NSR120 Millimeter Wave Radar

White Paper

Version history

Date	Version	Version description
2021-11-02	1.0	Initial Release

Contents

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Abstract: The NSR120 is an intelligent perimeter security radar with a detection range of up to 120 meters. It generates an alarm when a target intrudes into a predefined defense zone and can pinpoint the target's location using its range, azimuth, and speed data. The radar integrates with video analytics for verification and utilizes artificial intelligence (AI) algorithms to determine if a target is a genuine threat, reducing false alarms. It is commonly deployed with video fusion or sound and light alarm systems.

Capable of obtaining high-precision information on moving targets, the NSR120 effectively filters out false alarms caused by environmental clutter like leaves and branches. Supporting 4-channel alarm output, 1-channel alarm input, and an RS485 interface, it employs reliable transceiver integration technology. It is characterized by high sensitivity, strong environmental adaptability, accurate detection, easy integration, stable performance, and high cost-effectiveness.

The system provides 24/7 security for the perimeter of critical facilities and is widely used in prisons, military bases, public squares, airports, ports, and oil depots.

Keywords: NSR120, 120m range, perimeter security radar, high precision, high sensitivity, easy integration, alarm output.

1 Application Requirements of Perimeter Security Radar

1.1 Traditional Perimeter Security Faces Challenges

With social development and improved infrastructure, the demand for robust safety and security solutions is increasing. Existing perimeter security methods are often susceptible to environmental interference, leading to a high false alarm rate, imprecise intrusion target positioning, and low recognition rates for intruders or objects. Additionally, traditional means may suffer from weak anti-interference capabilities or prohibitively high installation and maintenance costs.

There is a growing demand for more scientific, intelligent, and versatile perimeter security solutions. The NSR120 millimeter wave perimeter security radar addresses this need by providing 24/7 all-weather protection with a low false alarm rate, intelligent target identification, and accurate positioning, thereby enhancing the overall intelligence of perimeter security systems.

Effective perimeter security must go beyond simply detecting intrusions at a boundary line. It requires the capability to monitor and respond to potential threats before an incident occurs. For instance, the system should detect suspicious activity, such as loitering individuals or slow-moving vehicles outside the perimeter, enabling security personnel to intervene preemptively.

Table 1 Advantages and Disadvantages of Traditional Perimeter Security Products

Perimeter security product	Advantage	Shortcoming
Infrared correlation	Low cost, easy installation	Susceptible to weather and environmental factors, high false alarm rate, cannot classify intruders, difficult to integrate with video analytics.
Electronic fence	Active deterrent with blocking and alarm functions, suitable for all-weather use.	Cannot pinpoint intrusion location, difficult to identify intrusion type, risk of electric shock, high deployment and maintenance costs.
Vibrating Fiber	Sensitive monitoring, low missed detection rate, strong environmental adaptability.	Susceptible to external interference, high false alarm rate, poor positioning accuracy, high deployment and maintenance costs.
Smart video	Strong ability to identify intrusion targets, highly intelligent, easy to deploy.	Recognition rate decreases beyond 100 meters; significantly affected by environmental factors, weather, and visibility, leading to false alarms.

1.2 Difference Between Millimeter Wave Security Radar and Traditional Perimeter Means

Traditional perimeter security systems are often compromised by limited optical visibility, adverse weather, or complex environments, leading to high rates of false and missed alarms. Furthermore, due to their simplistic technology, they often cannot provide detailed information about an intrusion target, lack early warning capability before a target enters the defense zone, and fail to offer actionable intelligence to security personnel.

Perimeter security radar continuously scans the monitored area, accurately detecting the range, angle, and speed of intrusion targets. It actively and continuously tracks and provides warnings for legitimate targets. Simultaneously, machine learning-based classification technology can effectively identify and pinpoint the location of the intrusion target.

A comparison of various security technologies reveals that security radar holds comprehensive advantages in installation convenience, environmental adaptability, target detection capability, intelligent application, and cost-effectiveness.

Table 2 Comparison of Perimeter Security Measures

	Video Surveillance	Infrared Sensor	Induction Coil	Leaky Cable	Microwave Sensor	Surveillance Radar
Installation & Configure	Complex	Simple and convenient	Complex	Complex	Simple	Simple
Light environment	Day	Day/night	Day/night	Day/night	Day/night	All-weather
Coverage area	Wide/Long	Wide/Short	Narrow/Short	Narrow/Short	Narrow/Medium	Wide/Long
Target information	Visual ID	Detection	Detection	Detection	Range	Speed Range Precision
False alarm factors	Insect, Weather	Insect, Leaves	None	Moisture, Metal	Animals, Foliage	Swaying Vegetation
Range Filtering	None	None	None	None	None	YES
Deterrent Capability	Event alarm	None	None	None	None	Audio/Visual Alarm
Cost	Moderate	Low	High Maintenance	High	Moderate	Moderate

2 Overview of the NSR120 Perimeter Security radar

2.1 Product Overview

Figure 1 NSR120 Product Appearance

The NSR120 perimeter security radar continuously transmits fan-shaped electromagnetic waves, analyzes the reflected signal from each resolution unit, and determines the presence of moving targets. It accurately detects the range, angle, and speed of intrusion targets. Multi-target tracking and localization are achieved using machine learning-based classification technology.

2.2 Basic Working Principle of Radar

The radar calculates the distance, angle, and speed of a target by transmitting a modulated signal and analyzing the received echo signal through data processing.

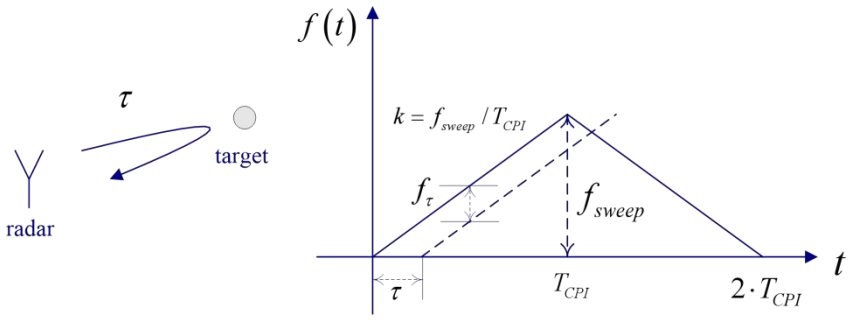

Figure 2 Echo Signal Analysis

The ranging principle of FMCW radar is based on the frequency shift between the transmitted signal and the echo received. This frequency shift is proportional to the time delay of the echo, which is used to calculate the target's distance. The direction of the target is determined based on the antenna beam direction where the received echo is strongest. When there is relative velocity between the target and the radar, the received echo signal's carrier frequency shifts, known as the Doppler shift, which is used to measure the target's speed.

2.3 Target Detection and Tracking

During each scan, if the echo energy of a reflected signal exceeds the radar's detection threshold, a detection point is generated. A single detection point cannot be defined as a confirmed target, as multiple detections (both real and false targets) may appear in the monitoring area. There is always a discrepancy between the detected and true values of a target's range, speed, and angle. Therefore, a single detection value cannot be used directly as accurate target information. The radar performs continuous tracking of detection points in subsequent scans. If a track meets the confirmation criteria, the radar outputs the target information and continues to track and report it.

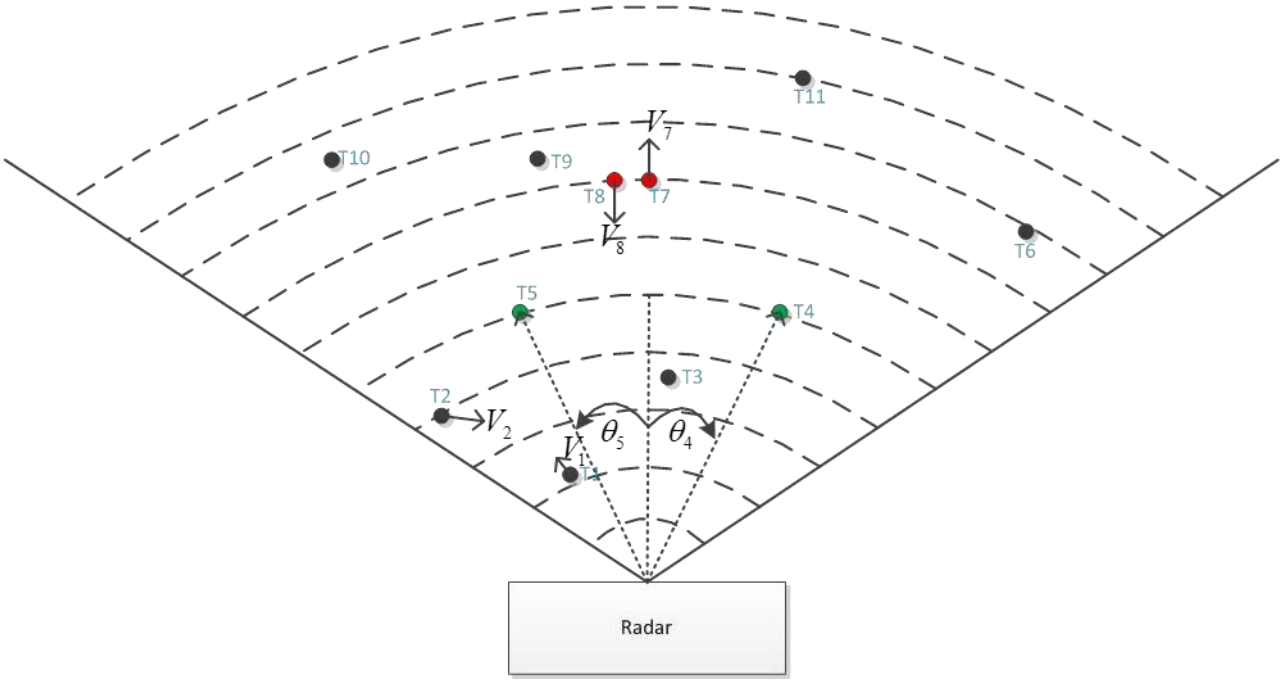

Figure 3 Field of View (FOV) of NSR120 Radar

2.4 Product Parameters

The NSR120 utilizes a Frequency Modulated Continuous Wave (FMCW) scheme. It features high performance, low power consumption (4 W), a compact size (150 × 125 × 45 mm), and a range resolution of 0.58 m. With a detection range of 120 meters, its lightweight design meets the demands of security applications requiring long-range detection, high precision, and strong environmental adaptability.

The outline of NSR120 is as follows:

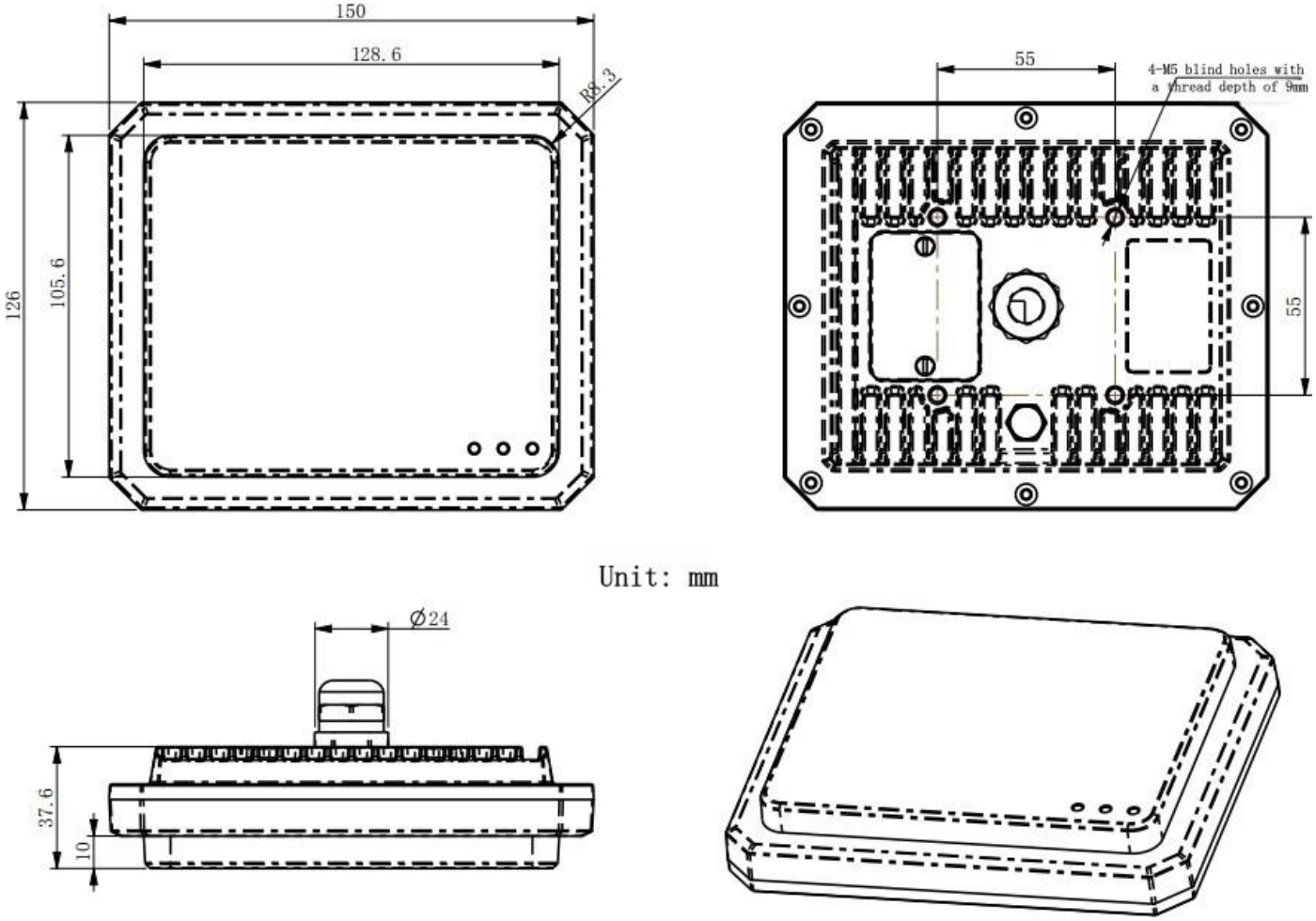

Figure 4 Product Outline Diagram

Table 3 NSR120 Performance Parameters

Parameter	Condition	Min	Typical value	Max	Unit
System characteristics					
Modulation mode			FMCW		
Update rate			12.5		Hz
Power Consumption	12V DC 25℃		4		W
Ranging characteristics					
Detection Range(Person)		1	1 ~ 120m (@ person 0 °) 1 ~ 120m (@ person, walk/run across)	120	m
Ranging Accuracy			±0.3		m
Angle accuracy			±0.5		°
Speed Range		-30		+30	m/s
Speed Accuracy			±0.025		m/s
Speed Resolution			0.05		m/s
Multi-target Tracking					
Simultaneous Tracks			16		A
Range resolution			0.58		m
Antenna characteristics					
Beam width	Horizontal		22		°
	Vertical		13		°
Interface characteristics					
Interface Characteristics			RJ45		
			RS485		
			100M（PoE）		
			2-way (0.5a/125 AC)		
			2-WAY (2500VAC)		
Other features					
Operating Voltage		12	12	28	V
Operating Current			0.3		A
Storage Temperature		- 40		85	℃
Operating Temperature		- 40		75	℃
Weight			<1		kg
Size			150×125×45		mm
Protection grade			IP66（The protection rating is not a permanent standard, and the protective capability may diminish due to product wear）		
laws and regulations			In certain countries or regions, this millimeter-wave radar may not be available for purchase. For details, please refer to local laws and regulations		

The NSR120 uses an advanced three-transmitter four-receiver planar microstrip array antenna. The Taylor weighting algorithm synthesizes low sidelobe patterns for both transmitting and receiving antennas. This low sidelobe design makes the radar less susceptible to interference from ground clutter and targets outside the main beam, significantly improving the signal-to-noise ratio for target detection.

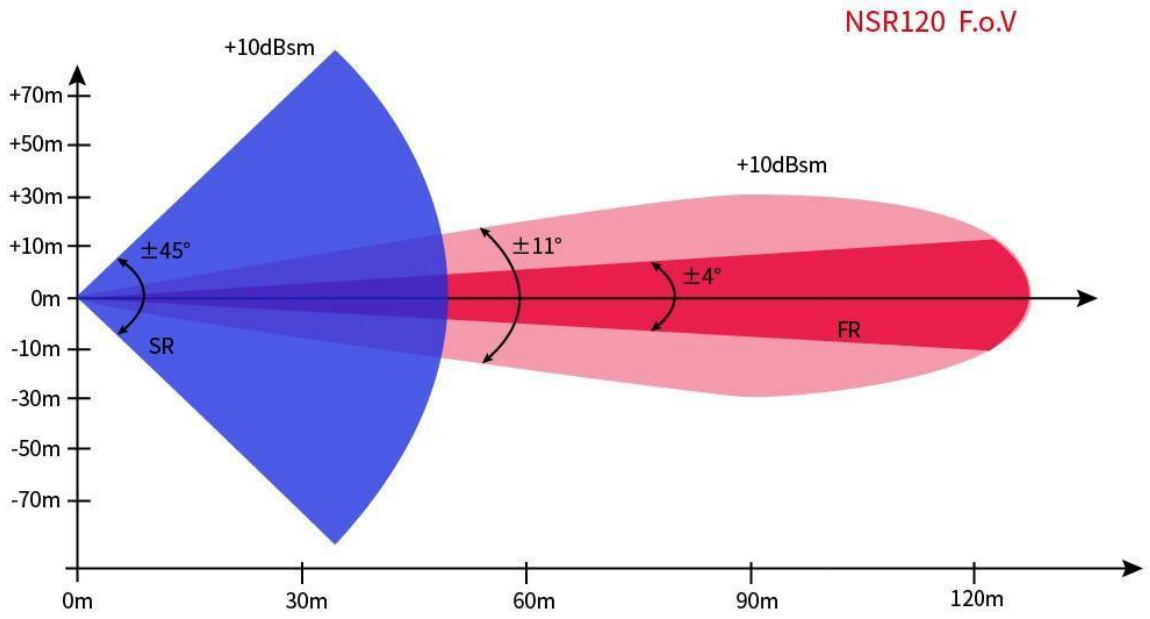

Figure 3 F. O. V of NSR120 perimeter security radar

2.4 Radar Interface

To facilitate customer development and testing, the NSR120 provides standard Ethernet (RJ45) and RS485 communication interfaces, enabling quick integration with host computers or other MCUs. This saves configuration time and simplifies the deployment and networking of multiple devices.

Additionally, the radar provides two optocoupler-isolated outputs and two relay outputs, enabling it to trigger audible and visual alarms directly. It also includes one optocoupler-isolated input, which can accept external trigger signals for functions like automatic sleep mode or scene switching. Three LED status indicators display the radar's current operational state, such as power status, alarm triggering, or fault condition.

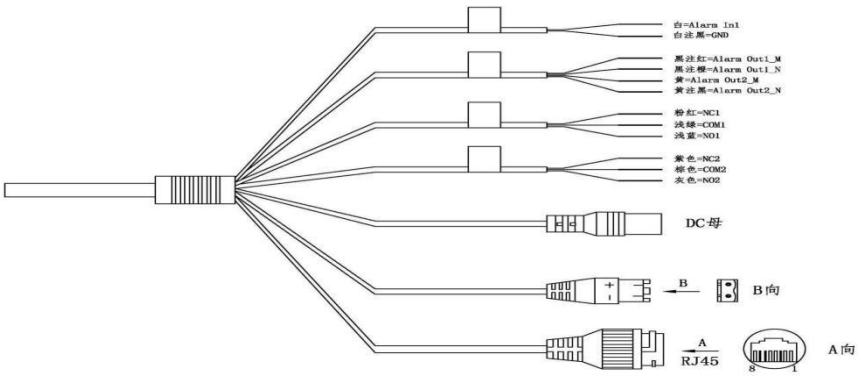

Figure 6 Radar Connection Interface Diagram

Table 3 Definition of radar physical interface

Serial number	Cable port	Port name	Functional description
1	Power source	Power input port	Input stabilized DC 12v/1A Caution: If the power is not supplied in accordance with the instructions, the equipment may be damaged
2	RJ45	Network port	Connects to standard Ethernet and provides power for PoE
3	Signal Line	光耦输出:开关量输出(干接点);常开,可承受电流	There are 2 groups of switching values, and the line sequence is defined as follows: Gray Note Black = Alarm Out 1 _ M, Orange Note Black = Alarm Out 1 _ N, Yellow Note White = Alarm Out 2 _ M, Yellow Note Black = Alarm Out 2 _ N,
4	Signal Line	Relay output: switching value output (Dry contact)	Withstand current (resistive load): 2a @ 30v, 0.5a @ 125v AC (full load electrical endurance: 100,000 times). If capacitive or inductive load is accepted, please reserve appropriate allowance for the current that can be borne. There are two groups of switching values, and the line sequence is defined as follows: Pink = nc1, light green = com1, brown = No1, Purple = nc2, brown-black = com2, gray = NO2, note: NC: normally closed, com: common terminal, no: normally open
	Signal Line	High and low level input:	It is the optocoupler drive end, and the drive current is required to be 20 mA; Line sequence definition: white = signal input; White note black = signal input －;
5	Signal Line	RS485	Transmitting radar data (target information) via RS485 line
6	Red, yellow and blue led status indicator, reflecting the working status of the equipment	The red light is always on	Normal power-on operation of radar
		The yellow light is always on	The radar enters the SD card burning state; After that, the yellow light goes out, and the burning is completed.
		Yellow light flashes	Moving target detected by radar
		The blue light is always on	Normal access of radar to network
		The blue light goes out	1. The access network interface is abnormal and the radar is not connected to the network. 2. The access network interface is normal, but the equipment fails.
		The red light is off	1. The input power supply is abnormal and the radar is not powered on. 2. If the input power supply is normal, the equipment fails.

2.5 Equipment Installation

2.5.1Channel Perimeter Scenario

The radar should be installed facing the area to be monitored, with its central axis (normal line) aligned with the center of the warning zone.

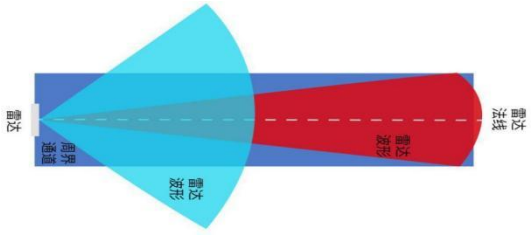

Figure 7 Radar Installation for Channel Perimeter

To ensure optimal detection accuracy and performance, the radar's scanning surface should be perpendicular to the perimeter line. The recommended installation height is between 1.5 and 3 meters, generally not exceeding 6 meters.

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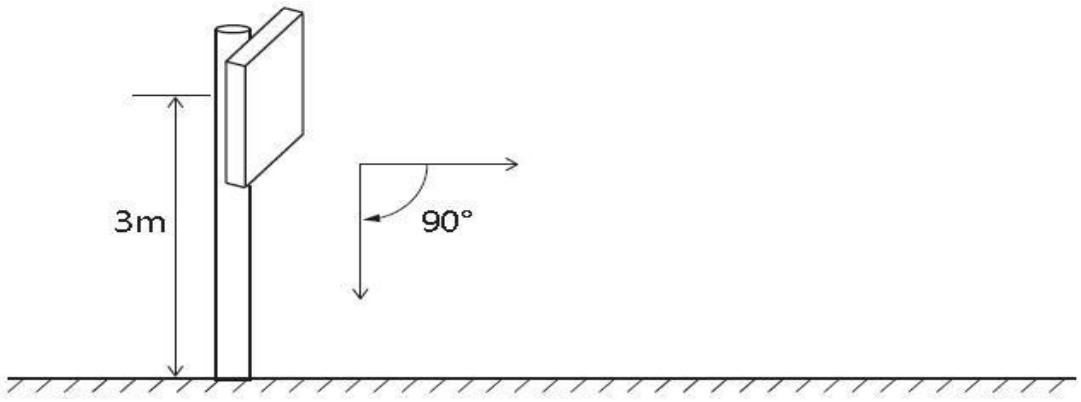

Figure 8 Recommended Installation Height and Angle

2.5.2 Radar Near Blind Area Data at Different Installation Height

Table 4 Blind Zone Data vs. Installation Height

Tilt Angle	Remark	Installation Height (m)	Far-end Blind Zone (m)	Near-end Blind Zone (m)
0°	1.7m tall person walking	1.5	2.8	1.2
		2	3.5	2.4
		3	7.3	6.5
		4	12.4	11.4
		5	17.9	15.5

3. Product application field

Airport Perimeter



Oil & Gas Facility Protection

Railway Platform Security



Prison/Detection Facility Security

Campus Protection



Protection of Historic Sites

Aquaculture Protection in Waters