X-Band 256-Channel

Two-dimensional active Phased Array Antenna

1.Product Composition and Technical Specifications

Product Information

The X-band 256-channel two-dimensional active phased array antenna consists of 256 antenna elements and comprises several components, including the antenna (radome), AIP module, sum-and-difference module, power supply and wave control module, frequency synthesizer module, cable assembly, and structural components.

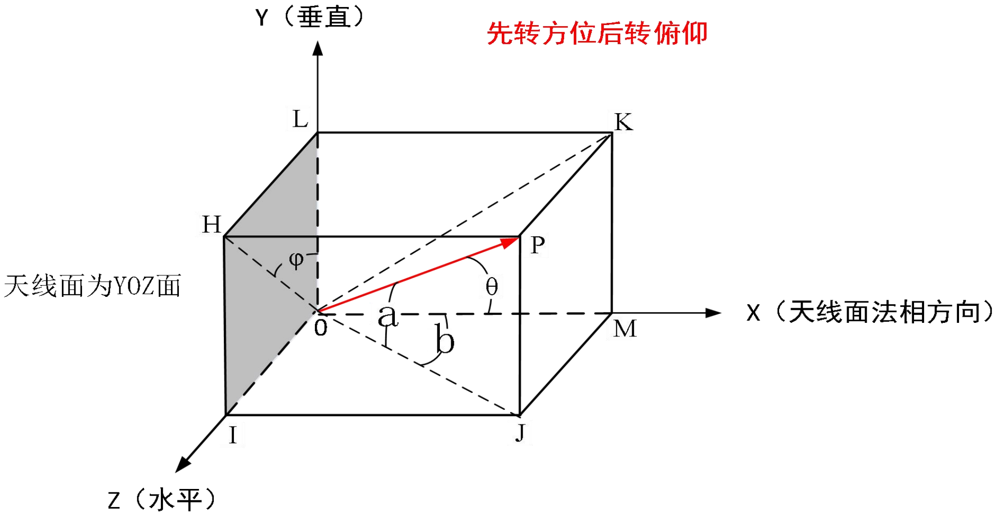
During reception, space-based electromagnetic wave signals are captured by an array antenna; these signals are then amplified, undergo phase compensation, and receive amplitude compensation via a receiving channel; subsequently, multiple-channel signals are synthesized using a power divider and a combiner to form a spatial beam, an azimuthal beam, and a pitch-angle beam, which are then transmitted to the backend receiver. During transmission, the RF excitation signal passes through the power divider and combiner, is divided among multiple transmission channels, undergoes phase compensation and amplification via the TR module's transmission channel, and is ultimately output to the antenna to generate a beam in a specified spatial direction.

Product function

a） State information such as the temperature and current of each sub-array can be reported in real time via wave control;

b） The PWM controller regulates the fan speed.

Product Coordinate System Definition



说明：
OP：为波束指向
b：方位角，为波束指向OP在XOZ面的投影OJ与OM的夹角∠JOM
a：俯仰角，为波束指向OP在XOZ面的投影OJ与OP的夹角∠JOP
θ：离轴角，为波束指向OP与OM的夹角∠MOP
φ：旋转角，为波束指向OP在YOZ面投影OH与OL的夹角∠LOH

Figure 1: Definition of the phased array antenna coordinate system

2.qualification

Platform Performance Specifications

The product technical specifications are shown in the table below; all specified parameters refer to conditions at room temperature.

NO.	name of index	Indicator Requirements
1.	Operating frequency band	9.2GHz～9.8GHz
2.	Operating frequency	The frequency step value is 30 MHz; it can be customized according to user requirements.
3.	Antenna Type	Active 2D scanning phased array antenna; azimuth–elevation 2D scanning
4.	Polarization method	Typical configuration: Vertical polarization (Note: Horizontal polarization modification can be performed as required.)

NO.	name of index	Indicator Requirements
5.	Array size	Azimuth direction: Nx=16 Pitch angle: Ny = 16 Total number of units: N = Nx × Ny = 256
6.	Antenna Gain (Normal Direction)	Output: ≥29 dB (unweighted; design guarantee) Reception: ≥28 dB (weighted, design guarantee)
7.	EIRP (Normal)	≥80 dBm across all frequency bands and at all temperatures
8.	G/T (Normal)	≥0.5 dB/°K across all frequency bands and operating temperatures
9.	Electrostatic scanning range	Azimuth ±45°, Pitch ±45°
10.	beam-pointing accuracy	Pointing error ≤ 0.3°; (within ±45° scan range) Pointing error ≤ 0.15°; (within ±20° scan range)
11.	Scan Down	Azimuth direction: ≤3 dB (within ±45° scan range) Pitch/roll: ≤3 dB (within ±45° scan range)
12.	Transmitter azimuth plane normal beam width	5.8° ± 0.3° @ center frequency
13.	Transmitter pitch-plane normal beam width	5.8° ± 0.3° @ center frequency
14.	Receiver azimuth normal beam width	6.8° ± 0.4° @ center frequency
15.	Received pitch-plane normal beam width	6.8° ± 0.4° @ center frequency
16.	Received azimuth-based normal component of the first sidelobe level (normal direction)	≤-22dB

NO.	name of index	Indicator Requirements
17.	Receive the first sidelobe level (normal direction) of the pitch plane	≤-22dB
18.	Receiving method for the zero-depth (normal) normal difference beam	Directional gain: -22 dB (typical value) Pitch: -22 dB (typical value)
19.	Reception channel active gain	≥15 dB (Design guarantee; adjustable)
20.	Receiver channel noise figure	<3.5 dB across all frequency bands and operating temperatures (as specified in the design);
21.	Duty cycle	Up to 20%
22.	Peak transmission power	≥27 dBm (single-channel, design guarantee)
23.	weighting scheme	Receives default weighting; transmits without weighting.
24.	Product Power Consumption	≤235W (transmission duty cycle: 20%)
25.	Beam handover time	≤50us

3.Weight ≤3.5Kg

4.Product appearance and dimensions

Product external dimensions

≤315 mm (azimuth) × 315 mm (pitch) × 60 mm (thickness).

Appearance and Surface Condition

Color-coated conductive oxide treatment on the surface of the metal cavity; white primer spraying on the surface of the antenna cover.

Product Structure Exterior View Diagram

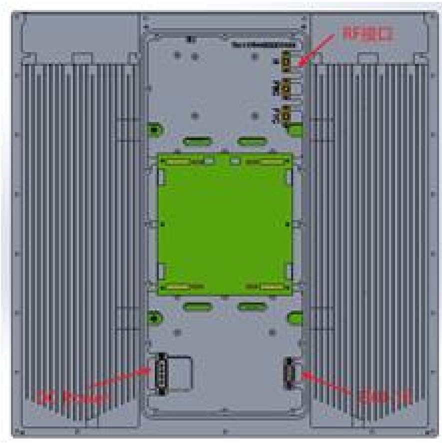


Figure 1: Schematic diagram of the phased array interface exterior

5.Product power supply requirements

Main power input voltage: DC 18V–36V

6.Interface Requirements

radio frequency interface:

Table 1: RF Interface Table

NO.	name	definition	direction	remarks
1	H	Phased-Array RF Input/Output 1	Phased Array → Frequency Synthesizer	Receive and transmit excitation ports
2	FWC	Phased-array RF Output 2	Phased array → Frequency synthesizer	Receiver azimuth difference
3	FYC	Phased-array RF Output 3	Phased array → Frequency synthesizer	Receive pitch difference

Control interface J30J_15ZK:

Pin Number	Signal Name	Signal Definition	Signal direction	explain
1	RXD+	Serial port receive data differential positive terminal	Data Acquisition Board-> Phased Array	RS422
2	RXD-	Serial port receive data differential negative	Data Acquisition Board-> Phased	RS422

		terminal	Array	
3	TXD+	Serial port data differential positive terminal	Phased Array → Data Acquisition Board	RS422
4	TXD-	Serial port data differential negative terminal	Phased Array → Data Acquisition Board	RS422
5	CLK+	Serial port receive clock differential positive terminal	Data Acquisition Board-> Phased Array	RS422(10MHz)
6	CLK-	Serial port receive clock differential negative terminal	Data Acquisition Board-> Phased Array	RS422(10MHz)
7	TRT+	Positive terminal of the transmit/receive switching signal	Data Acquisition Board-> Phased Array	RS422
8	TRT-	Negative terminal of the transmit-receive switching signal	Data Acquisition Board-> Phased Array	RS422
9	LD+	Feed the amplitude-phase data into the positive terminal of the signal.	Data Acquisition Board-> Phased Array	RS422
10	LD-	Feed the amplitude-phase data to the negative terminal of the signal.	Data Acquisition Board-> Phased Array	RS422
11	GND_COM	the earth	Data Acquisition Board <-> Phased Array	Signal Ground
12	TRR+	Positive terminal of the transmit/receive switching signal	Data Acquisition Board-> Phased Array	RS422
13	TRR-	Negative terminal of the transmit-receive switching signal	Data Acquisition Board-> Phased Array	RS422
14	BF+	reserve	Data Acquisition Board-> Phased Array	RS422
15	BF-	reserve	Data Acquisition Board-> Phased Array	RS422

Power supply interface J30J04P04P:

NO.	Jumper cable numbering	Signal Definition
1	A	+24V
2	B	+24V
3	C	GND
3	D	GND

7.environmental suitability

a)Operating temperature: -40°C to +70°C

b)Storage temperature: -50°C to +70°C

8.other

Meets general environmental requirements for electromagnetic compatibility, vibration, rain exposure, and wind resistance.

9.Communication Protocol Requirements

For detailed communication protocol specifications, refer to Appendix I; this protocol can be customized or modified.

Annex 1: X-band Two-Dimensional Phased Array Antenna Communication Protocol

The transmission of parameters between the Signal Processing Board and the Wave Control Board is achieved via a synchronous RS422 interface. CLK± provides the communication clock signal (≥10 MHz) from the Signal Processing Board to the Wave Control Board; RXD± represents the signal used by the Signal Processing Board to transmit data to the Wave Control Board; TXD± represents the signal used by the Wave Control Board to transmit data to the Signal Processing Board; and LD± serves as the control signal that, upon the transmission of parameters from the Signal Processing Board to the Wave Control Board, sets the wave control binding parameters on the multi-function chip.

When transmitting data packets via a synchronous serial interface, the transmitter updates the data at the clock's rising edge and transmits the data at the clock's falling edge. The transmitter first sends a 1-bit start bit (low-level active), followed by the packet data; the transmission order is such that packets with smaller sequence numbers are transmitted before those with larger sequence numbers. For single-byte transmissions, the higher-order bits of the byte are sent first, followed by the lower-order bits. If the packet content consists of multiple bytes, it is transmitted according to the big-endian mode (i.e., the high-order byte is sent first, followed by the low-order byte). Once all packet data has been transmitted, the transmitter sets the corresponding data signal lines to a high level, entering an idle state.

After the Wave Control Board sends a control command to the Signal Processing Board, it simultaneously sends back a set of packet data as a command response; except for the packet type, which may differ from the Signal Processing Board's command, all other fields in this response packet are consistent with the Signal Processing Board's command. Upon receiving the status information command packet, the Wave Control Board sends a status information packet back to the Signal Processing Board.

The control command message sent from the signal board to the wave control board is as follows:

Table 1: Data acquisition transmission wave control information packet (16 bytes)

order number	**Signal Name**	**Byte count**	**explain**	**remarks**
1	heading	1	0xAA	----
2	Message Type	1	0x13	Wave Control Response Data
3	Message length	1	0x10	The packet length is 16 bytes.
4	control word	1	0x80	Bit 7–Bit 6: Default is 2B10
	frequency code			Bit5–Bit0 frequency encoding: 1–9.2 GHz, 2–9.23 GHz,..., 21–9.8 GHz
5	work pattern	1	0x01	Transmit/Receive Control: 00: Reserved; 01: Receive Mode 10: Transmitter operation; 11: Transmitter and receiver operate simultaneously
6~7	Azimuth angle encoding	2	0x0000	Unsigned integer formatting; quantization unit: 0.05°; valid range: 0–2000.0: –50.00°; 1: –49.95°; 2: –49.90°; 2000:50°
8~9	Pitch angle encoding	2	0x0000	Unsigned integer formatting; quantization unit: 0.05°; valid range: 0–2000; 0: –50.00°; 1: –49.95°; 2: –49.90°; 2000:50°
10~11	channel switch	2	0xffff	Unsigned integer formatting; 256-channel selection: 0: All off; 1: Channel 1 enabled; 2: Channel 2 enabled; 256: Channel 256 enabled; 0xFFFF: All on
12	Phase Enable	1	0x01	Default value: 1
13	Attenuation Enable	1	0x01	Default value: 1
14-16	Reserved	3	0x0000000	Default value: 0

Table 1: Wave Control Send Response Command Message (16 bytes)

order number	Signal Name	Byte count	explain	remarks
1	heading	1	0xAA	----
2	Message Type	1	0x13	Wave Control Response Data
3	Message length	1	0x10	The packet length is 16 bytes.
4	control word	1	0x80	Bit 7–Bit 6: Default is 2B10
	frequency code			Bit5–Bit0 frequency encoding: 1–9.2 GHz, 1–9.23 GHz,..., 21–9.8 GHz
5	work pattern	1	0x01	Transmit/Receive Control: 00: Reserved; 01: Receive Mode 10: Transmitter operation; 11: Transmitter and receiver operate simultaneously
6~7	Azimuth angle encoding	2	0x0000	Unsigned integer formatting; quantization unit: 0.05°; valid range: 0–2000.0: –50.00°; 1: –49.95°; 2: –49.90°; 2000:50°
8~9	Pitch angle encoding	2	0x0000	Unsigned integer formatting; quantization unit: 0.05°; valid range: 0–2000; 0: –50.00°; 1: –49.95°; 2: –49.90°; 2000:50°
10~11	channel switch	2	0xffff	Unsigned integer formatting; 256-channel selection: 0: All off; 1: Channel 1 enabled; 2: Channel 2 enabled; 256: Channel 256 enabled; 0xFFFF: All on
12	Phase Enable	1	0x01	Default value: 1
13	Attenuation Enable	1	0x01	Default value: 1
14-16	Reserved	3	0x0000000	Default value: 0

Table 1: Wave Control Send Monitoring Command Information Packet (36 bytes)

order number	Signal Name	Byte count	explain	remarks
1	heading	1	0xAA	----
2	Message Type	1	0x32	PWM control status information
3	Message length	1	0x24	The packet length is 36 bytes.
4~19	Temperature information	16		Every two bytes represent one channel array.
20~35	Current information	16		Every two bytes represent one channel array.
36	Fan Information	1		Every two representatives correspond to one fan (01 indicates normal operation).

The control timing sequence between the Signal Processing Board and the Wave Control Board primarily consists of two components: the communication control timing sequence and the transmit–receive switching control timing sequence. The figure below illustrates the process by which the Signal Processing Board sends control commands to the Wave Control Board, receives wave control status information, and manages the transmit–receive control timing sequence. The data packet contains only one start bit and one stop bit; thus, a 16-byte data packet corresponds to a packet length of 16 × 8 bits + 2 bits (start bit/stop bit) = 130 bits.

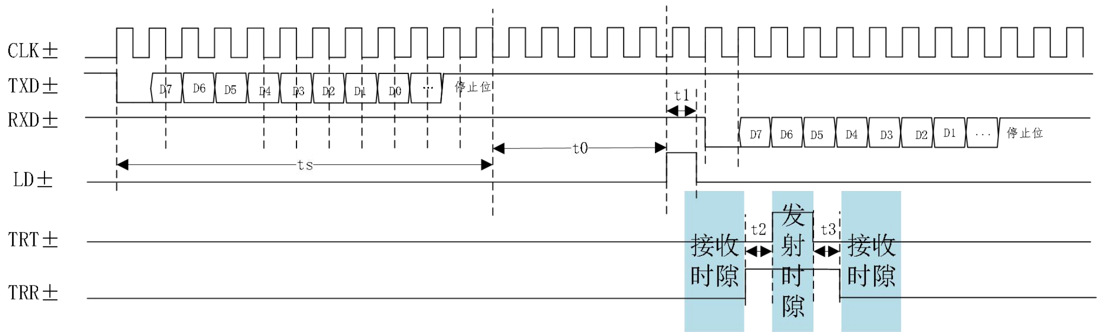


Figure 1: Data write and transmit/receive wave control timing diagram

Monitoring command sequence description: Bytes 4–19 contain two-byte temperature data for each channel (TEMP_CHANL1, TEMP_CHANL2, TEMP_CHANL3, TEMP_CHANL4, TEMP_CHANL5, TEMP_CHANL6, TEMP_CHANL7, TEMP_CHANL8). The temperature conversion formula is: TEMP × 0.625 / 10.

The current information for each channel (2 bytes per channel) is as follows: (CURRENT_CHANL1, CURRENT_CHANL2, CURRENT_CHANL3, CURRENT_CHANL4, CURRENT_CHANL5, CURRENT_CHANL6, CURRENT_CHANL7, CURRENT_CHANL8).

Current conversion formula:

$$\text{Current} = \underline{D[14:0]} \bullet 19.42\mu V/R_{SENSE}, \text{ if Sign} = 0$$

Here, Rsense = 0.01. The 36 bytes contain fan information: every two bytes represent one fan; '01' indicates normal operation; for example, '01010101' represents four fans operating normally.