ELLIPSE SERIES

High Performance, Miniature Inertial Sensors

Hardware Manual

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Covers Hardware Ellipse V3 and above

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Terminology

ADC: Analog to Digital Converter
AHRS: Attitude and Heading Reference System
CAN (Bus): Controller Area Network
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 Merchandise 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

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

Figure 1.1: Ellipse Series (Box units)

- The Ellipse-A version is an attitude and Heading Reference System (AHRS), providing accurate orientation in dynamic conditions.
- The Ellipse-E is an inertial Navigation System (INS), providing both orientation and navigation data using an external GNSS receiver. It can also be coupled with an odometer or DVL for improved navigation performance and embeds a barometric altimeter.
- The ELLIPSE-N and D are Inertial Navigation Systems with an integrated multi-band and multi-constellation GNSS receiver. They are capable of delivering outstanding performance with centimeter precision (RTK) and RAW data output for post-processing applications.
- The ELLIPSE-D also features a dual antenna heading delivering robust and accurate heading angle in the most challenging conditions. It's therefore capable of operating in low and high dynamic environments.

To achieve the best performance in every project, specific error models have been implemented to meet applications requirements. Sensor configuration is made easy through the sbgCenter interface, provided in the SDK. The Ellipse supports a proprietary protocol for best performance, but also standard protocols such as NMEA for direct integration into existing applications.

The Ellipse series is fully backward compatible with the first and second generation of Ellipse sensors.

1.1. Ellipse Overview

The following diagram shows the basic organization of an Ellipse.

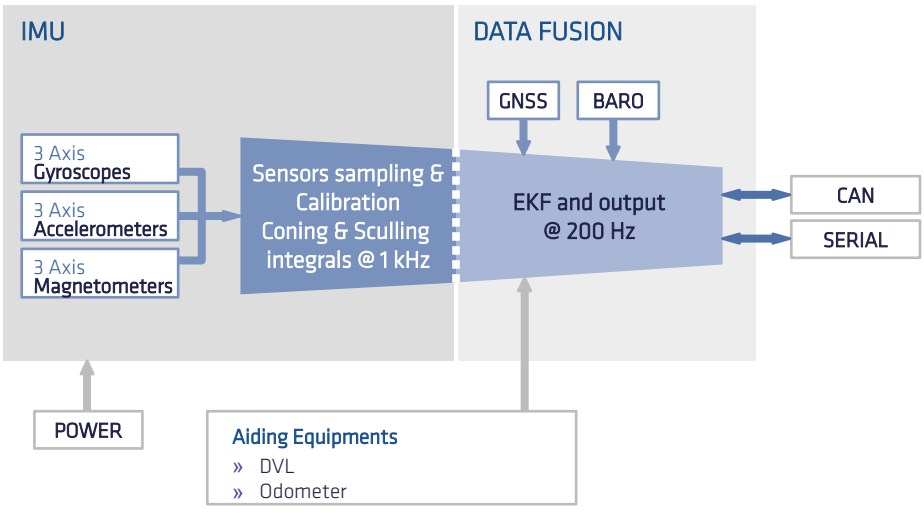


Figure 1.2: Ellipse simplified block diagram

1.2. Inertial measurement unit

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

1.2.1. Accelerometers

The new Ellipse IMU embeds 3 high performance, industrial grade MEMS accelerometers. Coupled with a cutting edge calibration, advanced filtering techniques and sculling integrals, these accelerometers will provide excellent performance, even in highly vibrating environment.

	Value	Remarks
Full scale (*g*)	**Marine:** 8 **Land/Air:** 20 **High dynamics:** 40	The Ellipse series are available in three versions depending on the application.
Scale factor stability (ppm)	1000	After one year accelerated aging
Non-Linearity (ppm of FS)	1500	Best Fit Straight Line
One year bias stability (m*g*)	5	After one year accelerated aging
Velocity Random Walk (µ*g*/√hz)	57	
In run bias instability (µ*g*)	14	Allan variance – @ 25°C
Vibration Rectification Error (µ*g*/*g*²)	50	Tested up to 3g RMS for A2 and 10g RMS for A3/A4
Bandwidth (Hz)	390	Internal low pass filters attenuation < 3 dB
Sampling rate (kHz)	4	Advanced anti-aliasing FIR filter
Orthogonality (°)	0.05	

1.2.2. Gyroscopes

The set of 3 high end industrial grade MEMS gyroscopes is sampled at 10 KHz. An efficient FIR filter and coning integrals computations ensures best performance in vibrating environments.

	Value	Remarks
Full scale (°/s)	**Marine:** 450 **Land/Air:** 450 **High dynamics:** 1000	The Ellipse series are available in three versions depending on the application.
Scale factor stability (ppm)	500	After one year accelerated aging
Non-Linearity (ppm of FS)	50	
One year bias stability (°/s)	0.4	After one year accelerated aging
Angular Random Walk (°/√hr)	0.18	Allan variance – @ 25°C
In run bias instability (°/hr)	8	Allan variance – @ 25°C
Vibration Rectification Error (°/h/g²)	< 1	Tested up to 10g RMS
Bandwidth (Hz)	133	Internal Gyro bandwidth
Sampling rate (kHz)	10	Advanced anti-aliasing FIR filter
Orthogonality (°)	0.05	

1.3. Aiding sensors

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

1.3.1. Internal Magnetometers

A set of three Anisotropic Magneto-resistive magnetometers is embedded within the Ellipse. This technology provides a very high sensitivity compared to coil based technologies.

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

Nevertheless, in many applications such AHRS applications, airborne or several marine 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 Ellipse Hard and Soft Iron Calibration Manual for more information about this.

Warning: Note that magnetometer sampling design makes it impossible to reject signal frequencies above 75Hz. User should ensure that high frequency noise is not disturbing magnetometers at the sensor's location.

	Specifications	Remarks
Full scale (Gauss)	50	
Scale factor stability (%)	0,5	
Noise (mGauss)	3	Over 1 to 25 Hz band
Bias stability (m Gauss)	1	
Bandwidth (Hz)	22	-3dB attenuation
Resolution (mGauss)	1.5	
Sampling rate (Hz)	100	
Orthogonality (°)	0.1	After user magnetic calibration

1.3.2. Ellipse-N and Ellipse-D internal GNSS receiver

The Ellipse-N and Ellipse-D embed a high performance GNSS receiver (L1/L2 GPS, GLONASS, GALILEO, BEIDOU), capable of DGNSS, SBAS and RTK positioning. The Ellipse-D also features a dual antenna heading delivering robust and accurate heading angle in the most challenging conditions. With a refresh rate of 5Hz, this receiver provides best accuracy and reliability in harsh GNSS environments. The standard RAW data output enables highest performance in post-processing applications.

	Specification		Remark
Signal tracking	**GPS**: L1C/A, L2C **GLONASS**: L1OF, L2OF **GALILEO:** E1, E5b	**Beidou** B1I, B2I **QZSS** L1C/A, L2C **SBAS**	All constellations & signals enabled by default
Frequency Range	1100 MHz – 1610 MHz		
Horizontal position accuracy	Single point	1.5 m	
	SBAS	1.0 m	
	RTK	1 cm + 1 ppm	
Velocity accuracy	0.05 m/s RMS		
True Heading Accuracy	0,55° 0.4° 0.3°	0.5m baseline 1m baseline 2m baseline	Ellipse-D only.
Velocity limit	500 m/s		
Time to First Fix	Cold start	< 24 s	
	Hot start	< 2 s	
Signal reacquisition		2 s	
Output frequency	5 Hz		
Diff. Corrections	RTCM V3.3		Sent on any serial port

1.3.3. Internal barometric altimeter

The Ellipse-E, N and D embed a MEMS pressure sensor, used as altimeter. This pressure sensor is fully calibrated and temperature compensated making it ideal to measure accurately absolute pressure.

The Ellipse converts this absolute pressure into altitude using the Standard Atmosphere model, assuming a constant temperature gradient over altitude, and a sea pressure level of 1013,25 hPa.

Barometer specifications

Pressure sensor	Specification	Remarks – Conditions
Resolution	1.2 Pa	10 cm resolution
Pressure accuracy	± 50 Pa ± 200 Pa ± 350 Pa	Relative – [25°C], 700...1100 hPa Absolute – [0...50°C], 450...1100 hPa Absolute – [-20...85°C], 450...1100 hPa
Long term stability	< 100 Pa/yr	
Update Rate	100 Hz	

1.3.4. External sensors

1.3.4.1. Third party GNSS receiver

The Ellipse-E model does not include a GNSS receiver, but can be connected to an external GNSS module. All GNSS receivers will provide velocity and position aiding.

Dual antenna systems can also provide a True Heading aiding. RTK GPS receivers can be used to improve positioning accuracy.

1.3.4.2. Odometer

In addition to the GNSS aiding, the Ellipse E, N and D include an odometer input which can greatly improve performance in challenging environments such as urban canyons. The odometer provides a reliable velocity information even during GNSS outages. This increases significantly the dead reckoning accuracy.

The Ellipse handles quadrature output or compatible odometers in order to support forward and backward directions and it is also able to use vehicle's odometer directly through the OBD-II connector (CAN bus odometer). This makes the ELLIPSE an outstanding INS for self driving cars and autonomous vehicles with incredible accuracy even in very dense urban environments.

Note: Odometer integration is made really simple as the Kalman filter will finely adjust odometer's gain and will correct residual errors in the odometer alignment and lever arm.

1.4. System Performance

All specifications are rated to 1 σ, over -40°C to +85°C (-40 to 185°F) unless otherwise stated.

These specifications have been measured based on typical mission scenarios with simulated GNSS outages and compared to post processed RTK data of a high end FOG based INS.

1.4.1. Ellipse AHRS orientation performance

1.4.1.1. Orientation specifications

	Performance	Remarks
Measurement range	360° in all axes, no mounting limitation	
Roll / Pitch accuracy	< 0.1°	Low dynamic conditions – No long term accelerations
Yaw Accuracy	0.8°	Clean magnetic environment – Magnetic calibration performed

1.4.2. Ellipse INS orientation and navigation performance

This section applies to ELLIPSE E, N and D sensors, with GNSS aiding available.

- SP refers to Single Point mode and is the default standalone L1/L2 fix quality
- RTK stands for Real Time Kinematics with a typical 1 cm accuracy position
- PPK stands for Post-Processed Kinematics using Qinertia

1.4.2.1. Marine & Subsea applications

Outage Duration	Positioning Mode	Position Accuracy		Velocity Accuracy		Attitude Accuracy (°)	
		Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
No outage	SP	1.2 m	1.5 m	0.05 m/s	0.05 m/s	0.1 °	0.8° magnetic heading
	RTK	0.01 m	0.02 m	0.03 m/s	0.03 m/s	0.05 °	0.5° Dual ant, 0.5m baseline 0.2 ° Dual ant, 2m baseline
	PPK	0.01 m	0.02 m	0.02 m/s	0.02 m/s	0.03 °	0.1 °
10 s	SP	3 m	3.5 m	0.15 m/s	0.15 m/s	0.1 °	0.8° magnetic heading
	RTK	1 m	1 m	0.1 m/s	0.1 m/s	0.05 °	0.2 ° Dual ant, baseline > 2m
	PPK	0.1 m	0.1 m	0.05 m/s	0.05 m/s	0.05°	0.1°

1.4.2.2. Land applications

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

Outage Duration	Positioning Mode	Position Accuracy		Velocity Accuracy		Attitude Accuracy (°)	
		Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
No outage	SP	1.2 m	1.5 m	0.05 m/s	0.05 m/s	0.1 °	0.2°
	RTK	0.01 m	0.02 m	0.03 m/s	0.03 m/s	0.05°	0.2°
	PPK	0.01 m	0.02 m	0.02 m/s	0.02 m/s	0.03 °	0.1 °
10 s	SP	1.7 m	2 m	0.1 m/s	0.1 m/s	0.1 °	0.2°
	RTK	0.8 m	0.8 m	0.1 m/s	0.1 m/s	0.05 °	0.2°
	PPK	0.1 m	0.1 m	0.05 m/s	0.05 m/s	0.05°	0.1°
60 s	SP	7 m	7 m	0.1 m/s	0.1 m/s	0.15 °	0.3°
	RTK	5,5 m	5 m	0.1 m/s	0.1 m/s	0.1 °	0.3°
	PPK	1 m	1 m	0.1 m/s	0.1 m/s	0.08°	0.2°

1.4.2.3. Airborne applications

Positioning Mode	Position Accuracy		Velocity Accuracy		Attitude Accuracy (°)	
	Horizontal	Vertical	Horizontal	Vertical	Roll / Pitch	Heading
SP	1.2 m	1.5 m	0.05 m/s	0.05 m/s	0.1 °	0.2° Dynamic / 2m baseline
RTK	0.01 m	0.02 m	0.03 m/s	0.03 m/s	0.05 °	0.2° Dynamic / 2m baseline
PPK	0.01 m	0.02 m	0.02 m/s	0.02 m/s	0.03 °	0.1 °

1.4.3. Heave performance (Marine version)

	Real Time Heave	Remark
Range	50 meters	
Period	0 to 15 s	
Accuracy	5 cm or 5%	Whichever is greater; Velocity aiding available, or no turn or speed change.
Mode	Real time, auto tuning	

Note: Ship motion recordings including Heave information are only available in Ellipse marine versions.

2. Mechanical and Electrical specifications

2.1. Box units

2.1.1. General specifications

2.1.1.1. Overview

The Ellipse box units 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 Ellipse connectors are high quality Ultimate Fischer connectors that offers IP-68 protection even unconnected. The Ellipse-D version also includes two SMA connectors to connect the GNSS antennas. When used with a waterproof GNSS antenna cable, this connector offers an IP-68 protection.

Note 1: If you are planing to use Ellipse internal magnetometers, please make sure that you don't use ferromagnetic materials to mount the device.

2.1.1.2. Specifications

The table below summarizes all mechanical and environmental specifications.

Item	Specification
Size	**A, E, N:** 46 x 45 x 24 mm **D:** 46 x 45 x 32 mm
Weight	**A:** 45 g **N:** 47 g **E:** 49 g **D:** 65 g
Shocks	**Operational:** 100g 6ms, half-sine wave **Non-operational:** 500g 0.1ms, half-sine wave
Operating Vibrations	8g RMS – 20Hz to 2 kHz as per MIL-STD-810G

Environmental Specifications	
Enclosure	Anodized Aluminum
IP rating	IP-68 (1 hour at 2 meters)
Operating temperature	-40 to 85°C (-40 to 185°F)
Storage	-40 to 85°C (-40 to 185°F)
Humidity	Sealed, no limit
MTBF (computed)	50,000 hours
Calibration interval	None required, maintenance free

2.1.1.3. Device mechanical alignment

For best measurement accuracy, a good mechanical alignment is required. During manufacturing, the Ellipse measurement frame has been carefully aligned to 0.05° with the base plate for roll, pitch and yaw angles.

To ease the yaw alignment (X axis), the base features two alignment holes Ø 2mm H8 that guarantees with two taper pins Ø 2mm h7 a yaw alignment better than ±0.05°.

2.1.1.4. 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.

2.1.1.5. Sensor (body) coordinate frame

This frame is attached to the IMU.

The following diagram shows the body coordinate frame as configured by default. In most situations, the body coordinate frame must be aligned with vehicle coordinate frame. Sensor alignment in vehicle can be rotated by software if the sensor coordinate frame cannot be aligned mechanically. Check Technical Reference Manual for more details about this software alignment.

Figure 2.1: Box version coordinate frame

2.1.2. Mechanical outline

2.1.2.1. Ellipse-A mechanical outline

All dimensions are in mm.

Front view

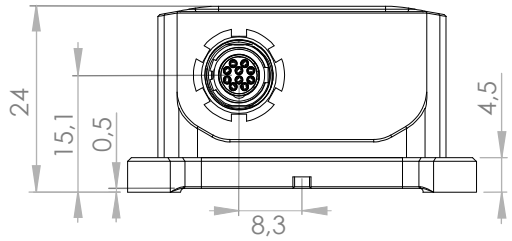


Figure 2.2: Ellipse-A front view

Top view

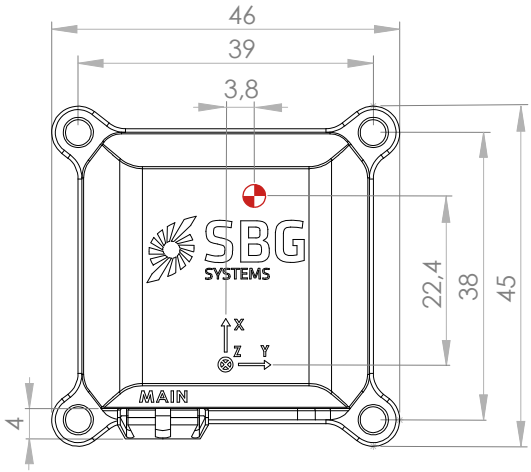


Figure 2.3: Ellipse-A top view

Right view

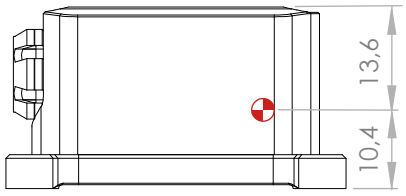


Figure 2.4: Ellipse-A right view

Bottom view

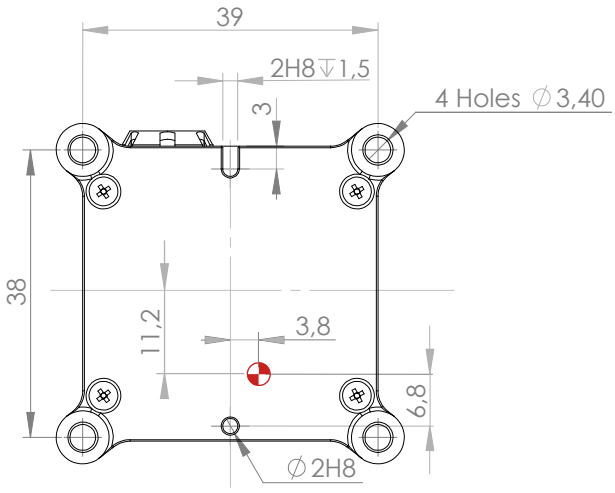


Figure 2.5: Ellipse-A bottom view

2.1.2.2. Ellipse-E mechanical outline

All dimensions are in mm.

Front view

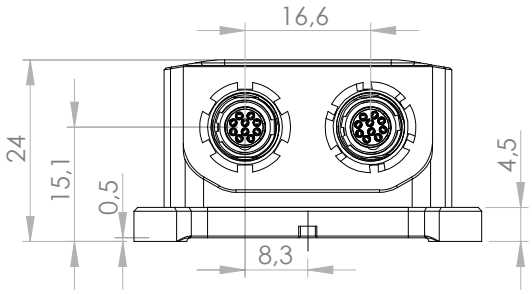


Figure 2.6: Ellipse-E front view

Top view

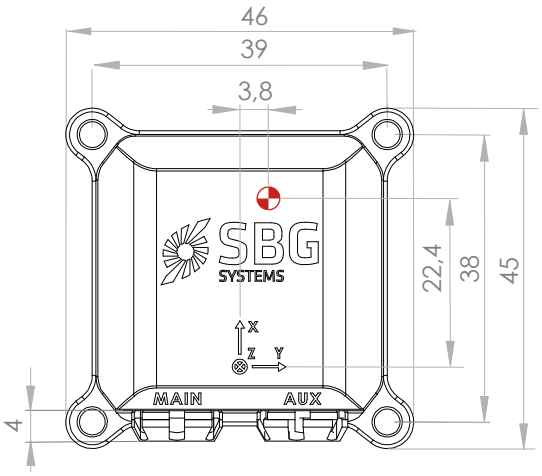


Figure 2.7: Ellipse-E top view

Right view

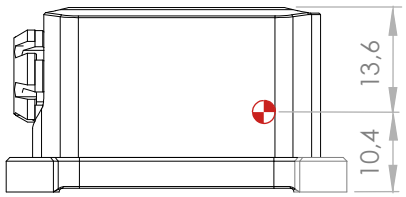


Figure 2.8: Ellipse-E right view

Bottom view

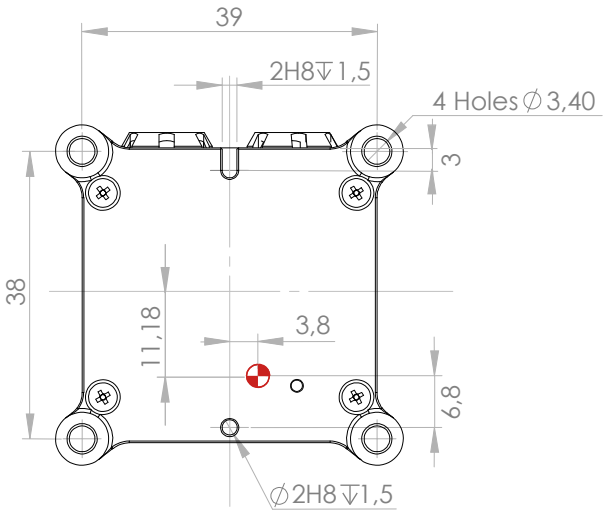


Figure 2.9: Ellipse-E bottom view

2.1.2.3. Ellipse-N mechanical outline

All dimensions are in mm.

Front view

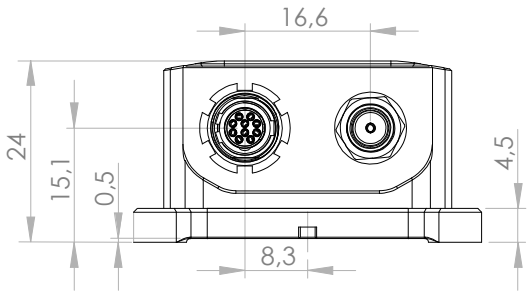


Figure 2.10: Ellipse-N front view

Top view

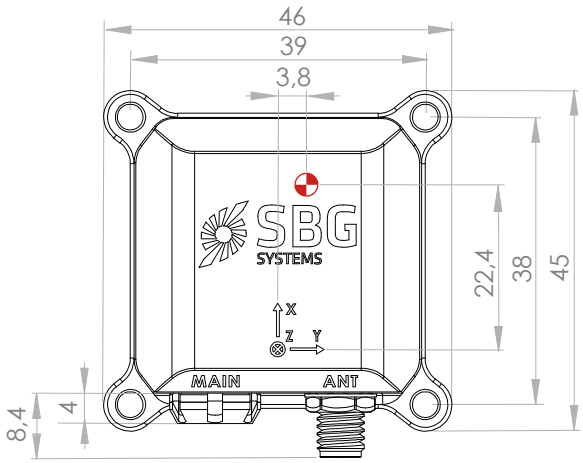


Figure 2.11: Ellipse-N top view

Right view

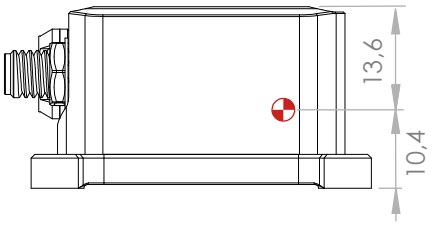


Figure 2.12: Ellipse-N right view

Bottom view

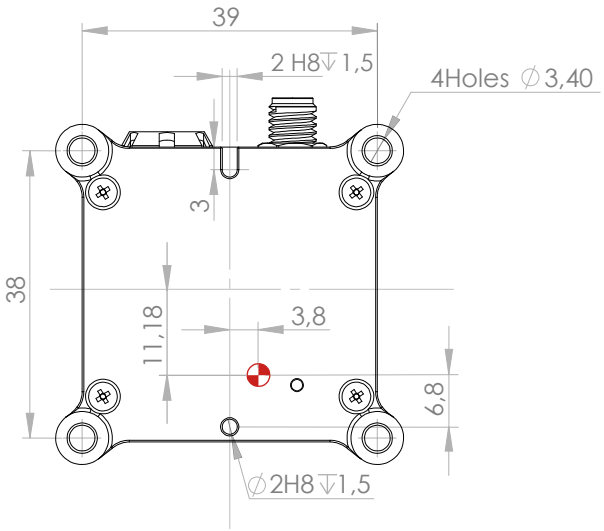


Figure 2.13: Ellipse-N bottom view

2.1.2.4. Ellipse-D mechanical outline

All dimensions are in mm.

Front view

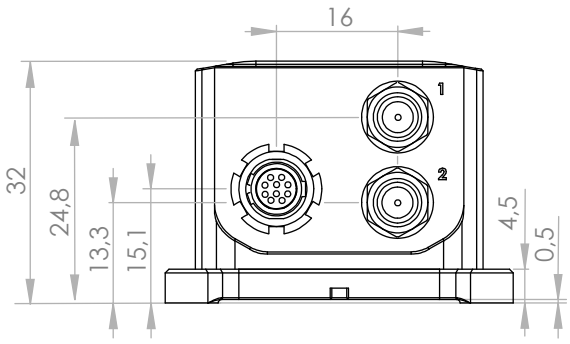


Figure 2.14: Ellipse-D front view

Top view

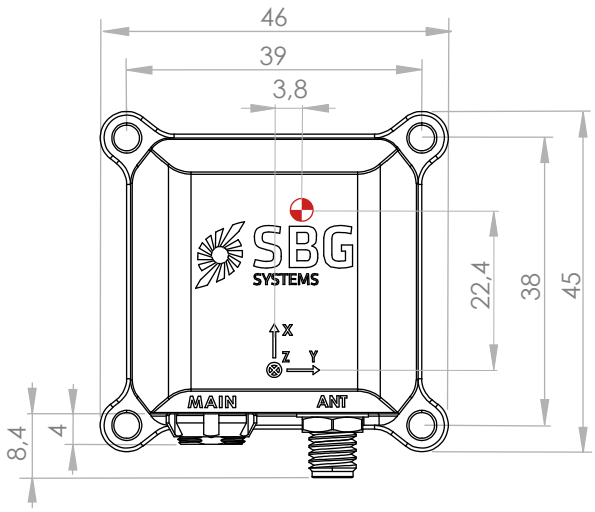


Figure 2.15: Ellipse-D top view

Right view

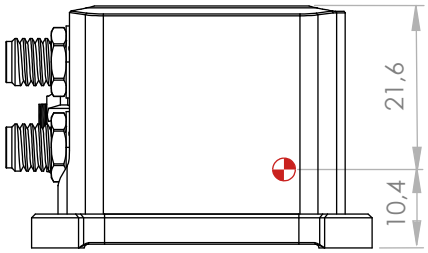


Figure 2.16: Ellipse-D right view

Bottom view

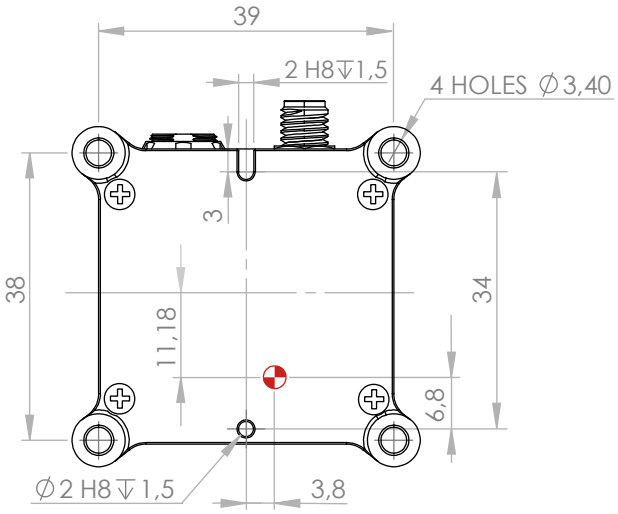


Figure 2.17: Ellipse-D bottom view

2.1.3. Equipment mounting

The Ellipse box units can be mounted using 2 locating pins and four M3 screws of minimum length 16 mm. We recommend A4 alloy or any non ferromagnetic material when using magnetometers.

Please use an appropriate torque to ensure proper mounting. Units must be mounted on a flat surface.

Mounting means	Description	Applied force	Quantity
Scews	Socket Cap TCHC DIN 912 M3 x 16mm Stainless Steel A4	1.15 N. m	4
Locating pins	MISUMI P/N: SFSSS3-L6,0-+P2,0-B2,0-H5,0-T1,0 SFSSS Serie, 2mm OD x 2mm h 5mm OD x 1 mm h, Shoulder, 3mm OD x 6 mm Lenght Press Fit Mounting, SS EN1,4301	N/A	2

2.1.4. Electrical specifications

The Ellipse connectors are all placed on the front panel. The connectors are referenced and identified by laser marking on the enclosure.

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 Ellipse development kit cables are not designed to offer an IP-68 protection. Contact SBG Systems to get further support about IP-68 protection.

2.1.4.1. Ellipse-A without GPS aiding

Figure 2.18: Ellipse AHRS

2.1.4.2. Ellipse-E with external aiding only

Figure 2.19: Ellipse INS without GPS (E version)

2.1.4.3. Ellipse-N with embedded GNSS receiver

Figure 2.20: Ellipse INS with GNSS receiver (N version)

2.1.4.4. Ellipse-D with embedded dual antenna GNSS receiver

Figure 2.21: Ellipse INS with dual antenna GNSS receiver (D version)

2.1.4.5. Main connector

The main connector provides access to most Ellipse features in a modular way. It provides:

- The main serial port (PORT A) that supports full-duplex communication. It operates in RS-232, or alternatively in RS-422 on B1 devices by pulling down to GND the pin 5.
- An optional RS-232 port (PORT E) that can be enabled on B1 devices, when PORT A is configured in RS-232 mode.
- One CAN 2.0A/B connection that supports up to 1 Mbit/s data rate used to output data – on B2 devices only
- Two multi-function input pins that can be used for:
  - Clock synchronization or event marker input pins
  - Single or dual channel Odometer input
  - Miscellaneous RS-232 input (PORT B) for RTCM data input on Ellipse-N and Ellipse-D.
- A Synchronization output signal for time stamping and to trigger some equipment.

Connector specifications

The connector on Ellipse box units is placed on the front panel. The connector is referenced and identified by laser marking on the enclosure.

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

Connector	Manufacturer	Part number	Description
ELLIPSE Box I/O connectors	Fischer Connectors	UR02W07 F010P BK1 E2AA	Connector, UltiMate Serie, Receptacle, Sockets, 10 cts
Mating connector	Fischer Connectors	UP01L07 M010S BK1 Z2ZA	Connector, UltiMate Serie, Plug, Pins, 10 cts

Note: The mating connector doesn't include the cable clamp sets. Other plugs with right angle or other options may be found if required.

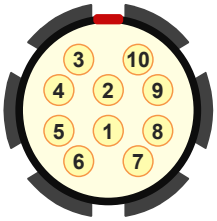


Figure 2.22: receptacle front view for Box units

Connector pin out for Ellipse B1 versions

Pin #	Signal Name	Description
1	SYNC IN A - ODO B	Multi function input. May be used as clock/event, or odometer input
2	SYNC IN B – PORT B RX - ODO A	Multi function input. May be used as clock/event, odometer input, or RS-232 Rx line
3	VIN	Power supply input
4	GND	Ground return signal
5	PORT A RS-232/ $\overline{\text{RS-422}}$	Port A RS-232 or RS-422 selector. Tie to GND to select RS-422
6	SYNC OUT A	Synchronization output signal.
7	PORT E TX – PORT A RS422 TX+	Port E Tx line, or Port A Tx+ in RS-422 mode
8	PORT A RS232 TX – PORT A RS422 TX-	Port A RS-422 Tx- or RS-232 Tx line
9	PORT A RS232 RX – PORT A RS422 RX+	Port A RS-422 Rx+ or RS-232 Rx line
10	PORT E RX – PORT A RS422 RX-	Port E Rx line, or Port A Rx- in RS-422 mode

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

Connector pin out for Ellipse B2 versions

Pin #	Name	Description
1	SYNC IN A – ODO B	Multi function input. May be used as clock/event, or odometer input
2	SYNC IN B – PORT B RX - ODO A	Multi function input. May be used as clock/event, odometer input, or RS-232 Rx line for RTCM correction input
3	VIN	Power supply input
4	GND	Ground return signal
5	NC	Not used. Leave unconnected.
6	SYNC OUT A	Synchronization output signal.
7	CAN L	CAN Low
8	PORT A RS232 TX	Port A RS-232 Tx line
9	PORT A RS232 RX	Port A RS-232 Rx line
10	CAN H	CAN High

2.1.5. Auxiliary connector (Ellipse-E)

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

- A full duplex RS-232 / RS-422 port for GNSS aiding connection (PORT C)
- An additional RS-232 input for upward compatibility (PORT D)
- Two synchronization input signals used for internal clock synchronization, data time stamping and/or event markers
- A Synchronization output signal for time stamping and to trigger some equipment.

2.1.5.1. Connector specifications

Please refer to section 2.1.4.5 Main connector for more details as the same connector type is used for Main and Aux connectors.

2.1.5.2. Connector pin out

Pin #	Name	Description
1	SYNC IN C	May be used as clock/event input
2	SYNC IN D	May be used as clock/event input
3	PORT D RX	RS-232 input for miscellaneous applications
4	GND	Ground return signal
5	NC	Not internally connected
6	SYNC OUT B	Synchronization output signal.
7	PORT C RS422 TX+	Port C RS-422 Tx+. Not used in RS-232 connection.
8	PORT C RS232 TX – PORT C RS422 TX-	Port C RS-422 Tx- or RS-232 Tx line
9	PORT C RS232 RX – PORT C RS422 RX+	Port C RS-422 Rx+ or RS-232 Rx line
10	PORT C RS422 RX-	Port C RS-422 Rx-. Not used in RS-232 connection.

2.1.5.3. Electrical specifications for BOX units

Recommended electrical specifications from -40°C to 85°C.

Item	Conditions	Min	Typical	Max	Unit
Power supply					
Input voltage range		5		36	V
Power consumption	Model A – @12V		300		mW
	Model E – @12V		325		mW
	Model N – @12V without GNSS antenna.		600		mW
	Model N – @12V with GNSS antenna.		750		mW
	Model D – @ 12V, without GNSS antennas		900		mW
	Model D – @ 12V, with GNSS antennas		1050		mW
RS-232 Receivers, Sync In pins					
Input range		-15		15	V
Low level threshold		0.6			V
High level threshold				2.0	V
Input resistance		3	5	7	kΩ
RS-422 Receivers					
Input differential threshold		-200	-125	-50	mV
Input hysteresis			25		mV
Input resistance		96			kΩ
RS-232 Transmitters					
Output range		+/-5	+/-5.5		V
RS-422 transmitters					
Differential output voltage		2			V
Common mode output voltage				3	V
Sync Out pins					
High Level Output voltage	I_{Load} < 100µA I_{Load} < 16mA	3.2 2.6			V V
Low Level Output voltage	I_{Load} < 100µA I_{Load} < 16mA			0.1 0.4	V V
CAN bus					
Recessive Bus Voltage		2	2.5	3	V
CAN H Output Voltage	dominant	2.75	3.5	4.5	V
CAN L Output Voltage	dominant	0.5	1.25	2.25	V
Absolute input voltage	CANH, CANL	-58		58	V
Differential input voltage	CANH, CANL	0.5	0.7	0.9	V

2.1.5.4. Absolute maximum ratings for BOX units

Item	Rating
VDD - GND	-36 to 36 V
Rx+, Rx-, Logic inputs pins input voltage to signal GND	±18V
Logic output Max current	50 mA
CANH, CANL	±80 V
ESD protection (Tx, Rx, Input & Output pins, CANH, CANL)	15 kV

2.1.5.5. GNSS antennas connectors for BOX units (Ellipse-N and D)

To connect an external GNSS antenna the Ellipse-D includes two IP-68 rated SMA connectors. The internal GNSS receiver only supports active GNSS antennas.

Figure 2.23: SMA antenna connector

Please be advise that the Ellipse doesn't implement any lightning protection. The GNSS antenna and cable 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 Ellipse GNSS estimates the noise floor of the antenna during the startup sequence.

GNSS antenna advice

The Ellipse-N and Ellipse-D embed a high performance GNSS receiver that supports GPS L1/L2, GLONASS G1/G2, Beidou B1/B2, Galileo E1/E5b signals. For best performance and robustness, please follow these recommendations.

Parameter	Specifications	Remark, conditions
Antenna connector	SMA female	IP-68 when connected
Input impedance	50 Ω	
LNA supply voltage	3.0 VDC	
LNA supply current	< 30 mA	
Maximum Power Input	10 dBm	Continuous wave, under 50 Ω
Minimum antenna gain	17 dB	
Maximum antenna gain	50 dB	

In order to enable proper measurements, L1/L2 GPS antennas are required, and tracking other constellations is recommended for optimal performance.

SBG Systems has selected some GNSS antennas for different applications. Please refer to the section 5.5 GNSS antennas to get more details on available antennas.

2.2. OEM units

All dimensions are expressed in millimeters using the International System of Units (SI) conventions.

2.2.1. Mechanical specifications

2.2.1.1. Overview

The Ellipse OEM units enclosure is made of aluminum surface treated for conductive finish.

The Ellipse OEM uses a high density Hirose DF40 connector. The Ellipse-N and Ellipse-D also includes U.FL standard coaxial connectors to connect the GNSS antennas.

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

2.2.1.2. Specifications

The table below summarizes all mechanical and environmental specifications.

Item	Specification
Size	A, E: 29.5 x 25.5 x 11 mm N, D: 29.5 x 25.5 x 16 mm
Weight	A, E: 8 g N, D: 17 g
Shocks	**Operational:** 100g 6ms, half-sine wave **Non-operational:** 500g 0.1ms, half-sine wave
Operating Vibrations	8g RMS – 20Hz to 2 kHz as per MIL-STD-810G

Environmental Specifications	
Enclosure	Aluminum, conductive surface finish
Operating temperature	-40 to 78°C (-40 to 172.4°F)
Storage	-40 to 85°C (-40 to 185°F)
MTBF (computed)	50,000 hours
Calibration interval	None required, maintenance free

2.2.1.3. 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.

2.2.1.4. Sensor (body) coordinate frame

This frame is attached to the IMU.

The following diagrams show the body coordinate frame as configured by default. In most situations, the body coordinate frame must be aligned with vehicle coordinate frame. Sensor alignment in vehicle can be rotated by software if the sensor coordinate frame cannot be aligned mechanically. Check Technical Reference Manual for more details about this software alignment.

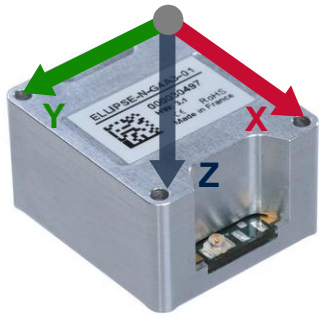


Figure 2.24: Coordinate frame OEM enclosure with integrated GNSS models N and D

2.2.1.5. Ellipse-A and E OEM mechanical outline

All dimensions are in mm.

Front and Back views

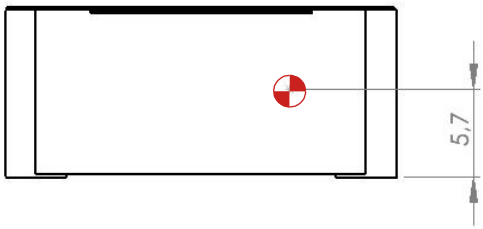


Figure 2.25: Ellipse-A/E front view

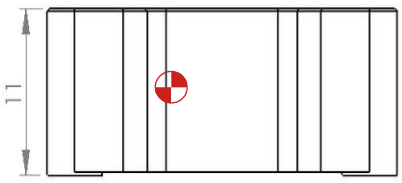


Figure 2.26: Ellipse-A/E back view

Top and Bottom views

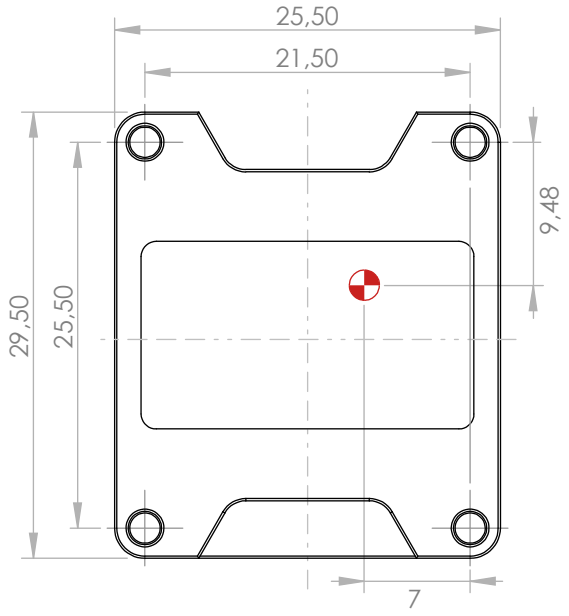


Figure 2.27: Ellipse-A/E top view

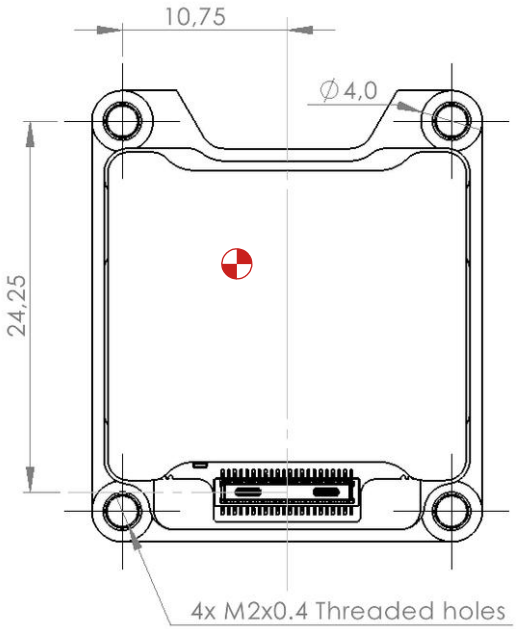


Figure 2.28: Ellipse-A/E Bottom view

Right and sectional views

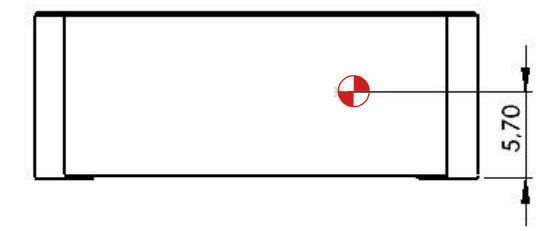


Figure 2.27: Ellipse-A/E right view

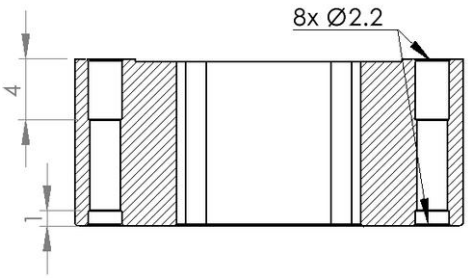


Figure 2.28: Ellipse-A/E sectional view

2.2.1.6. Ellipse-N and D OEM mechanical outline

All dimensions are in mm.

Front and Back views

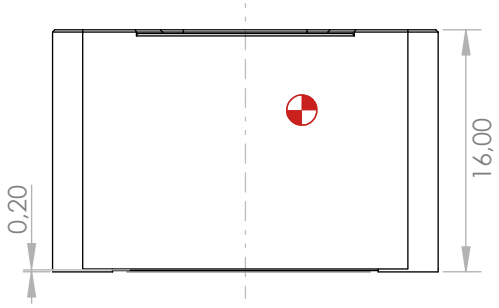


Figure 2.29: Ellipse-D front view

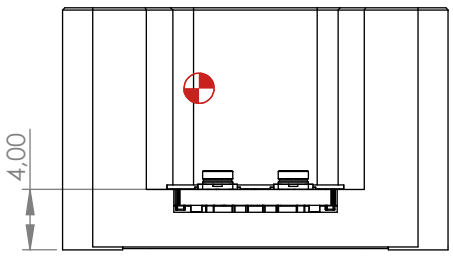


Figure 2.30: Ellipse-D rear view

Top and bottom views

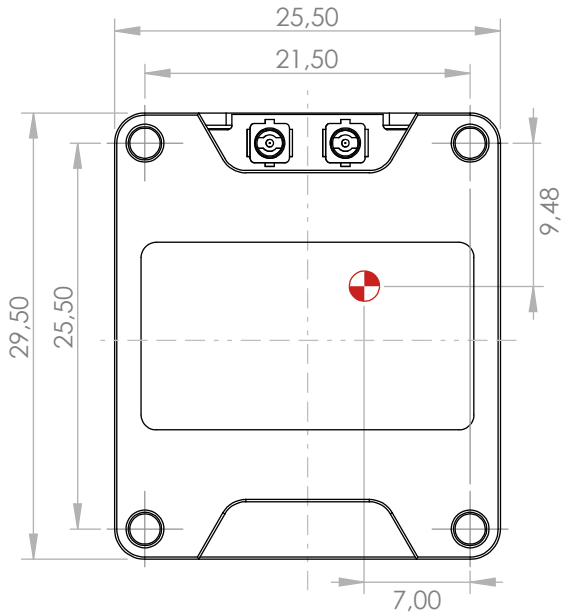


Figure 2.31: Ellipse-D top view

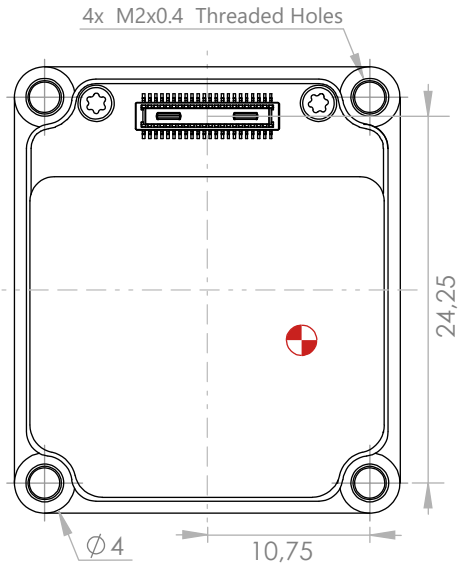


Figure 2.32: Ellipse-D Bottom view

Right and sectional views

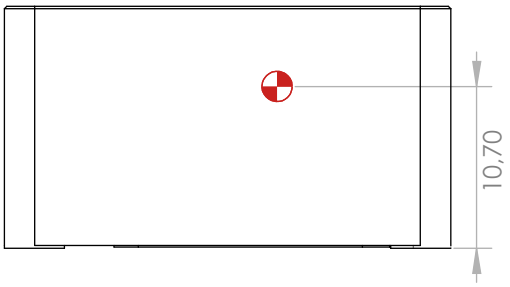


Figure 2.33: Ellipse-D right view

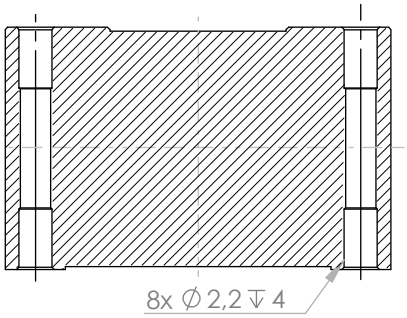


Figure 2.34: Ellipse-D sectional view

Note: Please note that only one UFL connector is available for the Ellipse-N OEM version. Otherwise, overall dimensions remain the same.

2.2.2. Electrical specifications

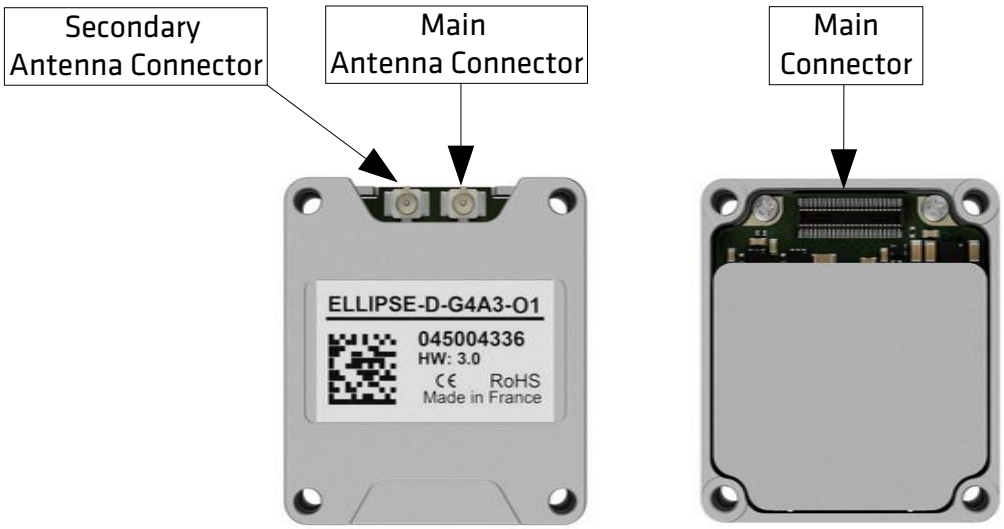


Figure 2.35: Ellipse INS with dual antenna GNSS receiver (OEM version)

Note: Only the Main Antenna Connector is available for the N version.

2.2.2.1. Main Connector

The main connector provides access to all Ellipse features using LVTTL signal levels for an easy integration. It provides:

- The main serial port (PORT A) that supports full-duplex communication.
- An additional serial port (PORT E) that supports full-duplex communication.
- One CAN 2.0A/B port that supports up to 1 Mbit/s data rate, to interface with an external CAN transceiver in order to output data on a CAN bus.
- Two multi-function input pins that can be used for:
  - Clock synchronization or event marker input pins
  - Single or dual channel Odometer input
  - Miscellaneous RS-232 input (PORT B) for RTCM data input.
- A synchronization output signal for time stamping and to trigger some equipment.
- A power enable input to turn on and turn off the device.
- A IO power input, separate from the main power input, to adjust the device signal level translation to the host system requirement

Connector specifications

The connector on Ellipse OEM units is placed under the device.

SBG Systems has selected high quality and high density connectors to offer a compact and robust integration.

Connector	Supplier	Part number	Description
ELLIPSE connector	HIROSE	DF40C-40DP-0.4V(51)	Connector, DF40 Series, Plug/Header, 40 cts, 0.4 mm pitch, SMD
Mating connector*	HIROSE	DF40HC(3.0)-40DS-0.4V(51)	Connector, DF40 Series, Receptacle, 40 cts, 0.4 mm pitch, SMD

Note: Matting connector with other receptacle variants with varying heights are available.

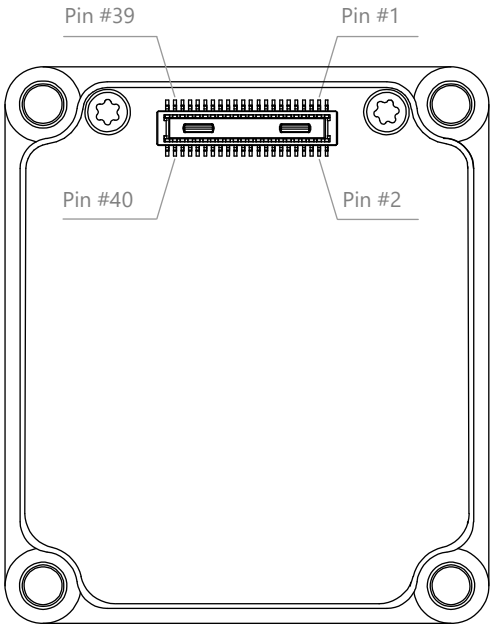


Figure 2.36: OEM units connector orientation (bottom view)

Connector Pin out for ELLIPSE OEM

Pin	Signal Name	Type	Description	Connection tips
1	GND	P	Ground return signal	All ground pins must be connected
2	GND	P	Ground return signal	All ground pins must be connected
3	GND	P	Ground return signal	All ground pins must be connected
4	GND	P	Ground return signal	All ground pins must be connected
5	VDD	P	Power supply input	All VDD pins must be connected
6	VDD	P	Power supply input	All VDD pins must be connected
7	VDD	P	Power supply input	All VDD pins must be connected
8	VDD	P	Power supply input	All VDD pins must be connected
9	VDD_IO	P	Power supply input to drive GPIO	Must be connected to VDD for instance
10	EN	I	Enable input	Must be connected to VDD for instance
11	PWR_GOOD	O	Power good output indication (high if good)	Leave unconnected if not used
12	SYNC_IN_A/ ODO_DIR	I	Multi function input. May be used as event input A, or odometer direction	Tie to VDD_IO if not used for better EMC
13	SYNC_OUT_A	O	Event output A signal	Leave unconnected if not used
14	SYNC_IN_B/ PORTB_RX/ODO	I	Multi function input. May be used as event input B, odometer pulse or Port B Rx line	Tie to VDD_IO if not used for better EMC
15	CAN_TX	O	Can Tx	Leave unconnected if not used
16	CAN_RX	I	Can Rx	Tie to VDD_IO if not used for better EMC
17	PORTA_TX	O	Port A Tx	Leave unconnected if not used
18	PORTA_RX	I	Port A Rx	Tie to VDD_IO if not used for better EMC
19	PORTE_TX	O	Port E Tx	Leave unconnected if not used
20	PORTE_RX	I	Port E Rx	Tie to VDD_IO if not used for better EMC
21	RESERVED	O	Reserved, do not connect	Leave unconnected
22	RESERVED	I	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
23	SYNC_OUT_B	O	Ellipse-A, N, D: No function Ellipse-E: Event output B signal	Leave unconnected if not used
24	SYNC_IN_C	I	Ellipse-A, N, D: No function Ellipse-E: Event input C signal	Leave unconnected or tie to VDD_IO for better EMC
25	PORTC_TX	O	Ellipse-A, N, D: No function Ellipse-E: Port C Tx	Leave unconnected
26	PORTC_RX	I	Ellipse-A, N, D: No function Ellipse-E: Port C Rx	Leave unconnected or tie to VDD_IO for better EMC
27	RESERVED	O	Reserved, do not connect	Leave unconnected
28	RESERVED	O	Reserved, do not connect	Leave unconnected
29	RESERVED	O	Reserved, do not connect	Leave unconnected
30	PORTD_RX	I	Ellipse-A, N, D: No function Ellipse-E: Port D Rx	Leave unconnected or tie to VDD_IO for better EMC
31	RESERVED	I	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
32	SYNC_IN_D	I	Ellipse-A: No function Ellipse-E, N, D: Event input D signal	Leave unconnected or tie to VDD_IO for better EMC
33	RESERVED	-	Reserved, do not connect	Leave unconnected or tie to GND for better EMC

34	RESERVED	-	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
35	RESERVED	-	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
36	RESERVED	-	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
37	RESERVED	-	Reserved, do not connect	Leave unconnected or tie to GND for better EMC
38	RESERVED	-	Reserved, do not connect	Leave unconnected
39	GND	P	Ground return signal	All ground pins must be connected
40	GND	P	Ground return signal	All ground pins must be connected

Note: Pin type P stands for Power Supply either VDD or GND. Other pins are either LVTTL input pins (I) or LVTTL output pins (O)

2.2.2.2. Electrical specifications for OEM units

Recommended electrical specifications from -40°C to 78°C.

Item	Conditions	Min	Typical	Max	Unit
Power supply					
Input voltage range		2.5		5.5	V
Power consumption	Model A - @5V		250		mW
	Model E- @5V		250		mW
	Model N - @5V, without GNSS antenna		550		mW
	Model N - @5V, with GNSS antenna		600		mW
	Model D - @ 5V, without GNSS antennas		800		mW
	Model D - @ 5V, with GNSS antennas		900		mW
Undervoltage Threshold	Falling Input Voltage	2.1	2.2	2.3	V
Recommended Decoupling Capacitance		2 x 47			µF
VDD_IO					
Supply Voltage Range		1.2		3.6	V
Operating current			5		mA
Recommended Decoupling Capacitance		1			µF
EN					
Input Voltage Range		0		5.5	V
High-Level Threshold Voltage		1.0			V
Low-Level Threshold Voltage				0.4	V
Start Time	Time from EN=High to operational mode		< 5		s
All other I/Os					
Input Voltage Range		0		3.6	V
High-Level Input Voltage	1.2V < VDD_IO < 1.95V	VDD_IO x 0.65			V
	1.95V < VDD_IO < 2.7V	1.6			V
	2.7V < VDD_IO < 3.6V	2			V
Low-Level Input Voltage	1.2V < VDD_IO < 1.95V			VDD_IO x 0.35	V
	1.95V < VDD_IO < 2.7V			0.7	V
	2.7V < VDD_IO < 3.6V			0.8	V
High or Low Level Output Current	VDD_IO = 1.2V	-3		+3	mA
	1.4V < VDD_IO < 1.6V	-6		+6	mA
	1.65V < VDD_IO < 1.95V	-8		+8	mA
	2.3V < VDD_IO < 2.7V	-9		+9	mA
	3.0V < VDD_IO < 3.6V	-12		+12	mA

2.2.2.3. Absolute maximum ratings for OEM units

Item	Rating
All pins to signal GND	-0.3 to 6 V
All input pins clamp current	-50 mA
All output pins clamp current	50 mA
VDD, EN ESD Rating - Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001	±1500 V
VDD, EN ESD Rating - Charged-device model (CDM), per JEDEC specification JESD22- C101	±500 V
VDD_IO & All other IO pins ESD Rating - Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001	±8000 V
VDD_IO & All other IO pins ESD Rating - Charged-device model (CDM), per JEDEC specification JESD22- C101	±1000 V
RESERVED pins - Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001	±1000 V
RESERVED pins - Charged-device model (CDM), per ANSI/ESDA/JEDEC JS- 002	±250 V

2.2.2.4. GNSS antennas connectors for OEM units

To connect an external GNSS antenna the Ellipse-D includes two IP-68 rated SMA connectors. The internal GNSS receiver only supports active GNSS antennas.

Figure 2.37: UFL antenna connector OEM units

Warning: Please be advised that the Ellipse doesn't implement any lightning protection. The GNSS antenna and cable are very sensitive to strikes and a proper installation with lightning protection devices may be required.

GNSS antenna advice

The Ellipse-D embeds a high performance GNSS receiver that supports GPS L1/L2, GLONASS G1/G2, Beidou B1/B2, Galileo E1/E5b signals. For best performance and robustness, please follow these recommendations.

Parameter	Specifications	Remark, conditions
Antenna connector	U.FL	
Input impedance	50 Ω	
LNA supply voltage	3.0 VDC	
LNA supply current	< 30 mA	
Maximum Power Input	10 dBm	Continuous wave, under 50 Ω
Minimum antenna gain	17 dB	
Maximum antenna gain	50 dB	

In order to enable proper heading measurements, L1/L2 GPS antennas are required, and tracking other constellations is recommended for optimal performance.

SBG Systems has selected some high quality GNSS antennas for different applications. Please refer to the section 5.5 GNSS antennas 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.

3. Interfaces specifications

3.1. Overview

The Ellipse features up to five serial interfaces (Port A to Port E) which provide all the main features of the Ellipse: Configuration, data input, data output.

In addition, the Ellipse supports CAN 2.0A/B connectivity to output log messages. Due to the CAN implementation and limitations (payload limited to 8 bytes), the CAN interface is not handled like the other interfaces.

Due to the limited number of pins inside the Ellipse connectors, some pins provide different functions which are multiplexed and cannot be used at the same time.

3.1.1. Interfaces availability and multiplexing

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

3.1.1.1. Box units

Port	Available models				Package		Function	RS-232/422 configuration Cable / software defined	Other functions / multiplexing
	A	E	N	D	B1	B2			
PORT A	●	●	●	●	●	●	Tx/Rx	Cable	RS-422 available on B1 units only
PORT B		●	●	●	●	●	Rx	RS-232 only	Multiplexed with Sync IN B and ODO A
PORT C		●			●	●	Tx/Rx	Software defined RS-232/422	
PORT D		●			●	●	Rx	RS-232 only	
PORT E	●	●	●	●	●		Tx/Rx	RS-232 only	Only available when PORT A is in RS-232
CAN	●	●	●	●		●	Tx/Rx	-	
SYNC IN A	●	●	●	●	●	●	input	-	Multiplexed with ODO B
SYNC IN B	●	●	●	●	●	●	input	-	Multiplexed with PORT B and ODO A
SYNC IN C		●			●	●	input	-	
SYNC IN D		●			●	●	input	-	
SYNC OUT A	●	●	●	●	●	●	output	-	
SYNC OUT B		●			●	●	output	-	
ODO A		●	●	●	●	●	input	-	Multiplexed with SYNC IN B and PORT B
ODO B		●	●	●	●	●	input	-	Multiplexed with SYNC IN A

3.1.1.2. OEM units

Port	Available model				Function	Other functions / multiplexing
	A	E	N	D		
PORT A	●	●	●	●	LVTTL Tx/Rx	
PORT B		●	●	●	LVTTL Rx	Multiplexed with Sync IN B and ODO A
PORT C		●			LVTTL Tx/Rx	
PORT D		●			LVTTL Tx/Rx	
PORT E	●	●	●	●	LVTTL Tx/Rx	
CAN	●	●	●	●	LVTTL Tx/Rx	
SYNC IN A	●	●	●	●	LVTTL input	Multiplexed with ODO B
SYNC IN B	●	●	●	●	LVTTL input	Multiplexed with PORT B and ODO A
SYNC IN C		●			LVTTL input	
SYNC IN D		●	●	●	LVTTL input	
SYNC OUT A	●	●	●	●	LVTTL output	
SYNC OUT B		●			LVTTL output	
$\overline{\text{ODO A}}$			●	●	LVTTL input	Multiplexed with SYNC IN B and PORT B
$\overline{\text{ODO B}}$			●	●	LVTTL input	Multiplexed with SYNC IN A

3.2. Serial interfaces

The Ellipse box units features up to 3 physical RS-232/RS-422 serial connections (PORT A, B, and E) on Ellipse-A, Ellipse-N and Ellipse-D models and up to 5 (PORT A, B, C, D and E) for Ellipse-E model. These serial ports have different uses as described in the next sections.

The Ellipse Serial interfaces support the standard baudrates:

- 4 800 bps
- 9 600 bps
- 19 200 bps
- 38 400 bps
- 57 600 bps
- 115 200 bps
- 230 400 bps
- 460 800 bps
- 921 600 bps

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

3.2.1. Supported protocols

The Ellipse 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, Ublox Binary protocol and others.

3.2.2. Ports functions Mapping

Due to the specificity of the internal GNSS embedded inside the ELLIPSE N and D versions, and also due to the number of available pins in the different sensor configurations, there are some variations in the different ports capabilities from one product to another.

The following tables provide more details about which functions are available on which port for each Ellipse model.

Note: Please remind that PORT E is only available on B1 units (box) and on O1 units (OEM).

3.2.2.1. Ellipse A version

	PORT A	PORT E
Binary commands (sbgECom)	•	
Regular outputs (sbgECom, NMEA or third party output)	•	•
Legacy protocol output (sbgCom)	•	
1KHz IMU output		•

3.2.2.2. Ellipse E version

	PORT A	PORT B	PORT C	PORT D	PORT E
Binary commands (sbgECom)	•				
Regular outputs (sbgECom, NMEA or third party output)	•		•		•
Legacy protocol output (sbgCom)	•				
1KHz IMU output			•		•
GNSS input		•	•	•	•

3.2.2.3. Ellipse N and D

	PORT A	PORT B	PORT E
Binary commands (sbgECom)	•		
Regular outputs (sbgECom, NMEA or third party output)	•		•
Legacy protocol output (sbgCom)	•		
1KHz IMU output			•
RTCM input	•	•	•

3.3. 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.

More over to help software development dbc file is provided in the SDK.

The Ellipse 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 Ellipse 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.

4. Important notices

4.1. Maintenance

The Ellipse 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.

Using the Ellipse in salt water environments is not recommended. In the event the Ellipse has been exposed to salt water, the Ellipse enclosure must be rinsed with clear water to remove any long term presence of salt on the enclosure.

4.1.1. Cleaning

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

4.2. 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.
1 avenue Eiffel
78420 Carrières-sur-Seine
FRANCE

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

Americas:

SBG Systems North America, Inc
Phone: +1 (657) 549-5807
support@sbg-systems.com

Asia:

SBG Systems Pte. Ltd.
Phone: +65 98 643 776
support@sbg-systems.com

4.3. 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.

5. Appendix A: Hardware code and Accessories

5.1. Ellipse hardware code

The following diagram shows the different sensors and interfaces options available.

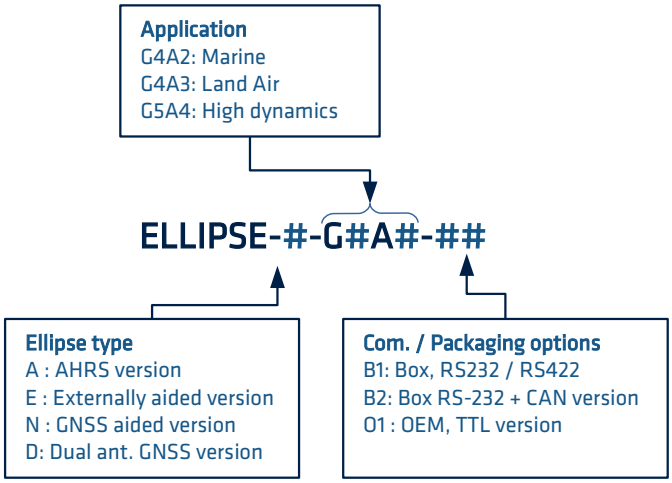


Figure 5.1: Hardware code

5.2. Development kits

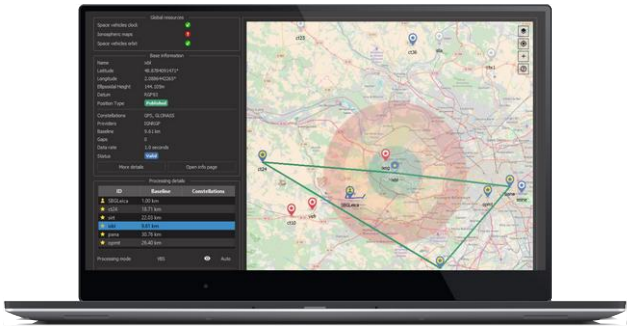
The Development Kit is an essential accessories that should be used along with the Ellipse series. The following Development kits are available for Box and OEM units.

PRODUCT	DESCRIPTION
DK Ellipse A and E - Box	Ellipse Development Kit: • USB to RS-232 cable, 3 meters. • Unlimited free phone and mail support
DK Ellipse A and E - OEM	Ellipse Development Kit: • Development Board for ELLIPSE OEM • Cable, USB A Male to USB Micro-B, 1m, black • AC/DC wall mount power supply, 3m cable and DC jack 2.1mm# (US, UK & EU adapters included) • Screw Philips M2xL10. • Unlimited free phone and mail support.
DK Ellipse N - Box	Ellipse Development Kit with Patch antenna: • USB cable to quickly connect the Ellipse sensor. • 1 patch antennas and ground plates. • Unlimited phone and email support.
DK Ellipse N - OEM	Ellipse Development Kit with Patch antenna: • Patch antenna and ground plate. • Development Board for ELLIPSE OEM • Cable, USB A Male to USB Micro-B, 1m, black • AC/DC wall mount power supply, 3m cable and DC jack 2.1mm# (US, UK & EU adapters included) • Coax Cable, U.FL to U.FL, Micro COAX 1.13/0.68 mm, 50 mm length • Screw Philips M2xL10. • Unlimited free phone and mail support.
DK Ellipse D - Box	Ellipse Development Kit with Patch antennas: • USB cable to quickly connect the Ellipse sensor. • 2 patch antennas and ground plates. • Unlimited phone and email support.
DK Ellipse D - OEM	Ellipse Development Kit with Patch antennas: • 2 patch antennas and ground plates. • Development Board for ELLIPSE OEM • Cable, USB A Male to USB Micro-B, 1m, black • AC/DC wall mount power supply, 3m cable and DC jack 2.1mm# (US, UK & EU adapters included) • 2 Coax Cable, U.FL to U.FL, Micro COAX 1.13/0.68 mm, 50 mm length • Screw Philips M2xL10. • Unlimited free phone and mail support.

5.3. Associated Software

5.3.1. SW-QINERTIA-LITE (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

5.4. Cables

5.4.1. CA-ELI-USB-3M

This 3 meters long cable provides an easy connection of an Ellipse device to any PC.

It includes in the USB plug a RS-232 to USB converter, and provides power to the Ellipse sensor.

Weight: 103g

Figure 5.2 : CA-ELI-USB

5.4.2. CA-ELI-D-USB-3M

This 3 meters long cable provides an easy connection of an Ellipse-D device to any PC.

It includes a 2.1mm jack DC power input connector in addition to the USB plug with a RS-232 to USB converter and.

Weight: 110g

Figure 5.3 : CA-ELI-D-USB

5.4.3. CA-PSU-12V-1.5M

This 1.5 meters long AC/DC international power supply can be used to provide power to an Ellipse sensor from an 110/220V AC power plug.

It supports US, UK and Europe standards and includes a standard DC 2.1mm jack plug. The output voltage is 12V.

Figure 5.4: Power adapter

5.4.4. CA-ELI-RS232-CAN-3M

This cable provides access to the Ellipse Main and Aux connectors. It's designed to communicate in RS-232 with the Ellipse B1 versions, but can also be used with the Ellipse B2 versions and Aux connectors. It has the following characteristics:

Figure 5.5 : CA-ELI-RS232-CAN-3M

- 1x UP01L07 M010S BK1 Z2ZA connector
- 1x open end
- Water proof
- 3 meters long
- Weight: 77g

Cable wiring is the following:

Pin on Fischer connector	Color	Main connector signal (B1 version)	Main connector signal (B2 version)	Aux connector signal (Ellipse-E)
1	GREEN	SYNC IN A – ODO B	SYNC IN A – ODO B	SYNC IN C
2	BLUE	SYNC IN B – PORT B RX ODO A	SYNC IN B – PORT B RX ODO A	SYNC IN D
3	RED	VIN	VIN	PORT D RX
4	BLACK	GND	GND	GND
5	N/A	Internally connected to GND for RS-422 comm.	Internally connected to GND	Internally connected to GND
6	BROWN	SYNC OUT A	SYNC OUT A	SYNC OUT B
7	WHITE	PORT E TX	CAN L	PORT C RS422 TX+
8	YELLOW	PORT A RS232 TX	PORT A RS232 TX	PORT C RS232 TX PORT C RS422 TX-
9	ORANGE	PORT A RS232 RX	PORT A RS232 RX	PORT C RS232 RX PORT C RS422 RX+
10	GREY	PORT E RX	CAN H	PORT C RS422 RX-

5.4.5. CA-ELI-RS422-3M

This cable provides access to the Ellipse Main and Aux connectors. It's designed to communicate in RS-422 with the Ellipse B1 versions, but can also be used with the Ellipse B2 versions and Aux connectors. It has the following characteristics:

Figure 5.6 : CA-ELI-RS422-3M

- 1x UP01L07 M010S BK1 Z2ZA connector
- 1x open end
- Water proof
- 3 meters long
- Weight: 77g

Cable wiring is the following:

Pin on Fischer connector	Color	Main connector signal (B1 version)	Main connector signal (B2 version)	Aux connector signal (Ellipse-E)
1	GREEN	SYNC IN A – ODO B	SYNC IN A – ODO B	SYNC IN C
2	BLUE	SYNC IN B – PORT B RX ODO A	SYNC IN B – PORT B RX ODO A	SYNC IN D
3	RED	VIN	VIN	PORT D RX
4	BLACK	GND	GND	GND
5	N/A	Internally connected to GND for RS-422 comm.	Internally connected to GND	Internally connected to GND
6	BROWN	SYNC OUT A	SYNC OUT A	SYNC OUT B
7	WHITE	PORT A RS422 TX+	CAN L	PORT C RS422 TX+
8	YELLOW	PORT A RS422 TX-	PORT A RS232 TX	PORT C RS232 TX PORT C RS422 TX-
9	ORANGE	PORT A RS422 RX+	PORT A RS232 RX	PORT C RS232 RX PORT C RS422 RX+
10	GREY	PORT A RS422 RX-	CAN H	PORT C RS422 RX-

5.4.6. CA-ELI-SPLIT-RS232-DB-0.5M

This cable provides an easy access through standard DB-9 plugs, to the different functions accessible on the ELLIPSE Main port.

The cable is composed of the following elements:

- 1x UP01L07 M010S BK1 Z2ZA connector
- Total length of 50cm (25cm before / after cable splitter)
- 2x Male DB-9 plugs
- 1x DC 2.1mm jack socket for power supply input
- Weight: 130g

Figure 5.7 : CA-ELI-SPLIT-RS232-DB-0.5M
Lengths not to scale

Cable wiring of the two DB-9 connectors is the following:

Pin on DB-9 "PORT A"	Function
1	-
2	PORT A RX
3	PORT A TX
4	-
5	GND
6	-
7	-
8	-
9	

Pin on DB-9 "SYNC/PORT E"	Function
1	SYNC IN A
2	PORT E RX
3	PORT E TX
4	SYNC OUT A
5	GND
6	-
7	-
8	SYNC IN B
9	-

The DC Jack plug is wired with VCC on the central pin and GND on the outer pin.

5.4.7. CA-ELI-SPLIT-CAN-DB-0.5M

This cable provides an easy access through standard DB-9 plugs, to the main serial port as well as the CAN bus output on the ELLIPSE.

The cable is composed of the following elements:

- 1x UP01L07 M010S BK1 Z2ZA connector
- Total length of 50cm (25cm before / after cable splitter)
- 1x Male DB-9 plugs (for serial PORT A)
- 1x Female DB-9 plug (for CAN bus)
- 1x DC 2.1mm jack socket for power supply input
- Weight: 130g

Figure 5.8 : CA-ELI-SPLIT-CAN-DB-0.5M
Lengths not to scale

Cable wiring of the two DB-9 connectors is the following:

Pin on DB-9 "SYNC/PORT A"	Function
1	SYNC IN A
2	PORT A RX
3	PORT A TX
4	SYNC OUT A
5	GND
6	-
7	-
8	SYNC IN B
9	

Pin on DB-9 "CAN"	Function
1	-
2	CAN L
3	GND
4	-
5	-
6	-
7	CAN H
8	-
9	-

The DC Jack plug is wired with VCC on the central pin and GND on the outer pin.

5.4.8. CA-ELI-SPLIT-AUX-RS232-DB-0.5M

This cable provides an easy access through standard DB-9 plugs to the AUX serial port of ELLIPSE E. It can be used for data output as well as connecting external GNSS receiver.

The cable is composed of the following elements:

- 1x UP01L07 M010S BK1 Z2ZA connector
- Total length of 50cm (25cm before / after cable splitter)
- 2x Male DB-9 plugs (for serial PORT C and D)
- Weight: 120g

Figure 5.9 : CA-ELI-SPLIT-AUX-RS232-DB-0.5M
Lengths not to scale

Cable wiring of the two DB-9 connectors is the following:

Pin on DB-9 "PORT C"	Function
1	SYNC IN C
2	PORT C RX
3	PORT C TX
4	SYNC OUT B
5	GND
6	-
7	-
8	-
9	-

Pin on DB-9 "PORT D"	Function
1	SYNC IN D
2	PORT D RX
3	-
4	-
5	GND
6	-
7	-
8	-
9	-

5.5. GNSS antennas

5.5.1. Dual Band Antenna – TW8889

These high performance antennas have been especially chosen for their excellent performance/size compromise.

The TW8889 provides a multi-constellation tracking, featuring GPS L1/L2, GLONASS G1/G2/G3, BEIDOU B1/B2, GALILEO E1/E5b, as well as SBAS (WAAS/EGNOS/MSAS) signals tracking.

The following specifications apply to the TW8889:

Figure 5.10 : Tallysman TW8889 antenna

5.5.1.1. Performance specifications

Parameter	Specification
Architecture	Dual band, orthogonal feeds combined in a hybrid combiner, wideband LNA, band-split for narrow filtering. Immunity to LTW and other cellular signals.
LNA Gain	26dB typical
Noise figure	2.5dB typ. at 25°C
VSWR (at LNA output)	< 1.5:1 typ.
Power consumption	12 mA typ.
Antenna gain (100mm ground plane)	GPS L1, L2: 4.0 dBic GLONASS G2: 3.0 dBic GLONASS G3, Galileo E5b: 1 dBic
Dimensions	Diameter: 47,3mm Height: 18,3mm
Cable and Connector	3m length Coax cable with SMA straight male (plug),
Weight	52grams (without cable and connector)
Environmental	Operating temp.: -40 to +85°C IP Rating: IP-67 housing Vibration: 3-axis, sweep = 15 min, 10 to 200 Hz sweep: 3 g Shock: Vertical axis: 50 g, other axes: 30 g

Note: A 100mm ground plane is highly recommended for these antennas.

5.5.1.2. Mechanical drawing

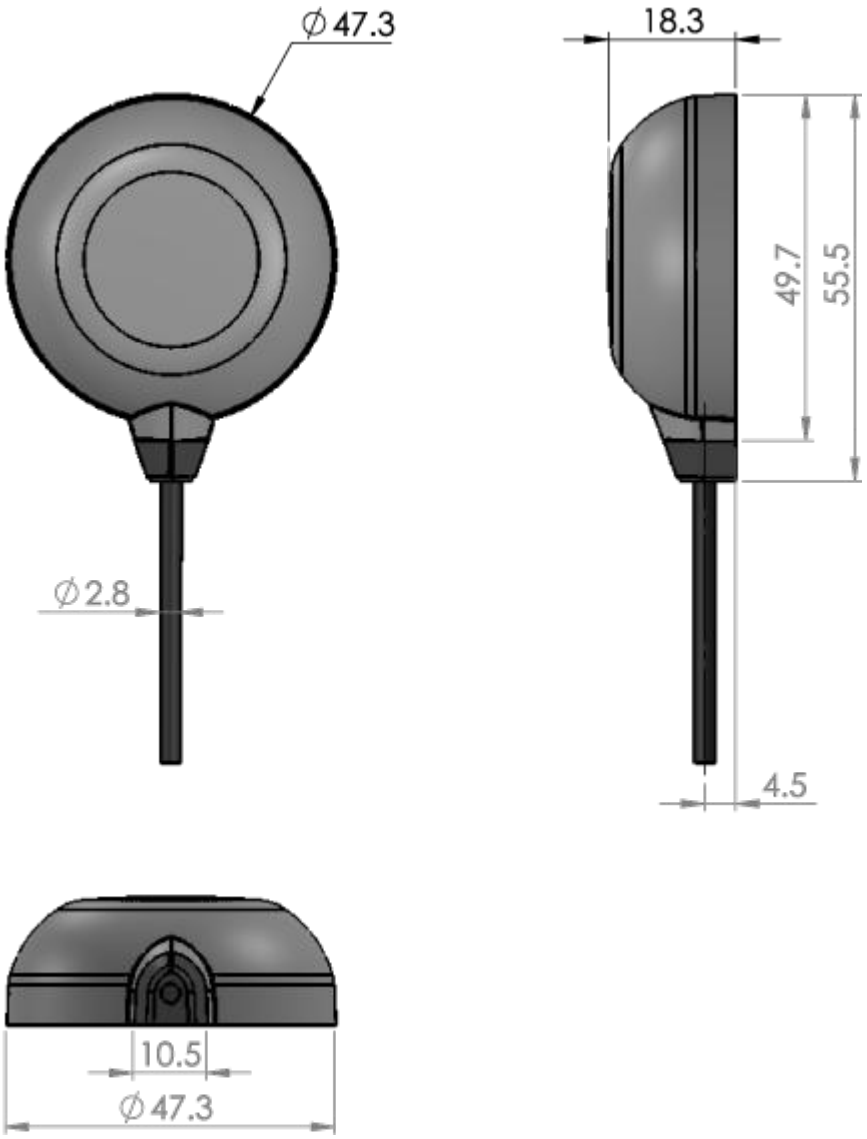


Figure 5.11: Tallysman 33-7882-07 mechanical drawing

5.5.2. Triple Band Antenna with L-band – TW7972

These high performance antennas have been especially chosen for their excellent performance/size compromise.

The TW7972 provides a multi-constellation tracking, featuring GPS L1/L2/L5, GLONASS G1/G2/G3, BEIDOU B1/B2/B2a, GALILEO E1/E5a/E5b, L-Band correction, as well as SBAS (WAAS/EGNOS/MSAS) signals tracking.

The following specifications apply to the TW7972:

Figure 5.12 : Tallysman TW7972 antenna

5.5.2.1. Performance specifications

Parameter	Specification
Architecture	Dual band, orthogonal feeds combined in a hybrid combiner, wideband LNA, band-split for narrow filtering. Immunity to LTW and other cellular signals.
LNA Gain	32dB typical
Noise figure	2.5dB typ. at 25°C
VSWR (at LNA output)	< 1.5:1 typ.
Supply Current	24 mA max.
Antenna gain (100mm ground plane)	GPS L1, L2: 4.0 dBic GLONASS G2: 2.5 dBic GLONASS G1, Galileo E1: 4 dBic Galileo E5b, GLONASS G2, G3: 2.5 dBic GPS L5, Galileo E5a: -1.5dBic
Dimensions	Diameter: 69mm Height: 22mm
Connector	SMA female bulckhead
Weight	180grams
Environmental	Operating temp.: -40 to +85°C IP Rating: IP-67 housing Vibration: MIL-STD-810-D Shock: 50 g (vertical), 30 g (other)

5.5.2.2. Mechanical drawing

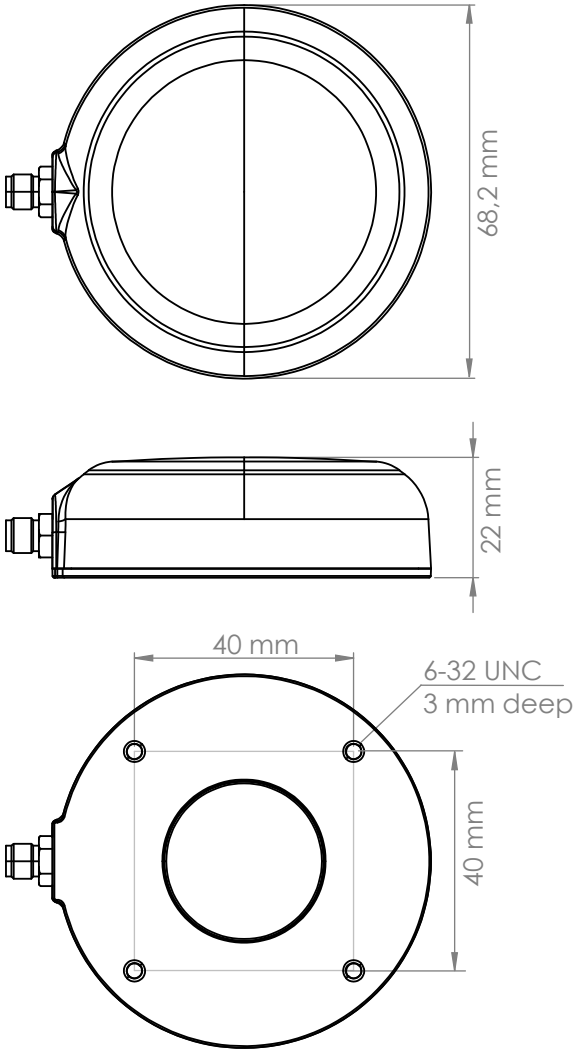


Figure 5.13: Tallysman 7972 mechanical drawing

5.5.2.3. SMA Cable

Finally, to connect the high performance GNSS antennas to an Ellipse sensor, Coax cables can be provided. All Coax cables are sealed. The following lengths:

Product Name	Description – Remarks	Photo
Cable SMA Male/Male - 3m	Coax cable, SMA male plug to SMA male plug, RG-174, 3m length Required to connect a SMA female antenna to an Ellipse sensor *Weight*: 50g	

Triple Band Antenna with L-band – TW3972

These high performance antennas have been especially chosen for their excellent performance/size compromise, and it is really suitable for marine applications or permanent roof mounting.

The TW3972 provides a multi-constellation tracking, featuring GPS L1/L2/L5, GLONASS G1/G2/G3, BEIDOU B1/B2/B2a, GALILEO E1/E5a/E5b, L-Band correction, as well as SBAS (WAAS/EGNOS/MSAS) signals tracking.

The following specifications apply to the TW3972:

Figure 5.14 : Tallysman TW3972 antenna

5.5.2.4. Performance specifications

Parameter	Specification
Architecture	Dual band, orthogonal feeds combined in a hybrid combiner, wideband LNA, band-split for narrow filtering. Immunity to LTW and other cellular signals.
LNA Gain	37dB typical
Noise figure	2.5dB typ. at 25°C
VSWR (at LNA output)	< 1.5:1 typ.
Supply Current	24 mA max.
Antenna gain (100mm ground plane)	GPS L1, L2: 4.0 dBic GLONASS G2: 2.5 dBic GLONASS G1, Galileo E1: 4 dBic Galileo E5b, GLONASS G2, G3: 2.5 dBic GPS L5, Galileo E5a: -1.5dBic
Dimensions	Diameter: 66mm Height: 21mm (connector not included)
Connector	TNC connector
Weight	185grams
Environmental	Operating temp.: -70 to +85°C IP Rating: IP-69K housing Vibration: MIL-STD-810-D Shock: 50 g (vertical), 30 g (other) Salt Fog MIL-STD-810F

5.5.2.5. Mechanical drawing

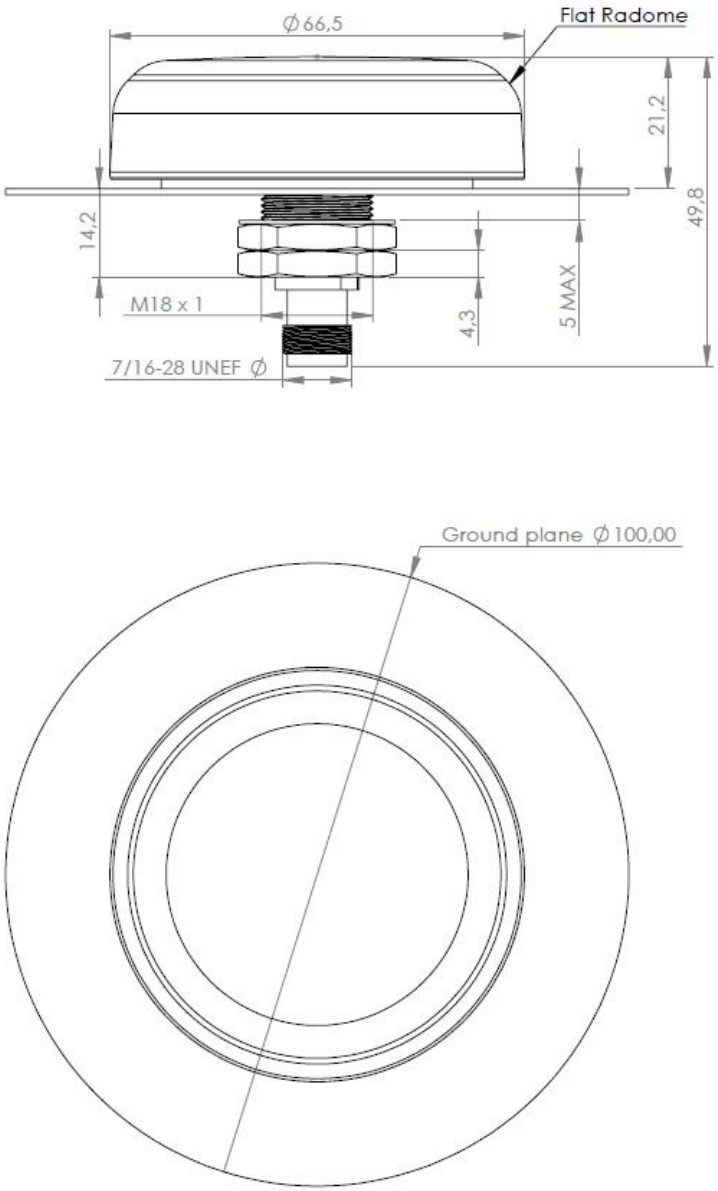


Figure 5.15: Tallysman TW3972 mechanical drawing

5.5.3. Helical Antenna – Maxtena M7HCT

This GNSS L1/L2 antenna is especially selected to be compliant with Ellipse-D requirements in both terms of signal tracking and small size / weight.

This antenna is an active multi-frequency, high-accuracy, GNSS antenna for the L1/L2 GPS, Galileo, Beidou and GLONASS bands.

This antenna should be used with a ground plane for optimal performance.

Figure 5.16 : Maxtena M7HCT-A-SMA antenna

5.5.3.1. Performance specifications

Parameter	Specification
LNA Gain	30 dB ±3 dB
Noise figure	1.5 dB typical, 2 dB max
Power consumption	25 mA max
Dimensions	Diameter: 34mm Height: 51mm
Connector	SMA male plug
Weight	25 grams
Environmental	Operating temp.: -40 to +105°C IP Rating: IP-67 housing

5.5.3.2. Mechanical drawing

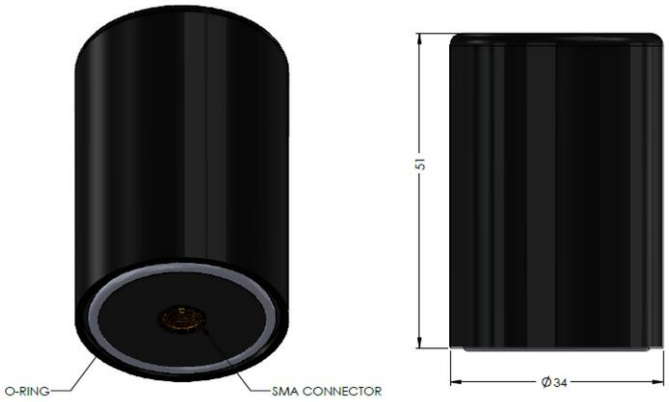


Figure 5.17: Maxtena M7HCT-A-SMA antenna mechanical layout. dimensions are in mm

5.5.3.3. SMA Cable

Finally, to connect the high performance GNSS antennas to an Ellipse sensor, Coax cables can be provided. All Coax cables are sealed. The following lengths:

Product code	Description – Remarks	Photo
[100-2448] CA-SMA-MF-RG174-3M	Coax cable, SMA male plug to SMA female bulkhead, RG-174, 3m length Required to connect a SMA female antenna to an Ellipse sensor *Weight*: 50g	

6. Appendix B: Ordering Information

Please find all the Ordering information for the Ellipse series sensors here after:

P/N	Product name	Hardware Code
100-2489	ELLIPSE-A | Marine AHRS	ELLIPSE-A-G4A2-B1
100-2490	ELLIPSE-A | Marine AHRS - CAN	ELLIPSE-A-G4A2-B2
100-2581	ELLIPSE-A | OEM Marine AHRS	ELLIPSE-A-G4A2-O1
100-2491	ELLIPSE-A | Land Air AHRS	ELLIPSE-A-G4A3-B1
100-2492	ELLIPSE-A | Land Air AHRS - CAN	ELLIPSE-A-G4A3-B2
100-2582	ELLIPSE-A | OEM Land Air AHRS	ELLIPSE-A-G4A3-O1
100-2493	ELLIPSE-A | High Dynamics AHRS	ELLIPSE-A-G5A4-B1
100-2494	ELLIPSE-A | High Dynamics AHRS - CAN	ELLIPSE-A-G5A4-B2
100-2583	ELLIPSE-A | OEM High Dynamics AHRS	ELLIPSE-A-G5A4-O1
100-2495	ELLIPSE-E | Marine INS - Ext. GNSS	ELLIPSE-E-G4A2-B1
100-2496	ELLIPSE-E | Marine INS - Ext. GNSS - CAN	ELLIPSE-E-G4A2-B2
100-2584	ELLIPSE-E | OEM Marine INS - Ext. GNSS	ELLIPSE-E-G4A2-O1
100-2497	ELLIPSE-E | Land Air INS - Ext. GNSS	ELLIPSE-E-G4A3-B1
100-2498	ELLIPSE-E | Land Air INS - Ext. GNSS - CAN	ELLIPSE-E-G4A3-B2
100-2585	ELLIPSE-E | OEM Land Air INS - Ext. GNSS	ELLIPSE-E-G4A3-O1
100-2499	ELLIPSE-E | High Dynamics INS - Ext. GNSS	ELLIPSE-E-G5A4-B1
100-2500	ELLIPSE-E | High Dynamics INS - Ext. GNSS - CAN	ELLIPSE-E-G5A4-B2
100-2586	ELLIPSE-E | OEM High Dynamics INS - Ext. GNSS	ELLIPSE-E-G5A4-O1
100-2501	ELLIPSE-N | Marine INS - GNSS RTK	ELLIPSE-N-G4A2-B1
100-2502	ELLIPSE-N | Marine INS - GNSS RTK - CAN	ELLIPSE-N-G4A2-B2
100-2503	ELLIPSE-N | OEM Marine INS - GNSS RTK	ELLIPSE-N-G4A2-O1
100-2504	ELLIPSE-N | Land Air INS - GNSS RTK	ELLIPSE-N-G4A3-B1
100-2505	ELLIPSE-N | Land Air INS - GNSS RTK - CAN	ELLIPSE-N-G4A3-B2
100-2506	ELLIPSE-N | OEM Land Air INS - GNSS RTK	ELLIPSE-N-G4A3-O1
100-2507	ELLIPSE-N | High Dynamics INS - GNSS RTK	ELLIPSE-N-G5A4-B1
100-2508	ELLIPSE-N | High Dynamics INS - GNSS RTK - CAN	ELLIPSE-N-G5A4-B2
100-2509	ELLIPSE-N | OEM High Dynamics - GNSS RTK	ELLIPSE-N-G5A4-O1
100-2422	ELLIPSE-D | Marine INS - GNSS RTK	ELLIPSE-D-G4A2-B1
100-2423	ELLIPSE-D | Marine INS - GNSS RTK - CAN	ELLIPSE-D-G4A2-B2
100-2428	ELLIPSE-D | OEM Marine INS - GNSS RTK	ELLIPSE-D-G4A2-O1
100-2424	ELLIPSE-D | Land Air INS - GNSS RTK	ELLIPSE-D-G4A3-B1
100-2425	ELLIPSE-D | Land Air INS - GNSS RTK - CAN	ELLIPSE-D-G4A3-B2
100-2429	ELLIPSE-D | OEM Land Air INS - GNSS RTK	ELLIPSE-D-G4A3-O1
100-2426	ELLIPSE-D | High Dynamics INS - GNSS RTK	ELLIPSE-D-G5A4-B1
100-2427	ELLIPSE-D | High Dynamics INS - GNSS RTK - CAN	ELLIPSE-D-G5A4-B2
100-2430	ELLIPSE-D | OEM High Dynamics - GNSS RTK	ELLIPSE-D-G5A4-O1

7. Appendix C: Device labels

SBG Systems manufacturing process is based on EN-9100 system with individual and full traceability of every component and operation. Each Ellipse 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 hardware code + hardware revision number are used to define exactly the device hardware and options.

You can find on the back side of the Ellipse 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 7.2: Ellipse BOX unit label sample

Figure 7.1: Ellipse OEM unit label sample