TCM873 millimeter wave radar User's manual

Hunan Nanoradar Technology Co., Ltd.

Hunan Nanoradar Science and Technology Co.，Ltd.

Disclaimer

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This manual contains important information and should be kept in reserve.

Version history

Date	Version	Version description
2024-7-25	1.0	

Table of contents

1 Overview

1.1 Important note

This user manual is written for the TCM873 millimeter wave radar developed by Hunan NanoradarTechnology Co., Ltd. There may be individual differences between different radars, which are not described in this manual.

 Hunan NanoradarTechnology Co., Ltd. guarantees the accuracy of all descriptions as far as possible. If there are still any errors or omissions, Hunan NanoradarTechnology Co., Ltd. will not assume any responsibility.

Hunan NanoradarTechnology Co., Ltd. shall not be liable for any personal injury or property damage caused by failure to comply with the description of this manual or improper use of the equipment, and all warranty claims shall be null and void. Random modifications and alterations to the radar sensor are not permitted for any reason whatsoever. Should any danger arise as a result of the above, all warranty claims will be null and void.

We reserve the right to make technical modifications or to modify the delivery specifications. If the customer needs to test the radar function or repair the radar, please contact us. Please be sure to keep the original packaging of the product to avoid TCM873 being destroyed by violence during transportation.

The manual will be updated according to the TCM873 millimeter wave radar. It is revised, corrected and enhanced according to the radar situation to meet customer development requirements and accuracy. This manual cannot list all possible applications or usage scenarios for the TCM873. After a new version is issued, the previous version of the manual will be invalid. Customers are requested to obtain the latest version of the user manual in a timely manner.

1.2 Feature overview

The TCM873 millimeter-wave radar provides short-range and medium-long-range dual-beam scanning coverage and can measure up to 500 meters. The radar supports the following functions:

1) It can simultaneously detect stationary and moving objects with relative speeds of -300km/H + 300km/H.

- The distance, speed and angle information of the object can be obtained.
- It can distinguish moving objects such as vehicles and pedestrians.
- Obstacles in different motion States can be identified, such as coming motion, going motion, static, etc.

2) Dual beam scanning coverage, up to 200m @ ± 40 ° in azimuth for short range scanning and up to 500m @ 0 ° for long range scanning.

3) Up to 512 tracking targets can be output through the network port.

4) If the radar is required to be integrated with other equipment (such as cameras), it needs to be developed by the customer.

1.3 Application scenario

TCM873 millimeter wave radar is suitable for traffic flow monitoring, intersection detection, perimeter security protection and other applications. Other atypical applications are as follows:

- Traffic flow: detect the traffic flow information on the road.
- Traffic monitoring: Safety applications such as traffic management and lane discrimination.
- Fork in the road warning: Fork in the road warning.

Even when the line of sight cannot be accurately judged, the high sensitivity and resolution of radar can ensure the detection of objects ahead.

1.4 Brief description of the principle

The TCM873 uses FMCW (Frequency Modulated Continuous Wave) modulation. Its basic principle is that the transmitted wave is a high-frequency continuous wave,

and its frequency changes with time according to the law of triangular wave. The change rule of the echo frequency received by FMCW is the same as that of the transmitted frequency, which is a triangular wave rule, but there is a time difference, and the target distance can be calculated by using this small time difference.

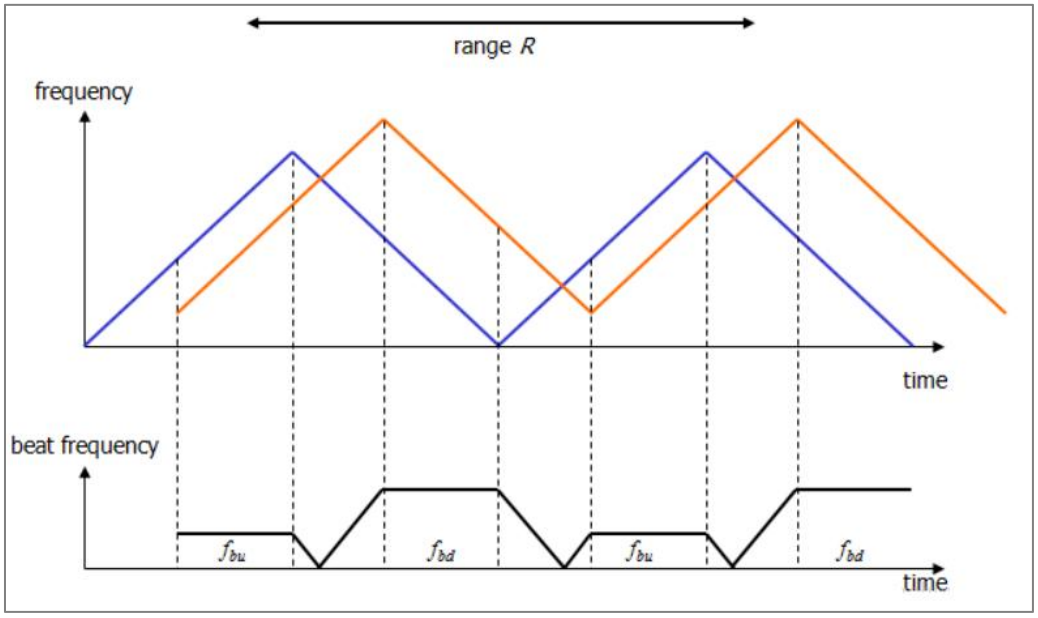


Fig. 1 Principle block diagram of continuous wave radar

The principle of radar ranging/velocity measurement is briefly introduced by taking triangular wave FMCW as an example. As shown in Figure 1, blue is the frequency of the transmitted signal, yellow is the frequency of the received signal, the sweep period is T, and the sweep bandwidth is B. When the transmitted signal is transmitted by the target, the echo signal will have a delay. In the frequency change of the triangular wave, the distance can be measured on both the rising edge and the falling edge.

1.5 Radar field of view

The TCM873 millimeter wave radar is a medium-range radar. It can detect the distance, speed and angle information of the target by receiving the radar reflection wave.

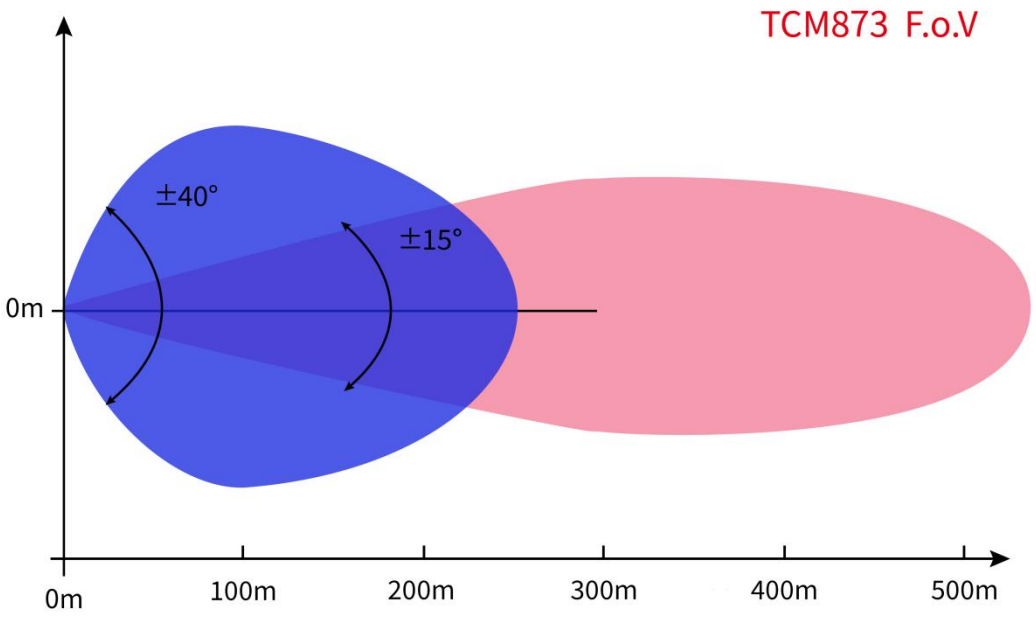


Figure 2 FoV of TCM873

1.6 Technical parameters

Measurement Performance General Objectives		
Modulation mode		FMCW
Ranging range		1.2~500m@0°
Range measurement resolution	Point target, non-tracking	1m
Distance measurement accuracy	Point target, non-tracking	0.5m
Azimuth beam		± 40 ° @ Wide Beam ± 15 ° @ Narrow Beam
Elevation beam		± 13 ° @ Wide Beam ± 5.5 ° @ narrow beam
Angular accuracy	Point target, non-tracking	0.6°
Speed range		-300km/H.. + 300km/H (+ means far from the target,-means close to the target)
Velocity resolution	Point target, non-tracking	0.05m/s
Speed accuracy	Point target, non-tracking	0.02m/s
Cycle period		About 80ms
Number of antenna channels		6TX/8RX = 48 channels

Operating conditions		
Radar transmitting frequency	Follow ETSI & FCC	80GHz
Transmission capacity	Average/Peak EIRP	29.8dBm
Power source		+9.0V…32VDC
Power consumption	At 12 V	12W
Operating temperature		-40℃…+70℃
Storage temperature		-40℃…+85℃
Degree of protection		IP67
Interface type		
Interface		RS485/Ethernet port
Structure		
Size	L * W (mm)	110*132
Weight	Harness is not included	/
Material	Enclosure Front/Rear Cover	/

Table 1 Specifications of TCM873

2 Radar settings

2.1 Interface connection

The current external interface of TCM873 only supports network port connection.

2.2 Configuration, startup, shutdown, and failure

When the TCM873 is connected to a device or PC through a network port, please refer to the TCM873 Millimeter Wave Radar Protocol Manual for relevant protocols.

Hot swap is not recommended for TCM873 radar. If an error is found in the internal detection of the system, it may cause the radar function to be abnormal, or even cause the radar to restart.

3 Installation specifications

3.1 Radar installation

In traffic flow detection and related applications, the TCM873 shall be installed at a height of 3 ~ 6 meters above the ground (recommended), and the radar antenna shall face straight ahead. It can be tilted downward by 0 ° ~ 15 ° according to the requirements of the customer's application for detection distance and blind area. Installation specifications are shown in Fig. 3 and Fig. 4:

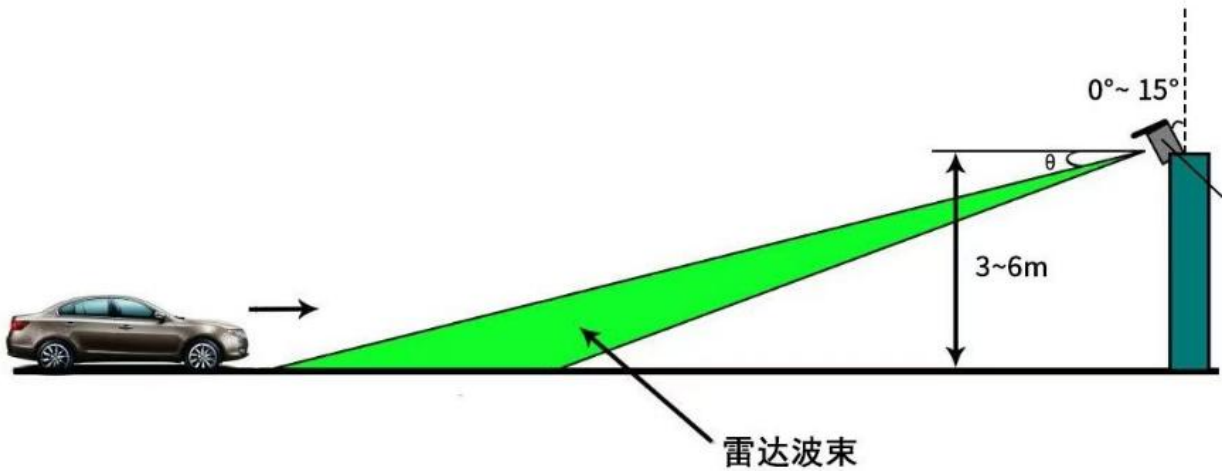


Fig. 3 Vertical Installation of TCM873 Radar

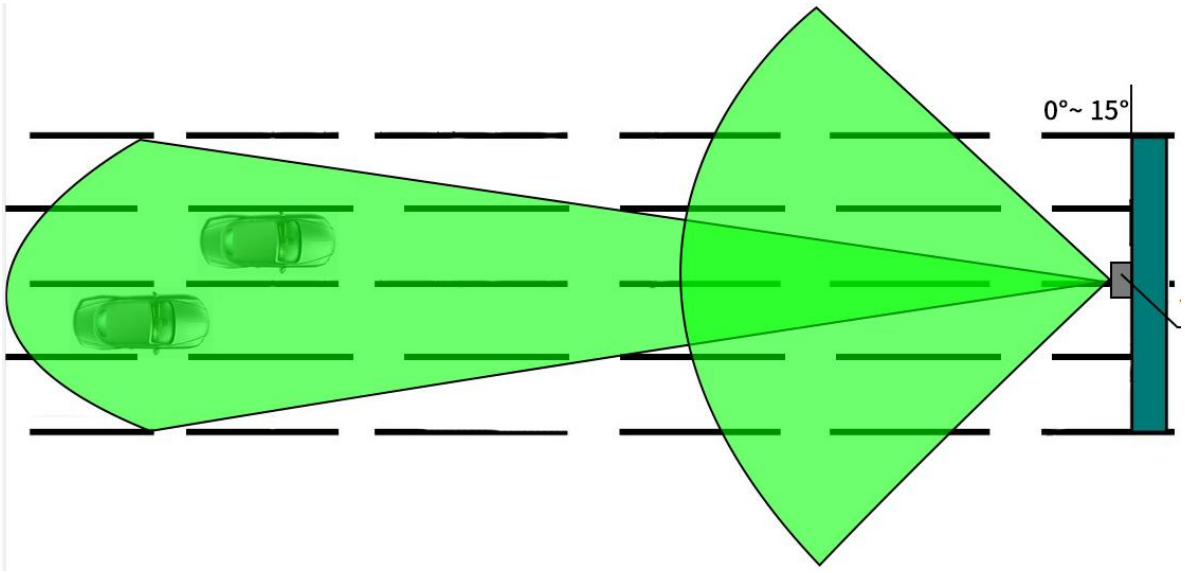


Fig. 4 Horizontal Installation of TCM873 Radar

3.2 Radar direction description

The beam width of TCM873 antenna is 80 ° in the azimuth plane and 26 ° in the

elevation plane. The direction in the Cartesian coordinate system is shown in Figure 5:

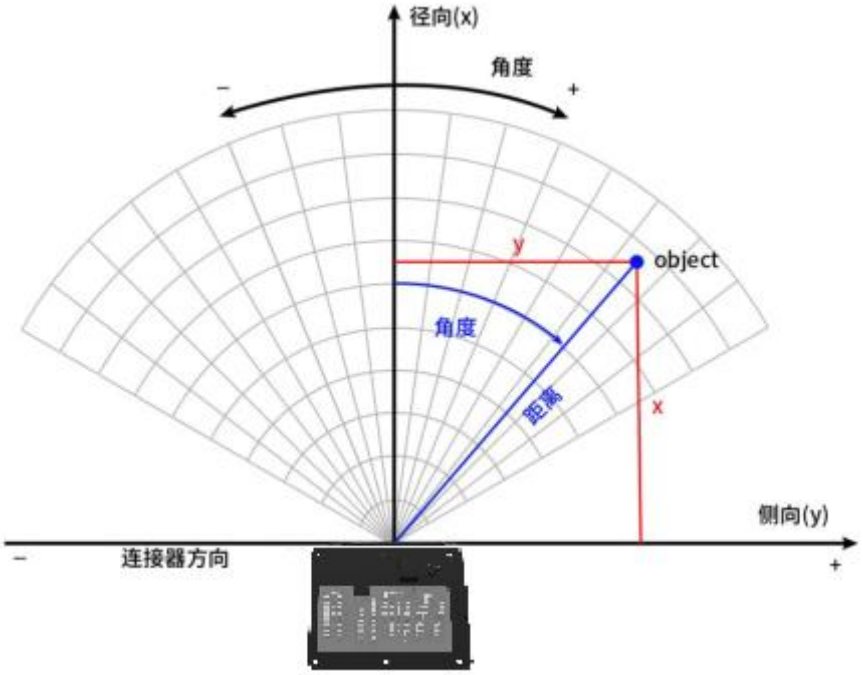


Fig. 5 Illustration of Radar Direction

3.3 Installation considerations

Installation principle of radar sensor:

- Keep away from other signal antennas as far as possible during installation;
- Install away from locations where large electrical equipment is frequently activated.

In addition, when installing the TCM873 millimeter wave radar, the following items shall be noted:

- When installing the sensor, make sure that the radome surface is free of ice particles or water mist.
- Do not perform welding activities near the radar sensor location.
- The radar sensor can only be wiped with a damp, lint-free cotton cloth to wipe the dust on the surface, and the surface of the sensor can not be scratched or damaged.
- The equipment needs to be checked on a daily basis before it is put into service.

- Make sure that the fixing position is not deformed and that the locking torque of the radar sensor does not exceed 7 Nm.

The customer can design the radome and other structures according to the application requirements. The radome material will have a greater impact on the radar performance. In essence, the radome affects the radar performance in three aspects. The first is that the radar wave can not completely penetrate the radome, resulting in the reduction of the effective radiation power of the radar, including reflection loss and dielectric loss. The second is that the radar antenna beam distortion makes the radar action area change, which may cause the radar to be interfered by backward targets. Third, the radome makes the radar standing wave worse. For the detailed design of the radome, please refer to the NanoradarTechnology 80 GHz Radome Design Guide. The design data comes from the theoretical value. In fact, the customer needs to conduct further tests according to the actual radome.

(1) Conductivity of the material:

Table 3 Conductivity of Radome Material

Material	Conductivity at 80 GHz
Polypropy lene (Polypropylene-PP)	2.35
Polyamide (polyamide polycarbonate-PA)	2.75
Polycarbonate (ester-PC)	2.8
PC-PBT	2.9
ABS	3.12
ASA	~3.8
PMMA	~3-4TBC

(2) Thickness:

Table 4 Effect of different material thickness on radar

Material	Optimum thickness 1 (mm)	Optimum thickness 2 (mm)	Optimum thickness 3 (mm)	Optimum thickness 4 (mm)	Attenuation (80GHz)	Applicability
PP	1.28	2.55	3.38	5.10	0.10	Excellent
ABS	1.19	2.39	3.58	4.77	0.30	Liang

PA	1.18	2.36	3.54	4.72	0.30	Liang
PC	1.16	2.33	3.49	4.66	0.17	Liang
SMC	0.88	1.77	2.65	3.54	1.10	Poor

The thickness of the radome needs to be carefully selected to ensure that the radar achieves high conductivity. In these materials, the thickness of the bumper should be an integer multiple of half the wavelength of the 80 GHz millimeter wave radar. For example, the thickness of the ABS material radome should be n * 1.2mm (n = 1, 2.. in the 80 GHz range). Attenuation increases as the thickness of the radome increases.

In order to prevent the distortion of the radar beam, the radome should be kept as flat as possible and its thickness should be uniform. Any slight bending will have a great impact on the radar beam.

(3) Spraying

In theory, the radome can be painted, but careful analysis and testing should be carried out to avoid significant degradation of radar sensor performance.

(4) Heat dissipation and electromagnetic shielding

If customers design their own radome and other structures, they also need to consider the impact of radar heat dissipation and electromagnetic shielding, and can refer to the design drawings provided by NanoradarTechnology.

4 Electrical characteristics

4.1 Harness connections

The TCM873 radar needs to be powered by battery or other equipment. 10 A wire is required for the power supply. In order to protect the radar from electromagnetic interference, the grounding wire must be as short as possible.

4.2 Test usage

The upper computer test software of Millimeter Wave Radar General Management Tool provided by NanoradarTechnology can obtain and analyze the TCM873 sensor data, and display the observation results intuitively. Using this tool is

helpful to use the TCM873 sensor.

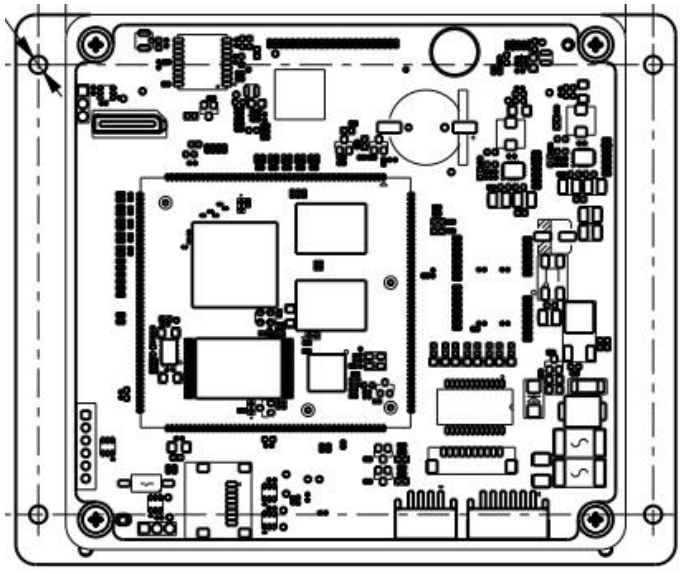
The method for teste that network port protocol is as follows: firstly, obtain the millimeter wave radar management tool (upper computer test software) and the us manual of Nanoradartechnology from the Nanoradarcustomer service or the official website, and installing and configuring the upper computer test software according to the user manual.

The test tools or software are shown in the following table:

Table 5 Tools for Product Testing

Serial number	Device name	Quantity
1	TCM873 millimeter wave radar	1
2	PC/Notebook	1
3	Network cable	1
4	12 V power adapter	1
5	Upper computer test software	1

Connect the radar, PC and TCM873 radar sensor through the Ethernet port. The interface definition is as follows:



The pins are defined in the following table:

Ethernet interface (4pin)

PIN	DESCRIPTION
1	ETH_MX1+
2	ETH_MX1-
3	ETH_MX2+
4	ETH_MX2-

485 connector (6pin)

PIN	DESCRIPTION
1	12V_IN
2	EGND
3	RS485A
4	RS485B
5	EGND
6	RESET

Schematic diagram of interface definition

1) Connect the PC, open the upper computer software, and first configure the parameters as shown in Figure 7. Then click the Connect Device button on the left.

Figure 7 Test interface of radar upper computer

2) Start the test. If the antenna surface of TCM873 radar is facing the moving target, or there is a small relative movement between the sensor and the target, the black box indicating the target will appear on the UI interface, and the target distance R will be displayed. If the black box does not appear, there is no target in the detectable distance and field of view.

5 Health and protection

The TCM873 millimeter-wave radar complies with national regulations and is therefore not harmful to human health. In addition, relevant studies have proved that radar has no negative effects on people.

5.1 Electrostatic protection measures

It is necessary to do a good job of electrostatic protection in the process of radar transportation, storage, use and access. When dealing with unintegrated independent modules, users must pay attention to: when the module is taken out of the sealed anti-static package, it is necessary to start to do a good job of electrostatic protection; Never touch or grab the surface of the radar antenna and the connector pins, only the corners.

Recommendation: Always wear anti-static gloves when working on all radar sensors.

◆ **Incorrect usage:**

- Wrapping the antenna with metal foil or partial metal parts;
- Use a multimeter to directly measure the pin, causing damage;

- Any kind of paint or varnish spray antenna structure;
- Wrap the antenna with CFK foil (conductive);
- The plastic material is in direct contact with the corroded antenna structure (which has a higher dielectric constant effect on the resonant frequency of the patch).

5.2 Identify electrostatic damage

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

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

5.3 Power supply protection

The radar input voltage range is 9 ~ 32 V DC, and the ripple is less than 20 mV. The power supply with large ripple will cause the radar to continuously output wrong target information, which will affect the normal use of the radar.

5.4 Space electromagnetic interference protection

The product has adopted shielding measures to avoid the adverse effects of electromagnetic interference as far as possible. However, the radar needs to be far away from strong electromagnetic interference sources such as motors and isolated metal shells during installation.

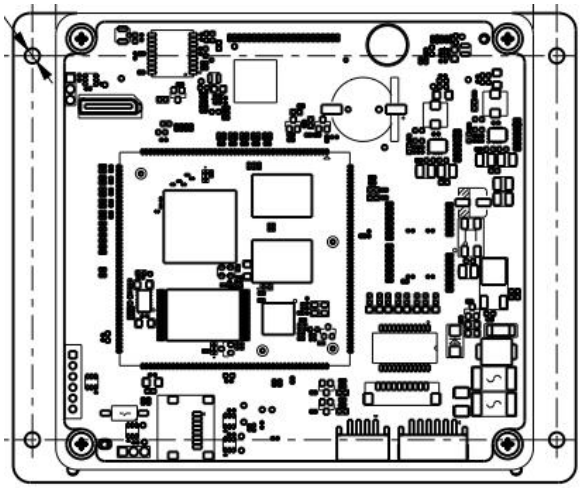
6 Interface definition

The default installation orientation should be such that the square fool-proof arrow is facing upward. The mounting direction affects the position of the TX and RX antennas. Since the TX and RX antenna apertures are not the same, they are affected differently by the secondary surface structure. For best performance, the wiring harness orientation should be evaluated based on the installation location, as evaluated by

customer testing.

The interface definition is shown in the figure below:

Schematic diagram of interface harness connection



Pin definition table of TCM873 network interface

Stitch number	Name
P1	ETH_MX1+
P2	ETH_MX1-
P3	ETH_MX2+
P4	ETH_MX2-

The TCM873 does not support reverse polarity of the power supply. Any consequences caused by reverse polarity shall be borne by the customer. The TCM873 is designed to meet the testing requirements of ISO 16750-2.

7 Size of equipment

Refer to Chapter 3 for the installation position of radar, which can be installed on the vertical bar or horizontal bar.

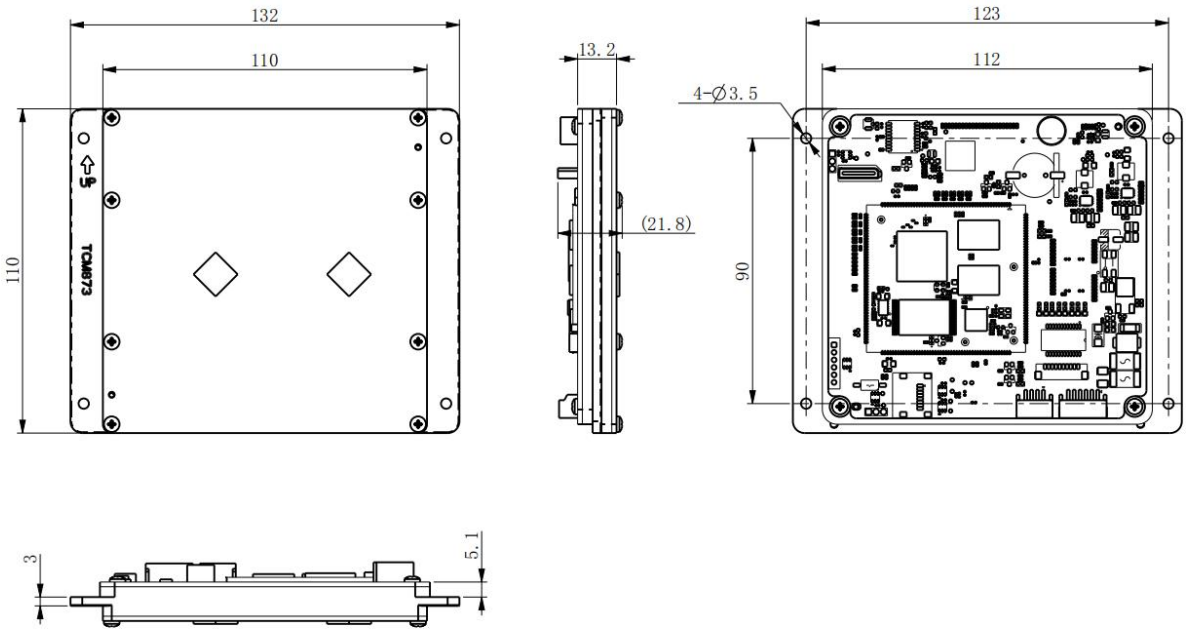


Fig. 9 Dimension of TCM873 Veneer

8 Safety and risk

The purpose of this chapter is to enable the customers and users of TCM873 to identify all possible risks in a timely and accurate manner.

TCM873 is developed for applications such as traffic flow statistics and perimeter security. Customers must have basic technical knowledge. The radar should be used by trained professionals. The person responsible for the equipment or the owner must ensure that these safety precautions are understood and followed by all operating personnel. If the TCM873 is part of an overall system, the system manufacturer is responsible for ensuring safety-related aspects such as operating manuals, labels, and instructions. Responsibilities are divided as follows:

(1) Extent of manufacturer's responsibility for the equipment

Hunan NanoradarTechnology Co., Ltd. is responsible for providing the equipment under technically safe and reliable conditions, including white papers, protocol manuals and user manuals.

(2) Extent of liability of third party accessory manufacturer

Manufacturers of third-party accessories are responsible for developing,

implementing and guaranteeing the safety and effectiveness of their products in conjunction with Hunan NanoradarTechnology Co., Ltd.'s TCM873 millimeter wave radar.

(3) Scope of responsibility of customer, end customer and end user

It is the responsibility of the customer, the end customer and the end user to ensure that the equipment is used for its intended purpose, for the actions of its employees, for giving instructions to employees, and for the operational safety of the equipment.

(4) The Customer, the End Customer and the End User have the following obligations:

- It is necessary to know the safety information on the radar and the instructions in the operating manual.
- Be familiar with applicable local accident prevention regulations.
- Hunan NanoradarTechnology Co., Ltd. must be notified of any safety defects in the equipment or equipment.

The customer must confirm that the end customer and end user have included a copy of the liability disclaimer and information, including a declaration of conformity to their product documentation responsibility manual.

The TCM873 millimeter wave radar sensor can be used for research and development testing purposes.

9 Reference documentation

[1] TCM873 Millimeter Wave Radar White Paper

[2] TCM873 Millimeter Wave Radar Color Page

[3] TCM873 Millimeter Wave Radar Communication Protocol

[4] Naray Technology 80 GHz Radome Design Guide

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