VB20SL3 20Hz GPS Data Logger With Slip, Pitch and Roll Angle

User Guide

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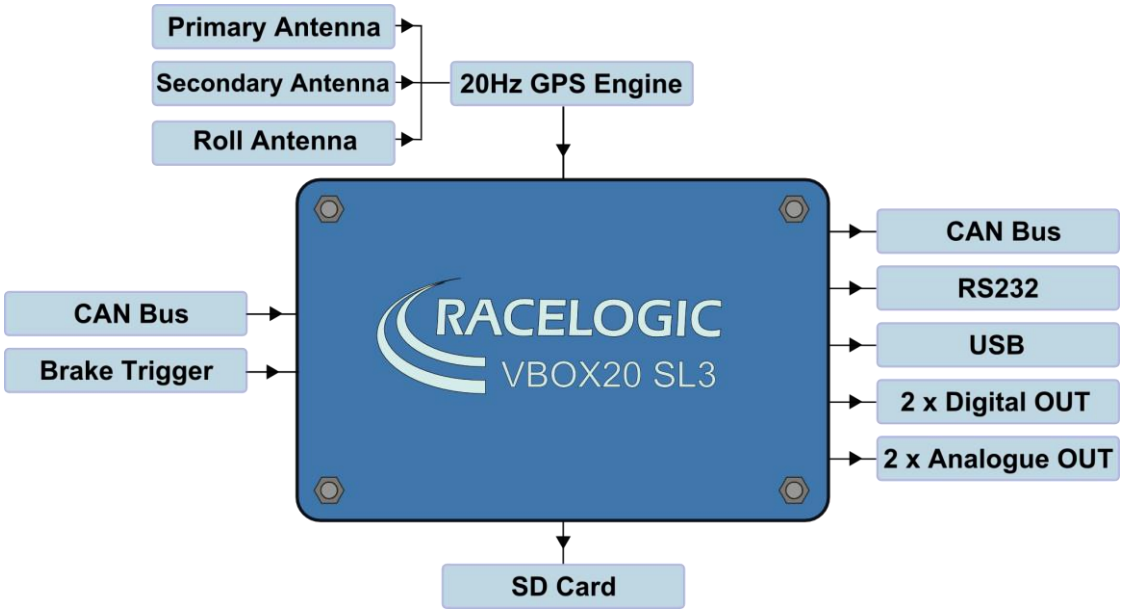
Introduction

The VB20SL3 is a multi-purpose non-contact speed sensor. Using two advanced dual antenna GPS engines, the VB20SL3 can calculate not only the speed and direction of travel of the object upon which it is placed, but also an accurate Slip angle and Pitch and Roll angle. This data is then logged to an inserted SD card, available on a configurable CAN output and present on a USB or serial output for direct monitoring or data processing by a connected PC running VBOXTools software.
The VB20SL3 also features a built-in graphic display allowing the user to set up and configure the unit without using a PC.

The VB20SL3 is compatible with all of the existing peripherals including the Multifunction display, ADC03, TC8, FIM03, Yaw Rate Sensor and Mini Input module.

Features

- Non-contact 20Hz speed and distance measurement using GPS
- VCI CAN input for connection to external CAN systems
- Slip, Pitch and Roll Angle and True Heading measurement
- 1 x CAN bus interface (on two sockets to allow daisy-chaining)
- USB for live data, configuration, upgrading and SD data transfer
- RS232 serial interface backup for live data and configuration
- SD Card logging
- 2 x 16bit user-configurable analogue outputs
- 2 x user-configurable digital outputs
- Brake trigger input with 210KHz scan rate
- Input voltage 6V to 30V operating range
- Logging of up to 20 data channels, in addition to up to 13 standard GPS channels
- Logging and serial rates configurable between 1Hz and 20Hz



Operation

Power

The VB20SL3 can be powered from a wide range of voltage sources including the supplied Vehicle Cigar adapter, a Ni-Mh battery pack, mains power supply or other source provided by the user. The maximum operating voltage input must not exceed 30V DC. Failure to observe this could result in damage to the VBOX.

A number of battery packs can be purchased from Racelogic for use with VBOX equipment. A battery can be connected to both a charger and a VBOX at the same time, allowing the battery to be charged whilst the external source is powering the VBOX. Please note that the battery cannot be used as an uninterruptible power supply; the battery takes time to switch between charging and powering modes, during which the VBOX will turn off.

Getting Started

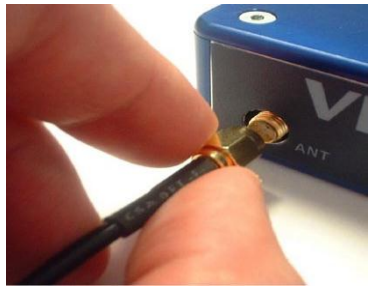
Required equipment (All supplied as standard unless specified)

- ❑ VB20SL3
- ❑ Fully charged battery pack or Cigar lighter 12v adapter lead
- ❑ GPS Antenna
- ❑ Blank SD card
- ❑ USB/RS232 Cable
- ❑ VBOXTools Software CD
- ❑ Laptop/PC (not supplied)

1. Install software

2. Place VBOX in vehicle

3. Fit antenna connector to VBOX



4. Mount GPS antenna(s) on vehicle roof

5.Connect USB or serial cable (CAB01) to computer

6. Connect other end of USB or serial cable to VBOX

7. Connect the power cable or battery pack to the VBOX

8. If using cigar lighter power cable, connect to vehicle

9. See below

9. With the power applied, the Display screen will illuminate. The VB20SL3 will start searching for satellites. The ST led will indicate the number of satellites currently in lock. For best results ensure the VBOX has acquired a lock on 5 or more satellites, essential for quality signal reception. When using the VBOX for the first time or when using the VBOX after a long period of time, allow the VBOX to sit for between 5 and 10 minutes to re-collect data needed to track satellites. As the vehicle begins moving, the display will show a file-writing screen, followed by the normal display screen with the file name of the current file. A small disk icon will appear next to the filename whenever the VBOX is actively logging new data.

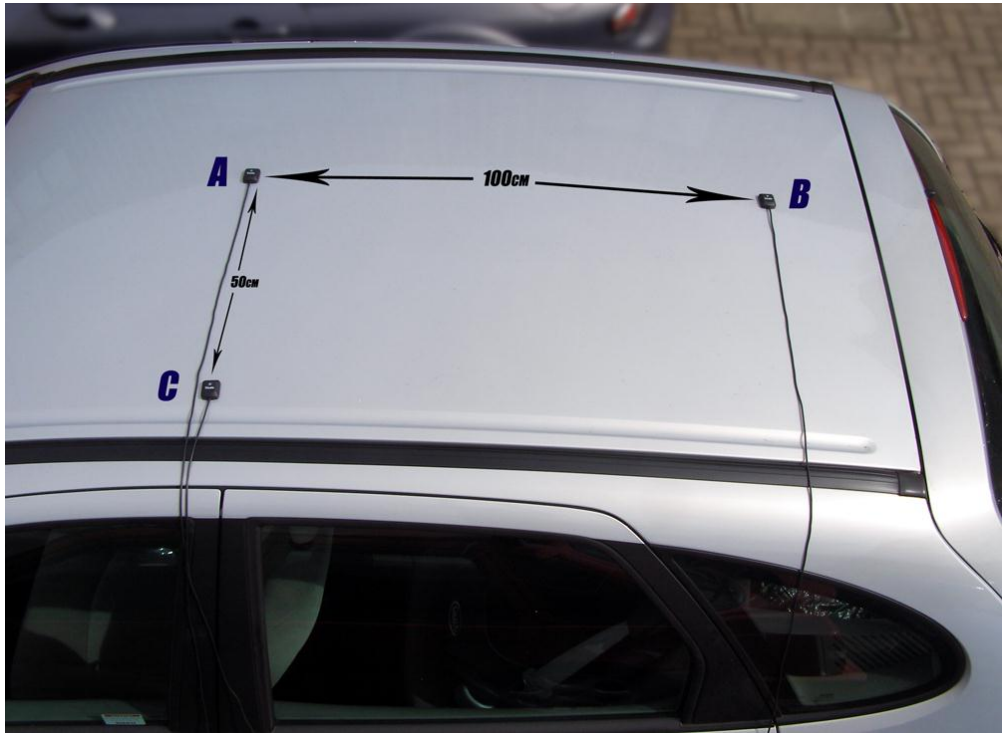
Antenna Types and Placement

Whilst installation and use of the VB20SL3 is intended to be fast and simple, careful attention must be paid to placement of the antennas.

Note: It is essential that the separation of Antenna B and Antenna C from Antenna A is exactly the same as the separation values set inside the VB20SL3 via the configuration screen. If the separation is incorrect, data may not be given or may be inaccurate. The measured distance between the antennas should be the straight-line distance between the antennas regardless of the mounting angle. It is not the 2D distance between the antennas as viewed from above.

The supplied tape measure will help ensure an accurate antenna separation.

Antenna A is the *primary antenna,* from which all calculations are based. If overall slip is to be measured (at the centre of the vehicle), the primary antenna should be placed at the centre of the vehicle. Alignment of the antennas is not completely essential as the Slip Angle Sensor has the ability to calculate any offset. See the Slip Angle Offset Section.
However if you wish to measure Pitch or Roll then the alignment of the antennas must be in line with the vehicle or at 90^{o} as accurately as possible.



The picture to the right shows a typical 3-antenna placement for the measurement of Body Slip Angle, Pitch and Roll angle. Antenna A the primary antenna is placed in the centre of the roof. Antenna B is placed behind Antenna A, allowing True heading, Slip angle and Pitch Angle to be measured. Antenna C is placed to the side of Antenna A allowing the measurement of Roll angle.

When measuring Slip angle Antenna B can be placed either in front or behind Antenna A. If it is placed behind Antenna A as in the picture above then the ‘Swap Antenna’ option needs to be enabled in the Antenna configuration options.

When measuring Slip angle at a specific point on a vehicle (for example over a given wheel), the primary Antenna A must be placed over this point on the vehicle.

GPS antennas require a ground plane to operate correctly. Usually, the metal roof of a vehicle performs this function. However, if a test requires an antenna to be placed off of the vehicle, then a special Ground Plane 'mushroom-style' antenna must replace the off-vehicle antenna, as these antennas are capable of operating without a ground plane.
If a vehicle roof also has obstacles such as roof bars then Ground plane antennas should be used as they can be mounted higher than the obstacle.
The Ground Plane 'mushroom' style antennas RLVBACS065 are available from your VBOX distributor. If only one antenna will be placed 'off-vehicle' then only one Ground Plane antenna need be purchased.

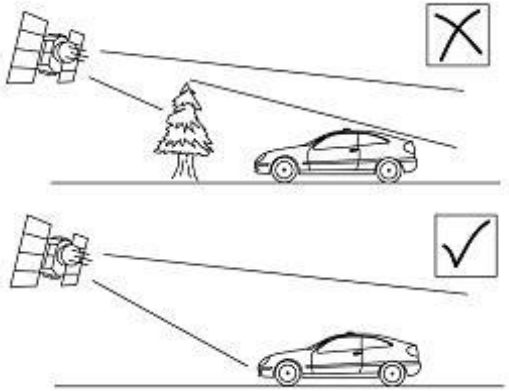
The VB20SL3 must only be used with the supplied antennas, unless instructed otherwise by Racelogic.

Antenna Separations Greater than 2m

When the antenna separation is greater than two metres, it is advised where possible to mount the antennas as level as possible so that the 'LEVEL' option can be enabled, otherwise the RTK lock becomes less reliable and the Slip, Pitch and Roll Angle data can drop out or become intermittent.

GPS Antenna

The GPS Antennas supplied with the VB20SL3 are 3.5v active antennas. For the best possible signal quality, it is important to maintain a clean connection between the antennas and the VBOX. Before fixing the antennas to the VBOX, ensure that there are no dust particles in either connector. Replacement antennas are available by contacting your VBOX distributor.



The antenna is a magnetic mounting type for quick and simple mounting to the vehicle roof. For optimum GPS signal reception, make sure that the antenna is fitted to the highest point of the vehicle away from any obstructions that may block satellite reception. The GPS antenna works best with a metal ground plane underneath (eg. Vehicle roof).
Please also note that when using any GPS equipment, a clear sky view is important. Objects in the surrounding area such as tall buildings or trees can block the GPS signal causing a reduction in the number of satellites being tracked, or introducing reflected signals that can decrease the accuracy of the system.
NOTE: VB20SL3 can struggle with maintaining an RTK lock required for Slip, Pitch and Roll measurement if the antennas are placed too close to Roof Bars. If a poor mounting position cannot be avoided then use Ground plane antennas, RLVBACS065.

Using the VB20SL3 with one GPS antenna

The VB20SL3 can be used like a traditional VBOX. Only Antenna A is needed if the VB20SL3 is to be used like a traditional VBOX without the requirement to measure Slip, Pitch, Roll, YAW rate and Lateral Acceleration channels.
For single antenna use (for standard, non-slip GPS data), the antenna should be connected to the Ant A connector.
Velocity can be output on either the Analogue or Digital outputs.
See the table below for the GPS data available with each antenna configuration.

Antenna Combinations	Sats	Time	Latitude	Longitude	Velocity	Heading	Height	Vertical Velocity	True Heading	Slip Angle	Pitch Angle	Yaw Rate	Lateral Velocity	Roll Angle
A	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	--
A + B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-
A + C	✓	✓	✓	✓	✓	✓	✓	✓	–	-	-	-	-	✓
A + B + C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The VB20SL3 has a brake trigger input so not only can the VB20SL3 measure and output Velocity it can measure and output Trigger Velocity, Trigger to zero Time and Trigger to zero Distance. This data is logged to SD card and available on the CAN bus or USB/serial connection bus along with all the other GPS data.

NOTE: When measuring a braking distance the GPS optimisation must be set to High and the Kalman filter Velocity parameter set to 0 (zero), via the front panel controls or the VBOXTools software.

Display Screen

The Display screen will display data when operating. It also displays all the menus required to configure the VB20SL3 via the front panel controls.
On start-up, the display screen shows the unit's firmware version and current offset value.
During normal operation, the display screen displays Speed (mph or km/h) and Slip Angle. Scroll left or right ('◄'and '►'), to display Pitch or Roll Angle instead of Slip angle. As well as the number of satellites that the VB20SL3 has locked on to, there are also three status indicators at the top of the display.

GPS STATUS	Front Panel Light Status		
No Satellite Lock	–	SAT (flashing)	RTK (flashing)
Full Lock	OK	-	-
Antenna A only sat lock	-	RTK (flashing)	RTK (flashing)
Antenna A and B sat lock	-	RTK	RTK (flashing)
Antenna A and C sat Lock	-	RTK (flashing)	RTK

If a DGPS modes is enabled it is indicated by the middle indicator light with one of the following messages.

DGPS mode	Light Status
WAAS, SBAS or EGNOS Differential correction	WAAS
40cm Differential correction from Base station	40cm

Logged File name:
When an SD card is inserted the file name of the logged file appears on the screen whilst data is being logged.

Front Panel Controls

The VB20SL3 can be configured using the front panel buttons, which enables configuration without the need for a computer.
From the main screen, press the'■' button to enter the configuration screen.
Once in the configuration screen, press the '◄'and '►' buttons to highlight the next or previous choice in any menu, and press '■' to select the highlighted option. Most Main menus contain sub-menus, for example the Settings and Setup Antennas menus contain separate menus for each parameter.

Main Menu

SETTINGS	COLDSTART	MODE	SETUP ANTENNAS	SMOOTHING	OUTPUTS	EXIT
Press'■' to enter the VBOX general settings menu.	Press'■' to perform a GPS cold start	Press'■' to change the mode of operation between VBOX module mode and Stand Alone mode. Then press '■' to confirm.	Press'■' to enter the antenna configurations menu. This menu contains separate sub-menus for pitch antenna and roll antenna pairs	Press'■' to edit the smoothing levels of the Slip, Pitch, Roll, Lat acc and Long acc channels.	Press'■' ' configure the digital and analogue outputs.	Press'■' to exit the setup menu and cause the settings to be saved in EEPROM

Settings Menu

UNITS	APPLICATION	USB MODE	CAN MODE	LOG OPTIONS	SERIAL RATE	GPS	TIME OFFSET	BACK
Press'■' to change the displayed Velocity units. Then press '■' to confirm. KMH, MPH or Knots	Press'■' and then use the '◄' and '►' buttons to select between AUTOMOTIVE or MARINE mode. Marine mode causes the box to display the Pitch, Roll and Slip angles as Trim, Heel and Leeway Angles on the built in screen and also as channel names inside the logged file	Press'■' and then use the '◄' and '►' buttons to select whether the USB port is assigned to Serial data mode or Card reader mode.	Press'■' and then the '◄' and '►' buttons to choose between the following modes: VCI MODE* To connect any external CAN modules to the input of the VB2oSL3 RACELOGIC MODULES MODE To connect Racelogic CAN modules to the RLVB20SL3 (input or output)	Press'■' to enter the Log Options Menu. In this menu the Logging Mode and Log rate can be set.	Press'■' and then use the '◄' and '►' buttons to select a serial data rate. The maximum serial rate is equal to the Log rate	Press'■' to enter the GPS configuration Menu. The Kalman Filter, Dynamic Mode and DGPS mode is configured within this menu.	Press' the '◄' and '►' buttons to set an Time offset in order to align the VBOX time to the users Local time.	Press'■' to go back to the Main menu.

*Note: In VCI Mode, the VB20SL3 cannot output CAN data or input data from Racelogic modules. If the unit is to be used as an input module to another VBOX, it must be set to Racelogic modules mode

Setup Antennas Menu (Pitch Antennas)

SEPARATION	LEVEL	SWAP ANTENNAS	SLIP OFFSET	PITCH OFFSET	BACK
Press'■' and then use the '◀' and '▶' buttons to change the antenna separation. Then press '■' to confirm. Range is 0.5 – 5.0M in 0.1M increments	Press'■' and then use the '◀' and '▶' buttons to enable or disable the LEVEL option. With the LEVEL set to YES the RTK lock is more resilient. But maximum ROLL or PITCH in this mode should be 10 degrees.	Set to 'ON' to allow the primary Antenna A to be mounted ahead of the Secondary Antenna B. Default is 'OFF'. Then press '■' to confirm.	Press'■' to enter the Slip offset sub menu. Within this sub menu the Slip offset can be calculated and applied or cleared.	Press'■' to enter the Pitch offset sub menu. Within this sub menu a Pitch offset can be calculated and applied or cleared.	Press'■' to go back to the Main menu.

Setup Antennas Menu (Roll Antennas)

SEPARATION	LEVEL	ROLL OFFSET	BACK
Press'■' and then use the '◀' and '▶' buttons to change the antenna separation. Then press '■' to confirm. Range is 0.5 – 5.0M in 0.1M increments	Press'■' and then use the '◀' and '▶' buttons to enable or disable the LEVEL option. With the LEVEL set to YES the RTK lock is more resilient. But maximum ROLL or PITCH in this mode should be 10 degrees.	Press'■' to enter the Roll offset sub menu. Within this sub menu a Roll offset can be calculated and applied or cleared.	Press'■' to go back to the Main menu.

Smoothing Menu

Lat Acc	Long Acc	Slip	Pitch	Roll	BACK
Press'■' and then use the '◀' and '▶' buttons to change the amount of smoothing applied to the calculated Lateral Acceleration output. Then press '■' to confirm. 0.0 –5.0 (0.1 steps)	Press'■' and then use the '◀' and '▶' buttons to change the amount of smoothing applied to the calculated Longitudinal Acceleration output. Then press '■' to confirm. 0.0 –5.0 (0.1 steps)	Press'■' and then use the '◀' and '▶' buttons to change the amount of smoothing applied to the Slip angle channel. Then press '■' to confirm. 0.0 –5.0 (0.1 steps)	Press'■' and then use the '◀' and '▶' buttons to change the amount of smoothing applied to the Pitch angle channel. Then press '■' to confirm. 0.0 –5.0 (0.1 steps)	Press'■' and then use the '◀' and '▶' buttons to change the amount of smoothing applied to the Roll angle channel. Then press '■' to confirm. 0.0 –5.0 (0.1 steps)	Press'■' to go back to the Main menu.

OUTPUTS: Digital Setup Menu (Channel 1 and 2)

OUTPUT	PULSES PER METER	MAX SPEED	MAX VALUE	MAX FREQUENCY	TEST	EXIT
	Only available when output is set to Velocity	Only available when output is set to SPEED	Only available when output is set to PITCH, SLIP, ROLL, LAT ACC or LONG ACC	Only available when output is set to PITCH, SLIP, ROLL, LAT ACC or LONG ACC		
Press'■' and then use the '◀' and '▶' buttons to associate either of the following channels SPEED, SLIP, PITCH, ROLL, LAT ACC and LONG ACC to the Digital output. Then press '■' to confirm.	Press'■' and then use the '◀' and '▶' buttons to set the number of pulses per revolution. Then press '■' to confirm. 0.1 –120 (0.1 Steps)	Press'■' and then use the '◀' and '▶' buttons to set the maximum Speed. Then press '■' to confirm. 0-400Km/h (1km/h steps)	Press'■' and then use the '◀' and '▶' buttons to set the maximum value of that channel. Then press '■' to confirm. 0- 180° (1° steps) for SLIP 0- 90° (1° steps) for PITCH 0- 90° (1° steps) for ROLL 0.5-2g (0.1g steps) for LAT ACC 0.5-2g (0.1g steps) for LONG ACC	Press'■' and then use the '◀' and '▶' buttons to set the maximum Frequency used on the digital output. Then press '■' to confirm. 1-50kHz (0.1Khz steps)	Press'■' and then use the '◀' and '▶' buttons to set a test value that the Digital output will simulate. Then press '■' to quit.	Press'■' to exit the setup menu and cause the settings to be saved in EEPROM

OUTPUTS: Analogue Setup Menu (Channel 1 and 2)

OUTPUT	VALUE @ +5V	VALUE @ 0V	VALUE @ -5V	TEST	EXIT
		Only available when output is set to SPEED	Only available when output is set to PITCH, SLIP, ROLL, LAT ACC or LONG ACC		
Press'■' and then use the '◀' and '▶' buttons to associate either of the following channels SPEED, SLIP or PITCH, ROLL, LAT ACC and LONG ACC to the Analogue output. Then press '■' to confirm.	Press'■' and then use the '◀' and '▶' buttons to set the value to represent +5V. Then press '■' to confirm. 1-400kmh (1km/h steps) –179° to 180° (0.1° steps) for SLIP -89° to 90° (1° steps) for PITCH -89° to 90° (1° steps) for ROLL -1 to 2g (0.1g steps) LAT ACC -1 to 2g (0.1g steps) LONG ACC	Press'■' and then use the '◀' and '▶' buttons to set the velocity to represent 0V. Then press '■' to confirm. 0-399kmh (1km/h steps)	Press'■' and then use the '◀' and '▶' buttons to set the value to represent -5V. Then press '■' to confirm. –180° to 179° (0.1° steps) for SLIP -90° to 89° (1° steps) for PITCH -90° to 89° (1° steps) for ROLL -2 to 1g (0.1g steps) LAT ACC -2g to 1g (0.1g steps) LONG ACC	Press'■' and then use the '◀' and '▶' buttons to set a test value that the Analogue output will simulate. Then press '■' to quit.	Press'■' to exit the setup menu and cause the settings to be saved in EEPROM

Slip Angle Offset

When using the VB20SL3 for measurement of Slip Angle, Pitch and Roll Angle, True Heading, Lateral Velocity or Yaw Rate, it is essential that the Slip Angle offset is determined before conducting tests. This then compensates for any misalignment in the placement of Antennas A and B.

There are also many occasions when the antennas cannot be placed directly in line with the car, such as when an 'off-vehicle' antenna is used to measure the Slip angle over a particular wheel.

Measuring Pitch Angle and Slip Angle
To measure Pitch angle accurately at the same time as Slip angle with Antennas A and B will require the antennas to be aligned as close as possible to a line parallel to the longitudinal line of the car.

Setting the Slip Offset

The VB20SL3 includes a built-in facility for calculating and setting the offset. With the antennas placed suitably and the antenna separation set correctly in the unit, enter the Setup Antenna configuration menu and select Slip offset 'Calc. Offset'. The unit will give instructions on its display screen to allow it to determine the offset.

First, the unit will instruct you to drive at a speed greater than 25km/h. Once this is achieved, the unit will tell you to drive straight, and will begin calculating the Slip Angle offset automatically. During the 5 second process, it is very important that you keep the vehicle in a straight line and above 25km/h. The Slip angle sensor beeps during this calculation and then stops beeping when it has finished calculating the offset.

If required, the Slip Angle offset can be re-calculated at any time by repeating this procedure. Selecting the 'Clear Offset' option in the Configuration Screen will clear the current offset value.

Please note that the unit will need to have a full RTK lock to perform this procedure – if the orange 'RTK' light is flashing, the procedure cannot be initiated.

Pitch and Roll Angle Offset

It is not always possible to mount the antennas on a vehicle so that they are perfectly level. In order to compensate for non-level antenna placements you should use the Pitch and/or Roll offset facility, which will automatically compute and then use an offset compensation.

Measuring Roll angle:
To measure Roll angle accurately with Antennas A and C will require the antennas to be aligned as close as possible to a line perpendicular 90^{o} to the longitudinal line of the car.

Setting the Offset

Press the '■' button to enter the Main menu then select the Setup Antenna Menu, and then select either the Pitch or Roll antenna setup menu.
From within either the Pitch or Roll antenna setup menu select either Pitch or Roll offset menu, when the screen shows 'CALC OFFSET' press the '■' to calculate a PITCH or ROLL offset.

If required, the Pitch or Roll angle offset can be re-calculated at any time by repeating this procedure. Selecting the 'Clear Offset' option will also clear the current offset value.

Setting Slip Angle Offset Remotely via CAN Messages

It is possible to request that the VB20SL3 calculates a Slip Angle Offset by sending it requests via CAN.
The CAN Baud rate is 500Kbit/s, Motorola 11 bit – Standard Frame, The DLC = 8
The VB20SL3 will respond on CAN to indicate stages of the Slip offset process and also indicate completion or failure.

Please see the table below:

Message Type		CAN ID	Data Bytes							
			0	1	2	3	4	5	6	7
Request	Start Slip offset calculation	0x7FE	46	49	4C	45	4D	41	4E	40
Request	Cancel Slip offset calculation	0x7FE	46	49	4C	45	4D	41	4E	41
Response	Increase speed to >25kmh	0x7FB	05	02	00	00	00	00	00	00
Response	Drive Straight	0x7FB	05	03	00	00	00	00	00	00
Response	Offset done – value shown in Data bytes 2-5	0x7FB	05	01	3F	9D	70	A4	00	00
Response	Offset failed	0x7FB	05	00	00	00	00	00	00	00

The Response message to indicate completion also contains the Offset value as a 32 bit IEEE float on Data bytes 2-5.
In the example above Data bytes 2 - 5 = 3F 9D 70 A4 which equals a decimal value of 1.23^{o}

Level

The 'LEVEL' option should be enabled (set to YES) when the antennas are mounted within 10^{o} of each other (from the horizontal), and not expected to exceed 10^{o} during testing. With the LEVEL option enabled the GPS engines maintains its RTK lock more efficiently and the Slip and Pitch channels are less likely to drop out.

If the expected angle between the antennas will be greater than 10^{o} then the 'LEVEL' option should be disabled (set to 'NO').

Note: When the antenna separation is <2m the RTK lock is very resilient in most conditions and scenarios when the 'Level' option is not enabled.

Memory Cards and Logging

The VB20SL3 stores logged data onto SD cards. The supplied SD cards are already optimised for use on the VB20SL3 and as such do not need formatting before use. Should the SD card subsequently need formatting due to card errors it should only be formatted using the 'Format Compact Flash' option in the VBOXTools software. The SD card will need to be inserted into an SD card reader (or a VB20SL3 set to 'Card Reader' USB mode) for this to work.

When logging data to an SD card, the OLED display will show a small disk icon next to the name of the current file at the bottom of the display. It is important not to remove the SD card while the VB20SL3 is logging. If the card is removed while the VBOX is writing data to it, there is a risk that the data file may be corrupted resulting in loss of data. If '**Log only when moving**' is the logging mode selected, wait a short time after the vehicle has stopped for logging to finish and the disk icon to disappear from the screen. Once the disk icon has gone, it is safe to remove the SD card. If '**Log continuously**' is selected, press the start/stop logging switch (if connected) to stop logging so that the card may be safely removed. If no start/stop logging switch is available, press '■' on the front panel to enter the on-board configuration screen. This will close the file so that the card can be removed.

It is recommended that files are removed from the disk regularly as writing continuously without fragments is easy. The more file fragments there are on an SD card, the harder it is to stream data to the card.

There are two Logging modes:

- **Log only when moving**: In this mode, the VBOX will start to log data only when a speed higher than 0.5km/h is detected. This requires a satellite lock.
- **Log continuously**: Data is continuously logged to the SD card regardless of vehicle velocity or the number of satellites.

To set channels to be logged, they must be selected in the VBOX setup window of VBOXTools. Please see the VBOXTools manual for further information. The maximum number of CAN channels available for logging varies according to whether or not the Kalman Filter is enabled, as follows:

- Maximum logged channels without Kalman Filter enabled (both velocity and position set to zero): All standard channels plus **20** CAN channels.
- Maximum logged channels with Kalman Filter enabled (either velocity or position set to non-zero values): All standard channels plus **10** CAN channels.

Smoothing and Filtering

Velocity:
The VB20SL3 has three smoothing settings (Dynamic Modes) for velocity: High Dynamics, Normal and Low Dynamics. High dynamics has the least amount of smoothing and must be used for high dynamic tests where Time or Distance measurements are critical, such as brake stop and acceleration tests.

Slip, Pitch, Roll Angle and Acceleration channels: The smoothing routine is set by selecting a value from 0 – 5.0 in 0.1 steps. This value corresponds the size in time (S) of a moving window smoothing routine.
e.g. if 0.3 is selected then a smoothing window of 0.3 seconds (6 samples @20Hz) will be applied to the data.

Kalman Filter:
This facility provides filtering separately to the Velocity and Position channels (long, lat and height). Note that with any live filter routine more latency will occur if higher levels of filtering are used, hence the Kalman Filter velocity settings should be set to zero for brake stops and acceleration runs.

It is often better to record unfiltered data then use the software filter routines available within the VBOXTools software (if necessary) as these will have much less impact on latency.

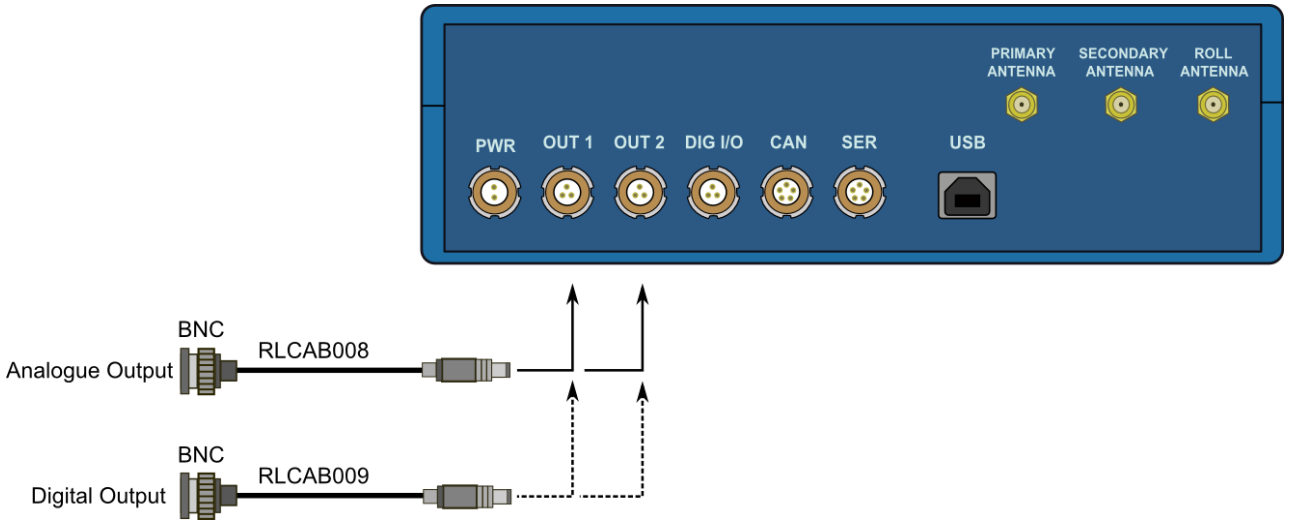
Digital and Analogue Outputs

The outputs on connectors OUT1 and OUT2 can be used either as frequency/pulse digital outputs or as analogue outputs that can be configured to represent any of the following parameters:

- Velocity
- Longitudinal Acceleration
- Lateral Acceleration
- Slip Angle
- Pitch Angle
- Roll Angle

For digital outputs, the scale and maximum output values can be adjusted using the VBOXTools software or via the front panel controls. For velocity, these are controlled by setting the maximum velocity and the pulses per metre. For the other parameters, the scale and maximum are controlled by setting the maximum frequency and the angle or acceleration value to which this relates. Please note that the digital outputs do not show the direction of angles and accelerations, only their magnitudes. Therefore “negative” angles or accelerations will be shown in the same way as their positive equivalents.

For analogue outputs, the values relating to the maximum voltage (+5V) and minimum voltage (0 for Velocity, –5V for all other channels) can be set, either via the front panel or using the VBOXTools software. The negative voltage capability of the analogue outputs allows the direction of angles and accelerations to be output.

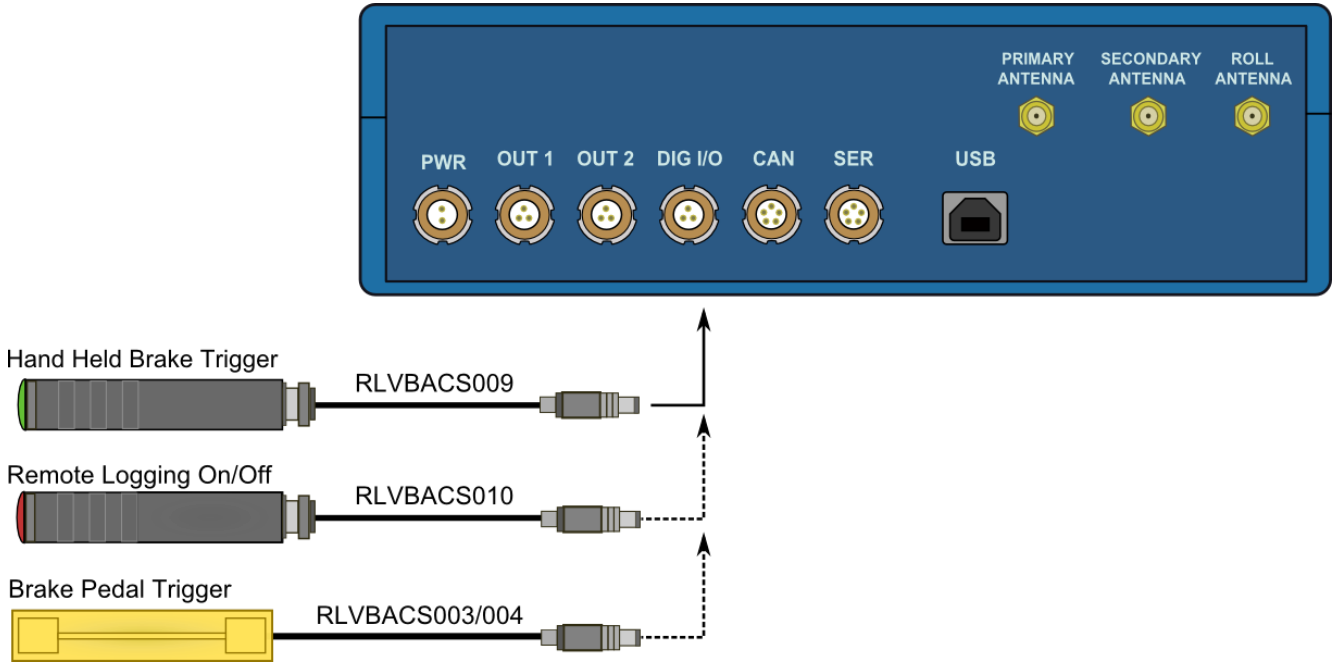


Digital Inputs

The DIGITAL I/O socket contains the two digital inputs for the VB20SL3, accessed by connecting to different combinations of the three pins.

The first digital input is most commonly referred to as the brake trigger input. This input is connected to an internal timer capture module that is able to record precisely an event time for use in brake distance calculation. This period of time is called the trigger event time, and is logged as the value in milliseconds between the last GPS sample and the trigger event. Typically, this will be connected to a pressure switch placed on the brake pedal, however a hand-held brake trigger is also available to allow the user to record marker events for other purposes.

The second digital input is used to control the VBOX's logging; a remote logging on/off switch is available for ease of use and when the front panel switch is not accessible.



CAN / SERIAL / USB Sockets

The VB20SL3 is equipped with a CAN bus interface, an RS232 serial socket and an USB socket. Either of the SERIAL or USB sockets can be used for all communication between the VBOX and a PC, including configuration of the VBOX and to transmit live data from the VBOX to the PC for viewing and performing real-time tests.

Note, however, that only the USB socket can be used for upgrading the VBOX's firmware.

The CAN Bus port is available in either the socket labelled CAN or the socket labelled Serial. This CAN port has three functions, CAN Input in VCI mode, CAN Input in Racelogic Modules Mode (Internal Mode) and CAN output in Racelogic Modules Mode (External Mode).

VCI Mode:
This mode should be selected if you wish to log incoming CAN data from external modules from other manufacturers. Note in VCI mode no CAN output or connection to Racelogic modules is possible.

Racelogic Modules mode
This mode should be selected when Racelogic modules are connected to the VBOX or VBOX CAN output is required. Depending upon configuration, VBOX Tools software should be set as follows:

- **Internal Mode:** This mode should be selected when Racelogic input modules are connected to the VBOX. In this mode the CAN id's and Baud rate are non configurable.
- **External Mode:** This CAN mode should be used when a VBOX CAN data output is to be used by an external CAN device such as a Data acquisition system. In this mode the attributes of the CAN output stream are configurable by the user in VBOXTools

See the section 'Setup' in the VBOXTools software manual for more information.

The Socket labelled CAN also contains a secondary RS232 port for direct connections to the GPS engine. These can be used to provide the GPS engine with Local DGPS correction messages, or occasionally for fault-finding under the instruction of a Racelogic employee.

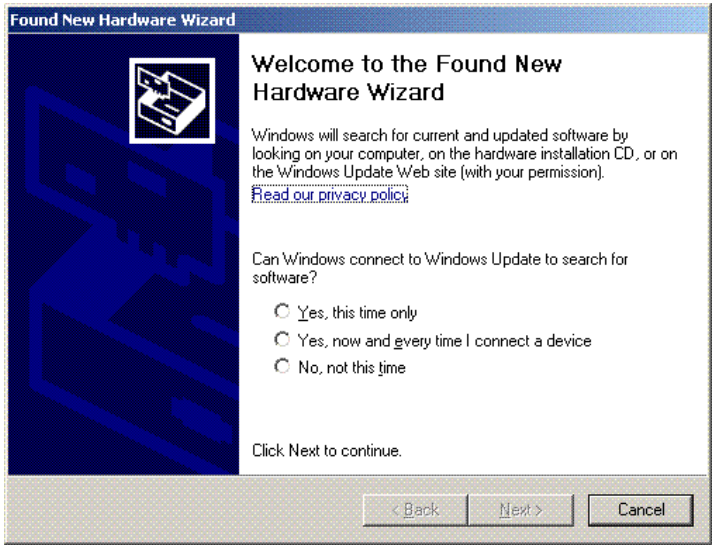
Using the USB cable

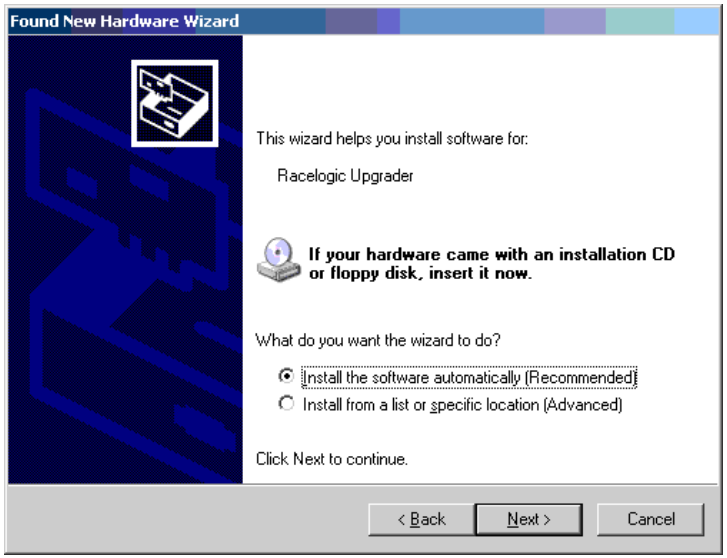
The first time you use the USB cable, you will need to follow the instructions below.

Connect the USB cable between the VB20SL3 and your computer.

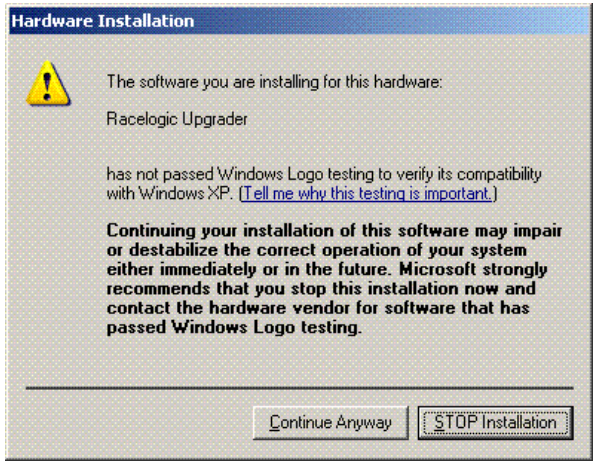
- Your computer will now recognise the presence of a new device, after a period of time a 'Found New Hardware Wizard' window will appear. See below.

Click the option 'No, not this time' and click 'Next' (see image, right)
A new window will appear at this window click 'Next' (see image, below)





A new 'Hardware Installation' window will appear. Click the button labelled 'Continue Anyway'.
At the last window click 'Finish' to complete the installation.
After a short period of time a window will ask you if you wish to reboot your computer, select 'NO'
Now disconnect the power from the VB20SL3 and then reconnect the power, your computer will now recognise the Slip angle sensor. When you run the VBOXTools software it will recognise the USB connections



VB20SL3 '.VBO' file format

The VB20SL3 data files are saved in standard space de-limited text format. This allows the data to easily be imported into third party applications such as word processors or spreadsheets. The files each contain a header section before the main data that describes the channel content and information about the VB20SL3 such as serial number and firmware version.

The [Column names] parameter specifies the data in each column of the data section.

An example of a VBOX .VBO file is shown on the right.

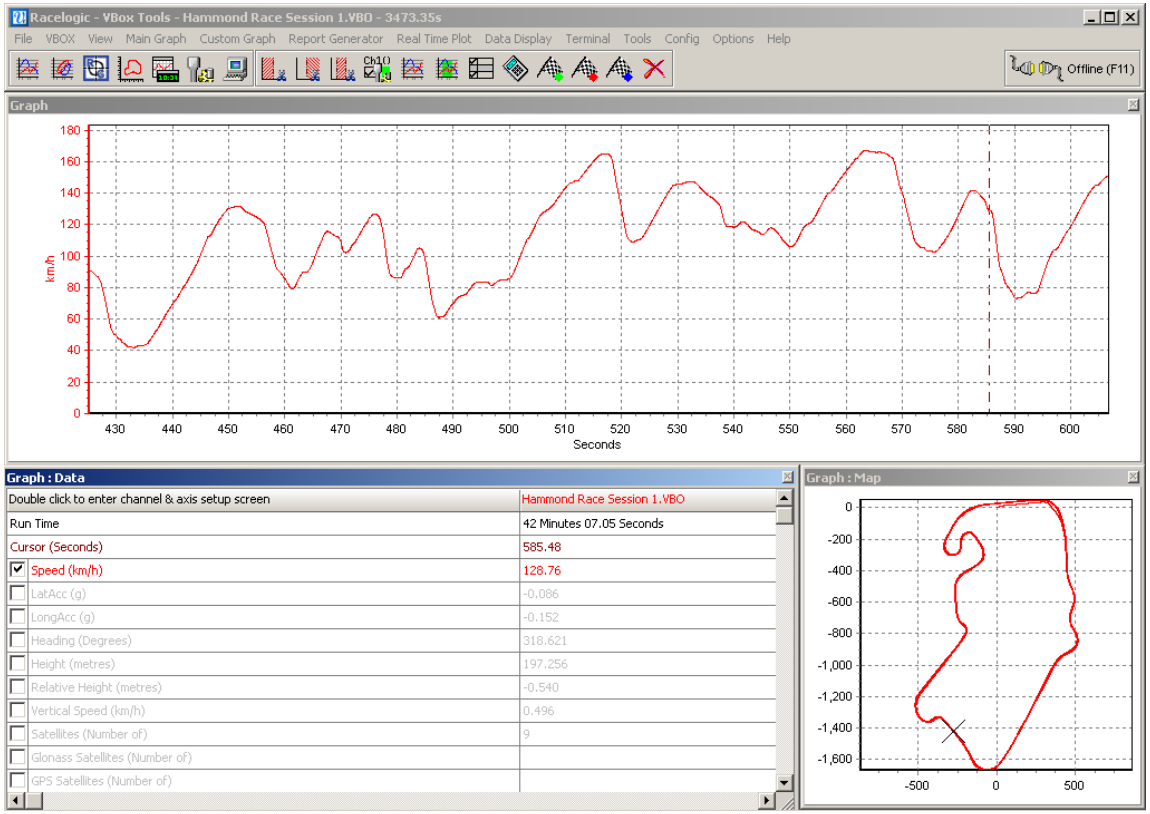
Note that the File created time and date is derived from UTC time and date, so will not reflect your local time unless you logged data on the Greenwich Meridian.

```
File created on 16/11/2006 @ 15:42

[header]
satellites
time
latitude
longitude
velocity kmh
heading
height
Event 1 time

[channel units]

[comments]
(c)2001 - 2005 Racelogic
VBII SL V01.01 Bld. 0131
GPS Firmware : SX2g

Serial Number : 00007194
Log Rate (Hz) : 20.00
Kalman Filter - Pos : 0  Vel : 0
GPS Time

[module Information]

[column names]
sats time lat long velocity heading height event-1

[data]
006 154215.35 +3119.240616 +00058.826374 000.000 000.00 +0158.13 0.00000
006 154215.40 +3119.240620 +00058.826371 000.820 326.60 +0158.12 0.00000
006 154215.45 +3119.240624 +00058.826378 000.000 000.00 +0158.13 0.00000
006 154215.50 +3119.240626 +00058.826378 000.000 000.00 +0158.12 0.00000
006 154215.55 +3119.240625 +00058.826380 000.000 000.00 +0158.13 0.00000
006 154215.60 +3119.240621 +00058.826378 000.000 000.00 +0158.12 0.00000
006 154215.65 +3119.240619 +00058.826379 000.000 000.00 +0158.12 0.00000
006 154215.70 +3119.240620 +00058.826381 000.000 000.00 +0158.13 0.00000
006 154215.75 +3119.240622 +00058.826380 000.000 000.00 +0158.12 0.00000
006 154215.80 +3119.240624 +00058.826382 000.000 000.00 +0158.12 0.00000
006 154215.85 +3119.240627 +00058.826378 000.000 000.00 +0158.12 0.00000
006 154215.90 +3119.240627 +00058.826375 000.000 000.00 +0158.12 0.00000
```

VBOXTools Software

The VBOXTools software is used for configuration of the VB20SL3 and also for analysis of the VBO data files.

For further information on the VBOXTools software refer to the VBOXTools software manual supplied with VB20SL3.



Double click to enter channel & axis setup screen	Hammond Race Session 1.VBO
Run Time	42 Minutes 07.05 Seconds
Cursor (Seconds)	585.48
Speed (km/h)	128.76
LatAcc (g)	-0.086
LongAcc (g)	-0.152
Heading (Degrees)	318.621
Height (metres)	197.256
Relative Height (metres)	-0.540
Vertical Speed (km/h)	0.496
Satellites (Number of)	9
Glonass Satellites (Number of)	
GPS Satellites (Number of)	

Upgrading the Firmware

Occasionally Racelogic releases new versions of firmware code for VBOX products, which may be required to fix bugs or to add new features.

New firmware for the VB20SL3 is loaded into the unit using a computer and the supplied USB cable.

The latest firmware upgrade (.RUF) file for the Speed Sensor is available from the VBOX website in the Support section:

http://www.velocitybox.co.uk/index.php/en/support.html

If you need the latest file, download it from the website and copy it to your computer.

If you are connecting your slip angle sensor to your computer with the USB cable for the first time then follow the instructions in the section 'Using the USB cable' earlier in this manual before following the instructions below.

How to upgrade the firmware

- Press and hold the '◀' button whilst the power is connected to the VB20SL3.
- The front panel screen will now display the UPGRADER screen, showing that it is ready for upgrading.
- Connect the USB cable to your computer.
- Double click on the .RUF firmware upgrade file that you have downloaded from the website.
- This will automatically run the upgrade program where you will see the progress of the upgrade.
- At the end of the process disconnect the USB and then disconnect and reconnect the power.

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

Specification

GPS

Velocity	
Accuracy	0.1 Km/h (averaged over 4 samples)
Units	Km/h or Mph
Update rate	20 Hz
Maximum velocity	1000 Mph
Minimum velocity	0.1 Km/h
Resolution	0.01 Km/h

Brake Stop Accuracy	
Accuracy	+/- 10cm

Absolute Positioning	
Accuracy	3m 95% CEP**
Accuracy with DGPS	To 40cm 95% CEP**
Update rate	20 Hz
Resolution	1 cm

Slip Angle	
Accuracy	<0.5° rms at 0.5m antenna separation <0.1° rms at 2m antenna separation

YAW Rate	
Yaw rate RMS Noise	0.75 degrees per second***

Acceleration	
Accuracy	0.5%
Maximum	20 G
Resolution	0.01 G
Update rate	20Hz

Memory	
SD/MMC Card	
Recording time	Dependent on flash card capacity*

** Approximately 4.3Mb per hour used when logging GPS data at 20Hz*

Distance	
Accuracy	0.05% (<50cm per Km)
Units	Metres / Feet
Update rate	20Hz
Resolution	1cm
Height accuracy	6 Metres 95% CEP**
Height accuracy with DGPS	2 Metres 95% CEP**

Time	
Resolution	0.01 s
Accuracy	0.01 s

Pitch and Roll Angle	
Accuracy	<1.0° rms at 0.5m antenna separation <0.25° rms at 2m antenna separation

Power	
Input Voltage range	6V to 30V DC
Current	Typically 560mA

Environmental and physical	
Weight	Approx500 grammes
Size	119mm x 128mm x 30mm
Operating temperature	-30°C to +60°C
Storage temperature	-40°C to +80°C
Industrial Protective Class (with case closed)	IP 64

Definitions

** CEP = Circle of Error Probable
95% CEP (Circle Error Probable) means 95% of the time the position readings will fall within a circle of the stated diameter

*** Note that for comparison, the VBOX YAW02 or IMU rate sensor has an RMS noise of 0.05 degrees per second, so it should be noted that the Slip Angle sensor calculated YAW rate is significantly noisier than a solid state sensor for yaw rate measurement.

Outputs

CAN Bus	Format; Motorola
Bit rate	125Kbit/s, 250Kbit/s, 500Kbit/s & 1Mbit/s selectable baud rate
Identifier type	Standard 11bit or extended 2.0A
Data available	Satellites in View, Latitude, Longitude, Velocity, Heading, Altitude, Vertical velocity, Distance, Longitudinal acceleration & lateral acceleration, Distance from trigger, Trigger time, trigger Velocity, True heading, Slip angle, Pitch Angle, Yaw Rate, Lateral Velocity, Roll Angle

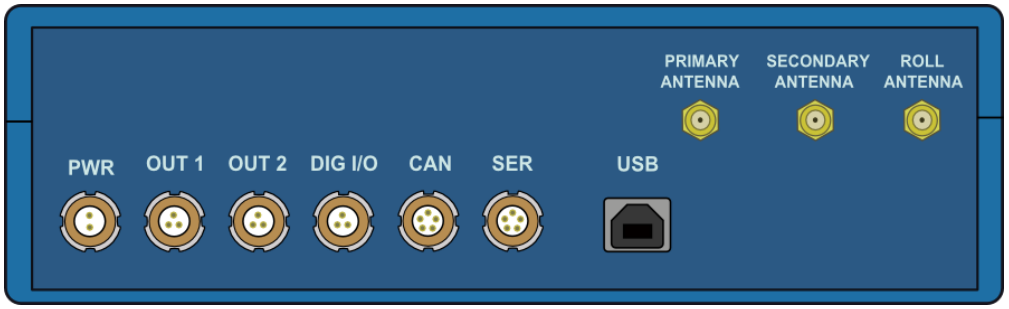
Analogue		**Digital**	
Voltage range	–5V to 5V DC	Frequency range	DC to 44.4Khz
Default setting *	Velocity 0.0125Volts per Km/h (0 to 400Km/h)	Default setting *	25Hz per Km/h (0 to 400Km/h)
Accuracy	0.1 Km/h		90 pulses per metre
Update rate	20Hz	Accuracy	0.1Km/h
		Update rate	20Hz

** The range settings can be adjusted by the user in software or via the front panel buttons*

Inputs

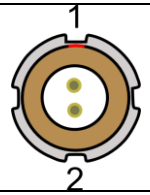
CAN Bus	Format: Motorola
VCI CAN mode	Up to 16 channels from any external CAN module
Racelogic modules mode	Up to 20 channels from any combination of ADC02, ADC03, FIM02, TC8, Yaw sensor or CAN01
Digital	
Brake/Event Trigger	Selectable signal polarity. 16bit timer capture with 5µs resolution
On/Off Logging control	Remote log control from hand-held switch

Connector Assignments



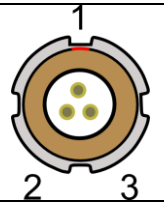
Connector 1 POWER (Dedicated 4.5V to 36V DC Power Connector)

Pin	I/O	Function
1	I	Power +
2	I	Ground
Chassis	I	Ground



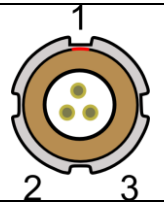
Connector 2 / 3 – OUT 1 / OUT 2 (One Analogue and One Digital Output Each)

Pin	I/O	Function
1	O	Analogue Out 1 / 2
2	O	Digital Out 1 / 2
3	I	Ground
Chassis	I	Ground



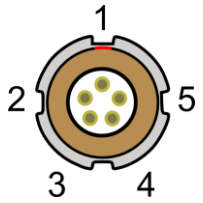
Connector 4 – DIG I/O (Wheel Speed and Brake Trigger Inputs)

Pin	I/O	Function
1	I	Wheel Speed (not available yet)
2	I	NC
3	I	Brake Trigger
Chassis	I	Ground



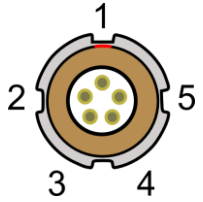
Connector 5 – CAN (First CAN Bus Connector, Serial Connection to GPS Engine)

Pin	I/O	Function
1	O	RS232 Tx GPS (Tx Data from GPS engine)
2	I	RS232 Rx GPS (Rx Data to GPS engine)
3	I/O	CAN High (Also direct connection to Connector 6 CAN High)
4	I/O	CAN Low (Also direct connection to Connector 6 CAN Low)
5	I/O	Power +
Chassis	I	Ground



Connector 6 – SERIAL (Setup / Upgrade, Second CAN Bus Connector)

Pin	I/O	Function
1	O	RS232 Tx Serial Data transmit
2	I	RS232 Rx Serial Data receive
3	I/O	CAN High (Also direct connection to Connector 5 CAN High)
4	I/O	CAN Low (Also direct connection to Connector 5 CAN Low)
5	I/O	Power +
Chassis	I	Ground



Connector 7 – USB (Setup / Upgrade)

Pin	I/O	Function
1		
2	I/O	USB–
3	I/O	USB+
4	I/O	Ground
Chassis	I	Ground

Connector 8 / 9 / 10 – PRIMARY ANTENNA / PITCH ANTENNA / ROLL ANTENNA (Antennae)

Pin	I/O	Function
1	I	Signal
Chassis	I	Ground

CAN Bus Data Format

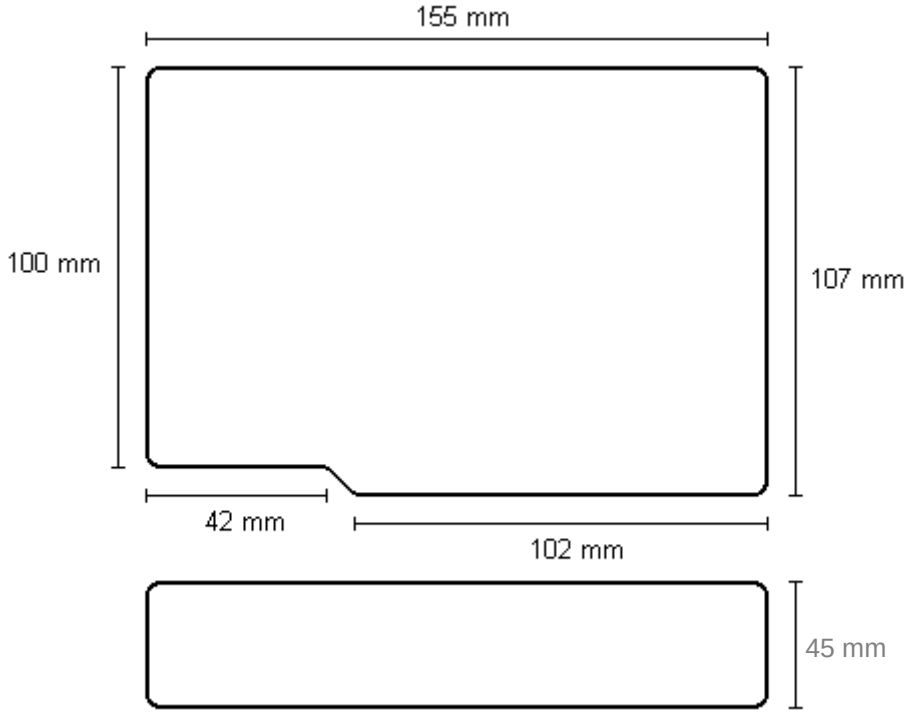
Format		Motorola							
ID*	Update Rate	Data Bytes							
		1	2	3	4	5	6	7	8
0x301	50ms	(1) Sats in view	(2) Time since midnight UTC			(3) Position – Latitude DDMM.MMMMM			
0x302	50ms	(4) Position – Longitude DDMMM.MMMMM				(5) Velocity. (Knots)		(6) Heading (Degrees)	
0x303	50ms	(7) Altitude. WGS 84. (Metres)			(8) Vertical velocity. (M/S)		Unused	(9) Status	(10) Status
0x304	50ms	(11) Distance. (Metres)				(12) Longitudinal Accel. (G)		(13) Lateral Accel. (G)	
0x305	50ms	(14) Distance travelled since VBOX reset (Metres)				(15) Trigger time		(16) Trigger Velocity (Knots)	
0x306	50ms	Unused		(17) True Heading (Degrees)		(18) Slip Angle (degrees)		(19) Pitch Angle (Degrees)	
0x307	50ms	(20) Lateral Velocity (Knots)		(21) Yaw Rate (Degrees/S)		(22) Roll Angle (degrees)		Unused	

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

(1) If Satellites in view < 3 then only Identifier 0x301 transmitted and bytes 2 to 8 are set to 0x00.
(2) Time since midnight. This is a count of 10ms intervals since midnight UTC. (5383690 = 53836.90 seconds since midnight or 14 hours, 57 minutes and 16.90 seconds).
(3) Position, Latitude * 100,000 (515924579 = 51 Degrees, 59.24579 Minutes North). Latitude highest bit indicates north/south hemisphere. 0=north, 1=south, Bit 7 in Status is also set.
(4)Position, Longitude * 100,000 (5882246 = 0 Degrees, 58.82246 Minutes West). Longitude highest bit indicates east/west of Greenwich meridian. 0=west,1=east. Bit 6 in Status is also set.
(5) Velocity, 0.01 knots per bit.
(6) Heading, 0.01° per bit.
(7) Altitude, 0.01 meters per bit, signed.
(8) Vertical Velocity, 0.01 m/s per bit, signed.
(9) Status. 8 bit unsigned char. Bit 0=VBOX Lite, Bit 1=Open or Closed CAN Bus (1=open), 2=VBOX3.
(10) Status is an 8 bit unsigned char. Bit 0 is always set, Bit 3=brake test started, Bit 4 = Brake trigger active, Bit 5 = DGPS active.
(11) Distance, 0.000078125 meters per bit, unsigned.
(12) Longitudinal Acceleration, 0.01G per bit, signed.
(13) Lateral Acceleration, 0.01G per bit, signed.
(14) Distance travelled in meters since VBOX reset.
(15) Time from Trigger event to Zero Km/h.
(16) Velocity at brake trigger point in Knots.
(17) True Heading of vehicle, 16-bit signed integer * 100.
(18) Slip Angle, 16-bit signed integer * 100.
(19) Pitch Angle, 16-bit signed integer * 100.
(20) Lateral Velocity, 16-bit signed integer * 100.
(21) Yaw Rate, 16-bit signed integer * 100.
(22) Roll Angle, 16-bit signed integer * 100

The VBOX CAN database is available in Vector Database (DBC File) format from the Racelogic VBOX website.

Module Dimensions



Fuse Reset Button

The VB20SL3 contains a fuse to protect it from excessive currents. If the unit is accidentally subjected to large currents and the fuse has become tripped, it can be reset by pressing the button marked ‘Fuse Reset’ all the way into the unit with a long, thin implement.

Contact Information

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Web: www.racelogic.co.uk

Revision	Date	Description	Author
1	18/08/07	First release	KB
2	03/12/07	Addition of Format: Motorola to CAN Bus Data Format table	NT
3	29/04/08	Inventory removed, address corrected.	KB
4	30/04/08	Updated Racelogic contact information	JH
5	18/06/08	Added VCI mode, additional menu options and updated menu parameters	NT
6	19/01/12	Updated Inventory, Images and general content	LN