Smart Force-2020 SynClock+®

Next Gen High Performance. Very High Frequency. Ultralow Noise. Lower G-Sensitivity. Custom Vibration-Isolated Profile. Auto-Adaptive SmarTiming+® SAASM/Non-SAASM GPS/GNSS Disciplining Technology @ 1ns Resolution.

APPLICATIONS

High Dynamic Platforms | Tactical Helicopter | Tactical Airborne | Drone (UAV/UGV)
Shipboard | Ground Communications | Mobile Satcom | Tactical Aerial Radar

KEY FEATURES

- Frequency-disciplined outputs : 10MHz or 100MHz* (2 each)
  **Others up to 500 MHz upon request*
- Single power supply voltage : 16V ±1 VDC
- Compact size with a single or dual vibration-isolated trays : 6x5.7x1.1" *(a)*
  6x5.7x1.4" *(b)*
- Initial accuracy at power-on : +5E-8 (until OCXO locks to Rb)
- Frequency offset over temp. range : <1E-10 over 0°C to +50°C
- Short-term stability : 2E-11 at 1 sec
- Auto-Adaptive SmarTiming+® SAASM/Non-SAASM GPS/GNSS disciplining technology
  - REF input : 1PPS from SAASM/Non-SAASM GPS/GNSS
  - REF locking resolution : 1ns
  - REF disciplining/filtering/controlling : Auto adaptive depending on the REF signal quality
    - Smart loop time constant : 270-100,000s
  - REF locking mode (user settable) : Sync or Track
  - REF types (PRS/Stratum 1 source) : GPS, Cesium, E1/T1, eLoran, Maser
  - OUT-disciplined time : 1PPS (2 each)
  - OUT frequency accuracy/stability
    - PRS/Stratum 1 locked : 1E-12, typical
    - Holdover (No PRS) : <5E-11/month
  - OUT time accuracy/stability
    - GPS locked : <50ns
    - Holdover (no GPS) : <2µs/48hrs or <1µs/24hrs
- Power : 34W during warm-up
  15W after warm-up at 25°C
- Warm-up time : <10 min, setting time <30 min *(a)*
  <12 min, setting time <30 min *(b)*
- Ultralow aging : <5E-11/ month
- Ultralow phase noise output (dBc/Hz) :

	10 MHz *(a)*	10 MHz *(b)*	100 MHz *(a)*
Static @ 1Hz[a]	-105	-105	-70
Under vibration profile @ 1Hz[a]	-85*	-85*	-64*

  [a]*Unmeasured* **internal 50Hz isolation*
- Vibration profile : 0.01 g^2/Hz random, 10-2000 Hz**
  ***Custom vibration profile available upon request*
- RS232 standard interface : Control & monitoring commands, 9600 b/s
- Weight : ≤ 3 lbs *(a)*
  ≤ 4 lbs *(b)*

Notes:
(a) With a single vibration-isolated OCXO tray
(b) With dual vibration-isolated Rb & OCXO trays for high shock level applications

REVISION TRACKING 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 <17W
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	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 Page 11, pinout description with additional information	

SPECIFICATIONS

ELECTRICAL

Spec	Smart Force-2020 SynClock+®	
Type	**Standard**	**Options**
RFOUT Frequency Number	10 MHz 2	100 MHz **(ordering code: 100M)** 2 Others: up to 500 MHz* **Spec not included below. Spec below is for the 100M option*
Frequency Offset Operating temperature	<1E-10 0°C to +50°C	<1E-10 0°C to +50°C
Frequency Accuracy @ Shipment	< 5E-11 (+25°C), typical	
Initial Accuracy at Power-On	±5E-8 until OCXO locks to Rb	
Aging (Free Running Freq. Stability)	< 5E-11 / month after 30 min settling time	
Short Term Stability 1s 10s	 2E-11 2E-11, typical	 5E-11 5E-11, typical
Phase Noise (dBc/Hz) *(RFOUT)* 1 Hz 10 Hz 100 Hz 1k Hz 10K Hz	Static / Under Vibe Profile** -105* / -85* -135 / -95 -155 / -125 -164 / -164 -165 / -165 **Not measured* ***Internal 50Hz isolation*	Static / Under Vibe Profile** -70* / -64* -100 / -74 -130 / -100 -155 / -143 -176 / -172 **Not measured* ***Internal 50Hz isolation*
Warm-Up Time Settling time	Single Anti Vibe* / Dual Anti Vibe** < 10 min / < 12 min < 30 min / < 30 min *OCXO **Rb & OCXO	Single Anti Vibe* < 10 min < 30 min
RFOUT Output level Output impedance Harmonics Spurious	 +10 dBm (±2 dB) 50 ohms < -30dBc < -80dBc	
Input Power Warm-up @+25°C (typical) +25°C Supply	 34 W 15 W 16V ±1 VDC	
Communication Interface **RS-232** Protocol speed	 See commands for control & monitoring below, including timing & locking control functions VMGA messages 9600, n, 8, 1	

SMARTIMING+® GPS/GNSS DISCIPLINING & FILTERING

Spec	Smart Force-2020 SynClock+®
PPSREF (1PPS Input) Number Level Pulse width (Logic High) Rise / Fall time Load impedance Reference types Disciplining & filtering Disciplining modes Architecture model	 1 +2 min to 5.5 VDC max (Logic High) 0V min to 0.8 VDC max (Logic Low) 20µs (±1µs) < 20ns / 1µs (10-90%) 50 ohms (nominal) GPS, E1/T1, Cesium, eLoran, Maser Auto-adaptive thru the SmarTiming+® technology (request Whitepaper) Sync (phase alignment) or Track (frequency alignment) See Manual

PPSOUT (1PPS Output) Number Startup time Level Pulse width (Logic High) Rise / Fall time Input to output offset & jitter	2 10s to 1PPS output CMOS 0-5V 400µs max (±40µs supply) < 5ns / < 50ns (20-80%) < 70ns (±2ns) & ±5ns jitter		
BIT OUTPUTS (TTL Compatible) PLL lock 1PPS lock	Status "0" is locked Status "1" is locked & ready		
PPSOUT Holdover Time Stability Temperature window *(After learning phase > 10 τ)*	< 1µs / 24 hrs Within ±2°C	< 3µs / 24 hrs Within 20°C	< 7µs / 24 hrs Within 40°C
Smart Loop Time Constant Phase/Frequency User settable	Auto-adaptive 280 to 100,000 sec Sync/Trak mode RS-232 command interface		

ENVIRONMENTAL

Spec	Smart Force-2020 SynClock+®	
Vibration	Lock acquisition & lock holding MIL-STD-810F, Table 514.5C-6, General Exposure	
Operating Vibration Profile	0.01 g^2/Hz random, 10-2000 Hz	Custom profile available upon request (duration, amplitude, frequency range)
Dynamic Phase Perturbations	Custom profile available upon request (x degree per y interval under given vibration, temp & shock profiles)	
Low g-sensitivity	Custom profile available upon request (e.g.: 2E-10/g per axis)	
Operating Temperature	0°C to +50°C	
Exposure Temperature	Normal operation after exposure from -40°C to +55°C	
Operating & Non-Op Pressure	0.82 to 15.10 psia	
Humidity, Salt Fog	Conformal coat PCBs, 0 to 90%, condensing	
Operating Altitude	Sea level up to 50,000 ft (15.24 Km)	

SCREENING

Spec	Smart Force-2020 SynClock+®	
Non-Operating Vibration	MIL-HDBK-2164, Figure 3, Z axis	
Non-Operating Thermal	MIL-STD 202G, Method 107, Cond A, 1 hour dwell	
Operating Shock	30g, 11ms, half sine	Custom profile available upon request (g, duration, # of pulse, pulse format)

PHYSICAL

Spec	Smart Force-2020 SynClock+®
Size (L x W x H) Single tray* (OCXO) Dual trays* (Rb & OCXO) **Vibration-isolated*	 6" x 5.7 " x 1.1" (152.4 x 144.7 x 27.9 mm) 6" x 5.7 " x 1.4" (152.4 x 144.7 x 36.8 mm)
Mounting	Helicoil, #4-40 (0.224" deep), on base, 4 places
Connectors	RF input / outputs: SMA (f) Power & monitoring: two 9-pin D-subs
Weight Single tray* (OCXO) Dual trays* (Rb & OCXO) **Vibration-isolated*	 ≤3 lbs (1.36 Kg) ≤4 lbs (1.81 Kg)
Mechanical Layout	See drawings below

MODEL PN ORDERING INSTRUCTIONS

PN: Force-2020 / XX (XX: options)

STANDARD RS-232 CONTROL & MONITORING COMMANDS

Frequency Adjustment & Monitoring Functions

The operating and monitoring parameters of the Force-2020 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, which are *M*, *Cxxxx*

M<CR><LF>: monitors the basic internal signals of the atomic clock.
The returned answer looks 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 2 (0 to 5V)
GG: reserved
FF: peak voltage of Rb-signal (0 to 5V)
EE: DC-Voltage of the photocell (5V to 0V)
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

*Cxx*xx<CR><LF> *****: output frequency adjustment through the synthesizer, by steps of 5.12×10^{-13} , 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 correction is not in use. The function **FC**sddddd do 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 10'000 in total (all commands cumulated).

Timing & Locking Control Functions

Using the same data interface, the smart Force-2020 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>	-	**TNTSRO-**aaa/rr/s.ss <CR><LF>	aaa: 100 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 :FR. PPSREF unstable s=6 :FR. No PPSREF s=7 :factory used s=8 :factory used s=9 :fault or Rb OOL
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 9 -> 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	**DE**ddddddd<CR><LF>	ddddddd=delay by 133ns step. Max 7499999 **DE**0000000 :synch to PPSREF	ddddddd<CR><LF>	ddddddd=delay by 133ns step. Max 7499999
Set PPSOUT Pulse Width	**PW**ddddddd<CR><LF> *	ddddddd=pulse Width by 133ns step. Max 7499999 **PW**0000000: no pulse	ddddddd<CR><LF>	ddddddd=Pulse Width by 133ns step. Max 7499999 0000000: 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,	ddddddd<CR><LF> or sppp<CR><LF> or ddddddd sppp <CR><LF> or hh:mm:ss<CR><LF> s<CR><LF> <CR><LF> yyyy-mm-dd hh:mm:ss s	ddddddd : delay in 133ns step 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 : +32767/-32768 **FC** ?????? : interrogation	sddddd<CR><LF>	s: +/- signe ddddd : frequ. Adj. in 5.12×10^{-13} step

Command name	Syntax command	Data field (if any)	Response syntax	Response data (if any)
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
Set Tracking Window	**TW**ddd**<CR><LF> ***	ddd = Half Tracking Window by 133ns step. From 1 to 255 ddd = ??? : interrogation	ddd<CR><LF>	ddd : Half Tracking Window by 133ns step.
Set no Alarm Window	**AW**ddd**<CR><LF> ***	ddd = Half no Alarm Window by 133ns step. From 1 to 255 ddd = ??? : interrogation	ddd<CR><LF>	ddd : Half no Alarm Window by 133ns step.
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 behaviour 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<CR><LF> *	s :+/- signe ddd : limited with range + 127 / - 128 CO???? : interrogation	sddd<CR><LF>	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.
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 133 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 10'000 in total (all commands cumulated)
But TR1 followed by TR0 and SY1 followed by SY0 don't write in NVM

PIN # 4 & 5 STATUS LEVELS			
Status	**Pin # 4** Xtal not locked to Rb line	**Pin # 5** Track/Synch alarm	
	Rb lock (open collector)	In Track Mode (TTL + 1K)	In Synch Mode (TTL + 1K)
s=0 :warming up	Low (<.2 V / 5 mA)	High	High
s=1 :tracking set-up	High	High	High
s=2 :track to PPSREF	High	**Low**	High
s=3 :synch to PPSREF	High	High	**Low**
s=4 :Free Run. Track OFF	High	High	High
s=5 :FR. PPSREF unstable	High	High	High
s=6 :FR. No PPSREF	High	High	High
s=7 :factory used	High	High	High
s=8 :factory used	High	High	High
s=9 :fault or Rb OOL	Low (<.2 V / 5 mA)	High	High

NMEA 0183 Format (BTA, BTB)

$PTNTA,yyyymmddhhnnss,q,**T3**,rrrrrrr,sfff,s,x,y***CS<CR><LF>**
yyyy: year; mm:month; dd: day; hh: hour; nn: minute; ss: second; q: quality, 0: Rb line not locked, 1: Free Run, 2: Disciplined; T3: format descriptor; rrrrrrr: effective time interval PPSOUT vs PPSREF; sfff: phase comparator;s: Status; x,y: reserved; CS: checksum.

$PTNTS,B,s,ffff,iiii,aaaa,x,y,s,cccccc,ggg.gg,x,y***CS<CR><LF>**
s: Status; ffff: actual frequency; iiii: holdover frequency; aaaa: average frequency on 24 hours; x,y: reserved; cccccc: loop time constant; ggg.gg: sigma; x,y: reserved; CS: checksum.

MECHANICAL LAYOUT

Mechanical Layout & Dimensions

All dimensions in inch ["] and the pictures are not to scale.

(a) With a single vibration-isolated OCXO tray: 6 x 5.77 x1.1"
(b) With dual vibration-isolated Rb & OCXO trays for high shock level applications: 6 x 5.77 x1.45"