Table of contents:

1   Features

- Up to 2000Hz sampling rate
- Data presentation and data log to file
- Available header pin rows for gyro sensor interface and signal access
- In-system programmable micro controller firmware (upgradable by USB)

2   General descriptions and system contents

The SAR100 and SAR150 evaluation platform (EVP) is an evaluation tool for rapid gyro sensor measurements in an office environment. Gyro sensor data is requested from PC software and results are presented on screen. Data log to file is supported and numerous gyro sensor signals are made available on header pin rows for evaluation and monitoring purposes. Add-on EVP satellite PCBs and interface cables for connections to the EVP main PCB are available. EVP main PCBs and EVP satellite PCBs are also available without any target gyro sensors pre-mounted. Source codes and hardware schematics are available.

System contents:

- EVP user manual (a printed version of this document)
- PC software
- USB cable
- EVP main PCB
- EVP satellite PCB (optional)
- Interface cable for EVP main to EVP satellite PCB connection (optional)
- Included CD-ROM (or memory stick) with EVP installation files and documentation

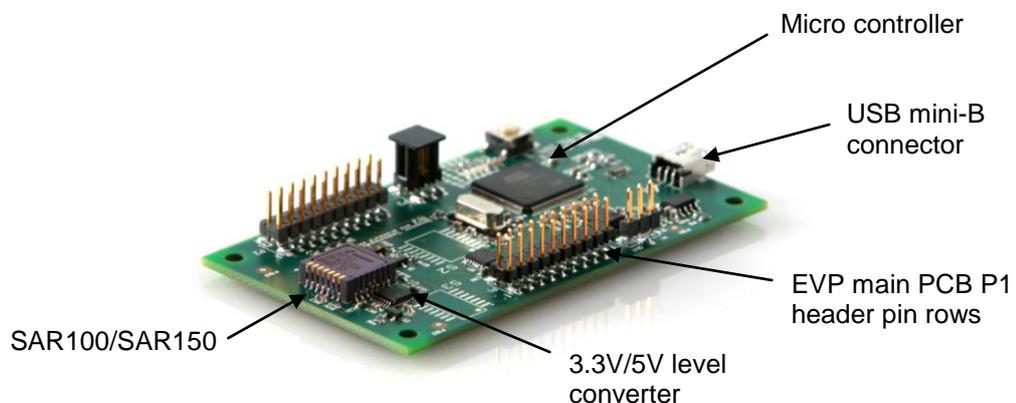**Figure 1: SAR100 and SAR150 EVP system setup schematics**

Figure 2: SAR100 and SAR150 EVP main PCB

3   Operating conditions

Table 1: EVP main PCB operating conditions

Parameter	Specification		
	Min	Max	Unit
Ambient temperature for EVP main PCB	10	30	°C

Testing over temperature can be performed by connecting the EVP main PCB to a satellite PCB. See chapter 8 and 9 for more information.

4   Getting started

PC software installation files and EVP documentation are included on a storage media (memory stick or CD-ROM) included in the package. The latest versions of files and documentation are also found at the Sensonor web site (www.sensonor.com).

To get started using these tools follow the step-by-step instructions below.

Step 1: Installation of PC software and EVP USB driver

1. Unzip and save the correct software installation file, e.g. the one for Win Xp operating system "PC Software SAR100 and SAR150 EVP vx.0.0 (Xp).zip", to a local drive
2. Run the setup file (setup.exe)
3. A pop-up message during installation will ask for permission to install a USB driver (6119.inf) for the EVP. This is a driver which is not verified by Windows. Select nevertheless the choice "Install this driver software anyway". The driver file does not represent a security threat

Figure 3: USB driver installation (click 'install this driver software anyway')

4. Complete the installation process by following the on-screen instructions. When the installation is completed, click "Finish". See Figure 4 and Figure 5.
5. Verify the USB driver successfully installed by connecting the EVP main EVP and finding the "AT91 USB to Serial Converter (COMx)" in the device manager (win Xp example). Notice at the same time the associated COM port number as this is needed for configuring the PC software correctly in the next step
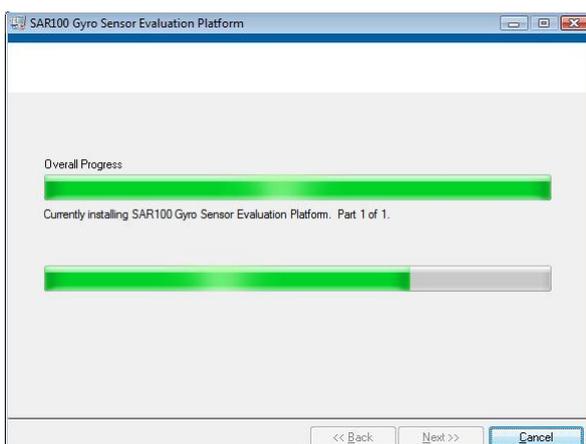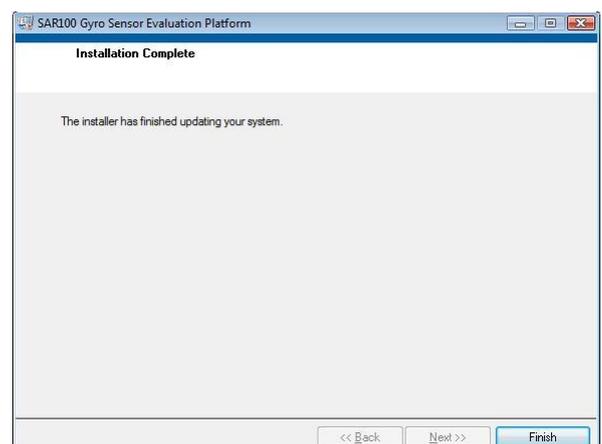
Figure 4: Installation in progress   **Figure 5: Installation complete**

Step 2: First PC software start-up

1. Keep the EVP main PCB connected to the PC via USB, or ensure to connect it again
2. Start PC software from PC start menu
3. The graphical user interface should appear on screen, and the EVP is now ready for use

5   PC Software descriptions

The EVP PC software has been developed in LabWindows CVI. There are a few classical roll-down menues available. Distributed buttons and input boxes are set up to control gyro sensor measurements.
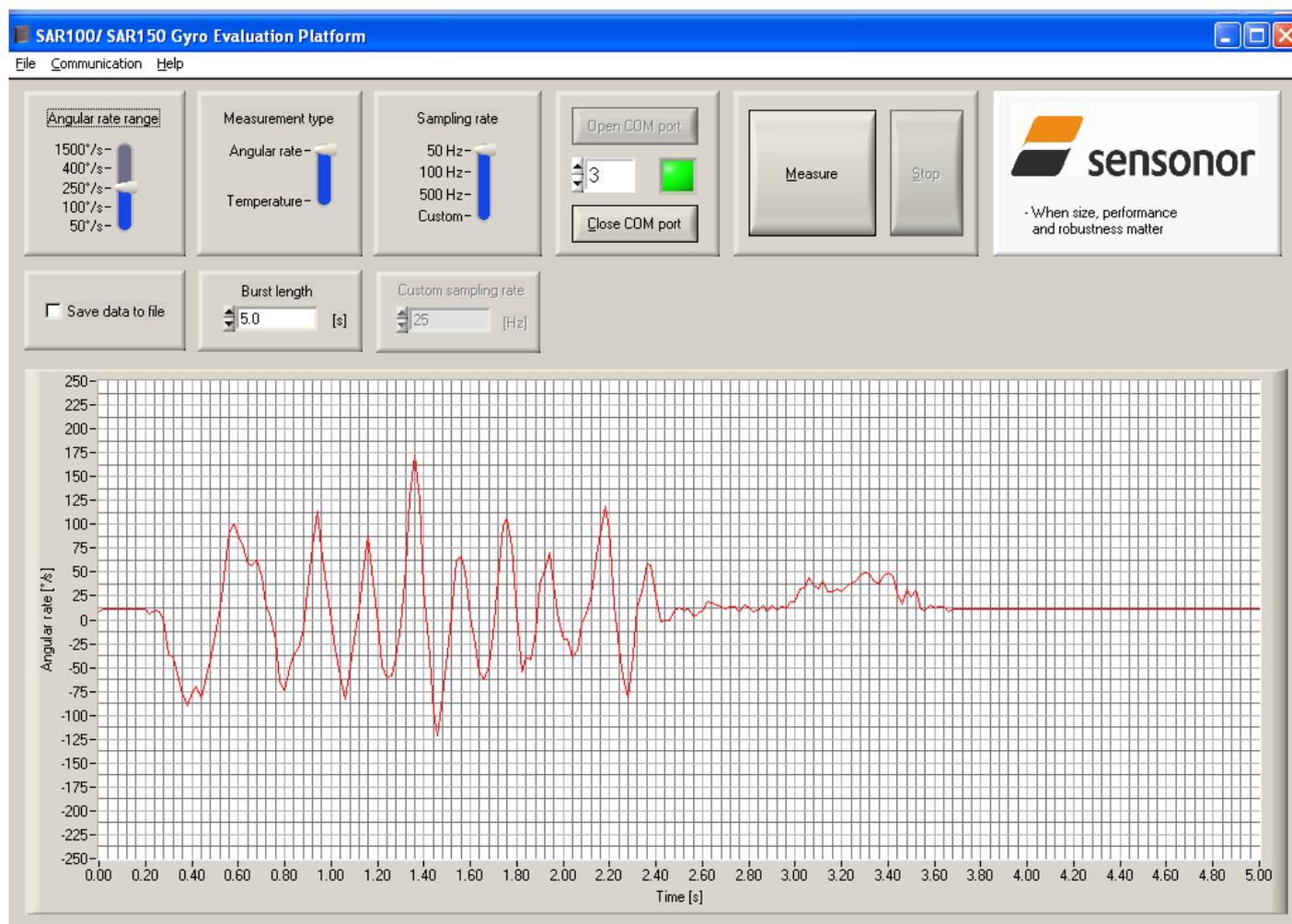

Figure 6: PC software graphical user interface. (Showing 5s burst length, 50Hz sampling rate, angular rate measurement sequence for 250deg/s SAR150. With COM 3 in use)

Description of first time usage of PC software:

1. Enter the correct COM port number for the EVP main PCB connection in the COM port input box and press the 'Open COM port' button. (The correct COM port number is the one noticed from the device manager list, as already described in step 1 in Chapter 4). Verify that the green LED becomes visible (as seen on Figure 6). This indicates that the COM port has been successfully opened and that the connection to the EVP main PCB is established.

2. Prepare to measure with the gyro sensor by selecting the correct angular rate range of the product, the desired measurement type, sampling frequency and burst length, and possibly selecting 'Save data to file' if a log file is this is required

3. Start a measurement series by pressing the 'Measure' button

Measurement results are graphically presented on screen and written to a text file if the 'Save data to file' box is checked.

Real time data is shown for sampling frequecies up to 61Hz, while data is post-presented for sampling frequencies from 62 to 2000Hz.

This was the quick start part of the manual in order to start measuring. For more details continue reading until the end of the document.

5.1   Detailed descriptions for menus, buttons etc.

COM port input box and buttons.

- COM port input box: For selecting the assigned COMport number for the EVP main PCB
- Open COM port button: Opens the selected COM port. (Visible when the COM port is closed)
  Note: "Good practice" is to ensure to open the COM port as the first operation after start-up of software
- Close COM port button: Closes the selected COM port. (Visible when the COM port is open)
  Note: "Good practice": is to ensure to close the COM port as the last operation before closing the software
- Connected/ Disconnected LED: This is a green LED which is visible when the selected COM port is open

Upper row of slides and buttons.

- 'Angular rate range' slide: To select the correct gyro sensor range, E.g. '250' or '100°/s'
- 'Measurement type' slide: To select the chosen measurement type, 'Angular rate' or 'Temperature'
- 'Sampling rate' slide: To select the sampling rate, '50', '100', or '500' Hz, or 'Custom' to prepare to chose a custom sampling rate (see below).
- 'Measure' button: To start measurements
- 'Stop' button: To stop measurements. (Enabled when a measurement sequence is in progress)

Lower row of check- and input boxes.

- 'Save data to file': To save the measured data to a text file. (An active check box saves measured data to file.)
- 'Burst length': To select a burst/sampling length (in seconds)
- 'Custom sampling rate': To select a custom sampling rate in Hz. The box is enabled when 'Custom' rate is chosen on the 'Sampling rate' ring slide. Steps of 25Hz are incrementations when using the arrows of this custom input box

Graphical results.

- Strip chart: The chart shows scaled measurement [°/s] or [°C] results vs. time [s]. Units and range on the axes are set according to selected measurement ranges and burst lengths. For lower sampling frequencies (up to 61 Hz) the results are plotted real time, while they for all higher sampling frequencies are plotted after data collection is completed (postprocessing of data)

Top GUI menus.

- 'File' ➔ 'Open': Opens selected log file
- 'Communication' -> 'Send special command'. Resets recoverable error conditions and re-enables signal processing (angular rate readouts) from the connected gyro sensor. This feature is to be used in case there has been an over-range situation which can be easily applied during a hands-on test, especially for the lower-range gyro sensors (as the 100 °/s range gyro sensor).
- 'Help' ➔ 'About': Opens an 'About' panel including the current PC software version

5.2   Example of measurement result log file

Figure 7 shows an example of a generated log file. The three first rows describe the measurement. Then, after an empty row/line, two columns for time tags [s] and results [lsb] follow. Results in the file should hence be scaled by the correct scale factor (see datasheets) in order to have rate data in °/s.

The results in the file may be further handled by a chosen program, as Excel, for e.g. scaling the data with the scale factor and integrating the angular rate data to a angle contributions [°].

```
Samplingtype        AR
Samplingrate        100 Hz
Burstlength         10 s

0.0000    15
0.0100    15
0.0200    15
0.0300    13
...
..
.
9.9700    14
9.9800    14
9.9900    14
10.0000   13
```

Figure 7: Example of angular rate measurement log file (not all shown). Sampling frequency is 100Hz, burst length is 10s

5.3   **Example of simple integrated angle test**

An example of a simple hands-on angle test with the EVP is described in this chapter. The completion of the test requires usage of the EVP log file plus some calculations and plotting in a suitable program before having a similar result as shown in Figure 8. (Excel was used in this example).
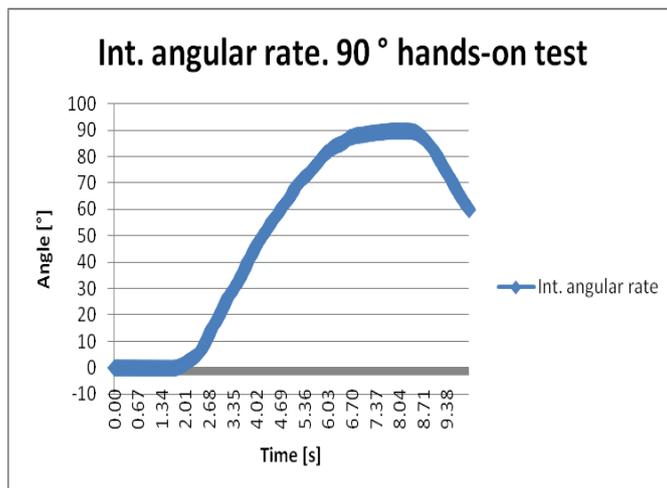

Figure 8: Shows a simple hands-on test done with the EVP. The PCB is tilted approximately +90° around the sensitive axis and the data from the log file is bias cancelled before integrated and plotted as incremented angle [°] vs. time [s].

A description of the hands-on integrated angle test

1. The angular rate data is logged over a short sequence, e.g. over approximately 10s, and the results are kept in the EVP log file (and thus the 'Save data to file' choice needs to be selected).
2. At first part of the test, directly after start of measurement (by pressing 'Measure'), the EVP main PCB is kept steady in order to collect the correct bias. Then, in the next part of the test, the EVP main PCB is tilted up on the side, around the gyro sensitive axis, in one more or less smooth movement, to approximately a + or - 90 degree position relative to the starting position
3. The EVP main PCB can be kept in this 90 degrees position until end of test, or moved back if the signal (the plotted angle) is desired to move back to zero in the final plot
4. When the test is finished (as indicated by 'Measure' button is again lit, and the 'Stop' button is not), the log file contents can be imported to a suitable program for further handling and data presentation. (An example of such a program is Excel, as used here)
5. The gyro bias is now found in the chosen program by averaging the first ten to fifty result (the exact number of averaged results is not so important unless the accuracy of the angle result is crucial).
6. Next, a gyro bias cancellation is done on all the collected gyro data (typically in a new column in the same spread sheet if in Excel)
7. Now, finally the bias cancelled data is summed up (integrated) to small angle contributions and plotted in a chart similar to the one shown in Figure 8.

Plots showing the integrated angle changing from 0 to approximately 90 degrees at the maximum for such a test are good confirmations for successful bias cancellations and correct use of scale factors.

5.4   Send special command for recoverable error handling

Flags of the gyro sensor Status Register are normally "1", which means gyro sensor status is OK. Status register contents are not shown by the EVP software, however any "0" in this status register will result in an error code pattern (1000 000) in response to all successive angular rate read commands. This error code is implemented by design and is different from any possibly valid output data, indicating that the gyro sensor is not reporting reliable data. Internal signal processing is held during the error condition, and it continues infinitely unless a hard reset (power-on reset), or a soft reset is performed. The soft reset is a specific user initiated routine that releases the gyro sensor from the recoverable error condition, involving usage of the PRCEN command.

The soft reset sequence is supported by the EVP, and the following sequence is sent when choosing 'Communication' ➔ 'Send special command' from the roll down menu.

Table 2: Gyro sensor error handling commands

Command	Code	Description	Comment
SGDIS1	01001110	SafeGuard Disable Command 1	MSB first
SGDIS2	01100011	SafeGuard Disable Command 2	MSB first
SGDIS3	00010010	SafeGuard Disable Command 3	MSB first
PRCEN	10101010	Re-enable signal processing after error condition	MSB first
SGEN	01010101	Safeguard Enable command	MSB first

PRCEN execution should obey the following sequence:

1. Waits until no recoverable error conditions are flagged (polling the Status Register)
2. Wait 1 second
3. Execute the SGDIS1, -2 and -3 commands
4. Execute the PRCEN command
5. Execute the SGEN command

Notice that both hard and soft reset mechanisms can be relevant for real applications in order to handle recoverable error situations (like over-range). The gyro sensor then returns to normal operation and continues to measure angular rate.

6   PC to main PCB interface descriptions

The micro controller to gyro sensor interface is SPI. Data transport between PC and micro controller is via USB, utilizing a USB framework to implement device-side "USB Communication Device Class (CDC)" functionality. This yields a 'virtual' COM-port on the PC (host) side when the EVP PCB is connected, with up to USB2.0 'full-speed' (12Mbps) data rate.

The implemented PC software to main PCB micro controller protocol is an ASCII format type, with the following details/definitions:

Standard format:
<LENGTH><COMMAND><RANGE><RATE><RATE><DATA>

Special commands (as e.g. the STOP command):
<LENGTH><STP_CMD>

7   Main PCB descriptions

PCB material is FR-4, with dimensions 85 mm x 50 mm, and thickness 1.6 mm.

List of PCB main components:

- USB mini-B contact for communication and 5V supply
- Gyro sensor
- 3.3V regulator
- 3.3V to 5V level/signal converter between micro controller and gyro sensor
- ARM micro controller
- 18 MHz crystal
- Header pin connectors for monitoring EVP signals and connection of satellite PCBs

8   Main PCB to satellite PCB wiring diagram

Table 3 shows EVP main PCB to satellite PCB wiring diagram.

Table 3: EVP main PCB to satellite PCB wiring diagram

Pin name	SAR100/SAR150 EVP P1 20 pin header pin row	SAR100/SAR150 satellite PCB P1 18 pin header pin row
SCLK (SPCK0)	Pin 09	Pin 01
MOSI (MOSI0)	Pin 10	Pin 06
MISO (MISO0)	Pin 11	Pin 07
NCS (NPCS00)	Pin 12	Pin 08

9   Satellite PCB descriptions

The EVP (SAR100/ SAR150) satellite PCB is shown in Figure 9. The P1 header pin rows enables access to gyro sensor singals and pins.
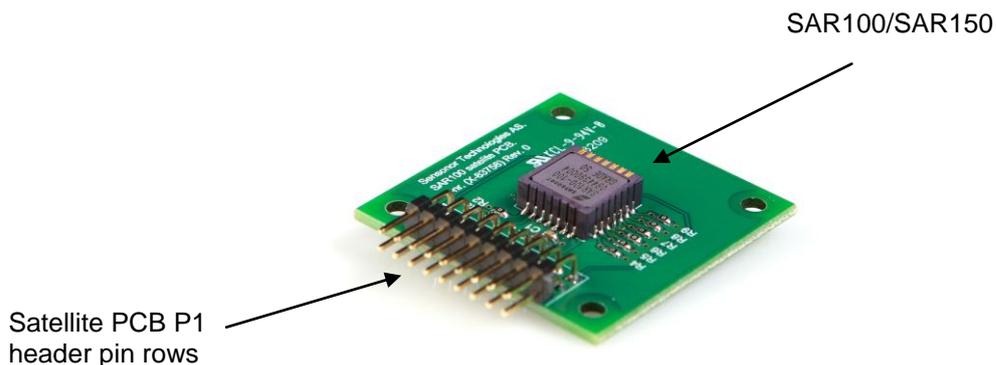

SAR100/SAR150

Satellite PCB P1 header pin rows

Figure 9: SAR100/SAR150 satellite PCB

10   Micro controller firmware descriptions

The PC software communicates with the micro controller on the EVP main PCB via USB, and gyro sensors expects SPI commands. Therefore, effectively the micro controller works as an USB to SPI bridge. The micro controller program expects the following COM port settings on the PC (host) side:

• 115200 bauds
• 8 bits of data
• No parity
• 1 stop bit
• No flow control

10.1   Micro controller to gyro sensor commands

A set of gyro supported commands and expected responses are implemented in the micro controller in order to perform measurements and forward results to the PC. Those commands and responses for the EVP that have direct gyro sensor relations, and are not yet mentioned, are listed below.

Table 4: Micro controller to gyro sensor commands

Command	Code	Description	Comment
RARH	1000 0000	Read AR, High Byte	MSB first
RARLX	1000 1110	Read AR, Low Byte eXtended	MSB first
RTMP	1011 0000	Read T	MSB first

Table 5: Gyro sensor to micro controller responses

Command	Code	Description	Comment
RARH	dddd dddd	Angular Rate, High Byte (issued before RARLX command)	MSB first. 12 bit AR data 2's compliment Scale factors:
RARLX	0101 dddd	Angular Rate, Low Byte eXtended	1.0°/s/LSB for 1500°/s range gyro sensors 0.25°/s/LSB for 400°/s range gyro sensors 0.25°/s/LSB for 250°/s range gyro sensors 0.1°/s/LSB for 100°/s range gyro sensors 0.05°/s/LSB for 50°/s range gyro sensors
RTMP	dddd dddd	Internal gyro sensor temperature	MSB first. 8 bit data 2's compliment Scale factor: 1 °C/LSB Tmin= 11011000 @ -40 °C Tmax=01011111 @ 95 °C

11   Summary tables for available EVPs and related tools

Table 6: EVPs

Description	Mounted/ Supported gyro sensors
Gyro and Pressure Sensors EVP	Without gyro sensor. Supports all SAR100 and SAR150 gyro sensors
SAR100-100 EVP	SAR100, range 100 °/s
SAR100-250 EVP	SAR100, range 250 °/s
SAR150-100 EVP	SAR150, range 100 °/s
SAR150-250 EVP	SAR150, range 250 °/s

Notice that EVP main PCBs must be without any gyros mounted when measuring from a connected satellite PCB. (The micro controller has only one SPI controller and cannot communicate with two gyro sensors in parallel.)

Table 7: EVP satellite PCBs

Description	Mounted/ Supported gyro sensors
SAR100/ SAR150 satellite PCB	Without gyro sensor. Supports all SAR100 and SAR150 gyro sensors
SAR100-100 satellite PCB	SAR100, range 100 °/s
SAR100-250 satellite PCB	SAR100, range 250 °/s
SAR150-100 satellite PCB	SAR150, range 100 °/s
SAR150-250 satellite PCB	SAR150, range 250 °/s

A cable for connecting satellite PCBs to EVP PCBs can be made by the customer, or ordered.

Table 8: EVP to satellite PCB interface cable

Description	Length
EVP to satellite PCB interface cable	30cm

12   Referred documents

Table 9: Referred documents

Ref	Doc	Description
[1]	TS1440	Datasheet SAR100
[2]	TS1514	Datasheet SAR150