CAR28F millimeter wave radar User Manual

NANORADAR
纳 雷 科 技

Hunan Nanoradar Science and Technology Co., Ltd.

Disclaimers

Thanks for your purchasing Nano product.You may visit www.nanoradar.cn to view more product details about CAR28F and you will find the latest product information and user manual here. Kindly notice that we will not inform you if there is any update about the product, so pay more attention on our website.

Version history

Date	Version	Version description
2018-06-11	1.0	The 1st version of CAR28F user manual

Contents

1 CAR28F Introduction

CAR28F is a compact 24GHz millimeter-wave radar sensor in the industry, it can accurately measure the distance, speed, angle and other information by testing the difference between radio wave and echo.

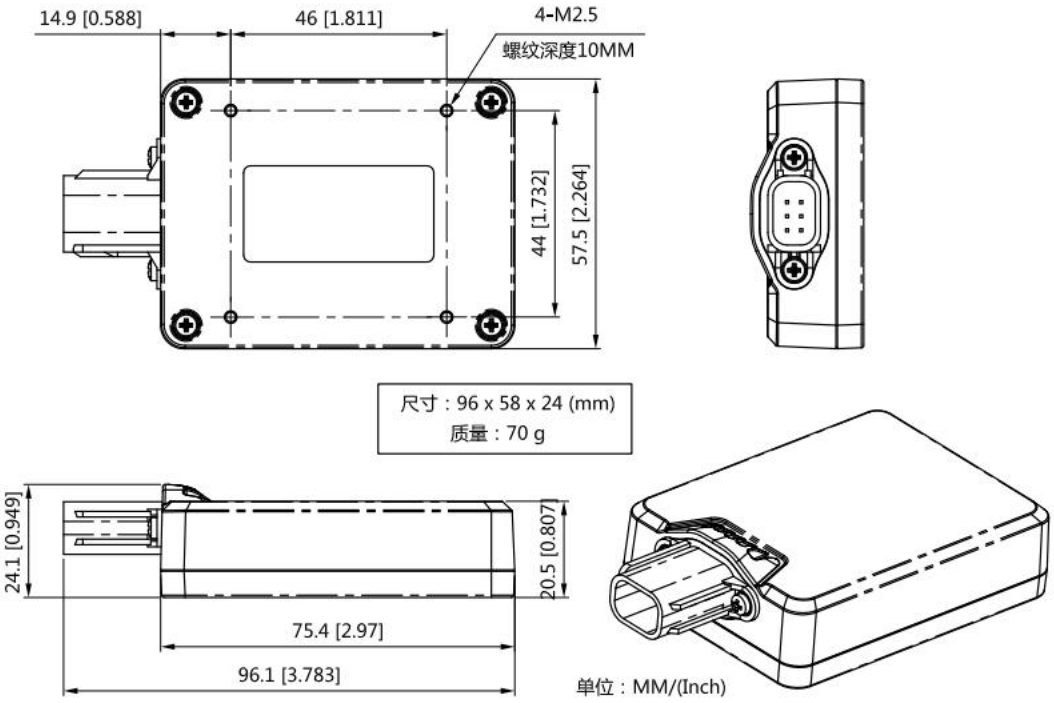
CAR28F compacts 96*57*20mm, detection range is 35meters, it has a leading performance and the integrated peripheral interface (CAN interface), especially it's cost effective. It has the below functions,

1.Front collision avoidance for slowly speed special vehicles.

2.Warning when car is back up.

3.Warning when there is a barrier in front of the driver-training car.

CAR28F can meet the rapid increase demands in the special car industrial.



Picture 1 CAR28F Outline

Note:

CAR28F packing list is not including electric wires, we will provide you 1m 4-core RVV wire if you need.

2 Notes when you use it

The below notes is very important, please pay more attention on it.

（1）The module antenna surface (convex surface) have to be installed across from the detection area, and it can't be covered by any metal items.

（2）You have to test the product in the outdoor large place.

Please kindly contact Nano technician if you have any problem during your use and installation , we will provide you a professional service.

3 Shipping list

The packing list is including 1*CAR28F sensor (picture2), 1*cable (picture3). Usually we are don't provide cable, please contact the sales purchase it separately if you need.

Picture 2 CAR28F sensor

Picture 3 CAR 28F cable

Note: CAR28F can be fixed with 4pcs M2.5 screws or magic stickers.

4 Quickly use guide

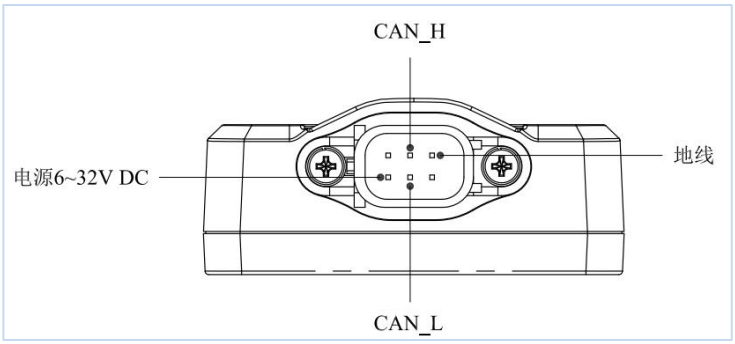
4.1 Cables installation

The definition for CAR28F sensor interface pins are shown in sheet 1

Sheet 1 The definition for CAR28F pin interface

No.	Definition	Range	Cable colors
1	CAN_H	-58~58V DC	yellow
2	CAN_L	-58~58V DC	white
3	GND		black
4	POWER IN	6~32V DC	red

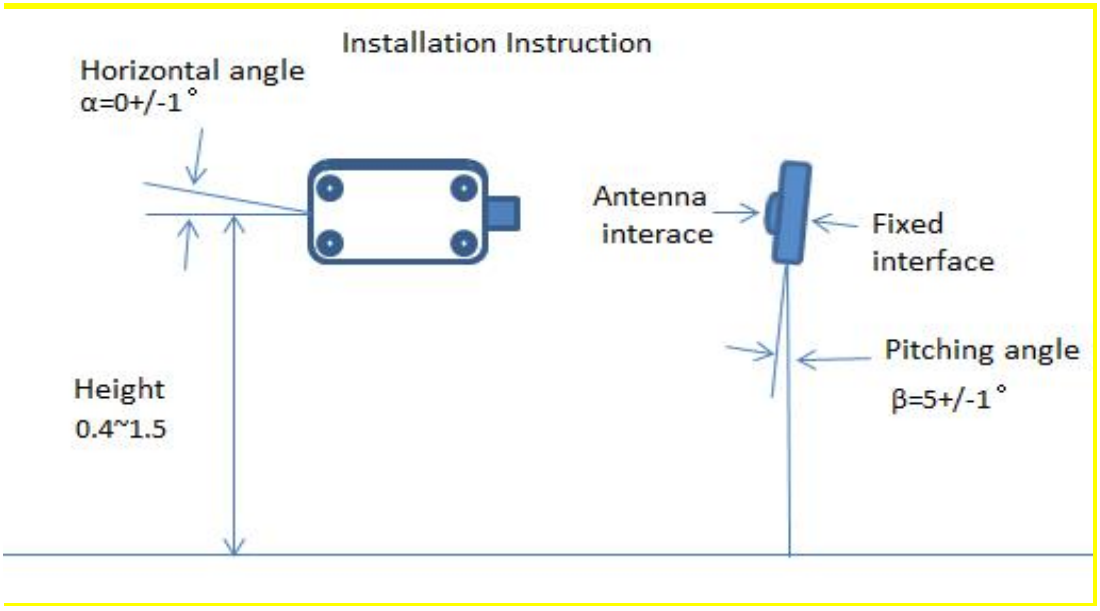
CAN28F pin interface instruction as below:



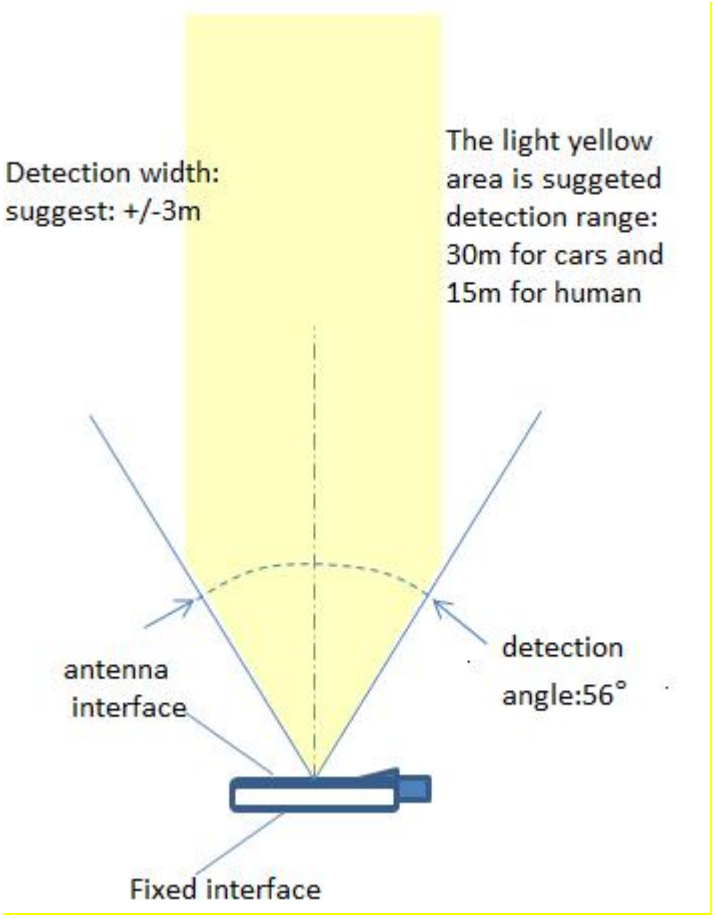
Picture 4　CAR28F pin interface（wireless connection）

4.2　The installation and coordinate system of CAR28F

The CAR28F should be installed 400-1500mm far away from the ground when it's used in front/rear detecting, the radar antenna have to be posited front. The installation diagram is as below.



Picture 5　Module installation instruction



Picture 6 Detecting range diagram

Note:

Please assure there is no metal items covered in front of the radar.

4.3 Test and use

CAR28F sensor data can be acquired and analysis by the " NSM Tools Management Platform" testing software, which is used to visually display the observation results. The tool is helpful in the use of CAR28F sensor.

Firstly, please get the "NSM Tools Management Platform" (PC test software), user manual, Micro USB drive from the Nano, then install and configure the PC test software according to the user manual.

Note:

1) The radar should be tested according to the the picture 5 installation instruction when you test the product functions.

2) "NSM Tools" utilizes the USB2CAN adapter shown in figure 8 to communicate with CAR28F. Other types of USB2CAN adapters are not supported at this time. The shipping list doesn't include USB2CAN adapters by default. Customers can get it from

Nanoradar's customer service to obtain CAB adapter link address to buy it.
Or Nanoradar can also help customers purchase it.

Picture 7 CAN box for

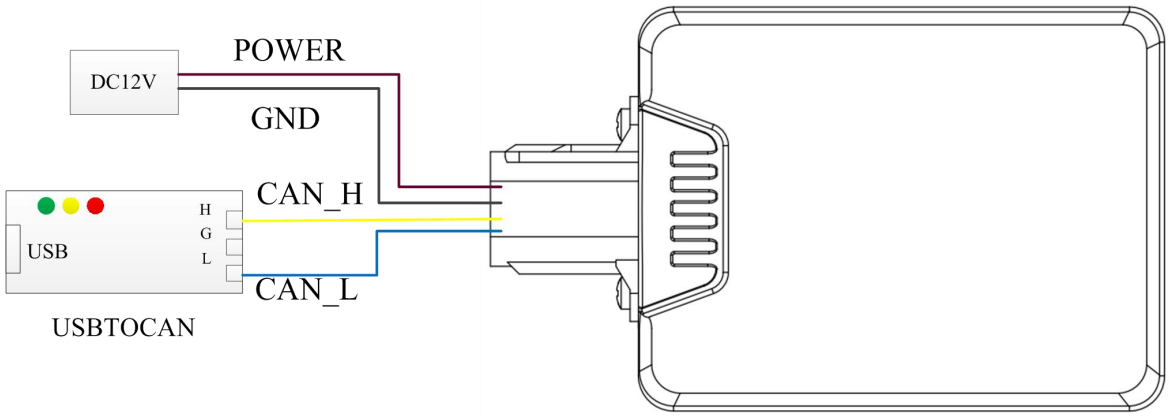
Test steps as below:

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

sheet 2 Product test and use tools

No.	Device name	Qty
1	CAR28F sensor	1
2	PC	1
3	Cable	2
4	12V DC power supply	1
5	PC test software	1
6	USBCAN box	1

2) Connect the PC and CAR28F radar sensor via USBCAN adapter, and the connection diagram is as follow.



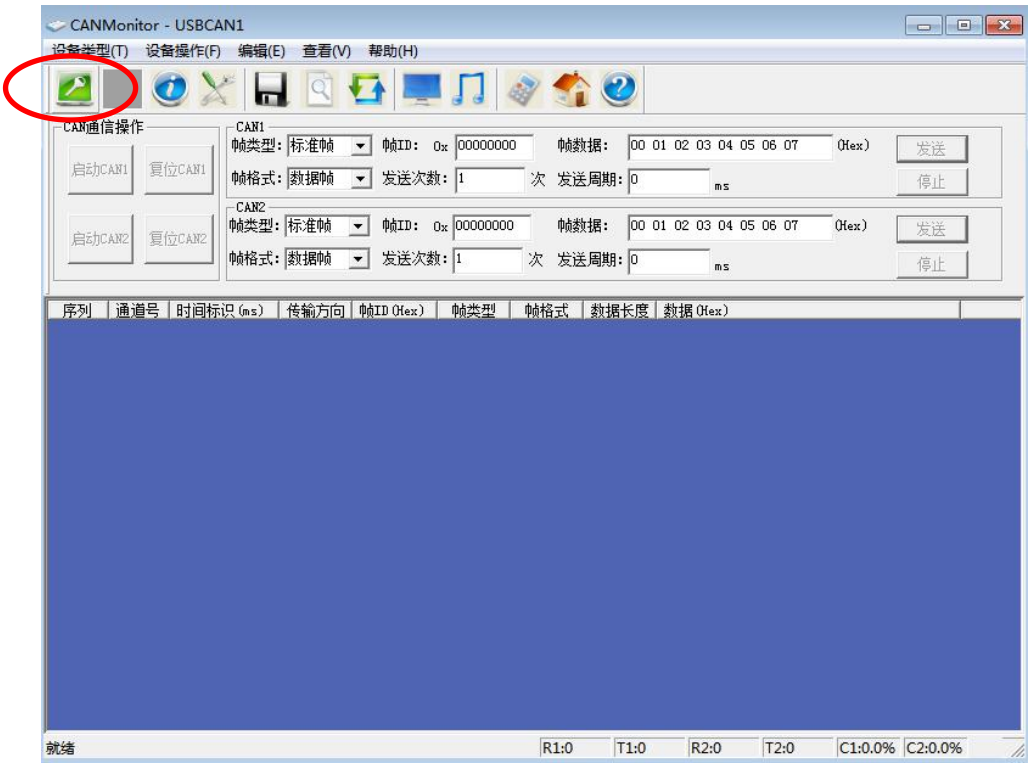
Picture 8 CANBUS connection and test diagram

Note:

The green light (POWER) in the USBCAN will continue lighting when CAR28F is connecting to the 12V DV power supply, and the yellow light will keep lighting when CAR28F is operating normally.

3) Open the CANMonitor drive, then configure the system as required, the user

screen is as below picture.

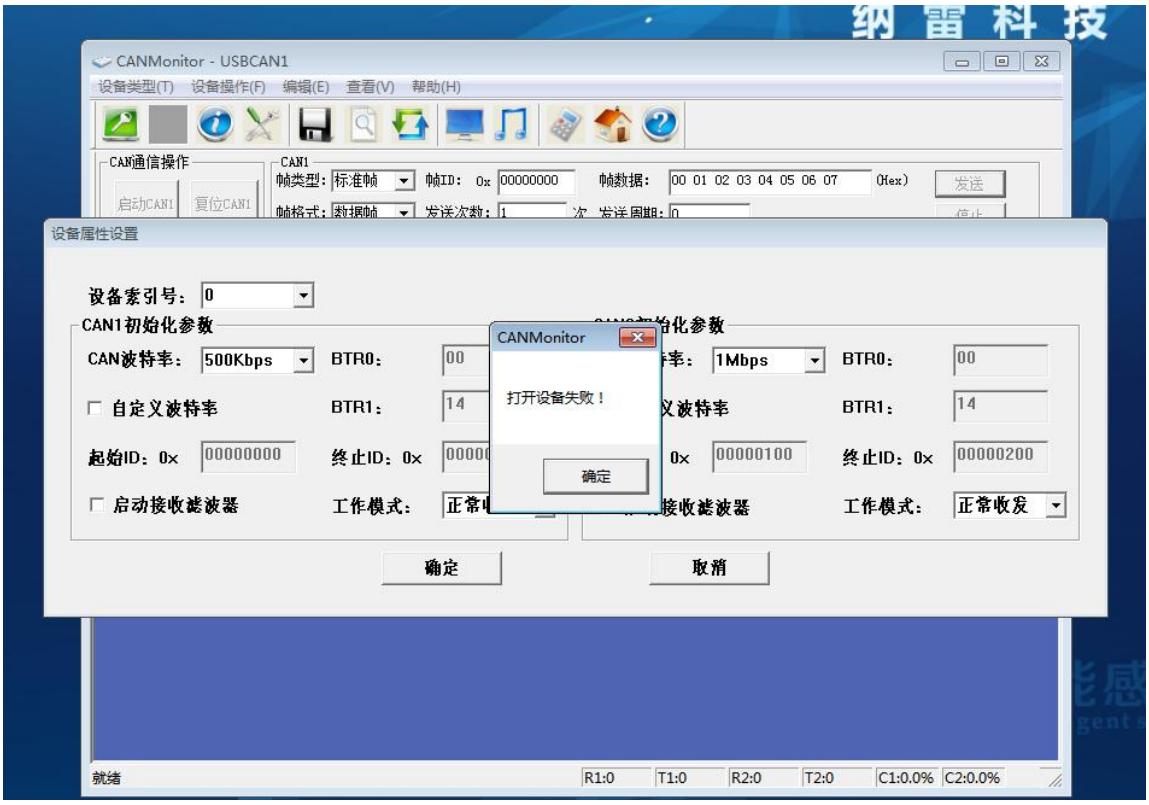


Picture 9 CANMonitor Screen

Click the green button on the left corner later you will see the screen as below picture, please don't revise any data, then click the "OK" button.

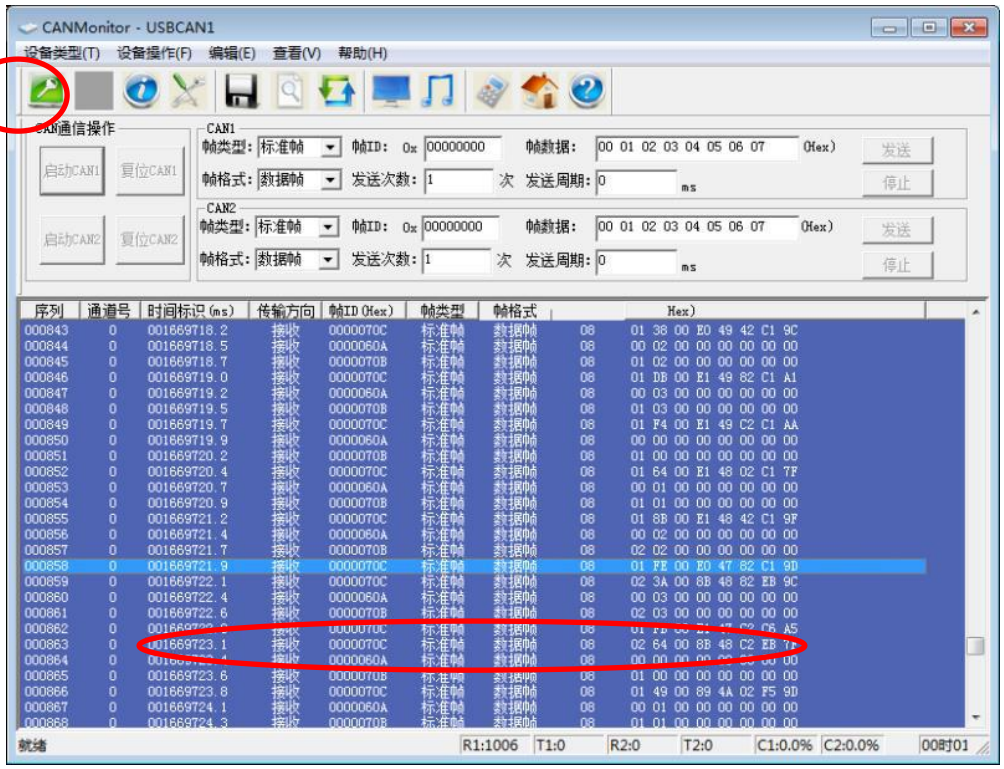
Picture 10 Device attributes setting screen

Please assure CAR28F is connect with PC correctly if there is show “Open device failure”.



Picture 11 Open device failure screen

Please click CAN1 button if the connection is correct, after your click the command line will show ”0x70C” list if there is a relative motion between radar and the target. Otherwise your connection or installation is wrong, please check it again.

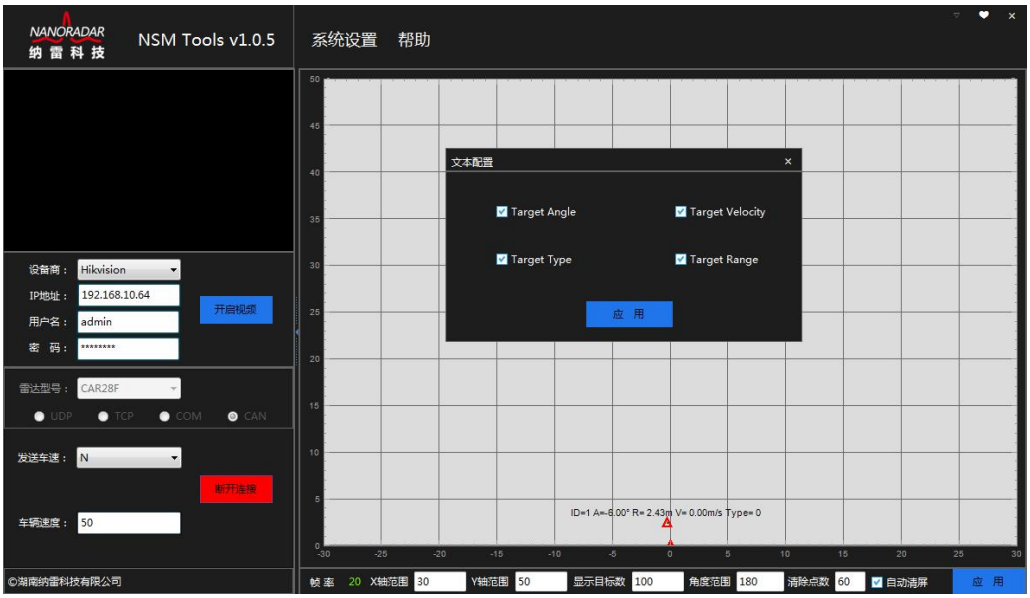


Picture 12 Initial test screen

4) Open the “NSM Tools” software and then start your testing. The test screen is show as below picture. Please choose radar Mo. CAR28F

Picture 13 Test screen

5) Please click ”device connect” after you choose “CAR28F”, then the radar will start working. The test screen is show as below picture.



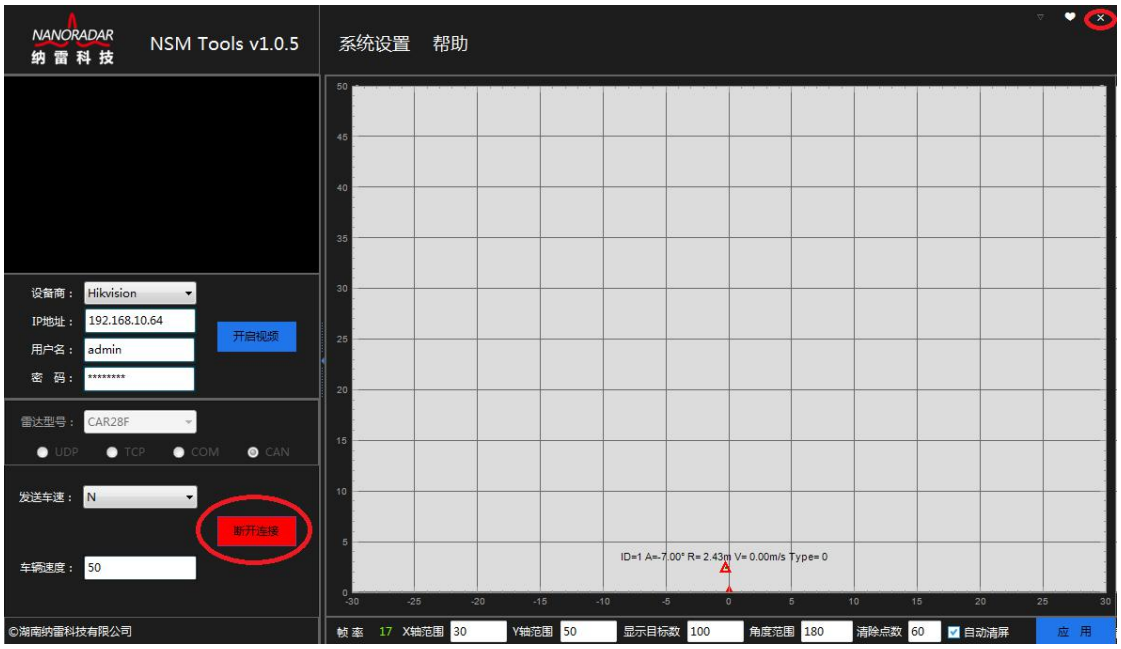
Picture 14 test screen

When the radar detecting a target you will see the screen as above picture. Users can click “system setting”- “test configuration” choose to output distance, speed, angle, or target type information as your required.

Suggested testing place: You have to test CAR28F in the outdoor large place. The target's move tracks will be off and on if you test it indoor because there is many interference.

6) Log out the test

Please click "disconnection" button after you finish the test, and click the "X" button on the right corner to close the program.



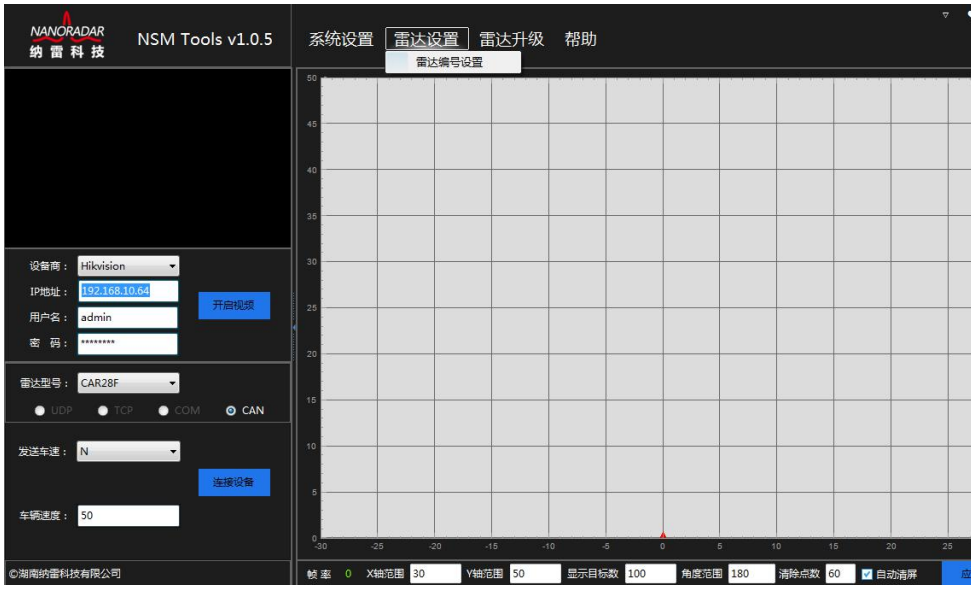
Picture 15 Log out the test

4.4 Amend radar ID

The "NSM Tools" which is provided by Nanoradar Technology can check and revise radar ID

1) Connecting the radar with PC according the above manual, then open the millimeter wave radar "NSM Tools" software.

2) Amend ID: Disconnect the device and click menu "radar setting" then choose "radar number setting", please see the picture as below.



Picture 16　Choose ”radar number setting” under the “radar setting”

3) Click the “Read” button to get this radar’s ID, this radar ID is 0 show as below.

Picture 17 Acquire the current radar ID

4) Amend this Radar ID from 0 to 5(amend 0 to 5, then click “Use” to save the new ID. Shown as below picture).

Picture 18 Amend the current Radar ID

4.5 Online upgrade for product firmware

CAR28F support online upgrade. After customers purchase products, you can get the millimeter wave radar upgrade tool and upgrade program from Nanoradar's customer service or Nanoradar's official website if the product program needs to be upgraded. The upgrade tool interface is shown as below.

Picture 19 CAR28F Radar Upgrade Tool Screen

5 Data analysis for CAN interface

CAR28F radar supports CAN interface. The communication network of CAN Bus complies with ISO11898-2 standard, with the transmission rate of 500bit/s. CAR28F

transmits radar signals to the surroundings and processes the received signals in multiple steps, to collect the targets groups and target tracks. The relative velocity and position of targets could be transmitted via CAN interface.

The CAN message of CAR28F is defined as follows：

Sheet 3 CAR28F Definition of frame message

CAN	Frame format	Basic information ID	Message ID	Contents	Source
1	CAN2.0(11Bit)	0x200	Radar Configuration	Radar configuration	CAR28F
1	CAN2.0(11Bit)	0x400	Radar Feedback	Radar back	CAR28F
1	CAN2.0(11Bit)	0x60A	Radar Status	Radar statue output	CAR28F
1	CAN2.0(11Bit)	0x70B	Target Status	Radar target statue	CAR28F
1	CAN2.0(11Bit)	0x70C	Target Information	Radar target information	CAR28F

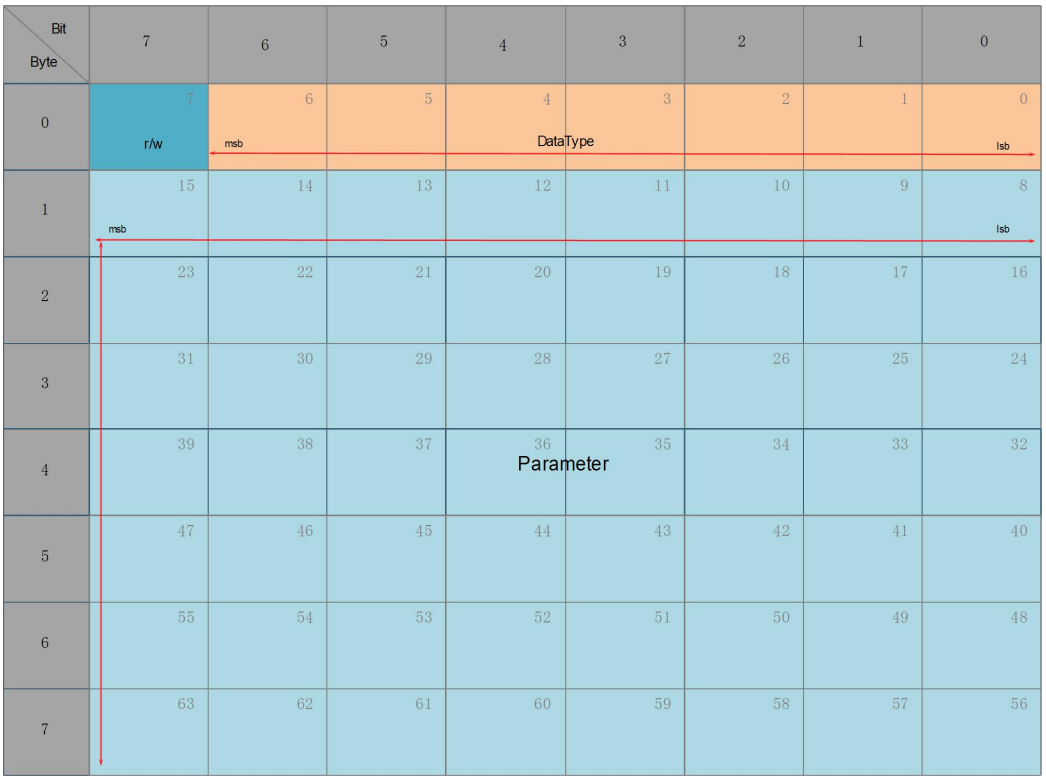
Note:

The detailed ID calculation format: Each radar message ID=radar ID*10+basic message ID. Due to that multiple devices could be mounted in the CAN bus, and each device has its own ID. In the above table, the default radar ID is 0 and the underlying message IDs are 0x200, 0x400, 0x60A, 0x28TB and 0x28TC. If the radar ID is configured as 1, then its Message ID is 0x210, 0x410, 0x61A, 0x71B, 0x71C, and so on.

5.1 CAR28F Configuration (Sensor Configuration)

CAR28F radar is configured through 0x200 messages. And the structure of radar configuration message is show as the following table：

Sheet 4 the structure of radar configuration message



The description for each field in the structure of radar configuration message is as the followings.

sheet 5 the description of the structure about radar configuration message

Parameter	Initial Position	Length (bit)	Definition
Data Type	0	7	1: Radar ID 2: Radar version 3: Start/stop the output of the target information 4: Distance filtering 5: Mode 6: Radar installation direction 7: Target output option 7e: for the internal test use 7f: Save parameters
R/W	7	1	0: Read parameters; 1: Write parameters
Parameter	8	56	In accordance with the definition of DataType

CAR28F will reply a message when you are reading or writing parameters, the message is including the results of writing parameters or returning the parameters is ready to read. Radar Feedback defines the format of the replied message. When

configuring CAR28F, the definition of Parameter is different for different Data Type. The definition is as follows:

1) Configuration of radar ID

The format of radar ID configuration is as follows.

Sheet 6 The format of radar ID configuration

Parameters	Initial position	Length	Value	Definition
Data Type	0	7	1	Radar ID Configuration
R/W	7	1	-	0: Read parameters 1: Read parameters
Parameter	8	4	0~15	ID_Number
Reserved	16	48	-	

When reading Radar ID, R / W is 0, and the ID_Number value is invalid; when writing Radar ID, R / W is 1, and ID_Number is the ID number of radar.

2) Obtain radar version

The frame format for obtaining radar version is as follows：

Sheet 7 Format for obtaining radar version

Parameters	Initial position	Length	Value	Definition
DataType	0	7	2	Obtain radar version
R/W	7	1	-	0: read parameters; 1: invalid
Master Version	8	8	0~255	Master version
Second Version	16	8	0~255	Second version
Step Version	32	8	0~ 55	Step version
Reserved	40	24	-	-

The obtained radar version is read-only. Please do not fill any value in the Master Version, Second Version, Step Version when you are getting the radar version, because CAR28F ignores these values. The current radar version information will fill up the fields in the reply message of 0x400 When CAR28F receives a message of obtained radar version.

3) Start/stop the output of target information

Format for start/stop target information data output is as follows：

Sheet 8 Format for start/stop target information data output

Parameters	Initial position	Length	Value	Definition
Data Type	0	7	3	Start/stop the output of target information
R/W	7	1	-	0: read parameters; 1: write parameters
Parameter	8	1		0: stop output; 1: start output
Reserved	9	55	-	-

4) Distance filtering

【Reserve】

Mode Configuration

CAR28F can output the processed target data (for example to output the target data within the setting range). It can also directly output the initial target data (including all of the target data within the detecting range), currently it output the initial target data by default. The target output selection format is as below sheet.

Sheet 9 The target output selection format

Parameters	Initial position	Length	Value	Definition
Data Type	0	7	7	Target output selection
R/W	7	1	-	0: Read parameters； 1: Write parameters
Parameter	8	1		0: Processed target data 1: Initial target data
Reserved	9	55	-	-

5) For internal test

【Reserve】

6) Save parameters

You need saving parameters to save the configured parameters. Then after reboot, the last configuration takes effect and it does not need to be re-configured. Otherwise, it

needs to be re-configured in the next startup. The format for saving the parameters (i.e. 0xFF00000000000000) is shown in the following table:

Sheet 10 Format of saving parameters

Parameters	Initial position	Length	Value	Definition
DataType	0	7	7f	Reserve parameters
R/W	7	1	1	Write parameters
Reserved	8	56	-	-

5.2 Radar back (Sensor Feedback)

Each time the host computer or other MCU sends the configuration signal to CAR28F, CAR28F will immediately return the execution result. The reply format of the reply is shown in the following table. In the radar reply, only Bit7 is different. Bit7 in Radar Configuration is defined as R / W, and Radar Feedback is defined as the result of the configured execution. The Parameter field Radar Configuration is used to write the parameter, which is used in the Radar Feedback to return the current value of the parameter.

Sheet 11 the structure of radar back message

Bit / Byte	7	6	5	4	3	2	1	0
0	7 Result	6 msb	5	4 DataType	3	2	1	0 lsb
1	15 msb	14	13	12	11	10	9	8 lsb
2	23	22	21	20	19	18	17	16
3	31	30	29	28	27	26	25	24
4	39	38	37	36 Parameter	35	34	33	32
5	47	46	45	44	43	42	41	40
6	55	54	53	52	51	50	49	48
7	63	62	61	60	59	58	57	56

The definition for the description of each field in radar reply is as follows:

Sheet 12 the description of each field in radar reply

Parameters	Initial position	Length	Definition
Data Type	0	7	1: Radar ID；2:Radar version 3: Start/stop the output of the target information 4: Distance filtering；5: Mode 6: Radar installation direction 7: Target output option 7e: For internal test use 7f: Save parameters
Result	7	1	0: Configure failed ; 1: Configure succeed
Parameter	8	56	In accordance with the definition of Data Type

5.3 Radar Status Information

The message 0x60A is including radar status message. And the structure of radar configuration message is as follows.

Sheet 13 the structure of radar status message（0x60A）

Byte \ Bit	7	6	5	4	3	2	1	0
0	7 msb	6 Radar_Mode	5	4 lsb	3 msb	2 Radar_ID	1	0 lsb
1	15	14	13	12	11	10	9 msb Radar_RollCount	8 lsb
2	23	22	21	20	19	18	17	16
3	31	30	29	28	27	26	25	24
4	39	38	37	36	35	34	33	32
5	47	46	45	44	43	42	41	40
6	55	54	53	52	51	50	49	48
7	63	62	61	60	59	58	57 Mount_Dir	56 Output_Type

The description for each filed in radar status message is as follows.

Sheet 14 the description for radar status message（0x60A）

Parameters	Initial position	Length	Value range
Radar_ID	0	4	0~15
Radar_Mode	4	4	0:BSD/LCA；1:RCTA 2:EAF；3:FCTA
Radar_RollCount	8	2	0~3
Radar_Output_Type	56	1	0:Processed;1:Origin
Radar_Mount_Dir	57	1	0: forward direction； 1: opposite direction

Note:

CAR28F currently don't support RCTA, EAF, FCTA functions.

5.4 Target Output Status

The target output status data message format for CAR28F system is as shown in the table, which NoOfCluster means the number of detected targets, and the value of RollCount value lies between successive cycles of 0-1-2-3-0-1-2-3 ••••••. When the host computer or an external MCU cannot process the output data of CAR28T sensor in time, it will cause the received RollCount value to be discontinuous. At this time you should find a faster moving and handling method to solve this problem.

Sheet 15 Target statue（0x70B）

Byte \ Bit	7	6	5	4	3	2	1	0
0	7 msb	6	5	4 NoOfCluster	3	2	1	0 lsb
1	15	14	13	12	11	10	9 ClusterSt_RollCount msb	8 lsb
2	23	22	21	20	19	18	17	16
3	31	30	29	28	27	26	25	24
4	39	38	37	36	35	34	33	32
5	47	46	45	44	43	42	41	40
6	55	54	53	52	51	50	49	48
7	63	62	61	60	59	58	57	56

The description for each field in target status is as follows.

Sheet 16 the description for target status（0x70B）

Parameters	Initial position	Length	Value range
NoOfCluster	0	8	0~255
ClusterSt_RollCount	8	2	0~3

5.5 Target output information

The message format for Car28T target output is as below.

Sheet 17 the structure of target information(0x70C)

Message 0x70C contains the target's distance, angle, speed and other information. When the radar sensor is working and the target is detected, the target output state message appears after the CAR 28F system status message, and finally there will be the target output information message.

The description of each field in the target message is described in the following table:

Sheet 18 the description for target information（0x70C）

Parameters	Initial position	Length	Calculation methods	Value range
Cluster_Index	0	8		0~127
Cluster_RCSValue	8	8	Val*0.5-50	-50~30
Cluster_Range	16	16	Val*0.01	0~655
Cluster_Azimuth	32	8	Val-90	-90~90
Cluster_Vrel	48	11	Val*0.05-35	-35~35
Cluster1_RollCount	46	2		0~3

Note:

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

Index = IndexValue // target ID

Rcs = RcsValue*0.5 – 50 // Factory test retention value, don't output

Range = (RangeHValue*256 + RangeLValue)*0.01

// the initial data unit is "cm", the target distance unit is meter after convert

Azimuth = AzimuthValue – 90 // target azimuth

RollCount = RollCountValue // Count

Verl = (VrelHValue*256 + VrelLValue) *0.05-35 // target speed, unit is m/s

SNR = Value-127 // Factory test retention value, don't output

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

Note:

The target speed is the relative movement velocity. The target speed value (Verl) is negative when the target is close to the radar sensor, the target speed value (Verl) is a positive number when the target is far away from the radar sensor.

5.6 Car Speed Status

The PC or control box send the current car speed statue to CAR28F via the message periodic, which makes CAR28F can automatic switch working mode according to the current car speed statue. The current car speed statue text format is as below sheet.

Sheet 19 current car speed message structure（0x6E0）

Byte \ Bit	7	6	5	4	3	2	1	0
0	7	6	5	4	3	2	1	0
1	15	14	13	12	11	10	9	8
2	23	22	21	20	19	18	17	16
3	31	30	29	28 CarSpeed	27	26	25	24
4	39	38	37	36	35	34	33	32 Enable
5	47	46	45	44	43	42	41	40
6	55	54	53	52	51	50	49	48
7	63	62	61	60	59	58	57	56

The message is send to radar by PC or control box periodic, the suggested send circle is 200ms, the car speed is 0.

When the radar works in the offset mode, at this time, the radar filter is still and away from the target, and only outputs the closed target.

After the vehicle driving, when the vehicle speed is >=15Km/h, the radar operates in non-reciprocal mode, at this time, the radar can output targets that are relatively static, relatively close, and slowly far away.

When the car speed is reduce from 15Km/h to 10Km/h or less than 10Km/h, radar switched to cancel mode, only output closed target.

Car speed statue information and each text description as below sheet

Sheet 20 Car speed statue information description（0x6E0）

Parameters	Initial position	Length	Value range
Car Speed	24	8	0~255
Enable	32	1	0~1

Note:

Car Speed is represent the current car speed, for example 0*10 means the current car speed is 16Km/h.

Enable means enable bits.

Enable=1 means the current car speed is valid, the radar will switch working mode based on the car speed.

Enable=0 means the current car speed is invalid, the radar default is on non reciprocal working mode.

Note:

The radar default is on non reciprocal working mode when PC or control box don't send this message.

6 Data analysis 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:

Message ID:

0x70C

Data Payload:

0x01 0xC8 0x07 0xD0 0x32 0x02 0xEE 0x96

Interpretation：

Message ID = 0x70C

Data Payload = 0x01 0xC8 0x07 0xD0 0x32 0x02 0xEE 0x96

Each field of Data Payload is parsed as following：

Index = 1

Rcs = 0xC8*0.5 – 50 = 50

Range = (0x07*0x100 +0xD0)*0.01 = 20 // Unit :m

Azimuth = 0x32-90 = -40

Rsvd1 = 0

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

Verl = (0x02*0x100 + 0xEE) *0.05-35 = 2.5//单位，m/s

SNR = 0x96 – 127 = 23

Note:

The user needs program to parse the sensor output data (hexadecimal). The data before being parsed is hexadecimal, and is decimal after being parsed. 0x2AF51 hexadecimal is converted to decimal:

10997=5*16^0+F*16^1+A*16^2+2*16^3。

7 Installation and notes for risks

7.1 Installation principle

Sensor instillation principles as below,

1. Keep away from the antenna within the body of the signal as far as possible when installing;

2. Keep away from the location of the large frequently started electrical equipment when installing;

3. Keep away from the motor actuator and drive.

The CAR28F radar sensor is recommended for installation in the position of the vehicle bumper. Same as the radome, the bumper material will also have a greater impact on radar performance. In essence, there are three aspects of impact on radar performance. Firstly, radar cannot penetrate completely through the radome, which will

reduce the effective radiated radar power, including reflection loss and dielectric loss; Secondly, the distortion of radar antenna beam causes the change of radar's effective areas, which may lead to the interference of the backward targets; Thirdly, the radome makes radar’s standing wave worse. Radar radome will reduce the detection sensitivity and coverage of radar.

When installing the rear bumper, try to follow the following guidelines:

1. Select the smooth surface area;

2. To avoid the corner or areas with the changes of thickness;

3. Avoid chrome plating or any other additional area with "the design of special decorative shape ".

4. Prohibit to sealant on the radar antenna surface

7.2 Notes for risks in use

CAR28F is designed and developed for automotive applications and requires technical expertise. The product can only be used by those with relevant training. When the users discover any product safety defect, you are required to notify Nanoradar's customer service promptly.

◆When installing the sensor, make sure there is no an ice particle or mist on the radome surface.

◆Weld activities should not be performed near the sensor position.

◆The sensor surface can only be wiped with a damp, lint-free cotton cloth and please never scratch the surface of the sensor.

◆The equipment needs to be inspected daily before it is put into service.

8 FAQ

(1) Q: When CAR28F millimeter wave radar is installed in the car, the output of the

ID is the same?

A: Each radar has its own ID. And also radar ID is related to its installation position.ID can be read out from the CAN message. For example, the ID of 0x28TC radar is 0, and that of 0x73C radar is 3. Therefore the IDs of radars on the same car are not the same, but the ID of radar in the same installation position is the same for different vehicles. And the ID of radar can be configured by program.

(2) Q: CAR28F supply voltage range?

CAR28F power supply voltage range is (5 ~ 32V DC). The power loss gets greater as the voltage gets bigger. If only the voltage meets the conditions during the operation, insufficient current will lead to the board failure.

(3) Q: What is the Millimeter Wave Radar Solution for Assisted Driving by Nanoradar?

A: Our auxiliary driving solution is currently the industry's leading high-level auxiliary driving one. First is about the hardware configuration- a long-range radar (CAR150) and four medium-range radars (CAR28F), which constitutes the entire hardware base. Second is about the fusion of visual and other multiple sensors, for the extraction of information, including the target detection of position, speed, angle and other information. And the extracted information will be highly integrated with the algorithm of moving targets and the map information. Finally it constitutes the control of the vehicle, with the demanding of control algorithm and the underlying function control to achieve it.

9 References

[1] White paper on CAR28F millimeter wave radar

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

[3] User manual for Nanoradar's radar upgrading tool

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