White paper on NRA24 millimeter wave radar

Hunan Nanoradar Science and Technology Co., Ltd.

Version history

Date	Version	Version description
2017-02-28	2.0	the 2nd version of white paper on NRA24

Contents

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Abstract: NRA24 is compact K-band radar altimeter developed by Hunan Nanoradar Science and Technology Co., Ltd. It adopts 24GHz-ISM frequency band, with the advantages of 2cm measuring accuracy, small size, high sensitivity, light weight, easy integration and stable performance, which satisfies the application requirements in unmanned flight platform (UAS), helicopters, small airships and other field. Its product performance has been recognized by many partners.

Keywords: NRA24, measuring accuracy, millimeter wave radar, altimeter

1 Application in UAV altimeter

1.1 Accurate weight of UAVs/Challenges in terrain following

Complex terrain is a major obstacle to UAV flight. And the precise height and terrain tracking can ensure a stable flight and the successful fulfillment of mission. The altimeter can measure the distance between the UAV and the ground, and guide the UAV to stabilize the flight.

1.2 Difference between mmw radar altimeter and traditional altimeter

UAV altimeter is divided into absolute height measurement altimeter and relative height measurement altimeter. Specific classification is shown as in Table 1.

Table 1 Classification of UAV altimeters

Altimeter	principle	Product	Height	Accuracy	Advantages	Disadvantages
GPS+ barometer	GPS	In UAVs with altitude measurement	30000km over the ground	±0.5m	Mature application; Low cost	Relative large error; Not suitable for plant protection UAVs
Ultrasonic + light stream	TOF+ Vision	Most manufacturers	0.3~10m	±0.1m	High accuracy Low cost	Requiring abundant ground texture; Not suitable for plant protection UAVs
Ultrasonic	TOF	Jinci Tech	0.3~3m	±0.1m	Low cost	Easy to penetrate the vegetation; The accuracy would be reduced due to the vegetation; With big error and high cost
Laser	TOF	Laser range finder	<200m	±0.02m	With higher accuracy in good measuring environment	The vegetation has poor laser reflection effect
MMW radar	FMCW	NanoradarNRA24	50m	±0.02m	High accuracy; Available at all weather and all day	Relative high cost

Absolute altitude measurement is the absolute height to the relative sea level, which is generally used for UAV flight platform in high altitude.

Absolute altitude measurement mainly includes barometric altimeter and GPS altimeter. Relative measurement is the relative height of the UAV platform from the earth's surface. It is generally used for low-altitude unmanned aerial platforms, including ultrasonic altimeter, laser and millimeter-wave radar altimeter.

Millimeter wave radar altimeter is a new type of UAV altimeter. With its advantages of being robust, high precision, all-weather and all-day performance, it is becoming popular among more and more UAV manufacturers. While due to that the effect range of traditional mainstream ultrasonic altimeter and it also has poor anti-interference ability, they are not suitable for the terrain with the coverage of vegetation.

Compared with other types of altimeter, millimeter-wave radar in the UAV altimeter has an irreplaceable advantage. It can help unmanned aerial vehicles in a variety of terrain conditions; especially plays a great role in the plant protection by unmanned aerial vehicle.

2 Overview of NRA24 altimeter

2.1 Product features

By emitting a fan-shaped microwave downwards to detect the reflection of the microwave, the NRA24 altimeter could then determine whether there is an obstacle below it, send feedback the relative height between the obstacle and the radar, and guide the UAV to fly at a stable altitude.

With a highly integrated MMIC, very low power consumption (1.5W), a smaller size (130×70×14.5mm), a distance resolution of 2cm, a height measurement of 50m and lightweight design, NRA24 could meet the application challenges in plant protection UAVs and export transport UAVs which has a much stricter requirement of height-measurement and high environmental adaptability. NRA24 is currently the only millimeter-wave radar altimeter in mass production in China market. Its high performance is highly recognized by our partners.

Figure 1 NRA24 physical map

The default rate of UART interface with board-level communications is 115200bit / s, and the target refresh rate is 50Hz. With the universal external interface, it can quickly be integrated with the host computer or other MCU, to save the user's configuration time.

2.2 Product specification

NRA24 adopts a highly complex FMCW modulation mode to accurately measure the distance to the ground or water surface within the measurement range.

Figure 2 NRA24 performance specifications

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
System performance					
Transmit frequency		24.00		24.20	GHz
Output power(EIRP)	Adjustable output		25		dBm
Modulation type			FMCW		
Update rate			50		Hz
Power consumption	@5V DC 25℃	1.4	1.5	1.8	W
Range-measuring performance					
Distance-measuring range	@0 dBsm	0.1		50	m
Ranging accuracy			±0.02		m
Multiple targets tracking characteristics					
Numbers of tracked targets simultaneously			1		pcs
Range resolution			0.75		m
Antenna features					
Beam width/TX	Azimuth(-6dB)		28		deg
	Elevation(-6dB)		18		deg
Beam width/RX	Azimuth(-6dB)		27		deg
	Elevation(-6dB)		17		deg
Side lobe level/TX	On the horizontal	-17	-18		dB
	On the vertical	-22	-23.5		dB
Side lobe level /RX	On the horizontal	-19	-20		dB
	On the vertical	-19	-20		dB
Other characteristics					
Supply voltage		5	12	20	V DC
Supply current	@5V/25℃	270	300	330	mA
Storage temperature		-40		85	℃
Operating temperature		-40		85	℃
Weight	Including shell and line		95		g
Dimensions		130×70×14.5 (LxWxH)			mm

The NRA24 utilizes an advanced integrated planar microstrip array antenna with 1T1R, which includes 40 vertically polarized radiating elements. Radar antenna in the azimuth and elevation are designed for narrow beam, with a beam width of about 28 °in the azimuth (-6dB), and a beam width of about 18 °in the pitch (-6dB).

Both the transmitting and receiving antennas utilize Taylor algorithm to perform low side lobe synthesis on the antenna pattern. The low side lobe design of the antenna makes the radar less susceptible to the interference of the ground clutter and the target outside the main beam, which can significantly improve the signal-to-noise ratio of the radar detection.

2.3 Product applications

- Safety range measurement and collision avoidance in UAVs

3 Typical application example

3.1 Altimeter in plant protection UAVs

Plant protection unmanned aerial vehicle can be remote controlled, to prevent spraying workers from exposure to pesticide, which could ensure the safety of spraying operations, and the efficient and fast operations save a lot of manpower and resources. Plant protection unmanned aerial vehicle is required to maintain a minimum fixed height of 1 ~ 2m from the crops, without restrictions on terrain and height. According to the terrain, it could automatically set the height, and avoid the obstacles automatically by adjusting the height. Moreover it has a high requirement if measurement accuracy (height error does not exceed ± 10cm), to meet the pesticide spraying in the appropriate distance, to achieve uniform and efficient spray.

Traditional plant protection drones utilized ultrasonic as an altimeter. As the ultrasonic frequency is generally around 40 KHz ~ 45 KHz, it is easy to penetrate the vegetation, and is close to the frequency of the surrounding environment, the ultrasonic altimeter is not suitable for deep forests, arable land and other vegetation covering terrain. Besides, the effect range of Ultrasonic altimeter distance is generally less than 5m, therefore it is difficult to meet the actual terrain demand.

TNRA24 is an altimeter specially designed for plant protection UAVs. With its flexible installation position, it is suitable for all types of UAV platforms. It can accurately sense the height of UAVs and vegetation, and transmit the UAV data to UAV flight control system through UART serial port, to achieve and maintain the flight in the appropriate altitude to vegetation, as shown below.

Figure 2 Application in plant protection UAV

The advantages of NRA24 altimeter:

1) High precision;

2) Small size and low power consumption;

3) Strong anti-interference ability, easy for integration.

4 Conclusion

NRA24 mmw radar altimeter is the most high-performance product among the current altimeters in plant protection UAVs. In the complex terrain conditions with the coverage of vegetation, especially on grass or water surface, it could work continuously and stably, to achieve the uniform spraying of pesticides and other operations for plant protection UAVs. The product performance has been highly recognized and verified by a number of unmanned aerial vehicle manufacturers. Therefore it has been a standard configuration in plant protection unmanned aerial vehicles.

Hunan Nanoradar Science and Technology Co., Ltd.
No.27 Wenxuan Road, Hi-tech District Changsha
B7 Lugu Compark
Tel.: +86(731)88939916
E-Mail: sales@nanoradar.cn
URL: www.nanoradar.cn