说明书

User Manual

(23 款摇摆成像毫米波雷达)

(2023 Millimeter-Wave 4D Imaging (Dynamic) Radar)

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一、功能说明

I. Introduction

摇摆成像毫米波雷达具有穿透雨、雾、尘且不受光照影响的特性，可全天候应用于农业作业环境感知，检测环境中的人、树木、电线、电线杆等目标的距离、速度和方位，输出 3D 位置点云信息和速度信息。传感器后端处理器将雷达输出的点云做目标检测、识别，并建立实时三维点云地图，供给智能设备路径规划、绕障使用。雷达内置云台电机，可实现波束扫描扩大视角范围，或保持固定视角功能。

The millimeter-wave 4D imaging (dynamic) radar is able to penetrate rain, fog as well as dust, and is invariant to lighting. It can be applied to agricultural environment sensing around the clock for the detection of the distance, velocity and orientation of targets including people, trees, power lines and poles in the environment, providing 3D point clouds and velocities. The back-end processor of the sensor detects and identifies targets using such point clouds, building real-time 3D point cloud maps for smart devices' route planning and obstacle avoidance. With an embedded gimbal motor, this radar is capable of beam scanning for a larger field of view or fixed angle scanning.

产品型号：RD24912

Model: RD24912

主要特性：

Main Features:

- 测距范围 1.5m~80m
- Distance Measurement Range: 1.5m~80m
- 距离分辨率 0.3m
- Range Resolution: 0.3m
- 测速范围±15.5m/s
- Velocity Measurement Range: ±15.5m/s
- FOV：方位角 80°、俯仰角 135°
- FOV: Azimuth: 80°; Pitch Angle: 135°
- 方位角分辨率 9.5°
- Azimuth Resolution: 9.5°
- 俯仰角分辨率 14°
- Pitch Angle Resolution: 14°
- 点云刷新率：50Hz
- Point Cloud Refresh Rate: 50Hz
- CAN-FD 接口
- CAN-FD Interface

- IP67 防水
- IP67 Waterproof
- 工作温度-40°C~+85°C
- Operating Temperature: -40°C~+85°C

典型应用：

Applications:

- 农业无人机

Agricultural Unmanned Aerial Vehicles

- 农业无人车

Agricultural Unmanned Ground Vehicles

- 农机自驾仪

Autopilot Consoles

二、关键性能

II. Specifications

表 1 主要性能

Table 1. Main Specifications

参数 Parameter	测试条件 Testing Condition	最小值 Min	典型值 Typical Value	最大值 Max	单位 Unit

系统特性 **System**					
发射频率 Transmit Frequency		24.05		24.25	GHz
调制方式 Modulation	FMCW				
刷新率 Refresh Rate			50		Hz
测量特性 **Measurement**					
测距范围 Distance Range	@FOV：方位±40°，俯仰+90°~-45° @FOV: Azimuth: ±40°; Pitch Angle: +90°~-45°	1.5		80	m
测距精度 Distance Accuracy	非跟踪点目标 Non-tracking Point Target		±0.1		m
测速范围 Velocity Range	远离目标为“-”，靠近目标为“+” Away from Target: “-”; Toward Target: “+”	-15.5		+15.5	m/s
测速精度 Velocity Accuracy	点目标 Point Target		±0.2		m/s
测角范围 Angle Range	方位角 Azimuth	-40		+40	°
	俯仰角 Pitch Angle	-45		+90	°
测角精度 Angle Accuracy	非跟踪点目标@方位角±40° Non-tracking Point Target @Azimuth: ±40°		±0.5		°
	非跟踪点目标@俯仰角±30° Non-tracking Point Target @Pitch Angle: ±30°		±0.8		°

多目标检测特性 **Multi-target Detection**					
同时检测目标 Targets Detected Simultaneously				128	个
距离分辨率 Distance Resolution	非跟踪点目标，满足 1.5 到 2 倍分辨率的条件下可以区分两个物体 For Non-tracking Point Targets, two objects are distinguishable at 1.5x to 2x zoom		0.3		m
速度分辨率 Velocity Resolution	非跟踪点目标，满足 1.5 到 2 倍分辨率的条件下可以区分两个物体 For Non-tracking Point Targets, two objects are distinguishable at 1.5x to 2x zoom		1		m/s
角度分辨率 Angle Resolution	非跟踪点目标@方位角±40°，满足 1.5 到 2 倍分辨率的条件下可以区分两个物体 For Non-tracking Point Targets @Azimuth: ±40°, two objects are distinguishable at 1.5x to 2x zoom		9.5		°
	非跟踪点目标@俯仰角-45°~+90°，满足 1.5 到 2 倍分辨率的条件下可以区分两个物体 For Non-tracking Point Targets @Pitch Angle: -45°~+90°, two objects are distinguishable at 1.5x to 2x zoom		14		°

天线特性 **Antenna**					
发射波束 (近距天线) Beams Transmitted (Close-Range Antenna)	方位角（-3dB） Azimuth (-3dB)		70		°
	俯仰角（-3dB） Pitch Angle (-3dB)		23		°
	天线增益 Antenna Gain	Antenna 1	12.2		dBi
		Antenna 2	19.8		
接口特性 **Interface**					
CAN-FD	通信速率 Communication Speed	1	4		Mbps
结构特性 **Structure**					
尺寸 Dimensions	宽*长*高 W*L*H	103*103*162			mm
材料 Material	雷达罩 Radar Housing	PA66+30%GF			
	后壳 Rear Cover	铝 Aluminum			
重量 Weight		700			g

三、接口

III. Interfaces

摇摆成像雷达与外部通信接口为 CAN-FD，接口定义 6PIN 接头、具体定义如下：

The interface on the 4D imaging (dynamic) radar for external communication is CAN-FD, working with a 6PIN connector defined as follows.

表 2 接口信号定义

Table 2. Interface Signal Definition

引脚	信号	类型	定义	连接器

Pin	Signal	Type	Definition	Connector
1	CAN_L	I/O	CAN-bus 低位线 CAN-bus (Low Level)	1# 绿 1# Green
2	CAN_H	I/O	CAN-bus 高位线 CAN-bus (High Level)	2# 蓝 2# Blue
3	SYNC	O	飞行控制器同步信号 Flight Controller Signal Synchronization	3# 黄 3# Yellow
4	NC	-	预留 Reserved	4# 白 4# White
5	BAT	P	电池电源正极 Battery Cathode	5# 红 5# Red
6	GND	P	电池电源负极 Battery Anode	6# 黑 6# Black

四、工作条件

IV. Operating Conditions

雷达模块正常使用需要一定的工作条件和工作环境，超出工作条件的范围使用可能导致工作不正常、烧毁等，具体要求如下表：

Certain operating conditions, as specified below, are required for the proper functioning of the radar module, otherwise, it might malfunction or burn out.

表 3 工作条件

Table 3. Operating Conditions

参数 Parameter	测试条件 Testing Condition	最小值 Min	典型值 Typical Value	最大值 Max	单位 Unit
工作电压 Operating Voltage	电池供电 Battery Powered	24	48	56	VDC
功耗 Power Consumption	@48VDC			12	W

静态功耗 Static Power Consumption	@48VDC		100		mW
工作温度 Operating Temperature		-20		+85	°C
存储温度 Storage Temperature		-40		+85	°C
冲击 Shock	500m/s²@6 ms half-sine(10 x shock each in +/-X/Y/Z dir.)				
振动 Vibration	20m/s² peak at 10Hz/0.14m/s² peak at 1000Hz				
防护等级 Protection Rating	IP67（水下 10cm） IP67 (10cm below the surface of water)				

五、规范要求

V. Standards & Requirements

表 4 测试规范标准

Table 4. Testing Requirements and Standards

规范 Requirement	测试项 Test Item	执行标准 Standard
EMC	ESD	IEC61000-4-2 Level 3 Class B
	传导与辐射 Conduction & Radiation	EN55032:2015 Class A
	高低温循环	ISO 16750-1 -20°C~+85°C

环境适应性 Environmental Adaptability	Temperature Cycling	
	振动测试 Vibration Testing	IEC 60068-2-64/无人机振动试验标准 IEC 60068-2-64/Random Vibration Testing
	防水 Waterproof	IP67
出口认证 Export Certification	雷达 Radar	CE/FCC/KCC

六、版本更新

VI. Version History

表 5 版本说明

Table 5. Version History

版本 Version	说明 Description
V1_1	新建文档 Document Created

FCC Statement:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- - Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- - Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

2.2

This device meets all the other requirements specified in Part15C, Section 15.249 of the FCC Rules.

2.3

1.Antenna type is an integrated antenna with no more than 19.8 dBi
2.Should be installed so that the end user cannot modify the antenna
3.Feed line should be designed in 50ohm
Fine tuning of return loss etc. can be performed using a matching network.

The antenna shall not be accessible for modification or change by the end user.

2.4

The module complies with FCC Part 15.249 and apply for Single module approval.

2.5

Trace antenna designs: Not applicable.

Any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

2.6

The module is limited to installation in mobile application. Host device must be operated a minimum of 20cm between people.
Here are two types of instruction for RF exposure:
1; The host product which the module installed shall be mobile application.
2; The end user manual shall be provide additional text from the host product manufacturer to end users, It shall include FCC compliance statements related to the transmitter or labeling requirements. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

A separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and difference antenna configurations.

2.7

Antenna type is an integrated antenna with antenna 1 12.2 dBi and antenna 2 19.8 dBi.

2.8

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains FCC ID: 2A46G-RD24912”. The grantee's FCC ID can be used only when all FCC compliance requirements are met.

The end product shall bear the following 15.19 statement: This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.

OEM/Host manufacturer responsibilities

Must use the device only in host devices that meet the FCC/ISED RF exposure category of mobile, which means the device is installed and used at distances of at least 20cm from persons.

2.9

Testing of the host product with all the transmitters installed – referred to as the composite investigation test- is recommended, to verify that the host product meets all the applicable FCC rules. The radio spectrum is to be investigated with all the transmitters in the final host product functioning to determine that no emissions exceed the highest limit permitted for any one individual transmitter as required by Section 2.947(f). The host manufacturer is responsible to ensure that when their product operates as intended it does not have any emissions present that are out of compliance that were not present when the transmitters were tested individually.
If the modular transmitter has been fully tested by the module grantee on the required number of channels, modulation types, and modes, it should not be necessary for the host installer to re-test all the available transmitter modes or settings. It is recommended that the host product manufacturer, installing the modular transmitter, perform some investigative measurements to confirm that the resulting composite system does not exceed the spurious emissions limits or band edge limits (e.g., where a different antenna may be causing additional emissions).

The testing should check for emissions that may occur due to the intermixing of emissions with the other transmitters, digital circuitry, or due to physical properties of the host product (enclosure). This investigation is especially important when integrating multiple modular transmitters where the certification is based on testing each of them in a stand-alone configuration.

2.10

OEM/Host manufacturers are ultimately responsible for the compliance of the Host and Module. The final product must be reassessed against all the essential requirements of the FCC rule such as FCC Part 15 Subpart B before it can be placed on the US market. This includes reassessing the transmitter module for compliance with the Radio and EMF essential requirements of the FCC rules. This module must not be incorporated into any other device or system without retesting for compliance as multi-radio and combined equipment.

2.11

The host manufacture is recommended to use D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties.

2.12

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system.

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

This device is intended only for OEM integrators under the following conditions:

1) The antenna must be installed such that 20 cm is maintained between the antenna and users,

and

2) The transmitter module may not be co-located with any other transmitter or antenna.

The OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

IMPORTANT NOTE:

In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

The module is tested for standalone mobile RF exposure use condition. Any other usage conditions such as co-location with other transmitter(s) or being used in a portable condition will need a separate reassessment through a class II permissive change application or new certification.

Additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).