SPEEDBOX
Reference Manual

Version 1.4

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1. Introduction

This manual is intended to provide all the information required for integration of a SPEEDBOX unit in to an existing data logging system. It does not cover the general operation of the unit which is fully covered in the SPEEDBOX Instruction manual.

1.1. Product Overview

The SPEEDBOX is the second generation of GPS-Inertial speed measurement system from Race-Technology. The SPEEDBOX combines data from GPS and inertial sensors to provide a full 200Hz speed update rate with outputs on RS232, CAN, digital pulse or analogue.
The RTK option enables the SPEEDBOX to provide high accuracy slip angle, pitch and yaw measurements.
The SPEEDBOX includes 4 high resolution analogue inputs/outputs, CAN bus output, and dual serial ports. All inputs and outputs are configurable from the dedicated PC software supplied.

Figure 1: SPEEDBOX general arrangement

1.2. Applications

The SPEEDBOX is designed to be used as a sensor head either for direct connection to a PC or to an additional data logging system, primarily for OEM testing and high-end motorsport applications, or anywhere a high accuracy real time speed measurement is required. OEM applications are not limited to the automotive industry; units are already in use in the rail industry and other applications have been identified.

1.3. Standard Features

The main feature of the SPEEDBOX is the 200Hz high accuracy speed output derived from combined accelerometer and GPS speed data. Key features of the SPEEDBOX include:

- High accuracy 200Hz speed output.
- 20Hz GPS speed and position output
- 3 Axis acceleration measurements. .
- Optional internal IMU.
- SPI Expansion port.
- Dual serial ports (3 output modes)
- CAN output port
- 4 x Analogue input / output ports
- Brake / event trigger input
- Wide 7-30v supply range
- Extremely low latency (2-3ms)
- Low power (3w)

2. Port / Connector details

2.1. Analogue Ports

Four ports which can be configured as inputs or outputs. Output levels are -5V to 5V with a 50Ω load, or -10V to 10V with infinite impedance. The four channels can be chosen from:

Combined speed
Longitudinal acceleration
Lateral acceleration
Local Z axis acceleration
GPS heading
GPS gradient
GPS speed
GPS speed accuracy
GPS number of satellites in solution
GPS derived lateral acceleration
GPS derived motorcycle lean angle

2.1.1. With RTK option:

RTK yaw
RTK pitch
RTK slip
RTK baseline
RTK accuracy

2.1.2. With IMU option:

Yaw rate
Pitch rate
Roll rate

When configured as inputs the channels have a range of 0-16V.

2.2. Pulse Output

The SPEEDBOX has a digital pulse output with frequency proportional to combined speed (0-5v). Pulse timing characteristics are user-configurable to allow the SPEEDBOX to act as a drop-in replacement for a wide range of '5th wheel' devices.

Alternatively, the pulse output can be configured to output a time pulse which is precisely synchronised to GPS time, the timepulse is output once per second, at a 50% duty cycle.

2.3. Trigger Input

A trigger input allows synchronisation of the SPEEDBOX output with external events, such as pedal depression, or passing a marker point, such as a laser barrier. The trigger may be configured to either turn the outputs on/off or to send accurate time stamps on the serial port and/or the CAN port.

The RS232 timing message can be used in conjunction with the PC based timing software to give external trigger based timings for test start and end points.

2.4. CAN Output

The SPEEDBOX CAN outputs can be set up for the Race Technology standard CAN output addresses, or can be configured for user defined addresses and rates. Can database (.dbc) files are available for the standard configuration. Full CAN message details are provided in the appendix.

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2.5. RS232 / USB Output

Two serial outputs and one USB port are available. When in use the USB port disables serial port 1.

Serial 1 and 2 output binary messages in uBlox format, ASCII messages in NMEA format, and binary Race Technology format messages. In addition to configuration by the Race Technology configuration software, the uBlox message can also be configured using the uCenter software tool available free of charge from uBlox.

2.6. PC based measurement

In addition to using the SPEEDBOX as a sensor head with a data logging system, the SPEEDBOX can be connected directly to a PC for live data recording via serial or USB as well as real time performance measurements using the dedicated Performance Monitor software.

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3. SPEEDBOX Specification

Specification SPEEDBOX		
Parameter	**Value**	
High accuracy non-interpolated combined speed output	200Hz	
Raw acceleration output	200Hz	
GPS receiver	Race Technology *Pure***Phase**	
Raw GPS output	20Hz	
Typical GPS positional accuracy*	3m CEP	
Optimum GPS positional accuracy*	1m CEP	
Typical combined speed output accuracy*	0.05 kph	
Accelerometer	3-axis, high precision, 0.0039g resolution, 2 or 6g range	
Power supply	9-36v 2.4W (RTK option 3W, IMU option 2.9W)	
Weight	800g	
Dimensions	199mm x 135mm x 43mm	
Pulse output	Either: Speed pulse: 0-5V, 10-100μS high time or 50% duty cycle, 1-400 pulses per meter. Frequency range DC – 50kHz Or Time pulse: 0-5V, 1Hz @ 50% duty cycle, precisely synchronised to GPS time.	
Analogue output	Up to 4, -5 to 5V @ 50Ω load, -10 to 10V @ infinite impedance	
Analogue inputs	0-16V single ended, 16 bit resolution	
Connectors	RS232 ports CAN Expansion port (front) Expansion port (back) Analogue ports Power Trigger input Pulse output GPS antenna	9 way male D-type 9 way male D-type 9 way male D-type 9 way male D-type LEMO 0B 4 pin LEMO 0B 2 pin BNC female BNC female SMA female
Antennas	3.3V active antenna	

- GPS speed can be calculated far more accurately than GPS position data. It is impossible to quote absolute positional accuracies of GPS systems simply because accuracy depends on satellite coverage, weather, antenna mounting, tree and building coverage, etc. The figures above represent typical real-world performance.

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3.1. IMU option specifications

Technical Specification Gyroscopes					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
GYROSCOPE SENSITIVITY	Each axis				
Initial sensitivity	25°C, dynamic range = ± 300°/s	0.0725	0.07326	0.0740	°/s/LSB
	25°C, dynamic range = ± 150°/s		0.03663		°/s/LSB
	25°C, dynamic range = ± 75°/s		0.01832		°/s/LSB
Temperature coefficient			40		ppm/°C
Gyroscope axis nonorthogonality	25°C, difference from 90° ideal		±0.05		Degree
Gyroscope axis misalignment	25°C, relative to base-plate and guide pins		±0.5		Degree
Nonlinearity	Best fit straight line		0.1		% of FS
GYROSCOPE BIAS					
In run bias stability	25°C, 1σ		0.015		°/s
Angular random walk	25°C		4.2		°/√hr
Temperature coefficient			0.01		°/s/°C
Linear acceleration effect	Any axis, 1σ		0.05		°/s/*g*
GYROSCOPE NOISE PERFORMANCE					
Output noise	25°C, ± 300°/s range, 2-tap filter setting		0.60		°/s rms
	25°C, ± 150°/s range, 8-tap filter setting		0.35		°/s rms
	25°C, ± 75°/s range, 32-tap filter setting		0.17		°/s rms
Rate noise density	25°C, f= 25 Hz, ± 300°/s, no filtering		0.05		°/s/√Hz rms
GYROSCOPE FREQUENCY RESPONSE					
3 dB bandwidth			350		Hz
Sensor resonant frequency			14		kHz

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Technical Specification Accelerometers					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
ACCELEROMETER SENSITIVITY	Each axis				
Dynamic range		±8	±10		*g*
Initial sensitivity	25°C	2.471	2.522	2.572	m*g*/LSB
Temperature coefficient			40		ppm/°C
Axis nonorthogonality	25°C, difference from 90° ideal		±0.25		Degree
Axis misalignment	25°C, relative to base-plate and guide pins		±0.5		Degree
Nonlinearity	Best fit straight line		±0.2		% of FS
ACCELEROMETER BIAS					
In-run bias stability	25°C, 1σ		0.7		m*g*
Velocity random walk	25°C		2.0		m/s/√hr
Temperature coefficient			0.5		m*g*/°C
ACCELEROMETER NOISE PERFORMANCE					
Output noise	25°C, no filtering		35		m*g* rms
Noise density	25°C, no filtering		1.85		m*g*/√Hz rms
ACCELEROMETER FREQUENCY RESPONSE					
3 dB bandwidth			350		Hz
Sensor resonant frequency			10		kHz

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4. Vehicle Installation and Setup

The unit must be mounted flat and level in order to give accurate acceleration readings. In addition, the unit must be mounted in the correct orientation. Orientate the unit using the marked "direction of travel" arrow. Mounting angle errors of up to 20° can be accommodated with reduced accuracy.

GPS speed and position readings are unaffected by unit mounting position. The GPS unit requires a 3.3V active antenna (supplied) which must be mounted in a position giving a good view of the sky. On top of the vehicle is recommended. Care should be taken not to crush the antenna lead with the vehicle window or door closure.

For the standard SPEEDBOX, GPS1 is the GPS antenna connection.

The SPEEDBOX-RTK unit requires two antennas. Both antennas must be mounted on the roof of the vehicle, on the vehicle centre line, in the same orientation, and the distance between them must be as close as possible to the RTK baseline distance set up in the unit by the configuration program. Note especially that **the antenna that is connected to GPS1 (the "base" antenna) must be to the rear of the antenna that is connected to GPS2 (the "moving" antenna).** The SPEEDBOX-RTK may optionally be supplied with a magnetic-mounting dual antenna strip, containing 2 low-noise antennas mounted 800mm apart on a flexible magnetic mounting strip. The direction of travel is clearly marked on the magnetic strip, and must be followed.

Figure 3 shows the antenna mounting arrangement for the SPEEDBOX-RTK, and the following set of guidelines describe the antenna mounting requirements in more detail. They **must** be followed in order to obtain optimal operation from the MB-RTK system.

- Both antennas must be on the roof of the car, mounted flat on metal. The metal under the antenna acts as a "ground plane" for the antenna and is important for correct operation of the antenna.
- The antennas must be mounted on the centre line of the vehicle
- The antennas must be within 2-3cm of the distance set in the configuration utility. The closer to the initial estimate that the antennas are placed, the faster and more reliable the initial lock-on will be.
- The antennas must be in the same orientation, so the cables should exit in the same direction – for example the cables from both antennas should exit towards the rear of the car.
- Both antennas should be of the same make and model.
- The antennas are magnetic mounting, do not use additional tape over the antennas to hold them down. Some adhesive tapes completely block the GPS signal.
- Care should be taken not to crush the antenna lead with the vehicle window or door closure.
- It is essential that both antennas are mounted on the roof of the vehicle.

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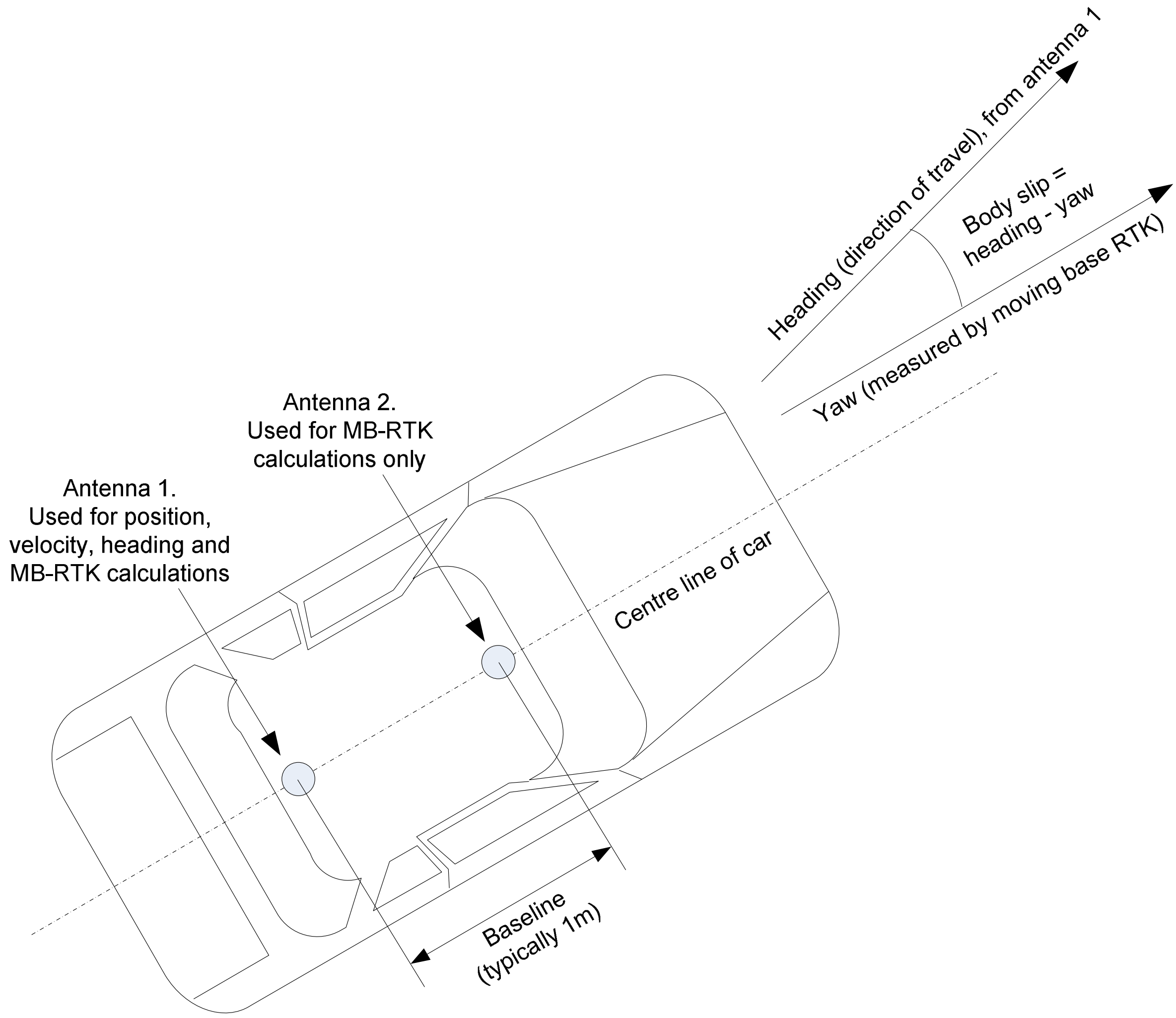

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Figure 3: MB-RTK antenna mounting location and angular outputs

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5. Dimensions

The physical dimensions of the SPEEDBOX are shown below in Figure 6. The mounting hole dimensions are shown in Figure 7. The mounting holes are sized to take an M4 socket cap or pan head machine screw.

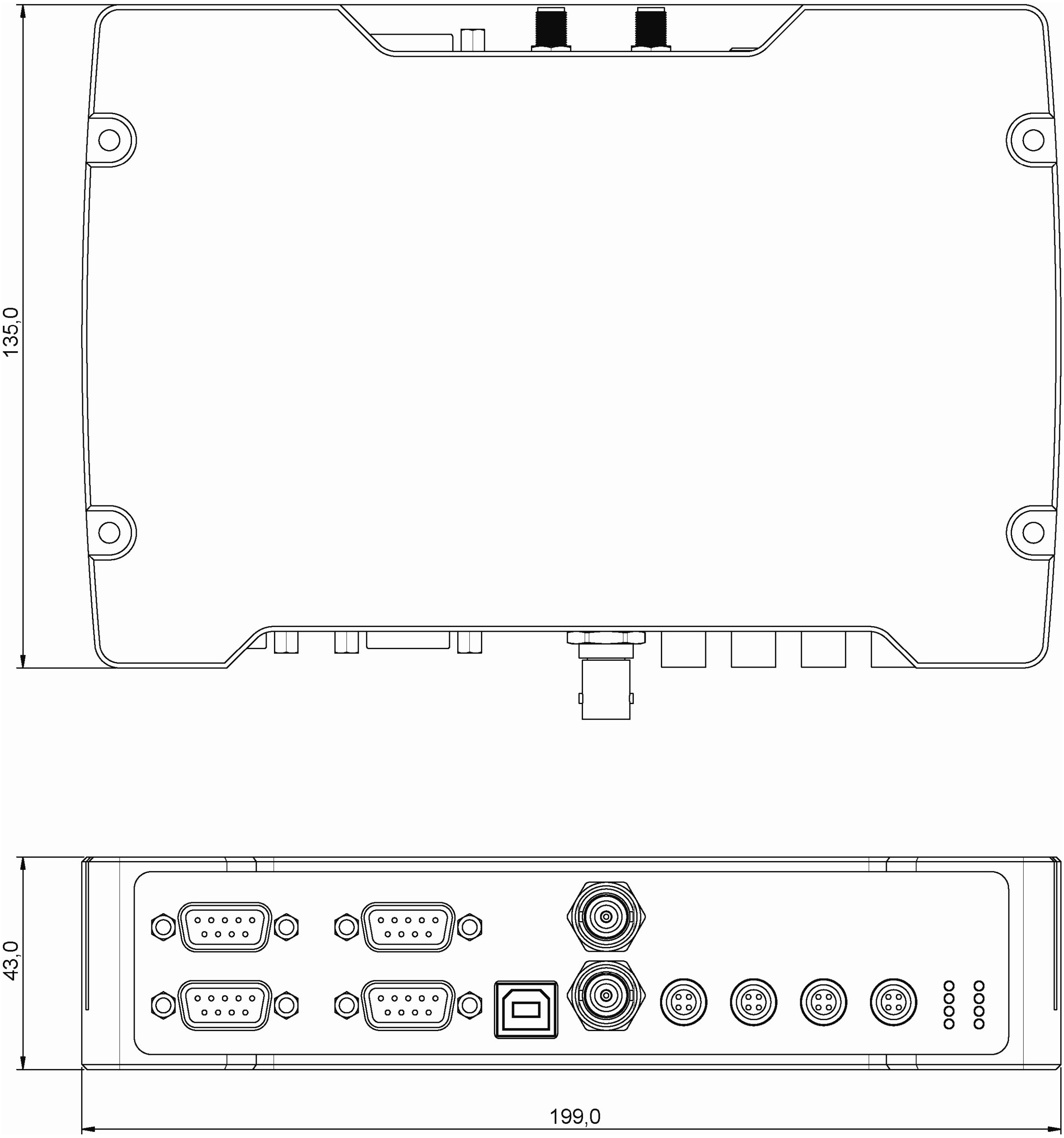

Figure 6: SPEEDBOX physical dimensions.

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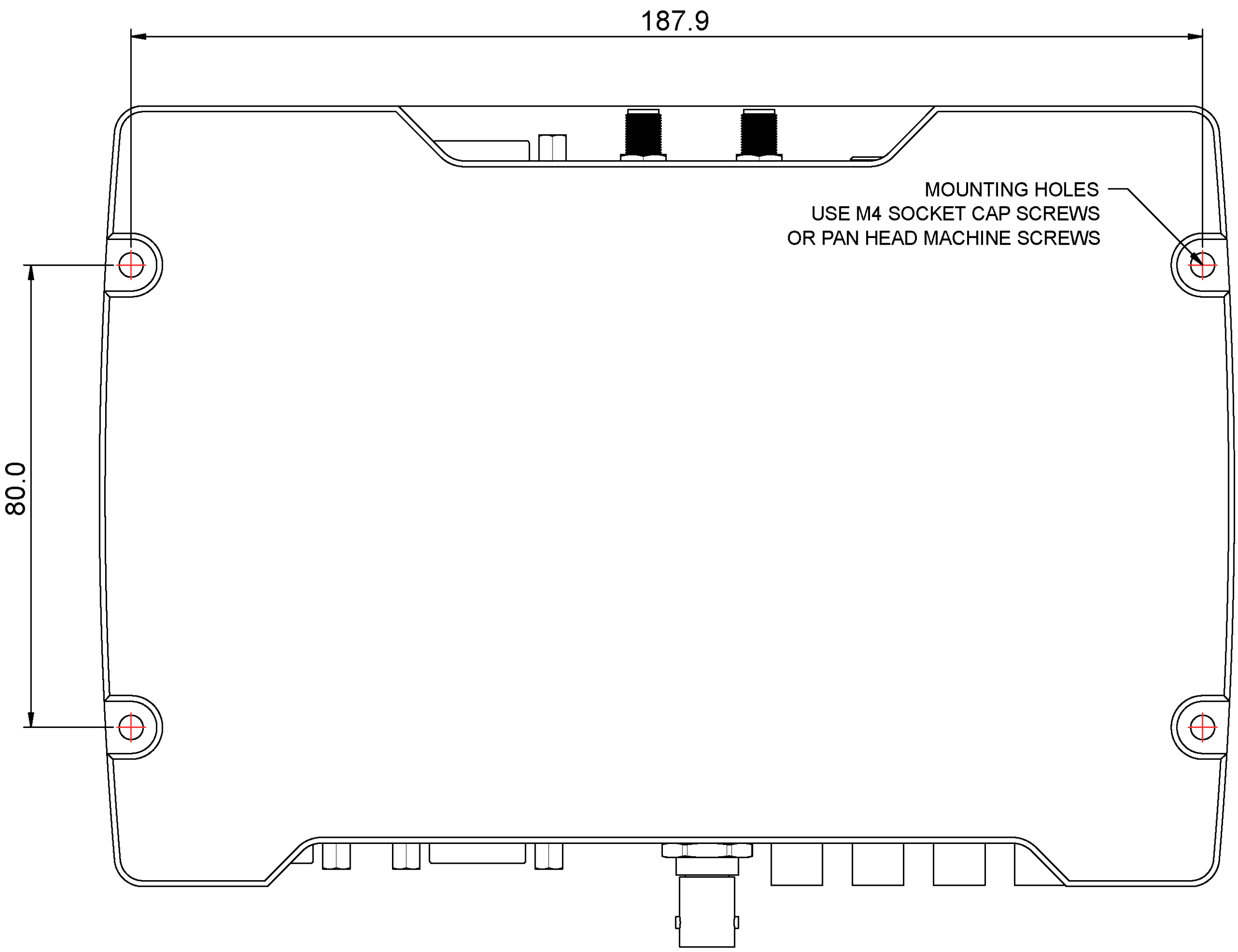

Figure 7: SPEEDBOX mounting detail.

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6. Connector details (Front panel)

6.1. Serial ports 1 and 2

9 way d-type male connector

Serial 1 and 2 connector pinout details	
Pin	**Function**
1	NC
2	Receive
3	Transmit
4	Secondary Transmit*
5	GND
6	Secondary Receive*
7	Power in +12V supply
8	NC
9	NC

*The secondary transmit and receive ports are not implemented presently, these pins should be left as NC.

6.2. Pulse output

BNC 50 ohm connector

Pulse output connector details		
Centre	Signal	0=0V 1=5V max 5mA
Shield	GND	

6.3. Trigger input

BNC 50 ohm connector

Pulse output connector details		
Centre	Signal	<2.5V=low. Internal pullup to 5V
Shield	GND	

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6.4. CAN port

9 way d-type male connector

CAN port connector pinout details	
Pin	**Function**
2	CAN L
7	CAN H
Termination	None Fitted
Dominant bit	>2.5V difference
Recessive bit	<0.9V difference

NOTE: No internal CAN termination is fitted within the SPEEDBOX, **it is essential that the user fits appropriate termination if required.** In general, if the SPEEDBOX is at one end of a two node CAN network with a CAN logging device at the other end, then the SPEEDBOX will need to be fitted with a 120Ω resistor between CAN H and CAN L in the cabling used to attach it to the network.

6.5. Expansion port

Both front and rear expansion ports have the same pinout, they are connected in parallel.
9 way d-type male connector

Expansion port connector pinout details		
Pin	**Function**	**Voltage range**
1	SPI clock	0-5V
2	SPI in	0-5V
3	SPI out	0-5V
4	SPI chip select	0-5V
5	GND	
6	External GPIO	0-5V
7	+16V supply	
8	Timepulse output	0-5V
9	External interrupt	0-16V transition level approx 1V, internal pullup

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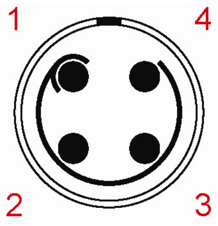
6.6. Analogue input

LEMO 4 pin connector part number FGG.0B.304.CLAD52Z



Analogue connectors pinout details		
Pin	**Function**	**Voltage range**
1	Signal ground	
2	Input/Output	-5 to +5V output (50Ω impedance) -10 to +10V output (infinite impedance) 0-16V input
3	NC	
4	NC	

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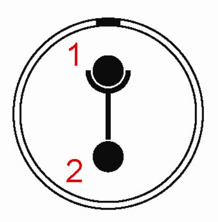
7. Connector Details (Rear panel)

7.1. Power connector

LEMO 2 pin connector part number FGG.0B.302.CLAD52Z



Power connector pinout details	
Pin	**Function**
1	+ve
2	GND

7.2. Antenna 1 and 2

SMA 3.3v feed to antennas

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8. LED Functions

Timepulse (yellow)
Flashes at 1Hz 50% duty cycle when the GPS receiver has a lock, the falling edge of the output is precisely synchronised with the second boundaries of GPS time. I.E. LED is lit for the second half of each second.

Trigger (blue)
When the trigger LED is on the triggered output is active

SBAS (yellow)
Indicates the SBAS correction status of the GPS solution. Not currently implemented.

Error (red)
Flashes to indicate different error conditions, number of flashes as follows:

1 GPS module 1 failure
2 GPS module 2 failure
3 GPS antenna 1 short circuit
4 GPS antenna 2 short circuit

More than one error can be present at one time, so a series of 3 flashes followed by 4 flashes would signify both error conditions 3 and 4 are present.

Power (red)
On when power is applied to the unit and the unit has started up correctly. This LED will then turn off briefly once per second as long as the firmware is running correctly. If the LED ceases to blink off once per second and instead remains continuously on, this is an indication that the unit has "frozen" and will need power-cycling to resume normal operation.

Status (green)
Off - No GPS lock.
Short flashes at 1Hz - GPS lock, but no carrier speed.
Long (50% duty cycle) flashes at 1Hz - GPS lock with carrier lock.
Continuously on (RTK unit only) - RTK lock.

GPS Status 1 (green)
On when GPS receiver 1 has a lock.

GPS Status 2 (green)
On when GPS receiver 2 has a lock (RTK version only).

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9. Data available in each output mode

The following table details which sections of data are available in each mode. RT, NMEA nd uBLOX are the RS232 output modes:

Key to Annotations:

N*	These outputs are not required in RT format, since they are automatically calculated from other variables in the RT Analysis software.
N**	Some GPS status information is output, but not all of the internal Speedbox GPS status can be described by these formats.

		CAN	ANALOG	RT	NMEA	uBLOX
INERTIAL	Combined Speed	Y	Y	Y	Y	N
	Accel X	Y	Y	Y	Y	N
	Accel Y	Y	Y	Y	Y	N
	Accel Z	Y	Y	Y	Y	N
	Total Distance	Y	N	N	N	N
	Distance reset by trigger	Y	N	N	N	N
	Trigger timestamp	Y	N	Y	N	N
IMU Only	Yaw rate	Y	Y	Y	Y	N
	Roll rate	Y	Y	Y	Y	N
	Pitch rate	Y	Y	Y	Y	N
GPS	Position Long/Lat/Alt	Y	N	Y	Y	Y
	Position ECEF XYZ	Y	N	N	N	Y
	Position UTM	N	N	N	N	N
	Velocity ENU or NED	Y	N	Y	N	Y
	Velocity ECEF XYZ	Y	N	N	N	Y
	GPS raw speed 2D	Y	N	N	Y	Y
	GPS raw speed 3D	Y	Y	Y	Y	Y
	Heading	Y	Y	Y	Y	Y
	Gradient	Y	Y	Y	Y	N
	GPS-derived lat accel	Y	Y	N	N	N
	GPS-derived m/cycle lean angle	Y	Y	N	N	N
	Number of satellites	Y	Y	N	Y	Y
	Speed Accuracy	Y	Y	Y	Y	Y
	Position Accuracy	Y	N	Y	Y	Y
	Heading Accuracy	Y	N	Y	Y	Y
	GPS Status	Y	N	N	N**	N**
	Time GPS	Y	N	Y	N	Y
	Time UTC	N	N	N	Y	Y
	Antenna Status	N	N	N	N	Y
	Satellite details (position and signal strength)	N	N	N	Y	Y
	Residuals	N	N	N	Y	N
RTK Only	MB-RTK Yaw	Y	Y	Y	Y	N
	MB-RTK Pitch	Y	Y	Y	Y	N
	MB-RTK Slip	Y	Y	N*	N	N
	MB-RTK Squat	Y	N	N*	N	N
	MB-RTK Baseline	Y	Y	Y	Y	N
	MB-RTK Accuracy	Y	Y	Y	Y	N
	MB-RTK Status	Y	N	N	N	N
Other	Analog input voltages	N	N	Y	N	N
	X, Y position offset from initial location	N	N	Y	N	N

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10. RS232 outputs

The general specifications of the serial ports are as shown in the table below.
NOTE: Serial port 1 is disabled when the USB connector is attached.

Serial output general specification	
Voltage levels	RS232
Data rate	4800 – 921600 baud (Serial 1) 4800 – 921600 baud (Serial 2)
Word length	8 bits
Parity bit	None
Start bit	1
Stop bit	1
Flow control	None

10.1. NMEA

All NMEA messages can be configured for transmission on either port at up to 20Hz, except the speed only version of GPVTG which can be transmitted at up to 200Hz.

The NMEA messages are based on the NMEA2.3 standard.

An NMEA checksum is calculated as the XOR of bytes between (but not including) the dollar sign and asterisk

10.1.1. GPGGA

Essential fix data which provide 3D location and accuracy data.

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

Where:

GGA	Global Positioning System Fix Data
123519	Fix taken at 12:35:19 UTC
4807.038,N	Latitude 48 deg 07.038' N
01131.000,E	Longitude 11 deg 31.000' E
1	Fix quality: 0 = invalid 1 = GPS fix (SPS)
08	Number of satellites being tracked
0.9	Horizontal dilution of position
545.4,M	Altitude, Meters, above mean sea level
46.9,M	Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field)	Time in seconds since last DGPS update
(empty field)	DGPS station ID number
*47	Checksum data, always begins with *

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10.1.2. GPGLL

Geographic latitude and longitude

$GPGLL,4916.45,N,12311.12,W,225444,A,A,*1D

Where:

GLL	Geographic position, Latitude and Longitude
4916.46,N	Latitude 49 deg. 16.45 min. North
12311.12,W	Longitude 123 deg. 11.12 min. West
225444	Fix taken at 22:54:44 UTC
A	Data Active or V (void)
A	Mode, A=GPS + Accelerometer, N= accelerometer only
*iD	checksum data

10.1.3. GPGSA

GPS DOP and active satellites. This sentence provides details on the nature of the fix. It includes the numbers of the satellites being used in the current solution and the DOP. DOP (dilution of precision) is an indication of the effect of satellite geometry on the accuracy of the fix. It is a unitless number where smaller is better. For 3D fixes using 4 satellites a 1.0 would be considered to be a perfect number, however for over determined solutions it is possible to see numbers below 1.0.

$GPGSA,A,3,04,05,,09,12,,,24,,,,,2.5,1.3,2.1*39

Where:

GSA	Satellite status	
A	Auto selection of 2D or 3D fix (M = manual)	
3	3D fix - values include:	1 = no fix
		2 = 2D fix
		3 = 3D fix
04,05...	PRNs of satellites used for fix (space for 12)	
2.5	PDOP (dilution of precision)	
1.3	Horizontal dilution of precision (HDOP)	
2.1	Vertical dilution of precision (VDOP)	
*39	the checksum data, always begins with *	

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10.1.4. GPGSV

Satellites in View shows data about the satellites that the unit might be able to find based on its viewing mask and almanac data. It also shows current ability to track this data. Note that one GSV sentence only can provide data for up to 4 satellites and thus there may need to be 3 sentences for the full information. The GSV sentence to contain more satellites than GGA might indicate since GSV may include satellites that are not used as part of the solution. It is not a requirement that the GSV sentences all appear in sequence.

$GPGSV,2,1,08,01,40,083,46,02,17,308,41,12,07,344,39,14,22,228,45*75

Where:

GSV	Satellites in view
2	Number of sentences for full data
1	sentence 1 of 2
08	Number of satellites in view
01	Satellite PRN number
40	Elevation, degrees
083	Azimuth, degrees
46	SNR - higher is better
for up to 4 satellites per sentence	
*75	the checksum data, always begins with *

10.1.5. GPRMC

The Recommended Minimum, which will look similar to:

$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W,A*6A

Where:

RMC	Recommended Minimum sentence C
123519	Fix taken at 12:35:19 UTC
A	Status A=active or V=Void.
4807.038,N	Latitude 48 deg 07.038' N
01131.000,E	Longitude 11 deg 31.000' E
022.4	3D speed in knots (NOTE: Standard NMEA message is speed over ground)
084.4	Track angle in degrees True
230394	Date - 23rd of March 1994
003.1,W	Magnetic Variation
A	Mode, A=GPS + Accelerometer, N= accelerometer only
*6A	The checksum data, always begins with *

10.1.6. GPVTG

Velocity made good.

$GPVTG,054.7,T,034.4,M,005.5,N,010.2,K,A*48

where:

VTG	Track made good and ground speed
054.7,T	True track made good (degrees)
034.4,M	Magnetic track made good
005.5,N	3D speed in knots (NOTE: Standard NMEA message is speed over ground)
010.2,K	3D speed in KPH (NOTE: Standard NMEA message is speed over ground)
A	Mode, A=GPS + Accelerometer, N= accelerometer only
*48	Checksum

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10.1.7. GPGRS

GPS Range Residuals
Example: $GPGRS,024603.00,1,-1.8,-2.7,0.3,,,,,,,,,*6C
Where:

GRS	Range residuals
024603	UTC time of associated GGA fix
1	Mode 0 = residuals used in GGA 1 = residuals calculated after GGA
-1.8	Residual (meters) of satellite 1 in solution
-2.7	Residual (meters) of satellite 2 in solution
0.3	Residual (meters) of satellite 3 in solution
*6C	Checksum

Unused entries are blank, the order matches the PRN number in the GSA sentence

10.1.8. GPGST

GPS Pseudorange Noise Statistics

Example: $GPGST,024603.00,3.2,6.6,4.7,47.3,5.8,5.6,22.0*58

Where:

GST	Pseudorange noise statistics
024603.00	UTC time of associated GGA fix
3.2	Total RMS standard deviation of ranges inputs to the navigation solution
6.6	Standard deviation (meters) of semi-major axis of error ellipse
4.7	Standard deviation (meters) of semi-minor axis of error ellipse
47.3	Orientation of semi-major axis of error ellipse (true north degrees)
5.8	Standard deviation (meters) of latitude error
5.6	Standard deviation (meters) of longitude error
22.0	Standard deviation (meters) of latitude error
*58	Checksum

10.1.9. GPZDA

Data and Time

$GPZDA,201530.00,04,07,2002,00,00*60

Where:

201530.00	Hours minutes seconds(UTC)
04	Day
07	month
2002	year
blank	local zone hours -13..13 (Not implemented)
blank	local zone minutes 0..59 (Not implemented)
*60	Checksum

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10.1.10. PRTLV

Race Technology message for 3D speed, it can be configured for transmission at up to 200Hz

$PRTLV,190214.930,000.30*7D

where:

RTLV	Race Technology kinematic velocity
190214.930	UTC time
000.30	3D speed in KPH
*7D	Checksum

10.1.11. PRTLA

Race Technology message for 3D acceleration readings, available at up to 200Hz

$PRTLA,190214.930,0.03,0.04,-1.00*6F

where:

RTLA	Race Technology 3D acceleration
190214.930	UTC time
0.03	X acceleration in G
0.04	Y acceleration in G
-1.00	Z acceleration in G
*6F	Checksum

10.1.12. PRTLT

Race Technology message for trigger time, available at up to 200Hz and on event

$PRTLT,190214.9307,5,1,2,3,4,5*6F

where:

RTLT	Race Technology trigger time
190214.9307	UTC time
5	Trigger number
1	Trigger edge: 0 falling edge 1 rising edge 2 currently high 3 currently low
*6F	Checksum

10.1.13. PRTLS

Race Technology message for GPS speed and direction of travel, available at up to 20Hz

$PRTLS,190214.95,3.54,3.65,1*6F

where:

RTLS	Race Technology velocity and speed
190214.95	UTC time
3.54	2D speed in kph
3.65	3D speed in kph
1	Direction indicator (1 for forwards, 0 for backwards)
*6F	Checksum

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10.1.14. PRTLH

Race Technology message for heading and gradient, available at up to 20Hz

$PRTLH,190214.95,0.04,23.32*83

where:

RTLH	Race Technology gradient and heading
190214.95	UTC time
0.04	Heading in degrees
23.32	Gradient in degrees
*83	Checksum

10.1.15. PRTLP

Race Technology message for speed, position and heading accuracy, available at up to 20Hz.

$PRTLP,190214.95,3.64,2.32,5.33*92

where:

RTLP	Race Technology accuracy figures
190214.95	UTC time
3.54	Speed accuracy in kph
2.32	Position accuracy in metres
5.33	Heading accuracy in degrees
*92	Checksum

10.1.16. PRTLR

Race Technology message for RTK information, available at up to 20Hz

$PRTLR,190214.95,3.54,1.32,812,76*92

where:

RTLR	Race Technology RTK data
190214.95	UTC time
3.54	RTK yaw in degrees
1.32	RTK pitch or roll in degrees
812	RTK baseline in mm
76	RTK accuracy in mm
*92	Checksum

Note, pitch or roll will depend on the installed orientation of the RTK strip.

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10.1.17. PRTLG

Race Technology message for gyro information (only with IMU option), available at up to 200Hz

```
$PRTLG,190214.930,3.5,2.3,13.5*43
```

where:

RTLG	Race Technology gyro readings
190214.930	UTC time
3.5	Yaw rate in degrees / second
2.3	Pitch rate in degrees / second
13.5	Roll rate in degrees / second
*43	Checksum

10.1.18. PRTLO

Race Technology message for current output status information, output at up to 200Hz

```
$PRTLO,190214.930,0,1,0,1,0,1,0,1*43
```

where:

RTLO	Race Technology output status
190214.930	UTC time
0	Analogue output 1 (1 active, 0 inactive)
1	Analogue output 2 (1 active, 0 inactive)
0	Analogue output 3 (1 active, 0 inactive)
1	Analogue output 4 (1 active, 0 inactive)
0	Pulse output (1 active, 0 inactive)
1	Serial output 1 (1 active, 0 inactive)
0	Serial output 2 (1 active, 0 inactive)
1	Trigger status (1 active, 0 inactive)
*43	checksum

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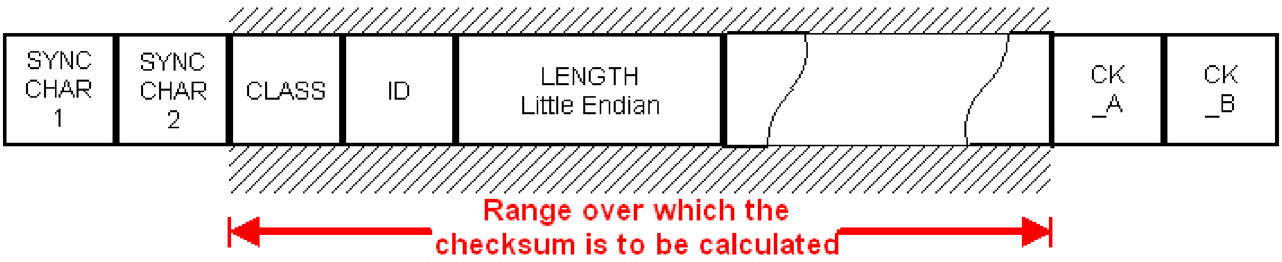
10.2.uBlox

All available uBlox messages can be configured at rates of up to 20Hz
All multi-byte values are ordered in Little Endian manner, unless mentioned otherwise. All floating point values are transmitted in IEEE754 single or double precision. A technical Description of the IEEE754 format can be found in the AnswerBook from the ADS1.x toolkit.
The following table gives information about the various values:

uBlox values					
Short	**Type**	**Size (bytes)**	**Comment**	**Min/Max**	**Res**
U1	Unsigned char	1		0..255	1
I1	Signed char	1	2's complement	-128..127	1
U2	Unsigned short	2		0..65535	1
I2	Signed short	2	2's complement	-32768..32767	1
U4	Unsigned long	4		0..4'294'967'295	1
I4	Signed long	4	2's complement	-2'147'483'648..2'147'483'647	1
R4	IEEE 754 single precision	4		-1*2^+127 .. 2^+127	~ value * 2^-24
R8	IEEE 754 double precision	8		-1*2^+1023 .. 2^+1023	~ value * 2^-53
CH	ASCII/ISO 8859.1 encoding	1			

The checksum is calculated over the packet, starting and including the CLASS field, up until, but excluding, the Checksum Field:



UBX Checksum Range

The checksum algorithm used is the 8-Bit Fletcher Algorithm, which is being used in the TCP standard (RFC 1145). This algorithm works as follows:

Buffer[N] contains the data over which the checksum is to be calculated.

The two CK_ values are 8-Bit Unsigned Integers, only! If you implement it with larger-sized integer values, make sure to Mask both CK_A and CK_B with 0xFF after both operations in the loop.

```
CK_A = 0, CK_B = 0
For(I=0;I<N;I++)
{
   CK_A = CK_A + Buffer[I]
   CK_B = CK_B + CK_A
}
```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10.2.1. NAV-POSECEF Position solution in ECEF

Message	**NAV-POSECEF**				
Description	**Position solution in ECEF**				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x01	20	20 bytes	CK_A CK_B
Payload contents:					

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	-	ECEF_X	cm	ECEF X coordinate
8	I4	-	ECEF_Y	cm	ECEF Y coordinate
12	I4	-	ECEF_Z	cm	ECEF Z coordinate
16	U4	-	PAcc	cm	Position accuracy estimate

10.2.2. NAV-POSLLH Geodetic position solution

Message	**NAV-POSLLH**				
Description	**Geodetic position solution**				
Comment	This message outputs the Geodetic position in the currently selected Ellipsoid. The default is the WGS84 Ellipsoid, but can be changed with the message CFG-DAT				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x02	28	28 bytes	CK_A CK_B
Payload contents:					

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	1e-7	LON	deg	Longitude
8	I4	1e-7	LAT	deg	Latitude
12	I4	-	HEIGHT	mm	Height above Ellipsoid
16	I4	-	HMSL	mm	Height above mean sea level
20	U4	-	HAcc	mm	Horizontal accuracy estimate
24	U4	-	VAcc	mm	Vertical accuracy estimate

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10.2.3. NAV-POSUTM Position solution in UTM (WGS84)

Message	**NAV-POSUTM**				
Description	**Position solution in UTM (WGS84)**				
Comment	Please note that: - UTM conversion does not output Zone Characters (i.e. the Northing Element of a Zone depression) - The UTM output does not support the irregularities in the UTM Grid in the Scandinavian and North Pole region				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x08	18	18 bytes	CK_A CK_B
Payload contents:					

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	-	EAST	cm	UTM Easting
8	I4	-	NORTH	cm	UTM Northing
12	I4	-	ALT	cm	Altitude
16	I1	-	ZONE	-	UTM Zone number
17	I1	-	HEM	-	Hemisphere Indicator (0=North, 1=South)

10.2.4. NAV-VELECEF Velocity solution in ECEF

Message	**NAV-VELECEF**				
Description	**Velocity solution in ECEF**				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x11	20	20 bytes	CK_A CK_B
Payload contents:					

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	-	ECEF VX	cm/s	ECEF X velocity
8	I4	-	ECEF VY	cm/s	ECEF Y velocity
12	I4	-	ECEF VZ	cm/s	ECEF Z velocity
16	U4	-	SAcc	cm/s	Speed accuracy estimate

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10.2.5. NAV-VELNED Velocity solution in NED

Message	**NAV-VELNED**				
Description	**Velocity solution in NED**				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x12	36	36 bytes	CK_A CK_B

Payload contents:

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	-	VEL_N	cm/s	NED north velocity
8	I4	-	VEL_E	cm/s	NED east velocity
12	I4	-	VEL_D	cm/s	NED down velocity
16	U4	-	Speed	cm/s	Speed (3D)
20	U4	-	GSpeed	cm/s	Ground speed (2D)
24	I4	1e-5	Heading	deg	Heading (2D)
28	U4	-	SAcc	cm/s	Speed accuracy estimate
32	U4	1e-5	CAcc	deg	Course/Heading accuracy estimate

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10.2.6. NAV-TIMEGPS GPS time solution

Message		**NAV-TIMEGPS**			
Description		**GPS time**			
Message structure		**Header**	**ID**	**Length**	**Payload**	**Checksum**
		0xB5 0x62	0x01 0x20	16	16 bytes	CK_A CK_B
Payload contents:					
Byte offset	**Number format**	**Scaling**	**Name**	**Unit**	**Purpose/Comment**
0	U4	-	ITOW	ms	GPS millisecond time of week
4	I4	-	Frac	ns	Nanoseconds remainder of rounded ms above, range -500000 .. 500000
8	I2	-	Week	-	GPS week (GPS time)
10	I1	-	LeapS	s	Leap Seconds (GPS-UTC)
11	U1	-	Valid	-	0x01 = Valid time of week 0x02 = Valid week number 0x04 = Valid UTC (Leap seconds already known?)
12	U4	-	TAcc	ns	Time accuracy estimate

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10.2.7. NAV-TIMEUTC UTC time

Message	**NAV-TIMEUTC**				
Description	**UTC time**				
Message structure	**Header**	**ID**	**Length**	**Payload**	**Checksum**
	0xB5 0x62	0x01 0x21	20	20 bytes	CK_A CK_B

Payload contents:

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	ITOW	ms	GPS millisecond time of week
4	U4	-	TAcc	ns	Time accuracy estimate
8	I4	-	Nano	ns	Nanoseconds of second, range -500000000 .. 500000000 (UTC)
12	U2	-	Year	y	Year, range 1999..2099 (UTC)
14	U1	-	Month	month	Month, range 1..12 (UTC)
15	U1	-	Day	d	Day of month, range 1..31 (UTC)
16	U1	-	Hour	h	Hour of day, range 0..23 (UTC)
17	U1	-	Min	min	Minute of hour, range 0..59 (UTC)
18	U1	-	Sec	s	Second of minute, range 0..59 (UTC)
19	U1	-	Valid		0x01 = Valid time of week 0x02 = Valid week number 0x04 = Valid UTC (Leap seconds already known?)

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10.2.8. NAV-SVINFO Space vehicle information

Message		NAV-SVINFO				
Description		Space vehicle information				
Message structure		Header	ID	Length	Payload	Checksum
		0xB5 0x62	0x01 0x30	8+NCH*12	8+NCH*12 bytes	CK_A CK_B
Payload contents:						
Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment	
0	U4	-	ITOW	ms	GPS millisecond time of week	
4	U1	-	NCH	-	Number of channels, range 0..16	
5	U1	-	RES1	-	Reserved	
6	U2	-	RES2	-	Reserved	
Start of repeated block (NCH times)						
8 + N*12	U1	-	chn	-	channel number, range 0..NCH-1	
9 + N*12	U1	-	SVID	-	Satellite ID	
10 + N*12	U1	-	Flags	-	Bitmask, made up of the following bit values 0x01 = SV is used for navigation 0x02 = Differential correction data is available for this SV 0x04 = Orbit information is available for this SV (Ephemeris or Almanach) 0x08 = Orbit information is Ephemeris 0x10 = SV is unhealthy / shall not be used 0x20 = reserved 0x40 = reserved 0x80 = reserved	
11 + N*13	I1	-	QI	-	Signal Quality indicator (range 0..7). The following list shows the meaning of the different QI values: 0: This channel is idle 1, 2: Channel is searching 3: Signal detected but unusable 4: Code Lock on Signal 5, 6: Code and Carrier locked 7: Code and Carrier locked, receiving 50bps data	
12 + N*13	U1	-	CNO	dbHz	Carrier to noise ratio - signal strength	
13 + N*13	I1	-	Elev	deg	Elevation in integer degrees	
14 + N*13	I2	-	Azim	deg	Azimuth in integer degrees	
16 + N*13	I4	-	PRRez	cm	Pseudo range residual in centimetres	

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10.2.9. MON-VER Receiver / software version

Message	MON-VER				
Description	Receiver/Software version				
Comment	This message is only sent when polled				
Message structure	Header	ID	Length	Payload	Checksum
	0xB5 0x62	0x0A 0x04	40 + N*30	40+N*30 bytes	CK_A CK_B

Payload contents:

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	CH[30]	-	SWVersion	-	Zero-terminated software version string
30	CH[10]	-	HWVersion	-	Zero-terminated hardware version string
Start of repeated block (N times)					
40 + N*30	CH[30]	-	Extension	-	Installed extension package version

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10.2.10. MON-HW Hardware status

Message	MON-HW				
Description	Status of different aspects of the hardware, such as antenna, PIO/peripheral pins, noise level, automatic gain control (AGC)				
Message structure	Header	ID	Length	Payload	Checksum
	0xB5 0x62	0x0A 0x09	64	64 bytes	CK_A CK_B

Payload contents:

Byte offset	Number format	Scaling	Name	Unit	Purpose/Comment
0	U4	-	PinSel	-	Mask of pins set as Peripheral/PIO
4	U4	-	PinBank	-	Mask of pins set as Bank A/B
8	U4	-	PinDir	-	Mask of pins set as Input/Output
12	U4	-	PinVal	-	Mask of pins value Low/High
16	U2	-	NoisePerMS	-	Noise level as measured by the GPS core
18	I2	-	AGCCnt	-	AGC Monitor (counts SIGHI xor SIGLO, range 0 to 8191)
20	U1	-	AStatus	-	Status of the Antenna Supervisor State Machine (0=INIT, 1=DONTKNOW, 2=OK, 3=SHORT, 4=OPEN)
21	U1	-	APower	-	Current PowerStatus of Antenna (0=OFF, 1=ON, 2=DONTKNOW)
22	U1	-	Flags	-	0x1 = RTC is calibrated
23	U1	-	RES1	-	Reserved for future use
24	U4	-	usedMask	-	Mask of pins that are used by the Virtual Pin Manager
28	U1[32]	-	VP	-	Array of pin mappings for each of the 32 physical pins
60	U4	-	PinIrq	-	Mask of pins value using the PIO Irq

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10.3. Race Technology format messages

Each channel is output using the following format:
Channel number, data bytes, checksum.
The checksum is the sum modulo 256 of the data bytes and the channel number byte

Update rates of up to 200Hz are available on acceleration, combined speed, roll pitch and yaw rates (when available) and on the four ADC channels. All GPS only based measurements are available at up to 20Hz. The Time stamp number measurement is fixed at 100Hz and can not be disabled.

10.3.1. Timing data (9,97)

Time stamp – Channel 9, 2 bytes		
Data bytes 1 and 2	**Time stamp within the run**	
	Format	Big endian (raw hex). 24 data bits
	Signing	Unsigned
	Units	s
	Scaling	Output = s x 1e-2

High resolution timer data – Channel 97, 6 bytes		
Data byte 1	**Bottom three bits are trigger number:**	
	000 001 010 011 100 101	
	Bit 7 is trigger edge:	
	Bit 7 = 0, triggered by falling edge Bit 7 = 1, triggered by rising edge	
Data bytes 2 to 6	**Microsecond time of week**	
	Format	Big endian (raw hex). 40 data bits
	Signing	Unsigned
	Units	µs
	Scaling	Output = µs

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10.3.2. Acceleration data (8,92)

Lateral and longitudinal acceleration – Channel 8, 4 bytes		
Data bytes 1 and 2	**Lateral acceleration**	
	Format	Big endian (raw hex). 15 data bits, 1 sign bit
	Signing	Sign-and-magnitude. First bit (msb) is sign (0 => -ve)
	Units	g
	Scaling	Output = g x 256
	Example	Acc(g) = (byte 1 & 0x&F) + (byte 2 / 256) If (byte 1 & 0x80) = 0, Acc = -Acc
Data bytes 3 and 4	**Longitudinal acceleration**	
	Format	All format the same as lateral acceleration above

Vertical acceleration – Channel 92, 2 bytes		
Data bytes 1 and 2	**Vertical acceleration**	
	Format	All format the same as lateral acceleration above

10.3.3. Processed speed output (64)

Combined speed – Channel 64, 3 bytes		
Data bytes 1 to 3	**Combined accelerometer and GPS speed**	
	Format	Big endian (raw hex). 24 data bits, unsigned
	Units	kph
	Scaling	Output – kph x 725.1315278
	Example	Speed(kph) = (byte1 x 0x10000 + byte2 x 0x100 + byte3) x 0.001379060159

10.3.4. GPS data (7,10,11,56,57,85)

GPS speed – Channel 11, 8 bytes		
Data bytes 1 to 4	**GPS speed**	
	Format	Big endian (raw hex). 32 data bits, unsigned
	Units	cm/s
	Scaling	None
Data bytes 5 to 8	**GPS speed accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits, unsigned
	Units	cm/s
	Scaling	None

GPS heading – Channel 56, 8? bytes		
Data bytes 1 to 4	**GPS heading**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Two's complement
	Units	Degrees
	Scaling	Output = degrees x 1e5

GPS altitude – Channel 57, 8 bytes		
Data bytes 1 to 4	**GPS altitude**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Two's complement
	Units	mm
	Scaling	None
Data bytes 5 to 8	**GPS altitude accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits, unsigned
	Units	mm
	Scaling	None

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GPS gradient – Channel 85, 8 bytes		
Data bytes 1 to 4	**GPS gradient**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Two's complement
	Units	Degrees
	Scaling	Output = degrees x 1e5
Data bytes 5 to 8	**GPS gradient accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Unsigned
	Units	Degrees
	Scaling	Output = degrees x 1e5

GPS time – Channel 7, 4 bytes		
Data bytes 1 to 4	**GPS millisecond time of week**	
	Format	Big endian (raw hex). 32 data bits, unsigned
	Units	ms since midnight on Saturday
	Scaling	None

GPS position – Channel 10, 12 bytes		
Data bytes 1 to 4	**Longitude**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Two's complement
	Units	Degrees
	Scaling	Output = degrees x 1e7
Data bytes 5 to 8	**Latitude**	
	Format	All format the same as longitude above
Data bytes 9 to 12	**Positional accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits, unsigned
	Units	cm
	Scaling	None

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10.3.5. RTK data (only with RTK option)

GPS RTK yaw angle – Channel 80, 2 bytes		
Data bytes 1 and 2	**GPS MB-RTK yaw**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Two's complement
	Units	Degrees
	Scaling	Output = degrees x 100

GPS RTK pitch angle – Channel 82, 3 bytes		
Data bytes 1 and 2	**GPS MB-RTK pitch angle**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Two's complement
	Units	Degrees
	Scaling	Output = degrees x 100
Data byte 3	Reserved for future use	

GPS RTK estimated baseline – Channel 90, 4 bytes		
Data bytes 1 and 2	**GPS MB-RTK estimated baseline**	
	Format	Big endian (raw hex). 16 data bits, unsigned
	Units	mm
	Scaling	None
Data bytes 3 and 4	**GPS MB-RTK accuracy estimate**	
	Format	Big endian (raw hex). 16 data bits, unsigned
	Units	mm
	Scaling	Output = mm x 10

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10.3.6. IMU Variables

When the IMU is present, acceleration values are read from the IMU

Yaw rate – Channel 79, 2 bytes		
Data bytes 1 and 2	**Yaw rate**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Unsigned
	Units	Degrees
	Scaling	Output = 327.68 – degrees x 0.01

Pitch rate – Channel 81, 3 bytes		
Data bytes 1 and 2	**Pitch rate**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Unsigned
	Units	Degrees
	Scaling	Output = 327.68 – degrees x 0.01
Data byte 3	**Pitch rate accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Unsigned
	Units	Undefined, lower is better

Roll rate – Channel 84, 3 bytes		
Data bytes 1 and 2	**Roll rate**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Unsigned
	Units	Degrees
	Scaling	Output = 327.68 – degrees x 0.01
Data byte 3	**Roll rate accuracy estimate**	
	Format	Big endian (raw hex). 32 data bits
	Signing	Unsigned
	Units	Undefined, lower is better

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10.3.7. Analogue channel outputs

Analogue channel 1 – Channel 27, 2 bytes **Analogue channel 2 –** Channel 25, 2 bytes **Analogue channel 3 –** Channel 26, 2 bytes **Analogue channel 4 –** Channel 24, 2 bytes		
Data bytes 1 and 2	**Analogue channel 1**	
	Format	Big endian (raw hex). 16 data bits
	Signing	Two's complement
	Units	mV
	Scaling	Output = mV

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11. CAN outputs

All messages use a 29 bit address, made up as follows:

3 bit priority
These are set by the transmitter. The lower the number the higher the priority.

2 bits for future expansion (currently set as 00)

16 bit data type
If the MSB is <128 then this is a destination specific message, the destination address is given by the LSB (Data Format 1)
If the MSB is >127 this is a broadcast message, the MSB determines the main data type, LSB determines the sub type (Data Format 2)

8 bit source address

The top three bits are the data group, the lower 5 bits are the particular unit within that group. Default values are set on units, these will only need to be changed when there is more than one of a particular unit on the CAN network. Groups are as follows.

1 Data source
2 Displays
3 Data stores

Units are assigned to a group based on their primary function. A data logger will be classed as a data store, even if it has some built in channels.

Default unit numbers are as follows:

Data source group

1 IMU06
2 SPEEDBOX
3 BRAKEBOX

Data stores group

None defined

Displays group

None defined

A shortened version of the identifier consisting of the 5lsb of the main data type and the 6 lsb of the sub type is also available.

11.1. Data format 2 message definitions

RT CAN Message Specification

For all messages, bit zero of the validity byte refers to the first data (not accuracy) packet, bit 1 to the next data packet, etc. When the bit is 1, the data is valid, when the bit is zero, the data is invalid.

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Since the last 5 bits of the address are made up of the unit id, this will need to be added to the addresses shown. The default unit ID is 2. A .dbc file containing all signals is available on request. The second ID in brackets is the ID for use when an 11 bit identifier is set.

11.2.Inertial messages (group 128)

11.2.1. RT_Accel 3 axis acceleration data

RT_Accel: 128, 0 (0x800020 + unit id) (0x000)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: Accel Longitudinal (g)
Bytes 4-5: Accel Lateral (g)
Bytes 6-7: Accel Vertical (g)

Accel resolution is g/1000.

11.2.2. RT_Gyro_Rates 3 axis gyro rates

RT_Gyro_Rates: 128, 1 (0x800120 + unit id) (0x001)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: Yaw rate (degrees/s)
Bytes 4-5: Pitch rate (degrees/s)
Bytes 6-7: Roll rate (degrees/s)

Rate resolutions are degrees/s/100. These are only available with the IMU option.

11.2.3. RT_Speed Calculated speed

RT_Speed: 128, 16 (0x801020 + unit id) (0x010)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-5: Combined speed (m/s)
Bytes 6-7: Unused

Combined speed resolution is m/s * 1e-5.

11.2.4. RT_Attitude Yaw, pitch and roll

RT_Attitude: 128, 17 (0x801120 + unit id) (0x011)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: Yaw (degrees)
Bytes 4-5: Pitch (degrees)
Bytes 6-7: Roll (degrees)

Yaw, pitch and roll resolution are degrees/100.
This message is used for attitude calculated from combining integrated gyro messages with RTK attitude.
There is a seperate message in the GPS section for RTK only attitude.

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11.2.5. RT_Distance_1 Cumulative time and distance

RT_Distance_1: 128, 32 (0x802020 + unit id) (0x020)

Byte 0: Validity
Bytes 1-3: Cumulative time (s)
Bytes 4-7: Cumulative distance (m)

Cumulative time resolution is s/100.
Cumulative distance resolution is m/1000.
Distance message 1 runs continuously from 1st good GPS lock.

11.2.6. RT_Distance_2 Cumulative time and distance

RT_Distance_2: 128, 33 (0x802120 + unit id) (0x021)

Byte 0: Validity
Bytes 1-3: Cumulative time (s)
Bytes 4-7: Cumulative distance (m)

Cumulative time resolution is s/100.
Cumulative distance resolution is m/1000.
Distance message 2 gets held/reset by the triggers.

11.3. GPS messages (group 140)

11.3.1. RT_GPS_Status Firmware version and GPS status information

RT_GPS_Status: 140, 0 (0x8C0020 + unit id) (0x300)

Byte 0: GPS status
Byte 1: Firmware version major
Byte 2: Firmware version intermediate
Byte 3: Firmware version minor
Byte 4: Number of satellites used
Byte 5: Number of satellites used by GPS2 (RTK units only)
Byte 6: Number of common satellites (RTK units only)
Byte 7: RTK status (RTK units only)

GPS status codes:
- 0: GPS module not detected
- 1: Insufficient satellites
- 2: Solution failed
- 3: Solution OK
- 4: Solution aborted
- 5: Unused
- 6: Searching for satellites
- 7: Exceeded maximum speed or altitude

RTK status codes:
- 0: Not attempting RTK solution
- 1: Insufficient common satellites
- 2: RTK solution failed
- 3: RTK solution OK

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11.3.2. RT_GPS_Time GPS time of week

RT_GPS_Time: 140, 1 (0x8C0120 + unit id) (0x301)

Byte 0: Validity

Byte 1: Accuracy

Bytes 2-3: GPS week

Bytes 4-7: GPS time of week (s).

GPS time resolution is s/1000.

GPS time of week is the number of seconds that have elapsed since midnight GMT on Saturday night.

11.3.3. RT_GPS_Pos_LLH GPS accuracy and latitude

RT_GPS_Pos_LLH_1: 140, 2 (0x8C0220 + unit id) (0x302)

Byte 0: Validity

Byte 1: Accuracy Latitude

Byte 2: Accuracy Longitude

Byte 3: Accuracy Altitude

Bytes 4-7: Latitude (degrees)

Latidue resolution is degrees * 1e-7.

The validity byte is used for the data packets in this message *and* in RT_GPS_Pos_LLH_2.

11.3.4. RT_GPS_Pos_LLH_2 GPS Longitude and altitude

RT_GPS_Pos_LLH_2: 140, 3 (0x8C0320 + unit id) (0x303)

Bytes 0-3: Longitude (degrees)

Bytes 4-7: Altitude (m)

Longitude resolution is degrees * 1e-7.

Altitude resolution is m/1000.

Validity is provided by RT_GPS_Pos_LLH_1.

11.3.5. RT_GPS_Pos_ECEF GPS XYZ accuracy and X position

RT_GPS_Pos_ECEF_1: 140, 4 (0x8C0420 + unit id) (0x304)

Byte 0: Validity

Byte 1: Accuracy X

Byte 2: Accuracy Y

Byte 3: Accuracy Z

Bytes 4-7: ECEF X Position (m)

ECEF position resolution is m/100.

The validity byte is used for the data packets in this message *and* in RT_GPS_Pos_ECEF_2.

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11.3.6. RT_GPS_Pos_ECEF_2 GPS Y and Z position

RT_GPS_Pos_ECEF_2: 140, 5 (0x8C0520 + unit id) (0x305)

Bytes 0-3: ECEF Y Position (m)
Bytes 4-7: ECEF Z Position (m)

ECEF position resolution is m/100.
Validity is provided by RT_GPS_Pos_ECEF_1.

11.3.7. RT_GPS_Speed GPS 2D and 3D speed

RT_GPS_Speed: 140, 16 (0x8C1020 + unit id) (0x310)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-4: GPS speed 2D (m/s)
Bytes 5-7: GPS speed 3D (m/s)

This message outputs GPS-only scalar speed.
Speed resolution is m/s * 1e-4

11.3.8. RT_GPS_Vel_NED_1 GPS North and East velocity

RT_GPS_Vel_NED_1: 140, 17 (0x8C1120 + unit id) (0x311)

Byte 0: Validity
Byte 1: Accuracy (N & E)
Bytes 2-4: GPS Velocity N (m)
Bytes 5-7: GPS Velocity E (m)

NED velocities are velocities in the local North, East and Down directions at the current location.
Speed resolution is m/s * 1e-4

11.3.9. RT_GPS_Vel_NED_2 GPS Down velocity

RT_GPS_Vel_NED_2: 140, 18 (0x8C1220 + unit id) (0x312)

Byte 0: Validity
Byte 1: Accuracy (D)
Bytes 2-4: GPS Velocity D (m)
Bytes 5-7: Unused

NED velocities are velocities in the local North, East and Down directions at the current location.
Speed resolution is m/s * 1e-4

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11.3.10. RT_GPS_Vel_ECEF_1 X,Y,Z accuracy and X velocity

RT_GPS_Vel_ECEF_1: 140, 19 (0x8C1320 + unit id) (0x313)

Byte 0: Validity
Byte 1: Accuracy X
Byte 2: Accuracy Y
Byte 3: Accuracy Z
Bytes 4-6: ECEF Velocity X
Byte 7: Unused

ECEF velocities are velocities in the Earth-Centered Co-ordinate Frame.
Speed resolution is m/s * 1e-4

11.3.11. RT_GPS_Vel_ECEF_2 Y and Z velocity

RT_GPS_Vel_ECEF_2: 140, 20 (0x8C1420 + unit id) (0x314)

Byte 0: Validity
Bytes 1-3: ECEF Velocity Y
Bytes 4-6: ECEF Velocity Z
Byte 7: Unused

ECEF velocities are velocities in the Earth-Centered Co-ordinate Frame.
Speed resolution is m/s * 1e-4

11.3.12. RT_GPS_Heading_Gradient1 Heading and gradient 1

RT_GPS_Heading_Gradient: 140, 21 (0x8C1520 + unit id) (0x315)

Byte 0: Validity
Byte 1: Accuracy Heading
Bytes 2-3: GPS Heading (-180 – 180 degrees)
Byte 4: Accuracy Gradient
Bytes 5-7: GPS Gradient

Resolution of heading and gradient is degrees/100

11.3.13. RT_GPS_Heading_Gradient2 Heading and gradient 2

RT_GPS_Heading_Gradient: 140, 21 (0x8C1620 + unit id) (0x316)

Byte 0: Validity
Byte 1: Accuracy Heading
Bytes 2-3: GPS Heading (0-360 degrees)
Byte 4: Accuracy Gradient
Bytes 5-7: GPS Gradient

Resolution of heading and gradient is degrees/100

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11.3.14. RT_RTK_Attitude Roll, pitch, yaw and accuracy

RT_RTK_Attitude: 140, 32 (0x8C2020 + unit id) (0x320)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: RTK Yaw (degrees)
Bytes 4-5: RTK Pitch (degrees)
Bytes 6-7: RTK Roll (degrees)

RTK Yaw, pitch and roll resolution are degrees/100.
This message is used for attitude calculated from the RTK solution only, with no inertial input.

11.3.15. RT_RTK_Slip RTK baseline, slip and squat

RT_RTK_Slip: 140, 33 (0x8C2120 + unit id) (0x321)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: RTK Slip (degrees)
Bytes 4-5: RTK Squat (degrees)
Bytes 6-7: RTK Estimated baseline (mm)

Slip is yaw - heading. Squat is pitch - gradient.
Resolution of slip and squat is degrees/100.
Resolution of estimated baseline is mm.

11.3.16. RT_GPS_Mcycle_Lean Motorcycle lean angle

RT_GPS_Mcycle_Lean: 140, 48 (0x8C3020 + unit id) (0x330)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2-3: GPS Lateral Acceleration (g)
Bytes 4-5: Motorcycle lean angle (degrees)
Bytes 6-7: Unused

Resolution of GPS lateral acceleration is g/1000.
Resolution of mcycle lean angle is degrees/100.
Motorcycle lean angle is the theoretical lean angle of the center of mass of the combined m/cycle and rider.

11.4. Other messages (group 141)

11.4.1. RT_Trigger_Timestamp Trigger timestamp

RT_Trigger_Timestamp: 141, 0 (0x8D0020 + unit id) (0x340)

Byte 0: Validity
Byte 1: Accuracy
Bytes 2: Trigger Type (bit 7), Trigger number (bits 0 – 6)
Bytes 3-7: GPS time of week (micro-seconds)

This message is not output at a constant rate, but if enabled is output in response to detected trigger events.

The trigger type (byte 2, bit 7) is 0 if the event was generated by a falling edge, 1 if the event was generated by a rising edge.

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The trigger number in the message is zero-based, but the trigger labelling on the unit fascias are 1-based, so a message trigger number of 0 corresponds to trigger 1 on the unit.
The time output is GPS time (time since midnight GMT on Saturday night) in micro-seconds.

11.4.2. RT_Output_Status Output port status

RT_Output_Status 141, 1 (0x8D0120 + unit id) (0x341)

Byte 0: Validity
Byte 1: Output port status 1
Bytes 2: Output port status 2
Bytes 3-7: GPS time of week (micro-seconds)

Outputs the status of different potential outputs on the unit. Status is 1 for active and 0 for inactive.

Output bits for port status 1 are:
0 Analogue output 1
1 Analogue output 2
2 Analogue output 3
3 Analogue output 4
4 Pulse output
5 Serial output 1
6 Serial output 2
7 Trigger status

Bits for output port 2 are undefined

The time output is GPS time (time since midnight GMT on Saturday night) in micro-seconds.

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12. Revisions

1.3 2nd February 2009

Updated CAN GPS message 128.16 Calculated speed
Added CAN GPS message 140.22 Gradient
Added CAN GPS message 141.1 Output status
Modified PRTLT message to add status conditions 2 and 3
Added PRTLO status output message

1.4

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