SMC IMU

User Guide

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TABLE OF CONTENTS

1 INTRODUCTION

This user manual provides information about your IMU motion sensor and how to use it.

The SMC motion sensors are used in a wide range of applications.
Some examples are:

- Hydrographic surveying for heave compensation using multi beam sonars, single beam sonars and sub bottom profilers.
- System integration for different type of monitoring systems such as helideck monitoring and crane monitoring systems.
- Active heave compensation for cranes and winches.
- Dynamic positioning systems

Products Covered in this User Guide

Surface units

	Roll & Pitch (Dynamic)	Heave	Acceleration
IMU-007	0,25 RMS	N/A	0,01 m/s^2 RMS
IMU-008	0,25 RMS	5cm or 5%	0,01 m/s^2 RMS
IMU-106	N/A	5cm or 5%	N/A
IMU-107	0,03 RMS	N/A	0,01 m/s^2 RMS
IMU-108	0,03 RMS	5cm or 5%	0,01 m/s^2 RMS

Subsea units, 30 m depth rated

	Roll & Pitch (Dynamic)	Heave	Acceleration
IMU-008-30	0,25 RMS	5cm or 5%	0,01 m/s^2 RMS
IMU-108-30	0,03 RMS	5cm or 5%	0,01 m/s^2 RMS

Special units

	Roll & Pitch (Dynamic)	Heave	Acceleration
IMU-007-L	0,25 RMS	N/A	0,01 m/s^2 RMS
IMU-108R-L	0,03 RMS	5cm or 5%	0,01 m/s^2 RMS
IMU-108R-30	0,03 RMS	5cm or 5%	0,01 m/s^2 RMS

As an option Analog outputs are available and covered by this user guide

1.1 DEFINITIONS

Alignment
The alignment of the motion sensor is the positioning of the IMU onto the structure of the rig or vessel. The physical alignment should be done as accurately as possible and then it can be fine-tuned in the system software by entering offsets for roll, pitch and the Z-axis.

Yaw in the SMC units
Without an external aiding input the yaw in the SMC motion sensor will drift over time and so it cannot be used as an absolute heading output. Positive yaw is a clockwise rotation.
The yaw output from the SMC unit, when it is not aided from an external heading input, is basically the integration of the yaw gyro or the integrated rotation in the Z axis in the earth coordinate system.

Roll
Roll is the rotation about the roll axis (X) of the vessel. SMC defines the port up as a positive roll.

Pitch
Pitch is the rotation about the pitch axis (Y) of the vessel. SMC defines the bow down as a positive pitch.

Heave
Heave is the vertical dynamic motion of the vessel. The heave is calculated by a double integration of the vertical acceleration. The vertical position is filtered with a high pass filter.
Heave measures the relative position dynamically and cannot be used for a static height position measurement. An upwards motion is defined as a positive heave.

Surge and Sway
Surge and Sway are the horizontal dynamic motion of the vessel.
Surge is the linear motion along the roll axis; a positive surge is when the vessel is moving in the bow direction.
Sway is the linear motion along the pitch axis where a positive sway is in the port direction.
The surge and sway calculation is attained by a double integration of the horizontal acceleration. The horizontal position is filtered with a high pass filter.
The dynamic horizontal linear measurement is a relative position and cannot be used for a static horizontal position measurement.

Center of Gravity
Centre of gravity CG is the mass center of a vessel.

X-axis/Roll axis
The X axis is the bow/stern axis in the vessel. Rotation in the X axis will generate a roll motion where a positive rotation is port side up.

Y-axis/Pitch axis
The Y axis is the port/starboard axis in the vessel. Rotation in the Y axis will generate a pitch motion where a positive rotation is bow down.

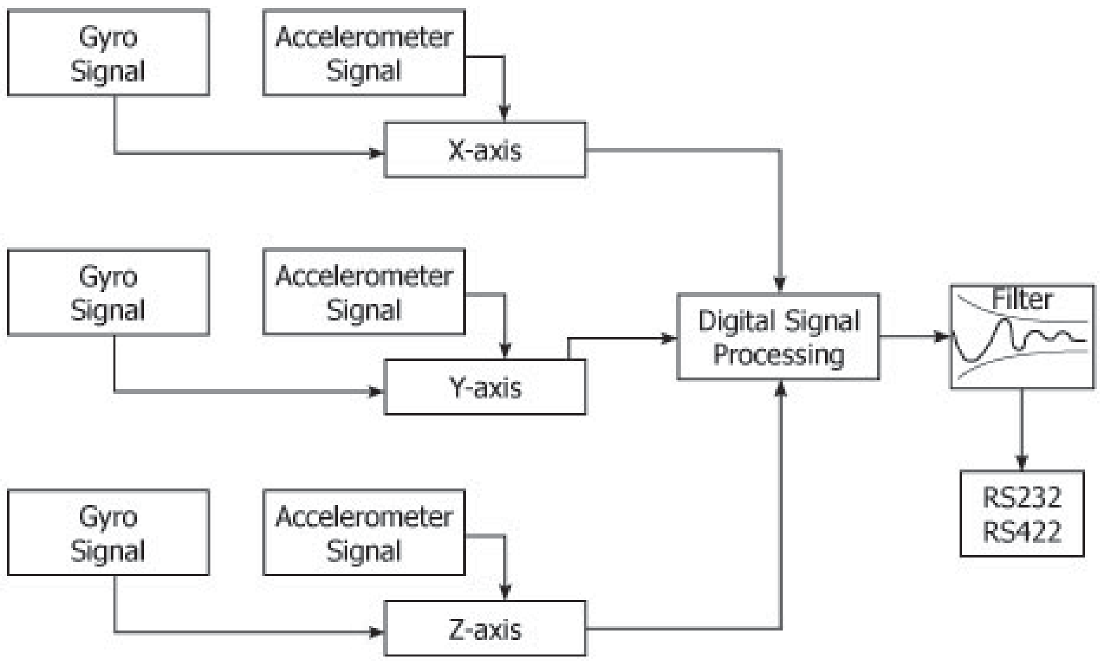
Z-axis
The Z axis is the vertical axis pointing up and down in the vessel. Rotation in the Z axis will generate a yaw motion, where positive yaw is a clockwise rotation.

RMS
Root mean square (RMS) is a statistical measure of the magnitude of a varying quantity.

2 SYSTEM DESCRIPTION

The SMC motion sensors have three separate axial measurement component groups converting signals from actual movements via three accelerometers and three gyroscopes into output data of angles and attitude.
The output parameters are presented in a digital output string via RS422 and RS232.

The signal from the gyroscopes are combined with the signal from the accelerometers and are processed in a Kalman filter inside the IMU to provide output value for acceleration, attitude and angle with limited influence from noise and other inaccuracies.

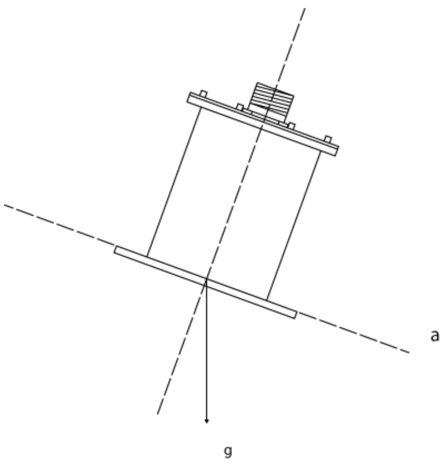


Heave, surge and sway are calculated by integrating the acceleration in the X, Y and Z axis twice. The integration is then filtered with a high pass filter.
The calculations of the distances are optimized for continuous motion and not for static distance measurements, as the high pass filter will filter the position over time to zero.
The dynamic motion filtering is designed to measure motions over a period between 1 s and 25 s.

Before delivery all motion sensors are calibrated and the readings from the accelerometers and angular rate gyroscopes are verified for alignment, linearity and temperature, to ensure they meet the performance specifications.
The calibration is run up to +/-30 degrees of angle. The best performance is achieved within this angle range.
If the motion sensor angle exceeds the calibrated angular range the calibration data will be extrapolated outside the calibrated range, which may lead to decreased performance.

2.1 SPATIAL MOVEMENT (COORDINATE SYSTEM)

The SMC motion sensor defines its body axis from the Tait-Bryan/Euler angles used to describe the orientation of a vessel.



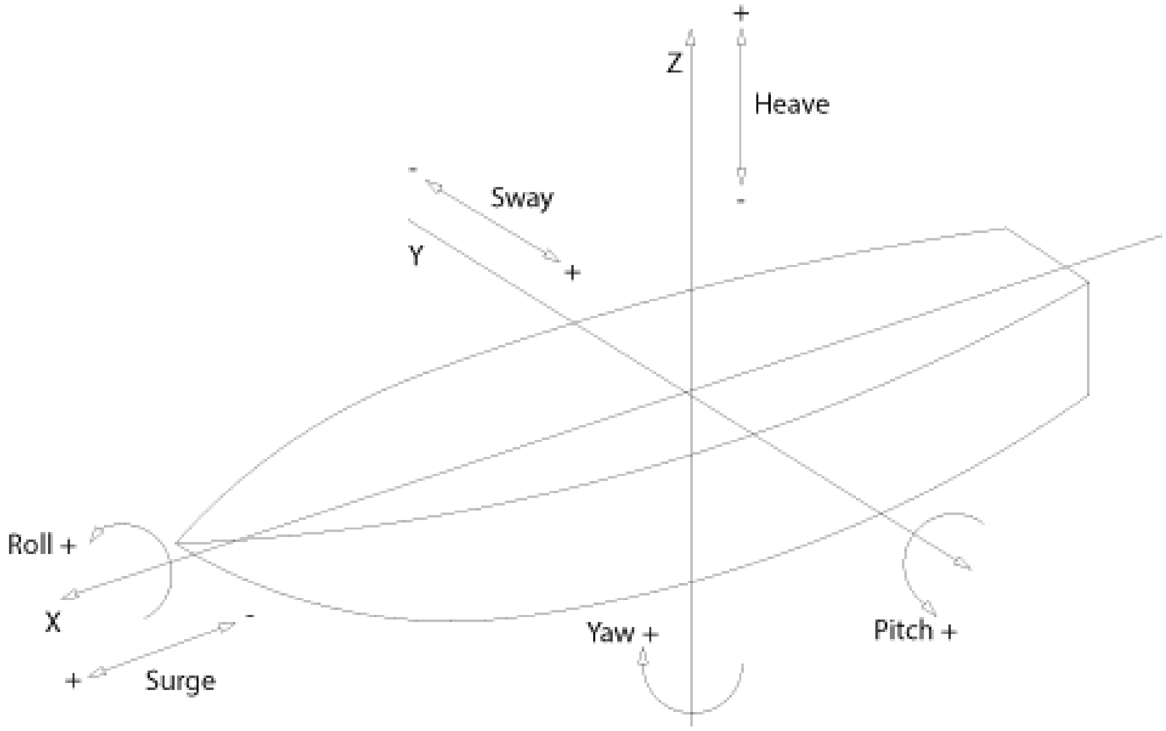
In the SMC motion sensors the coordinate system can be defined by a setting option in the SMC configuration software that is included with the motion sensor. The user can choose between the rigid body coordinate system and the absolute earth coordinate system.
The standard IMU setting is for Earth Coordinates without earth G in Acc.

The measurement of gravity (g) and the measured acceleration in different directions from the accelerometers is used to calculate the orientation of the accelerometers in relation to earth.

Motion sensor offset in roll, pitch and Z axes can be set for alignment errors in the physical installation. It is also possible to invert the axis to suit the receiving application.
The SMC IMU default rotational and acceleration directions are defined in the drawing below. By setting an offset the motion sensor rotates its coordinate system. For optimum performance align the motion sensor as accurately as possible before setting up offsets electronically.

Note that the Z-axis offset is used to compensate for a physical misalignment in the Z-axis mounting and is not used to set the yaw angle output in the motion sensor. An improper Z-axis rotation will rotate the coordinate system. Also a misalignment in the Z axis will induce roll motion readings in the pitch axis and the vice versa.

Pitch is the rotation around the transverse axis, the axis running form starboard to port of the vessel.
Roll is the rotation around the longitudinal axis, the axis running from the bow to the stern of the vessel.
Yaw is the rotation around the vertical axis.
See the figure below:


+
Z
Heave
-
-
Sway
Y
+
Roll +
X
-
+
Surge
Yaw +
Pitch +

3 STORAGE AND UNPACKING

Unpack the equipment and remove all the packaging materials and shipping carton.

The motion sensor is delivered in a transit case designed to protect it from high shocks during transit.

When the unit has been received it should be inspected for damage during shipment. If damage has occurred during transit, all the shipping cartons and packaging materials should be stored for further investigation. If damage is visible a claim for shipping damage should be filed immediately.

Because of the sensitive nature of the IMU the package must not be dropped.

Standard Delivered Items

- IMU
- Transit Case
- Junction Box   Fitted with
    - IMU to JB 10m 12 core cable
    - Serial Output Data lead 1.5m
    - AC Input Cable 0.9m
- Calibration Certificate
- CD with IMU Configuration Software and IMU User Manual

4 INSTALLATION

The SMC motion sensor must be installed according to the instructions in this manual.
The motion sensor is designed to be installed in an internal environment.

4.1 LOCATION

The optimal position for the sensor is as close as possible to the vessels center of gravity. However for certain applications, mainly when heave and accelerations are to be measured at a specific location, it is advised to mount the motion sensor as close as possible to the actual measurement point, for example in Helideck systems and some hydrographic survey systems.

Recommendations for location of the motion sensor to obtain optimal performance:

Roll & Pitch

When mounting the IMU, take care to align the sensor to the vessels roll and pitch axis. If there is an axis misalignment in the Z-rotation, roll motions will induce errors in pitch measurements and vice versa.
Small alignment errors can be adjusted mathematically inside the motion sensor. The alignment offsets can be set from the SMC setup software.

Heave/acceleration

If the motion sensor is equipped with Heave/acceleration measurement it is recommended that the motion sensor is placed as close to the point where Heave/acceleration is to be measured. For a helideck installation it is required to install the unit within 4 meters from the center of the helideck.

Temperature

The SMC motion sensors have been calibrated and designed to work within the stated temperature range as specified in the motion sensor technical specifications. SMC recommend that the motion sensor is mounted in a location without extreme variations in temperature.

Vibrations

Avoid mounting the motion sensor on any hull location that is subject to substantial vibrations. Also avoid mounting the sensors near to machines with sporadic operation e.g. hydraulic pumps.

Water

The SMC IMU-007, IMU-008, IMU-106, IMU-107 and IMU-108 as a standard is IP66 protection rated. The standard surface unit is designed to be mounted in indoors but it is possible to mount it outdoors, an enclosure of some sort is still recommended to prolong service life.
The SMC IMU-108-30 is IP68 water resistant to 30 meters depth or optional 1000 meters.

Mounting orientation

The IMU is calibrated from the factory for Deck or Sideways orientation.
Deck orientation is when the IMU is mounted on a horizontal surface. Deck mounting calibration is the default orientation.
Sideways orientation is when the IMU is calibrated to be mounted on a vertical surface.
A unit that has been calibrated for Deck mounting cannot be used in a sideways mounting and vice versa without recalibration of the IMU at the factory.

4.2 MOUNTING INSTRUCTIONS

The IMU base plate has been specifically designed to enable ease of installation and alignment by allowing freedom of movement around the mounting fixings.
The motion sensor is not shipped with mounting screws or bolts. The base plate can be used with a maximum M8 screw or bolt. Remove the motion sensor while the mounting location is prepared. See motion sensor Dimensions **Section 4.6**

After drilling any holes for mounting, be sure to de-burr the holes and clean the mounting location of any debris that could induce errors.

Mount and screw the motion sensor in position, taking care to align the IMU as best as possible.

A deck mounting motion sensor, has to be mounted with the connector pointing upwards. It is not designed to be mounted with the connector pointing downwards.

In the SMC Configuration software there is a function to fine tune the motion sensor alignment in the X, Y and Z axis electronically. This setting will rotate the coordinate system electronically inside the motion sensor. See **Section 5.1** on Motion Sensor Configuration Software for further instructions.

When mounting the motion sensor sideways there are 4 mounting options in the SMC setup software to rotate its coordinate system correctly. For more information see **Section 4.5** for sideways calibrated setup.

If an incorrect mounting selection is chosen the coordinate system will be inverted. In this case the roll motion will become the pitch motion or alternatively the positive negative rotation of the angles will be inverted.

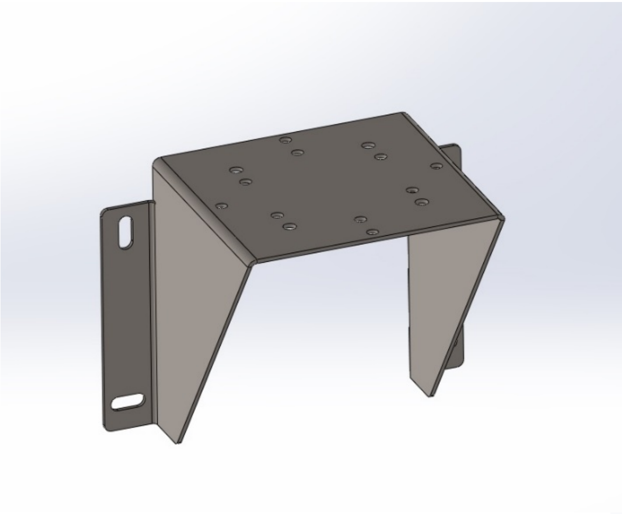
When the motion sensor is calibrated for sideways mounting (connector pointing horizontally) and is mounted upside down, with the single notch pointing in the wrong direction, the output signal from the motion sensor will display – 180 degrees wrong angle for roll output. If the IMU is mounted incorrectly it will not work within its calibrated range and will output inaccurate values.

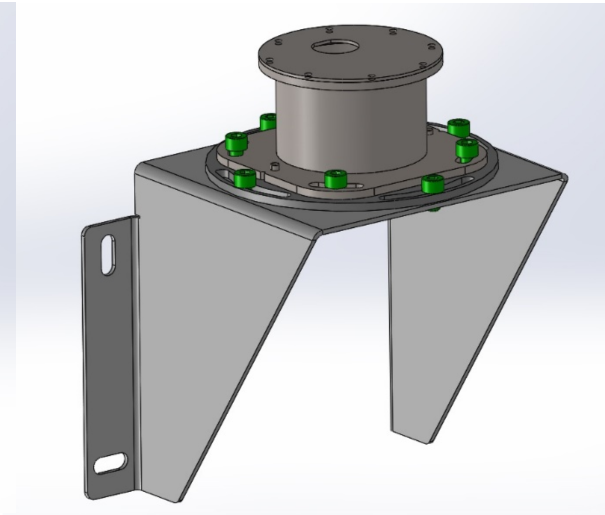
4.2.1 IMU MOUNTING BRACKET - OPTIONAL

An optional mounting bracket is available, designed to provide a secure mounting location, combined with easy motion sensor alignment.

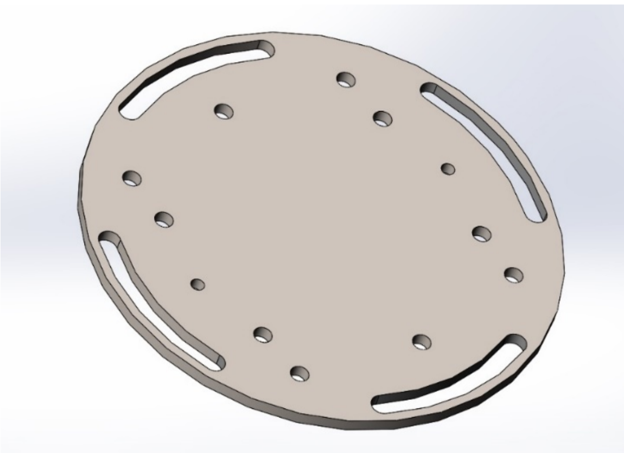
The bracket base plate has two pins that correspond to two of the notches in the IMU base. Alignment adjustments can then be made by rotating the bracket base plate.

The advantage is that the motion sensor can be removed for servicing or recalibration and replaced in exactly the same position.





The base plate, included with the bracket, allows 45 degrees of rotational adjustment.



See 4.6.5 for details of the mounting bracket dimensions.

4.3 ALIGNMENT

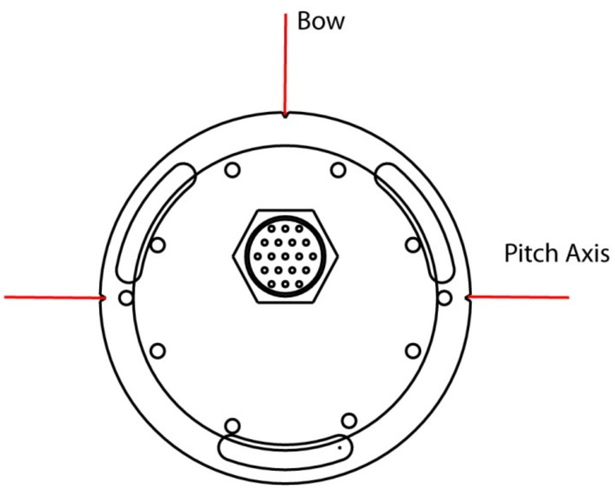
To achieve maximum performance it is important to perform an accurate alignment of the motion sensor along the vessel longitudinal axis.
The physical alignment should be as accurate as possible using the notches on the motion sensor mounting plate for reference.
For the deck mounting option the single notch is to be pointing to the fore direction of the vessel. A misalignment in the Z-rotation (yaw) will generate a cross axis motion, where pitch will generate in a roll reading from the motion sensor and vice versa.
From the SMC configuration software it is possible to fine tune the alignment of the motion sensor.

Note the Z-axis alignment is only to be used to correct the physical misalignment and not to change the yaw output reading from the motion sensor.

4.4 DECK MOUNTED (MOUNTED ON HORIZONTAL SURFACE)

When the IMU is calibrated for Deck mounting the unit cannot be used for sideways mounting without a recalibration at the factory.

Mounting of the motion sensor should be carried out with the mounting plate lying horizontally. The notches on the plate mark the orientation points of the motion sensor.
The indexes (see below) marking the Pitch axis should be aligned to port/starboard, along the vessels center of rotation or on the axis you have defined.
The single notch is to be mounted pointing to the bow of the vessel.



4.5 SIDEWAYS MOUNTING

When the IMU is calibrated for Sideways mounting the unit cannot be used for Deck mounting without a recalibration at the factory.

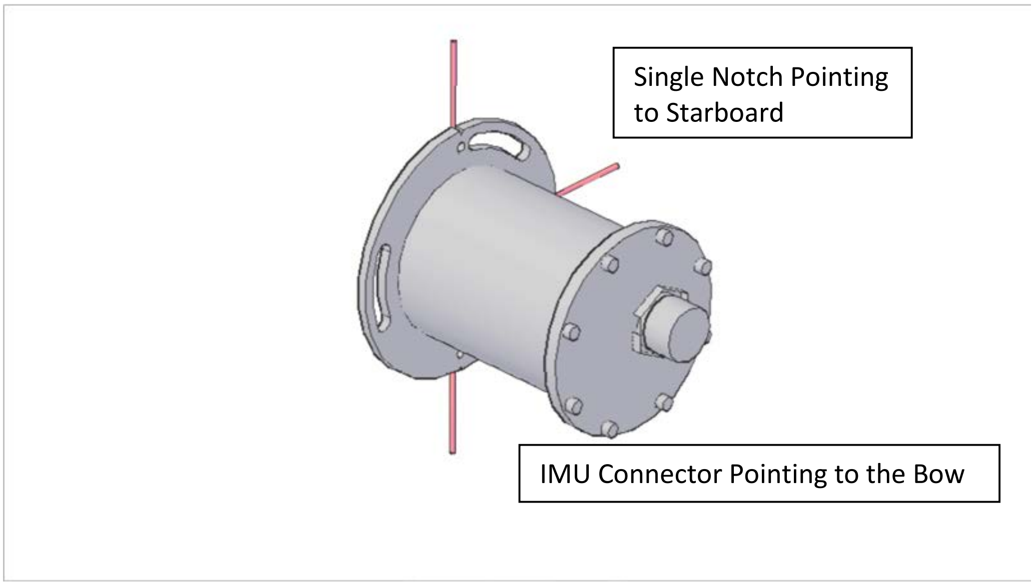
The mounting of the motion sensor should be carried out with the mounting plate lying vertically. The notches on the plate mark the orientation points of the motion sensor.
The indexes marking the P-axis should be mounted pointing to vertical. The single notch should be mounted pointing horizontally to the bow/stern/port/starboard of the vessel.
Depending on the mounting orientation the unit will need its coordinate system to be setup for in the SMC configuration software.

Note: The IMU cannot be mounted in the sideways orientation unless it has been specifically calibrated to do so. Contact SMC if clarification is required.

4.5.1 TOP OF THE IMU POINTING TO THE BOW

When the IMU top (where the connector is located) is pointing to the Bow of the vessel the single notch should be pointing horizontally to Starboard.

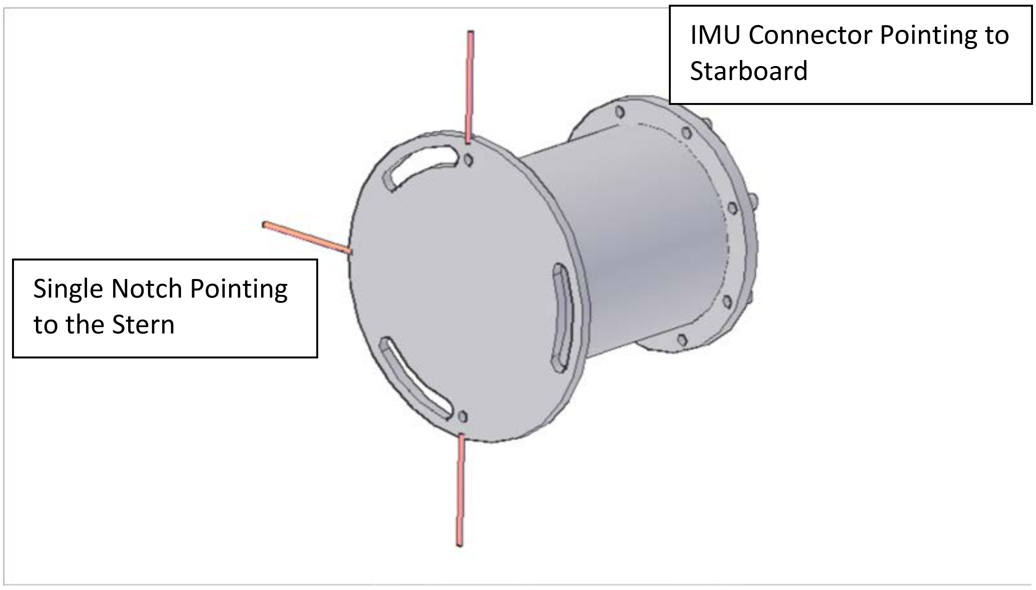
In the SMC setup software **IMU top to the Bow** must be selected.



4.5.2 TOP OF THE IMU POINTING TO THE STARBOARD

When the IMU top (where the connector is located) is pointing to the **Starboard** of the vessel the single notch should be pointing horizontally to the **Stern**.

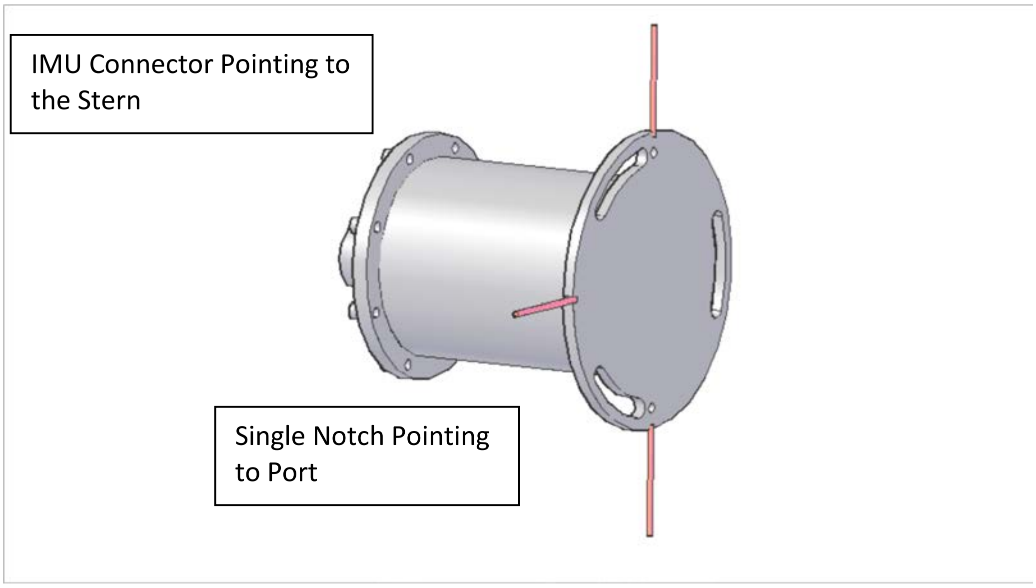
In the SMC setup software **IMU top to the Starboard** must be selected.



4.5.3 TOP OF THE IMU POINTING AT THE STERN

When the IMU top (where the connector is located) is pointing to the **Stern** of the vessel the single notch should be pointing horizontally to **Port**.

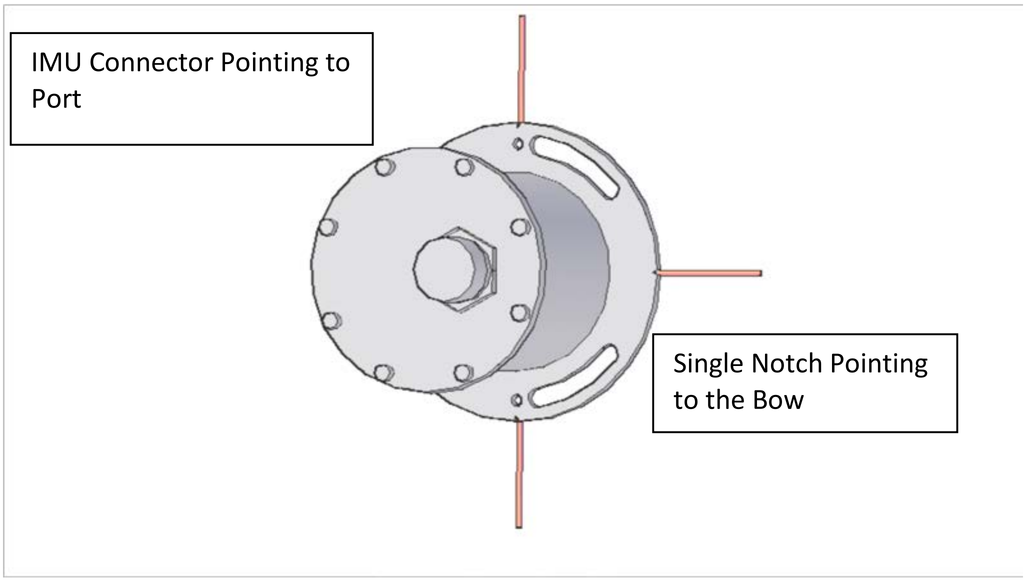
In the SMC setup software **IMU top to the Stern** must be selected.



4.5.4 TOP OF THE IMU POINTING TO THE PORT

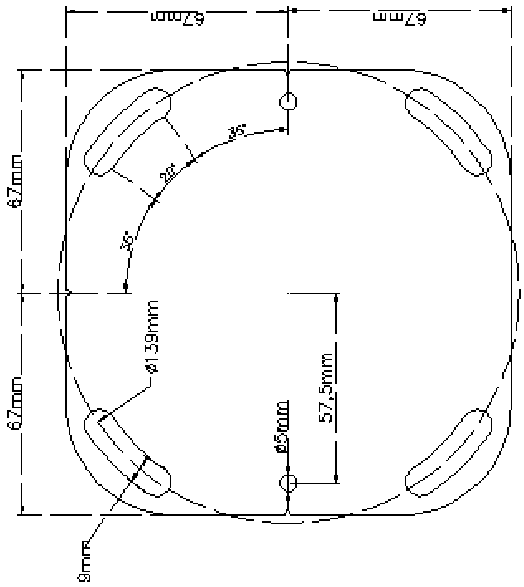
When the IMU top (where the connector is located) is pointing to the **Port** of the vessel the single notch should be pointing horizontally to the **Bow**.

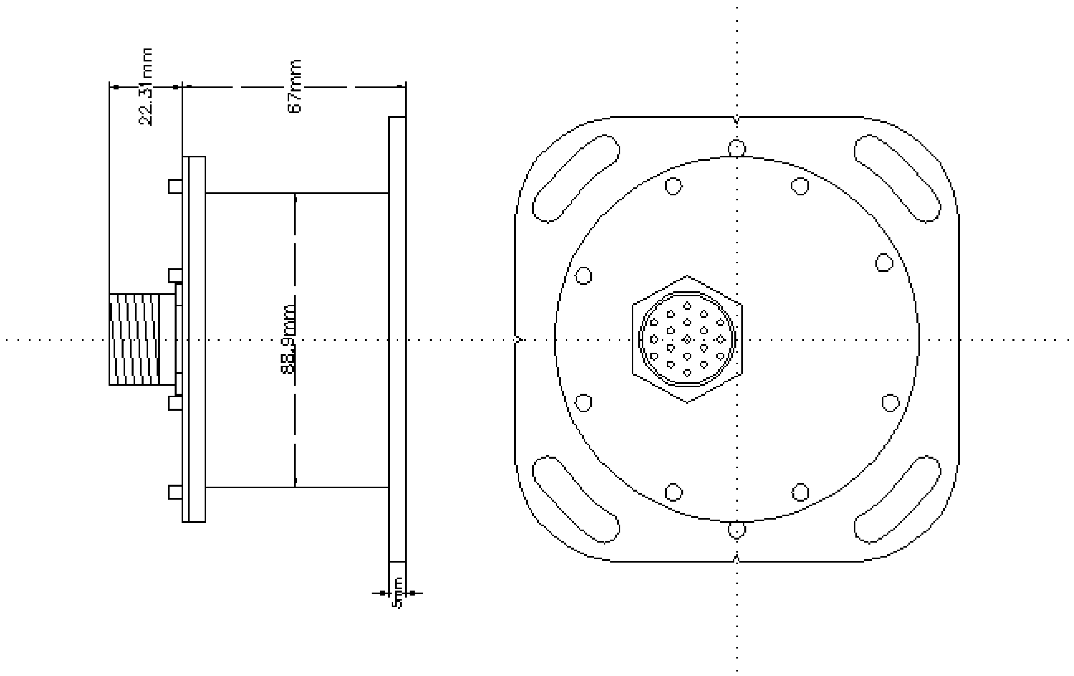
In the SMC setup software **IMU top to the Port** must be selected.



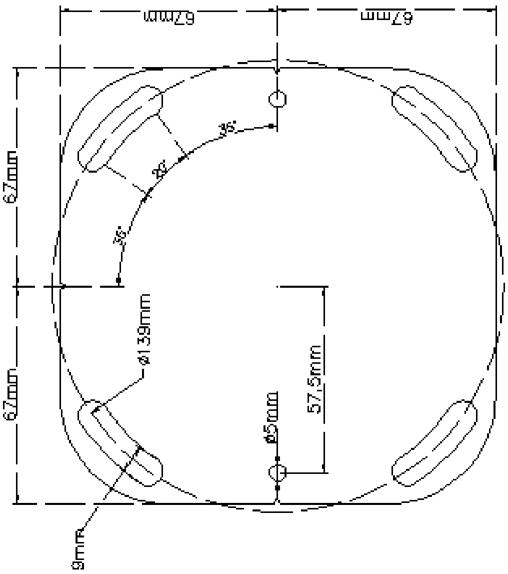
4.6 IMU DIMENSIONS

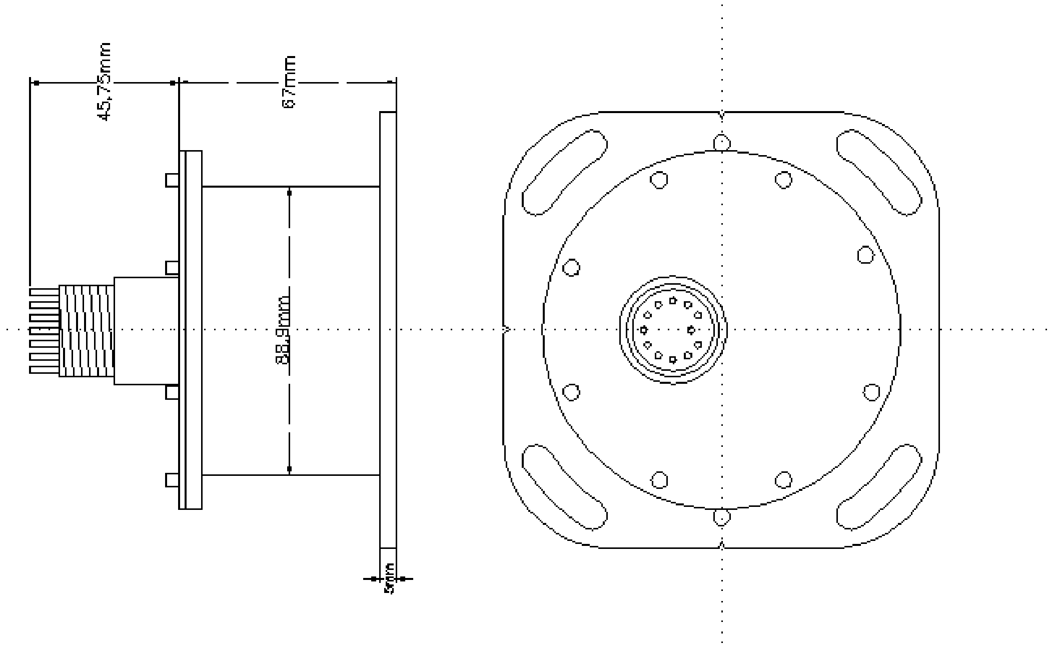
4.6.1 IMU-00X SURFACE UNIT



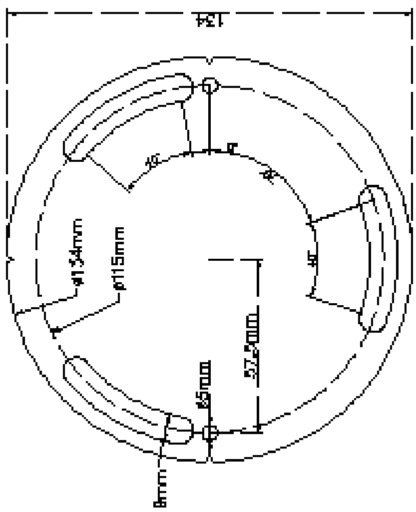


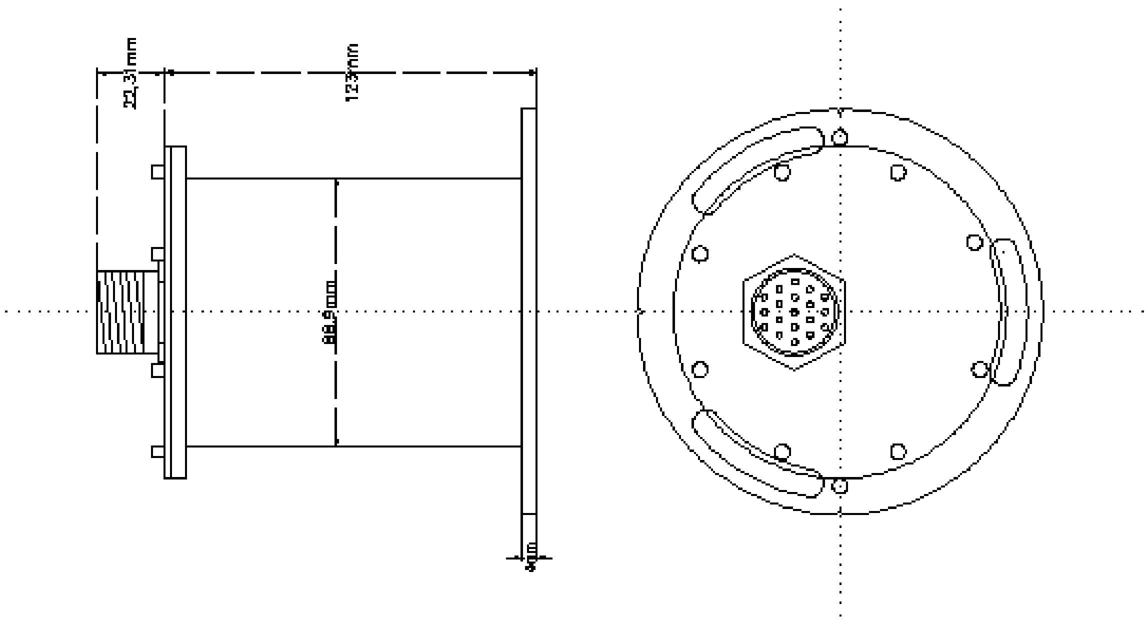
4.6.2 IMU-00X 30M DEPTH RATED UNIT



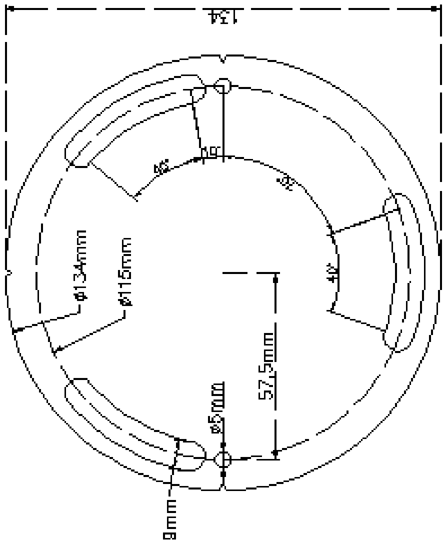


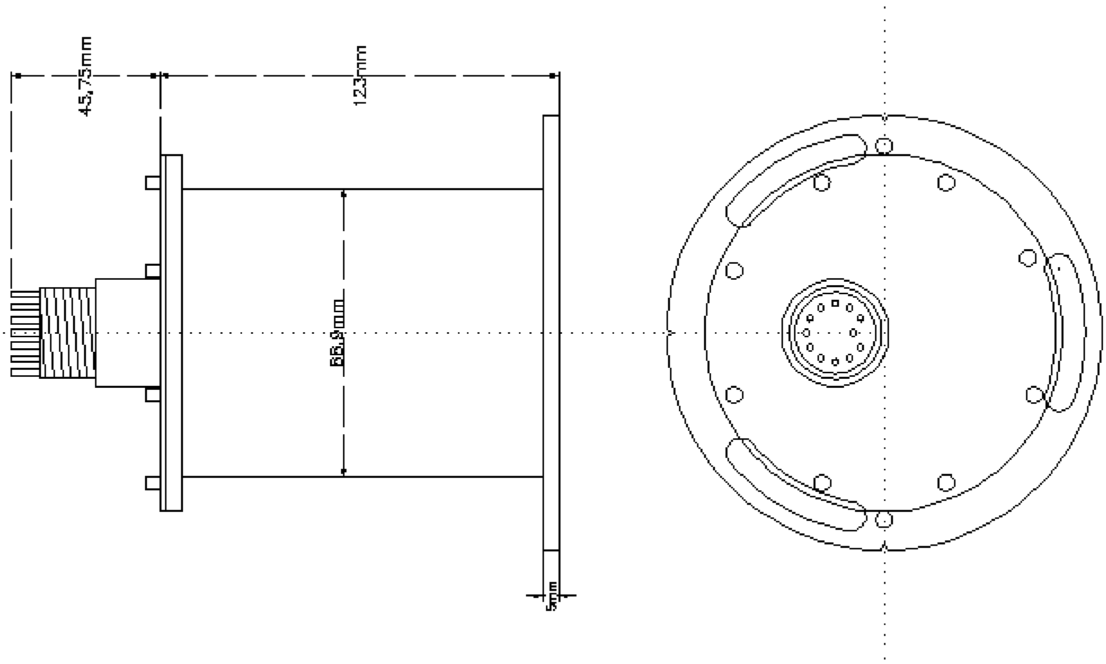
4.6.3 IMU-10X SURFACE UNIT



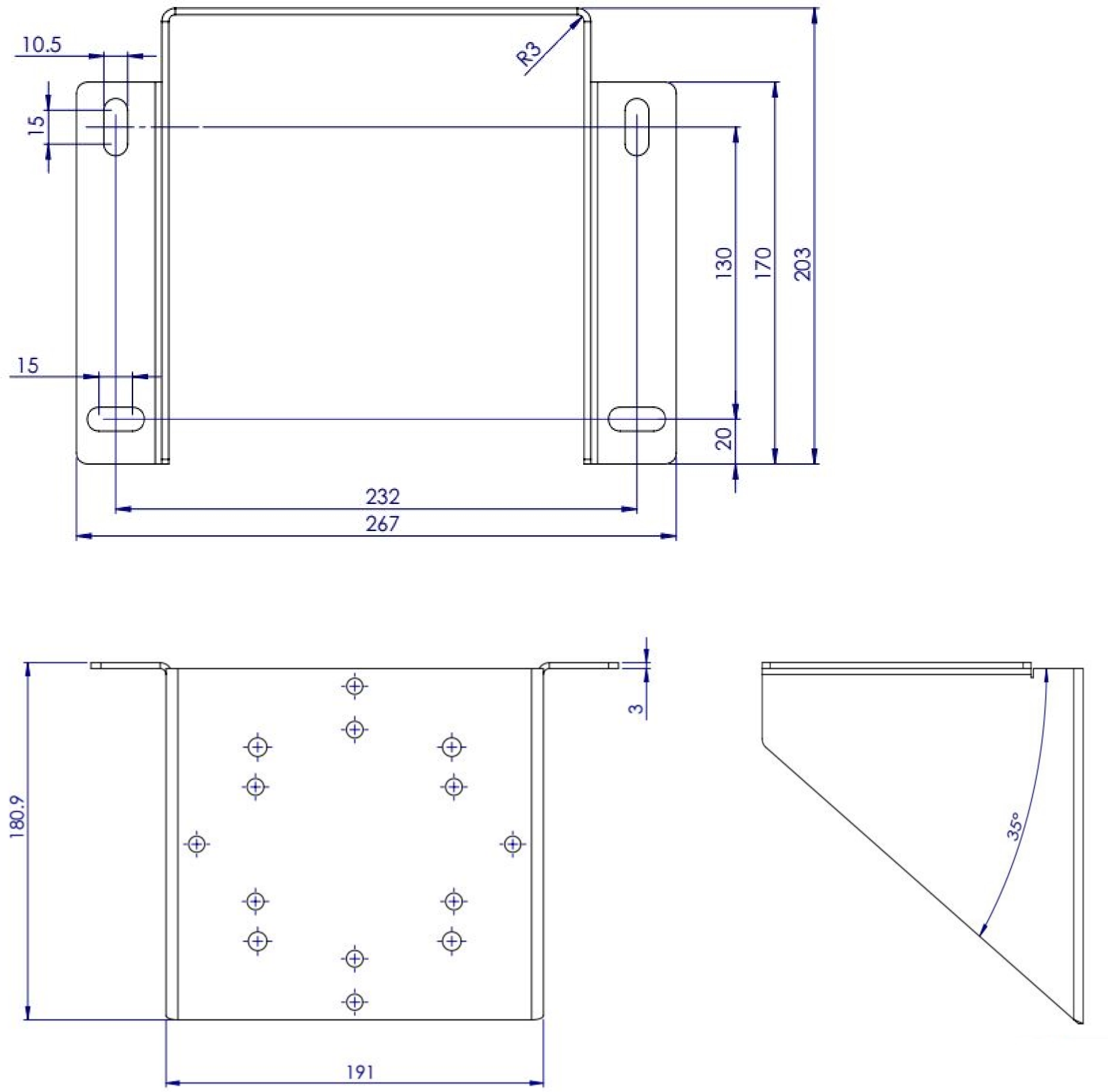


4.6.4 IMU-10X 30M DEPTH RATED UNIT





4.6.5 IMU OPTIONAL MOUNTING BRACKET



4.7 ELECTRICAL COMMUNICATION

The SMC IMU can operate from a 12-30 VDC power supply. The power consumption during normal conditions is between 2 and 2.5 watts.

The SMC IMUs have both RS422 and RS232 serial outputs as standard. The Junction Box shipped with the unit is preconfigured in the factory for RS232 or RS422. This can be changed in the field by changing the wiring of the serial cable inside the junction box. See the wiring diagram for wiring details.

RS422 communication can achieve data transfer over long distance cables.
RS232 is designed for short distance communication, (max 20 meters).
The RS422/RS232 cable normally terminates with a conventional DB9 connector.

Two RS232 serial ports are also available for aiding the motion sensor by GPS or Compass.

WARNING

! Permanent damage to the motion sensor may occur if power is applied to the digital connections. It is important to check the power connections by measuring the voltage at the connector prior to the motion sensor being connected. Damage resulting from incorrect connection is not covered by the warranty.

4.7.1 SERIAL RS232 AND RS422 INTERFACE CONNECTION GUIDE

The IMUs are equipped with both an RS422 and RS232 interface. The tables below show the configuration information for the IMU power and communication pairs.
The motion sensor is at all times communicating over both RS232 and RS422 and no configuration is needed inside the motion sensor.

The IMU can supply data output on both the RS232 and RS422 interfaces at the same time. However, only one data string output format (protocol) can be used for both outputs.

As a default there is one cable interface into the junction box. Below are tables for RS232 and RS422 connections. The DB9 connector should have the configuration in the tables below.

4.7.2 IMU SURFACE UNITS OUTPUT CONNECTION CABLING

RS232 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
1	White	RS232 – RxD	3
2	Red	RS232 – TxD	2
11	Grey	Supply Voltage -	5
12	Pink	Supply Voltage 12 – 30 Vdc	

RS422 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
3	Brown	RS422 – TxD+	3
4	Orange	RS422 – TxD-	4
5	Green	RS422 – RxD-	1
6	Purple	RS422 – RxD+	2
11	Grey	Supply Voltage -	5
12	Pink	Supply Voltage 12 – 30 Vdc	

4.7.3 IMU SURFACE UNITS INPUT CONNECTIONS

RS232 Serial Input 1 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
7	Yellow	RS232 – RxD	3
8	Transparent	RS232 – TxD	2
11	Grey	Supply Voltage -	5
12	Pink	Supply Voltage 12 – 30 Vdc	

RS232 Serial Input 2 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
9	Black	RS232 – RxD	3
10	Blue	RS232 – TxD	2
11	Grey	Supply Voltage -	5
12	Pink	Supply Voltage 12 – 30 Vdc	

4.7.4 IMU 30 DEPTH RATED UNIT

RS232 Output Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
1	Black	RS232 – RxD	3
2	White	RS232 – TxD	2
11	Blue/Black	Supply Voltage -	5
12	Black/White	Supply Voltage 12 – 30 Vdc	

RS422 Output Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
3	Red	RS422 – TxD+	3
4	Green	RS422 – TxD-	4
5	Orange	RS422 – RxD-	1
6	Blue	RS422 – RxD+	2
11	Blue/Black	Supply Voltage -	5
12	Black/White	Supply Voltage 12 – 30 Vdc	

RS232 Serial Input 1 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
7	White/Black	RS232 – RxD	3
8	Red/Black	RS232 – TxD	2
11	Blue/Black	Supply Voltage -	5
12	Black/White	Supply Voltage 12 – 30 Vdc	

RS232 Serial Input 2 Connections DB9 Connections

Sensor Connector	Cable Colour	Sensor Function	DB9 to PC/Converter
9	Green/Black	RS232 – RxD	3
10	Orange/Black	RS232 – TxD	2
11	Blue/Black	Supply Voltage -	5
12	Orange/Black	Supply Voltage 12 – 30 Vdc	

4.7.5 RS422 CABLE CONNECTION

The RS422 cable consists of two twisted-pair conductors (4 wires) for bi-directional communication.

The thickness of power cables is such that there is no more than a 2V drop with a 50 mA current applied over an exceptional length of cable. Cable and conductors are supplied on demand for an additional cost.
The maximum cable length allowed is approximately 1 300 m using RS422.

4.7.6 RS232 CABLE CONNECTION

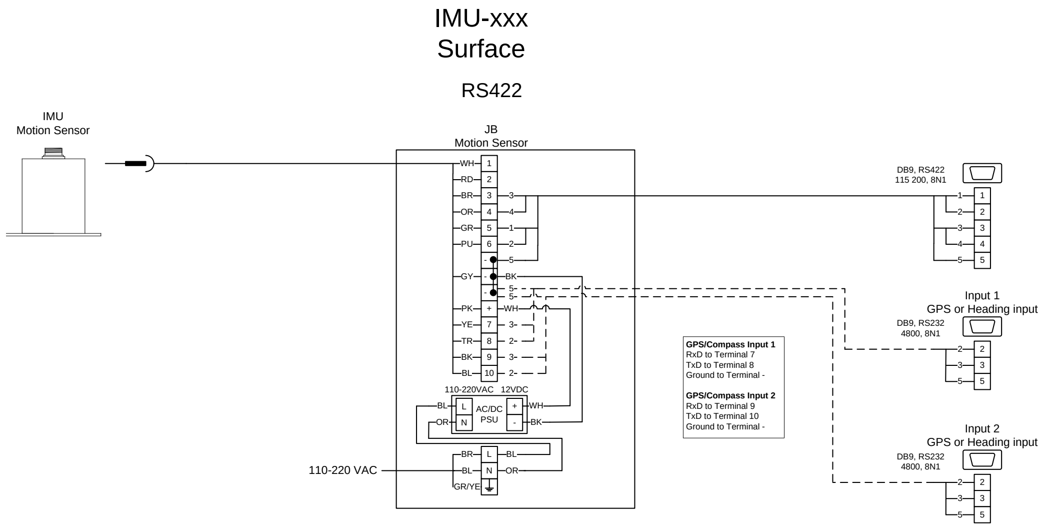
The RS232 cable consists of single twisted-pair conductors (2 wires) for bi-directional communication, plus 2 power supply wires, total of 4 conductors.
The maximum cable length allowed is approximately 20 m using RS232.

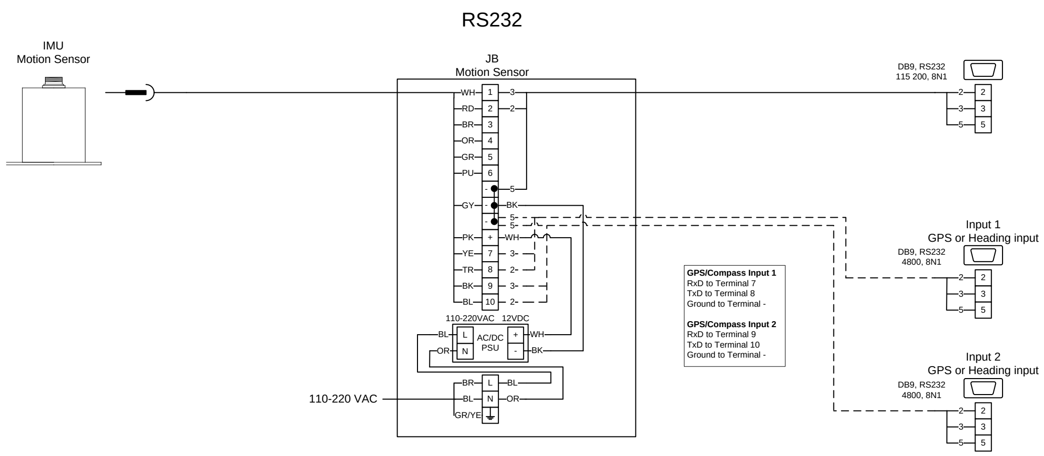
4.8 ELECTRICAL INSTALLATION

The SMC IMUs are powered with a standard 12 VDC or 24 VDC supply. It is possible however to supply power at any voltage between 9 VDC and 30 VDC.

The SMC IMUs do not have an on/off switch. The motion sensor operates as soon as power is supplied to it. There is an initialization of the IMU that prevents it from outputting numerical data for the first 1 minute after the motion sensor has been powered up.

4.8.1 IMU-XXX SURFACE UNIT WITH SERIAL INPUTS

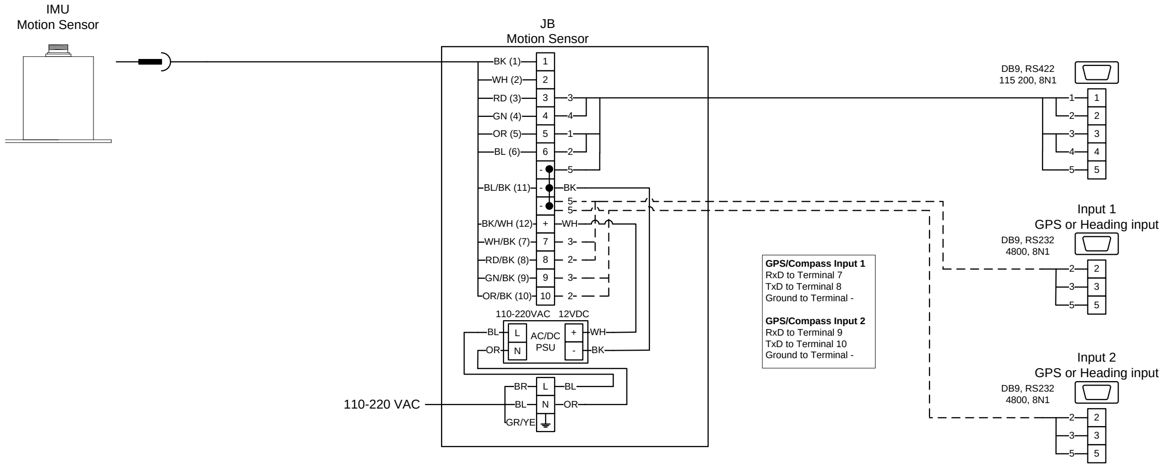




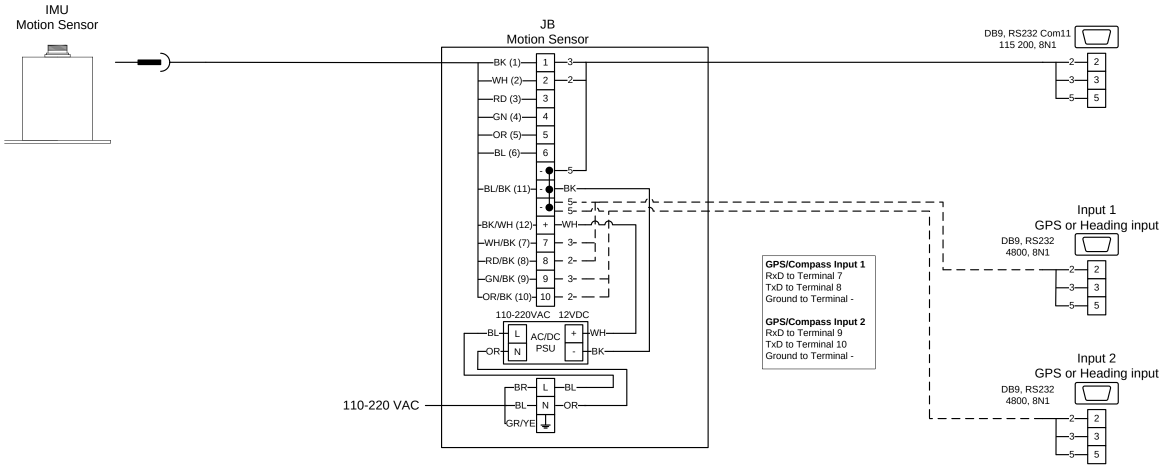
4.8.2 IMU-XXX-30 DEPTH RATED UNIT

IMU-xxx-30

RS422

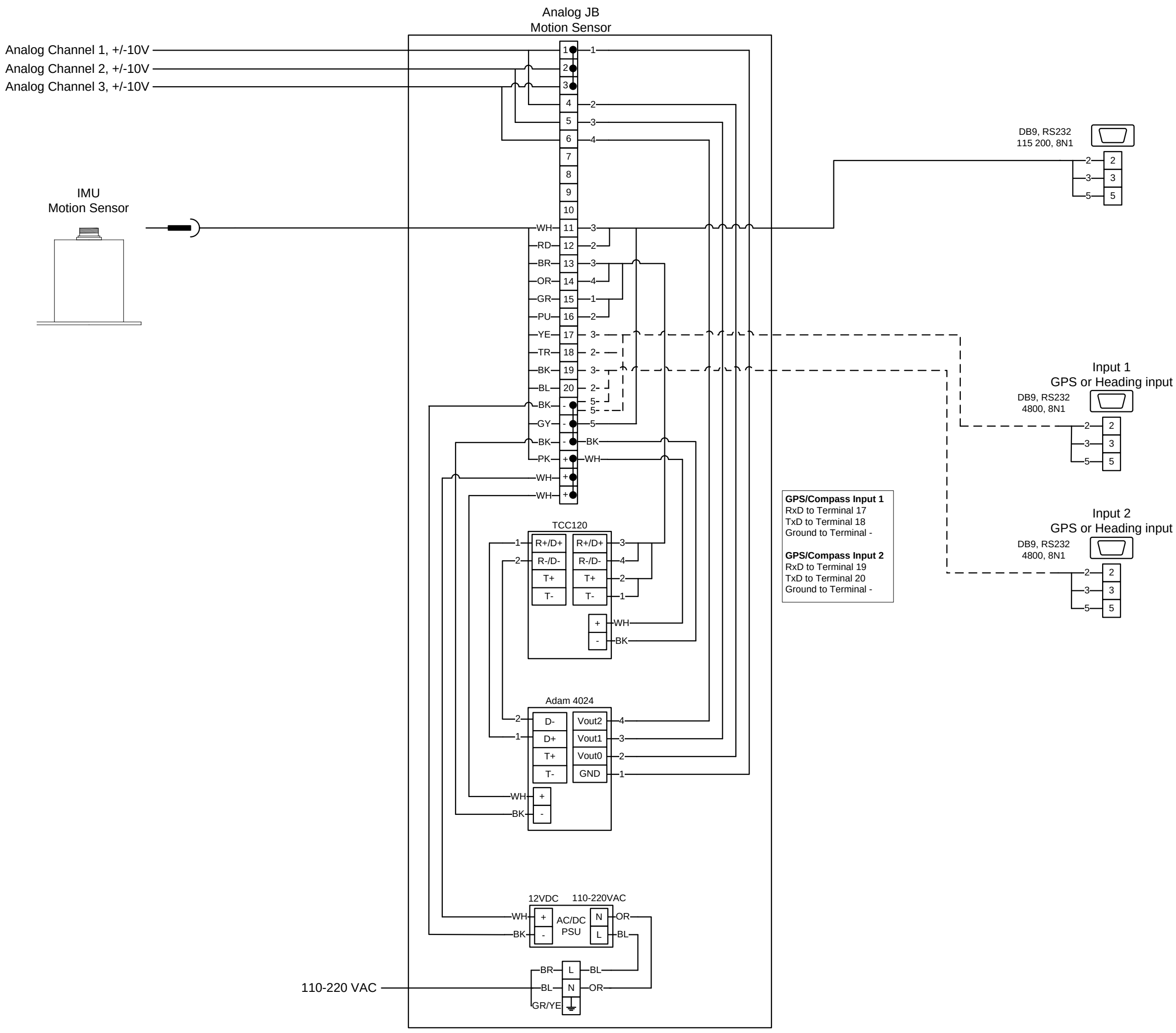


RS232



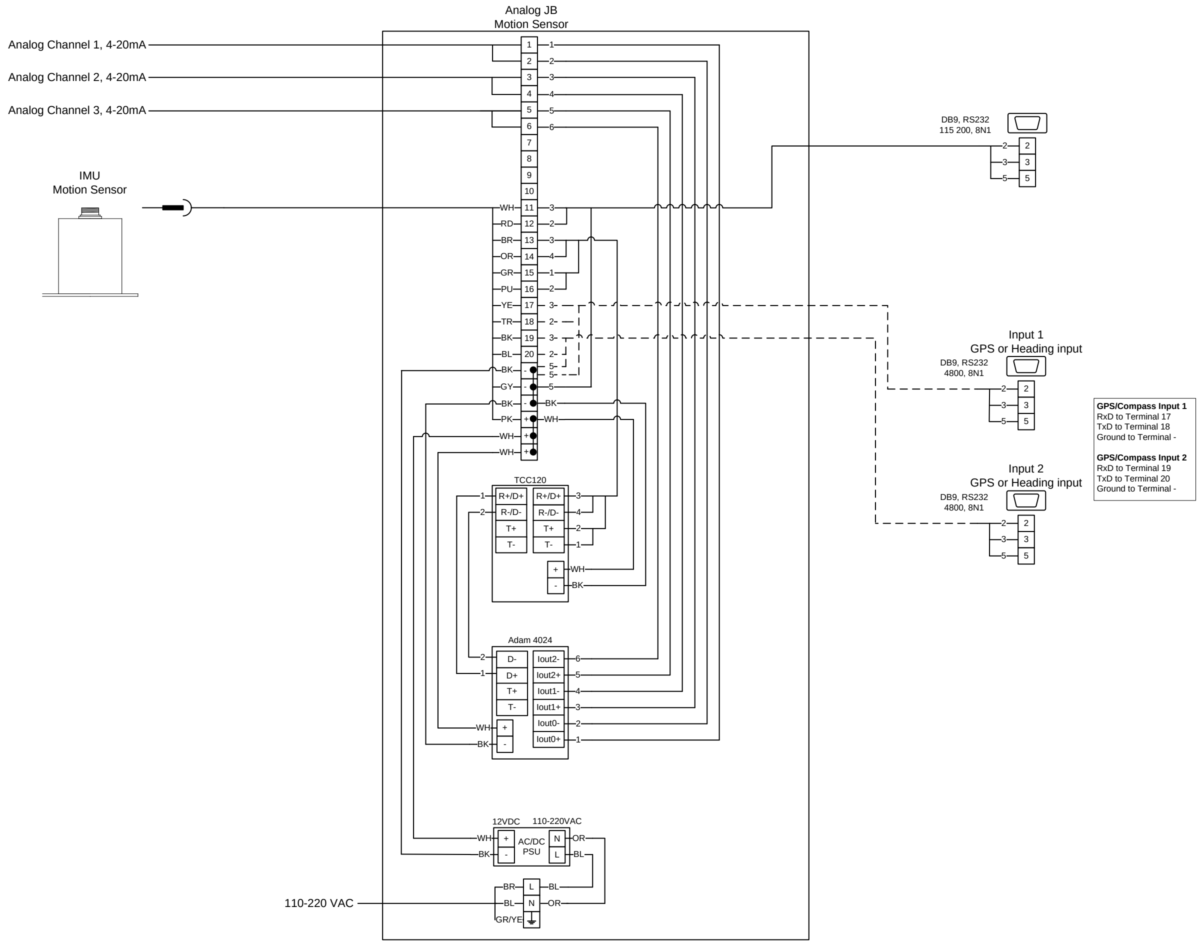
4.8.3 IMU-XXX ANALOG VOLTAGE OUTPUTS

IMU-xxx analog output

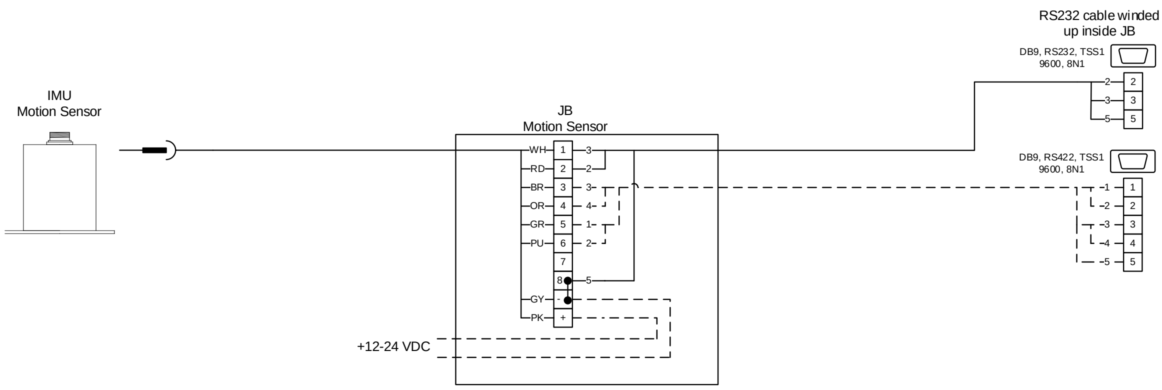


4.8.4 IMU-XXX ANALOG CURRENT 4-20MA OUTPUTS

IMU-xxx analog output



4.8.5 IMU-XXX JUNCTION BOX WITHOUT POWER SUPPLY AND SERIAL INPUT

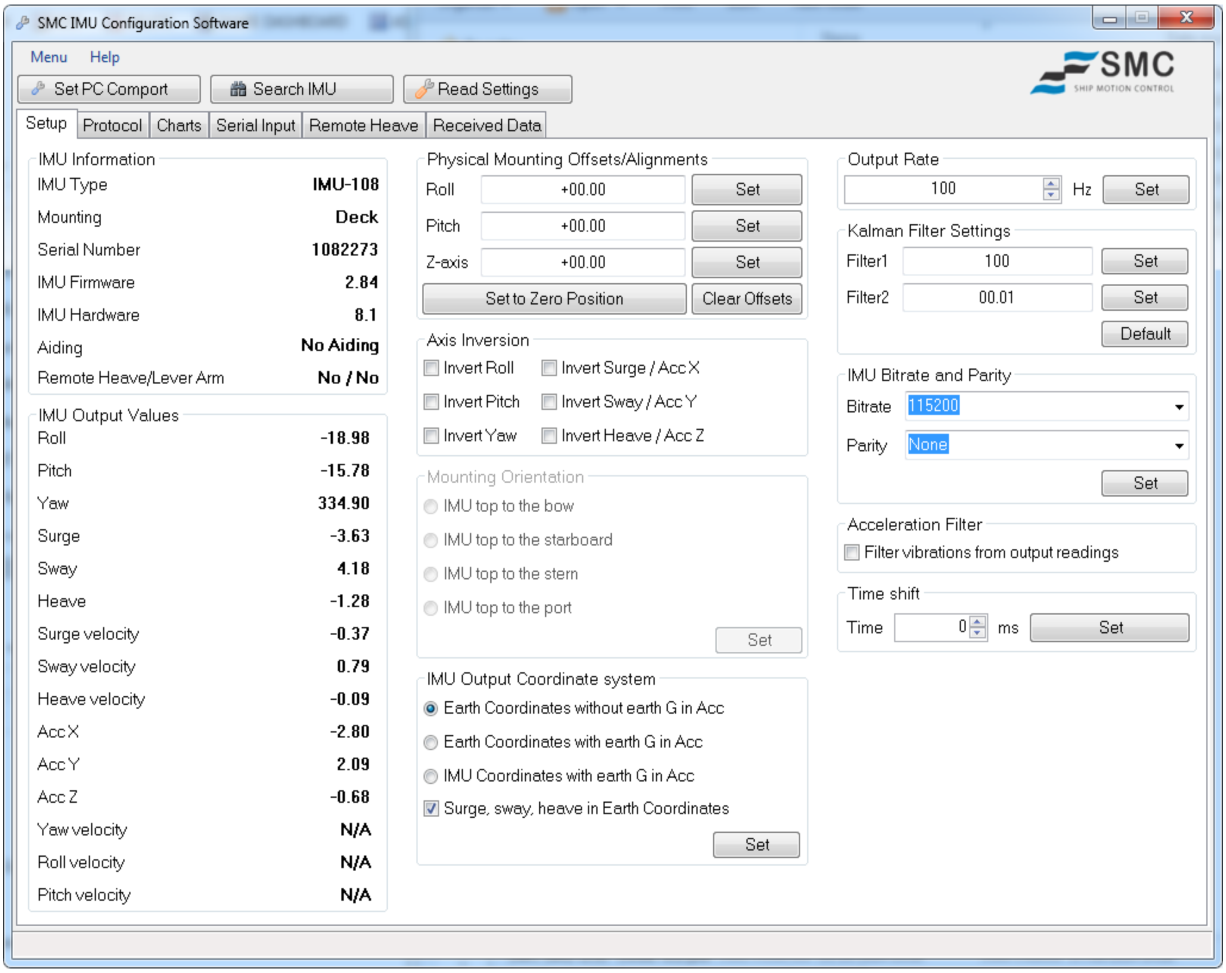


5 IMU CONFIGURATION GUIDE

5.1 IMU CONFIGURATION SOFTWARE V3.3.7.60

After the motion sensor has been mounted correctly the SMC IMU Configuration software can be used to set up the Motion sensor configuration and communication parameters according to the user requirements.

The settings made in the IMU Configuration software are written to the motion sensor. The settings are stored in flash memory inside the motion sensor and are not dependent on power supply or battery power.



5.1.1 DEFAULT SETTINGS AT FACTORY

There are several Motion Sensor parameters that can be selected, if you want to change the default settings it is recommended to do it after the installation but before you connect to any systems. Please refer to 5.1.2 (setup).
The factory default settings are as follows.

Settings	Selection	Factory Default
Output Rate	1 – 100Hz	100
Kalman Filter Settings	Filter 1 (0 – 1000) Filter 2 (0 – 1000)	IMU-00x Filter 1 (25) Filter 2 (0.01) IMU-10x Filter 1 (100) Filter 2 (0.01)
IMU Bit Rate and Parity	4800 9600 19200 38400 57600 115200	115200
Parity	None Even Odd	None
IMU Output Coordinate System	Earth Coordinates without earth G in Acc Earth Coordinates with earth G in Acc IMU Coordinates with earth G in Acc	Earth Coordinates without earth G in Acc

5.1.2 SETTINGS

Set PC Comport
Changes the COM port communication settings used by the configuration software to connect to the motion sensor. The IMU sensor will always send its data in 8 data bits, 1 stop bit and no parity but the bitrate may have to be changed to match the IMU settings.

IMU Information
Shows information about motion sensor IMU type, mounting orientation, serial number, IMU firmware, IMU Hardware, Aiding and Remote Heave/Lever Arm.

IMU Output Values
Shows data sent from the motion sensor in real time. Only values that are being output from the IMU are displayed in this section.

Physical Mounting Offsets/Alignments
By pressing the **Set to Zero Position** button the current IMU inclination will be set to be the zero point, i.e. reference point for the angle measurements.
The **Clear Offsets** button will enter 0 offset for the roll, pitch and yaw values.
The offsets can be manually entered into the motion sensor instead of using the IMU Set to Zero Position.
The offset entered into the IMU rotates its coordinate system. To achieve accurate angles outputs from the motion sensor the axis alignment is very crucial. Try to mount the motion sensor as well as possible physically before adjusting the offsets electronically.

Axis Inversion
Enables the sign inversion of the output signals from the motion sensor. See **Section 2** for information about SMC rotational definitions.

Mounting Orientation
Is only available if the IMU has been calibrated for sideways mounting orientation. See **Section 4** for more information about the mounting orientation options.

IMU Output Coordinate System
The IMU can be set to output its data in the earth coordinate system or in the IMU coordinate system.

Earth Coordinates without earth G in Acc; in this configuration the IMU will use the earth (horizon) as the system by which Roll & Pitch & Heave are based around. The acceleration will not include G as part of the value.

Earth Coordinates with earth G in Acc; in this configuration the IMU will use the earth (horizon) as the system by which Roll, Pitch & Heave are based around. The acceleration will include the G value of 9.81m/s².

IMU Coordinates with earth G in Acc; in this configuration the IMU will use its form or the equipment it is mounted to as a basis around which Roll, Pitch & Heave are calculated around. The acceleration will include the G value of 9.81m/s².

Surge, Sway and Heave can be set to be output in the earth coordinate system regardless of the IMU coordinate setting has been selected for the angles.

Output Rate
Adjusts the number of times the IMU outputs its string per second. Choose the required value in the list box and press the **Set** button to set the frequency.

Kalman Filter Settings
Filter 1 sets the filter for the accelerometers (default 100)
Filter 2 sets the filter for the gyros (default 0.01)

The value entered in the angle filter setting specifies how much each sensor type (accelerometer and gyro) is "applied". The lower value the more we apply the sensor type.

This means that the higher value that is set on the accelerometer the less influence the acceleration will have. But it will also generate a bigger random walk from the gyros.

It is not advisable to change the settings for the Kalman Filter without consulting with SMC
The default button will reset the filter settings to the factory defaults.

IMU Bitrate and Parity
Adjusts the bit rate that the sensor uses for transmitting data. To be able to connect to the IMU a matching communication setting must be set for the receiving device

Available Bit rates: 4800, 9600, 19200, 38400, 57600, 115200

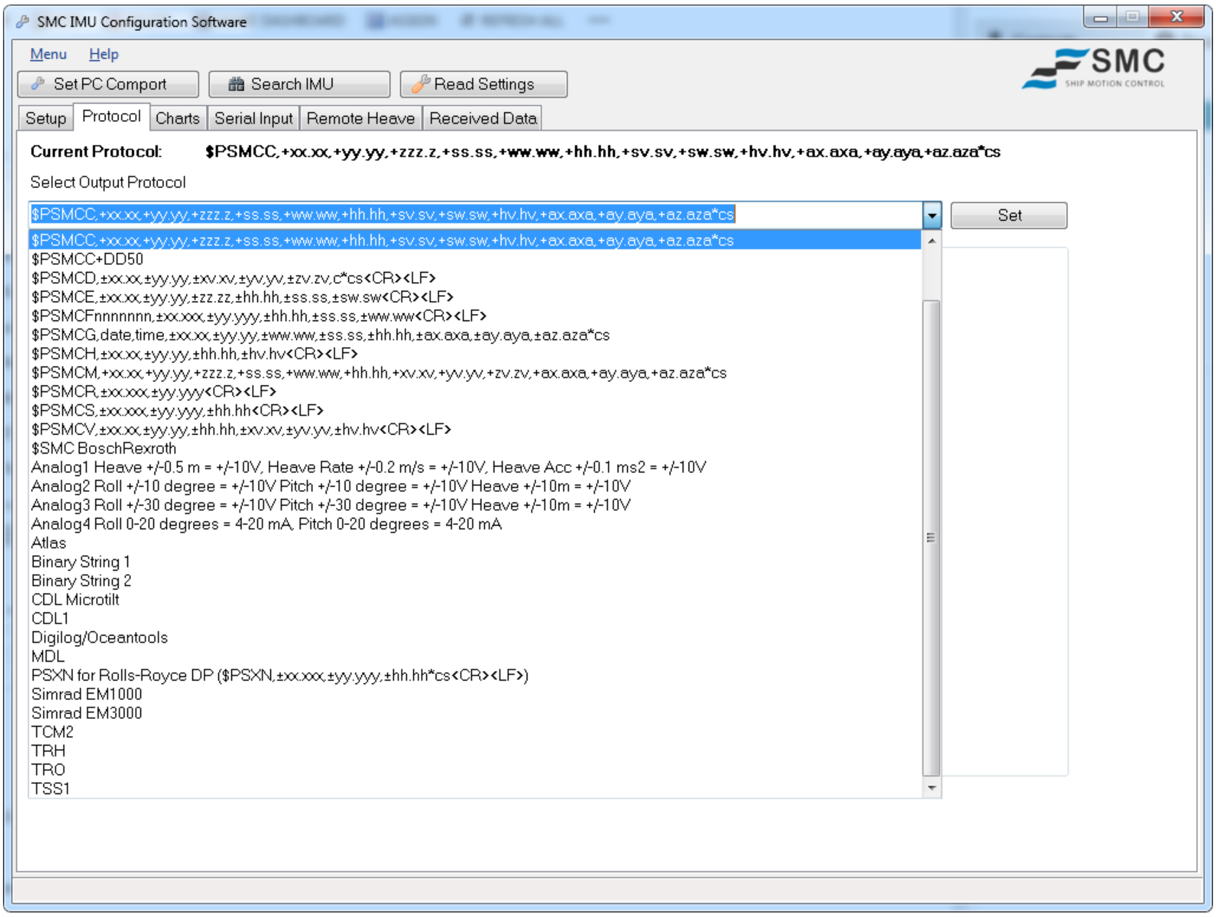
Note: For Long protocols such as SMCT / SMCA & SMCF using a high data output frequency like 100Hz, a high Bitrate like 115200 will be needed, to be able to transfer the data from the motion sensor.
See notes beside each protocol.

Read Settings
Clicking on the **Read Settings** button will prompt the setup software to check the current IMU settings and display them in the setup software.

5.2 PROTOCOLS

The SMC IMU Configuration software enables the selection of a number of standard protocols from a drop down menu. Apply the chosen protocol by clicking on the **Set** button.

Additional protocols can be setup by SMC on request.



5.2.1 SMC STANDARD PROTOCOLS

SMC Standard - This is a NMEA 0183 based compatible string.

5.2.2 SMCA

Data Frame
$PSMCA,±xx.xxx,±yy.yyy,±hh.hh,±ss.ss,±ww.ww<CR><LF>

Example
$PSMCA,+00.089,-00.888,-00.04,+00.20,-00.10

Note: For the SMCA protocol to run at a Data Output Rate Frequency of 100Hz, the sensor bitrate must be set at a minimum of 38400.
To run the sensor at a Bit Rate of 19200 the data **Output Rate** frequency needs to be below 53Hz. Failure to do this may result in problems with the output data.

Note: During startup roll, pitch and heave is output as -123456.

Description	Form
Start Characters	$PSMCA
Roll Angle (xx.xxx)	±100 degrees Resolution 0.001° (+ve=port up)
Pitch Angle (yy.yyy)	±100 degrees Resolution 0.001° (+ve=bow down)
Heave (hh.hh)	±10m Resolution 0.01m
Surge (ss.ss)	±10m Resolution 0.01m
Sway (ww.ww)	±10m Resolution 0.01m
Termination Characters	<CR><LF>

5.2.3 SMCB

Complete output of all available internal values.

Data Frame
$PSMCB,±xx.xx,±yy.yy,±zzz.z,±xv.xv,±yv.yv,±zv.zv,±GG.GGG,±HH.HHH,±II.III,±ss.ss,±ww.ww,±hh.hh,±sv.sv,±sw.sw,±hv.hv,±ax.axa,±ay.aya,±az.aza

Note: A very long protocol, it does not work at 100Hz, use 70Hz or below at 115200 baud.

Description	Form
Start Characters	$PSMCB
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (zzz.zz)	0 – 359.9° Resolution 0.1°
Roll Velocity (xv.xv)	Degrees/second Resolution 0.01°/s
Pitch Velocity (yv.yv)	Degrees/second Resolution 0.01°/s
Yaw Velocity (zv.zv)	Degrees/second Resolution 0.01°/s
Roll Acceleration (GG.GGG)	Degrees/second^2 Resolution 0.01°/s^2
Pitch Acceleration (HH.HHH)	Degrees/second^2 Resolution 0.01°/s^2
Yaw Acceleration (II.III)	Degrees/second^2 Resolution 0.01°/s^2
Surge (ss.ss)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Surge Velocity (sv.sv)	±100m/s Resolution 0.01m/s
Sway Velocity (sw.sw)	±100m/s Resolution 0.01m/s
Heave Velocity (hv.hv)	±100m/s Resolution 0.01m/s
Acceleration X (ax.axa)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Y (ay.aya)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Z (az.aza)	±100 m/s2 Resolution 0.001 m/s2
Termination Characters	<CR><LF>

5.2.4 SMCC

Data Frame
$PSMCC,+xx.xx,+yy.yy,+zzz.z,+ss.ss,+ww.ww,+hh.hh,+sv.sv,+sw.sw,+hv.hv,+ax.axa,+ay.aya,+az.aza*cs

Example
$PSMCC,-09.42,-02.85,+144.1,+00.28,-00.05,+00.00,+00.01,-00.00,+00.00,+00.004,-00.000,-00.005*71

Note: For the SMCC protocol to run at a Data Output Rate Frequency of 100Hz the sensor bit rate must be set at a minimum of 115200. To run the sensor at a Bit Rate of 38400 the Data Output Rate Frequency needs to be below 30 Hz. Failure to do this may result in problems with the output data.

Note: There is a version of the SMCC protocol that alternates with analog output for a DD50 display.

Description	Form
Start Characters	$PSMCC
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (zzz.z)	0 – 359.9° Resolution 0.1°
Surge (ss.ss)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Surge Velocity (sv.sv)	±100m/s Resolution 0.01m/s
Sway Velocity (sw.sw)	±100m/s Resolution 0.01m/s
Heave Velocity (hv.hv)	±100m/s Resolution 0.01m/s
Acceleration X (ax.axa)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Y (ay.aya)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Z (az.aza)	±100 m/s2 Resolution 0.001 m/s2
Checksum	*xx <CR><LF>

5.2.5 SMCD

Data Frame
$PSMCD,±xx.xx,±yy.yy,±xv.xv,±yv,yv,±zv.zv,c*cs<CR><LF>

Description	Form
Start Characters	$PSMCD
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Roll Velocity (xv.xv)	Degrees/second Resolution 0.01°
Pitch Velocity (yv.yv)	Degrees/second Resolution 0.01°
Yaw Velocity (zv.zv)	Degrees/second Resolution 0.01°
Checksum	<CR><LF>

5.2.6 SMCE

Data Frame
$PSMCE,±xx.xx,±yy.yy,±zzz.z,±hh.hh,±ss.ss,±sw.sw

Description	Form
Start Characters	$PSMCE
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (zzz.z)	0 – 359.9° Resolution 0.1°
Heave (hh.hh)	±100m Resolution 0.01m
Surge (ss.ss)	±100m Resolution 0.01m
Sway (sw.sw)	±100m Resolution 0.01m
Termination Characters	<CR><LF>

5.2.7 SMCF

Data Frame
$PSMCFnnnnnnn,±xx.xxx,±yy.yyy,±hh.hh,±ss.ss,±ww.ww

Description	Form
Start Characters	$PSMCF
Serial Number (nnnnnnn)	7 digit serial number
Roll Angle (xx.xxx)	±100 degrees Resolution 0.001° (+ve=port up)
Pitch Angle (yy.yyy)	±100 degrees Resolution 0.001° (+ve=bow down)
Heave (hh.hh)	±100m Resolution 0.01m
Surge (ss.ss)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Termination Characters	<CR><LF>

5.2.8 SMCG

Data Frame
$PSMCG,DateTime, xx.xxx, yy.yyy, ww.ww, ss.ss, hh.hh, ax.axa, ay.aya, az.aza

Description	Form
Start Characters	$PSMCG
Date, time	7 character string
Roll Angle (xx.xxx)	±100 degrees Resolution 0.001° (+ve=port up)
Pitch Angle (yy.yyy)	±100 degrees Resolution 0.001° (+ve=bow down)
Sway (ww.ww)	±100m Resolution 0.01m
Surge (ss.ss)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Acceleration X (ax.axa)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Y (ay.aya)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Z (az.aza)	±100 m/s2 Resolution 0.001 m/s2
Checksum	

5.2.9 SMCH

Data Frame
$PSMCH,±xx.xx,±yy.yy,±hh.hh,±hv.hv

Description	Form
Start Characters	$PSMCH
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Heave (hh.hh)	±100m Resolution 0.01m
Heave Velocity (hv.hv)	±100m/s Resolution 0.01m/s
Termination Characters	<CR><LF>

5.2.10 SMCI

Data Frame
$PSMCI,+rr.rr,+pp.pp,+yyy.y,+rv.rv,+pv.pv,+yv.yv,+su.su,+ww.ww,+hh.hh,+sv.sv,+sw.sw,+hv.hv*hh

Description	Form
Start Characters	$PSMCI
Roll (rr.rr)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch (pp.pp)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (yyy.y)	0 – 359.9° Resolution 0.1°
Roll velocity (rv.rv)	Degrees/second Resolution 0.01°
Pitch velocity (pv.pv)	Degrees/second Resolution 0.01°
Yaw velocity (yv.yv)	Degrees/second Resolution 0.01°
Surge (su.su)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Surge velocity (sv.sv)	±100m/s Resolution 0.01m/s
Sway velocity (sw.sw)	±100m/s Resolution 0.01m/s
Heave velocity (hv.hv)	±100m/s Resolution 0.01m/s
Checksum	*xx <CR><LF>

5.2.11 SMCM

Data Frame
$PSMCM,+xx.xx,+yy.yy,+zzz.z,+ss.ss,+ww.ww,+hh.hh,+xv.xv,+yv.yv,+zv.zv,+ax.axa,+ay.aya,+az.aza*cs

Description	Form
Start Characters	$PSMCM
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (zz.zz)	0 – 359.9° Resolution 0.1°
Surge (ss.ss)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Roll Velocity (xv.xv)	±100°/s Resolution 0.01°/s
Pitch Velocity (yv.yv)	±100°/s Resolution 0.01°/s
Yaw Velocity (zv.zv)	±100°/s Resolution 0.01°/s
Acceleration X (ax.axa)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Y (ay.aya)	±100 m/s2 Resolution 0.001 m/s2
Acceleration Z (az.aza)	±100 m/s2 Resolution 0.001 m/s2
Checksum	*xx <CR><LF>

5.2.12 SMCR

Data Frame
$PSMCR,±xx.xxx,±yy.yyy

Description	Form
Start Characters	$PSMCR
Roll Angle (xx.xxx)	±100 degrees Resolution 0.001° (+ve=port up)
Pitch Angle (yy.yyy)	±100 degrees Resolution 0.001° (+ve=bow down)
Termination Characters	<CR><LF>

5.2.13 SMCS

Data Frame
$PSMCS,±xx.xxx,±yy.yyy,±hh.hh
Example
$PSMCS,+00.089,-00.888,-00.04

Note: For the SMCS protocol to run at an Data Output Rate Frequency of 100Hz the sensor bit rate must be set at a minimum of 38400. To run the sensor at a Bit Rate of 19200 the Data Output Rate Frequency needs to be below 53Hz. Failure to do this may result in problems with the output data.

Description	Form
Start Characters	$PSMCS
Roll Angle (xx.xxx)	±100 degrees Resolution 0.001° (+ve=port up)
Pitch Angle (yy.yyy)	±100 degrees Resolution 0.001° (+ve=bow down)
Heave (hh.hh)	Heave ±100m Resolution 0.01m
Termination Characters	<CR><LF>

5.2.14 SMCT

Data Frame
$PSMCT, YYYY/MM/DD,HH:MM:SS.SS,±xx.xx,±yy.yy,±hh.hh

Note: This protocol will only be available in specially requested code versions.

Description	Form
Start Characters	$PSMCT
Year (YYYY)	
Month (MM)	1-12
Day (DD)	1-31
Hour (HH)	0-23
Minute (MM)	0-59
Second (SS.SS)	0-59.99
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Heave (hh.hh)	Heave ±100m Resolution 0.01 m
Termination Characters	<CR><LF>

5.2.15 SMCU

Note PSMCU is a combined output with $PSMCE when GPS aiding is used.

Data Frame
$PSMCU,<datestring><timestring><mode> *cs (only output when time input in last 1.1s)

Description	Form
Start Characters	$PSMCU
<timestring> (9 characters)	
<datestring> (6 characters)	
<mode>(2 characters)	
	$PSMCE
Roll Angle (rr.rr)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (pp.pp)	±100 degrees Resolution 0.01° (+ve=bow down)
Yaw (yyy.y)	0 – 359.9° Resolution 0.1°
Heave (hh.hh)	±100m Resolution 0.01m
Surge (ss.ss)	±100m Resolution 0.01m
Sway (ww.ww)	±100m Resolution 0.01m
Heave (hh.hh)	±100m Resolution 0.01m
Roll Velocity (xv.xv)	±100°/s Resolution 0.01°/s
Termination Characters	*xx <CR><LF>

5.2.16 SMCV

Data Frame
$PSMCV,±xx.xx,±yy.yy,±hh.hh,±xv.xv,±yv.yv,±hv.hv

Description	Form
Start Characters	$PSMCV
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Heave (hh.hh)	±100m Resolution 0.01 m
Roll Velocity (xv.xv)	Degrees/second Resolution 0.01°
Pitch Velocity (yv.yv)	Degrees/second Resolution 0.01°
Heave Velocity (hv.hv)	±100m/s Resolution 0.01m/s
Termination characters	<CR><LF>

5.2.17 TCM2

Data Frame
$C0.0P-1.8R-0.5X0.00Y0.00Z0.00T0.0E000*29

Description	Form
Start Characters	$C0
Pitch	P
Pitch Angle	±100 degrees Resolution 0.1° (+ve=bow down)
Roll	R
Roll Angle	±100 degrees Resolution 0.1° (+ve=port up)
X field	µT – micro Tesla
Y field	µT – micro Tesla
Z field	µT – micro Tesla
Temperature	°C
Distortion flag	E001 if a magnetic anomaly is nearby
Checksum	*xx <CR><LF>

5.2.18 TRH

Data Frame
$PHTRH,0.00,M,0.00,B0.00,0*14

Description	Form
Start Characters	$PHTRH
Pitch	±100 degrees Resolution 0.1° (+ve=bow down)
P or M	P Positive M Negative
Roll	±100 degrees Resolution 0.01° (+ve=port up)
B or T	B roll to starboard, T roll to port
Heave	m/s
O or U	O upwards U downwards acceleration
Checksum	*xx

5.2.19 TRO

Data Frame
$PHTRO,0.00,M,0.00,B*5B

Description	Form
Start Characters	$PHTRO
Pitch	±100 degrees Resolution 0.1° (+ve=bow down)
P or M	P Positive M Negative
Roll	±100 degrees Resolution 0.01° (+ve=port up)
B or T	B roll to starboard, T roll to port
Checksum	*xx

5.2.20 MDL

Data Frame
H0000.P-/+0000.R+/-0000.

Description	Form
Start Characters	H0000
Pitch	+/- (+ve=bow down)
Roll	+/- (+ve=port up)

5.2.21 DIGILOG / OCEAN TOOLS

Data Frame
$HhhhhP+ppppR+pppp (Digilog)
$HhhhhP+ppppR+pppps (Ocean Tools)
Example
$H0014P+0030R-0024E (Ocean Tools)

Description	Form
Heading designator	H
Heading*10 (hhhh)	0-3599°*10
Pitch designator	P
Pitch Angle*100 (pppp)	±9999°*100 Resolution 0.01° (+ve=port up)
Roll Designator	R
Pitch Angle (yy.yyy)	±9999°*100 Resolution 0.01° (+ve=bow down)
Status character (s) (only Ocean Tools)	E/S (valid compass yes/no)
Termination Characters	<CR><LF>

5.2.22 HYDROGRAPHIC PROTOCOLS

Note: ATLAS protocol is found under binary protocols.

5.2.23 CDL MICROTILT

Data Frame:
Pyy.yyRxx.xx

Description	Form
Pitch designator (P)	P
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Roll designator (R)	R
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Termination Characters	<CR><LF>

5.2.24 CDL1

Data Frame:
Hzzz.zPyy.yyRxx.xxs

Description	Form
Heading designator (H)	H
Heading (zzz.z)	Yaw 0 – 359.9° Resolution 0.1°
Pitch designator (P)	P
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Roll designator (R)	R
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Ending string (s). Gives 0 for not available values. 30 characters.	T00.0D0000.00B00.0A00W00LN00F0
Termination Characters	<CR><LF>

5.2.25 TSS1

TSS Proprietary protocol with Heave

Note: For the TSS1 protocol to run at a Data Output Rate Frequency of 100Hz the sensor bit rate must be set at a minimum of 38400. To run the sensor at a Bit Rate of 19200 the Data Output Rate Frequency needs to be below 58Hz. Failure to do this may result in problems with the output data.

Note: When settling, in addition to having the status flag 'U'; roll, pitch and heave will be 0.

Data Frame
:XXAAAA (S or -)HHHH (U or u) (S or -)RRRR (S or -)PPPP

Description	Form
Start Character LSB	:
Header	Hex value
Space	
Positive or negative	(+ve=bow up)
Pitch	Hex value
Status flag	U
Positive or negative	(+ve=port up)
Roll	Hex value
Space	
Positive or negative	Negative, heave downwards
Heave	Hex value
Termination Characters	<CR><LF>

5.2.26 TSS3

Description	Form
Start Character LSB	:
Value prefix	space if positive, minus if negative
Remote Heave	hhhh
Space Character	S
Value prefix	space if positive, minus if negative
Heave	HHHH Hex value
Status Flag	Q
Value prefix	space if positive, minus if negative
Roll	RRRR Hex value
Space Character	S
Value prefix	space if positive, minus if negative
Pitch	PPPP Hex value
Termination Characters	<CR><LF>

5.2.27 RDID

Data Frame
$PRDID,±yy.yy,±xx.xx,±hhh.hh<CR><LF>

Description	Form
Start Characters	$PRDID
Pitch Angle (yy.yy)	±100 degrees (+ve=bow up)
Roll Angle (xx.xx)	±100 degrees (+ve=port up)
Heading (hhh.hh)	Heading 0 – 359.9° Resolution 0.01°
Termination Characters	<CR><LF>

5.2.28 SXN

Rolls-Royce NMEA protocol
Data Frame
$PSXN,,,R.RRReE,P.PPPeE, P.PPPeE,,,*cs<CR><LF>

Note: When settling roll, pitch and heave will be 0.

Description	Form
Start Characters	$PSXN
Roll Angle (R.RRReE)	Radians. Scientific format with exponent
Pitch Angle (P.PPPeE)	Radians. Scientific format with exponent
Heave (P.PPPeE)	Meters. Scientific format with exponent
Termination Characters	*xx <CR><LF>

ANALOG OUTPUTS

5.2.29 ANALOG1 ±0.5M ±10V

Data Frame
#01C0+hh.hhh
#01C1+vv.vvv
#01C2+aa.aaa

Description	Form
1st Header	#01C0
Heave (hh.hhh)	±100m*20 Resolution 0.001m*20
Termination Characters	<CR><LF>
2nd Header	#01C1
Heave rate (vv.vvv)	±100m/s*50 Resolution 0.001m/s*50
Termination Characters	<CR><LF>
3d Header	#01C2
Heave acceleration (aa.aaa)	±100m/s^2*50 Resolution 0.001m/s^2*100
Termination Characters	<CR><LF>

5.2.30 ANALOG2 ±10 DEGREES ±10V

Data Frame
#01C0+xx.xxx
#01C1+yy.yyy
#01C2+hh.hhh

Description	Form
1st Header	#01C0
Roll Angle (xx.xxx)	±100 degrees (+ve=port up) Resolution 0.001°
Termination Characters	<CR><LF>
2nd Header	#01C1
Pitch Angle (yy.yyy)	±100 degrees (+ve=bow up)) Resolution 0.001°
Termination Characters	<CR><LF>
3rd Header	#01C2
Heave (hh.hhh)	Heave ±100m Resolution 0.001m
Termination Characters	<CR><LF>

5.2.31 ANALOG3 ±30 DEGREES ±10V

Data Frame
#01C0+xx.xxx
#01C1+yy.yyy
#01C2+hh.hhh

Description	Form
1st Header	#01C0
Roll Angle/3 (xx.xxx)	±60 °3 (+ve=port up) Resolution 0.001°*3
Termination Characters	<CR><LF>
2nd Header	#01C1
Pitch Angle/3 (yy.yyy)	±60 °/3 (+ve=bow up)) Resolution 0.001°*3
Termination Characters	<CR><LF>
3rd Header	#01C2
Heave (hh.hhh)	Heave ±100m Resolution 0.001m
Termination Characters	<CR><LF>

5.2.32 ANALOG4 0-20 DEGREES 4~20 MILLIAMPS

Data Frame
#01C0+xx.xxx
#01C1+yy.yyy

Description	Form
1st Header	#01C0
Roll Angle (xx.xxx)	±20° (+ve=port up) Resolution 0.001°
Termination Characters	<CR><LF>
2nd Header	#01C1
Pitch Angle (yy.yyy)	±20 °/3 (+ve=bow up)) Resolution 0.001°
Termination Characters	<CR><LF>

5.2.33 ANALOG5 ±60 DEGREES 4~20 MILLIAMPS

Data Frame
#01C0+12.004
#01C1+11.796
#01C2+11.799
#01C3+16.000

Available from firmware version 2.94

Description	Form
1st Header	#01C0
Heave (hh.hhh) ±6m	In meters (4mA== - 6m;;; 20mA== +6m)
Termination Characters	<CR><LF>
2nd Header	#01C1
Pitch Angle (yy.yyy)	±60˚ 4mA== - 60˚;;; 20mA== +60˚
Termination Characters	<CR><LF>
3rd Header	#01C2
Roll (xx.xxx)	±60˚ 4mA== - 60˚;;; 20mA== +60˚
Termination Characters	<CR><LF>
4th Header	#01C3 Ready Signal(Not Ready == 8mA;;; Ready ==16mA)

5.2.34 ANALOG6 ±5M 4~20 MILLIAMPS

Data Frame
#01C0+00.370
#01C1+00.171
#01C2+01.144 Available from firmware version 2.982

Description	Form
1st Header	#01C0
Heave Amplitude (hh.hhh)	±5m
Termination Characters	<CR><LF>
2nd Header	#01C1
Heave Velocity (vv.vvv)	±5m/s
Termination Characters	<CR><LF>
3rd Header	#01C2
Heave Acceleration (aa.aaa)	±5m/s²
Termination Characters	<CR><LF>

5.2.35 DD50

Data Frame
(no line break in actual data)
DDA@1 "IMU / MRU",Units,Roll 00.03 deg,Pitc -00.02 deg,Heav -00.00 m,@2 "Accs ",Units,AccX 00.00 ms2,AccY -00.01 ms2,AccZ -00.00 ms2<CR><LF>
Note: This output alternates with the SMCC protocol.

Description	Form
Roll Angle (xx.xx)	±100 degrees Resolution 0.01° (+ve=port up)
Pitch Angle (yy.yy)	±100 degrees Resolution 0.01° (+ve=bow down)
Heave (hh.hh)	±100m Resolution 0.01m
Acceleration X (ax.ax)	±100 m/s2 Resolution 0.01 m/s2
Acceleration Y (ay.ay)	±100 m/s2 Resolution 0.01 m/s2
Acceleration Z (az.az)	±100 m/s2 Resolution 0.01 m/s2
Termination characters	<CR><LF>

5.2.36 BINARY PROTOCOLS

5.2.37 ATLAS (HYDROGRAPHIC)

Each field in the Atlas output string is a 16-bit 2's complement number expressed as two binary coded digits. Attitude measurements are supplied in units (360°/65536=0.0054931641°). Heave measurements are in mm. The frame contains 9 bytes in binary format.

Data Frame (bytes)
ERRPPHHSE

Description	Bytes	Form
DLE (E)	1	0x10
Roll (RR)	2	Unsigned 16 bit, i.e. 0..65535 representing 360° with a resolution of 360°/65536 range 0..360°
Pitch (PP)	2	Unsigned 16 bit, i.e. 0..65535 representing 360° with a resolution of 360°/65536 range 270°..90°
Heave (HH)	2	Signed 16 bit range -32767 mm to + 32766 mm Positive when elevated.
Status (S)	1	1*unsettled+2*velocityaiding+4*heading aiding (where variables are interpreted as 0=false, 1=true)
DLE (E)	1	0x10

5.2.38 SIMRAD EM1000 & EM 3000

Data Frame
SHRRPPHHYY
Contains 10 bytes
Note: When settling roll, pitch and heave will be 0.

Description	Scaling	Format	Bytes	Value
Status byte (S)			1	0 (EM1000) 0x90 (EM3000)
Header (H)			1	0x90
Roll (RR)	0.01 degrees	Signed hex	2	-17999 - 18000 hundredths of °
Pitch (PP)	0.01 degrees	Signed hex	2	-17999 - 18000 hundredths of °
Heave (HH)	0.01 m	Signed hex	2	-32767 - 32766 cm
Heading (YY)	0.01 degrees	Unsigned hex	2	0 - 35999 hundredths of °

5.2.39 BOSCH REXROTH HEXADECIMAL HEAVE

Data Frame (bytes)
$SMCHHVVAA<CR><LF>
Contains 12 bytes:

Note: When the IMU is settling, roll, pitch and heave will be 0.

Description	Bytes	Form
Header	4	$SMC
Heave (HH)	2	Signed 16 bit range -32767 mm to + 32766 mm Positive when elevated.
Heave velocity (VV)	2	Signed 16 bit range -32767 mm/s to + 32766 mm/s
Heave acceleration(AA)	2	Signed 16 bit range -32767 mm/s^2 to + 32766 mm/s^2
Termination characters	2	<CR><LF> (0x15 0x12)

5.2.40 BINARY STRING 1

Data Frame (15 bytes)

5.2.41 BINARY STRING 2

Data Frame (15 bytes)

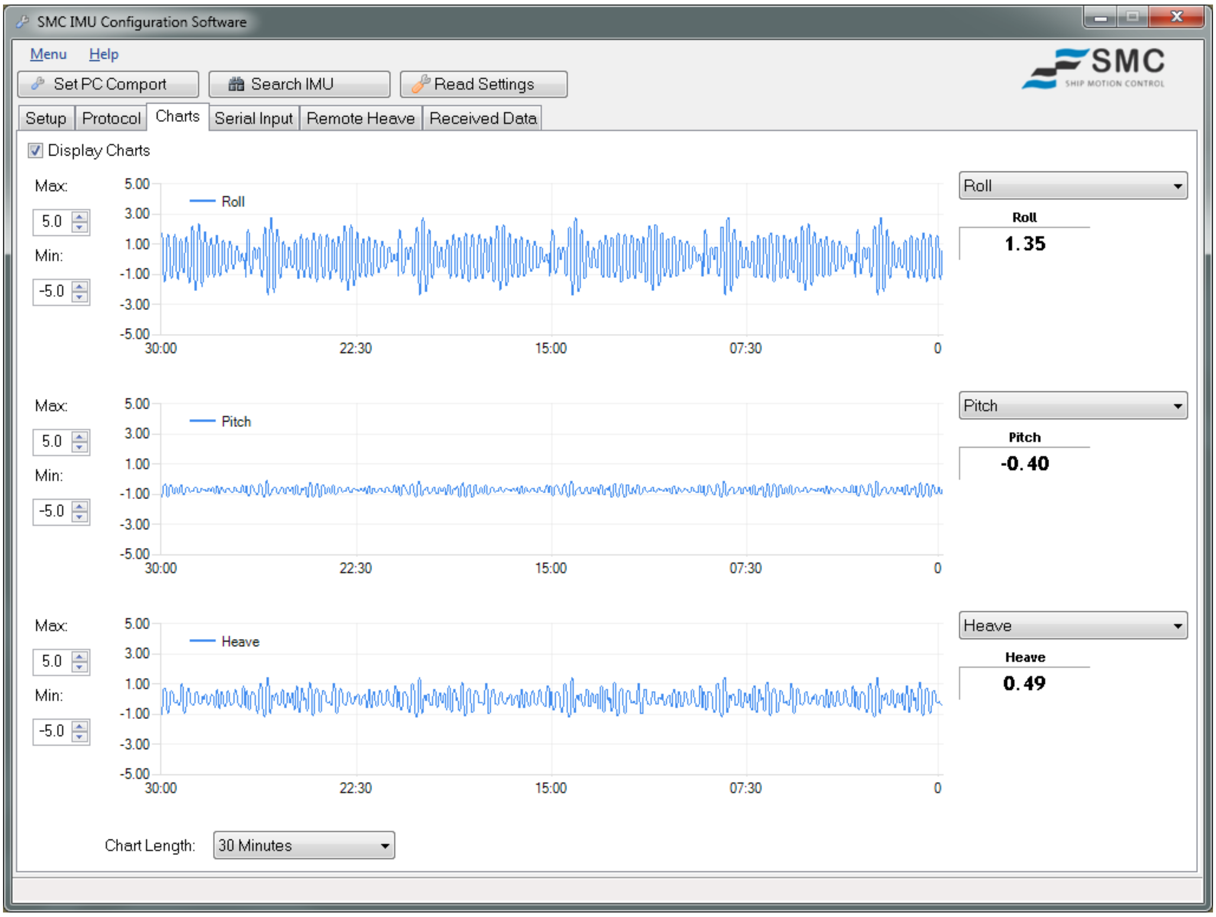
Description	Bytes	Hex	Form
Header (32 bits)	4	0x01	
SOH		0x0D	Start of header Byte
Message length		0x00	Remaining number of Bytes to follow
Message Type			Message code
EOH			End of Header
Data	10		
Pitch Byte 1		LSB	Positive Pitch = Bow up
Pitch Byte 2			
Pitch Byte 3			
Pitch Byte 4		MSB	
Roll Byte 1		LSB	Positive Roll = Port up
Roll Byte 2			
Roll Byte 3			
Roll Byte 4		MSB	
Pitch invalid			Invalidity byte flag 0x00=Valid, 0x01-0xFF=Invalid
Roll invalid			Invalidity byte flag 0x00=Valid, 0x01-0xFF=Invalid
Footer			
EOM		0x04	End of Message

Pitch/Roll Value = $360/(2^{32})$
0 (00000000 Hex) = 0 Degrees
1 (00000001 Hex) = +0.0000008382 Degrees
-1 (FFFFFFFF Hex) = -0. 0000008382 Degrees

5.3 CHARTS

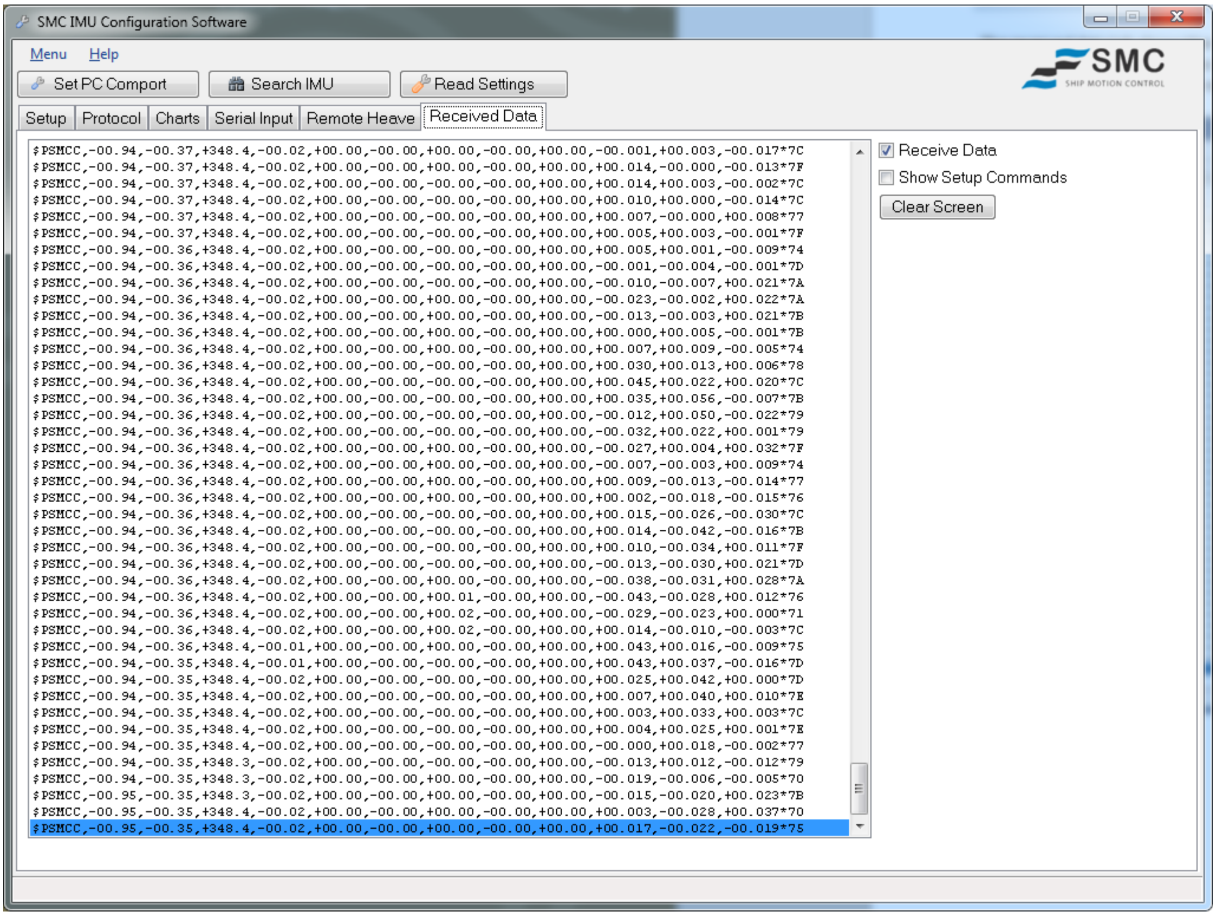
As a visual aid to or as a simple motion monitoring system, SMC have a Chart screen that displays up to 3 parameters in a graphical representation.

After selecting the Charts tab tick the Display Charts tick box to activate the data display.
Beside each chart is a drop down menu from where the parameter to be displayed can be selected.
The chart scale is set on the left of the screen with a Maximum and Minimum setting. The chart length is set for all the charts from the drop down menu at the bottom of the screen.



5.4 RECEIVED DATA

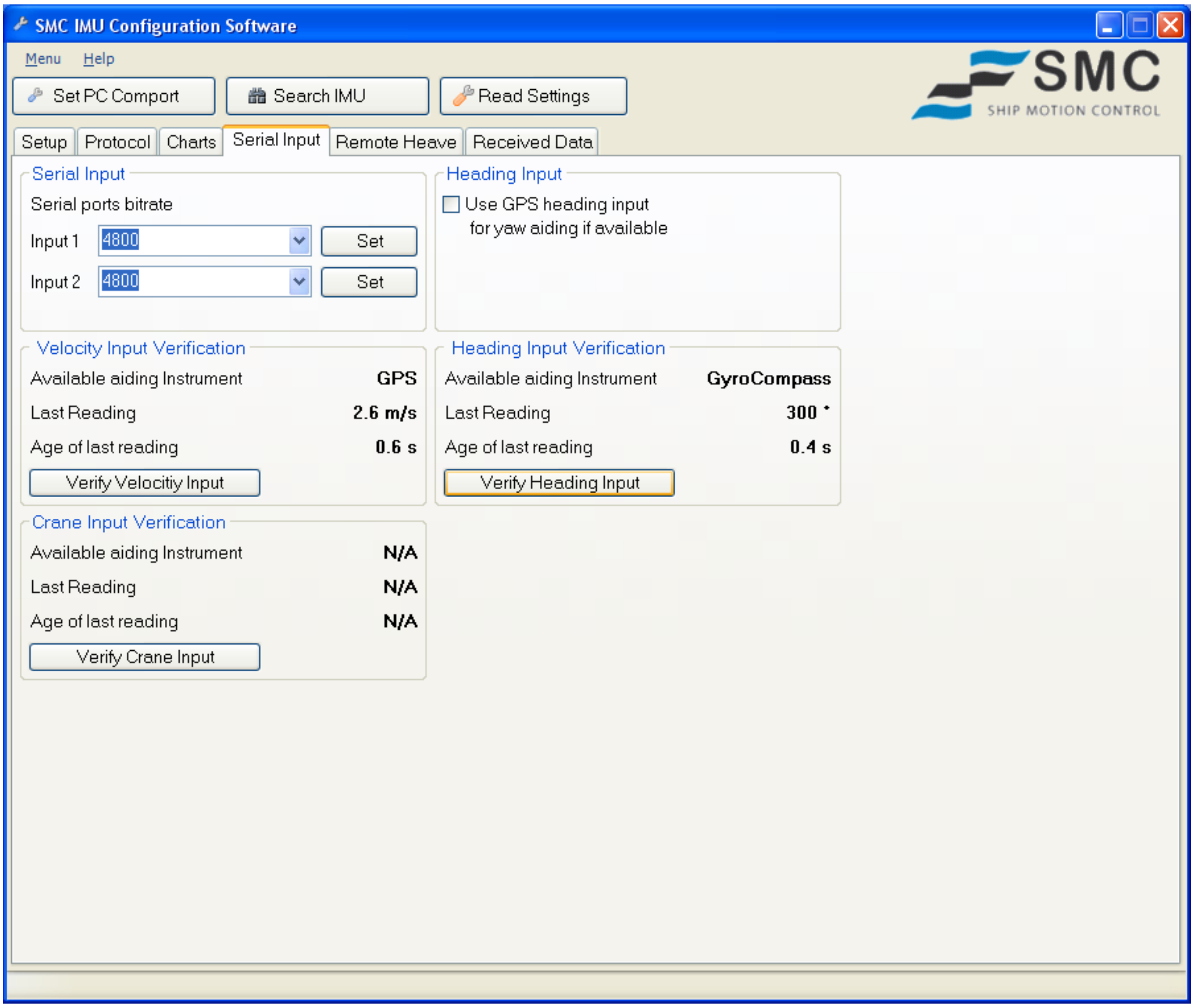
The received data tab shows the raw data string that the sensor sends. Check the Receive checkbox to show the sent data. Press the clear button to clear the window from the sensor strings. Binary strings will not be shown in the received data tab.



5.5 SERIAL INPUT

The SMC IMU has two RS232 serial ports for input from external devices.

The ports can be used for
- Aiding in vessel turns; input from GPS, Speed log
- Heading aiding; GyroCompass or GPS
- Remote heave for AHC (Active Heave Compensation) in crane applications; Encoders via PLC (Programmable Logic Controllers)



5.5.1 AIDING VIA GPS AND SPEED LOG

During vessel turns with small vessels a centrifugal force is generated from the turn. This force has a negative effect on the angle and heave calculation. By knowing the vessel velocity the centrifugal force can be estimated inside the IMU and the centrifugal effect can be heavily reduced, improving the accuracy of the readings from the IMU.

The SMC IMU accepts velocity input from a GPS or a speed log.
The accepted input strings for the velocity input are
$xxRMC
$xxRMA
$xxVTG
$xxVBV
$xxVHW

To confirm that the IMU is receiving data from the velocity device, select **Verify Velocity Input** in the serial input tab. The IMU replies with information about the time since the last reading and the velocity received.

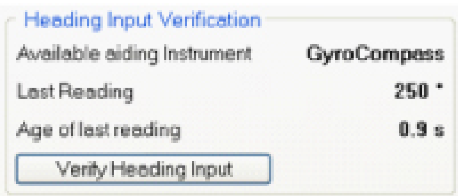
5.5.2 HEADING INPUT

When a gyrocompass is connected (or a GPS is selected to be used for heading input), the IMU will use the gyrocompass for aiding the yaw signal, combining the data from internal gyros in the IMU with the input from the external gyrocompass.
The output is available in strings where yaw or heading is available. Refer to **Section 5.2.1** of this manual for a list of available data strings.

The accepted strings from the GyroCompass are $xxHDT and $xxHDG.

Heading can also be retrieved from the GPS string but is not advisable if the vessel is not under constant motion. The $GPHDG string is not accepted as default for the heading input.
To use the GPS heading data for yaw aiding tick the *Use GPS heading input for yaw aiding if available* checkbox in the Serial Input tab otherwise the $GPHDG string will be ignored.

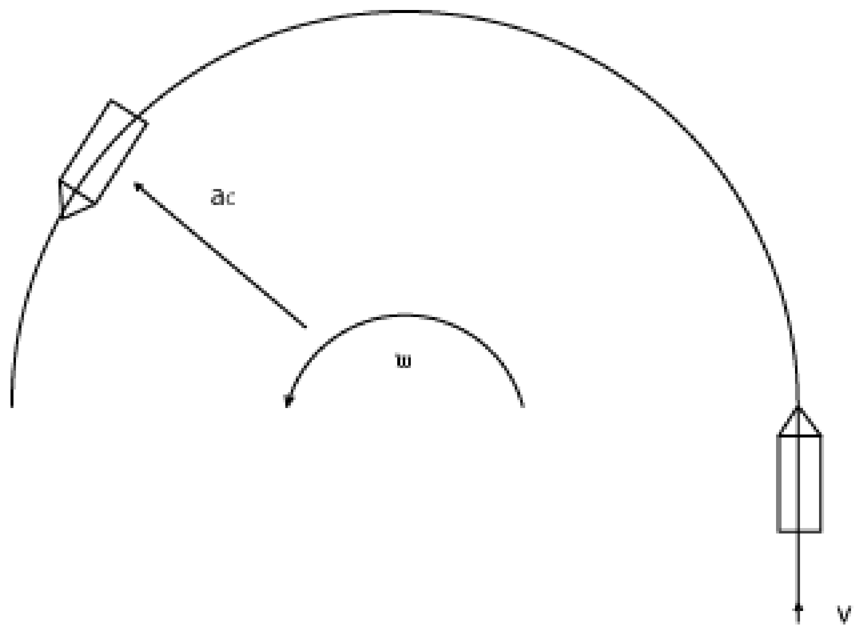
To confirm that the IMU is receiving data from the heading device click the *Verify Heading Input* button on the Serial Input tab. The IMU replies with the time since the last reading and the heading received.



5.5.3 VESSEL TURNS

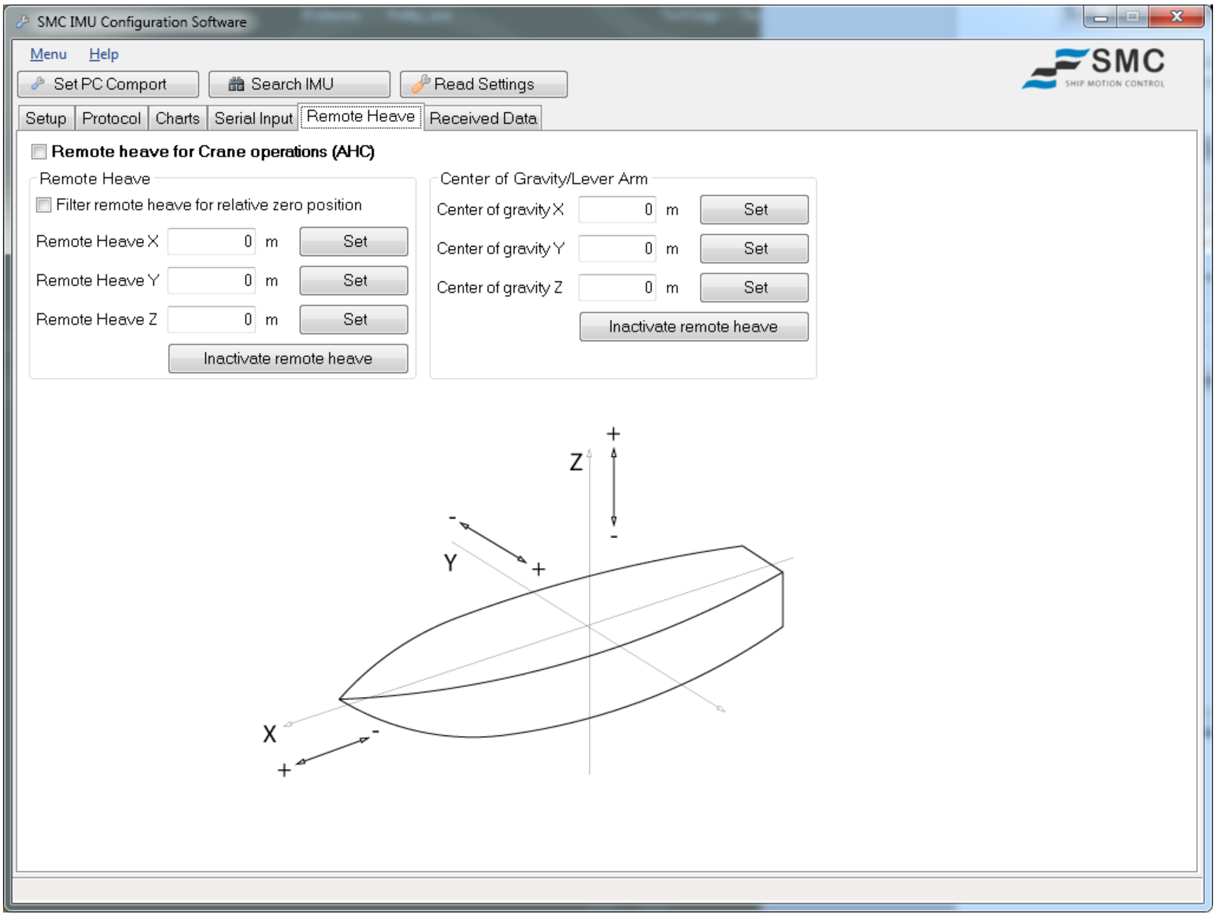
When a vessel makes a turn without the additional information of vessel speed and position change the IMU can interpret the turn as an acceleration value and that will affect the accuracy of the output data.

The IMU uses the vessel speed and rate of turn to calculate the centripetal acceleration and remove it from the measurements during a vessel turn.



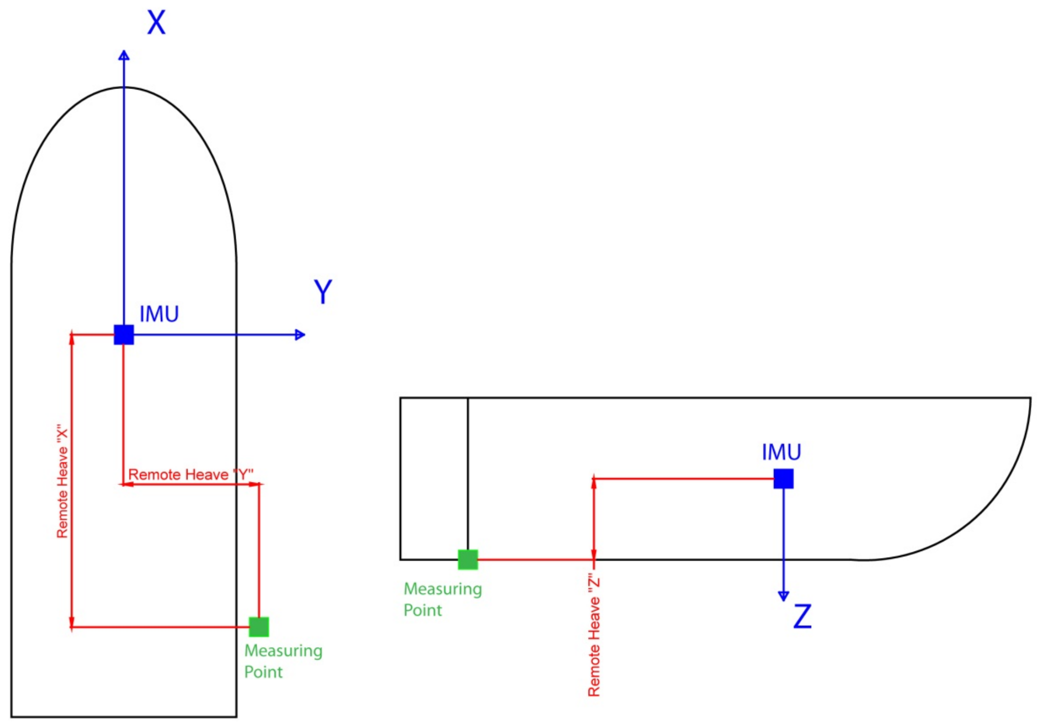
5.6 REMOTE HEAVE

The Remote Heave Screen has three control setups:
Remote Heave
Center of Gravity/Lever Arm
Remote Heave for Crane operations (AHC)



5.6.1 REMOTE HEAVE

The remote heave function calculates the heave and the heave velocity output of the IMU in its physical location relative to a remote location. The setup of the remote heave is in the remote heave tab.



“Remote heave X” is the fore aft distance in meters between the IMU and the remote heave point. Where a positive distance represents that the motion sensor is located aft of the desired measurement point.

“Remote heave Y” is the sideways distance in meters between the IMU and the remote heave point. Where a positive distance represents that the motion sensor is located to the starboard side of desired measurement point.

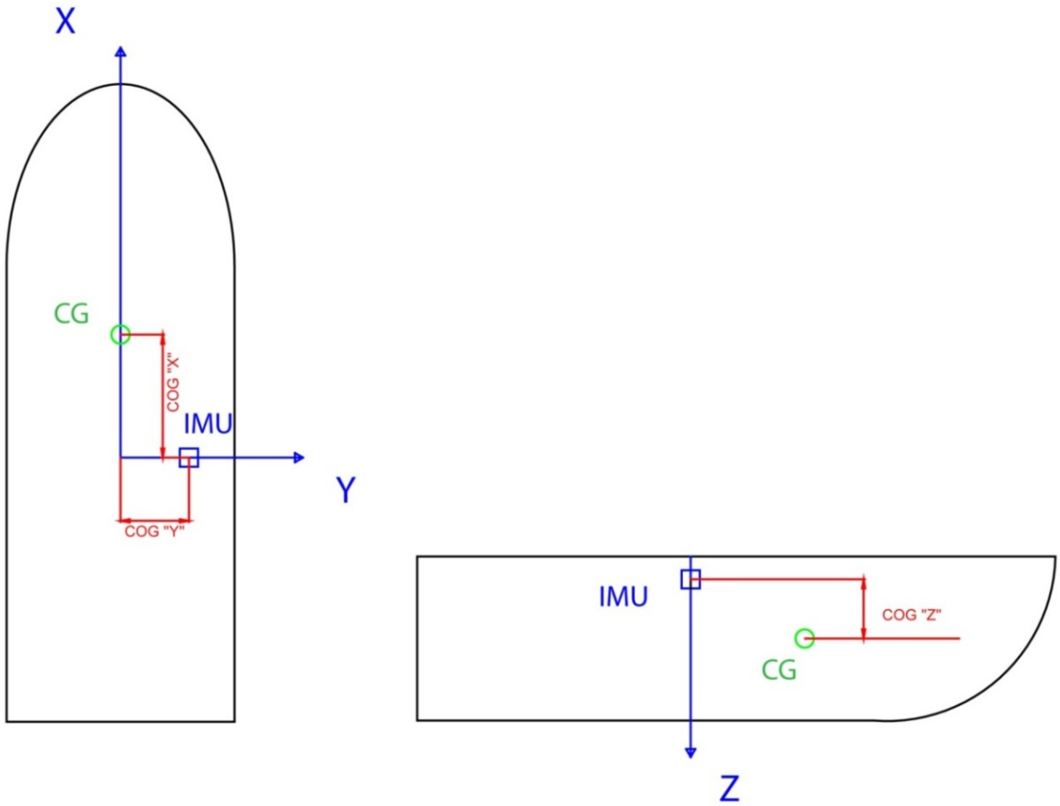
“Remote heave Z” is the vertical distance in meters between the IMU and the remote heave point. Where a positive distance represents that the motion sensor is located below the desired measurement point.

As the remote heave calculation is a combination of distance, angles and heave, a fixed angle will give a constant heave position that is different from zero. As the heave definition is a relative motion and the angle is an absolute angle, SMC has added a filter to remove a fixed trim of the vessel from the remote heave output. This is selectable from the checkbox **Filter remote heave for relative zero position**.

Note that remote heave will not be as accurate as heave at the physical location of the IMU as the remote heave is a combined calculation of heave and angle from a remote location. The calculation assumes that the vessel is rigid so if the remote heave distance is far from the physical location of the IMU the error from any small angular error in the motion sensor, from flexing hulls etc. may generate a significant error in the remote heave output.

5.6.2 CENTER OF GRAVITY CG LEVER ARM

The best placement for the motion sensor is at the center of gravity (CG). If the sensor is placed in another location; the accuracy of the output in general and heave in particular can be improved by giving the location of CG with respect to the sensor in the setup program. It is preferable to have a close approximation of the CG rather than no data. These values are given in the same way as the values for the remote heave location coordinates i.e.:



"CG X" is the fore aft distance in meters between the IMU and the CG. Where a positive distance represents that the motion sensor is located aft of the CG.

"CG Y" is the sideways distance in meters between the IMU and the CG. Where a positive distance represents that the motion sensor is located to the starboard side of the CG.

"CG Z" is the vertical distance in meters between the IMU and the CG. Where a positive distance represents that the motion sensor is located below the CG.

Unless **Filter remote heave for relative zero position** is checked (which you typically do not want to have) setting a non-zero distance to CG may result in a heave that is not "centered" at 0 when the vessel is not leveled even when you have zero remote-heave distance (have the IMU as the point for which heave is desired). This means that the IMU is horizontally displaced with respect to the position it would have when the vessel is leveled and is usually what is desired.

5.6.3 AHC (ACTIVE HEAVE COMPENSATION)

SMC has developed a remote heave function that accepts dynamic crane position data for active heave compensation in marine crane applications.

A “failsafe” handling system must be built into the system so that if there is a failure in the IMU, PLC or the encoder feeding the active heave operation will be cancelled automatically.
Note that SMC will not be responsible for damages that occur related to Active Heave Compensation.

With the remote heave for Crane Operations active, the IMU will continually calculate the remote heave data based on the information that is supplied to the IMU from the crane encoders.
Remote heave and remote heave velocity data is then calculated for any requested single point location along the crane boom which can be used to compensate for the vessel motions during crane operations.

Tick the checkbox **Remote heave for Crane Operations (AHC)** in the remote heave tab and the crane settings will be enabled.

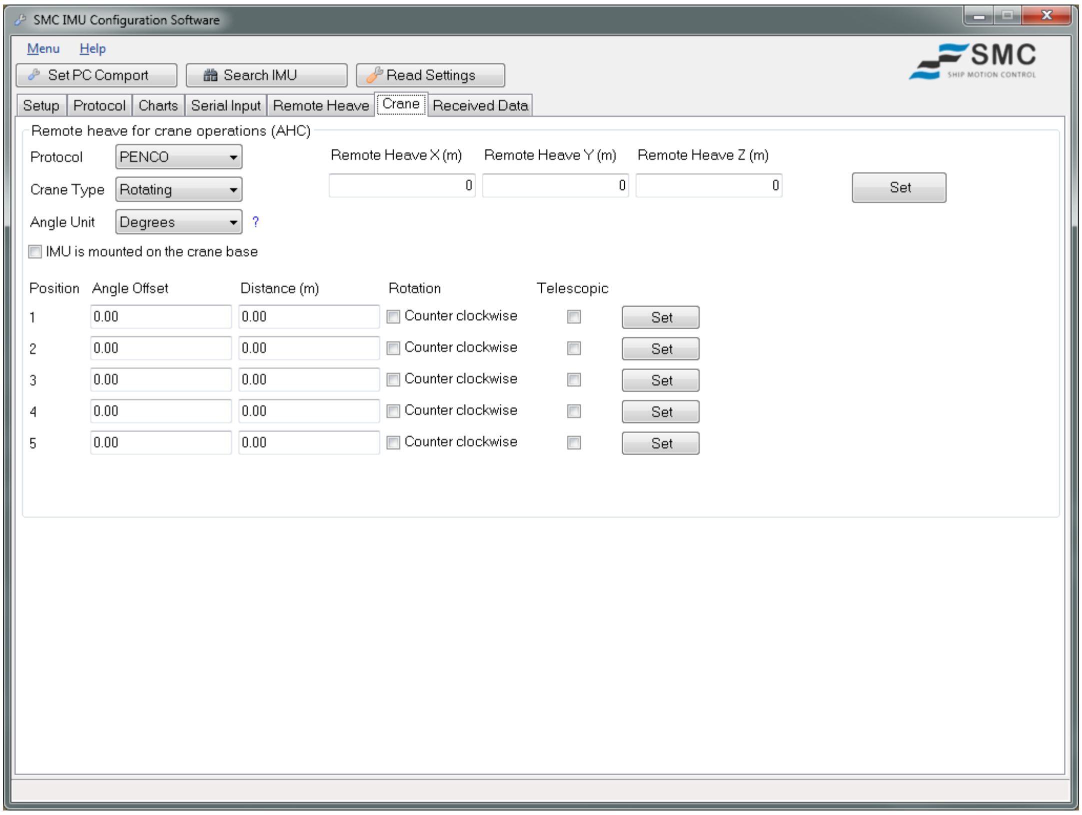
5.6.4 SETUP OF CRANE LAYOUT

SPECIFICS IN SETTING UP SMC SENSOR FOR CRANE USE USING THE CONFIGURATION SOFTWARE

1. On "Remote heave" tab, check "Remote heave for Crane operations (AHC)" box. This inactivates remote heave settings on this tab and opens a new "Crane" tab where the remote heave settings now can be found.
2. On "Remote heave" tab, fill in center of gravity settings as described in 5.6.2 in the manual. As is noted there these settings do not have to be absolutely correct (they will not be since the z-value is dependent on the loading of the ship), but the more accurately they are given, the more accurate the sensor output will be. Note that "Center of gravity" is often called "Center of mass" in the literature
3. On the "Crane" tab. set the type of protocol "PENCR" for use of hexadecimal values in the crane data strings sent to the sensor and "PENCO" for standard text encoded values. These strings are described in 5.6.6
4. On the "Crane" tab, currently only "Rotating" crane type can be chosen.
5. On the "Crane" tab, chose angular unit "Degrees" or "Radians".
6. For a crane that is actually rotating you need to check "IMU is mounted on crane base" if that is the case i.e. the IMU rotates with the crane.
7. On the "Crane" tab, enter the remote heave settings in accordance with 5.6.4 of the manual.
8. On the "Crane" tab, if there are offsets in the values that will be sent in the command strings (this is usually the case) these have to be set in accordance with 5.6.5 of the manual.

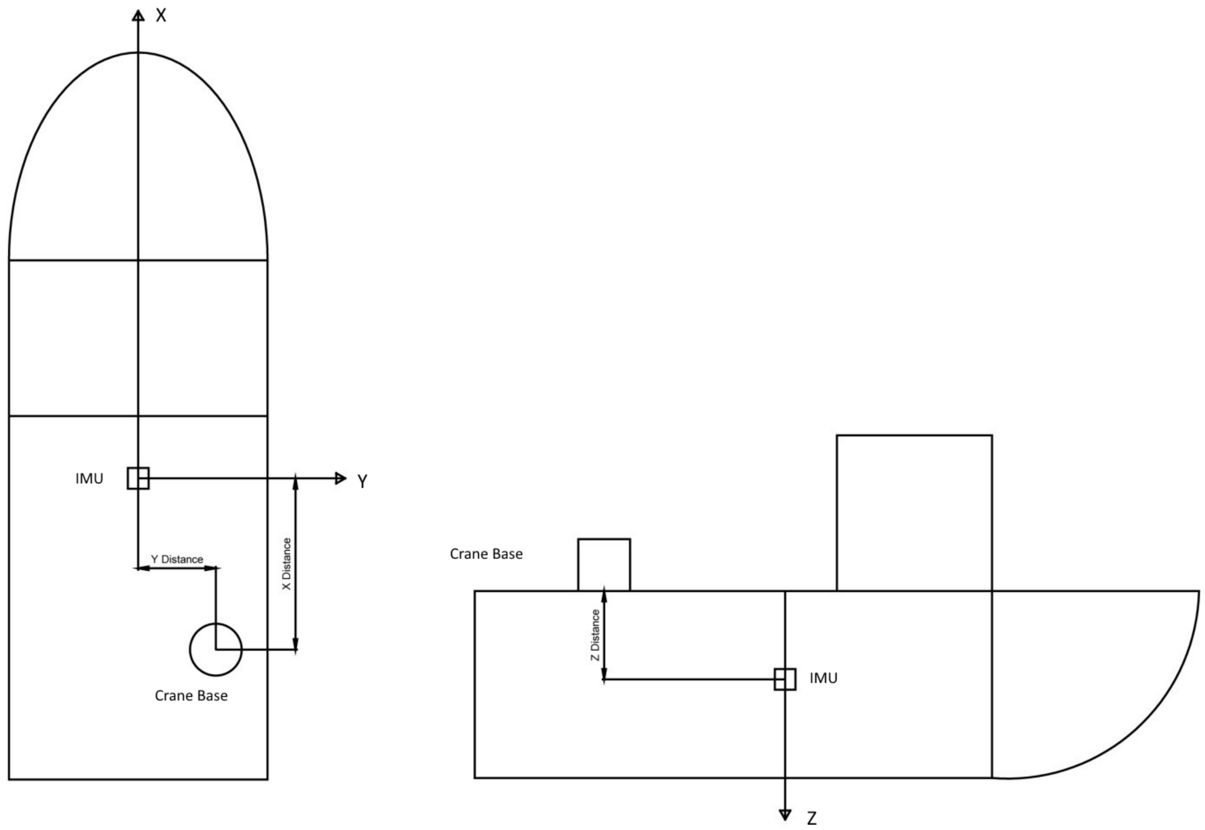
IMU mounted on the crane
If the IMU is mounted on the crane base the single notch should be aligned with the crane arm (i.e. single notch is pointing to the boom tip). Tick the checkbox **IMU is mounted on the crane base**. When this checkbox is ticked the IMU is assumed to be rotating with the yaw rotation of the crane.

In the crane tab - Position 1, the yaw encoder value, which is the first encoder input, should be left empty or as a value zero in the input string from the PLC.



IMU not mounted on the crane base

If the IMU is not mounted on the crane, the single notch of the motion sensor base should point towards the bow. Mount the IMU as close as possible to the crane base to optimize the remote heave output.
The remote distance between the crane base and the IMU should be entered in the Remote Heave boxes under the crane tab.
The fields are marked as Remote Heave X, Remote Heave Y and Remote Heave Z in the below figure. The units are in meters.



"Remote heave X" is the fore aft distance in meters between the IMU and the crane base. Where a positive distance represents that the motion sensor is located aft of the crane base

"Remote heave Y" is the sideways distance in meters between the IMU and the crane base. Where a positive distance represents that the motion sensor is located to the starboard side of the crane base

"Remote heave Z" is the vertical distance in meters between the IMU and the crane base. Where a positive distance represents that the motion sensor is located below the crane base.

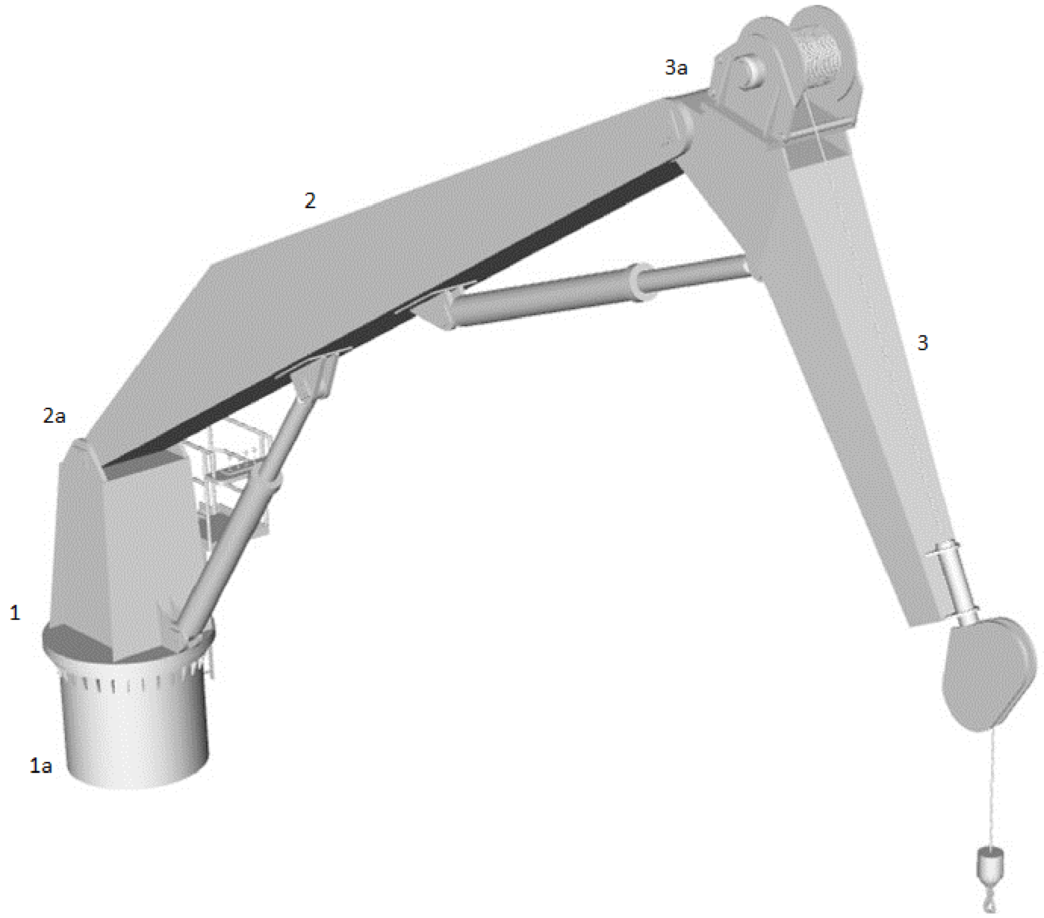
5.6.5 SETTING ANGLE OFFSETS

In the **Crane tab** angles and offsets can be set.
Positions 1 to 5 represent encoder values. Encoders measure angle and distance.
The offset information is entered in the column labelled Angle offset.

For Position 1 Angle Offset, the yaw encoder, marked as 1a in the crane drawing, the offset has its reference position aligned with the vessel for fore-aft line.
Encoder1 angles are seen from above.
When the crane is pointing to the:

- Fore of the vessel the encoder should display 0 degrees.
- Starboard side the encoder should display 90 degrees angle.
- Port side the encoder value should be 270 degrees or -90 degrees if the default clockwise rotation is being used.

The offset settings can be done either in the PLC or by entering the offset value in the SMC configuration software.
Position 1, Distance (m) encoder, the height of the first node from the crane base is entered, it is marked as 1 in the below crane image.



For the encoders 2, 3, 4 and 5 the angle is relative to the previous leg measurement of the crane. This means that when there is no angular difference between the crane leg 2 and 3, the encoder angle 3a has a 0 angle.
The encoder angles are illustrated as 2a and 3a in the crane drawing above.

Encoder 2, 3, 4 and 5 rotations are seen from the starboard side of the crane.
Clockwise positive rotation is the default, when seeing the crane from this position.
Counter clockwise positive rotation can be selected by ticking the **Counter clockwise** checkbox for the relevant encoder position.
I.e. a default positive rotation is when the crane arm is being adjusted downwards towards the water line.
If the crane has zero angles from the encoders and no offsets entered this would mean that the crane is pointing straight up.

The distance from the encoder position to the next encoder position is to be entered under the column labelled Distance.
If the next encoder position is a telescopic arm, the distance to be entered is the length of the telescopic arm fully retracted.
The distances are marked as 1, 2, and 3 in the crane drawing above.

5.6.6 STRING INPUT

When using crane serial input communication, the data has to be transmitted over an RS232 serial interface.
When the crane position data is being fed into the motion sensor, the output string from the unit will use the current crane position for a remote heave calculation. For the motion sensor to calculate the remote heave on an operating crane installation the crane encoder readings are transferred to the motion sensor for the new crane working position. Below is the description of the predefined data strings to be sent to the motion sensor serial input

Two string options are available for the data input
$PENCR and $PENCO

$PENCR
The $PENCR data string includes up to 5 encoder values:
$PENCR,Value1,Value2,Value3,Value4,Value5<CR><LF>

Description	Form
Start Characters	$PENCR
Value1	Value1 is the encoder for the Z-axis/yaw/base rotation. I.e. typically the complete crane rotation. Data with the resolution 360°/65536
Value2	Value2 is the encoder for the first knuckle or telescopic arm. When it is being used as a knuckle the data with the resolution 360°/65536 is being entered. If it is a distance being returned from the crane it is in the format 0 – 65535 cm
Value3	Value3 is the encoder for the second knuckle or telescopic arm. When it is being used as a knuckle the data with the resolution 360°/65536 is being entered. If it is a distance being returned from the crane it is in the format 0 – 65535 cm
Value4	Value4 is the encoder for the second knuckle or telescopic arm. When it is being used as a knuckle the data with the resolution 360°/65536 is being entered. If it is a distance being returned from the crane it is in the format 0 – 65535 cm
Value5	Value5 is the encoder for the first knuckle or telescopic arm. When it is being used as a knuckle the data with the resolution 360°/65536 is being entered. If it is a distance being returned from the crane it is in the format 0 – 65535 cm

Description of the encoder values:
The encoder readings are sent in an Unsigned 16 bit. The values are in hexadecimal format 0…65535 = 0x0000 …0xFFFF representing 0° - 360°.
If an encoder input is set to be used as a “Telescopic” in the IMU Configuration software, the given encoder value represents a distance value.
The length of a telescopic arm is given in the range of values:
Unsigned 16 bit; values in hexadecimal format 0…65535 = 0x0000 …0xFFFF representing 0 – 65535 cm.
If one rotational point is not being used or is not available input 0, 0000 or leave the position blank in the PLC string.
For example when Z-axis rotation is not available
$PENCR,0,Value2,encoder3,encoder4,encoder5
Or
$PENCR,,encoder2,encoder3,encoder4,encoder5

$PENCO
The $PENCO data string is similar to the $PENCR data string but uses standard notation for the values instead of hexadecimal i.e.:
$PENCO,value1,value2,value3,value4,value5<CR><LF>
$PENCO,32.1,-19.5,0.12,30.4,20.57
In the below example the knuckle at node 2 at 90 degrees so that the second leg of the crane is directed horizontally. From the second leg there is a telescopic arm extended 10 meters.
$PENCO,0,90,10,0,0
It is possible to also add decimals to the $PENCO string:
$PENCO,0,90.0,10.00,0.0,0.0

If there is no first value (crane rotation) it is excluded or sent as 0 in the same way as the $PENCR string.

Description	Form
Start Characters	$PENCO
Value1	Value1 is the encoder for the Z-axis/yaw/base rotation. I.e. typically the complete crane rotation. Data is in radians or degrees for angles depending of the settings.
Value2	Value2 is the encoder for the first knuckle or telescopic arm. When it is being used as a knuckle the data is entered as degrees or radians. If it is a distance being returned from the crane it is in meters.
Value3	Value3 is the encoder for the second knuckle or telescopic arm. When it is being used as a knuckle the data is entered as degrees or radians. If it is a distance being returned from the crane it is in meters.
Value4	Value4 is the encoder for the second knuckle or telescopic arm. When it is being used as a knuckle the data is entered as degrees or radians. If it is a distance being returned from the crane it is in meters.
Value5	Value5 is the encoder for the first knuckle or telescopic arm. When it is being used as a knuckle the data is entered as degrees or radians. If it is a distance being returned from the crane it is in meters.

Description of the encoder values:
The encoder readings are sent in standard encoding i.e.: -17.5, 0.123 and is given as radians or degrees depending on the setting in the configuration program.
If an encoder input is set to be used as a "Telescopic" in the IMU Configuration software, the given encoder value represents a distance value.
The length of a telescopic arm is given in meters i.e. 12cm is sent as 0.12

5.6.7 VERIFICATION STRING AND EXAMPLE STRINGS

When the IMU receives a proper $PENCR string with the crane position it will output a verification string with the latest received reading. The verification string is being output on the main com port and not in the serial input port.

The verification string corresponds to the $PENCR string and has the same string format.

If data is being received but is not readable by the motion sensor a fault message will be returned instead of the normal verification string. The Fault message is defined as a string that is not complete or cannot be parsed by the motion sensor.

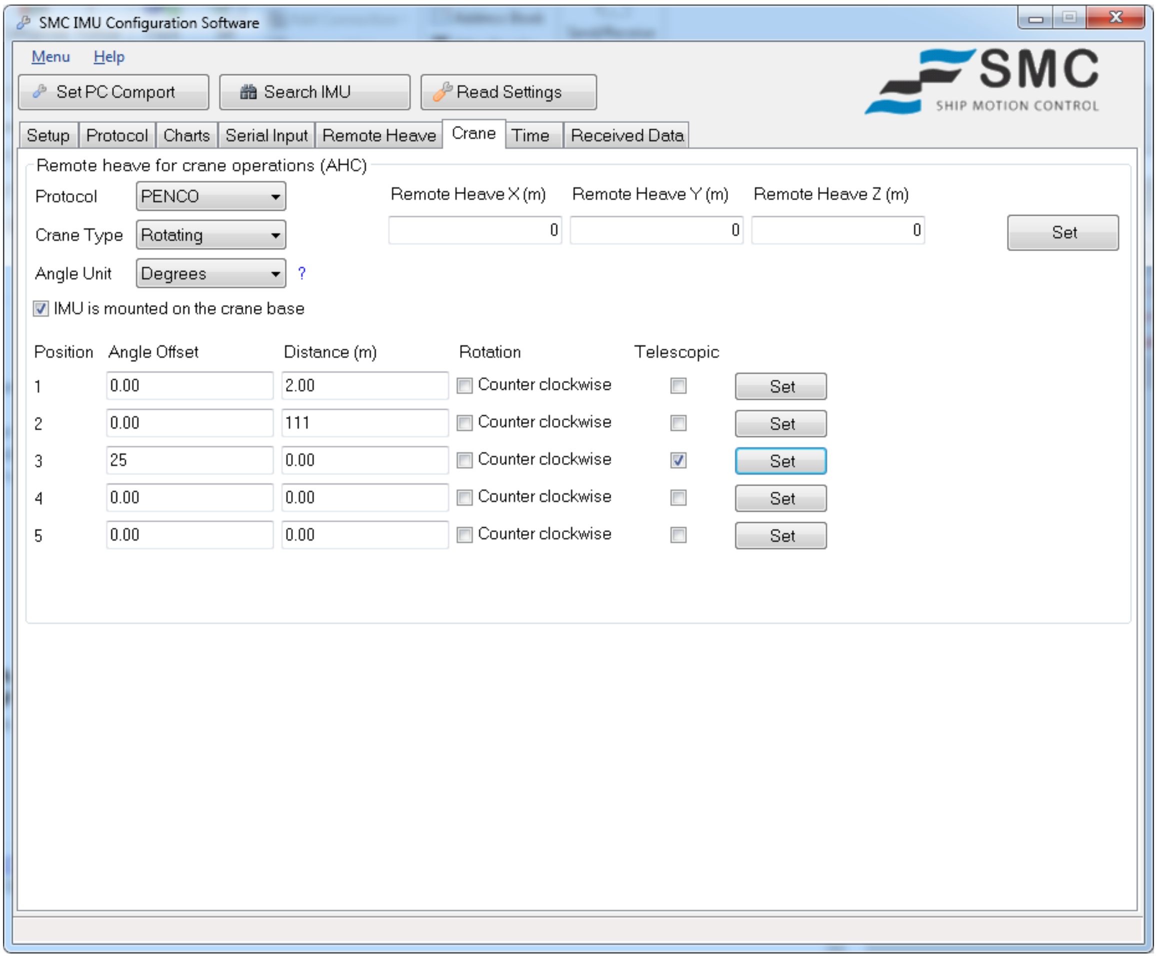
Example fault message
$PENCT,0000,0000,0000,0000,0000<CR><LF>

When this encoder position below is sent using the $PENCR string:
$PENCR,0000,3FFF,03E8,0000,0000
The motion sensor would return
$PENCT,0000,3FFF,03E8,0000,0000

5.6.8 TELESCOPIC ARM INPUT DATA

If the crane has a telescopic arm the **Telescopic** check button should be ticked for its position.
The distance column is disabled when the telescopic arm is ticked, as the distance to the start of the telescopic arm is to be entered in the previous row distance.
Zero encoder distance value is when the telescopic arm is fully retracted.

An angle offset can be entered for the telescopic position and it is referring to the offset in the telescopic arm.



If the crane has a fixed bend, it can be applied by either entering a fixed encoder value from the PLC/sending device or by entering an offset for the bend. This is done by entering an offset that is negative in value i.e. if the crane bend is clockwise positive/downwards the entered angular offset should be negative.

5.7 OPTIONAL SMC SOFTWARE

There are several optional PC based software packages available from SMC.
They present the vessel motions measured by the motion sensor in a graphical form.
Meteorological instruments are commonly integrated to the SMC software together with the motion sensor. The software displays the integrated instruments in real-time and is also logging the data for future analysis

Examples of SMC software packages are
SMC**mms**: Motion Monitoring System, a general monitoring tool that makes it possible to log and display all ship motions.
SMC**hms:** Helideck Monitoring System, a custom made system to monitor the motions of a helicopter deck.
SMC**ems:** Environmental Monitoring System
SMC**wms:** Weather Monitoring System

6 MOTION SENSOR OPERATION

6.1 SETTLING TIME

The SMC IMU internal filtering system uses both past and present data to calculate the output. Hence, immediately after being connected to its power source, the sensor will produce less accurate measurements since there are only short sequences of historical data available for processing.

The SMC IMU has a settling time of approximately 1 minute. This means that from the motion sensor startup it will take 1 minute till output data is shown. During this settling time the sensor output dependent on protocol selected could read for example $PSMCS,+rr.rr,+pp.pp,+hh.hh

6.2 HEAVE OPERATION

SMC IMU-008, IMU-106 and IMU-108 uses a heave measurement and filter system that continually monitors the motions and reviews the previous motions to maintain accurate results whatever the vessel size and sea state. Heave is not available on the IMU-007 and IMU-107 motion sensor.

Heave Zero Point, the zero point is set by the spectral analysis of the sinusoidal waveform along with using filtering techniques that can track the zero point of the heave motions within a maximum of 5 cycles. There is no need to input data of vessel type and sea states expected.

Heave Period; The SMC IMU technology enables the measurement of heave cycles with different periods without any manual setup. The IMU-008, IMU-106 and IMU-108 units adjust their calculations after the current motion and sea state and heave period.

7 SERVICE AND WARRANTY

7.1 TECHNICAL SUPPORT

SMC recommend a recalibration or verification of the motion sensor every second year of usage. This is due to the aging over time of the internal sensors and components in the motion sensor.

If you experience any problem, or you have a question regarding your sensor please contact your local agents or Ship Motion Control directly.

Refer to website www.shipmotion.se/contact.html

Please have the following information available
- Equipment Model Number
- Equipment Serial Number
- Fault Description

Worldwide Service contact
Telephone: +46 8 644 50 10 (CET 8am – 5pm)
E-mail: support@shipmotion.eu

Return Procedure

If this is not possible to solve the problem a Ship Motion Control technician will issue a Return Material Authorization Number (RMA#). Please be ready to provide the following information.
- Name
- Address
- Telephone, Fax, E-mail
- Equipment Model Number
- Equipment Serial Number
- Installation Date

If the Sensor is under warranty, repairs are free. If not there is a repair charge. Please see Ship Motion Controls warranty statement.

Pack the sensor in its original packaging, or suitable heavy packaging.

Mark the RMA# on the outside of the package

Return the Sensor, prepaid carrier to the address below.

SMC Ship Motion Control
203 Rue D'Argens, Area 2A
GZR1368 Gzira
Malta

7.2 WARRANTY

All products are inspected prior to shipment and guaranteed against defective material or workmanship for a period of two (2) years after date of purchase. Liabilities are limited to repair, replacement, or refund of the factory quoted price (SMC's option). SMC must be notified and provided with sufficient time to remedy any product deficiencies that require factory attention. This time period may include but is not limited to standard production lead times, travel time and raw material lead times. SMC will not be responsible for any charges related to repair, installation, removal, re-installation, or any actual, incidental, liquidated, or consequential damages. All claims by the buyer must be made in writing. All orders returned to SMC must have an issued RMA number supplied by SMC prior to shipment. Only SMC shall have the authority to issue RMA numbers.

Any products manufactured by others supplied with and/or installed with SMC's products are covered by the original manufacturers' warranty and are excluded from SMC's warranty

The product must be sent to SMC for repair or replacement.

7.2.1 LIMIT OF LIABILITY

SMC shall have no liability under the warranties in respect of any defect in the Products arising from: specifications or materials supplied by the Buyer; fair wear and tear; willful damage or negligence of the Buyer or its employees or agents; abnormal working conditions at the Buyer's premises; failure to follow SMC's instructions (whether oral or in writing); misuse or alteration or repair of the Products without SMC's approval; or if the total price for the Products has not been paid.

SMC shall in no event be liable for any indirect or consequential, or punitive damages or cost of any kind from any cause arising out of the sale, use or inability to use any product, including without limitation, loss of profits, goodwill or business interruption. In case of failure in the product SMC is not liable to compensate the buyer with anything exceeding the cost of the product sold by SMC Ship Motion Control.

The exclusion of liability in the Terms & Conditions shall not apply in respect of death or personal injury caused by SMC's negligence.

SMC shall not be bound by any representations or statements on the part of its employees or agents, whether oral or in writing, including errors made in catalogues and other promotional materials.

Please read the SMC Ship Motion Control terms and conditions for complete information.

7.2.2 RESTRICTION OF WARRANTY

The warranty does not cover malfunction of the motion sensor generated from

- If the IMU has been exposed to extreme shock and vibrations
- If the IMU case has been opened by the customer in an attempt to carry out repair work
- If the IMU has been fed with an over voltage in the power supply wires or the signal wires

The motion sensor electronics are shielded in a cast of plastic supported inside an outer casing made of Titanium to prevent damage from impact and moisture.

The SMC IMU should not be opened as this could affect the warranty on the unit. All operations inside the sensor should be carried out by SMC personnel.

8 TECHNICAL SPECIFICATIONS

8.1 IMU-00X TECHNICAL SPECIFICATIONS

Technical Specification	IMU-007	IMU-008
Roll / Pitch	Yes	Yes
Accelerations X,Y,Z	Yes	Yes
Heave	N/A	

Performance		
Angle Accuracy Static	0.2° RMS	0.2° RMS
Angle Accuracy Dynamic @ ±5º simultaneous roll and pitch	0.25° RMS	0.25° RMS
Resolution Angle	0.001°	0.001°
Resolution Heave	N/A	0.01m
Angle Range Roll / Pitch	±30°	±30°
Heave Range	N/A	± 10m
Heave Accuracy	N/A	5cm or 5%
Acceleration Accuracy	0.05 m/s² RMS	0.05 m/s² RMS

Communications	
IMU Configuration Software	The IMU is shipped with SMC configuration windows software allowing on site setup
Output Signal Protocol	Multiple, user selectable Output Protocols ASCII NMEA and binary
Communications Interface	Output RS422 and RS232, Analog and remote converter (optional) 2 x RS232 External inputs, (not available on all models) Velocity input formats RMC, RMA, VTG, BBV, VHW; Heading input formats HDT, HDG

Physical	
Dimensions for IMU-00x (WxH)	Tube Ø89 mm, mounting plate 134 mm, flange Ø110mm x 67 mm excl. connector
Weight	~0.5 kg
Housing Material	Titanium

Environmental	
Temperature (absolute max)	0° to +55° Celsius (-10° to 65°); Storage Temperature -40° to + 65° Celsius
Mounting Orientation	Vertical or Horizontal mounting (factory set)
Power Requirements	12 – 30 VDC; 2 W
MTBF (computed)	50 000 hours
Depth Rating	IP66 (standard); IP68 30 meter depth rated (optional)
Standards	IEC 60945/EN60945 standards on electromagnetic compatibility (immunity and radiation)

Warranty & Support	
Warranty	2-year Limited Hardware & Software Warranty
Support	Free Technical & Hardware Support

Bundled Delivery	
Junction Box	Multiple input & output connection case, including 10m cable (Longer Options available).

8.2 IMU-10X TECHNICAL SPECIFICATIONS

Technical Specifications	IMU-106	IMU-107	IMU-108
Roll / Pitch	N/A	Yes	Yes
Accelerations X,Y,Z	N/A	Yes	Yes
Heave	Yes	N/A	Yes

Performance			
Angle Accuracy Static	N/A	0.02° RMS	0.02° RMS
Angle Accuracy Dynamic @ ±5º simultaneous roll and pitch	N/A	0.03° RMS	0.03° RMS
Resolution Angle	N/A	0.001°	0.001°
Resolution Heave	0.01m	N/A	0.01m
Angle Range Roll / Heave	±30°	±30°	±30°
Heave Range	±10m	N/A	±10m
Heave Accuracy	5cm or 5%	N/A	5cm or 5%
Acceleration Accuracy	N/A	0.01 m/s² RMS	0.01 m/s² RMS

Communications	
IMU Configuration Software	The IMU is shipped with SMC configuration windows software allowing on site setup
Output Signal Protocol	Multiple, user selectable Output Protocols ASCII NMEA and binary
Communications Interface	Output RS422 and RS232, Analog and remote converter (optional) 2 x RS232 External inputs, (not available on all models) Velocity input formats RMC, RMA, VTG, BBV, VHW; Heading input formats HDT, HDG

Physical	
Dimensions for IMU-10 (W x H)	Tube Ø89 mm, mounting plate 134 mm, flange Ø110mm x 127 mm excl. connector
Weight	~2 kg
Housing Material	Titanium

Environmental	
Temperature (absolute max)	0° to +55° Celsius (-10° to 65°); Storage Temperature -40° to + 65° Celsius
Mounting Orientation	Vertical or Horizontal mounting (factory set)
Power Requirements	12 – 30 VDC; 2 W
MTBF (computed)	50 000 hours
Depth Rating	IP66 (standard); IP68 30 meter depth rated (optional)
Standards	IEC 60945/EN60945 standards on electromagnetic compatibility (immunity and radiation)

Warranty & Support	
Warranty	2-year Limited Hardware & Software Warranty
Support	Free Technical & Hardware Support

Bundled Delivery	
Junction Box	Multiple input & output connection case, including 10m cable (Longer Options available).

9 FAQ & SUPPORT

If no communication is seen or bad data is displayed, please refer to the FAQs below which cover the most common configuration problems.

Configuration

Is the unit sending data with RS422 or RS232?

The motion sensor is “always on” and sends data over the RS232 and RS422 channels simultaneously. The IMU sensor junction boxes are dispatched pre-configured for either RS422 or RS232.
Check the wiring as per the Electrical configuration guide to see which output is being used.

Data is being received but is either seen as bad data or wrong data.

Check which format your sensor has been configured with or contact SMC quoting the units serial number for confirmation.

When applying a setting change in the SMC setup software the output signals can display bad data. This occurs during the automatic restart of the sensor unit, the values will settle after a few minutes.

Data that is being received is missing data or freezing. First check if the Output Rate is set too high for the configured output string and baud rate. Details are supplied in **Section 5.2** for each protocol.

Also check the Serial port, if using a Serial to USB adapter, use a high quality adapter. Contact SMC for advice.

Parameters changed in the Configuration software are not being set in the IMU.

If after pressing the set button the parameters set in the IMU are not changing, check if the IMU serial number and software version is displayed in the configuration software.
If not, press the **Read Settings** button. If the data is still not showing this is typically due to the lack of two way communication to the IMU. The Receive data lines are connected but not the Transmit data lines. Check the wiring through to the IMU.

Are the cables connected correctly? See Chapter 4 **Sections 4.7 and 4.8**

No Communication with the IMU

Check the cable connection and disconnect and reconnect is necessary.
Is the sensor powered up? Voltage should be 9 to 30 VDC see **Section 4.7 and 4.8**

Check what Baud Rate and Output Rate should be used or has been set up. Use the **Search IMU** button to scan all available ports.

The default baud rate set when the unit is shipped from SMC is 115200 and the standard output rate is set to 100Hz. (note for SMCems software the IMU output rate should be 10Hz).

If there is a chance that the baudrate has been changed and the **Search IMU** button does not find the IMU, systematically check each baud rate option in the SMC setup software till the correct rate is found.

When applying a setting change in the SMC configuration software the output signals can display bad data. This occurs during the automatic restart of the sensor unit, the values will settle after a few minutes.

No GPS or Gyro data is received

Select the relevant **Verify** button in the Serial Input configuration screen.
If no data is received check the baud rate setting of the GPS device. Set the GPS to 4800 baud rate if set higher and verify again.
Check the wiring of the RS232 serial input see **Section 4.7 & 4.8**.

Heading Information from GPS is not shown in the Output Protocol

There is a check button in the SMC configuration software to accept the heading string from the GPS ($GPHDT) See **Section 5.5**. Check the box labeled **Use GPS Heading input for Yaw aiding if available**.