MicroBrain Intelligent

UAV-R121-1（UART）UAV obstacle avoidance radar sensor user manual

Microbrain Intelligent Technology Co., Ltd.

Disclaimer

Welcome to purchase this product.

Microbrain Intelligent Technology Co., Ltd. official website: https://www.microbrain.com.cn/en.

Please read this statement carefully before using this product. Once used, it is deemed to be recognition and acceptance of the contents of this statement. Please strictly follow the manual to install and use this product. If there is damage or injury caused by improper use, Microbrain Intelligent Technology Co., Ltd. will not be responsible for the corresponding losses and compensation.

Historic version

Date	Version	Version description
2024.04.03	1.0	UAV-R121-1 Open source flight controller application

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1.UAV-R121-1 Introduction

UAV-R121-1(UART)Obstacle Avoidance Radar is a tiny & light millimeter wave obstacle avoidance radar sensor, which is self-designed and manufactured by MicroBrain Intelligent. It has advantages of high precision, small body, high sensitive, light weight, easy for integration and stable performance. This product can distinguish whether there's obstacle ahead or not by forward sending fan-shaped 79GHz electromagnetic wave and dealing with the returned signals. It will send back the relative distance, speed and angle data between obstacles and radar to make the drone keep away from obstacles and ensure its safe working.

UAV-R121-1(UART)Medium distance radar has performance as below:

1.1. 2T4R MIMO array antenna design,±15°azimuth FOV,High angular resolution and angular detection accuracy；

1.2. Working frequency 77GHz~81GHz，sensitive for motion and precise for distance detection.

1.3. Effective detection distance 120m；

1.4. Support UART protocol output，Default baud rate115200；

1.5. Apply DSP + ARM dual core structure for signal process and control unit. Execute radar data process, target detection and tracking arithmetic on inside high speed digital signal processor.

2.Product Feature

Type：Obstacle Avoidance Radar

Model：UAV-R121-1

Dimensions：76*71.5*19.6mm

Weight：87g（Including cables）

Protection：IP67

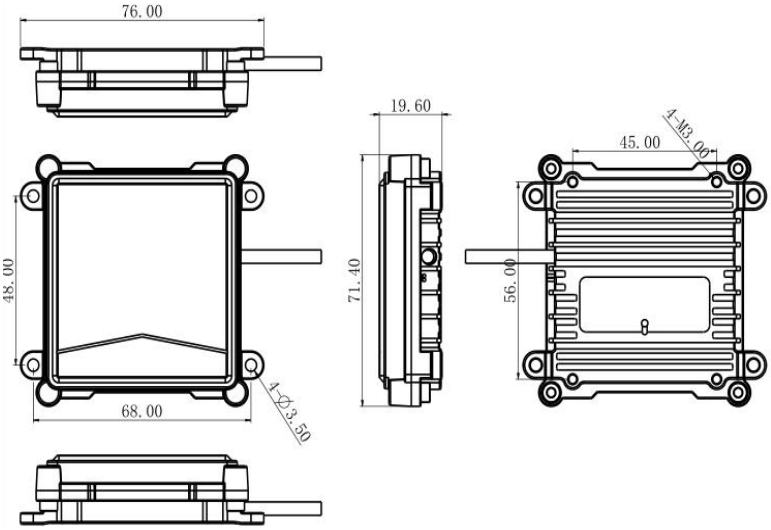


Figure 1 UAV-R121-1 Dimensions

3.Product Parameters

Item	Parameters	Data
Antenna performance	Azimuth	±15°
	Elevation	-5°~+3°
	EIRP(dBm)	30
Radar performance	Distance detection range(m)	1.5~120
	Distance detection accuracy(m)	±0.1m
	Distance detection resolution(m)	0.9
Radar Performance	Frequency(GHz)	79

	Refresh rate(Hz)	20
	Bandwidth(GHz)	0.16
System property	Working voltage(V)	5-24
	Working Temperature	-40℃~85℃
	Power consumption(W)	3W
	Protection rating	IP67
	Communication Interface	UART
	PCB size (mm)	55*52*1.6

4.Product Picture

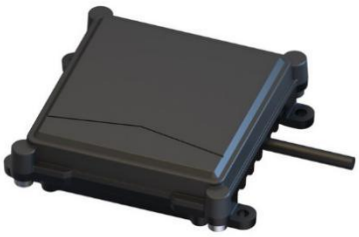


Figure 2 UAV-R121-1 Product Photo

5.Installation

UAV-R121-1 Radar Installation Step：

5.1 Installation location:There shouldn't have any obstacles in the area of beam azimuth width ±15° or elevation width -5°~ +3°.

5.2 Installation direction: The antenna is on the back of radar where there's an arrow. While installing, the direction of arrow on radar's back should be upward, cables of radar be right towards, and the front side of radar towards the flying direction of drone.

5.3 Installation angle: While installing, the antenna side (radar front side) points to the front direction of drone. The radar installed inclined upwards according to the largest inclination angle during drone flying. The best install angle is relative to the biggest flying incline angle and flying height. Ordinary speaking, 12°incline angle is recommended.

Assume the drone flying incline angle as θ, drone working height as H, max alarm distance as $R_{\max}$, then it comes:

$$\frac{\mathrm{H}}{\sin(\theta+3)} > R_{\max}$$

And then:

$$\theta < \arcsin\left(\frac{\mathrm{H}}{R_{\max}}\right) - 3$$

If make $\theta_0 = \arcsin\left(\frac{\mathrm{H}}{R_{\max}}\right) - 3$, then θ_0 is the largest drone incline angle that the radar install can accept; If the drone incline angle is bigger than θ_0, then it needs amendment, which will need the radar be installed upward inclined. The installation angle is θ_{comp} and make $\theta\text{-}\theta_{\mathrm{comp}} < \theta_0$, Then the installation angle should be:

$$\theta_{\mathrm{comp}} > \theta\text{-}\theta_0$$

Furthermore, the more stable of platform, the smaller fluctuation will radar beam has. And the smaller install angle, the more stable detection the radar will have for front obstacles.

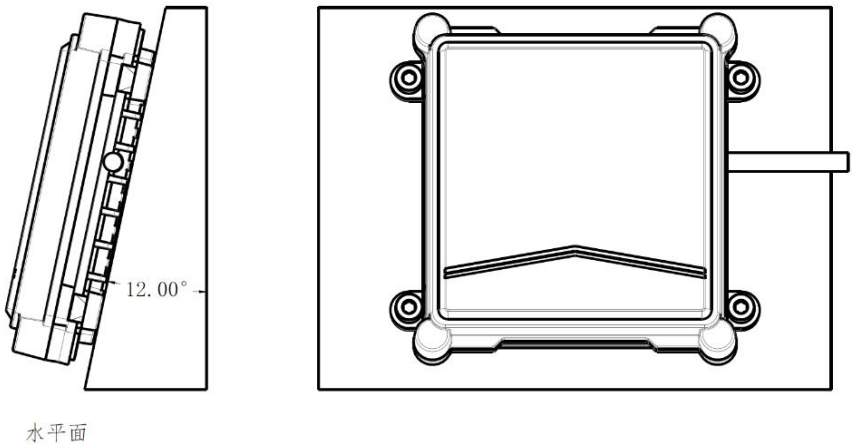


Figure3 Radar installation

6.Quickly Guidance

● Pin Definition

UAV-R22-1 The interface pin definition of the sensor, as shown in the table 1：

PIN	Definition	Range
1	POWER_IN（Red）	5~24V DC
2	GND（Black）	-
3	TX（Green）	0~3.3V
4	RX（White）	0~3.3V

Table 1：UAV-R121-1 Pin interface definition

● Testing using

Superior machine testing software provided by Microbrain Intelligent can obtain and analyze UAV-R121-1 sensor data, and intuitively display the observation results. Use this tool to help the use of UAV-R121-1 obstacle avoidance radar distance detection

Use the UART protocol test method as follows：

First obtain UAV-R121-1 upper computer test software from Microbrain Intelligent customer service or website.Please install and configure the upper computer testing

software according to the manual.

Table 3 Testing tools

No.	Device	Number
1	UAV-R22-1 radar sensor	1
2	PC	1
3	TTL-USB	1
4	5~24V power adapter	1
5	Upper computer test software	1

1） Through TTL-USB module，Connect PC with UAV-R121-1 radar sensor，picture as follow ：

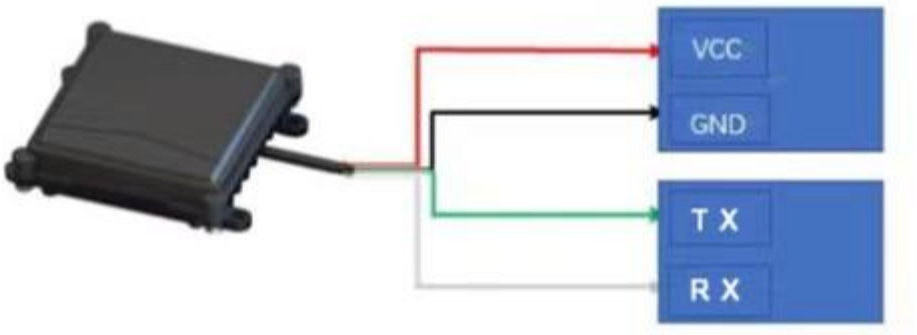
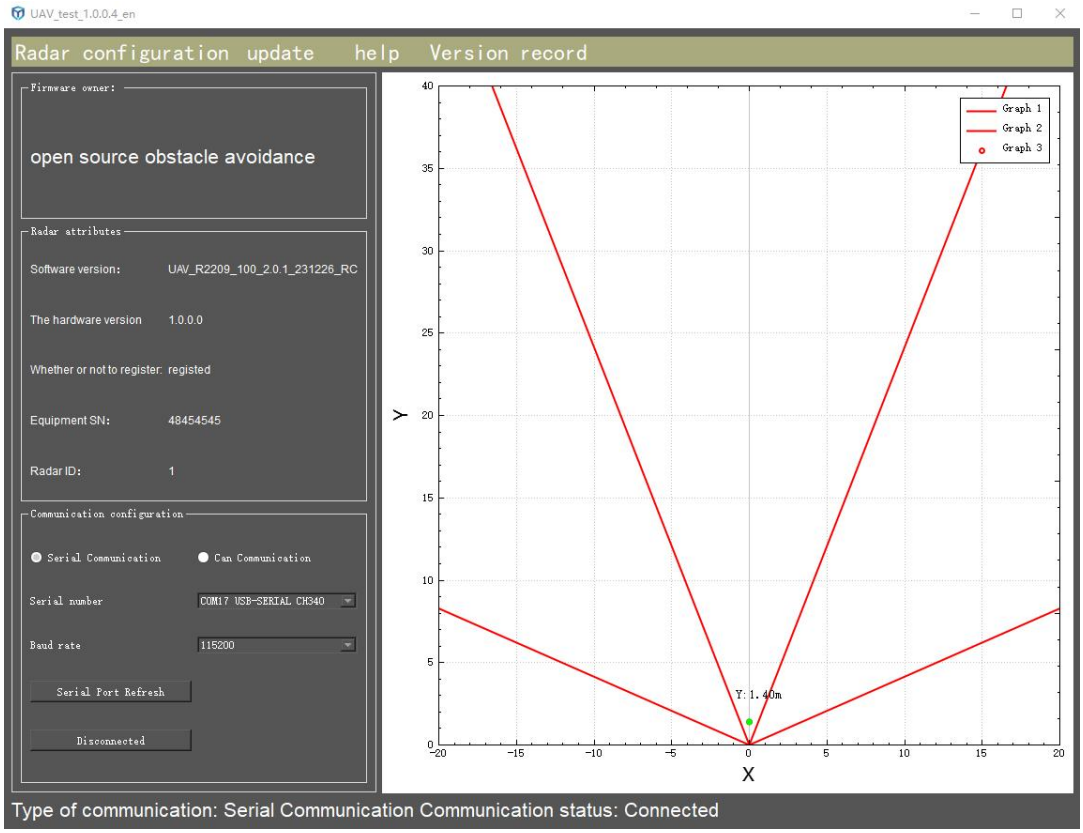


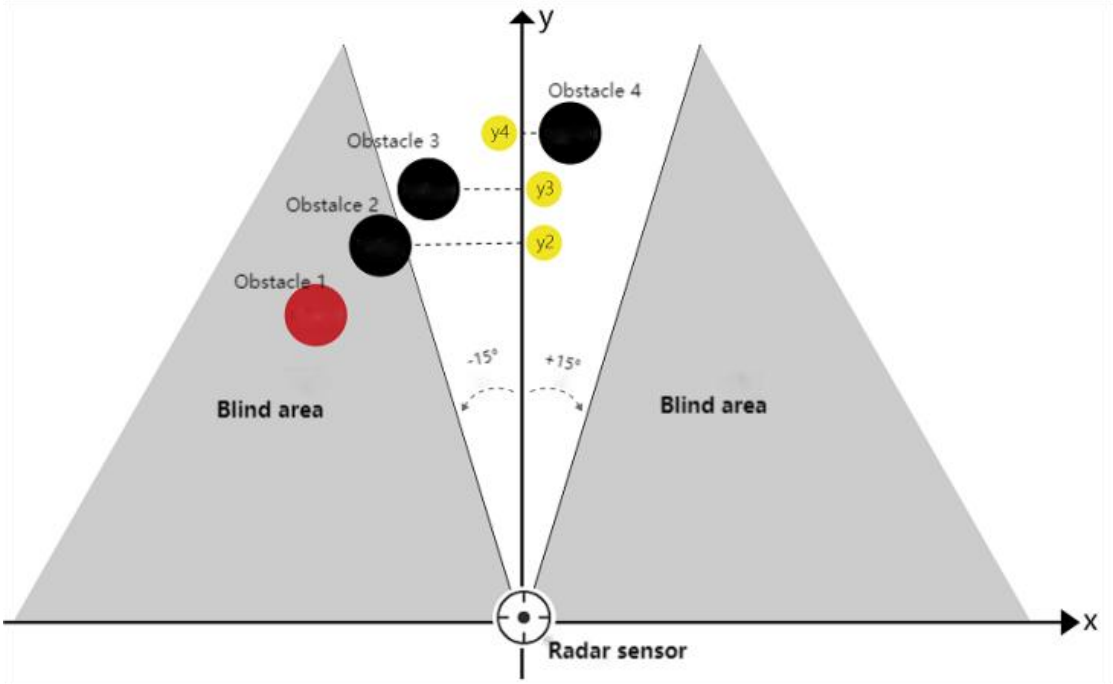
Figure 4 Serial port line connection

Connect with PC and radar sensor, open upper computer test software, Click to start ,the test result as shown in the figure follow



Serial data analysis

UAV-R121-1radar sensor outputs the Y coordinate of the recent obstacle.as shown in the figure below,obstacle 1is not within the range of radar beams, can not detected by radar.Among the obstacle 2、3 and 4，the distance between obstacle 2 is the closest to Y2, The final output value of radar is Y2



Serial port baud rate 115200，Support 3.3V electric level，Data refresh rate 20Hz，Data unit（cm），Send specified data packet format according to customer needs，Each frame of data packet is executed according to the customer's protocol。UAV-R121-1 data as follow.

UAV-R121-1 77GHz mmWave radar is UART output, 115200bps, 8N1. Output Frequency 20Hz. Specific protocol format is as follows：

Header Byte D1 D2 D3 D4 D5 D6 D7 D8 D9 CRC

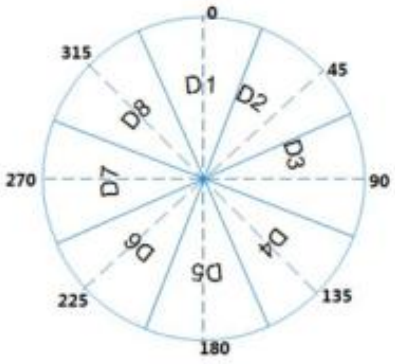
Byte	Parameter Description		Unit	Explanation	Remark
Byte 0	Header Byte 1	uint8_t		Fixed‘T’, that is 0x54	
Byte 1	Header Byte 2	uint8_t		Fixed‘H’, that is 0x48	
Byte 2~3	D1	uin16_t	cm	0 degree sector obstacle distance	
Byte4~5	D2	uin16_t	cm	45 degree sector obstacle distance	
Byte 6~7	D3	uin16_t	cm	90 degree sector obstacle distance	
Byte	D4	uin16_t	cm	135 degree sector	

8~9				obstacle distance	
Byte10~11	D5	uin16_t	cm	180 degree sector obstacle distance	
Byte 12~13	D6	uin16_t	cm	225 degree sector obstacle distance	
Byte 14~15	D7	uin16_t	cm	270 degree sector obstacle distance	
Byte 16~17	D8	uin16_t	cm	315 degree sector obstacle distance	
Byte 18	D9	Uint8_t		Fixed, 'M' ascii is decimal 77 (0x4D)	
Byte 19	CRC	Uin8_t		CRC8 check	See description below

Obstacle Distance Unit: millimeter. The high 8 bits are in front, the low 8 bits are in the back. for example, 0 degree sector obstacle distance 0x07D0.

Byte 2=0x07, byte 3=0xD0, then the actual distance is 2m.

Note: It must be sent regardless of whether there is radar data or not. When the data is invalid, DX is filled with 0XFFFF. UAV-R22-1 77GHz MMwave radar obstacle avoidance system outputs D1, D2, D3, D4...D8 sector obstacle distances, and other sectors are invalid data. Fill with 0xFFFF.



Radar output CRC8 check

Crc.cpp：

```
static const uint8_t crc8_table[] = {
```

```
0x00, 0x07, 0x0e, 0x09, 0x1c, 0x1b, 0x12, 0x15, 0x38, 0x3f, 0x36, 0x31, 0x24,
0x23, 0x2a, 0x2d, 0x70, 0x77, 0x7e, 0x79, 0x6c, 0x6b, 0x62, 0x65, 0x48, 0x4f,
0x46, 0x41, 0x54, 0x53, 0x5a, 0x5d, 0xe0, 0xe7, 0xee, 0xe9, 0xfc, 0xfb, 0xf2,
0xf5, 0xd8, 0xdf, 0xd6, 0xd1, 0xc4, 0xc3, 0xca, 0xcd, 0x90, 0x97, 0x9e, 0x99,
0x8c, 0x8b, 0x82, 0x85, 0xa8, 0xaf, 0xa6, 0xa1, 0xb4, 0xb3, 0xba, 0xbd, 0xc7,
0xc0, 0xc9, 0xce, 0xdb, 0xdc, 0xd5, 0xd2, 0xff, 0xf8, 0xf1, 0xf6, 0xe3, 0xe4,
0xed, 0xea, 0xb7, 0xb0, 0xb9, 0xbe, 0xab, 0xac, 0xa5, 0xa2, 0x8f, 0x88, 0x81,
0x86, 0x93, 0x94, 0x9d, 0x9a, 0x27, 0x20, 0x29, 0x2e, 0x3b, 0x3c, 0x35, 0x32,
0x1f, 0x18, 0x11, 0x16, 0x03, 0x04, 0x0d, 0x0a, 0x57, 0x50, 0x59, 0x5e, 0x4b,
0x4c, 0x45, 0x42, 0x6f, 0x68, 0x61, 0x66, 0x73, 0x74, 0x7d, 0x7a, 0x89, 0x8e,
0x87, 0x80, 0x95, 0x92, 0x9b, 0x9c, 0xb1, 0xb6, 0xbf, 0xb8, 0xad, 0xaa, 0xa3,
0xa4, 0xf9, 0xfe, 0xf7, 0xf0, 0xe5, 0xe2, 0xeb, 0xec, 0xc1, 0xc6, 0xcf, 0xc8,
0xdd, 0xda, 0xd3, 0xd4, 0x69, 0x6e, 0x67, 0x60, 0x75, 0x72, 0x7b, 0x7c, 0x51,
0x56, 0x5f, 0x58, 0x4d, 0x4a, 0x43, 0x44, 0x19, 0x1e, 0x17, 0x10, 0x05, 0x02,
0x0b, 0x0c, 0x21, 0x26, 0x2f, 0x28, 0x3d, 0x3a, 0x33, 0x34, 0x4e, 0x49, 0x40,
0x47, 0x52, 0x55, 0x5c, 0x5b, 0x76, 0x71, 0x78, 0x7f, 0x6a, 0x6d, 0x64, 0x63,
0x3e, 0x39, 0x30, 0x37, 0x22, 0x25, 0x2c, 0x2b, 0x06, 0x01, 0x08, 0x0f, 0x1a,
0x1d, 0x14, 0x13, 0xae, 0xa9, 0xa0, 0xa7, 0xb2, 0xb5, 0xbc, 0xbb, 0x96, 0x91,
0x98, 0x9f, 0x8a, 0x8d, 0x84, 0x83, 0xde, 0xd9, 0xd0, 0xd7, 0xc2, 0xc5, 0xcc,
0xcb, 0xe6, 0xe1, 0xe8, 0xef, 0xfa, 0xfd, 0xf4, 0xf3
};
uint8_t crc_crc8(const uint8_t *p, uint8_t len)
{
    uint16_t i; uint16_t crc = 0x0;
    while (len--)
    {
        i = (crc ^ *p++) & 0xFF; crc = (crc8_table[i] ^ (crc << 8)) & 0xFF;
    }
    return crc & 0xFF;
}
```

Debugging way：crc8 = crc_crc8(buffer, 1)；//buffer is the data receiving buffer array

7.Precautions of product use

- Radar needs to be fully protected against static electricity during transportation, storage, operation and handling.If there is no target object within the radar detection coverage,The radar continues to output irregular targets or when DC parameter values such as power supply voltage and source current are within the normal range.the output signal cannot be obtained,then the radar maybe damaged
- Please keep the radar cover clean during installation. To clean the cover, wipe it with a soft damp cloth and then let it dry naturally
- When installing, please pay attention to the shape of the radar and ensure

that the installed radar is not deformed. Do not squeeze, bump, or beat it.

- When installing, make sure the radar is the factory original. Do not disassemble or assemble by yourself.

7.FAQ

1> Q: What is the detect range of UAV-R121-1? Why the minimum detect distance is 1.5m?

A: The drone obstacle detection range is 1.5~27m. Considering about the drone wing length, it needs to stop while the distance between drone and obstacle is less than 1.5m. So the minimum detection distance is 1.5m.

2> Q: Don't know how to calculate the best install angle, is there a recommended angle?

A: According to the installation angle recommendation and the test result, we suggest flight controller be inclined 12°upward for installation.

3> Q: Will the radar have data output if it hasn't detected any obstacles?

A: Radar outputs data in real time. While radar hasn't detected any obstacle or the obstacle distance longer than 120m, it outputs data 0; While radar detected obstacle successfully, it outputs the actual distance of obstacle.

Please contact service manager freely if need any help during installation.

MicroBrain will always be here for your service!

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