SP70C millimeter wave Radar
User manual

Hunan Nanoradar Science and Technology Co., Ltd.

Disclaimers

Thanks to purchase this product. There is web pages about SP70C radar sensor 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
2016-10-14	1.0	the 1st version of user manual on SP70C

Contents

1 Brief introduction about SP70C

SP70C is compact K-band radar developed by Hunan Nanoradar Science and Technology Co., Ltd. It adopts 24GHz ISM band, with dual receiving antenna design, small size, high sensitivity, light weight, easy integration and stable performance. And it could satisfy the demands of industrial range-measurement and collision avoidance, security personnel positioning and tracking, auto-driving and active safety and other fields.

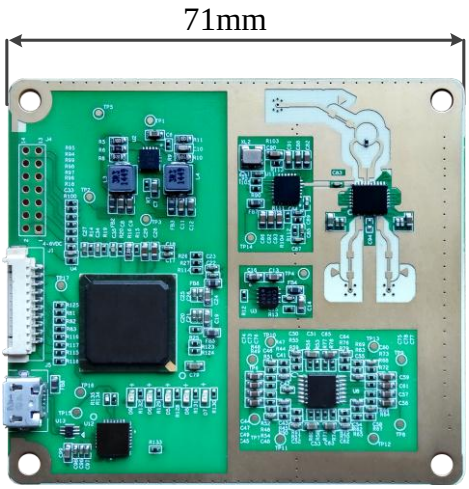

Figure 1 front view of SP70C

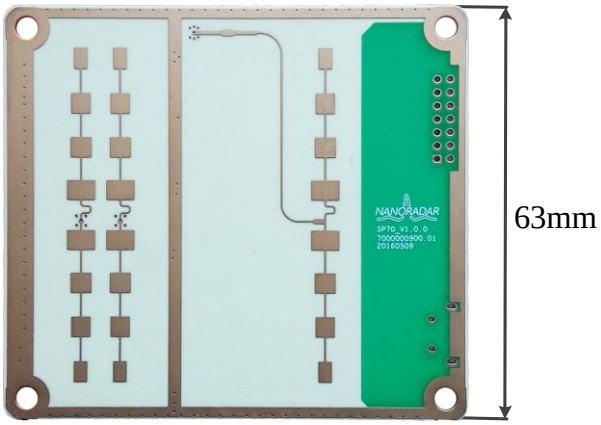

Figure 2 antenna plane of SP70C

2 Matters needing attention in use

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

(1) Do not directly contact with the antenna surface by hand or other objects;

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

(3) Please refer to "Radome Design Guide for Nanoradar 24GHz radar" to design SP70C antenna housing.

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

3 Shipping list

The shipping list includes：SP70C sensor 1x，as in figure 3，cable 1x，as in figure 4.

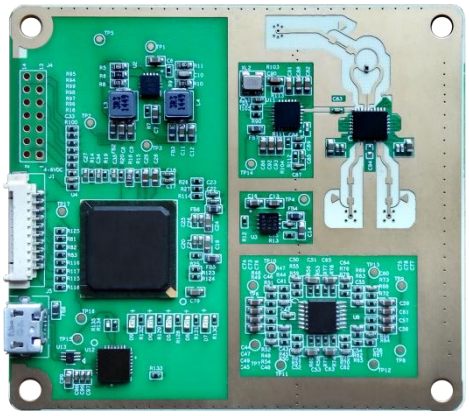

Figure 3 SP70C sensor

Figure 4 cables

4 Quick-to-use steps

4.1 Cables installation

The definition for SP70C sensor interface pins are as shown in table1.

Table 1 The definition for SP70C pin interface

Pins	Definition	Range
1	POWER IN	4~6 V DC
2	-	-
3	GND	-
4	-	-
5	TTL USART_RX	0~3.3V DC
6	TTL USART_TX	0~3.3V DC
7	-	-
8	-	-
9	-	-
10	-	-

Cables are shown in figure 4. The red line is the 1st pin, which is defined as power supply interface. The connection between cables and SP70C sensor is shown in figure 5.

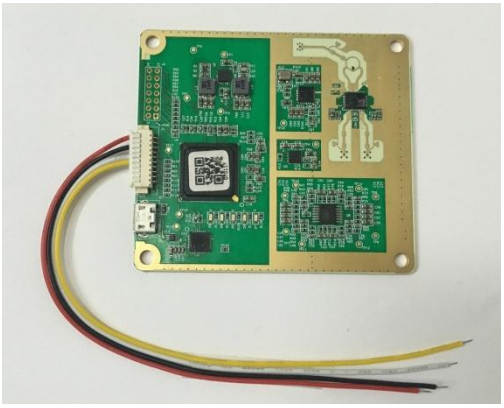

Figure 5 the schematic diagram for cable

Note:

SP70C comes with a fast-debug Micro USB interface that can be used to debug or burn a program (the customer needs to weld a 33 ohm resistor at R135 when the program is burned to the NSP70C). It is not necessary to solder the R135 resistor when burning a program via the UART interface.

4.2 Test and use

SP70C 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 SP70C sensor.

Fast debugging includes two methods: UART interface debugging method and MicroUSB interface debugging method.

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

Method 1：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	SP70C	1
2	PC	1
3	Serial port adaptor to connect USB to TTL	1
4	Cables	4
5	5V power adaptor	1
6	PC test software	1

(2) With a USB connection to TTL serial port adaptor, to connect PC and SP70C, as shown in figure 6

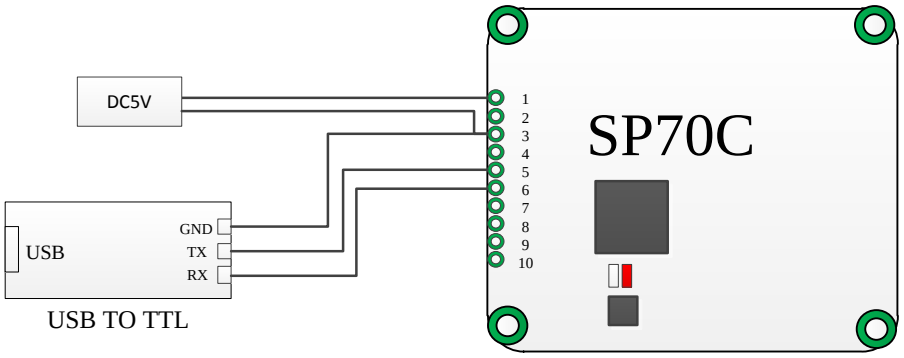

Figure 6 Diagram for serial port connection

Note:

- The red part of the sensor is resistor R134 and the resistance value is 33 Ohms.
- 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 SP70C sensor.

USB serial port adapter is connected to PC. And then open the PC test software to configure parameters like in figure 7 (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 SP70C (SP70C uses SP70C upper computer test program), while the blue part is the adjusted coordinate range according to the test distance. Then click the right button "Connect to Device ".

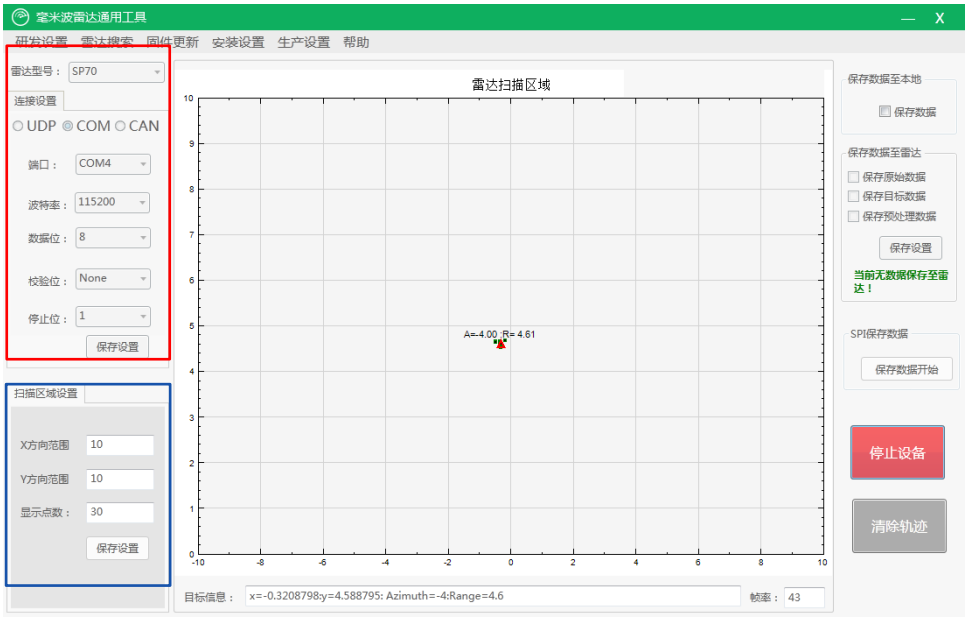

Figure 7 Radar PC test interface

(3) Start to test. SP70C 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 7, the radial distance of the target from the radar is 4.51 meters (SP70C could detect the target within 40 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 red one indicates the current location of targets, while the green one indicates the previous track of targets). The following table shows the relationship between the sensor indicator light and the corresponding indication status:

Table 3 SP70C sensor indicator light

Indicator light	Status
D5	Continue flickering during RF module normal operation
D6	Continue flickering during sytem normal operation
D9	Continuous shining during Micro USB debugging

Method 2：Debugging via Micro USB

(1) Test tool or software is as the following table：

Table 4 Product test tool

No.	Device name	Qty
1	SP70C	1
2	PC	1
3	PC test software	1
4	Micro USB cables	1
5	Micro USB drive	1

(2) With the Micro USB cable to connect NRA24, and USB to connect to PC, like the following figure：

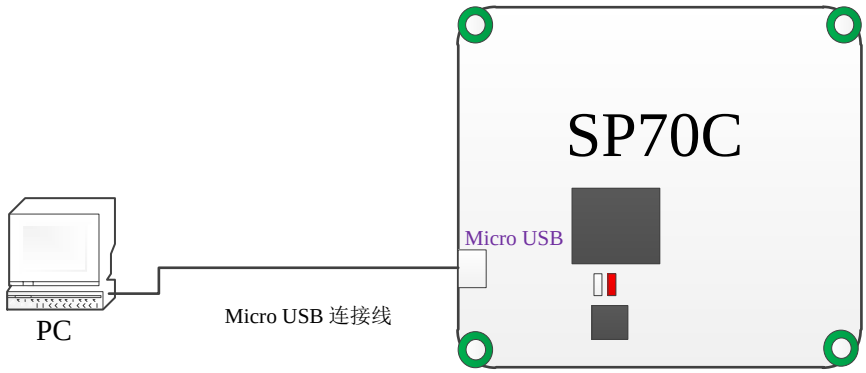

Figure 8 Test connection via Micro USB

(3) The test procedure is as the steps 3 and 4 in method 1,after connection with upper PC

Note:

When mounting, use 4 Φ3 screws to secure SP70C.

5 Guide to Radome design

5.1 Radome material selection

Radome is the radar shell, which is used to protect the radar antenna from the environment. In the installation, you cannot use metal materials antenna or metal layer wrapped antenna; and for plastic materials and plastic foam, as long as it does not contain carbon, it can be used for wrapping antenna. The relationship among the antenna, the radome and the radar beam is shown below:

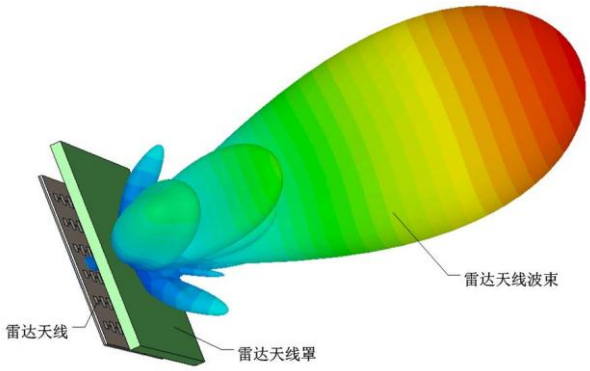

Figure 9 Radar antenna waveform

The following materials or methods are not suitable for protecting or wrapping antennas：

- With metal foil or partial metal parts to wrap
- Spray the antenna structure with any type of paint or varnish
- wrapped with CFK sheet (conductive)
- directly contact with plastic material or corroded antenna structure (having a higher dielectric constant influence on the patch resonant frequency)

The following materials or methods are suitable for protecting or wrapping antennas：

- If the plastic material is not directly in contact with the antenna structure. And the right thickness and space have been estimated. You can consider using plastic materials (ABS, PVC and other materials)to wrap it;
- If the relative dielectric constant of foam (such as a Stypopor or similar material) is close to 1, it can be mounted directly on the antenna surface.

5.2 Radome design principles

Radar radome will reduce the detection sensitivity and coverage. The radar radome should be designed to transmit radar waves as far as possible through the radome.

The antenna material with appropriate thickness must be chosen according to the characteristics of the product. If the radome is too thick, the increase of the insertion loss must be considered. Besides, the thick antenna cover may have an influence on the antenna pattern. The radome installation diagram is as shown in figure 10.

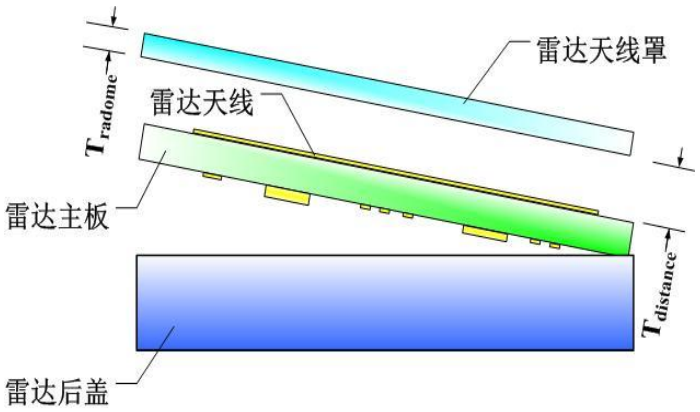

Figure 10 Radome installation diagram

Radome must be uniform material of the same thickness. It should be reasonable for the choice of materials, material thickness and the spacing between the antenna radome and the antenna. And the radar radome is formed as shown in the following figure.

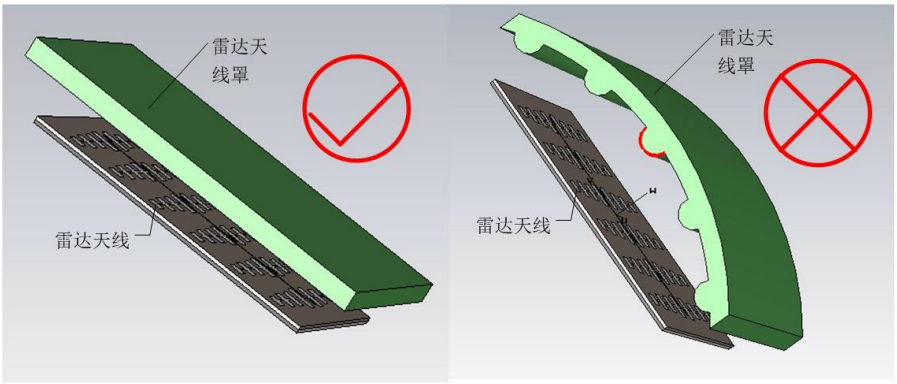

Figure 11 the forming of radar radome

6 Serial-port data parsing

SP70C 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 SP70C (20ms), the message for SP70C 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 SP70C 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 5 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 5 Definition of Message ID

Num	Message ID	Message Name	Comment
1	0x200	Sensor Configuration	SP70C configuration
2	0x400	Sensor Back	SP70C back
3	0x60A	Sensor Status	SP70C 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 SP70C message is 0xAA 0xAA | 0x0A 0x06 | Data Payload | 0x55 0x55, which indicates that the message ID is 0x60A (SP70C system status) and Data Payload is the SP70C system status.

6.1 SP70C configuration (Sensor Configuration)

SP70C configuration message is shown in the following table. The start sequence (0xAAAA) and the termination sequence (0x5555) have been omitted from the table.

Table 6 SP70C 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..63	1	-	u32	-

Note:

Currently, SP70C only supports reading version information. Other functions are not yet available. If R / W are 0, that is, 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.

6.2 SP70C back (Sensor Back)

After the PC or other MCU sends the configuration signal to SP70C, SP70C 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 7 SP70C 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, SP70C 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.

6.2.1 Sensor Version

After the PC or other MCU sends the read version information of sensor to SP70C, the SP70C will return the execution result. When the version information is returned, the corresponding Parameter field format is as follows:

Table 8 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	-

6.3 SP70C system status (Sensor Status)

The SP70C 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 9 SP70C system status message format

Message ID 0x60A					
Signal Name	Bit	Resolution	Interval	Type	Comment
ACTL_Mode	0..6	1	0…127	u7	SP70C 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	SP70C is fixed to 1
Rsvd2	15..63	1	-		-

6.4 Targets output status (Target Status)

The data message format for SP70C 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 SP70C 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 10 SP70C 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	-

6.5 Target output information (Target Info)

The target output message format of SP70C 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 SP70C system status message, and then outputs the target output status message, and finally outputs the target output information message.

Table 11 SP70C 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	1	0…255	u8	The section of radar reflection
RangeH	16..23	1m	0…255	u8	Target distance high 8 bit
RangeL	24..31	1m	0…255	u8	Target distance low 8 bit
Azimuth	32..38	-	0…255	u8	Target azimuth
Rsvd0	39	1	0	u1	-
VrelH	40..42	1m/s	0..7	u3	Target velocity high 3 bit
Rsvd1	43..45	-	0	u3	-
RollCount	46..47	1	-	u2	SP70C is fixed to 0
VrelL	48..55	1m/s	0..255	u8	Target velocity low 8 bit
SNR	56..63	1m/s	0..255	u8	SNR

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
- Azimuth = Val*2-90
- Vrel = (VrelH *256 + VrelL)*0.05-35
- RollCount = RollCountValue
- SNR = Value-127

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

7 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:

0xAA 0xAA 0x0C 0x07 0x01 0xC8 0x07 0xD0 0x46 0x03 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 0x46 0x03 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

Azimuth = 0x46 * 2 - 90 = 50

Vrel = (0x03 * 256 + 0xEE) * 0.05-35 =15.3

RollCount = (0x03) >> 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

8 Electrostatic protection

8.1 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).

8.2 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.

9 Frequently asked questions (FAQ)

(1) Q: What is effect of radome on radar?

a. Radar waves cannot be completely penetrate through the radome, so that the effective radiated power of the radar is reduced, including the reflection loss and dielectric loss.

b. Radar radome deteriorates the standing wave of radar antennas. And the radome will reduce the detection sensitivity and coverage of radar.

c. The distortion of Radar antenna beam causes the change of radar effective range, which may lead to the influence of the backward targets on the radar.

(2) Q: The definition of the lead in SP70C test sample is the same as that of the interface pin of the NRA24 data sheet?

A: Both SP70C and NRA24 use a pair of 1.25 * 10Pin interface as the communication port. Therefore, the definition for the interface pins of the two data manuals are the same. For the definition of each pin, you can check the product manual of SP70C or NRA24.

(3) Q: In the use of millimeter-wave radar management tool test, if the test for SP70C is for a single target (man), the radar can very well follow the target. But if the test is for the two targets (man) which move back and forth, it is difficult for the radar to track two people at the same time to get distance and azimuth; sometimes it can keep up with one, while the other is hidden; sometimes two people cannot be tracked, or the trajectory jump back and forth?

A: The multi-target test for radar involves the parameter of distance resolution. If the distance between two people is not very far, it is not easy to distinguish them. Especially when the two people are close and the movement way is not consistent, it will affect the association of the

radar targets.

10 References

[1] White paper on SP70C millimeter wave radar

[2] Guideline for 24GHz antenna radome design by Nanoradar

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

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