Ekinox Subsea series

Inertial Navigation Systems

Hardware Manual

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Revision history

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1.4	Jun 9, 2016	Alexis Guinamard	[EKIDOC-61] Added missing power supply specifications [EKIDOC-47] Improve distinction between Ekinox-M and Ekinox-U capabilities [EKIDOC-62] Split User Manuals in two new documents: Technical Reference Manual and Hardware Manual [EKISUBHM-7] Update support contact details [EKISUBHM-9] Clarify pinout for power GND and data GND
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Terminology

ADC: Analog to Digital Converter
AHRS: Attitude and Heading Reference System
DHCP: Dynamic Host Configuration Protocol
DVL: Doppler Velocity Log
EKF: Extended Kalman Filter
EEPROM: Electrically-Erasable Programmable Read-Only Memory
FIR: Finite Impulse Response (filter)
FTP: File Transfer Protocol
FS: Full Scale
FOG: Fiber Optic Gyroscope
GNSS: Global Navigation Satellite System
GPS: Global Positioning System
IIR: Infinite Impulse Response (filter)
IMU: Inertial Measurement Unit
INS: Inertial Navigation System
IP: Internet Protocol
LBL: Long Baseline
MAC (address): Media Access Control
MEMS: Micro Electro-Mechanical Systems
NED: North East Down (coordinate frame)
NA: Not applicable
NMEA (NMEA 0183): National Marine Electronics Association (standardized communication protocol)
PPS: Pulse Per Second (signal)
RAM: Random Access Memory
RMA: Return Merchandize Authorization
RMS: Root Mean Square
RTCM: Radio Technical Commission for Maritime Services (Protocol)
RTK: Real Time Kinematics
SI: International System of Units
TBD: To Be Defined
TCP: Transmission Control Protocol
UDP: User Datagram Protocol
UTC: Coordinated Universal Time
USBL: Ultra Short Base Line
VRE: Vibration Rectification Error
WGS84: World Geodetic System 1984
WMM: World Magnetic Model

1. Introduction

Figure 1.1: The Ekinox Subsea

Ekinox Subsea series are state of the art, MEMS based Motion Reference Unit (Ekinox-M) and Inertial Navigation System (Ekinox-U) which achieves tactical grade accuracy in a compact subsea enclosure. It includes an Inertial Measurement Unit (IMU) and runs an on-board enhanced Extended Kalman Filter (EKF). In addition, to vessel orientation, the Ekinox subsea will provide accurate ship motion data (heave, surge and sway) at high rate. Created to achieve the best accuracy for every application, Ekinox Subsea also integrates data from various aiding equipments such as GPS, DVL, etc.

To achieve the best performance in every project, specific error models have been implemented to meet applications requirements. An embedded web interface enables easy configuration and a wide connectivity as well as standard protocols output provide direct integration into existing applications.

1.1. Ekinox INS Overview

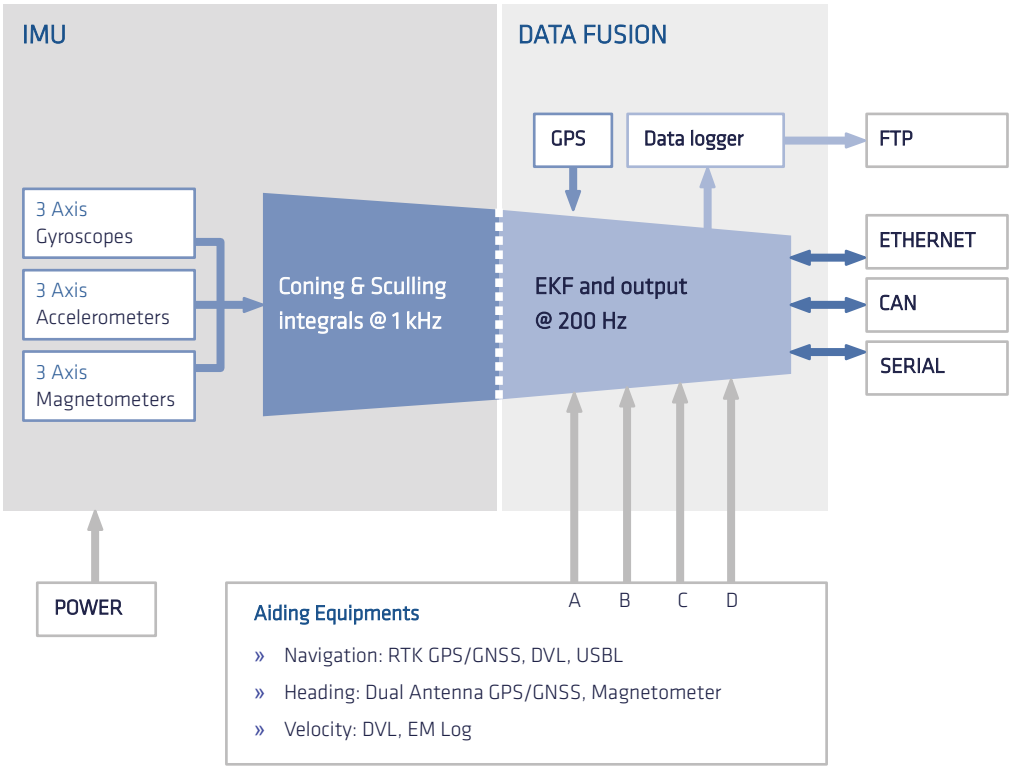


Figure 1.2: Ekinox Subsea simplified block diagram

2. Performance specification

2.1. Inertial measurement unit

As an IMU is the main component of an inertial navigation system, the Ekinox IMU has been carefully designed to take full advantage and performance of MEMS technology.

2.1.1. Accelerometers

The Ekinox IMU embeds a set of 3 MEMS capacitive accelerometers. Coupled with advanced filtering techniques and sculling integrals, these accelerometers will provide consistent performance, even in vibrating environment.

	A1	A3	Remarks
Full scale (*g*)	2	10	
One year bias stability (µ*g*)	300	1500	
In run bias instability (µ*g*)	10	40	Allan variance – @ 25°C
Velocity Random Walk (µ*g*/√hz)	18	100	Allan variance – @ 25°C
Gain (ppm)	300	300	
Linearity (% of FS)	0.05	0.05	
Noise (µ*g*)	90	450	Over 1 to 25 Hz band
Bandwidth (Hz)	100	100	Attenuation < 3 dB
Resolution (m*g*)	0.1	0.6	
Sampling rate (kHz)	5	5	
Orthogonality (°)	0.03	0.03	

2.1.2. Gyroscopes

The set of 3 high end tactical grade MEMS gyroscopes is sampled at 1 000 KHz. An efficient FIR filter and coning integrals computations ensures best performance in vibrating environments.

	G4	Remarks
Full scale (°/s)	400	Specified performance, saturates at 450°/s
One year bias stability (°/hr)	< 300	Total composite bias
In run bias instability (°/hr)	< 3	Allan variance – @ 25°C
Angular Random Walk (°/hr/√hz)	< 30	Allan variance – @ 25°C
Gain (ppm)	300	
Linearity (% of FS)	0.05	
Noise (°/s)	0.3	Over 1 to 25 Hz band
Bandwidth (Hz)	100	Attenuation < 3 dB
Resolution (°/s)	0.03125	
Sampling rate (kHz)	1	

Orthogonality (°)	0.03

2.1.3. Magnetometers

The Ekinox embeds a high performance, three axis Anisotropic Magnetoresistive Magnetometer.

	Specifications	Remarks
Full scale (Gauss)	6	
Gain (ppm)	1000	
Linearity (% of FS)	0.1	
Noise (µGauss)	50	Over 1 to 25 Hz band
Bandwidth (Hz)	50	Attenuation < 3 dB
Resolution (µGauss)	120	
Sampling rate (kHz)	1	
Orthogonality (°)	0.1	After user magnetic calibration

2.2. Aiding sensors

Many different aiding sensors can be used to aid the Ekinox INS.

2.2.1. Internal magnetometer

Although part of the Ekinox internal IMU, the magnetometer is in fact considered as an “aiding sensor” and is not mandatory for proper operation.

Nevertheless, in some applications this magnetometer is still a reliable and efficient way to observe heading.

Note: Magnetometer use requires a specific in place calibration in order to compensate surrounding ferromagnetic materials and magnets. Please refer to the Ekinox Iron Calibration Tools documentation for more information about this.

2.2.2. External aiding sensors

The Ekinox-M accepts a single external GNSS receiver connection to improve orientation performance

The Ekinox-U accepts up to two external GNSS receivers to provide navigation data and improve orientation performance In addition, a DVL can be connected on Ekinox-U as velocity aiding input.

2.3. Orientation and Navigation Performance

All specifications are rated to 1σ, over -40°C to +75°C unless otherwise stated.

These specifications have been obtained by field tests, using typical mission scenarios and comparison to reference units using post-processing. Outage performance validated by simulation of repeated, pure GNSS outages, separated by at least 200s of optimal GNSS condition, compared to a reference RTK trajectory.

Performance parameters may be affected in multi-path and poor GNSS reception environments such as Urban canyons.

For each application, we present the specified accuracies for the following positioning modes:

- **SP:** Single Point mode and is the default L1 GPS fix quality
- **RTK:** Real Time Kinematics with a typical 1 cm accuracy position
- **PP**: Post Processed data using Inertial Explorer with at least Precise Point Positioning data

2.3.1. Common specifications

	Performance	Remarks
Measurement range	360° in all axes, no mounting limitation	Solid state sensors
Orientation noise	< 0.03° RMS	Static

2.3.2. Orientation and navigation

All specifications are valid with dual antenna aiding for typical marine survey trajectories.

Outage Duration	Positioning Mode	Position Accuracy		Velocity Accuracy		Attitude Accuracy (°)	
		Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
0 s	**SP**	1.20 m	2.0m	0.02 m/s	0.02 m/s	0.05°	0.1 (baseline > 2m)
	RTK	0.01 m	0.02m	0.02 m/s	0.02 m/s	0.05°	0.05 (baseline > 4m)
	PP	0.01 m	0.02 m			0.02°	0.04°
10 s	**SP**	2.0 m	3.0m	0.1 m/s	0.03 m/s	0.1°	0.15 (baseline > 2m)
	RTK	0.35 m	0.15m	0.1 m/s	0.03 m/s	0.1°	0.1 (baseline > 4m)
	PP	0.03 m	0.03 m			0.02°	0.05°
30 s	**SP**	5.5m	2.5 m	0.3m/s	0.5 m/s	0.15°	0.2(baseline > 2m)
	RTK	4.0 m	0.5 m	0.3 m/s	0.05 m/s	0.15°	0.15 (baseline > 4m)
	PP	1.5 m	0.5 m			0.04°	0.07°

2.3.3. Heave performance

	Real Time Heave	ShipMotionHP	Remark
Range	50 meters	50 meters	Automatic adjustment to every sea conditions
Period	0 to 25 s	0 to 50 s	
Accuracy	5 cm or 5%	2.5 cm or 2.5 %	Whichever is greater; Velocity aided heave
Mode	Real time, auto tuning	Fixed 450s delay	On board computation

2.3.4. Real time Performance monitoring

The Extended Kalman filter provides feedback about its performance. The following thresholds are defined for the Ekinox series:

	Threshold	Comments
Attitude Valid	0.3° / 0.07°	AHRS / Normal INS mode
Heading Valid	0.5° / 0.2°	AHRS / Normal INS mode
Velocity Valid	0.2m/s	Total velocity error (3D)
Position Valid	1m	Total position error (3D)

Note: The thresholds are less accurate in AHRS mode, when there is no GNSS aiding available. Full performance can be reached with GNSS aiding

3. Mechanical specifications

3.1. Overview

The Ekinox Subsea enclosure is composed of titanium parts, one for the cover and one for the base plate. The device uses high quality alloys and connectors to offer a depth rating of 200 m or 6 000 m, and good resistance to seawater environment.

Note: If you are planing to use Ekinox internal magnetometers, please make sure that you don't use ferromagnetic materials to mount the device.

3.1.1. Main Specifications

The table below summarizes all mechanical and environmental specifications.

Specifications	Titanium 200 (EL)	Titanium 6 000 (ED)
Depth Rating	200m	6 000m
Weight in air	1.55 Kg (3.4 lbs)	2.34 Kg (5.2 lbs)
Weight in water	0.86 Kg (1.9 lbs)	1.43 Kg (3.2 lbs)
Diameter	8.7 cm (3.4")	9.2 cm (3,6")
Height	13.8 cm (5.4")	15.5 cm (6.1")
Shocks	500 g for 0.3 ms	
Operating Vibrations	1g RMS – 20Hz to 2 kHz as per MIL-STD-810G	
Operating Temperature range	-20 to 60°C (-4 to 140°F)	
Storage Temperature range	-20 to 60°C (-4 to 140°F)	
MTBF (computed)	50.000 hours	
Calibration interval	None required, maintenance free	

3.1.2. Device mechanical alignment

For best measurement accuracy, a good mechanical alignment is required. During manufacturing, the Ekinox measurement frame has been carefully aligned to 0.02° with the base plate for roll, pitch and yaw angles.

To ease the yaw alignment (X axis), the base plate features two alignment holes Ø 4 mm H8 that guarantees with two taper pins Ø 4 mm h7 a yaw alignment better than ±0.04°.

3.1.3. Origin of measurements

The center of measurement for acceleration, velocity and position is represented on the mechanical outlines by the ◓ symbol. It is referenced to the base plate fine alignment hole.

3.1.4. Device label

SBG Systems manufacturing process is based on EN-9100 system with individual and full traceability of every component and operation. Each Ekinox is identified by a unique serial number that can be used to trace all operations during the product lifetime such as manufacturing, calibration, tests and repairs.

In addition to a unique serial number, a product code is used to define exactly the device type and options. Finally, the Ekinox features an Ethernet interface and a unique MAC address is required to identify the device on a network.

You can find on the back side of the Ekinox a laser printed label that hold all these identification information. This label also includes a data-matrix code that encodes the device unique serial number.

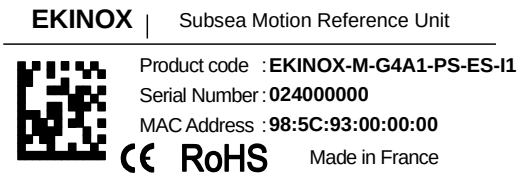
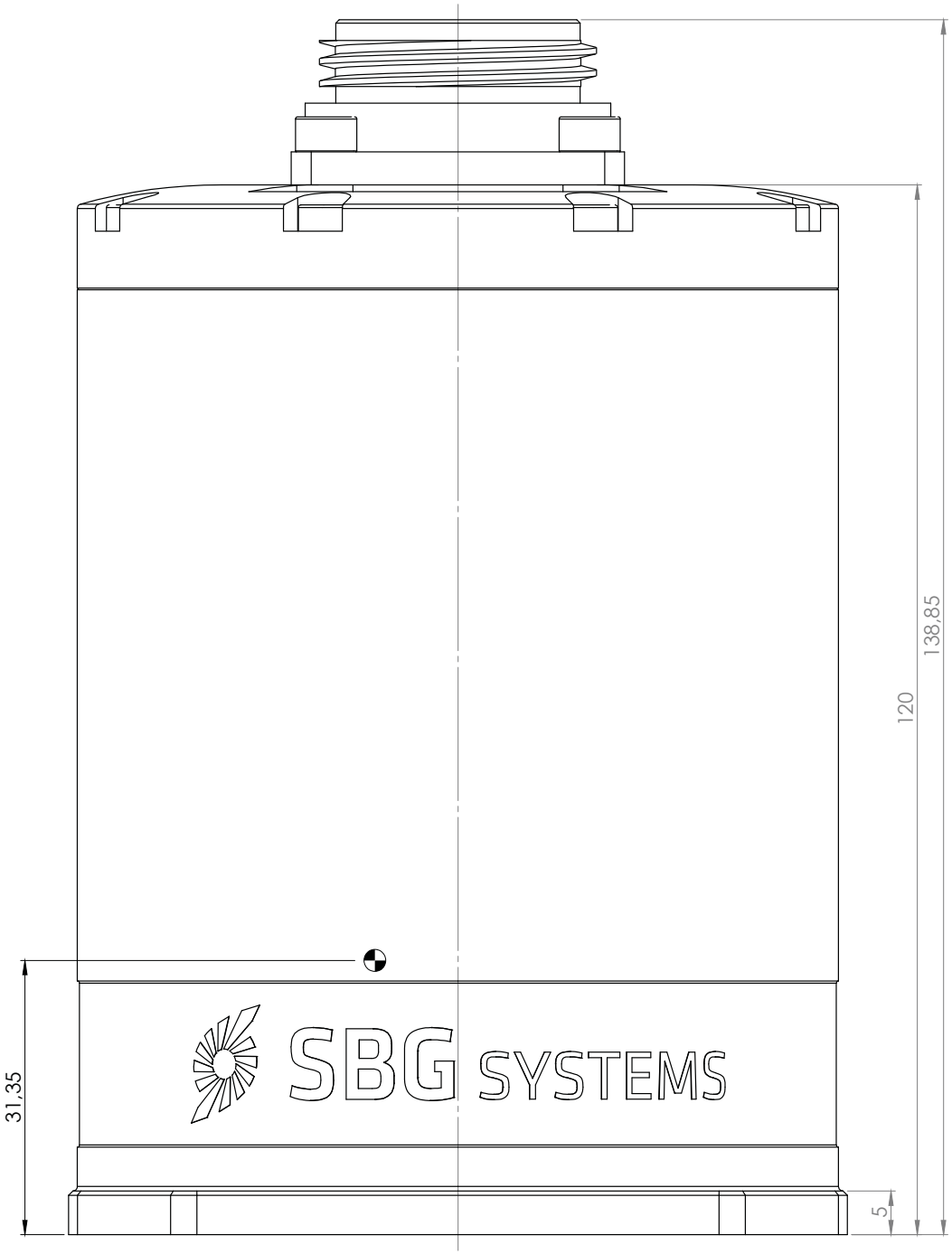


Figure 3.1: Ekinox device label sample

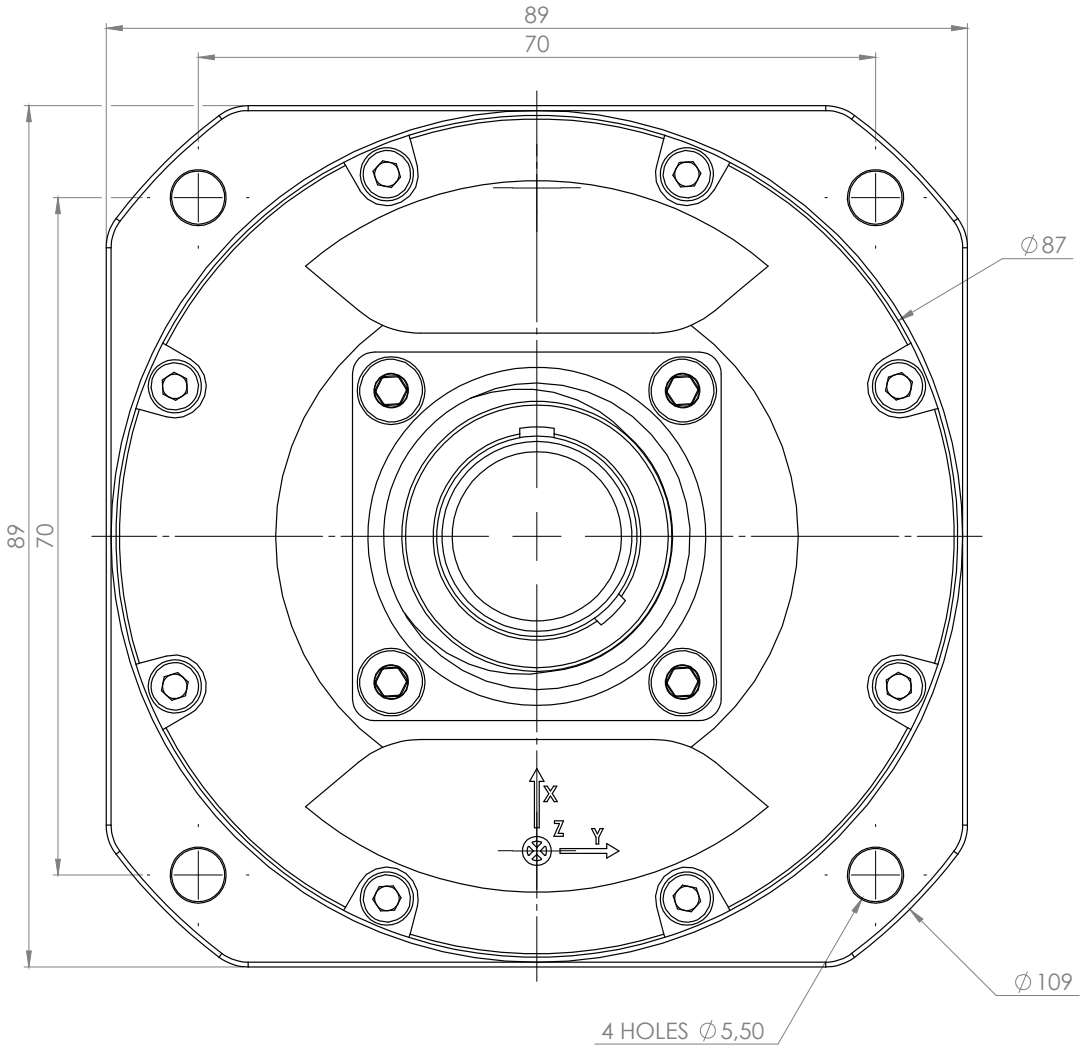
3.2. EKINOX Subsea EL mechanical outline (200 m)

All dimensions are in mm.

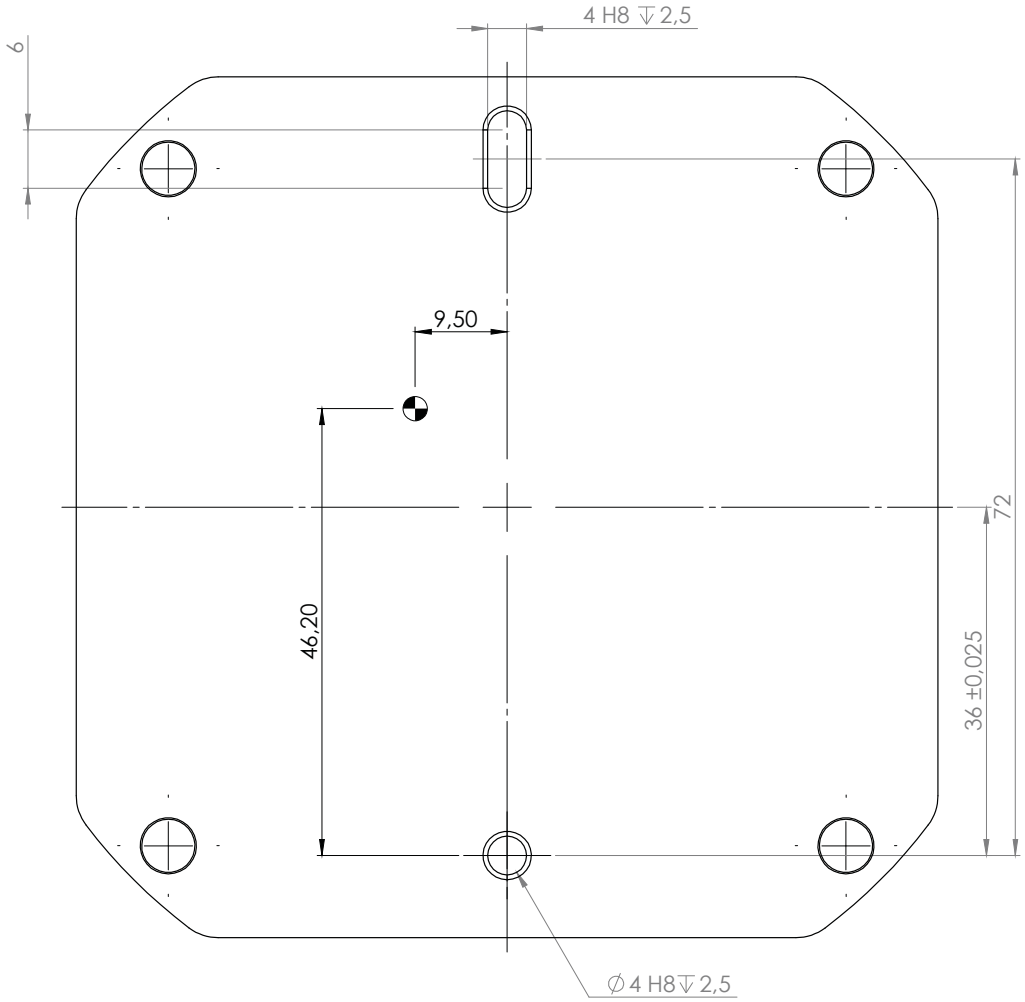
3.2.1. Front view



3.2.2. Top view



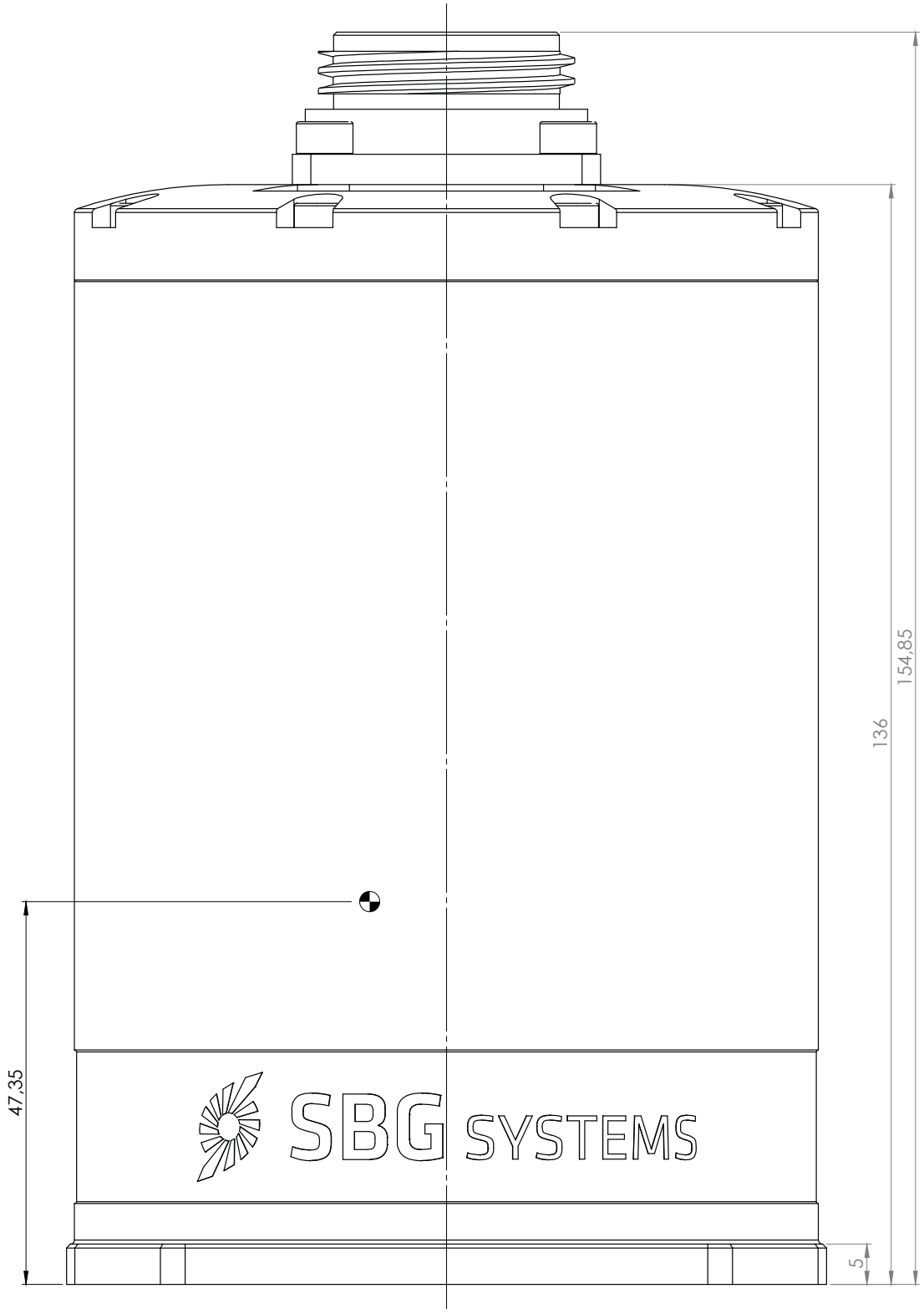
3.2.3. Bottom view



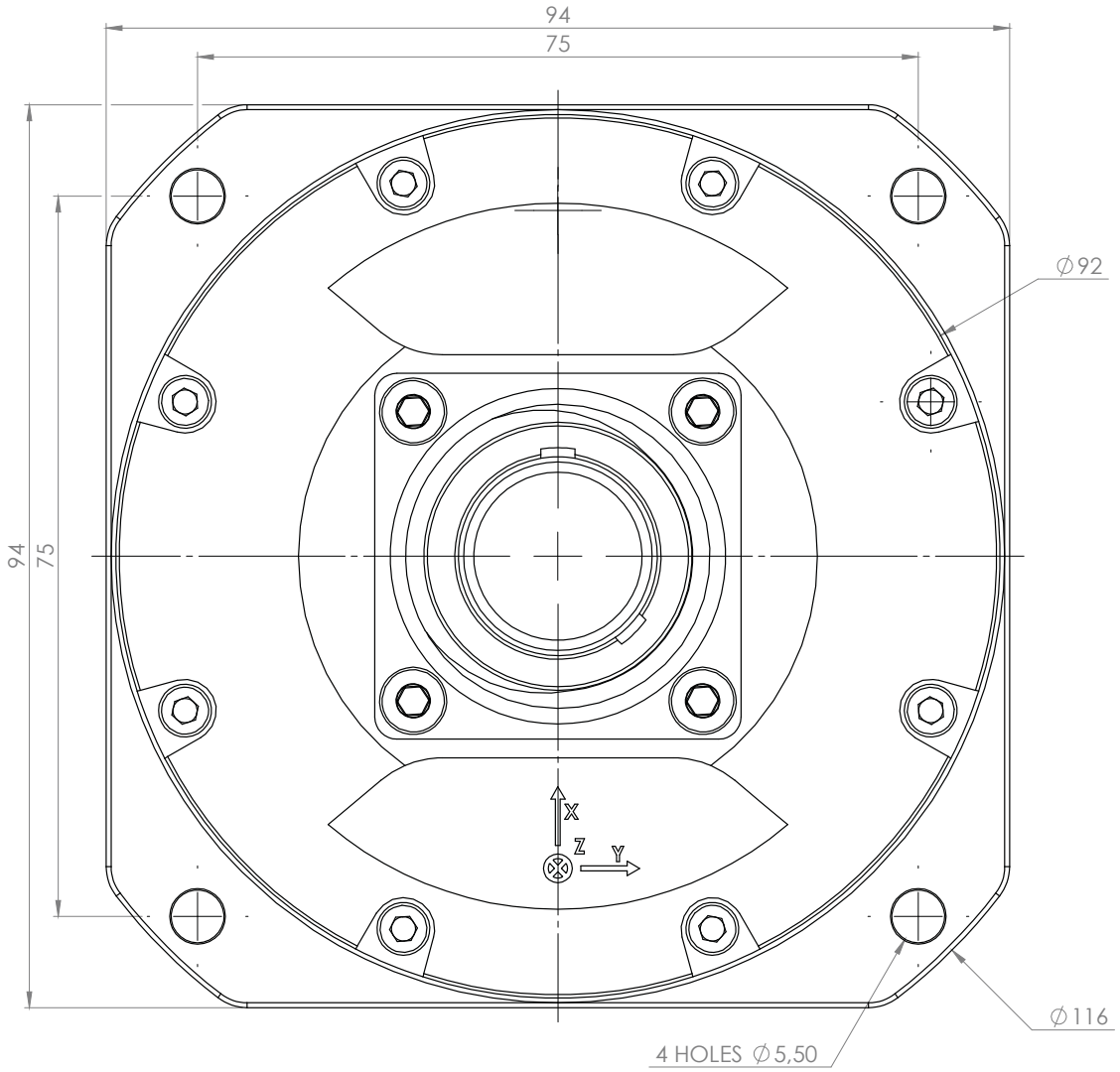
3.3. EKINOX Subsea ED mechanical outline (6 000 m)

All dimensions are in mm.

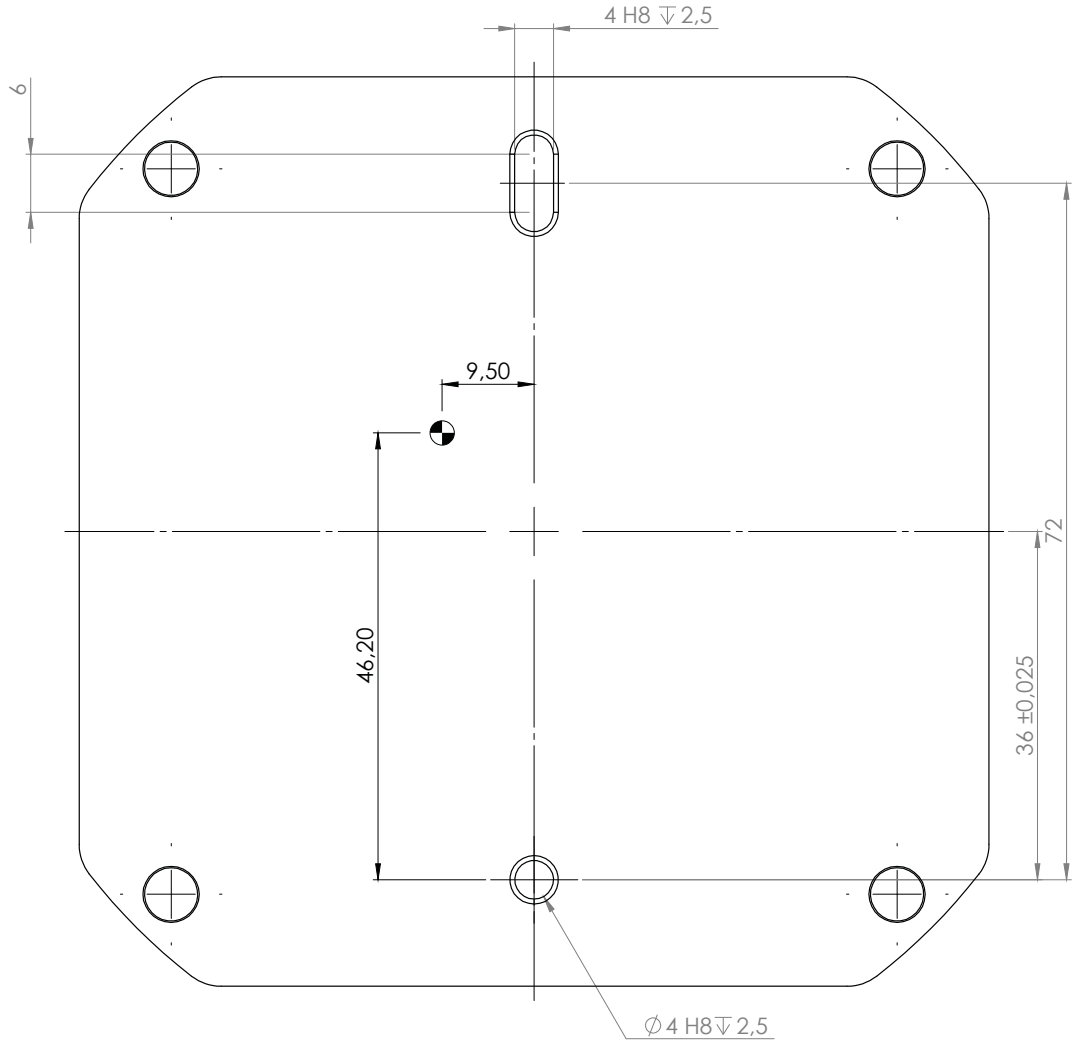
3.3.1. Front view



3.3.2. Top view



3.3.3. Bottom view



4. Electrical specifications

4.1. Main connector

The main Ekinox Subsea connector, located on the top of the enclosure, is an underwater electrical dry-mate SEACON 37 ways MINI-CON connector. The exact reference is MINM37#22-FCR-Ti.

It is manufactured from Titanium Ti6Al4V and withstands up to 20000 PSI, thus exceeding the pressure rating of the enclosure for all its variants. A Titanium version is also available, extending the depth rating up to 13700m (a specific enclosure would be needed to reach this rating).

The following diagram shows the pin-out definition for the Ekinox Subsea connector.

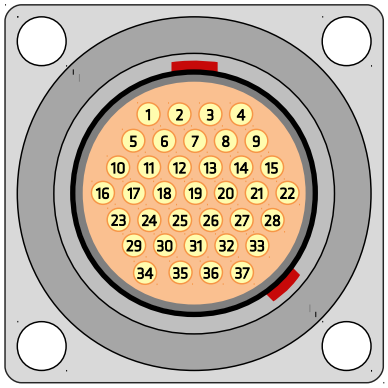


Figure 4.1: MINM37#22-FCR pin numbering

4.1.1. Main connector pin out

Pin #	Name	Remarks
1	Port A - RS-422 - Tx+	Port A serial output RS-422
2	Port A - RS-232/RS-422 - Tx-	Port A serial output RS-232/RS-422
3	Port B - RS-232/RS-422 - Rx+	Port B serial input RS-232/RS-422
4	Port B - RS-422 - Rx-	Port B serial input RS-422
5	Ethernet Rx+	White/Orange RJ45 pin# 3
6	Ethernet Rx-	Orange RJ45 pin# 6
7	NC	Not connected
8	Port C - RS-422 - Tx+	Port C serial output RS-422
9	Port C - RS-232/RS-422 - Tx-	Port C serial output RS-232/RS-422
10	Ethernet Tx+	White/Green RJ45 pin#1
11	Ethernet Tx-	Green RJ45 pin#2
12	Port A - RS-232/RS-422 - Rx+	Port A serial input RS-232/RS-422
13	Port A - RS-422 - Rx-	Port A serial input RS-422
14	Port C - RS-232/RS-422 - Rx+	Port C serial input RS-232/RS-422
15	Port C - RS-422 - Rx-	Port C serial input RS-422

Pin #	Name	Remarks
16	VDD_PWR	Positive power supply
17	Sync In D	Synchronization input signal D
18	GND_PWR	Data Ground return
19	NC	Not connected
20	Port B - RS-422 - Tx+	Port B serial output RS-422
21	Port B - RS-232/RS-422 - Tx-	Port B serial output RS-232/RS-422
22	GND	Power Ground return
23	Sync In B	Synchronization input signal B
24	GND	Power return, the enclosure is isolated from the electrical ground
25	Port D - RS-232/RS-422 - Rx+	Port D serial input RS-232/RS-422
26	Port D - RS-422 - Rx-	Port D serial input RS-422
27	Sync Out B	Synchronization output signal B
28	GND	Data Ground return
29	Sync In A	Synchronization input signal A
30	GND	Data Ground return
31	NC	Not connected
32	Port E - RS-232/RS-422 - Rx+	Port E serial input RS-232/RS-422
33	Port E - RS-422 - Rx-	Port E serial input RS-422
34	Sync In E	Synchronization input signal E
35	GND	Data Ground return
36	Sync Out A	Synchronization output signal A
37	GND	Data Ground return

Note: Unlike the Ekinox surface version the subsea one doesn't provide Sync In C signal. However, please keep in mind that the synchronization input signals are not hard linked to a serial port.

Note 2: The enclosure is isolated from the electrical grounds. The power and data ground are internally connected but their pinout must be respected for forward compatibility

Warning: For previous Ekinox Subsea units with product codes EKINOX-#-G4A1-PS-E#-I#, the Sync In C signal was available instead of the Sync In D.
Please not that it will only impact the Ekinox software configuration as no electrical modification has been made.

4.2. Electrical specifications

Electrical specifications from -20°C to 60°C.

Parameter	Conditions	Min.	Typ.	Max.	Units
Power supply					
Operating voltage		9	12	36	VDC
Power consumption			3		W
Allowable Input Voltage Ripple				400	mV p-p
Under voltage lock out	Turn on threshold		8,5		V
	Turn off threshold		7,5		V
Galvanic Isolation				200	VDC
Sync Out A, Sync Out B					
Output Type		Open-Drain			-
High-level Input Voltage				25	V
Low-level Output Voltage			0,25	0,4	V
Low-level Output Current				40	mA
Sync In A, B, D, E					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0,8	1,5		V
	Threshold High		1,8	2,7	V
Input Hysteresis			300		mV
Input Resistance		3	5	7	kΩ
Maximum Sync Pulse Rate		1			kHz
Port A, B, C, D, E – RS-422 – Receiver					
Receiver Data Rate		4800		921600	bps
Input Resistance	-7V < Common Mode Voltage < +12V	96			kΩ
Input Current	Common Mode Voltage = -7V			-0,075	mA
	Common Mode Voltage = +12V			0,125	mA
Input Differential Threshold	-7V < Common Mode Voltage < +12V	-200		-50	mV
Input Hysteresis			30		mV
PORT A, B, C – RS-422 – Transmitter					
Transmitter Data Rate		4800		921600	bps
Transmitter Rise & Fall Time	Data rate <= 230400	200	400	800	ns
	Data rate > 230400		10	25	ns
Differential Output Voltage		2			V
Change in Magnitude of Output Voltage for Complementary Output States				0,2	V
Common-Mode Output Voltage				3	V

Parameter	Conditions	Min.	Typ.	Max.	Units
Output Short-circuit Current	-7V < TX+ or TX- < +12V			±250	mA
Port A, B, C, D, E – RS-232 Receivers					
Receiver Data Rate		4800		921600	bps
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0,8			V
	Threshold High			2,4	V
Input Hysteresis			500		mV
Input Resistance		3	5	7	kΩ
PORT A, B, C – RS-232 – Transmitters					
Transmitter Data Rate		4800		921600	bps
Transition-Region Slew Rate	Data Rate <= 230400 bps	4		30	V/µs
	Data Rate > 230400 bps	13		150	V/µs
Output Voltage Swing	Tx loaded with 3kΩ to GND_MAIN	±5	±5,4		V
Output Short-Circuit Current	Tx = GND		±30	±60	mA

4.3. Typical wiring

In this section, we briefly describe a few recommended wiring diagrams.

4.3.1. RS-232 basic communications

Below is shown the main interface (Port A) connection, using a full duplex RS-232 connection using the standard cable provided with the Ekinox Subsea. See section Appendix A: Ordering codes and Accessories for more details about this cable.

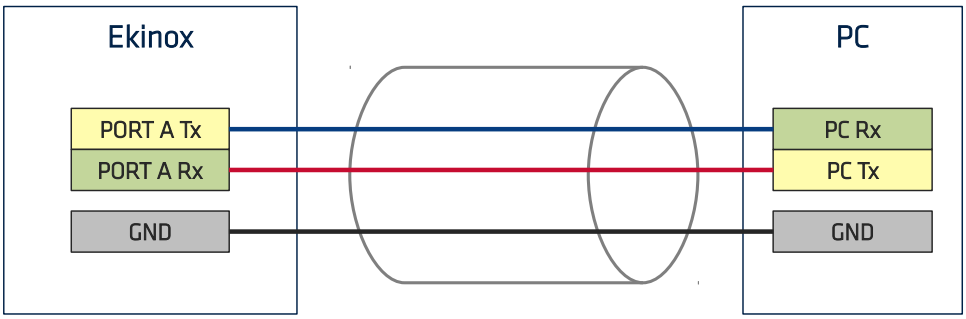


Figure 4.2: Main serial interface full duplex connection in RS-232

4.3.2. RS-422 basic communication

Below is shown the main interface (Port A) connection, using a full duplex RS-422 connection using the standard cable provided with the Ekinox Subsea. See section Appendix A: Ordering codes and Accessories for more details about this cable.

Note the termination resistors (Usually 120 ohms) that can optionally be placed on receiver side to avoid communication errors in long distance communications. These resistors can be omitted in short distance communications in order to reduce power consumption.

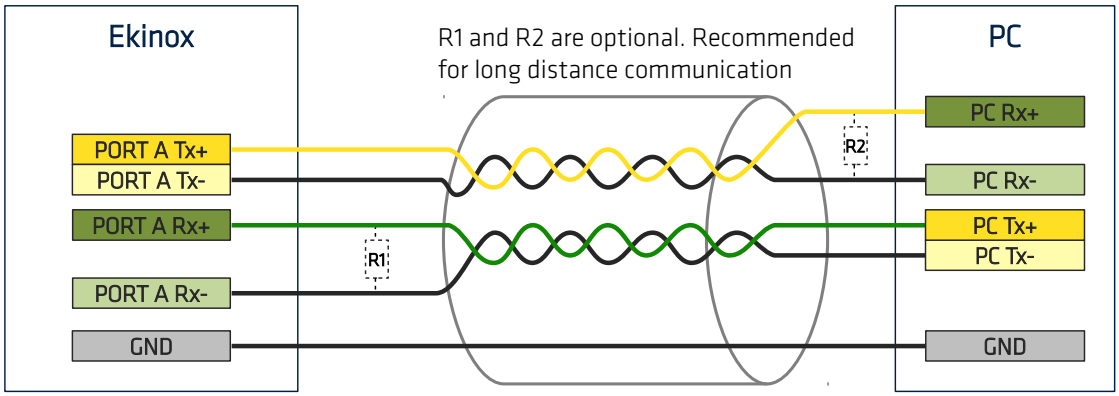


Figure 4.3: Main serial interface full duplex connection in RS-422 mode

4.3.3. GNSS connection in RS-232 mode

For this typical connection, a shielded AWG 26 cable should be used. Depending on PPS signal strength, we do not recommend this cable to measure more than a few meters. For long distance, PPS signal and GPS NMEA signals should be separated in two cables for better noise immunity.

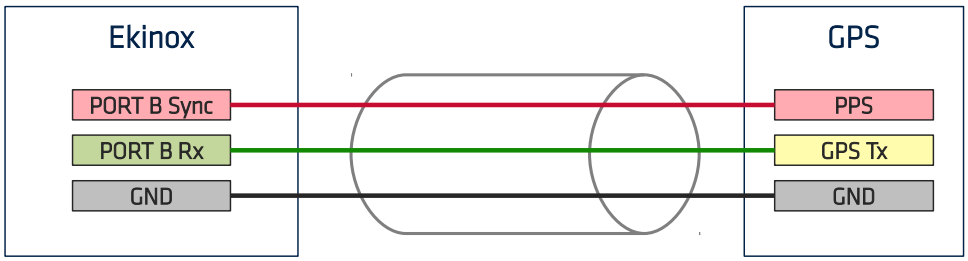


Figure 4.4: Typical wiring diagram for Ekinox M / U with external GNSS receiver

4.3.4. Triggering external devices with the sync Out

Consider a camera that must take a picture when an event is provided on Event Out pin. Event Out and Sync Out are “open drain” outputs, which means a pull up resistor must be used on receiver side, as shown on the diagram.

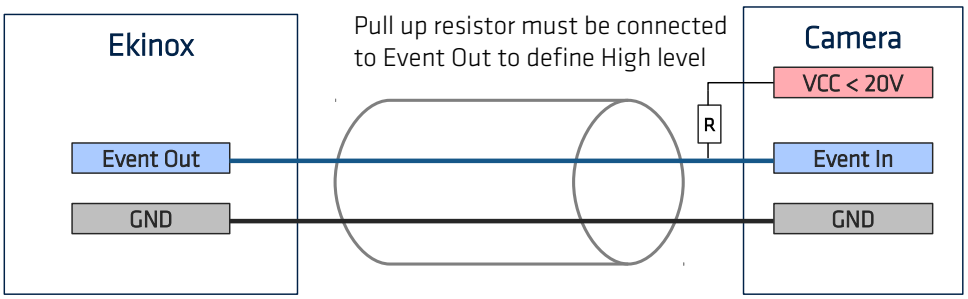


Figure 4.5: Sync Out connection with pull up resistor

4.4. Typical connection topologies

The following use cases are presented to quickly show how to connect the Ekinox to various external materials in different applications.

4.4.1. Ekinox-U in marine application

In the next application example, the Ekinox is used for both vessel display and monitoring, as well as ship motion sensor for several third party equipments.

Connections are made easy using Ethernet interface when available with external devices.

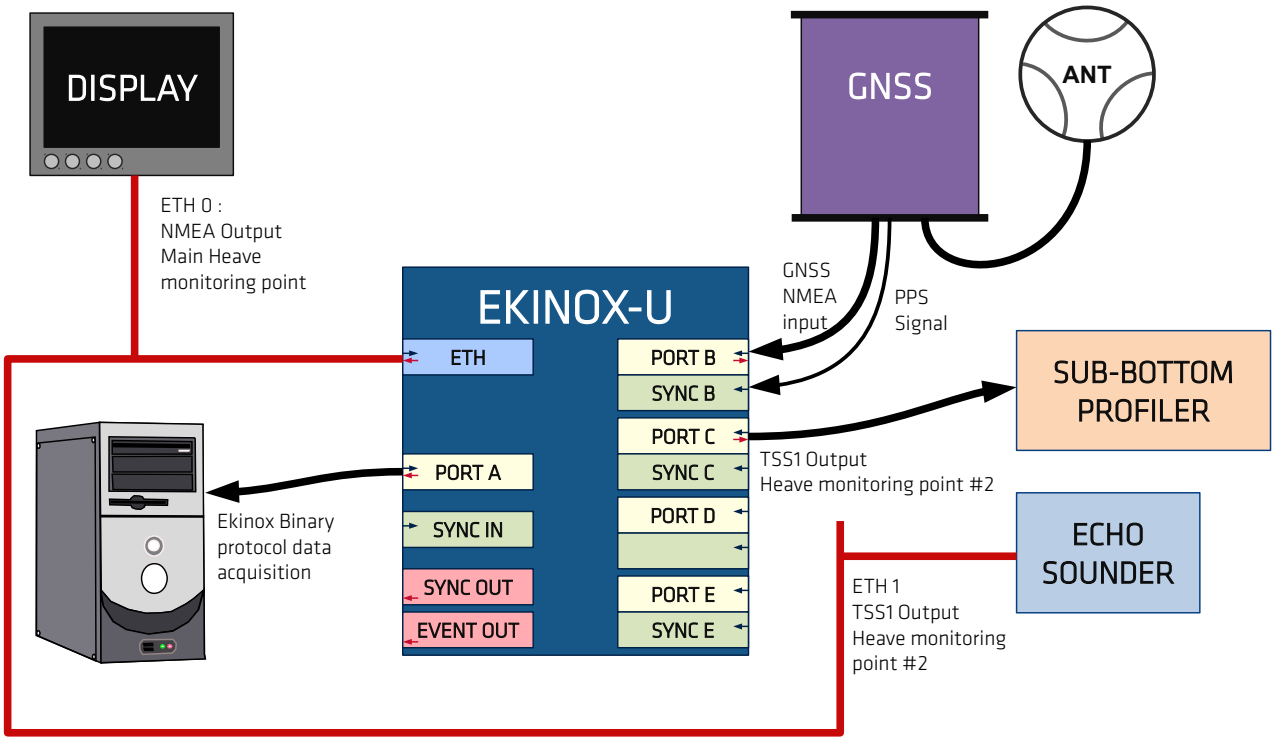


Figure 4.6: Ekinox-U use in advanced Marine application

5. Interfaces specifications

5.1. Interfaces Overview

The Ekinox Subsea series feature the following interfaces:

- An Ethernet Interface
- 5 Physical RS-232/RS-422 serial ports (Port A to Port E).
- Internal data logger

5.2. Ethernet specifications

The Ekinox main port features an Ethernet 100BASE-T interface. This interface is used for the device installation and configuration through an embedded web page.

The Ekinox Development Kit contains an Ethernet cable to allow quick setup, configuration and tests on any system that features a modern web browser.

This Ethernet interface is a key feature of the Ekinox device as it provides the following services:

- A Bonjour service used to easily discover any connected Ekinox and get its IP address
- An embedded web interface used to configure the device and visualize output data
- An FTP access to download logs recorded in the internal Flash memory
- Five virtual serial ports Eth0 to Eth4 that support either UDP or TCP/IP protocols

5.2.1. Accessing the Ekinox web page

Thanks to the ZeroConf technology, you can easily access the web page using the Ekinox serial number. Indeed, the Ekinox broadcast a web service so you can connect to the configuration web page using the following address:

http://ekinox_020000001.local.

Where 02000001 is the device serial number. It can be found on a label located on the enclosure's right side.

If your web browser supports DNS Service Discovery such as Safari, you should directly see a link to all Ekinox devices available on the network.

Note 1: Please, don't forget to append the last "." character to get a valid URL address.

Note 2: For more details about the Ethernet interface capabilities, please read the Ellipse Ekinox and Apogee Technical Reference Manual.

Browser Compatibility: SBG Systems recommend using latest version of Chrome, Safari or FireFox web browser. Due to Internet Explorer limitations, only versions 9 and above are supported.

5.3. Serial interfaces

The Ekinox subsea features 5 physical RS-232/RS-422 serial connections (Port A, B, C, D and E) and virtual serial ports (Eth 0, 1, 2, 3, 4) through Ethernet UPD or TCP/IP connections.

Some physical serial ports provide both an input and output signal, some just have an input signal. All virtual serial interfaces have both input and output lines. For best flexibility, the input and the output of a given port is handled separately.

For example, the Port C input can accept NMEA data from a GPS and the Port C output can, at the same time, send TSS1 frame with deported heave to an echo sounder.

5.3.1. Physical serial interfaces

Physical serial interfaces are designated as Port A, B, C, D and E. Each port can be configured to operate in RS-232 or RS-422 mode at a baud rate from 4 800 to 921 600 bps.

Some ports offer special functionalities. For example, the Port A is the only port that accepts Ekinox Binary Protocol commands.

Note: The Ekinox automatically limits the serial signals slew-rate to minimize EMI and reduce communication error when the baud rate is below 230 400 bps.

5.3.1.1. Main port A

The Port A has been designed to be the main serial connection between the device and a host system. It can be software selectable to use RS-232 or RS-422 signals.

The Port A is the only physical port that accepts Ekinox Binary Protocol commands. It can be used, for example, to send some device configurations.

The factory default configuration for the Port A is:

Parameter	Value
Mode	RS-232
Baudrate	115200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	Disabled

Warning: For previous subsea units with product codes EKINOX-#-G4A1-PS-E#-I#, the Port A mode (RS-232/RS-422) was selected at order and can't be changed without returning the unit to SBG Systems' factory.

5.3.1.2. Aiding ports B, C, D and E

The serial Port B, C, D and E are intended to connect aiding external equipments and/or to send output data to third party systems. The RS-232/RS-422 mode is selected trough the Web Interface.

By default, Port B, C, D and E are all disabled for both data input and output.

Note: Please refer to the connection mapping table below to understand exact connections availability.

5.3.2. Virtual serial interfaces

Virtual serial interfaces are a very simple and powerful way to increase the number of inputs/outputs without adding too much cables and connectors. Some equipments directly support virtual serial interfaces and other, that only have standard RS-232/RS-422 connections, can still use virtual serial interfaces trough an Ethernet to serial converter.

A virtual serial interface is just a TCP/IP or UDP connection that can send and receive raw data. The Ekinox implements the following modes to create a virtual serial interface:

- Raw UDP to reduce latencies and allow high throughput
- TCP/IP client or server to guarantee message delivery and ordering

As for the physical serial interface Port A, the Eth 0 virtual serial port can be used to send commands trough the Ekinox Binary Protocol. Virtual serial port Eth 1 to 4 can be used indifferently to input aiding data and to output log messages.

Note: Virtual serial interfaces are handled internally exactly the same way as physical interfaces. For example, you can either connect an external GNSS to Port C or to Eth 1.

5.4. Supported protocols

The Ekinox has been designed to be connected to a large range of aiding equipments and materials. In addition to the native sbgECom binary protocol, other third party or standard protocols are also supported such as NMEA, RTCM, TSS1, Septentrio SBF, Novatel Binary protocol, Trimble and others:

Note: For a complete description of the sbgECom and other supported protocols, please refer to the Ekinox and Apogee Firmware Reference Manual.

5.5. Connections Mapping

You will find below the available connections configuration for aiding inputs.

5.5.1. Ekinox-M version

	Port A	Port B	Port C	Port D	Port E	Eth 0	Eth 1-4
Binary commands	•					•	
GNSS 1 input	•	•	•	•	•		•

5.5.2. Ekinox-U version

	Port A	Port B	Port C	Port D	Port E	Eth 0	Eth 1-4
Binary commands	•					•	
GNSS 1 input	•	•	•	•	•		•
GNSS 2 input	•	•	•	•	•		•
DVL input	•	•	•	•	•		•

Note 2: If Port A input is not used to connect any external aiding sensor, it will be dedicated to sbgECom binary protocol.

5.6. Internal Datalogger

The Ekinox includes an internal datalogger capable of storing all data at 200Hz for 48 hours. The internal datalogger is composed of a high speed memory buffer and an 8 GB flash storage. To allow high bandwidth and to reduce power consumption, the memory buffer is saved to the flash storage ten times per second.

6. Important notices

6.1. Maintenance

The Ekinox will not require any specific maintenance when properly used. In the case you observe sub-optimal performance, please contact SBG Systems support.

Nevertheless, if you would like to maintain your sensor performance to the highest level, SBG Systems can provide a maintenance service with regularly planned checkups and calibrations.

6.1.1. Cleaning

Disconnect the Ekinox from the power supply as well as other connections. Use clear water and damp cloth to clean the enclosure. Do not use any solvent or abrasive materials for cleaning.

6.2. Absolute maximum ratings

Stresses above those listed under the Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Rating
VDD – GND	+/- 36 V
Galvanic isolation: Power supply connector to chassis ground Main connector GND to chassis ground Extended connector to chassis ground	+/- 200V
Rx+, Rx-, Logic inputs pins input voltage to signal GND	±25V
Logic I/O ESD protection (Human body model)	15 KV
Sync Out voltage	-0,3V to +25V
Logic output Max current	150 mA
Shock	500 g for 0.3ms
Operating temperature range	-20 to 60°C (-4 to 140°F)
Storage temperature range	-20 to 60°C (-4 to 140°F)

Table 1: Absolute maximum ratings

6.3. Support

Our goal is to provide the best experience to our customers. If you have any question, comment or problem with the use of your product, we would be glad to help you, so feel free to contact us:

EMEA:

SBG Systems S.A.S.
3 bis, chemin de la Jonchère
92500 Rueil-Malmaison
FRANCE

Phone: +33 1 80 88 43 70
support@sbg-systems.com

Americas:

SBG Systems North America, Inc
5932 Bolsa Avenue, Suite #103
Huntington Beach, CA 92649
USA

Phone: +1 (657) 549-5807
support@sbg-systems.com

6.4. Warranty, liability and return procedure

SBG Systems provides a warranty covering this product against any defect in materials or manufacture for a period of two (2) years from the date of shipment. In the event that such a defect becomes obvious during the stipulated warranty period, SBG Systems will undertake, at its sole discretion, either to repair the defective product, bearing the cost of all parts and labor, or to replace it with an identical product.

In order to avail itself of this warranty, Customer must notify SBG Systems of the defect before expiry of the warranty period and take all steps necessary to enable SBG Systems to proceed. Upon reception of required information (Sensor serial number, defect description), SBG Systems will issue an RMA and will provide return instructions. Customer shall be responsible for the packaging and the shipment of the defective product to the repair center notified by SBG Systems, the cost of such shipment being borne by Customer.

This warranty shall not be construed as covering defects, malfunctions or damages caused by improper use or inadequate maintenance of the product. Under no circumstances shall SBG Systems be due to provide repair or replacement under this warranty in order a) to repair damage caused by work done by any person not representing SBG Systems for the installation, repair or maintenance of the product; b) to repair damage caused by improper use or connection to incompatible equipment, and specifically, the opening of the housing of the equipment under warranty shall cause the warranty to be automatically canceled.

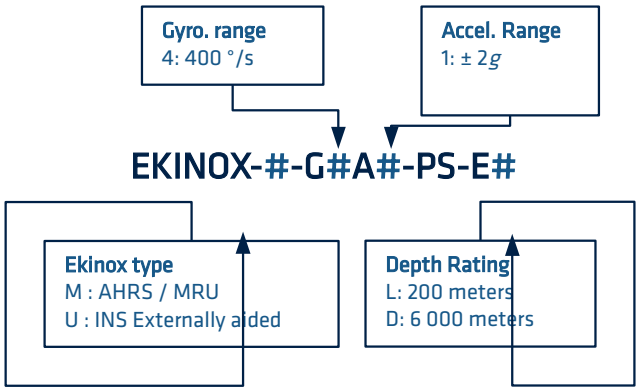
This warranty covers the product hereunder and is provided by SBG Systems in place of all and any other warranty whether expressed or implied. SBG Systems does not guarantee the suitability of the product under warranty for sale or any specific use.

SBG Systems' liability is limited to the repair or replacement of defective products, this being the sole remedy open to Customer in the event the warranty becomes applicable. SBG Systems cannot be held liable for indirect, special, subsequent or consequential damage, irrespective of whether SBG Systems has or has not received prior notification of the risk of occurrence of such damage.

7. Appendix A: Ordering codes and Accessories

7.1. Ekinox SubSea ordering codes

The following diagram showing the different sensors and interfaces options available, might help you ordering an Ekinox SubSea product.



7.2. Transport Cases

The Ekinox Subsea is shipped by default in a specific shock proof carton box. For long term protection, transport case may be required.

7.2.1. CASE-EKI-03

This large transport case can be used to securely ship or store:

- An Ekinox U or M
- An up to 10 meters Subsea cable
- A SplitBox with all its accessories
- Up to two GNSS antennas ref ANT-SEP-POLANT-MC
- The Inertial Software Development Kit USB Key
- Documentations and calibration report
- Various additional items in the open hole.

Figure 7.1 : 9.2.2. CASE-EKI-03

7.3. SplitBox for easy connection

The SplitBox is the easiest way to connect your Ekinox Subsea to various equipments without special developments or cables. It provides standard Ethernet, SUB-D9 and SMA connectors for each available port.

There are two different SplitBox versions, one with an embedded high performance GNSS receiver so you can easily input GNSS data to an Ekinox-M or Ekinox-U and an other version that just split all Ekinox Subsea input and output ports to standard and easy to use connectors.

Note: Please check the SplitBox User Manual for more information about this product, and additional product options.

7.3.1. SPLITBOX-SUB

The subsea SplitBox is a high quality IP-65 junction box that exposes all Ekinox Subsea connections to standard and easy to use connectors.

For example, the Ekinox serial port A, B, C, D and E are directly accessible through DB-9 connectors. Two SMA connectors are also present to access the PPS output signal or to input external synchronization signal.

Figure 7.2: SPLITBOX-SUB

7.3.2. SPLITBOX-SUB-S

This 'S' version embeds, in the exact same enclosure as the SPLITBOX-SUB, a very high performance Septentrio L1/L2/L5 GNSS receiver. It supports GPS, GLONASS, BEIDOU, GALILEO constellations as well as L-Band Terrastar and Veripos corrections.

It features a very powerful dual antenna heading with the world's leading sub centimeter RTK reacquisition time and availability.

7.3.3. SPLITBOX-SUB-T

The 'T' version embeds, in the exact same enclosure as the SPLITBOX-SUB, a very high performance Trimble BD982 L1/L2/L5 GNSS receiver. It supports GPS, GLONASS, BEIDOU, GALILEO constellations as well as L-Band Omnistar and MarineStar corrections.

It also features a very powerful dual antenna heading with highly accurate RTK positioning.

7.4. Associated Software

7.4.1. SW-AEK-SDK (Software Development Kit)

The Ekinox Software Development Kit is very helpful to configure, playback recorded logs, export data to text files or third party software and even develop custom code for the Ekinox.

It contains the following items:

- sbgCenter analysis software
- sbgECom C library and examples
- All documentations and low level protocol specifications
- Unlimited free software upgrades

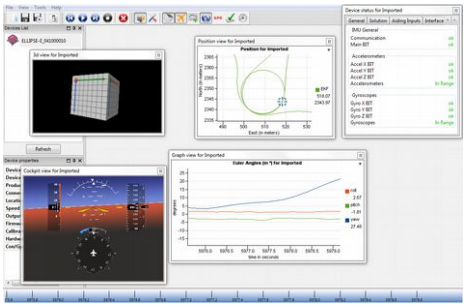


Figure 7.3: sbgCenter analysis tool

7.4.2. SW-NOV-PP-GPS-IMU-U (Post-processing suite)

The post-processing software suite is based on Novatel Inertial Explorer. It provides:

- Easy Ekinox integration into Post-processing software suite
- Much higher accuracy than real time processing
- Loosely and tightly coupled GNSS/INS processing
- Precise Point Positioning (PPP) processing, for accurate positioning, even without RTK station.
- 1 Year support and updates

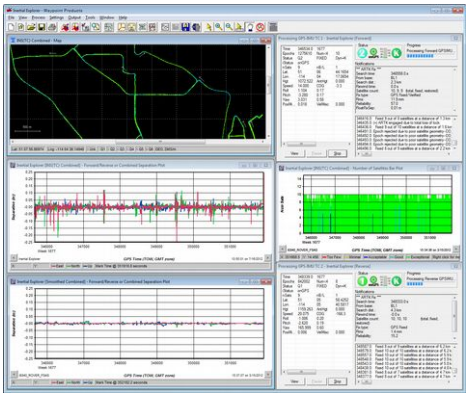


Figure 7.4 : Inertial Explorer

7.5. Cables

7.5.1. CA-AEK-SUB-DPT500-10M

10 meters wire ended sub sea cable depth rated for 500 meters.

7.5.1.1. Cable Construction

This high quality subsea cable is wire ended on one side and has a Seacon MINIM-37#22-CCP-Ti connector over-moulded on the other side. The 37 ways Seacon connector is made of Titanium perfectly compatible with the Ekinox housing to ensure minimal degradation during long time immersions in salt water.

The cable is composed of two AWG-22 thinned copper conductors for the power supply and four cable triads for communication signals. Each triad includes four shielded AWG-26 thinned copper twisted pairs.

The following diagrams show the cable overview and internal section for better understanding:

Figure 7.5 : 9.3.1. CA-AEK-SUB-DPT500-10M overview

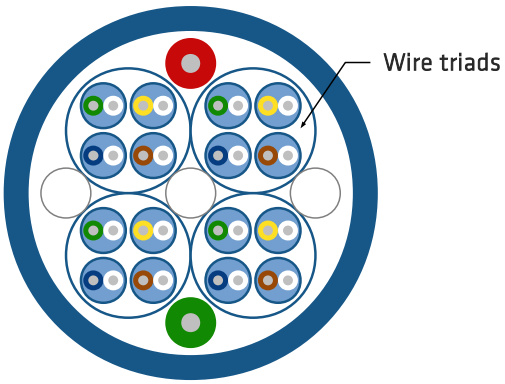


Figure 7.6: 9.3.1. CA-AEK-SUB-DPT500-10M internal section

7.5.1.2. Electrical characteristics

General Minimum Insulation Resistance	Rating
Core to Core	> 900 MΩ/km @ 500 V
Core to Screen	> 500 MΩ/km @ 500 V
Screen to Screen	> 10 MΩ/km @ 500 V
26 AWG Screen Twisted Paris (Signals)	
Nominal Conductor Resistance	181.10 Ω/km @ 20 °C
Nominal Impedance	100 Ω
Nominal Capacitance	84 pF/m
22 AWG Conductors (Power Supply)	
Nominal Conductor Resistance	59.30 Ω/km @ 20 °C
Max Recommended Voltage	500 V

7.5.1.3. Mechanical characteristics

Temperature characteristics Limits	Rating
Static Operating Temperature	+90 °C
Dynamic Operating Temperature	+80 °C
Cold Flex Temperature	-40 °C
Mechanical characteristics	
Cable Length	10 meters
Cable Diameter	17 mm ± 0.30 mm
Depth Rating	500 meters
Weight In Air	267 kg/km
Weight In Sea Water	34 kg/km @ SG 1.025
Recommended Bend Radius Limits	
Static	85 mm
Dynamic	160 mm

7.5.1.4. Cable wiring

Triad	Pair/Pos	Color	Signal
Triad n°1	Pair n°1	Green	Ethernet Tx+
		White	Ethernet Tx-
	Pair n°2	Orange	Ethernet Rx+
		White	Ethernet Rx-
	Pair n°3	Brown	Port A - RS-422 - Tx+
		White	Port A - RS-232/RS-422 - Tx-
	Pair n°4	Blue	Port A - RS-232/RS-422 - Rx+
		White	Port A - RS-422 - Rx-
Triad n°2	Pair n°5	Green	Port B - RS-422 - Tx+
		White	Port B - RS-232/RS-422 - Tx-
	Pair n°6	Orange	Port B - RS-232/RS-422 - Rx+
		White	Port B - RS-422 - Rx-
	Pair n°7	Brown	Port C - RS-422 - Tx+
		White	Port C - RS-232/RS-422 - Tx-
	Pair n°8	Blue	Port C - RS-232/RS-422 - Rx+
		White	Port C - RS-422 - Rx-
Triad n°3	Pair n°9	Green	Sync Out A
		White	GND
	Pair n°10	Orange	Port D - RS-232/RS-422 - Rx+
		White	Port D - RS-422 - Rx-
	Pair n°11	Brown	Sync Out B
		White	GND

Triad	Pair/Pos	Color	Signal
	Pair n°12	Blue	Port E - RS-232/RS-422 - Rx+
		White	Port E - RS-422 - Rx-
Triad n°4	Pair n°13	Green	Sync In A
		White	GND
	Pair n°14	Orange	Sync In B
		White	GND
	Pair n°15	Brown	Sync In D
		White	GND
	Pair n°16	Blue	Sync In E
		White	GND
Main cable section	-	Red	POWER VDD
Main cable section	-	Green	POWER GND

7.5.2. CA-AEK-SUB-DPT500-20M

20 meters wire ended sub sea cable depth rated for 500 meters.

Please refer to 7.5.1 CA-AEK-SUB-DPT500-10M for all technical details as the two cables are exactly the same except the cable length.

7.5.3. CA-AEK-SUB-DPT6000-5M

5 meters wire ended sub sea cable depth rated for 6 000 meters.

7.5.3.1. Cable Construction

This high quality subsea cable is wire ended on one side and has a Seacon MINIM-37#22-CCP-Ti connector over-moulded on the other side. The 37 ways Seacon connector is made of Titanium perfectly compatible with the Ekinox housing to ensure minimal degradation during long time immersions in salt water.

The cable is composed of two AWG-22 thinned copper conductors for the power supply and four cable triads for communication signals. Each triad includes four shielded AWG-26 thinned copper twisted pairs.

The following diagrams show the cable overview and internal section for better understanding:

Figure 7.7 : 9.3.1. CA-AEK-SUB-DPT6000-5M overview

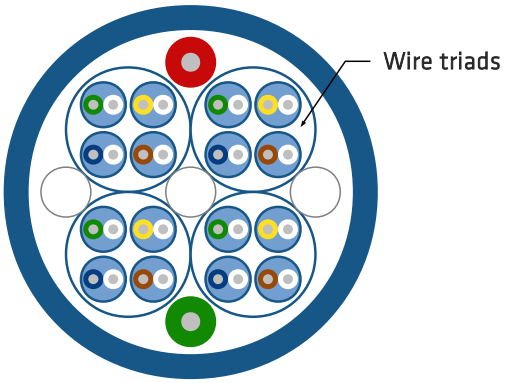


Figure 7.8: 9.3.1. CA-AEK-SUB-DPT6000-5M internal section

7.5.3.2. Electrical characteristics

General Minimum Insulation Resistance	Rating
Core to Core	> 900 MΩ/km @ 500 V
Core to Screen	> 500 MΩ/km @ 500 V
Screen to Screen	> 10 MΩ/km @ 500 V
26 AWG Screen Twisted Paris (Signals)	
Nominal Conductor Resistance	181.10 Ω/km @ 20 °C
Nominal Impedance	100 Ω
Nominal Capacitance	84 pF/m
22 AWG Conductors (Power Supply)	
Nominal Conductor Resistance	59.30 Ω/km @ 20 °C
Max Recommended Voltage	500 V

7.5.3.3. Mechanical characteristics

Temperature characteristics Limits	Rating
Static Operating Temperature	+90 °C
Dynamic Operating Temperature	+80 °C
Cold Flex Temperature	-40 °C
Mechanical characteristics	
Cable Length	5 meters
Cable Diameter	17.3 mm ± 0.50 mm
Depth Rating	6 000 meters
Weight In Air	334 kg/km
Weight In Sea Water	94 kg/km @ SG 1.025
Recommended Bend Radius Limits	
Static	85 mm

Dynamic	160 mm

7.5.3.4. Cable wiring

Triad	Pair/Pos	Color	Signal
Triad n°1	Pair n°1	Green	Ethernet Tx+
		White	Ethernet Tx-
	Pair n°2	Orange	Ethernet Rx+
		White	Ethernet Rx-
	Pair n°3	Brown	Port A - RS-422 - Tx+
		White	Port A - RS-232/RS-422 - Tx-
	Pair n°4	Blue	Port A - RS-232/RS-422 - Rx+
		White	Port A - RS-422 - Rx-
Triad n°2	Pair n°5	Green	Port B - RS-422 - Tx+
		White	Port B - RS-232/RS-422 - Tx-
	Pair n°6	Orange	Port B - RS-232/RS-422 - Rx+
		White	Port B - RS-422 - Rx-
	Pair n°7	Brown	Port C - RS-422 - Tx+
		White	Port C - RS-232/RS-422 - Tx-
	Pair n°8	Blue	Port C - RS-232/RS-422 - Rx+
		White	Port C - RS-422 - Rx-
Triad n°3	Pair n°9	Green	Sync Out A
		White	GND
	Pair n°10	Orange	Port D - RS-232/RS-422 - Rx+
		White	Port D - RS-422 - Rx-
	Pair n°11	Brown	Sync Out B
		White	GND
	Pair n°12	Blue	Port E - RS-232/RS-422 - Rx+
		White	Port E - RS-422 - Rx-
Triad n°4	Pair n°13	Green	Sync In A
		White	GND
	Pair n°14	Orange	Sync In B
		White	GND
	Pair n°15	Brown	Sync In D
		White	GND
	Pair n°16	Blue	Sync In E
		White	GND
Main cable section	-	Red	POWER VDD
Main cable section	-	Green	POWER GND