PolaRx5S

User Manual

User Manual Version 1.0.2
Applicable to versions 5.0.1 and 5.0.2 of the PolaRx5S Firmware

May 02, 2016

Thank you for choosing the PolaRx5S! This user manual provides detailed instructions on how to use PolaRx5S and we recommend that you read it carefully before you start using the device.

Please note that this manual provides descriptions of all functionalities of the PolaRx5S product family. However, the particular PolaRx5S options you purchased may not support all the functions described.

While we try to keep the manual as complete and up-to-date as possible, it may be that future features, functionality or other product specifications change without prior notice or obligation. The information contained in this manual is subject to change without notice.

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1 Introduction

1.1 User Notices

1.1.1 CE Notice

PolaRx5S receivers carry the CE mark and are as such compliant with the 2004/108/EC - EMC Directive and amendments, 2006/95/EC - Low Voltage Directive, both amended by the CE-marking directive 93/68/EC.

With regards to EMC, these devices are declared as class B, suitable for residential or business environment.

1.1.2 ROHS/WEEE Notice

PolaRx5S receivers comply with European Union (EU) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive).

PolaRx5S receivers comply with the European Union (EU) Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). The purpose of this Directive is the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. If purchased in the European Union, please return the receiver at the end of its life to the supplier from which it was purchased.

1.1.3 Safety information

Statement 1: The power supply provided by Septentrio (if any) should not be replaced by another. If you are using the receiver with your own power supply, it must have a double isolated construction and must match the specifications of the provided power supply.

Statement 2: Ultimate disposal of this product should be handled according to all national laws and regulations.

Statement 3: The equipment and all the accessories included with this product may only be used according to the specifications in the delivered release note, manual or other documents delivered with the receiver.

1.1.4 Support

For first-line support please contact your PolaRx5S dealer.

Additional documentation can be found in the following manuals:

- **The PolaRx5S Reference Guide** includes information on the receiver operation, the full list of receiver commands and a description of the format and contents of all SBF (Septentrio Binary Format) blocks.
- **The RxControl Manual** covers the RxTools software suite, including RxControl and RxLogger.

Further information can be found on our website or by contacting Septentrio Technical Support.

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2 PolaRx5S overview

The PolaRx5S is a multi-frequency multi-constellation receiver dedicated to ionospheric monitoring and space weather applications.

The PolaRx5S incorporates a state-of-the-art multi-frequency receiver engine and an ultra low noise OCXO frequency reference in a rugged housing. The housing provides a multitude of interfaces including WiFi, USB and Ethernet.

An intuitive User Graphical Interface is provided for data logging and remote control. Designed with space weather and ionospheric monitoring applications in mind, the logging tool (RxLogger) supports continuous logging and monitoring of TEC and scintillation indices. Available indices include the S4, σ_ϕ, spectral slope and SI indices for all satellite constellations and frequency bands.

2.1 Key features

- Tracks all visible GNSS signals (GPS, GLONASS, Galileo, BeiDou, IRNSS, QZSS and SBAS)
- High precision, ultra-low noise measurements
- Unique interference monitoring and mitigation
- Powerful web interface and logging tools
- Rugged housing with multiple interfaces
- Up to 8 independent logging sessions
- Logging both internally and to an external device
- Low-jitter internal OCXO (Oven-Controlled Crystal Oscillator)
- Logging and monitoring of TEC (Total Elector Content) and scintillation indices including S4 and σ_ϕ

2.1.1 GNSS Technology

- 544 hardware channels for simultaneous tracking of all visible satellite signals
- Supported signals: GPS (L1, L2, L5), GLONASS (L1,L2,L3), GALILEO (E1, E5a, E5b, AltBoc, E6), BEIDOU (B1, B2, B3), IRNSS (L5), QZSS (L1, L2, L5)
  (Galileo, BeiDou and IRNSS are optional features)
- All-in-view SBAS (EGNOS, WAAS, GAGAN, MSAS, SDCM) (incl. L5 tracking)
- Up to 100Hz Raw data output (code, carrier, navigation data)
  (optional feature)
- A Posteriori Multipath Estimator (APME+) including code and phase multipath mitigation
- AIM+/WIMU interference mitigation unit, including chirp jammers
- Scalable Power Consumption
- All multipath mitigation and smoothing algorithms can be disabled
- Spectrum analyzer
- 100 Hz IQ correlation values (user selectable)

2.1.2 Formats

- Highly compact and detailed Septentrio Binary Format (SBF) output
- NMEA v2.30 and v4.10 output format
- Includes intuitive GUI (RxControl, web interface and RxTools) accompanied by detailed operating and installation manual
- ISMR (Ionospheric Scintillation Monitoring) file generation using the provided sbf2ismr utility

2.1.3 Connectivity

- x PPS output (max 100Hz)
- 4 hi-speed serial ports
- 1 Ethernet port (100MBps)
- Integrated WiFi (802.11 b/g/n)
- Power-Over-Ethernet
- 1 full speed USB port
- 1 USB host for external disk
- 16 GB standard on-board logging
- Up to 8 simultaneous logging sessions
- Advanced web interface providing full receiver control
- Status monitoring, ftp server, ftp push
- Ntrip server and client
- Convenient TCP/IP socket interface for easy integration with other software applications

2.2 Hardware Specifications

2.2.1 Power Consumption

The power consumption of the PolaRx5S depends on its configuration. The following settings directly influence the amount of power consumed:

- The number of enabled GNSS frequency bands. For example, a receiver configured to track signals only in the L1 and L2 bands will consume less than a receiver configured to track in the L1, L2 and L5 bands. Use the **setSignalTracking** command to enable/disable signals. Note that a given frequency band is disabled only when all GNSS signals in that band are disabled.
- Activation of the Ethernet interface: in power-critical applications, it is recommended to not use Ethernet and to turn off the associated hardware. This can be done with the **setEthernetMode** command.
- Activation of the WiFi interface: use the **setWiFiMode** command or press the WiFi button to turn the WiFi module off or on.
- The REF OUT frequency reference output: in power-critical applications, REF OUT can be turned off with the **setREFOUTMode** command.

The following table shows the nominal power consumption measured when 12 VDC is supplied to the PWR connector:

Configuration	**Power Consumption***
GPS + GLONASS L1, tracking and PVT	3.8W
GPS + GLONASS L1/L2, tracking and PVT	3.9W
GPS L1/L2/L5, GLO L1/L2, GAL E1/E5a, SBAS L1/L5, BDS B1/B2	4.0W
All constellations and all signals (enabling GAL E6 and/or BDS B3 increases the power by 650mW)	4.8W
Enabling Ethernet (**setEthernetMode** command)	+650mW
Enabling WiFi (**setWiFiMode** command)	+450mW
Enabling REFOUT (**setREFOUTMode** command)	+30mW
Enabling wide-band interference mitigation (**setWBIMitigation** command)	+160mW
Stand-by mode†	1.6W

* Note that initial power consumption can be 3W higher than the values listed due to warming up of the internal OCXO.
† Stand-by mode is described in Section 2.3.4

2.2.2 Physical and Environmental

Size:	284 x 140 x 37 mm (length including connectors)
Weight:	1.06 kg
Temperature Range:	-40 to +65 °C (operational) -40 to +85 °C (storage)
Shock:	MIL-STD-810F, 516.5
Vibration:	MIL-STD-810F, 514.5

2.3 PolaRx5S design

2.3.1 Front panel

The front-panel layout of the PolaRx5S is shown in Figure 2-1. A description of the front-panel sockets as well as their PIN assignments can be found in Appendix A. The cables available for use with the PolaRx5S are listed in Appendix C and the LED behaviour is described in Appendix D.

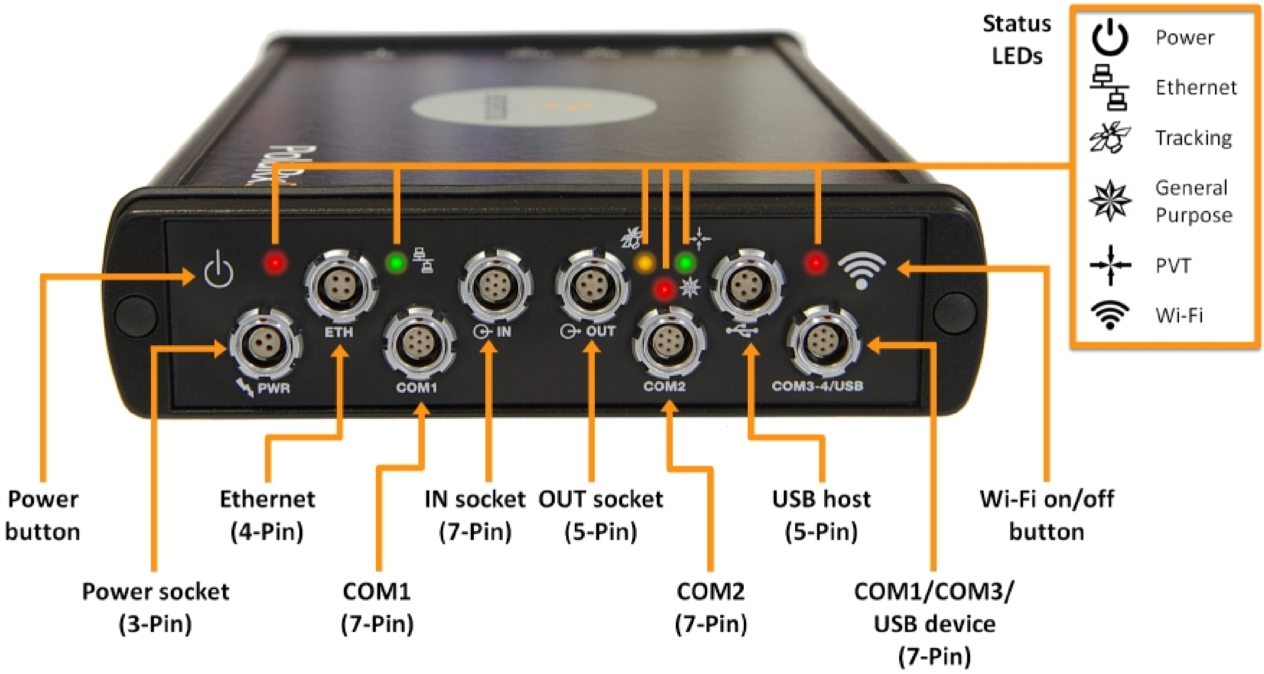


Figure 2-1: PolaRx5S front-panel layout

2.3.2 Rear panel

Figure 2-2 shows the layout of the rear-panel connectors on the PolaRx5S. More information on these connectors can be found in Appendix B and on the available cables in Appendix C.

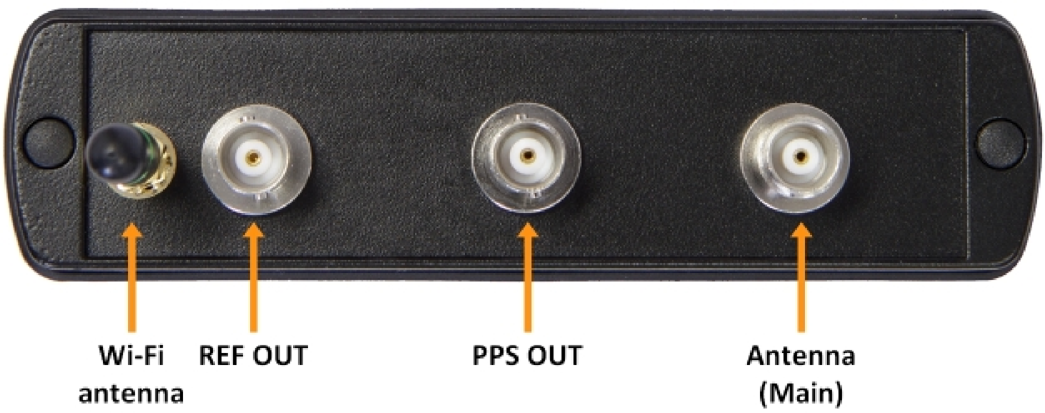


Figure 2-2: PolaRx5S rear-panel layout

2.3.3 Powering the Receiver

The receiver can be powered through either:

- The PWR connector (9-30 VDC)
- The Ethernet connector (Power over Ethernet - PoE, 37-57 VDC). Please note that only mode A, as specified in the 802.3af standard, is supported.

If power is provided through both the Ethernet and the PWR connectors, Ethernet power takes precedence. This allows the connection of a back-up battery to the ODU PWR connector. The battery will only be used in case of an outage of the power over Ethernet.

The current power source (PWR or Ethernet connector), and the voltage at the PWR connector are reported in the `PowerSupply` SBF bock.

2.3.4 Power Button

When power is initially applied to the PWR or Ethernet connector, or after a power outage, the receiver always starts up without the need to press the power button.

Pressing the power button when the receiver is turned on will send the receiver into stand-by mode. Pressing the button again switches the receiver back on.

In all cases, the state of the power button is not retained across a power outage. If the receiver was in stand-by mode before the power outage, it will restart when power is restored.

2.3.5 WiFi Button

The WiFi button toggles the WiFi modem on and off.

When the receiver starts up, WiFi is enabled or disabled according to the settings of the **setWiFiMode** command stored in the boot configuration file. When the receiver is operating, pressing the WiFi button turns WiFi on and off in turn. The red WiFi LED next to the WiFi button lights when WiFi is enabled.

2.3.6 Internal memory

The PolaRx5S has a 16 GB Memory for internal data logging. Data can be logged in SBF or RINEX format and may be retrieved via the logging tab of the web interface.

2.3.7 External memory

The PolaRx5S can log data to an external memory device with a maximum capacity of 32 GB.

2.4 Options and Accessories

2.4.1 Standard shipment

The GNSS options and accessories included in a standard shipment with the PolaRx5S are listed in the Table below.

Included in:	Item	Part Number	Description
PolaRx5S receivers	PolaRx5S	410128B1593	Multi-frequency GPS/GLO reference receiver dedicated to ionospheric monitoring and space weather applications
	PolaRx5S FULL	410128B1595	Includes all GNSS options listed in Section 2.4.2
	SM_PolaRx5S	410128B1591	PolaRx5S stock model. Activation code is needed.
Accessories	PWRe_ADAPTER	200431	Power adapter
	CBLe_COM_1.8	200416	COM1/COM2 (DSUB9-female) serial cable
	CBLe_ETH_MS	200418	Ethernet to hub/switch cable (RJ45)
	CBLe_USB	210202	USB communication cable
	ANT_AxU_BT_WIFI	202163	Bluetooth/WiFi Antenna, Dipole 2.4 GHz

2.4.2 Optional items

The additional GNSS options and accessories available for purchase with the PolaRx5S are listed in the Table below.

Included in:	Item	Part Number	Description
GNSS	Base	P2012	Output of RTCM/CMR correction data
	Event	P2022	Event marker option (2 marker inputs)
	GAL	P2102	Galileo tracking and measurement generation
	IRNSS	P2312	IRNSS L5 tracking and measurement generation
	BDS	P2252	BeiDou tracking and measurement generation
Accessories	CBLe_PWR_OE	200422	Open-ended cable for the PWR connector
	CBLe_GPO_OE_5	201203	Open-ended cable to be used with the OUT connector
	CBLe_GPI_OE	200419	Open-ended cable to be used with the IN connector
	CBLe_COM_DUO_7	201204	Dual COM3 and COM4 to PC (DSUB9-female)
	CBLe_USB_HOST	214935	USB host cable (e.g. to connect an external disk)
	PWRe_FOPX	410000	Power failover (see Appendix E). Power source management device that switches automatically to 12 V battery backup during main power supply outages.
	MNTe	201459	Mounting kit for PolaRx5S

3 Getting started with the PolaRx5S

This section details how to power-up, connect to and communicate with the PolaRx5S. The PolaRx5S has an on-board web interface which the user can connect to in three ways: Ethernet, USB or WiFi. The PolaRx5S is fully configurable using the web interface. Please note that older versions of certain browsers may not properly display the web interface.

3.1 Powering the PolaRx5S

You can power the PolaRx5S by connecting the power adapter that is supplied as standard to the front-panel power socket as indicated in Figure 3-1. The receiver will start up without the need to press the power button.

Figure 3-1: Front-panel power socket

The PolaRx5S can also be powered over Ethernet (PoE) as described in Section 2.3.3 or by supplying 9 to 30 V via PIN 1 of the open-ended power cable (CBLe_PWR_OE) as detailed in Appendix A.8.

3.2 Connecting an antenna

The rear panel of the PolaRx5S has a TNC connector labelled MAIN to connect a GNSS antenna. Connect an antenna to the PolaRx5S using an antenna cable as shown in Figure 3-2. The connector can provide 5V DC and up to 200 mA to power an antenna (see Appendix B.1 for more information).

Figure 3-2: Rear-panel antenna connector

Before connecting an antenna, the orange front-panel tracking LED will be blinking fast indicating that it is searching for satellites. After connecting an antenna that has a clear view of the sky, the PolaRx5S will start to track satellites and the tracking LED will start to blink more slowly. The number of blinks between pauses indicates the number of satellites being tracked as described in Appendix D.

3.3 Connecting to the PolaRx5S via the Web Interface

You can connect to the receiver on any device that supports a web browser using the receiver's on-board Web Interface. The connection can be made over USB, Ethernet or WiFi. The following sections describe each of the connection methods.

3.3.1 Using the USB cable

Connect the USB cable (CBLe_USB) to the socket labelled 'COM3-4/USB' on the front panel of the PolaRx5S as indicated in Figure 3-3.

Figure 3-3: Connecting to the front-panel USB socket

The first time that the USB cable is connected to your pc, you may be prompted to allow installation of drivers which can take several minutes. When the drivers have been installed, it is recommended to unplug then re-plug in the USB cable on your device to fully activate the drivers.

If the USB drivers do not install automatically, they can be installed manually by double clicking on the executable Installer file found in the folder 'driver' as shown in Figure 3-4

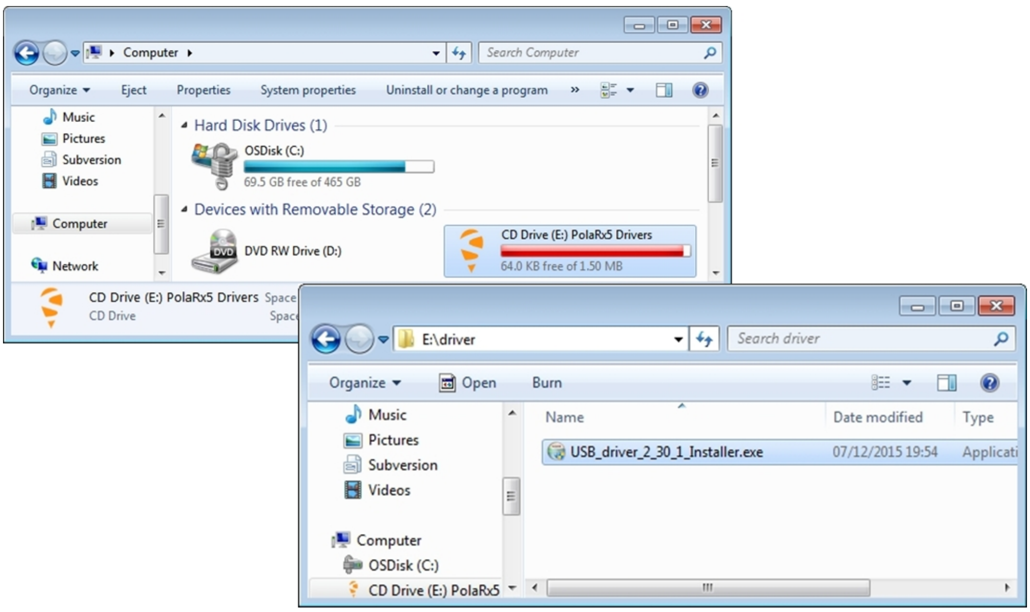


Figure 3-4: Manually installing the USB drivers

Again, when the drivers have been installed, it is recommended to unplug then re-plug in the USB cable on your device to fully activate the drivers.

The USB of the PolaRx5S functions as a network adapter and the DHCP server running on the receiver will always assign the PolaRx5S the IP address 192.168.3.1.

To connect to the PolaRx5S, you can then simply open a web browser using the IP address **192.168.3.1** as shown in Figure 3-5.

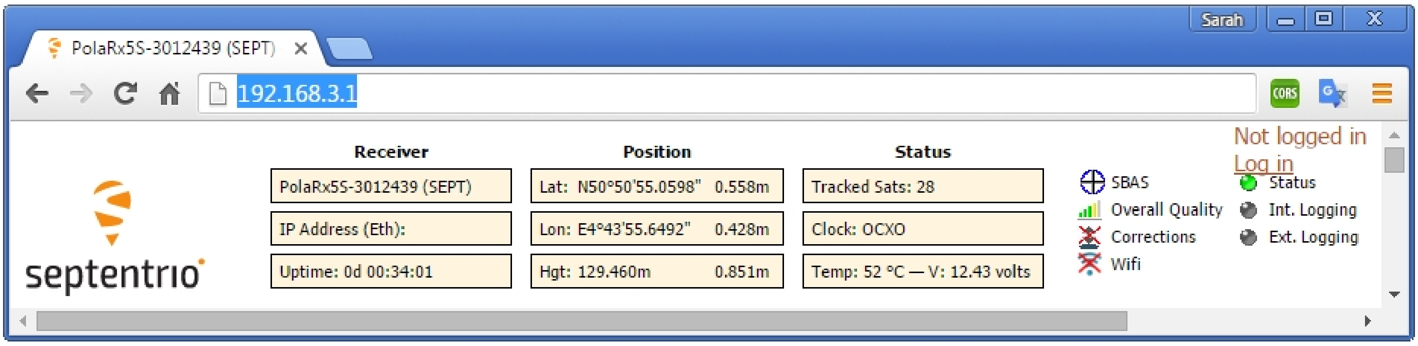


Figure 3-5: Connect to the Web Interface of the PolaRx5S over USB using the IP address **192.168.3.1** on any web browser

3.3.2 Over WiFi

The Web Interface can also be accessed over a WiFi connection. You can turn on the WiFi modem of the PolaRx5S by pressing firmly on the WiFi button as shown in Figure 3-6.

Figure 3-6: Press firmly on the front-panel WiFi button to turn on the WiFi modem. When active, the red WiFi led will be lit.

On your PC or tablet, search for visible WiFi signals: the PolaRx5S identifies itself as a wireless access point named 'PolaRx5S-*serial number*'. The serial number of the PolaRx5S can be found on an identification sticker on the receiver housing. Select and connect to the PolaRx5S as shown in Figure 3-7.

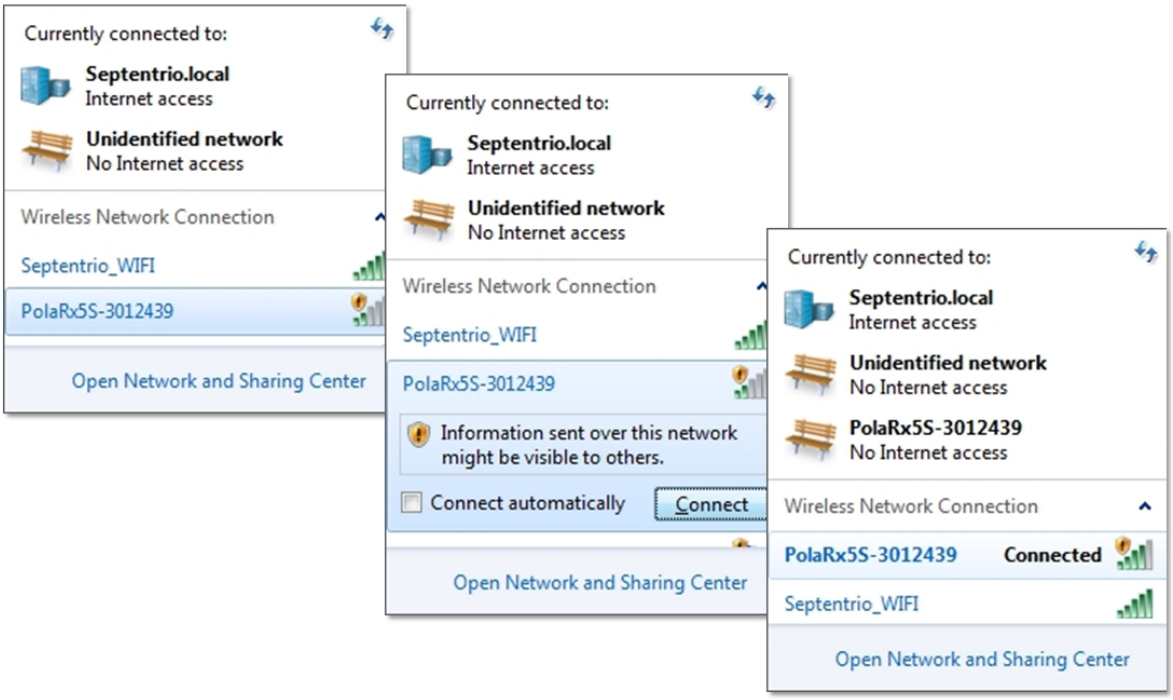


Figure 3-7: Select the PolaRx5S from the list of detected wireless signals and connect

When your PC has connected to the PolaRx5S WiFi signal, you can open a web browser using the IP address: **192.168.20.1** as shown in Figure 3-8.

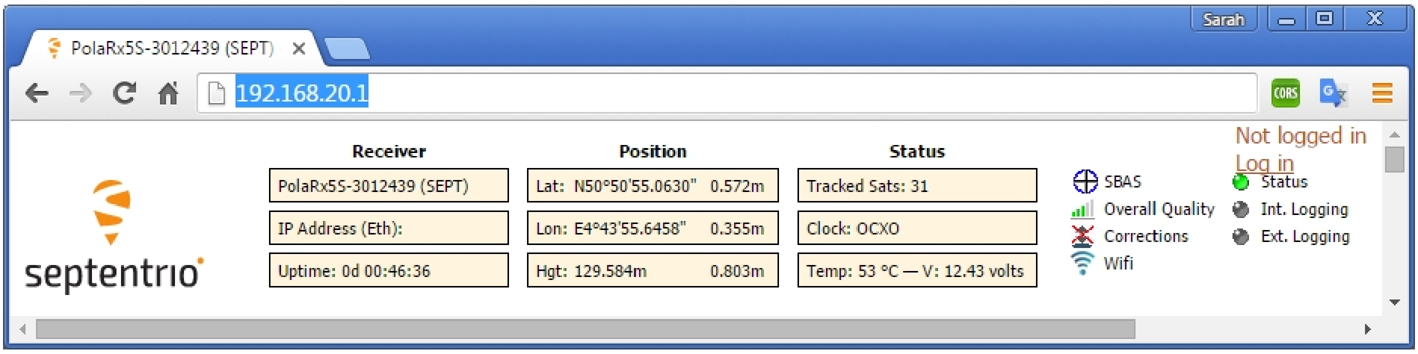


Figure 3-8: Connect to the Web Interface of the PolaRx5S over WiFi using the IP address **192.168.20.1** on any web browser

3.3.3 Using the Ethernet cable

Connect the Ethernet cable cable (CBLe_ETH_MS) to the socket labelled 'ETH' on the front panel of the PolaRx5S as shown in Figure 3-9.

Figure 3-9: Connecting to the front-panel Ethernet socket

For the most straightforward setup, the RJ45 socket of the Ethernet cable should be connected to a network running a DHCP server. The IP address assigned to the receiver will be associated with the hostname PolaRx5S-*xxxxxxx*, where *xxxxxxx* are the 7 digits of the PolaRx5S serial number. The serial number can be found on an identification sticker on the receiver housing. You can then make a connection to the receiver using the web address 'http://PolaRx5S-*xxxxxxx*'. Figure 3-10 shows a screenshot of an Ethernet connection to a receiver with serial number 3012439 using '**http://PolaRx5S-3012439/**'.

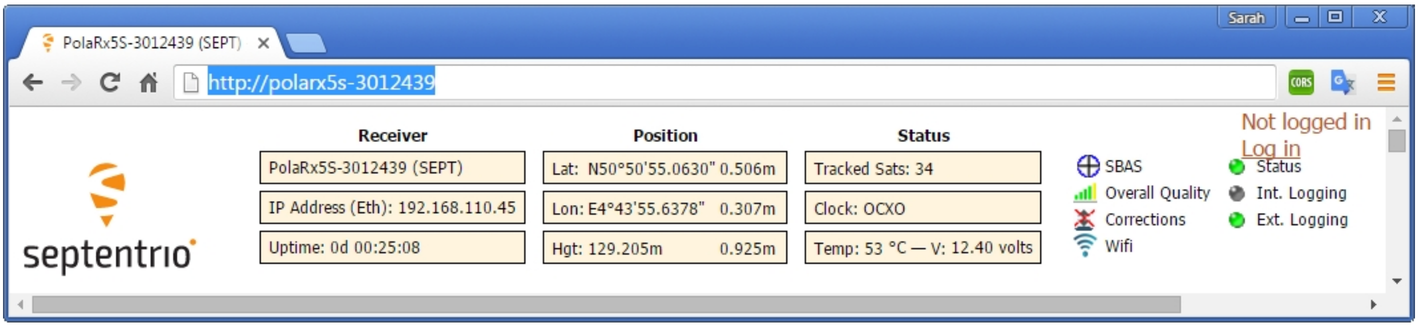


Figure 3-10: Connecting to the Web Interface over Ethernet

4 Scintillation monitoring with the PolaRx5S

This chapter covers the configuration of the PolaRx5S receiver and the RxLogger tool for ionospheric scintillation and TEC monitoring.

4.1 High-Level Operation Overview

In a typical setup, the PolaRx5S generates and outputs 50 Hz phase and amplitude samples for all visible satellites and frequency bands. These samples are logged on a host PC in hourly files using the provided RxLogger graphical interface tool. At the end of every hour, TEC and scintillation indices are computed for all visible satellites and logged as comma-delimited ASCII records.

The receiver can also output S4 and σ_ϕ indices in real time for all tracked satellites.

Appendices F, G and H provide further information on operating the receiver at 100 Hz, real-time S4 and σ_ϕ output and, on the TEC calibration tool built into **`sbf2ismr`**.

4.2 Configuring RxLogger

Septentrio provides the RxTools suite of GUI tools among which is RxLogger. The RxLogger tool provides and easy and convenient way to log and monitor ISMR data from the PolaRx5S. A short description of the various RxTools and how to install them can be found in Appendix I. This section details how to use RxLogger for ISMR file generation.

4.2.1 Connecting To the Receiver

The first time you run RxLogger, you will need to create a new connection. Future connections will reuse the last connection by default.

Refer to the RxControl Manual for a complete description of the connection options

⚠ It is recommended to use one of the two Virtual USB COM port connections to connect RxLogger to the receiver as shown in Figure 4-1. A TCP/IP (Ethernet) connection can also be used however, depending on your network topology, this may lead to occasional data gaps when logging at high rates. The standard serial ports should not be used because their bandwidth is too low to support the high data throughput required for ionospheric scintillation monitoring.

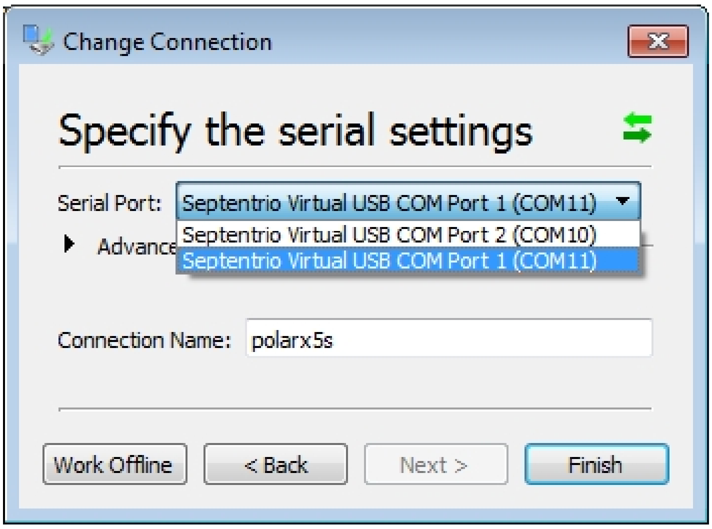


Figure 4-1: Connecting to the PolaRx5S over USB using RxLogger

4.2.2 Selecting file names and directories

You need to specify where to store the raw data from the receiver. Raw data (high-rate phase and amplitude and low-rate support data) are stored in SBF (Septentrio Binary Format). Raw data files will be referred to as *SBF files* in the remainder of this chapter.

In the main window of RxLogger, on the 'Global' tab select the directory where data files will be logged. In the example shown in Figure 4-2, data will be stored in the folder `C:\Users\dean\DATA\`.

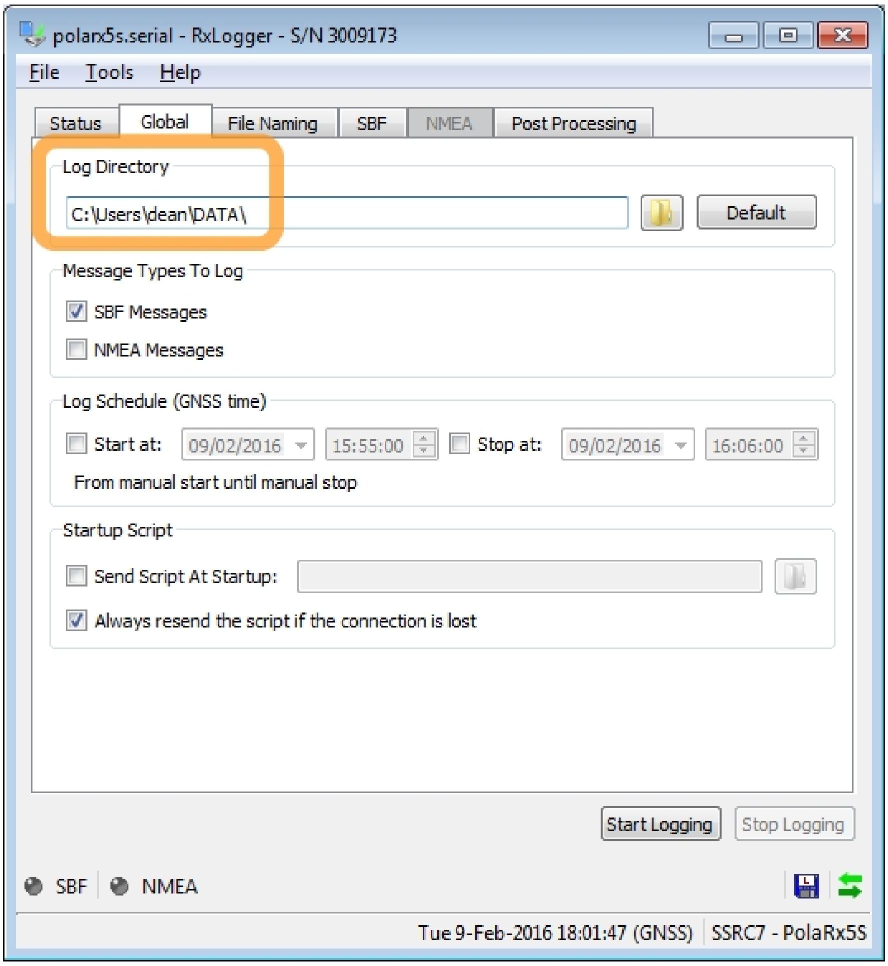


Figure 4-2: Select the location on your PC where data files will be logged

In the 'File Naming' tab, you can set the file naming convention to one of the IGS options. Selecting 'IGS 1 hour' for example, will cause RxLogger to create hourly SBF files.

Every day, a new directory will be created under the directory specified in the 'Global' tab, with the name being formed from a concatenation of the two-digit year number and the 3-digit day-of-year. Within each of the daily directories, the hourly SBF files follow the IGS file naming convention:

```
ssssdddf.yy_
|   |   | |
|   |   | |
|   |   | |
|   |   | +---  yy:  two-digit year
|   |   |
|   |  +-----    f:  file sequence character within day
|   |                A:  1st hour 00h-01h; B: 2nd hour 01h-02h; ...
|   |                X: 24th hour 23h-24h
|   |
|   +-------  ddd:  day of the year of first record in file
|
+----------- ssss:  4-character station name designator
```

The ‘ssss’ field (the station name designator) can be freely chosen by selecting ‘Force the MarkerName to:’. In the example shown in Figure 4-3, the ‘ssss’ field has been set to ‘SEPT’.

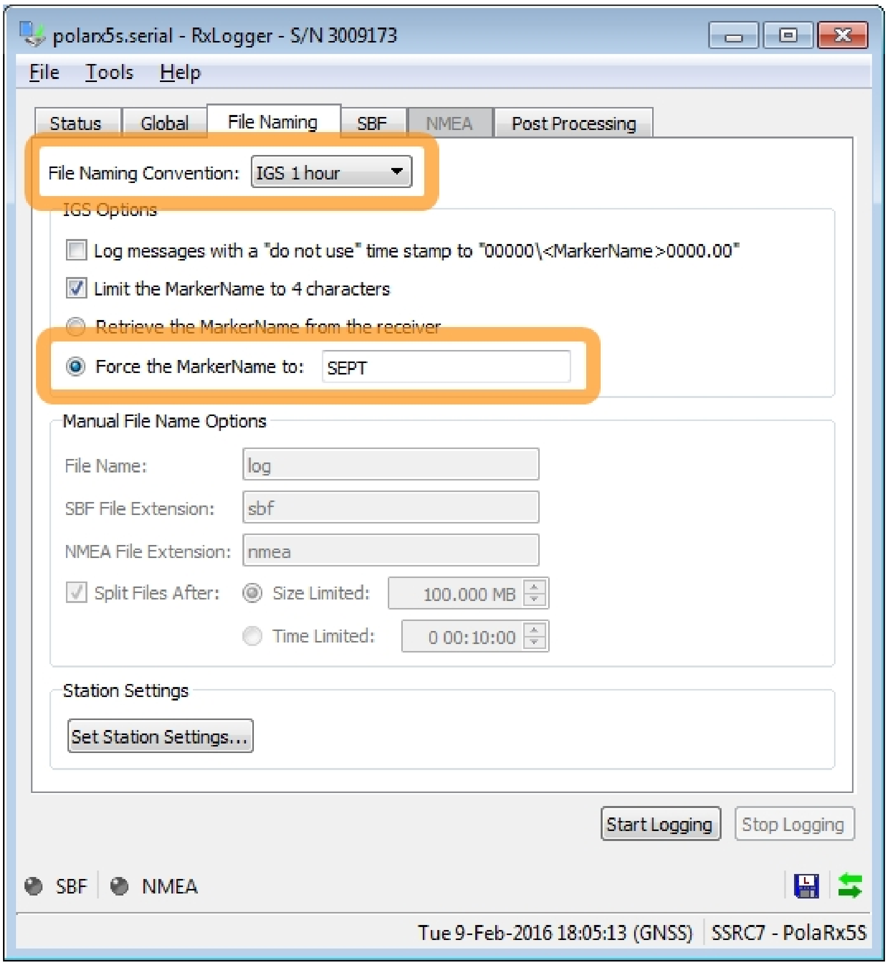


Figure 4-3: Specifying the station name designator as ‘SEPT’

Figure 4-4 shows an example of data files logged on February 26, 2016. The files with the ‘`.16_`’ extension are SBF files containing the raw data from the receiver. The files with the ‘`.16_.ismr`’ extension are the post-processed files containing the scintillation indices. Section 4.2.4 describes how to configure post-processing actions.

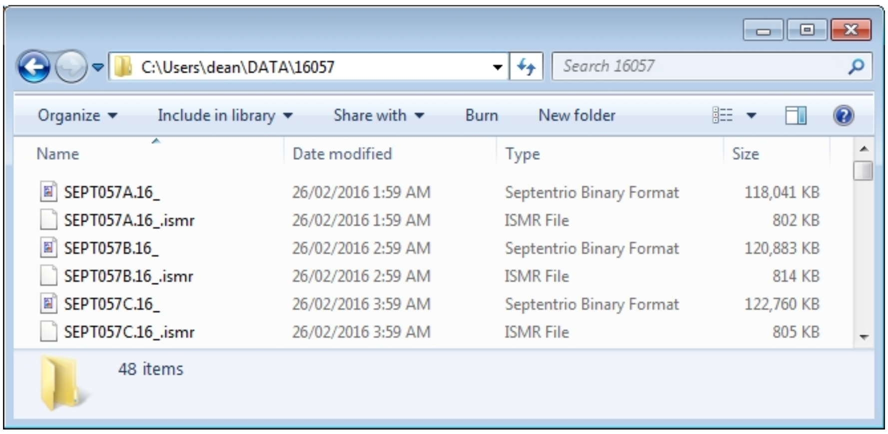


Figure 4-4: An example of hourly SBF and ISMR files logged on day 57 in 2016

4.2.3 Selecting the set of raw data to log

Raw data in SBF format are arranged in so-called SBF blocks. You need to tell RxLogger which blocks to log and at what interval which is done in the 'SBF' tab of the main window of RxLogger. For ionospheric scintillation and TEC monitoring, the following SBF blocks should be logged:

- At an interval of 20ms (50Hz):
  - IQCorr
- At an interval of 1s (1Hz)* :
  - MeasEpoch
  - MeasExtra
- At an interval of 10s:
  - ReceiverStatus
  - ChannelStatus
  - ReceiverSetup
- At an interval of *OnChange*:
  - GPSNav
  - GLONav
  - GALNav
  - CMPNav
  - QZSNav

Click the 'Add Stream' button to add a new column in the window.

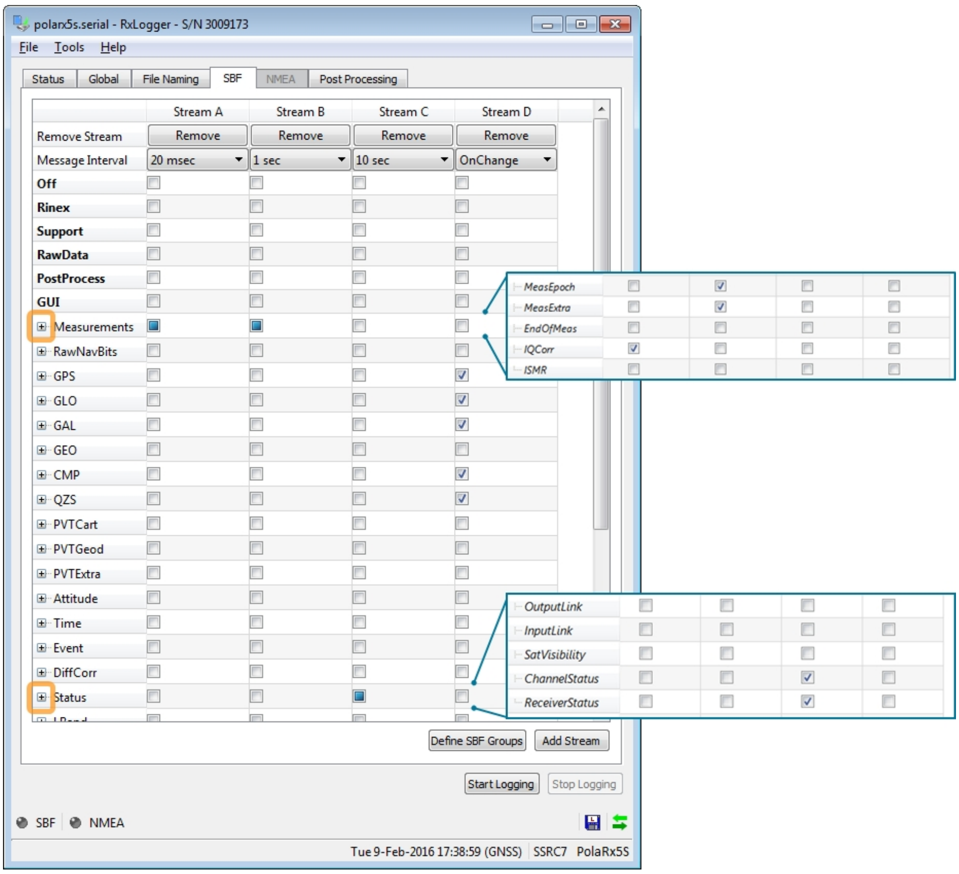


Figure 4-5: Select the SBF blocks and logging rates needed for ISMR file generation

*The MeasEpoch and MeasExtra SBF blocks can be logged at 1 Hz to reduce the CPU load and keep file sizes to a minimum

4.2.4 Configuring the post processing options

The SBF files themselves do not contain the scintillation indices however, they can be computed using the **sbf2ismr** conversion program. RxLogger can be configured to automatically execute **sbf2ismr** on SBF files. You can do this by defining a post-processing action on the 'Post Processing' tab of the main window of RxLogger. When logging hourly files, as in this example, **sbf2ismr** will be executed every hour.

Refer to Section 4.3 for a detailed description of the **sbf2ismr** conversion program.

Click the 'Add' button to start defining a new post processing action. From there you can select 'ISMR Conversion' from the drop-down list as shown in Figure 4-6. Then click on 'Next'.

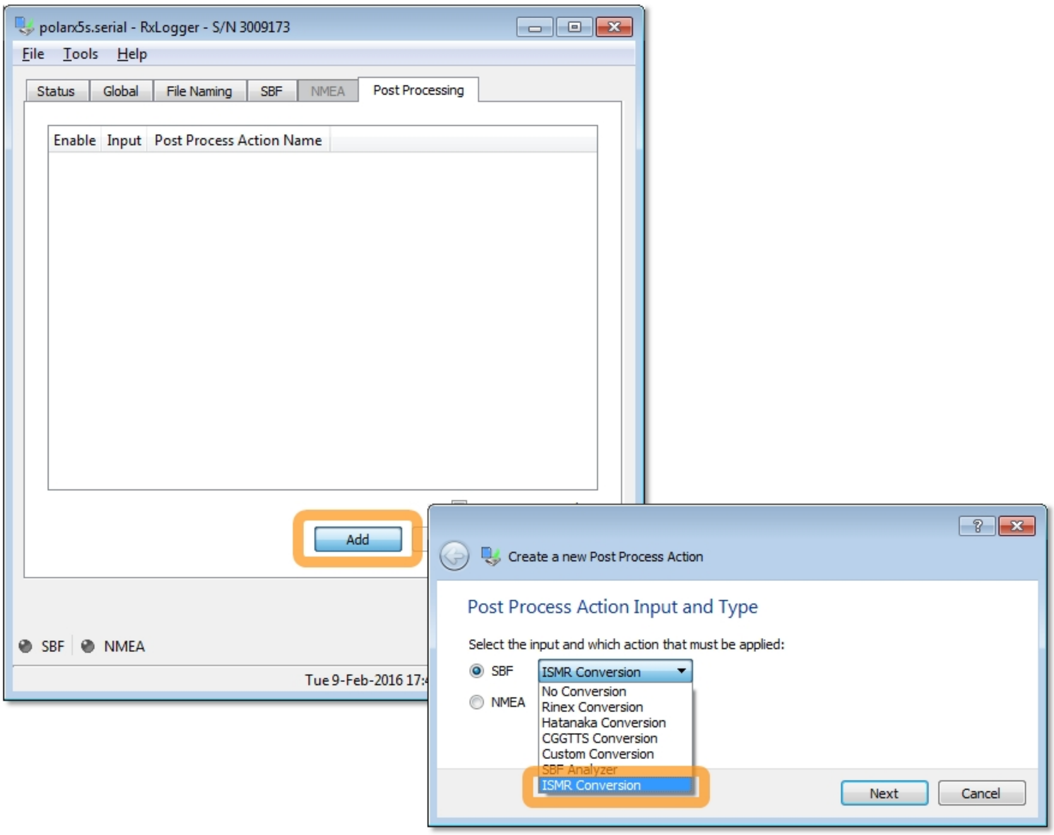


Figure 4-6: Selecting automatic generation of ISMR from SBF data files

On the 'ISMR Parameters' page shown in Figure 4-7, you can select the desired phase detrending cut-off frequency - the default is 0.10 Hz).

You may want to reduce the number of columns in the ISMR file if for example, you are only interested in single-frequency indices. Section 4.3.1 gives more details on how this can be done.

You can also exclude one or more constellations from the ISMR file, even if the data from satellites from these constellations are contained in the SBF file.

Optionally, you can also provide a TEC calibration file in order to correct for TEC biases. Section 4.3.1 provides more details on TEC calibration.

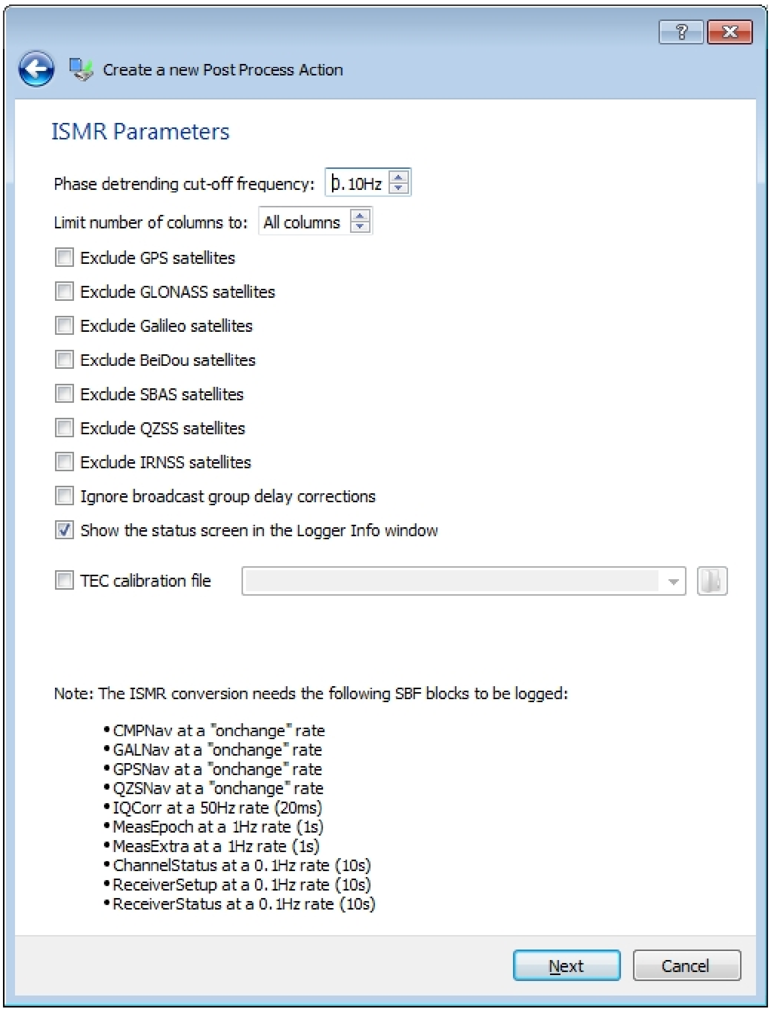


Figure 4-7: The default parameters for SBF conversion to ISMR

After clicking 'Next', you can select then select which compression to apply to the ISMR file. As these files are typically small (<200kbytes), file compression is not normally required.

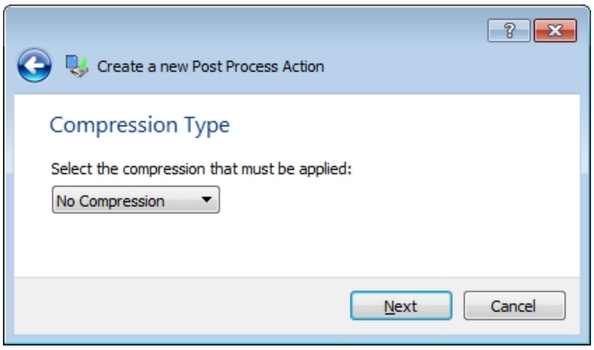


Figure 4-8: Selecting not to compress the generated ISMR files

Clicking 'Next' in Figure 4-8 will now bring you to the 'Output File Settings' window where you can select a destination for the newly created ISMR files. A remote FTP server location can be selected or, clicking on 'Next' will select the default settings, as shown in Figure 4-9. This will store the ISMR files in the same directory as the raw SBF files.

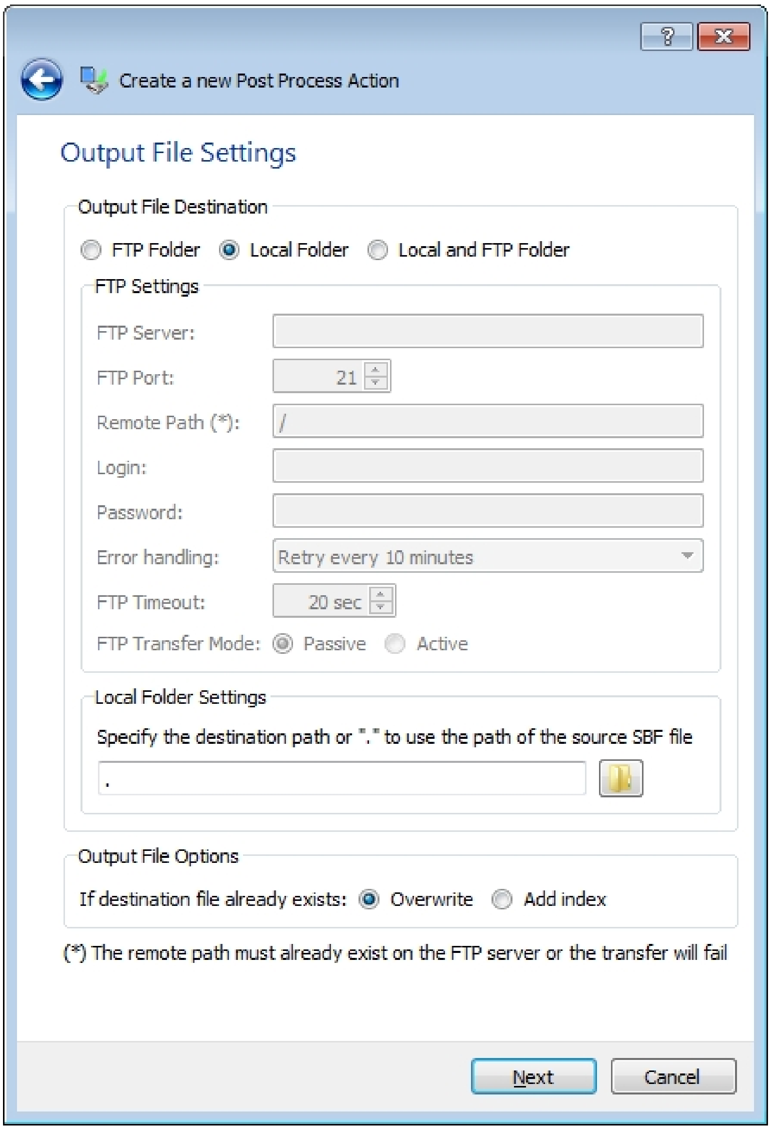


Figure 4-9: Storing the generated ISMR files in the default location - alongside the logged raw SBF files

On the final configuration window shown in Figure 4-10, you are prompted to enter a name for the post-processing action and a description. The name used is for information only and has no bearing on the post processing.

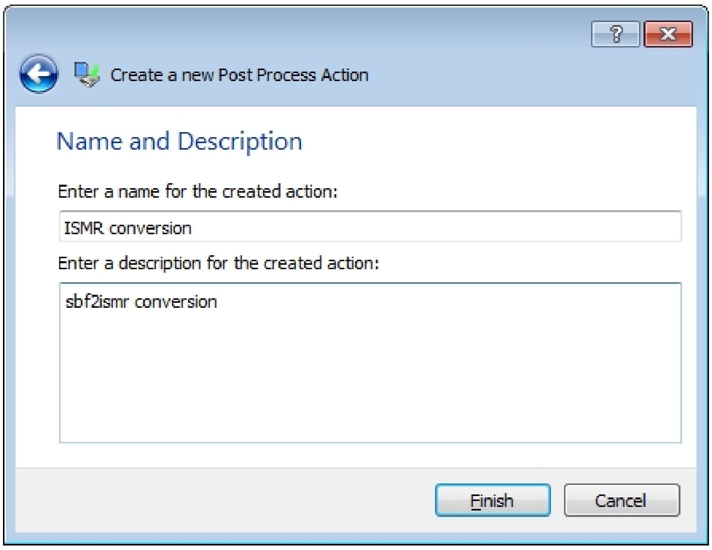


Figure 4-10: Enter a name and description for the newly configured SBF to ISMR conversion

Click 'Finish' to finalise the configuration and you will see the 'ISMR conversion' action appearing in the list of post processing actions. You can now click 'Start Logging' to start logging.

4.2.5 Monitoring logging and ISMR status

In the 'Logger Info' field on the 'Status' tab of the main window of RxLogger as shown in Figure 4-11, you can follow the progress of the logging and post-processing and get a snapshot of the ISMR indices.

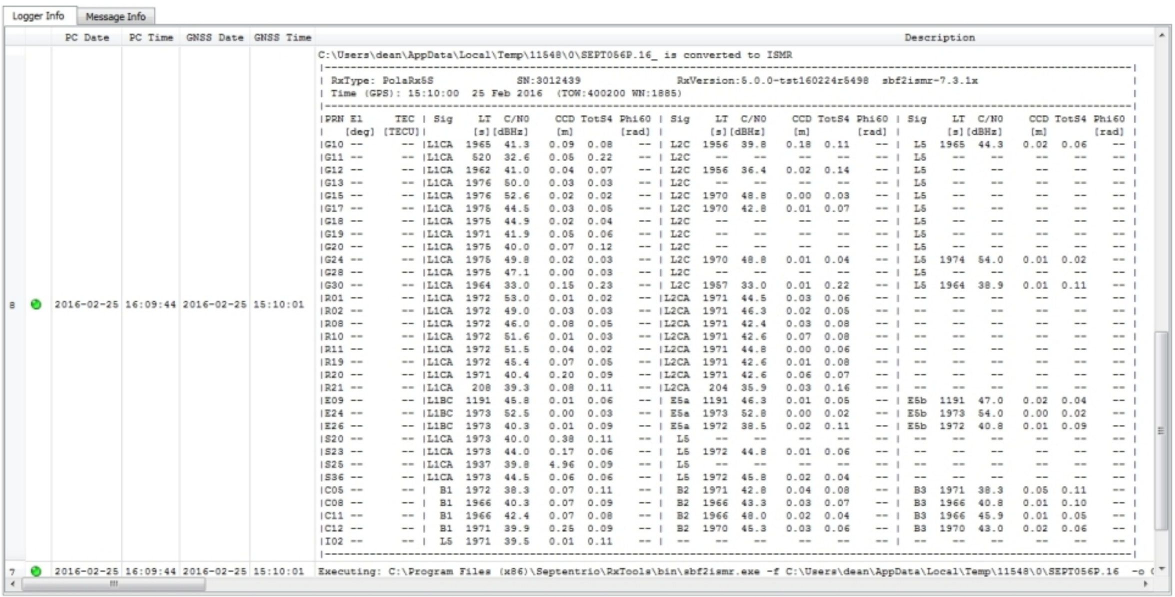


Figure 4-11: The Logger Info filed gives summary information on the ISMR indices as well as logging and post processing

At any time, logging can be stopped by clicking 'Stop Logging'.

4.2.6 Compressing the raw SBF files

The hourly SBF files can be very large so it may be a good idea to compress these files. This can be done by defining a second post-processing action on the 'Post Processing' tab of the main window of RxLogger.

In the same way as before, click 'Add' to configure a new post-processing action as shown in Figure 4-12. This time, in the 'Post Process Action Input and Type' window, just click 'Next' as there is no conversion to apply. You can now select the compression program to use.

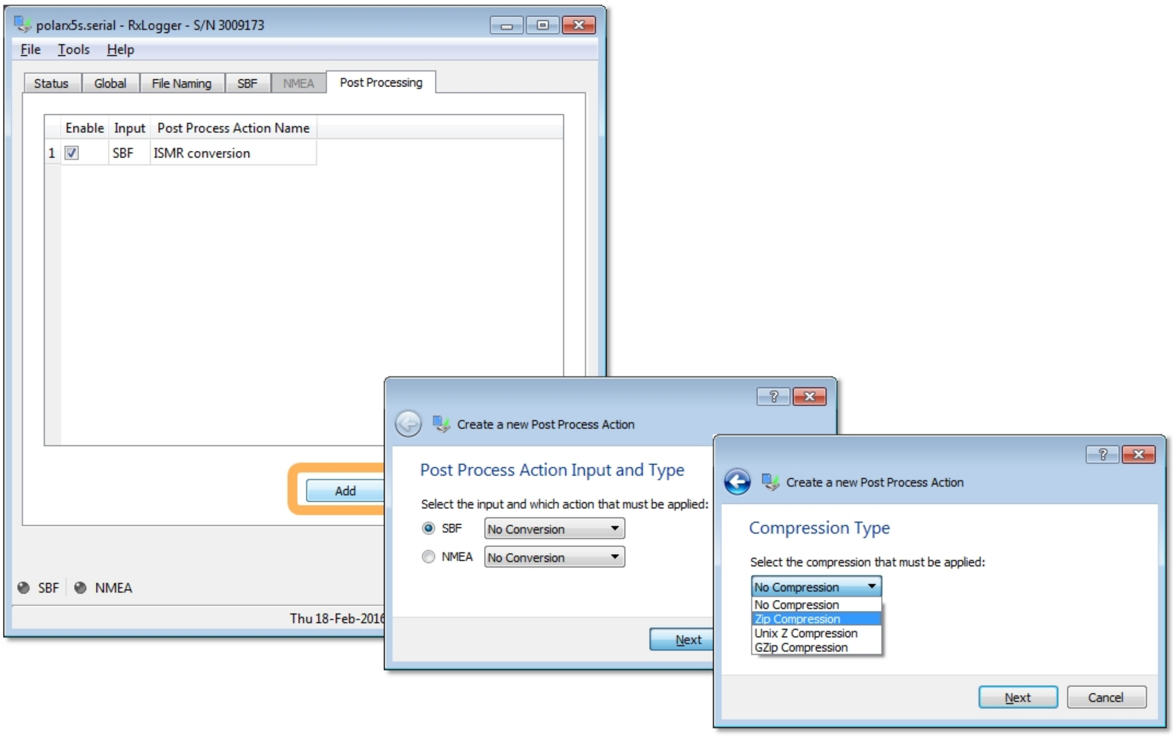


Figure 4-12: Add a second post processing action

As before, enter a name and description of this new post-processing action and click 'Finish'.

Make sure to check the 'Remove Source Files' box in the *Post Porcessing* tab as shown in Figure 4-13 in order to delete the original (non-compressed) SBF files.

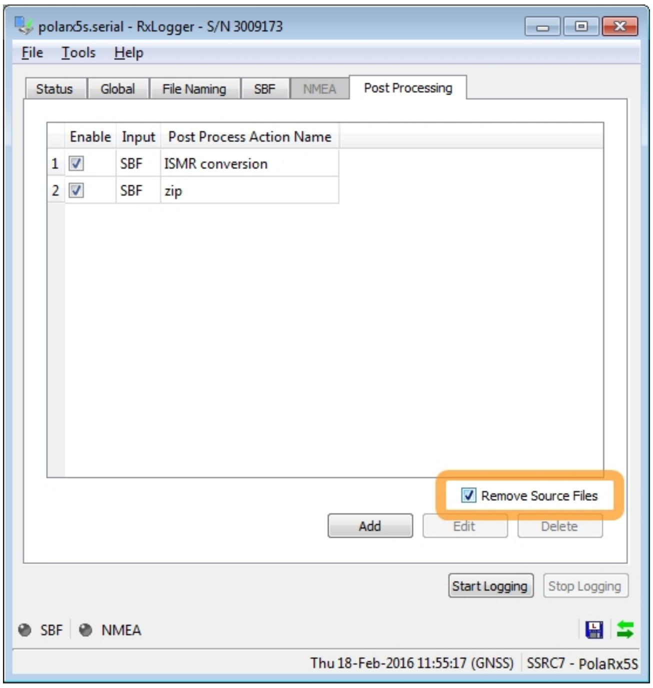


Figure 4-13: Select 'Remove Source Files' to delete the non-compressed raw SBF files after generating the compressed files

4.2.7 Exiting and restarting RxLogger

When exiting and restarting RxLogger, all the user settings from the previous session of RxLogger are preserved: they are stored in the file `.septentrio\rxlogger.conf` in the user's home directory. Thus, the configuration steps described above need only be carried out once.

4.2.8 Starting RxLogger from the command line

RxLogger can be launched from the command line, as shown in Figure 4-14.

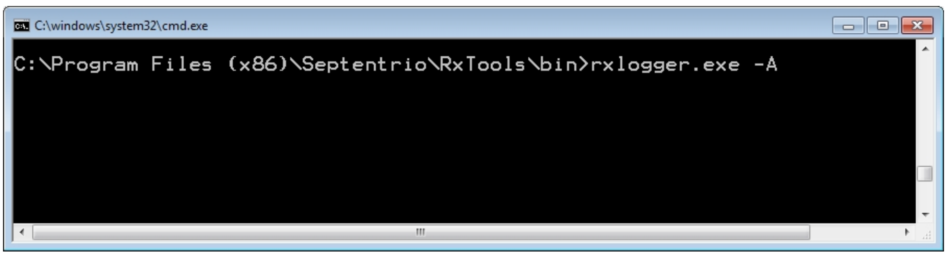


Figure 4-14: Launching RxLogger from the command line

Rxlogger starts in the configuration as stored in the `rxlogger.conf` file. The -A command line option causes RxLogger to immediately start logging without any user interaction. The command '`rxlogger -A`' can be included in a boot script on the host PC to automatically start RxLogger at each boot.

4.3 sbf2ismr Program

The **sfb2ismr** program converts a binary SBF file containing 50 or 100 Hz raw correlation and phase data into an ASCII ISMR file containing ionospheric scintillation and TEC indices. In addition, **sfb2ismr** can also produce an ASCII file containing the unprocessed 50 or 100 Hz raw correlations and phase data. **sfb2ismr** can also be used for TEC calibrations.

sfb2ismr is a command line tool: both Windows and Linux versions are provided. Typically, **sfb2ismr** is automatically started from RxLogger at the end of each hourly file but, it can also be manually called at any time to get an instant overview of the scintillation indices, or to reprocess the raw high-rate data.

The output ISMR file contains comma-delimited ASCII records for all satellites in view for every minute. An example of the contents of an ISMR file is given below:

```
1462,540300, 11,00000074, 27,15,48.2, 0.029, 0.000, 0.017, 0.023, 0.028, 0.028, 0.028, 2.397, 0.071, 18.811, 0.042, 18.830, 0.044, 18.782, 0.055, 19.934, 0.033, 3581,0, 3578,37.5, 0.8
1462,540300, 10,00000074,232,29,48.2, 0.049, 0.030, 0.026, 0.032, 0.036, 0.036, 0.036, -3.606, 0.066, 13.851,-0.031, 14.099,-0.026, 14.384,-0.021, 14.061,-0.032, 4210,0, 4202,37.6, 1.5
1462,540300, 23,00000074,232,68,48.2, 0.039, 0.007, 0.023, 0.029, 0.033, 0.033, 0.034, -5.799, 0.073, 7.283, 0.004, 5.559,-0.003, 7.273, 0.013, 5.864,-0.006,11894,0,11888,37.6, 1.3
1462,540300, 17,00000074,152,15,48.2, 0.039, 0.006, 0.020, 0.026, 0.030, 0.030, 0.031, -1.774, 0.056, 18.259, 0.010, 19.839, 0.014, 19.230, 0.006, 19.458, 0.006,22381,0,22376,37.7, 1.1
1462,540300, 1,00000074,344,23,48.2, 0.030, 0.000, 0.018, 0.024, 0.029, 0.029, 0.029, -2.851, 0.061, 16.669,-0.041, 17.002,-0.032, 16.412,-0.035, 17.973,-0.036, 3761,0, 3752,37.5, 0.9
1462,540300, 2,00000074, 17,45,48.2, 0.041, 0.012, 0.019, 0.025, 0.030, 0.030, 0.030, -1.537, 0.168, 10.215,-0.019, 10.976,-0.024, 10.329,-0.014, 10.548,-0.021, 2981,0, 2977,37.6, 1.1
1462,540300, 15,00000074, 85,37,48.2, 0.029, 0.000, 0.017, 0.023, 0.028, 0.029, 0.029, -4.356, 0.062, 9.643, 0.008, 10.691, 0.002, 10.748,-0.002, 11.128, 0.007,29080,0,29072,37.7, 0.9
1462,540300, 24,00000074,170,47,48.2, 0.029, 0.000, 0.016, 0.022, 0.028, 0.028, 0.028, -5.024, 0.053, 8.872, 0.012, 8.882, 0.023, 9.082, 0.023, 9.253, 0.024,17000,0,16994,37.7, 0.8
1462,540300, 8,00000074,308,16,48.2, 0.031, 0.000, 0.017, 0.023, 0.029, 0.029, 0.029, -1.904, 0.054, 17.773,-0.001, 19.134,-0.002, 17.611, 0.006, 18.916, 0.002,10137,0,10130,37.6, 0.9
1462,540360, 11,00000074, 27,15,48.0, 0.028, 0.000, 0.016, 0.022, 0.028, 0.029, 0.030, 2.446, 0.048, 18.906, 0.060, 18.744, 0.038, 19.020, 0.052, 18.954, 0.049, 3641,0, 3638,37.6, 0.8
1462,540360, 10,00000074,232,30,48.0, 0.045, 0.022, 0.019, 0.024, 0.030, 0.031, 0.031, -3.654, 0.047, 14.184,-0.022, 13.899,-0.027, 13.575,-0.021, 14.460,-0.017, 4270,0, 4262,37.6, 1.4
1462,540360, 23,00000074,231,68,48.0, 0.039, 0.000, 0.018, 0.023, 0.029, 0.031, 0.031, -5.799, 0.074, 6.616, 0.005, 7.006, 0.003, 6.473, 0.005, 8.339, 0.010,11954,0,11948,37.7, 1.2
1462,540360, 17,00000074,152,15,48.0, 0.037, 0.000, 0.017, 0.022, 0.028, 0.030, 0.030, -1.734, 0.073, 17.887, 0.019, 19.591, 0.008, 19.468, 0.007, 18.697, 0.012,22441,0,22436,37.7, 1.0
1462,540360, 1,00000074,344,23,48.0, 0.030, 0.000, 0.017, 0.022, 0.029, 0.030, 0.030, -2.863, 0.055, 15.289,-0.029, 15.365,-0.043, 15.641,-0.035, 15.774,-0.034, 3821,0, 3812,37.6, 0.8
1462,540360, 2,00000074, 17,45,48.0, 0.042, 0.014, 0.019, 0.024, 0.030, 0.032, 0.032, -1.521, 0.059, 9.843,-0.012, 8.758,-0.018, 9.605,-0.017, 9.615,-0.015, 3041,0, 3037,37.6, 1.2
1462,540360, 15,00000074, 85,37,48.0, 0.029, 0.000, 0.016, 0.022, 0.028, 0.029, 0.030, -4.354, 0.052, 11.167, 0.007, 11.852,-0.000, 12.414, 0.010, 10.929, 0.006,29140,0,29132,37.7, 0.8
1462,540360, 24,00000074,170,46,48.0, 0.030, 0.000, 0.017, 0.022, 0.028, 0.029, 0.030, -5.017, 0.062, 10.205, 0.017, 9.482, 0.025, 8.596, 0.017, 9.205, 0.026,17060,0,17054,37.7, 0.9
1462,540360, 8,00000074,309,16,48.0, 0.032, 0.000, 0.018, 0.022, 0.028, 0.030, 0.030, -1.926, 0.069, 17.764, 0.004, 18.354, 0.001, 17.802, 0.002, 19.268, 0.002,10197,0,10190,37.6, 0.9
```

The command **sfb2ismr** with the `-h` option prints the help screen, including a definition of all the fields (or columns) in a record:

```
C:\Program Files (x86)\Septentrio\RxTools\bin>sbf2ismr.exe -h

sbf2ismr is a utility to convert the data in a SBF file into ASCII ionospheric scintillation
monitoring records.  The SBF file needs to contain the following SBF blocks at at least
the specified interval:
    IQCorr,         20ms
    MeasEpoch,      1s
    MeasExtra,      1s
    ReceiverStatus, 10s
    ChannelStatus,  10s
    ReceiverSetup,  10s
    GPSNav,         OnChange
    GALNav,         OnChange
    CMPNav,         OnChange
    QZSNav,         OnChange

Command line options:

sbf2ismr -f InputFile [-o ISMRFile][-p PreviousFile][-x Systems][-c DetFreq]
                      [-n NoCols][-S][-r RawFile][-g][-b StartEpoch]
                      [-e EndEpoch][-V][-h]

  -f InputFile :  (mandatory) Name of the input SBF file.
  -o ISMRFile :   Name of the output file containing the ISMR records (see
                  format below).
                  This argument is optional.  If not provided, the output file
                  name is the same as the input file name, with the extension
                  .ismr being added. See below the format of the ISMR file.
  -p PrevFile :   Name of the previous input file, i.e. name of the SBF file
                  logged just before input_file.  The last epochs of the
                  previous file are used to initialize the detrending filters.
                  If there is no previous file, skip this option or use NA as
                  PrevFile.
  -C TECCalFile:  Name of the TEC calibration input file (see format below).
  -x Systems:     Exclude one or more satellite systems from the observation
```

```
                file. Systems may be G (GPS), R (Glonass), E (Galileo),
                S (SBAS), C (Compass), J (QZSS), I (IRNSS) or any combination thereof.
                For instance -xERSCJI produces a GPS-only observation file.
  -c DetFreq :  Cutoff frequency of the carrier phase detrending filter
                (6th order high pass butterworth).  Units of Hz. Valid values
                 range from 0.01 to 1.0 Hz, default 0.1Hz.
  -n NoCols :   Output the first NoCols in the ISMR file and discard the others
                (see column format below).  By default, -n62 is assumed.
  -S :          Do not generate the ISMR file, but still print the status
                screen.
  -g :          When computing TEC, do not correct for satellite inter-frequency
                biases, i.e. ignore the group delay corrections transmitted by
                the satellites in their navigation message.
  -r RawFile :  Name of the "raw file" containing the raw data
                (carrier phase and correlations) in ASCII format.  This
                argument is optional.  If not provided, the raw file is
                not created. See below the format of the raw file.
  -b StartEpoch Time of first epoch to parse from the SBF file (in GPS time
                scale). Format: yyyy-mm-dd_hh:mm:ss.
  -e EndEpoch   Time of last epoch to parse from the SBF file (in GPS time
                scale). Format: yyyy-mm-dd_hh:mm:ss.
  -as           Do not generate ISMR data, but print TEC calibration values using
                the SBAS ionospheric corrections as reference.
  -ak           Do not generate ISMR data, but print TEC calibration values using
                the Klobuchar ionospheric model as reference.
  -V :          Display the version of sbf2ismr.
  -h :          Display this help screen.


Format of the ISMR output file
------------------------------

  Note: "Sig1" means L1CA for GPS/GLONASS/SBAS/QZSS, L1BC for GALILEO, B1 for BeiDou and L5 for IRNSS.
        "Sig2" means L2C for GPS/GLONASS/QZSS, E5a for GALILEO, L5 for SBAS, B2 for BeiDou.
        "Sig3" means L5 for GPS/QZSS, E5b for GALILEO, B3 for BeiDou.

Col  1: WN, GPS Week Number
Col  2: TOW, GPS Time of Week (seconds)
Col  3: SVID (see numbering convention in the 'SBF Outline' section of the Reference Guide)
Col  4: Value of the RxState field of the ReceiverStatus SBF block
Col  5: Azimuth (degrees)
Col  6: Elevation (degrees)
Col  7: Average Sig1 C/N0 over the last minute (dB-Hz)
Col  8: Total S4 on Sig1 (dimensionless)
Col  9: Correction to total S4 on Sig1 (thermal noise component only) (dimensionless)
Col 10: Phi01 on Sig1,  1-second phase sigma (radians)
Col 11: Phi03 on Sig1,  3-second phase sigma (radians)
Col 12: Phi10 on Sig1, 10-second phase sigma (radians)
Col 13: Phi30 on Sig1, 30-second phase sigma (radians)
Col 14: Phi60 on Sig1, 60-second phase sigma (radians)
Col 15: AvgCCD on Sig1, average of code/carrier divergence (meters)
Col 16: SigmaCCD on Sig1, standard deviation of code/carrier divergence (meters)
Col 17: TEC at TOW-45s (TECU), taking calibration into account (see -C option)
Col 18: dTEC from TOW-60s to TOW-45s (TECU)
Col 19: TEC at TOW-30s (TECU), taking calibration into account (see -C option)
Col 20: dTEC from TOW-45s to TOW-30s (TECU)
Col 21: TEC at TOW-15s (TECU), taking calibration into account (see -C option)
Col 22: dTEC from TOW-30s to TOW-15s (TECU)
Col 23: TEC at TOW (TECU), taking calibration into account (see -C option)
Col 24: dTEC from TOW-15s to TOW (TECU)
Col 25: Sig1 lock time (seconds)
Col 26: sbf2ismr version number
Col 27: Lock time on the second frequency used for the TEC computation (seconds)
Col 28: Averaged C/N0 of second frequency used for the TEC computation (dB-Hz)
Col 29: SI Index on Sig1: (10*log10(Pmax)-10*log10(Pmin))/(10*log10(Pmax)+10*log10(Pmin)) (dimensionless)
Col 30: SI Index on Sig1, numerator only: 10*log10(Pmax)-10*log10(Pmin) (dB)
Col 31: p on Sig1, spectral slope of detrended phase in the 0.1 to 25Hz range (dimensionless)
Col 32: Average Sig2 C/N0 over the last minute (dB-Hz)
Col 33: Total S4 on Sig2 (dimensionless)
Col 34: Correction to total S4 on Sig2 (thermal noise component only) (dimensionless)
Col 35: Phi01 on Sig2,  1-second phase sigma (radians)
Col 36: Phi03 on Sig2,  3-second phase sigma (radians)
Col 37: Phi10 on Sig2, 10-second phase sigma (radians)
Col 38: Phi30 on Sig2, 30-second phase sigma (radians)
```

```
Col 39: Phi60 on Sig2, 60-second phase sigma (radians)
Col 40: AvgCCD on Sig2, average of code/carrier divergence (meters)
Col 41: SigmaCCD on Sig2, standard deviation of code/carrier divergence (meters)
Col 42: Sig2 lock time (seconds)
Col 43: SI Index on Sig2 (dimensionless)
Col 44: SI Index on Sig2, numerator only (dB)
Col 45: p on Sig2, phase spectral slope in the 0.1 to 25Hz range (dimensionless)
Col 46: Average Sig3 C/N0 over the last minute (dB-Hz)
Col 47: Total S4 on Sig3 (dimensionless)
Col 48: Correction to total S4 on Sig3 (thermal noise component only) (dimensionless)
Col 49: Phi01 on Sig3,  1-second phase sigma (radians)
Col 50: Phi03 on Sig3,  3-second phase sigma (radians)
Col 51: Phi10 on Sig3, 10-second phase sigma (radians)
Col 52: Phi30 on Sig3, 30-second phase sigma (radians)
Col 53: Phi60 on Sig3, 60-second phase sigma (radians)
Col 54: AvgCCD on Sig3, average of code/carrier divergence (meters)
Col 55: SigmaCCD on Sig3, standard deviation of code/carrier divergence (meters)
Col 56: Sig3 lock time (seconds)
Col 57: SI Index on Sig3 (dimensionless)
Col 58: SI Index on Sig3, numerator only (dB)
Col 59: p on Sig3, phase spectral slope in the 0.1 to 25Hz range (dimensionless)
Col 60: T on Sig1, phase power spectral density at 1 Hz (rad^2/Hz)
Col 61: T on Sig2, phase power spectral density at 1 Hz (rad^2/Hz)
Col 62: T on Sig3, phase power spectral density at 1 Hz (rad^2/Hz)


Format of the raw ASCII output file (option -r)
-----------------------------------------------

Col  1: TOW, GPS Time of Week (seconds)
Col  2: SVID (see numbering convention in the 'SBF Outline' section of the Reference Guide)
Col  3: Signal type (see numbering convention in the 'SBF Outline' section of the Reference Guide)
Col  4: Carrier phase (cycles)
Col  5: I correlation (dimensionless)
Col  6: Q correlation (dimensionless)

Format of the TEC calibration input file (option -C)
----------------------------------------------------

The TEC calibration file is a text file that can be provided as input to
sbf2ismr to correct for TEC biases.
Each line of the file must contain a satellite identifier (RINEX convention)
followed by the TEC calibration value in TECU for that particular satellite.
It is possible to apply the same calibration value to all satellites of a
constellation by replacing the satellite number by wildcards.
If the calibration value is set to 'NA', no TEC is computed for the specified
satellite.
If the same satellite is addressed multiple times in the file, only the last
entry is taken into account.
Comments can be added by preceding them with a '#' character.
Example of a valid calibration file:

#This is a comment
E12 9.45
R03 -0.3
G** 2.4
G21 2.8
S** NA

With this file, the TEC calibration value is 9.45TECU for Galileo E12, -0.3TECU
for GLONASS R03, 2.4 for all GPS satellites except G21 where it is 2.8TECU.  TEC
should not be computed for SBAS satellites (calibration value set to 'NA').  For
all satellites not addressed in the calibration file, the TEC calibration value
is assumed to be zero.
Corrected TEC values are obtained by subtracting the TEC calibration value
from the raw TEC.  The ISMR file contains corrected values.
```

4.3.1 ISMR Record Details

Time Tag

The first two columns contain the week number and time-of-week. The time scale is GPS time, even for non-GPS satellite records.

Supported Satellites

ISMR records are generated every minute for all satellites tracked by the receiver.

The SVID column identifies the satellite and the different constellations are assigned their own range of values. For example, SVID values in the range 1-37 refer to GPS satellites. You can find the full list of satellite constellation SVID ranges in the 'SBF Outline' section of the 'PolaRx5S Reference Guide'.

Number of Columns

By default, the ISMR file contains 62 columns, i.e. 62 values for each satellite every minute.

It is possible to specify the number of columns to be included in the ISMR file by using the `-n` option of **`sfb2ismr`**. For example, a user only interested in the satellite azimuth and elevation (columns 5 and 6) could use the option `-n6` to skip all columns after the 6th one.

Not-Applicable Values

Not-applicable columns or fields for which the value is unknown contain the 'nan' (not-a-number) string.

S4 index

The total S4 (columns 8, 33 and 47) is the standard deviation of the 50 Hz raw signal power normalized to the average signal power over the last minute.

The S4 correction (columns 9, 34 and 48) accounts for the thermal noise contribution in the total S4.

The corrected S4 (i.e. without the thermal noise contribution) can be computed as follows:

$$X = S4^2_{total} - S4^2_{corrected}$$

$$S4_{corrected} = \begin{cases} \sqrt{X} & \text{if } X > 0 \\ 0 & \text{if } X \leq 0 \end{cases}$$

Phi*xx* indices

The Phi*xx* indices (columns 10 to 14, 35 to 39 and 49 to 53) contain the standard deviation, in radians, of the 50 Hz detrended carrier phase averaged over intervals of 1, 3, 10, 30 and 60 seconds. More specifically:

- Phi01 is the average of the 60 standard deviations computed over 1-s intervals during the last minute.
- Phi03 is the average of the 20 standard deviations computed over 3-s intervals during the last minute.
- Phi10 is the average of the 6 standard deviations computed over 10-s intervals during the last minute.
- Phi30 is the average of the 2 standard deviations computed over 30-s intervals during the last minute.
- Phi60 is the standard deviation computed over the whole last minute.

The phase detrending is done by filtering the raw 50 Hz carrier phase measurements by a 6th order Butterworth high-pass filter. The cutoff frequency of that filter is user selectable with the `-c` option of **`sfb2ismr`**.

Code-Phase Divergence

Columns 15-16, 40-41and 54-55 report the average value and the standard deviation of the difference between the pseudorange and the carrier phase measurements over the last minute.

TEC

TEC and dTEC values (both in TECU unit) are provided in columns 17-24.

Absolute TEC values are reported every 15 seconds (there are 4 TEC columns per ISMR record) which are based on dual-frequency pseudorange measurements only. dTEC values report the change of TEC over the four 15-second intervals of the previous minute. dTEC is computed from the carrier phase measurements only. It is much more accurate than TEC but only gives information on the TEC variation over time.

Note that absolute TEC values can be biased by satellite and station inter-frequency biases. Sources of station biases include the antenna, the antenna cable, splitters, amplifiers, and the receiver.

The table below lists the signals used for each constellation in the determination of TEC values as well as how the satellite biases are handled for that constellation.

Satellite system	TEC signal combination	Default handling of satellite-induced biases
GPS*	L1P-L2P	The correction (T_{GD}) transmitted by GPS satellites is applied.
GLO	L1CA-L2CA	Uncorrected
GAL	E1-E5a	The correction (BGD(E1,E5a)) transmitted by Galileo satellites is applied.
BDS	B1-B2	The correction (T_{GD1}, T_{GD2}) transmitted by BeiDou satellites is applied.
QZSS	L1CA-L2C	The correction (T_{GD}) transmitted by QZSS satellites is applied.
SBAS	L1CA-L5	Uncorrected
IRNSS	-	Only one frequency (L5) of IRNSS satellites is available so not possible to determine TEC values.

* For GPS, the TEC is based on the P-code measurements (as opposed to the C/A-code) on L1 and L2. There is therefore no need for correction of the L1P-L1CA satellite biases.

It is possible to disable the correction of the satellite inter-frequency biases, i.e. to ignore the corrections transmitted by the satellites. This is done using the option '`-g`' with **`sfb2ismr`**

Station biases (and residual satellites biases) can be provided in a TEC calibration file using the '`-C`' option with **`sfb2ismr`**. See the help text in Section 4.3 for the TEC calibration file format. **`sfb2ismr`** can be used to generate the calibration file. See Appendix H for details.

Note that, by default, the receiver does not apply any code smoothing which results in noise of a few TECUs on the TEC values. To reduce the noise at the expense of filtering short-term TEC variations, code smoothing can be enabled using the '**`setSmoothingInterval`**' command on the receiver. This remark does not apply to dTEC, which is computed on the basis of carrier phase measurements.

Scintillation Index

The SI index (columns 29, 43 and 57) is computed as follows:

$$SI = \frac{10log(Pmax) - 10log(Pmin)}{10log(Pmax) + 10log(Pmin)}$$

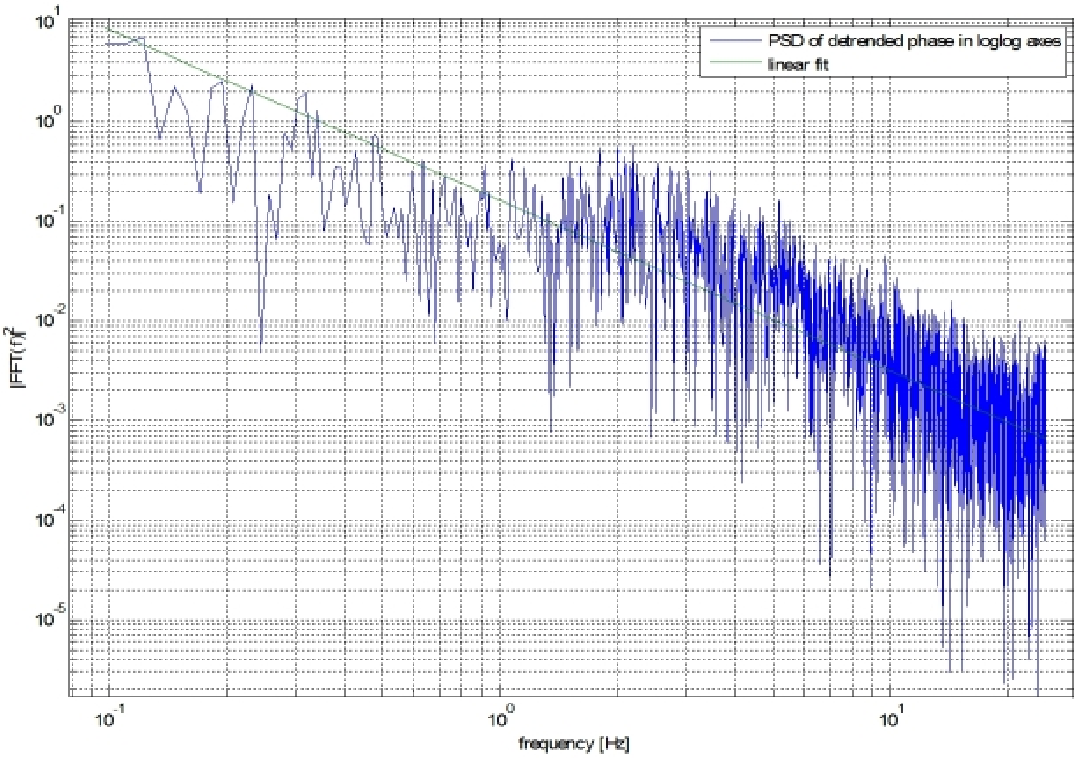
Where Pmax is conventionally defined as the power amplitude of the third peak down from the maximum excursion over the 3000 samples in the last minute, and Pmin is the power amplitude of the third level up from the minimum excursion.

Columns 30, 44 and 58 provide a modified scintillation index where only the numerator is computed (it is expressed in dB).

Spectral Slope and Strength

Columns 31, 45 and 59 provide the opposite of the slope (often denoted '*p*') of the phase PSD in log-log axes, where the PSD is obtained by computing the FFT of the 3000 detrended phase samples in the last minute. The slope is computed by fitting a linear polynomial to the PSD over the 0.1 to 25 Hz frequency range.

The figure below illustrates the way the slope is computed. In the example depicted, *p* is about 1.7.



Next to the spectral slope, the spectral strength (often noted '*T*') is provided in columns 60 to 62. The spectral strength is the detrended phase power spectral density at 1.0 Hz, i.e. the intercept of the linear polynomial described above.

4.3.2 Monitoring the Current Scintillation Status with sbf2ismr

Invoking **sfb2ismr** with the -S option produces a 'status screen' output, which is handy for checking the current status of the receiver and the level of the major scintillation indices. When using the -S option, no ISMR file is created, a status screen only is produced.

```
C:\sbf2ismr -S
|----------------------------------------------------------------------------------------------------------------------------|
| RxType: PolaRx5S_PRO          SN:2003886                RxVersion:2.3-tst111205r33427   sbf2ismr-4.6.0x                    |
| Time (GPS): 09:00:00  05 Jan 2012  (TOW:378000 WN:1669)                                                                    |
|----------------------------------------------------------------------------------------------------------------------------|
|PRN El      TEC | Sig     LT  C/N0   CCD TotS4 Phi60 | Sig     LT  C/N0   CCD TotS4 Phi60 | Sig     LT  C/N0   CCD TotS4 Phi60 |
|    [deg] [TECU]|         [s][dBHz]  [m]       [rad] |         [s][dBHz]  [m]       [rad] |         [s][dBHz]  [m]       [rad] |
|S24  7       -- |L1CA 11320  36.3  2.67  0.19  1.34 |  --     --    --    --    --    -- |  --    --    --    --    --    -- |
|G20 61     22.6 |L1CA 13829  49.8  0.08  0.06  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|G23 50     25.2 |L1CA 11793  50.8  0.06  0.05  0.02 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|G31 16     32.8 |L1CA 18480  42.1  0.34  0.26  0.05 | L2C 18910  39.5  0.25  0.13  0.04 |  L5    --    --    --    --    -- |
|G13 35     28.9 |L1CA  6297  48.4  0.15  0.10  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|G16 20     39.5 |L1CA  4075  42.3  0.28  0.16  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|G32 53     19.6 |L1CA 17439  50.7  0.09  0.08  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|R11 72     66.9 |L1CA  7058  49.1  0.13  0.06  0.03 |L2CA  6966  42.2  0.21  0.09  0.04 |  --    --    --    --    --    -- |
|G07 18     12.2 |L1CA  2426  42.8  0.16  0.13  0.04 | L2C  2415  36.8  0.38  0.20  0.06 |  L5    --    --    --    --    -- |
|G11 38     31.0 |L1CA 17724  48.3  0.07  0.10  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|G30 22     31.7 |L1CA  6491  44.3  0.13  0.07  0.03 | L2C     --    --    --    --    -- |  L5    --    --    --    --    -- |
|S20 42       -- |L1CA 65534  43.0  0.58  0.07  0.56 |  --     --    --    --    --    -- |  --    --    --    --    --    -- |
|R01 28     71.9 |L1CA  5624  45.0  0.22  0.22  0.08 |L2CA  4894  35.8  0.47  0.23  0.09 |  --    --    --    --    --    -- |
|R08 42     39.2 |L1CA 16188  49.1  0.17  0.07  0.11 |L2CA 14929  46.8  0.17  0.07  0.08 |  --    --    --    --    --    -- |
|S38 23       -- |L1CA 65534  44.5  0.80  0.06  0.45 |  --     --    --    --    --    -- |  --    --    --    --    --    -- |
|R23 13     76.5 |L1CA 13454  44.2  0.27  0.15  0.08 |L2CA 13475  40.3  0.31  0.23  0.08 |  --    --    --    --    --    -- |
|R12 22     75.8 |L1CA  2787  47.7  0.23  0.08  0.11 |L2CA  2546  42.7  0.21  0.08  0.09 |  --    --    --    --    --    -- |
|R07 13     73.5 |L1CA 25367  42.7  0.43  0.17  0.10 |L2CA 20359  42.4  0.27  0.10  0.08 |  --    --    --    --    --    -- |
|S33 32       -- |L1CA 20553  42.3  0.83  0.08  0.50 |  --     --    --    --    --    -- |  --    --    --    --    --    -- |
|R10 38     80.4 |L1CA 12821  48.9  0.19  0.07  0.04 |L2CA 12758  41.5  0.31  0.10  0.04 |  --    --    --    --    --    -- |
|G01 59     22.7 |L1CA 15012  50.5  0.09  0.08  0.03 | L2C 14593  47.8  0.15  0.06  0.02 |  L5 14593  53.5  0.15  0.05  0.02 |
|R24 16     60.5 |L1CA  7164  44.1  0.41  0.11  0.07 |L2CA  7164  42.4  0.35  0.22  0.06 |  --    --    --    --    --    -- |
|E31 -- -1242.7 |L1BC 12346  46.9  0.10    --    -- | E5a 12346  46.8  0.08  0.05  0.16 | E5b    --    --    --    --    -- |
|----------------------------------------------------------------------------------------------------------------------------|
```

4.3.3 Parsing the Raw Data

Using the -r option, in addition to the ISMR file, **sfb2ismr** produces an ASCII comma-delimited file containing the raw phase and correlation values. The format of this file is described in the help screen of **sfb2ismr** (see the screen dump in Section 4.3).

For example, to extract raw data from the SBF file `test1.sbf`, use the following command:

```
C:\sbf2ismr -f test1.sbf -r out_ascii.txt
```

The output file (`out_ascii.txt` in the example above) contains records such as those given below:

```
183601.00,101,20,98042793.214,119,11
183601.00,13,0,120929967.314,-305,-2
183601.00,2,0,120488916.249,258,-5
183601.00,8,0,108470409.601,-890,0
183601.00,10,0,107547455.595,806,0
183601.00,4,0,133013504.780,-165,7
183601.00,7,0,108677898.257,-836,-13
183601.00,7,3,84684077.234,266,5
183601.00,26,0,118815821.740,-323,-2
183601.00,5,0,110675377.978,727,-27
...
```

5 Receiver Monitoring

5.1 Basic operational monitoring

The ‘Overview’ page of the web interface in Figure 5-1 shows at a glance a summary of the PolaRx5S’s operational status.

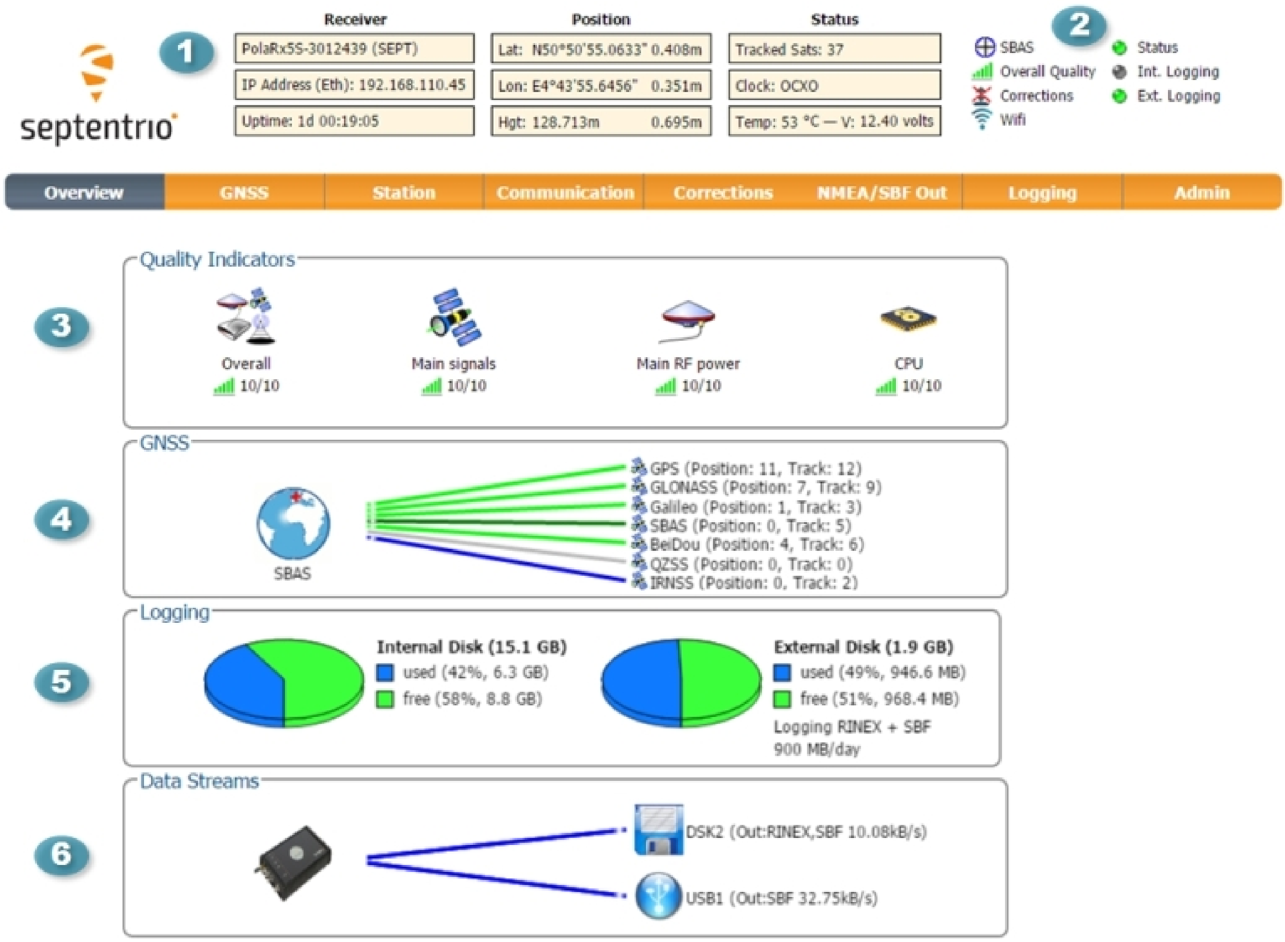


Figure 5-1: The Overview page of the web interface

1. The main information panel at the top of the window gives some basic receiver information: receiver type and serial number, the IP address if connected to the internet and the length of time since last power cycle (uptime). The total number of satellites in tracking is also given. The ‘Clock’ field indicates the receiver has an OCXO (Oven-Controlled Crystal Oscillator). The temperature on the receiver board and the voltage supplied is also shown.

2. The icons to the right of the information panel show that, in this example, the receiver has an SBAS position. The overall signal quality is excellent (5 out of 5 bars) and the receiver is logging to an external USB memory device (Ext. Logging). The active WiFi icon indicates that the on-board WiFi modem is turned on.

3. The Quality indicators give a simple overview of signal quality, RF antenna power and CPU load of the receiver.

4 The GNSS field details how many satellites for each constellation are being tracked and used in the position solution (PVT). A green line indicates that at least one satellite in the constellation is being used in the PVT, a blue line indicates that satellites are being tracked but not used and a grey line that there are no satellites from that particular constellation in tracking. More information can found in the 'Satellites and Signal' page on the 'GNSS' menu.

5 The Logging field summarises the current logging sessions and disk capacities. The complete logging information and configuration windows can be found via the 'Logging' menu.

6 The 'Data Streams' field gives and overview of the data stream into (green line) and out from (blue line) the receiver. In this example, the receiver is logging RINEX and SBF data to an external disk (DSK2) and there is a USB connection to the receiver.

5.2 AIM+: Using the spectrum analyser to detect and mitigate interference

The PolaRx5S is equipped with a sophisticated RF interference monitoring and mitigation system (AIM+). To mitigate the effects of narrow-band interference, 3 notch filters can be configured either in auto or manual mode. These notch filters effectively remove a narrow part of the RF spectrum around the interfering signal. The L2 band being open for use by radio amateurs is particularly vulnerable to this type of interference. The effects of wideband interference both intentional and unintentional can be mitigated by turning on the WBI mitigation system. The WBI system also reduces, more effectively than traditionally used pulse-blanking methods, the effects of pulsed interferers.

The spectrum view plot

In the Spectrum window of the GNSS menu, you can monitor the RF spectrum and configure three separate notch filters to cancel out narrowband interference. Figure 5-2 shows the L2 frequency band with the GPS L2P signal at 1227.60 MHz indicated. Different bands can be viewed by clicking on the 'Show table' button as shown. The spectrum is computed from baseband samples taken at the output of the receiver's analog to digital converters.

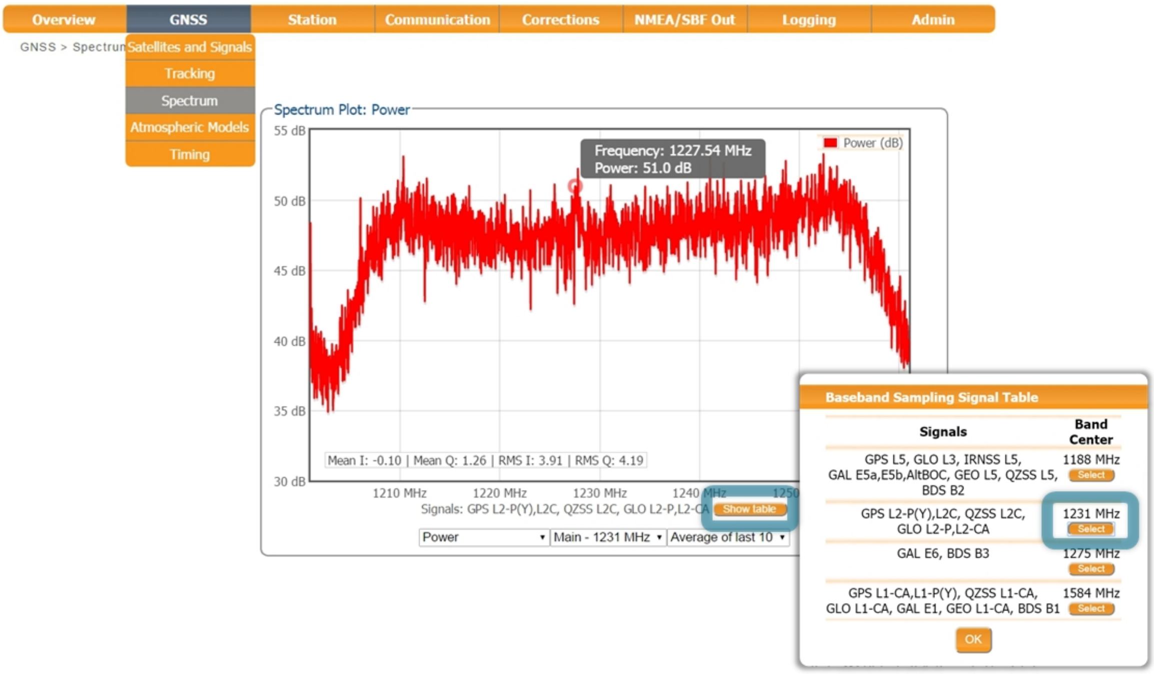


Figure 5-2: The RF spectrum of the L2 Band

5.2.1 Narrowband interference mitigation

Configuring the notch filters

In the default auto mode of the notch filters, the receiver performs automatic interference mitigation of the region of the spectrum affected by interference. In manual mode as shown configured for Notch1 in Figure 5-3, the region of the affected spectrum is specified by a centre frequency and a bandwidth which is effectively blanked by the notch filter.

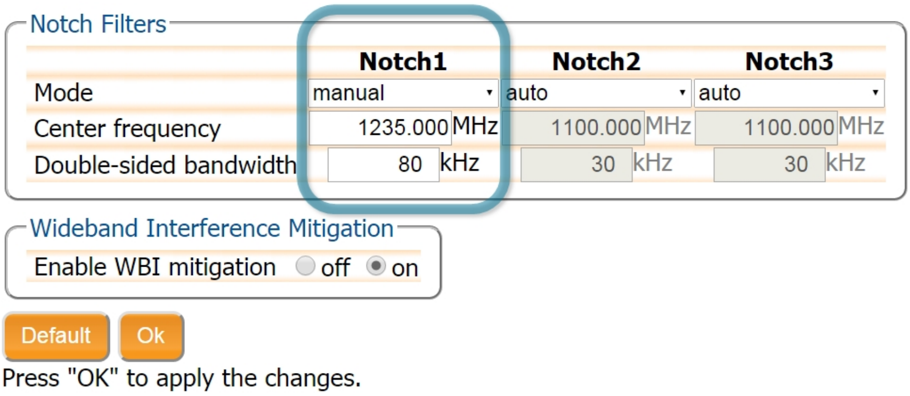


Figure 5-3: Configuring the first notch filter Notch1 at 1235 MHz

With the Notch1 settings as shown in Figure 5-3, the L2-band after the notch filter (After IM) is shown in Figure 5-4 with the blanked section clearly visible.

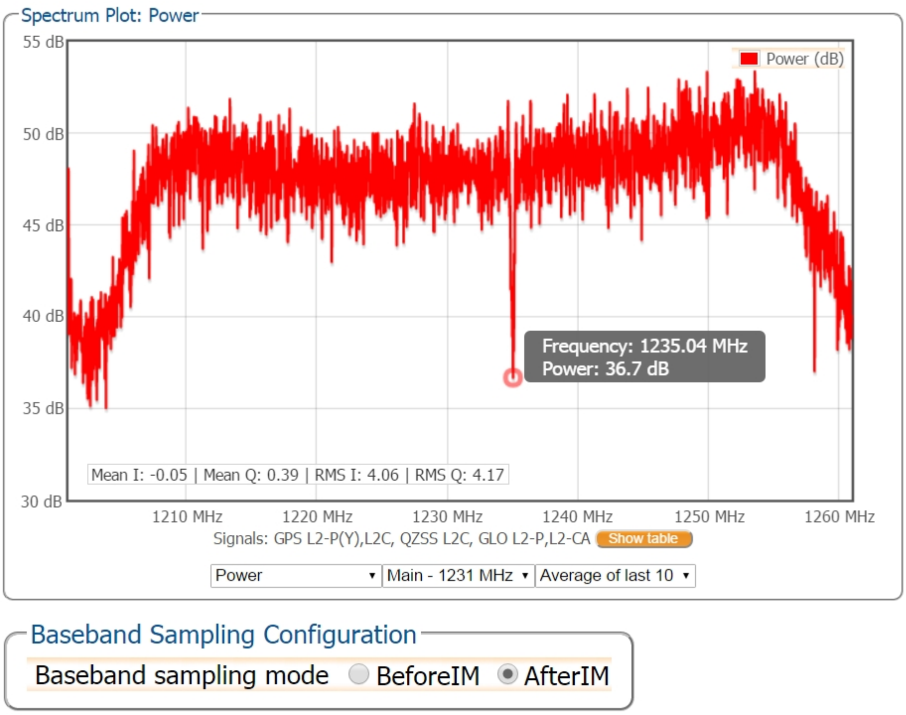


Figure 5-4: The RF spectrum of the L2 Band after applying the notch filter at 1235 MHz

5.2.2 Wideband interference mitigation

Wideband interference of GNSS signals can be caused unintentionally by military and civilian ranging and communication devices. There are also intentional sources of interference from devices such as chirp jammers. The wideband interference mitigation system (WBI) of the PolaRx5S can reduce the effect of both types of interference on GNSS signals.

Configuring WBI mitigation

The wideband interference mitigation system (WBI) can be enabled by selecting 'on' as shown in Figure 5-5. Enabling WBI will increase the power consumed by the PolaRx5S (see Section 2.2.1 for more details).

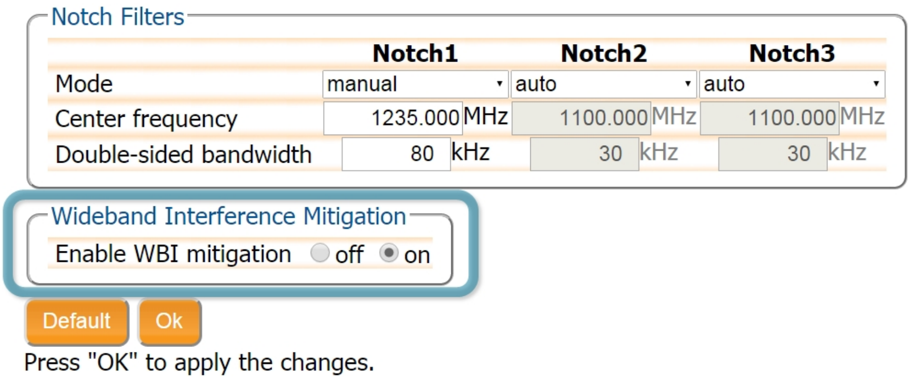


Figure 5-5: Select 'on' to enable wideband interference mitigation then 'OK' to apply the new setting

WBI mitigation in action

The GPS L1 band interference shown in Figure 5-6 is produced by combining the GNSS antenna signal with the output from an in-car GPS chirp jammer.

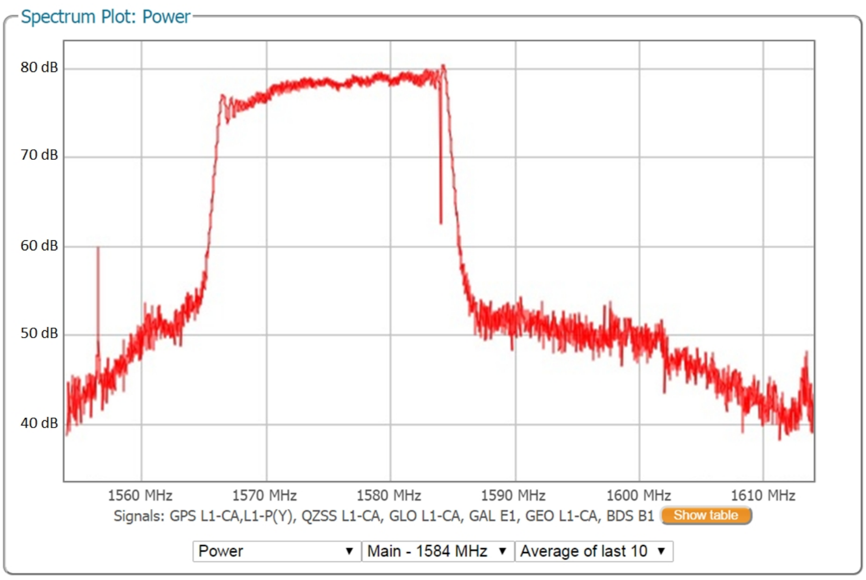


Figure 5-6: Simulated wideband interference in the GPS L1 band using an in-car chirp jammer

When WBI mitigation is enabled, the effect of the interference is dramatically reduced as Figure 5-7 shows.

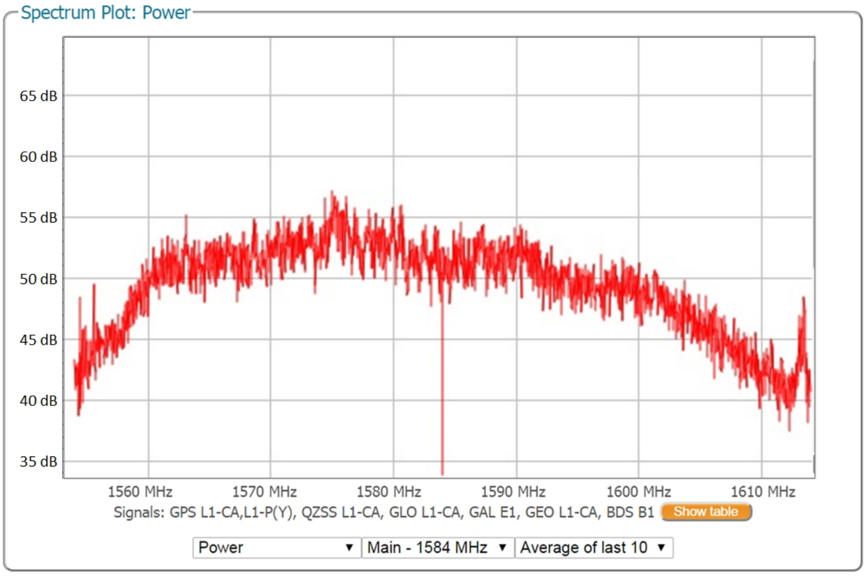


Figure 5-7: Enabling WBI interference mitigation greatly reduces the effect of the interference caused by the chirp jammer

5.3 How to log data for problem diagnosis

If the PolaRx5S does not behave as expected and you need to contact Septentrio Support Department, it is often useful to send a short SBF data file that captures the anomalous behaviour.

Step 1: Configuring a new logging session

On the menu bar select 'Logging' then the 'Log Sessions' window where you can define a new logging session.

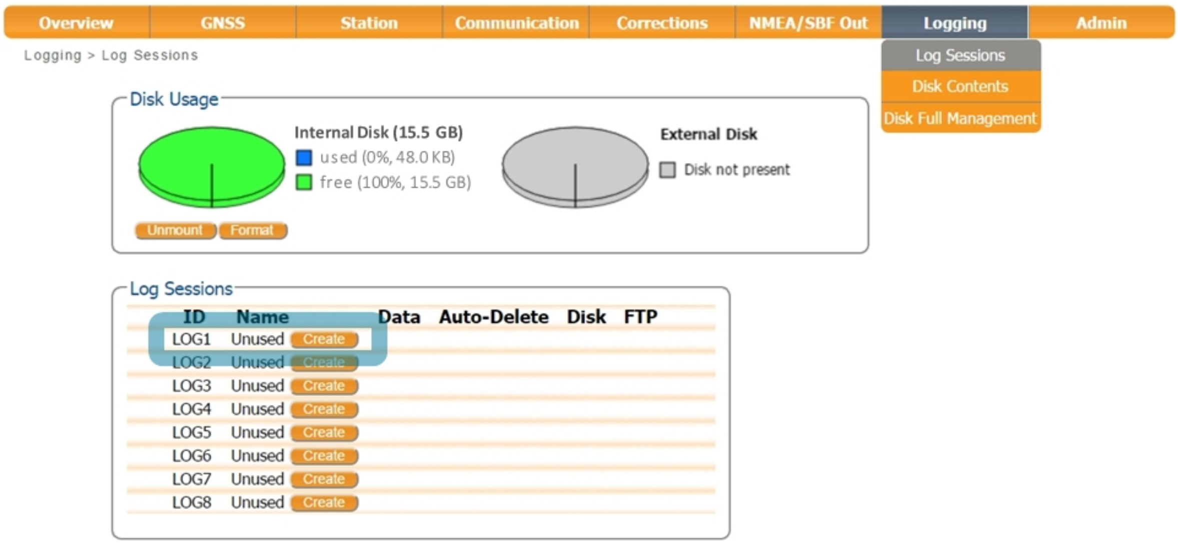


Figure 5-8: Click on the 'Create' button to start defining a new logging session

Step 2: Select to log the Support data blocks

In the 'Edit Session' window click on 'SBF Logging' and 'New SBF stream' as usual. In the final 'Edit SBF Stream' field, make sure to select the 'Support' option as shown in Figure 5-9. This option automatically selects all the SBF blocks that are useful for the Support Department to help with diagnosing receiver problems.

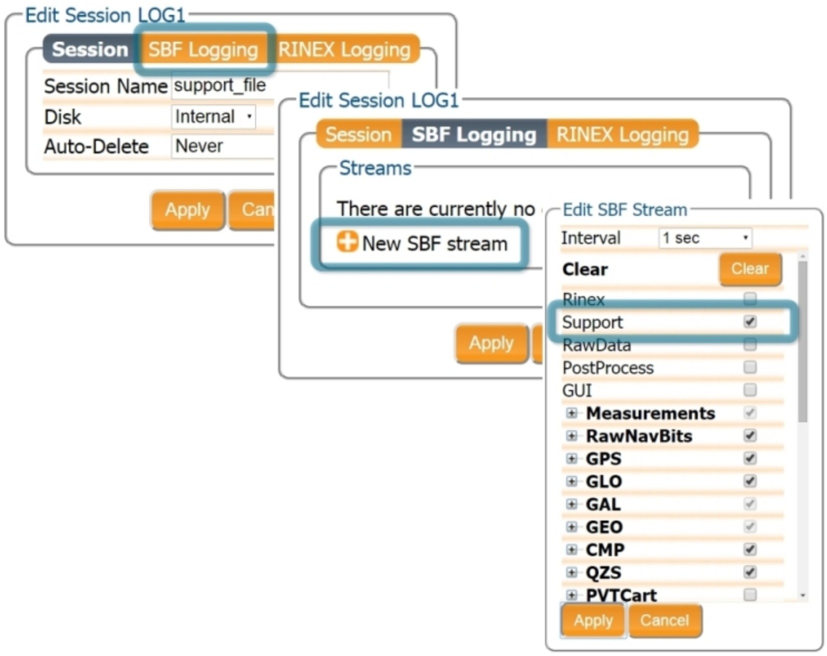


Figure 5-9: Configure a logging session selecting 'Support' in the 'Edit SBF Stream' field

When logging has been correctly configured, the 'Log Sessions' window will show the newly defined session as active as indicated in Figure 5-10

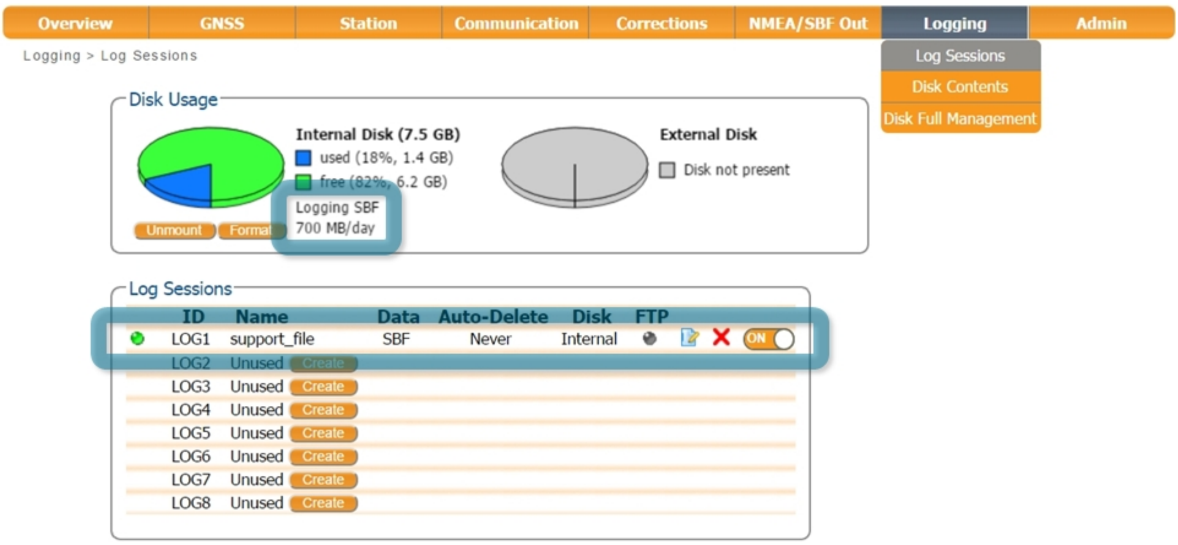


Figure 5-10: 'Log Session' window showing an active logging session

Step 3: Downloading the logged SBF file

The logged SBF file can be downloaded on the 'Disk Contents' page as shown in Figure 5-11. Click on the download icon next the SBF file you want to download.

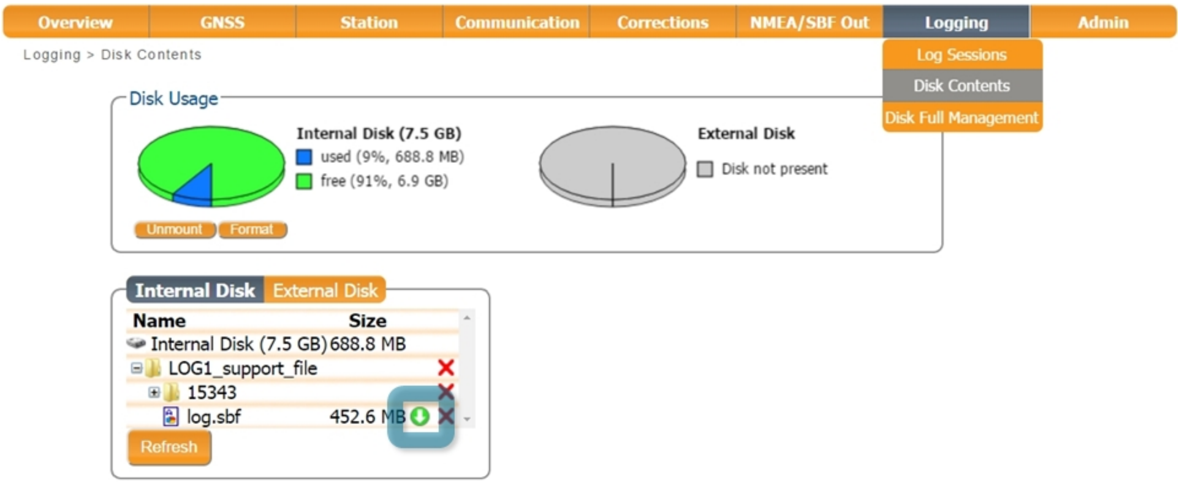


Figure 5-11: Click on the green download icon to next to the file you want to download

5.4 Activity logging

The PolaRx5S reports various events in the 'Receiver Messages' window of the 'Admin' menu that can be used to check the receiver operations. The example in Figure 5-12 shows that four, 15 minute SBF files have been successfully FTP pushed to a remote location.

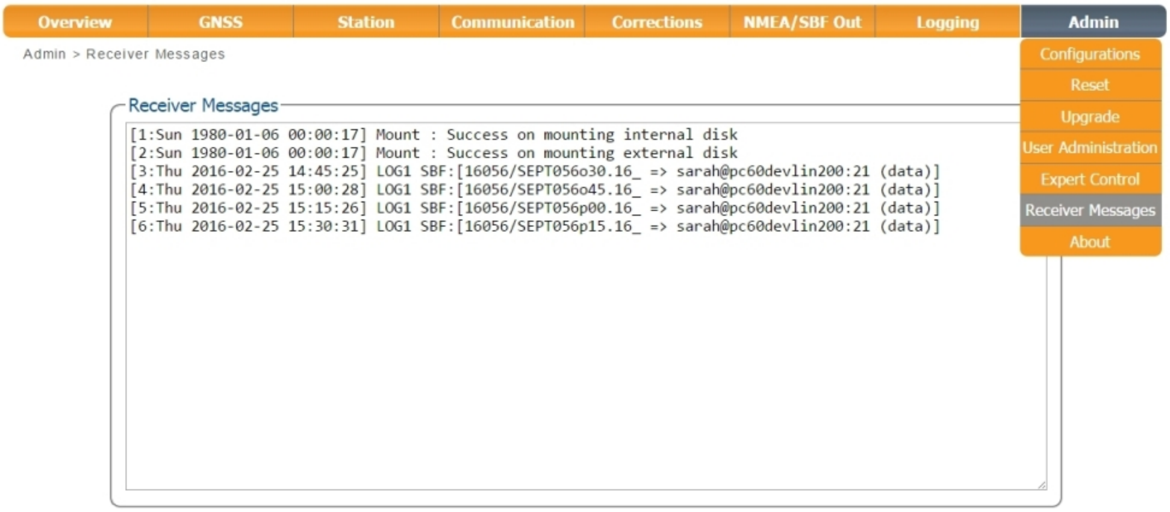


Figure 5-12: Receiver events reported by the PolaRx5S in the Receiver Messages window

6 Security

6.1 How to manage access to the PolaRx5S

You can manage the access that users have to the PolaRx5S in the 'User Administration' window of the 'Admin' menu.

By default, the web interface, FTP and communication ports are all assigned User-level access as shown in Figure 6-1. 'User' level allows full control of the receiver while 'Viewer' level only allows viewing the configuration.

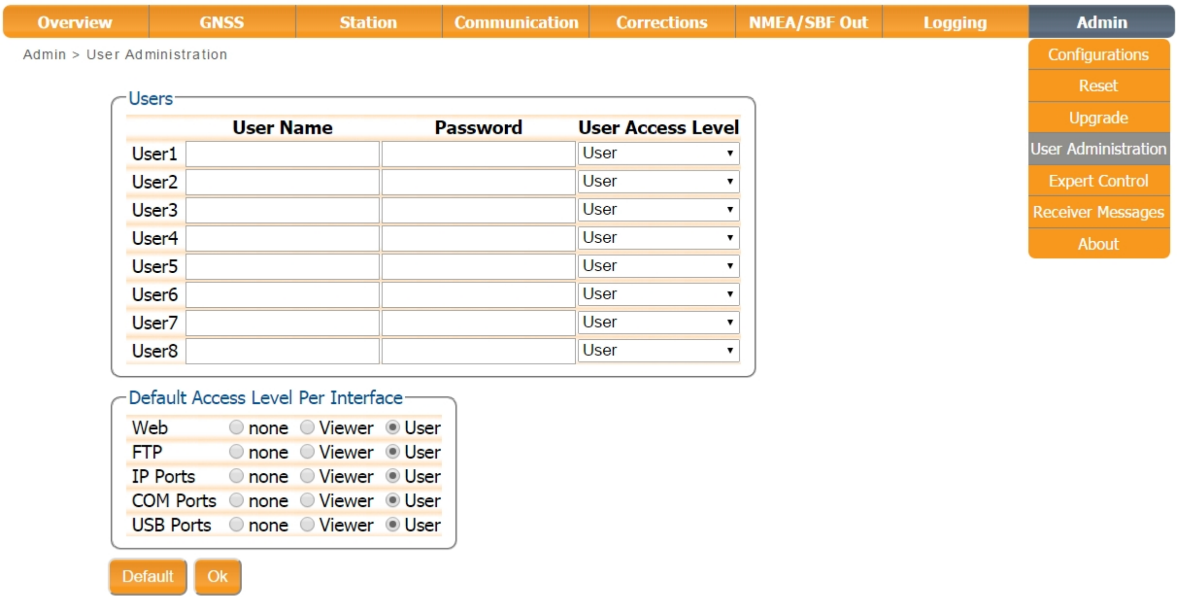


Figure 6-1: The default access levels of the PolaRx5S

In the example shown in Figure 6-2:

Web Interface: Anonymous users (without password) can connect to the receiver via the web interface as Viewers. They can browse the various windows but cannot change any of the settings. Only George, who has User access, can change receiver settings via the web interface.

FTP: Anonymous users have full access over FTP so can download and delete logged data files.

IP, COM and USB Ports: Only George has User access to the IP, COM and USB ports so can change receiver settings over these connections. Mildred has only viewer access to the IP, COM and USB ports so can only send commands to show the configuration. Anonymous users can neither change or view the receiver configuration over these connections.

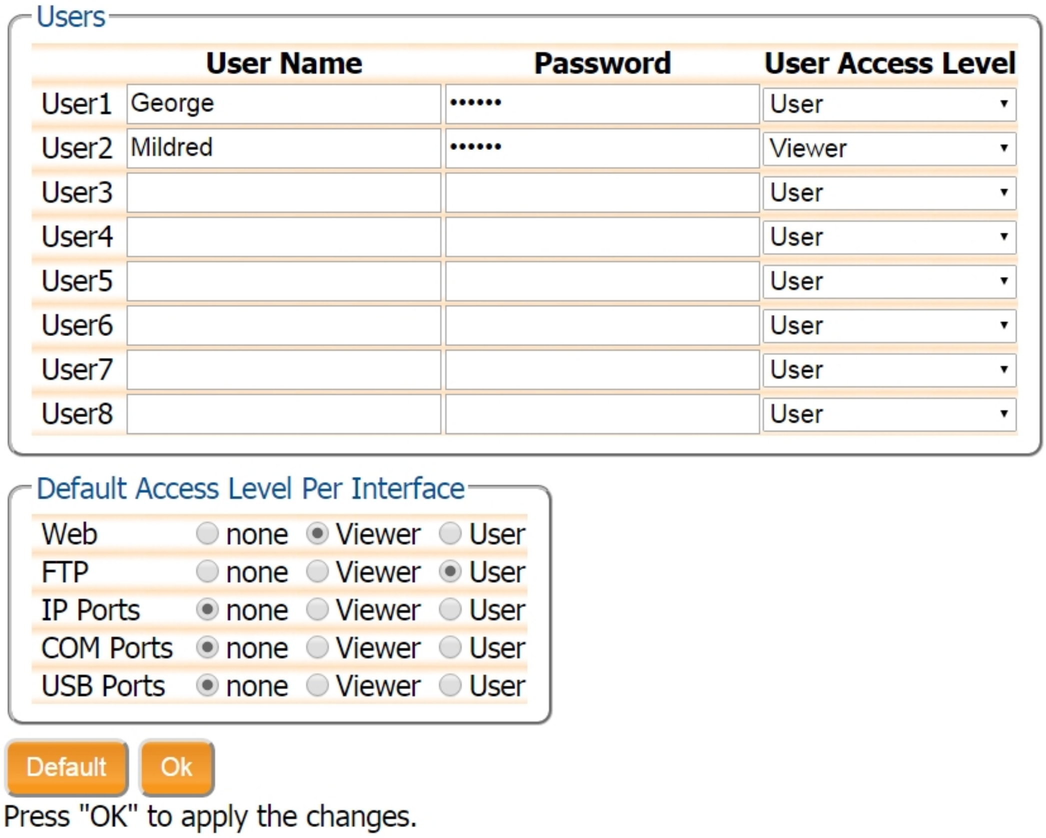


Figure 6-2: Changing the user access levels

After defining the Users/Viewers and their access levels, they can login on the web interface by clicking on ‘Log in’ on the upper-right corner as shown in Figure 6-3.

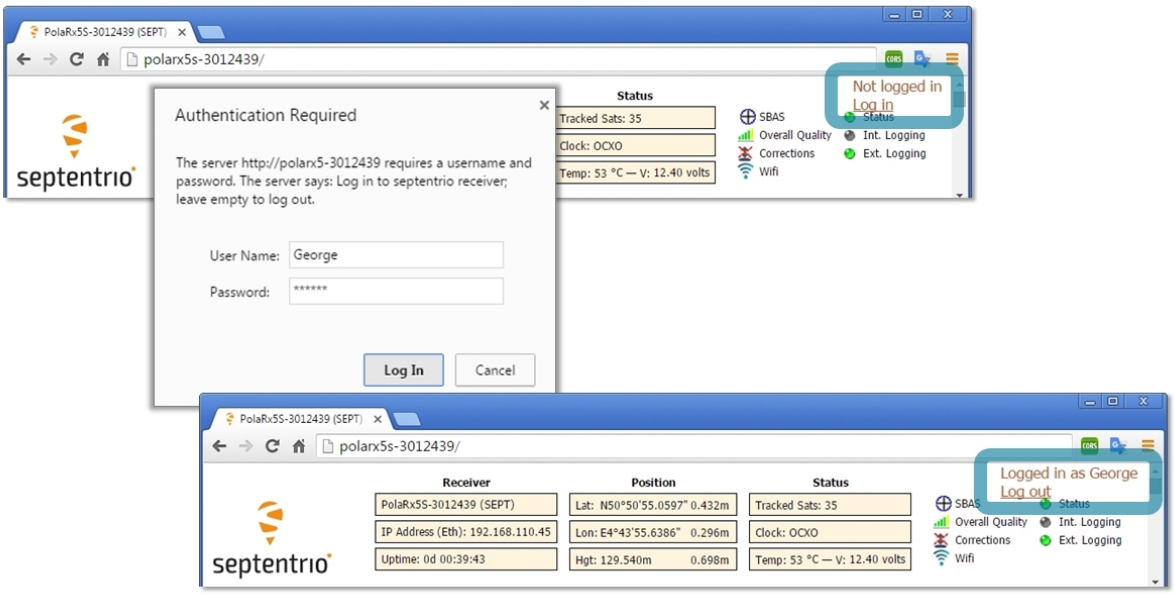


Figure 6-3: Logging in on the PolaRx5S web interface

Users/Viewers can logout by clicking on 'Log out' on the upper-right corner and leaving the 'User Name' and 'Password' fields of the pop-up empty as shown Figure 6-4.

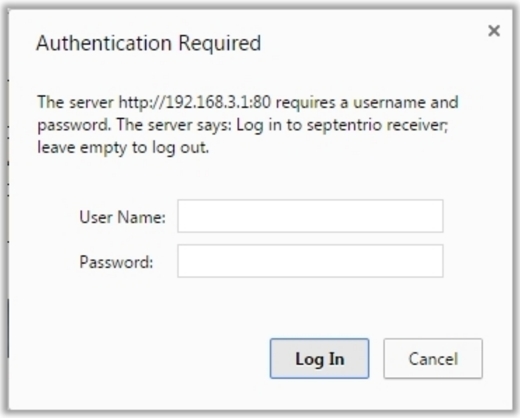


Figure 6-4: Logging out

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7 Receiver operations

7.1 How to track specific satellites and signals

In its default configuration, the PolaRx5S tracks the signals from all visible satellites in all constellations. You can configure the receiver not to track the satellites from a particular constellation in the 'Satellites and Signals' window of the 'GNSS' menu. In the example shown in Figure 7-1, the receiver will track only GPS, GLONASS and Galileo satellites.

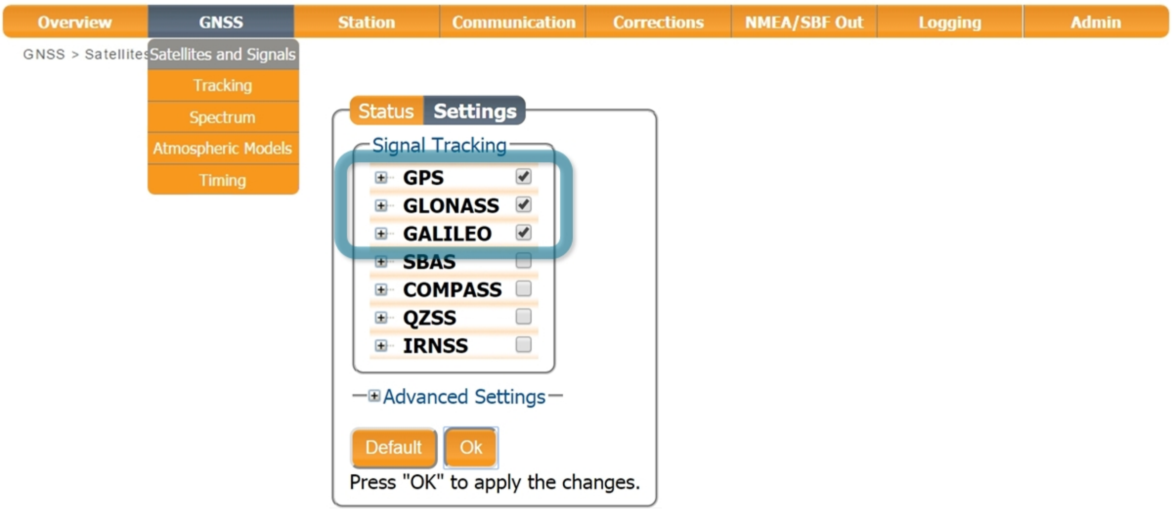


Figure 7-1: Configuring the receiver to track only satellites from the GPS, GLONASS or Galileo constellations

You can also select which signals from each constellation that you wish to track. With the configuration shown in Figure 7-2, the receiver will not track the GPS L5 signal.

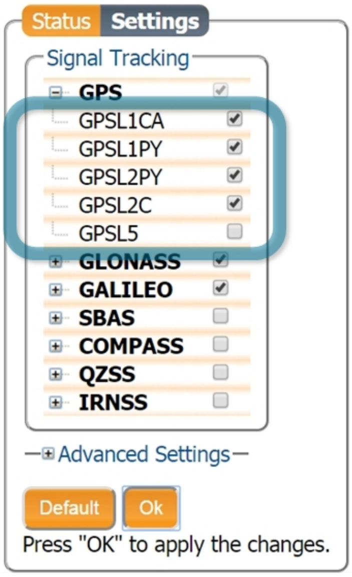


Figure 7-2: Configuring the receiver not to track the GPS L5 signal

7.2 How to change IP settings of the PolaRx5S

The IP settings of the PolaRx5S can be configured in the Ethernet window of the Communication menu. By default the PolaRx5S is configured to use DHCP to obtain an IP address. You can specify a 'Static' address in the TCP/IP Settings field as shown in Figure 7-3.

In Static mode, the receiver will not attempt to request an address via DHCP but will use the specified IP address, netmask, gateway, domain name and DNS. DNS1 is the primary DNS and DNS2 is the backup DNS. In DHCP mode, the arguments IP, Netmask, Gateway, Domain, DNS1, and DNS2 are ignored.

Having entered the settings, click on 'Ok' then 'Apply And Reboot' in the pop-up dialog as shown, as the receiver needs to be reset for the new settings to become active.

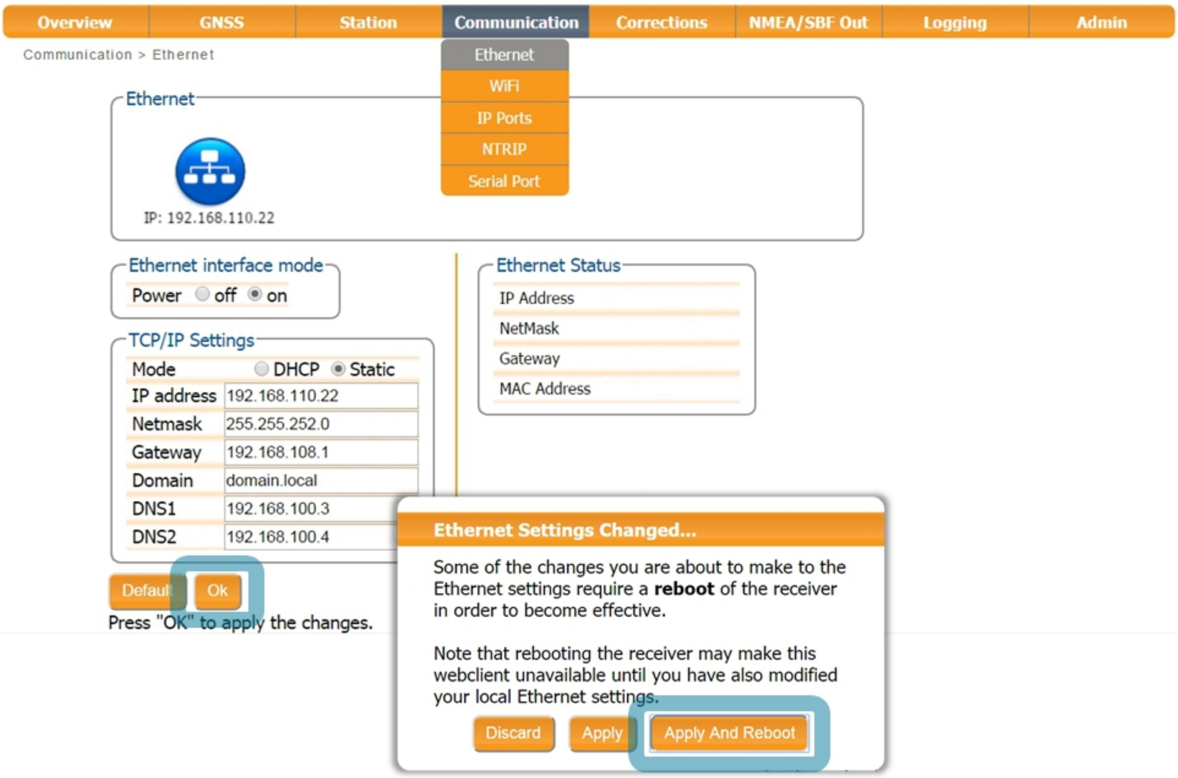


Figure 7-3: Changing the TCP/IP settings of the PolaRx5S

After reboot, the Ethernet Status field should now show the correct IP settings as shown in Figure 7-4.

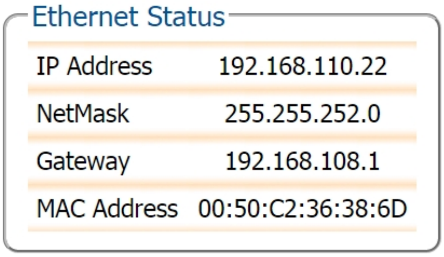


Figure 7-4: TCP/IP settings

Note that the IP settings will keep their value after a power cycle and even after a reset to factory default in order to avoid accidentally losing an Ethernet connection to the receiver.

7.3 How to configure Dynamic DNS

Dynamic DNS allows remote contact with the PolaRx5S using a hostname.

When devices are connected to the internet, they are assigned an IP address by an internet service provider (ISP). If the IP address is *dynamic* then it may change over time resulting in a loss of connection. Dynamic DNS (DynDNS or DDNS) is a service that addresses this problem by linking a user-defined hostname for the device to whichever IP address is currently assigned to it.

To make use of this feature on the PolaRx5S, you should first create an account with a Dynamic DNS provider (**dyndns.org** or **no-ip.org**) to register a hostname for your receiver. In the example shown in Figure 7-5, the hostname *polarx5s.mine.nu* has been registered with dyndns.org. The *Bind* option, selected in this case, tells the Dynamic DNS provider only to update IP addresses assigned over an Ethernet LAN connection.

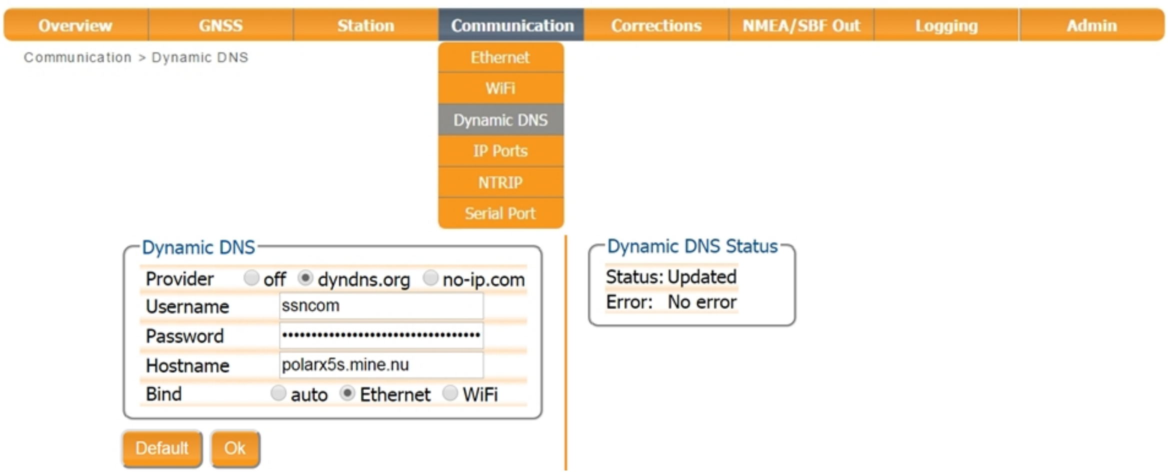


Figure 7-5: Configuring Dynamic DNS

7.4 How to upgrade the firmware or upload a new permission file

The PolaRx5S firmware and permission files both have the extension .suf (Septentrio Upgrade File) and can be uploaded to the PolaRx5S as shown in the steps below. Firmware upgrades can be downloaded from the Septentrio website and are free for the lifetime of the receiver. Permission files enable additional features on the PolaRx5S and can be purchased from our sales department.

Step 1: Select the .suf file and start the upgrade

The upgrade procedure is started by clicking on the 'Choose file' button in the 'Upgrade' window of the 'Admin' menu and which is highlighted in Figure 7-6.

Figure 7-6: Selecting the .suf file to upload to the receiver

Having already saved the .suf file to your pc, you can then select this file and click on the 'Start upgrade' button. The pop-up window shown in Figure 7-7 will show the progress of the upgrade.

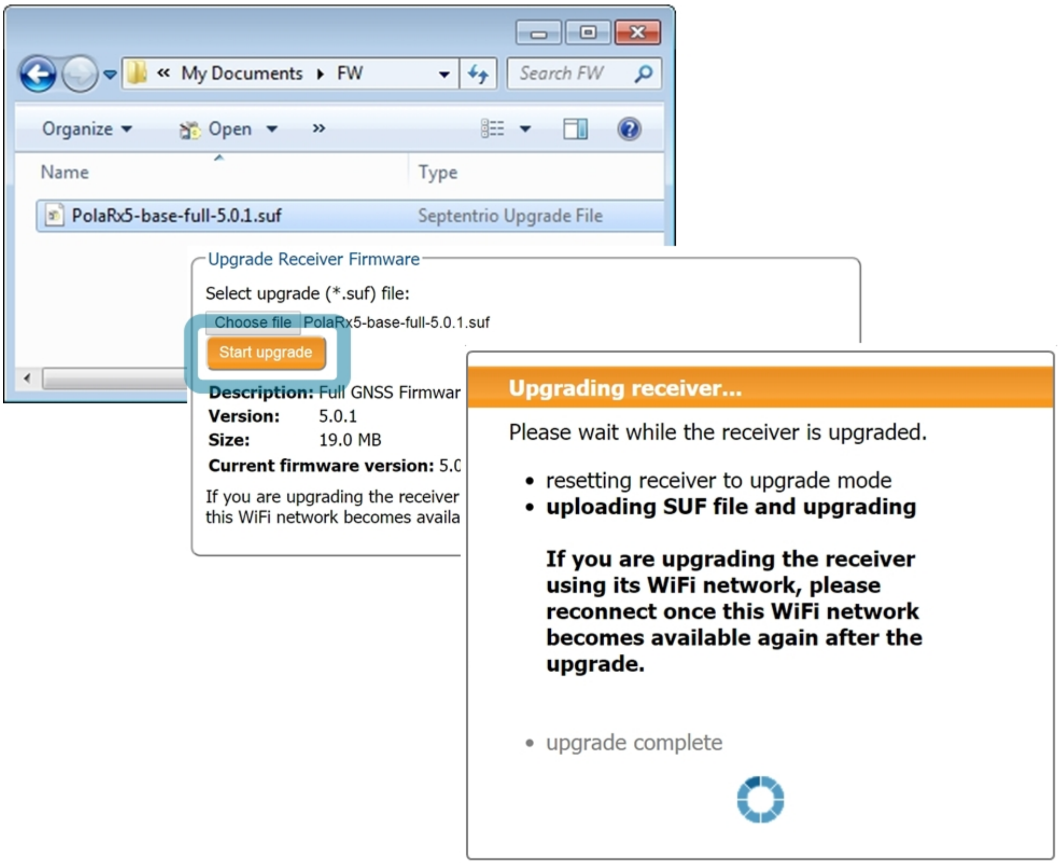


Figure 7-7: The upgrade procedure

Step 2: Verifying the upgrade

If there were no problems with the upgrade, the message 'Upgrade successful' will appear. You can then check on the Admin/About window, as shown in Figure 7-8, that the new firmware version or permission file has been updated.

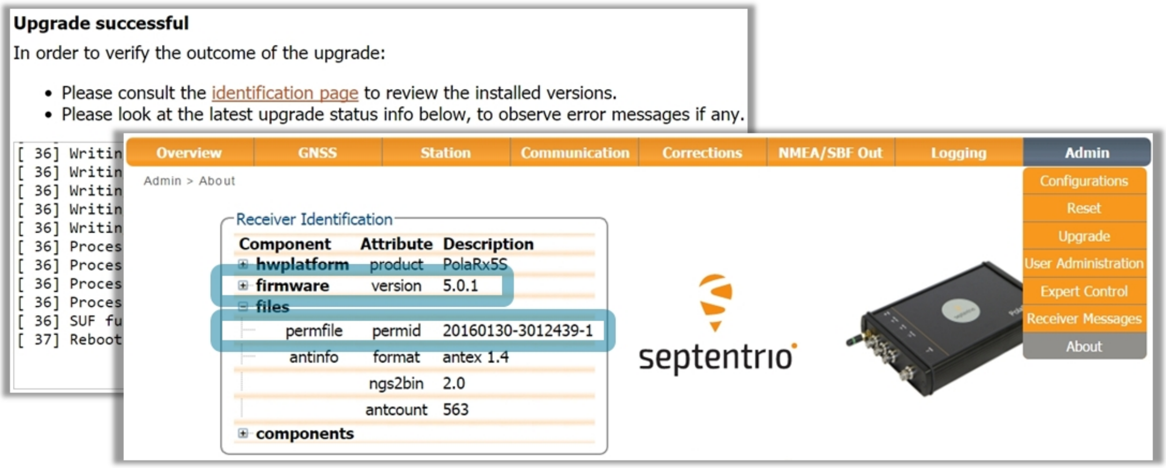


Figure 7-8: Checking the firmware and permission file versions

7.5 How to set the PolaRx5S to its default configuration

You can set the PolaRx5S configuration to its default settings on the Configurations window of the Admin menu as shown in Figure 7-9. Select 'RxDefault' from the 'Source' drop-down list and either 'Current' or 'Boot' in the 'Target' menu. You will then be prompted to Save the new current configuration as the boot configuration so the receiver will boot up with saved configuration after a power cycle.

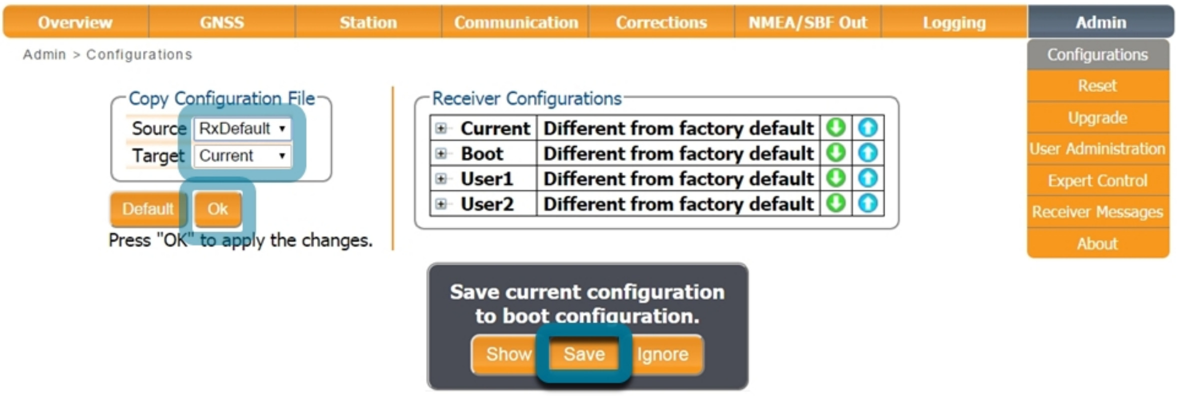


Figure 7-9: Setting the PolaRx5S to its default configuration

7.6 How to reset the PolaRx5S

If the PolaRx5S is not operating as expected, a simple reset may resolve matters. The PolaRx5S can be fully power-cycled by disconnecting then reconnecting the power supply. However, on the Admin/Reset window as shown in Figure 7-10 different functionalities can be reset individually. A 'Soft' level reset will cause the PolaRx5S to boot up with its current configuration while a 'Hard' reset will use the configuration stored in the boot file.

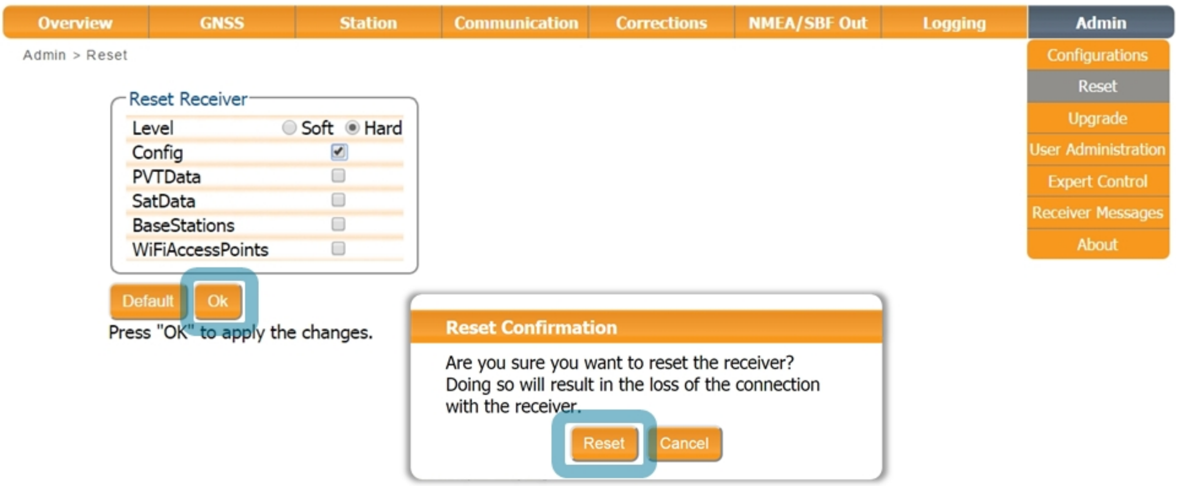


Figure 7-10: Resetting the PolaRx5S configuration to its boot configuration using a Hard reset

7.7 How to copy the configuration from one receiver to another

In the Admin/Configurations window, the configuration of a PolaRx5S can be easily saved to a PC as a text file. A saved configuration can then be uploaded to any other PolaRx5S.

Step 1: Downloading the configuration from a PolaRx5S

Click the green download arrow next the configuration you wish to download as shown in Figure 7-11. The configuration will be saved as a .txt file.

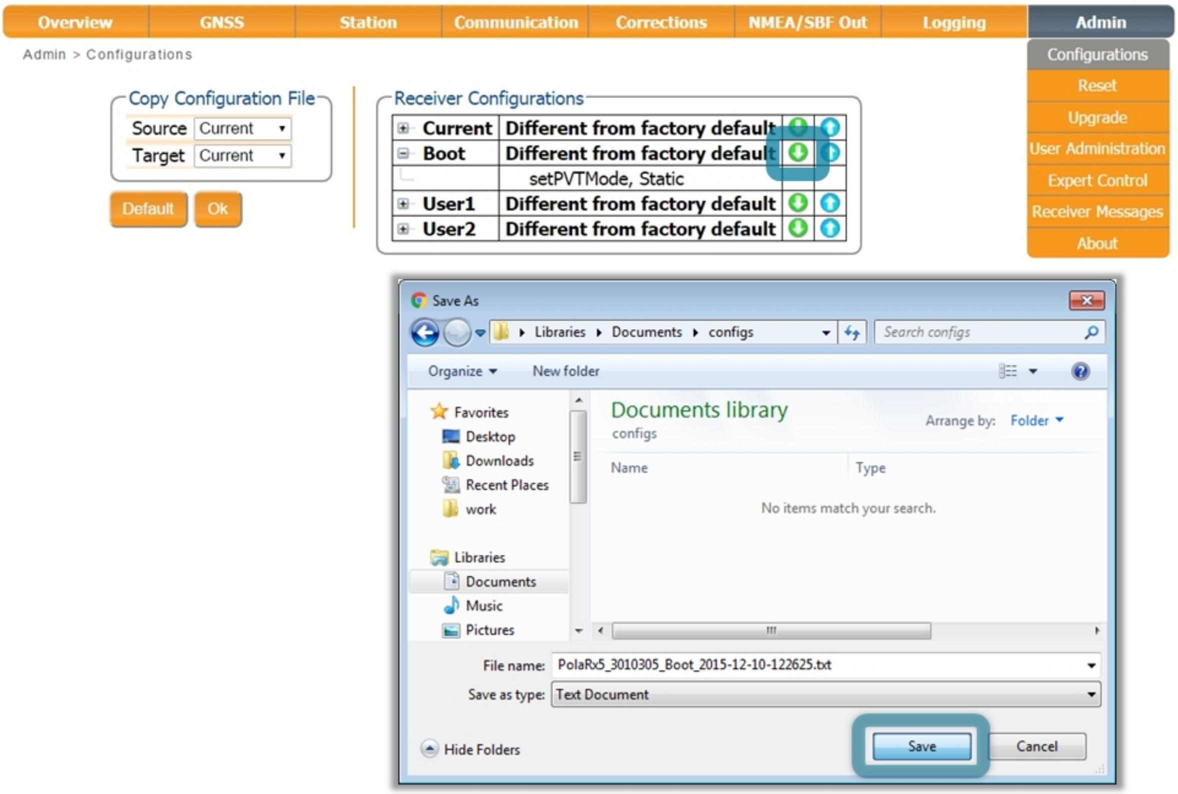


Figure 7-11: Saving a configuration from a PolaRx5S as a text file

Step 2: Uploading the configuration to another PolaRx5S

Again on the Admin/Configuratoins window, click on the blue upload arrow, as indicated in Figure 7-12, to upload a configuration file stored on you PC. In this example, the saved file will be uploaded as the Boot configuration.

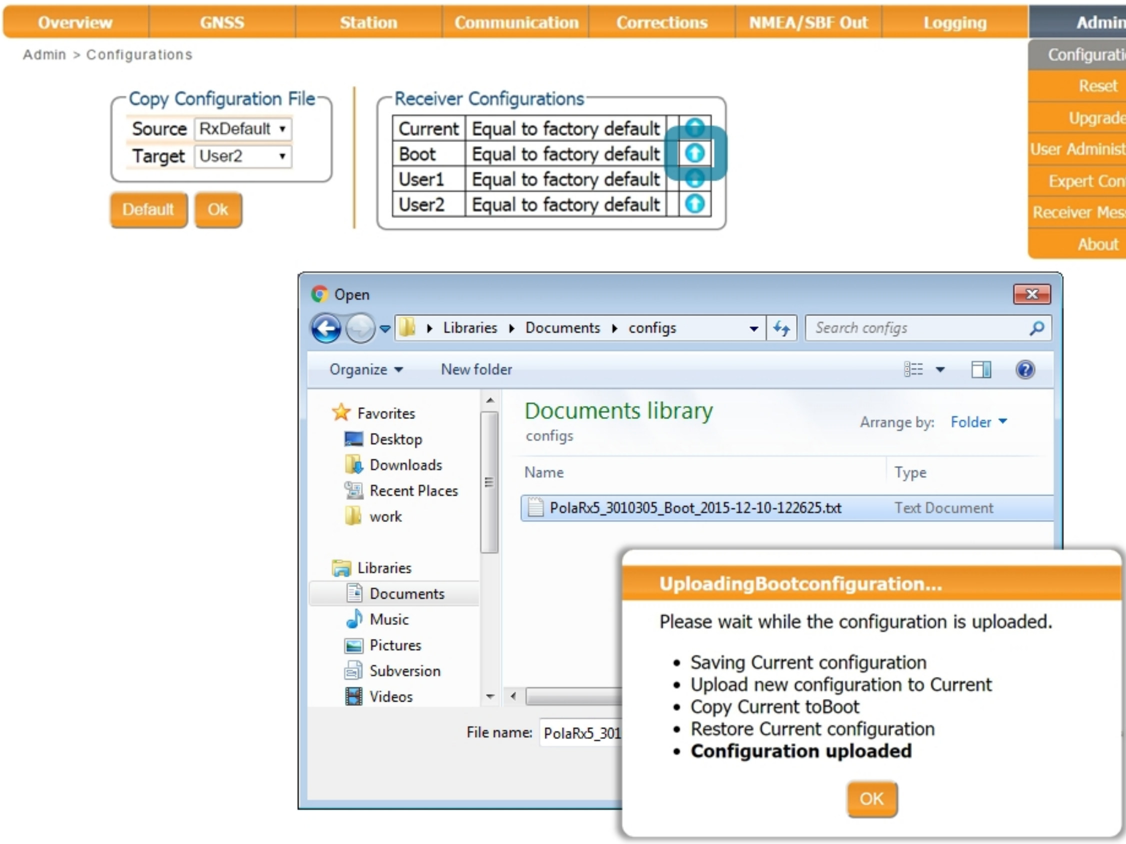


Figure 7-12: Uploading a configuration to a PolaRx5S

A Front-panel port descriptions

The PolaRx5S front panel features 8 ODU connectors which are described in the following sections. These connectors are all of type ODU MINI SNAP Series F. The pinout of the female connectors and the ODU part number of the corresponding male connectors are shown in Figure A-1.

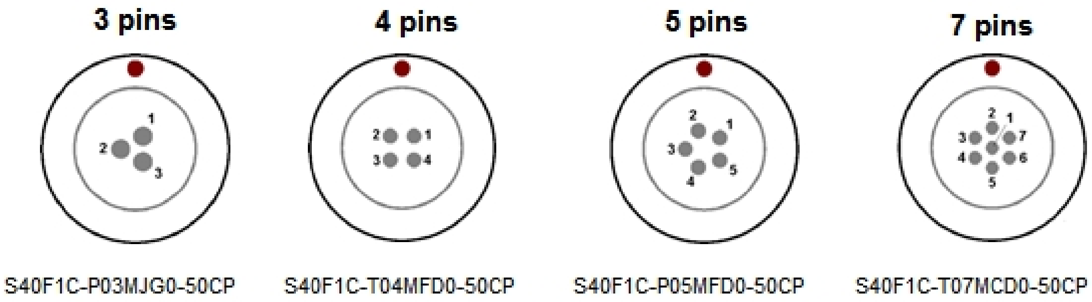


Figure A-1: Pinout of the front-panel female connectors and the ODU part numbers of the corresponding male connectors

A.1 COM1

This 7-pin connector provides access to the first serial port (COM1). The receiver behaves as Data Terminal Equipment (DTE).

PIN #	Description
1	Not connected
2	Signal ground (GND)
3	Not connected
4	Not connected
5	Receive Data (RXD - input to the receiver)
6	Transmit Data (TXD - output from the receiver)
7	Not connected

A.2 COM2

This 7-pin connector provides access to the second serial port (COM2). The receiver behaves as Data Terminal Equipment (DTE).

PIN #	Description
1	+5V DC output
2	Signal ground (GND)
3	Clear To Send (CTS - input)
4	Request To Send (RTS - output)
5	Receive Data (RXD - input to the receiver)
6	Transmit Data (TXD - output from the receiver)
7	Not connected

A.3 COM3-4/USB

This 7-pin connector can be configured in two modes:

- COM3 and COM4
- USB device

The electrical level at pin#7 defines the operating mode.

COM3-4 device

This mode is selected by leaving pin#7 unconnected.

PIN #	Description
1	Not connected
2	GND
3	COM4 RX
4	COM4 TX
5	COM3 RX
6	COM3 TX
7	Leave unconnected

USB device

This mode is selected by applying 5V DC to pin#7.

PIN #	Description
1	Not connected
2	GND
3	USB D−
4	Reserved
5	USB D+
6	Reserved
7	USB Vbus

A.4 Ethernet

The receiver can be powered through the Ethernet port (Power-Over-Ethernet). Please note that only mode A, as specified in the 802.3af standard, is supported on the PolaRx5S.

PIN #	Description
1	TxD+
2	TxD−
3	RxD+
4	RxD−

A.5 OUT

PIN #	Description
1	Reserved
2	GND
3	GP1 output, 3.3V. Use the command **setGPIOFunctionality** to set the level of this pin.
4	GP2 output, 3.3V. Use the command **setGPIOFunctionality** to set the level of this pin.
5	nRST_OUT. Open-collector output, driven low when the receiver is resetting.

A.6 IN

PIN #	Description
1	Reserved, leave unconnected.
2	Ground
3	Reserved, leave unconnected.
4	nRST_IN. Driving this pin low resets the receiver. Internally pulled-up. Debouncing and deglitching is foreseen.
5	EVENTA input, 0-30V, pulled down. Input voltage should be at least 3V to be detected as high. First input for external event timing. Event polarity is controlled by the **setEventParameters** command.
6	EVENTB input, 0-30V, pulled down. Input voltage should be at least 3V to be detected as high. Second input for external event timing. Event polarity is controlled by the **setEventParameters** command.
7	ANT_EXT, external antenna power. Can be used to apply an external supply voltage to the antenna. The voltage applied to ANT_EXT(V$_{ANT}$) determines the voltage source on the MAIN connector, as follows: • if $V_{ANT} < 2.0V$ or ANT_EXT left open, the antenna is powered by the internal 5V supply; • if $3.0V < V_{ANT} < 4.0V$, there is no power provided to the MAIN connector; • if $5.0V < V_{ANT} < 12.0V$, the antenna power supply is taken from ANT_EXT. **Warning:** Exceeding 12.0V for V$_{ANT}$, or drawing more than 200mA from the antenna connector can permanently damage the receiver.

A.7 USB Host

PIN #	Description
1	USB-H VBus (max current: 500mA)
2	Ground
3	USB-H D$-$
4	USB-H D$+$
5	Reserved

A.8 PWR

PIN #	Description
1	Power: 9 to 30V DC
2	Always ON. When this pin is tied to pin#1 the receiver is always on regardless of the state of the power button. Connect to Ground to enable the power button.
3	Ground

B Rear-panel connectors

The following sections describe the connectors on the rear-panel of the PolaRx5S.

B.1 MAIN (TNC)

Connect an active GNSS antenna to this connector. The gain at the connector (antenna gain minus cable losses) must be in the range 15 to 50dB.

By default, the receiver provides a 5V DC supply on the MAIN connector to feed the antenna. Other voltages can be supplied through pin ANT_EXT of the IN connector on the front panel (see Appendix A.6). The maximum supported current is 200mA.

Never inject a DC voltage into the MAIN connector as it may damage the receiver. When using a splitter to distribute the antenna signal to several receivers, make sure that no more than one output of the splitter passes DC. Use DC-blocks otherwise.

B.2 PPS OUT (BNC)

xPPS output (5V, output impedance 50-Ω). The rate and polarity of the xPPS output signal can be specified by the **setPPSParameters** command or on the Web Interface The pulse duration is 5ms.

B.3 REF OUT (BNC)

The REF OUT connector provides a 10 MHz output signal synchronized with the frequency of the internal receiver clock. It is a sinusoidal signal with unloaded peak-to-peak amplitude of 1.1V and output impedance of 50 Ω.

Note that the REF OUT signal can be turned off with the **setREFOUTMode** command. See also Section 2.2.1

B.4 WiFi (SMA)

Connector for the WiFi antenna.

C Cables

<table>
<tr><th>Cable Name (Part #)</th><th>Details</th></tr>
<tr><td>CBLe_COM_1.8
(200416)</td><td>COM1/COM2 to PC (DSUB9-female). To be connected to either the COM1 or COM2 connector. Note that RTS/CTS lines are only available when connected to COM2.</td></tr>
<tr><td>CBLe_COM_DUO_7
(201204)</td><td>Dual COM3 and COM4 to PC (DSUB9-female). To be connected to the COM3-4/USB connector. Note that RTS/CTS is not supported on these ports.</td></tr>
<tr><td>CBLe_GPO_OE_5
(201203)</td><td>Open-ended cable to be used with the OUT connector (see pinout in Appendix A.5).
<table>
<tr><th>Pin #</th><th>Function</th><th>Wire Colour</th></tr>
<tr><td>1</td><td>Reserved</td><td>Blue</td></tr>
<tr><td>2</td><td>Ground</td><td>Blue/Black</td></tr>
<tr><td>3</td><td>GP1 output</td><td>Orange</td></tr>
<tr><td>4</td><td>GP2 output</td><td>Green</td></tr>
<tr><td>5</td><td>nRST_OUT</td><td>Brown</td></tr>
</table></td></tr>
<tr><td>CBLe_GPI_OE
(200419)</td><td>Open-ended cable to be used with the IN connector (see pinout in Appendix A.6).
<table>
<tr><th>Pin #</th><th>Function</th><th>Wire Colour</th></tr>
<tr><td>1</td><td>Reserved</td><td>Orange</td></tr>
<tr><td>2</td><td>Ground</td><td>Green</td></tr>
<tr><td>3</td><td>Reserved</td><td>Yellow</td></tr>
<tr><td>4</td><td>nRST_IN</td><td>Black</td></tr>
<tr><td>5</td><td>EVENTA</td><td>Red</td></tr>
<tr><td>6</td><td>EVENTB</td><td>Purple</td></tr>
<tr><td>7</td><td>ANT_EXT</td><td>Brown</td></tr>
</table>
Do not leave the red and purple wires floating, tie them to ground if not used. This will avoid crosstalk effects that could lead to spurious level transitions on the EVENTA and EVENTB inputs.</td></tr>
<tr><td>CBLe_USB
(201202)</td><td>USB device cable to be connected to the COM3-4/USB connector.</td></tr>
<tr><td>CBLe_USB_HOST
(214935)</td><td>USB host cable to be connected to the USB host connector.</td></tr>
<tr><td>CBLe_ETH_MS
(200418)</td><td>Ethernet to hub/switch (straight) (RJ45). To be connected to the ETH connector.</td></tr>
<tr><td>CBLe_PWR_OE
(200422)</td><td>Open-ended cable for the PWR connector (see pinout in Appendix A.8).
<table>
<tr><th>Pin #</th><th>Function</th><th>Wire Colour</th></tr>
<tr><td>1</td><td>Power</td><td>Blue and green (these two wires are both connected to Pin#1)</td></tr>
<tr><td>2</td><td>ON/OFF</td><td>Red</td></tr>
<tr><td>3</td><td>Ground</td><td>Black and Purple (these two wires are both connected to Pin#3)</td></tr>
</table></td></tr>
<tr><td>PWRe_ADAPTER
(200431)</td><td>A power adapter to be connected to PWR connector.</td></tr>
</table>

D LED behaviour

<table>
<tr><th>LED name</th><th>colour</th><th>Icon</th><th>Behaviour</th></tr>
<tr><td>POWERLED</td><td>red</td><td></td><td>Off: Receiver is powered off
On: Receiver is powered on</td></tr>
<tr><td>LANLINKLED</td><td>green</td><td></td><td>Off: No Ethernet connection
Blinking: Sending or receiving data over Ethernet</td></tr>
<tr><td>TRACKLED</td><td>orange</td><td></td><td>
<table>
<tr><th>Behaviour</th><th>Number of satellites in tracking</th></tr>
<tr><td>Blinks fast (10 per second)</td><td>0</td></tr>
<tr><td>Blinks once, then pauses</td><td>1, 2</td></tr>
<tr><td>Blinks twice, then pauses</td><td>3, 4</td></tr>
<tr><td>Blinks 3 times, then pauses</td><td>5, 6</td></tr>
<tr><td>Blinks 4 times, then pauses</td><td>7, 8</td></tr>
<tr><td>Blinks 5 times, then pauses</td><td>9 or more</td></tr>
</table>
</td></tr>
<tr><td>GPLED</td><td>red</td><td></td><td>
By default, GPLED functions as DIFFCORLED but, it can also be configured as LOGLED using the setLEDMode command.
<table>
<tr><th>Behaviour
(configured as DIFFCORLED)</th><th>Number of satellites with corrections</th></tr>
<tr><td>Off</td><td>No diff corr received</td></tr>
<tr><td>On</td><td>The LED is solid 'ON' when the receiver outputs differential corrections as a static base station.</td></tr>
<tr><td>Blinks fast (10 per second)</td><td>0</td></tr>
<tr><td>Blinks once, then pauses</td><td>1, 2</td></tr>
<tr><td>Blinks twice, then pauses</td><td>3, 4</td></tr>
<tr><td>Blinks 3 times, then pauses</td><td>5, 6</td></tr>
<tr><td>Blinks 4 times, then pauses</td><td>7, 8</td></tr>
<tr><td>Blinks 5 times, then pauses</td><td>9 or more</td></tr>
</table>
<table>
<tr><th>Behaviour
(configured as LOGLED)</th><th>Logging status</th></tr>
<tr><td>Off</td><td>Not logging</td></tr>
<tr><td>On</td><td>Logging active</td></tr>
</table>
</td></tr>
<tr><td>PVTLED</td><td>green</td><td></td><td>Off: No PVT available
On: PVT available</td></tr>
<tr><td>WIFILED</td><td>red</td><td></td><td>Off: WiFi disabled
On: Access-point mode or client mode
Blinking slowly: Establishing a connection in client mode
Blinking quickly: Error, not connected</td></tr>
</table>

E Power Failover

The optional power failover is a power source switch which automatically switches over to a 12 V battery backup supply during outages of the main power supply. The typical setup is depicted in Figure E-2.

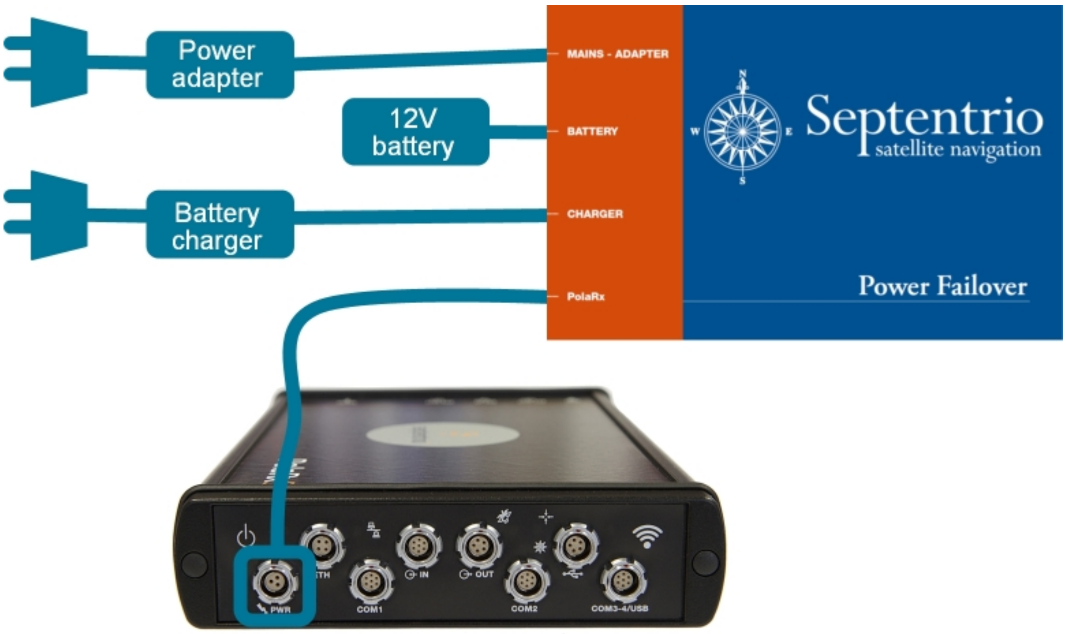
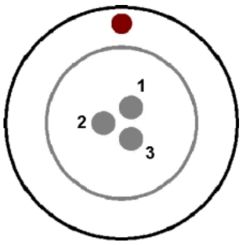


Figure E-2: Typical setup of the power failover with the PolaRx5S

During normal operation, the receiver is powered by the supply connected to 'MAINS - ADAPTER'. When the voltage at that connector drops below 10.8 V, the receiver is then powered from the 12 V battery instead. A charger is permanently connected to the 'CHARGER' input to charge the battery when the battery is not used to power the receiver.

E.1 Power Failover Connectors

The four connectors are all of type ODU MINI SNAP Series F, 3 pins. The ODU part number of the corresponding male connectors is S40F1C-P03MJG0-50CP. The pinout of the female connector is shown below:



E.1.1 MAINS-ADAPTER

PIN #	Description
1	To be connected to the main power supply: 12 V DC. The voltage provided to the MAINS - ADAPTER connector must not exceed 12V.
2	Internally connected to pin#2 of the RECEIVER connector
3	Ground

E.1.2 BATTERY

PIN #	Description
1	To be connected to the '+' terminal of the battery.
2	Power source indicator: DC level is 0 V when power at the RECEIVER connector is drawn from battery, and 12 V when drawn from mains.
3	To be connected to the '-' terminal of the battery.

E.1.3 CHARGER

PIN #	Description
1	To be connected to the '+' terminal of the battery charger.
2	Not Connected
3	To be connected to the '-' terminal of the battery charger.

To avoid damaging the battery, only use a charger made for your particular battery type.

E.1.4 RECEIVER

PIN #	Description
1	12 V DC power output
2	Internally connected to pin#2 of the MAINS - ADAPTER connector
3	Ground

E.2 Power Failover Connectors

<table>
<tr><th>Cable Name
(Part #)</th><th>Details</th></tr>
<tr><td>CBLe_PWR_OE
(200422)</td><td>Open-ended cable:
<table>
<tr><th>Pin #</th><th>Description</th><th>Wire Colour</th></tr>
<tr><td>1</td><td>Two wires both connected to Pin#1</td><td>Blue and Green</td></tr>
<tr><td>2</td><td>-</td><td>Red</td></tr>
<tr><td>3</td><td>Two wires both connected to Pin#3</td><td>Black and Purple</td></tr>
</table></td></tr>
<tr><td>CBLe_PWR_FOPX
(213468)</td><td>Failover to PolaRx5S cable. Used to connect the RECEIVER connector of the power failover device to the PWR connector of the PolaRx5S receiver.</td></tr>
</table>

E.3 Power Failover Hardware Specifications

Size:	118 x 84.6 x 34.6 mm (length includes the connectors)
Temperature Range:	-40 to +60 °C (operational) -55 to +85 °C (storage)
Ingress Protection:	IP65
Shock:	MIL-STD-810F, 516.5
Vibration:	MIL-STD-810F, 514.5

F 100 Hz Output Rate

As described in the previous chapters, ionospheric monitoring typically involves sampling I&Q correlation and carrier phase data at a 50 Hz rate. However, the PolaRx5S also supports 100 Hz rate for advanced research.

When operating at 100 Hz output rate, we recommend the following:

- To prevent overloading the receiver's CPU, the only SBF block that should be output at 100 Hz is the IQCorr block. That block contains the I&Q correlation values and the carrier phase modulo 65.536 cycles. To be able to reconstruct the full carrier phase at 100 Hz (i.e. to fix the 65.536-cycle ambiguity), it is sufficient to log the `MeasEpoch` SBF block at a lower rate, e.g. 1 Hz.

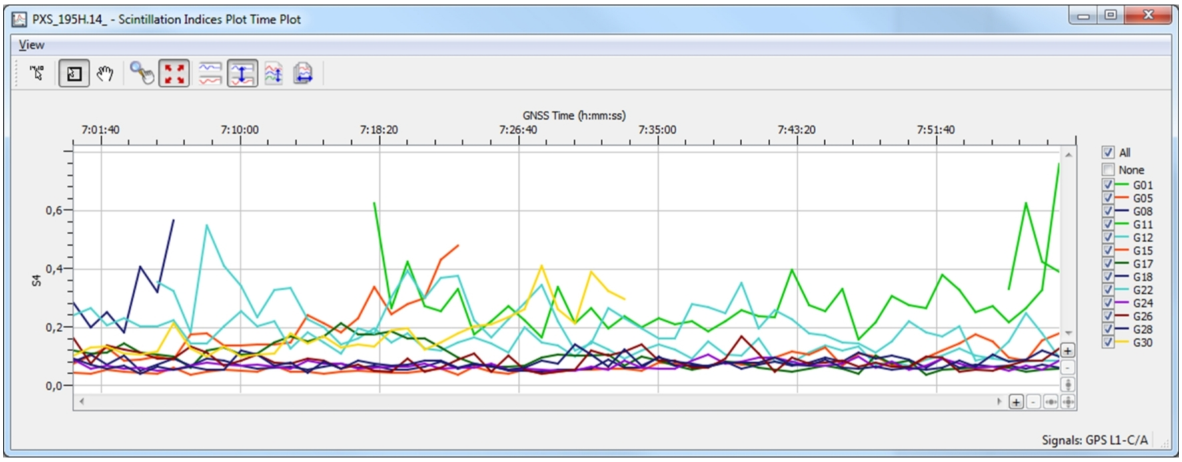
  The **`sfb2ismr`** program, with the `-r` option, can be used to recover full carrier phase and correlation values from a SBF file containing 100 Hz `IQCorr` blocks and 1 Hz `MeasEpoch` blocks. See Section 4.3.3 for details.

- To avoid data gaps, it is recommended to use the receiver's USB connection when operating at 100 Hz. Depending on the Ethernet network topology, streaming 100 Hz data over a TCP/IP connection may be unreliable.

G Real-Time ISMR

The PolaRx5S contains a built-in real-time S4 and σ_ϕ monitor. S4 and σ_ϕ are computed every minute for all tracked satellites and signals (except GPS (L1P and L2P) and GLONASS (L2P)), and are made available in the ISMR SBF block.

Using the RxControl graphical interface, it is possible to view the S4 and σ_ϕ indices in real-time. This is enabled in the *View* > *Time Plots* > *Scintillation Indices Plot* menu. An example of real-time S4 view is shown below.



H TEC Calibration

Absolute TEC values can be biased by satellite and station inter-frequency biases. Sources of station biases include the antenna, the antenna cable, splitters, amplifiers, and the receiver. Satellite biases are compensated for when available (see Section 4.3.1), but station biases need to be calibrated. This Appendix details a procedure to calibrate the station biases.

As of version 7.0.0, **`sbf2ismr`** includes a tool for TEC calibration. Calibration values can be computed for the TEC computed from GPS, Galileo, Compass/BeiDou, GLONASS and QZSS satellites.

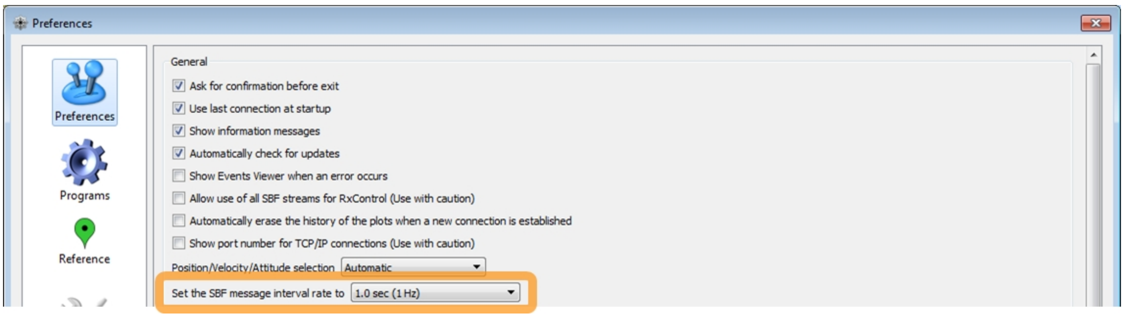
Calibration is done by comparing the measured TEC values (after correction of the satellite biases as documented in Section 4.3.1) with reference TEC values. The TEC reference can either be the SBAS ionospheric corrections or the Klobuchar ionospheric model. The bias between the measured and the reference TEC values is averaged over several passes for each satellite individually or, for a whole constellation in case satellite biases are corrected. A fixed elevation mask of 15 degrees is applied.

To perform a TEC calibration with respect to SBAS, **`sbf2ismr`** must be invoked with the '`-as`' option. To use the Klobuchar model as a reference, the '`-ak`' option must be used. When using Klobuchar as a reference, only the satellites tracked between 00:00 and 06:00 local time are considered, to avoid times of increased ionospheric activity. The Klobuchar parameters are decoded from the GPS navigation messages.

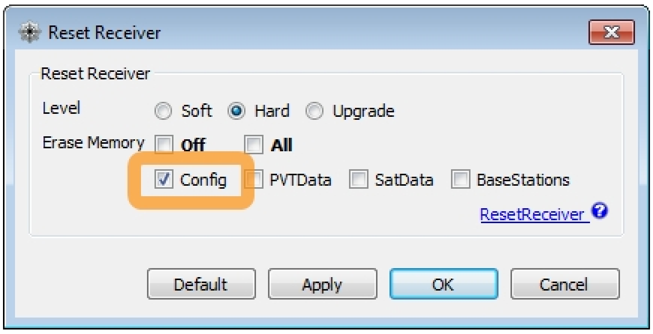
In regions covered by an SBAS system, it is recommended to calibrate against SBAS for better accuracy.

The recommended procedure for generating a TEC calibration file is outlined below. TEC calibration is most accurate in times of quiet ionospheric conditions. If strong ionospheric activity is foreseen, it is preferable to delay the calibration procedure until a time of lower activity.

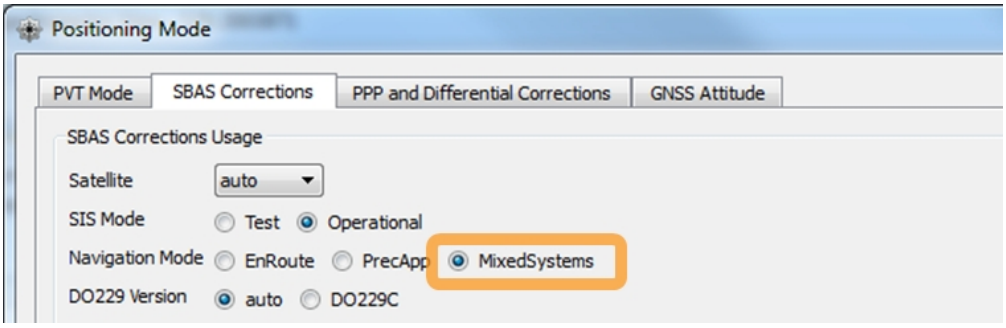
1. Connect to the receiver using the RxControl graphical interface.
2. In the *File* > *Preferences* menu, make sure that the SBF message interval is set to 1.0s (this is the default).



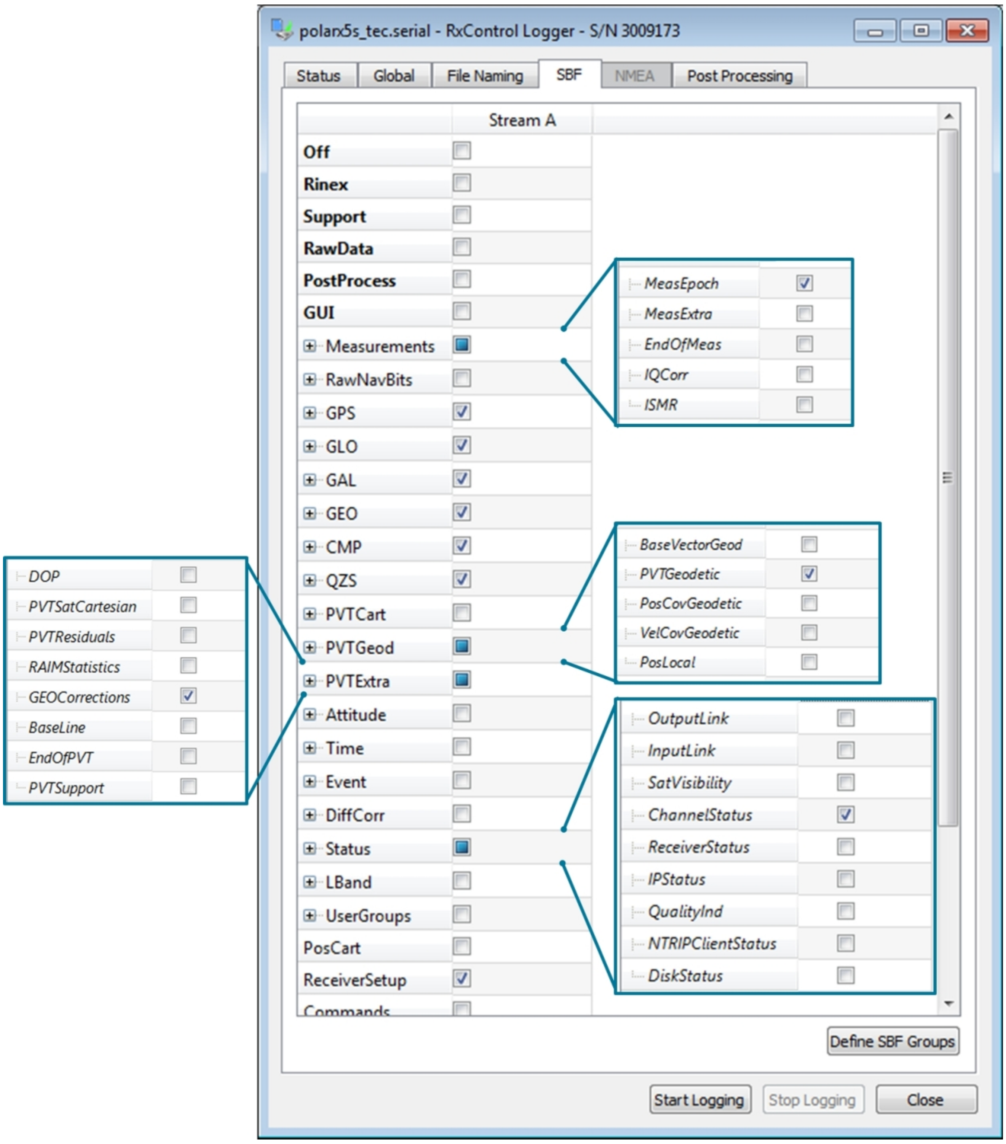
3. Make sure that the receiver is in its default configuration. This can be done by checking the 'Config' option in the *File* > *Reset Receiver* menu:



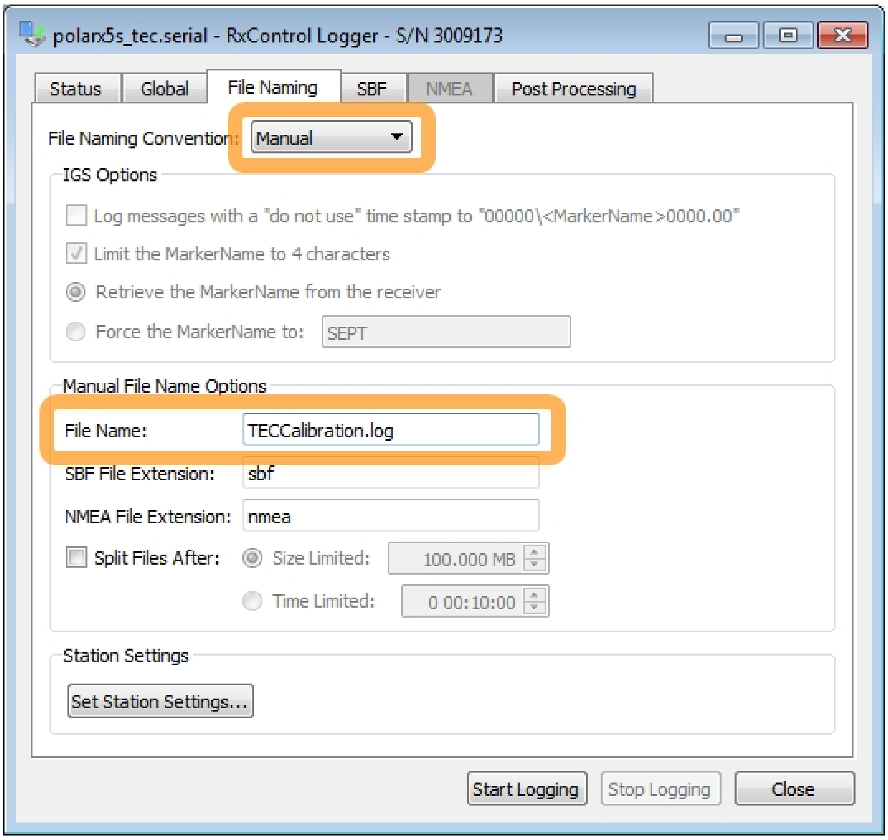
4. Navigate to the *Navigation* > *Positioning Mode* > *SBAS Corrections* menu and make sure the receiver is configured in `MixedSystems` navigation mode:



5. Under the *Logging* > *RxControl Logging* > *SBF* menu, enable the following SBF blocks for logging: `MeasEpoch`, `PVTGeodetic`, `GEOCorrections`, `GPSNav`, `GPSIon`, `GLONav`, `GALNav`, `GEONav`, `QZSNav`, `CMPNav`, `ChannelStatus` and `ReceiverSetup`.



6. In the *File Naming* tab, select manual file naming, and provide a file name:



Note: the logging directory can be specified under the Global tab.

7. Start logging by clicking the 'Start Logging' button

8. Collect data for at least 24 hours. The longer the log file, the more accurate the TEC calibration. Stop logging by clicking the 'Stop Logging' button.

9. Open a command window and run **sbf2ismr** in TEC calibration mode. On Windows, **sbf2ismr.exe** can usually be found under `C:\Program Files (x86)\Septentrio\RxTools\bin`.

   In regions covered by an SBAS system, use the option '`-as`' to generate TEC calibration values using SBAS ionospheric corrections as reference. Otherwise use the option '`-ak`'.

   For example, assuming that the path to the log file collected in step 7 is `P:\TECCalibrationLog.sbf`, the **sbf2ismr** command and its output is shown below:

```
c:\Program Files (x86)\Septentrio\RxTools\bin>sbf2ismr -f P:\TECCalibrationLog.sbf -as

#TEC calibration in TECU for AsteRx4 sn#3008212, sbf2ismr-7.0.0x
#Start WN/TOW:1830/86400s  Stop WN/TOW:1830/172799s
#Approx Lat:50.84823deg Lon:4.73178deg
#SBAS ionospheric corrections used as reference, 15-degree elevation mask
#Broadcast group delay corrections applied for GPS, Galileo, QZSS and BeiDou
G**    -13.92  # mean of    666489 samples with a standard deviation of 3.01 TECU
C**      4.61  # mean of    144962 samples with a standard deviation of 4.84 TECU
J**    -13.92  # mean of    666489 samples with a standard deviation of 3.01 TECU
R01     37.61  # mean of     19076 samples with a standard deviation of 2.71 TECU
R02     23.22  # mean of     23344 samples with a standard deviation of 3.34 TECU
R03     19.86  # mean of     24994 samples with a standard deviation of 3.31 TECU
R04     20.60  # mean of     25838 samples with a standard deviation of 2.84 TECU
R05     27.50  # mean of     25772 samples with a standard deviation of 3.02 TECU
R06      7.10  # mean of     24802 samples with a standard deviation of 2.83 TECU
R07     23.46  # mean of     23227 samples with a standard deviation of 3.44 TECU
R08     20.58  # mean of     19132 samples with a standard deviation of 2.86 TECU
R09     17.49  # mean of     29589 samples with a standard deviation of 2.75 TECU
R10     47.09  # mean of     26861 samples with a standard deviation of 3.31 TECU
R11     34.20  # mean of     23164 samples with a standard deviation of 3.82 TECU
R12     31.41  # mean of     21628 samples with a standard deviation of 3.18 TECU
R13     27.32  # mean of     17783 samples with a standard deviation of 2.75 TECU
R14     46.25  # mean of     19072 samples with a standard deviation of 2.72 TECU
R15     41.73  # mean of     21482 samples with a standard deviation of 3.11 TECU
R16     27.93  # mean of     28903 samples with a standard deviation of 2.81 TECU
R17     22.47  # mean of     26187 samples with a standard deviation of 3.32 TECU
R18     25.56  # mean of     28952 samples with a standard deviation of 3.18 TECU
R19     17.88  # mean of     25297 samples with a standard deviation of 3.03 TECU
R20     44.44  # mean of     20647 samples with a standard deviation of 3.32 TECU
R21     26.19  # mean of     17841 samples with a standard deviation of 4.13 TECU
R22     19.59  # mean of     21528 samples with a standard deviation of 2.95 TECU
R23     44.33  # mean of     14089 samples with a standard deviation of 2.45 TECU
R24     18.36  # mean of     23573 samples with a standard deviation of 3.18 TECU

c:\Program Files (x86)\Septentrio\RxTools\bin>_
```

The output of **sbf2ismr** can be copied into a TEC calibration file without modification, and this file can be provided as TEC calibration input with the '-C' option of **sbf2ismr** (see Section 4.3.1).

I RxTools

The RxTools is a suite of Graphical User Interface tools for advanced monitoring and configuration of the receiver. They can be used to log SBF (Binary Format) data files (including raw measurements) as well as analyse the logged SBF data files and convert them to various other formats. The RxTools manual contains detailed instructions on how to use the tools.

RxControl is a graphical user interface which allows configuration and monitoring of the receiver in real time. It offers numerous views for monitoring data and a simple logger for recording data files. RxControl can also be used to upgrade receiver firmware.

SBF Converter is a GUI for converting SBF data files to various other formats including ASCII, RINEX and KML.

SBF Analyzer allows users to generate time plots from SBF files for detailed analysis. It can also create standard reports for reporting purposes.

RxLogger allows flexible logging of SBF and NMEA data. Users can select multiple streams each with a different update rate.

RxPlanner is a Satellite Mission Planning software. It shows the satellite visibility and DOP at the user defined location over a selectable time period

I.1 Installing RxTools

You can install the full suite of RxTools by running the RxTools Installer. The Installer file can be found on the memory stick provided with the receiver. The latest version of the Installer is also available for download from the Support section of the Septentrio website: `http://www.septentrio.com/support`

To run the Installer, double click on the executable file.

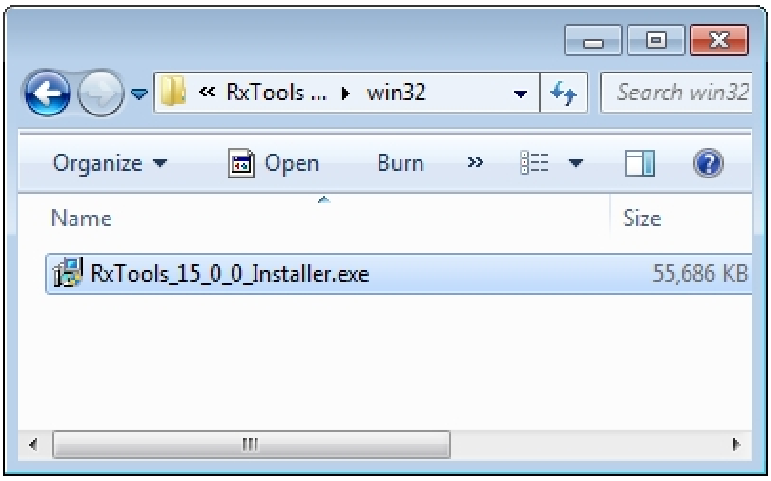


Figure I-1: Install the suite of RxTools by running the Installer file