RAC-D1M High-precision positioning module specification

RAC high precision GNSS receiver

Achieve high-precision satellite positioning without differential stations and ground-based augmentation networks

Real-time Array Calibration

Product Model: RAC-D1M

Hardware version: RAC_D1M_M10_V1.0

Software Version: D1M_BSS_V1.1_

211201

Document Revision History

Version	Revision Date	Version described
V1.0	2022/03/10	New Document
V1.1	2022/06/22	Document optimization

Disclaimer

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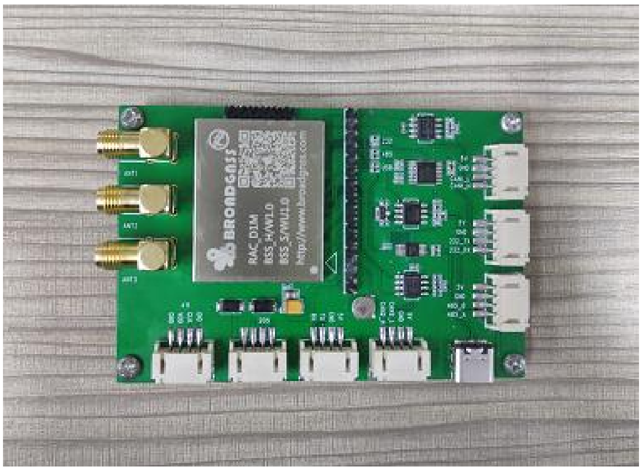
1. Product Description

1.1Product Overview

Product Name: RAC-D1M High-precision positioning module

RAC-D1M module appearance



Development board appearance

The RAC-D1M is a single-frequency high-precision positioning module with three external positioning antennas, offering full-range high-precision positioning capabilities. The positioning accuracy can reach less than 1.0 meter in static mode and less than 0.6 meters in dynamic mode, meeting the strict requirements of industrial-grade positioning as well as personal use needs.
Through technological innovation, the product has two core competitive advantages: no need for differential stations and no use of L2 or B3 pseudo-range codes, resulting in a low cost. Unlike traditional high-precision satellite positioning technologies, our technology eliminates the reliance on differential systems, significantly reducing costs. This is the key advantage that places us ahead of similar products worldwide.

1.2 Product Features

UART interface output for faster applications;

Uses KDS 0.5PPM high-precision TCXO;

Data output: 115200bps, 5Hz;

Data output protocol: NMEA0183;

Self-developed antenna element design ensures the phase center and geometric center coincide, minimizing the impact of antenna measurement errors;

Manufactured using lead-free processes, complying with RoHS standards.

1.3 Certification Testing

The positioning chip is AEC-Q100 certified.

The positioning module has passed ISO16750 testing.

The positioning product has passed ISO7637 testing.

The production line complies with ISO/TS-16949 certification.

1.4 Application

Autonomous driving, positioning navigation, and tracking products for vehicles;

Drone applications, agricultural plant protection machinery, and precision agriculture;

UTC time synchronization and timekeeping applications;

Widely used in channel measurement and marine survey;

Products for trajectory recording and GPS data point calibration;

High-precision map creation, area measurement, and distance measurement in surveying;

Road construction, earthquake monitoring, bridge deformation monitoring, landslide monitoring, and container operations at docks.

1.5 Performance Indicators

Sensitivity	Track	- 167dBm
	Capture	- 160dBm
	Cold Start	- 148dBm
	Hot Start	- 159dBm
TTFF (Time to First Fix)	Cold Start	Average ≤30S
	Warm start	Average<5S
	Hot Start	Average<2S
Type	Frequency GPS L1 1575.42MHz, BDS B1 1561.098MHz	
External position accuracy	External static positioning accuracy:1.0m（2σ）	
	External dynamic positioning accuracy:0.6m（2σ）	
Internal positioning accuracy	Internal static positioning accuracy:0.2m（2σ）	
	Internal dynamic positioning accuracy:0.5m（2σ）	

	Coordinate system	Coordinate basis:WGS-84
Speed accuracy	0.1m/s	
Update rate	5HZ	
PPS	100ms（1pps=1Hz=1times/second)	
Operational restrictions	High	<80000m
	Speed	<500m/s
	Acceleration	<4g
Data Format	NMEA 0183 General Protocol	

Power Specifications

Power supply	DC 5.0V
Working current	Peak:180mA
Standby current	<5uA
Functional Interface	UART

Physical properties

Temperature	Operating temperature	- 40℃~85℃
	Storage temperature	- 40℃~85℃

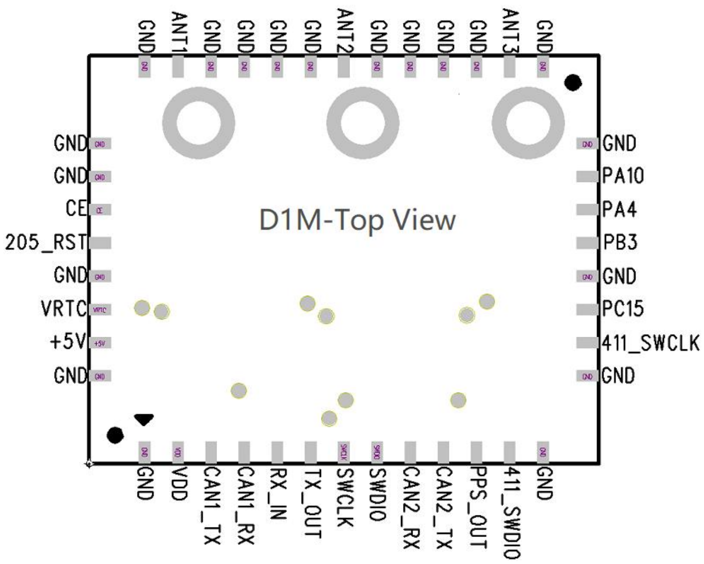
1.6 Product port definition

The product output supports UART and CAN interfaces. The specific pin definitions are shown in the following table:

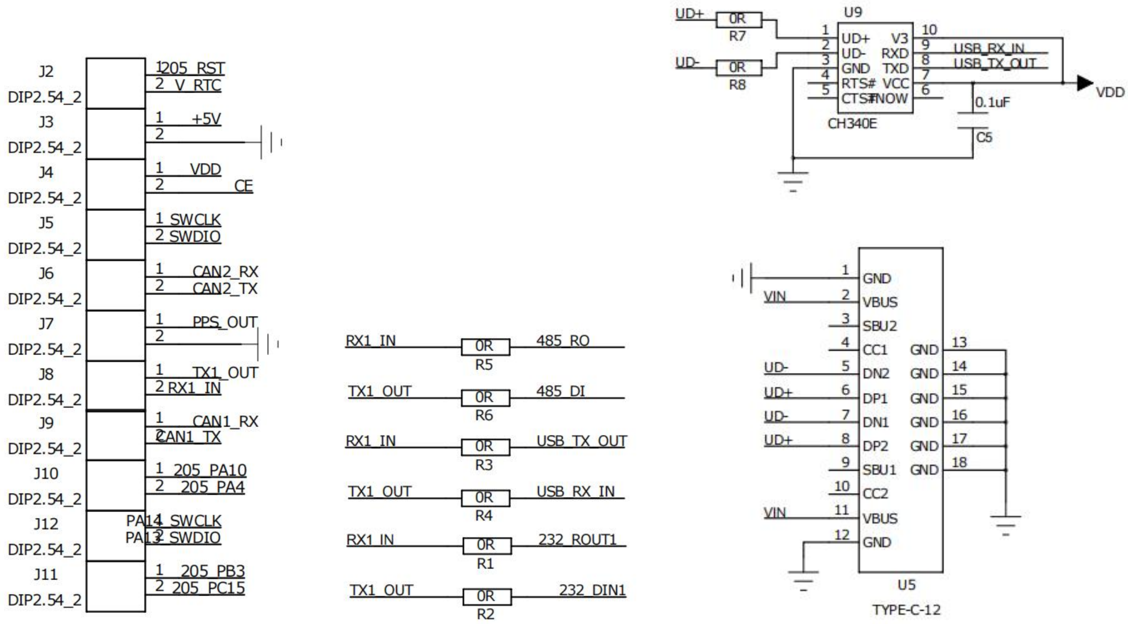
Pin NO.	Pin Name	I/O	Remark
1	GND	land	land
2	VDD	power supply	Burning power supply 3.3V
3	CAN1_TX	Output	CAN Transmit
4	CAN1_RX	enter	CAN Receive

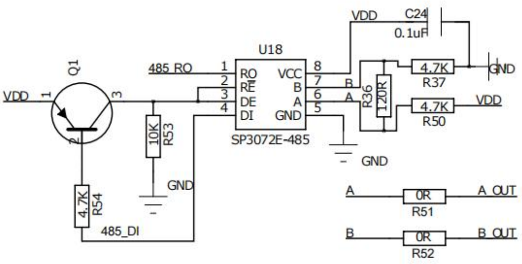
5	RX_IN	enter	TTL serial port receiving
6	TX_OUT	Output	TTL serial port transmission
7	SWCLK	I/O	205-Clock
8	SWDIO	I/O	205-Data
9	CAN2_RX	enter	CAN Receive
10	CAN2_TX	Output	CAN Transmit
11	PPS_OUT	Output	1PPS signal
12	411_SWDIO	I/O	411-Data
13	GND	land	land
14	GND	land	land
15	411_SWCLK	I/O	411-Clock
16	PC15	I/O	Reserve
17	GND	land	land
18	PB3	I/O	Reserve
19	PA4	I/O	Reserve
20	PA10	I/O	Reserve
21	GND	land	land
22	GND	land	land
23	ANT3	enter	RF_IN antenna signal input
24	GND	land	land
25	GND	land	land
26	GND	land	land
27	GND	land	land
28	ANT2	enter	RF_IN antenna signal input

29	GND	land	land
30	GND	land	land
31	GND	land	land
32	GND	land	land
33	ANT1	enter	RF_IN antenna signal input
34	GND	land	land
35	GND	land	land
36	GND	land	land
37	CE	enter	Module power enable (high level enables, low level turns off)
38	205_RST	enter	205-RST
39	GND	land	land
40	V_RTC	enter	Module backup power
41	VCC	power supply	DC 5.0V
42	GND	land	land
The middle of the bottom of the module is a reserved test point			



Development Board Schematic





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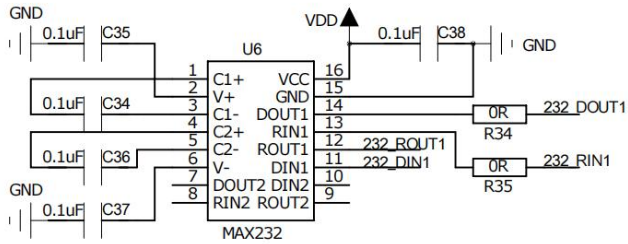
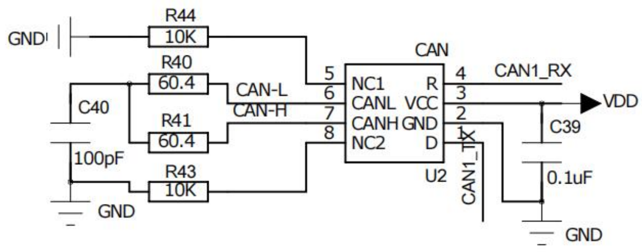
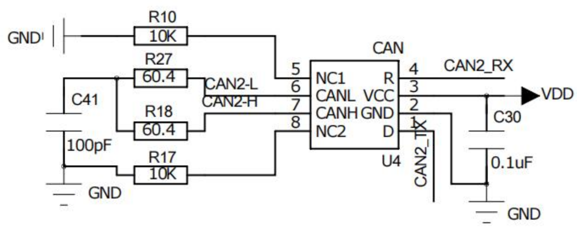


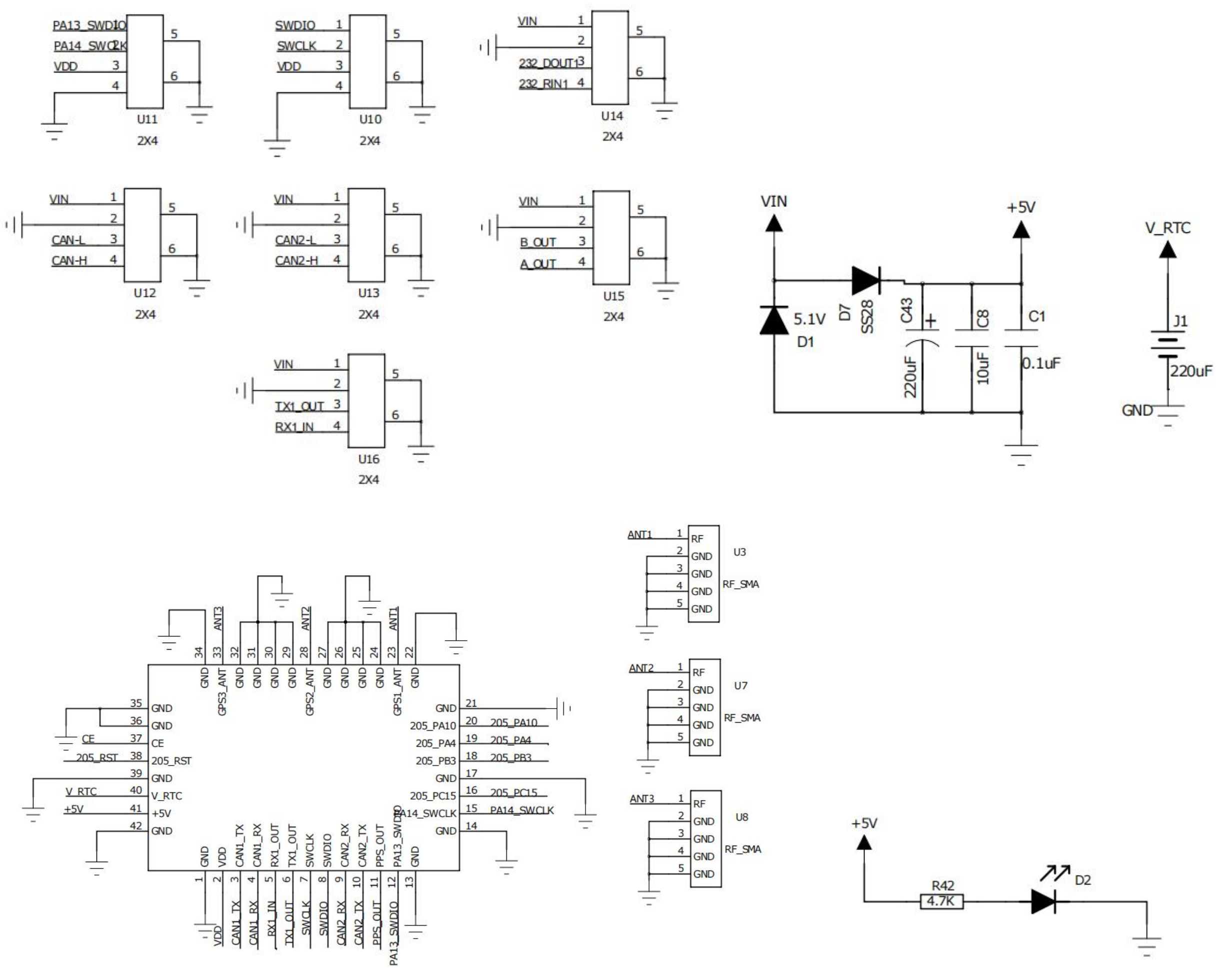
MAX232



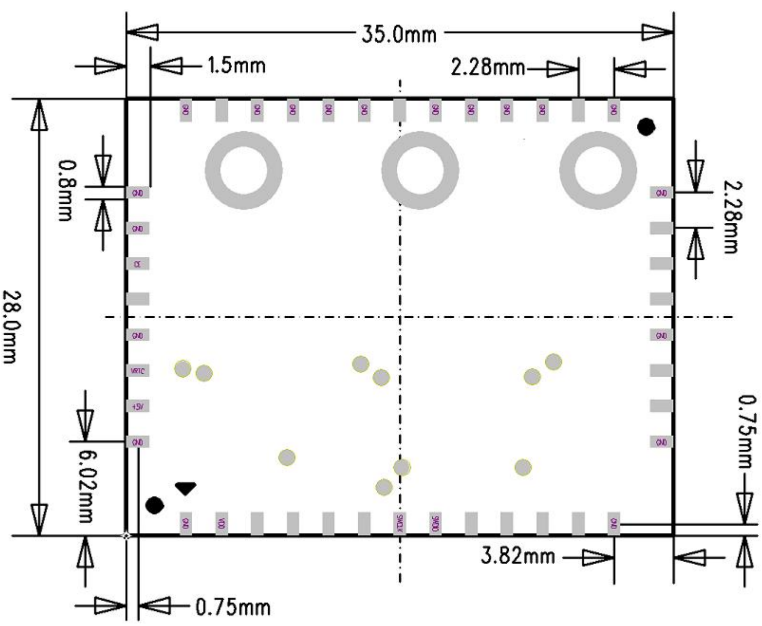
CAN1



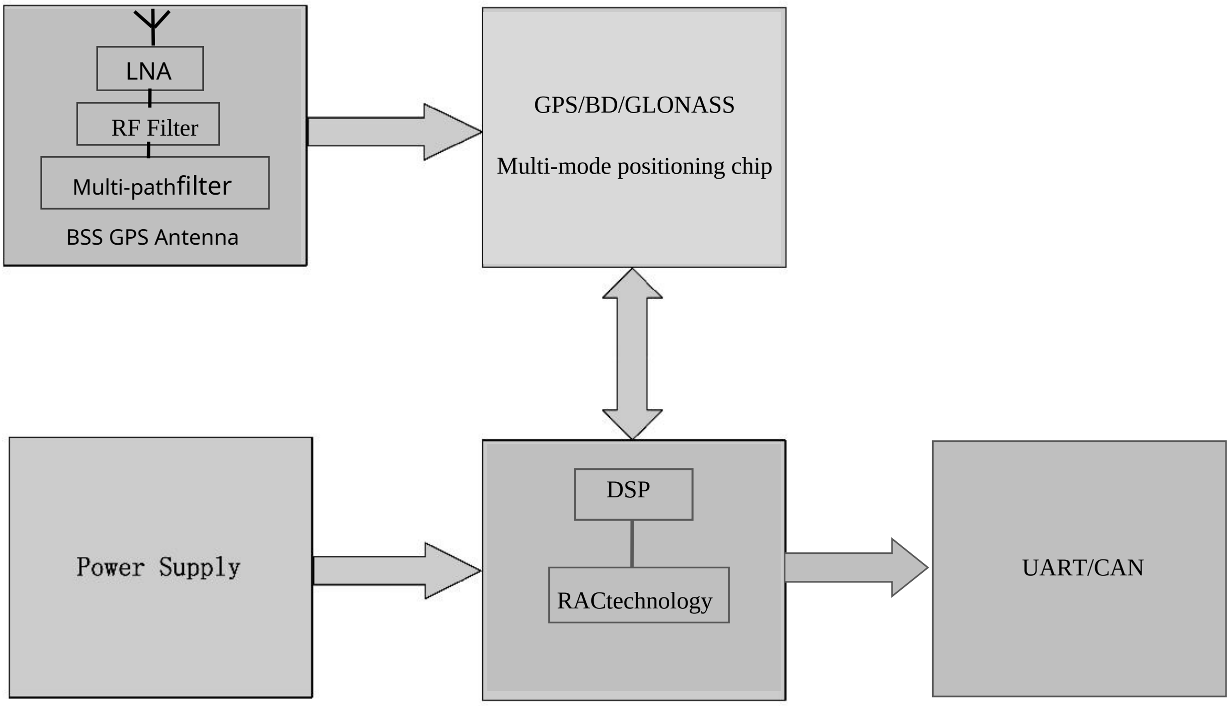
CAN2



Module solder joint spacing



1.7Functional Block Diagram

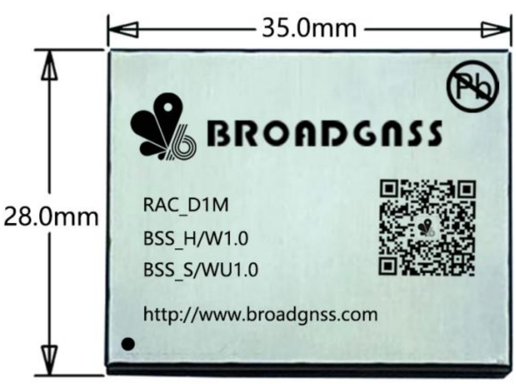


The RAC-D1M high-precision positioning module features a self-developed antenna element design, ensuring the phase center and geometric center coincide, minimizing the impact of antenna measurement errors. The antenna receives satellite signals from the sky and transmits them to the chip's RF unit. The RF unit then sends the signals to the chip's baseband unit, where they are processed through a series of analyses before being transmitted to the DSP. After processing by RAC's self-developed algorithms, high-precision positioning data is output via the TTL serial port.

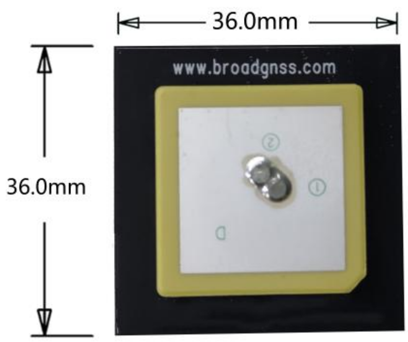
1.8 Product size

Module size: length35mm*Width28mm*high4mm

Antenna size: Long36mm*Width36mm*high10mm



Module size diagram



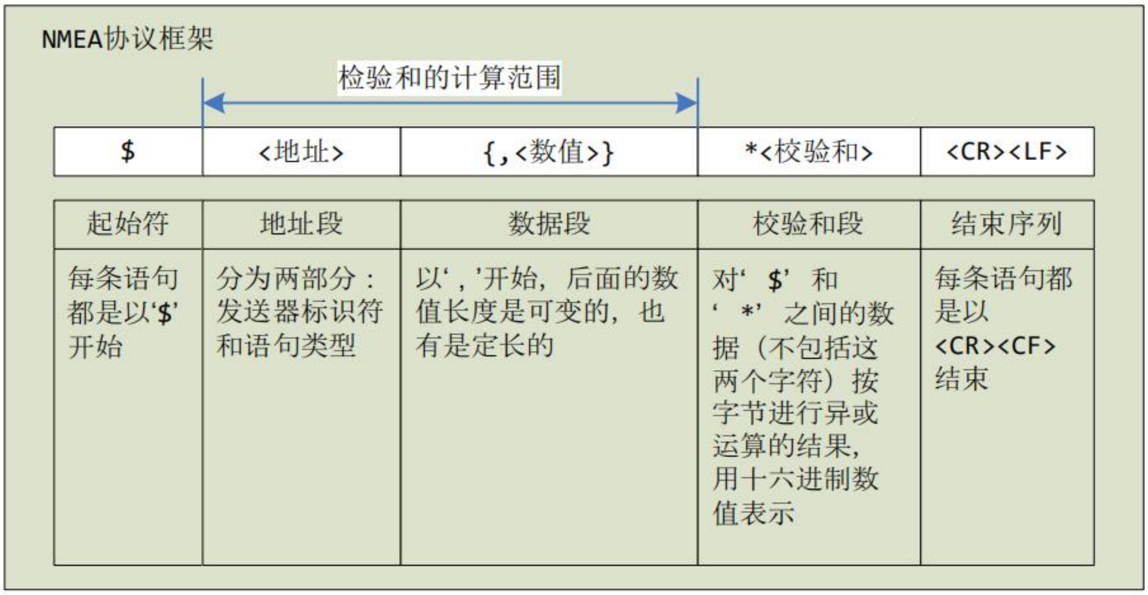
Antenna Dimensions

2. Output Statement

2.1 Output Statement

2.1.1 NMEA 0183protocol

NMEA 0183 is the standard format developed by the National Marine Electronics Association (NMEA) for marine electronic devices. It has become the unified RTCM (Radio Technical Commission for Maritime Services) standard protocol for GPS navigation equipment. The NMEA 0183 protocol uses ASCII encoding to transmit GPS positioning information. The data format and protocol framework are as follows:



Statement output:

	information	illustrate
1	RMC	Recommended minimum dedicated navigation data
2	GGA	Receiver positioning data
3	GST	GNSS pseudorange error

2.1.1.1 Minimum dedicated navigation data recommended by RMC

Information	RMC
Describe	Recommended minimum positioning information
Type	Output
Format	$--RMC,UTCtime,status,lat,uLat,lon,uLon,spd,cog,UTCdate,mv,mvE,mode*CS<CR><LF>
Example	$GPRMC,084103.00,A,2233.39544,N,11356.55665,E,0.035,,220618,,,A*7A
Parameter Description	

Fields	Name	Format	Parameter Description
1	$--RMC	String	Message ID, RMC statement header, '--' is the system identifier
2	UTC time	hhmmss.ss	The current location's UTC time
3	status	character	Position valid flag. V = invalid data A = valid data
4	lat	ddmm.mmmmm	Latitude, the first two characters represent degrees, the following characters represent minutes
5	uLat	character	Latitude direction: N-North, S-South
6	lon	dddmm.mmmmm	Longitude, the first 3 characters represent degrees, the following characters represent minutes
7	uLon	character	Longitude direction: E-East, W-West
8	spd	Numeric	Ground speed, in knots
9	cog	Numeric	True heading relative to the ground, in degrees (output is empty when static)
10	UTC date	ddmmyy	Date (dd for day, mm for month, yy for year)
11	mv	Numeric	Magnetic declination, in degrees. Fixed to be empty
12	mvE	character	Magnetic declination direction: E-East, W-West. Fixed to empty
13	Mode	character	Mode indication (A = autonomous positioning, D = differential, R = RTK, E = estimation, N = invalid data)
14	navStatus	character	Navigation status indicator (V means the device does not provide navigation status information)NMEA v4.1 and above only
15	CS	Hexadecimal value	Checksum, the XOR result of all characters between $ and * (excluding $ and *)
16	<CR><LF>	character	Carriage return and line feed

2.1.1.2 GGA receiver positioning data

Information	GGA		
Describe	Receiver time, location and positioning related data		
Type	Output		
Format	$--GGA,UTCtime,lat,uLat,lon,uLon,FS,numSv,HDOP,msl,uMsl,sep,uSep,diff Age,diffSta*CS<CR><LF>		
Example	$GPGGA,235316.00,2959.99250,S,12000.00900,E,1,06,1.21,62.77,M, 0.00,M,,*7B		
Parameter Description			
Fields	name	Format	Parameter Description
1	$--GGA	String	Message ID, GGA statement header, '--' is the system identifier
2	UTC time	hhmmss.ss	The current location's UTC time
3	lat	ddmm.mmmmm	Latitude, the first two characters represent degrees, the following characters represent minutes
4	uLat	character	Latitude direction: N-North, S-South
5	lon	dddmm.mmmmm	Longitude, the first 3 characters represent degrees, the following characters represent minutes
6	uLon	character	Longitude direction: E-East, W-West
7	FS	Numeric	GPS positioning status (0 = no positioning, 1 = non-differential positioning, 2 = differential positioning)
8	numSv	Numeric	The number of satellites used for positioning, 00~12

9	HDOP	Numeric	Horizontal Dilution of Precision
10	msl	Numeric	Altitude, that is, the height of the receiver antenna relative to the geoid high
11	uMsl	character	Altitude unit, meter, fixed character M
12	sep	Numeric	The distance between the reference ellipsoid and the geoid, " - " indicates The geoid is lower than the reference ellipsoid
13	uSep	character	Altitude unit, meter, fixed character M
14	diffAge	Numeric	Differential time (from the last differential signal received) Seconds, non-differential positioning, this item is empty)
15	diffStat	Numeric	The ID of the differential reference station (empty for non-differential positioning)
16	CS	Hexadecimal value	Checksum, all characters between $ and * (excluding $ and *) XOR result
17	<CR><LF>	character	Carriage return and line feed

2.1.1.3 GST GNSS pseudorange error

Information	GST		
Describe	GNSS pseudorange error		
Type	Output		
Format	$--GST,UTCtime,rangeRms,stdMajor,stdMinor,orient,stdLat,stdLong,stdAlt * cs<CR><LF>		
Example	$GPGST,082356.00,1.8,,,,1.7,1.3,2.2*7E		
Parameter Description			
Fields	name	Format	Parameter Description
1	$--GST	String	Message ID, GST statement header, '--' is the system identifier
2	UTC time	hhmmss.ss	The current location's UTC time
3	rangeRms	Numeric	The RMS value of the standard deviation of the pseudorange used for navigation calculations
4	stdMajor	Numeric	Ellipsoid semi-major axis standard deviation (meters) (output is empty)
5	stdMinor	Numeric	Ellipsoid semi-minor axis standard deviation (meters) (output is empty)
6	orient	Numeric	Ellipsoid semi-major axis direction (degrees) (output is empty)
7	stdLat	Numeric	Standard deviation of latitude error (meters)
8	stdLong	Numeric	Standard deviation of longitude error (meters)
9	stdAlt	Numeric	Standard deviation of height error (meters)
10	CS	Hexadecimal value	Checksum, all characters between $ and * (excluding $ and *) XOR result
11	<CR><LF>	character	Carriage return and line feed

2.2 Reference Program

2.2.1 NMEA0183Protocol Verification Reference Program

```
unsigned char Calc_GPS_Sum( const char* Buffer ) {

    unsigned char i, j, k, sum;
    sum = 0;
    for ( i = 1; i < 255; i++ ) //ifrom1The beginning is to flash the $ start character {

        if ( ( Buffer[i] != '*' ) && ( Buffer[i] != 0x00 ) ) //Determine the end character {

            sum ^= Buffer[i]; //GPSThe checksum algorithm isXOR
        }
        else
        {
            break;
        }
    }
    j = Buffer[i + 1]; //Take the two characters after the
    terminator k = Buffer[i + 2];

    if ( isalpha( j ) ) //Determines whether the character is an English letter. If it is an English letter, it returns a non-zero value, otherwise it returns zero. {

        if ( isupper( j ) ) //If the character is an uppercase English letter, it returns a non-zero value, otherwise it returns zero {

            j -= 0x37;//Forced to16Base
        }
        else
        {
            j -= 0x57;//Forced to16Base
        }
    }
    else
    {
        if ( ( j >= 0x30 ) && ( j <= 0x39 ) ) {

            j -= 0x30;//Forced to16Base
        }
    }

    if ( isalpha( k ) ) //Determines whether the character is an English letter. If it is an English letter, it returns a non-zero value, otherwise it returns zero. {

        if ( isupper( k ) ) //If the character is an uppercase English letter, it returns a non-zero value, otherwise it returns zero {

            k -= 0x37; //Forced to16Base
        }
        else
        {
            k -= 0x57; //Forced to16Base
        }
    }
```

```
        else
        {
                if ( ( k >= 0x30 ) && ( k <= 0x39 ) ) {

                        k -= 0x30; //Forced to16Base
                }
        }

        j = ( j << 4 ) + k; //Force merge to16Base //
        gps_sum = j;

        if ( sum == j )
        {
                return Valid; //Checksum OK
        }
        else
        {
                return Invalid; //Checksum Error
        }
}
```

3. Contact Us

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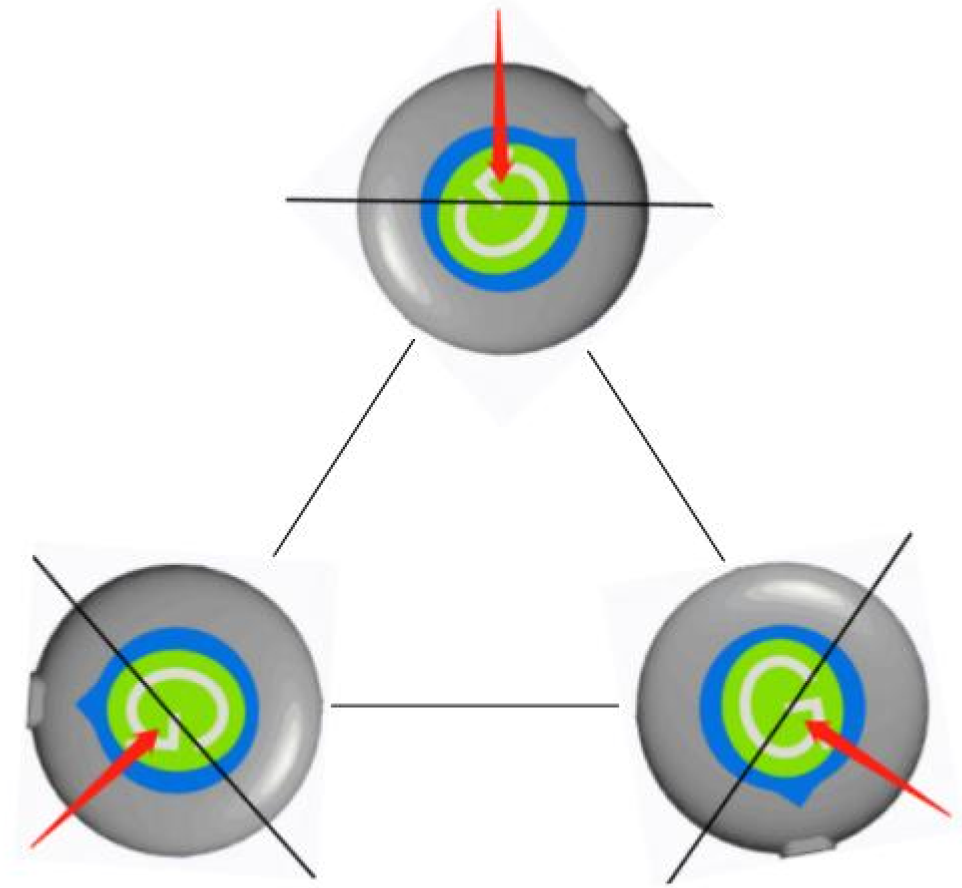
4. Equipment Installation

Place the RAC-D1M horizontally and fix it on the center console, with the three antennas arranged in a triangular configuration. This arrangement ensures that the three antenna modules form an antenna array to improve accuracy. (Two antennas should be placed on the left and right sides of the center console, while the third antenna can be installed inside the shark fin on the roof.)
Antenna Installation Angle Diagram:The three antennas are not distinguished from one another. During installation, ensure that the antennas are facing upward, with the screw holes positioned on the back. The antenna modules require a specific installation angle. For each antenna, try to orient the lower-right corner outward when installing. The antennas should ideally be placed flat to ensure full exposure to the sky. The antennas can also be installed at an inclined angle, but the tilt should ideally not exceed 45°, which will still allow for about 3/4 of the sky to be covered.Additionally, avoid any metal objects obstructing the top of the antennas, as this could interfere with satellite signal reception.



Specific installation example: