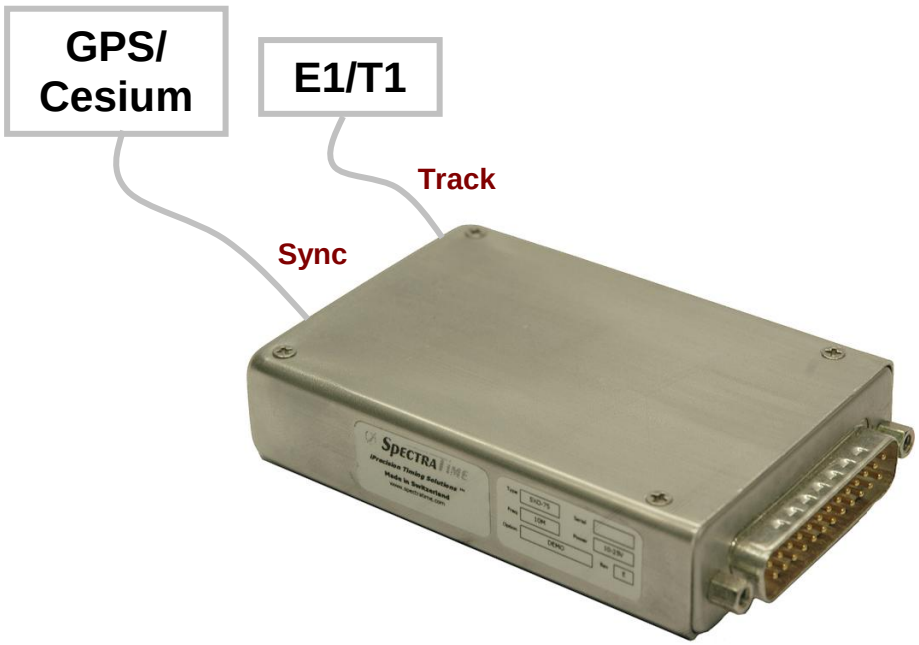
iSync+® Smart SXO SynClock+® Spec

Version 1.19 (7th March 2011)
Ver. D

Low-Cost GPS/E1/T1/Cesium-Synchronized Crystal Clock (SXO-75)

Patented SXO-75 SynClock+®

Auto-Adaptive SmarTiming+® Disciplining & Filtering @ 1ns Resolution



APPLICATIONS

Telecom | Navigation | Broadcast | Defense | Instrument

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KEY FEATURES

Smart SXO-75 SynClock+®:

- Single power supply voltage : 10 to 25V
- Very small volume : 5.5 in^3
- Frequency offset over temp. range : ≤ ±5E-10
- Industry's first SmarTiming+® technology
  - REF locking resolution : 1ns
  - REF disciplining/filtering/controlling : Auto adaptive(a)
    - Smart loop time constant : 100-10'000s
    - E1/T1 jitter & wander : ITU-T G.823/824
  - REF locking mode (user settable) : Sync(b) or Track(c)
  - REF types (PRS(d)/Stratum 1 source) : GPS, Cesium, E1/T1, LORAN-C, Maser
  - OUT frequency accuracy/stability
    - PRS(d)/Stratum 1 locked : 1E-12, typical
    - Holdover (no PRS(d)) : <1E-10/24hr
  - OUT time accuracy/stability
    - GPS locked : <50ns
    - Holdover (no GPS) : <7μs/8 hr or <10μs/24 hr
  - Standards compliance:
    - PRS(d) locked/unlocked : ANSI T1.101, Stratum 1/2/TNC/3E, GR-1244 ITU-T G.811/G.812, PRC, Type I/II/III/V CDMA IS-95, UMTS 3GPPS 25.104
- Low warm-up current : <0.8A/24V heater current
- Ultra low aging : <1E-11/day
- Ultra low phase noise output : 10MHz –120dBc @ 10 Hz
- Synthesized output : 1-30 MHz
- RS232 standard interface : Control & monitoring commands, 9600 b/s

Notes

(a) *Request our **SmarTiming+® Technology White Paper** to compare performance at SynClock@spectratime.com*

(b) *REF/OUT phase alignment*

(c) *REF/OUT frequency alignment*

(d) *PRS: Stratum 1 Primary Reference Source such as* GPS, Cesium, E1/T1, LORAN-C, Maser

REVISION TRACKING LIST

Software Revision :			Hardware Revision :
Date	**Version**	**Comment**	
2005-04-28	2.09	SXO Software. For new controller.	2005-01-13 (C)

SPECIFICATIONS

ELECTRICAL

Spec	Smart SXO-75 SynClock+®	
Type	**Standard**	**Options**
RFOUT Frequency	10 MHz	
Synthesizer Output Frequency	Not applicable	2.048 MHz, 1.544 MHz, etc RFOUT not available **(ordering code: 2.048M or 1.544M)** RFOUT available** **(ordering code: 10M/2.048M or 1.544 M)** *** degraded spurious & sub-harmonics levels*
Frequency Change Operating temperature range *(Thermal chamber with air flow)*	≤ ±5E-10 –5°C to +60°C	
Aging *(After 3 months of continuous operation)*	< 1E-10 /day (typical: 4·E-11/day)	
Short Term Stability 1 to 100 s	< 2E-11	
Phase Noise (dBc/Hz) *(RFOUT 10 MHz)* 1 Hz 10 Hz 100 Hz 1k Hz 10K Hz	10 MHz -90 -120 -135 -145 -150	
Frequency Retrace Off/On *(In stable temperature, gravity, pressure & magnetic field conditions)*	< 1E-8 24 hr / 1 hr	
Warm-up Time @ +25°C Frequency stability	15 min < 5E-8	
Analog Frequency Adjustment *[An external voltage (0-5 VDC) can be applied to pin 6 (FA). The cursor pin of a 10 kΩ variable resistor placed between pin 7 and GND can provide this voltage. If not used, pin 6 must be floating]*	> 4E-7 (±2E-7)	
Digital Frequency Adjustment *(Through RS-232 commands)*	> 4E-7 (±2E-7)	
RFOUT Levels Output Spurious f_0 ± 100kHz Sub-harmonics	Sine wave 0.5 VRms (± 10% / 50Ω) < -80dBc ** < -60dBc ** *** Not applicable when both RFOUT & synthesizer outputs are available*	
Synthesizer Option Output level Frequency range Spurious Frequency resolution	Not applicable	**For optional frequency only** Square wave CMOS 5V 1 to 30 MHz (factory setting) -80dBc 1 KHz
Supply Voltage (DC) Max Power Supply Ripple	10 to 25 V < 50 mV peak to peak (from 1Hz to 1 MHz frequency band)	
Input Power Warm up @+25°C - 5°C +25°C +65°C	Typical < 12 W @ 12 V & < 16 W @ 24 V < 8 W < 6 W < 3 W	
Communication Interface Protocol speed Compatible with	RS-232 commands for control & monitoring (see commands below) Timing and locking control functions VMGA messages 9600, n, 8, 1 SRO model	

SMARTIMING+® DISCIPLINING & FILTERING

Spec	Smart SXO-75 SynClock+®		
PPSREF Level Reference types Disciplining & filtering Disciplining mode Architecture Model	CMOS 0-5V or 0-3.3V rising edge GPS, E1, T1, Cesium, LORAN-C, Maser, etc Auto-adaptive through SmarTiming+® technology (request white paper) Sync (phase alignment) or Track (frequency alignment) See Principles of Operation below		
GPS Receiver Comm. Interface GPS control & monitoring T-RAIM Position hold	Multi-vendor GPS support Pins 12 & 16 Serial Interface (see pin-out info below) Continuous monitoring for optimum timing, if supported by GPS User settable for optimum timing, if supported by GPS		
PPSOUT Output Level Current	CMOS 0-5V ± 20 mA sink/source		
PPSOUT Pulse Width (PW) Duty cycle	User settable 0 to 1s in 50 ns/step		
PPSOUT to PPSREF Sync Error Conditions (Sync mode)	< 50 ns No PPSRef noise, ± 1°C temp fluctuations		
PPSOUT to PPSREF (DE) Programmable delay (Track mode)	0 to 1s 50 ns / step		
PPSOUT Holdover Time Stability Temperature window *(After learning phase > 10 τ)*	< 10µs / 24 hr Within ±2°C	< 7µs / 8 hr Within 40°C	< 4µs / 6 hr Within 20°C
Smart Loop Time Constant Phase/Frequency User settable	Auto-adaptive 100 to 10'000 sec Sync/Trak mode RS-232 command interface		

ENVIRONMENTAL

Spec	Smart SXO-75 SynClock+®
Magnetic Field Sensitivity	< $2 \cdot 10^{-10}$ / Gauss in worst axis
Storage Temperature	- 55°C to + 85°C
Humidity	GR-CORE-63, Section 5.1.2
Operating Vibration	GR-CORE-63, Section 5.4.2 Random and Sinusoidal MIL-PRF-28800F, Class 3, 4
Shock	Survival: 40g / 11ms
G-Tip-Over Test	< 5E-10 / g in worst axis
Altitude	Max 15'000 m / 49'212 ft

PHYSICAL

Spec	Smart SXO-75 SynClock+®
Size (L x W x H)	3.25" x 2.25 " x 0.75" (82.55 x 57.15 x 19.05 mm)
Weight	200 g (7.1 oz)
Mounting & Mechanical Layout	See drawings below
Connector Compatible with	Male D-sub 25 pins (see drawing below) SRO model

MODEL ORDERING INSTRUCTIONS

SXO-75 / XX / XX / 10M

↓ ↓ ↓ ↓

Type Option(s) Frequency (standard)

EXECUTIVE PRINCIPLES OF OPERATION

SmarTiming+® SXO SynClock+®

The smart SRO/SXO SynClock+® uses SmarTiming+® technology. It auto-adaptively locks multi-vendor Stratum-1 references such as GPS, Cesium, LORAN-C, CDMA and E1/T1 at industry's first 1ns resolution for the highest performance level, and generates a perfectly aligned 1PPS output signal (PPSOUT) and time of day (TOD) information.

As illustrated in Fig. 1 below, the smart SXO has two basic modes of operation: "Track" and "Sync". "Track" is used for frequency alignment while "Sync" is used for phase alignment applications.

In "Track" mode, the smart SXO uses an external PPS reference (PPSREF) to align the frequency of the SXO. The frequency alignment is computed by an internal phase-time error signal that is generated by an internal PPS signal (PPSINT), which measures the signal at 1ns resolution through its SmarTiming+® technology. The PPSINT then aligns the PPSREF phase.

In the "Sync" mode, the smart SXO phase aligns the PPSOUT to the PPSREF with the PPSINT reference signal, which uses SmarTiming+® algorithm to 1) compare the PPSOUT and PPSREF signals at 1ns resolution within a ± 500ns dynamic range and 2) auto-adaptively align them.

The smart SXO has also the capability to dynamically analyze the stability of the PPSREF signal through the excellent short-term frequency stability of the internal high end crystal resonator. Thus, the 1PPS reference of a Stratum-1 source such as GPS can be directly fed to smart SXO without specific analysis of the internal optimization parameters of the GPS engine - i.e., number of satellites in view, signal to noise ratio, etc.

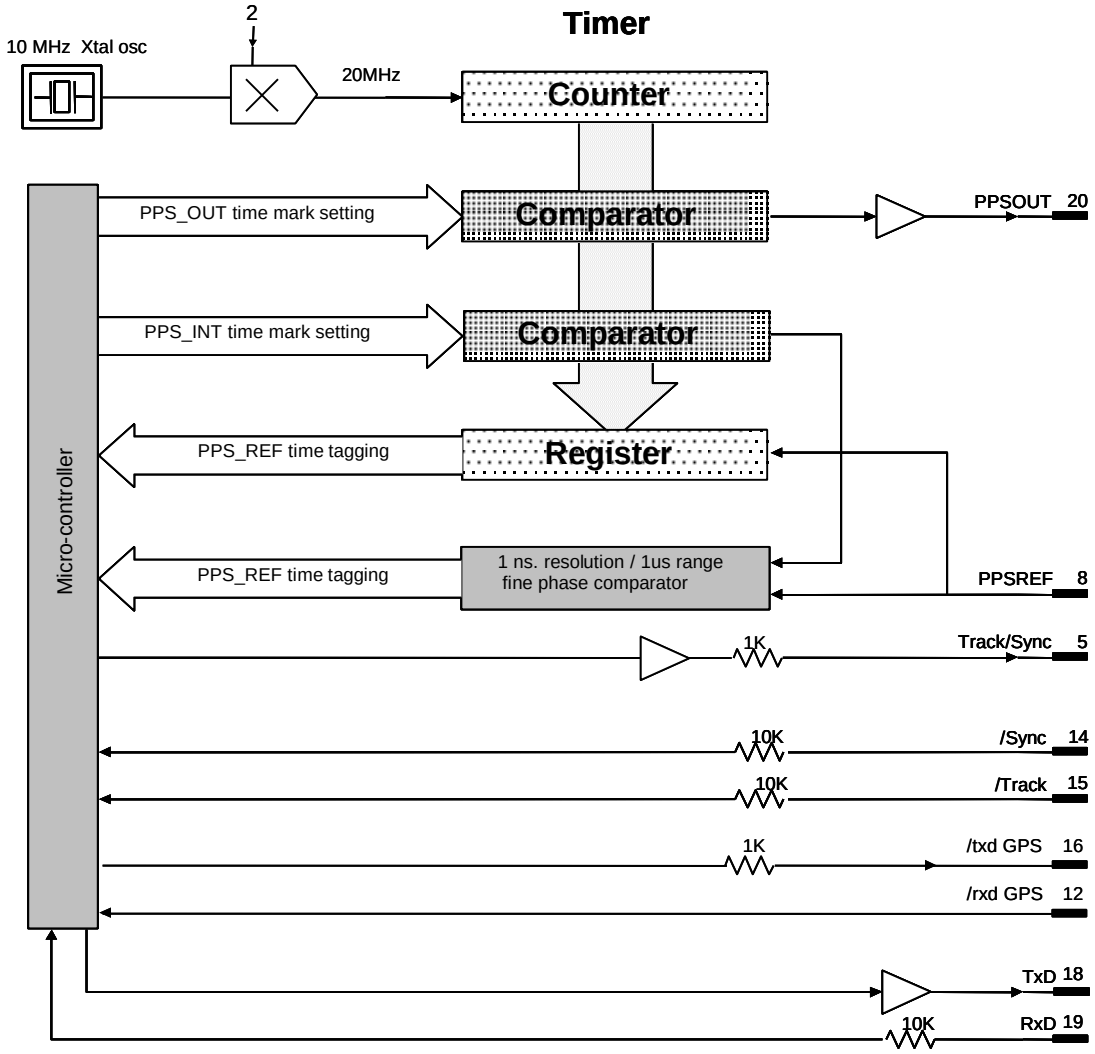


Fig.1: SmarTiming+® Control Block Diagram

As illustrated in Fig. 2 below, the “Track” mode aligns the PPSINT to the PPSREF within 50ns. After about 10τ , the PPSINT is perfectly aligned to the PPSREF.

The smart SXO is also capable to perfectly align the PPSOUT to the PPSREF or to adjust the PPSOUT from 0-1s with a 50ns resolution. This time adjustment can be programmed through the RS232 interface. After a descending edge of the “Sync” signal, the PPSOUT will be aligned to the PPSREF (see figure 2).

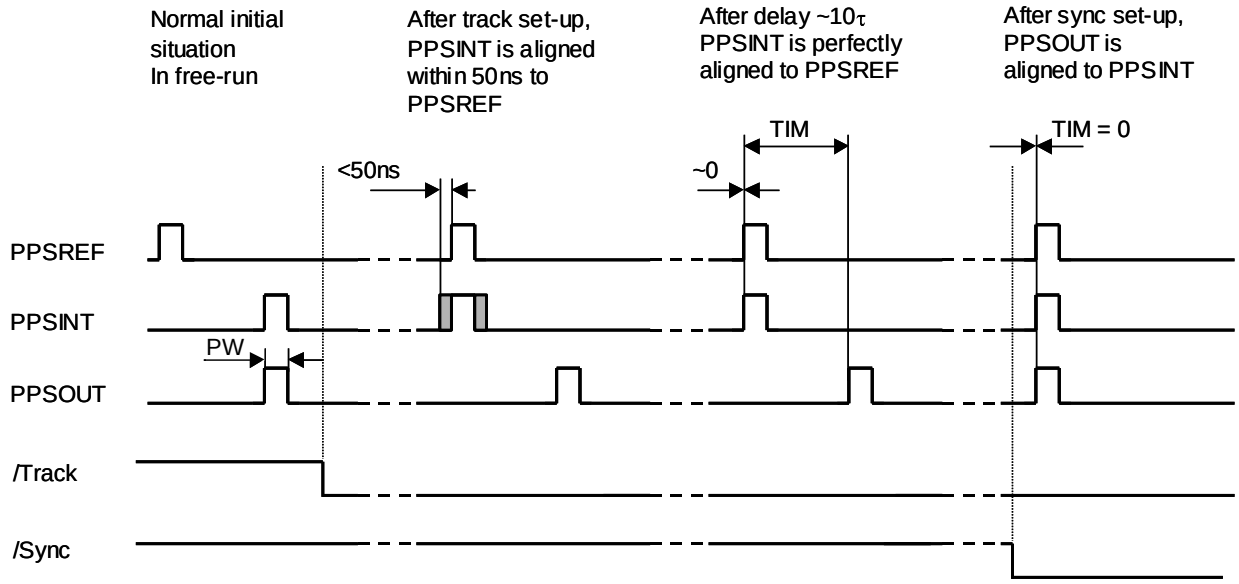


Figure 2 : "Track" mode and "Sync" mode

STANDARD RS-232 CONTROL & MONITORING COMMANDS

Frequency Adjustment & Monitoring Functions

The operating and monitoring parameters of the smart SXO SynClock+® are accessible for read and write operations through the serial RS-232 port (9600 bits/sec., no parity, 1 start bit, 8 data bits, 1 stop bit).

There are 2 basics commands as follows: *M* and *Cxxxx*

M<CR><LF> : monitors the basic internal signals of the atomic clock.

The returned answer is:
***HH GG FF EE DD CC BB AA* <CR> <LF>**
Of which 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

***Cxxxx*<CR><LF> *** : output frequency adjustment through a DAC, by steps of approx. $6 \cdot 10^{-12}$, where xxxx is a signed 16 bits word in hexa coded ASCII. This value is automatically stored in a EEPROM as last frequency which is applied after RESET or power-ON operation.
In Track mode this command is not active. The command **FC**sddddd does the same, but the data format is different.
***** 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).

Timing & Locking Control Functions:

Using the same data interface, the smart SXO SynClock+® models can accept the following basic ASCII commands: Data is in decimal ASCII code.

Command name	Syntax command	Data field (if any)	Response syntax	Response data (if any)
Identification	**ID**<CR><LF>	-	**TNTSXO-**aaa**/**rr**/**s.ss <CR><LF>	aaa: 075 if SXO-75 rr: revision number s.ss: software version
Serial number	**SN**<CR><LF>	-	xxxxxx<CR><LF>	xxxxxx : 6 digits serial nbr
Status	**ST**<CR><LF>	-	**s**<CR><LF>	s:Status s=0 :warming up s=1 :tracking set-up s=2 :track to PPSREF s=3 :synch to PPSREF s=4 :Free Run. Track OFF s=5 :PPSREF unstable(hldovr) s=6 :No PPSREF(holdover) s=7 :factory used s=8 :factory used s=9 :fault
Set Tracking PPSINT - PSSREF	**TR**x<CR><LF> *	x=0 : Track never * x=1 : Track now x=2 : Track ever * x=3 : Track now + ever * x=? : Interrogation	x<CR><LF>	x:Tracking commands status x=0 : Track OFF x=1 : Track ON (when Status 0 -> 4
Set Synchronisation PPSOUT – PPSINT	**SY**x<CR><LF> *	X=0 : Synch. never * x=1 : Synch. now x=2 : Synch. ever * x=3 : Synch. now + ever * x=? : Interrogation	x<CR><LF>	x:Sync. commands status x=0 : Synch. OFF x=1 : Synch. ON (When Status 1 -> 2)
Set PPSOUT delay (rounded to 50ns)	**DE**ddddddddd<CR><LF>	ddddddddd=delay in ns. Max 999999950 **DE**000000000 :synch to PPSREF	ddddddddd<CR><LF>	ddddddddd=delay in ns. Min 000000050 Max 999999950
Set PPSOUT Pulse Width (rounded to 50ns)	**PW**ddddddddd<CR> * <LF>	dddddddd=pulse Width by 1ns step. Max 999999950 **PW**000000000: no pulse	ddddddddd<CR><LF>	ddddddddd=Pulse Width by 1ns step. Max 999999950 000000000: no pulse
Time of day	**TD**<CR><LF>	-	hh:mm:ss<CR><LF>	hh:hours mm:minutes ss:seconds
Set time of day	**TD**hh:mm:ss<CR><LF>	hh:Hours mm:Minutes ss:seconds	hh:mm:ss<CR><LF>	hh:hours mm:minutes ss:seconds
Date	**DT** <CR><LF>		yyyy-mm-dd	yyyy : year mm : month dd : day
Set date	**DT** yyyy-mm-dd <CR><LF>	yyyy : year mm : month dd : day	yyyy-mm-dd	yyyy : year mm : month dd : day
Beat every second on serial port.	**BT**x<CR><LF>	x=0 : Stop beat x=1 : Effective Time interval PPSOUT vs PPSREF x=2 : Phase comparator x=3 : Both x=1 & x=2 x=4 : Beat Time of day x=5 : Beat status x=6 : Beat <CR><LF> x=7 : Beat Date, Time, Status x=A : Beat NMEA $PTNTA, x=B : Beat NMEA $PTNTS,B, x=Z : Beat NMEA $LOZDA,..	ddddddddd<CR><LF> or sppp<CR><LF> or ddddddddd sppp <CR><LF> or hh:mm:ss<CR><LF> s<CR><LF> <CR><LF> yyyy-mm-dd hh:mm:ss s	ddddddddd : delay in 1ns (rounded to 50 ns) sppp:phase error in ns s: +/- signe hh:hours mm:minutes ss:secondes s: status yyyy:year, mm:month,dd:day
Set frequency adjustment	**FC**sddddd<CR><LF> *	s=+/- signe ddddd = limited within range – 32768/+32767 (signed int) **FC** ?????? : interrogation	sddddd<CR><LF>	s: +/- signe ddddd : frequ. adj. in approx. $6 \cdot 10^{-12}$ step
Set frequency save. Integral part, when Status = 2, 3	**FS**x<CR><LF> *	x=0 : never save x=1 : save every 24 hours x=2 : save right now x=3 : save actual freq. now x=? : interrogation	x<CR><LF>	x=0 : never save x=1 : save every 24 hours

Command name	Syntax command	Data field (if any)	Response syntax	Response data (if any)
Set Tracking Window (rounded to 50ns)	**TW**ddddd**<CR><LF> ***	ddddd = Half Tracking Window in ns. From 00050 to 12750 ddddd = ????? : interrogation	ddddd<CR><LF>	ddddd : Half Tracking Window in ns.
Set no Alarm Window (rounded to 50ns)	**AW**ddddd**<CR><LF> ***	ddddd = Half no Alarm Window in ns. From 00050 to 12750 ddd = ????? : interrogation	ddddd<CR><LF>	ddddd : Half no Alarm Window in ns.
Set tracking phase loop time constant	**TC**dddddd**<CR><LF> ***	dddddd = Time constant in seconds (001000 to 999999) TC000000 : change to auto. (<)TC001000 : no change	dddddd<CR><LF>	dddddd : time constant in seconds
Set module customization	**MC**sxx [cc…c] **(*)** <CR><LF>	s = L : Load parameter s = S : Store parameter ccc..c* s = B : Load start behavior s = A : Activate msg at start * s = C : Cancel msg at start * s = H : Load Help s = T : Load Data Type xx = 00..FF: msg number, ccc…c : new welcome message, up to 24 characters	cc..c<CR><LF> or d<CR><LF> or xy<CR><LF>	ccc..c : response to MCLxx or to MCHxx. d : 0, 1 response to MCBdd or xy : Data Type, response to MCTxx, x=0 RAM, x=1 eeprom, x=2 Flash, y=0 Byte, y=1 sByte, y=2 Word, y=3 sWoord, … y=8 string ASCII, y=9 strng binary
Set phase comparator Offset	**CO**sddd *	s :+/- signe ddd : limited with range + 127 / - 128 CO???? : interrogation	sddd	s :+/- signe ddd : offset in approx 1 ns steps
View PPSRef Sigma	**VS**<CR><LF>		ddd.d<CR><LF>	ddd.d : Sigma of PPSRef in ns. In tracking, Status 2, 3.
View Time constant	**VT**<CR><LF>		dddddd<CR><LF>	dddddd : Loop time constant now in use, in ns.
Freeze thermal correction always Freeze frequency during tracking	**FREEZE**xx<CR><LF>	xx=00 : cancel xx=01 : keep frequency xx=02 : integral frequency xx=04 : no thermal correction xx=?? : interrogation	xx**<CR><LF>**	xx=00 : no freeze xx=01 : last frequency xx=02 : integral frequency xx=04 : no thermal correction
Raw phase adjust	**RA**sddd<CR><LF>	s :+/- signe ddd : limited with range + 127 / - 128	sddd <CR><LF>	s :+/- signe ddd : raw phase just asked in 50 ns steps
Reset micro controller	**RESET**<CR><LF>			(Identification & welcome message, GPS binary)

* Warning : These commands are 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 and SY1 followed by SY0 don't write in NVM.

Pins # 4 & 5 Status Levels			
Status	Pin # 4: SXO: NC, ever high	Track/Synch alarm Pin # 5	
		In Track Mode (TTL + 1K)	In Synch Mode (TTL + 1K)
s=0 :warming up		High	High
s=1 :tracking set-up		High	High
s=2 :track to PPSREF		**Low**	High
s=3 :synch to PPSREF		High	**Low**
s=4 :Free Run. Track OFF		High	High
s=5 :PPSREF unstable		High	High
s=6 :No PPSREF		High	High
s=7 :factory used		High	High
s=8 :factory used		High	High
s=9 :fault		High	High

NMEA 0183 Format (BTA, BTB, BTZ)

$PTNTA,yyyymmddhhnnss,q,**T3**,rrrrrrr,sfff,x,y***CS<CR><LF>**
yyyy: year; mm:month; dd: day; hh: hour; nn: minute; ss: second; q: quality, 0: Low, warming up, 1: Free Run, 2: Disciplined; T3: format descriptor; rrrrrrr: effective time interval PPSOUT vs PPSREF; sff: phase comparator; x,y: reserved; CS: checksum.

$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; iiii: integral part of PI regulator; aaaa: average frequency on 24 hours; x,y: reserved; cccccc: loop time constant; ggg.gg: sigma; x,y: reserved; CS: checksum.

$LOZDA,hhnnss,dd,mm,yyyy,x,y*****CS**<CR><LF>** (equivalent to GPS $GPZDA,..)
hh: hours; nn: minutes; ss: seconds; dd: day; mm: month; yyyy: year; x,y: no use; CS: checksum.

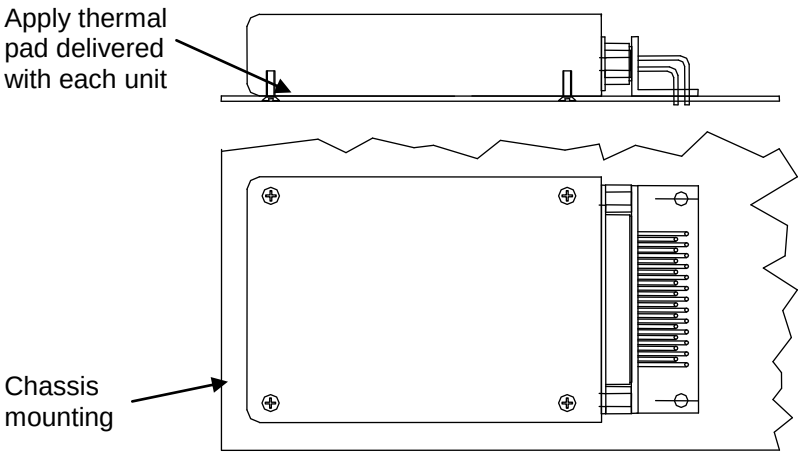
PIN-OUT INFORMATION

Pin #	Smart SXO-75 SynClock+®	*Compared to Smart SRO-100 SynClock+®*	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) / **NC** (standard version)	***Factory use***	NA
12	**/RxD 2**	***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 2**	***NC***	Output
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**(**10**MHz sinus 7dBm into 50Ω) / **NC** according to option	***RFOUT**(**5**, **10** or **15**MHz sin. 7dBm/50Ω)*	Output
25	**GND**	***GND***	Ret

MOUNTING & MECHANICAL LAYOUT

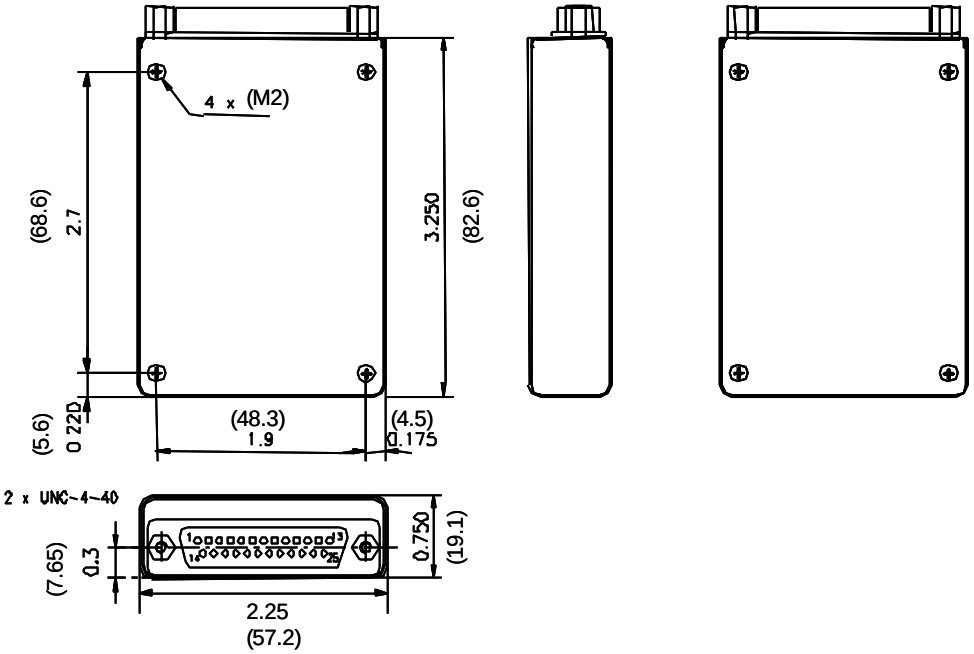
Mounting Description:

Heat sink options:
1) Mount the SXO on a copper ground PCB with the provided thermal pad or thermal paste in between and a base plate under the PCB
2) Mount the SXO against a system chassis using the 4xM2 screws with the provided thermal pad or thermal paste in between and wire bridge the D-Sub connector
3) Mount a radiator on top of the SXO with the provided thermal pad or thermal paste in between, if no base plate is available

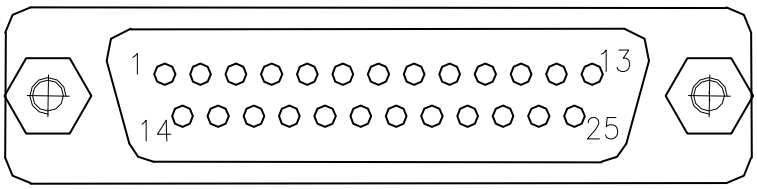


Mechanical Dimensions (SXO)

Not to scale. European drawing. Dimensions in inch (mm)



Connector Front View (SXO/SRO Compatible)



Male D-Sub 25 Pins