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ProMove-2

Wireless Inertial and Orientation Sensor Platform

User Manual
v1.1

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Table of contents

1 Introduction

The ProMove-2 is a highly miniaturized inertial sensor node that captures and communicates wireless full 3-D motion and orientation information. It combines the latest advances in MEMS sensor design and low-power wireless communication. Featuring a suite of modern inertial and magnetic sensors, a dedicated microcontroller for application-specific software, and a separate System-on-Chip (SoC) solution for wireless networking, ProMove-2 is a powerful, versatile platform for motion sensing applications.

The sensor information provided by ProMove-2 consists of: 3-D acceleration, 3-D turn rate (gyroscope) and 3-D magnetic field intensity (compass). The data is communicated using the 2.4 GHz wireless radio to a central node – the FastGateway, which connects through USB to a computer. The data can be visualized in the ProMove GUI software and is logged for post-analysis.

Multiple ProMove-2 nodes can form a network and report the sensor data fully synchronized to the FastGateway. The sampling rate scales with the number of nodes in the network and the activated sensors, e.g. 200 Hz for all inertial sensors for 6 nodes, 100 Hz for 12 nodes.

ProMove-2 features additionally an RF power amplifier for extended coverage and improved sensitivity and a mini-USB connector for charging the Li-Ion battery. Everything fits in a compact casing of 65x50x30 mm.

2 Setup

2.1 System description

The system consists of a number of sensor nodes (the ProMove-2), the USB gateway (FastGateway) and the Graphical User Interface (ProMove GUI) software for monitoring and logging the inertial data.

The setup is depicted in Figure 1. The sensor nodes communicate wirelessly with the gateway, using the proprietary FastMAC protocol. The gateway is connected via its mini-USB connector with a PC that runs the ProMove GUI. The gateway can be easily recognized because it has no on/off switch and has only two LEDs (whereas the sensor nodes have four LEDs).

Figure 2 shows the top-view and side-view layout of the ProMove-2 nodes, with the identification of reference system axes (X-Y-Z), on/off switch, mini-USB connector and LEDs.

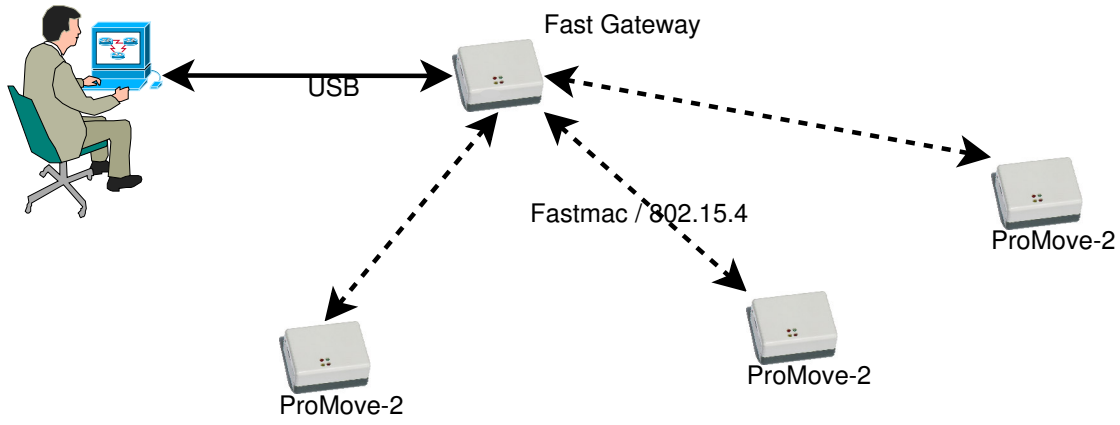

Figure 1: Setup of sensor nodes, gateway and GUI

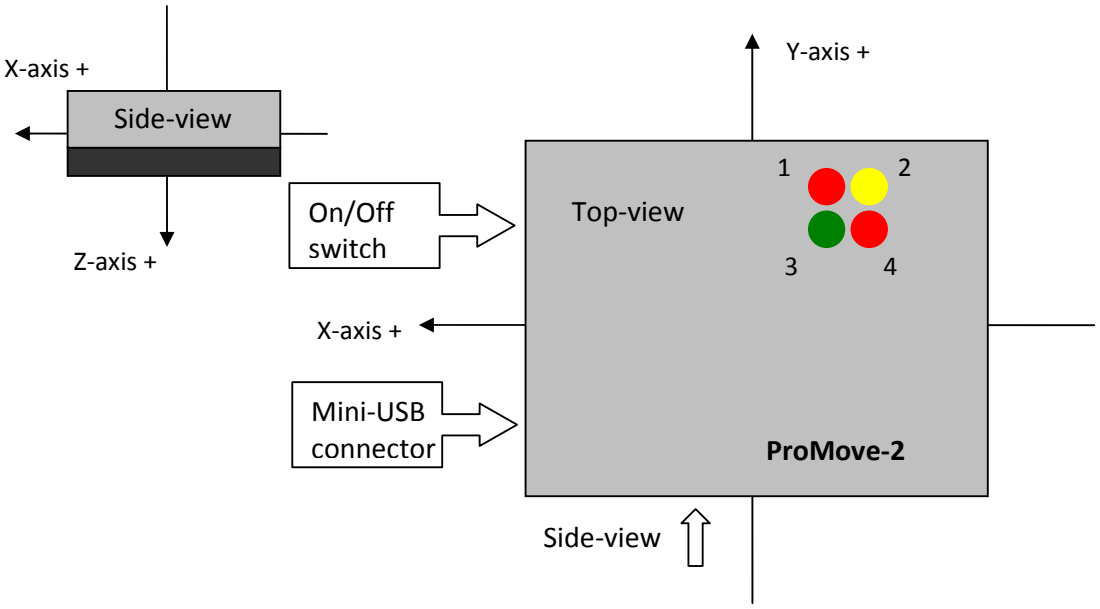

Figure 2: The ProMove-2 node layout

The description of the LEDs functionality is given in the table below.

LED	1	2	3	4
Colour	RED	YELLOW	GREEN	RED
On	Charging, turns off when charging is completed	-	-	-
Blinking fast	-	For future use	Communication with sensors*	Wireless communication*
Blinking slow	-	For future use	Communication with sensors*	Wireless communication*

* *Slow* or *fast* blinking depends on the set data rate.

2.2 Recharging the batteries of the sensor nodes

The internal batteries of the sensor nodes should be periodically recharged using their mini-USB connector, either from the USB ports of a computer / active USB hub, or using standard USB chargers. The gateway has no internal battery and therefore does not require recharging.

A red LED on the sensor nodes, marked as number 1 in Figure 2, indicates the charging status. It is turned on while the sensor node is charging. It turns off once the sensor node is fully charged.

2.3 Installing the Gateway driver

The FTDI driver must be installed for the USB connection of the Gateway to the PC. There is a setup application for the different ms-windows operating systems in the Drivers directory on the installation CD. Windows7 can find the FTTD driver itself when it is connected to the internet.

2.4 Installing the Visual-C redistributable

The Visual-C redistributable is required for the ProMove GUI to run. This redistributable is available as a setup application in the Drivers directory of the installation CD.

2.5 Installing the ProMove GUI

The ProMove GUI can be found in the ProMoveGUI folder on the installation CD. Copy the folder ProMoveGUI from the CD to the hard drive of your PC. Double-click on the application ProMoveGUI to launch the program.

3 Graphical User Interface

Figure 3 shows the Graphical User Interface (GUI). It is available for Microsoft Windows and for recent versions of Ubuntu Linux. The GUI contains 10 Graphs that show by default the following parameters:

- Acceleration on X, Y and Z axes
- Compass / magnetic field intensity on X, Y and Z axes
- Gyroscope / turn rate on X, Y and Z axes
- Signal strength (RSSI) information

A different line colour corresponds to a different sensor node in the network.

The *Control and Info Area* at the bottom right shows :

1. The *Packet loss statistics* panel, displaying:
    a. The number of lost packets
    b. The total number of packets received from the sensor nodes
    c. The button for resetting the statistics
    d. The drop-down menu for the *Complete history*
    e. The drop-down menu for selection of one or *All nodes*
2. The *Toolbox* panel, used to control the data capturing, to zoom and pan the data
3. The reserved area for system messages
4. The legend with the corresponding colors for each sensor in the graphs

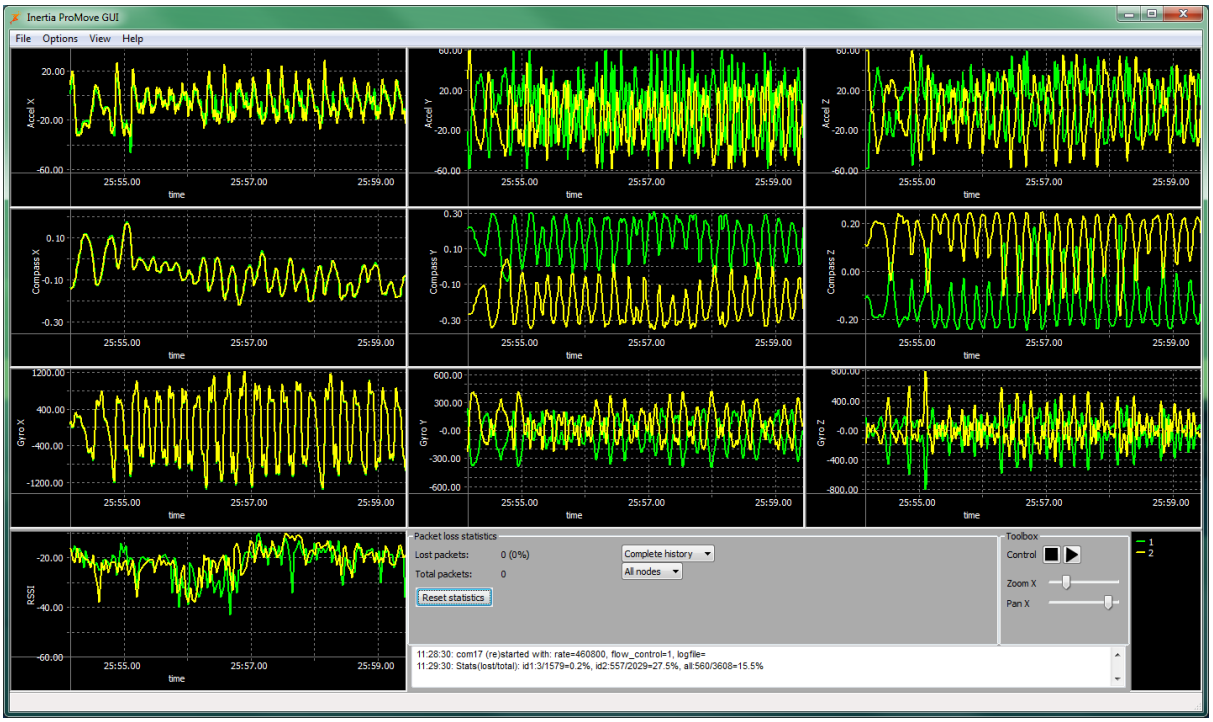

Figure 3: ProMove GUI with 2 nodes, Main window

3.1 Data graphs

In the default setting the following graphs are displayed from left to right and top to bottom:

- Acceleration X
- Acceleration Y
- Acceleration Z
- Compass X
- Compass Y
- Compass Z
- Gyroscope X
- Gyroscope Y
- Gyroscope Z
- RSSI (Received Signal Strength Indicator)

3.2 Control and info area

A close-up of the *Control and Info Area* is depicted in Figure 4.

Figure 4: The *Control and Info Area* window of the ProMove GUI

Packet loss statistics
The drop-down menu *Complete history* selects between statistics for *One minute* or for the *Complete history*. The *All nodes* drop-down menu gives the option to monitor the statistics of one node or all nodes. The statistics can be reset by pushing the *Reset statistics* button. After changing the sensor configuration, it is recommended to reset the statistics.

Toolbox
Push ■ to *Stop* capturing and ▶ to *Start* capturing. The Zoom slider zooms in or out the data displayed in the graphs. The Pan X option enables shifting the data displayed in the graphs to left or right.

Legend
The legend window shows which line color is used for each sensor node in the graphs.

System messages
The system messages are displayed in the reserved area.

3.3 Menus

There are four top menus: *File, Options, View* and *Help*. The *File* menu has the menu items *Capture*, for setting the data capture configuration, and *Exit* to quit the GUI. The *Options* menu has the menu item *Wireless configuration*, which configures the sensor and the wireless connection parameters. The *View* menu has the menu items *Config*, for the configuration of the graphs, and *Clear all graphs*, for clearing the graph windows. The *Help* menu has the items *Manual*, for a copy of the users manual, and *About*, with the revision information for the ProMoveGUI.

The menus and functionality are further described in the following sections.

4 Real-time data capture

The *File-Capture* menu enables the real-time data capturing and logging to files.

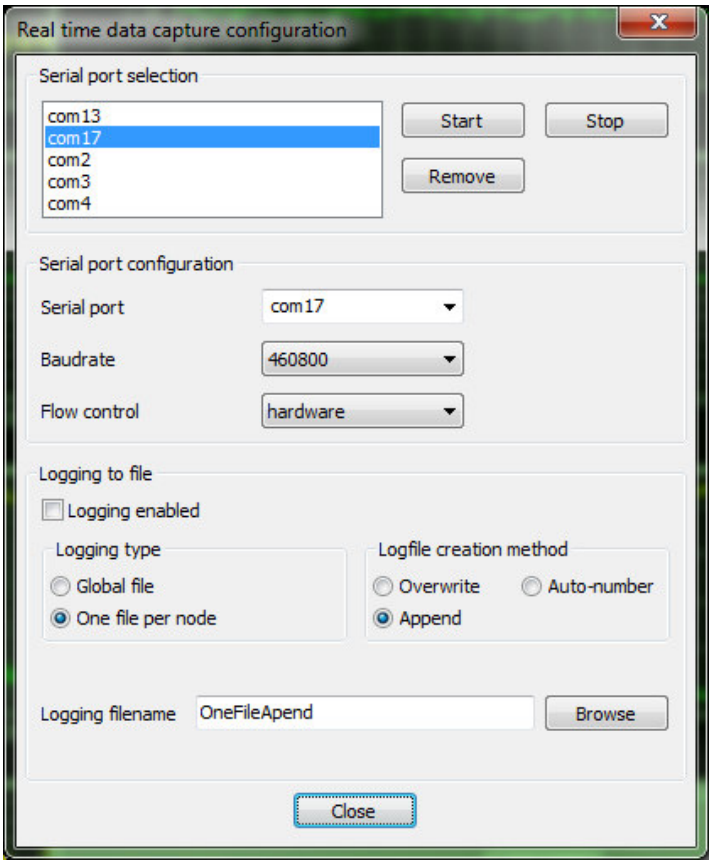

Figure 5: The *File-Capture* window

4.1 Serial port selection and configuration

The serial port (COM) must be set for the ProMove GUI. See section 4.3 for an example on how to find the correct serial port. For COM ports higher than 9, type in directly the COM number in the drop box . It is recommended to use the default settings for *Baudrate* and *Flow control*.

Use the *Start* and *Stop* buttons to start and stop receiving data. A previous serial connection will be removed after pressing the *Remove* button.

4.2 Logging to file

Data logging is performed in real-time, in parallel with plotting the graphs. Log files can optionally be split in separate files per sensor node. Data logging is done in comma-separated values file format, with the following fields on each line:

- *timestamp*: a 16 bit timestamp
- *node-id*: the node id
- *ax*: the x-value of the acceleration
- *ay*: the y-value of the acceleration
- *az*: the z-value of the acceleration
- *cx*: the x-value of the compass
- *cy*: the y-value of the compass
- *cz*: the z-value of the compass
- *gx*: the x-value of the gyroscope
- *gy*: the y-value of the gyroscope
- *gz*: the z-value of the gyroscope
- *rssi*: the RSSI value of the last received packet

Note that there can be empty values in a log file, since not all sensors sample at the same rate. The sampling rate can be adjusted separately per sensor type (see section 6). The compass sensor has an internal maximal sampling rate of 50 Hz, so only one out of four values is actually sampled when the global sampling rate is set at 200Hz. Additionally, the RSSI information is relevant for one out of seven samples.

To enable logging, tick the box *Logging enabled* and select the type of logging:

- *Global file* for one file with all the nodes data
- *One file per node* for one file per senor node

For the *Logfile creation method* there are the following options:

- *Overwrite*: the existing file is overwritten
- *Append*: data is added after the last entry in the current file
- *Auto-number*: all created files are numbered in sequence

In the *Logging filename* field, the filename for the log should be given.

4.3 Finding the serial port of the Gateway

The serial port used by the ProMove Gateway must be specified in the GUI. After plugging in the ProMove Gateway on one of the USB connections of your computer, you need to get the number of this serial port.

As an example, for Windows 7 Home Premium, go to Menu *Start* and select peripherals and printers. A list of all connected equipment will appear.

The Gateway

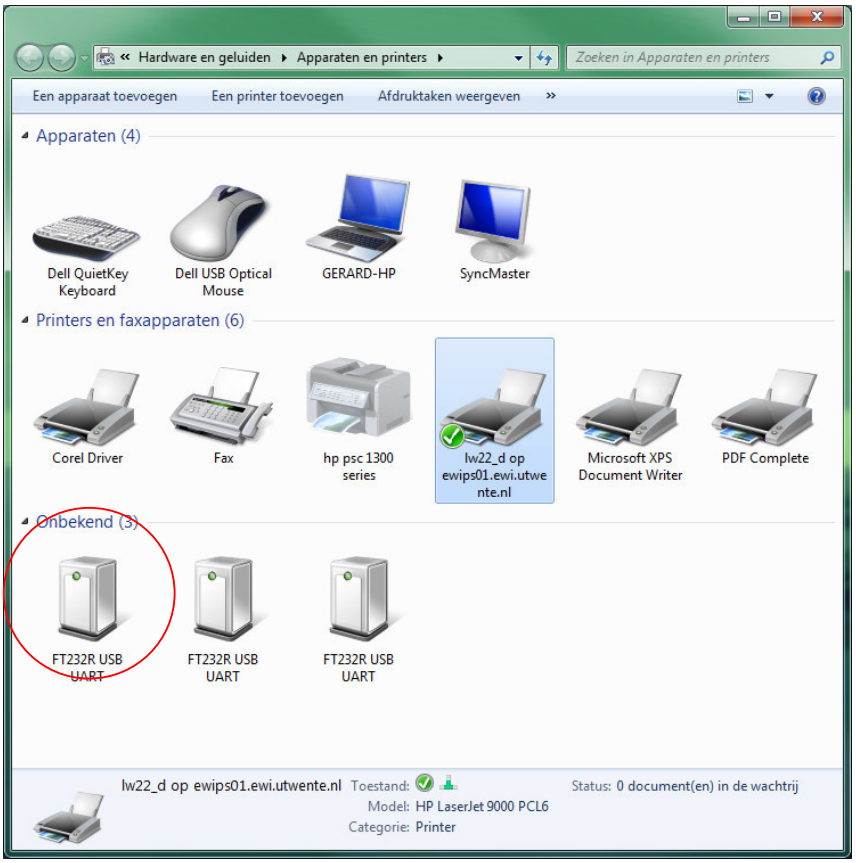

Figure 6: Finding the serial port

Select the *FT232 USB UART*, click right, and select *Properties* from the menu.

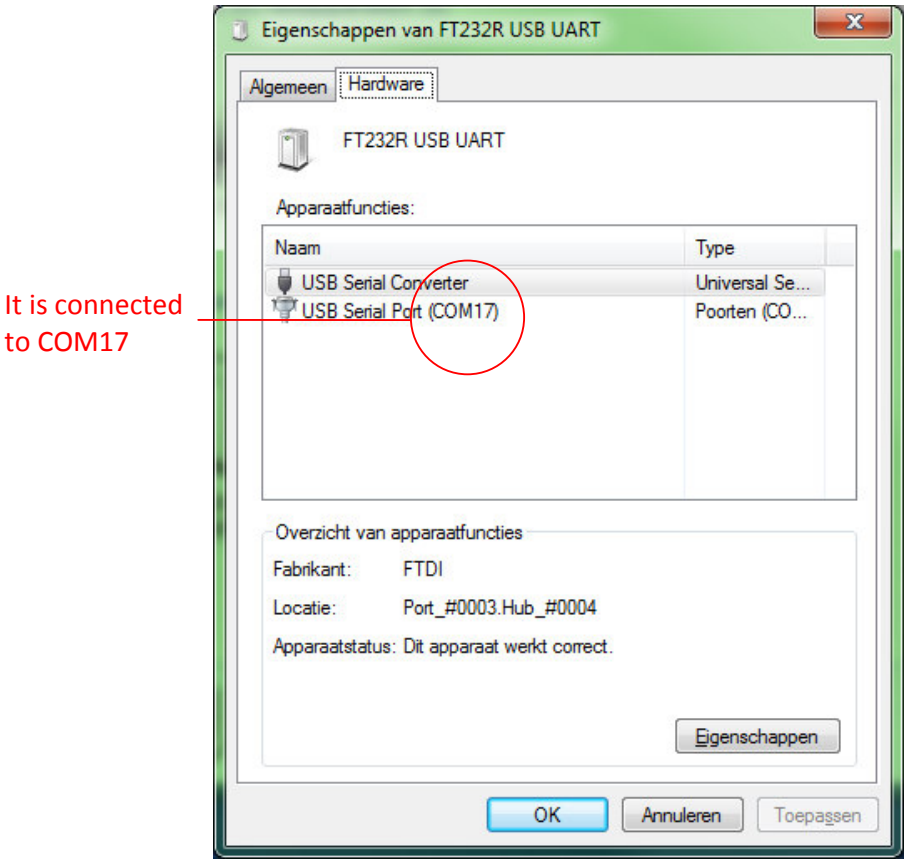

Figure 7: Properties of the serial port

5 Visualization settings

The *View-Config* menu shows the various options for visualization.

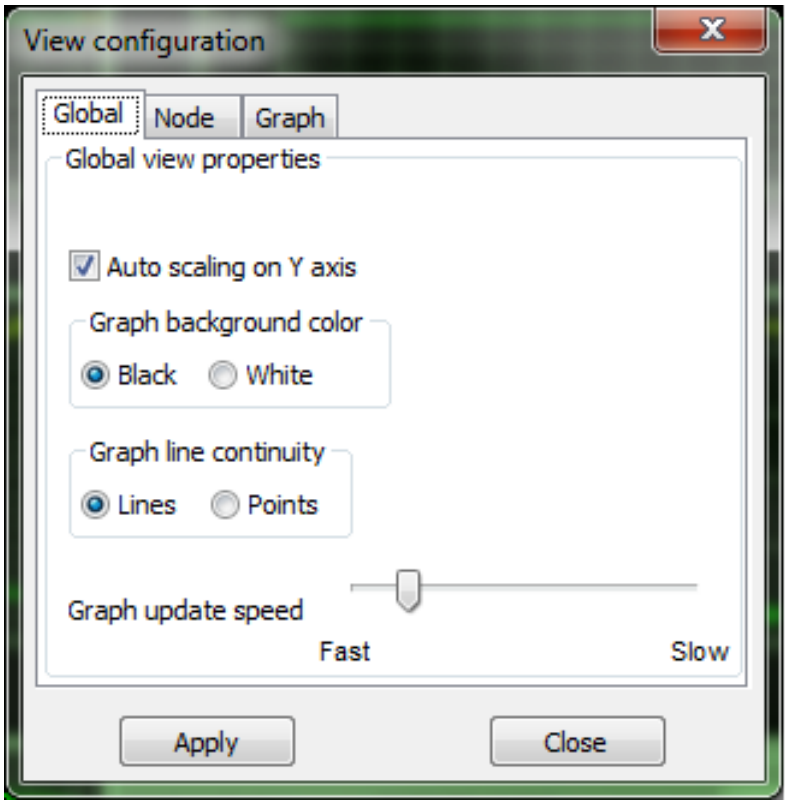

Figure 8: View configuration, *Global* tab

Tick the box to set *Auto scaling on the Y axis*.
Select *Black* or the *White* for the background colour.
Select *Lines* or *Points* for the type of Graph you prefer.
Select the Graph update speed by moving the slider between the *Fast* and *Slow* markers.

Choose *Apply* to make the changes or choose *Close* to exit while discarding all changes.

Select the *Node* tab:

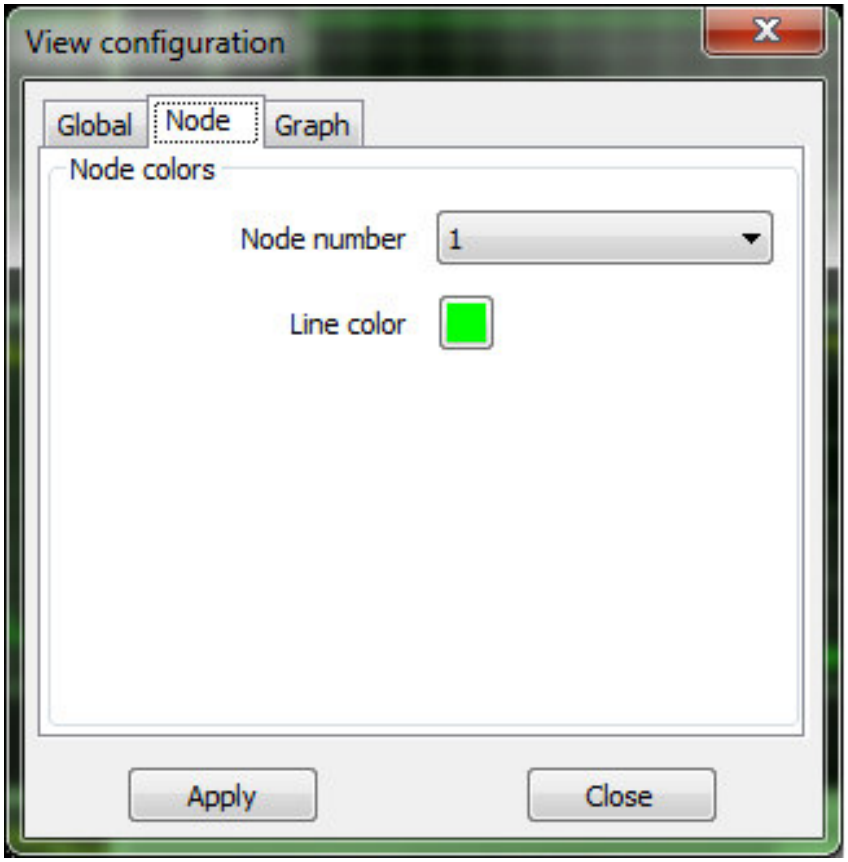

Figure 9: View configuration, *Node* tab

The line color for each node can be changed by selecting the node number and pressing the color button after *Line color*.

Select the *Graph* tab.

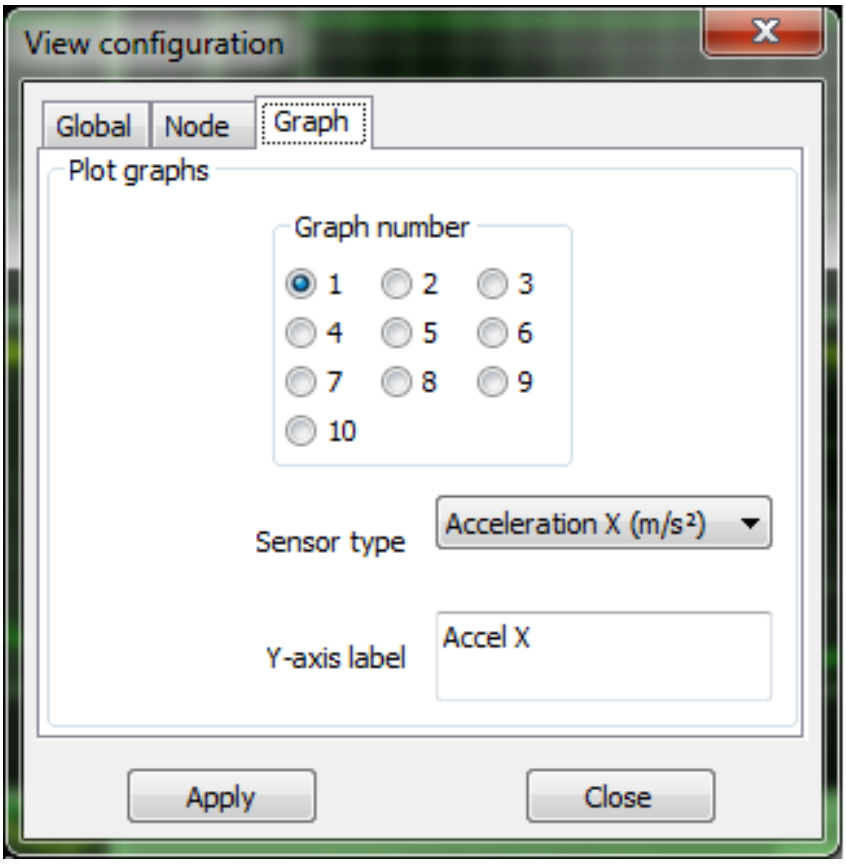

Figure 10: View configuration, *Graph* tab.

The *Graph number* corresponds to the graph windows seen in the ProMove GUI from left to right and top to bottom.

Select the *Graph number* and then the *Sensor type* you would like to see in that graph window. You can add your own label by typing a text in the box *Y-axis label*.

6 Wireless configuration

The configuration of the sensor nodes can be changed wirelessly. All configurable options are accessible via the *Options-Wireless configuration* menu.

The changes made through wireless configuration are not permanent. This means that once the nodes are powered off and back on, the default settings are automatically reloaded on the sensor nodes.

6.1 Global configuration options

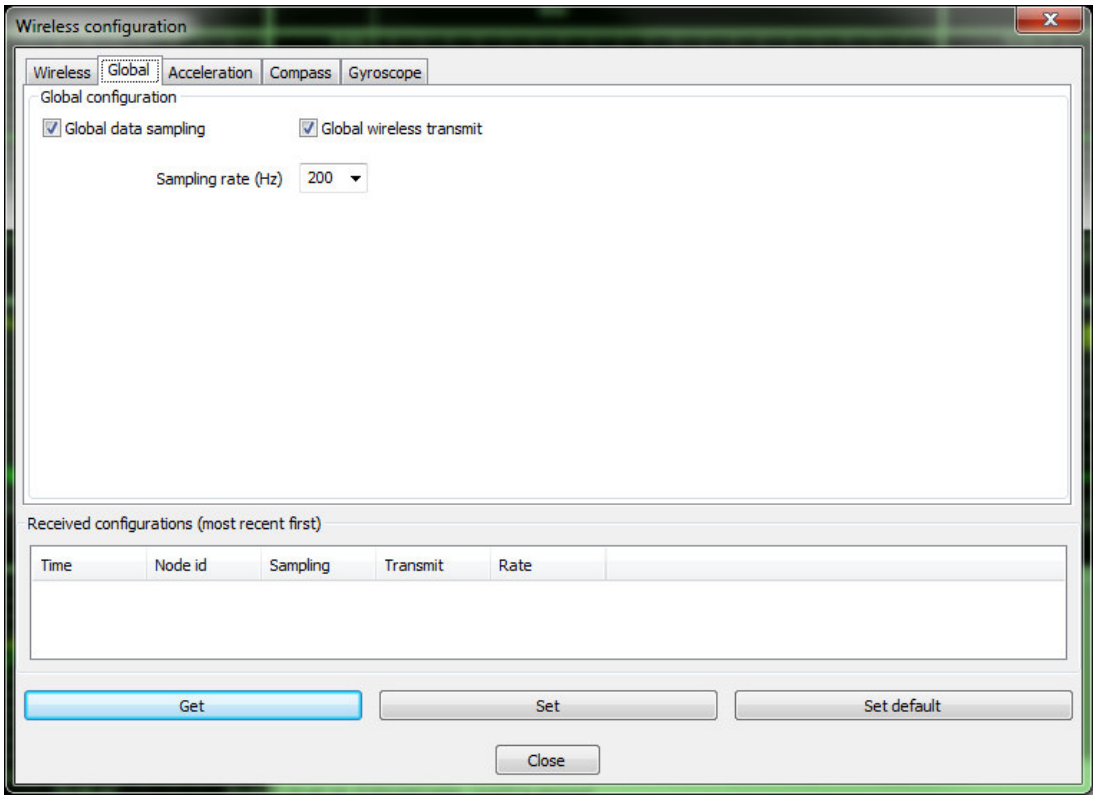

Figure 11: The *Global* configuration tab

Press the *Get* button. The received result is shown in the *Received Configurations* panel. Double clicking on a line loads the result in the settings window. The default settings are restored by pushing the *Set Default* button.

The following parameters can be changed in the *Global configuration* window:

- *Global data sampling:* Overall sampling is enabled. If switched off, no data is sampled
- *Global wireless transmit:* Can be switched off to stop receiving data

- *Sampling rate:* Set the rate at which data is sampled for each sensor. Currently supported rates are [*50, 100, 150* and *200 Hz*]

6.2 Wireless configuration options

The *Wireless* configuration is depicted in Figure 12. This configuration can be used to change the following characteristics of the radio communication:

- *Config destination* specifies the target of the configuration – the *Gateway* or the *Nodes*
- *Frequency channel* specifies the frequency channel to be used
- *Gain* specifies the sensitivity of the receiver (*High gain* is recommended)
- *Transmit power* selects the transmission power level [*High*, *Medium* and *Low*]

When changing the frequency channel, first set the node configuration and then the gateway configuration, otherwise the gateway may not be able to connect to the nodes anymore.

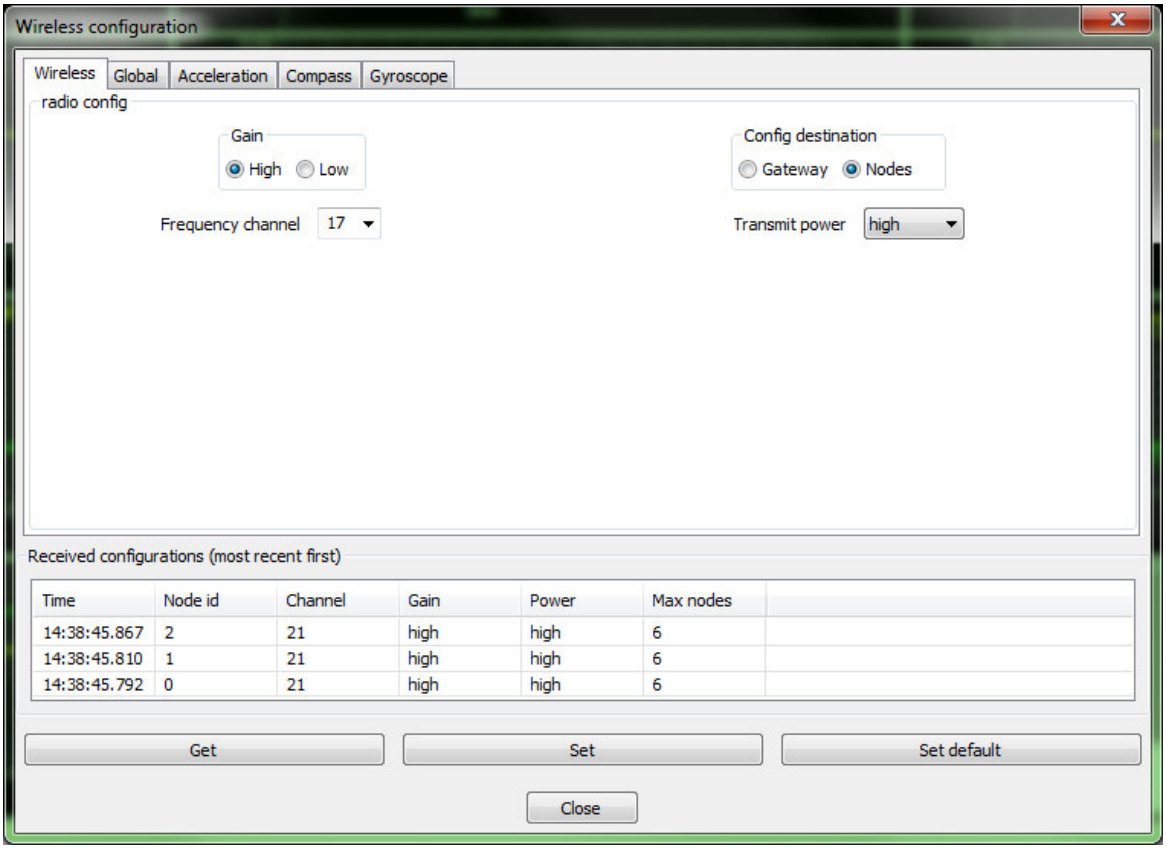

Figure 12: The *Wireless* configuration tab

6.3 Acceleration configuration options

The *Acceleration* configuration is depicted in Figure 13. The following options are available:

- *Enable sampling and transmission* of acceleration
- Set the measurement *range* (2g or 6g)
- *Adjust sampling modulus* allows the sampling rate to be reduced for this sensor. For instance when modulus is set to 2, the number of samples that this sensor sends is divided by 2 (i.e. when the sampling rate is 100Hz, the sensor will send at 50Hz)

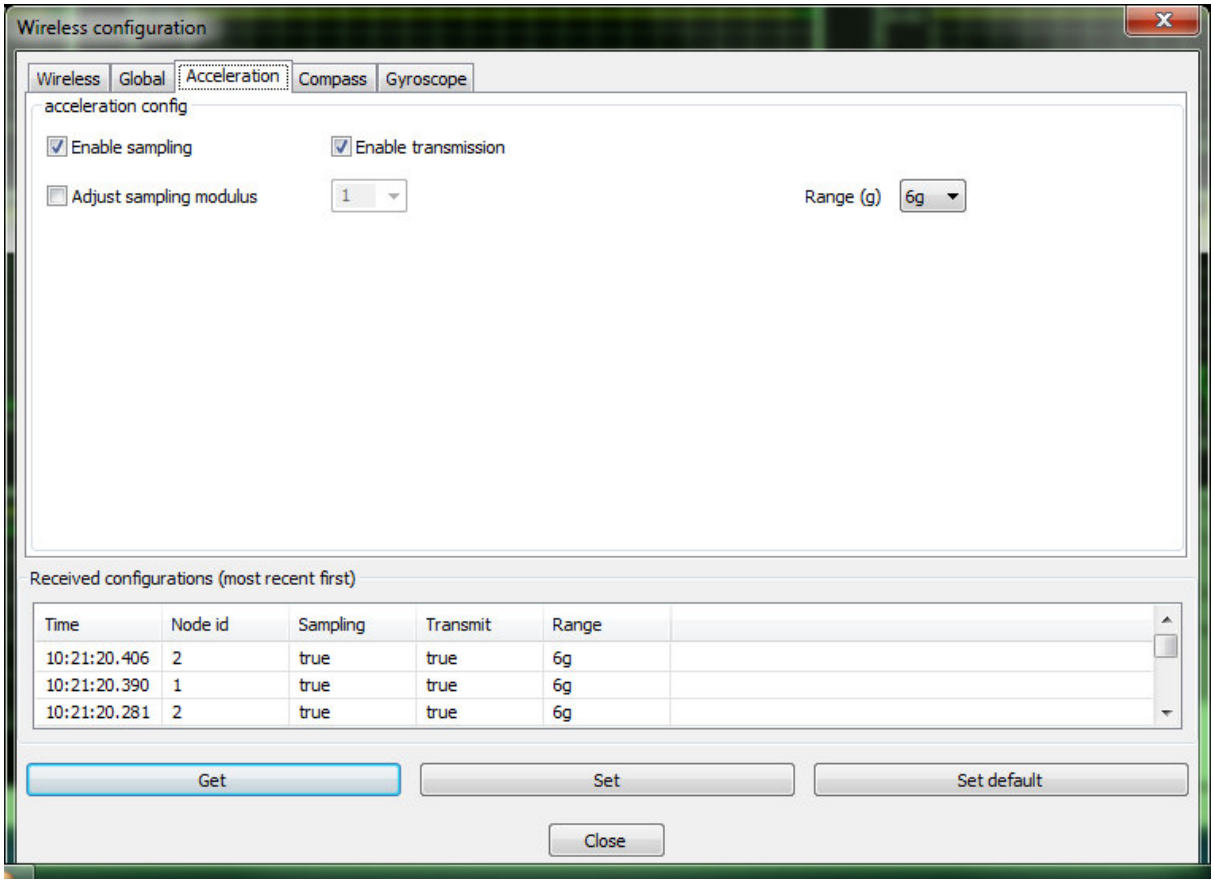

Figure 13: The *Acceleration* configuration tab

6.4 Compass configuration options

The *Compass* configuration is depicted in Figure 14. The following options are available:

- *Enable sampling* and *transmission* of compass values
- Set the measurement *range* to one of the following values:
  0.7 1 1.5 2 3.2 3.8 4.5 6.5 Gauss
- *Adjust sampling modulus* allows the sampling rate to be reduced for this sensor. For instance when modulus is set to 2, the number of samples that this sensor sends is divided by 2 (i.e. when the sampling rate is 100Hz, the sensor will send at 50Hz)

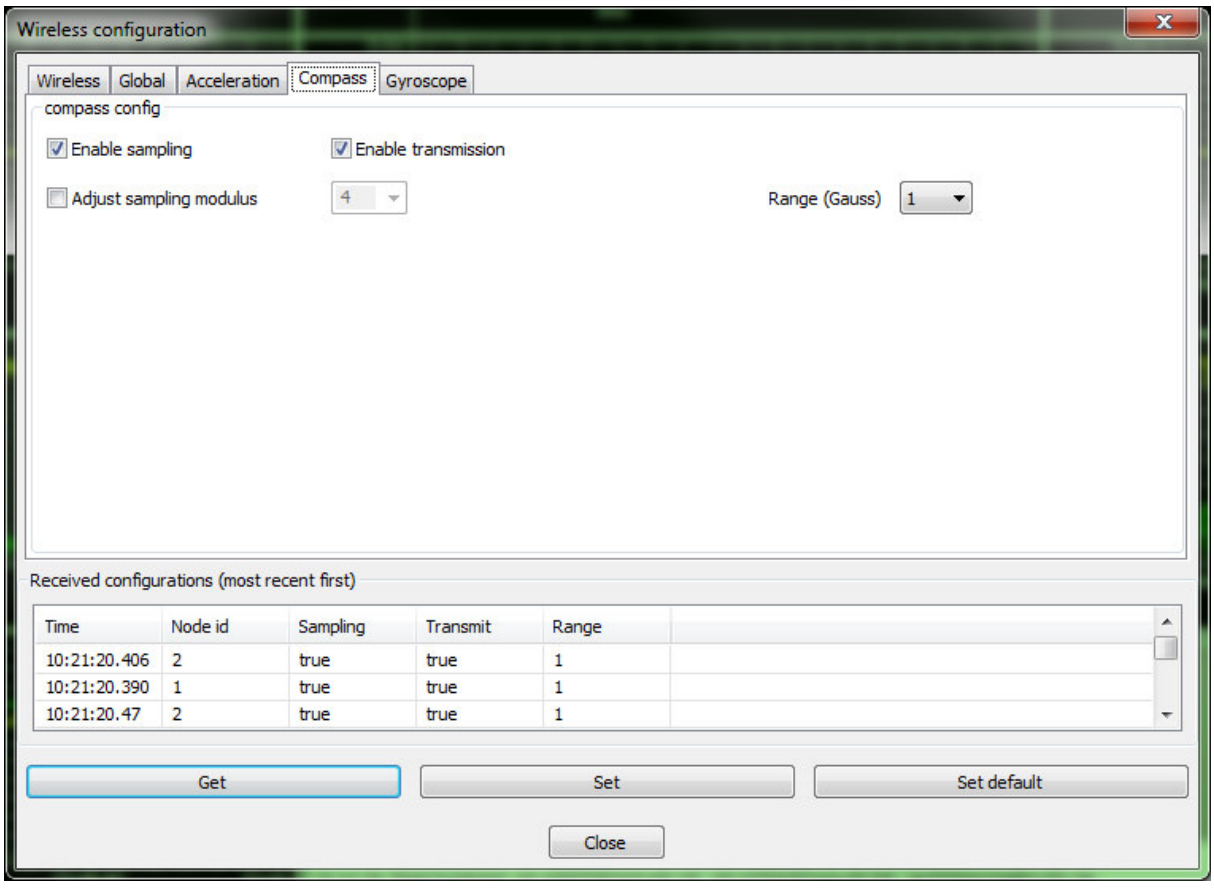

Figure 14: The *Compass* configuration tab

6.5 Gyroscope configuration options

The *Gyroscope* configuration is depicted in Figure 15. The following options are available:

- *Enable sampling* and *transmission* of gyroscope values
- Set the measurement *range* (2000°/s or 440°/s)
- *Adjust sampling modulus,* allows the sampling rate to be reduced for this sensor. For instance when modulus is set to 2, the number of samples that this sensor sends is divided by 2 (i.e. when the sampling rate is 100Hz, the sensor will send at 50Hz)

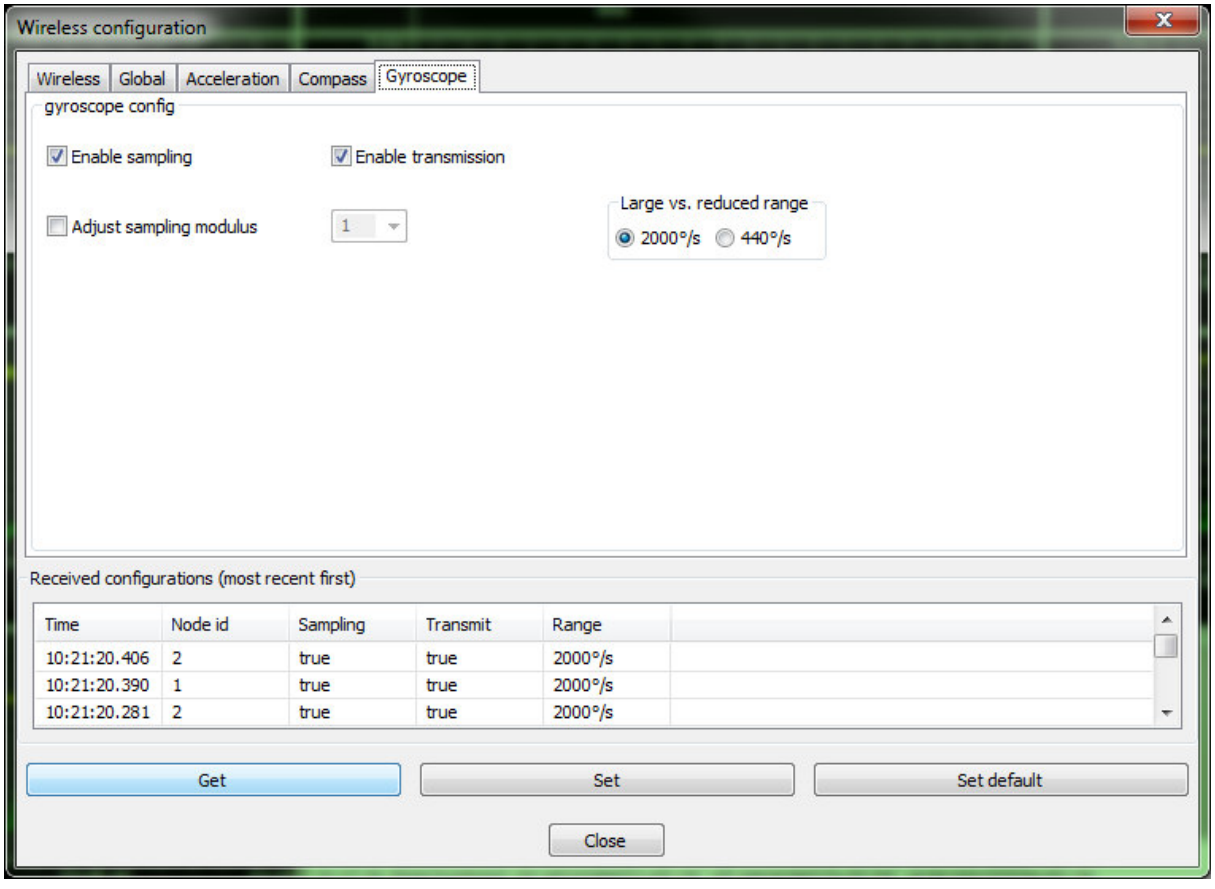

Figure 15: The *Gyroscope* configuration tab

7 Calibration

All sensors are factory calibrated. For improved performance and adaptation to the specific experimental environment, we recommend to perform:

- Custom compass calibration of the offset and scale values, by using for example the method presented in [1].
- Custom gyroscope calibration of the offset values, by collecting a short data log in still position.

[1] Caruso, M. J., 2000, *Applications of magnetic sensors for low cost compass systems*. IEEE Position Location and Navigation Symposium, pp. 177–184

8 Technical Specifications

Accelerometer	
Range	±2 g / ±6 g
Resolution	1 mg @ ±2 g range
Sensitivity	1024 LSb/g @ ±2 g range
Non-linearity	±2 %FS
Cross-axis	±3.5 %
Calibration	On-chip factory calibration
Gyroscope	
Range	Dual 440 °/s and 2000 °/s
Non-linearity	<1 %FS
Resolution	0.21 °/s @ 440 °/s range 0.98 °/s @ 2000 °/s range
Cross-axis	±1 %
Calibration	On-chip factory calibration
Compass	
Range	±4.5 Gauss
Resolution	7 mGauss
Cross-axis	±0.2 %FS/Gauss
Wireless communication	
Frequency band	2.4 GHz
Data rate	250 kbps
TX power	Selectable, max. 22 dBm
RX sensitivity	11 dB high-gain, 1 dB low-gain
Range	> 50 m at max. TX power
Data collection	
Sampling rate	Scales with the number of nodes in the network 200 Hz for 6 nodes, 100 Hz for 12 nodes
Synchronization	< 6 µs
Wired interface	USB 2.0 full-speed compatible
Storage	128 Mbit Flash memory
Software and accessories	
Visualization software	ProMove GUI (runs on Windows 7/Vista/XP/2000, Ubuntu Linux)
Gateway	FastGateway, with USB interface
Electrical characteristics	
Power consumption in real-time streaming mode	275 mW - max. TX power, high-gain 260 mW - max. TX power, low-gain 210 mW - min. TX power, low-gain
Battery	3.7 V / 950 mAh rechargeable > 10 h operation at max. TX power
Form factor	
Dimensions	65x50x30 mm
Weight	70g (with enclosure)