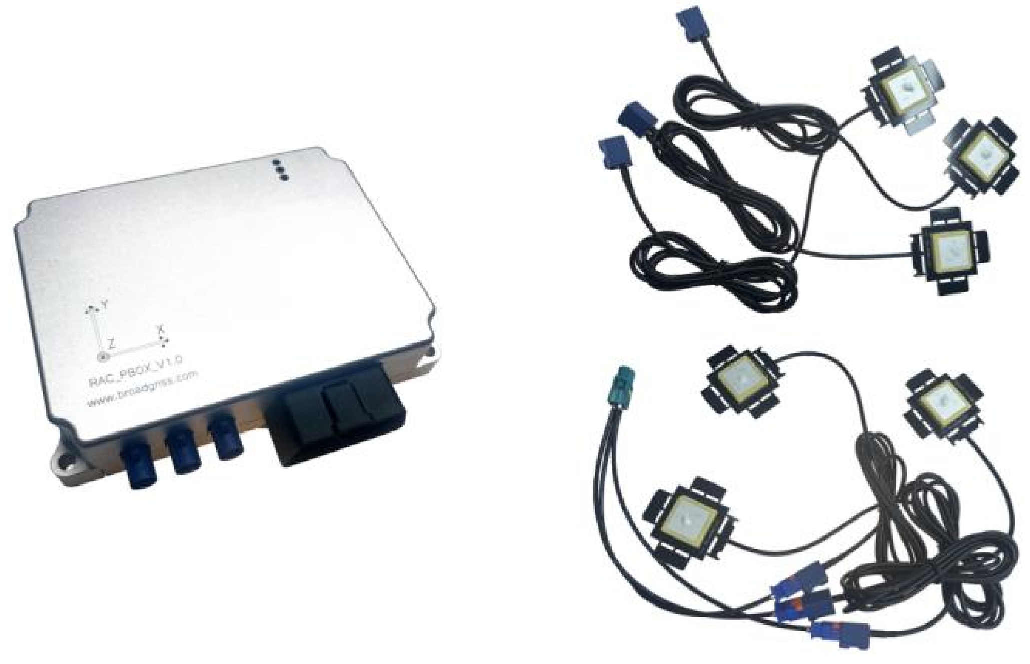
RAC-PBOX Integrated Navigation System User Manual

Table of contents

1. System Overview

The RAC-PBOX combined navigation system utilizes high-precision MEMS (Micro-Electro-Mechanical System) gyroscopes, accelerometers, and RAC high-precision positioning to achieve high-precision combined navigation functions. It calculates the position, speed, heading, and attitude of the carrier in real-time, with anti-blocking and multi-path interference capabilities, ensuring long-duration, high-precision, and reliable navigation in complex environments. The system features a compact design, small volume, and lightweight, providing standardized communication protocols and excellent scalability. The product is widely applicable in fields such as autonomous driving, assisted driving, unmanned vehicles, robotics, map collection vehicles, high-speed trains, ships, drones, aerial surveying, and agricultural machinery.

Device form: Integrated inertial navigation + satellite navigation (satellite antenna separated), with data transmitted via the OBD interface and CAN bus.



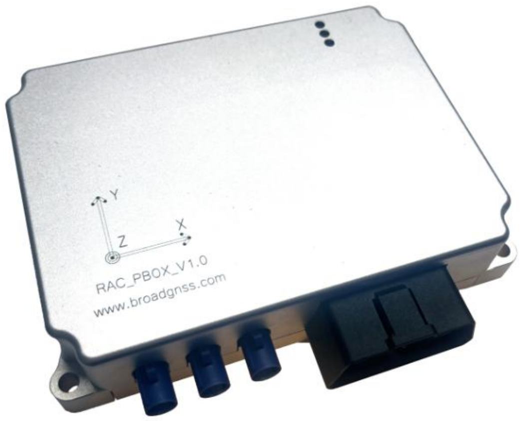
惯导+卫导一体集成（P_BOX）

2. System composition

2.1 Hardware

Serial number	Product Name	Quantity	Unit	Remark
1	MEMS Inertial-satellite combined navigation Navigation system host	1	tower	
2	Positioning antenna	3	tower	
3	OBD interface cable	1	root	

2.1.1 Combined navigation system host + cable



Appearance of the main unit of the inertial-satellite integrated navigation system

2.1.2 Cable interface pin definition

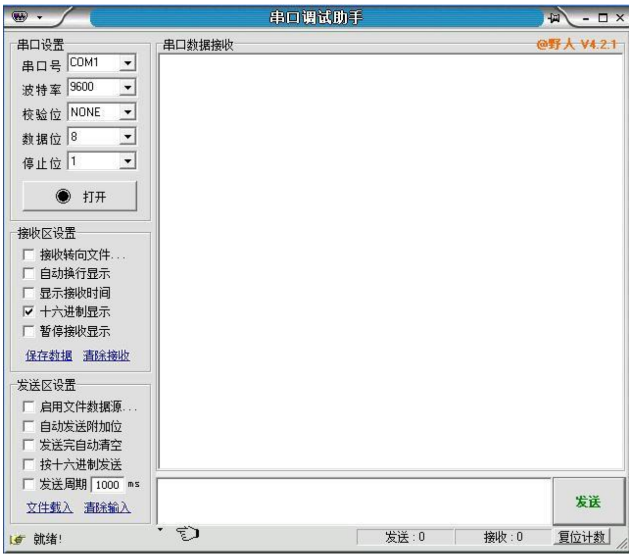
Serial number	Name	Interface Type	Connector Pin Definition
1	PPS+UART	DB9 interface	1-PPS 2-UART-TX3-UART-RX
2	RS232	DB9 interface	2-RS232-TX3-RS232-RX 5-GND
3	RS485	DB9 interface	3-RS485-A4-RS485-B

4	CAN	DB9 interface	2-CAN-L7-CAN-H
5	power supply	DC power interface	DC power supply (12V)

2.2 Software

2.2.1 Serial Port Assistant Tool:UartAssist

Serial Port Assistant Tool



Serial Port Assistant Tool Main Interface

2.2.2 Host computer software:GkTest2

Host computer software icon

Main interface of host computer software

3. Technical Parameters

System indicators		
1	Heading accuracy	0.2°（1σ）
2	Pitch and roll accuracy	0.2°（1σ）
3	Position accuracy	Single Point≤0.6m(2σ）
4	Speed accuracy	＜0.05m/s（1σ）
5	GNSS Frequency band	GPS:L1
		BeiDou:B1
		GLONASS:L1
6	GNSS Loss of lock accuracy	0.3% (ratio of error to unlocked mileage)
7	Data update rate	100Hz (Configurable)

8	Initialization time	＜10s	
9	Time to First Fix	＜35s	
Inertial device characteristics			
11	Gyro	Range	±300°/s
		Bias stability	5.5°/h
12	Accelerometer	Range	±6g
		Bias stability	0.06mg
Communication interface			
13	Interface	OBD connector support TTL, RS232, RS485, CAN	
14	Transfer rate	115200~460800bps(Configurable)	
Physical dimensions and electrical characteristics			
15	Supply voltage	12V DC	
16	size	120*107*27mm	
17	Protection level	IP65	
18	Operating temperature	-25°C~+65°C	

4. Communication protocols and commands

4.1 Communication Protocol

The module can output four protocols: NMEA0183 GIAVP, NMEA0183 GPINS, Hex Protocol 1 (default output protocol), and Hex Protocol 2. The output rate can be configured to the following values: 115200, 256000, and 460800.
$GIAVP,GPSWeek,GPSTime,Heading,Pitch,Roll,Lattitude,Longitude,Altitude,Ve,Vn,Vu,Baseline,Nsv1,Nsv2,Status,SpeedStatus,VehicleSpeed,AccX,AccY,AccZ,GyroX, GyroY,GyroZ*cs<CR><LF>

Field Number	Name	Illustrate	Format	Example
1	Header	Protocol Header	$AACCC	$GIAVP

2	GPSWeek	since1980/1/6To current week number (Greenwich Mean Time)	wwww	1451
3	GPSTime	This Sunday0:00:00To current Seconds	ssssss.sss	368123.300
4	Heading	Heading angle (0-359.99)	ddd.dd	112.12
5	Pitch	Pitch angle (-90~90)	+ /-dd.dd	5.21
6	Roll	Roll angle (-180~180)	+ /-ddd.dd	10.12
7	Lattitude	latitude(-90,90)	+ /-dd.dd	28.224692
8	Longitude	longitude(-180~180)	+ /-ddd.dd	112.286135
9	Altitude	Height, unit (m)	+ /-hhh.hh	56.78
10	Ve	Eastward speed, unit (m/s)	+ /-eee.eee	5.412
11	Vn	North speed, unit (m/s)	+/-nnn.nnn	10.020
12	Vu	Celestial velocity, unit (m/s)	+ /-uuu.uuu	0.018
13	Baseline	Baseline length, unit (m)	+ /-bb.bbb	2.121
14	Nsv1	antenna1Number of satellites	nn	20
15	Nsv2	antenna2Number of satellites	nn	18
16	Status	Low ByteASCIIcode 0: Initialized/unpositioned 1: Single point positioning 2:RTD 4:RTKFixed solution 5:RTKFloating point solution 6:RACHigh Precision Mode	S	4
17	SpeedStatus	0: No vehicle speed information 1： With vehicle speed information	s	1
18	VehicleSpeed	Vehicle speedKm/h	+ /-vv.v	25.6
19	AccX	AccelerationXaxis,m/s2	+/-aa.aaa	1.658799
20	Y	AccelerationYaxis,m/s2	+/-aa.aaa	11.132578
21	ZGar	AccelerationZaxis,m/s2	+/-aa.aaa	0.2874586
22	GyroX	GyroscopeXAxis, unit: °/s	+ /-gg.ggg	0.145852
23	Y	GyroscopeYAxis, unit: °/s	+ /-gg.ggg	1.89756
24	GyroZ	GyroscopeZAxis, unit: °/s	+ /-gg.ggg	0.36847
25	cs	check	*hh	* 64
26	<CR><LF>	Fixed tail		<CR><LF>

$GPINS,GPSWeek,GPSTime,Heading,Pitch,Roll,Lattitude,Longitude,Altitude,Ve,Vn,Vu, Baseline,Nsv1,Nsv2,GPSStatus,HeadingStatus,Status,
VehicleAlign,SpeedStatus,VehicleSpeed,AccX,AccY,AccZ,
GyroX, GyroY,GyroZ*cs<CR><LF>

Field Number	Name	Illustrate	Format	Example
1	Header	Protocol Header	$AACCC	$GPINS
2	GPSWeek	since1980/1/6To current week number (Greenwich Mean Time)	wwww	1451

3	GPSTime	This Sunday0:00:00To current Seconds	ssssss.sss	368123.300
4	Heading	Heading angle (0-359.99)	ddd.dd	112.12
5	Pitch	Pitch angle (-90~90)	+ /-dd.dd	5.21
6	Roll	Roll angle (-180~180)	+ /-ddd.dd	10.12
7	Lattitude	latitude(-90,90)	+ /-dd.dd	28.224692
8	Longitude	longitude(-180~180)	+ /-ddd.dd	112.286135
9	Altitude	Height, unit (m)	+ /-hhh.hh	56.78
10	Ve	Eastward speed, unit (m/s)	+ /-eee.eee	5.412
11	Vn	North speed, unit (m/s)	+/-nnn.nnn	10.020
12	Vu	Celestial velocity, unit (m/s)	+ /-uuu.uuu	0.018
13	Baseline	Baseline length, unit (m)	+ /-bb.bbb	2.121
14	Nsv1	antenna1Number of satellites	nn	20
15	Nsv2	antenna2Number of satellites	nn	18
16	GPS Status	Antenna positioning status 0: Initialized/unpositioned 1: Single point positioning 2:RTD 4:RTKFixed solution 5:RTKFloating point solution 6:RACHigh Precision Mode	S	4
17	Heading Status s	Heading positioning status 0: Initialized/unpositioned 4: RTKFixed solution 5:RTKFloating point solution	S	4
18	Status	Combined navigation solution status 0: Initialization/ Misalignment 1: Inertia solution 2: Vehicle constraints 3: Stationary detection 4： Combination solution	S	4
19	VehicleAlign	0： Odometer calibration in progress 1: Odometer calibration successful	S	1
20	SpeedStatus	0: No vehicle speed information 1： With vehicle speed information	S	1
21	VehicleSpeed	Vehicle speedKm/h	+ /-vv.v	25.6
22	AccX	AccelerationXaxis,m/s2	+/-aa.aaa	1.658799
23	Y	AccelerationYaxis,m/s2	+/-aa.aaa	11.132578
24	ZGar	AccelerationZaxis,m/s2	+/-aa.aaa	0.2874586
25	GyroX	GyroscopeXAxis, unit: °/s	+ /-gg.ggg	0.145852
26	Y	GyroscopeYAxis, unit: °/s	+ /-gg.ggg	1.89756
27	GyroZ	GyroscopeZAxis, unit: °/s	+ /-gg.ggg	0.36847
28	cs	check	*hh	* 64
29	<CR><LF>	Fixed tail		<CR><LF>

Hexadecimal Protocol 1, one frame of 93 bytes (default output protocol):

Byte	Name	Illustrate	Data Types
1~4	Header	Fixed frame header0x553ACE01	uint32
5	UTC time:hours	hour	uint8
6	UTC time:minutes	point	uint8
7	UTC time: seconds	Second	uint8
8~9	UTC time:millisecond	millisecond	uint16
10~13	Heading	Heading angle (0-359.99)	float
14~17	Pitch	Pitch angle (-90~90)	float
18~21	Roll	Roll angle (-180~180)	float
22~29	Lattitude	latitude(-90,90)	double
30~37	Longitude	longitude(-180~180)	double
38~41	Altitude	Height, unit (m)	float
42~45	Ve	Eastward speed, unit (m/s)	float
46~49	Vn	North speed, unit (m/s)	float
50~53	Vu	Celestial velocity, unit (m/s)	float
54~57	baseline	Baseline length, unit (m)	float
58	Nsv1	antenna1Number of satellites	uint8
59	Nsv2	antenna2Number of satellites	uint8
60	Status	Low ByteASCIIcode 0: Initialized/unpositioned 1: Single point positioning 2:RTD 3:RTKFloating point solution 4:RTKFixed solution 6:RACHigh Precision Mode	uint8
61	SpeedStatus	0: No vehicle speed information 1： With vehicle speed information	uint8
62~65	VehicleSpeed	Vehicle speedKm/h	float
66~69	AccX	AccelerationXaxis,m/s2	float
70~73	Y	AccelerationYaxis,m/s2	float
74~77	ZGar	AccelerationZaxis,m/s2	float
78~81	GyroX	GyroscopeXAxis, unit: °/s	float
82~85	Y	GyroscopeYAxis, unit: °/s	float
86~89	GyroZ	GyroscopeZAxis, unit: °/s	float
90	RTCMStatus	1:haveRTCMData Flow 0: noneRTCMData Flow	uint8

91	Odoíal	Odo_flag[7:4]: 1.Odometer calibration successful 2.Odometer not calibrated Al_status[3:0]: Combined navigation solution status 0: Initialization/Misalignment 1: Inertia solution 2: Vehicle constraints 3: Stationary detection 4：Combination solution	uint8
92~93	CheckSum	check	uint16

Hexadecimal Protocol 2, one frame of 101 bytes:

Byte	Name	Illustrate	Data Types
1~4	Header	Fixed frame header0x553ACE02	uint32
5~6	Week	Week of the second within the week	uint16
7~14	GPST	Seconds of the week, in (s)	double
15~18	Heading	Heading angle (0-359.99)	float
19~22	Pitch	Pitch angle (-90~90)	float
23~26	Roll	Roll angle (-180~180)	float
27~34	Lattitude	latitude(-90,90)	double
35~42	Longitude	longitude(-180~180)	double
43~46	Altitude	Height, unit (m)	float
47~50	Ve	Eastward speed, unit (m/s)	float
51~54	Vn	North speed, unit (m/s)	float
55~58	Vu	Celestial velocity, unit (m/s)	float
59~62	baseline	Baseline length, unit (m)	float
63	Nsv1	antenna1Number of satellites	uint8
64	Nsv2	antenna2Number of satellites	uint8
65	GPSStatus	Antenna positioning status 0: Initialized/unpositioned 1: Single point positioning 2:RTD 4:RTKFixed solution 5:RTKFloating point solution 6:RACHigh Precision Mode	uint8
66	HeadingStatus	Heading positioning status 0: Initialized/unpositioned 4 :RTKFixed solution 5:RTKFloating point solution	uint8

67	Status	Combined navigation solution status 0: Initialization/Misalignment 1: Inertia solution 2: Vehicle constraints 3: Stationary detection 4：Combination solution	uint8
68	Vehicle Align	0：Odometer calibration in progress 1: Odometer calibration successful	uint8
69	RTCM Status	1:haveRTCMData Flow 0: noneRTCMData Flow	uint8
70	Reserved	reserve	uint8
71	SpeedStatus	0: No vehicle speed information 1：With vehicle speed information	uint8
72~75	VehicleSpeed	Vehicle speedKm/h	float
76~79	AccX	AccelerationXaxis,m/s2	float
80~83	Y	AccelerationYaxis,m/s2	float
84~87	ZGar	AccelerationZaxis,m/s2	float
88~91	GyroX	GyroscopeXAxis, unit: °/s	float
92~95	Y	GyroscopeYAxis, unit: °/s	float
96~99	GyroZ	GyroscopeZAxis, unit: °/s	float
100~101	CheckSum	check	uint16

Hexadecimal transmission in little-endian order, with the low byte transmitted first and the high byte transmitted second; the checksum method is calculated by summing all previous bytes, ignoring overflow beyond uint16.

```
uint16_t check_sum16(uint8_t *ptr, uint16_t len) {

    uint16_t i;
    uint16_t res_val = 0;

    if(!ptr)
        return 0;

    for(i=0; i<len; i++)
    {
        res_val += ptr[i];
    }

    return res_val;
}
```

4.2 Command Configuration Table

4.2.1 Output(output)

$CMD,OUTPUT,COMx,protocol,freq*FF\r\n

inxforCOMThe value range is0~3.

Protocol" refers to the output protocol (baudrate is special; it does not represent a protocol but indicates the configured baud rate, with "freq" representing the value of the baud rate). " Freq" refers to the output frequency. Below is the protocol field table:

Output Configuration Fields	Protocol Interpretation	Maximum output frequency Rate
GIAVP	$GIAVPprotocol	100HZ
GPINS	$GPINSprotocol	100HZ
HEX	HEXprotocol1	100HZ
HEX2	HEXprotocol2	100HZ
GNSS	GNSSRaw data	5HZ
PACKED	The original data before the old version was parsed and packaged and entered the algorithm data	100HZ
IMU	byASCUIIAfter parsing the code outputIMUData reconciliation Odometer data after analysis	200HZ
BAUDRATE	Baud rate	460800

For example: $CMD,OUTPUT,COM0,GIAVP,100*FF\r\nreply:

$ACK,OUTPUT,COM0,GIAVP,100*FF\r\n

4.2.2 Configuration parameters (setparams)

$CMD,SETPARAMS,param_type,params,params...*FF\r\n

"param_type" represents the parameter to be configured, and "params" refers to the values of the parameters, which can be multiple. Below is the parameter field table:

Parameter configuration fields	Parameter Explanation	Parameter value range
LEVERARM	Lever arm value	They are 3 Decimal, unit: meter
ODOM	Odometer Protocol CAN	Natural Numbers 0~N
ODOTHRD	Speed threshold for odometer calibration	Greater than 0, unit:m/s

ISODOCAL	Whether to use odometer	1:use, 0: Not used
CANBAUD	CAN Baud rate	100,200,250,500 unit:10 3̂
CANSEND	Send CAN	1:use, 0: Not used

For example: $CMD,SETPARAMS,ISRTK,1*FF\r\nBack

Reply: $ACK, SETPARAMS,ISRTK,1*FF\r\n

3. Special statements

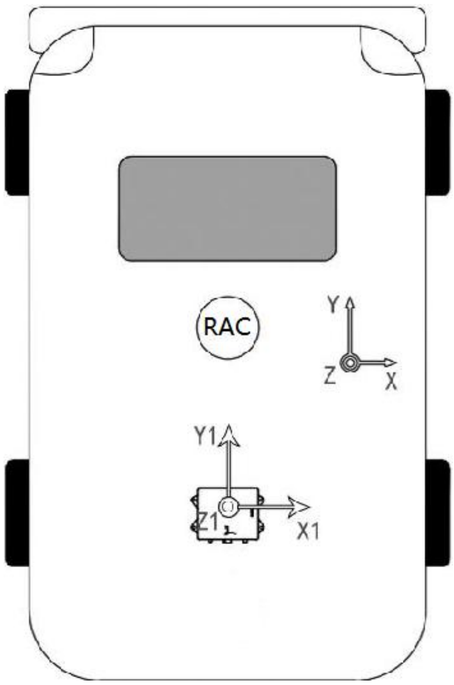
$CMD,SAVECONF,1*FF\r\n

Save all configuration information

5. Usage Process

5.1 Hardware Installation

5.1.1 Fixed integrated navigation system host

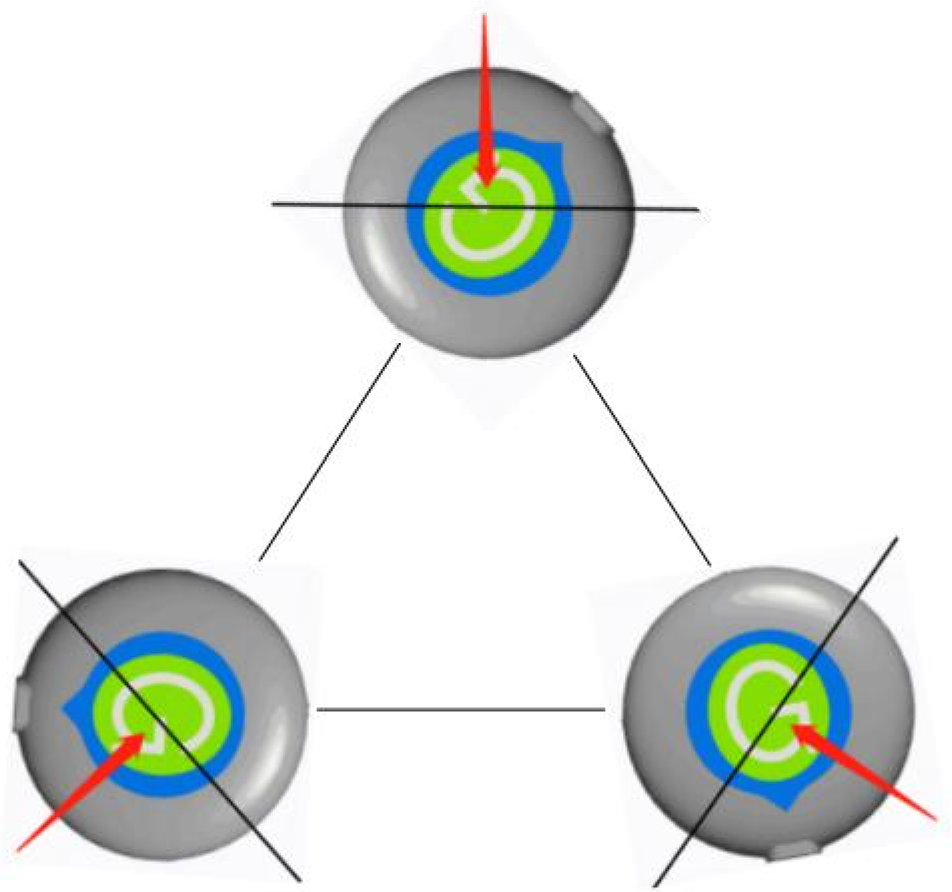


Integrated navigation system installation diagram

During installation, the combination navigation system host should be rigidly connected to the carrier, ensuring that the carrier's forward direction Y is parallel to the MEMS inertial-satellite combination navigation system's inertial module forward axis Y1 (as shown in Figure 9).

5.1.2 Fixed Antenna

The three antennas should be installed in a triangular formation to ensure that the three antenna modules form an antenna array, improving accuracy. (Two antennas are placed on the left and right sides of the center console, and the third can be placed inside the shark fin on the roof.)
Antenna installation angle diagram: The three antennas are not distinguished; during installation, they should be oriented with the front facing upward, and the side with screw holes is the back. The antenna modules must be installed at a specific angle. When installing each antenna, try to orient the bottom-right part of the antenna module outward. It is best to place the antenna flat to ensure full contact with the sky. The antennas also support tilted placement, and the tilt angle should ideally be within 45° to ensure that the antenna can receive signals from about 3/4 of the sky. Avoid placing metal objects above the antennas to prevent interference with satellite signal reception.



5.1.3 Interface Connections

1. The device is powered and transmits data via the OBD interface.
2. The OBD supplies power (12V) to the integrated navigation system host.
3. The odometer connects through the OBD CAN interface to obtain the vehicle's mileage data (The CAN interface supports only certain vehicle models and can be customized based on user requirements).

5.2 Software Usage

1. Ensure the computer is connected to the internet.

2. In the computer's GkTest2-win32-x64 folder, click on GkTest2.exe to open the host software.

3. Click "Close Serial Port."

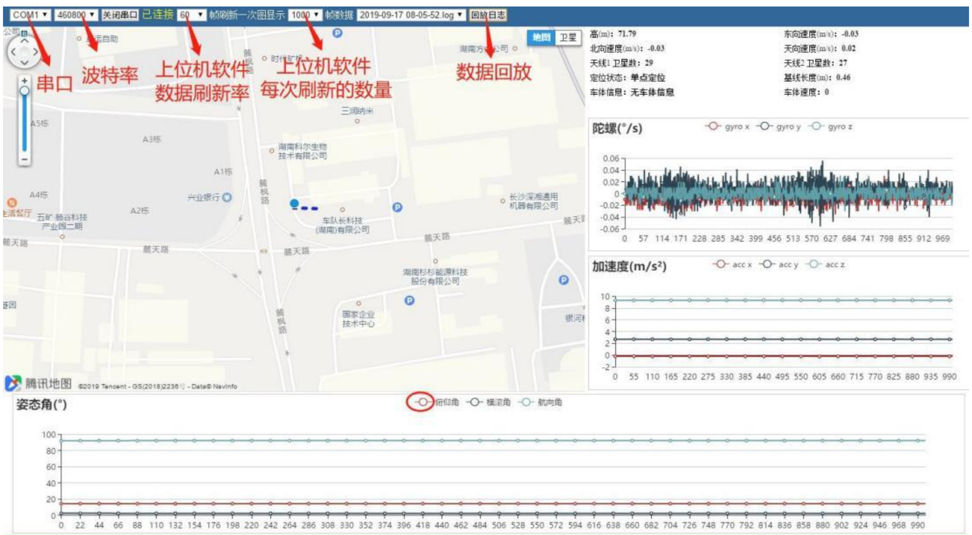
4. The default baud rate is 460800. If the baud rate is modified, select the modified baud rate.

5. The default data refresh rate for the host software is 20Hz. If the actual data refresh rate from the serial port is not 20Hz, click the drop-down arrow next to "20" and select the actual refresh rate for configuration.

6. Click "Open Serial Port," then wait for the successful positioning to display location, satellites, gyro, accelerometer, heading angle, pitch angle, roll angle, and other information.

7. If data replay is needed, after closing the serial port, select the log file and click "Replay Log" to replay the data.

8. In the attitude angle display interface, click the icon before "Pitch," "Roll," or "Heading" to toggle the display of the corresponding data.



Schematic diagram of host computer software

6. Notes

1. The installation of the combined navigation system host and antennas must strictly follow the required installation procedures.

2. The system host, antennas, and the carrier should be firmly connected to maintain the same movement state.

3. The module will only output data after successfully obtaining satellite signal positioning. Please install and initialize the system in an area with satellite signals.

4. The host software supports parsing of NMEA0183 GNGGA and hexadecimal data 1 and 2, but does not currently support parsing of NMEA0183 GIAVP data.

5. After sending the command, the save command must be sent: $cmd,saveconf,1*ff. After configuration is successful, the system host must be powered on again.

6. The odometer supports the CAN interface, but only supports certain vehicle models. Custom solutions are available based on user needs.

7. If using an odometer, calibration is required. After successful positioning, if the carrier's accumulated speed for 2 minutes exceeds the odometer calibration speed threshold (default is 10/ms, configurable), calibration is complete. If calibration is not finished and the system enters a loss of lock state, the positioning performance may be slightly affected.

8. The host software requires the computer to be connected to the internet. Otherwise, the map will not load.

9. The Y-axis scale in the "Gyro," "Accelerometer," and "Attitude Angle" interfaces of the host software is auto-adjusted dynamically with the data and cannot be manually set.

10. The module can output four protocols: NMEA0183 GPINS, NMEA0183 GIAVP, hexadecimal protocol 1, and hexadecimal protocol 2. The module ’ s data format, data refresh rate, and output rate are configurable. See the product protocol for specific configuration details.

12. After use, first disconnect the main serial port from the computer, and then disconnect the power of the combined navigation system host.

13. The system host and antennas must be at least 20 cm away from high-speed cameras (if any), and there must be isolation between them.

Appendix 1 (CAN protocol, Intel format, baud rate 500kbps)

CAN Protocol						
ID=0x360						
filed	description	scale	unit	format	size	offset
week	GPS Week	1		Uint16	2	0
millisecond	GPS milliseconds of week	1	ms	Uint32	4	2
position_type	0-none,1-single,2-psrdiff,3-rtkfloat,4-rtkint	1		Uint8	1	6
satellites	Calculate the number of satellites used	1		Uint8	1	7
ID=0x361						
latitude	latitude	1e-7	deg	Int32	4	0
longitude	longitude	1e-7	deg	Int32	4	4
ID=0x362						
altitude	high	1e-3	m	Int32	4	0
heading	Heading, 0~360 degrees, due north is 0, clockwise	1e-3	deg	Uint32	4	4
ID=0x363						
latitude_dev	Latitude standard deviation	0.01	m	Uint16	2	0
longitude_dev	Longitude standard deviation	0.01	m	Uint16	2	2
altitude_dev	Height standard deviation	0.01	m	Uint16	2	4
heading_dev	Heading standard deviation	0.01	deg	Uint16	2	6
ID=0x364						
year	UTCYear, from2000Starting from the year,2020The value for the year20	1	Year	Uint8	1	0
month	UTCmoon,1~12	1	moon	Uint8	1	1
day	UTCday,1~31	1	day	Uint8	1	2
hour	UTChour,0~23	1	hour	Uint8	1	3
minute	UTCpoint,0~59	1	point	Uint8	1	4
second	UTCSecond,0~59	1	Second	Uint8	1	5
millisecond	UTCmillisecond,0~999	1	millisecond	Uint16	2	6
ID=0x365						
Pitch	Pitch angle (-90~90)		deg	Float	4	0
Roll	Roll angle (-180~180)		deg	Float	4	4
ID=0x366						
Nv	Northbound speed		m/s	Float	4	0
ewE	Eastbound speed		m/s	Float	4	4
ID=0x367						
D	Ground speed		m/s	Float	4	0
AccX	Acceleration X axis		m/s^2	Float	4	4

ID=0x368						
Y	Acceleration Y axis		m/s^2	Float	4	0
ZGar	Acceleration Z axis		m/s^2	Float	4	4
ID=0x369						
GyroX	Gyroscope X axis		°/s	Float	4	0
Y	Gyroscope Y axis		°/s	Float	4	4
ID=0x370						
GyroZ	Gyroscope Z axis		°/s	Float	4	0
ID=0x371						
latitude	latitude	1e-10	deg	Int64	8	0
ID=0x372						
longitude	longitude	1e-10	deg	Int64	8	0