Rd-03 Serial communication protocol

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Document Resume

Version	Date	Develop/revise content	Formulate	Approval
V1.0.0	2023.06.29	First formulated	Zekai Qian	Jie Wei
V1.0.1	2024.11.28	Added automatic generation of threshold related instructions	Zekai Qian	Hong Xu

Content

1. Communication interface introduction

1.1. Pin definition and wiring

The Rd-03 module has a total of 5 pins, as shown in the pin diagram. The pin function definition table is the interface definition.

Front   Back
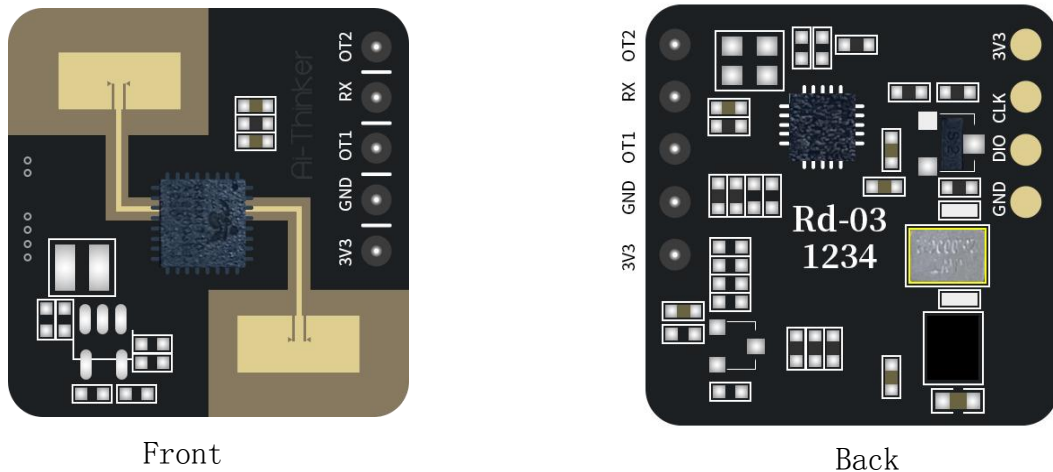
Figure 1 Pin diagram

Table 1 Rd-03 connected to TTL

Rd-03	USB to TTL
3.3V	3.3V
GND	GND
RX	TXD
OT1	RXD
OT2	Output high and low levels according to the detection results, no wiring

1.2. Configuration parameters and parameter descriptions

Users can modify the configuration parameters of the module through the serial port of Rd-03 to adapt to different application requirements. The configurable radar detection parameters are shown in Table 2.

Table 2 Rd-03 configuration parameters

Parameter name	Available range	Explanation
Minimum detection distance gate	0~15	Used to set the minimum detection distance of the radar. The length of a distance gate is 70cm.
Maximum detection distance gate	0~15	Used to set the maximum detection distance of the radar. The length of a range gate is 70cm
Delay time for target to disappear	0~65535	It takes a delay of "T"for the target status to switch from manned to unmanned. During this period, if a person is detected, the timing of this period will be restarted. The radar will only switch to the unmanned state and report that no one is there after detecting that the unmanned state has lasted for a full "T" time. The unit is seconds.
Trigger threshold	0~(2^32)-1	Module squared
Keep Threshold	0~(2^32)-1	Module squared
Debug Mode	N/A	Serial port reports RDMap (host computer analysis)
Normal Mode	N/A	Serial port print output status
Reporting Mode	N/A	The serial port reports the energy value and detection results of each distance gate (to be parsed by the host computer)

2. Communication Protocol

This communication protocol is mainly used by users who need to be independent of visualization tools. Rd-03 communicates with the outside world through the serial port (TTL level). The radar's data output and parameter configuration commands are all carried out under this protocol. The default baud rate of the radar serial port is 115200, 1 stop bit, and no parity bit.

2.1. Radar command configuration method

2.1.1. Radar command configuration steps

The process of setting parameters: Enter command mode → Configure/get parameter command → Exit command mode

1. The host computer sends "Open Command Mode" to make the MCU enter the command mode. At this time, the MCU does not perform human body detection and only waits for the command from the host computer.
2. The host computer sends commands such as parameter setting and parameter reading.
3. The host computer sends "exit command mode", at which point the MCU enters normal working mode and performs human body detection.

2.1.2. Radar Configuration Notes

Note：

1. The maximum data length of a single serial command does not exceed 64 bytes (the size is subject to the actual situation and may be different for each platform. When the host computer sends a start command, the result returned by the slave computer includes the cache size of the command communication). Therefore, when reading and writing multiple registers, if it exceeds 64 bytes, it needs to be divided into multiple commands.
2. Byte order: Little endian
3. Because the serial port will output radar waveform data by default, you need to switch to command mode before issuing commands. The usual practice is divided into three steps:
(1) Send "Open Command Mode" (because the chip may still be outputting data, the data received by the serial port will contain waveform data, so the returned result will not be analyzed).
(2) Clear the serial port buffer data (usually delay about 100ms to ensure that all serial port data are cleared).
(3) Send "Open Command Mode" again and analyze the returned results.
After the command mode ends, send "Close command mode" to start waveform data transmission.
4．It is recommended that the custom command ID range be between 0x0060 and 0x00A0.

2.2. Protocol Format

2.2.1. Protocol data format

The serial data communication of Rd-03 uses the little-endian format. All the data in the following table are in hexadecimal.

2.2.2. Command protocol frame format

The radar configuration command and ACK command formats defined by the protocol are shown in Tables 3 to 6.

Table 3 Send command protocol frame format

Frame Header	Data length in frame	Intra-frame data	Frame end
FD FC FB FA	2 bytes	Refer to Table 4	04 03 02 01

Table 4 Data format content in the sending frame

Command word (2 bytes)	Command value (N bytes)

Table 5 ACK command protocol frame format

Frame Header	Data length in frame	Intra-frame data	Frame end
FD FC FB FA	2 bytes	Refer to Table 6	04 03 02 01

Table 6 ACK frame data format

Send command word (2 bytes)	Command execution status (2 bytes)	Return value (N bytes)

2.3. Send command and ACK

2.3.1. Open command mode

Any other command issued to the radar must be executed after this command is issued, otherwise it will be invalid.

Command word:0x00FF

Command value:0x0001

Return value: 2-byte ACK status (0 for success, 1 for failure) + 2-byte protocol version (0x0002) + 2-byte buffer size (0x0020)

Send data：

Frame Header	Data length in frame	Command word	Command value	Frame end
FD FC FB FA	04 00	FF 00	01 00	04 03 02 01

Radar ACK (success):

Frame Header	Data length in frame	Command word	ACK	Protocol Version	Buffer size	Frame end
FD FC FB FA	08 00	FF 01	00 00	02 00	20 00	04 03 02 01

2.3.2. Turn off command mode

End the configuration command, and the radar will resume working mode after execution. If you need to send other commands again, you need to send the enable configuration command first.

Command word：0x00FE

Command value：N/A

Return value: 2-byte ACK status (0 for success, 1 for failure)

Send data：

Frame Header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	FE 00	04 03 02 01

Radar ACK (success):

Frame Header	Data length in frame	Command word	ACK	Frame end
FD FC FB FA	04 00	FE 01	00 00	04 03 02 01

2.3.3. Parameter configuration commands

This command sets the radar minimum detection distance gate, maximum detection distance gate, target disappearance delay time, trigger threshold and hold threshold parameters. For specific parameter words, please refer to Table 7.

Command word：0x0007

Command value：2-byte parameter word + 4-byte parameter value

Return value: 2-byte ACK status (0 for success, 1 for failure)

Table 7 0x0007 Protocol Parameter Word

Parameter name	Parameter word	Parameter range
Minimum detection distance gate	0x0000	0~15
Maximum detection distance gate	0x0001	0~15
Target disappearance delay time	0x0004	0~65535 (in seconds)
Trigger threshold	0x0010~0x001F	0~(2^32)-1, the square of the modulus
Hold threshold	0x0020~0x002F	0~(2^32)-1, the square of the modulus

Send data: Maximum detection distance gate 3 (not saved when power off)

Frame Header	Data length in frame	Command word	Parameter ID	Parameter Value	Frame end
FD FC FB FA	08 00	07 00	01 00	03 00 00 00	04 03 02 01

Radar ACK (success):

Frame Header	Data length in frame	Command word	ACK	Frame end
FD FC FB FA	04 00	07 01	00 00	04 03 02 01

Trigger threshold and hold threshold setting guide:

The threshold value is the signal-to-noise ratio, the input value is S/N, the calculation formula is $10\lg(S/N)$, the range is $0 \sim (2^{32})-1$

If the final threshold value is 47.47, the calculation method is $47.74 = 10\lg X$, $X = 10^{4.774}$, the calculation result of X is 59,429, and the final hexadecimal value is E825

The following configuration is required for the power-off saving parameters:

To query ABD, you need to add the ABD parameter when sending parameters.

1. To read ABD, send the following command

Frame header	Data length in frame	Command word	ABD	Frame end
FD FC FB FA	04 00	08 00	2F 00	04 03 02 01

2. The radar's ACK data will contain ABD parameters

Frame header	Data length in frame	Command word	ACK	ABD parameter	Frame end
FD FC FB FA	04 00	08 01	00 00	64 00 00 00	04 03 02 01

3. Maximum detection distance gate 3 power-off save reference, add ABD and parameters based on the command not sent

Frame header	Data length in frame	Command word	Parameter ID	Parameter Value	ABD	ABD parameter	Frame end
FD FC FB FA	0E 00	07 00	01 00	03 00 00 00	2F 00	64 00 00 00	04 03 02 01

4. Modify the trigger threshold of the first distance gate to 47.47 and save (the trigger threshold distance gate starts from 10, and the hold threshold distance gate starts from 20)

Frame header	Data length in frame	Command word	Parameter ID	Parameter Value	ABD	ABD parameter	Frame end
FD FC FB FA	0E 00	07 00	11 00	25 E8 00 00	2F 00	64 00 00 00	04 03 02 01

2.3.4. Read parameter command

This command can read the current configuration parameters of the radar

Command word: 0x0008

Command value: 2-byte parameter value

Return value: 2-byte ACK status (0 success, 1 failure) + 4-byte parameter value

Send data: Read the maximum detection distance gate

Frame header	Data length in frame	Command word	Parameter ID	Frame end
FD FC FB FA	04 00	08 00	01 00	04 03 02 01

Radar ACK: The maximum detection range gate is 3

Frame header	Data length in frame	Command word	ACK	Parameter Value	Frame end
FD FC FB FA	08 00	08 01	00 00	03 00 00 00	04 03 02 01

2.3.5. Start automatically generating threshold commands

This command sets the parameters for automatically generating thresholds and enables the MCU to start automatically generating threshold calculations. For specific parameter words, refer to Table 8.

Table 8 Automatically generated threshold parameter table

Parameter name	Parameter range	Explanation
Trigger threshold generation coefficient	0x000A~0x00C8	10 times magnification factor, for example, when the factor is 2, the parameter value is 0x0014
Hold threshold generation coefficient	0x000A~0x00C8	10 times magnification factor, for example, when the factor is 2, the parameter value is 0x0014

Command word: 0x0009

Command value: 4-byte parameter value

Return value: 2-byte ACK status (0 success, 1 failure).

Send data: Trigger threshold generation coefficient is 4, hold threshold generation coefficient is 1.5.

Frame header	Data length in frame	Command word	Parameter Value	Frame end
FD FC FB FA	06 00	09 00	28 00 0F 00	04 03 02 01

Radar ACK: Maximum detection range gate is 3.

Frame header	Data length in frame	Command word	ACK	Frame end
FD FC FB FA	04 00	09 01	00 00	04 03 02 01

2.3.6. Automatically generate threshold progress query commands

This command can query the progress of automatically generating thresholds. The return value contains the progress percentage. When the percentage is 100, it means that the threshold generation is complete.

Command word: 0x000A

Command value: None

Return value: 2-byte ACK status (0 success, 1 failure) + 2-byte percentage

Send data:

Frame header	Data length in frame	Command word	Frame end
FD FC FB FA	02 00	0A 00	04 03 02 01

Radar ACK: Success, percentage is 60%

Frame header	Data length in frame	Command word	ACK	Percent	Frame end
FD FC FB FA	06 00	0A 01	00 00	3C 00	04 03 02 01

2.3.7. Configuring system parameters

This command can configure the radar system parameters, parameter word

0x0000-systemMode

Command word: 0x0012

Command value: 2 bytes parameter word + 4 bytes parameter value

Return value: 2 bytes ACK status (0 success, 1 failure)

Table 9 0x0012 Protocol Parameter Word

Parameter name	Parameter Value	Explanation
Debug mode	0x0000	Serial port reports RDMap
Report mode	0x0004	Serial port reports energy value and detection results of each distance gate
Normal mode	0x0064	Serial port prints output status

Send data: Set to debug mode

Frame header	Data length in frame	Command word	Parameter ID	Parameter Value	Frame end
FD FC FB FA	08 00	12 00	00 00	00 00 00 00	04 03 02 01

Radar ACK：

Frame header	Data length in frame	Command word	ACK	Frame end
FD FC FB FA	04 00	12 01	00 00	04 03 02 01

2.4. Radar data output protocol

Rd-03 outputs radar detection results through the serial port. By default, it outputs basic target information, including target status and movement distance. If the radar is configured in reporting mode, the radar will additionally output the energy value of each range gate. Radar data is output in the specified frame format.

2.4.1. Reporting data frame format

In the normal radar mode defined by the protocol, the reporting message frame format is shown in Table 10. In the debugging mode and reporting mode, the definition of the reporting data type value is shown in Table 11 and Table 12.

Table 10 Normal mode

Target state	Movement distance
No	range distance（cm）
OFF	N/A

Table 11 Debug mode

Frame header	Data	Frame end
AA BF 10 14	RDMAP: 20 (Doppler) * 16 (range gate) * 4 (square of modulus)	FD FC FB FA

Table 12 Reporting Mode

Frame header	Data length	Test result	Target distance	Energy of each range gate	Frame end
F4 F3 F2 F1	2 bytes, the total number of bytes of detection results, target distance and energy values of each range gate	1 byte 00 No one 01 Someone	2 bytes	32 bytes, 16 (total number of range gates) * 2 bytes	F8 F7 F6 F5

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