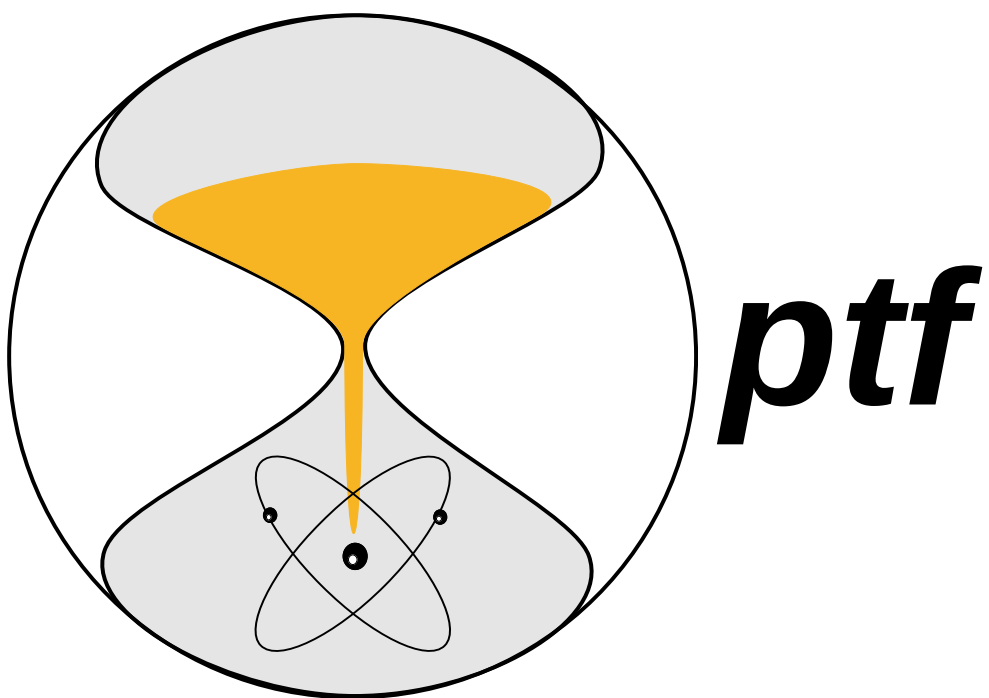




Precise Time and Frequency, Inc

***ptf* 4211A**

Operation and Maintenance Manual



Document #	10322
Revision	C

Introduction

Congratulations on your purchase of the **ptf** 4211A Disciplined Rubidium frequency standard !

This product meets the highest standards of quality and reliability, and Precise Time and Frequency, Inc wants to insure that you enjoy the maximum benefits and functionality that this unit can provide.

The technology within this unit uses the decades of experience in time and frequency applications of our engineering team, to give a product that is highly advanced, and provides an extremely stable and accurate reference for your timing and frequency application,

Operation of the unit is straightforward and the contents of this manual are designed to provide a basic understanding of the product, set-up and functionality, and procedures for maintenance and repair.

If you have any questions or concerns, please do not hesitate to contact our technical service department who will be pleased to provide assistance.

Please help us to live up to our stated objectives, our company motto is:

KNOW THE NEEDS AND EXPECTATIONS OF YOUR CUSTOMER...THEN DELIVER!

Once again, thank you for purchasing our product, and we look forward to you utilizing Precise Time and Frequency, Inc. for your future time and frequency instrumentation needs.



President
Precise Time and Frequency, Inc.

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1. Rubidium Atomic Module

The heart of the **ptf** 4211A is a rubidium atomic clock module that provides a highly accurate and stable 10MHz reference.

The atomic standard operates by disciplining an internal quartz crystal oscillator to a hyperfine transition at 6.834,682,612 GHz in the rubidium. A photo detector is used to detect the amount of light (transmitted by a rubidium discharge lamp) that is transmitted through a resonance cell.

The module uses a microprocessor to control the complex functions of the unit, including disciplining control of the crystal oscillator.

In addition to providing the very accurate 10MHz output the unit also supplies the output 1PPS signal. If desired a 1PPS input reference can be used and the **ptf** 4211A will lock the output 1PPS to this input reference.

2. *ptf 4211A* Rubidium Standard - Technical Overview

The *ptf 4211A* utilizes an internal rubidium module, and (optionally) distributes and conditions the 10MHz signal to provide a range of outputs at 1MHz (optional), 5MHz (optional) and 10MHz. The unit also provides a 1PPS disciplining input and a 1PPS output.

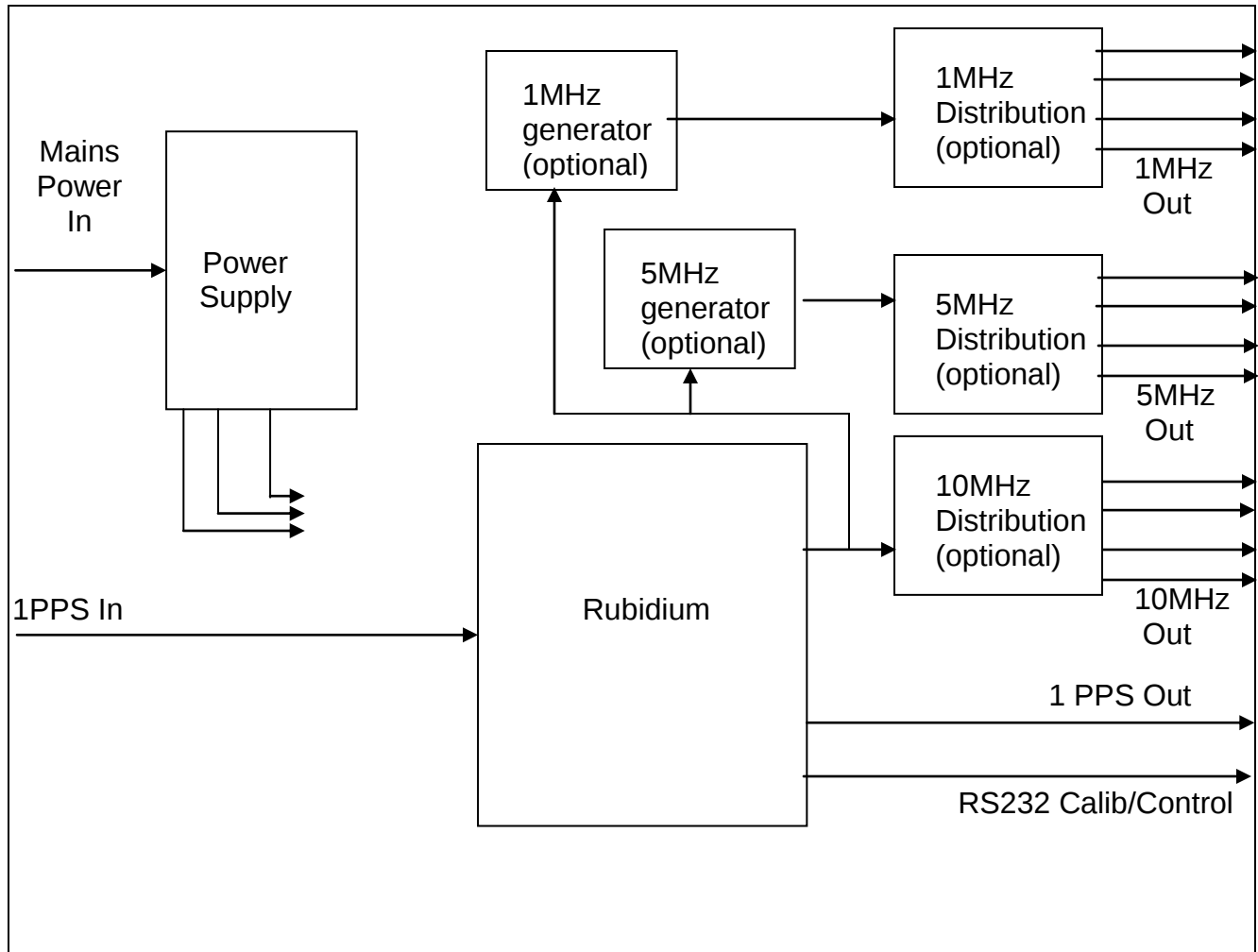


Figure 1. *ptf 4211A* Rubidium Standard Schematic

2.1. Technical Description

The **ptf** 4211A Rubidium Standard has an inherent stability due to the atomic reference, which is suitable as a stand alone reference for many demanding applications.

In addition, the unit comes complete with an external 1PPS input which can be used to lock the **ptf** 4211A to another external reference, for example a GPS receiver, which may have excellent long term stability but is unable to provide the short and medium term stability performance of the **ptf** 4211A.

The external 1PPS input is fed directly to the rubidium module and, if present, is used internally within the module to “lock” the rubidium 10MHz output to the 1PPS input. The time constant of this adjustment can be adjusted by means of the RS232 remote control input, over a period of 16 minutes to 27 hours, to accommodate different quality levels of the external reference. This capability is also an excellent means of calibrating the **ptf** 4211A if a higher accuracy reference is available.

Additionally, the 1PPS output, which comes directly from the internal rubidium module, can be offset relative to the 1PPS input by up to 1 second, with a step resolution of 133 nano seconds, via the external RS232 interface.

Any adjustments required (e.g. calibration, frequency offset etc.) are applied directly to the rubidium module.

Details of input commands etc. available via the RS232 calibration/control connector can be found in section 5 of this manual.

3. *ptf* 4211A Rubidium Standard - Specifications

3.1. Electrical

RF Outputs	
Frequency	10MHz (sine wave)
Optionally	1MHz, 5MHz
Amplitude	>7dbM (+13dBm with Distribution) 0.5V rms
1PPS Output	5V TTL Level
Stability (Allan Deviation)	
1 second	3E-11
10 seconds	1E-11
100 seconds	3E-12
Aging	
after 30 days of operation	<5E-11/month
per year	<5E-10
Accuracy at shipment	<5E-11
Phase Noise	
Offset from (10MHz) carrier	Phase Noise(dBc)
1Hz	-75
10Hz	-95
100Hz	-125
1000Hz	-145
10000Hz	-145
Spurious	<-80dBc
Input Power requirements	110 to 240 V (+/-10%) AC / 50-60 Hz

3.2. Mechanical/Environmental

Dimensions	1U(1.75") high x 19"wide x 12" deep
Temperature	
Operating	0 to 50 degrees Celsius
Storage	-10 to +70 degrees Celsius
Humidity	0 to 95%, non-condensing
Weight	< 12 lbs

4. Unpacking/Inspection/Installation

4.1. Unpacking/Inspection

The **ptf** 4211A Rubidium Standard together with accessories, is shipped in a custom designed package. Upon receipt the equipment should first be visually inspected for any signs of visible damage.

If visible damage is apparent immediate notification should be given to both Precise Time and Frequency, Inc., and the carrier responsible for shipment. Do not discard the shipping container that should be made available for inspection by the carrier.

For purposes of unit reference, the unit serial number located on the rear panel of the unit should be quoted in all communications.

4.2. Chassis Installation

The ptf 4211A Rubidium Standard chassis is supplied with rack ears ready for simple installation into a standard 19-inch rack frame/cabinet.

For adequate support when mounted into the rack, a rear supporting bar or tray should be used as the rack ears are designed to secure the unit in the rack, NOT to support the full weight of the unit.

Attention should be given to the internal rack environment to insure the unit operates within it's specified operating temperature range of 0 to 50 deg. C also noting that the unit relies upon convection for cooling, so there should be sufficient air flow to accommodate this.

4.3. Connections

A diagram showing the connectors is provided in section 4.3.4 at the end of this section.

4.3.1. Power Connection

Power is supplied by connecting the supplied ac power cable to and ac source, at 120 or 230 V ac, +/-15%. The ac input is a universal input – no range switching is required.

4.3.2. Timing Input/Output Connections

BNC connectors are provided for the standard **ptf** 4211A Rubidium Standard outputs, the 10MHz sine wave, 1 pulse per second (PPS), and the 1 pulse per second (PPS) input.

4.3.3. Calibration/Control Connections

Control and monitoring is available through an RS232 port (female 9-contact D connector). The RS232 port is configured as DCE, receiving data on pin 3 and transmitting data on pin 2. Pin 5 is chassis ground, and the other lines are unused.

4.3.2.1 Multiple Output Module (Optional)

The **ptf** 4210A equipped with an optional **Multiple Output Module (MOPS)** provides both 1MHz *and* 5MHz output capabilities.

4.3.4. Diagram of connections

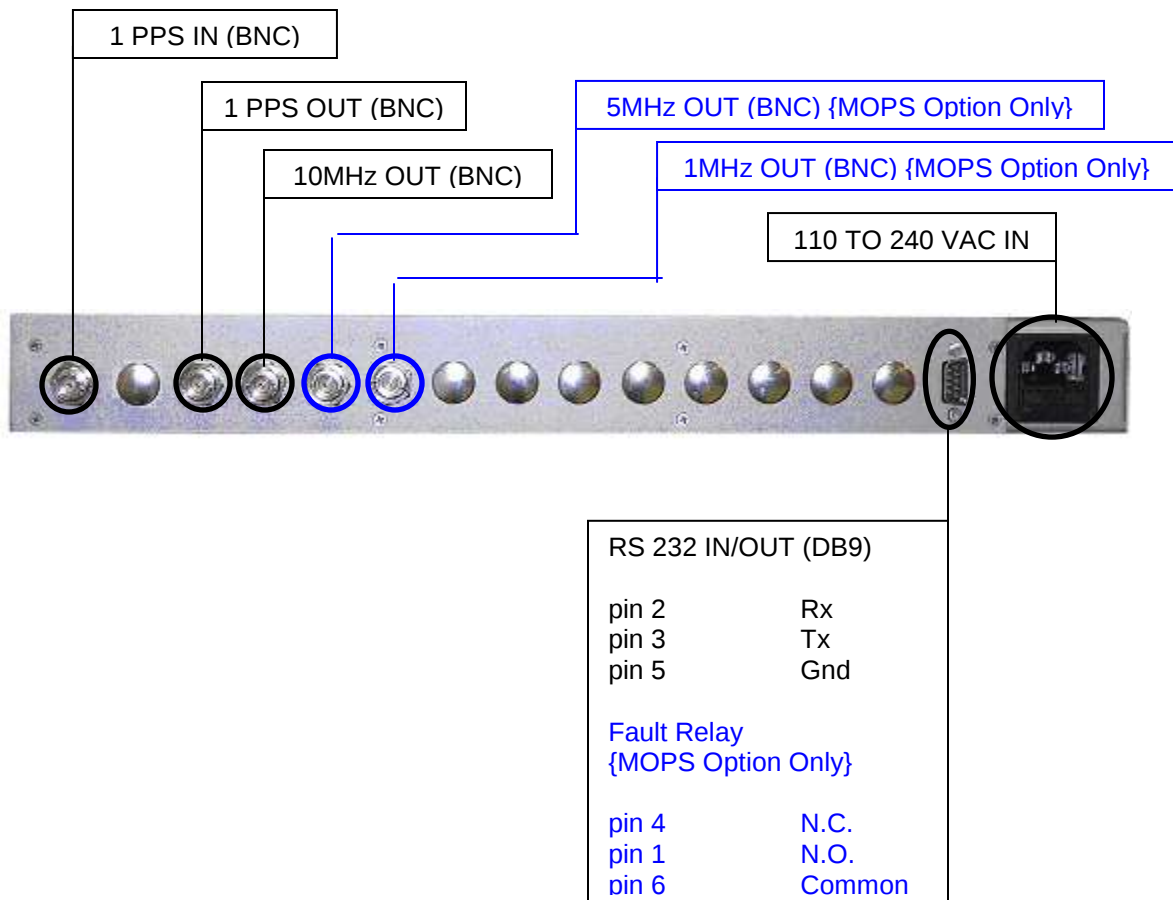


Figure 2. Unit Rear Panel Connectors

5. **ptf** 4211A Rubidium Standard – Operation

5.1. Initialization

Warm up.

When first powered on the unit will take approximately 5 minutes to warm up and achieve lock on the rubidium.

5.2. Operation

5.2.1. Normal Use

For many applications, powering on is all that is required as the unit is used in its default configuration. For applications requiring more flexible or complex set-up, the RS 232 calibration/monitor port may be used

5.2.2. Timing Operation

In addition of being a Rubidium Frequency Standard, the **ptf** 4211A generates a one pulse per second signal (PPSOUT), as well as time of day information.

The **ptf** 4211A has two basic modes of operation: “Track” and “Holdover”.

In the “Track” mode, the unit can use an external PPS reference (PPSREF) to correct the Rubidium oscillator frequency.

This correction is calculated from an internal phase-time error signal measured within 1 ns resolution issued from an internal PPS signal (PPSINT) aligned to the PPSREF signal (see figure 3).

Furthermore, the unit self analyzes the stability of the PPSREF signal, thanks to the very good mid-term frequency stability offered by Rubidium technology.

Therefore, the PPS reference of a GPS engine can be directly applied to the ptf 4211A without specific analysis of the internal parameters of the engine (number of satellites in view, signal to noise ratio, etc).

The PPSINT is directly compared with PPSREF signal using precise phase comparator (PC) with 1 ns resolution and +-500 ns dynamic range. (see figure 3 below).

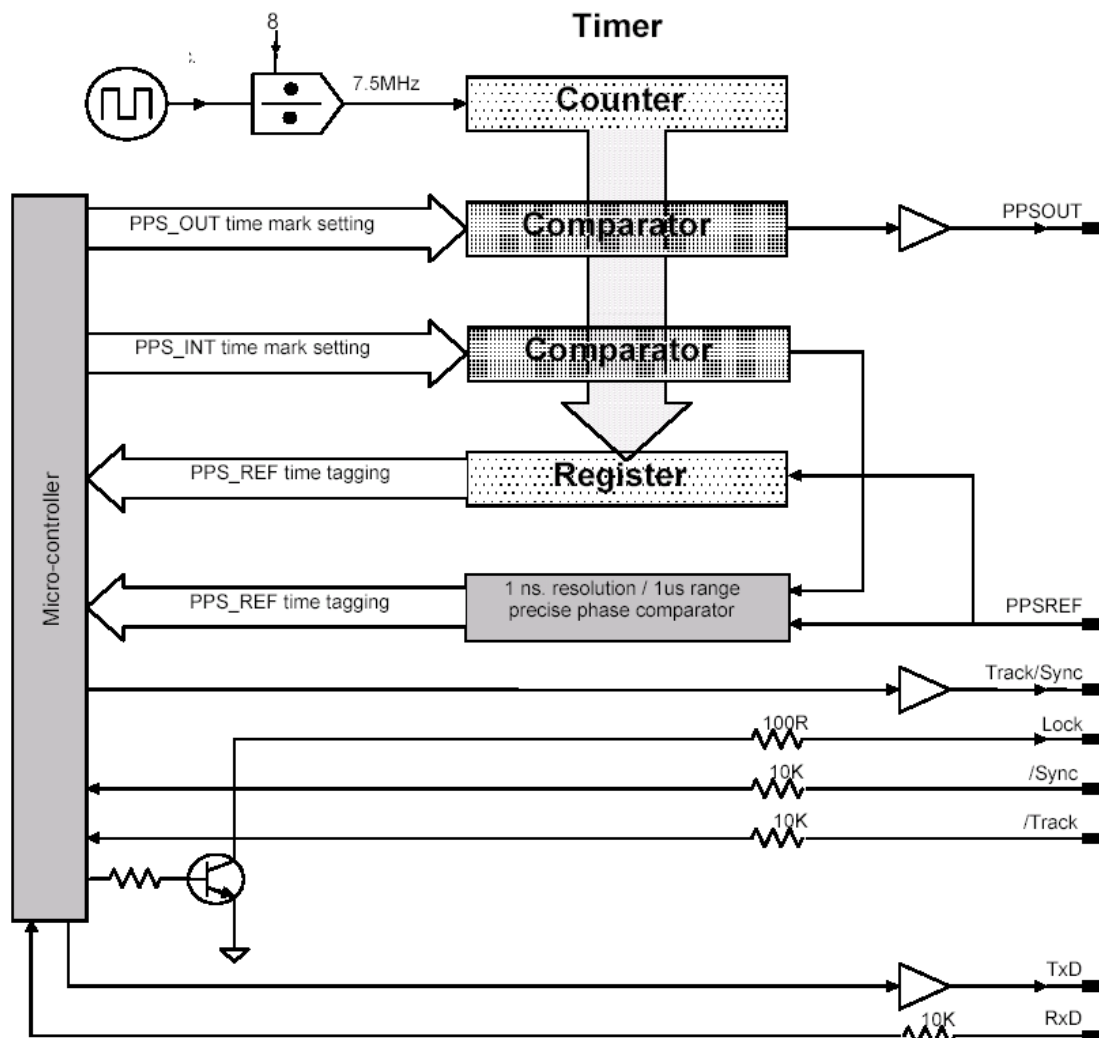


Figure 3. PPS and Control Block Diagram

When "Track" mode is set-up, the PPSINT is aligned to the PPSREF within 133 ns (see figure 4). Then the mid-term frequency stability analysis of the PPSREF can start providing disciplining for the internal crystal oscillator locked to the Rubidium atomic resonance. Such analysis is performed continuously and the PPSINT will be phase locked to the PPSREF. The phase lock loop time constant t is automatically selected as a function of PPSREF short-term stability. When standard GPS receiver is used, the typical time constant will be 10'000 to 100'000 sec. With a low noise signal, the typical selected time constant will be 1000 sec.

After about $10t$, The PPSINT will be perfectly aligned to the PSREF.

The **ptf 4211A** is also capable of providing a PPSOUT signal perfectly aligned to the PPSREF or up to 1 s offset with a resolution of 133 ns. This time offset can be set using RS232 interface.

After a descending edge of the 'Sync' signal, PPSOUT will be aligned to the PPSREF. (see figure 4).

Further, the PPSOUT pulse duration can also be programmed up to 1s with 133ns resolution.

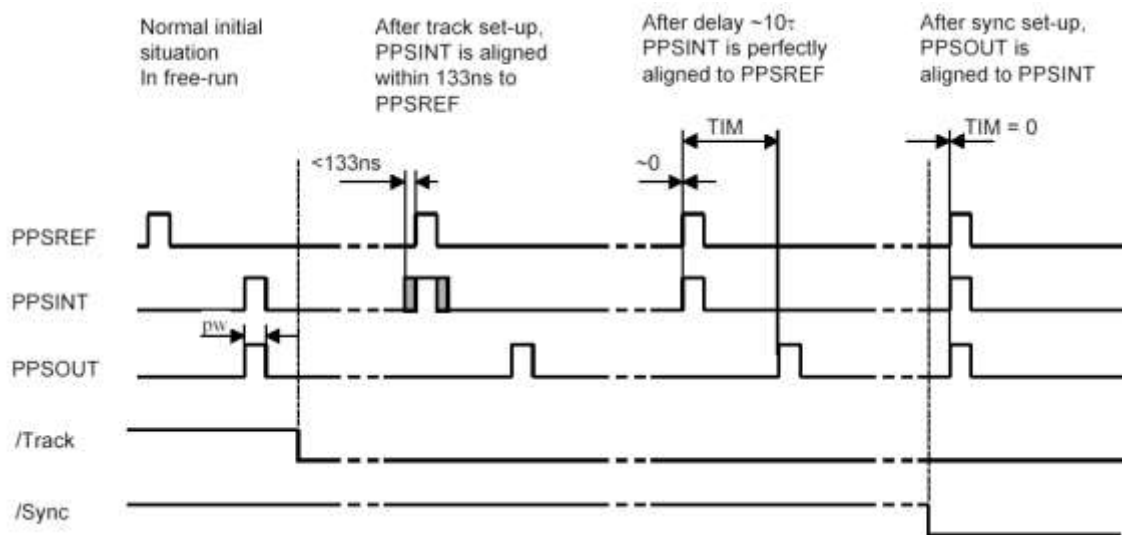


Figure 4 : "Track" mode and "Sync" mode

5.2.3. RS 232 Configuration

The RS232 port factory default setting is 9600-8N1.

A brief description of syntax and summary of the instruction set available on the Calibration/Monitor port is shown in the next section.

5.2.4. Calibration/Monitor Summary Instruction Set

5.2.4.1. Command List

Parameters accessible through RS232:

frequency adjustment and Rb loop monitoring functions

The working and monitoring parameters of the *ptf* 4211A 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 basic commands, which are *M*, and *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

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 an EEPROM as the last frequency correction which is applied after RESET or power-ON operation.

In Track mode this correction is not in use. The function **FC**sdddd does the same. But the data format is different.

There is a command to set the DDSOUT frequency :

Txxxxxxxx<CR><LF> : Where xxxxxxxx is an unsigned 32 bits in hex coded ASCII stored in EEPROM. The frequency is changed after a reset by

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

Timing and tracking control functions:

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 - PPSREF	TRx<CR><LF>	x=0 : Track never x=1 : Track now x=2 : Track ever x=3 : Track now + ever x=9 : Interrogation	x<CR><LF>	x: Tracking commands status x=0 : Track OFF x=1 : Track ON (when Status 9 -> 4
Set Synchronisation PPSOUT - PPSINT	SYx<CR><LF>	X=0 : Synch. never x=1 : Synch. now x=2 : Synch. ever x=3 : Synch. now + ever x=9 : Interrogation	x<CR><LF>	x: Sync. commands status x=0 : Synch. OFF x=1 : Synch. ON (When Status 1 -> 2)
Set PPSOUT delay	DEddddddd<CR><LF>	ddddddd=delay by 133ns step. Max 7499999 DE0000000 :synch to PPSREF	ddddddd<CR><LF>	ddddddd=delay by 133ns step. Max 7499999
Set PPSOUT Pulse Width	PWddddddd<CR><LF>	ddddddd=pulse Width by 133ns step. Max 7499999 PW0000000: 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	TDhh:mm:ss<CR><LF>	hh:Hours mm:Minutes ss:seconds	hh:mm:ss<CR><LF>	hh:hours mm:minutes ss:seconds
Beat every second on serial port.	BTx<CR><LF>	x=0 : Stop beat x=1 : Effective Time interval PPSOUT vs PPSREF x=2 : Phase comparator	ddddddd<CR><LF> or sppp<CR><LF> or ddddddd sppp	Ddddddd : delay in 133ns step sppp:phase error in ns s: +/- signe

Frequency setting functions:

		x=3 : Both x=1 & x=2 x=4 : Beat Time of day x=5 : Beat status x=6 : Beat <CR><LF>	<CR><LF> or hh:mm:ss<CR><LF> s<CR><LF> <CR><LF>	hh: hours mm: minutes ss: secondes s: status
Set frequency correction	FCsdddd<CR><LF>	s= +/- signe dddd = limited within range : +32767/-32768 FC+99999 : interrogation	sdddd<CR><LF>	s: +/- signe dddd : frequ. corr. in 5.12×10^{-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 actual freq. now x=9 : interrogation	x<CR><LF>	x=0 : never save x=1 : save every 24 hours
Set Tracking Window	TWddd<CR><LF>	ddd = Half Tracking Window by 133ns step. From 1 to 255 ddd = 999 : interrogation	ddd<CR><LF>	ddd : Half Tracking Window by 133ns step.
Set no Alarm Window	AWddd<CR><LF>	ddd = Half no Alarm Window by 133ns step. From 1 to 255 ddd = 999 : interrogation	ddd<CR><LF>	ddd : Half no Alarm Window by 133ns step.
Set tracking phase loop time constant	TCdddddd<CR><LF>	dddddd = Time constant in seconds (001000 to 999999) TC000000 : change to auto. (-)<TC001000 : no change	Ddddddd<CR><LF>	dddddd : time constant in seconds
Set welcome messages configuration	MCsdd [cc...c] <CR><LF>	s = L : Load message s = S : Store message ccc...c s = B : Load start behaviour s = A : Activate msg at start s = C : Cancel msg at start dd = 01..08 : msg number, ccc...c : new welcome message, up to 24 characters	cc...c<CR><LF> or d<CR><LF>	ccc...c : up to 24 characters response to MCLdd or d : 0, 1 response to MCBdd

Other functions:

Status	Xtal not locked to Rb line Pin No 4	Track/Synch alarm Pin No 5	
	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

5.2.5. Calibration

Specialized equipment is required for calibration of the unit, and therefore it is recommended that the unit be returned to the factory for calibration.

If the user has available the necessary equipment, including a primary reference stand (e.g. cesium standard) phase monitor etc. calibration may be accomplished using the unit's software controls.

Refer to section 5.2.4.1 for frequency adjustment instructions

6. Maintenance

6.1. Overview

The **ptf** 4211A Rubidium Standard uses highly advanced technology components together with some specialty components such as the internal OCXO oscillator.

Advanced techniques with highly sophisticated equipment, are used for assembly and test of the unit.

Due to the above, very little periodic maintenance of the unit is required and the units can be expected to deliver many years of trouble free operation. The sections below describe the few items that may require periodic maintenance.

Any maintenance or service of the unit should be performed at a Precise Time and Frequency, Inc. authorized facility, to insure the appropriate equipment and expertise is available.

6.2. Local Oscillator

In normal operation, the Rubidium module phase locks an internal quartz oscillator to the rubidium output, and in turn, if used, the one pulse per second input signal.

Due to aging characteristics of the local oscillator, over a period of time the control voltage used for disciplining moves in one direction, and after a very long period (>10 years) may reach the limit of it's control voltage.

If this occurs, the unit will cease to control the oscillator, and lock will be lost from the PLL. In this situation the unit should be returned for mechanical adjustment to "center" the control voltage.

7. Contact Information – Technical Assistance

The Precise Time and Frequency, Inc service department normal hours of operation are from Monday to Friday, between the hours of 8.00 a.m. and 5.00 p.m. US Eastern Standard Time.

24 hour, 7-day technical assistance is available under special contract.

Before returning any equipment for service or repair please contact our service department for an RMA number.

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