October 29, 2019

Smart, Low-Cost & High-Performance GPS & Rubidium Reference Source

GPSReference™-2000

Smart GPS & SRO Rubidium Primary Reference Source

SmarTiming+® 1ns-Resolution Disciplining Technology Inside

APPLICATIONS

Synchronization | Timing | Reference/Test Source | Time/Frequency Source

KEY FEATURES

- Integrated GPS receiver & SRO Rb clock
- Integrated GPS disciplinable SRO Rb clock using SmarTiming+® technology at 1ns resolution
- Output Frequencies (4x 10MHz / 4x 1PPS or 8x 10 MHz)
- User programmable SYNTH output
- Integrated smart auto calibration
- Internal Bit Alarm
- RS232 standard interface (9600 b/s)
- Windows XP, seven software application
- GPS antenna types (patch or rooftop)
- Power supply voltage (AC input 85-264VAC / 47-63Hz)
- Compact 1U rack mountable chassis

SPECIFICATIONS

ELECTRICAL

Spec	GPSReference-2000	
Reference module	**Standard**	**Options**
RFOUT Frequency Number of Output	10MHz 4x backplane 1x faceplate	10MHz 8x backplane 1x faceplate **(ordering code: 8RF**)
PPSOUT Functionality Number of Output	1PPS See SMARTIMING+ 4x backplane 1x faceplate	1PPS See SMARTIMING+ **(ordering code: 8RF**) 1x faceplate
Short Term Stability 1s 10s 100s	1E-11 3E-12 1E-12	
Phase Noise (dBc/Hz) *(RFOUT: 10 MHz)* 1Hz 10Hz 100Hz 1kHz 10kHz	 -80 -100 -125 -145 -145	
Aging *(Measured after 3 months of continuous operation)*	< 5E-11 / month *(typical: 3E-11 / month)*	
Frequency Retrace Off/On *(In stable temperature, gravity, pressure and magnetic field conditions)*	< 5E-11 24 hr / 1 hr	
RFOUT Levels Output Impedance Harmonics Spurious $f_0 \pm$ 100kHz (SYNTH Off)	 Sine wave, 0.5 Vrms (±10% / 50 Ω), 1x faceplate **Sine wave, 1.0 Vrms (±10% / 50 Ω), 4x backplane **(** ordering code: 8RF 8x**)** 50 Ω ±20% < -25dBc < -80dBc	
SYNTHESIZER (SYNTH) Output level Frequency range Resolution Spurious	 Square wave 3.3V LV CMOS 0 to 20 MHz 3.97mHz (Fout= N×60'000'000/2^{32}) -35dBc (1-10 MHz) -30dBc (10-20 MHz)	
GPS Antenna Connector	SMA	

SMARTIMING+® FUNCTIONALITY

Spec	GPSReference-2000
Disciplining module	**Standard**
PPSOUT Output level Pulse width (PW) or duty cycle	1PPS CMOS 0-5V (+- 20 mA sink/source) User settable, 0 to 1s in 133ns/step
PPSOUT to PPSREF Sync Error In Sync mode	< 50 ns No GPS PPSRef noise, ± 1°C temp fluctuations
PPSOUT to PPSREF (DE) Programmable delay (In Track mode)	 0 to 1 s in 133 ns steps
PPSOUT Holdover Time Stability	Within ± 2°C 1 µs/24 hr
Smart Loop Time Constant Phase/Frequency User settable	Auto-adaptive 1000 to 100,000 sec User settable Sync/Track mode ** Selected by RS232 interface ** *Sync: phase/time alignment; Track: frequency alignment*

GPS ANTENNA

Spec	GPSReference-2000	
	Standard	**Option**
Antenna Types Lightning Surge Protector Cable Length	Patch antenna kit Not applicable ≥5 m / 16.4'	**(ordering code: RA)** Rooftop antenna kit included **(ordering code: CA)** 5+15m / 16.4' + 49'
Antenna mounting bracket	Not applicable	**(order code: BRA)**

POWER

Spec	GPSReference-2000
	Standard
Power Supply	AC input 85-264VAC
Power Input Fluctuation	±10% of nominal supply voltage (230V~)
Input Frequency	47 – 63 HZ
Power Consumption @25°C	< 25W after warm-up
Connector Type	IEC plug

ENVIRONMENT

Spec	GPSReference-2000
	Standard
Operating Temperature	0 to 40°C *(Relative humidity: 10-85%)*
Storage	-25 to 55°C
Transportation	-25 to 70°C

PHYSICAL

Spec	GPSReference-2000	
	Standard	**Option**
Size	445 x 300 x 44 mm (1U) / 17.52 x11.81x1.73 in.	
Weight	2.2 kg / 4.85 lbs	
Mounting	Tabletop feet	19" rack mountable ears **(ordering code: E)**

SYSTEM SUPPLY

Type	GPSReference-2000	
1x	GPSReference-2000	
1x	GPS patch antenna kit (with option code RA : Rooftop antenna kit)	
1x	Cables SUB-D male/female for PC serial COM	
2x	19" rack mountable ears or tabletop feet	
1x	iSyncMgr software & Operating manual & specifications	
1x	Euro Power Cable Standard	US Power Cable **(ordering code: US)** China Power Cable **(ordering code: CN)** Swiss Power Cable **(ordering code: CH)** Indian Power Cable **(ordering code: IN)**

SOFTWARE UPGRADES

GPSReference-2000
Download the latest software upgrades at www.spectratime.com

ORDERING INSTRUCTIONS

GPSReference-2000 / XX / YY / …..

Type Option 1 Option 2

SYSTEM DESCRIPTION

The GPSReference-2000 integrates a smart Rubidium atomic clock and a GPS receiver. It has 3 basic modes of operation: Free Run, Track and Sync. The Free Run mode is when the Rubidium clock is not locked to a reference, and thus free running. The Track mode is when the reference is used to perform frequency alignment applications, whereas the Sync mode is when the reference is used to perform phase alignment applications.

As illustrated in Figure 1, when the GPSReference-2000 works in Track mode it uses the PPS_GPS as a reference (PPSREF) to align the frequency of the Rubidium clock. 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 GPSReference-2000 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 GPSReference-2000 has also the capability to dynamically analyze the stability of the PPSREF signal through the excellent mid-term frequency stability of the Rubidium technology. Thus, the 1PPS-GPS reference can be directly fed to the Rubidium clock without specific analysis of the internal optimization parameters of the GPS engine - i.e., number of satellites in view, signal to noise ratio, etc.

Figure 2 illustrates the typical frequency stability performance of the GPSReference-2000, using its built-in 10MHz Rubidium reference clock.

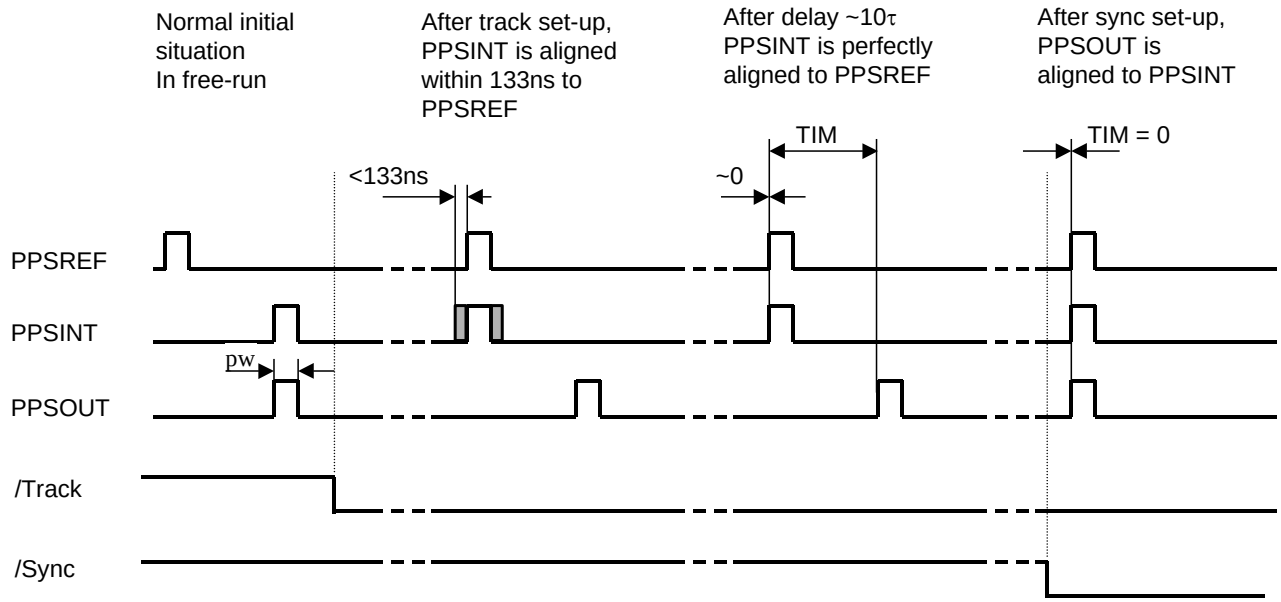


Figure 1 - Track & Sync Modes

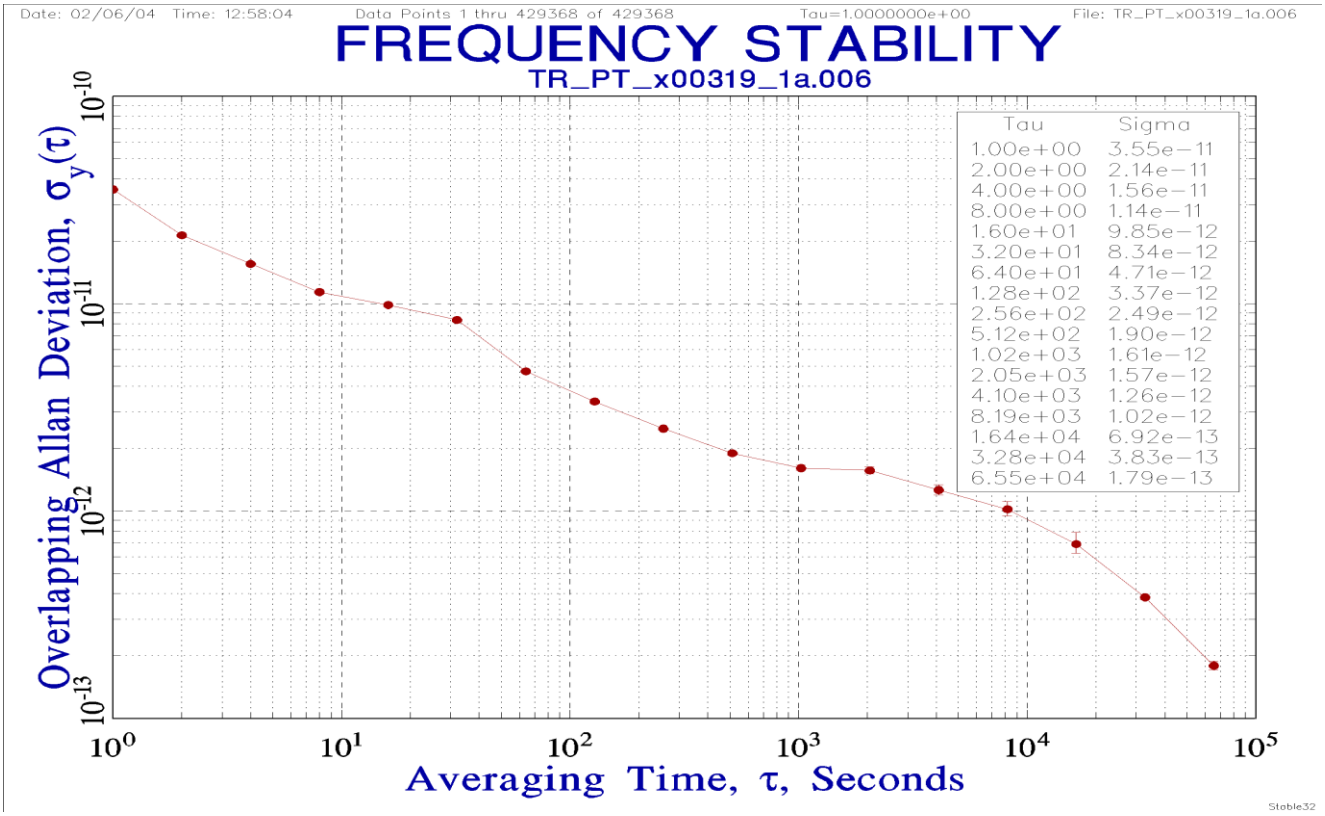
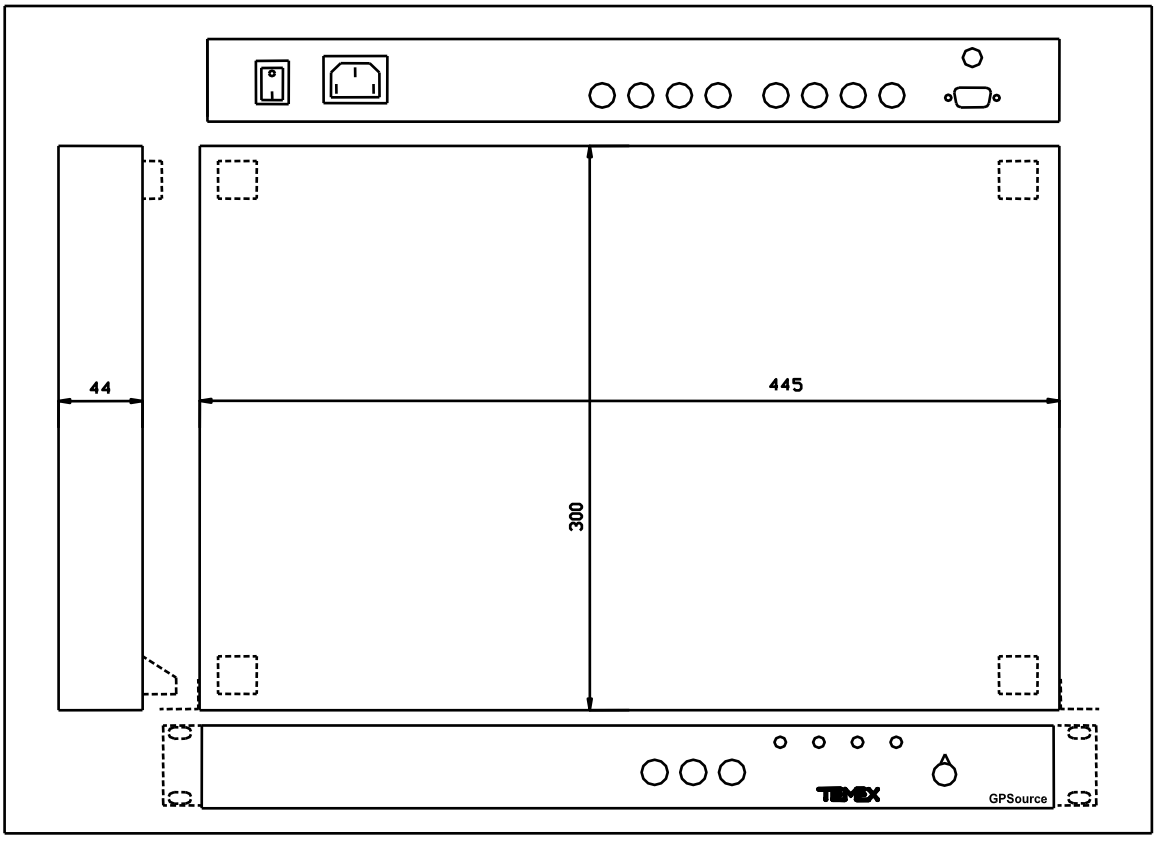
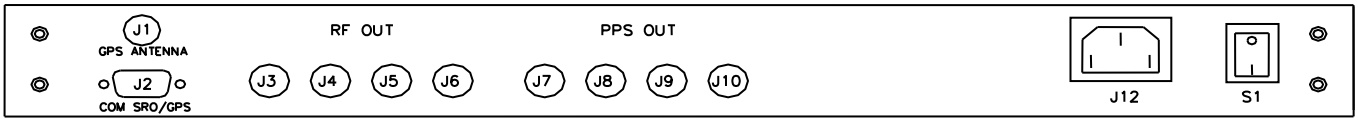


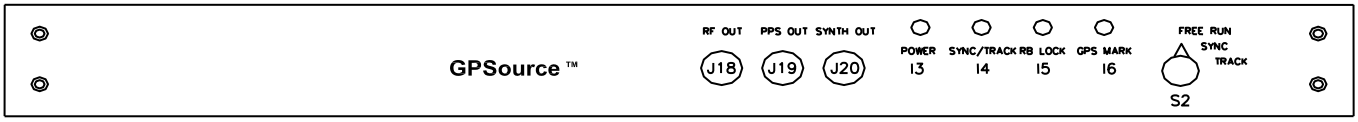
Figure 2 - Frequency Stability Performance

MECHANICAL LAYOUT



I/O INTERFACES





Back Panel

N°	Type	Definition	I/O
J1	SMA	GPS antenna connection	I
J2	SUB-D9-F	Serial communication RS232 Pin 2 TxD / Pin 3 RxD / Pin 5 GND	I/O
J3-J6	BNC	4x 10MHz sine reference outputs	O
J7-J10	BNC	4x 1PPS outputs (4x 10 MHz sine reference outputs with option code 8RF)	O
J12	IEC PLUG	Power connection	I
S1	SWITCH	On/Off switch	-

Front Panel

N°	Type	Definition	I/O
J18	BNC	10MHz sine reference output	O
J19	BNC	1PPS output	O
J20	BNC	SYNTH output	O
I3	Green LED	Power indicator	-
I4	Green LED	Sync or Track mode enabled	-
I5	Red LED	Rubidium clock locked alarm	-
I6	Green LED	1PPS GPS applied	-
S2	SWITCH	Free run, Sync or track selection switch	-

RS-232 CONTROL & MONITORING COMMANDS

Frequency Adjustments & Rb Loop Monitoring Functions

The working and monitoring parameters of the Frequency Reference module 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 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

Cxxxx<CR><LF>: output frequency correction 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 correction which is applied after RESET or power-ON operation.
In Track mode this correction is not in use. The function **FC**sddddd does the same, but the data format is different.

There is a command to set the SYNTH output frequency:
Txxxxxxxx<CR><LF>: Where xxxxxxxx is an unsigned 32 bits in hexa coded ASCII stored in EEPROM. The frequency is changed after a reset $Frequency = \frac{xxxxxxxx}{2^{32}} \cdot 60\,MHz$

Timing & Locking Control Commands

Using the same data interface, the Reference module 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 x 10^{-13} step
Set frequency save. Integral part, when Status = 2, 3	**FSx<CR><LF>** *	x=0 : never save x=1 : save every 24 hours x=2 : save right now x=3 : save current 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	**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
Go fast during beginning of tracking	**GF**ddddd <CR><LF> *	ddddd= Time during this mode is active, in seconds DF?????: interrogation	ddddd <CR><LF>	ddddd: Value stored in eeprom
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)

Standard GPS Antenna

A GPS patch antenna with 5 meters (16.4') of cable is included in the normal package. This antenna can be installed close to a window. If installed in a region susceptible to lightning, a surge arrestor must be installed. For the installation, please refer to our GPSReference-2000 user manual, section "Safe GPS Antenna installation".

Optional Rooftop GPS Antenna Kit (Ordering code: RA)

This kit contains the following items:

- a roof antenna
- a cable of 15 meter (49')
- a cable of 5 meter (16.4')
- a lightning arrestor

Custom GPS Antenna

The customer can install another antenna. In such case, the antenna connector of the device supplies 5V/30 mA for the amplifier. Please note that the device is CE tested only for an antenna cable less than 30 meters (98').

For the installation, please refer to our AppNote "Custom GPS Antenna Installation".