AXTAL ADVANCED XTAL PRODUCTS

User Manual

Specification:	**AXRB9000_Rev.7**	
Type:	Very High Stability Rubidium Clock	
Frequency:	10.000 MHz	
Author:	HH	
Revision / Date:	1	08.11.2022

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1 Introduction

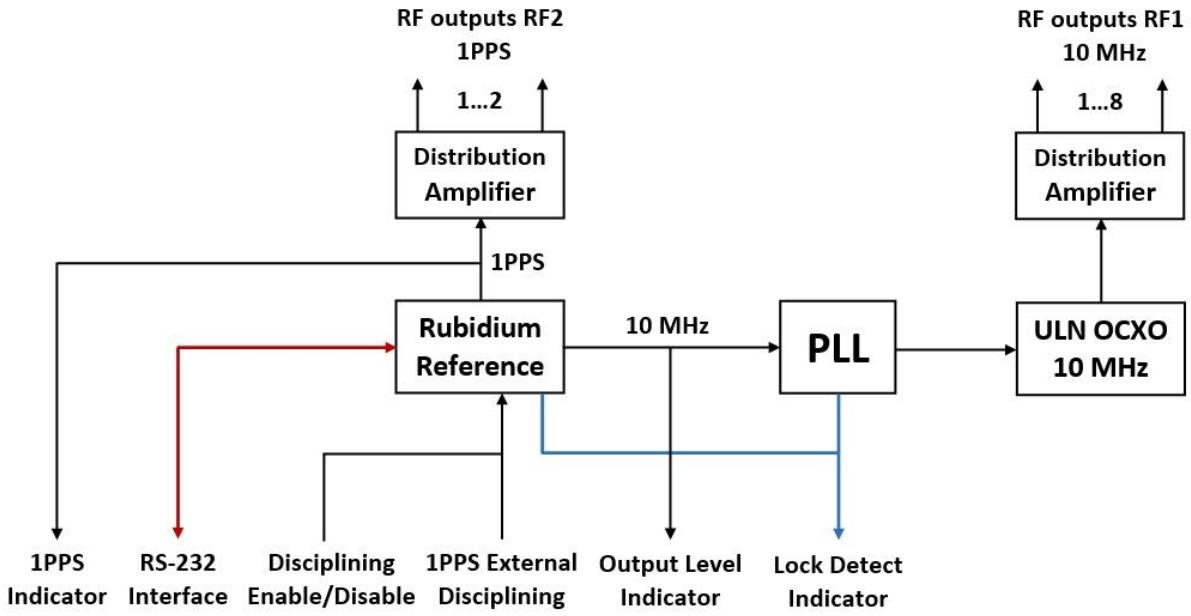
The AXRB9000 is a very high stability ultra-low noise Rubidium clock and is perfectly matched for systems with no or limited access to GNSS timing or for critical applications, where the disadvantages of GNSS-disciplined clocks cannot be accepted.

The Rubidium exhibits ultra-low phase noise performance and high spectral purity due to the internal OCXO clean-up. It has also integrated ultra-low noise and low jitter distribution amplifiers for the 1PSS and 10 MHz signal, which allow for an easy frequency distribution without additional modules.

The AXRB9000 incorporates a 1PPS reference input, which can be used to discipline the Rubidium to an external frequency reference. The disciplining function can be controlled via the software interface to react on a compromised external reference or if Rubidium holdover mode shall be set manually.

The Rubidium can be monitored and controlled via a RS-232 interface. A special adapter for the interface, which is part of the accessories, allows for an easy connection to the application. The Rubidium reference clock is designed for a very long lifetime without any mandatory maintenance and may only require calibration after long times of operation.

The block diagram below shows the basic design topology of the AXRB9000.



2 Enclosure drawing and connections

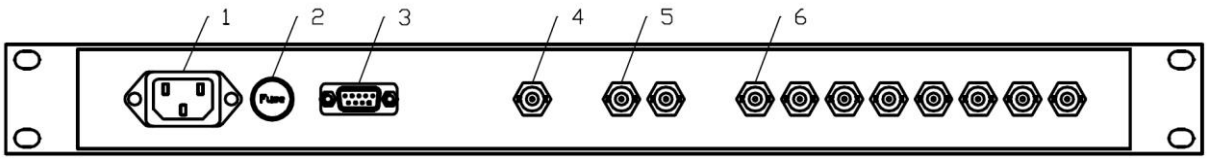


Figure 1: Rear Panel

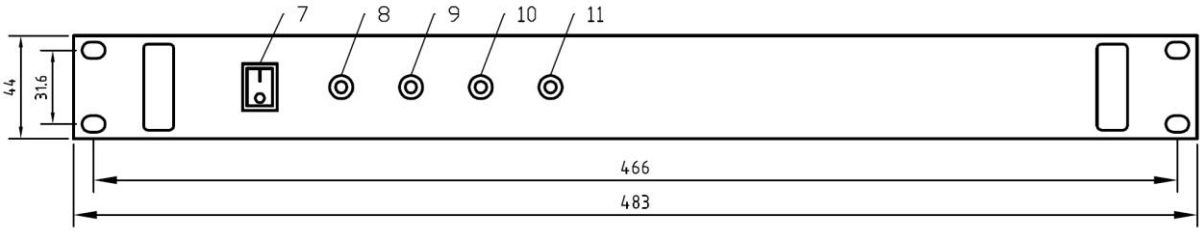
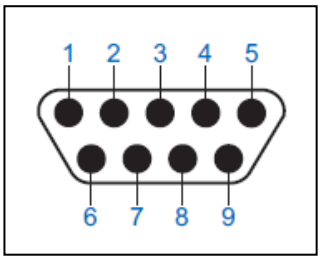


Figure 2: Front Panel

#	Panel	Symbol	Function
1	**Rear**	POWER IN	AC Supply Input (IEC 60320-1 / C14)
2		FUSE	2 A Slow 5x20 mm Fuse
3		COMM	Interface for Monitoring & Control *(see pin connections in Table 2)*
4		RF IN	External Disciplining Input 1PPS
5		RF OUT	RF Outputs 1…2 RF2 – 1PPS
6		RF OUT	RF Outputs 1…8 RF1 – 10 MHz
7	**Front**	POWER SWITCH	Power Switch ON/OFF
8		POWER ON	LED – Power ON Indicator
9		LOCK DETECT	LED – Rubidium Ready Indicator (Locked)
10		OL	LED – Output Level Indicator (Internal Rubidium)
11		PPS	LED – 1PPS Indicator (Internal Rubidium)

Table 1: Connections



Front View D-Sub connector

#	Symbol	Function	Type	Description
1	N.C.	No Connection	-	-
2	RX	Receive Data	Monitor/Control	RS-232 Logic Level
3	TX	Transmit Data	Monitor/Control	RS-232 Logic Level
4	N.C.	No Connection	-	-
5	GND	Ground	-	-
6	DIS	Disciplining Enable/Disable	Control	5V Logic Level, High = Disciplining enabled (default – internal pull-up) Low = Discipling disabled (ignores 1PPS input signal)
7	LD	Lock Detect	Monitor	5V Logic Level, High = Rubidium & OCXO Locked
8	OL	Output Level	Monitor	5V Logic Level, High = Output Level Rubidium OK
9	PPS	1PPS	Monitor	5V Logic Level, 1PPS HCMOS Pulse Rubidium

Table 2: Sub-D connector pin-connections

Please be aware of the different logic levels (RS-232 and 5V) for the various monitor & control functions. Do not directly connect a RS-232 terminal (like a PC) as this may interfere with the other functions. Only pins 2, 3 and 5 are used for the RS-232 interface and must be separated.

The Rubidium comes with an adapter/cable assembly AXCAB01, which takes care of the different logic levels and allows easy connection to the system periphery (see figure 3). AXCAB01 separates the RS-232 from the COMM interface. The other pin connections are identical with COMM.

The AXCAB01 is an optional interface adapter and not mandatory for operation.

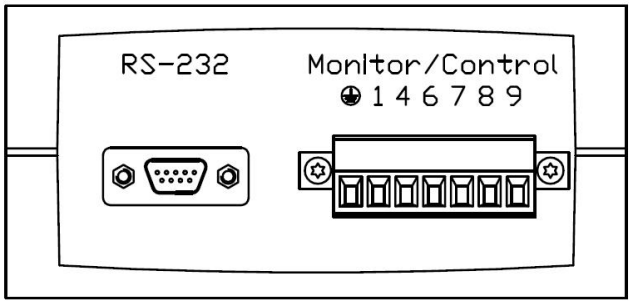


Figure 3: AXCAB01 Front View

3 Safety

Do not install or operate the unit without having read this manual and the detail specification.

Verify that the AC input voltage and power capacity are within the specification before connecting the unit. Ensure proper grounding and ESD precautions.

The unit shall be handled by skilled persons only. Do not open the unit to modify or repair the unit by yourself. Any damage or malfunction shall be reported to AXTAL.

Do not replace the fuse, if the unit is powered on!

4 Unpacking & Mounting

4.1 Unpacking

Carefully remove the unit from the shipping box and ensure ESD precautions.

Inspect the unit for any visible damage before mounting or operation. Immediately report any damage to AXTAL and in case of a damaged shipping box also to the forwarder.

Check that the correct model was delivered. The label on the side of each unit shows the detail part number of the unit.

4.2 Cooling

The unit does not require cooling, but ensure that the maximum operating temperature is not exceeded. The unit shall not be submitted to direct airflow and a stable operating temperature is recommended for best performance.

4.3 Mounting

If the unit is placed on a table, then apply the sockets, which were shipped with the unit, to the bottom plate. The unit is preferably mounted in a 19” rack with suitable rack slides. It is allowed to obstruct the air inlets of the housing as it is not required for cooling.

The unit can operate independent of the mounting orientation, but horizontal mounting is recommended. Do not obstruct the front panel to ensure reading the LED indicators.

5 Power-on & Warm-up

5.1 Power line quality

The quality of the AC power supply shall be compatible with the surge and burst testing levels of IEC 61000. This ensures that the unit is not damaged and that the performance is as defined in IEC 61000.

5.2 Power-on

Connect a matching power cable to the AC supply input (#1) and switch on the unit (#7). The LED indicator (#8) at the front panel must be lid, if the unit is properly powered. Check the fuse (#2), if the unit does not power-on even though proper power supply is applied. Please contact AXTAL, if the fuse repeatedly burns. See also Safety precautions above.

After powering on the unit, the LED Rb locked indicator (#9) will be lid for about 2 seconds signalling start-up mode. After a successful start-up it will go OFF and the 1PPS LED indicator (#11) starts to blink.

5.3 Warm-up

The AXRB9000 requires sufficient warm-up time for the internal Rubidium and OCXO to stabilize and to lock. The unit should be fully locked within 10~30 minutes under all operating conditions. To achieve the full frequency stability as specified, the unit must run continuously for at least 24 hours. Ensure a stable temperature environment.

6 Environmental Specifications & Maximum Ratings

Please refer to the detail specification for environmental conditions, operating range and maximum ratings. Do not exceed any of the stated limits! Otherwise, the unit may be permanently damaged including adjacent units and risk for the user may arise in extreme cases.

The instrument is designed to be installed in a clean room or laboratory environment. Thus, no more pollution than pollution degree 1 shall occur to the equipment. External cleaning may be done with a wet soft cloth, but no water shall enter the unit!

7 Operation

The AXRB9000 sources a 10 MHz sine wave and a 1PPS pulse signal with multiple outputs within a 50 Ohm impedance environment. Both signals exhibit very high long-term stability. Please refer to the datasheet for details and read carefully before operating the amplifier.

7.1 Non-disciplined Rubidium operation

As stated under “Warm-up” the unit requires maximum 30 minutes to stabilize and lock after power on, if it is operated properly and in accordance with the instructions given in the datasheet and this manual. A proper lock is indicated by the LED (#9) on the front panel and by the monitor (#3 – Pin 7). If the unit doesn’t lock after 1 hour, please check the operation details and try to restart the unit.

To achieve the full frequency stability as specified in the datasheet, the unit must run continuously for at least 24 hours. Best holdover performance is reached after at least 7 days operation.

The unit is sensitive to vibration and it shall only be used under static conditions. Please make sure, that no air flow is applied to the unit and that temperature fluctuations are kept to a minimum. Otherwise, the electrical performance may be degraded significantly.

7.2 Disciplined Rubidium operation

The basic operation is identical with the non-disciplined operation as described above. In factory default setup the Rubidium will be disciplined to the external reference as soon as a 1PPS signal is present at the input (#4). The disciplining algorithm has a long time constant and is meant to discipline the stability for times > 1000 seconds. No frequency jumps will occur if the disciplining is started or stopped.

The discipling functionality can be enabled or disabled either via the control (#3 – Pin 6) or the RS-232 interface (see software commands below).

7.3 Output RF1 – 10 MHz

The internal Rubidium core is continuously monitored. The LED indicator (#10) must be lid and the monitor output (#3 – Pin 8) must be high. Otherwise, the 10 MHz signal is compromised.

The output ports (#6) deliver a sine wave signal with typical +13~+14 dBm output level at a 50 Ohm load. A proper 50 Ohm termination is required in conjunction with high-quality coaxial cables to ensure best performance. The output ports are protected against continuous short-circuit, but this should be prevented in any case. Even though this will not damage the unit, no proper operation and performance can be guaranteed for a permanent short-circuit at any output port.

The distribution amplifier exhibits very high inter-channel isolation, which guarantees no interference between the output ports. The very low residual inter-channel stability guarantees that no stability degradation occurs, if output ports are compared to each other.

7.4 Output RF2 – 1PPS

The internal Rubidium core is continuously monitored. The LED indicator (#11) must be lid with the 1PPS cycle and the monitor output (#3 – Pin 9) must be present. Otherwise, the 1PPS signal is compromised.

The output ports (#5) deliver a square wave signal with typical 4 V_{P-P} output level at a 50 Ohm load, which is DC coupled and TTL compatible. The signal has typically 1% duty cycle and is driven by high-speed buffers, which allow very fast rise and fall times in the low nanosecond range.

7.5 Frequency Tuning

The AXRB9000 can be tuned in a range of ±1 ppb via the RS-232 interface (see below). This calibration functionality should only be used by trained personnel and should only be performed against primary frequency references! Otherwise, the frequency accuracy can be significantly degraded. Please contact AXTAL for calibration service.

7.6 RS-232 Communication Interface

The AXRB9000 acts as a Data Terminal Equipment (DTE) in terms of the RS-232 specification. Therefore, a null modem cable has to be used to connect to another DTE like a PC. As shown in *Table 2*, only 3 signals are used for a minimal communication standard.

The configuration of the serial port, which must be used with any preferred terminal emulator (e.g. *Hyper-Terminal* or the free *TeraTerm* or *Termite* for Windows, *xterm* for Linux), is as follows:

Baud rate	115200
Data bits	8
Stop bits	1
Parity	None
Flow Control	None

Table 3: Serial port configuration

Once the connection is established and the Rubidium is powered-on, it will send a start-up information confirming, that it was properly started and is warming-up.

7.6.1 Command Format

All commands must have the following basic format, where the data field is optional:

<!> <COMMAND> <DATA> <CR> <LF>

The mandatory format end <CR> = 0x0d and <LF> = 0x0a should be configured in the terminal emulator and will not be shown in the command list below.

7.6.2 Command Overview

Command	Function	Example
!SF?	Request model (Rubidium core), serial number and firmware version	XHTF1021, 2103102, 3.03
!F?	Request current frequency adjustment value	Return: Steer = 0
!FA*XX*	Set new adjustment value (absolute)	Command: !FA-123000 Return: Steer = -123
!FD*XX*	Set new adjustment value (relative)	Command: !FD-123000 Return: Steer = -246
!FL	The frequency adjustment value is permanently stored into the non-volatile memory.	Return: Steer Latched Return: Steer = 0
!Md	Disable disciplining mode	Return: OpMode = 0x0012
!MD	Enable disciplining mode	Return: OpMode = 0x0002
!M?	Request disciplining mode	Return: OpMode = 0x0012

Table 4: Command overview

7.6.3 Request Rubidium Model

Command = !SF?

This command returns the model number of the Rubidium core, the serial number and firmware version (comma separated).

7.6.4 Request Frequency Adjustment Value

Command = !F?

This command returns the current frequency adjustment value (Steer) and has a multiplier of 1E-12. The Steer can have values in the range of ±1000, which corresponds to ±1 ppb. After power-on and after storing a new value with the <!FL> command the Steer value is always 0.

7.6.5 Set New Absolute Frequency Adjustment Value

Command = !FA*XX*

This command sets a new frequency adjustment value (Steer) and has a multiplier of 1E-15. The Steer can have values in the range of ±1,000,000, which corresponds to ±1 ppb. After setting the new value the Steer is returned with 1E-12 multiplier. The new value is not permanent and needs to be stored with the <!FL> command.

7.6.6 Set New Relative Frequency Adjustment Value

Command = !FD*XX*

This command sets a new frequency adjustment value (Steer) relative to the current value and has a multiplier of 1E-15. This means it adds or subtracts to the current value. The Steer can have values in the range of ±1,000,000, which corresponds to ±1 ppb. After setting the new value the Steer is returned with 1E-12 multiplier. The new Steer is not permanent and needs to be stored with the <!FL> command.

7.6.7 Store Frequency Adjustment Value

Command = !FL

This command stores the new frequency adjustment value (Steer) permanently in the non-volatile memory, which was set by the <!FA> or <!FD> command. The execution of this command is confirmed by "Steer Latched & Steer = 0". The Steer value is reset to 0 and the frequency adjustment is immediately and permanently active.

7.6.8 Disable Disciplining Mode

Command = !Md

This command disables the disciplining mode. Any 1PPS input signal is ignored and the Rubidium is free-running (default holdover mode). The execution of this command returns "OpMode = 0x0002".

7.6.9 Enable Disciplining Mode

Command = !MD

This command enables the disciplining mode. Disciplining starts as soon as a 1PPS input signal is present. The execution of this command returns "OpMode = 0x0012". Please be aware, that this command is overwritten by the control input (#3 – Pin 6). The latter one allows fast disabling in case of a compromised 1PPS input signal without programming the unit.

7.6.10 Request Disciplining Mode

Command = !M?

This command requests the current disciplining mode. It returns either "OpMode = 0x0002" for "Disabled" or "OpMode = 0x0012" for "Enabled". The return value is only valid for the internal Rubidium and does not consider the control input (#3 – Pin 6).