

22<sup>nd</sup> December 2011

**Low Cost GPS/MultiReference-Synchronized Crystal Oscillator (SXO-75)**

**Patented SXO-75 SynClock+®**  
**Auto-Adaptive SmarTiming+™ Technology Inside**



**Telecom | Navigation | Broadcast | Defense | Instrument**

**Applications**

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## Revision list :

| Software Revision : |         |   | Hardware Revision : |
|---------------------|---------|---|---------------------|
| Date                | Version | Comment                                   |                     |
| 2005-04-08          | 2.09    | Beta SXO Software. For 20 MHz controller. | 2005- 01- 13        |

## 1. INTRODUCTION

The Model SXO-75 is a double oven XTAL oscillator with extended PPS (Pulse Per second) facilities. The standard version provides following signals:

- High stability 10 MHz sinus. (5 MHz in option).
- PPS Out.

And in option the following signal:

- Synthesized frequency for Telecom.

This device can track a PPS Ref signal provided by a stable reference like a GPS receiver. The SXO is designed for navigation, communication and timing instruments requiring extremely stable and precise frequency referenced to the atomic world standard.

This manual contains information about the operation and field maintenance of the SXO. SynClock+® is the general designation of the SRO-100 or SXO-75. SRO/SXO means that a matter concern as well the SRO as the SXO.

Chapter 2 contains a general description of the unit. It also presents a basic theory of operation for a technician or engineer who requires a better understanding of the unit's operation.

Chapter 3 lists all specifications and operation requirements of the SXO.

Chapter 4 gives information on how to install and operate the unit. It is recommended that these chapters be read prior to operate the unit. This chapter describes also the possible serial interface connection for the monitoring and tuning of the internal parameters and the timing signals operations.

## 2. SXO SYSTEM DESCRIPTION

### 2.1 Difference between SRO and SXO

The SRO quartz is driven by a Rubidium atomic transition while the SXO quartz is a high quality factor oscillator isolated in a double oven.

This bring some differences in the way to tune the 2 devices:

- The frequency of the SRO is tuned digitally by a DDS
- The frequency of the SXO is tuned analog by a varactor.

In consequence the relationship between a numerical step and the frequency change is constant and the same for each device by the SRO. By the SXO, the relationship is not linear and change from one device to the other.

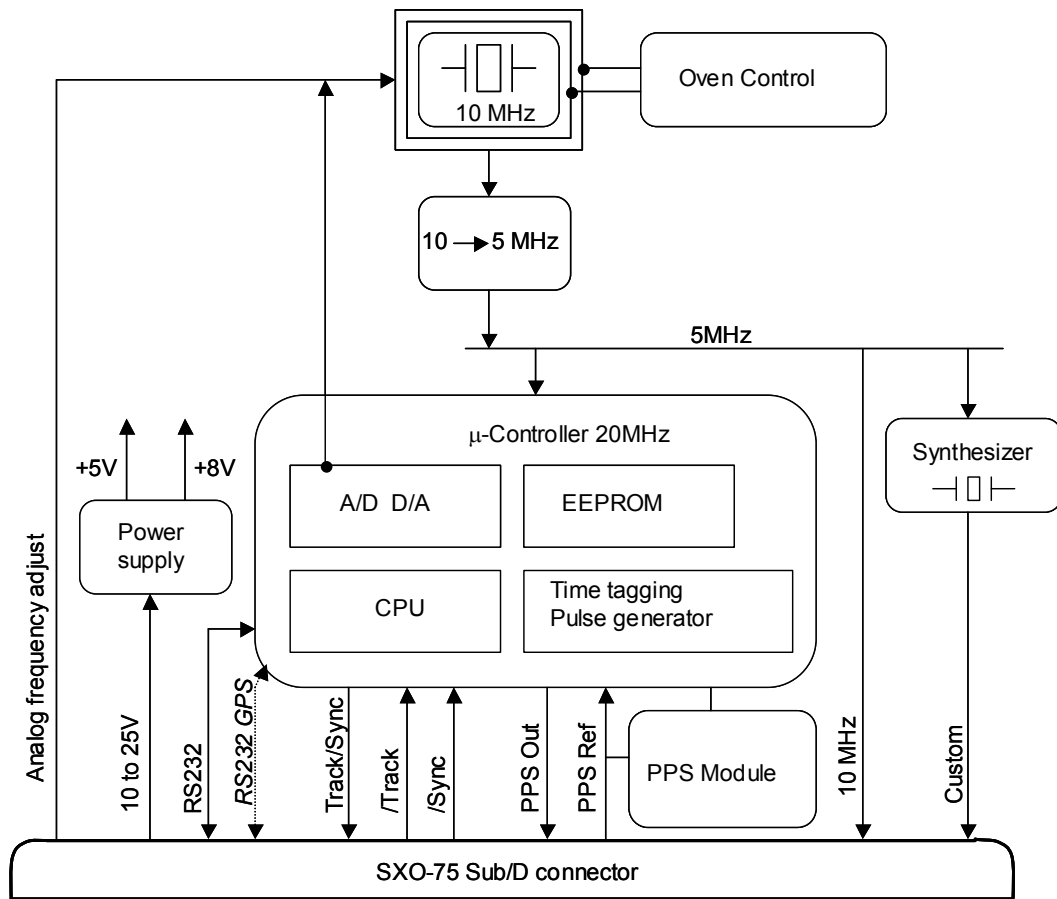


Fig. 2-1 : **SXO block diagram.**

An analog frequency control input is available to the user for center frequency adjustment by external potentiometer or external digital to analog converter.

A serial interface connection for the monitoring and tuning of the internal parameters and the PPS facilities is provided to the user.

The PPS functions can be simply controlled by grounding 2 pins. (Track: pin 15, Sync: pin 14.)  
When the SXO is successfully tracking an external PPSREF, a TTL signal goes low.(Track/Sync: pin 5).

A detailed block diagram of the SXO is given in Fig. 2-1.

## 2.2 THE TIMING AND TRACKING SYSTEM

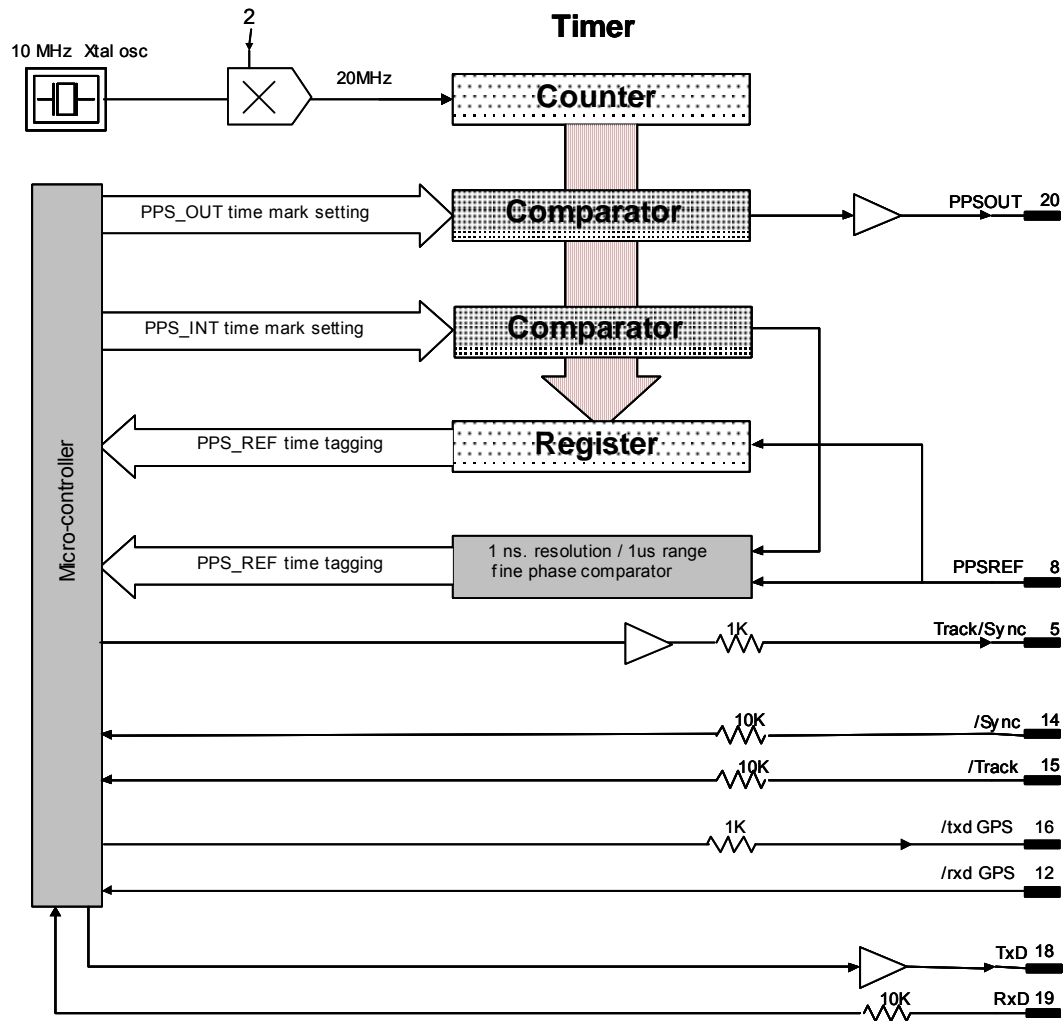


Fig. 2-2: Timing system.

The SXO-075 model includes extended PPS (Pulse Per Second) facility. The hardware of this facility consists of two modules. The first module is a timer clocked at 20 MHz. This timer tags the PPSREF connected to the device and generates two other PPS. The first one is called PPSINT and is used internally. The second one is called PPSOUT and appears on pin 20 of the connector.

The second module is a phase comparator with 1 ns resolution and 1 μs 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 calculating the noise of this PPSREF. The calculation is used to adjust the time constant of the tracking loop. This way, a noisy PPSREF can be directly connected to the device without adjustments by hardware or software.

As mentioned before, a tracking can be initiated by grounding pin 15 (/Track). If PPSOUT must be in phase to PPSREF, pin 14 (/Sync) must be grounded too. If the tracking is successful, the pin 5 (Track/Sync) goes low. But all of the tracking and PPS functions can also be controlled via the serial interface port RS232.

### 2.2.1 THE “TRACK” MODE AND THE “SYNC” MODE.

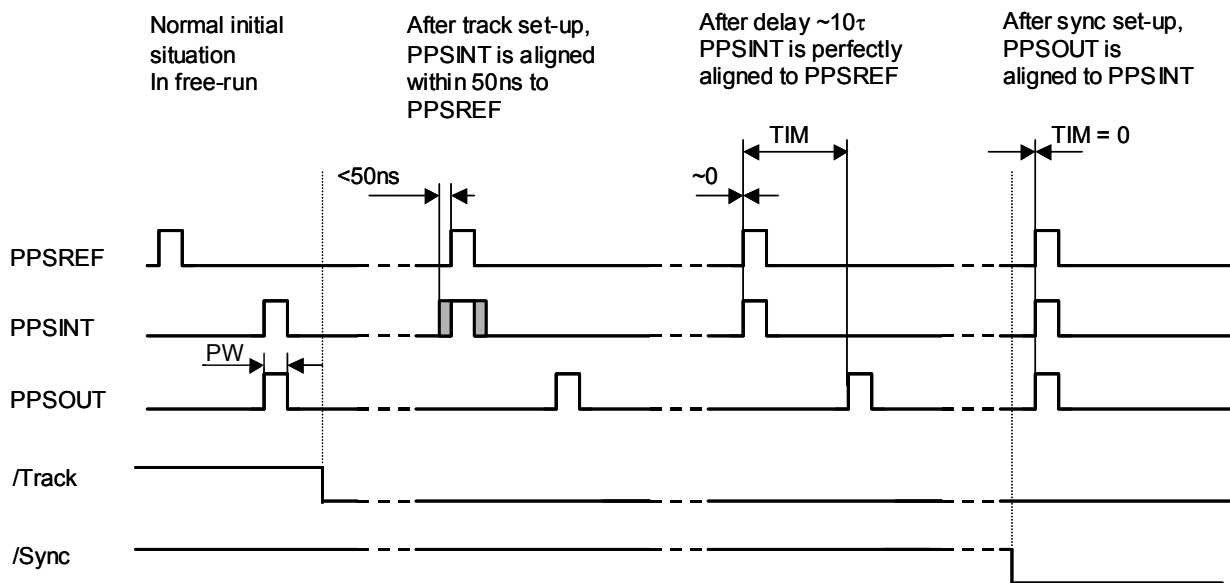


Fig. 2-3 : “Track” mode and “Sync” mode.

When “track” mode is set-up, the PPSINT is aligned to the PPSREF within 50 ns and the device start to track it. At the beginning the loop time constant is set to an arbitrary low value. Then the phase comparator starts the long-term frequency stability analysis of the PPSREF and the loop time constant is set consequently.

If “sync” mode is not active, the PPSOUT is let in the place where is was before going in tracking.

If “sync” mode is active, the PPSOUT is aligned to PPSINT, just after going in tracking if it was set already or just after it is set elsewhere.

Remark: Just after the beginning of tracking, PPSINT is not perfectly aligned to PPSREF. The error can be as big as 50 ns. Of course, the tracking loop will cancel this error after some time.

### 2.2.2 THE FREQUENCY LEARNING

When the device is tracking the PPSREF of a master oscillator, in reality, it align it's frequency to the one of the master.

The learning process is simply the memorization of this frequency from time to time to use it after a reset or Power-On.

By default, when the device is continuously and successfully tracking a PPSREF, the average value of the frequency is saved in EEPROM every 24 hours.

With the command `FSx<CR>`, it is possible to cancel the learning or to make an immediate save.

### 2.2.3 THE FREQUENCY IN USE

With the PPSREF facilities, the frequency in use is different depending on the situation. Let know first, that the frequency just currently in use is located in a single register, and that this register can ever be read by the user. The command to read this register is: `FC??????<CR>`.

On a device connected through the serial interface to a terminal, it is possible to follow the evolution of the tracking by this way.

The frequency in use in different situations is as following:

- After a Reset or Power-On, the frequency is copied from the EEPROM to the RAM and then is used.
- After the start of a tracking, the frequency is the one of the EEPROM.
- During a tracking, the frequency changes continuously to align as good as possible the PPSINT to the PPSREF. By default, the average value is saved in EEPROM every 24 hours.
- If the SXO is stopped in its tracking, and put in FREE RUN mode by the user, with the command TR0 for example, the frequency 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 hold-over.

## 2.2.4 USER FREQUENCY CORRECTION

This correction is only possible in Free Run mode and is made with the command FCsxxxxx.

The command has 2 effects:

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

## 2.2.5 THE PPS TRACKING LOOP

The SXO 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 the user with the command TCxxxxxx.

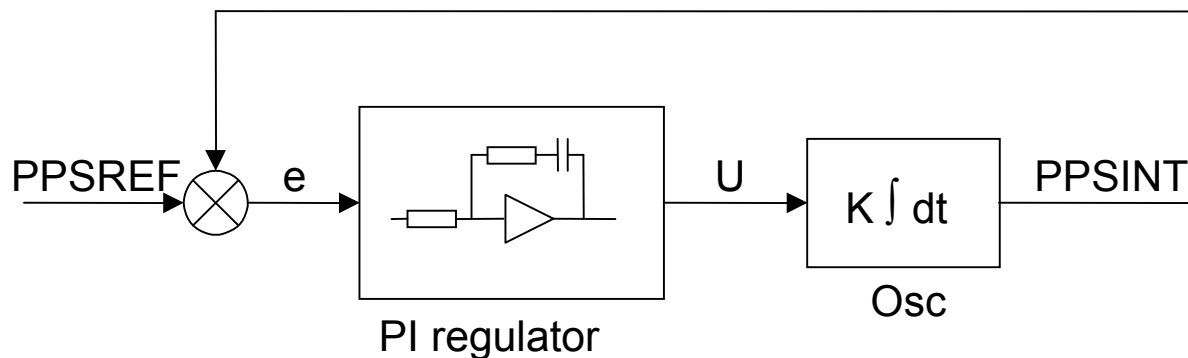


Figure 2-4 Schematic of the PPSREF regulation loop.

By default, the optimum loop time constant is computed by the device from information's like PPSREF noise and temperature fluctuations. In this case, if the fine phase comparator cannot give valid information's, the time constant is forced to 1000s.

But the loop time constant can also be forced by the user to a fixed value. In this case, the time constant, is ever the one asked by the user. The command to do that is TCxxxxxx<CR>.

## 2.2.6 TRACKING LIMITS AND ALARMS

If the frequency between the SXO and the master to track is too large, after some time, the phase time error between PPSINT and PPSREF can become too big for some applications.

There are two limits. If the phase time error becomes bigger than the first limit, an alarm is raised up, but the tracking continues. If the phase time error comes bigger than the second limit, then the tracking stops. The first limit is called (no) alarm window and the second window tracking window.

The value of the half (no) alarm window can be changed by the user with the command AWxxxxx.

For the SXO, the default value is  $\pm 2\mu\text{s}$ .

The value of the half tracking window can be changed by the user with the command TWxxxxx.

For the SXO, the default value is  $\pm 6\mu\text{s}$ .

For more details, see the Chapter "TIMING AND TRACKING COMMANDS".

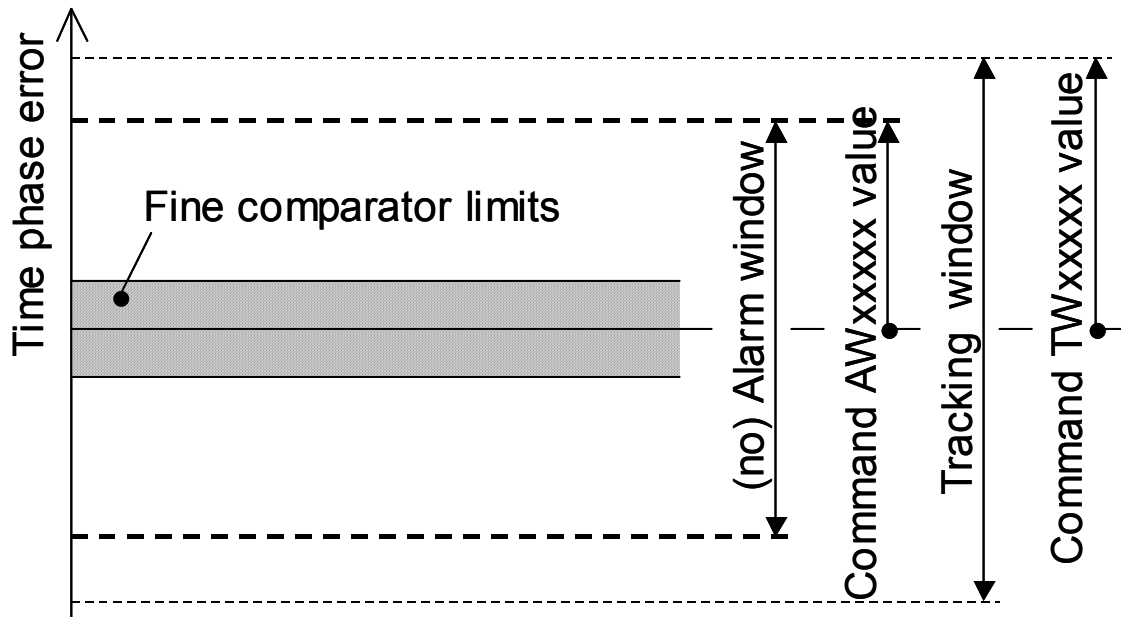


Figure 2-5 Tracking limits.

### 2.2.7 FREQUENCY FLUCTUATIONS DURING THE TRACKING

To track a PPSREF, the device change it's frequency. The frequency register is a 16 bit. So, normally the frequency can vary from  $-32768$  to  $32767$ . But the frequency variations can be forced to a lower limit. If during the tracking of a PPSREF the SXO reach a frequency limit, nothings happen as long the phase time error is staying in the (no) alarm window.

If the device is connected to a terminal through the serial port, the user can read out 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 limitations of the frequency register.

The user can also check out if the device is actually under frequency limitation by typing `R4F<CR>`. If there is a problem, the bit 1 and bit 2 of this register will not be set to 0.

### 2.2.8 FINE PHASE COMPARATOR OFFSET

This fine offset adjustment can be used in case of precise phase calibration. The range of the offset is  $+127 / -128$  steps of the fine phase comparator. As the fine comparator works analogue, a step corresponds to approx. 1 ns. The command to put the offset is `COsddd <CR>`

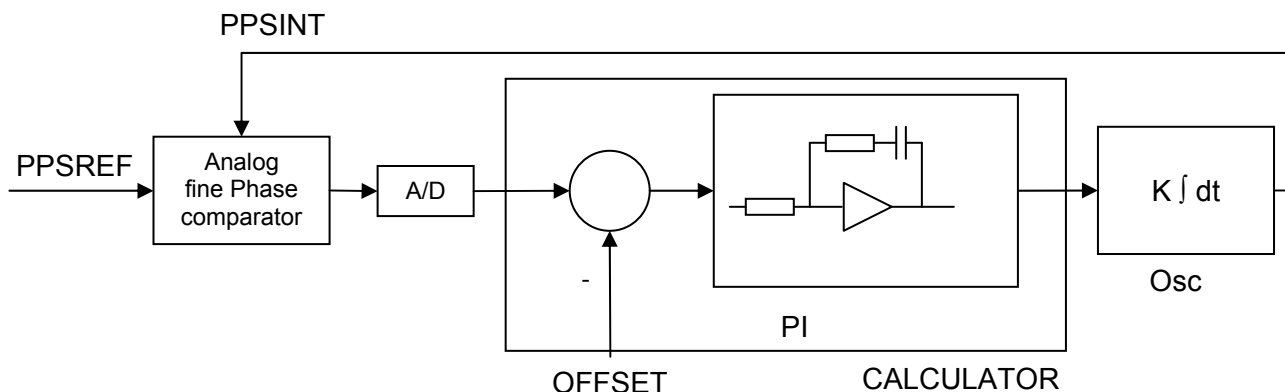


Figure 2-6 schematic of the analog fine phase comparator regulation loop

### 2.2.9 START OF THE TRACKING, EXPLICATIONS.

In free run and during a holdover, the frequency and reliability of an external PPSREF connected to pin 8 is continually analyzed. At the start of a tracking, followings happen:

- 1) If Flag1 is set **and** the reliability of the pps ref is good enough, **then** the tracking starts.



- 2) The pps int , see Fig 2.3, is gently aligned to pps ref. This can take 1 minute.
- 3) **If** Flag2 is set **and** the frequency of the pps ref well known **then** the frequency of the SXO is aligned suddenly to the one of the pps ref. To know well the frequency of pps ref, 100 seconds of analysis are necessary. This can be done during 2).
- 4) A few seconds later, the pps int is perfectly aligned to pps ref and the tracking starts.

Now imagine the SXO goes in holdover because of an important phase jump of pps ref.

**If** Flag3 is set **and** the new pps ref is reliable during 255 seconds, **then** a new tracking re-start at 2).

The Flag1, Flag2 and Flag3 are stored in eeprom. They can be accessed by the user with the command MCsxx, parameter 06.

Important: By default, only Flag2 is set. In fact the benefit of Flag1 is low as it is supposed the reliability of the pps ref is high. Due to the aging, the frequency of an SXO can vary since it's factory setting and a tracking to a world standard frequency can missed if the Flag2 is not set. The user must take account the sudden frequency jump. The Flag3 setting give some comfort during laboratory tests as the device don't stack in case another pps ref source is connected to pin 8. But if the device must work in the field with a GPS receiver, it is strongly recommended to not set Flag3. Because some GPS receiver continue to produce a pps ref based on there internal low quality crystal even without satellites in view.

Remark: As the warm-up time of the SXO is much longer than by a Rb based oscillator like the SRO, it is not recommended to initiate a tracking just after power-on.

Start of the tracking flags:

DTMCPA06

|  |  |  |  |  |        |        |        |
|--|--|--|--|--|--------|--------|--------|
|  |  |  |  |  | 2      | 1      | 0      |
|  |  |  |  |  | Flag 3 | Flag 2 | Flag 1 |
|  |  |  |  |  | 0      | 1      | 0      |

- Flag1: initial frequency test
- Flag2: sudden frequency alignment allowed
- Flag3: restart of the tracking allowed

### 3. SXO SPECIFICATIONS

Latest version of the SXO-075 specification can be downloaded from <http://www.spectratime.com> website.

## 4. SXO INSTALLATION AND OPERATION

### 4.1 INTRODUCTION

This chapter of the manual contains information regarding the installation and operation of the SpT Model SXO. It is recommended to read this chapter carefully prior to operate the unit.

### 4.2 SHIPPING AND RECEIVING INFORMATION

The SXO is packaged and shipped in a foam-lined box. The unit is inspected mechanically and electrically prior to shipment. Upon receipt of the unit, a thorough inspection should be made to ensure that no damage has occurred during shipping. If any damage is discovered, please contact

SPECTRATIME SA  
PHONE: +41 32 732 16 66  
FAX: +41 32 732 16 67  
CH-2000 NEUCHÂTEL / SWITZERLAND

Should it be necessary to ship the unit back, the original case and packing should be used. If the original case is not available, a suitable container with foam-packing is recommended.

#### CAUTION

Care must be taken for the transportation of the SRO/SXO to ensure that the maximum acceleration due to a choc 50g/ 18ms is not exceeded.

SXO contains crystal resonators and crystal filters.

When SRO/SXO is integrated into an instrument, such instrument shall be packed in a suitable container, similar to containers generally used for the transportation of instruments like scope, video display or computer.

### MOUNTING

The unit should be mounted in preference to a metallic base-plate or thermal dissipater.

The heat transfer characteristics of the mounting surface must be adequate to limit the rise of the unit's base plate to  $< +60^{\circ}\text{C}$ . Since the minimum total power consumption for proper operation of the device is around 300mA / 24V, the allowable environmental temperature ( $T_{a_{\max}}$ ), for this mounting is:

$$T_{a_{\max}} = 60^{\circ}\text{C} - V_s \times I_s \times R_k$$

$V_s$  = Supply voltage  
 $I_s$  = Supplied current  
 $R_k$  = Heat sink thermal resistance

#### CAUTION

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Care must be taken to ensure that the maximum operating temperature is not exceeded, ( $+60^{\circ}\text{C}$  as measured at the unit's base plate).

The device is designed for being directly mounted on the host instrument PCB, involving a problem of thermal dissipation. The device mounting depends on the available space, the ambient temperature into the instrument box and the distance of the device case to the nearest instrument heat sink.

#### 4.2.1 SXO-75 PACKAGE.

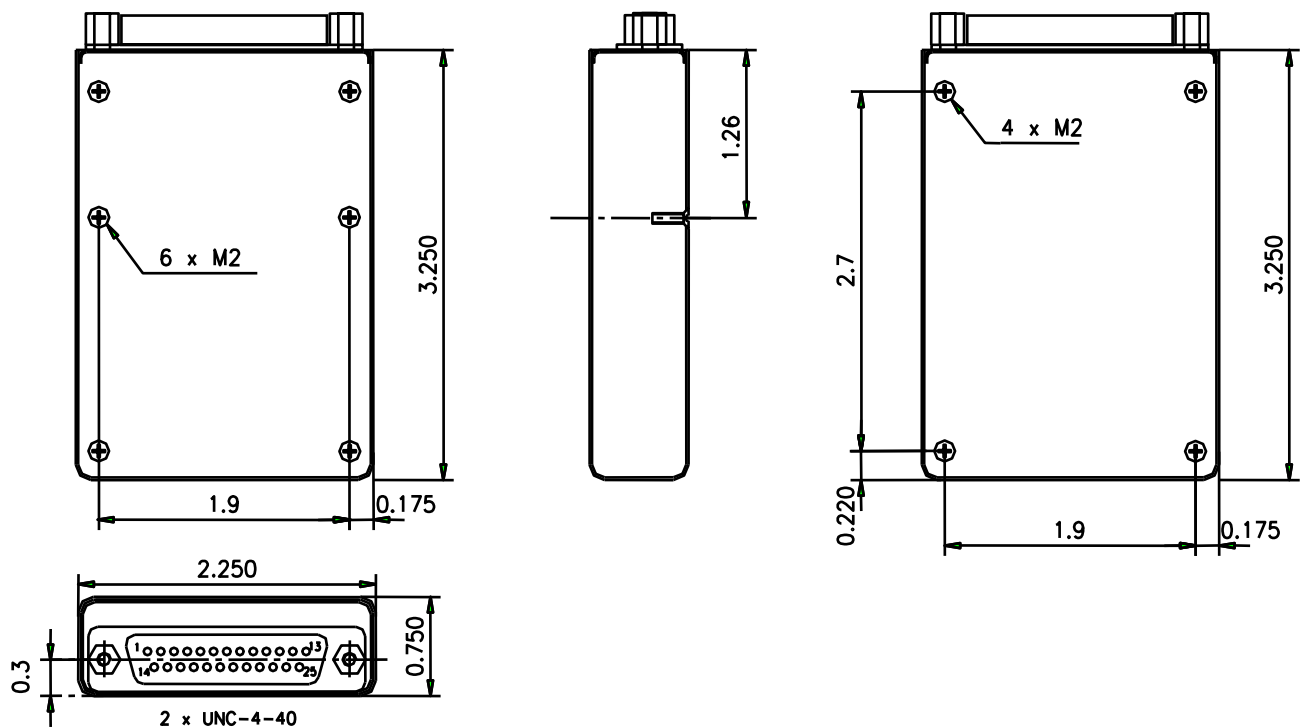
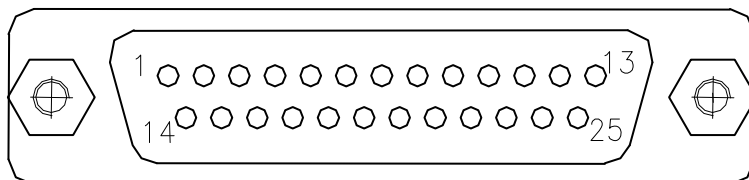


Fig. 4-1 : Mechanical layout of the SXO-75. All dimensions are in inches, except screws, not to scale.

4.3 **Connector Front View:** (all models)

D-Sub 25 pins male



## 4.3.1.1 PIN OUT

| Pin nbr. | 4.3.1.2 SXO-75                                 | (For information: SRO-100)           | Dir    |
|----------|--|--------------------------------------|--------|
| 1        | 10V to 25V                                     | 12V(11.2 to 16) or 24V (18 to 32)    | Input  |
| 2        | 10V to 25V                                     | 12V(11.2 to 16) or 24V (18 to 32)    | Input  |
| 3        | GND  | GND                                  | Ret    |
| 4        | NC (Future use. Pulled to TTL high)            | Rb lock (open collector) (lock=open) | Output |
| 5        | Track/Synch Alarm (TTL+1K) (lock=0V)           | Track/Synch                          | Output |
| 6        | FA (analog frequency adjust input)             | FA                                   | Input  |
| 7        | Vref out (+5V internal reference)              | Vref out                             | Output |
| 8        | PPSREF (reference time pulse)                  | PPSREF                               | Input  |
| 9        | NC (Factory use or diagnostics)                | NC (Factory use or diagnostics)      | Output |
| 10       | GND  | GND                                  | Ret    |
| 11       | Synthesizer (Square wave 5V CMOS)              | DDSOUT                               | Output |
| 12       | /rxd GPS                                       | GND                                  | Input  |
| 13       | NC (Future use. Grounded with 1kΩ)             | 60M                                  | Output |
| 14       | /Sync(synchronize PPSOUT to PPSREF)            | /Sync                                | Input  |
| 15       | /Track (PPSREF phase tracking)                 | /Track                               | Input  |
| 16       | /txd GPS                                       | NC                                   | Out    |
| 17       | /Reset (Micro controller)                      | /Reset                               | Input  |
| 18       | TxD (RS232 Transmit 0-5V)                      | TxD                                  | Output |
| 19       | RxD (RS232 Receive 0-5V)                       | RxD                                  | Input  |
| 20       | PPSOUT (output time pulse from internal clock) | PPSOUT                               | Output |
| 21       | GND  | GND                                  | Ret    |
| 22       | GND  | GND                                  | Ret    |
| 23       | GND  | GND                                  | Ret    |
| 24       | RFOUT(5 or 10MHz sinus 7dBm into 50Ω)          | RFOUT(5, 10 or 15MHz sin. 7dBm/50Ω)  | Output |
| 25       | GND  | GND                                  | Ret    |

## 4.4 NORMAL OPERATION

When Vdc (10 to 25V) is applied to pins 1/2 (+) and 3/10/21/22/23/25 (-), the unit will immediately begin to generate a 10 MHz signal from the crystal oscillator. After some time, the temperature of the XTAL inside the double oven will reach a stable value and the frequency be consequently stable.

### 4.4.1 ANALOG FREQUENCY PULLING

The SXO is equipped with an analog frequency adjustment circuit which provides center frequency adjustment by applying an external voltage from 0 to 5V on pin 6. SXO standard frequency pulling range for 0 to 5V is  $\sim 2 \cdot 10^{-7}$ . This analog voltage can be generated with an external potentiometer connected to Vref, pin 7 and GND (see pin function layout). **Please let pin 6 potential free if this functionality is not used!**

### 4.4.2 PPS FACILITIES

Immediately after power-on, a PPSOUT signal is provided.

Once the SXO's frequency is stable enough, a tracking to a PPSREF can be initiated by grounding the pin 15 ("/Track").

When the SXO is successfully tracking this PPSREF, the pin 5 goes low.

The PPSOUT can be aligned to the PPSREF by grounding the pin 14 ("/Sync").

If the pin 15 (/Track) is continuously grounded, the SXO initiates immediately to track a PPSREF after it's internal temperature is stable enough.

Remark: As considering previously, it is however not recommended to proceed like that as the SXO needs some time before it's frequency become stable.

If the pin 14 (/Sync) is continuously grounded, the SXO will immediately align PPSOUT to PPSREF after it starts to track this PPSREF.

### 4.4.3 OTHER PROVIDED SIGNALS (OPTION)

- Customer telecom frequency synthesizer on pin 11.

## 4.5 SIMPLE SERIAL INTERFACE OPERATION

### 4.5.1 INTRODUCTION

The SXO is equipped with a micro-controller which supervises the normal working of the device. All the working parameters are stored in a built-in EEPROM memory.

The built-in serial interface allows an automatic parameter adjustment during the manufacturing.

The serial interface serves also for the monitoring and tuning of the internal parameters and the PPS facilities.

### 4.5.2 SERIAL INTERFACE CONNECTION

The data transfer from the SXO can be made by direct connection to a PC or standard terminal.

The data transfer parameters are the following:

bit rate: 9600 bits/s.

parity: none

start bit: 1

data bits: 8

stop bit: 1

#### IMPORTANT NOTE:

In most cases, the serial PC interface accepts the 0 to 5V level and a direct connection can be made. In case this 0 to 5V standard is not working, please refer to the small adaptation circuit called 'RS 232 adapter circuit' described in annex I.

If you experience problems with the serial interface, have a look into the FAQ section of the [www.spectratime.com](http://www.spectratime.com) web site.

### 4.5.3 SXO INTERNAL PARAMETERS MONITORING

The internal parameters monitoring is made via the serial interface and with the use of single command "M" followed by a carriage return character.

**M<CR>[<LF>] \***

The SXO will respond to this single character command with an eight ASCII / HEX coded string which look like

**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 user provided frequency adjustment voltage on pin 6 (0 to 5V)

**GG:** reserved

**FF:** reserved

**EE:** reserved

**DD:** varactor control voltage (0 to 5V)

**CC:** Oven 1 heating current (Imax to 0)

**BB:** Oven 2 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 provided by the user .This information can be used for a read-back of the actual voltage applied to pin 6 of the SXO connector.

- **Reserved**

**GG:**

- **Reserved**

**FF:**

- **Reserved**

**EE:**

- **Frequency adjustment voltage.**

**DD: VCXO control voltage (0 to 5V for \$00 to \$FF)**

This parameter corresponds to the voltage applied to the varactor of the XTAL.

- **Oven 1 heating limiting current.**

**CC: Oven 1 heating limiting current (Imax to 0 for \$00 to \$FF)**

This parameter corresponds to 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).

- **Oven 2 heating limiting current.**

**BB: Oven 2 heating limiting current (Imax to 0 for \$00 to \$FF)**

This parameter corresponds to 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:**

## CENTRE FREQUENCY ADJUSTMENT WITH THE SERIAL INTERFACE

A single character command is available to the user for center frequency adjustment.

**Cxxxx <CR>[<LF>]** : output frequency correction through the synthesizer, by steps of approx.  $6 \cdot 10^{-12}$ , where xxxx is a signed 16 bits integer in hexadecimal string representation.

This value is automatically stored in an EEPROM as last frequency correction which is applied after RESET or power-ON operation.

- The argument of this command can vary from 8000 to 7FFF (-32768 to 32767).
- In track state, the frequency is changed internally by the software for optimum alignment and this command is no more active.
- The basic command FCsdddd do the same. See chapter 4.7.

Note : \* Warning :: This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Examples:

**C0000<CR>** : return to the nominal value (factory setting).

**C0010<CR>** : the actual frequency is increased of 16 steps.

**CFFF0<CR>** : the actual frequency is decreased of 16 steps.

### 4.5.4 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 frequ. corr. in use after RESET or power-ON.

**L06<CR>[LF]** : read-back low byte of user frequ. corr. in use after RESET or power-ON.

- In track state, the value of all of these registers is subject to change by the software for optimum alignment.

### 4.5.5 DDS OUT FREQUENCY SETTING

This hardware version don't have a dds output option.

## **4.6 PPS SERIAL INTERFACE**

The SRO/SXO use the same serial interface to set and control the PPS and timing facilities. For this purpose, a more complex supervision of the device is introduced.

### **4.6.1 GENERAL STATUS OF THE SXO**

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

#### **General status:**

- 0** Warming up. This happens when the SXO is just powered on and the temperature of the ovens is not high enough.
- 1** Tracking set-up: The SXO is in this state when it goes from free-run status to the track status after a track set-up. The duration of this state should not exceed 3 minutes.
- 2** Track to PPSREF. PPSINT is aligned to PPSREF.
- 3** Sync to PPSREF. PPSINT and PPSOUT are aligned to PPSREF.
- 4** Free Run. Track off.
- 5** Free Run. PPSREF unstable. The stability of the PPSREF is too low to be tracked.
- 6** Free Run. No PPSREF was detected.
- 7** Factory used.
- 8** Factory used.
- 9** Fault.

### **4.6.2 TIMING AND TRACKING COMMANDS FORMAT**

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

Remark: Due to improved possibilities of the SXO controller, the length of some commands or messages is increased compared to the SRO. (SXO software since 2.09, compared to SRO software 1.09 and lower.)



## TIMING AND TRACKING COMMANDS

**ID<CR>[<LF>]** : Identification  
 Answer: **TNTSXO-aaa/rr/s.ss<CR><LF>**  
 aaa: 075 for SXO-075  
 rr: revision number  
 s.ss: software version  
 Example: **ID<CR>**, answer: **TNTSXO-075/00/1.09<CR><LF>**

**SN<CR>[<LF>]** : Serial number  
 Answer: **xxxxxx<CR><LF>**  
 xxxxxx: 6 digits serial number  
 Example: **SN<CR>**, answer: **000098<CR><LF>**

**ST<CR>[<LF>]** : General Status  
 Answer: **s<CR><LF>**  
 s: status  
 0: warming up  
 1: tracking set-up  
 2: track to PPSREF  
 3: sync to PPSREF  
 4: Free Run. Track OFF  
 5: PSREF unstable (Hold over)  
 6: No PPSREF (Hold over)  
 7: factory used  
 8: factory used  
 9: Fault  
 Example: **ST<CR>**, answer: **4<CR><LF>** (Free Run. No 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: Track now + ever (1→EEPROM) \*  
 ?: Interrogation  
 Answer: **x<CR><LF>**  
 x: Tracking enable at power-up  
 0: Not enabling tracking at power-up  
 1: Enabling tracking at power-up

## Notes:

- The tracking mode setting is kept in EEPROM.
- The SXO can also be set in tracking mode by grounding the pin 15 of the connector.
- Whatever from software or from hardware, the Track mode 1 has the priority. The answer takes this situation into account.
- The SXO needs a few minutes to be in tracking state. During this delay, ST<CR> answers 1.
- The command TRx has no influence on the phase of PPSOUT if the command SY?<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 0 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)
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).  
 But TR1 followed by TR0 is not acting in NVM

Example: **TR3<CR>**, answer: **1<CR><LF>**. Will ever be in tracking mode. If not yet in this mode, start to track PPSREF.  
**TR0<CR>**, answer: **1<CR><LF>**. In tracking mode because pin 15 is grounded.

**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) \*  
 ?: 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.
- The SXO can also be set in sync. mode by grounding the pin 14 of the connector.
- Whatever 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.)
- \* Warning :: This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).  
 But SY1 followed by SY0 is not acting in NVM

Example: **SY?<CR>**, answer: **1<CR><LF>**. Sync. done when General Status goes from 1 to 2.

**DEdddddddd<CR>[<LF>]** Set the delay of PPSOUT pulse vs PPSINT.

dddddddd: Delay in ns, rounded to 50 ns.  
 000000050: minimum delay.  
 999999950: maximum delay (approx. 1 s)  
 000000000: sync. to PPSINT, the same as SY1.  
 ??????????: interrogation.

Answer:

**dddddddd**: Delay in ns.  
 ??????????: Delay information not valid.

Reset value:

000000000

Notes:

- When going into tracking state, the information delay become no longer valid and the SXO will respond ??????????<CR><LF>.
- In tracking state, after a command SY1<CR><LF>, PPSOUT is aligned to PPSINT and the answer is 000000000<CR><LF>.

Example: **DE?????????<CR>**, answer: **000000000<CR><LF>**

**PWdddddddd<CR>[<LF>]** \* : Set the PPSOUT pulse width.

dddddddd: Pulse width ns, rounded to 50 ns.  
 000000050: minimum pulse.  
 999999950: maximum pulse.  
 000000000: no pulse.  
 ??????????: interrogation.

Answer:

**dddddddd**: Pulse width in ns.  
 000100000 (100 µs)

Factory setting :

Reset value : Last Value stored in EEPROM

Example: **PW?????????<CR>**, answer: **000100000<CR><LF>**

Notes: \*

- Warning :: This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

**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 SXO 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 SXO 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 SXO 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 SXO 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: **ddddddddd<CR><LF>**  
               ddddddddd: delay in ns (rounded to 50 ns).
- 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: **ddddddddd sppp<CR><LF>**  
               ddddddddd: delay in ns (rounded to 50 ns).  
               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
- A: Beat Date, Time, Counter data in NMEA 0183 proprietary format  
     Answer: **\$PTNTA,yyyymmddhhnss,q,T3,rrrrrrrr,sfff,x,y\*cs<CR><LF>**  
               (See NMEA PROPRIATARY FORMAT Chapter)
- B: Beat Frequencies, Tra. loop parameters in NMEA 0183 proprietary format  
     Answer: **\$PTNTS,B,s,ffff,iiii,aaaa,x,y,s,cccccc,ggg.gg,x,y\*cs<CR><LF>**  
               (See NMEA PROPRIATARY FORMAT Chapter)
- Z: Beat NMEA 0183 message \$LOZDA,..., equivalent to \$GPZDA,...  
     Answer: **\$LOZDA, hhnss,dd,mm,yyyy,x,y\*cs<CR><LF>**  
               (See NMEA PROPRIATARY FORMAT Chapter)

## 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 ??????????<CR><LF> if no pulse is found.
- This can happen when the SXO 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 **0<CR><LF> 0<CR><LF> ... 4<CR><LF> 4<CR><LF>**. This means the quartz oscillator is just reaching it's operating temperature.

**FCsdddd<CR>[<LF>]** \*: Set user frequency correction  
 sdddd: frequency correction in approx.  $6 \cdot 10^{-12}$  step.  
 +00000: no correction.  
 +20000: highest recommended pull-up.  
 -20000: lowest recommended pull-down.  
 ??????: interrogation.

Answer: **sdddd<CR><LF>**  
 sdddd: frequency correction actually in use.  
 +00000  
 Factory setting: Last value stored in EEPROM.  
 Reset value: In free-run state, the last value stored with the commands  
 FCsdddd or Cxxxx.  
 In track state, the last value stored automatically or with the  
 command FSx.

Notes:

- In 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??????).
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

**FSx<CR>[<LF>]** \*: Set frequency save mode.  
 x: mode.  
 0: no saving. (0→EEPROM)  
 1: save integral part of tracking correction in EEPROM every 24 hours.  
 (1→EEPROM)  
 2: save integral part of tracking correction in EEPROM now.  
 3: save user frequency in EEPROM now.  
 ?: interrogation.

Answer: **x**: frequency save mode as written in EEPROM  
 0: no saving.  
 1: 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 SXO is in track state. (General Status 2 or 3).
- If the PPSREF is missing or rejected, the 24 hours period is increased.

Notes:

- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Example: **FS?<CR>**, answer **1<CR><LF>**.

**TWdddd<CR>[<LF>]** \* : Set tracking window. Set the window in which time interval PPSINT vs PPSREF should stay. Stored in EEPROM.

dddd: half tracking window, rounded to 50 ns, from 50 ns to 12750 ns.

?????: interrogation

Answer: **dddd**: half tracking window in ns.

Factory setting: 06000 ( $\pm 6\mu s$ )

Reset value: Last value stored in EEPROM.

Notes:

- If the time interval PPSINT vs PPSREF becomes bigger than the tracking window, the tracking stop.
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Example: **TW07000<CR>**, answer **07000<CR><LF>**.

**AWdddd<CR>[<LF>]** \* : Set alarm window.

An alarm is raised up if time interval PPSINT vs PPSREF become bigger than this value. Stored in EEPROM.

dddd: half alarm window, rounded to 50 ns, from 50 ns to 12750 ns.

?????: interrogation

Answer: **dddd**: half alarm window in ns.

Factory setting: 02000 ( $\pm 2\mu s$ )

Reset value: Last value stored in EEPROM.

Notes:

- This command is limited to track state.
- A tracking alarm puts the pin 5 of the output connector to high. 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 TWdddd.
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Example: **AW?????<CR>**, answer **02000<CR><LF>**.

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

dddddd: time constant in seconds.

000000: change to auto selection mode.

001000: minimum value, 1000 s.

999999: maximum value, 999999 s.

??????: interrogation.

Answer: **dddddd**: 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.  $\pm 500$  ns, the time constant is set to 1000 s.
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Example: **TC??????<CR>**, answer **000000<CR><LF>**

**MCSxx[cc..c]<CR>[<LF>]** \* Set module customization

s : action to do

L : Load parameter

S : Set parameter, only data Type is RAM or eeprom \*

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 : position (message), from 00 to FF

cc...c : parameter, up to 24 ACSII character if it is the user message

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 lword, y=7 slword, y=8 string ASCII, y=9 string binary

Answer:

| Pos. | Active.(Def) | Parameter(Default)           | Comment   |
|------|--------------|------------------------------|---|
| 00   | 1            | TNTSXO-075/00/1.09           | Factory welcome message                         |
| 01   | 0            | <b>Free for user message</b> | User welcome message                            |
| 02   | --           | <b>05</b>                    | GPS configuration delay                         |
| 03   | --           | <b>03</b>                    | GPS configuration interval                      |
| 06   | --           | <b>02</b>                    | Tracking start flags                            |
| 07   | --           | <b>01</b>                    | Error message send                              |
| 10   | 0            | @@En..                       | Time RAIM setup (OnCore, Jupiter –T)            |
| 11   | 0            | @@At..                       | Position hold, site survey (OnCore, Jupiter –T) |
| 20   | 0            | @@Gd..                       | Position control message (M12+)                 |
| 21   | 0            | @@Gc..                       | PPS control message (M12+)                      |
| 22   | 0            | @@Ge..                       | Time RAIM algorithm (M12+)                      |
| 23   | 0            | @@Gc..                       | Time RAIM alarm message (M12+)                  |
| 30   | 0            | Binary                       | Quiet (Zodiac binary)                           |
| 40   | 0            | Binary #63                   | InitLink, quiet (SuperStar II)                  |
| 41   | 0            | Binary #81                   | Set mask angle (SuperStar II)                   |
| 42   | 0            | Binary #69                   | Set timing parameter (SuperStar II)             |
| 43   | 0            | Binary #80                   | Set operating mode (SuperStar II)               |

- Parameters in **bold** can be modified by the user
- Pos. \$01 is the User welcome message, that can be modified by the user and is stored in EEPROM.
- Pos. \$02 and \$03 Parameters are the delay, resp. the interval of time in second at witch the GPS configuration messages are sent out at Start up.
- Pos. \$06 is the location of the Tracking start flags. See "START OF THE TRACKING, EXPLICATIONS"
- Pos. \$07: 0:no "?" is sent out in case of unknown command.
- Pos. \$10-\$11 are GPS messages to configure an Oncore or Jupiter-T receiver for timing application.
- Pos. \$20-\$23 are GPS messages to configure an M12+ receiver for timing application.
- Pos. \$30 is a GPS message to make a Zodiac binary based receiver quiet.
- Pos. \$40-\$43 are GPS messages to configure a SuperStar II receiver for timing application.
- This command is best used with the program iSyncMgr.exe.

## Notes:

- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

Example : MCS01An user message **<CR>**, **MCA01 <CR>** send the following message after start : An user message **<CR><LF>**



**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  
       ????: 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
- \* Warning : This command is acting into non volatile memory. Numbers of commands sent during the whole unit life time limited to 100'000 in total (all commands cumulated).

**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: **dddddd<CR><LF>**  
           dddddd: Time constant in s

**FREEZExx<CR>[<LF>]** : Freeze thermal correction always. Freeze frequency during tracking.

xx: mode.  
       00: no freezing.  
       01: Tracking state -> Holdover state. Frequency is kept.  
       02: Tracking state -> Holdover state. Integral part of frequency in use.  
       04: Thermal correction is no more active.  
       ?? interrogation.

Answer: **xx**: Freeze status.

Notes:

- With FREEZE01, there is no frequency jump when going in holdover.
- The arguments be can added. FREEZE05 is allowed. FREEZE03 is the same like FREEZE01.
- FREEZE01/02 is cancelled when the tracking is stopped by TR0 or by the pin 15 /Track high.

Example: **FREEZE??<CR>**, answer **00<CR><LF>**.

**RA sddd<CR>[<LF>]** : raw phase adjust  
 sddd: raw phase adjust in 133 ns steps  
       +127: highest adjust  
       -128: lowest adjust  
       ????: 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 don't move the PPSOUT pulse and don't modify the reading of BT1 or BT3
- This command have an influence on the delay value, command DE dddddddddd, as the delay is in fact referenced to PPSINT

Example : **DE????????? <CR>**, answer **000000000<CR><LF>** . Now we do **RA+003**, answer **+003<CR><LF>**. And then we do **DE????????? <CR>**, the answer is **999999850<CR><LF>**



**RAQUIK<CR>[<LF>]** : this command quickly align PPSINT to PPSREF

Answer: **+000<CR><LF>**

**Warning:**

- This command can strongly degrade the initialisation and current value of some parameters
- This command can be useful when the device is used as 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 initialised correctly after the use of this command

**RESET<CR>[<LF>]** : this command reset the SXO micro controller

Answer: (Standard identification and welcome messages, may be followed by GPS configuration binary)

## 4.7 NMEA PROPRIATARY FORMAT

Since software Version 1.09, the SynClock+® is able to give out once per second NMEA 0183 proprietary format messages. This behavior is activated by the command BTx.

DATE, TIME, COUNTER:

**\$PTNTA,yyyymmddhhnnss,q,T3,rrrrrrrr,sfff,x,y\*cs<CR><LF>**

Activated by BTA<CR><LF>

yyyymmddhhnnss: year, month, day, hour, minute, second  
 q: timing quality indicator, 0: Rb line not locked, 1: Free Run, 2: Disciplined  
**T3**: format of the following 5 data. **T3** means:  
 rrrrrrrr: time interval PPSREF vs PPSOUT, from 000000000 to 999999950 in ns. Rounded to 50 ns.  
 sfff: phase comparator, from -511 to +512, in approx. ns  
 s: general SXO status  
 x: don't care, for future use  
 y: don't care, for future use  
 cs: checksum in hexa, xor of the characters between \$ and \*

Example: **\$PTNTA,20040130160834,2,T3,000000000,+019,3,,\*16<CR><LF>**

FREQUENCIES, TRACKING LOOP PARAMETERS

Activated by BTB<CR><LF>

**\$PTNTS,B,s,ffff,iiii,aaaa,x,y,s,cccccc,ggg.gg,x,y\*cs<CR><LF>**

s: general SXO status  
 ffff: actual frequency offset, signed hexa, steps of  $5.12 \cdot 10^{-13}$   
 iiii: integral part of tracking loop, signed hexa, steps of  $5.12 \cdot 10^{-13}$   
 aaaa: average frequency on 24 hours, signed hexa, steps of  $5.12 \cdot 10^{-13}$   
 x: don't care, for future use  
 y: don't care, for future use  
 s: loop time constant mode 0: fixed value, 1: automatic  
 cccccc: loop time constant in use, from 001000 to 999999 seconds  
 ggg.gg: sigma (1s) of PPSRef in approx. ns.  
 x: don't care, for future use  
 y: don't care, for future use  
 cs: checksum in hexa, xor of the characters between \$ and \*

Example:      `$PTNTS,B,3,00B3,00BA,00C1,,,1,001000,000.00,,*12<CR><LF>`

And:

`$LOZDA,hhnnss,dd,mm,yyyy,x,y*cs<CR><LF>`    Equivalent to GPS `$GPZDA,..`  
Activated by BTZ<CR><LF>

hh:    hours  
nn:    minutes  
ss:    seconds  
dd:    day  
mm:    month  
yyyy:   year  
x,y:    no use  
cs:    checksum in hexa, xor of the characters between \$ and \*

Example:      `$LOZDA,120058,22,10,2004,,*41<CR><LF>`

#### 4.8 CONNECTING A PPSREF TO THE SXO

The SXO PPSREF input is equipped with a simple CMOS buffer. The PPSREF signal should swing between 1 V and 3 V with abrupt enough edges. To connect a PPSREF to the device, a simple shielded cable should be enough for distances up to 2 m. For longer distances, up to 10 m, a transmission cable is recommended. As the device input needs enough voltage level, it is not possible to match the impedance on both sides of the cable. So it is recommended to match the impedance only on the side of the PPSREF source with a resistor in serial. The splitting of the cable to feed another PPSREF receiver is to be avoided absolutely. For distances longer than 10 m, a line receiver is recommended.

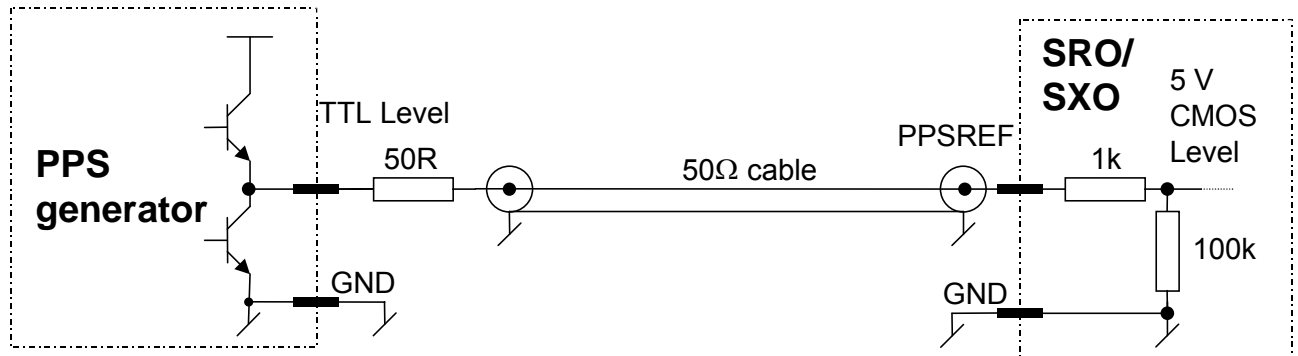


Figure 4-3 This schematic is recommended to connect a PPSREF to the SXO on distances up to 10 m.