24GMilimeterwave Bio-sensing radar

R24BBD1-Respiratory sleep radar

Datasheet (Ver.2.0)

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Content

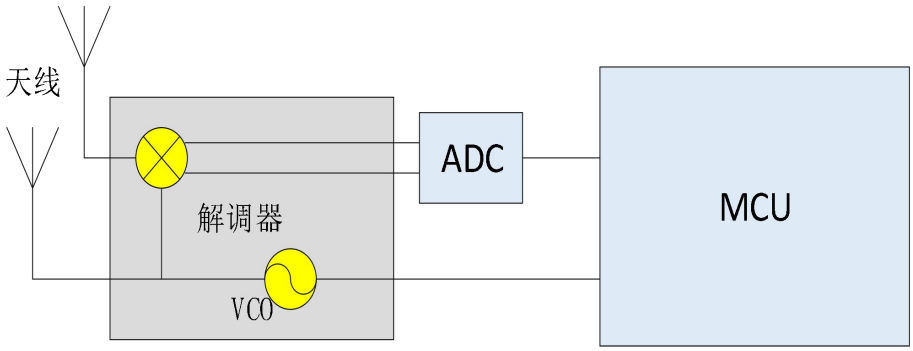
Overview

This document mainly describes the use of the radar, the problems that need to be paid attention to at each stage, reduce the design cost and increase the stability of the product as much as possible, and improve the completion efficiency of the project.

From the hardware circuit reference design, the layout requirements of the radar antenna and the housing, how to distinguish the interference and the multi-function standard UART protocol output.

This radar is a self-contained space sensing sensor. It is a module composed of a radio frequency antenna, a radar chip and a high-speed main frequency MCU. It relies on the core of a stable, flexible and superior algorithm architecture to solve users' various scene detection needs. It can be equipped with a host computer or host to flexibly output detection status and data, and meet several groups of GPIOs for user-customized development.

1. Working principle



The radar transmits millimeter wave signals in the 24G frequency band, and the measured target reflects the electromagnetic wave signal, and demodulates the transmitted signal,and then processes it through amplification, filtering, and ADC to obtain echo demodulated signal data. In the MCU unit, the amplitude, frequency and phase of the echo signal are calculated,and the target parameter(breathing,motion, micro-motion, etc.) measurement and scene evaluation are finally realized.

2. Hardware Design Considerations

The radar's rated power supply voltage needs to meet 4.9 - 6V, and under normal working conditions, the rated current requires an input of more than 200mA. Power supply design, power supply ripple should be ≤ 100mv.

2.1. The power supply can refer to the following circuit design

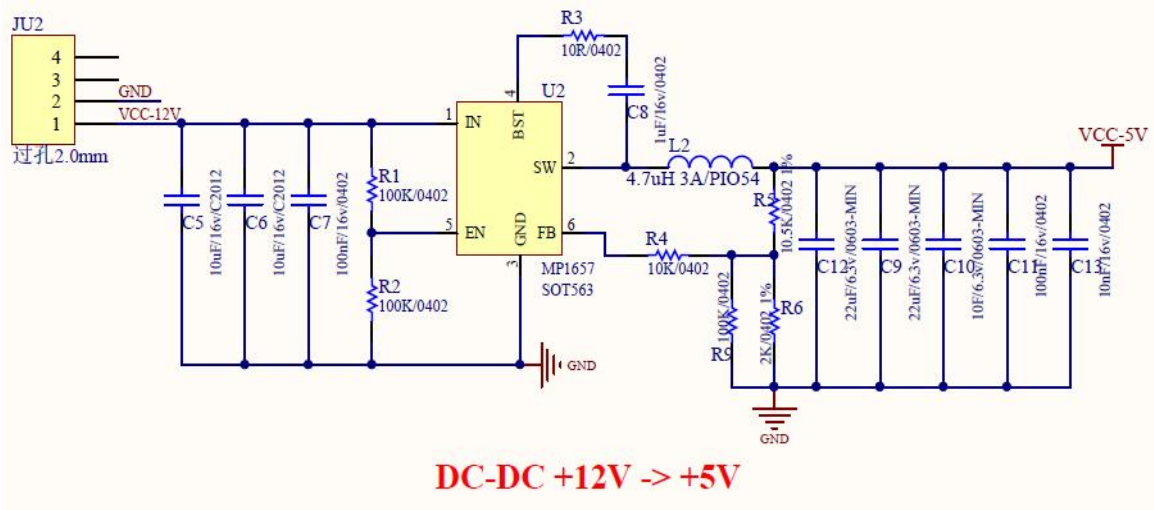


figure 1

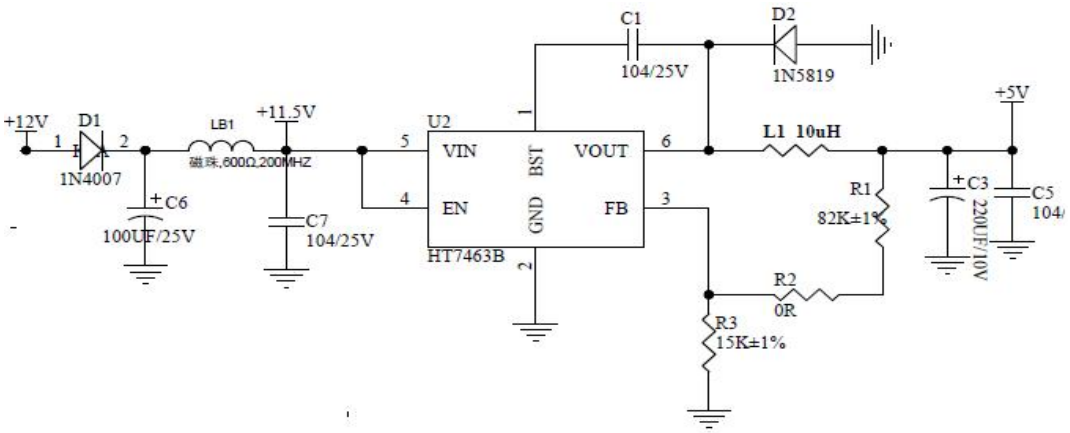


figure 2

2.2. Use wiring diagrams

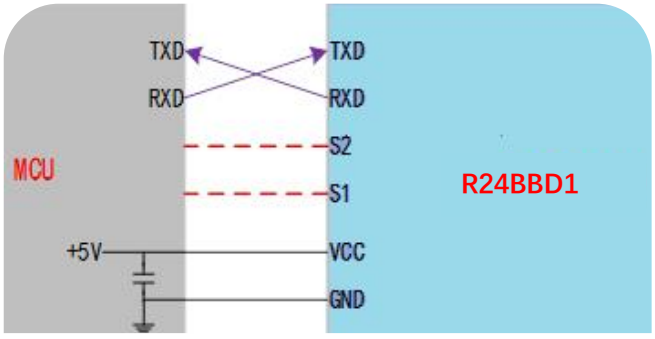


Figure 3 Schematic diagram of the connection between the radar module and the peripherals

3. Layout Requirements for Antenna and Housing

PCBA: Need to keep the height of the radar patch ≥ 1mm than other devices

Shell structure: It is necessary to maintain a distance of 2 - 5mm between the radar antenna surface and the shell surface

Shell detection surface: non-metallic shell, need to be straight, avoid curved surface, affect the performance of the entire scanning area.

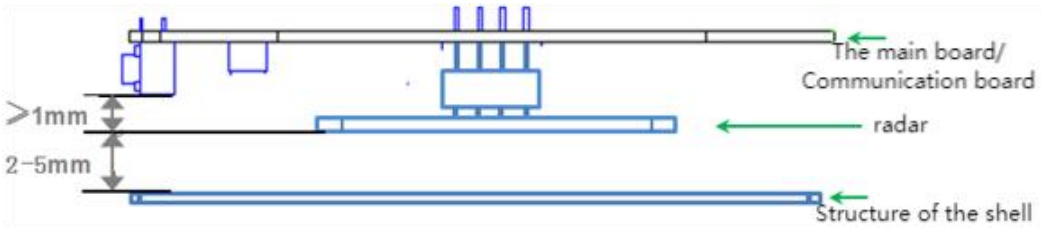


Figure 4

4. Static Protection

Radar products have static-sensitive circuits inside, which are prone to electrostatic hazards. Therefore, it is necessary to fully protect against static electricity during transportation, storage, work and handling.Do not touch and grab the radar module antenna surface and connector pins. Only touch its corners.

When handling the radar sensor, please wear anti-static gloves as much as possible.

5. Functional distraction

5.1 No one state, abnormal output is someone

In normal state, the radar will accurately determine the human body's sedentary state and the existence of sleep, and output information such as breathing and vital signs

A. The radar scanning area is large, the doorway, the next door movement of the plank wall is detected

Adjustment method: reduce radar sensitivity, radar provides scene settings

B. Below the radar is the air conditioner in operation, the fan
Adjustment method: adjust the radar position, do not directly face the air conditioner,fan

C. Object shaking caused by air-conditioning wind
Adjustment method: cotton, non-metallic items will not cause false alarms, metal items need to be fixed

D. Radar is not fixed, vibration causes false alarms
Adjustment method: avoid support shaking and vibration

E. Occasional moving objects such as pets and birds
Adjustment method: Since the radar measures fretting and has high sensitivity, this interference cannot be ruled out

F. Power disturbances, resulting in occasional misjudgments
Adjustment method: try to keep the power supply current stable and reduce the ripple

5.2 Person status, abnormal output unmanned

Radar transmits and receives electromagnetic waves to determine the presence of a human body. The closer you are to the radar, the higher the accuracy.

A. The human body is out of radar range
Radar scanning range, adjust the installation angle. The radar measurement range, in different environments, the electromagnetic wave reflection area is different, and the scanning area will be slightly different.

B. Metal occlusion causes false output
Too thick office chairs, metal seats. It will block the penetration of electromagnetic waves and cause misjudgment.

C. Scan angle difference
The radar did not scan the torso. cause misjudgment.

D. Radar sensitivity too low

Radar provides parameter adjustment to increase sensitivity improvement.

6. Detailed function

6.1. Function point description

function points	State change time/function explanation
DP1: Someone/Nobody	No one to someone, report within 0.5s From someone to no one, the unmanned state is output in about 1-2 minutes
DP2: Someone is stationary / Someone is active	Static and dynamic switching, reporting within 0.5 seconds
DP3: Someone approaching the device/someone moving away from the device/someone moving without direction	Output status once every 2 seconds
DP4: Body Motion Amplitude Parameter 0 - 100	Output data once every 5 seconds [Reference: Description of Body Motion Amplitude Parameter Output]
DP5: Getting in/Out of bed	From bed to bed, report to bed within 0.5s, output the bed-off status in about 1-2 minutes
DP6: Sleep state (awake/light/deep)	When in bed, judge and report the sleep state once every 10 minutes
DP7: Sleep Quality Score	At the end of the sleep process, report the score of this segment of sleep, with a score ranging from 0 to 100 points.
DP8: Respiratory rate	Output data once every 3 seconds, the unit is times/minute
DP9: breathing signal (abnormal breath hold/normal signal/no	Abnormal suffocation reported when breathing returns to zero

signal/abnormal movement)	When breathing is normal, the report signal is normal Report no signal when no one is in the state Report motion abnormality when exercising
DP10: Sleep switch	Control whether the sleep state data is output
DP11: Breathing switch	Controls whether breathing data is output
DP12: Sensitivity settings 1 - 10 steps	The default is sensitivity 4, which can support 10 gear adjustments
DP13: Scene mode (area detection, bathroom, hotel, bedroom, office, default mode)	Default is area detection scene mode Adapt to different scenarios according to the size of the area

6.2. Body Motion Amplitude Parameter Output Description

Body Motion Parameter		
0%	unmanned	unmanned environment
1%	still (sleep)	Only breathing without limb
2%-30%	micro-motion	Only slight head or limb movement
31%-60%	Ambulation/rapid body	slower body movement
61%-100%	running/close range	rapid body movement

7. Protocol description

This agreement applies to 24G Communication between the millimeter wave sleep detection radar and the host computer.

This protocol briefly introduces the radar workflow, briefly introduces the structure of the interface protocol, and gives the control commands and data required for the related radar work. The serial port communication is defined as follows:

Interface level: TTL
Baud rate: 9600bps
Stop bit: 1
Data bits: 8
Parity: None

8. Communication command and parameter definition

8.1. Frame structure definition and description

A, frame structure definition

start	Data length		function	address	address	data	check code	
0X55	Lenth_L	Lenth_H	Command	Address_1	Address_2	Data	Crc16_L	Crc16_H
1 Byte	1 Byte	1 Byte	1 Byte	1 Byte	1 Byte	n Byte	1 Byte	1 Byte

B, frame structure description

a. Start code: 1Byte, fixed as 0x55.

b. Data length: 2 Byte, low byte first, high byte after.

Length = data length + function code + address code 1+Address code 2+data+check code.

c. Function code: 1Byte

Read command: 0X01

Write command: 0X02

Passive report to order: 0X03

Active report command: 0X04

d. Address code: address code 1 means function classification, address code 2 indicates a specific function. See address assignment and data information description.

e. Data: n Byte

f. Check code: 2 Byte, low byte first, high byte after.

use CRC16 check, refer to appendix for reference code 1.

8.2. Address allocation and data information description

24G biological perception radar interface content					
	function code	Address code 1	Address code 2	data	Remark
1	read command 0x01	Identity query 0x01	Device ID 0X01		
2			Software version 0x02		
3			Hardware version 0x03		
4			Protocol version 0x04		
5		Radar information query	Environment status 0x05		
6			Physical		

		0x03	parameters 0x06		
7		System parameter query 0x04	Threshold gear 0x0C		
8			scene setting 0x10		
			Force into unmanned stall 0X12		
9		Other information inquiries 0X05	Sleep detection parameter switch 0X0D		Inquire Current sleep detection switch state
			Respiratory parameter switch 0X10		Inquire Current breathing parameter switch status

24G biological perception radar interface content					
1	write command 0x02	System parameter 0x04	Threshold gear 0x0C	enum range 1~10	correspond respectively 1 2 3 4 5 6 7 8 9 10 gears (default 4 gears) The larger the gear, the more sensitive
2			scene setting 0x10	Maximum area mode 0x00	
3				Area detection (top mounted) 0x01	default scene
4				Toilet (top mounted) 0x02	
5				Bedroom (top loading) 0x03	
6				Living room (top mounted) 0x04	
7				Office (top-mounted) 0x05	
8				Hotel (top loading) 0x06	
			Force into unmanned stall 0X12	Do not use coercion Enter the unmanned function	

				0x00	
				10s 0X01	
				30s 0X02	
				1min 0X03	
				2min 0X04	
				5min 0X05	
				10min 0X06	
				30min 0X07	
				60min 0X08	
9		Other functions 0X05	restart 0x04		
			Sleep function switch 0x0D	off 0x00	
				open 0x01	
			Respiratory parameter switch 0x10	off 0x00	
				open 0x01	
10			Start OTA upgrade 0X08	4byte integer data (firmware package size) + nbyte (software version number)	
			Upgrade package transfer 0X09	Packet offset (4byte) + Packet (1024byte)	
			Upgrade end message 0X0A	Fixed character 0X0F	

24G biological perception radar interface content					
1	Passive report command 0x03	Reporting module ID 0x01	Device ID 0x01	12 Byte data	
2			Software version 0x02	10 Byte data	
3			Hardware version 0x03	8 Byte data	
4			Protocol version 0x04	8 Byte data	

24G biological perception radar interface content					
1	Passive report command 0x03	Report radar information 0X03	Environment Status 0x05	Unmanned state 00 FF FF	
2				Someone is still 01 00 FF	
3				Someone sports 01 01 01	
4			Physical parameters 0x06	4 Byte Float data **(See Appendix 2)**	
5		report system parameters 0X04	Threshold gear 0X0C	Current gear value (0X01~0X0a)	
6			scene setting 0x10	Maximum area mode 0x00	
7				Area detection (top mounted) 0x01	default scene
8				Toilet (top mounted) 0x02	
9				Bedroom (top loading) 0x03	
10				Living room (top mounted) 0x04	
11				Office (top-mounted) 0x05	
12				Hotel (top loading) 0x06	
			Force into unmanned stall 0X12	Do not use coercion Enter the unmanned function 0x00	
				10s 0X01	
				30s 0X02	
				1min 0X03	
				2min 0X04	
				5min 0X05	
				10min 0X06	
				30min 0X07	
				60min 0X08	
13		Report other information 0X05	Sleep function switch 0X0D	off 0x00	
				open 0x01	
			Respiratory parameter switch 0X10	off 0x00	
				open 0x01	
14			Feedback OTA upgrade started	failure 0x00	
15				success 0x01	

			0X08		
16			Feedback OTA transmission 0X09	Fixed character 0X0F	

24G biological perception radar interface content						
1	Active report command 0x04	Report radar information 0x03	Environment Status 0x05	Unmanned state 00 FF FF		
2				Someone is still 01 00 FF		
3				Someone sports 01 01 01		
4			Movement sign parameter 0x06	4 Byte Float data		
5			close to far away state 0x07	fixed character 0x01 0x01	no 0x01	
					close to 0x02	
					stay away from 0x03	
6		Report other information 0X05	Heartbeat packet 0X01	Unmanned state 00 FF FF		
7				Someone is still 01 00 FF		
8				Someone sports 01 01 01		
9			Abnormal reset 0X02	0X0F		When the radar is restarted or powered on again will report first abnormal reset command start over initialization process final report Initialize success command
			Initialization successful 0X0A	0X0F		

					stands for radar Initialization successful start normal operation
24G biological perception radar interface content					
1	Sleep radar data report 0x05	Breathing parameter 0x01	Respiratory rate 0x01	1Byte integer data	
			Heartbeat 0x04	Abnormal suffocation 0x01	
				no 0x02	
				normal 0x03	
				Abnormal movement 0X04	When the movement of the National People's Congress occurs, it will prompt abnormal movement, informing the user that the big movement may affect the radar's detection of breathing
				Abnormal shortness of breath 0X05	
2		Scenario evaluation 0x03	Getting in/Out of bed 0x07	Get out of bed 0x00	
3				Bed 0x01	

				no 0x02	When the sleep switch is off, it shows no
4			sleep status assessment 0x08	awake 0x00	
5				light sleep 0x01	
6				deep sleep 0x02	
7				no 0x03	When the sleep switch is off, it shows no
8		Duration parameter 0x04	Awake time 0x01	4Byte shaping data	unit min
			Light sleep duration 0x02	4Byte shaped data	
			Deep sleep duration 0x03	4Byte shaping data	
9		Sleep quality parameter 0x05	Sleep quality score 0x01	1Byte integer data	
		Heart rate parameter 0x06	Heart rate value 0x01	1Byte integer data	Unit times/min
	sleep radar read command 0x0F	Scenario evaluation 0x03	Bed entry/exit monitoring 0x07	Get out of bed 0x00	
				Bed 0x01	
				no 0x02	
			sleep status assessment 0x08	awake 0x00	
				light sleep 0x01	
				deep sleep 0x02	
				no 0x03	

Description:

1) The read and write commands are commands sent by the host computer to the radar.

2) The report command is for the radar to send information to the upper computer.

3) The human body sensitivity is 1-10 gears, and the default is 7 gears. The larger the gear, the more sensitive it is.

appendix1: CRC check code reference parsing code

```
const unsigned char cuc_CRCHi[256]=
{
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40
};
```

```
const unsigned char   cuc_CRCLo[256]=
{
    0x00, 0xC0, 0xC1,   0x01, 0xC3, 0x03,   0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7,
    0x05, 0xC5, 0xC4,   0x04, 0xCC, 0x0C,   0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E,
    0x0A, 0xCA, 0xCB,   0x0B, 0xC9, 0x09,   0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9,
    0x1B, 0xDB, 0xDA,   0x1A, 0x1E, 0xDE,   0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC,
    0x14, 0xD4, 0xD5,   0x15, 0xD7, 0x17,   0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
    0x11, 0xD1, 0xD0,   0x10, 0xF0, 0x30,   0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32,
    0x36, 0xF6, 0xF7,   0x37, 0xF5, 0x35,   0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D,
    0xFF, 0x3F, 0x3E,   0xFE, 0xFA, 0x3A,   0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38,
    0x28, 0xE8, 0xE9,   0x29, 0xEB, 0x2B,   0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF,
    0x2D, 0xED, 0xEC,   0x2C, 0xE4, 0x24,   0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
    0x22, 0xE2, 0xE3,   0x23, 0xE1, 0x21,   0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1,
    0x63, 0xA3, 0xA2,   0x62, 0x66, 0xA6,   0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4,
```

```
    0x6C, 0xAC, 0xAD,   0x6D, 0xAF, 0x6F,   0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB,
    0x69, 0xA9, 0xA8,   0x68, 0x78, 0xB8,   0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA,
    0xBE, 0x7E, 0x7F,   0xBF, 0x7D, 0xBD,   0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
    0x77, 0xB7, 0xB6,   0x76, 0x72, 0xB2,   0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0,
    0x50, 0x90, 0x91,   0x51, 0x93, 0x53,   0x52, 0x92, 0x96, 0x56, 0x57, 0x97,
    0x55, 0x95, 0x94,   0x54, 0x9C, 0x5C,   0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E,
    0x5A, 0x9A, 0x9B,   0x5B, 0x99, 0x59,   0x58, 0x98, 0x88, 0x48, 0x49, 0x89,
    0x4B, 0x8B, 0x8A,   0x4A, 0x4E, 0x8E,   0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
    0x44, 0x84, 0x85,   0x45, 0x87, 0x47,   0x46, 0x86, 0x82, 0x42, 0x43, 0x83,
    0x41, 0x81, 0x80,   0x40
};
```

```
static unsigned shortint      us_CalculateCrc16(unsigned char *lpuc_Frame,unsi
    gned short int    lus Len)
{
    unsigned char luc_CRCHi = 0xFF;
    unsigned char luc_CRCLo = 0xFF;
    int li_Index=0;

    while (lus Len--)
    {
        li_Index = luc_CRCLo ^ *(lpuc_Frame++);
        luc_CRCLo = (t_BYTE)(luc_CRCHi ^cuc_CRCHi[li_Index]);
        luc_CRCHi = cuc_CRCLo[li_Index];
    }
    return (unsigned short int )(luc_CRCLo << 8 |luc_CRCHi);
}
```

Appendix 2: Motion Sign Parameter Parsing Code

```
typedef union
{
        unsigned char Byte[4];
        float Float;
}Float_Byte;


void main()
{
         Float_Byte fb;
         fb.Byte[0] = 0x9A;
         fb.Byte[1] = 0xFB;
        fb.Byte[2] = 0xE7;
        fb.Byte[3] = 0x3F;
        printf("%f\r\n",fb.Float);
}
```

9. Historical version update instructions

Revision	Release Data	Summary
V1.0_0212	2020/02/12	first draft
V1.1_0319	2021/03/19	readjust
V1.2_0628	2021/6/28	increased Human body sensitivity gear description
V1.3_0906	2021/9/06	Human Sensitivity changed from 0-9 to 1-10
V1.5_0210	2022/2/10	Added initialization success command protocol
V1.6_0221	2022/2/21	Add forced into unmanned stall protocol
V1.7_0224	2022/2/24	Added "none" protocol in bed in and out state And heart rate data reporting protocol
V1.8_0303	2022/3/3	Added respiratory parameter control switch protocol
V1.9_0309	2022/3/9	Added sleep radar read command
V2.0_0608	2022/6/8	Adjust the document cover and related data details