MR76 77GHz MMW Radar User Manual

湖南纳雷科技有限公司

Hunan Nanoradar Science and Technology Co.,Ltd.

Disclaimers

Thanks to purchase this product. There is web pages about MR76 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
2018-11-20	1.0	The 1st version of user manual on MR76
2020-3-10	1.1	Content add and revise

CONTENT

1. Introduction

1.1 Features

The MR76 77GHz millimeter-wave radar provides short--range and medium-range dual-beam scanning coverage for obstacles up to 170 meters.

It supports the following features:

A. Simultaneous detection of stationary and moving objects with relative speeds from -200km/h to 300km/h.

a) Information on the distance, velocity and angle of the object.

b) Classification of moving objects such as trucks, cars and pedestrians.

B. Dual scan provides detections in far range (up to 170 m) and extended field of view (FoV) in short range up to 90°(-16dB)

C. Up to 64 tracking targets can be output via the CAN interface.

D. Support the integration of radar with other devices (such as cameras), which needs to be developed by customers.

1.2 Application examples

The MR76 77GHz millimeter wave radar is suitable for applications such as special vehicles collision avoidance and automotive forward collision avoidance. Other atypical applications are as follows:

A. Distance Monitoring/Warning: Distance monitoring with warning message if the distance to the preceding object is too close.

B. Detection and tracking of people, vehicles, animals and equipment for collision avoidance in industrial, construction, agricultural and mining applications.

C. Monitoring of automated manufacturing processes.

D. Condition monitoring of industrial plants.

E. Traffic monitoring for traffic management and safety applications with ability to distinguish objects on different lanes

F. Monitoring and protection of vehicle and pedestrians on railway and passenger crossing

The High Sensitivity and High Resolution of the sensor ensures a safe detection of preceding vehicles and also allows detection of targets in front of the preceding vehicle (by underbody reflections) even if the line of sight is covered.

1.3 Radar principle

The MR76 adopts the modulation method of FMCW (Frequency Modulated Continuous Wave). The basic principle is that the transmitted wave is a high-frequency continuous wave, and its frequency changes with the sawtooth wave rules by time. The changing rules of echo frequency received by the FMCW is the same as the transmitted frequency, which is sawtooth wave rules. However, there is a time difference. The target distance can be calculated by using thisl time difference.

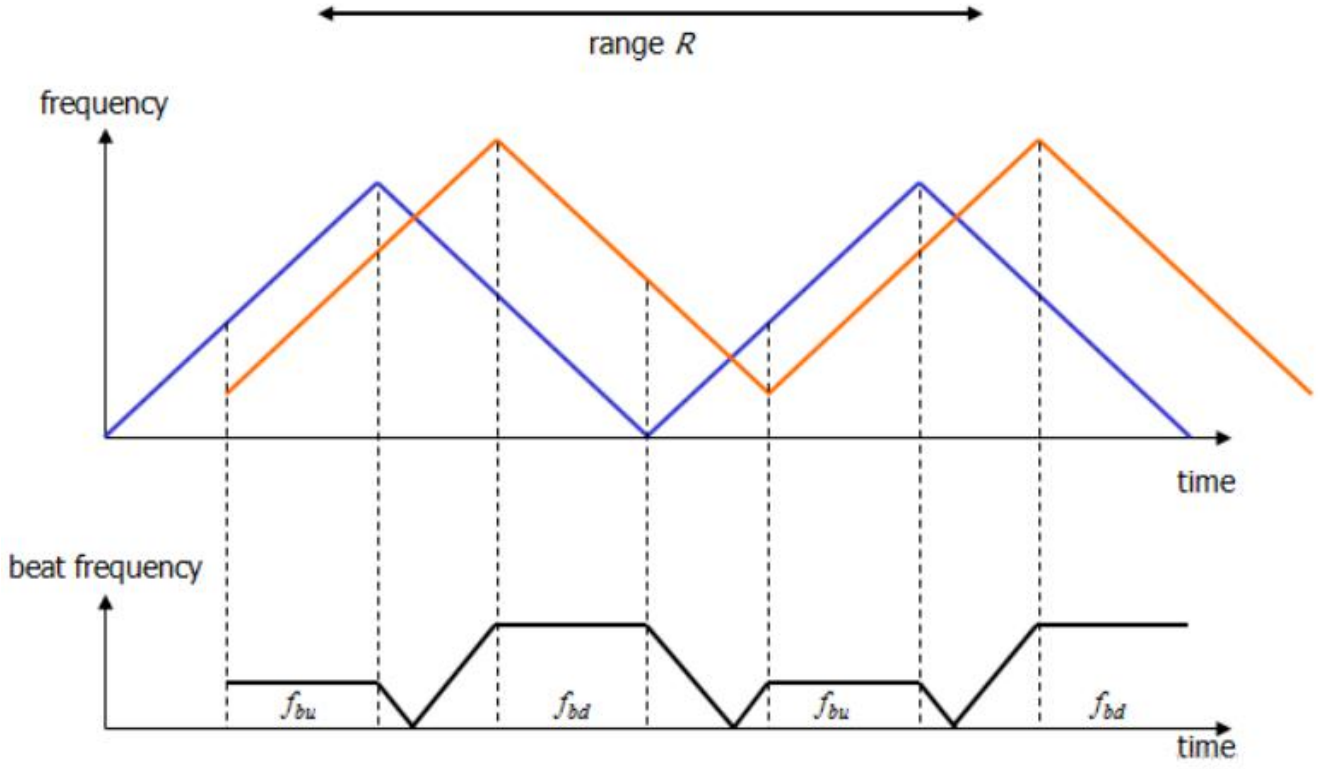


Figure1 FMCW radar block diagram

Taking the sawtooth frequency modulated continuous wave as an example to briefly introduce the radar's ranging/velocity measurement principle. As shown in Figure 1.1, blue is the transmitting signal frequency, yellow is the receiving signal frequency, the sweep period is T, the sweep bandwidth is B, the transmitted signal is transmitted through the target, and the echo signal has a delay, in the sawtooth frequency change rules, the distance measurement can be performed on both the rising edge and the falling edge.

1.4 Radar FOV

The MR76 77GHz millimeter wave radar is a mid-range radar. It can detect target distance, velocity and position information by receiving radar reflections. Its FoV can reach ±45° in the close range and ±9° in the medium range.

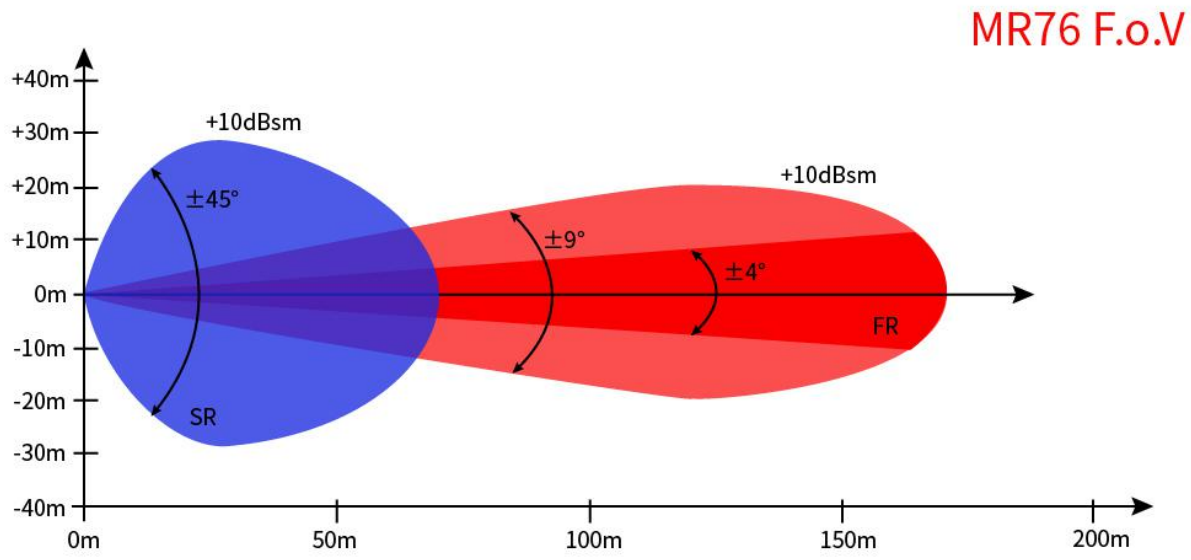


Figure2 MR76 FoV

1.5 Technical Parameter

Table 1 MR76 Technical Parameter

Measuring performance		**to natural targets (non-reflector targets)**
Modulation		FMCW
Distance Range		0.20~170m@±4°，0.20~120m@±9°(Mid range mode) 0.20~70m@±9°，0.20 - 40m@45° (short range mode)
Distance Resolution	spot target, none tracking	0.68m，ability to separate targets and objects 1.5…2 x resolution
Distance Accuracy	spot target, none tracking	±0.30m
FOV		±45°@-16dB
Angle Resolution	spot target, none tracking	±0.1°(middle mode), ±0.3°@0°、 ±1°@±45°(short mode)
Velocity Range		-200km/h...+300km/h (-leaving object，+approximation)
Velocity Resolution	spot target, none tracking	±1.23km/h
Velocity Accuracy	spot target, none tracking	±0.5km/h
Antenna Channels		2TX/4RX=8 channels
Cycle Time		60ms
Elevation beam	-6dB	14°
Azimuth beam	-6dB	18°

MR76 Dual beams (mid-range and short-range) work simultaneously and can not be switched. The detected targets are output in order of distance or RCS. By default, they are output by distance from near to far.		
Operation Condition		
Transmit frequency	ETSI&FCC	76…77GHz
Transmit capacity	average/peak EIRP	29.8dBm
Power		+8.0V~32VDC
Consumption		2.5W
Working Temp		-40℃…+85℃
Storage Temp		-40℃…+90℃
Protection class		IP67
Interface		
Interface		1xCAN- High speed 500kbit/s
Cover		
Dimension	W*L*H	140*70*35mm
Weight		200g
Material	front/back	PBT+GF30 for front shell，Die-cast aluminum sump for back shell.

2. Radar Connection

2.1 Interface Connection

MR76 support CAN bus Connection

2.2 Configuration and Startup/Shutdown/Failure Behavior

When the MR76 is connected to the bus or PC through the CAN protocol or serial port, please refer to the "MR76 77GHz Millimeter Wave Radar Protocol Manual" for related protocols.

The MR76 radar does not support hot swapping. If the internal detection of the system finds an error, it may cause the radar to malfunction or even cause the radar to restart.

3. Installation and Mounting Specification

3.1 Mounting on Vehicle

Radar Mounting

For front/rear detection and related applications, the MR76 is mounted at a height of 0.4 to 1.5 m from the ground, and the radar antenna faces directly in front. The installation specification is shown in

Figure 3 and Figure 4.

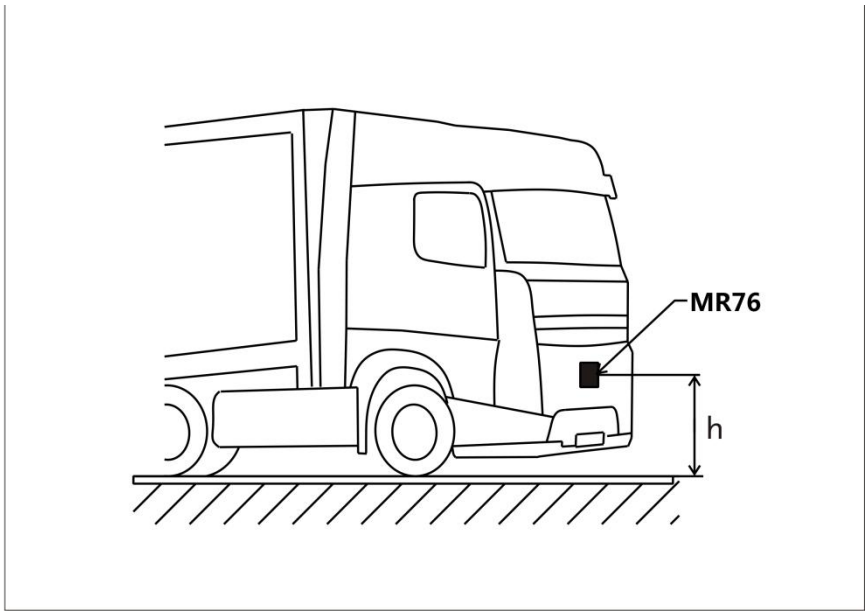


Figure 3 Radar vertical installation instruction

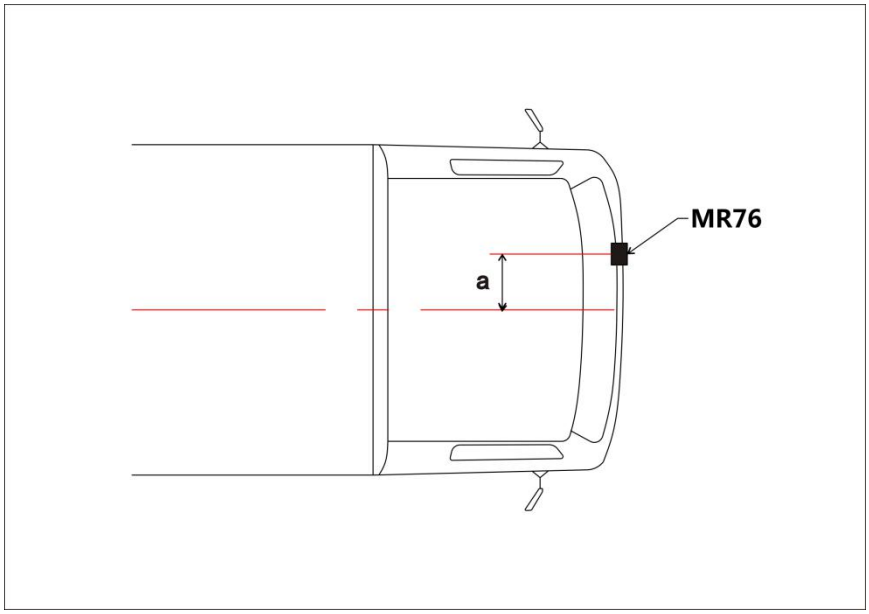


Figure 4 Radar horizontal installation instruction

3.2 Radar direction description

The beam width of the MR76 antenna is horizontal 90° (short distance), 8° (middle distance), and elevation angle 14°. The direction is as follows:

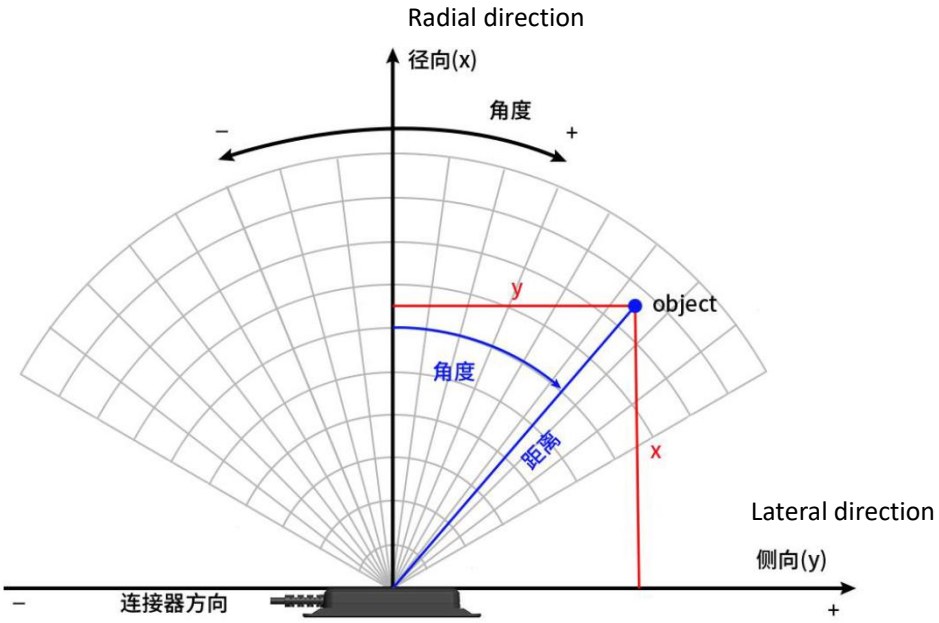


Figure 5 Radar direction description

3.3 Radar sensor installation principles:

a. Keep as far as possible from the vehicle signal antenna

b. Keep away from the frequent starting position of large power equipment

c. Keep away from car motor actuators and drivers.

It is not recommended to install the radar in the bumper. Like the radome, the bumper material has a great influence on the performance of the radar. In theory, there are three factors in the bumper that will affect the performance of the radar. The first is that the radar wave cannot completely penetrate the radome due to the reflection loss and the loss of the medium will reduce the power of the radar signal.The second is that the distortion of the antenna beam causes the radar detection area to change, which may cause the radar to be interfered by the backward target. The third is that the radome will deteriorate the standing wave of the radar. Radar radomes reduce radar detection sensitivity and detection range. If you must install the radar in the bumper,please adhere to the following principles:

a. Select smooth surface;

b. Avoid areas with corners or thickness changes;

c. Avoid chrome plating or any other additional "special decorative shape design" area;

d. It is forbidden to glue on the radar antenna surface.

In addition, when installing the MR76 77GHz millimeter wave radar, you should also pay attention to the following:

a. When installing the radar sensor, make sure there are no ice particles or water mist on the surface of the radome.

b. Welding cannot be performed near the radar sensor installation location.

c. Can only wipe the radar surface with a damp, lint-free cotton cloth, and can not scratch the surface of the radar sensor.

d. The equipment needs to be inspected daily before it is put into use.

e. Ensure that the deformation of the fixed position is not caused, and the radar sensor locking torque cannot exceed 7Nm.

f. The surface of the radar sensor should be installed in a material compatible with the chemical elements released by the vehicle itself.

3.4 Requirements for bumpers

According to the radar sensor mounting position, the distance between the radar sensor radome and the bumper should be large enough to reduce the effects of mechanical interference, thermal geometry changes or mechanical stress. In addition, the distance from the radar to the bumper should be large enough to avoid continuous rain, snow or mud blockage. It is recommended that the minimum distance between the MR76 and the bumper is 20mm.

Too small mounting tilt angle can result in multipath reflections between the radar sensor and the bumper and lead to increased noise levels. Reduce non-blurred angular areas can cause false alarms. Excessive tilt angles will increase the relative thickness and increase the attenuation due to material loss. In order to achieve best radar performance, we recommend an installation tilt angle of $10° < X < 30°$.

a. Conductivity of the material:

Table 2 Conductivity of ordinary bumper materials

Material	Conductivity(under 77GHZ)
Polypropylene	2.35
Polyamide	2.75
Polycarbonate	2.8
PC-PBT	2.9
ABS	3.12
ASA	~3.8

PMMA	~3-4TBC

b. Thickness：

Table3 Influence of different material bumper thickness on radar

Material	Optimum thickness 1(mm)	Optimum thickness 2(mm)	Optimum thickness 3(mm)	Optimum thickness 4(mm)	Attenuation (77GHz)	Applicability
PP	1.28	2.55	3.38	5.10	0.10	Excellent
ABS	1.19	2.39	3.58	4.77	0.30	Good
PA	1.18	2.36	3.54	4.72	0.30	Good
PC	1.16	2.33	3.49	4.66	0.17	Good
SMC	0.88	1.77	2.65	3.54	1.10	Bad

In order to achieve high conductivity, the thickness of the bumper should be carefully selected. In the above materials, the bumper thickness should be an integral multiple of half the wavelength of the 77 GHz millimeter wave radar. For example, the ABS material bumper thickness should be n*1.1mm (at 77GHz, n=1, 2,...). As the thickness of the bumper increases, so does the attenuation.

In order to prevent distortion of the radar beam, the bumper should be as flat and uniform as possible, and any slight bending will have a great impact on the radar beam.

c. Spraying

In theory, the bumper can be sprayed, but detailed analysis and inspection should be carried out to avoid degrading the performance of the radar sensor.

In general, bumpers are originally provided with a primer, paint and varnish layer. These coatings combine with structural materials to affect surface reflection and attenuation characteristics. Metal materials cannot be used for bumpers because metal materials can affect the detection of radar.

The effect of general metallic paint on radar depends mainly on below factors:

- Metal content of enamel paint (percentage)
- The size and shape of the sprayed surface
- Layer of primer and paint thickness

d. Alignment

A metal plate reflector is a possibility to use for the alignment procedure, which needs to be precisely adjusted perpendicularly to the vehicle driving vector or in measuring direction. Proper alignment of the

metal plate has to be ensured in both, horizontal and vertical direction. Any misalignment between the vehicle driving vector or measuring direction and the metal plate will lead to a failure of object detection. Instead of a metal plate reflector it would also be possible to use a corner reflector.

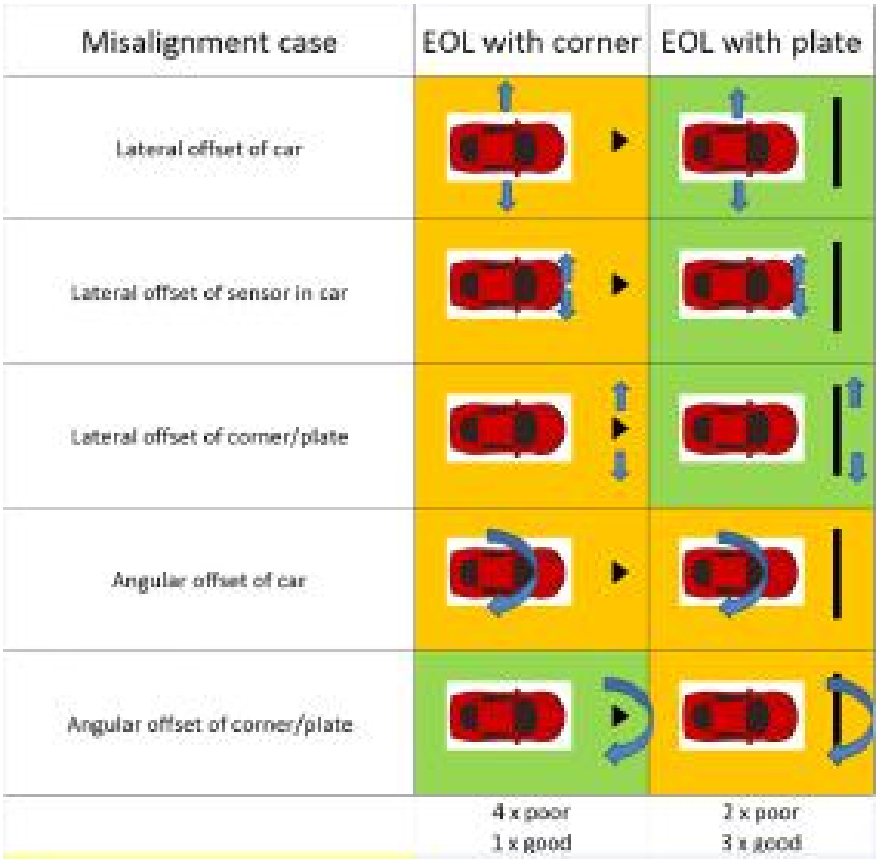


Figure 6 Advantage of plate compared to corner reflector

The distance a between sensor device and the metal plate shall be within the range 0.8m < a < 2 m.

Requirements for the material of reflector plate: Aluminum,Iron, Steel.

Requirements for the surface finish of the plate:

- Flatness of surface shall be at least f=0.1 mm in each subarea of 80 mm x 80 mm
- Roughness RZ < 50 (is equal to <50 μm)

4. Electrical Conditions

4.1 Cable Connection

The MR76 connecting cable is with a length of 3 meters, including the positive and negative pole of the power supply, the CAN high and the CAN low.

The MR76 radar needs to be powered by battery or other equipment. The power supply line requires a 10A wire. In order to protect the radar from electromagnetic interference, the grounding wire must be as short as possible.

4.2 CAN Interface

The CAN interface allows the notebook or PC to communicate USB with the device via a USBCAN converter. The interface pins of the CAN interface are defined as follows:

Table 4 Pin definition

Pin	Definition	Range
8	POWER IN(Brown)	6～32V DC
5	GND(Black)	-
4	CAN_H(Yellow)	0～3.3V DC
3	CAN_L(Blue)	0～3.3V DC

4.3 Test and Use

Nanoradar Provide NSM_77 Tools test software to acquire the target information with visual and direct data. This tool can help the user understand or evaluate the performance of the radar sensor.

Download the NSM_77 Tools installation package, user manual, and USBCAN box driver from Nanoradar official website: http://www.nanoradar.cn/. Install and configure the test software according to the manual.

1)The radar should be tested according to the the pic3.1 installation instruction when you test the product functions.

2) NSM_77 Tools utilizes the USB2CAN adapter shown in figure 7 to communicate with SR73F. 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 customer service to obtain CAN adapter purchase link or buy it directly from Nanoradar.

Test steps as below：

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

Table 4 Product test and use tools

No.	Device name	Qty
1	MR76 sensor	1
2	PC	1
3	Cable	2
4	12V DC power supply	1
5	PC test software	1
6	USBCAN Adapter	1

2) Connect the PC and SR73F radar sensor via USBCAN adapter, and the connection diagram is as follow.

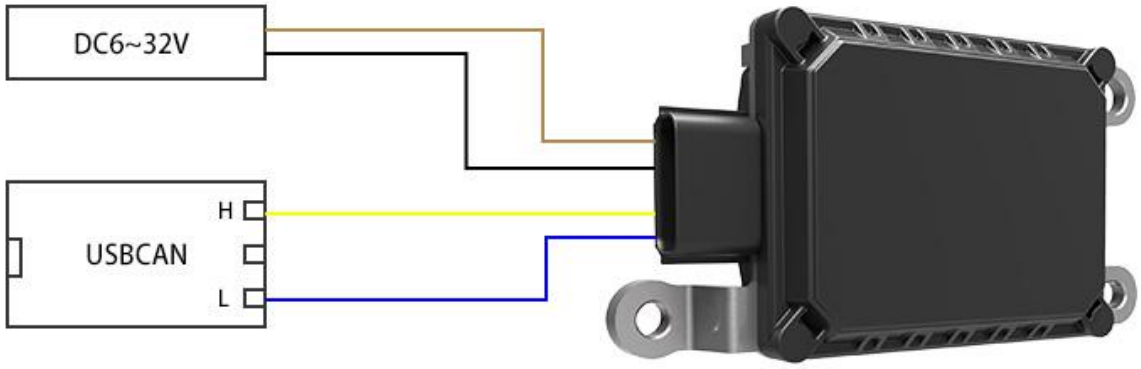


Figure 7 CANBUS connection and test diagram

Note:

The test needs to use the USBCAN adapter shown in the figure below to communicate with the MR76. Nanoradar NSM_77 Tools does not support other types of USBCAN adapters. The shipping list does not include the USBCAN adapter by default. Customers can purchase the CAN adapter on taobao link shared by Nanoradar or buy it from Nanoradar.

Figure 8 USBCAN Adapter for test

3) Open the "NSM_77 Tools" software and then start your testing. The test screen is show as below picture. Please choose radar Model. MR76 . The red rectangle is MR76 parameter configuration and the blue rectangle coordinates range is configuration.

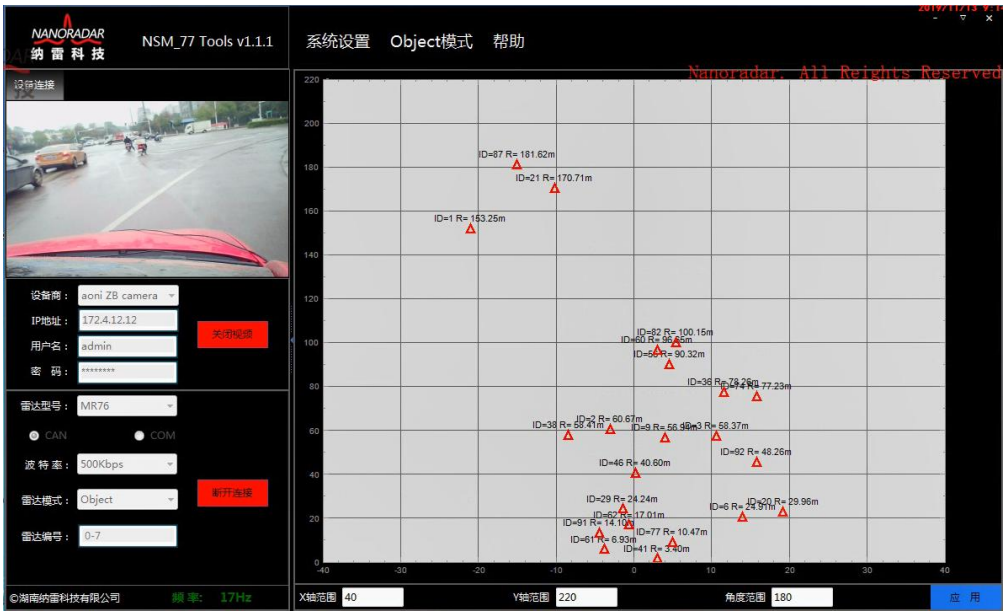


Figure 9 Radar test UI

4) Start the test. If MR76 radar antenna face is facing the moving target, or the radar sensor has a slight motion relative to the target, you can view the red triangle of the target indication on the UI interface and display the target distance R. Figure 3.3, the target's radial distance to the radar is 2m, 5.2m (MR76 can detect the target within 170 meters). If there is no red triangle indication, there is no target in the detectable distance and the field of view.

5. Influence on Human Health

MR76 is compliant with international regulatory requirements and accordingly should not be hazardous to human health. In addition studies by independent experts have proven that automotive radars have no

negative influence on persons.

5.1 Electrostatic protection measures

It is necessary to fully perform static protection work during the process of radar transportation, storage, work and pick-and-place. When dealing with independent radar equipment, users must pay attention to below advice: when the radar is taken out of the sealed anti-static packaging, it is necessary to start electrostatic protection work; never touch or grab the radar antenna surface and connector pins, only touch Its corners.

Please wear anti-static gloves when handling all radar sensors.

Wrong Operation

- Wrap the antenna with metal foil or some metal parts;
- directly measure the pin with a multimeter, causing damage;
- Spray the antenna structure with any type of paint or varnish;
- Wrap the antenna with CFK sheet (conductive);
- The plastic material is in direct contact with the corroded antenna structure (the effect of dielectric constant on the resonant frequency of the patch).

5.2 Identify electrostatic damage

In general, the following two conditions indicate that the module has suffered electrostatic damage:

- When there is no target object in the radar detection coverage, the radar continuously outputs an irregular target;
- When the DC parameter values such as power supply voltage and power supply current are within the normal range, the signal cannot be output.

5.3 Power protection

The radar input voltage range is 6~32V DC, and the ripple is less than 20mV. A large ripple power supply will cause the radar to continuously output incorrect target information.

5.4 Space electromagnetic interference protection

The product has adopted shielding measures to minimize the adverse effects of electromagnetic interference in space. However, the radar still needs to be away from electromagnetic interference sources such as motors and isolated metal casings during installation.

6. Technical Parameter

Customers can upgrade the firmware version , parameter configuration functions will be developed later. The Object mode can output the tracking target, and the existing version supports up to 64 targets.

6.1 The Field of View (FoV)

The Field of View (FoV) is the function relevant part of the radar cone as described in the mounting guideline section. Within the FoV object detection for the different object classes is guaranteed in the limit as depicted in the data sheet chapter 7.

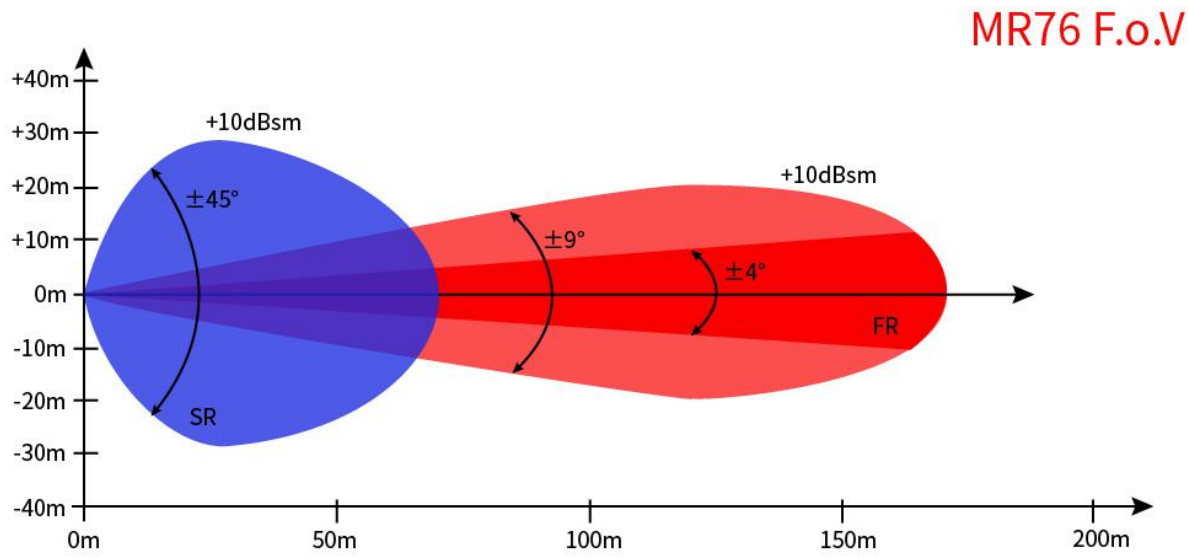


Figure 10 MR76FoV

Table 5 FoV Maximum detection range

Maximum detection range for the far range				
Azimuth angle	Passenger car	Motorcycle	Moped	Pedestrian
	10 dBsm ($10m^2$)	5 dBsm ($3m^2$)	0 dBsm ($1m^2$)	-7 dBsm ($0.2m^2$)
0°	170	130	90	70
±9°	120	90	70	55
±45°	25	20	15	12
Note: The table was generated based on the following worst case considerations: 1) M ax. 3dB radome attenuation and no rain 2) Sensor component with minimal valid S/N (as defined for production limit)				

3) Radom and rain attenuation of 4dB (radome only generated typically 2-3 dB attenuation, thus without including rain attenuation the values are about 12% higher)

4) For the effective RCS no typical values are set, but values of the range bottom for Radar Cross Section (RCS) scatter of the related types was used.

7. Cable Connection

7.1 Connection configuration

The assignment in the connection cable is as follows. The default installation direction should be that the radar interface is facing to the left.

The mounting orientation affects the position of the TX and RX antennas. Because the TX and RX antennas have different apertures, they are subject to different secondary surface structures. For best performance, the mounting location and cable connection direction shall be finalized after customer test evaluation.

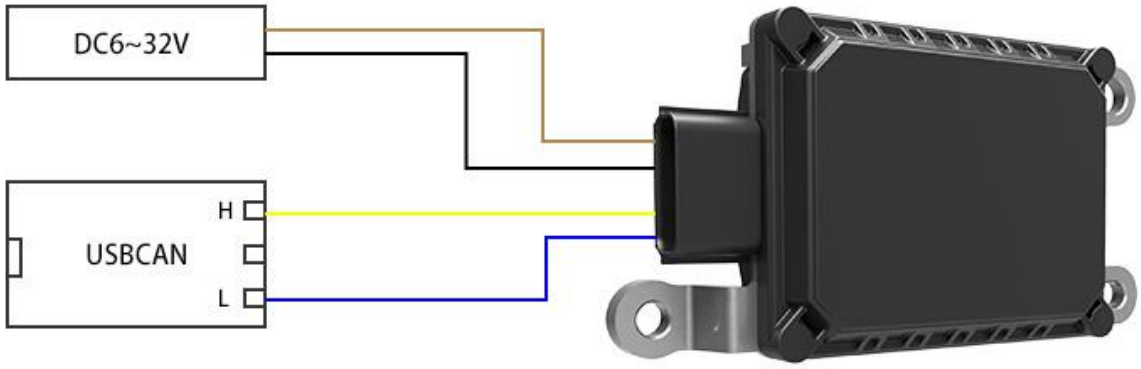


Figure 11 Radar connection illustration

The MR76 cable configuration and definition are as follows:

The MR76 does not support the polarity reversal of the power supply. Any consequences arising from the reverse connection, it should be at the customer's expense. The MR76 meet the test requirements of ISO 16750-2.

7.2 Pin definition

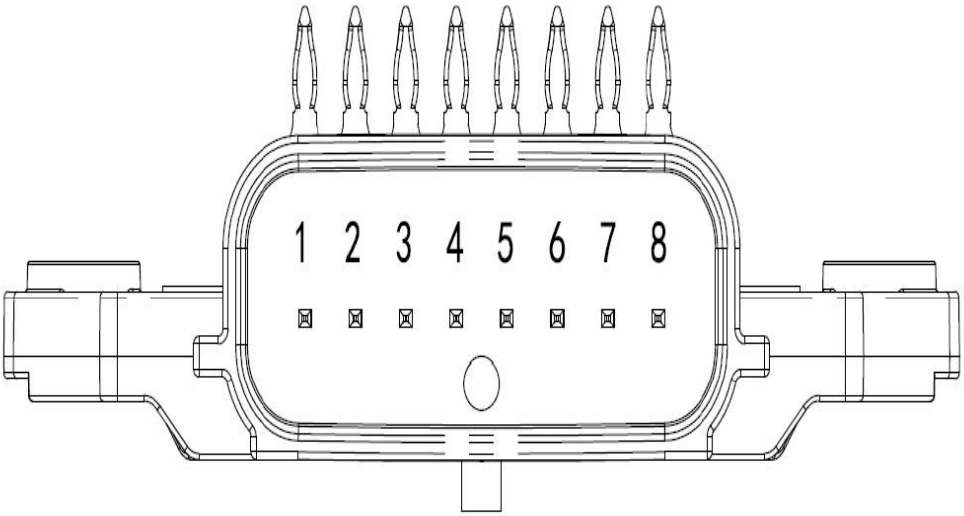


Figure 12 Radar connection illustration

Table 6 MR76 Pin out definition

Pin No.	Definition	Description	Cable color
1	VCC	8-32V DC Power Supply	Brown
2	NC	Not available	Not available
3	NC	Not available	Not available
4	GND	Ground	Black
5	CAN-H	500Kbit/s	Yellow
6	CAN-L	500Kbit/s	Blue
7	NC	Not available	Not available
8	NC	Not available	Not available

8. Interfaces

8.1 CAN interface

CAN is the abbreviation of Controller Area Network (CAN). It was developed by German BOSCH, which is famous for developing and producing automotive electronics products, and eventually became an international standard (ISO 11898). In North America and Western Europe, the CAN bus protocol has become the standard bus for automotive computer control systems and embedded industrial control LANs, and has the J1939 protocol designed for large trucks and heavy machinery vehicles with CAN as

the underlying protocol.

8.2 CAN bus features:

(1) There is no master-slave relationship in data communication. Any node can initiate data communication to any other node(s). The order of communication is determined by the priority order of each node information. The high-priority node information is communicated at 134μs. ;

(2) When multiple nodes initiate communication at the same time, the lower priority will give way to the high priority , which can avoid congestion on the communication line;

(3) The communication distance can be up to 10KM (the rate is lower than 5Kbps) and the rate can reach 1Mbps (communication distance is less than 40M);

(4) CAN bus transmission medium can be twisted pair, coaxial cable. CAN bus is suitable for large data volume short-distance communication or small data volume long-distance communication in real-time or case like multi-master multi-ordinary or each node is used in the same field.

Table 7 Line Specification

Line length	Max. transfer rate	Specific line resistance	Cable cross section
0-40m	1Mbit/s	70mΩ/m	0.25-0.34mm^2
40-300m	200Kbit/s	＜60mΩ/m	0.34-0.60mm^2
300-600m	100Kbit/s	＜40mΩ/m	0.50-0.75mm^2
600-1000m	50Kbit/s	＜26mΩ/m	0.75-0.80mm^2

Table 6.2 Protective measures

Condition	Protection
Inverse-polarity protection	
Input resistance (differential)	＞19kOhm
CAN pin short-circuit current limiter	200mA

8.3 Input Signals- Possible Dynamic Parameters

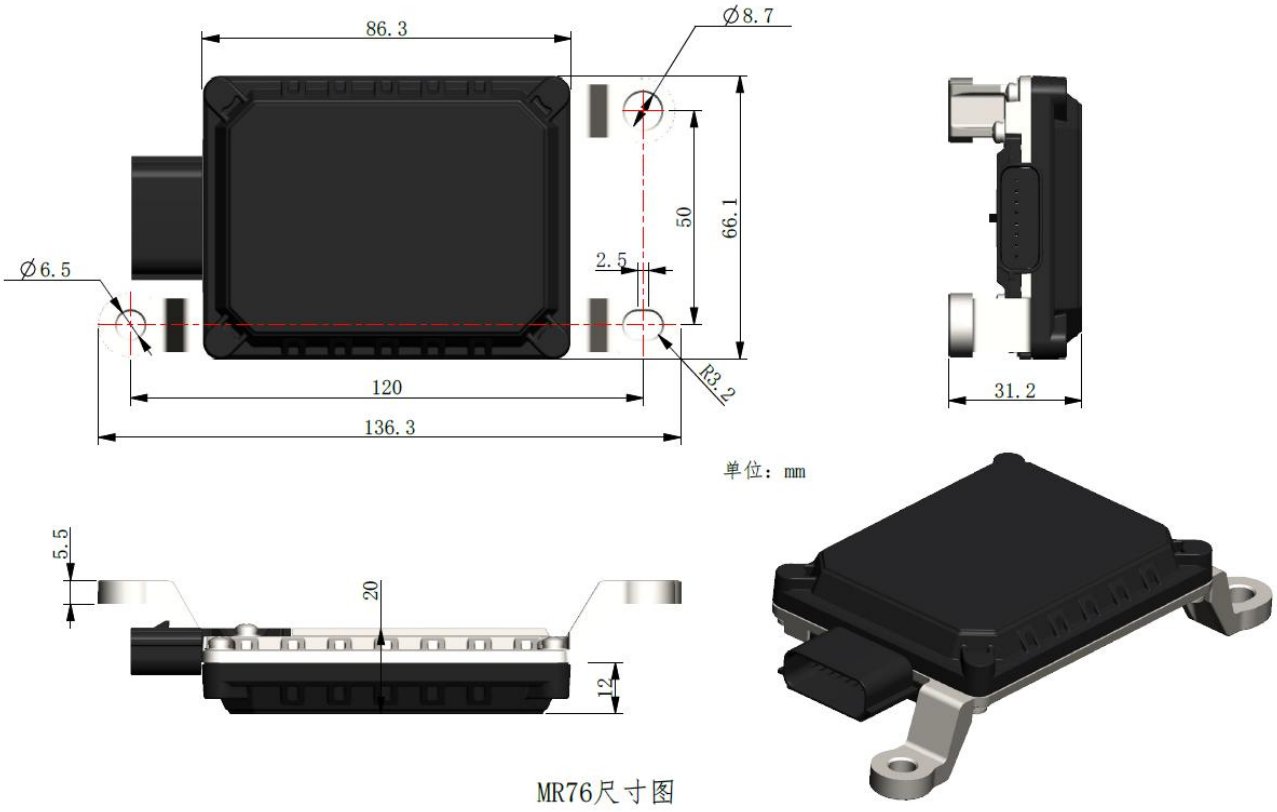
Required signal quality depends on expected sensor performance and need to be tested by the customer.

9. Device Dimensions

For automotive applications the device needs to be integrated in the front end of the vehicle.

9.1 Dimensions

	Length	Width	Highet
With shell	136.3mm	66.1mm	31.2mm



Pic 7.1 Radar Dimension

10. Notes on Safety and Risks

This chapter is intended to enable owners and operators of the MR76 to recognize all usage-related risks in good time, i.e. in advance wherever possible.

The MR76 was developed for use in automobiles. Users must be in possession of basic technical knowledge, and it is assumed that this is the case. The device should only be used by trained operators. The person or owner responsible for the device must ensure that all operators understand and observe these safety notes. If the MR76 is part of a system, the system manufacturer is responsible for ensuring that the safety-related aspects are heeded, e.g. the operating manual, labeling and instructions.

10.1 Areas of responsibility

(1)Scope of responsibility of the manufacturer regarding the original device or equipment: Hunan Nanoradar Science &Technology Co., Ltd is responsible for supplying the device, including the short description and the original accessories, in a technically safe and sound condition.

(2)Scope of responsibility of the manufacturer of third-party accessories:

Manufacturers of third-party accessories are responsible for the development, implementation and communication of safety concepts for their products, and their effects in conjunction with the MR76 from NANORADAR.

(3)Scope of responsibility of the owner (customer, end customer and end user):

The owner is responsible for ensuring that the device (and equipment) are used for their intended purpose, for the actions of his employees, for giving instruction to the employees, and for the operational safety of the equipment.

(4)The owner is subject to the following obligations:

- The owner is subject to the following obligations:
- He must be familiar with the locally applicable accident prevention regulations.
- He is to notify NANORADAR as soon as a device or the equipment displays any safety defects.

The owner is responsible and has to confirm that the owner (customer, end customer and end user) will add resp. copy the following disclaimer and information, incl. the declaration of conformity in their own documentation resp. manual.

MR76 77GHz MMW radar is allowed for the usage in research & testing purposes.

11. Common faults and solutions

1) False alarm in the second djacent lane

Solution： The radar installation angle is too large (over than 25° +1 ° / -2 °), need to remove the bumper to adjust the radar angle.

2) The alarm target is opposite to the alarm direction

Solution：The radar is reverse installed and adjust the radar direction to the oposite.

3) Following car false alarm

Solution： The radar installation angle is too small (over 25° +1° / -2°) or the installation position is wrong. The radar needs to be reinstalled accroding to previous installation instruction.

4) Missing Alarm

Solution：There are wire bundle, uneven thickness, sharp corners or other metal partsn front of the radar installation location, which shall be replaced or removed.

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