

AFM 711 Millimeter Wave Radar White Paper

Version history

Date	Version	Version description
2024-8-6	1.0	AFM711 White Paper Version 1

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AFM 711 Millimeter Wave Radar White Paper

Abstract: AFM711 is a 77 GHz compact short-distance low-speed obstacle avoidance radar developed by Hunan Nanoradar Technology Co., Ltd. The AFM711 radar detects the reflection of the electromagnetic wave by emitting a conical electromagnetic wave to the front, judges whether there is an obstacle ahead, and feeds back the relative distance, angle, speed and other information between the obstacle and the radar; And accurately prompt that driver of obstacle information in the forward or reverse drive process of the low-speed vehicle. The AFM711 has a large detection angle (120 ° for both horizontal and elevation detection angles), and can accurately analyze the information, category, and motion state of the target. The AFM711 has a compact size (40x40x24.5mm with a shell), a long measurement distance (20m), an integrated peripheral interface (CAN/485/TTL), and a slow forward/backward anti-collision function, which can meet the rapidly growing demand for safe driving assistance for forward or backward reversing of low-speed vehicles, as well as various obstacle avoidance needs of robots.

Keywords: AFM711, 77GHz, Large Angle

1 Application requirements of short range radar

1.1 Development of L2 Advanced Driver Assistance System

According to the forecast of Zuosi Production and Research Institute, including low-speed manned unmanned vehicles, low-speed cargo unmanned vehicles and unmanned operation vehicles, the sales of low-speed automatic driving vehicles in China will reach 11000 units in 2020 and 104000 units in 2024. The four years from 2020 to 2023 are a year of rising sales of low-speed self-driving vehicles, and a variety of low-speed self-driving vehicles have entered the commercial stage, such as airport unmanned shuttle, unmanned sweeper, agricultural unmanned vehicle, unmanned patrol vehicle and so on.

Automatic driving can be divided into several levels from L0 to L5 according

to the system and the degree of human control over the vehicle. Among them, the automatic driving system of L0 ~ L3 level mainly plays an auxiliary role for the driver, and when the automatic driving system reaches L2 level, the system can completely get rid of the driver and take charge of the operation of the vehicle autonomously in a specific environment.

The L2 automatic driving system realizes the complete takeover of vehicle operation in a specific area. The system needs to realize the perception of surrounding obstacles, vehicle positioning and path planning. To realize these functions, the technical architecture of perception layer, decision-making layer and execution layer needs to be constructed. These three technical layers represent the eyes and ears, brain and hands and feet of the L2 automatic driving system respectively.

The perception layer is mainly used to obtain the external road environment data for the automatic driving system and help the system to locate the vehicle. At present, the representative sensors in the unmanned driving system include laser radar, camera, millimeter wave radar, ultrasonic radar, GNSS/IMU, etc. Due to their different working principles and technical characteristics, their applicable application scenarios are different. Therefore, at present, most vehicles use a variety of sensor fusion to deal with various possible situations and ensure system redundancy.

At present, the sensor collocation of autopilot manufacturers is basically convergent, and the speed of L2 autopilot landing depends more on the decision-making link of the system, including related algorithms and computing platforms. We know that sensors generate a large amount of data every second, and the computing platform needs to be able to process and analyze a large amount of data in a very short time and give operational instructions to the vehicle executive layer to ensure the safe driving of autonomous vehicles.

On the basis of ordinary millimeter wave radar, environmental perception radar can provide more accurate road edge information, and provide more accurate

auxiliary positioning information for high-speed driving and lane change. At the same time, it has higher detection accuracy for static targets, especially under congestion conditions, and can effectively avoid safety accidents such as rear-end collision. Therefore, the environmental awareness radar is an integral part of the L2 level automatic driving system.

1.2 Application requirements of environment-aware radar

The traditional driver assistance system is mainly composed of laser radar, vision system, GPS and other modules, which can not accurately detect the surrounding obstacles in bad weather conditions, often leading to serious traffic accidents, and the vision system requires a harsh working environment. Due to the limitations of technology, production process, material cost and physical size, environmental perception radar is mainly used in the field of high-end vehicles and forward radar.

The environment perception radar has all-weather and all-day working characteristics, has accurate azimuth angle resolution capability, can perceive and image the surrounding environment in real time, output the four-dimensional information of distance, speed, azimuth angle and pitch angle of the target, and can effectively analyze the outline, category and behavior of the target. This means that the environmental awareness radar system can adapt to more complex road conditions, including the identification of smaller objects, occluded objects and the detection of stationary objects and lateral moving obstacles.

In the field of traditional passenger cars, automatic parking is a field suitable for L4 level automatic driving. With the gradual maturity of automatic parking technology for passenger cars, the main engine factory has continuously increased its investment in automatic parking system, and achieved rapid growth from 2020. It is expected that the assembly rate will exceed 20% in 2023, which has become one of the first landing functions in the field of automatic driving. The problems of traditional ultrasonic radar sensors have become prominent, and the problems of false alarm and false alarm need to be solved urgently. L2-level automatic parking

high-resolution radar has become the product direction of various radar manufacturers.

At the same time, L2 automatic driving is also very suitable for conditional L2 automatic driving applications in cleaning, distribution, logistics, industrial transportation and other commercial fields. At the same time, compared with the highway, for more closed use scenarios, such as transportation operations in large mines and construction sites. In these environments, traffic participants are more single, routes are more fixed, and some scenarios have high operational risks. Replacing workers with L2 self-driving trucks saves costs and avoids distress.

2. Overview of AFM 711 Millimeter Wave Radar

2.1 Product features

AFM711 is a short-range W-band millimeter-wave radar with a detection range of 20 meters. It uses FMCW modulation mode to detect the distance, speed and angle of moving targets, and

has high ranging and speed measurement

- Speed
- Distance (length, width, height)
- Direction
- Angle

accuracy.



Fig. 1 Appearance of AFM 711 millimeter wave radar

AFM711 has short-distance low-speed target detection capability and can support the front/rear anti-collision function of low-speed vehicles. The product function diagram is as follows:



Figure 2 Functional Diagram of AFM 711 Millimeter Wave Radar

2.2 Product parameters

The specifications of AFM 711 millimeter wave radar are as follows:

Application Case

Table 1 Characteristic parameters of AFM 711 millimeter wave radar

Measurement Performance General Target (Non-Reflective Target)		
Modulation mode		FMCW
Ranging range		0.10~20m
Range measurement resolution	Point target, non-tracking	0.2m
Distance measurement accuracy	Point target, non-tracking	$\pm 0.1\text{m}$
Angular accuracy	Point target, non-tracking	$\pm 1^\circ$
Speed range		-60km/h ~+60km/h
Velocity resolution	Point target, non-tracking	0.36m/s
Speed accuracy	Point target, non-tracking	$\pm 0.18\text{m/s}$
Number of antenna channels		3TX/4RX = 12 channels
Cycle period		40ms
Elevation beam	-6dB	120°
Azimuth beam	-6dB	120°
By default, the target data is output in the order of the radial distance of the target from near to far.		
Operating conditions		
Radar transmitting frequency	Follow ETSI & FCC	76...77GHz
Transmitting power	Average/Peak EIRP	16.0dBm
Power source		9.0V~24VDC
Power consumption		2.5W
Operating temperature		-40°C...+85°C
Storage temperature		-40°C...+105°C
Degree of protection		IP67
Interface type		
Interface		1xCAN-ISO11898-2 compliant (default 500K) 1x485/TTL
Enclosure		
Size	L*W*H	40x40x24.5mm
Weight		60g
Material	Enclosure Front/Rear Cover	PBT+GF30

The CAN communication network interface of AFM711 sensor complies with ISO11898-2 specification, and the default communication rate is 500kb/s. Universal external communication interface facilitates integration with the host computer or other sensor modules.

The radar antenna is an AoP antenna with three transmitters and four receivers, which has the ability to accurately measure the azimuth and elevation angles. Through the unique antenna and algorithm optimization design, it can detect and track the target within 20 meters, and output the information of distance, speed and angle of the target in real time. The system pattern of the AFM711 millimeter wave radar is as follows:

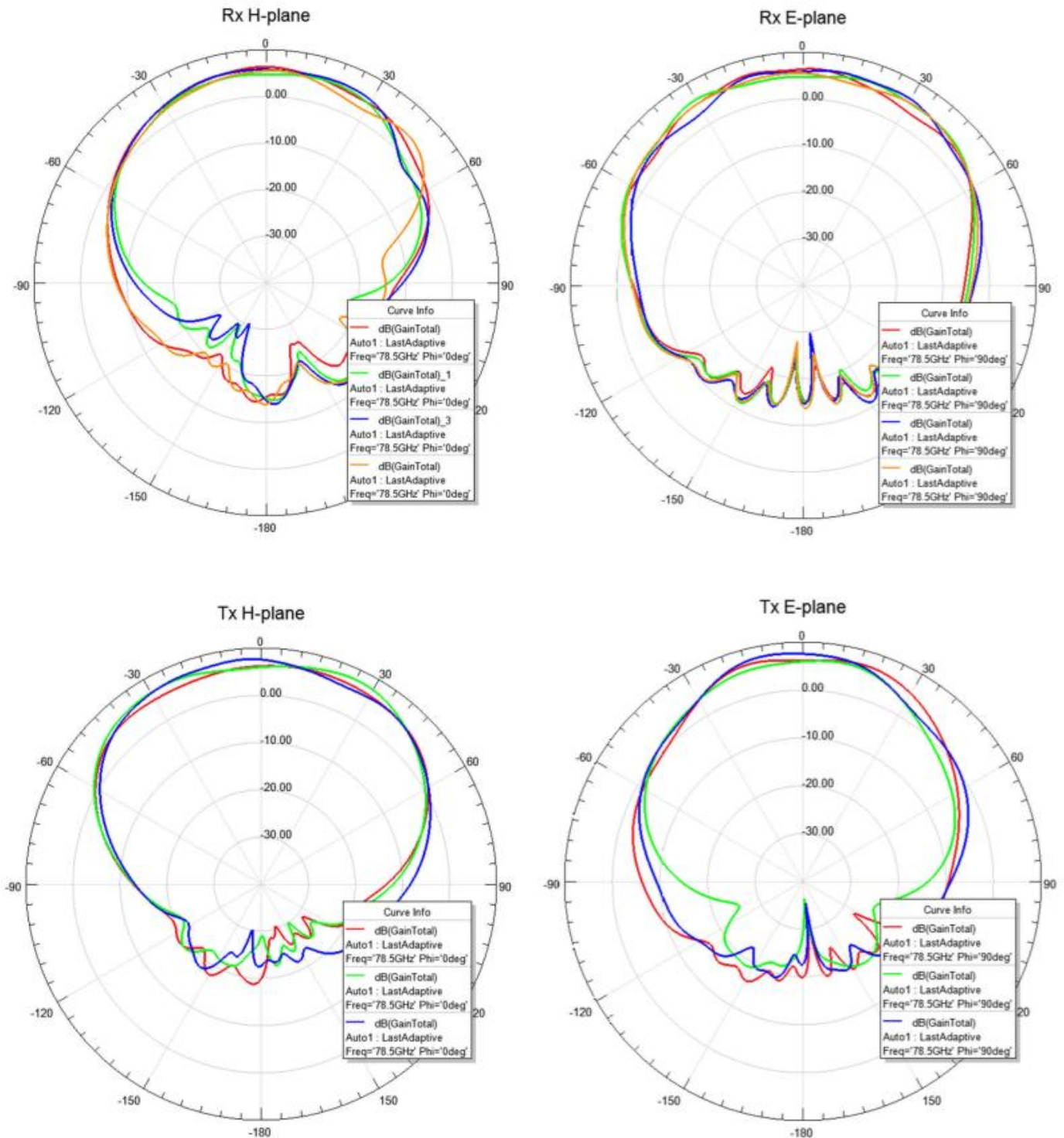


Figure 3 Antenna Pattern of AFM 711 Millimeter Wave Radar

The product outline of AFM711 millimeter wave radar is shown in the figure below:

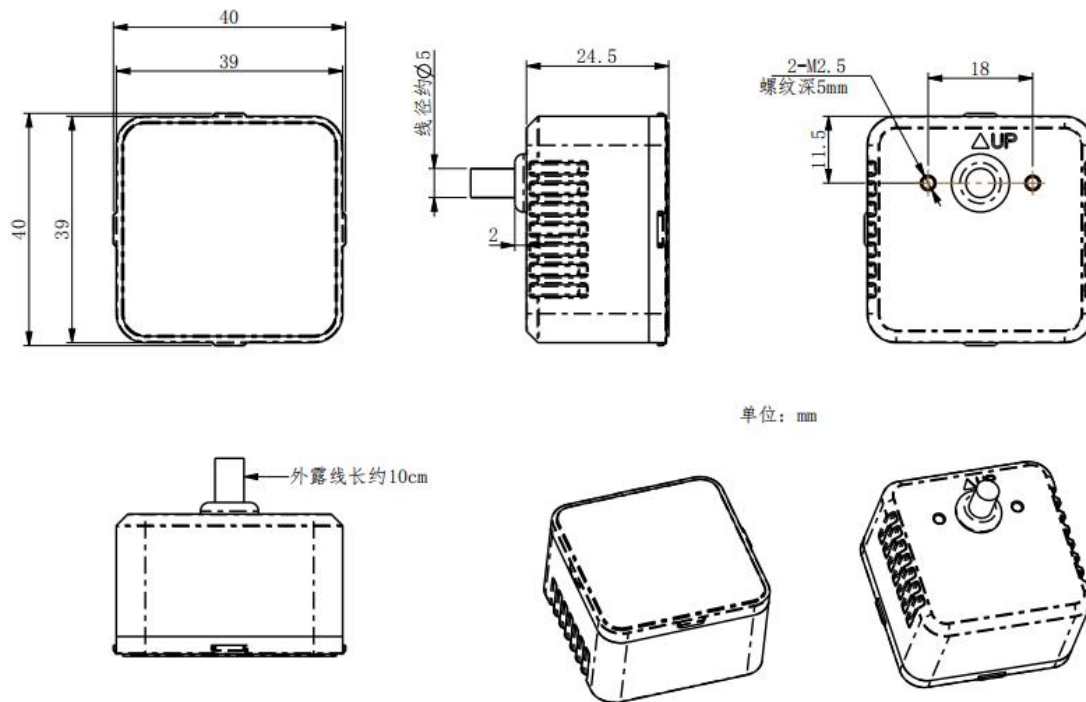


Figure 4 Product Outline of AFM 711 Millimeter Wave Radar

2.3 Product application field

- Forward Collision Prevention (FCW)
- Robot obstacle avoidance
- Sanitation truck
- Forklift
- Rear Collision Prevention (RCW)
- Engineering vehicle
- Shuttle bus
- Crane

3 Typical application cases

3.1 Anti-collision system for low-speed vehicles

Low-speed vehicle anti-collision system, agricultural vehicle anti-collision system, robot anti-collision system and other systems use AFM711 millimeter wave radar sensor to sense the environment in front of or behind the vehicle, output the distance, speed and angle information of the target and send it to the main control box. The main control box combines the information of the surrounding environment of the radar with the information of the vehicle, and the integrated decision-making system has the function of risk early warning or automatic braking.

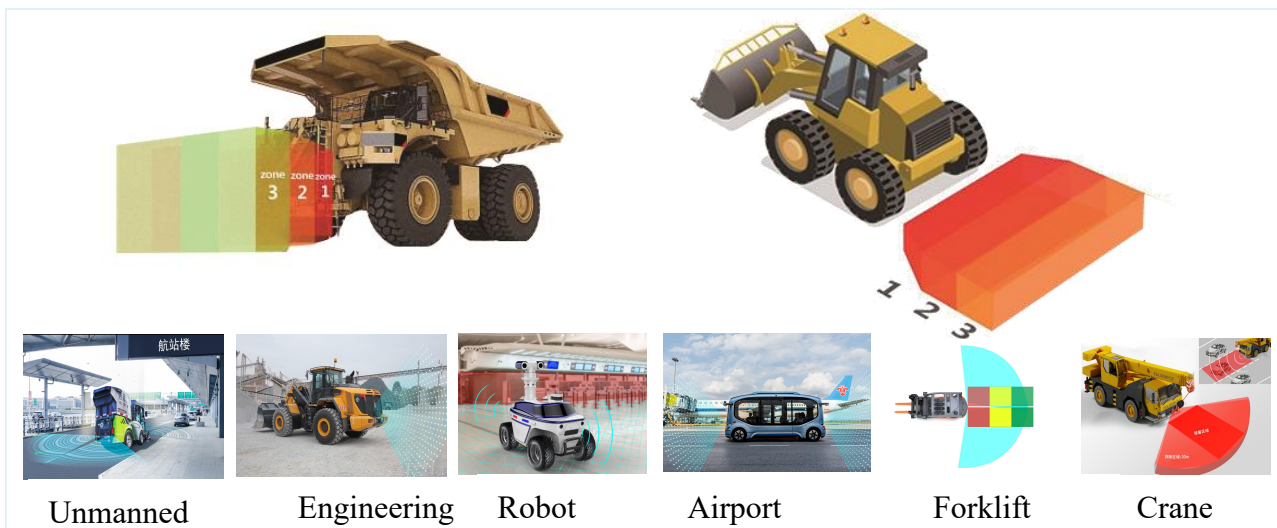


Figure 5 Typical Application Diagram of AFM 711 Millimeter Wave

Advantages of AFM711 in applications:

- 1, compact packaging, solid state technology;
- 2, that cost performance is high, and the detection angle is large;
- 3, that detection precision is high;
4. Leading performance and durability;
- 5, compact size;

4 Concluding remarks

AFM711 is a short-distance vehicle-mounted low-speed millimeter wave radar independently developed by Nanoradar. The product adopts advanced AoP technology and signal processing technology. The radar is small in size, large in detection angle, accurate in speed measurement and stable in performance. It can be widely used in low-speed vehicle front/rear anti-collision and other fields. The product can significantly improve the safety performance of the vehicle, reduce the driving burden of the driver and improve the driving safety.