IG-30: sub-miniature static orientation sensor with optional GPS

Document : IG30UM.6
Revision: 6 – 27 June 2012

SBG Systems
3bis, chemin de la Jonchère
92500 Rueil Malmaison
FRANCE

Email : support@sbg-systems.com
Phone: +33 (0)1 80 88 45 00

Revision History

Revision	Date	Author	Information
6	27 June 2012	Alexis GUINAMARD	Updated address information Renumbered connectors pins to be consistent with manufacturers
5	November 30, 2009	Alexis GUINAMARD	New features updated: User buffer management Updated sensors specifications
4	April 24, 2009	Alexis GUINAMARD	Minor corrections on units of raw GPS outputs
3	16 Feb. 2009	Alexis GUINAMARD	Added explanations about altitude reference. Added CE conformity Minor editorial changes
2	11. Dec. 2008	Alexis GUINAMARD	Added new features : Magnetic declination and GPS source for heading. Advanced GPS outputs and configuration
1	1. Sept. 2008	Alexis GUINAMARD	First release of this document

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1. Introduction

1.1. Product description

The IG-30 is a miniature static orientation sensor that includes a tri-axial accelerometer and magnetometer. Based on these MEMS sensors and using an on board processing, the IG-30 outputs an accurate 3d orientation in quasi-static conditions.

Thanks to an advance calibration procedure, the IG-30 delivers accurate results over a wide temperature range. Each product is individually calibrated to get the best of the embedded sensors.

The SBG Systems' calibration procedure corrects all sensors errors such as bias and gain variations over temperature, misalignment and cross-axis as well as soft and hard iron effects.

The IG-30 can be purchased in Box, as well as in OEM version, making it very easy to integrate in any system or application.

Two versions are available, the IG-30A, and the IG-30G that also includes a GPS receiver and a barometric sensor. This product is perfect for platform stabilization or antenna tracking systems.

1.1.1. IG-30A

The IG-30A is a static orientation sensor that uses 3 accelerometers, 3 magnetometers and temperature sensors to measure and compute a precise motion and compute 3D orientation.

The tri-axial accelerometer is used to compute roll and pitch angles by tracking the earth gravity. The yaw angle is calculated using the earth magnetic field measured by the tri-axial magnetometer.

Outputs provided by the IG-30A are:

- Orientation (Euler Angles, Matrix or Quaternion),
- Sensor calibrated data (3D Acceleration, 3D Magnetic field, Temperatures),
- Raw sensor data.

1.1.2. IG-30G

The IG-30G combines in the same miniature package an IG-30A, a GPS and a barometric altimeter. It thus provides a precise static orientation, as well as a GPS position and altitude. The GPS addition is a good way to gain very useful features without any loss in terms of size and weight. Barometric sensor can provide pressure as well as a barometric altitude. Although altitude accuracy can be affected by weather changes, the sensor is always precise in tracking altitude variations.

Outputs provided by the IG-30G are:

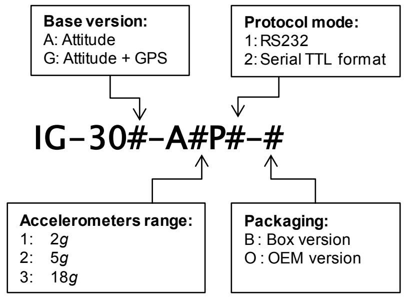
- Orientation (Euler Angles, Matrix or Quaternion),
- Sensor calibrated data (3D Acceleration, 3D Magnetic field, Temperatures),
- Raw sensor data.
- 3D Raw GPS Position,
- Pressure,
- Barometric altitude.
- Advanced GPS information

1.2. Ordering information

Standard version is the box version, with ± 5*g* accelerometers, and RS232 communications.

Standard product codes are:

- `IG-30A-A2P1-B`
- `IG-30G-A2P1-B.`



1.3. Block diagram

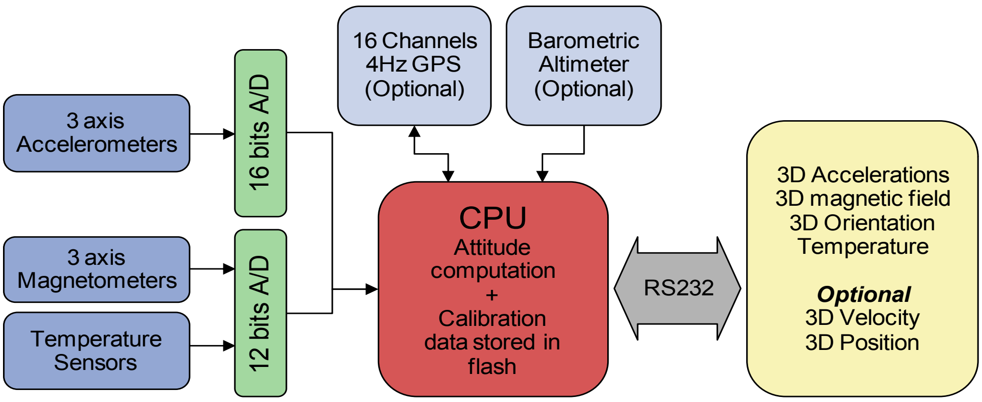


Figure 1: Simplified block diagram of the IG-30

1.3.1. Internal computations

The IG-30 runs an embedded filter that detects magnetic north and local gravity and computes an orientation valid in 360° for all axes. The device can measure a very accurate orientation, but only in static conditions. Movements make the accelerometers precision decrease, and magnetometers can be disturbed by irons, and magnets moving near the product. These sensors can give good orientation accuracy, at low bandwidth.

1.3.2. Sensors

Accelerometers are sampled with a 16 bits sigma-delta Analog to Digital Converter. Magnetometers and the two on board temperature sensors are sampled by a 12 bits sigma-delta Analog to Digital Converter. High speed sampling (1 kHz) allows virtually sampling all sensors at the same time. This High sampling frequency also improves the sensor immunity in vibrating environments.

1.3.2.1. Factory calibration procedure

Our products are provided with fully calibrated accelerometers and magnetometers. We calibrate and test each product in our factory. Calibration report is also shipped with each product.

This calibration procedure allows taking the maximum precision of each sensor. This procedure contains:

- Temperature compensation of gain and bias for accelerometers,
- Temperature compensation of gain for magnetometers,
- Cross-axis and misalignment effects compensation for accelerometers and magnetometers,

Note: *There is no temperature compensation of bias for magnetometers because it is stable over temperature by hardware design.*

1.3.2.2. Magnetometers calibration

Magnetometers are fully calibrated in factory. However, they are very sensitive to their close environment and mainly the object on which they are strapped. Some ferromagnetic materials can make distortions of the magnetic field causing errors in heading estimation. These distortions are often called Hard and Soft Iron effects and must be addressed for good attitude results.

The IG-30 includes a powerful algorithm especially designed to easily compensate both **Hard AND Soft** iron effects.

We advise user to use this procedure when:

- A loss of precision is observed in heading estimation,
- The device is mounted on a object that may contain ferromagnetic materials or magnets,
- The device is removed from an object containing ferromagnetic materials or magnets.

Note: *Please refer to the Magnetometers Calibration Tools documentation for a complete description of the magnetometers calibration procedure.*

1.3.2.3. GPS and barometric altimeter integration (IG-30G only)

Global Positioning System

The IG-30 includes a high precision 16 channels GPS receiver. Thanks to the SuperSense® technology and a gain of -158dB, this receiver can work in light indoor environments. In optimal conditions, this GPS can deliver positions with an error of less than 2 meters.

This new generation of GPS receiver provides navigation information such as speed, heading, altitude and position at a high refresh rate of 4 Hz. Compatible with SBAS(EGNOS), DGPS and Galileo ready, the positioning error can be reduced.

The box version of the IG-30G is shipped with an active antenna connected to the device through a standard SMA connector. The OEM version features a micro RF connector (U.F.L format) especially chosen for its small size, light weight and ease of use for tight integration purpose.

Please refer to sections 5.3.3.2 and 5.2.3.1 for more information such as connectors drawing and references.

***Warning**: The IG-30G includes an extremely small GPS receiver that doesn't support antenna short circuit detection protection. This means that user should be careful when connecting an external antenna. A short circuit on antenna connector can permanently damage the GPS receiver.*
We also advise user to connect the antenna before powering-on the device, because the GPS estimates antenna noise at startup.

***Note:** Most GPS patch antennas include magnets to stick on a car roof. The antenna provided by SBG Systems has been carefully chosen to include no magnets, in order to avoid accidental magnetization of the IG-30. Be careful when using standard GPS antennas not to accidentally magnetize your IG-30.*

Barometric Altimeter

The Global Positioning System can output altitude based on satellites information. Unfortunately, this altitude is only available in good reception conditions and the error is, most of the time, greater than 10 meters.

With the only GPS altitude information, the IG-30G will not be able to track small changes in altitude. To address this limitation, a pressure sensor was added to the IG-30G.

This small pressure sensor is fully calibrated and temperature compensated in factory making it ideal to measure accurately absolute pressure.

The IG-30G converts this absolute pressure into altitude information relative to a ground pressure reference defined at startup or by the user. This algorithm uses the Standard Atmosphere model. We assume a constant temperature gradient over altitude.

The following simplified formula is used to convert the barometric pressure P, given a reference pressure P_{ref} to an altitude (in meters):

$$H = 44307 \times \left(1 - \frac{P}{P_{ref}}^{0.1902}\right)$$

Please note that this altitude output does not take into account weather changes; it is also referenced on a defined pressure, which may not be ground pressure if the reference is not set at startup.

1.3.3. Specifications

All specifications are valid in the full temperature range -40°C to 85°C unless otherwise specified.

Parameter	Specification		Remarks
Attitude			
Sensing range	360° in all axes		
Static accuracy	± 0.3° (Pitch, Roll) ± 0.8° (Heading)		 Homogenous magnetic field
Repeatability	< 0.2°		
Resolution	< 0.1°		
Output frequency	0.01 to 200 Hz 0.01 to 75 Hz		Calibrated sensor data only Orientation mode
Standard Sensors	**Accelerometers**	**Magnetometers**	
Measurement range	± 2 *g*	± 1.2 Gauss	Accelerometers available in 5*g* and 18*g*
Non-linearity	< 0.2% of FS	< 0.2% of FS	
Bias stability	± 2 m*g*	± 0.5 mGauss	Over temperature range
Noise density	0.22 m*g*/√Hz		
Alignment error	< 0.1°	< 0.1°	
Bandwidth	50 Hz	0.1 to 50 Hz	
Sampling rate	1 000 Hz	100 Hz	
GPS receiver (IG-30G)			
Receiver type	L1 frequency, C/A Code, 16-Channels		
Position accuracy	2.0 m 2.5 m 5.0 m		With SbAS support CEP (Horizontal accuracy) SEP (Vertical accuracy)
Acquisition time	< 3.5 s / < 34 s		Hot start / Cold start
Tracking sensitivity	-158 dB		Tracking
Operational limits	4*g* 515 m/s		Acceleration Speed
Pressure sensor (IG-30G)			
Resolution	6 Pa		
Pressure accuracy	± 50 Pa[1] ± 200 pa		Relative Absolute – Temperature [-30° - 70°C]
Long term stability	100 Pa		Over 1 year – Temperature [-30° - 70°C]
Update rate	9 Hz		
Communication			
Output modes	Euler angles, Quaternion, Matrix, 3D velocity, 3D Position, Calibrated sensor data, Raw sensor data.		Each output can be enabled or disabled by the user
Interface options	Serial (RS-232 or TTL 3.3V), USB using provided usbToUart		
Serial data rate	9 600 to 230 400 bps		User selectable
Physical			
Dimensions (OEM)	27x30x14 mm		
Dimensions (Box)	36x49x22 mm		
Weight (OEM)	6 grams / 9 grams		IG-30A / IG-30G
Weight (Box)	39 grams / 45 grams		IG-30A / IG-30G
Operating temperature	-40° to 85°C		Non condensing environment
Storage temperature	-40° to 85°C		
Shock limit	1 000*g* (Powered), 2 000 *g* (unpowered)		Shocks may affect performance
Electrical			
Operating voltage	3.3 to 30 V		
Power consumption	175 mW @ 5.0 V 350 mW @ 5.0 V		IG-30A, optimal consumption at 5.0 V IG-30G, optimal consumption at 5.0 V
Start-up time	< 30s		For optimal attitude measurement

Table 1 : IG-30 specifications

[1] Absolute accuracy and long term stability may not reach specification if used below -30°C or above +70°.

1.3.3.1. Optional sensors specifications:

Here are summarized the optional sensors specifications. The main differences with standard sensors are the noise density, the linearity errors and the bias stability.

Optional Accelerometers	A2	A3
Measurement range	± 5*g*	± 18*g*
Non-linearity	< 0.2% of FS	< 0.2% of FS
Bias stability	± 5 m*g*	± 10 m*g*
Noise density	0.25 mg/√Hz	0.32 mg/√Hz
Alignment error	< 0.1°	< 0.1°
Bandwidth	50 Hz	50 Hz
Sampling rate	1 000 Hz	1 000 Hz

1.4. Presentation of the development kit

The IG-30 SDK has been developed to make integration of the IG-30 very easy and efficient. Provided software and libraries will give the opportunity to rapidly develop powerful applications. The addition of the UsbToUart converter makes the connection of an IG-30 to a computer very comfortable.

1.4.1. Content of a development kit

Each IG-30 SDK is provided with the following elements:

- An IG-30A *(or an IG-30G)*,
- The calibration report of the device,
- A UsbToUart converter,
- A USB cable to connect the device (OEM versions),
- A quick start manual,
- A GPS active antenna *(IG-30G),*
- A set of compatible screws to mount easily your IG-30
- A CD-Rom containing :
  - UsbToUart converter driver,
  - sbgCenter analyze software,
  - sbgUpdater software,
  - sbgCom library,
  - Example software,
  - Full documentation :
    - IG-30 User Manual,
    - Low Level Protocol Specifications,
    - sbgCom Library Reference Manual,
    - Magnetometers Calibration Tools,
    - sbgCenter User Manual.

Figure 2: The IG-30G SDK

1.4.2. Quick start with provided software

1.4.2.1. The sbgCenter

The sbgCenter is a very powerful program suit. It allows to deeply analyzing outputs of the IG-30, by displaying, recording, and exporting a set of data. Graphs can be displayed, as well as 3D representation of orientation.

A powerful time management allows to deeply exploring any recording, with the ability to display in a single frame 50 ms of recording, or the whole record, if it's what the user needs.

To get a quick start of the sbgCenter, follow these steps:

1. Connect one or more IG-30 to the computer,
2. Launch sbgCenter,
3. Click on the "Refresh" button,
4. Double-click on the device in the device list,
5. Click on the 3D Cube icon to open the 3D view,
6. Start playing!

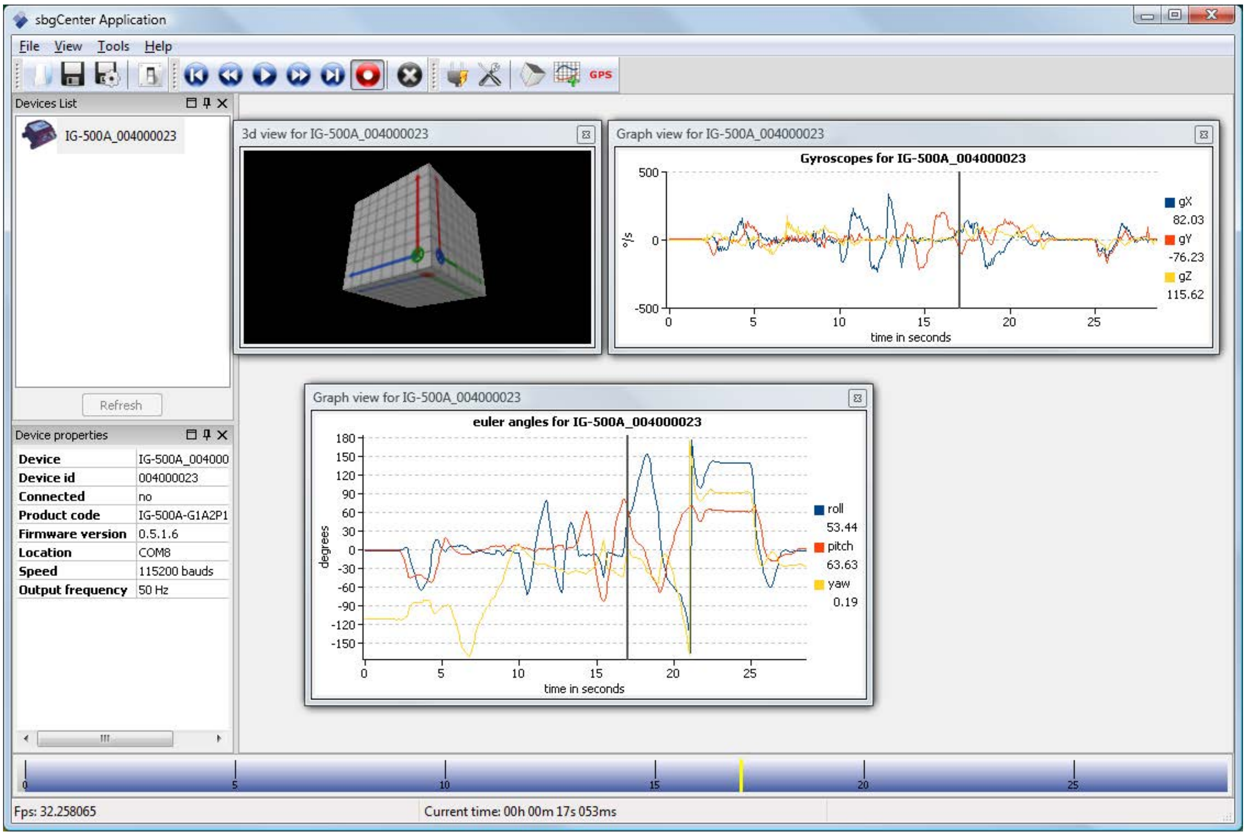


Figure 3: sbgCenter is an excellent analyze tool

Note: *Please refer to the sbgCenter User Manual for more information*

1.5. Communicate with the device

SBG Systems provides multiple ways to interface the IG-30 with another system. An easy to use C library is included in the SDK, as well as the low level protocol documentation.

1.5.1. The C library sbgCom

The IG-30 DK provides an easy access to the device with the library sbgCom. This library allows access to all the functionalities of the IG-30, including continuous mode of communication.

This library is developed for most popular OS: Ms Windows, Linux, and Mac OS X. It should also be easily compiled on all UNIX platforms.

sbgCom was designed to simplify the work needed to port the library to a specific platform, by separating the low level communication functions such as serial com port from the high level one.

Note: *Please refer to the sbgCom Reference Manual to have a complete description of the library.*

Example programs provided with sbgCom

- **Minimal example:** This small C example is simply the smallest program you can write to use the IG-30. Only 6 lines of code are needed to initialize the device, start communications and display in real time results. This example illustrates the simplicity of use of sbgCom.

- **3D Cube:** This 3D Cube is a small C example, which source is available in the SDK. To use it, you just have to define the right com port and serial communication baud rate in the file "main.c" and compile the project. If everything goes well, you should obtain the two windows below:

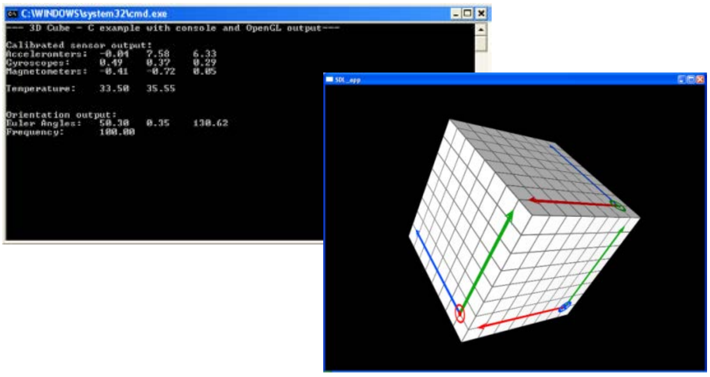


Figure 4: Overview of the 3D Cube example program

1.5.2. Low level communication with IG-30

When it is not possible to use sbgCom, you can still communicate directly with the device, by implementing its low level communication protocol based on the provided documentation.

***Note:** Please refer to the IG-30 Low Level Protocol Specifications to have a complete documentation of the protocol format, the commands and their parameters.*

1.5.3. Matlab and Labview integration

1.5.3.1. Matlab

The sbgMatlab plug-in developed by SBG Systems allows a direct access in real time to your IG-30. Main functions of the sbgCom have been implemented in a Matlab class CSbgMatlab, providing an easy interface for users.

The plug-in is in a DLL form on windows platforms. A UNIX version of this dynamic library is being finalized and will be available in a next release.

A few example codes may help you in your developments. Also note that continuous mode has to be enabled in order to retrieve outputs of the IG-30.

1.5.3.2. Labview integration

The sbgLabView library provides the full support of the IG-30 on labView. An example using this library is provided for a better understanding of the library. Also note that continuous mode has to be enabled in order to retrieve outputs of the IG-30.

2. Output provided by IG-30

2.1. Calibrated sensors output

The IG-30 includes 8 calibrated sensors: 3 accelerometers, 3 magnetometers and 2 temperature sensors. These 8 calibrated sensors values can be outputted by the device. By calibrated value, we mean value in real units such as $m \cdot s^{-2}$ and compensated for any sensor errors (temperature effects, linearity errors, sensor misalignment…).

Accelerometers values

Accelerometers calibrated values are the three accelerations measured on the device coordinate system.

Accelerometers values are expressed in $m \cdot s^{-2}$.

Magnetometers values

Magnetometers calibrated values reflect the local magnetic field in the device coordinate system. These values are temperature compensated and corrected for soft and hard iron effects (as evaluated in the last calibration procedure).

Magnetometers values are expressed in an arbitrary unit and in homogeneous magnetic field, the norm of the magnetic field vector should be the same in all orientations and ideally equal to 1.0.

Temperature values

The temperature calibrated output is the temperature measured by the external magnetometers and accelerometers temperature sensor, and the internal ADC temperature sensor.

Temperature is expressed in $°\,C$.

2.2. Orientation output

Euler angles

These Euler angles provide Roll, Pitch and Yaw, expressed in *rad*. (If the device can be rotated in all directions, you would prefer rotation matrix or quaternion forms as they do not suffer from singularities when pitch approaches $\pm\frac{\pi}{2}$.

Rotation Matrix

This form provides the nine coefficients of the rotation matrix representing the current orientation of the IG-30.

Quaternion

The quaternion is the smallest form that provides a full coverage of 3D orientations.

Note: *Please refer to chapter 3. to have more information about how orientation can be represented and the coordinate frames of the IG-30.*

2.3. Other outputs

Raw sensors output

Accelerometers, Magnetometers, Gyroscopes and Temperatures can be output by the IG-30 in raw form. The raw sensor output is the reading of the Analog to Digital Converter, then filtered by the averaging filter and eventually the low pass filter. These values are not exploitable directly but may sometimes be useful they reflect the real values of the physical sensors.

Raw values are variables of type `uint16`.

Time since last reset

This output provides in *ms* the time elapsed since the last reset of the IG-30. This time is measured at the beginning of the sampling and calculation loop of the device.

The type of this output is `uint32`.

UTC Time reference

The IG-30G outputs a UTC time reference derived from the internal GPS receiver. This time references the sample time, with an accuracy better than 1 µs. This output contains the full date information: Year, Month, Day, Hour, Minutes, Seconds, and Nano-Seconds.

Before receiving any GPS time data, the timer starts on January 1st, 2009.

In addition to this UTC time reference, three flags are available in the next output (Device Status). These flags inform the user about the quality of the time information:

- The first flag is set if the GPS already knows the “Leap seconds” between UTC time and GPS atomic clocks time. A leap second is introduced to keep the GPS time close to the mean solar time (which is not perfectly constant by nature). At the time of writing those lines, there are 15 positive leap seconds. This is why when this flag become set, the time output jumps of several seconds. It may take up to 15-20 minutes for the GPS receiver to obtain leap seconds information.

- The seconds informs the availability of a “rough accuracy”. This 0.25s accuracy is achieved when The GPS receiver starts sending valid time information (independently of the leap seconds), but without sending synchronization pulses. The accuracy comes from the unknown calculation time of the GPS data, and is achieved when the GPS receiver actually tracks satellites, but has no position fix.

- The third flag states that the UCT clock is “synchronized”. In that case, the timer achieve better than 1µs accuracy. The synchronization is done by the use of a synchronization pulses from the GPS receiver. These pulses are sent as soon as the GPS receiver has a valid position fix. If the GPS receiver loses its position fix for more than 2 minutes, the time accuracy is degraded to “rough accuracy”.

Device Status

The IG-30 performs at startup a sensor Self-Test, as well as some internal initialization checks. This self test inform user of potential device failure. Note that the sensor self test is only reliable if the device is not moving at startup.

Some other outputs are updated in real time and inform about the health of the Kalman filter.

The bit-field is contained in a uint32 word.

Bit	Name	Description
0	SBG_CALIB_INIT_STATUS_MASK	Set to 1 if the calibration structure is well initialized
1	SBG_SETTINGS_INIT_STATUS_MASK	Set to 1 if the settings structure is well initialized
[2 – 4]	SBG_ACCEL_X_SELF_TEST_STATUS_MASK	Set to 1 if the X accelerometer has passed self test
5	SBG_ACCEL_RANGE_STATUS_MASK	Set to 1 if the readings of accelerometers do not exceed operating range.
[6 – 9]	-	Reserved
10	SBG_MAG_CALIBRATION_STATUS_MASK	Set to 1 if the magnetic field calibration looks OK
11	SBG_ALTI_INIT_STATUS_BIT_MASK	Set to 1 if altimeter could initialize
12	SBG_GPS_INIT_STATUS_BIT_MASK	Set to 1 if GPS receive could initialize properly
[13 – 16]	-	Reserved
17	SBG_UTC_VALID_MASK	Bit mask for GPS UTC Validation: Leap Seconds already known
18	SBG_UTC_ROUGH_ACCURACY_MASK	Bit mask for UTC time validation with rough accuracy
19	SBG_FINE_ACURACY_MASK	Bit mask for UTC time synchronization
[20 – 31]	-	Reserved – Set to 0

Magnetic field Calibration Data

This 12 bytes buffer contains data used for the SBG Systems Magnetic Calibration tools.

Check the Magnetic calibration tools documentation for more information about this output.

2.3.2. Raw GPS information

Raw 3D Position

3D position is basically Latitude Longitude and Altitude, according to the WGS84 system. These outputs are `int32` integers.

- Latitude and Longitude are expressed with: $1\ lsb = 10^{-7\circ}$.
- Altitude is expressed in *mm* (above ellipsoid or mean sea level, depending on the unit configuration).

Raw 3D Velocity

3D velocity represents the velocity in the X, Y and Z axes.

These three outputs are `int32` integers, and are expressed in $cm \cdot s^{-1}$.

Raw Heading

The heading corresponds to the direction of the trajectory of the GPS antenna.

Heading is a `uint32` integer, and is expressed between 0 and 360°, with $1\ lsb = 10^{-7\circ}$.

GPS info

These outputs inform the user about how many satellites are used in the position and navigation solution, the state of the UTC timer.

GPS Time of Week

This time is the GPS time of the current week. There is about 15 seconds of error between the GPS time and the UTC time. For UTC synchronization, use the UTC time reference output.

Time is a `uint32` integer, and is expressed in *milliseconds*.

2.3.3. Pressure sensor information

Absolute pressure

Absolute pressure is given by pressure sensor. This `uint32` integer represents pressure in *Pa*.

Relative altitude

According to the Standard Atmosphere model, altitude is calculated with respect to the ground pressure (set by user, default value is 1013.25 HPa).

Altitude is an `int32` integer, expressed in *cm*.

2.3.4. Advanced GPS output

The IG-30G has also the capability to output information about the receiver channels. Each channel can track one satellite (or Space Vehicle). Information about signal quality or satellite position is given by a specialized command. Information retrieved for each channel is the following:

Field	Type	Comments
satelliteID	uint8	Space Vehicle ID
flagsQuality	uint8	**Bit [0 – 4] : Bitmask, made up of the following bit values** • 0x01 = SV is used for navigation • 0x02 = Differential correction data is available for this SV • 0x04 = Orbit information is available for this SV (Ephemeris or Almanach) • 0x08 = Orbit information is Ephemeris • 0x10 = SV is unhealthy / shall not be used **Bit [5-7] : Signal Quality Indicator (range 0..7). Different QI values are**: • 0: This channel is idle • 1, 2: Channel is searching • 3: Signal detected but unusable • 4: Code Lock on Signal • 5, 6: Code and Carrier locked • 7: Code and Carrier locked, receiving 50bps data
signalStrength	uint8	Carrier to Noise Ratio expressed in *dbHz*
azimuth	int8	Azimuth of the SV. 1 LSB = 32/45 degree
elevation	int8	Elevation of te SV. 1 LSB = 32/45 degree

Depending on the device version, there can be up to 50 channels.

> ***Note:*** *This information is not available with the standard output. A specific command in Question/Answer mode has to be sent to retrieve satellites information.*

3. Orientation, position and velocity representation

3.1. Coordinate systems

User has to distinguish two coordinate frames when working with an inertial measurement unit, such as the IG-30. The first coordinate frame is the inertial (or device) coordinate frame, in which values are expressed in this local coordinate frame. This coordinate frame follows the movements of the device. The fixed coordinate frame represents the environment of the device.

In other words, the device frame is moving and rotating in the fixed frame. When the two frames are aligned (X, Y, Z axes of the two frames are aligned), the device should output no rotation ($yaw = pitch = roll = 0$).

In all case, all coordinate systems are "Right handed" and the positive direction for rotations is clockwise in the direction of the axis:

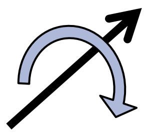


Figure 5: Positive rotations

3.1.1. Device coordinate system

Below is defined the inertial coordinate frame for both OEM and Box versions.

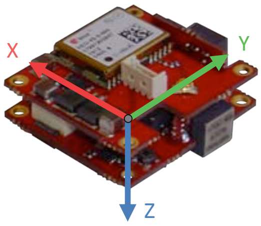


Figure 6: Inertial coordinate frame for the OEM Version

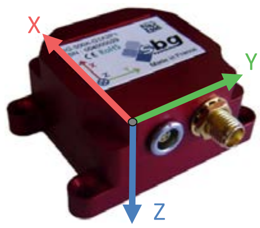


Figure 7: Inertial coordinate frame for the Box Version

3.1.2. Fixed coordinate system (North – East - Down)

The fixed coordinate frame is defined by these three vectors:

- *X* vector is aligned with the local magnetic north,
- *Z* vector is aligned with the local gravity, turned down,
- *Y* vector is chosen such as the coordinate frame is “right-handed”. Therefore, *Y* is turned toward East.

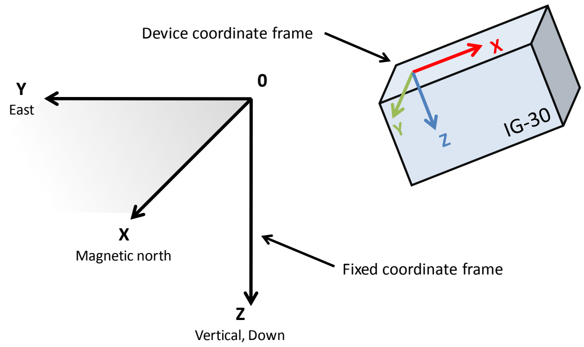


Figure 8: Representation of a sensor in the fixed coordinate system

3.1.2.1. Magnetic North vs. true North

In order to achieve good performance, it is important that the device’s representation of the Earth fixed coordinate system is aligned with the one used by the GPS receiver.

However, magnetometers are not aligned with the true north, but with the magnetic north. In the opposite, the GPS system is always referenced to the real north. The difference between the real north direction and the magnetic north direction is called declination.

The magnitude of declination may vary significantly: About 0.5° near Paris, it may grow to 20° in Canada and even more in other locations. The declination depends on the location on Earth, as well as the current date, as the declination may vary over time.

It is possible to evaluate automatically the local declination of the device, or to set manually the magnetic declination.

3.1.3. Geographic coordinate system

It is common to represent position on Earth in terms of Latitude, Longitude and Altitude. This geographic coordinate system allows locating any point on the ellipsoid shape of Earth.

Most of the GPS systems use the standard WGS84 physical model of Earth. Some countries use local physical models which are locally more accurate, but these local models cannot be used on the whole globe. The IG-30G uses by default the standard WGS84 as reference.

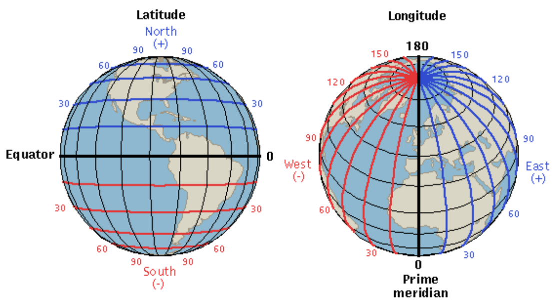


Figure 9 Geographic coordinates on Earth

3.1.3.1. Altitude reference

Altitude can be expressed in several different ways. The mostly used are the "Altitude above mean sea level", and "Altitude above Ellipsoid".

In order to understand the difference between these two representations, you have to understand that Earth's surface is irregular. The geoid shape is often used to approximate Earth's irregularities. But actually a geoid is much smoother than the real Earth surface. There are many geoid models with different precision. Normally, the mean sea level is always at zero altitude on a geoid surface.

In the opposite, all GPS systems use an ellipsoid shape to approximate Earth's surface, which is much simpler mathematically than a geoid representation. The WGS84 standard defines the ellipsoid parameters. As there are some differences between the geoid and the ellipsoid, the altitude of the sea level is not always at zero if we are based on the ellipsoid.

It is possible to convert the altitude between the two models with correction tables. The total variation between a perfect ellipsoid shape and a geoid is less than 200m.

The diagram below shows the Earth's surface and the different shapes:

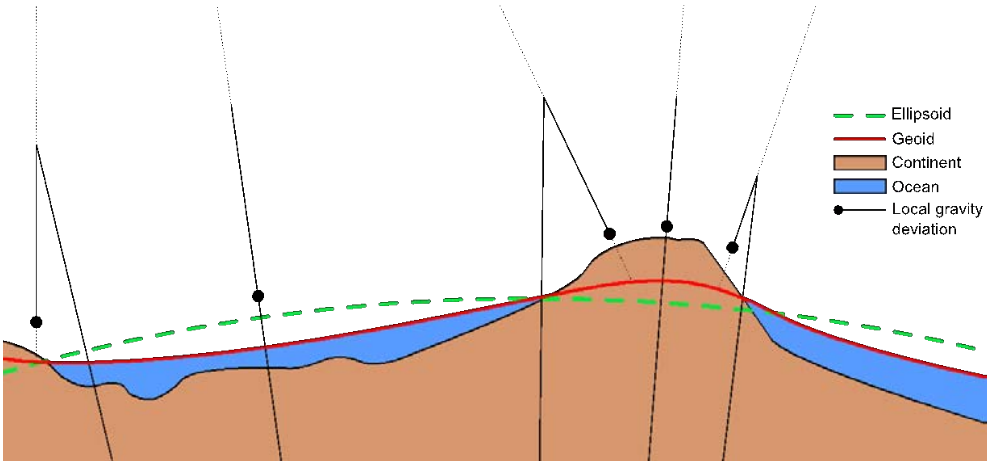


Figure 10: Ellipsoid and Geoid representation

The IG-30G can be configured to output altitude referenced either to Ellipsoid, using the standard WGS 84, or Mean Sea Level.

For best accuracy, you may use the altitude above ellipsoid (default).

3.2. Orientation representation

There are several ways to represent the orientation of the device that are provided by the IG-30. Some are easy to understand, others are very efficient such as quaternion form:

3.2.1. Euler Angles

Euler angles are a commonly used representation of spatial orientation. Euler angles are in fact a composition of rotation from the reference (Earth fixed) frame. This spatial orientation is defined by the sequence of the three rotations around X, Y and Z axis of the fixed frame.

Euler angles are widely used because of their ease of interpretation. The three parameters: Roll, Pitch and Yaw define rotations around the fixed frame's axes:

- Roll (φ): Rotation around X axis. $\varphi \in [-\pi\,;\pi]$
- Pitch (θ): Rotation around Y axis. $\theta \in \left[-\frac{\pi}{2}\,;\frac{\pi}{2}\right]$
- Yaw (Ψ): Rotation around Z axis. $\psi \in [-\pi\,;\pi]$

> ***Note:*** *As Euler angles suffer from a singularity called "Gimbal lock", when Pitch approaches $\pm\frac{\pi}{2}$, we do not advise to use Euler angles if the sensors has to be used in a wide range of orientations. Quaternion and Rotation matrix do not suffer from this problem.*

3.2.2. Rotation matrix (Direction Cosine Matrix)

The Direction Cosine Matrix (DCM) is a rotation matrix that transforms one coordinate reference frame to another. Rotation matrices are a complete representation of a 3D orientation, thus there is no singularity in that model.

A DCM locates three unit vectors that define a coordinate frame. Here the DCM transforms the sensor coordinate frame to the earth fixed coordinates. The DCM is the combination of the three rotation matrices RM_φ , RM_θ and RM_ψ respectively around Earth X, Y and Z axes.

Here is defined a DCM in terms of Euler Angles:

$$DCM = RM_\psi \, RM_\theta \, RM_\varphi$$

$$DCM = \begin{pmatrix} \cos\psi & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\varphi & -\sin\varphi \\ 0 & \sin\varphi & \cos\varphi \end{pmatrix}$$

$$DCM = \begin{pmatrix} \cos\theta\cos\psi & \sin\varphi\sin\theta\cos\psi - \cos\varphi\sin\psi & \cos\varphi\sin\theta\cos\psi + \sin\varphi\sin\psi \\ \cos\theta\sin\psi & \sin\varphi\sin\theta\sin\psi + \cos\varphi\cos\psi & \cos\varphi\sin\theta\sin\psi - \sin\varphi\cos\psi \\ -\sin\theta & \sin\varphi\cos\theta & \cos\varphi\cos\theta \end{pmatrix}$$

As for any rotation matrix, the inverse rotation equals to the transposed matrix:

$$DCM^{-1} = DCM^T$$

In order to transform a vector expressed in the sensor coordinate system into the Earth fixed frame, user will use the DCM as expressed below:

$$V_{Earth} = DCM \cdot V_{Sensor}$$

Reciprocally:

$$V_{Sensor} = DCM^T \cdot V_{Earth}$$

3.2.3. Quaternions

Quaternions are an extension of complex numbers, as defined here:

$Q = q_0 + q_1 \cdot i + q_2 \cdot j + q_3 \cdot k$ Where i, j and k are imaginary numbers.

Particular quaternions such as $\|Q\| = 1$ can represent, as DCMs, a complete definition of the 3D orientation, without any singularity.

Quaternion algebra do not require a lot of computational resources, they are therefore very efficient for orientation representation.

The inverse rotation of Q is defined by the complex conjugate of Q, denoted $\overline{Q}$:

$$\overline{Q} = q_0 - q_1 \cdot i - q_2 \cdot j - q_3 \cdot k$$

Quaternion can be defined in terms of the DCM coefficients:

$$q_0 = \frac{1}{2}\sqrt{1 + \mathrm{DCM}_{11} + \mathrm{DCM}_{22} + \mathrm{DCM}_{33}}$$
$$q_1 = \frac{1}{4\,q_0}(DCM_{32} - DCM_{23})$$
$$q_2 = \frac{1}{4\,q_0}(DCM_{13} - DCM_{31})$$
$$q_3 = \frac{1}{4\,q_0}(DCM_{21} - DCM_{12})$$

Or in terms of Euler Angles:

$$q_0 = \frac{1}{2}\sqrt{1 + \cos\theta\sin\psi + \sin\varphi\sin\theta\sin\psi + \cos\varphi\cos\psi + \cos\varphi\cos\theta}$$
$$q_1 = \frac{1}{4\,q_0}(\sin\varphi\cos\theta - \cos\varphi\sin\theta\ \sin\psi + \sin\varphi\cos\psi)$$
$$q_2 = \frac{1}{4\,q_0}(\cos\varphi\sin\theta\cos\psi + \sin\varphi\sin\psi + \sin\theta)$$
$$q_3 = \frac{1}{4\,q_0}(\cos\theta\sin\psi - \sin\varphi\sin\theta\cos\psi + \cos\varphi\sin\psi)$$

3.2.4. Other useful conversion formulas

Some other conversion formulas can be useful for many users, and are listed below:

3.2.4.1. Quaternion to DCM

It may be useful to compute a DCM based on the quaternion's parameters:

$$DCM = \begin{pmatrix} 2q_0^2 + 2q_1^2 - 1 & 2q_1q_2 - 2q_0q_3 & 2q_0q_2 + 2q_1q_3 \\ 2q_1q_2 + 2q_0q_3 & 2q_0^2 + 2q_2^2 - 1 & 2q_2q_3 - 2q_0q_1 \\ 2q_1q_3 - 2q_0q_2 & 2q_2q_3 + 2q_0q_1 & 2q_0^2 + 2q_3^2 - 1 \end{pmatrix}$$

3.2.4.2. Quaternion to Euler

Here is the quaternion translated into Euler angles.

$$\varphi = \tan^{-1}\left(\frac{2q_2q_3 + 2q_0q_1}{2q_0^2 + 2q_3^2 - 1}\right)$$
$$\theta = -\sin^{-1}(\, 2q_1q_3 - 2q_0q_2)$$
$$\psi = \tan^{-1}\left(\frac{2q_1q_2 + 2q_0q_3}{2q_0^2 + \ 2q_1^2 - 1}\right)$$

3.2.4.3. DCM To Euler

Finally the DCM matrix is converted into Euler Angles.

$$\varphi = \tan^{-1}\left(\frac{DCM_{32}}{DCM_{33}}\right)$$
$$\theta = -\sin^{-1}(\, DCM_{31})$$
$$\psi = \tan^{-1}\left(\frac{DCM_{21}}{DCM_{11}}\right)$$

4. Configure your IG-30

The IG-30 is a widely configurable device. Everything has been done to improve user experience: most of the default configuration should be suitable to all users, but advanced users who desire to tune the IG-30 can do this very deeply. All configurable settings can be saved in the non-volatile memory or not. Thanks to this mechanism, the user can configure his device permanently or temporary depending on his needs.

Indeed, all settings stored in volatile memory will be erased when the device is turned off.

4.1. Protocol configuration

4.1.1. Protocol mode

The protocol mode option defines the baud rate of the serial line. User can select one of those speeds.

`[9600; 19200; 38400; 57600; 115200; 230400]`

Default configuration is 115200 bps.

4.1.2. Output mode

The output mode contains in fact two configurations:

- Endianness of transmitted data that can be little or big-endian to fit user platform requirements. X86 platforms use little-endian. Some other architectures such as Power PC use big-endian.
- Format for real numbers that can be either standard float IEEE 754, or 32 bits signed fixed point numbers in [12:20] format (1 sign bit, 11 integer part bits and 20 fractional part bits).

The default configuration for output mode is big-endian, and float.

4.1.3. User ID

Each device can be configured with a user ID. This ID can help user to identify sensors if many sensors are connected to the same computer. Default configuration is 0.

4.1.4. User Buffer

As a complement of the User ID, the IG-30 is shipped with a 640 bytes buffer reserved for user convenience. This buffer can be written read, and saved to non volatile memory. It is possible to write a single byte or up to 500 bytes with only one protocol operation.

4.1.5. Default output mask

The IG-30 protocol allows polling all the output information (sensors data, orientation for example) in one frame. The default output mask is used to configure which information is included in the default output frame.

By default, the default output mask contains a standard set of data:

- Time since reset in ms
- Orientation quaternion, Euler angles
- Accelerometers and magnetometers calibrated data, and temperature.

4.1.6. Normal / Continuous modes

The normal mode is a classical Question / Answer mode. Each question of the user is acknowledged or answered by the device. This also means that user has to spend some time to ask his questions.

The continuous mode requires less processing power and can output data more regularly. In continuous mode, the device sends at a fixed frequency the default output frame. The device expects no answer from the user. User has just to manage all the data that come through the serial port.

When the continuous mode is active, the user can select a frequency divider to choose the frequency of the continuous frame. The output frequency is defined as follows:

$$F_{Data\,output} = \frac{F_{Filter}}{divider}$$

By default, the continuous mode is enabled with the divider set at 2. The output frequency is then 50Hz.

Note: *The normal mode is still functional while continuous mode is enabled.*

Note 2: *When continuous mode is enabled, some continuous frames can be skipped if the user is asking some other questions and the device's answer is too big for the serial buffer. Normal mode has always priority to the continuous mode. Once the serial buffer is not saturated anymore, the continuous frames will be sent again.*

4.2. Sensors configuration

The IG-30 includes several options that allow user to tweak sensors parameters. These settings can be useful, for example, to reduce errors in vibrating environments.

4.2.1. Internal low pass cut-off frequencies

Setting the cut-off frequency of the internal low pass filters may help to limit the influence of vibrations on the device.

Inertial sensors and magnetometers are filtered by an internal low pass filter. The filter cut-off frequency is configurable. If user needs better accuracy, the cut-off frequencies can be set as low as 0.1 Hz. By setting the cut-off frequency of the filter to the sampling frequency, the internal low pass filter is simply disabled.

Default configuration is:

- 1 Hz for accelerometers,
- 1 Hz for magnetometers.

Note: *Using very low cut-off frequencies will increase precision of attitude estimation.*

Note 2: *Setting low pass cut-off frequencies could be useful to increase IG-30 vibration immunity but the device still need to be mechanically isolated from a vibrating part as much as possible.*

4.3. Internal computation loop configuration

The internal processing is also deeply configurable. This allows advanced users to enhance the behaviors of the device in some particular situations.

4.3.1. Filter frequency

The internal filter frequency is configurable from 20 Hz to 200 Hz. When the device is configured to compute an attitude, the filter frequency is always below 75 Hz. If you would like to output sensors data faster than 75 Hz, you have to disable the attitude computation.

Default configuration is 75 Hz.

4.3.2. Advanced options

4.3.2.1. Enable attitude computation

When you are only interested in calibrated or raw sensors values, it's possible to disable the attitude computation. Disabling the orientation computation allows the device to output sensors data at higher update rates.

4.3.2.2. Select heading source

Sometimes, the environment is so magnetically disturbed that magnetometers readings are not related to heading anymore. They cannot be used as a reference for heading. In this case, magnetometers could be ignored.

Three options are provided for now:

- No source, the magnetometers are simply disabled. The heading is initialized to 0 at startup. Only roll and pitch will stay valid.
- Magnetometers. The standard heading source, here, the magnetometers are used as heading source.
- GPS heading: This option may be useful in car motion analysis, as generally the cars do not slip. And they are turned in the direction of motion.

4.3.2.3. Setting the local magnetic declination

It is possible to set the local magnetic declination for the magnetometers. An automatic mode takes into account the current time and GPS position data to evaluate the local magnetic declination. It is also possible to set manually the current declination.

This declination does not affect magnetometers calibrated values, but only the orientation output.

By default the declination is set to 0°.

4.4. Navigation options and features

With the addition of two other sensors (barometer and GPS), the IG-30G have some other settings that allow you to adapt the system as much as possible to your needs.

4.4.1. Setting the reference pressure for ground level

A barometric altimeter gives only a poor accuracy if we do not take into account a reference pressure at ground level. Weather changes can sometimes introduce an error bigger than the altitude of the sensor, especially when the sensor is placed near the ground.

This is why we allow user to configure the pressure at ground. Two possibilities are offered: Use the current pressure as the ground pressure (to set during the initialization of the device for example), or set a specific pressure (therefore, the ground pressure can be updated during the flight of a small UAV for example).

4.4.2. GPS management

4.4.2.1. Setting the dynamic platform model

The GPS receiver has a built in filter which is able to get a very good precision by taking into account some dynamic constraints: The pedestrian mode will not accept huge accelerations and speeds; in the opposite, the airborne mode will not accept a 2D Fix as valid and will accept larger accelerations. Different models offered are:

Platform	Description
Stationary	Timing applications (antenna must be stationary) or other stationary applications • Velocity is constrained to 0 m/s zero dynamics) • No process noise (assuming
Pedestrian (Default)	Applications with low accelerations and low speed, as any portable devices carried and moved by manpower. • Assuming low accelerations
Automotive	Used for applications that can be compared with the dynamics of a passenger car. • Assuming low vertical acceleration • Assuming low process noise
At Sea	Recommended for applications at sea, with zero vertical velocity. • Assuming zero vertical velocity • Assuming low process noise
Airborne < 1g	Used for applications those have to handle a higher dynamic range than a car and higher vertical accelerations. • Assuming intermediate process noise • No 2D position fixes supported
Airborne < 2g	Recommended for a typical airplane environment • Assuming high process noise • No 2D position fixes supported
Airborne < 4g	Only recommended for an extreme dynamic environment. • Assuming high process noise • No 2D position fixes supported

4.4.2.2. Configure GPS use

SBAS management

The GPS receiver also offers the possibility to include differential correction data with the use of SBAS (Satellite Based Augmentation System; WAAS in USA, or EGNOS in Europe, etc). This system improves the quality of the positioning by removing most of the error due to the ionosphere. These corrections are sent by geostationary satellites, which cover, each one, a part of the globe. If differential correction data is available, the DGPS flag will be set in the advanced GPS data output. The SBAS system offers also the possibility to have an additional GPS satellite (SBAS Ranging).

Finally it offers integrity information that may help to ignore satellites that have failures. This feature is always activated.

Options that are configurable are the SBAS ranging, and the SBAS differential corrections. Both are enabled by default.

Altitude reference

It is possible to choose between two different altitude references: Mean Sea Level or Ellipsoid. The altitude above ellipsoid is the most accurate output, but it can be convenient to have directly an altitude above mean sea level.

Default value is: Altitude Above Ellipsoid.

4.5. Coordinate frames transformation

Two types of coordinate transformations are proposed: “Pre” and “Post” rotations. These two types can be combined together, which give to the IG-30 a great flexibility.

4.5.1. Pre Rotations

Sometimes, it is hard to align the device local axes with the object on which it installed. IG-30 devices have an easy way to manage these kinds of problems. Those three functions allow user to realign the local coordinate frame with the object axes.

We call that kind of transformations “pre rotations” as it is applied on sensors input. Once this transformation is set, all sensors calibrated data and orientation output will be expressed with respect of the new coordinate frame.

> ***Note:*** *Calibrated sensors are affected by pre-rotations, as well as orientation output. Raw sensor output, altitude and GPS data will remain unchanged.*

4.5.1.1. Z Reset

This procedure can be called when the device's X axis is not aligned to the object X axis.

To perform this calibration procedure, align the object in direction of the magnetic north and call the function. Once performed, the device will express its values in the object coordinate frame.

4.5.1.2. XY Reset

In that kind of reset, we assume that the device is strapped on the object pointing to the same heading (X axis of the device is in the XZ plane of the object). The object must be set horizontal while calling this function. After reset, the device's sensors data will be realigned in the object coordinate system.

4.5.1.3. XYZ Reset

This function can be used if the device is strapped in a fully arbitrary orientation on the object. The object must be first precisely aligned with the magnetic north and set horizontal for this procedure to be well executed.

4.5.1.4. Manual transformation

Reset functions are easy to execute, but have some limits: It is not always possible to level properly the object, or align it with the magnetic north.

With the manual procedure, user can set a rotation matrix to perform the transformation. This is the best method to keep the full precision of the device.

> ***Note:*** *Results of Z and XYZ resets in pre-rotations are only valid when magnetometers source of heading is selected.*

4.5.2. Post Rotations

So called "post rotations" are transformations that are applied on the orientation output. These transformations allow user to rotate the output coordinate frame.

These post rotations only affect orientation output. Sensors data will stay in the device local coordinate frame.

4.5.2.1. Z Reset

It may be useful that the *Z* axis stays along vertical, while the *X* axis points to a specific direction (for example *X* axis pointing to the screen of a computer). A *Z* reset in post rotation is designed for that purpose. This reset function will set the device's heading to 0.

4.5.2.2. XY Reset

It could be useful to realign the output coordinate to a local horizontal which is different from the real horizontal, while keeping the real north information. If your desk is not perfectly horizontal for example, you can use the post reset *XY* function to realign the output horizontal with your desk.

4.5.2.3. XYZ Reset

When this function is called, orientation is reset to a zero in all angles: roll pitch and yaw, whatever is your orientation. If the screen on which you want to display the IG-30 orientation is not vertical but is fixed on the ceiling or the ground for example, you can simply point the device to the screen, and its orientation will be referenced with respect to the screen.

4.5.2.4. Manual transformation

As for "pre" rotations, a manual transformation of the output is possible, by setting the rotation matrix that may be applied on output.

Note: *When the magnetometers source of heading is not selected, a Z reset will act as a reset of the IG-30, and the* XYZ *and* XY *resets will have the same results.*

4.6. Calibration procedures

4.6.1. Magnetometers calibration

As explained in the Magnetometers section, a calibration procedure may have to be performed when the device is placed near ferromagnetic objects.

Once the calibration is performed, user can save its results to the non-volatile flash memory or into the volatile memory. Using the second option, the user can check if his new magnetometers calibration delivers better results than the current one stored in flash memory without erasing it.

It's also possible to restore default factory magnetometers calibration.

Note: *The whole procedure is described in the Magnetometers Calibration Tools documentation.*

5. Electrical and mechanical specifications

5.1. Absolute maximum ratings

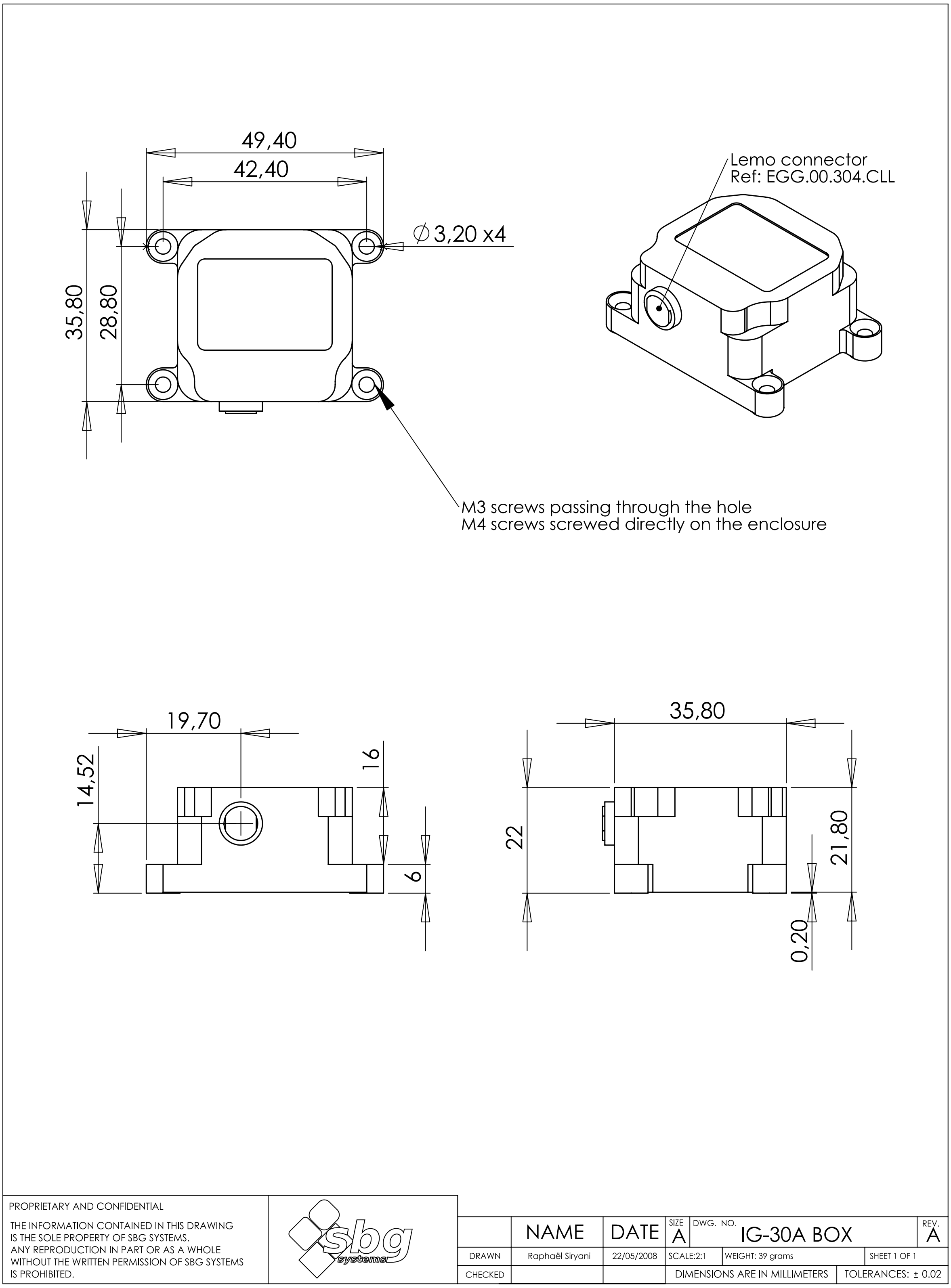
Stresses above those listed under the Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to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

Parameter	Rating
VDD - GND	-0.3 V to 30V
Acceleration (powered)	+ 1 000 *g* for 0.3s
Acceleration (unpowered)	+ 2 000 *g* for 0.3s
I_{Vreg} (OEM)	10 mA
Rx pin input voltage (OEM)	-0.3V to 4.0V
Rx pin input voltage (Box)	±25V
Operating temperature range	-40 to 85°C
Storage temperature range	-40 to 85°C

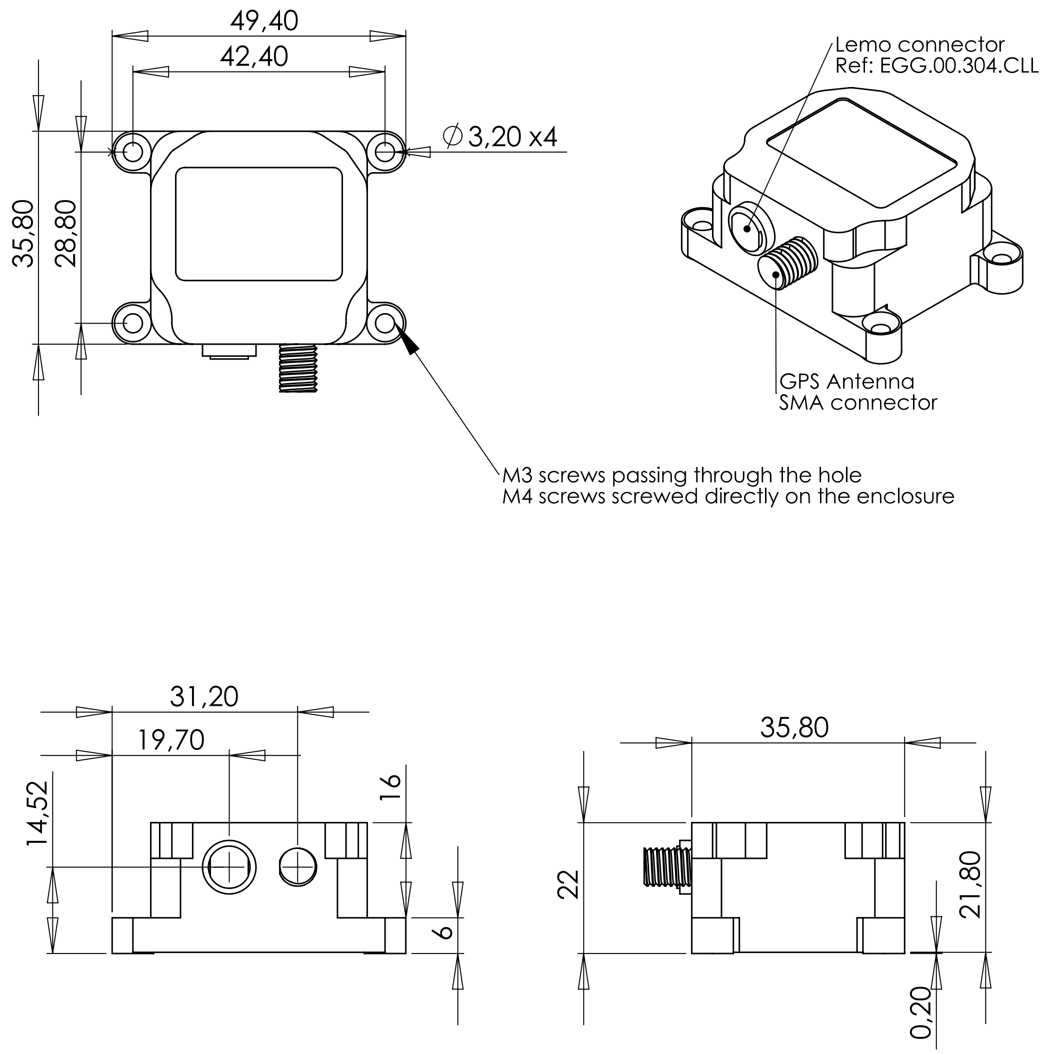
Table 2 : Absolute maximum ratings

5.2. *Box version specifications*

5.2.1. Mechanical outline for IG-30A



5.2.2. Mechanical outline for IG-30G



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	NAME	DATE	SIZE A	DWG. NO. IG-30G BOX		REV. A
DRAWN	Raphaël Siryani	22/05/2008	SCALE:2:1	WEIGHT: 45 grams	SHEET 1 OF 1	
CHECKED			DIMENSIONS ARE IN MILLIMETERS		TOLERANCES: ± 0.02	

5.2.3. Box device connectors

5.2.3.1. Main connector

The main connector is a Lemo receptacle which mates with a four wire Lemo connector, ref `FGG.00.304.CLAD35`. Other suppliers such as ODU provide compatible connectors (ref `S1L0C-P04MCC0-3500`).

Figure 11: Lemo/ODU Connector

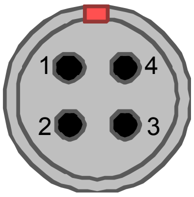


Figure 12: Pin numbering connector back face. (Solder face)

Pin	Name	Description	Type
1	RX	Serial input	INPUT
2	TX	Serial output	OUTPUT
3	GND	Ground	SUPPLY
4	VDD	Supply voltage [3.3V -> 12V]	SUPPLY

Table 3 : Device pin-out for Box version

5.2.3.2. GPS Connector

GPS connector is a standard SMA connector. An active antenna has to be plugged in it.

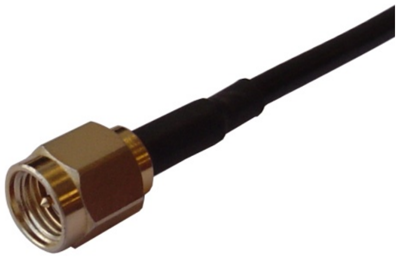
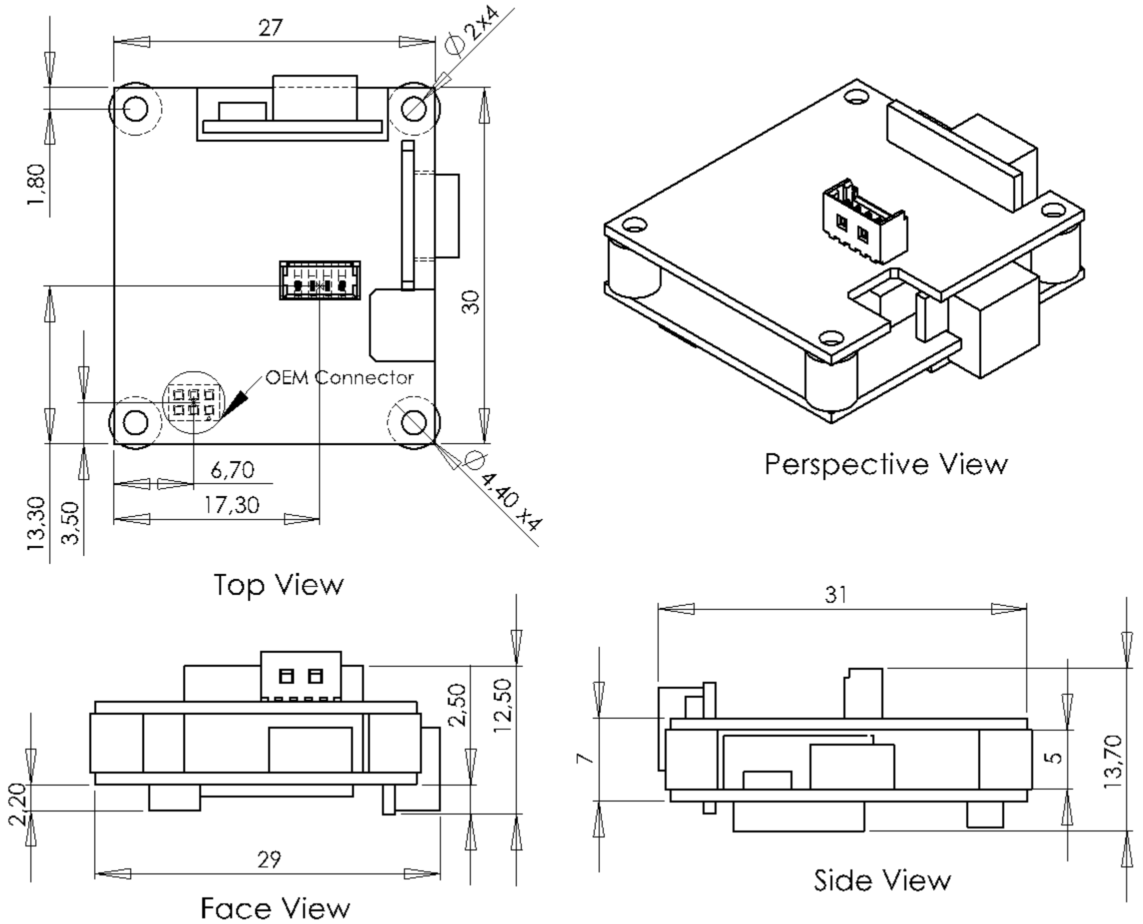


Figure 13: SMA connector

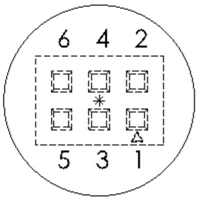
Note: *For best performance, antenna should be connected to the IG-30G at the power-up of the device, as the GPS estimates the noise floor of the antenna at startup.*

5.3. *OEM version specifications*

5.3.1. Device footprint for IG-30A



OEM Connector
1.27 mm Pitch
Top Viewed



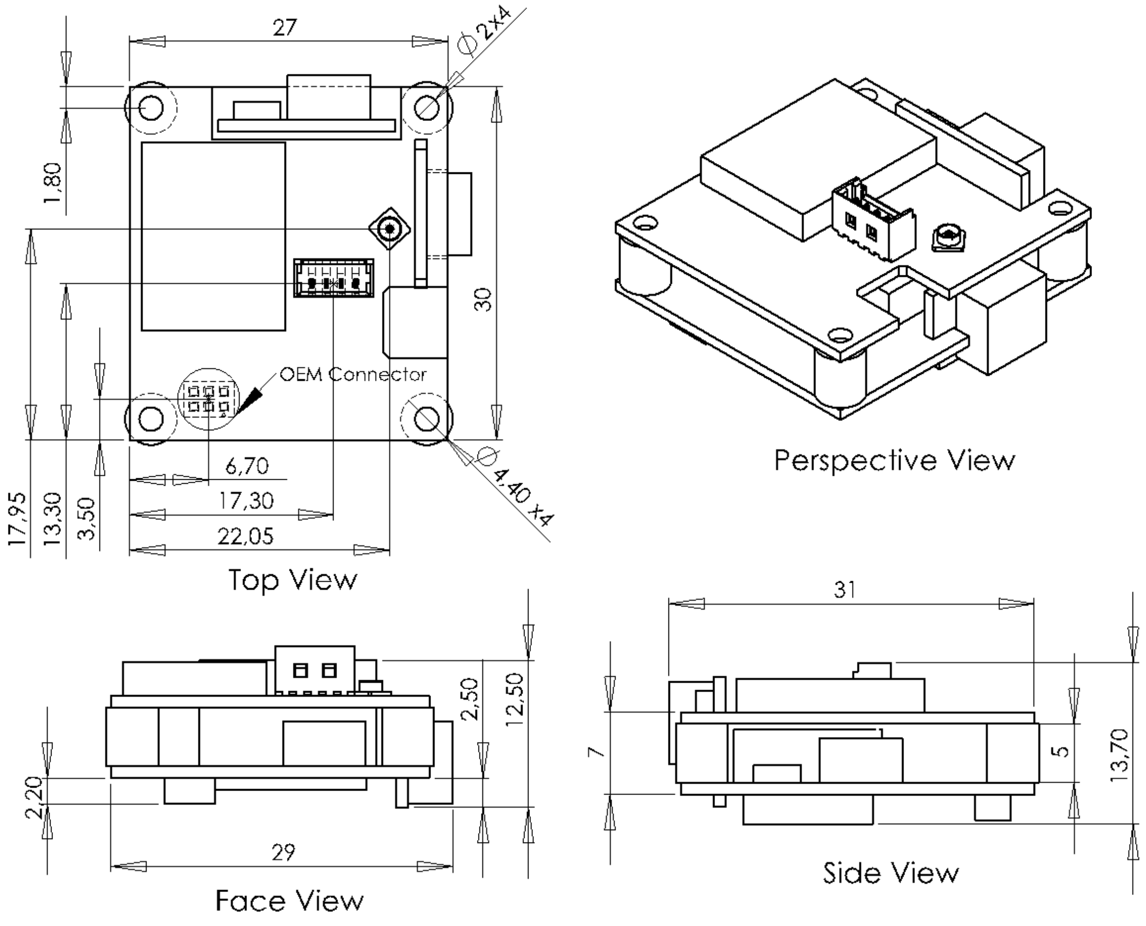
Vendor: E-Tec
Ref: BS2-006-TB22

OEM Connector	
Pin	Function
1	VDD
2	GND
3	EN
4	VREG
5	TX
6	RX

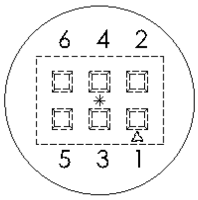
Warning: You must leave at least 4.5 mm free between the top board and other parts
You must leave at least 3.0 mm free between the bottom board and other parts.

	NAME	DATE	SIZE A	DWG. NO. IG-500A OEM	REV. B
DRAWN	Raphaël Siryani	01/10/2009	SCALE 2:1	WEIGHT: 9 grams	SHEET 1 OF 1
CHECKED				ALL DIMENSIONS ARE IN MILLIMETERS	

5.3.2. Device footprint for IG-30G



OEM Connector
1.27 mm Pitch
Top Viewed



Vendor: E-Tec
Ref: BS2-006-TB22

OEM Connector	
Pin	Function
1	VDD
2	GND
3	EN
4	VREG
5	TX
6	RX

Warning: You must leave at least 4.5 mm free between the top board and other parts
You must leave at least 3.0 mm free between the bottom board and other parts.

	NAME	DATE	SIZE A	DWG. NO. IG-500N OEM	REV. B
DRAWN	Raphaël Siryani	01/10/2009	SCALE: 2:1	WEIGHT: 0 grams	SHEET 1 OF 1
CHECKED			ALL DIMENSIONS ARE IN MILLIMETERS		

5.3.3. OEM device connectors

5.3.3.1. OEM Board to Board connector

OEM integration of the IG-30 is made easy by the the OEM Board to Board Connector. It is used to power the device and communication in serial TTL format. The connector is a 2*3 ways 1.27mm pitch from ACCA, ref `BA03N-6SV2-1GT(23)` which is compatible with Samtec `CLP-103-02-G-D`.This connector mates with ACCA `BA03N-6PV2-1GT(19)` (or Samtec `FTS-103-03-L-DV`).

Pin	Name	Description	Type
1	VDD	Supply voltage [3.3V -> 12V]	SUPPLY
2	GND	Ground	SUPPLY
3	RES	Reserved. Do not Connect	–
4	VREG	3.3 V internal regulator output.	OUTPUT
5	TX	Serial output; 3.3V TTL format.	OUTPUT
6	RX	Serial input ; 3.3V TTL format	INPUT

Table 4 : OEM connector Pinout

Note 1: *VREG can be used to achieve a 3.3V to 5V signal conversion with a MAX3378E for example.*

Warning: *Pins 5 and 6 can only be used with the 3.3V TTL serial format. Please order a TTL version of the device if you wish to use this connector.*
For RS-232 devices, pins 5 and 6 cannot be used and you should use the OEM Board connector as described in section 5.3.3.3

5.3.3.2. GPS connector

GPS connector in OEM version is a UFL connector. The active antenna can be directly plugged into this UFL connector, or can be connected to a SMA to UFL cable.

Figure 14: U.F.L connector

5.3.3.3. OEM Board to Wire connector

To connect the IG-30 OEM version to your application, you can also use the OEM board to wire if you are using a boxed version (RS-232) without its enclosure, you should use the OEM Board to Wire connector located on the top of the device.

This connector mates with a 4 ways with a 1.25mm pitch; Female, Molex connector, reference `51021-0400`. This connector uses the crimp terminal Molex ref `50058` or `50079`.

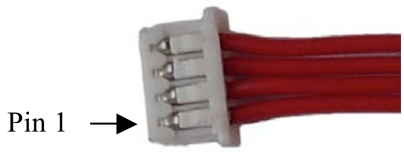


Figure 15: OEM Board connector

Pin	Name	Description	Type
1	**RX**	Serial input; 3.3V TTL or RS-232 format.	INPUT
2	**TX**	Serial output; 3.3V TTL or RS-232 format.	OUTPUT
3	**VDD**	Supply voltage [3.3V -> 12V]	SUPPLY
4	**GND**	Ground	SUPPLY

Table 5 : OEM Board connector Pinout

***Warning**: Please check your device's product code to define if pins 1 and 2 are using 3.3V TTL signals or standard RS-232 format. For OEM version, the default product code is `IG-500A-G4A2P2-O` that means 3.3V TTL format. If your device has a product code with `P1` instead of `P2`, pins 1 and 2 are using RS-232 signals, the default option for boxed versions.*

5.4. UsbToUart interface

The UsbToUart interface that is shipped has those characteristics:

- 64x42x20 mm box
- 3 meters long cable
- USB 1.1 or higher compatible
- Communication speed allowed up to 921 600 bps

Figure 16: UsbToUart interface

5.4.1. Cable provided

A 3 meters long cable is part of the UsbToUart interface. The ODU/Lemo connector is linked to a 4 wire Molex connector (ref 51021-0400) which mates with Molex 53047-0410 or Molex 53261-0471.

The connections on the molex connector are described in the table below:

Pin	Connection	Color (Old cable)	Color (New cable)
1	GND	**Black**	**Black**
2	IG-500 Tx	**Green**	**Yellow**
3	IG-500 Rx	**Blue**	**Red**
4	VCC	**Red**	**Pink**

Table 6 : Uart cable pinout

5.5. GPS antenna electrical and mechanical specifications

As any patch antenna, the performance of the GPS active antenna provided with this SDK is significantly improved when the antenna is placed on a ground plane. The ground plane does not have to be physically connected to the antenna.

Parameter	Specification
LNA Gain	28 dB
Noise	0.8 dB
VSWR	1.5:1 max (at connector)
Power consumption	7.5mA at 3.3 V
Gain	3.0 dB (without ground plane) 5.5 dB (with 10 cm² ground plane)
Cable length	3 meters
Connector	SMA
Size	45 x 51 x 12 mm
Weight	120 grams
Operating temp.	-40°C to +80°C

Table 7: GPS active antenna specifications

Figure 17: The provided GPS antenna

6. Limitations and advises for optimal operation

6.1. Environmental considerations

The normal condition for operating the IG-30 is between -40 and 85°C, in a dry and non condensing environment. If the device is operated beyond absolute maximum ratings, expressed in Table 2 : Absolute maximum ratings, the device may be damaged.

Temperature variations cannot be modeled in the sensor calibration. This is why for optimal results the temperature during measurements should be as much stable as possible. Moreover, a 10 minutes warm-up should be allowed to the IG-30 in order to get optimal results.

The IG-30 should be protected from humidity and dust, as it can damage the internal hardware.

The IG-30 should be protected from drops onto hard surfaces and violent handling.

6.1.1. Accelerations

6.1.1.1. Vibrations

As a rule of thumb, the IG-30 must be mechanically isolated as much as possible from any vibrations to get the best performance. Vibrations generate accelerations that are measured by accelerometers. The IG-30 is quite configurable, so by tweaking sensors sampling frequency and low-pass filters cut-off frequencies, it is generally possible to avoid some vibrations problems.

However, in some cases, a better mechanical isolation is needed to get the full performance of the device:

- High amplitude vibrations can saturate accelerometers. This may generate a bias in acceleration reading, and therefore an error in attitude estimate.
- High frequency vibrations can generate aliasing noise in accelerometers measurements. This can be seen as a low oscillation of accelerometers readings. Sometimes, a tweak of the sampling frequency can reduce this effect.

6.1.2. Magnetic fields

Ferromagnetic materials or magnets that are placed in the vicinity of the device can generate error in the magnetometers readings by distorting the magnetic field. High current power supplies or the associated wires may also generate magnetic fields.

The IG-30 should be placed as far as possible to ferromagnetic materials, particularly those who can be moved independently with respect to the IG-30. In practice placing the device 1 meter away from moving ferromagnetic materials is enough to avoid generating error.

In most cases, a calibration procedure can be performed to map the magnetic distortions and therefore get the full performance of the unit. The IG-30 can compensate both Hard and Soft iron interferences.

> ***Note 1:*** *See Iron Calibration Tools documentation for more information about the magnetometers calibration procedure.*

> ***Note 3:*** *As any magnetometer or compass based system, the heading provided by the device will not be valid at north or south poles.*

6.2. Power supply

The power supply of the IG-30 has been designed to isolate as much as possible sensors from power supply noise. However keep in mind that a noisy power supply can decrease sensors performance. For best performance, power supply should be isolated from high frequency by inductors or ferrite beads and from low frequency by a regulator.

6.3. GPS Antenna placement

The GPS antenna that is shipped with IG-30G is a standard patch antenna. Here are some considerations that should be taken into account:

- Antenna should have a large view of the sky.
- Avoid placing the antenna near a vertical metallic plane, which could reflect GPS signals and cause error in positioning.
- Placing the antenna on a horizontal metallic surface is a good thing, as the metal acts as an extension of the antenna ground plane.
- Avoid the direct radiation from transmitting antennas (such as GSM antenna, RF transceivers).
- Keep in mind that the position returned by the device is not the position of the IG-30G, but the position of the antenna.

7. Warranty and Support

7.1. Support information

Our goal is to provide the best experience to our customers. If you have any question, comment or problem with the use of your IG-30, we would be glad to help you, so please feel free to contact us. Please do not forget to mention your Device ID of your IG-30 (written on your IG-30's label).

You can contact us by:

- Email : support@sbg-systems.com
- Phone : +33 (0)1 80 88 45 00

7.2. Warranty

All products shipped by SBG Systems are provided with a 1 (ONE) year warranty, from date of shipment.

7.2.1. Return procedure

Before returning any product, please contact the support team. There is maybe no need to return the product.

In case of return, please mention the following information:

- Name,
- address,
- phone number,
- Installation date,
- Description of the failure,
- Date of the failure

Please make sure there is adequate packing around all sides of the equipment.

7.2.2. Return address

Use the following address for all product returns.

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

Appendix A. CE Declaration of conformity

The company,

SBG Systems SAS
3bis, chemin de la Jonchère
92500 Rueil-Malmaison
FRANCE

Hereby certifies on its sole responsibility that the products listed below:

IG-30A-A1P1-B , IG-30A-A2P1-B, IG-30A-A3P1-B, IG-30A-A1P2-B, IG-30A-A2P2-B, IG-30A-A3P2-B, IG-30G-A1P1-B , IG-30G-A2P1-B, IG-30G-A3P1-B, IG-30G-A1P2-B, IG-30G-A2P2-B, IG-30G-A3P2-B

Comply with the requirements of the following European Directives:

EMC Directive: 89/336/EEC
EN 301489-19 V1.2.1, 2002
EN 301489-1 V1.6.1, 2005
EN 61000-4-2
EN 61000-4-3

Environment to be used is light industrial / laboratory.

Class of emission is B.

The results are summarized in the Electromagnetic Compatibility Test Report #: RC-030-M42-08-103910-1.

November, the 10th 2008, Rueil-Malmaison, FRANCE

Alexis GUINAMARD
Chief Technology Officer
SBG Systems SAS

Appendix B. Older products specifications

Since October 2009, the IG-30 devices hardware has been updated. This update provides performance improvements, while maintaining as much as possible backward compatibility. Some minor differences with the new hardware are present, but migration is really straightforward.

Older devices have a device ID < 009000100 (IG-30A) or < 010000100 (IG-30G), and a main board hardware revision < 2.0.0.0.

This appendix presents the particular specifications of hardware V 1.

Specifications

Parameter	Specification		Remarks
Standard Sensors	**Accelerometers**	**Magnetometers**	
Measurement range	± 5 g	± 1.2 Gauss	Accelerometers available in 2*g* and 18*g*
Non-linearity	< 0.2% of FS	< 0.2% of FS	
Bias stability	± 2 mg	± 0.5 mGauss	Over temperature range
Noise density	0.01 g/√Hz		
Alignment error	< 0.1°	< 0.1°	
Bandwidth	0.1 to 100 Hz	0.1 to 50 Hz	User selectable
Sampling rate	100 to 2 000 Hz	100 Hz	User selectable
Physical			
Dimensions (OEM)	27x30x14 mm		
Dimensions (Box)	36x49x22 mm		
Weight (OEM)	5 grams / 8 grams		IG-30A / IG-30G
Weight (Box)	39 grams / 45 grams		IG-30A / IG-30G
Operating temperature	0° to 60°C		Non condensing environment
Storage temperature	-40° to 85°C		
Shock limit	1 000*g* (Powered), 5 000 *g* (unpowered)		Shocks may affect performance
Electrical			
Operating voltage	2.5 to 12 V		
Power consumption	165 mW @ 4.0 V 320 mW @ 4.0 V		IG-30A, optimal consumption at 4.0 V IG-30G, optimal consumption at 4.0 V
Start-up time	< 30s		For optimal attitude measurement

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.

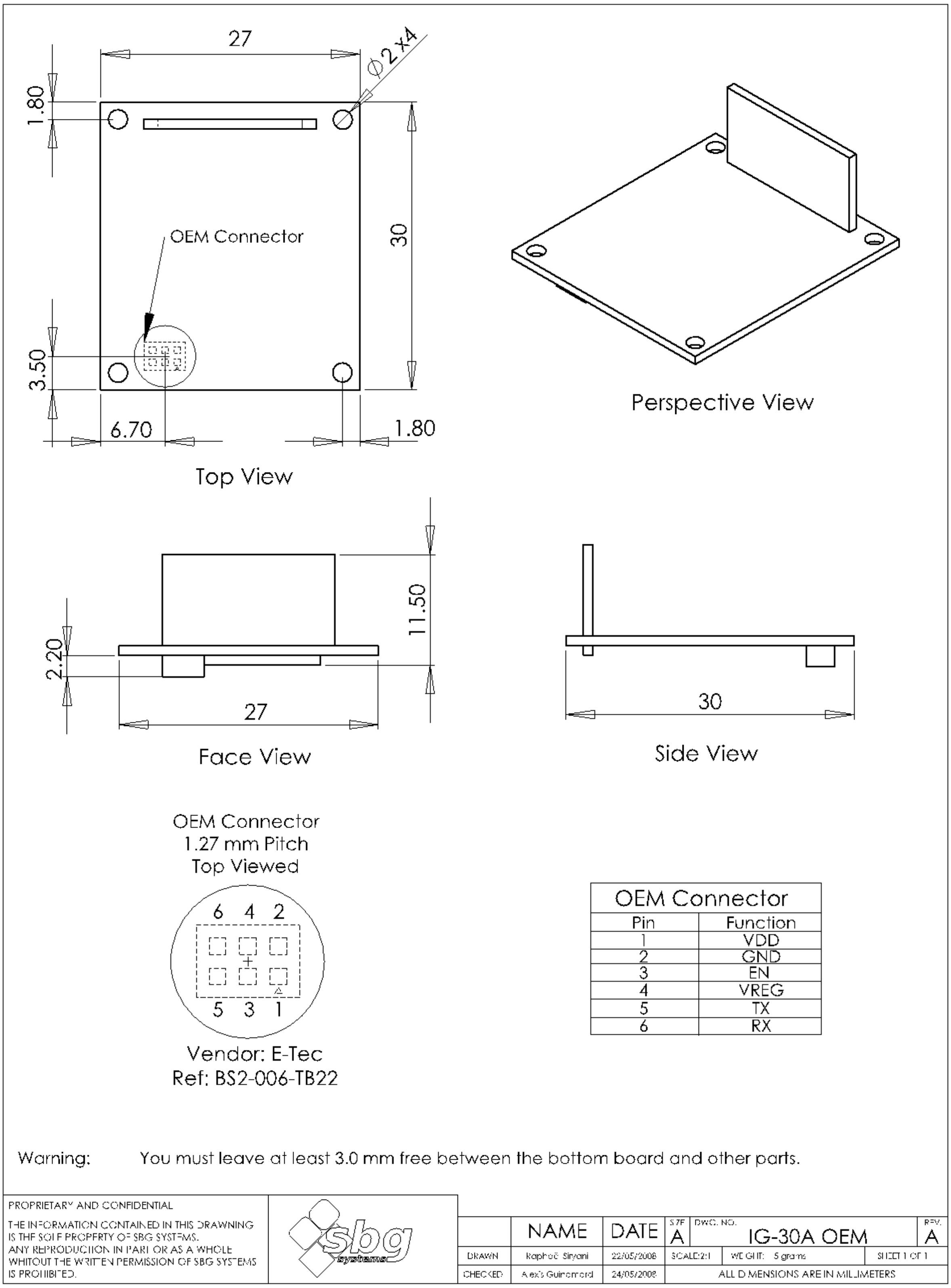
Parameter	Rating
VDD - GND	-0.3 V to 16V
Acceleration (powered)	+ 2 000 g for 0.3s
Acceleration (unpowered)	+ 5 000 g for 0.3s
I_{Vreg} (OEM)	10 mA
Rx pin input voltage (OEM)	-0.3V to 4.0V
Rx pin input voltage (Box)	±25V
Operating temperature range	-40 to 70°C
Storage temperature range	-40 to 85°C

Table 8 : Absolute maximum ratings

Device Outputs

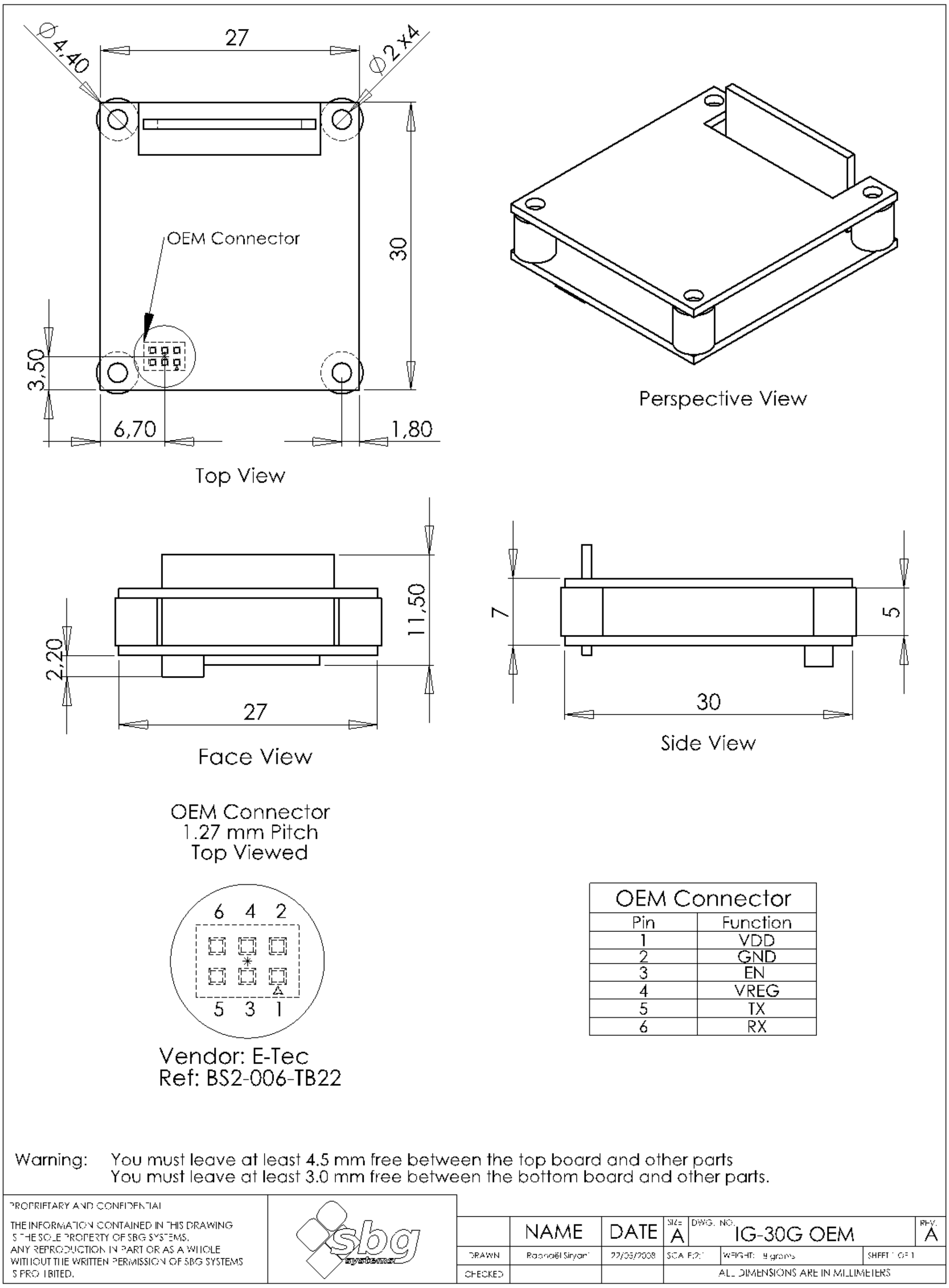
The hardware V1 does not support sensor Self test. The corresponding bits are always set to 1 (valid Self Test).

Device footprint for IG-30A



OEM Connector	
Pin	Function
1	VDD
2	GND
3	EN
4	VREG
5	TX
6	RX

Device footprint for IG-30G



OEM Connector	
Pin	Function
1	VDD
2	GND
3	EN
4	VREG
5	TX
6	RX

Warning: You must leave at least 4.5 mm free between the top board and other parts
You must leave at least 3.0 mm free between the bottom board and other parts.