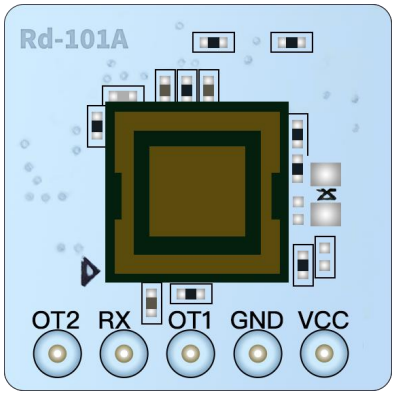
Rd-101A / Rd-103A Serial Communication Protocol

1. Introduction to the Communication Interface

1.1 Pin Definition and Wiring

Both Rd-101A and Rd-103A expose power supply and UART-related pins. They communicate with a host computer or MCU via a USB-to-TTL (3.3V level) converter. Rd-101A (front view, from left to right): OT2, RX, OT1, GND, VCC.



Rd-103A (front view, from top to bottom): 3.3V, GND, OT1, RX, OT2.

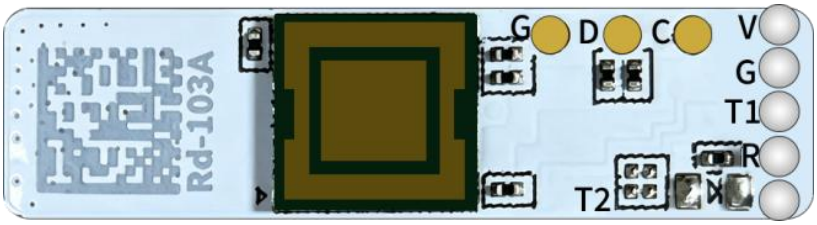


Figure 1 Pin Diagram

Table 1 Rd-101A / Rd-103A Wiring

Rd-101A / Rd-103A	USB-to-TTL	Description
VCC / 3.3V	3.3V	Power supply: 3.0–3.6V, typical 3.3V. Connecting 5V is strictly prohibited.
GND	GND	A common ground is required.
RX	TXD	Module UART_RX; receives commands from the host.
OT1	RXD	Module UART_TX; outputs detection results / ACK.
OT2	Not connected	Outputs a high or low level according to the detection result: high when a person is present and low when no person is present. Connect this pin only when a GPIO indicator is required.

UART cross-connection: module OT1 → TTL RXD; module RX → TTL TXD.

Physical wiring example:

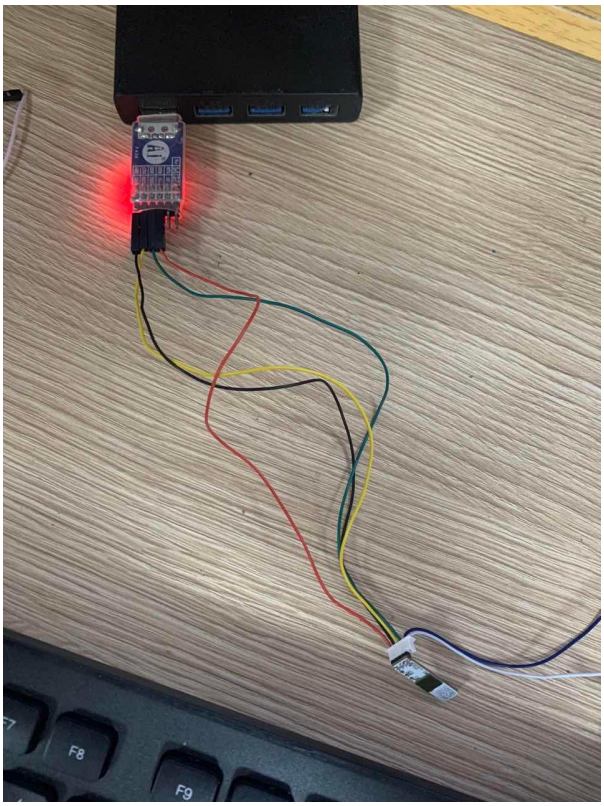


Figure 2 Example Connection Between Module and USB-to-TTL

1.2 Configuration Parameters and Descriptions

Users can modify configuration parameters through the serial port to meet different application requirements. The configurable radar detection parameters are listed in Table 2.

Table 2 Rd-101A / Rd-103A Configuration Parameters

Parameter	Configurable Range	Description
Maximum detection range gate	0 – 108	Sets the farthest valid detection range. **One range gate = 0.1m**. For example, 0x0A = 1.0m.
Target disappearance delay	0 – 65535	T seconds is required before switching from occupied to unoccupied state. If a person is detected again during the delay, the timer restarts. The unoccupied state is reported only after the unoccupied condition persists for the full T seconds. Unit: seconds.
Installation method	0, 1	Host computer “Param 7”: 0 = ceiling-mounted, 1 = wall-mounted.
Starting range gate for vital-sign detection	0 – 16	Host computer “Param 1”.
Motion detection threshold coefficient	10 – 500	Host computer “Param 2”.
Vital-sign detection threshold coefficient	10 – 500	Host computer “Param 3”.
Param 4 / 5 / 6	0 – 65535	Reserved.
Motionless Threshold	0 – 2^32	Squared magnitude, covering 16 range gates. The host computer displays the value in dB, with a range of 0 – 96.32 and a precision of 0.01. The value can be calculated using “Gen. Thres.”. See Section 2.2.5 for the conversion.
Power interference alarm	See description	**Read-only.** Low 16 bits: 0 = not performed, 1 = no interference, 2 = interference detected. High 16 bits: interference frequency 0 – 256kHz, valid only when the low 16 bits equal 2.
Report mode	N/A	Serial port print output status (no person: OFF, person detected: distance: + target range)
Debug mode	N/A	Serial port reports the energy values of each range gate and the detection result (parsed by the host computer).

2. Communication Protocol

This communication protocol is mainly intended for users who need to operate the radar without the visualization tool. The Rd-101A / Rd-103A communicates with external devices through a serial port (TTL-level). Both radar data output and parameter configuration commands use this protocol.

The default baud rate for the radar serial port is **115200**, with 1 stop bit and no parity bit (8N1).

2.1 Protocol Format

2.1.1 Protocol Data Format

Serial communication data for the Rd-101A / Rd-103A uses **little-endian** format. All data in the following tables is represented in hexadecimal.

2.1.2 Command Protocol Frame Format

The protocol-defined formats for radar configuration commands and ACK commands are shown in Tables 3–6.

Table 3 Outgoing Command Frame Format

Frame Header	In-Frame Data Length	In-Frame Data	Frame Tail
FD FC FB FA	2 bytes	See Table 4	04 03 02 01

Table 4 Outgoing Frame Data Format

Command Word (2 bytes)	Command Value (N bytes)

Table 5 ACK Command Frame Format

Frame Header	In-Frame Data Length	In-Frame Data	Frame Tail
FD FC FB FA	2 bytes	See Table 6	04 03 02 01

Table 6 ACK Frame Data Format

Outgoing Command Word (2 bytes)	Command Execution Status (2 bytes)	Return Value (N bytes)

2.2 Outgoing Commands and ACKs

Unless otherwise specified, all other commands sent to the radar must be issued after enabling configuration mode. Otherwise, the commands are invalid.

Reading photosensitive value 0x0028 and reading ChipID 0x0029 are common commands, and do not require entering configuration mode.

Command Summary:

Function	Command Word
Read firmware version	0x0000
Configure sensor register	0x0001
Read sensor register	0x0002
Configure sensor parameters	0x0007
Read sensor parameters	0x0008
Write serial number	0x0010
Read serial number	0x0011
Configure system parameters	0x0012
Report automatic-threshold interference	0x0014
Read photosensitive sensor ADC	0x0028
Read ChipID	0x0029
Read version and build information	0x002A
Read device ID	0x0075
Save sensor parameters	0x00FD
Exit configuration mode	0x00FE
Enable configuration mode	0x00FF

2.2.1 Entering Command Mode

All other configuration commands sent to the radar must be issued after this command. Otherwise, they are invalid.

- Command word: 0x00FF
- Command value: 0x0001
- Return value: 2-byte ACK status (0 = success, 1 = failure) + 2-byte protocol version (0x0002) + 2-byte buffer size (0x0020)

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Command Value	Frame Tail
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

Radar ACK (successful example):

Frame Header	In-Frame Data Length	Command Word	ACK	Protocol Version	Buffer size	Frame Tail
FD FC FB FA	08 00	FF 01	00 00	02 00	20 00	04 03 02 01

Protocol version = 2, and the send/receive buffer size = 32 bytes.

2.2.2 Exiting Command Mode

This command ends configuration mode. After execution, the radar returns to normal operating mode. To issue other commands again, command mode must first be enabled.

- Command word: 0x00FE
- Command value: None
- Return value: 2-byte ACK status (0 = success; any other value = failure)

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	FE 00	04 03 02 01

Radar ACK (successful example):

Frame Header	In-Frame Data Length	Command Word	ACK	Frame Tail
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

2.2.3 Read Firmware Version

This command reads the firmware version of the millimeter-wave sensor SDK.

- Command word: 0x0000
- Command value: None
- Return value: Version-number length (2 bytes) + version-number string

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	00 00	04 03 02 01

ACK (successful example):

Frame Header	In-Frame Data Length	Command Word	ACK	Version Length	Version	Frame Tail
FD FC FB FA	0C 00	00 01	00 00	06 00	76 34 2E 32 2E 30	04 03 02 01

76 34 2E 32 2E 30 is the ASCII string v4.2.0.

2.2.4 Read Firmware Version and Build Information

This command reads the software version and build time. After an OTA update, it can be used to verify the information of the version package.

- Command word: 0x002A
- Command value: None
- Return value: Information length (2 bytes) + ASCII string

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	2A 00	04 03 02 01

ACK (successful example):

```
FD FC FB FA 29 00 2A 01 00 00 23 00 72 65 6C 65 61 73 65 2F 76 31 2E 30 2E 30 20 41 75 67 20 31 33 20 32 30 32 36 20 31 35 3A 30 30 3A 34 38 04 03 02 01
```

Field	Original bytes	Interpretation	
In-frame data length	29 00	41 = command word 2 + status 2 + length 2 + string 35	
Response command	2A 01	0x002A	0x0100
Status	00 00	ACK_OK	
String length	23 00	35 bytes	
String	72 65 6C … 34 38	ASCII release/v1.0.0 Aug 13 2026 15:00:48	

Here, release/v1.0.0 is the software version, and Aug 13 2026 15:00:48 is the build time.

2.2.5 Parameter Configuration Command

This command sets the millimeter-wave sensor parameters. The parameter IDs are listed in Table 7.

- Command word: 0x0007
- Command value: (2-byte parameter ID + 4-byte parameter value) × N
- Return value: 2-byte ACK status (0 = success, 1 = failure)

Table 7 Sensor Parameters

Parameter	Parameter ID	Range	Description
Maximum detection range gate	0x0001	0 – 108, 1 gate = 0.1m	Example: 0C 00 00 00 represents 1.2m.
Target disappearance delay	0x0004	0 – 65535	Unit: seconds.
Power interference alarm	0x0005	See right	**Read-only.** Low 16 bits: 0 = not performed, 1 = no interference, 2 = interference detected. High 16 bits: interference frequency 0 – 256kHz, valid only when the low 16 bits equal 2.
Starting range gate for vital-sign detection	0x0008	0 – 16	Host computer “Param 1”.

Motion detection threshold coefficient	0x0009	10 – 500	Host computer “Param 2”.
Vital-sign detection threshold coefficient	0x000A	10 – 500	Host computer “Param 3”.
Param 4 / 5 / 6	0x000B – 0x000D	0 – 65535	Reserved.
Installation method	0x000E	0, 1	Host computer “Param 7”: 0 = ceiling-mounted, 1 = wall-mounted.
Motionless Threshold	0x0030 – 0x003F	0 – 2^32	16 distance gates, squared magnitude. Host computer dB value: dB = 10lg(X).

Outgoing data: maximum detection range gate = 12 (1.2m, not retained after power-off)

Frame Header	In-Frame Data Length	Command Word	Parameter ID	Parameter Value	Frame Tail
FD FC FB FA	08 00	07 00	01 00	0C 00 00 00	04 03 02 01

Radar ACK (successful)

Frame Header	In-Frame Data Length	Command Word	ACK	Frame Tail
FD FC FB FA	04 00	07 01	00 00	04 03 02 01

Configure the target disappearance delay to 12 seconds:

```
FD FC FB FA 08 00 07 00 04 00 0C 00 00 00 04 03 02 01
```

Configure ceiling-mounted installation:

```
FD FC FB FA 08 00 07 00 0E 00 00 00 00 00 04 03 02 01
```

Configure wall-mounted installation:

```
FD FC FB FA 08 00 07 00 0E 00 01 00 00 00 04 03 02 01
```

Motionless Threshold (Micro-Motion and Stationary Threshold) Configuration Guide

The threshold value is the signal-to-noise ratio. The value input through the protocol is the squared magnitude X. The host computer displays the value in dB. The conversion is:

$$dB = 10 \lg(X)$$

For example, if the input value is S/N, calculate 10lg(S/N). The range is 0 to (2^32) - 1. If the final threshold value is intended to be 47.74, the calculation is: 47.74 = 10lgX, X = 10^4.774. The calculated value of X is 59,429, whose hexadecimal representation is E825.

Modify the micro-motion and stationary threshold of the second range gate to 47.74 (the threshold parameter IDs start at 0x0030, corresponding to range gate 0):

Frame Header	In-Frame Data Length	Command Word	Parameter ID	Parameter Value	Frame Tail
FD FC FB FA	08 00	07 00	31 00	25 E8 00 00	04 03 02 01

Saving Parameter Configuration After Power-Off

After configuring parameters such as the maximum range gate, no-person delay, installation method, and thresholds, send this command. The sensor then saves the current parameters.

- Command word: 0x00FD
- Command value: None
- Return value: 2-byte ACK status (0 = success, 1 = failure)

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	FD 00	04 03 02 01

ACK (successful):

Frame Header	In-Frame Data Length	Command Word	ACK	Frame Tail
FD FC FB FA	04 00	FD 01	00 00	04 03 02 01

If 0x00FD is not sent, the parameters will be lost after power-off.

2.2.6 Read Parameters

This command reads the sensor's current configuration parameters.

- Command word: 0x0008
- Command value: (2-byte parameter ID) × N
- Return value: (4-byte parameter value) × N

Outgoing data: read the maximum range gate configuration

```
FD FC FB FA 04 00 08 00 01 00 04 03 02 01
```

Radar ACK (successful; maximum range gate = 12):

```
FD FC FB FA 08 00 08 01 00 00 0C 00 00 00 04 03 02 01
```

Read the installation method:

```
FD FC FB FA 04 00 08 00 0E 00 04 03 02 01
```

Parameter value 00 00 00 00 indicates ceiling-mounted installation, while 01 00 00 00 indicates wall-mounted installation.

2.2.7 Configure System Parameters

This command configures the radar system parameters.

- Command word: 0x0012
- Command value: (2-byte parameter ID + 4-byte parameter value) × N
- Return value: 2-byte ACK status (0 = success; any other value = failure)

The parameter values correspond to the following modes.

Table 8 System Modes

No.	Parameter Value	Description
1	04 00 00 00	Debug mode: reports the energy values of each range gate and the detection result for parsing by XenD101HSTool.
2	64 00 00 00	Report mode: serial port print output status (no person: OFF, person detected: distance: + target range)

Outgoing data (example: debug mode, parameter ID = 0x0000):

```
FD FC FB FA 08 00 12 00 00 00 04 00 00 00 04 03 02 01
```

Outgoing data: configure reporting mode:

```
FD FC FB FA 08 00 12 00 00 00 64 00 00 00 04 03 02 01
```

Radar ACK:

```
FD FC FB FA 04 00 12 01 00 00 04 03 02 01
```

Use report mode when integrating the product with an MCU. When connecting to XenD101HSTool, the tool automatically switches to debug mode.

2.2.8 Read Photosensitive Sensor ADC

This command reads the photosensitive sensor ADC (four-sample averaging). The photosensitive resistor is not installed by default; the interface is reserved. Forced entry into configuration mode is not required.

- Command word: 0x0028
- Command value: None
- Return value: raw (u16 LE) + mV (u16 LE)

Conversion: mV = raw × 3300 / 4095

Outgoing data:

```
FD FC FB FA 02 00 28 00 04 03 02 01
```

ACK (successful example):

```
FD FC FB FA 08 00 28 01 00 00 FA 0F DF 0C 04 03 02 01
```

Field	Original bytes	Interpretation	
Response command	28 01	0x0028	0x0100
Status	00 00	ACK_OK	
raw	FA 0F	0x0FFA = 4090 (12-bit, full scale = 4095)	
mV	DF 0C	0x0CDF = 3295mV ≈ 3.295V	

4090 × 3300 / 4095 ≈ 3295 mV. When the voltage is close to 3.3V, this generally indicates a dark environment or an uninstalled photosensitive resistor in a typical “pull-up + photosensitive resistor to ground” circuit.

2.2.9 Read ChipID

This command reads the 96-bit UID. Forced entry into configuration mode is not required. Different modules have different IDs.

- Command word: 0x0029
- Command value: None
- Return value: 12-byte UID, (little-endian 3 × u32: UID_w0 | UID_w1 | UID_w2)

Outgoing data:

```
FD FC FB FA 02 00 29 00 04 03 02 01
```

ACK (successful example):

```
FD FC FB FA 10 00 29 01 00 00 50 34 50 41 0A 31 38 35 48 47 B2 00 04 03 02 01
```

Field	Original bytes	Interpretation
UID_w0	50 34 50 41	0x41503450
UID_w1	0A 31 38 35	0x3538310A
UID_w2	48 47 B2 00	0x00B24748

Complete 96-bit ChipID: 0x41503450_3538310A_00B24748.

When comparing with the IAP device ID, the device ID should be equal to UID_w0.

2.2.10 Read Device ID

This command reads the IAP device ID (the first 32 bits of the ChipID). It corresponds to the device ID on the "Update FW" page of XenD101HSTool. Configuration mode must be enabled first.

- Command word: 0x0075
- Command value: None
- Return value: 4-byte device ID (little-endian)

Outgoing data:

```
FD FC FB FA 02 00 75 00 04 03 02 01
```

ACK (successful example):

```
FD FC FB FA 08 00 75 01 00 00 50 34 50 41 04 03 02 01
```

The returned value 50 34 50 41 is consistent with UID_w0 from command 0x0029.

2.2.11 Read / Write Serial Number

Read Serial Number

- Command word: 0x0011
- Command value: None
- Return value: 2-byte ACK status (0 = success, 1 = failure) + SN length (2 bytes) + SN

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	11 00	04 03 02 01

ACK (successful, SN as example):

Frame Header	In-Frame Data Length	Command Word	ACK	SN Length	SN	Frame Tail
FD FC FB FA	08 00	11 01	00 00	02 00	CD AB	04 03 02 01

When no serial number has been programmed, the returned data area is FFFFFFFF, and the host computer displays the SN as FFFFFFFF. The SN length may also be 8 bytes (08 00 + 46 46 46 46 46 46 46 46).

Write Serial Number

- Command word: 0x0010
- Command value: SN length (2 bytes) + SN byte string
- Return value: 2-byte ACK status (0 = success, 1 = failure)

Outgoing data (example SN = AB CD):

Frame Header	In-Frame Data Length	Command Word	SN Length	SN	Frame Tail
FD FC FB FA	06 00	10 00	02 00	CD AB	04 03 02 01

ACK (successful):

Frame Header	In-Frame Data Length	Command Word	ACK	Frame Tail

FD FC FB FA	04 00	10 01	00 00	04 03 02 01

2.2.12 Read Sensor Register Command

This command reads the millimeter-wave sensor registers.

- Command word: 0x0002
- Command value: 2-byte chip address + (2-byte register address) × N
- Return value: (2-byte register data) × N

Outgoing data (example):

Frame Header	In-Frame Data Length	Command Word	Chip Address	Register Address	Frame Tail
FD FC FB FA	06 00	02 00	40 00	40 00	04 03 02 01

ACK (successful example):

Frame Header	In-Frame Data Length	Command Word	ACK	Register Data	Frame Tail
FD FC FB FA	06 00	02 01	00 00	07 02	04 03 02 01

2.2.13 Configure Sensor Register Command

This command writes to the millimeter-wave sensor registers.

- Command word: 0x0001
- Command value: 2-byte chip address + (2-byte register address + 2-byte register data) × N
- Return value: 2-byte ACK status (0 = success, 1 = failure)

Outgoing data (example):

Frame Header	In-Frame Data Length	Command Word	Chip Address	Register Address	Register Data	Frame Tail
FD FC FB FA	08 00	01 00	40 00	40 00	07 42	04 03 02 01

ACK (example):

Frame Header	In-Frame Data Length	Command Word	ACK	Frame Tail
FD FC FB FA	04 00	01 01	00 00	04 03 02 01

Note: Command word 0x0001 is for **register write**, while parameter ID 0x0001 represents **the maximum range gate**. Do not confuse the two.

2.2.14 Report Automatic-Threshold Interference

This command reports the automatic-threshold human-motion interference alarm from the millimeter-wave sensor.

Outgoing data:

Frame Header	In-Frame Data Length	Command Word	Frame Tail
FD FC FB FA	02 00	14 00	04 03 02 01

ACK:

Frame Header	In-Frame Data Length	Command Word	Parameter Value	Frame Tail

FD FC FB FA	06 00	14 01	2-byte status + 2-byte range gate status	04 03 02 01

Status values:

- 0000: Success, no interference
- 0001: Failure, interference detected

Example range gate status: 0x8402, when converted to binary, is 1000_0100_0000_0010; this indicates interference in range gates 1, 10, and 15.

2.3 Radar Data Output Protocol

Under the factory-default firmware normal operating mode, the Rd-101A / Rd-103A outputs detection results through the serial port. There are two output modes: **debug mode** and **report mode**.

When configured for report mode, the radar outputs the string OFF when no target is detected and outputs the string distance: + the target range when a target is detected. When configured for debug mode, the data format is defined in Table 10. Radar data is output according to the specified frame format.

2.3.1 Report Mode Data Format

Under the **report mode** (parameter value 0x64), the data format is shown in Table 9.

Table 9 Report Mode

Target Status	Motion Range
distance:	Target range
OFF	None

2.3.2 Debug Mode Data Format

Table 10 Debug Mode Data Frame Format

Field	Content
Frame header	F4 F3 F2 F1
Length	2 bytes; total byte count of the detection result, target range, and energy values of all range gates
Detection result	1 byte: 00 = no person, 01 = person detected
Target distance	2 bytes
Photosensitive value	2 bytes (reserved; the photosensitive sensor is not installed by default)
Motion energy	16 range gates × 4 bytes
Motion trigger threshold	16 range gates × 4 bytes
Stationary energy	16 range gates × 4 bytes
2D FFT data header	1 byte, 0xAA
2D FFT data	4 range gates × 4 bytes
Frame tail	F8 F7 F6 F5

2.4 Radar Command Configuration Method

2.4.1 Radar Command Configuration Procedure

The parameter configuration process is as follows:

1. The host computer sends “Enter Command Mode” to make the MCU enter command mode. At this time, the MCU does not perform human-body detection and only waits for commands from the host computer.
2. The host computer sends parameter-setting, parameter-reading, and other commands.
3. If the parameters need to be retained after power-off, send the save command 0x00FD.
4. The host computer sends “Exit Command Mode”. The MCU then enters normal operating mode and resumes human-body detection.

Shortest example (wall-mounted, maximum range gate = 10, disappearance delay = 12 seconds, save the settings, and restore report mode):

```
FD FC FB FA 04 00 FF 00 01 00 04 03 02 01
FD FC FB FA 08 00 07 00 0E 00 01 00 00 00 04 03 02 01
FD FC FB FA 08 00 07 00 01 00 0A 00 00 00 04 03 02 01
FD FC FB FA 08 00 07 00 04 00 0C 00 00 00 04 03 02 01
FD FC FB FA 02 00 FD 00 04 03 02 01
FD FC FB FA 08 00 12 00 00 00 64 00 00 00 04 03 02 01
FD FC FB FA 02 00 FE 00 04 03 02 01
```

Each command should receive an ACK with status 00 00. When a person approaches, distance: should be output. When the person leaves and the full delay has elapsed, OFF should be output.

2.4.2 Radar Configuration Precautions

1. The maximum data length of a single serial command must not exceed the buffer size (The buffer size is returned in the ACK for entering command mode and is 32 bytes in the current firmware). When reading or writing multiple registers exceeds this length, divide the operation into multiple commands.
2. Byte order: little-endian.
3. Because the serial port outputs radar data by default, the radar must be switched to command mode before sending commands. The usual procedure consists of three steps:

   Step 1. Send “Enter Command Mode” (The chip may still be outputting data, so the serial-port input may contain waveform data or OFF / distance: strings. The first response does not need to be analyzed).

   Step 2. Clear the serial port receive buffer (A delay of approximately 100ms is generally sufficient to ensure that the serial port data has been cleared).

   Step 3. Send “Enter Command Mode” again and analyze the returned result.
4. After command mode ends, send “Exit Command Mode” to resume detection and data output.
5. Custom command IDs are recommended to use the range 0x0060 – 0x00A0.
6. Commands 0x0028 and 0x0029 do not require entering configuration mode. Command 0x0075, parameter read/write operations, register read/write operations, system mode configuration, and similar commands require 0x00FF first.
7. The host computer tool and a third-party serial port tool cannot be used simultaneously.
8. Command word 0x0001 is used to configure sensor registers, while parameter ID 0x0001 represents the maximum range gate. Distinguish between them during parsing.