IG-20: two-axis Inclinometer

Document : IG20UM.5
Revision: 5 – 27 June 2012

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Revision History

Revision	Date	Author	Information
5	27 June 2012	Alexis GUINAMARD	Renumbered connectors pins to be consistent with manufacturers Updated company address details
4	1-Dec-09	Alexis GUINAMARD	Updated specifications for newer devices Added self test specifications Added user buffer management
3	16 Feb 2009	Alexis GUINAMARD	Minor editorial updates Added CE conformity declaration
2	12 Dec. 2008	Alexis GUINAMARD	Updated fixed coordinate frame definition Removed obsolete sampling frequency configuration
1	1. Sept. 2008	Alexis GUINAMARD	First release of this document

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1. Introduction

1.1. Product description

The IG-20 is a miniature two axis inclinometer that includes a tri-axial accelerometer. Based on this MEMS sensor and using an on board processing, the IG-20 outputs an accurate 2d orientation (roll, pitch) in quasi-static conditions by tracking the earth gravity.

Thanks to an advance calibration procedure, the IG-20 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.

The IG-20 can be purchased in Box, as well as in OEM version, making it very easy to integrate in any system or application.

This product is perfect for platform stabilization or as a G-Meter.

Outputs provided by the IG-20 are:

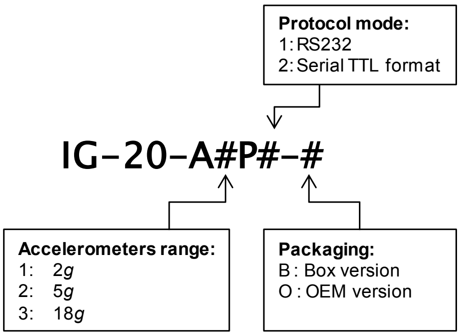
- Orientation (Euler Angles, Matrix or Quaternion),
- Sensor calibrated data (3D Acceleration, Temperatures),
- Raw sensor data.

1.2. Ordering information

Standard version is the box version, with ± 2*g* accelerometers, and RS232 communications.

Standard product codes are:

- `IG-20-A1P1-B`



1.3. Block diagram

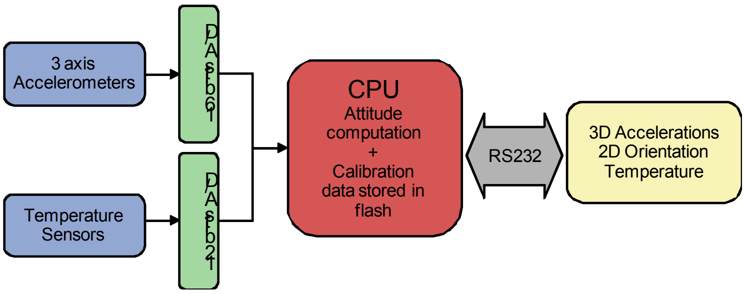


Figure 1: Simplified block diagram of the IG-20

1.3.1. Internal computations

The IG-20 measures the local gravity and computes an orientation valid in ±180° for roll and ±80° for pitch axes. The device can measure a very accurate 2d inclination, in static conditions.

1.3.2. Sensors

Accelerometers are sampled with a 16 bits sigma-delta Analog to Digital Converter. High speed sampling (1 kHz) improves the sensor immunity in vibrating environments.

1.3.2.1. Factory calibration procedure

Our products are provided with fully calibrated accelerometers. 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,
- Cross-axis and misalignment effects compensation.

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	± 180° ± 80°	Roll Pitch
Static accuracy	± 0.3° (Pitch, Roll)	
Repeatability	< 0.1°	
Resolution	< 0.05°	
Output frequency	0.01 to 200 Hz 0.01 to 75 Hz	Calibrated sensor data only Attitude output
Standard Sensors	**Accelerometers**	
Measurement range	± 2 *g*	Accelerometers available in 2*g* and 18*g*
Non-linearity	< 0.2% of FS	
Bias stability	± 2 m*g*	Over temperature range
Noise density	0.22 m*g*/√Hz	
Alignment error	< 0.1°	
Bandwidth	50 Hz	
Sampling rate	1 000 Hz	
Communication		
Output modes	Euler angles, Quaternion, Matrix, 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)	9 g	
Weight (Box)	38 g	
Operating temperature	-40° to 85°C	Non condensing environment
Storage temperature	-40° to 85°C	
Shock limit	1 000*g* (Powered), 5 000 *g* (unpowered)	Shocks may affect performance
Enclosure	Robust and high precision aluminum	
Electrical		
Operating voltage	3.3 to 30 V	
Power consumption	150 mW @ 5.0 V	Optimal power consumption at 5.0 V
Start-up time	< 30s	Optimal measurement

Table 1: IG-20 specifications

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-20 SDK has been developed to make integration of the IG-20 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-20 to a computer very comfortable.

1.4.1. Content of a development kit

Each IG-20 SDK is provided with the following elements:

- An IG-20,
- The calibration report of the device,
- A UsbToUart converter,
- A USB cable to connect the device (OEM versions),
- A quick start manual,
- A set of compatible screws to mount easily your IG-20
- A CD-Rom containing :
  - UsbToUart converter driver,
  - sbgCenter analyze software,
  - sbgUpdater software,
  - sbgCom library,
  - Example software,
  - Full documentation :
    - IG-20 User Manual,
    - Low Level Protocol Specifications,
    - sbgCom Library Reference Manual,
    - Magnetometers Calibration Tools,
    - sbgCenter User Manual.

Figure 2: The IG-20 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-20, 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-20 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!

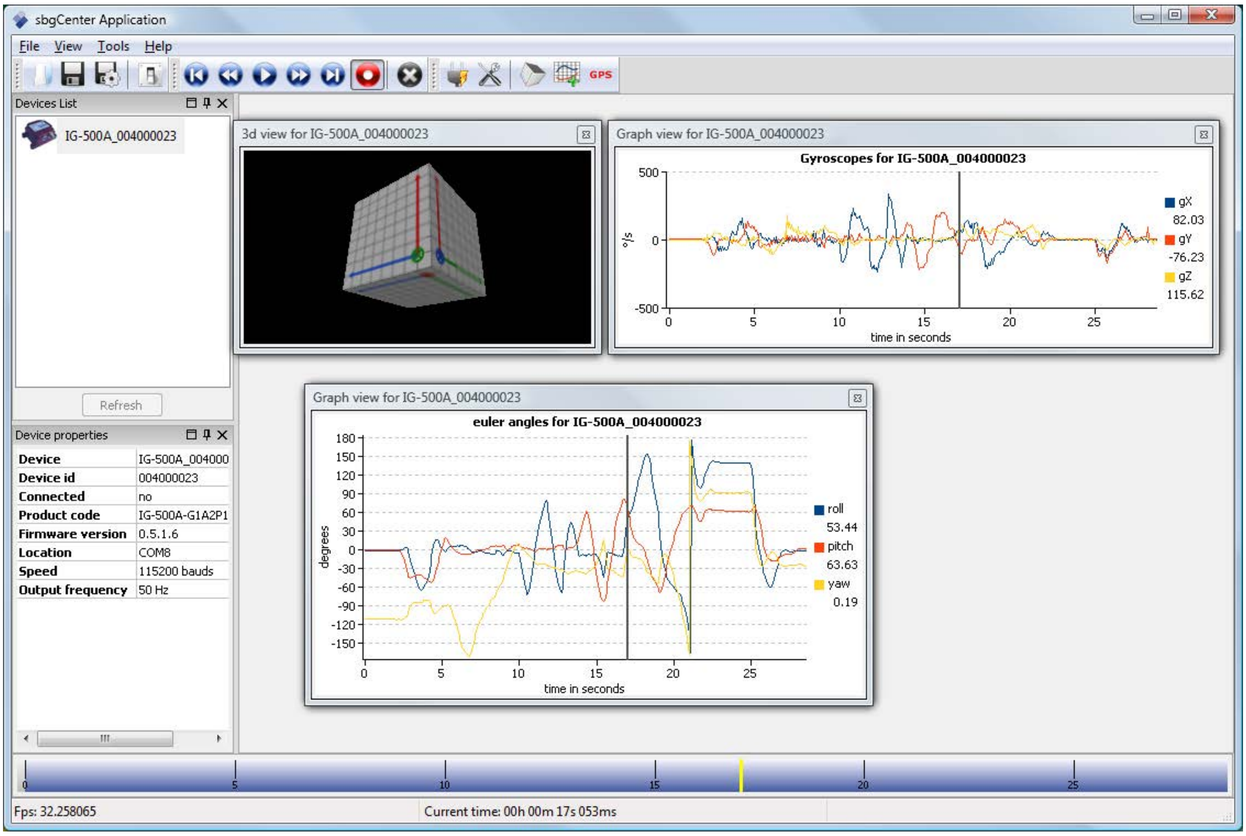


Figure 3: sbgCenter is an excellent analyze tool

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-20 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-20 SDK provides an easy access to the device with the library sbgCom. This library allows access to all the functionalities of the IG-20, 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.*

1.5.1.1. Example programs provided with sbgCom

Minimal example

This small C example is simply the smallest program you can write to use the IG-20. 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:

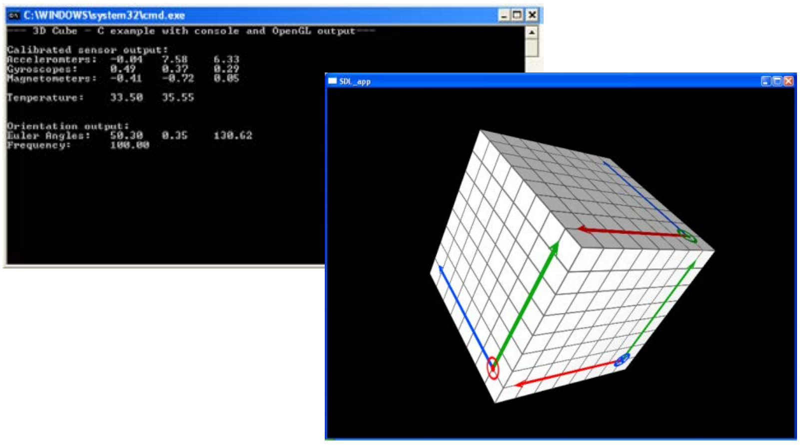


Figure 4: Overview of the 3D Cube example program

1.5.2. Low level communication with IG-20

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-20 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-20. 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-20.

1.5.3.2. Labview integration

The sbgLabView library provides the full support of the IG-20 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-20.

2. Output provided by IG-20

2.1. Sensors output

2.1.1. Calibrated sensors output

The IG-20 includes 5 calibrated sensors: 3 accelerometers and 2 temperature sensors. These 5 calibrated sensors values can be output 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, sensor misalignment)

2.1.1.1. Accelerometers values

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

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

***Note:** Accelerometers values include gravity. In order to get the delta velocities, please make sure that you have removed the gravity component of the acceleration.*

2.1.1.2. Temperature values

The temperature calibrated output is the temperature measured by the two on-board temperature sensors.

Temperature is expressed in $°C$.

2.1.2. Raw sensors output

Accelerometers and Temperatures can be outputted by the IG-20 in raw form. The raw sensor output is basically the reading of the Analog to Digital Converter. 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`.

2.1.3. Device Status

The IG-20 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.

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/Y/Z 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 – 31]	-	Reserved

2.2. Orientation output

2.2.1. 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 easy interpretation. The three parameters: Roll, Pitch and Yaw define rotations around the fixed frame's axis:

- 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:*** *On the IG-20, we recommend using Euler angles, as it is a very simple orientation representation. The yaw output is always set to 0 as the IG-20 does not have heading information.*

2.2.2. 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:

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

2.2.3. 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 a very efficient way of 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:

$$q_0 = \frac{1}{2}\sqrt{1 + \cos\theta \sin\psi + \sin\varphi \sin\theta \sin\psi + \cos\varphi \cos\psi + \cos\varphi \cos\theta}$$

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

$$q_2 = \frac{1}{4\,q_0}(\cos\varphi \sin\theta \cos\psi + \sin\varphi \sin\psi + \sin\theta)$$

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

2.2.4. Other useful conversion formulas

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

2.2.4.1. Quaternion to DCM

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

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

2.2.4.2. Quaternion to Euler

Here is the quaternion is translated into Euler angles.

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

2.2.4.3. DCM To Euler

Finally the DCM matrix is converted into Euler Angles.

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

2.3. Coordinate systems

User has to distinguish two coordinate frames when working with an inertial measurement unit, such as the IG-20. 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:

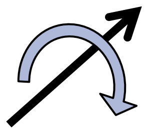


Figure 5: Positive rotations

2.3.1.1. Inertial coordinate system

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

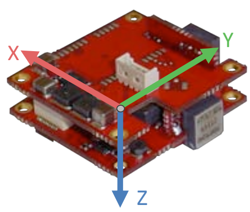


Figure 7: Inertial coordinate frame for OEM Version

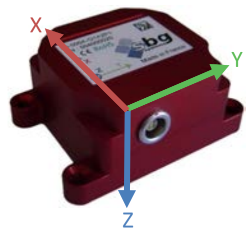


Figure 6: Inertial coordinate frame for Box Version

2.3.1.2. Fixed coordinate system

The fixed coordinate frame is defined by these three vectors:

- *Z* vector is aligned with the local gravity, turned down,
- *X* vector is coplanar to the XZ plane of the device.
- *Y* vector is chosen such as the coordinate frame is "right-handed".

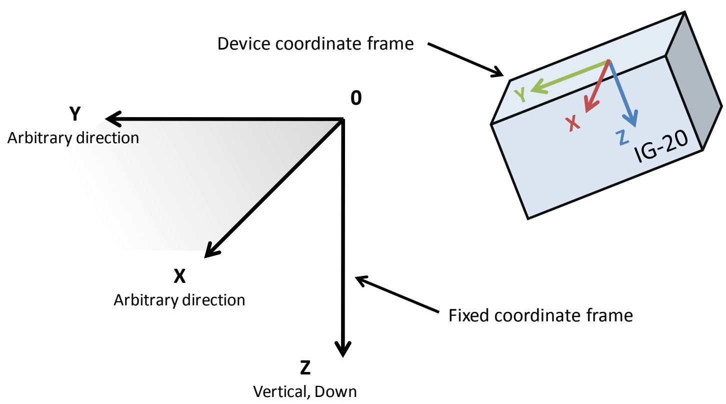


Figure 8: Representation of a sensor in the fixed coordinate system

3. Configure your IG-20

The IG-20 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-20 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.

3.1. Protocol configuration

3.1.1. 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.

3.1.2. 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.

3.1.3. 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.

3.1.4. User Buffer

As a complement of the User ID, the IG-20 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.

3.1.5. Default output mask

The IG-20 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 calibrated data, and temperature.

3.1.6. 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.*

3.2. Sensors configuration

The IG-20 includes several options that allow user to tweak sensors parameters. These settings can be useful, for example, to reduce errors in vibrating environments.

3.2.1. 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.

Accelerometers sensors 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

Note: *Using very low cut-off frequencies will increase precision of inclination computation.*

Note 2: *Setting low pass cut-off frequencies could be useful to increase IG-20 vibration immunity but the device still need to be mechanically isolated from a vibrating part as much as possible.*

3.3. *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.

3.3.1. 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.

3.3.2. Advanced options

3.3.2.1. 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.

3.4. *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-20 a great flexibility.

3.4.1. Pre Rotations

Sometimes, it is hard to align the device local axes with the object on which it installed. IG-20 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 will remain unchanged.*

3.4.1.1. 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.

3.4.1.2. XYZ Reset

For the IG-20, this procedure produces the same result as the Pre Reset XY one.

3.4.1.3. Manual transformation

Reset functions are easy to execute, but have some limits: It is not always possible to level properly the object.

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.

3.4.2. 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.

3.4.2.1. Z Reset

This procedure isn’t applicable for the IG-20 because, the device has no yaw information.

3.4.2.2. XY Reset

It could be useful to realign the output coordinate to a local horizontal which is different from the real horizontal 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.

3.4.2.3. XYZ Reset

For the IG-20, this procedure produces the same result as the Post Reset XY one.

3.4.2.4. 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.

4. Electrical and mechanical specifications

4.1. Absolute maximum ratings

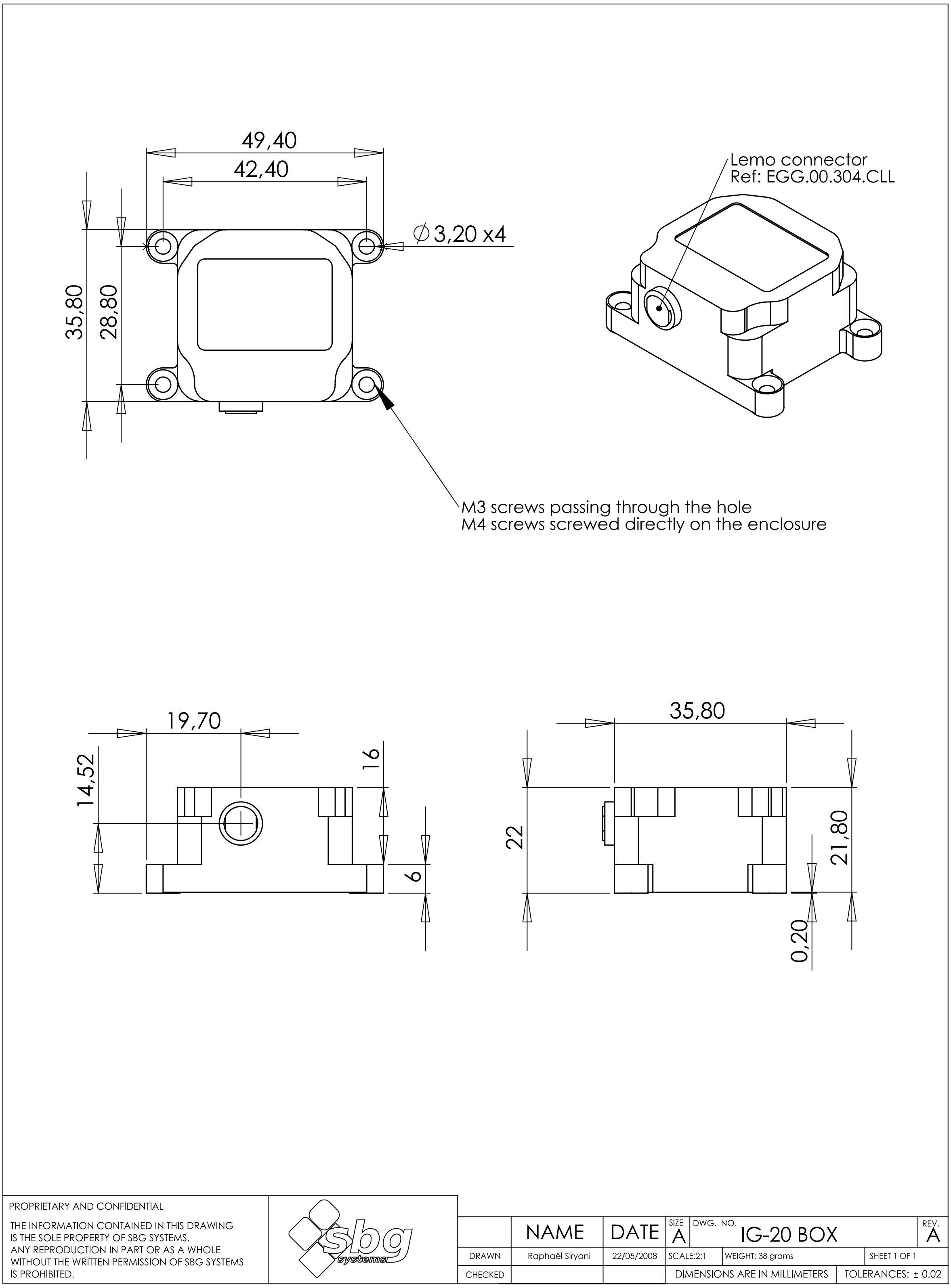
Stresses above those listed under the Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to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

Parameter	Rating
VDD - GND	-0.3 V to 30V
Acceleration (powered)	+ 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 85°C
Storage temperature range	-40 to 85°C

Table 2 : Absolute maximum ratings

4.2. Box version specifications

4.2.1. Mechanical outline for IG-20



4.2.2. Box device connectors

4.2.2.1. 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 9: Lemo/ODU Connector

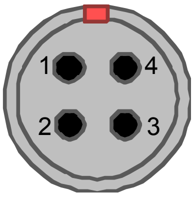


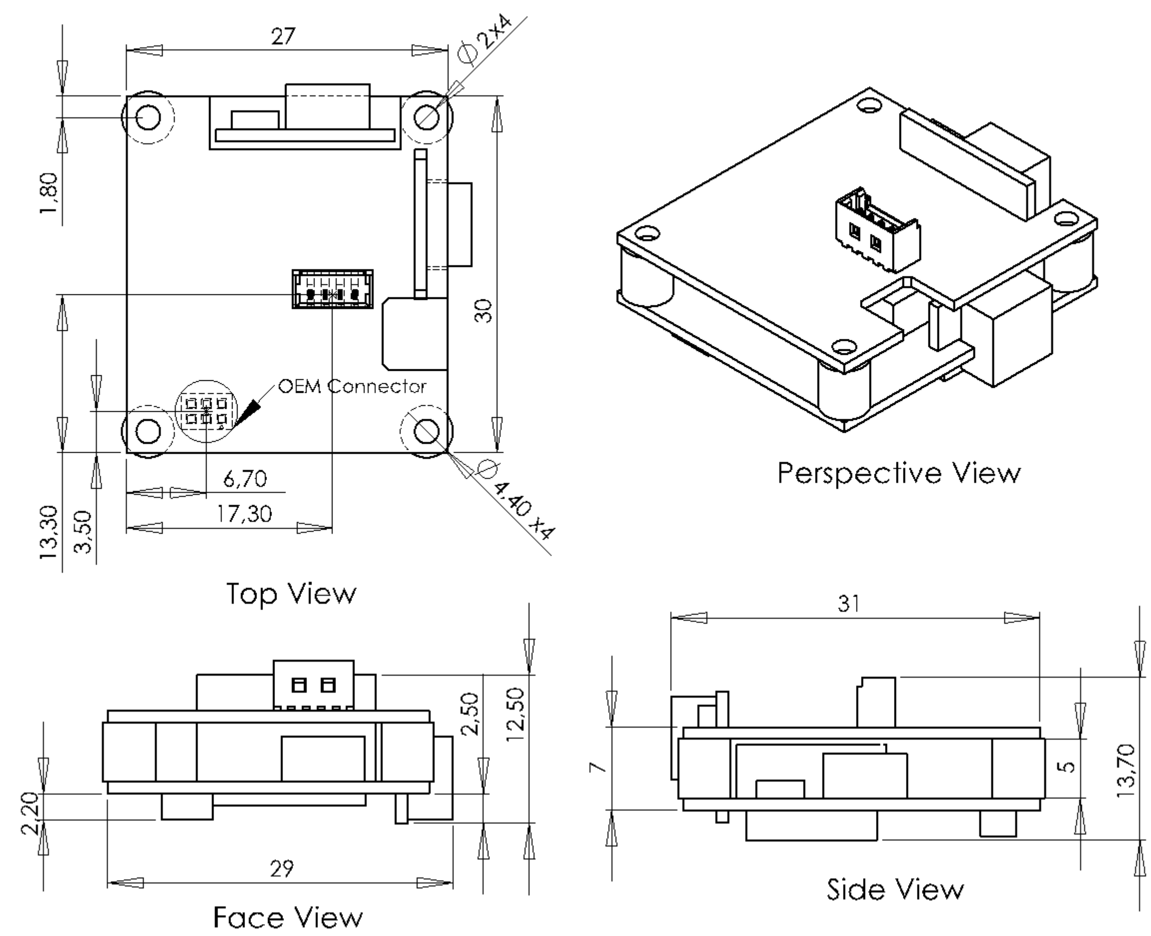
Figure 10: Pin numbering connector back face. (Solder face)

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

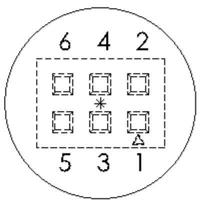
Table 3 : Device pin-out for Box version

4.3. OEM version specifications

4.3.1. Device footprint for IG-20



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			

4.3.2. OEM device connectors

4.3.2.1. OEM Board to Board connector

OEM integration of the IG-20 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 4.3.2.2

4.3.2.2. OEM Board to Wire connector

To connect the IG-20 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`.

Pin 1

Figure 11: 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.*

4.4. 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 12: UsbToUart interface

4.4.1. Cable provided

A 3 meters long cable is part of the UsbToUart interface. The Lemo/ODU 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-20 Tx	Green	Yellow
3	IG-20 Rx	Blue	Red
4	VCC	Red	Pink

Table 6 : Uart cable pinout

5. Limitations and advises for optimal operation

5.1. Environmental considerations

The normal condition for operating the IG-20 is between -40 and 85°C, in a dry and non condensing environment. If operating beyond those specifications, the accuracy may decrease. 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 2 minutes warm-up should be allowed to the IG-20 in order to get optimal results.

The IG-20 should be protected from humidity and dust, as it can damage the internal hardware.

The IG-20 should be protected from drops onto hard surfaces and violent handling.

5.2. Accelerations & Vibrations

As a rule of thumb, the IG-20 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-20 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.

5.3. Power supply

The power supply of the IG-20 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. Warranty and Support

6.1. 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-20, 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-20 (written on your IG-20's label).

You can contact us by:

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

6.2. Warranty

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

6.2.1. 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.

6.2.2. 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-20-A1P1-B , IG-20-A2P1-B, IG-20-A3P1-B, IG-20-A1P2-B, IG-20-A2P2-B, IG-20-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

AGuinamard

Alexis GUINAMARD
Chief Technology Officer
SBG Systems SAS

Appendix B. Older devices specifications

Since October 2009, the IG-20 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 < 008000100, and a main board hardware revision < 2.0.0.0.

This appendix presents the particular specifications of hardware V 1.

Coordinate frame

Below is defined the inertial coordinate frame for OEM version.

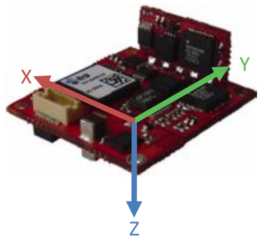


Figure 13: Inertial coordinate frame for OEM Version

Specifications

Parameter	Specification	Remarks
Standard Sensors	**Accelerometers**	
Measurement range	± 5 g	Accelerometers available in 2*g* and 18*g*
Non-linearity	< 0.2% of FS	
Bias stability	± 2 mg	Over temperature range
Noise density	0.01 g/√Hz	
Alignment error	< 0.1°	
Bandwidth	0.1 to 100 Hz	User selectable
Sampling rate	100 to 2 000 Hz	User selectable
Physical		
Dimensions (OEM)	27x30x14 mm	
Dimensions (Box)	36x49x22 mm	
Weight (OEM)	5 grams	
Weight (Box)	39 grams	
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	140 mW @ 4.0 V	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 7 : Absolute maximum ratings

Device footprint for IG-20