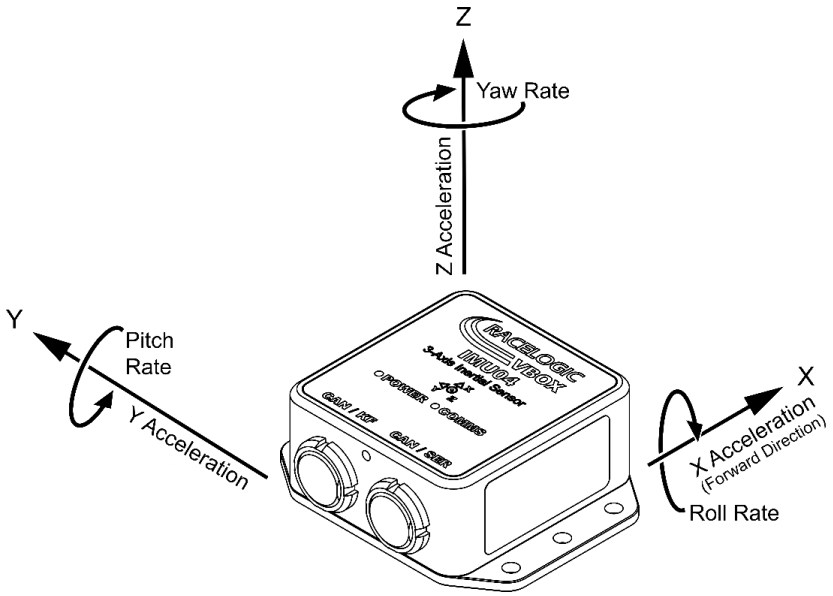
IMU04 Inertial Sensor

User Guide



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Introduction

The IMU04 from Racelogic is a full inertial measurement unit that can measure Z, Y and X axis rotational rate (yaw, pitch and roll) as well as X, Y and Z axis acceleration.

The IMU04 is constructed with a splash-proof casing which has to an IP rating of IP67, making it ideal for use on boats or in harsh environments.

Features

- YAW rate range ±450 °/s
- Acceleration range ±5 g in each axis
- YAW rate resolution 0.014°/s
- Acceleration resolution 0.15mg
- 0.1° (RMS) pitch/roll and 0.5° (RMS) yaw angle accuracy when used in conjunction with a VBOX3i
- Internal temperature compensation
- CAN Bus interface
- Integration with GNSS for consistent and accurate data in weak/degraded satellite signal conditions.
- RS-232 serial interface for firmware upgrade and setup
- 24bit internal resolution
- Splash Proof: IP67 rating

Standard inventory

Description	Qty	Racelogic Part #
Inertial sensor unit	1	VBIMU04
5W S/P Serial cable for PC coms	1	RLCAB030-S
6W S/P IMU to 5W VBOX data cable	1	RLCAB120
VBOX IMU04 Manual	1	VBIMU04MAN

Optional

IMU Integration cable - 25W D to 6W S/P	1	RLCAB119

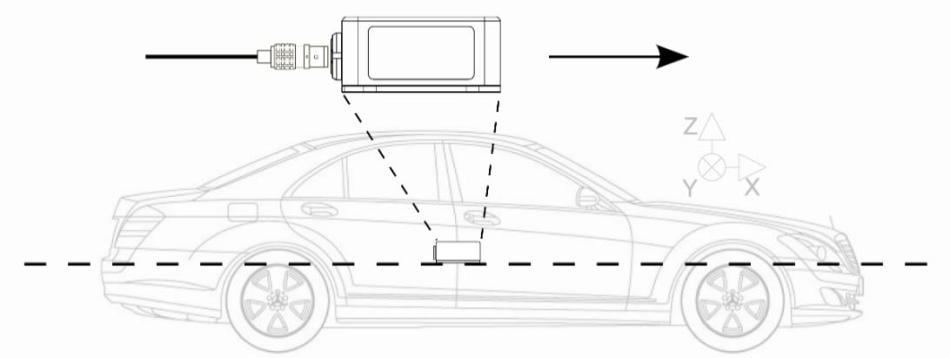
Operation

The IMU04 power supply range is 7V to 30V. When using with a VBOX logging system, power is either obtained through the CAB120 CAN cable or the CAB119 serial cable. If powered from a separate source, the maximum operating voltage input must not exceed 30V DC.

LED Indicator operation

LED	Colour		
Power	**Red**	**Amber**	**Green**
	Initial boot up phase.	Temperature checks. If temperature outside optimum operation range, LED will remain orange.	Fully operational.
Comms	**OFF**	**Amber**	**Green**
	No comms	Using IMU integration, inertial data being sent to host VBOX via RS232.	Inertial data being sent to host system via CAN.

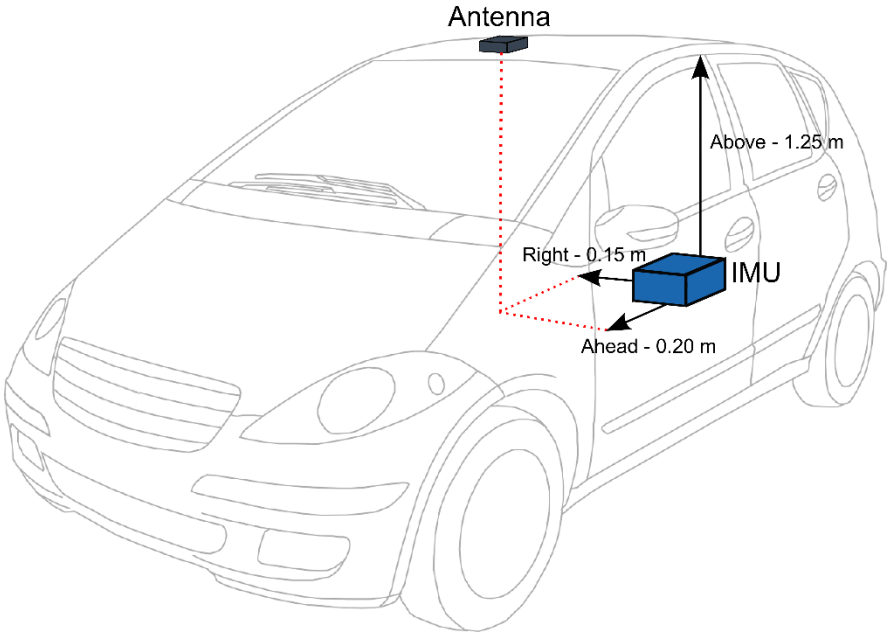
Mounting



The IMU04 should be rigidly mounted on a flat surface, mid-way along the vehicle wheelbase. The securing bolts should be tightened to a maximum of 1.5 Nm. Try to position the unit as close as possible to the centre of the vehicle, making sure it is mounted in the direction of travel - as shown in the image above. It is also important to mount the sensor so that it is level with the ground.

For best results, mount the IMU and GPS antenna as close to each other as possible. For example: Bolt the IMU to the seat rails and place the GPS antenna on the roof directly above.

When mounting an IMU04, you must measure the relative position of the antenna in relation to the IMU to at least within +/- 5cm. These distances must then be entered into the VBOX either via VBOX Tools > VBOX Setup or using a VBOX Manager.



Using the IMU04 with a Racelogic VBOX

Connect with IMU integration – Requires VB3i-V3

Required equipment:

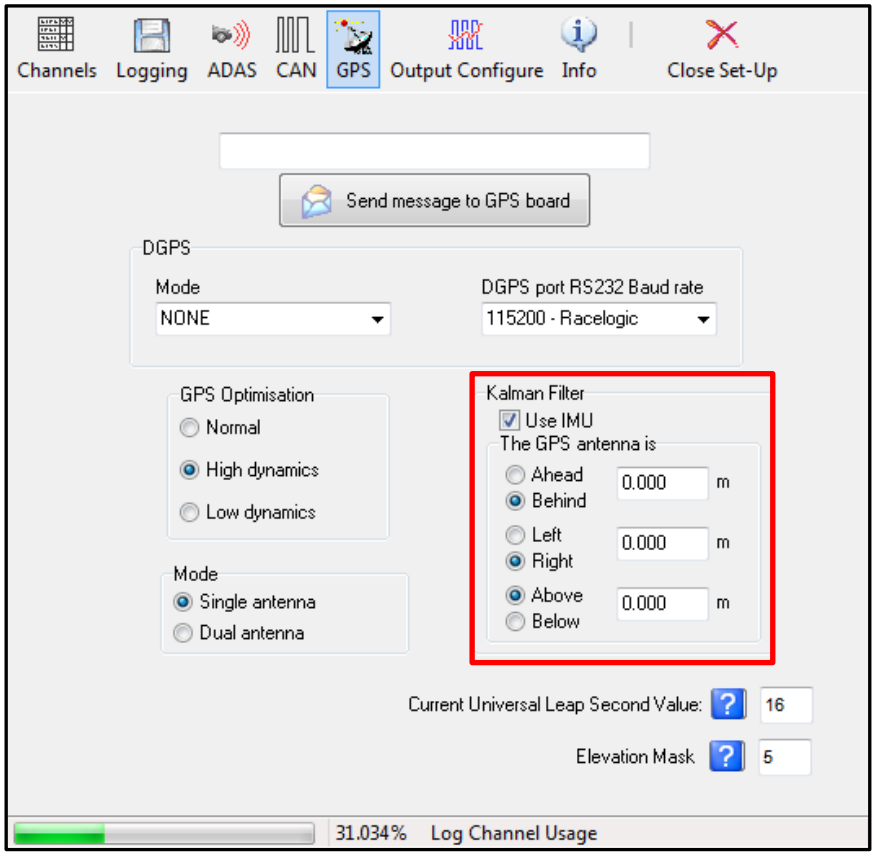
- ❑ IMU04
- ❑ VBOX3i V3
- ❑ RLCAB119 VBOX-IMU connecting cable
- ❑ RLCAB001 / RLCAB066-2 – VBOX PC connection cable (RS232 or USB)

Setup:

1. Mount the VB3i and IMU04 in test vehicle. The IMU04 should be mounted rigidly to the vehicle mid-way along the wheelbase in the direction of vehicle travel.
2. Fit VB3i GPS, GPS/GLONASS antenna to centre of vehicles roof. Connect antenna to VB3i.
3. Measure the relative position from the top centre of the GPS antenna to the top centre of the IMU (see mounting info for more detail) and enter these distances in the highlighted box below.
4. Connect IMU04 (CAN/KF port) to VB3i (25W D analogue input port) using RLCAB119 cable.
5. After the IMU04 is connected, apply power to VB3i.
6. Connect VB3i to PC using RLCAB001 or RLCAB066-2 cable (RS232 or USB).
7. Open VBOX Tools and VBOX Setup.
8. Tick 'Use IMU' box and enter the distances measured from GPS antenna to the IMU.

Important note: IMU04 must be connected to VB3i before power is applied to ensure data is correctly synchronised.

Important note: IMU04 communicates to VBOX Kalman filter for IMU integration via RS232 only (RLCAB119).



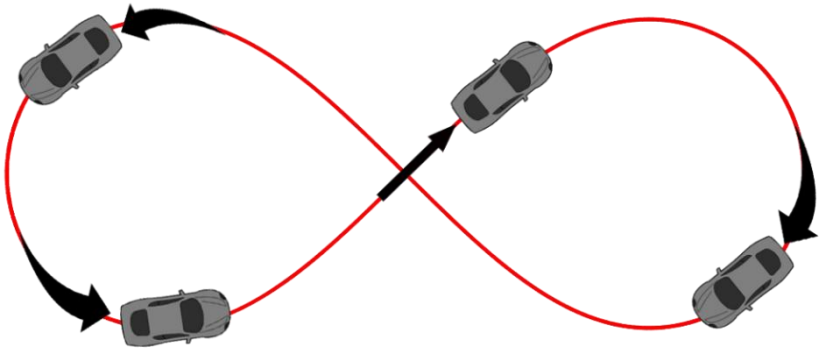
Kalman Filter calibration – High dynamic tests

To produce the optimum level of accuracy as quickly as possible, you can perform a series of specific manoeuvres that help the Kalman filter characterise the outputs from the IMU. Note that while this is recommended, it is not completely necessary as the Kalman filter will have enough data to achieve accurate results within a few minutes of normal dynamic driving (including left and right hand turns, braking and accelerating).

Recommended procedure

1. Wait for IMU to complete 30 second stationary initialisation, VB3i front panel IMU LED will change from flashing orange to flashing green upon completion. If the vehicle moves before initialisation finishes, the 30 second process will restart once stationary again.

2. Drive in a 'figure of eight' at least twice.
These can be as little as 5m in radius (almost full-lock in some vehicles), but 10m is better. The vehicle should be travelling above 15km/h during this procedure in order to generate sufficient forces for the calibration process.



3. Accelerating hard from standstill to 50km/h or above, perform two brake stops with a decel force of at least 0.5g.

When is the calibration required?

When carrying out high dynamic tests such as braking and ESC testing, this recommended process calibrates the Kalman filter as quickly as possible. When carrying out low dynamic tests such as driving on urban routes, or doing long term data collection, then this calibration is not as critical.

Re-running the calibration

The Kalman filter is constantly adapting its calibration depending on the information received from GPS and the IMU. Therefore, if the vehicle is left stationary for a long time, or the IMU is moved from its mounting position, then the calibration procedure should be repeated if further high dynamic testing is to be carried out.

The calibration should also be repeated after anything which causes the communication to break between IMU and VBOX, such as:

- Power cycle to either IMU or VBOX.
- 'RL Config' software is used to read IMU settings.
- 'VBOX Tools' software is used to read VBOX settings.
- A GPS Coldstart is performed

What happens if this isn't done?

If this procedure cannot be carried out as above then the speed accuracy will be reduced, especially for the first few minutes until the Kalman Filter is able to calibrate itself. We strongly recommend that the Kalman Filter is calibrated when carrying out high dynamic tests.

Connect as standalone Racelogic module

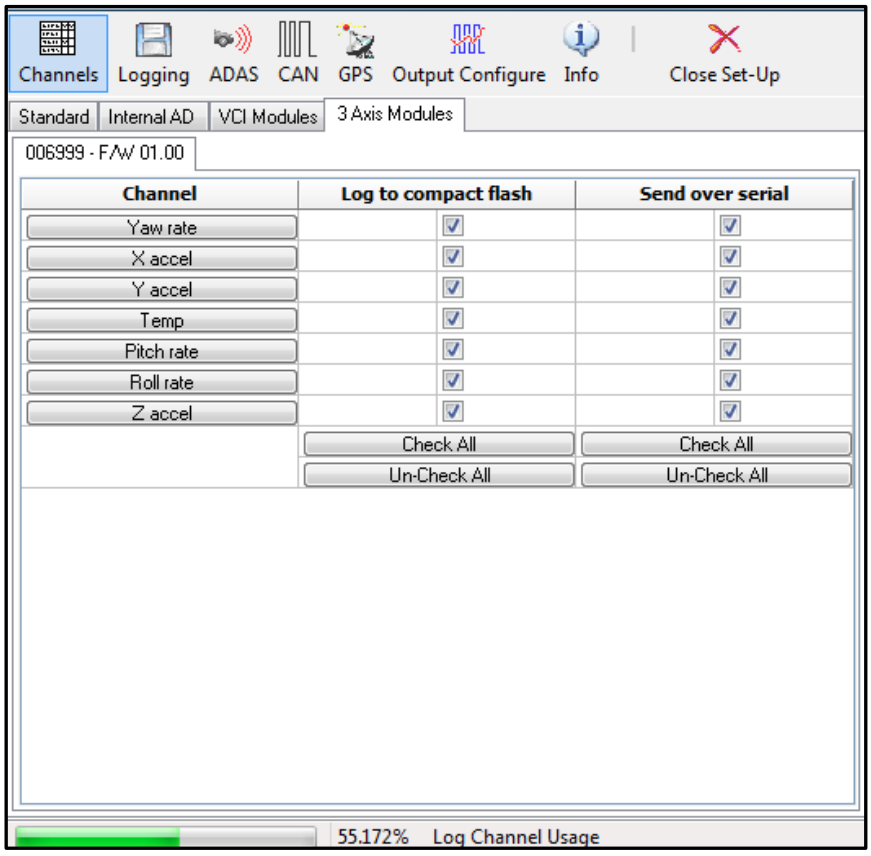
Important note: IMU04 CAN based coms are not supported by Kalman filter, so RLCAB005-CS connection method cannot be used for IMU integration. This CAN module connection can be used purely to log IMU04 data channels.

Required equipment:

- ❑ IMU04 set in Racelogic CAN mode
- ❑ VBOX unit such as VB3i, VB2SX
- ❑ RLCAB120 VBOX-IMU connecting cable
- ❑ RLCAB001 / RLCAB066-2 – VBOX PC connection cable (RS232 or USB)

Setup:

1. Connect IMU04 (CAN/SER port) to VBOX (CAN port) using RLCAB005-CS cable.
2. Connect VBOX to PC using RLCAB001 or RLCAB066-2 cable (RS232 or USB).
3. Open VBOX Tools and VBOX Setup.
4. Click on the 3 Axis Module tab, and tick all IMU channels to be logged and sent over serial.
5. Mount the VB3i and IMU04 in test vehicle. The IMU04 should be mounted rigidly to the vehicle mid-way along the wheelbase in the direction of vehicle travel.
6. Fit VB3i GPS, GPS/GLONASS antenna to centre of vehicles roof. Connect power and antenna to VB3i.

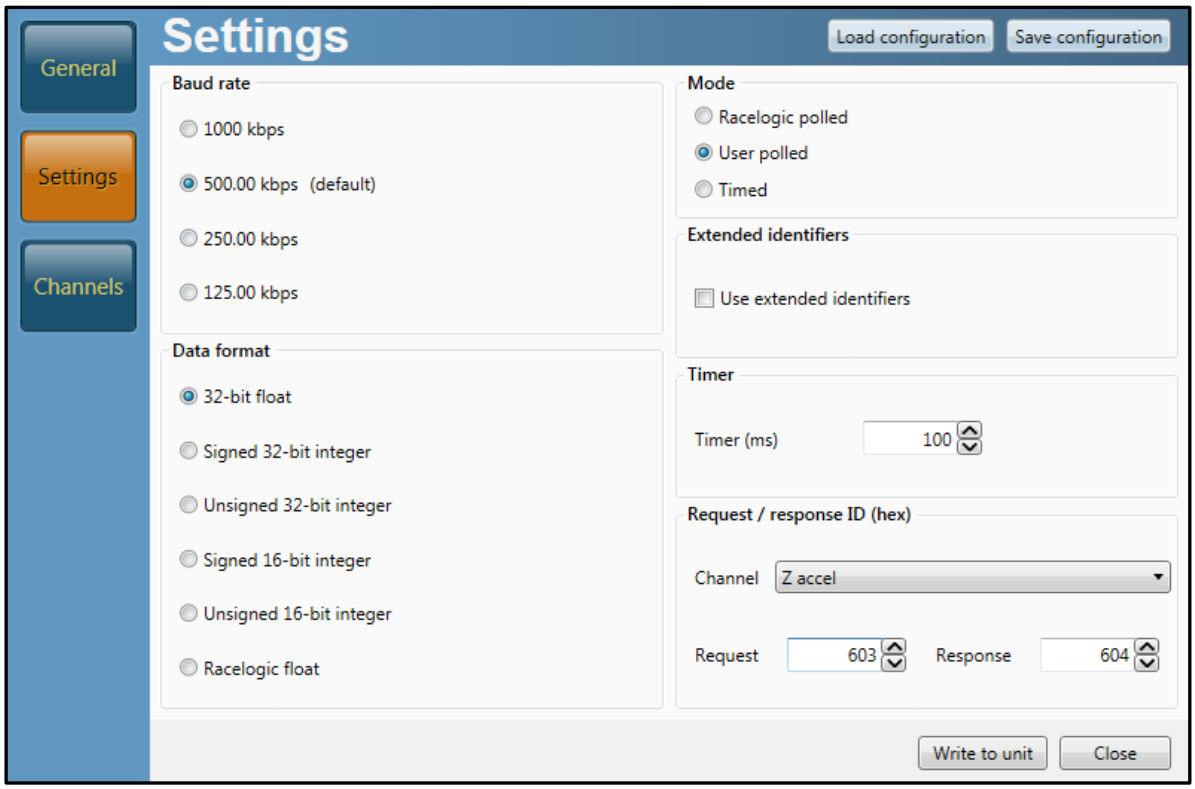


Using the IMU04 with another data logger

The IMU04 can be easily configured to run in 'standalone' CAN operating modes using the supplied RLVBCAB30-S cable and Racelogic Config software.

Configuring an IMU04 with Racelogic Module Setup Software

1. Connect the IMU04 to a PC using the supplied RLVBCAB30 cable.
2. Power up the IMU04 using a suitable 12v power source.
3. Run Racelogic Config software.
4. Select the correct COM port the IMU is assigned to (check device manger if unsure) and the software will display the current settings for the attached IMU. The screenshot shows the settings for an IMU04.
5. Make the changes required and then click the "save configuration" button.



Note: When any change is made using Racelogic Config Software the IMU04 must be powered cycled for the changes to take effect.

CAN operating modes

The IMU04 can operate in one of three different modes:

- Racelogic polled CAN mode
- User polled CAN mode
- Timed CAN mode

Racelogic polled CAN mode – default mode

This mode should be set if the IMU04 is to be used with a Racelogic VBOX. All the CAN parameters are set to work with the Racelogic VBOX CAN protocol. In this mode no other parameters can be set.

User polled CAN mode

This mode allows a user's own data logging system to poll the IMU04 for data using the CAN bus. The IMU04 can be polled up to 100Hz. The following parameters are used in this mode:

- Baud rate (selectable from 125kbit/s, 250kbit/s, 500kbit/s or 1Mbit/s)
- Extended identifiers (OFF or ON)
- Request identifiers (identifiers used to request data from the sensor)
- Response identifiers (identifiers used to transmit data from the sensor)

The timer parameter has no effect in this mode.

Timed CAN mode

In this mode the IMU04 will send CAN data at intervals determined by the timer value. The following parameters are used in this mode:

- Timer (time interval in milliseconds between output data)
- Baud rate (selectable from 125kbit/s, 250kbit/s, 500kbit/s or 1Mbit/s)
- Extended identifiers (OFF or ON)
- Response identifiers (identifiers used to transmit data from the sensor)

The request identifiers have no effect in this mode.

Data format in user polled and timed CAN mode

IMU04 has 7 channels:

- ❑ Channel 1 Yaw_Rate (deg/sec)
- ❑ Channel 2 X_Accel (g)
- ❑ Channel 3 Y_Accel (g)
- ❑ Channel 4 Temp (deg C)
- ❑ Channel 5 Pitch_Rate (deg/sec)
- ❑ Channel 6 Roll_Rate (deg/sec)
- ❑ Channel 7 Z_Accel (g)

Channels are sent as pairs, so channels 1 and 2 will be sent together, 3 and 4 together and so on. The pairing of channels cannot be changed. The channel data is in an IEEE 32 bit float format so each channel occupies 4 bytes. The first 4 data bytes contained within a data packet are the lower channel; the second 4 bytes are for the higher data channel. A CAN DBC file containing default settings for each sensor is available on request from Racelogic.

Setup parameters

Timer

The timer value is in milliseconds (ms). A smaller value means data will be sent more frequently, a larger value means data will be sent less frequently. The range of values that can be entered is 0 to 65535, however the minimum value that should be entered is 10. Below this level data values may be repeated on successive cycles. If a value of 0 is entered, the IMU04 will change it to 1000 on the next power cycle.

Frequency output can be calculated as follows:

Freq = (1/Timer) * 1000

The timer value for a required frequency can be calculated as follows:

Timer = (1/Freq) * 1000

Here are some example timer values are shown against the frequency output.

Timer value [ms]	Frequency [Hz]
10	100
50	20
100	10
400	2.5
1000	1

Baud rate

Baud rate sets the bit rate of the CAN messages (not the frequency at which the messages are sent). There are four options that baud rate can be set to – 1000 Kbit/s, 500 Kbit/s, 250 Kbit/s and 125 Kbit/s. Most light vehicles have a baud rate of 500Kbit/s, so this is the default setting. If you wish to change the baud rate, use the main settings tab within Racelogic Config software.

Extended identifiers

The extended identifiers box can be marked or unmarked. If it is unmarked, the CAN identifier type will be standard (11 bit). If it is marked, the CAN identifier type will be extended (29 bit). The standard identifier type allows 2048 different CAN message identifiers or message “names”. The extended identifier type allows 436207616 different CAN message identifiers. The identifier type should be set to match the CAN data logging equipment that the IMU04 is connected to.

Request and response identifiers

The request identifiers only have an effect in user polled CAN mode. They set the identifier values that the IMU04 will filter for. If a CAN message is received that matches a request identifier then the IMU04 will respond by sending the corresponding channel data on the corresponding response identifier. *Note: All channels can have the same request identifier – this means that on receipt of a single CAN message the IMU04 will respond with all channels of data. The response identifiers MUST all be different.*

In timed mode the channel data will be sent at intervals with the corresponding response identifier – the request identifiers have no effect.

When using standard identifiers the maximum value for the identifiers is 0x7FF. Entering a value higher than this may cause unexpected results, for instance a response identifier of 0x00FFAA23 will result in a message being sent with identifier 0x223. To avoid anything unexpected, the request and response identifiers should be set appropriately for use with standard identifiers.

Firmware upgrades

Firmware refers to the operating software inside the IMU04. The firmware is responsible for all of the functions within the IMU04 and from time to time, firmware updates may be released by Racelogic to improve or enhance the way that the IMU04 works. The latest firmware will always be available on the Racelogic website in the download directory.

It is recommended to check the web site periodically for updates. The IMU04 upgrade files have a ".RUF" file extension. To upgrade the firmware, download the latest firmware file from the Racelogic web site. The RLVBCAB30-S cable can then be used to connect the IMU04 to the PC serial connector. Using a suitable 12V power source, power up the IMU04 and double-click on the downloaded upgrade file. Follow the on screen instructions to complete the upgrade.

If you have any questions regarding the firmware upgrade of any Racelogic product, please do not hesitate to contact support@racelogic.co.uk

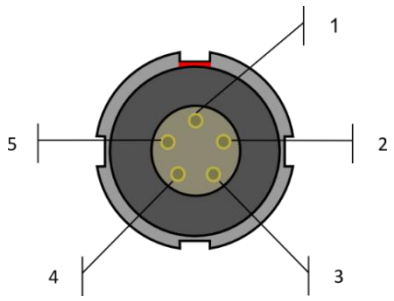
Specification

Specification	
Gyroscopes (Angular rate sensors)	
Dynamic range	Full-Scale: ±450 °/s
Nonlinearity	% of full scale: 0.01%
Resolution	16 bit ADC (0.014 °/s)
Bandwidth	50 Hz
Noise density	0.015 °/s/√Hz
Bias stability	±0.0035 °/s
Bias repeatability (1 year)	0.5 °/s
Accelerometers	
Range	±5G
Nonlinearity	% of full scale: 0.03 %
Resolution	16 bit ADC (0.15 mg)
Bandwidth	50 Hz
Noise density	150 µg/√Hz
Bias stability	40 µg
Bias repeatability (1 year)	0.005 g
Temperature Sensor	
Temperature calibration range	0°C to 55°C
Temperature resolution	0.1°C
Maximum Power Consumption	1.7W
Typical Power Consumption	1.3W
Voltage	7 – 30V DC.
Operating Temperature	-20 to +70 °C
Maximum Ratings (Shock)	Powered (0.5ms): 2000g

Connection data

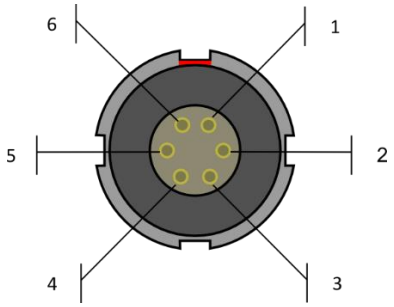
Lemo socket connections CAN / SER

Pin	I/O	Function
1	O	TxD, serial data transmit- configuration- RS232
2	I	RxD, serial data receive- configuration- RS232
3	I/O	CAN high
4	I/O	CAN low
5		+ V power 7V to 30V DC
Chassis		Ground



Lemo socket connections CAN / KF

Pin	I/O	Function
1	O	TxD, serial data transmit – RS232
2	I	RxD, serial data receive – RS232
3	I/O	CAN high
4	I/O	CAN low
5		+ V power 7V to 30V DC
6	I	1PPS
Chassis		Ground



CAN data format

Each data channel is in an IEEE 32 bit float Motorola form

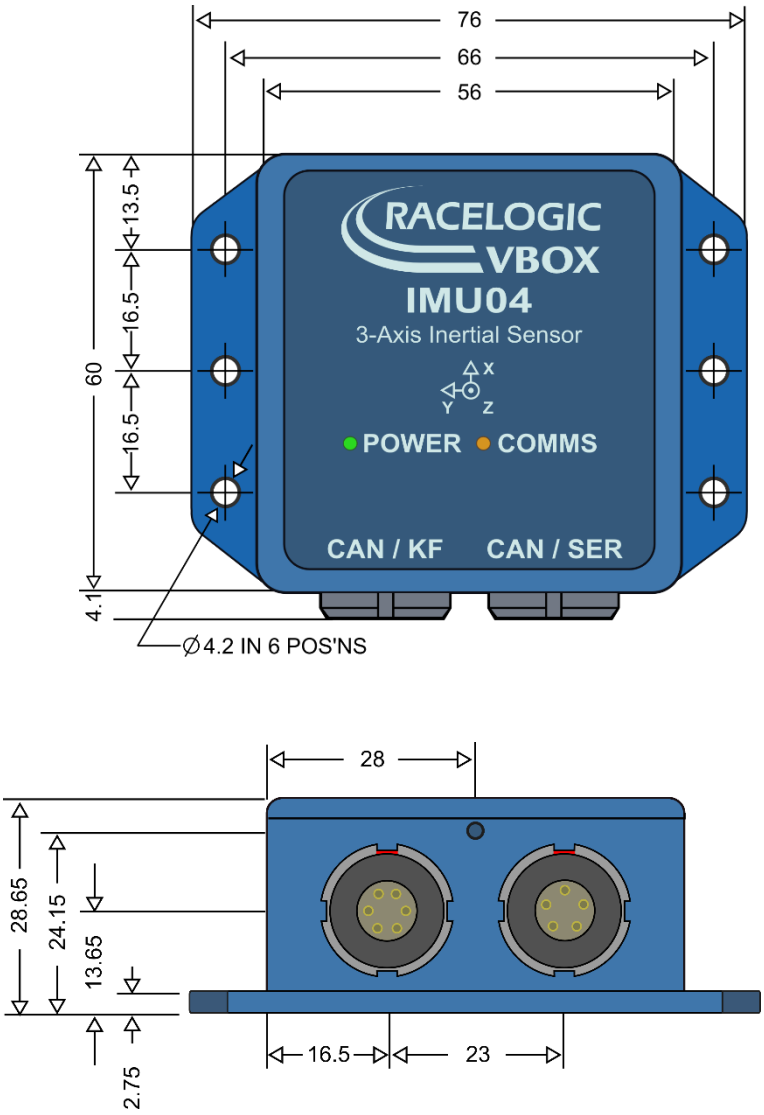
ID**	Data Bytes							
	0	1	2	3	4	5	6	7
0x600	Yaw Rate				X Acceleration			
0x601	Y Acceleration				Temperature			
0x602	Pitch Rate				Roll Rate			
0x603	Z Acceleration							

* In timed mode the update rate can be changed using the configuration software

** Default Identifiers. The identifiers can be changed using the configuration software

The IMU CAN database is available in vector database (DBC File) format on the Racelogic website

Unit dimensions



Contact Information

Racelogic Ltd
Unit 10 Swan Business Centre
Osier Way
Buckingham
MK18 1TB
UK

Tel: +44 (0) 1280 823803
Fax: +44 (0) 1280 823595

Email: support@racelogic.co.uk

Web: www.racelogic.co.uk