NRA24 millimeter wave radar User manual

(With check sum)

Hunan Nanoradar Science and Technology Co., Ltd.

Disclaimers

Thanks to purchase this product. There is web pages about NRA24 altimeter in our official website (www.nanoradar.cn).You can find the latest product information and user manual on the pages. The user manual is subject to change without notice.

Please read this manual carefully before using this product. Once used, it is deemed to have recognized and accepted the content of this manual. Please strictly follow the manual to install and use the product. Any improper use may cause damage or injury, and Nanoradar would not bear the corresponding loss and liability.

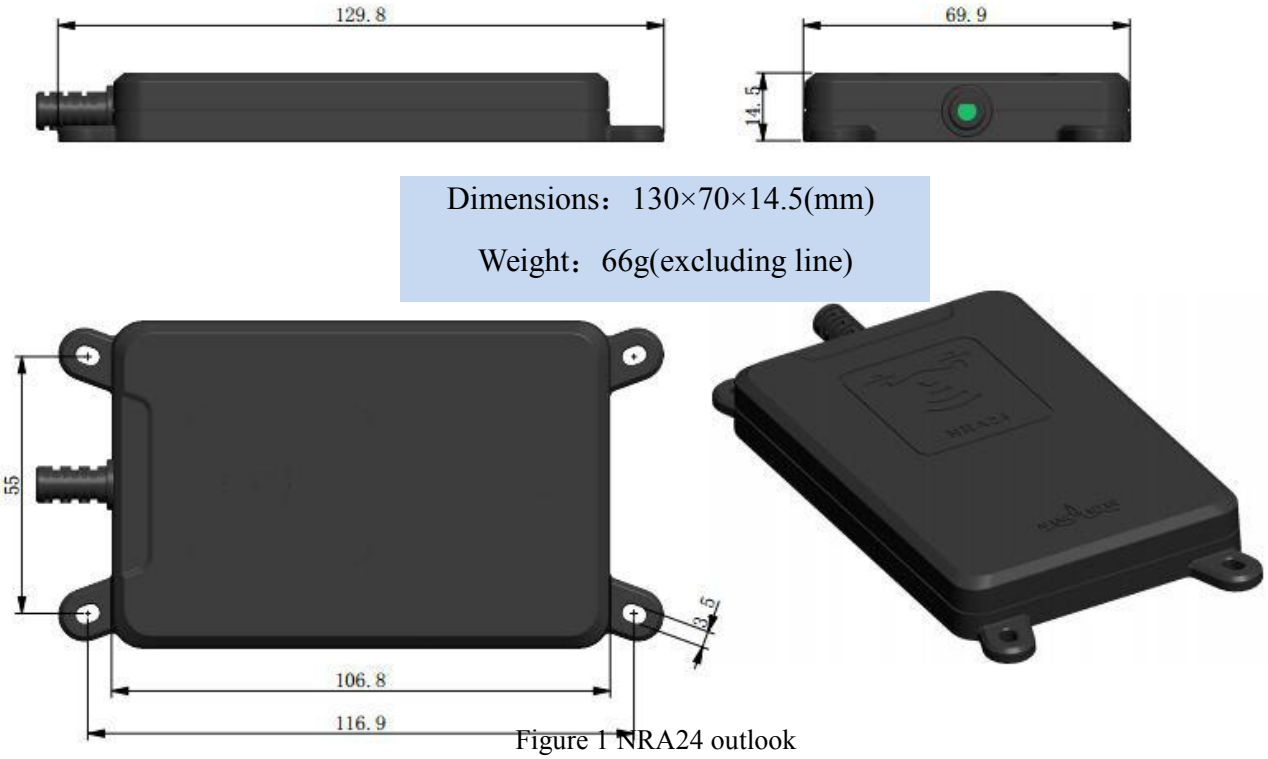
Version history

Date	Version	Version description
2017-02-28	2.0	the 2nd version of user manual on NRA24
2017-08-31	2.1	Increase the parity bit in the data load

Contents

1 Brief introduction of NRA24

NRA24 is compact K-band radar altimeter developed by Hunan Nanoradar Science and Technology Co., Ltd. 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.



Dimensions：130×70×14.5(mm)

Weight：66g(excluding line)

Figure 1 NRA24 outlook

2 Matters needing attention in use

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

(1) The power pins shall be connected separately to 5~20V DC stabilized power supply;

(2) Fix the NRA24 with 4 M3 screws.

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

3 Shipping list

The shipping list includes：NRA24 sensor 1x，as in figure 2.

Figure 2 NRA24 delivery physical map

4 Quick-to-use steps

4.1 Pin definition

The definition for NRA24 sensor interface pins are as shown in table1.

Table 1 The definition for NRA24 pin interface

Pin No.	difinition	value
1	POWER IN(red)	5~20 V DC
2	GND(black)	-
3	TTL USART_RX(white)	0~3.3V DC
4	TTL USART_TX(yellow)	0~3.3V DC

4.2 Test and use

NRA24 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 NRA24 sensor.

Fast debugging is UART interface debugging method.

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.

Debugging via UART interface:

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

Table 2 Product test and use tools

No.	Device name	Qty
1	NRA24	1
2	PC	1
3	Serial port adaptor to connect USB to TTL	1
4	12V power adaptor	1
5	PC test software	1

2) With a USB connection to TTL serial port adaptor, to connect PC and NRA24, as shown in figure 6 .

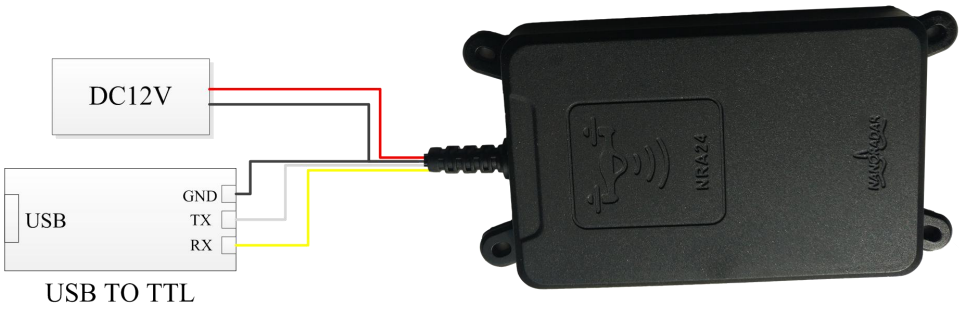


Figure 3 Diagram for serial port connection

Note:

- Separately supply power from 12V DC stabilized power supply, and do not use 5V power supply of USB2TTL adapter.
- Input voltage range of 5 ~ 20VDC, 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 NRA24 sensor.

3) USB serial -port adapter is connected to PC. And then open the PC test software to configure parameters like in figure 4 (plug 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 NRA24, while the blue part is the adjusted coordinate range according to the test distance. Then click the right button "Connect to Device".

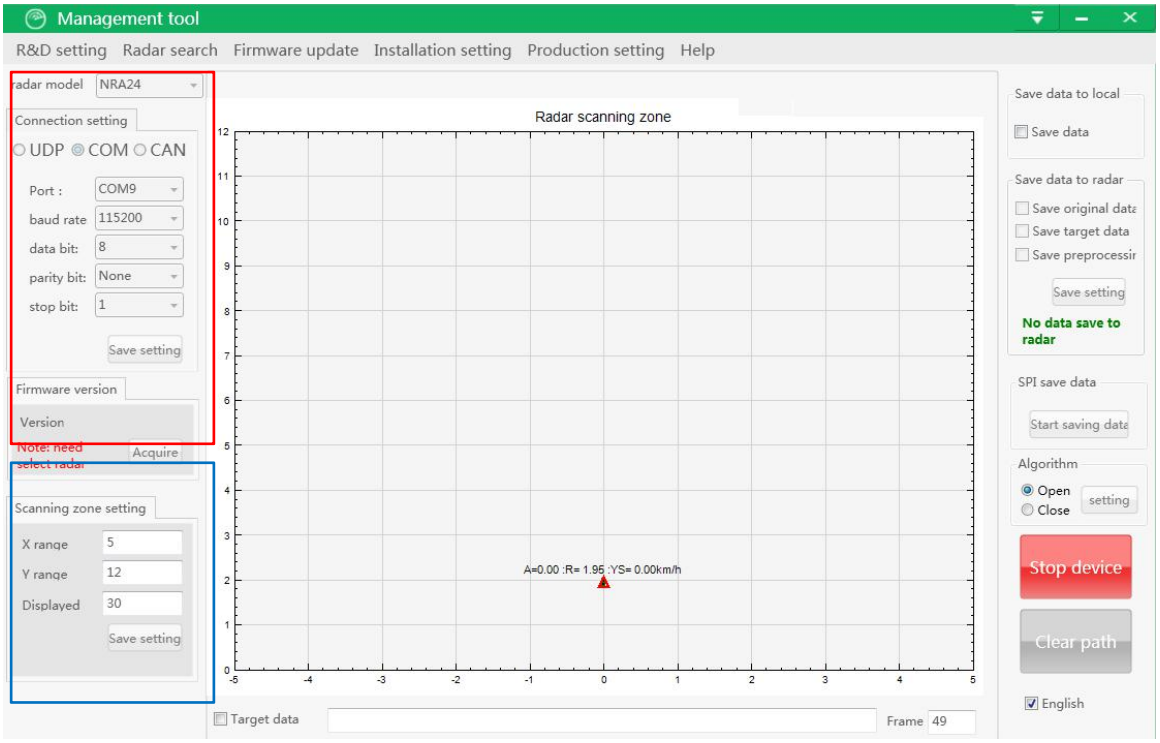


Figure 4 Radar PC test interface

4) Start to test. NRA24 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 4, the radial distance of the target from the radar is 1.95meters (NRA24 could detect the target within 50 meters to ground). If no red triangle is indicated, it states that there is no target within the detectable distance and field of view. The following table shows the relationship between the sensor indicator light and the corresponding indication status:

5 Serial-port data parsing

NRA24 radar sensor utilizes a UART-TTL interface with a default transmission rate of 115200 baud, 8 bit data bit, 1 stop bit, no parity bit, no flow control. Starting with a start sequence and terminating with a termination sequence for each data message. At each data cycle of NRA24 (20ms), the message for NRA24 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 NRA24 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 (7 x Uint8)							
5								
6								
7								
8								
9								
10								
11	Check Sum (1 x Uint8)							
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.

Note:

The 11th byte is the check sum, which is the lower eight bits of the sum of the first seven data payloads, that is the sum of bytes 4,5,6,7,8,9,10 of the lower eight.

Table 4 Definition of Message ID

Num	Message ID	Message Name	Comment
1	0x200	Sensor Configuration	NRA24configuration
2	0x400	Sensor Back	NRA24 back
3	0x60A	Sensor Status	NRA24 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 NRA24 message is 0xAA 0xAA | 0x0A 0x06 | Data Payload | 0x55 0x55, which indicates that the message ID is 0x60A (NRA24 system status) and Data Payload is the NRA24 system status.

5.1 NRA24 configuration (Sensor Configuration)

NRA 24 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 NRA24 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 DataType
Reserved	32..55	1	-	-	-
Check Sum	56..63	1	0…127	u8	The sum of lower eight bits of first seven bytes

Note:

Currently, NRA24 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 NRA24 back (Sensor Back)

After the PC or other MCU sends the configuration signal to NRA24, NRA24 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 NRA24 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
esult	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..55	1	-	-	-
Check Sum	56..63	1	0…127	u8	The sum of lower eight bits of first seven bytes

Note:

At present, NRA24 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 NRA24, the NRA24 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..55	1	-	-	-
Check Sum	56..63	1	0…255	u8	The sum of lower eight bits of first seven bytes

5.3 NRA24 system status (Sensor Status)

The NRA24 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 NRA24 system status message format

Message ID 0x60A					
Signal Name	Bit	Resolution	Interval	Type	Comment
ACTL_Mode	0..6	1	0…127	u7	NRA24 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	NRA24is fixed to 1
Rsvd2	15..55	1	-	-	-
Check Sum	56..63	1	0…255	u8	The sum of lower eight bits of first seven bytes

5.4 Targets output status (Target Status)

The data message format for NRA24 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 NRA24 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 NRA24 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..55	1	-	-	-
Check Sum	56..63	1	0…255	u8	The sum of lower eight bits of first seven bytes

5.5 Target output information (Target Info)

The target output message format of NRA24 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 NRA24 system status message, and then outputs the target output status message, and finally outputs the target output information message.

Table 10 NRA24 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	NRA24 is fixed to 0
VrelL	48..55	0.05m/s	0..255	u8	-
Check Sum	56..63	1dB	0..255	u8	The sum of lower eight bits of first seven bytes

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 // Target ID = 1. According to Track information, NRA24 outputs only one target.
- Rcs = RcsValue*0.5 – 50 // Factory test retention value, do not do output
- Range = (RangeHValue*256 + RangeLValue)*0.01 // The original data unit of the radar output is cm, and the unit of target distance after conversion is meters
- RollCount = RollCountValue // counter
- Check sum = Check Sum // check sum Verify whether there is an error in the data transmission

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

6 Data parsing examples

Take Message ID as the target output information (Target Info) 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 0x90 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 0x90

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

Check sum = 0x90 // The sum of lower eight bits of first seven bytes: 0x90 = 0xFF&0x290;

//0x290=0x01+0xC8+0x07+0xD0 +0x00+0x02 +0xEE

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 Electrostatic protection

7.1 Electrostatic protection measures

We need take the full electrostatic protection in the radar transport and storage. When handling discrete modules that are not integrated, it is important to note that when the module is removed from the sealed antistatic package, it is time to start with electrostatic protection. Never touch or grab the radar antenna surface and connector pins, but the corner part.

Recommendation: When handling all radar sensors, please try to wear anti-static gloves.

Wrong methods：

- ✧ Use metal foil or some metal parts to wrap the antenna;
- ✧ Measure the pin directly with a multimeter, causing damage.
- ✧ Use any type of paint or varnish to spray antenna structure;
- ✧ wrap antenna with CFK sheet (conductive);
- ✧ The plastic material is in direct contact with the corroded antenna structure (which has a higher dielectric constant for the resonant frequency of the patch).

7.2 Identification of electrostatic damages

In general, the following conditions indicate that the module has been subjected to electrostatic damage:

- ✧ Radar continuously outputs non-regular targets when there is no target in radar coverage;
- ✧ When the DC value of the power supply voltage and current is within the normal range, the output signal cannot be obtained.

8 Frequently asked questions (FAQ)

(1) Q: What about the angular accuracy of NRA24?

A: NRA24 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: What is the height accuracy of NRA24 at a height of 0.5 m?

A: TNRA24 adopts one transmitting and one receiving antenna, and the separation design of antennas makes the radar have a high isolation in transmit / receive link, to improve the dynamic range of radar target detection. At the same time, NRA24 utilizes the advanced integrated planar microstrip array antenna, which contains 40 vertical polarization radiation units for transmitting and receiving antennas. Therefore, it could achieve height accuracy during the effective measurement range of 0.1-50m.

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

A: NRA24 is millimeter-wave radar with high range accuracy developed by Nanoradar. In practical application, if the height is less than 3m, there would be great air flow below the plane, 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 in case that the vegetation density is large, then the reference point should be vegetation.

9 References

[1] White paper on NRA24 millimeter wave radar

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

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FCC Caution：

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.

-Increase the separation between the equipment and receiver.

-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-Consult the dealer or an experienced radio/TV technician for help.