistive element. In normal operation, this current depends on the ambient temperature but should stay between \$1A and \$E6. During warm-up, this current is set to its maximal value \$00 (no current limiting).

- **Rb cell heating limiting current.**

BB: Rb cell heating limiting current (Imax to 0 for \$00 to \$FF) This parameter corresponds to the heating limiting current applied to the cell heating resistive element. In normal operation, this current depends on the ambient temperature but should stay between \$1A and \$E6. During warm-up, this current is set to its maximal value \$00 (no current limiting).

- **Reserved AA:**

Center frequency adjustment via serial interface A single character command is available to the user for center frequency adjustment. Cxxx <CR>[<LF>]:

- output frequency correction through the synthesizer, by steps of $5.12 \cdot 10^{-13}$, where XXXX is a signed 16 bits. This value is automatically stored in an EEPROM as the last frequency correction which is applied after RESET or power-ON operation.
- In the track state, the user frequency correction is changed internally by the software for optimum alignment.
- The basic command FCsdddd has the same effect. See chapter 4.7.

Examples:

- C0000<CR> : return to the nominal value (factory setting)
- C7FFF<CR> : the actual frequency is increased of 16.7 ppb. 10'000'000.000 Hz become 10'000'000.167 Hz.
- C8000<CR> : the actual frequency is decreased of 16.7 ppm. 10'000'000.000 Hz become 9'999'999.833 Hz.

Center frequency read-back

- R05<CR>[LF]: read-back high byte of user frequency correction actually in use.
- R06<CR>[LF]: read-back low byte of user frequency correction actually in use.
- L05<CR>[LF]: read-back high byte of user frequency in use after RESET or power-ON.
- L06<CR>[LF]: read-back low byte of user frequency in use after RESET or power-ON.
- In the track state, the value of all of these registers is subject to change by the software for optimum alignment.

SYNTH out frequency setting

- The module integrates a frequency synthesizer.
- There is a command to set the SYNTH output frequency:
- Txxxxxxx<CR>[<LF>]: SYNTH OUT frequency setting. Where xxxxxxxx is an unsigned 32 bits in Hexa coded ASCII stored in EEPROM The SYNTH OUT frequency is changed after RESET or power-ON.

$$Frequency = \frac{xxxxxxx}{2^{32}} \cdot 60MHz$$

TIMING SERIAL INTERFACE

The module uses the same serial interface to set and control the PPS and timing facilities. For this purpose, more complex supervision of the device is introduced.

Commands for setting & control

The commands are not case-sensitive. But they should have the exact length. The termination character is <CR>. An additional <LF> is tolerated and has no effect. Blank characters are not tolerated. Chained commands are tolerated if the total length is not exceeding ~30 characters.

Commands of Timing &Tracking

TRx<CR>[<LF>]: Set tracking mode of PPSINT to PPSREF

- x: tracking mode setting
- 0: Track never, Free Run. (0→EEPROM)

1. Track now.
2. Track ever. (1→EEPROM)
3. The track now + ever (1→EEPROM)
4. Interrogation

Answer: x<CR><LF>

- Tracking enables at power-up
- Not enabling tracking at power-up
- Enabling tracking at power-up

Notes:

- The tracking mode setting is kept in EEPROM.
- Whether from software or from hardware, Track mode 1 has the priority. The answer takes this situation into account.
- The module needs a few minutes to be in a tracking state. During this delay, ST<CR> answers 1.
- The command TRx has no influence on the phase of PPSOUT if the command SY9<CR> answers 0<CR><LF>.
- When track mode is set to 1 by hardware or software, the tracking of PPSINT to PPSEXT starts when General

Status goes from 9 to 4.

- This command doesn't give out the actual tracking state. For that, use the command ST<CR>.(answers 2 <CR><LF> when tracking)

Example: TR3<CR>, answer: 1<CR><LF>. Will ever be in tracking mode. If not yet in this mode, start to track PPSREF. SYx<CR>[<LF>]: Set synchronization PPSOUT to PPSINT mode.

- x: synchronization mode setting
- 0: synchronize never (0->EEPROM)
- 1: synchronize now
- 2: synchronize ever (1->EEPROM)
- 3: sync. now + Ever (1->EEPROM)
- 9: interrogation
- Answer: x<CR><LF>
- x: synchronize command status
- 0: synchronization mode 0.
- 1: synchronization mode 1.

Notes:

- The synchronization mode setting is kept in EEPROM.
- Whether from software or from hardware, the synchronization mode 1 state has priority. The answer takes this situation into account.
- When sync. mode is set to 1 by hardware or software, the synchronization of PPSOUT to PPSINT happens when General Status goes from 1 to 2.
- This command doesn't give out the actual sync. state. Therefore, use the command ST<CR>.(answer 3 <CR><LF> when synchronized.)

Example: SY9<CR>, answer: 1<CR><LF>. Sync. done when General Status goes from 1 to 2. DEddddddd<CR>[<LF>] Set the delay of PPSOUT pulse vs PPSINT.

- ddddddd: Delay in 133 ns steps.
- 0000001: minimum delay.
- 7499999: maximum delay. (approx. 1 s)
- 0000000: sync. to PPSINT, the same as SY1.
- 9999999: interrogation.
- Answer: DDD DDD: Delay in 133 ns steps.
- 9999999: Delay information is not valid.
- Reset value: 0000000

Notes:

- When going into the tracking state, the information delay becomes no longer valid and the unit will respond 9999999<CR><LF>.

- In the tracking state, after a command SY1<CR><LF>, PPSOUT is aligned to PPSINT and the answer is 0000000<CR><LF>.
- In the tracking state, after a command DEddddd<CR><LF>, the PPSOUT is delayed vs PPSINT and the answer is correct.

Example: DE9999999<CR>, answer: 0000000<CR><LF>

- PWddddd<CR>[<LF>] : Set the PPSOUT pulse width.
- dddddd: Pulse width in 133ns steps.
- 0000001: minimum pulse.
- 7499999: maximum pulse.
- 0000000: no pulse.
- 9999999: interrogation.

Answer: dddddd: Pulse width in 133 ns steps.

- Factory setting : 0001000 (133 us)
- Reset value : Last Value stored in EEPROM

Example: PW9999999<CR>, answer: 0001000<CR><LF>

Commands of timing Set-up

- TD<CR>[<LF>] : Send out the time of day
- Answer: hh:mm:ss<CR><LF>
- hh: Hours mm: Minutes ss: seconds

Notes:

After reception of this command, the module responds following the rules of the command BTx. This means the answer is not immediate but can be delayed up to 1 s.

Example: TD<CR>, answer: 16:30:48<CR><LF>

- TDhh:mm:ss<CR>[<LF>] : Set the time of day hh:mm:ss<CR><LF>
- hh: Hours mm: Minutes ss: seconds
- Answer: hh:mm:ss<CR><LF>
- hh: Hours mm: Minutes ss: seconds
- Reset value: 00:00:00

Notes:

After reception of this command, the module responds following the rules of the command BTx. This means the answer is not immediate but can be delayed up to 1 s.

Example: TD13:00:00<CR>, answer: 13:00:00<CR><LF>

- DT<CR>[<LF>] : Send out the date
- Answer: yyyy-mm-dd <CR><LF>
- yyyy: Year mm: Month dd: Day

Notes:

After reception of this command, the module responds following the rules of the command BTx. This means the answer is not immediate but can be delayed up to 1 s.

Example: DT<CR>, answer: 2003-12-08<CR><LF> The calendar works from 2000-01-01 to 2099-12-31

- DTyyyy-mm-dd<CR>[<LF>] : Set the date yyyy-mm-dd<CR><LF>
- yyyy: Year mm: Month dd: Day
- Answer: yyyy-mm-dd<CR><LF>
- yyyy: Year mm: Month dd: Day
- Reset value: 2000-01-01

Notes:

- After reception of this command, the module responds following the rules of the command BTx. This means the answer is not immediate but can be delayed up to 1 s.

Example: DT2003-12-08<CR>, answer: 2003-12-08<CR><LF>

The calendar works from 2000-01-01 to 2099-12-31

BTx<CR>[<LF>] : Beat every second on the serial port

x: parameter to beat.

0: Stop beat.

1: Beat effective time interval PPSOUT vs PPSREF.

Answer: dddddd<CR><LF>

dddddd: delay in 133 ns steps.

2: Beat phase comparator value.

Answer: sppp<CR><LF>

s: +/- sign ppp: phase error, approx. in ns

3: Beat effective time interval PPSOUT vs PPSREF + phase comparator value.

Answer: dddddd sppp<CR><LF>

dddddd: delay in 133 ns steps.

s: +/- sign ppp: phase error, approx. in ns

4: Beat time of day.

Answer: hh:mm:ss<CR><LF>

hh: Hours mm: Minutes ss: Seconds

5: Beat general status.

Answer: x<CR><LF>

x: general status. (See command STx)

6: Beat <CR><LF>.

7: Beat Date, Time, Status

Answer: yyyy-mm-dd hh:mm:ss x <CR><LF>

yyyy : Year mm: Month dd: Day

Notes:

- The answer is delayed a few ms after the PPSINT pulse. This delay can vary a little.
- When beating time interval PPSOUT vs PPSREF, the answer is 9999999<CR><LF> if no pulse is found.
- This can happen when the module is going to tracking state, General Status = 1.
- Regarding the phase comparator, no precision or linearity can be expected. This comparator just increases the resolution of the phase used by the tracking algorithm.

Example: BT5<CR>, answer 9<CR><LF> 9<CR><LF> ... 4<CR><LF> 4<CR><LF>. This means the quartz oscillator is just locked to the Rubidium line.

Commands of control

FCsdddd<CR>[<LF>] : Set user frequency correction

- sdddd: frequency correction in 5.12-10-13 step.
- +00000: no correction.
- +32767: highest pull-up, +16.7 ppb.
- -32768: lowest pull-down, -16.7 ppb.
- +99999: interrogation.
- Answer: sdddd<CR><LF>
- saddled: frequency correction actually in use.
- Factory setting: +00000
- Reset value: Last value stored in EEPROM.

In a free-run state, the last value is stored with the commands FCsdddd or Cxxxx. In the track state, the last value is stored automatically or with the command FSx.

Notes:

- In the track state, the user frequency correction is changed internally by the software for optimum alignment
This command should never be used in track state. (Exept FC+99999).
- FSx<CR>[<LF>] : Set frequency value.
- x: parameter.
- no saving. (0→EEPROM)
- save integral part of tracking correction in EEPROM every 24 hours. (1→EEPROM)
- save integral part of tracking correction in EEPROM now.
- save user frequency in EEPROM now. interrogation.
- Answer: x: frequency save mode as written in EEPROM
- no saving.
- save integral part of tracking correction in EEPROM every 24 hours.
- Factory setting: 1
- Reset value: Last value stored in EEPROM.

Notes:

- In frequency save mode 1, the saving is only done if the module is in track state. (General Status 2 or 3).
- If the PPSREF is missing or rejected, the 24 hours period is increased.

Example: FS9<CR>, answer 1<CR><LF>.

- TWddd<CR>[<LF>] : Set tracking window. Set the window in which time interval PPSINT vs PPSREF should stay. Stored in EEPROM.
- DDD: half tracking window, from 1 to 255 steps of 133 ns.
- 999: interrogation
- Answer: DDD: half tracking window in 133 ns steps.

- Factory setting: 015 ($\sim \pm 2\mu\text{s}$)
- Reset value: Last value stored in EEPROM.

Notes:

- If the time interval PPSINT vs PPSREF becomes bigger than the tracking window, the tracking stops.

Example: TW020<CR>, answer 020<CR><LF>.

- AWddd<CR>[<LF>] : Set alarm window.
- An alarm is raised if the time interval PPSINT vs PPSREF becomes bigger than this value. Stored in EEPROM.
- DDD: half alarm window, from 1 to 255 steps of 133 ns.
- 999: interrogation
- Answer: DDD: half alarm window in 133 ns steps.
- Factory setting: 015 ($\sim \pm 2\mu\text{s}$)
- Reset value: Last value stored in EEPROM.

Notes:

- This command is limited to track state.
- The General Status becomes 5. (PPSREF unstable).
- The alarm window cannot be bigger than the tracking window. This window may be reduced by the command TWddd.

Example: AW999<CR>, answer 015<CR><LF>.

Warning: This command can strongly degrade the initialization and current value of some parameters. Modifications of the alarm window should be avoided.

TCdddddd<CR>[<LF>] Set tracking loop time constant.

- ddddd: time constant in seconds.
- 000000: change to auto selection mode.
- 001000: minimum value, 1000 s.
- 999999: maximum value, 999999 s.
- 000099: interrogation.
- Answer: ddddd: last time constant selected, in seconds.
- Factory setting: 000000
- Reset value: 000000

Notes:

- In auto selection mode, the time constant is automatically adapted to the PPSREF noise.
- In auto selection mode, if the time interval PPSREF vs PPSINT goes out of the phase comparator range, approx. ± 500 ns, the time constant is set to 1000 s.

Example: TC000099<CR>, answer 000000<CR><LF>

Warning: This command can strongly degrade the initialization and current value of some parameters. Modifications of loop time constant should be avoided.
MCsxx[cc..c]<CR><LF>] Set module customization

- s: action to do
- L: Load message
- S: Set message (user message only)
- B: Load the behavior at the start of the clock
- A: Activate a message at the start of the clock
- C: Cancel a message at the start of the clock
- H: Load Help message
- T: Load data Type
- xx: message number, from 00 to FF
- cc...c: up to 24 ASCII characters, to set the user message
- Answer: cc...c: message, answer to MCLxx or to MCHxx or
- 0/1: Behavior of a message at the start of the clock, answer to MCBxx or
- XY: data Type, answer to MCTxx
- x=0 in RAM, x=1 in EEPROM, x=2 in Flash
- y=0 byte, y=1 sbyte, y=2 word, y=3 sword, y=4 dword, y=5 sdword,
- y=6 word, y=7 sword, y=8 string ASCII, y=9 string binary

Pos.	Active. (Def)	Parameter(Default)	Comment
00	1	TNTSRO-100/00/1.07	Factory welcome message
01	0	Free for user message	User welcome message
02	—	05	GPS configuration delay
03	—	03	GPS configuration interval
07	—	01	Error message send
10	0	@@En	Time RAIM setup
11	0	@@At	Position hold, site survey
20	0	@@Gd	Position control message
21	0	@@Gc	PPS control message
22	0	@@Ge	Time RAIM algorithm
23	0	@@Gc	Time RAIM alarm message

- Pos. \$01 Message can be modified by the user and is stored in EEPROM.
- Pos. \$02 and \$03 Parameters are the delays, resp. the interval of time in seconds at which the GPS configuration messages are sent out at Startup.
- Pos. \$10-\$11 are GPS messages to configure an Oncore, Jupiter-T, or Jupiter-Pico receiver for a timing application.
- Pos. \$20-\$23 are GPS messages to configure an M12+ receiver for a timing application.

- This command was renewed and extended since Version 07.
- This command is best used with the free program exe, since Version 1.07.
- COsddd<CR>[<LF>] : fine phase comparator offset
- sddd: fine phase offset in approx. 1 ns steps
- +000: no offset
- +127: highest offset
- -128: lowest offset
- +999: interrogation.

Answer: sddd<CR><LF>

- sddd: phase offset actually in use.
- Factory setting: +000
- Reset value: Last value stored in EEPROM.

Notes:

- This command stores the value in EEPROM VS<CR>[<LF>] : view the Sigma of PPSRef. In tracking Status 2 or 3.

Answer: ddd.d<CR><LF>

- ddd.d: Sigma in ns
- VT<CR>[<LF>] : view the time constant of the tracking loop.

Answer: ddddddd<CR><LF>

- ddddddd: Time constant in s
- RAsddd<CR>[<LF>] : raw phase adjust
- sddd: raw phase adjust in 133 ns steps
- +127: highest adjust
- -128: lowest adjust
- +999: interrogation, ever +000

Answer: sddd<CR><LF>

- sddd: raw phase adjust asked in 133 ns steps

Notes:

- This command offset the PPSINT by itself
- This command can be useful for some timing applications to bring the fine comparator into an area where it works
- This command doesn't move the PPSOUT pulse and doesn't modify the reading of BT1 or BT3

- This command has an influence on the delay value, command DEddddddd, as the delay is in fact referenced to PPSINT

Example: DE9999999 <CR>, answer 00000000<CR><LF> . Now we do RA+003, answer +003 <CR><LF>. And then we do DE9999999<CR>, the answer is 7499997<CR><LF>
 RAQUIK<CR>[<LF>]: this command quickly aligns PPSINT to PPSREF

Answer: +000<CR><LF>

Warning:

- This command can strongly degrade the initialization and current value of some parameters
- This command can be useful when the device is used as a timing machine and there is no time so that “TR1” takes effect
- This command is given to liking well but without guarantee none regarding the integrity and good continuation of the program. It is to the user to make sure that the parameters are initialized correctly after the use of this command

System I/O Interfaces

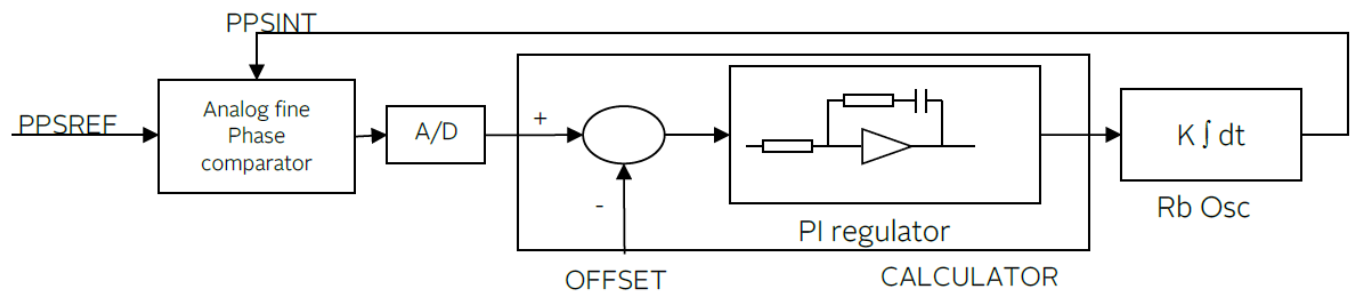


Figure 7 - Schematic of the Analog Fine Phase Comparator Regulation Loop

Backplate

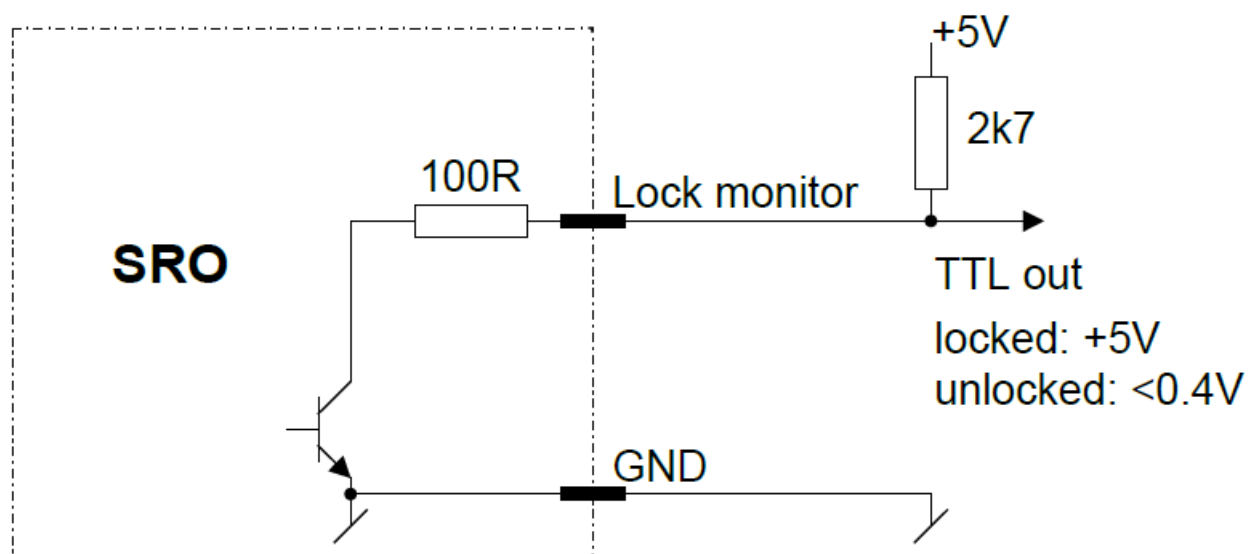
N°	Type	Definition	I/O
J1	SMA	Rb A 10MHz outputs	I
J2	SUB-D9-F	Rb A Serial communication RS232 + OOL bit alarm	I/O
J3	SMA	Rb B 10MHz outputs	O
J4	SUB-D9-F	Rb B Serial communication RS232 + OOL bit alarm	I/O
J5	P. PLUG	Rb A Power connection	I
S1	SWITCH	Rb AOn/Off switch	—
J6	P. PLUG	Rb A Power connection	I
S2	SWITCH	Rb AOn/Off switch	—

Faceplate

N°	Type	Definition	I/O
I1	Green LED	Power ON rubidium A	–
I2	Red LED	Out-of-Lock alarm (OOL)	–
I3	Green LED	Power ON rubidium B	–
I4	Red LED	Out-of-Lock alarm (OOL)	–

Lock indicator

TTL OR CMOS LEVEL “OUT OF LOCK ALARM” SIGNAL GENERATION



The lock monitor can be directly connected to the TTL load, or a pull-up resistor can be added for CMOS compatibility

DIRECT VISUAL “OUT OF LOCK ALARM” GENERATION

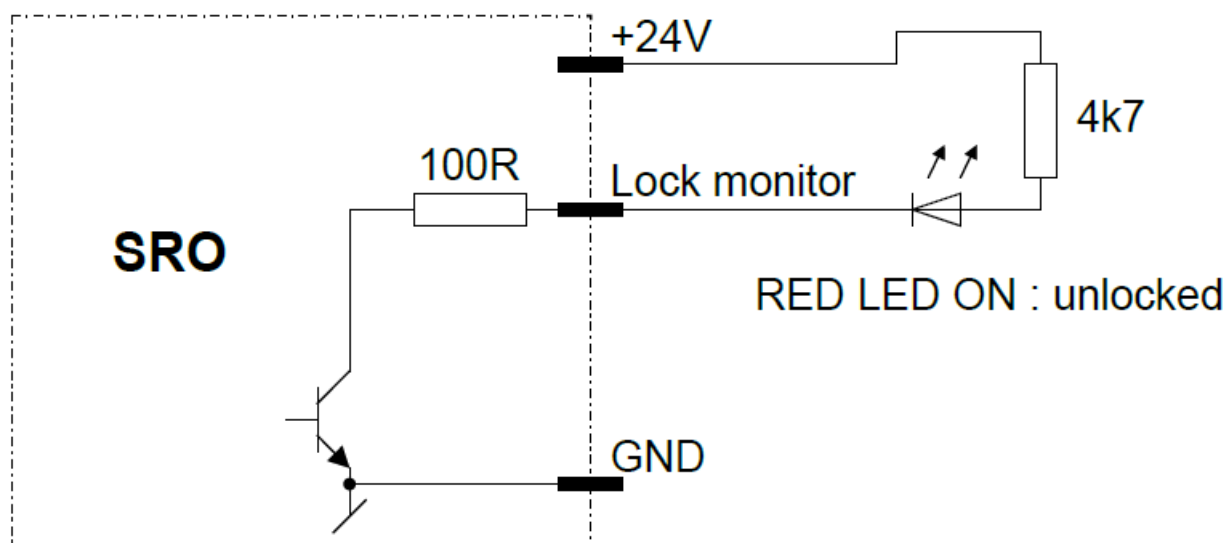



Fig. 4-5 : Visual "Out Off Lock" generation.

The value of the 4k7 resistor should be adapted to the LED drive current.

GLOSSARY

- Adobe Acrobat Reader A software program that enables people to read and print files saved in PDF format.
- Allan Deviation Square root of Allan Variance: It indicates the typical deviation from one measurement to the next.
- DDS Direct Digital Synthesizer
- DUT Device Under Test
- FSMS Frequency Stability Measurement System
- IF Intermediate Frequency
- BP Band Pass filter
- LP Low Pass filter
- SRO Synchronized Rubidium Oscillator
- XTAL Quartz crystal
- PDF Portable Document Format, file extension to be used by Adobe Acrobat Reader

Documents / Resources

	orolia RBSOURCE-1600-DUAL High-Performance Rubidium Reference Dual Source [pdf] User Manual RBSOURCE-1600-DUAL, High-Performance Rubidium Reference Dual Source
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