NRA15 millimeter wave radar
User manual

Hunan Nanoradar Science and Technology Co., Ltd.

Disclaimer

- Thanks to purchase this product. There is web pages about NRA15 altimeter in our official website (www.nanoradar.cn), which allows you to get the latest product information and user manual. The user manual is subject to change without notice.
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- This manual contains important information, please keep it for future use.

Version history

Date	Version	Version Description
2018-05-29	1.0	the 1st version of application manual on NRA15

Contents

1 Brief introduction of NRA15

NRA15 is compact K-band radar altimeter developed by Hunan Nanoradar. It adopts 24GHz-ISM frequency band, with the advantages of 2cm measuring accuracy, small size, high sensitivity, light weight, easy integration and stable performance, which satisfies the application requirements in unmanned aircraft system (UAS), helicopters, small airships and other field.

2 Matters needing attention in use

Much attention should be paid to the "matters needing attention".

(1) Please make sure no obstructions under the radar during installation in order to ensure accurate detection data. Because The radar determines the height of the drone by transmitting MMW downwards.

(2) Please make sure that the radar module is vertically down during installation to ensure accurate detection data.

(3) The radar cannot be installed near the nozzle of the atomizer to prevent the pesticide from corroding the radar.

(4) The product has adopted shielding measures to avoid the adverse effects caused by electromagnetic interference in space. Meanwhile, the radar should be away from electromagnetic interference sources such as motors and suspended metal casings during installation.

(5) The radar input voltage range is 5~20V DC, and the ripple is less than 20mv. An unclean power supply will cause a number of fixed interference frequency components in the spectrum during algorithm analysis, affecting the test results, and continuously output a target at a fixed distance.

Any problem in installation, please feel free to contact Nanoradar.

3 Shipping list

The shipping list includes：NRA15 sensor 1x and connection cable 1x , as shown in figure 1.

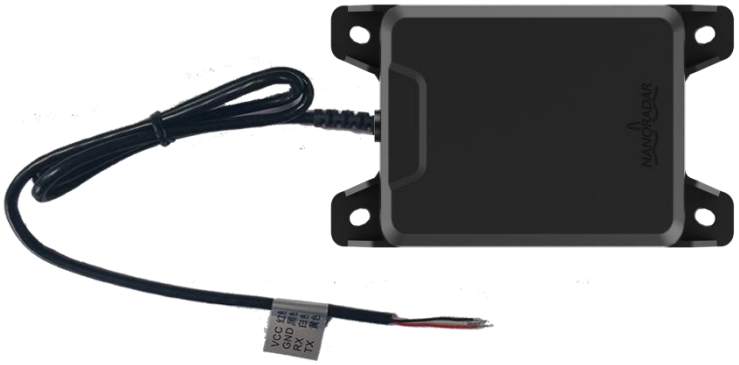

Figure 3 NRA15 sensor

4 Quick-to-use steps

4.1 Connection cable installation

The definition for NRA15 sensor interface pins are as shown in table 1.

Table 1 The definition for NRA15 pin interface

Pin No.	definition	value	color
1	POWER IN	4~6 V DC	red
2	GND	-	black
3	TTL USART_RX	0~3.3V DC	white
4	TTL USART_TX	0~3.3V DC	yellow

4.2 Test and use

NRA15 sensor data can be acquired and parsed by the "MMW Radar general Management Tool" testing software, which is used to visually display the observation results. The tool is helpful in the use of NRA15 sensor.

The UART serial port test method is as follows:

First of all, the "millimeter-wave radar general management tool" (PC test software), user manual shall be provided by Nanoradar. According to the user manual, install and configure the PC test software.

1) Test tools and software are as the following table：

Table 2 Product test and use tools

No.	Device name	Qty
1	NRA15	1
2	PC	1
3	Serial port adaptor to connect USB to TTL	1
4	5V power adaptor	1
5	PC test software	1

2) With a USB connection to TTL serial port adaptor, to connect PC and NRA15, as shown in figure 2 .

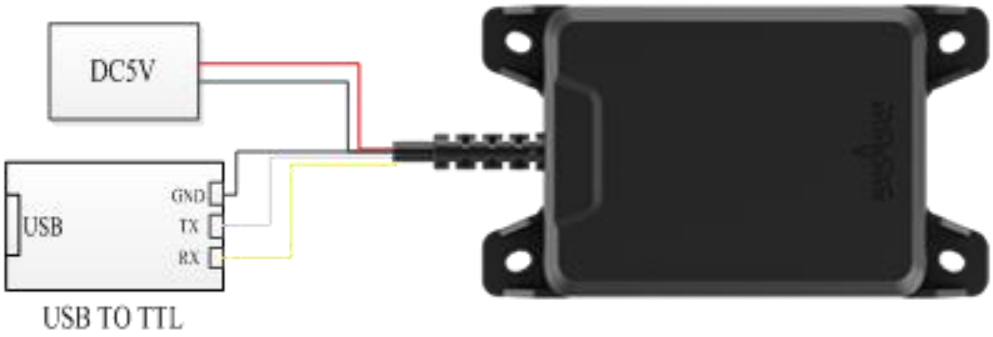

Figure 2 Diagram for serial port connection

Note:

- Separately supply power from 5V DC stabilized power supply, and do not use 5V power supply of USB2TTL adapter.
- Input voltage range of 4 ~ 6VDC, ripple wave is less than 20mv. Unclean Power supply will result in the appearance of a number of fixed interference frequency components in the spectrum during the algorithm analysis, which would have an impact on test results and result in the continuous target output in a certain fixed distance.
- The TX and RX pins of the USB-to-TTL adapter need to be cross-connected to the TX and RX pins of the NRA15 sensor.

3) USB serial-port adapter is connected to PC. And then open the PC test software to configure parameters like in figure 5 (plug connection cable into the computer, then open the PC software, the software will automatically detect the port). The red part in the figure is parameter configuration of NRA15, while the blue part is the adjusted coordinate range

according to the test distance. Then click the right button "Connect to Device".

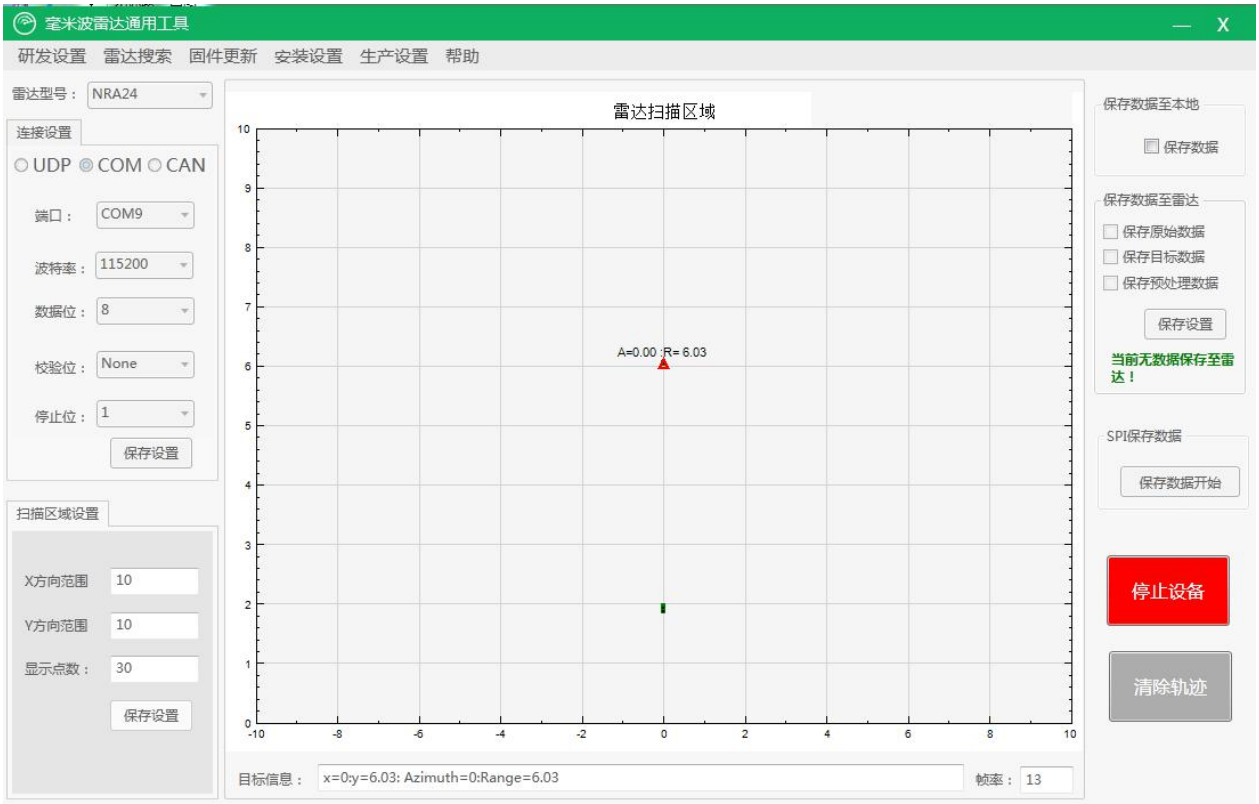

Figure 3 Radar PC test interface

4) Start to test. NRA15 radar antenna faces directly to the moving target, or there is relatively small movement between the sensor and the target. You can see the target indicator of the red triangle in the UI interface, and the target distance R. In Figure 5, the radial distance of the target from the radar is 6.03 meters (NRA15 could detect the target within 100 meters to ground). If no red triangle is indicated, it states that there is no target within the detectable distance and field of view.

5 Serial-port data parsing

NRA15 radar sensor utilizes a UART-TTL interface with a default transmission rate of 115200 baud. Starting with a start sequence and terminating with a termination sequence for each data message. At each data cycle of NRA15 (20ms), the message for NRA15 system status and target output status would be output. If the field of detected target numbers in message of the detected target output status is 1, the target output status message is followed by the target output information message which contains the height parameter of the target.

PC or the peripheral device configures the NRA15 with the same message format, and the corresponding message ID is 0x200.

A complete data message of UART-TTL communication is 14 bytes. Each byte of data is

unsigned8bit. The data range is 0 ~ 255 (0 ~ 0xFF). And the format is shown in the following table. Each data message contains a message ID to distinguish between different types of messages.

Table 3 Format of data message

Byte \ Bit	7	6	5	4	3	2	1	0
0	Start Sequence (2 x Uint8)							
1								
2	Message ID (2 x Uint8)							
3								
4	Data Payload (8 x Uint8)							
5								
6								
7								
8								
9								
10								
11								
12	End Sequence (2 x Uint8)							
13								

The start Sequence is a constant value 0xAAAA, and the Message ID is defined as follows. The Data Payload is defined according to the Message ID (see the next section). The End Sequence is set to 0x5555.

Table 4 Definition of Message ID

Num	Message ID	Message Name	Comment
1	0x200	Sensor Configuration	NRA15 configuration
2	0x400	Sensor Back	NRA15 back
3	0x60A	Sensor Status	NRA15 status
4	0x70B	Target Status	Target output status
5	0x70C	Target Info	Target output information

Note：

The Message ID is represented by 2 bytes, Byte2 is the low byte, and Byte3 is the high byte. For example, the output of the NRA15 message is 0xAA 0xAA | 0x0A 0x06 | Data Payload | 0x55 0x55, which indicates that the message ID is 0x60A (NRA15 system status) and Data Payload is the NRA15 system status.

5.1 NRA15 configuration(Sensor Configuration)

NRA 15 configuration message is shown in the following table. The start sequence (0xAAAA) and the termination sequence (0x5555) have been omitted from the table.

Table 5 NRA15 configuration message format

Message ID 0x200					
Signal Name	Bit	Resolution	Interval	Type	Comment
DataType	0..6	1	0…127	u7	1: Sensor ID 2: Sensor Version 3: Start/stop the target information output 4: filter the range 7e: for internal test 7f: save parameter
R/W	7	1	0…1	u1	0: Read parameter; 1: write parameter
Parameter	8..31	1	-	u24	According to the definition of Data Type
Reserved	32..63	1	-	u32	-

Note:

Currently, NRA15 only supports reading version information. Other functions are not yet available. If R / W are 0, reading the parameters and the Parameter content is meaningless. If the R / W are 1, that is, writing parameters, Parameter is defined according to DataType.

5.2 NRA15 back (Sensor Back)

After the PC or other MCU sends the configuration signal to NRA15, NRA15 will return the execution result. The format is shown in the following table. The start sequence (0xAAAA) and the termination sequence (0x5555) have been omitted from the table.

Table 6 NRA15 back message format

Message ID 0x400					
Signal Name	Bit	Resolution	Interval	Type	Comment
DataType	0..6	1	0…127	u7	1: Sensor ID 2: Sensor Version 3:Start/stop,target information output 4: range filtering 7e:for internal test 7f:Save parameters
Result	7	1	0…1	u1	0: fail to configure; 1:succeed to configure
Parameter	8..31	1	-	u24	Defined according to the DataType
Reserved	32..63	1	-	u32	-

Note:

At present, NRA15 will only return version information; other functions are not yet available. DataType indicates the configuration item, result indicates the configuration result, and Parameter is the value of the configured DataType.

5.2.1 Sensor Version

After the PC or other MCU sends the read version information of sensor to NRA15, the NRA15 will return the execution result. When the version information is returned, the corresponding Parameter field format is as follows:

Table 7 Sensor Version back format

Message ID 0x400					
Signal Name	Bit	Resolution	Interval	Type	Comment
DataType	0..6	1	2	u7	1: Sensor ID 2: Sensor Version 3: Start/stop target information output 4: range filtering 7e: for internal test 7f: Save parameters
Result	7	1	0…1	u1	0:fail to read 1:succeed to read
Parameter	8..15	1	0…255	u8	Master Version
	16..23	1	0…255	u8	Second Version
	23..31	1	0…255	u8	Step Version
Reserved	32..63	1	-	u32	-

5.3 NRA15 system status (Sensor Status)

The NRA15 system status message format is shown in the following table. The start sequence (0xAAAA) and the termination sequence (0x5555) have been omitted from the table, where the value of RollCount is fixed to 0.

Table 8 NRA15 system status message format

Message ID 0x60A					
Signal Name	Bit	Resolution	Interval	Type	Comment
ACTL_Mode	0..6	1	0…127	u7	NR15 is fixed to 1
RollCount	8..9	1	0…3	u2	The cycle count is 0-1-2-3, and it change one time per cycle
Rsvd1	10..11	1	-	u2	-
CfgStatus	12..15	1	-	u4	NRA15 is fixed to 1
Rsvd2	15..63	1	-		-

5.4 Targets output status (Target Status)

The data message format for NRA15 system target output status is shown as in the table below. The start sequence (0xAAAA) and termination sequence (0x5555) has been omitted for the table, where the value of RollCount is continuously cycled between 0-1-2-3-0-1-2-3 ..... When the PC or an external MCU cannot process the output data of the NRA15 sensor in time, it will cause the received RollCount value to be discontinuous. At this time a faster removal methods should be found to solve this problem.

Table 9 NRA15 Targets output status message format

Message ID 0x70B					
Signal Name	Bit	Resolution	Interval	Type	Comment
NoOfTarget	0..7	1	0…255	u8	The numbers of detected targets
RollCount	8..9	1	0…3	u2	The cycle count is 0-1-2-3, and it change one time per cycle
Rsvd1	10..63	1	-	u54	-

5.5 Target output information (Target Info)

The target output message format of NRA15 is shown in the following table. The start sequence

(0xAAAA) and the termination sequence (0x5555) have been omitted from the table. When the radar sensor works normally and detects the target, it outputs the NRA15 system status message, and then outputs the target output status message, and finally outputs the target output information message.

Table 10 NRA15 target output information format

Message ID 0x70C					
Signal Name	Bit	Resolution	Interval	Type	Comment
Index	0..7	1	0…255	u8	Target ID
Rcs	8..15	-	0…255	u8	The section of radar reflection
RangeH	16..23	0.01m	0…255	u8	Target distance high 8 bit
RangeL	24..31	0.01m	0…255	u8	Target distance low 8 bit
Rsvd1	32..39	-	-	u8	-
VrelH	40..42	0.05m/s	0..7	u3	-
Rsvd1	43..45	1	1	u3	-
RollCount	46..47	1	-	u2	NRA15 is fixed to 0
VrelL	48..55	0.05m/s	0..255	u8	-
SNR	56..63	1dB	0..255	u8	Signal-Noise Ratio

Note:

The value of each field in the table is not the true value of the target information. The true value of the target information needs to be calculated through the following relations:

- Index = IndexValue
- Rcs = RcsValue*0.5 – 50
- Range = (RangeHValue*256 + RangeLValue)*0.01
- RollCount = RollCountValue
- SNR = Value-127

The target reflection Radar-Cross Section (RCS), the target range (Range), Signal-Noise Ratio(SNR) can be obtained by these calculations, to accurately detect the targets.

6 Data parsing examples

Taking Message ID as an example, there is a frame of the Target Info data message as follows:

Target Info Data:

0xAA 0xAA 0x0C 0x07 0x01 0xC8 0x07 0xD0 0x00 0x02 0xEE 0x96

0x55 0x55

Description:

Start Sequence Message ID Data Payload End Sequence

Interpretation：

Start Sequence = 0xAAAA

Message ID = 0x0C + 0x07*0x100 = 0x70C

Data Payload = 0x01 0xC8 0x07 0xD0 0x00 0x02 0xEE 0x96

End Sequence = 0x5555

Each field of Data Payload is parsed as following：

Index = 1

Rcs = 0xC8*0.5 – 50 = 50

Range = (0x07*0x100 +0xD0)*0.01 = 20

Rsvd1 = 0

RollCount = (0x0 & 0xE0) >> 5 = 0

SNR = 0x96 – 127 = 23

Note:

The user needs to program to parse the sensor output data (hexadecimal).

The data before being parsed is hexadecimal, and is decimal after being parsed. 0x2AF5 hexadecimal is converted to decimal: 10997=5*16^0+F*16^1+A*16^2+2*16^3

7 Frequently asked questions (FAQ)

1) Q: What about the angular accuracy of NRA15?

NRA15 is a 24GHz mmw radar altimeter with 1T1R antenna, which is developed by Nanoradar. It cannot measure the target angle. For the radar with more than two receiving antennas, it has the ability to measure the angle. Besides, the more antennas it has, the higher accuracy of angle resolution it could realize.

2) Q: In the height measurement of NRA15, which will it be subjected to when there is vegetation and ground? When the ground is water, is it based on the ground surface or the water

surface?

A: NRA15 is MMW radar with high range accuracy developed by Nanoradar. In practical application, the airflow under the aircraft is large if the height is less than 3m, and the vegetation is likely to be blown away, so the reference point is the ground or water surface. If the airplane reaches over 5m, the airflow would not affect the vegetation below. And if the vegetation density is large, the reference point should be vegetation.

8 References

[1] White paper on NRA15 millimeter wave radar

[2] User manual for the general management system of Nanoradar mmw radar