Apogee Surface series

Ultimate Accuracy MEMS Inertial Sensors

User Manual

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Covers Hardware	Apogee -A and -E V2 and above Apogee -D V3 and above

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Revision history

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1.2	Jul 12, 2017	Alexis Guinamard	[APGHM-6] Add cover coordinate frame location specifications for IMU center of measurement [APGHM-4] Remove obsolete virtual odometer data
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Terminology

AHRS: Attitude and Heading Reference System
CAN (Bus): Controller Area Network
CMR: Compact Measurement Record (protocol)
DC: Direct Current
DGNSS: Differential GNSS
DMI: Distance Measuring Instrument
DVL: Doppler Velocity Log
EKF: Extended Kalman Filter
EMI: Electro Magnetic Interferences
FIR: Finite Impulse Response (filter)
FTP: File Transfer Protocol
GND: Ground
GNSS: Global Navigation Satellite System
GPS: Global Positioning System
IMU: Inertial Measurement Unit
INS: Inertial Navigation System
IP: Internet Protocol / Ingress Protection
LNA: Low Noise Amplifier
MEMS: Micro Electro-Mechanical Systems
MRU: Motion Reference Unit
MTBF: Mean Time Between Failures
NA: Not applicable
NMEA (NMEA 0183): National Marine Electronics Association (standardized communication protocol)
PP: Post Processing
PPS: Pulse Per Second (signal)
RoHS: Risk Of Hazardous Substance
RMA: Return Merchandise Authorization
RMS: Root Mean Square
RTCM: Radio Technical Commission for Maritime Services (Protocol)
RTK: Real Time Kinematics
SBAS: Satellite Based Augmentation System
SDK: Software Development Kit
SP: Single Point
TCP: Transmission Control Protocol
UDP: User Datagram Protocol
UTC: Coordinated Universal Time
VRE: Vibration Rectification Error
WGS84: World Geodetic System 1984

1. Introduction

Apogee series is a line of very high performance, MEMS based Inertial Systems which achieve exceptional orientation and navigation performance in a compact and affordable package. It includes an Inertial Measurement Unit (IMU) and runs an on-board enhanced Extended Kalman Filter (EKF). The Apogee line is divided in a comprehensive set of sensors:

Figure 1.1: The Apogee-D model

- The Apogee-A version is a Motion Reference Unit (MRU) / Attitude and Heading Reference System (AHRS), providing accurate orientation in dynamic conditions as well as heave, surge and sway data. It can be coupled with an external GNSS receiver for optimal orientation accuracy.
- The Apogee-E version is an Inertial Navigation System (INS). It provides accurate orientation in dynamic conditions as well as heave, surge and sway data and can be connected to an external GNSS receiver.
- The Apogee-D is an Inertial Navigation Systems (INS) that embeds a dual antenna, triple frequency (L1/L2/L5) survey grade GNSS receiver. Thanks to the four constellations support (GPS, GLONASS, BEIDOU, GALILEO), it provides an excellent position accuracy in all environments. The GNSS receiver also features the world's leading RTK engine delivering sub centimeter accuracy with very high availability and fast re-acquisition time. The dual antenna operation enables accurate measurements even in low dynamic conditions (such as in marine applications). The use of a dual antenna heading also reduce dramatically the initial alignment time compared to traditional gyro compassing solutions.

To achieve the best performance in every project, specific error models have been implemented to meet applications requirements and to adapt the Apogee to your vehicle. Sensor configuration is made easy through the modern embedded web interface.

The Windows based sbgCenter application also provides a very powerful and easy to use tool to monitor, analyze, record, playback and export all measurements, status and information of your Apogee.

Finally, the 8 GB embedded data-logger enables seamless post processing work-flow with Qinertia post-processing software for the most demanding applications.

1.1. Apogee Overview

The following diagram shows the basic organization of an Apogee. On the Apogee-A and E versions, this block diagram is slightly simplified as there is no embedded GNSS.

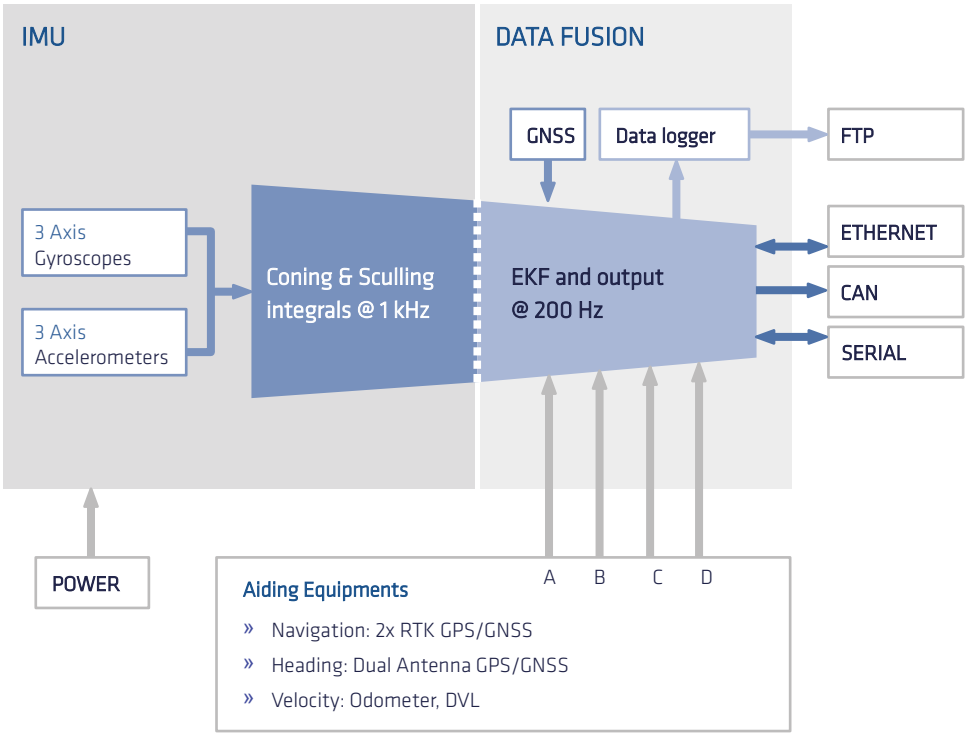


Figure 1.2: Apogee simplified block diagram

2. Performance specifications

2.1. Inertial measurement unit

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

2.1.1. Accelerometers

The Apogee V2 and V3 IMU embeds a set of 3 MEMS capacitive accelerometers. Coupled with advanced filtering techniques and high frequency integration, these accelerometers will provide consistent performance, even in vibrating environment.

	A3	Remarks
Full scale (*g*)	± 10	
Velocity Random Walk (µg/√hz)	30	Allan variance – @ 25°C
In run bias instability (µg)	7	Allan variance – @ 25°C
Bandwidth (Hz)	100	Attenuation of 3 dB
Orthogonality (°)	< 0.02	Over temperature range

2.1.2. Gyroscopes

The Apogee V2 and V3 IMUs embeds 3 high performance MEMS gyroscopes. The specifications are listed below:

	G3	Remarks
Full scale (°/s)	± 200	
In run bias instability (°/hr)	0.05	Allan variance – @ 25°C
Angular Random Walk (°/√hr)	0.012	Allan variance – @ 25°C
Bandwidth (Hz)	100	Attenuation of 3 dB
Orthogonality (°)	< 0.02	Over temperature range

2.2. Aiding sensors

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

2.2.1. Apogee-D internal GNSS receiver

The Apogee-D embed a very high end, survey grade GNSS receiver with dual antenna heading capability.

It features L1/L2/L5 signals tracking and uses GPS, GLONASS, BEIDOU and GALILEO constellations to provide very accurate and reliable measurements even in harsh environments.

This latest generation GNSS receiver also features very accurate RTK positioning with the world's leading signal availability and minimal re-acquisition time after a GNSS outage. With a refresh rate of 20 Hz, this receiver provides best accuracy and reliability in harsh GNSS environments thanks to a very advanced auto mitigating algorithms that detects and eliminates multi-path situations or Inmarsat / Iridium jamming.

The internal dual L-Band demodulator supports Fugro Marinestar™ PPP services to delivery world wide, with no specific infrastructure, a positioning accuracy better than 10 cm.

	Specification		Remark
Channels	544		
Signal tracking	**GPS**: L1 C/1, L2, L2C, L5 **GLONASS**: L1 C/A, L2 C/A, L2P, L3 **GALILEO:** E1, E5a, E5b **Beidou:** B1I, B1C, B2a, B2I, B3I	**QZSS:** L1 C/A, L2C, L5 **SBAS** **integrated L-band**	All constellations & signals enabled by default
Horizontal position accuracy	Single Point L1/L2/L5	1.2 m	RTK enabled by default
	SBAS / DGNSS	0.6 m / 0.4 m	
	RTK	0.6 cm + 0.5 ppm	
Velocity Accuracy	0.03 m/s RMS		
True Heading Accuracy	0.15° 0.03°		1 m baseline 5 m baseline
Velocity limit	515 m/s		Due to export licenses
Time to First Fix	Cold start	< 45 s	
	Hot start	< 20 s	
Signal reacquisition	L1/L2/L5	< 1 s	
Output frequency	PVT: 5 Hz (Max 20 Hz) RAW data: 1 Hz (Max 100 Hz)		
Diff. Corrections	RTCM V2.x, V3.x CMR V2.0, CMR+		Sent via serial PORT D

Note: All these specifications reflect the intrinsic GNSS receiver accuracy. Please refers to section 2.3 Orientation and Navigation Performance for complete Apogee accuracy specifications.

2.2.2. External aiding sensors

The Apogee-A accepts a single external GNSS receiver connection to improve orientation performance.

The Apogee-E, N and D models accepts up to two external GNSS receivers to provide navigation data and improve orientation performance. In addition, a DVL or an odometer can be connected on Apogee-E/N/D as velocity aiding inputs.

Maximum supported odometer pulse rate is 10 kHz

2.3. Orientation and Navigation Performance

All specifications are rated to 1σ, over -20°C to +60°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 200 s 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 accuracy for the following positioning modes:

- **SP:** Single Point mode which is the default L1/L2/L5 GNSS fix quality
- **RTK:** Real Time Kinematics with a typical 1 cm accuracy position
- **PPK**: Post Processed data using Qinertia 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	< 0.002° RMS	Static conditions

2.3.2. Marine & Subsea applications

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

Outage Duration	Positioning Mode	Position Accuracy (m)		Velocity Accuracy (m/s)		Attitude Accuracy (°)	
		Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
0 s	SP	1.0 m	1.0 m	0.02 m/s	0.01 m/s	0.01°	0.02° (baseline > 2 m)
	RTK	0.01 m + 0.5 ppm	0.015 m + 1 ppm	0.01 m/s	0.01 m/s	0.008°	0.01° (baseline > 4 m)
	PPK	0.01 m+ 0.5 ppm	0.015 m + 1 ppm	0.01 m/s	0.01 m/s	0.005°	0.01°
10 s	SP	1.2 m	1.1 m	0.03 m/s	0.015 m/s	0.01°	0.03° (baseline > 2 m)
	RTK	0.17 m	0.1 m	0.02 m/s	0.015 m/s	0.008°	0.02° (baseline > 4 m)
	PPK	0.03 m	0.02 m	0.015 m/s	0.01 m/s	0.005°	0.015°
60 s	SP	5.0 m	2.0 m	0.15 m/s	0.075 m/s	0.015°	0.05° (baseline > 2m)
	RTK	4.0 m	0.75 m	0.15 m/s	0.075 m/s	0.012°	0.04° (baseline > 4m)
	PPK	0.15 m	0.05 m	0.04 m/s	0.03 m/s	0.008°	0.025°

2.3.2.1. Heave performance

	Real Time Heave	Delayed Heave (ShipMotionHP)	Remark
Range	50 meters	50 meters	Automatic adjustment to every sea conditions
Period	0 to 20 s	0 to 40 s	
Accuracy	5 cm or 5 %	2 cm or 2 %	Whichever is greater; Velocity aided heave
Mode	Real time, auto tuning	Fixed 150 s delay	On board computation

2.3.3. Land applications

All specifications are valid with DMI (odometer) aiding for typical land mapping trajectories.

Outage Duration	Positioning Mode	Position Accuracy (m)		Velocity Accuracy (m/s)		Attitude Accuracy (°)	
		Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
No Outage	SP	1.0 m	1.0 m	0.02 m/s	0.01 m/s	0.01°	0.03°
	RTK	0.01 m + 0.5 ppm	0.015 m + 1 ppm	0.01 m/s	0.01 m/s	0.008°	0.02°
	PPK	0.01 m + 0.5 ppm	0.015 m + 1 ppm	0.01 m/s	0.01 m/s	0.005°	0.01°
10 s	SP	1.1 m	1.0 m	0.03 m/s	0.02 m/s	0.01°	0.04°
	RTK	0.05 m	0.05 m	0.02 m/s	0.02 m/s	0.008°	0.03°
	PPK	0.02 m	0.02 m	0.015 m/s	0.01 m/s	0.005°	0.015°
60 s / 1 km	SP	1.5 m	1.3 m	0.03 m/s	0.02 m/s	0.015°	0.06°
	RTK	0.5 m	0.3 m	0.02 m/s	0.02 m/s	0.012°	0.06°
	PPK	0.1 m	0.05 m	0.02 m/s	0.015 m/s	0.008°	0.025°

2.3.4. Airborne applications

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

Positioning Mode	Position Accuracy (m)		Velocity Accuracy (m/s)		Attitude Accuracy (°)	
	Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
SP	1.0 m	1.0 m	0.02 m/s	0.01 m/s	0.01°	0.02° (baseline > 2 m)
RTK	0.01 m + 0.5 ppm	0.015 + 1 ppm	0.01 m/s	0.01 m/s	0.008°	0.01° (baseline > 4 m)
PPK	0.01 m + 0.5 ppm	0.015 + 1 ppm	0.01 m/s	0.01 m/s	0.005°	0.01°

2.3.5. Real time Performance monitoring

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

	Threshold	Comments
Attitude Valid	0.3° / 0.025°	AHRS / Normal INS mode
Heading Valid	0.5° / 0.08°	AHRS / Normal INS mode
Velocity Valid	0.2 m/s	Total velocity error (3D)
Position Valid	1 m	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 Apogee enclosure is composed of two anodized aluminum parts, one for the cover and one for the base plate. The device uses high quality alloys and connectors to offer a full IP-68 enclosure and a good resistance to harsh environments.

The cover part is made of 6061 aluminum alloy for its resistance to both seawater and industrial chemical environments. In addition, this material offers a nice visual aspect.

The base plate is made of 7075 aluminum alloy to ensure best durability and accuracy. Indeed, this alloy offers an incredible mechanical strength to guarantee the base plate integrity and accuracy during device installation.

The cover and base plates are sealed together by four M3 stainless steel A4 screws (3016L). The Apogee should be installed to the host interface using four M4 stainless steel A4 screws.

The Apogee connectors are high quality Fischer connectors that offer IP-68 protection even unconnected. The Apogee-D version also include TNC connectors to plug the GNSS antennas.

Warning: The Apogee is not designed for prolonged operation in salt water environments. Check section Maintenance for more details about operation in sea water environments.

3.1.1. Main Specifications

The table below summarizes all mechanical and environmental specifications.

Item	E	D
Height	58 mm (2.28")	75 mm (2.95")
Width	130 mm (5.12")	130 mm (5.12")
Depth	100 mm (3.94")	100 mm (3.94")
Weight	685 g (1.5 lb)	899 g (1.98 lb)
Shocks	500 g for 0.3 ms	
Operating Vibrations	8 g RMS – 20 Hz to 2 kHz as per MIL-STD-810G (A3 range options)	

Environmental Specifications	
Enclosure	Anodized Aluminum
IP rating	IP-68 (24 hours at 2 meters)
Specified temperature	-20°C to 60°C (-40°F to 140 °F)
Operating temperature	-40°C to 71°C (-40°F to 160°F)
Storage	-40°C to 85°C (-40°F to 185°F)
Humidity	Sealed, no limit
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 Apogee 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°.

Note: The base plate is the same for the Apogee-A, E, and D models.

3.1.3. Origin of measurements

The Apogee offers the possibility to output data at different measurement points.

The default center of measurement is located on top of Apogee enclosure, on the coordinate frame center drawing. It is represented on the mechanical outlines by the ◓ symbol. This point is defined to simplify installation.

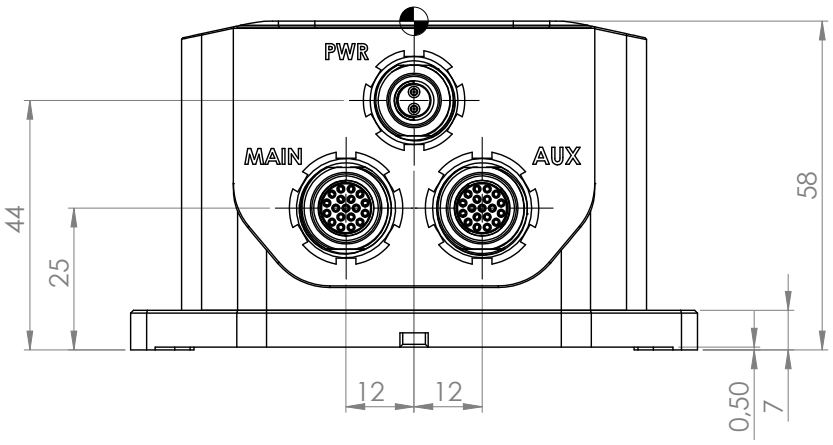
Alternatively, user can select between two other center of measurement points:

- Alignment hole (aligned to the bottom of the base plate)
- Bare IMU center of measurement, represented by the ◓ symbol.

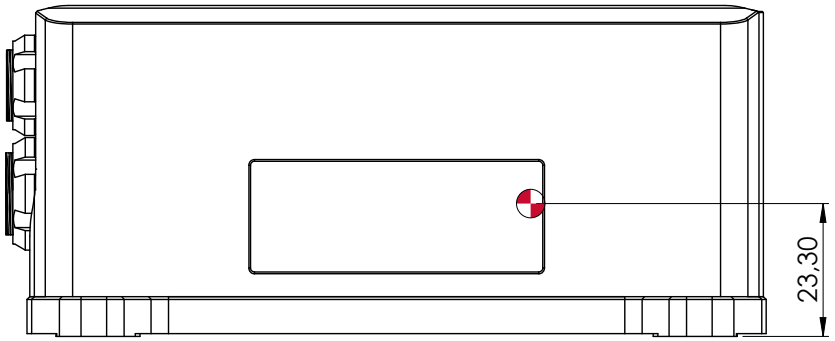
3.2. Apogee-A / E mechanical outline

All dimensions are in mm.

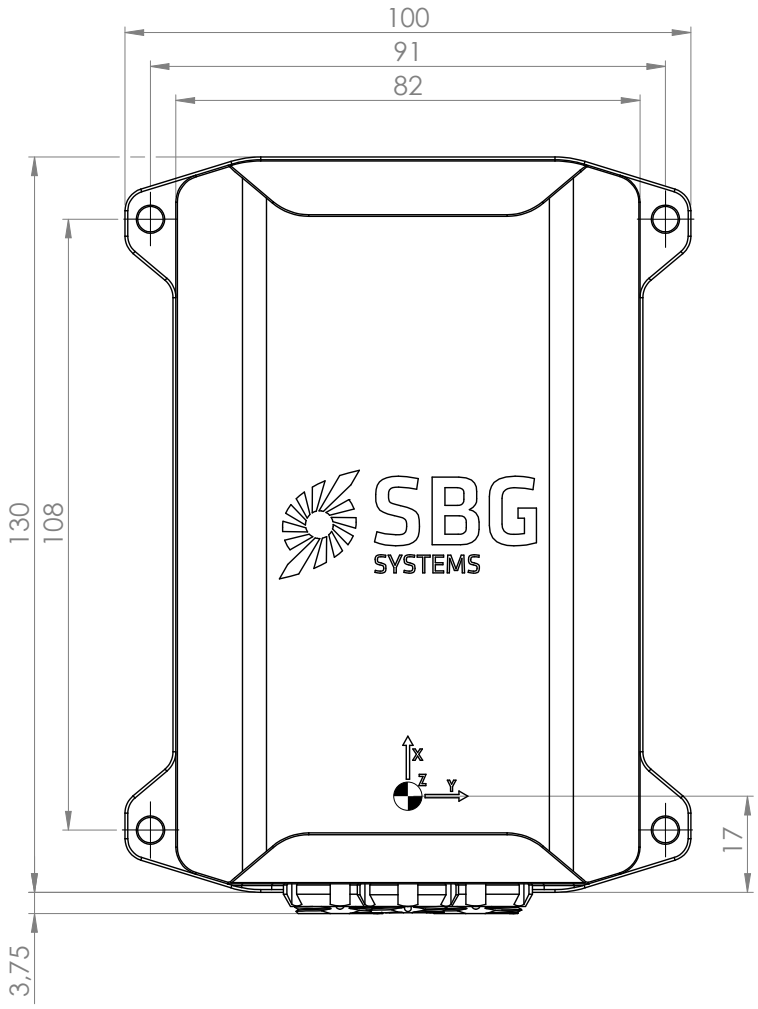
3.2.1. Front view



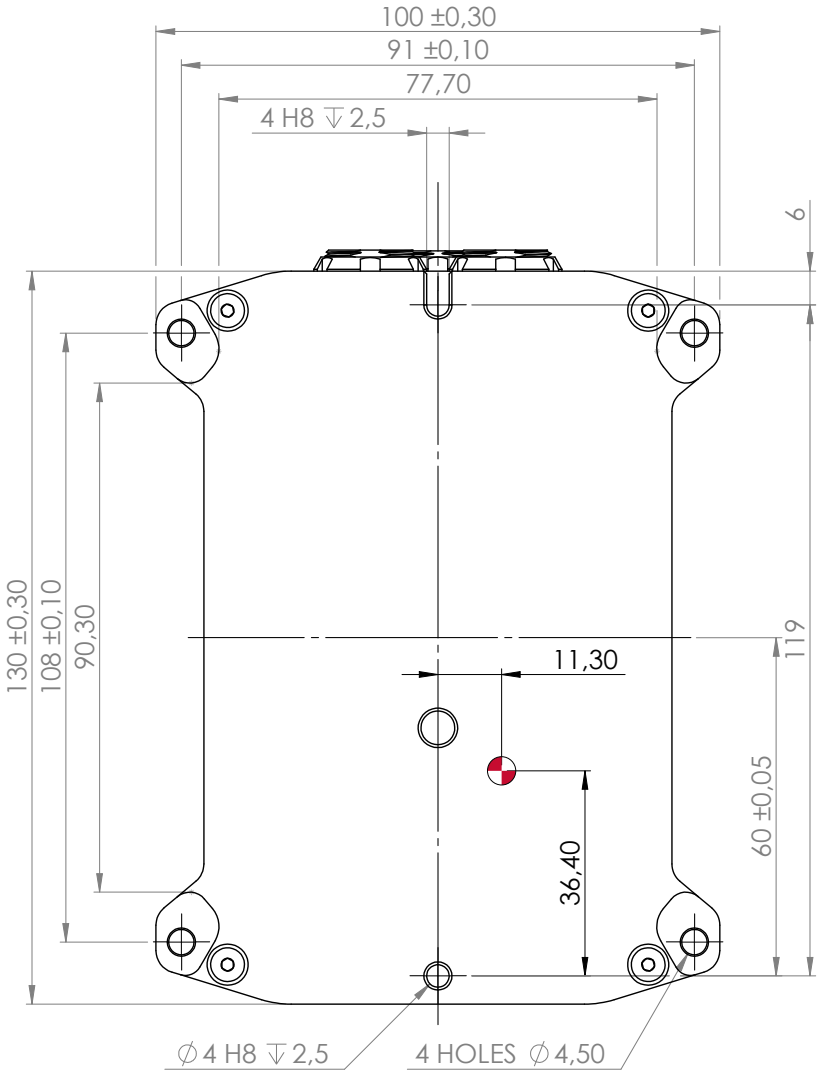
3.2.2. Right view



3.2.3. Top view



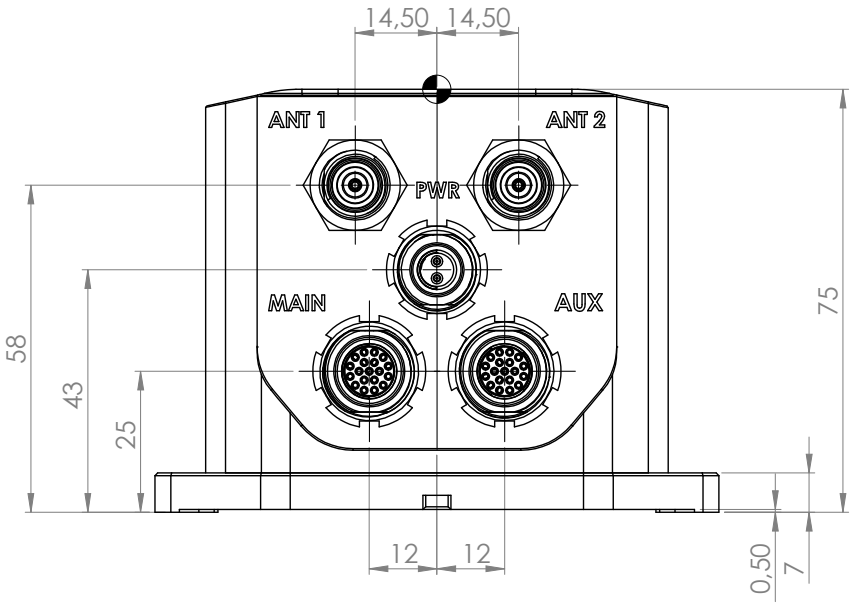
3.2.4. Bottom view



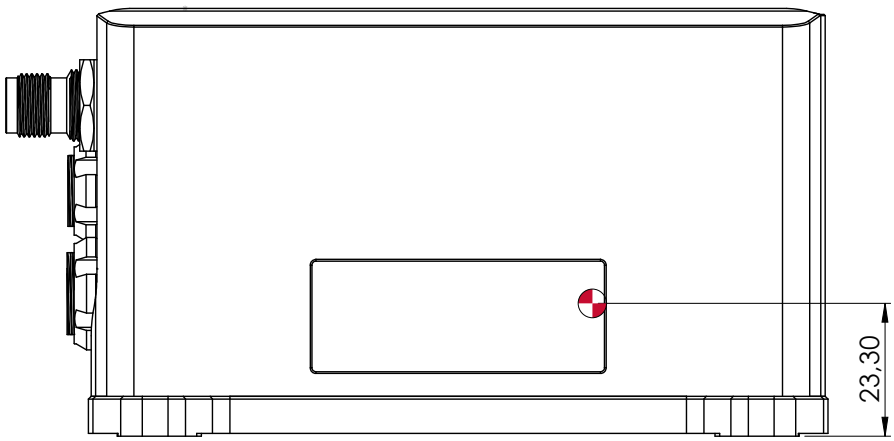
3.3. Apogee-D mechanical outline

All dimensions are in mm.

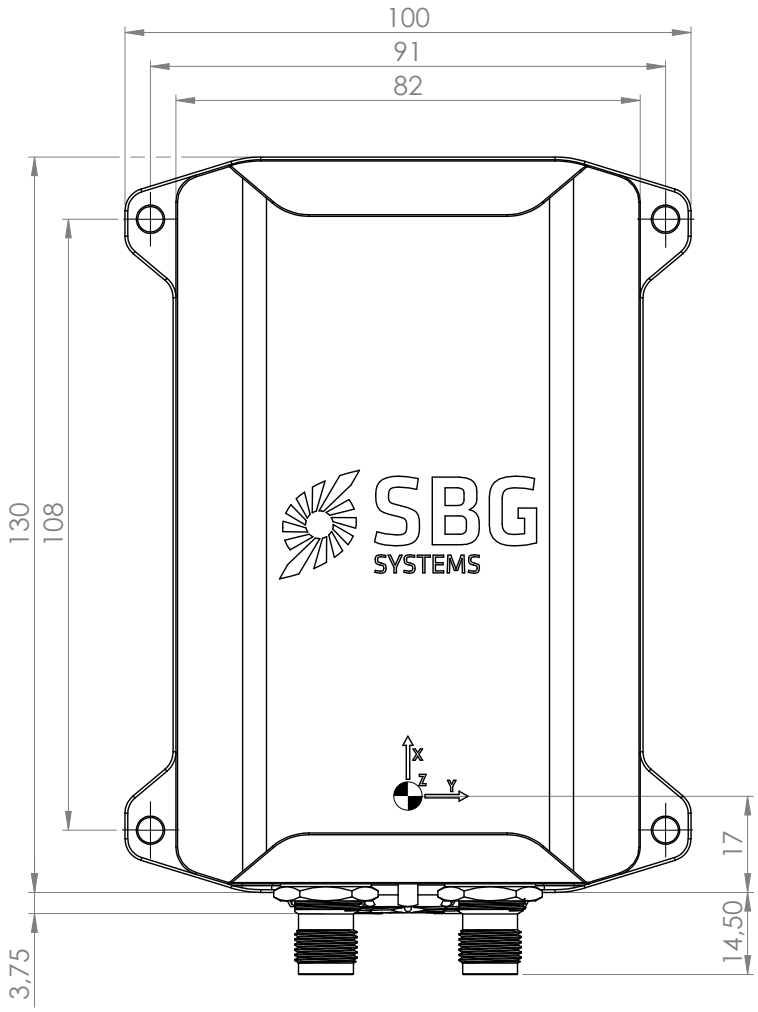
3.3.1. Front view



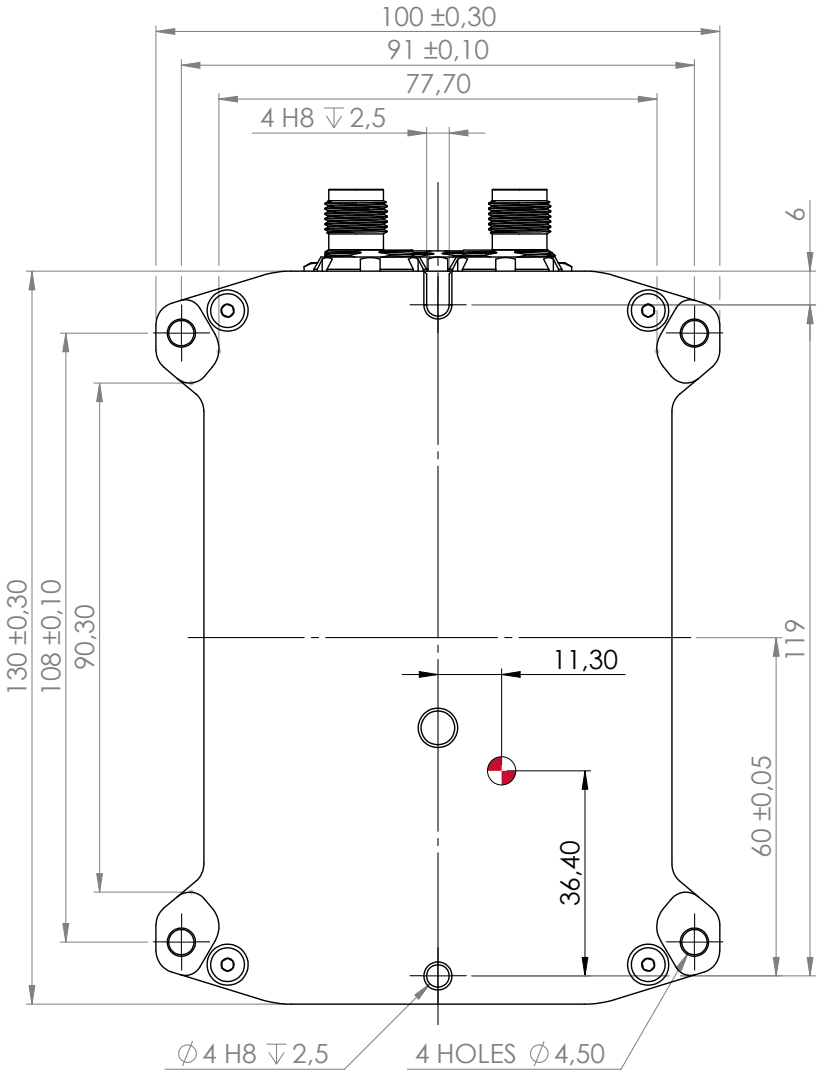
3.3.2. Right view



3.3.3. Top view



3.3.4. Bottom View



4. Electrical specifications

4.1. Overview

The Apogee connectors are all placed on the front panel. The connectors are referenced and identified by laser marking on the enclosure. Each connector is different and fool proofed using a specific keying to avoid any misconnection.

SBG Systems has selected high quality connectors designed for harsh environments. They offer an IP-68 protection when the plug is properly mounted.

Note: The Apogee cables are not all designed to offer an IP-68 protection. Contact SBG Systems to get further support about IP-68 protection.

4.1.1. Apogee-A and E

Figure 4.1: Apogee-A and E connectors

4.1.2. Apogee-D with embedded GNSS

Figure 4.2: Apogee-D connectors

4.2. Power supply connector

The Apogee can be powered by a DC voltage from 9 to 36 Volts. For best robustness and to reduce power consumption, the internal power module is a high efficiency isolated DC/DC converter.

Apply a constant power supply to VIN+ and VIN- pins. The shield is directly connected to the device mechanical enclosure. It should not be used as the ground return signal.

4.2.1. Connector specifications

The power supply uses a 2 ways male AluLite Fischer connector which is compatible with the Fischer Core Series. The exact receptacle reference is: AL1731-DBPU-103-Z051PB11-12G13

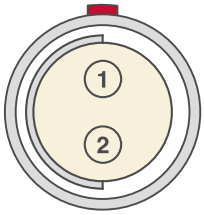


Figure 4.3: Power receptacle front view

Figure 4.4: Power plug top view

This size 103 connector mates with the following plugs references in AluLite or Core Series. Alternative plugs can be found if required (eg short plug). Don't forget that these two references don't include the cable clamp sets.

- AL1731-S-103-Z051SR11-11 (AluLite version)
- S-103-Z051-130 (Core Series version)

Note: Although Fischer connectors are IP68 and specified to operate from -40°C to +75°C, the plug should be connected at temperatures above -20°C and in a dry environment.

Warning: The power receptacle uses male connectors for obvious security reasons. Please make sure that you order the correct plug reference.

4.2.2. Connector pin-out

Pin #	Name	Description
Shield	Shield	Connected to mechanical ground
1	VIN+	Connected to the power supply
2	VIN-	Connected to the electrical ground

4.2.3. Electrical specifications

Recommended electrical specifications from -40°C to 71°C.

Parameter	Min.	Typ.	Max.	Units	Conditions
Operating voltage	9	12	36	VDC	
Power consumption		3		W	Apogee-A and E versions
		<6		W	Apogee-D version
Allowable Input Voltage Ripple			400	mV p-p	
Under voltage lock out		8.5		V	Turn on threshold
		7.5		V	Turn off threshold
Galvanic Isolation			200	VDC	VIN+ to Mechanical Ground VIN- to Mechanical Ground

4.3. Main connector

The main connector is mainly used to configure the device and read data from it. It features the following interfaces:

- One serial interface that supports full-duplex operations at up to 921 600 bps. It can be configured to operate as an RS-232 or RS-422 interface by pulling down the pin 2.
- One CAN 2.0A/B interface that supports up to 1 Mbit/s data rate used to output data.
- One Ethernet 100BASE-T interface for device configuration, FTP access and virtual UDP or TCP/IP serial ports.
- One synchronization input / event marker signal for clock synchronization or to output data on a signal event.
- Two Synchronization output signals for time stamping and to trigger some equipment and virtual odometer capability.

4.3.1. Connector specifications

The main connector uses a 19 ways female AluLite Fischer connector which is compatible with the Fischer Core Series. To avoid misconnection the main connector uses the keying code 11. The exact receptacle reference is: AL1731-DBPU-104-A092PB11-12G13

Figure 4.5: Main receptacle front view

Figure 4.6: Main plug

This 104 size connector mates with following Core Series and AluLite plugs: Don't forget that these two references don't include the cable clamp sets. Other compatible references, with possibly right angle design can be found.

- AL1731-S-104-A092SR11-11 (AluLite version)

- S-104-A092-130 (Core Series version)

4.3.2. Connector pin-out

Connector's pin-out is sorted by function rather than pin numbering.

Pin #	Name	Description
Shield	Shield	Connected to the mechanical ground
1	GND	Connected to the main connector electrical ground
5	GND	Connected to the main connector electrical ground
7	GND	Connected to the main connector electrical ground
2	RS-232/RS-422	Pull to GND to select RS-422 mode
3	Sync Out A	Synchronization output signal A
4	Sync Out B	Synchronization output signal B
6	Sync In A	Synchronization input signal A
8	Port A – RS-422 - Rx+	Port A serial input data / configuration RS-422
9	Port A – RS-422 - Rx-	Port A serial input data / configuration RS-422
10	Port A – RS-422 - Tx-	Port A serial output data / configuration RS-422
11	Port A – RS-422 - Tx+	Port A serial output data / configuration RS-422
12	Port A – RS-232 - Rx	Port A serial input data / configuration RS-232
13	Port A - RS-232 - Tx	Port A serial output data / configuration RS-232
14	CAN H	CAN bus 2.0 high line
15	CAN L	CAN bus 2.0 low line
16	Ethernet Tx+	White/Green RJ45 pin#1
17	Ethernet Tx-	Green RJ45 pin#2
18	Ethernet Rx-	Orange RJ45 pin# 6
19	Ethernet Rx+	White/Orange RJ45 pin# 3

Note: By default, if you leave the RS-232/$\overline{\text{RS-422}}$ signal unconnected, the Port A will operate in RS-232 mode.

4.3.3. Electrical specifications (V1 hardware)

Recommended electrical specifications from -40°C to 71°C.

All signals are referenced to GND_MAIN. Pins #3, #4 and #7 are internally connected.

Parameter	Conditions	Min.	Typ.	Max.	Units
RS-232/RS-422					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8	1.5		V
	Threshold High		1.8	2.7	V
Internal Pull-Up Resistor	Pull Voltage = +5 VDC		1		kΩ
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
Port A – RS-422 – Receiver					
Receiver Data Rate		4 800		921 600	bps
Input Resistance	-7 V < Common Mode Voltage < +12 V	96			kΩ
Input Differential Threshold	-7 V < Common Mode Voltage < +12 V	-200		-50	mV
Input Hysteresis			30		mV
Port A – RS-422 – Transmitter					
Differential Output Voltage		2			V
Common-Mode Output Voltage				3	V
Port A – RS-232 – Receiver, Sync In A					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8			V
	Threshold High			2.7	V
Input Hysteresis			500		mV
Input Resistance		3	5	7	kΩ
Port A – RS-232 – Transmitter					
Output Voltage Swing	Tx loaded with 3kΩ to GND_MAIN	±5	±5.4		V
CAN					
Recessive Bus Voltage		2		3	V
CAN H Output Voltage	Dominant	3.0		4.25	V
CAN L Output Voltage	Dominant	0.5		1.75	V
Differential Input Voltage	-12 V ≤ Common Mode Voltage ≤ +12 V	0.5	0.7	0.9	V

4.3.4. Electrical specifications (V2 hardware)

Recommended electrical specifications from -40°C to 71°C.

All signals are referenced to GND_MAIN. Pins #3, #4 and #7 are internally connected.

Parameter	Conditions	Min.	Typ.	Max.	Units
RS-232/RS-422					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8	1.5		V
	Threshold High		1.8	2.7	V
Internal Pull-Up Resistor	Pull Voltage = +5 VDC		1		kΩ
Sync Out A, Sync Out B					
Output Type		Push pull			-
High-level output Voltage	I < 30mA	3.5	5.0		V
Low-level output Voltage	I < 30mA		0.0	1.5	V
Port A – RS-422 – Receiver					
Receiver Data Rate		4 800		921 600	bps
Input Resistance	-7 V < Common Mode Voltage < +12 V	96			kΩ
Input Differential Threshold	-7 V < Common Mode Voltage < +12 V	-200		-50	mV
Input Hysteresis			30		mV
Port A – RS-422 – Transmitter					
Differential Output Voltage		2			V
Common-Mode Output Voltage				3	V
Port A – RS-232 – Receiver, Sync In A					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8			V
	Threshold High			2.7	V
Input Hysteresis			500		mV
Input Resistance		3	5	7	kΩ
Port A – RS-232 – Transmitter					
Output Voltage Swing	Tx loaded with 3kΩ to GND_MAIN	±5	±5.4		V
CAN					
Recessive Bus Voltage		2		3	V
CAN H Output Voltage	Dominant	3.0		4.25	V
CAN L Output Voltage	Dominant	0.5		1.75	V
Differential Input Voltage	-12 V ≤ Common Mode Voltage ≤ +12 V	0.5	0.7	0.9	V

4.3.5. Electrical specifications (V3 hardware)

Recommended electrical specifications from -40°C to 71°C.

All signals are referenced to GND_MAIN. Pins #3, #4 and #7 are internally connected.

Parameter	Conditions	Min.	Typ.	Max.	Units
RS-232/RS-422					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8	1.5		V
	Threshold High		1.8	2.7	V
Internal Pull-Up Resistor	Pull Voltage = +5 VDC		1		kΩ
Sync Out A, Sync Out B					
Output Type		Push pull			-
High-level output Voltage	I < 30mA	3.5	5.0		V
Low-level output Voltage	I < 30mA		0.0	1.5	V
Port A – RS-422 – Receiver					
Receiver Data Rate		4 800		921 600	bps
Input Resistance	-7 V < Common Mode Voltage < +12 V	96			kΩ
Input Differential Threshold	-7 V < Common Mode Voltage < +12 V	-200		-50	mV
Input Hysteresis			30		mV
Port A – RS-422 – Transmitter					
Differential Output Voltage		2			V
Common-Mode Output Voltage				3	V
Port A – RS-232 – Receiver, Sync In A					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.8			V
	Threshold High			2.7	V
Input Hysteresis			500		mV
Input Resistance		3	5	7	kΩ
Port A – RS-232 – Transmitter					
Output Voltage Swing	Tx loaded with 3kΩ to GND_MAIN	±5	±5.4		V
CAN					
Recessive Bus Voltage		2		3	V
CAN H Output Voltage	Dominant	3.0		4.25	V
CAN L Output Voltage	Dominant	0.5		1.75	V
Differential Input Voltage	-12 V ≤ Common Mode Voltage ≤ +12 V	0.5	0.7	0.9	V

4.4. External aiding connector

The external aiding connector is mainly used to connect aiding equipment to the Apogee. It features the following connections:

- Up to two RS-232 or RS-422 ports that support full-duplex operations
- Two Rx only RS-232 or RS-422 ports
- Four synchronization input signals

4.4.1. Connector specifications

The external connector uses a 19 ways female AluLite Fischer connector which is compatible with the Fischer Core Series. To avoid misconnection the external connector uses the keying code 12. The exact receptacle reference is: AL1731-DBPU-104-A092PB12-12G13

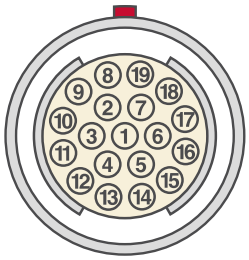


Figure 4.7: External receptacle front view

Figure 4.8: External plug

This 104 size connector mates the following core series and AluLite versions connectors. Other compatible references, with possibly right angle design can be found.

- AL1731-S-104-A092SR12-11 (AluLite version)
- S-104-A092-230 (Core Series version)

4.4.2. Connector pin-out

Connector's pin-out is sorted by function rather than pin numbering.

Pin #	Name	Description
Shield	Shield	Connected to the mechanical ground
1	GND	Connected to the external connector electrical ground
5	GND	Connected to the external connector electrical ground
7	GND	Connected to the external connector electrical ground
4	Sync In B	Port B input synchronization
12	Port B – RS-232/RS-422 – Rx+	Port B serial input RS-232/RS-422
13	Port B – RS-422 – Rx-	Port B serial input RS-422
14	Port B – RS-422 – Tx+	Port B serial output RS-422
15	Port B – RS-232/RS-422 – Tx-	Port B serial output RS-232/RS-422
6	Sync In C	Port C input synchronization
16	Port C – RS-232/RS-422 – Rx+	Port C serial input RS-232/RS-422
17	Port C – RS-422 – Rx-	Port C serial input RS-422

Pin #	Name	Description
18	Port C – RS-232/RS-422 – Tx-	Port C serial output RS-232/RS-422
19	Port C – RS-422 – Tx+	Port C serial output RS-422
2	Sync In D	Port D input synchronization
8	Port D – RS-232/RS-422 – Rx+	Port D serial input RS-232/RS-422
9	Port D – RS-422 – Rx-	Port D serial input RS-422
3	Sync In E	Port E input synchronization / Odometer B
10	Port E – RS-422 – Rx-	Port E serial input RS-422
11	Port E – RS-232/RS-422 – Rx+	Port E serial input RS-232/RS-422 / Odometer A

For Apogee-D, if the internal GNSS receiver is enabled, the PORT B will not be available as it is used internally by the GNSS receiver. However, the Sync In B signal will still be available.

4.4.2.1. Electrical specifications

Recommended electrical specifications from -40°C to 71°C.

Parameter	Conditions	Min.	Typ.	Max.	Units
Sync In pins, Port B, C, D, E – RS-232 – Receiver					
Input Voltage Range		-25		+25	V
Input Threshold	Threshold Low	0.6	1.2		V
	Threshold High		1.5	2.4	V
Input Resistance		3	5	7	kΩ
Port B, C, D, E – RS-232 – Transmitter					
Output Voltage Swing	Tx loaded with 3 kΩ to GND_AUX	±5	±5.4		V
Port B, C, D, E – RS-422 – Receiver					
Input Resistance	-7 V < Common Mode Voltage < +12 V	48			kΩ
Input Differential Threshold	-7 V < Common Mode Voltage < +12 V	-200		-50	mV
Input Hysteresis			30		mV
Port B, C, D, E – RS-422 – Transmitter					
Differential Output Voltage		2			V
Common-Mode Output Voltage				3	V
Output Short-circuit Current	-7 V < TX+ or Tx- < +12 V			±250	mA

4.5. GNSS antenna connectors

To connect external GNSS antennas, the Apogee-D version includes two IP-68 TNC connectors. Each Apogee is provided with dust caps to seal the TNC connector offering an IP-68 protection. The internal GNSS receiver only supports active GNSS antennas.

4.5.1. Connector specifications

The female TNC connector, manufactured by Molex (reference 73216-2380), is made of nickel-plated brass. This connector offers an IP-68 protection even unmated.

Figure 4.9: GNSS antenna connector

Any standard GNSS cable with a TNC male connector can be used with the Apogee. However, care should be taken to select a high quality coaxial cable with low loss.

Figure 4.10: Typical TNC antenna cable

Please be advise that the Apogee doesn't implement any lightning protection. The GNSS antennas and cables are very sensitive to strikes and a proper installation with lightning protection devices may be required.

Note: For best performance, the antenna(s) should be connected before the power is applied. The Apogee-D GNSS receiver estimates the noise floor of the antenna during the startup sequence.

Warning: With the Apogee-D, for correct dual antenna operations, please use the exact same TNC cables and antennas for the primary and secondary GNSS.

4.5.2. Electrical specifications

Recommended electrical specifications for GNSS antenna selection from -40°C to 71°C.

Parameter	Specifications		Remark, conditions
Antenna connector	TNC female		IP-68 when connected
Input impedance	50 Ω		
LNA supply voltage	5 VDC		±5 %
LNA supply current	< 150 mA		Per antenna
RF input frequencies	GPS L1 C/A	1575.42 MHz ± 15.345 MHz	
	GPS L2C & L2 P(Y)	1227.60 MHz ± 11 MHz	
	GPS L5	1176.45 MHz ± 12.5 MHz	
	Glonass L1 C/A	1598.0625-1605.375 MHz ± 0.511 MHz	
	Glonass L2 C/A & L2P	1242.9375-1248.625 MHz ± 0.511 MHz	
	Glonass L3	1202.025 MHz ± 10.23 MHz	
	Galileo E1	1575.42 MHz ± 20.46 MHz	
	Galileo E5a	1176.450 MHz ± 10.23 MHz	
	Galileo E5b	1207.140 MHz ± 10.23 MHz	
	Beidou B1I	1561.098 MHz ± 4.092 MHz	
	Beidou B1C	1575.42 MHz ± 16.368 MHz	
	Beidou B2I	1207.140 MHz ± 10.23 MHz	
	Beidou B2a	1176.45 MHz ± 10.23 MHz	
	Beidou B3I	1268.520 MHz ± 20.46 MHz	
Recommended Gain	15 dB to 45 dB		Antenna gain minus cable losses

Note: If you use an amplified antenna splitter or special GNSS antennas such as a Trimble Zephyr 2, please make sure that the actual gain at the Apogee input stays in range 15-45 dB.

4.5.3. GNSS antenna advice

The Apogee-D embed a high performance multi-constellation GNSS receiver that supports GPS L1/L2/L5, GLONASS L1/L2/L3, BEIDOU B1/B2/B3 and GALILEO E1/E5a/E5b signals. For best performances and robustness, please use low noise and high gain active GNSS antennas that support the frequency bands you are planning to use.

In addition, the Apogee-D requires at least an L1/L2 GPS + GLONASS antennas to compute correct true heading solutions.

Don't forget to also check the GNSS antenna LNA power requirements such as input voltage (must accepts 5 VDC) and input current (must be below 150 mA per antenna).

SBG Systems has selected some high quality GNSS antennas for different applications. Please refer to the support center to get more details on available antennas.

Note: As a rule of thumb, true heading and/or RTK measurements require higher quality GNSS antennas to achieve the stated accuracy.

4.6. Typical wiring

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

4.6.1. Power supply connection

Concerning power supply, we recommend shielded cable, with at least AWG 24 wires.

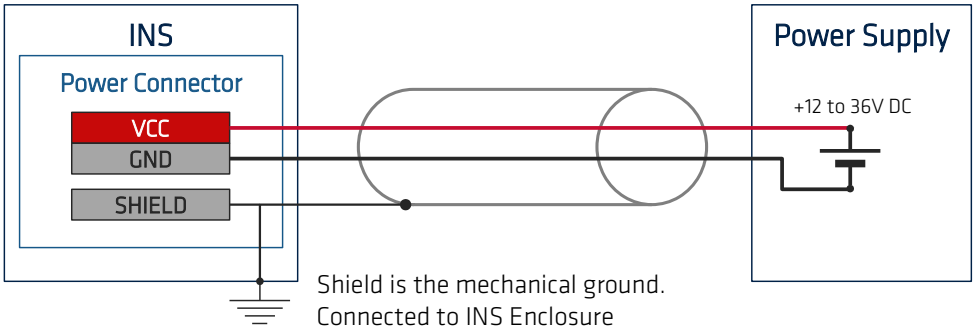


Figure 4.11: Power supply wiring connections

4.6.2. Main interface connection on RS-232

Below is shown the main interface (Port A) connection, using a full duplex RS-232 connection. The recommended cable is a shielded AWG 26 cable.

A protocol selector pin is left open in RS-232 mode.

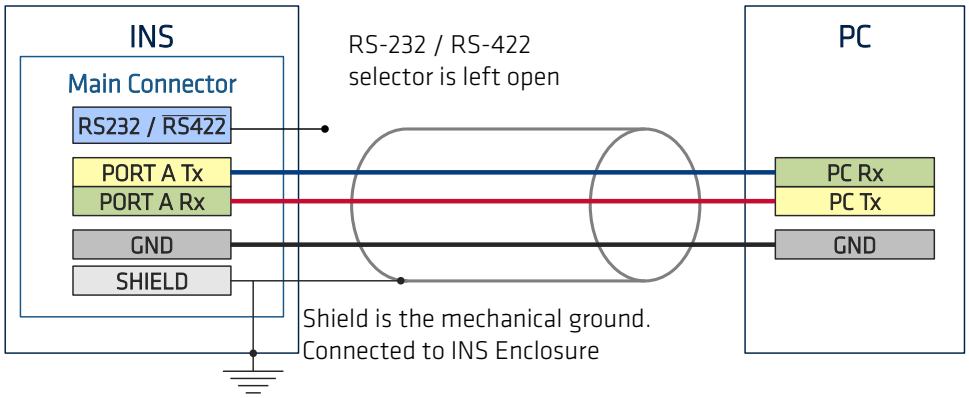


Figure 4.12: Main serial interface full duplex connection in RS-232

4.6.3. Main interface connection on RS-422

Below is shown the main interface (Port A) connection, using a full duplex RS-422 connection. The recommended cable is a shielded twisted pairs AWG 26 cable.

Note the termination resistors (Usually 120 Ω) 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.

A protocol selector pin is connected to GND in RS-422 mode.

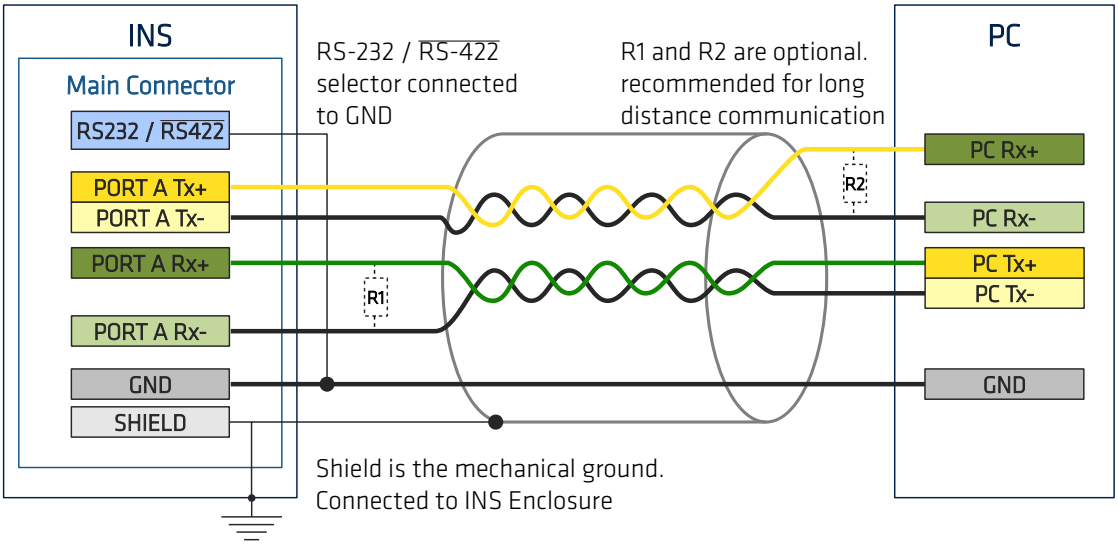


Figure 4.13: Main serial interface full duplex connection in RS-422 mode

4.6.4. CAN Bus typical wiring

CAN bus is designed to operate with low cost twisted pairs cables. The bus may be terminated by a single 60 Ω resistor, or multiple resistors on each bus ends (as long as the equivalent parallel impedance is 60 Ω). This resistor is not present in the Apogee.

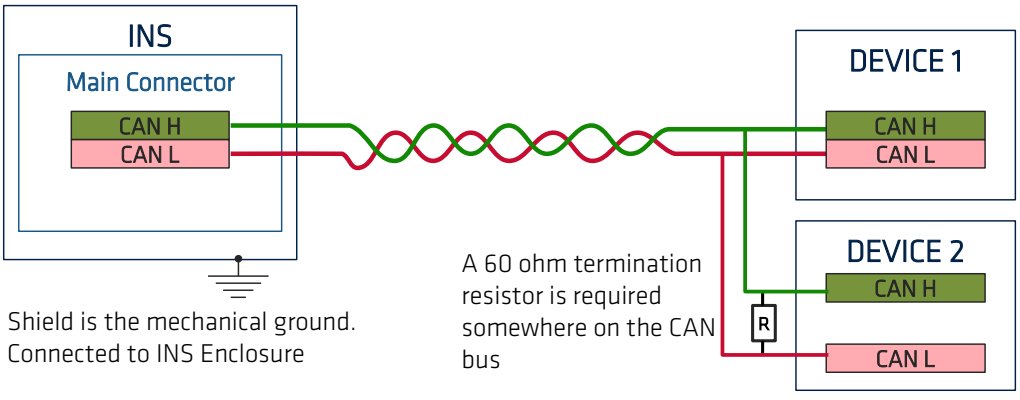


Figure 4.14: Basic CAN bus wiring

4.6.5. 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 GNSS NMEA signals should be separated in two cables for better noise immunity.

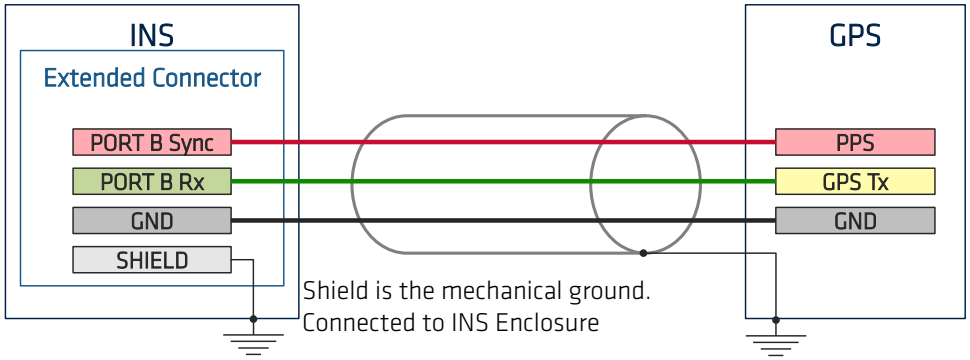


Figure 4.15: Typical wiring diagram for Apogee with external GNSS receiver

4.6.6. Third party aiding equipment connected in RS-422

For this connection, we recommend shielded twisted pairs AWG 26 cable. As for main communication interface, a termination resistor may be required depending on the communication distance.

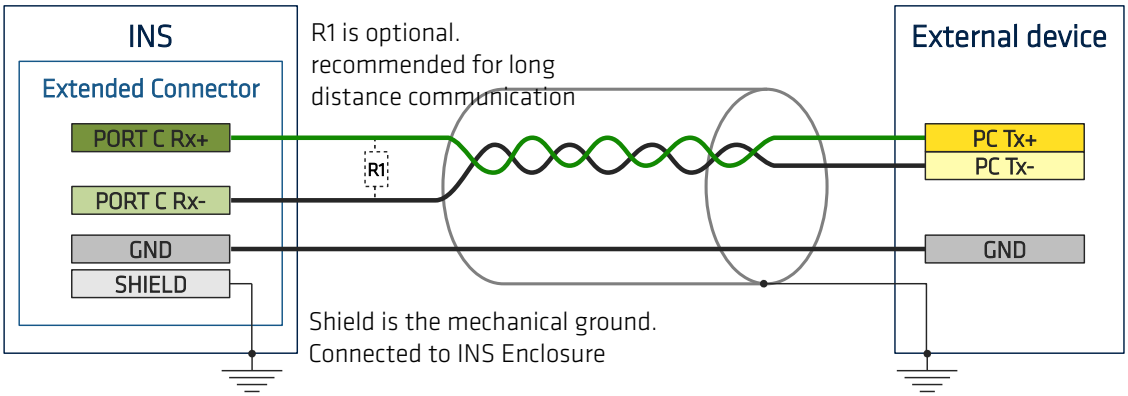


Figure 4.16: Third party aiding equipment with RS-422 interface

4.6.7. 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.

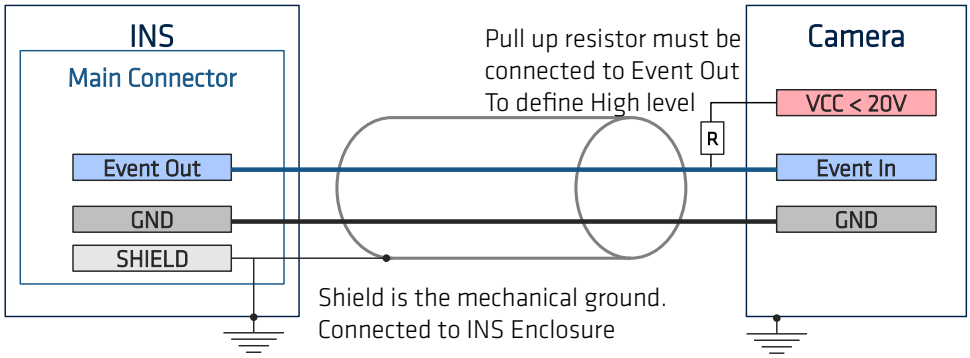


Figure 4.17: Sync Out connection with pull up resistor

4.7. Typical connection topologies

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

4.7.1. Apogee-D in advanced automotive application

Here we present an advanced use case where the Apogee-D sensor is used in a land survey application. The Apogee configuration is the following:

- On the aiding/input side:
  - Two GNSS antennas are connected for GNSS true heading measurement
  - RTCM data coming from a RTK base station is connected to PORT C to provide RTK accuracy to internal GNSS.
  - An odometer is connected to PORT E to provide velocity aiding in harsh GNSS environments.
  - Finally an event input is triggered by user at several instants. For example, this helps locating physical objects within the recorded data.
- On the output side:
  - Sync Out pulse is configured as 10 Hz output to trig a camera 10 times per second.
  - Data output is stored on a PC through ETH 0 interface. A new log is sent for each captured picture.

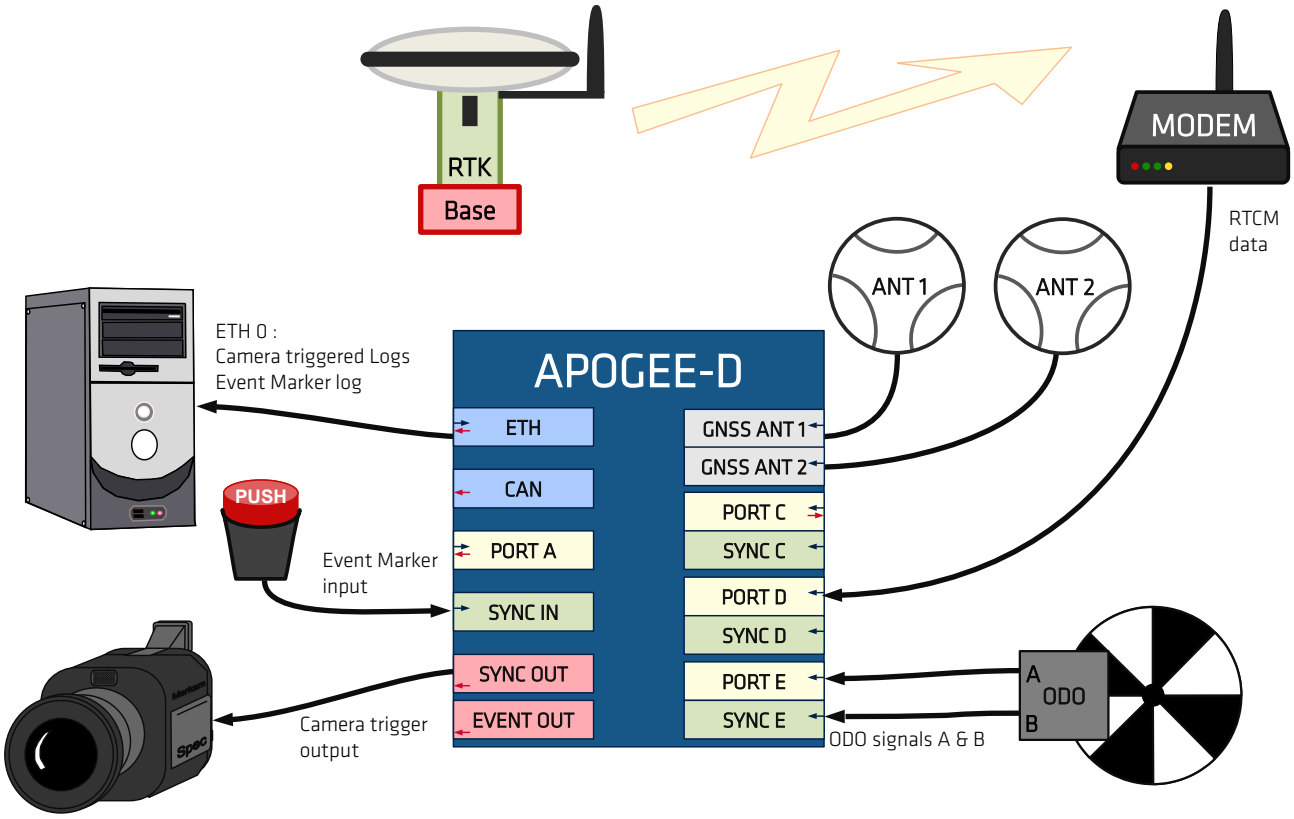


Figure 4.18: Apogee-D connection in an advanced automotive application

4.7.2. Apogee-E in marine application

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

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

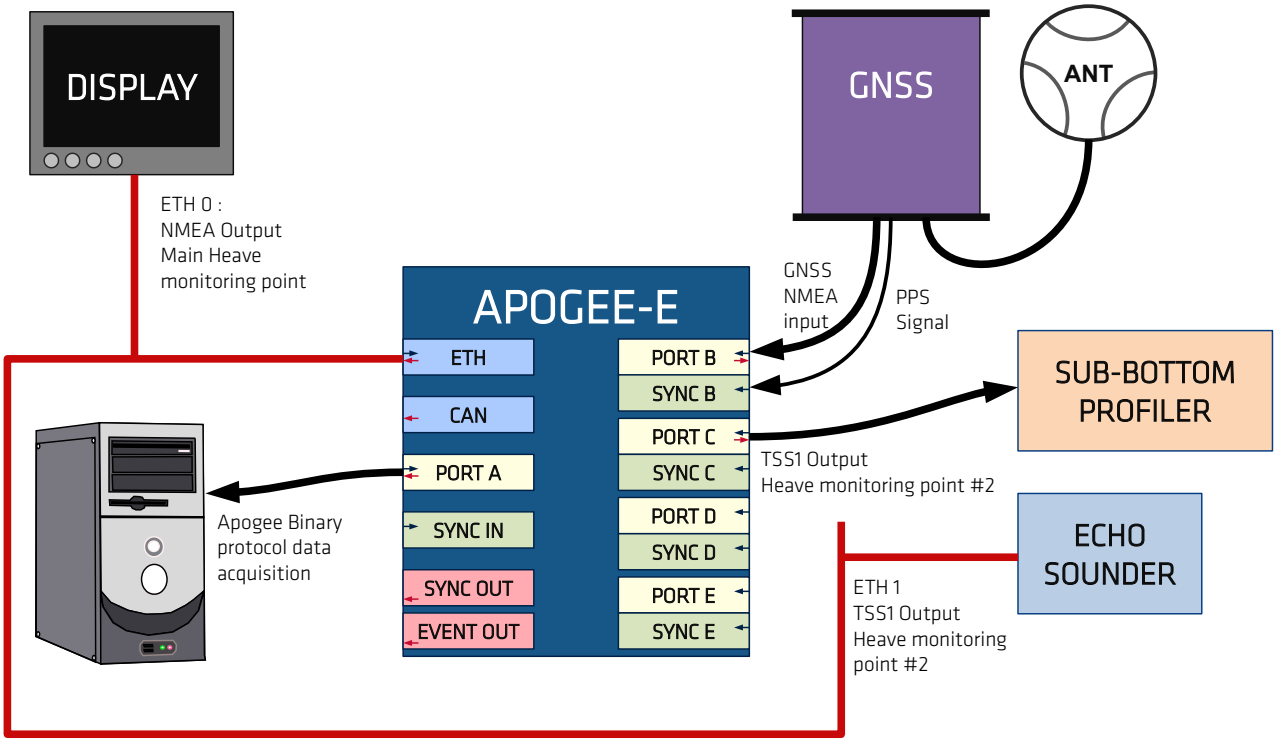


Figure 4.19: Apogee-E use in advanced Marine application

5. Interfaces specifications

5.1. Overview

The Apogee features the following interfaces:

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

5.2. Ethernet specifications

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

The Apogee can be ordered with 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 Apogee device as it provides the following services:

- A Bonjour service used to easily discover any connected Apogee 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 Apogee web page

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

http://apogee_050000001.local

Where 05000001 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 Apogee devices available on the network.

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

Physical serial interfaces are designated as Port A, B, C, D and E and have the following common characteristics:

- 4 800 to 921 600bps operation (Default set to 115 200)
- RS-232 or RS-422 modes, configured by software
- Parity control enabling/disabling (disabled by default)
- Data bits: 8
- Stop bits: 1

The following table provides more details about each port specificity in terms of availability, and capabilities:

Port	Availability	Tx / Rx availability	RS-232/422 configuration Cable / software defined	SbgECom binary commands input	Other functions / multiplexing
A	All	Tx/Rx	Cable	Yes	
B	E	Tx/Rx	Software	-	
C	All	Tx/Rx	Software	-	
D	All	Rx	Software	-	
E	All	Rx	Software	-	Multiplexed w. Odometer input

5.4. Supported protocols

The Apogee has been designed to be connected to a large range of aiding equipment 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.

5.4.1. Connections Mapping

You will find below the available connections configuration for aiding inputs. The Apogee-A, E and D share roughly the same mapping but there are some specificity due to the embedded GNSS receiver present in the Apogee-D.

5.4.1.1. Apogee-A version

The Apogee-A is an MRU (Motion Reference Unit) and doesn't provide any navigation capabilities. However, the device accepts external GNSS data to enhance computed roll, pitch, heading and heave measurements.

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

5.4.1.2. Apogee-E version

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

5.4.1.3. Apogee-D

The Apogee-D embed a high performance GNSS receiver that supports RTK positioning. To enable RTK accuracy, differential corrections have to be sent to the embedded GNSS receiver through the Port D.

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

Note 1: Please remember that the Port B is not available for the Apogee-D versions when the internal GNSS is enabled.

5.5. Internal Datalogger

The Apogee includes an internal datalogger capable of storing all data at 200 Hz 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.

5.6. CAN 2.0 A/B interface

The main port contains a CAN 2.0 A/B interface that supports transfer rate at up to 1 Mbits/s. This CAN interface is mainly used to output log messages. By default, the CAN interface is disabled.

The CAN bus implementation and especially timing settings complies with the CAN in Automation (CiA) DS-102 standard.

The Apogee supports the following standard CAN bus bitrates:

- 1 000 kBit/s
- 500 kBit/s
- 250 kBit/s
- 125 kBit/s
- 100 kBit/s
- 50 kBit/s
- 20 kBit/s
- 10 kBit/s

Note: The Apogee does not include any termination resistor, and it belongs to user to ensure that the CAN bus includes termination resistors in order to get proper communications.

6. Important notices

6.1. Maintenance

The Apogee 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.

When used in harsh environments, please use damp clothes to clean the surface of the Enclosure.

Although not recommended, it is possible to use the Apogee in salt water environments. In such environments, the Apogee enclosure must be rinsed with clear water to remove any long term presence of salt on the enclosure.

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	± 200 V
Rx+, Rx-, Logic inputs pins input voltage to signal GND	±25 V
Sync Out max current	30 mA Short circuit protected
CANH, CANL	±80 V
Shock	500 g for 0.3 ms
Specified performance temperature range	-20°C to 60°C (-40°F to 140°F)
Operating temperature range	-40°C to 71°C (-40°F to 160°F)
Storage temperature range	-40°C to 85°C (-40°F to 185°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 at 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. Apogee variants

The following Apogee variants are available to order. Please contact your sales representative for more information.

Apogee Variant
APOGEE-A | Marine MRU
APOGEE-E | Marine INS
APOGEE-E | Land Air INS
APOGEE-D | Marine INS - GNSS RTK
APOGEE-D | Land Air INS - GNSS RTK

7.2. Transport Case

7.2.1. CASE-AEK-01

This larger transport case can be used to securely ship or stock:

- An Apogee-A, E or D
- Up to two survey grade GNSS antennas
- Many cables or third party devices

Figure 7.1 : 9.2.2. CASE-AEK-01

7.3. Associated Software

7.3.1. Inertial SDK

The SBG Systems Inertial SDK is very helpful to configure, playback recorded logs, export data to text files or third party software and even develop custom code for the Apogee.

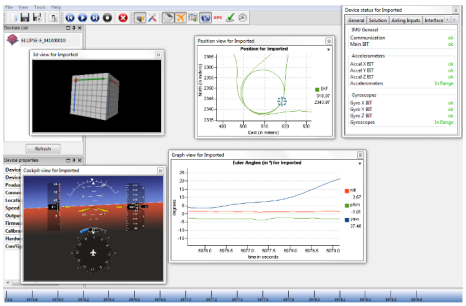


Figure 7.2: sbgCenter analysis tool

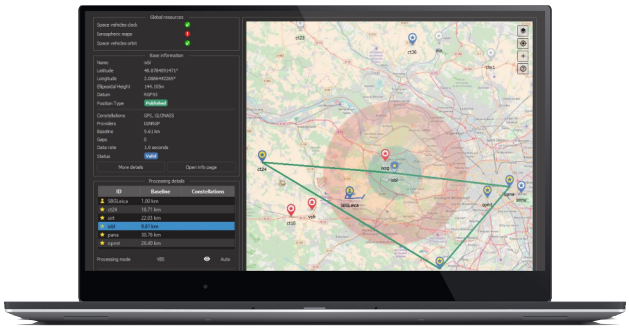
It contains the following items:

- sbgCenter analysis software
- sbgECom C library and examples

The Inertial SDK can be downloaded on the SBG Systems support center.

7.3.2. SW-QINERTIA-PRO (GNSS/INS Post Processing Software)

Qinertia is a 100 % in-house post-processing software solution. This full-featured software enhances SBG Systems inertial navigation systems performance by post processing inertial data with raw GNSS observable in both forward and backward directions.



Key Features:

- Tight Coupling INS/GNSS fusion
- Achieve highest possible accuracy
- + 7 000 Base Stations always up-to-date
- Open to all Industry Standards
- Fastest Processing available on the market
- Modern & Intuitive Interface

7.4. Cables

7.4.1. CA-AEK-PWR-PSU-1.5M

Figure 7.3 : AC / DC power adapter

This cable is an international AC/DC adapter to power up the Apogee or the SplitBox.

- 110 / 250 V input with UK, US and EU plugs.
- 12 V output
- No IP rating

7.4.2. CA-AEK-PWR-3M

Figure 7.4 : Alternative Power cable

This cable mates with the POWER connector to power up the Apogee or the SplitBox from external power supply.

- 1 x Fischer Core Series S-103-Z051-130 connector
- 1 x open end
- IP-68 rating
- 3 m long AWG 18 cable
- Weight: 170 g

Cable wiring is:

Pin	Signal	Color
SHIELD	NC	SHIELD
1	V+	Red
2	V-	Black

7.4.3. CA-AEK-MAIN-ETH-2.5M

Figure 7.5 : Ethernet cable

This cable provides easy Ethernet access to the Apogee.

- 1 x Fischer Core Series S-104-A092-130.
- 1 x RJ-45 connector for Ethernet connection.
- No IP rating.
- 2.5 m cable (CAT5 type)
- Weight: 90 g

Cable wiring is:

Pin on Fisher connector	Signal	Color
SHIELD	SHIELD	SHIELD
16	ETHERNET_TXD+	Green / White
17	ETHERNET_TXD-	Green
18	ETHERNET_RXD-	Orange
19	ETHERNET_RXD+	Orange/ White

Unspecified pins or colors are not connected internally.

7.4.4. CA-AEK-MAIN-RS232-3M

This cable is designed to mate with the MAIN connector and provides RS-232 communication with PORT A as well as other MAIN connector pins access.

- 1 x Fischer Core Series S-104-A092-130
- 1 open end
- IP-68 rating
- 3 m AWG 26 shielded cable with twisted pairs
- Weight: 300 g

Figure 7.6 : Main RS-232 cable

Cable wiring is:

Pin on Fisher connector	Signal	Color
SHIELD	SHIELD	SHIELD
1	GND	Grey
2	RS422/232 PORT A	
3	SYNC OUT A	Pink
4	SYNC OUT B	Purple
5	GND	Black
6	SYNC IN A	Light blue
7	GND	Light green
8	PORTA_422_RX+	
9	PORTA_422_RX-	
10	PORTA_422_TX-	
11	PORTA_422_TX+	
12	PORTA_232_RX	Grey / White
13	PORTA_232_TX	Grey / Red
14	CAN_H	Brown / White
15	CAN_L	Brown
16	ETHERNET_TXD+	Dark green / White
17	ETHERNET_TXD-	Dark green
18	ETHERNET_RXD-	Orange
19	ETHERNET_RXD+	Orange / White

Unspecified pins or colors are not connected internally.

7.4.5. CA-AEK-MAIN-RS422-3M

This cable is designed to mate with the MAIN connector and provides RS-422 communication with PORT A as well as other MAIN connector pins access.

- 1 x Fischer Core Series S-104-A092-130
- 1 open end
- IP-68 rating
- 3 m AWG 26 shielded cable with twisted pairs
- Weight: 300 g

Figure 7.7 : Main RS-422 cable

Cable wiring is:

Pin on Fisher connector	Signal	Color
SHIELD	SHIELD	SHIELD
1	GND	Grey
2	RS422/232 PORT A	- Internally connected to pin 1 -
3	SYNC OUT A	Pink
4	SYNC OUT B	Purple
5	GND	Black
6	SYNC IN A	Light blue
7	GND	Light green
8	PORTA_422_RX+	White
9	PORTA_422_RX-	Red
10	PORTA_422_TX-	Dark blue
11	PORTA_422_TX+	Dark blue / White
12	PORTA_232_RX	
13	PORTA_232_TX	
14	CAN_H	Brown / White
15	CAN_L	Brown
16	ETHERNET_TXD+	Dark green / White
17	ETHERNET_TXD-	Dark green
18	ETHERNET_RXD-	Orange
19	ETHERNET_RXD+	Orange / White

Unspecified pins or colors are not connected internally.

7.4.6. CA-AEK-AUX-3M

This cable is designed to mate with the AUX connector and provides access to all AUX connector pins.

- 1 x Fischer Core Series S-104-A092-230
- 1 open end
- IP-68 rating
- 3 m AWG 26 shielded cable with twisted pairs
- Weight: 300 g

Figure 7.8 : Auxiliary cable

Cable wiring is:

Pin	Signal	Color
SHIELD	SHIELD	SHIELD
1	GND	Grey
2	Sync In D	Yellow
3	Sync In E	Pink
4	Sync In B	Purple
5	GND	Grey / Red
6	Sync In C	Light blue
7	GND	Grey / White
8	Port D – RS-232/RS-422 – Rx+	White
9	Port D – RS-422 – Rx-	Red
10	Port E – RS-422 – Rx-	Dark blue
11	Port E – RS-232/RS-422 – Rx+	Dark blue / White
12	Port B – RS-232/RS-422 – Rx+	Light green
13	Port B – RS-422 – Rx-	Black
14	Port B – RS-422 – Tx+	Brown / White
15	Port B – RS-232/RS-422 – Tx-	Brown
16	Port C – RS-232/RS-422 – Rx+	Dark green / White
17	Port C – RS-422 – Rx-	Dark green
18	Port C – RS-232/RS-422 – Tx-	Orange
19	Port C – RS-422 – Tx+	Orange / White

Unspecified pins or colors are not connected internally.

7.4.7. CA-AEK-SPLIT-MAIN-0.5M

This cable provides a robust and easy access to all interfaces available on the Apogee MAIN connector using standard plugs.

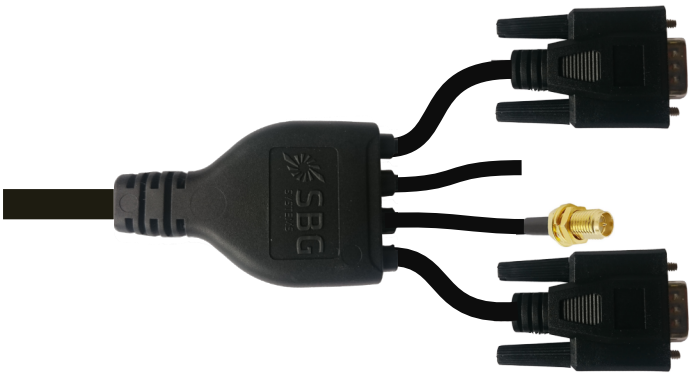


Figure 7.9: CA-AEK-SPLIT-MAIN-0.5M – Lengths not to scale

The cable has following characteristics:

- 1 x Fischer Core Series S-104-A092-130 that connects on MAIN connector
- 1 x DB-9 for PORT A in RS-232 mode, full duplex
- 1 x RJ-45 plug for Ethernet connection
- 1 x Female DB-9 plug for CAN bus output
- 1 x Male SMA plug for Sync IN A (External GNSS PPS connection)
- Total length: 50 cm (25 cm before / after cable splitter)

Connectors pin-outs are defined below:

Pin on DB-9 "PORT A"	Function
2	PORT A RX
3	PORT A TX
4	SYNC OUT A
5	GND

Pin on DB-9 "CAN"	Function
2	CAN L
3	GND
7	CAN H

Pin on RJ45 ETH	Function
1	Tx+
2	Tx-
3	Rx+
6	Rx-

Pin on SMA "SYNC IN A"	Function
Central pin	SYNC IN A
Outer	GND

7.4.8. CA-AEK-SPLIT-MAIN2-0.5M

This cable provides a robust and easy access to all interfaces available on the Apogee MAIN connector using standard plugs.

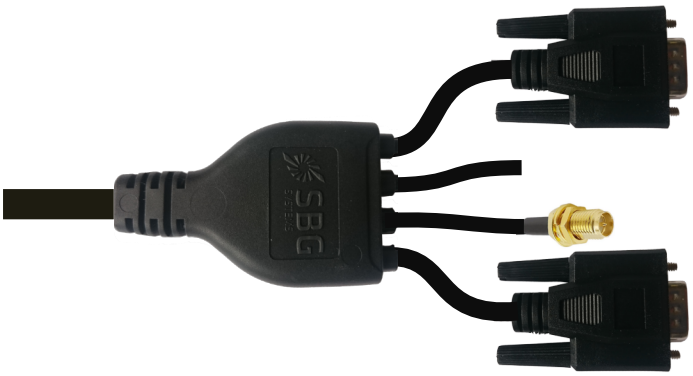


Figure 7.10: CA-AEK-SPLIT-MAIN2-0.5M – Lengths not to scale

The cable has following characteristics:

- 1 x Fischer Core Series S-104-A092-130 that connects on MAIN connector
- 1 x DB-9 for PORT A in RS-232 mode, with access to SYNC IN A and SYNC OUT A
- 1 x RJ-45 plug for Ethernet connection
- 1 x Female DB-9 plug for CAN bus output
- 1 x Male SMA plug for Sync OUT B (For time sync with external equipment)
- Total length: 50 cm (25 cm before / after cable splitter)

Connectors pin-outs are defined below:

Pin on DB-9 "PORT A"	Function
1	SYNC IN A
2	PORT A RX
3	PORT A TX
4	SYNC OUT A
5	GND

Pin on DB-9 "CAN"	Function
2	CAN L
3	GND
7	CAN H

Pin on RJ45 ETH	Function
1	Tx+
2	Tx-
3	Rx+
6	Rx-

Pin on SMA "SYNC OUT B"	Function
Central pin	SYNC OUT B
Outer	GND

7.4.9. CA-AEK-SPLIT-AUX-0.5M

This cable provides a robust and easy access to all serial ports available on the Apogee AUX connector using standard DB-9 plugs.

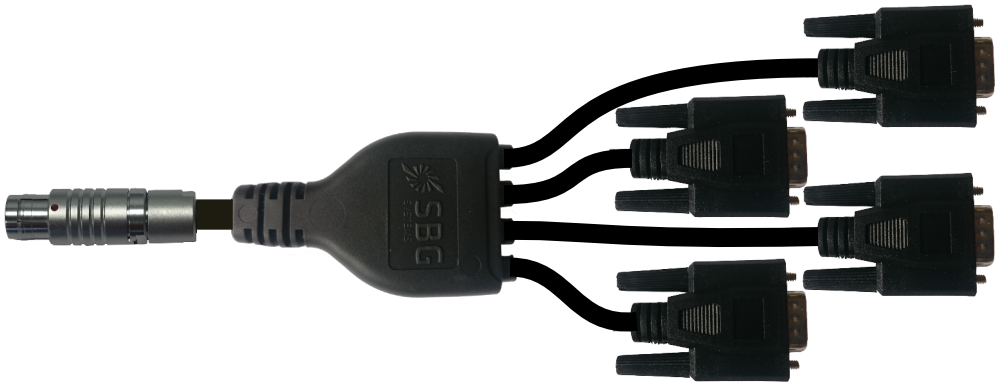


Figure 7.11: CA-AEK-SPLIT-AUX-0.5M – Lengths not to scale

The cable has following characteristics:

- 1 x Fischer Core Series S-104-A092-130 that connects on MAIN connector
- 4 x DB-9 for PORT B C, D and E in RS-232/RS-422 modes
- Total length: 50 cm (25 cm before / after cable splitter)
- Weight: 253 g

Connectors pin-outs are defined below:

Pin on DB-9 "PORT B/C"	Function
1	SYNC IN B/C
2	PORT B/C RS232 Rx / RS-422 Rx+
3	PORT B/C RS232 Tx / RS422 TX-
5	GND
6	PORT B/C RS422 Rx-
7	PORT B/C RS422 Tx+

Pin on DB-9 "PORT D/E"	Function
1	SYNC IN D/E
2	PORT D/E RS232 Rx / RS-422 Rx+
5	GND
6	PORT D/E RS422 Rx-

8. APPENDIX B: Packaging, labeling

8.1. Board Identification

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

In addition to a unique serial number, a "Hardware Code" and associated hardware revision are used to identify the exact hardware model.

Finally, the "Part Number" is used for logistics purpose. It identifies uniquely the full product configuration, including hardware type, software options, and any software or process customization.

You can find on then side of your Apogee a laser printed labels that hold the Hardware Code as well as Serial Number and Hardware Revision. This labels also include a data-matrix code that encodes the device unique serial number.

In addition, the packaging box includes a second label that provides other useful information such as exact part number and installed firmware version.

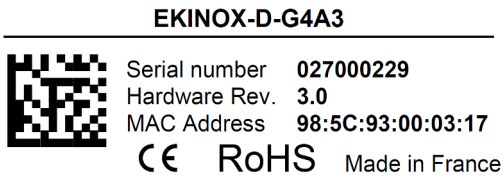


Figure 8.1: Example of INS label

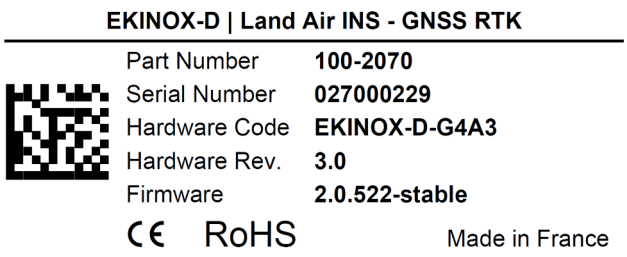


Figure 8.2: Example of packaging label