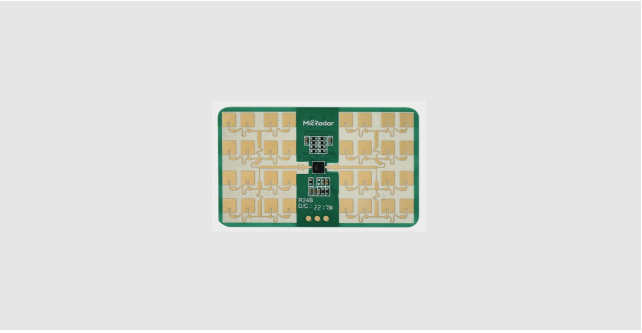

seed studio MR24BSD1 24GHz mmWave Module User Manual

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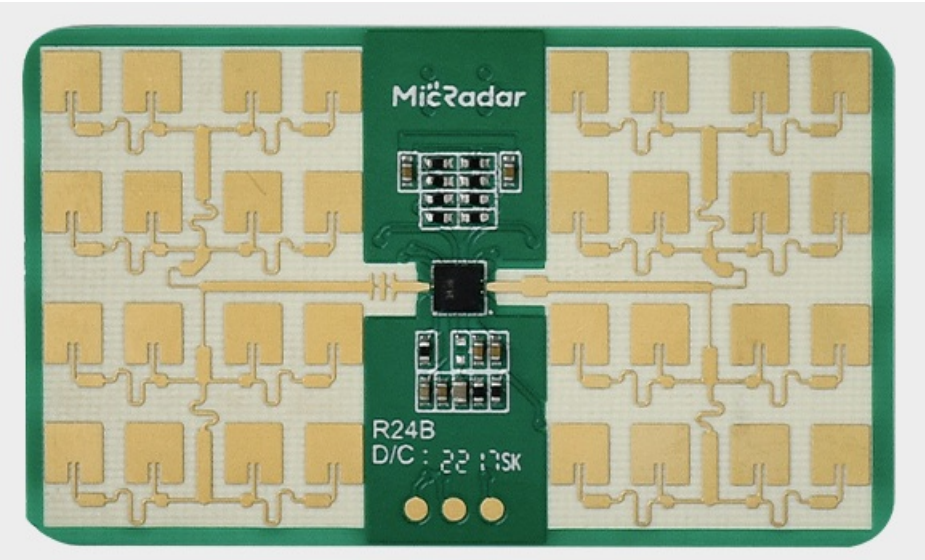
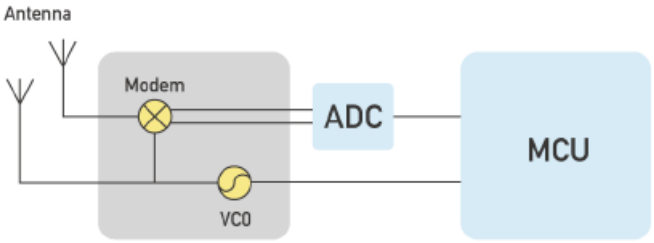
seed studio MR24BSD1 24GHz mmWave Module



Overview

This document focuses on the use of the radar, the issues that need to be addressed at each stage to minimize design costs and increase product stability and improve the efficiency of project completion. From hardware circuit reference design, radar antenna and housing layout requirements, how to differentiate between interference and multi-functional standard UART protocol outputs.
The radar is a self-contained space sensing sensor, consisting of RF antenna, radar chip and high speed main frequency MCU together with a module that relies on a stable and flexible superior algorithm architecture core to solve the user's various scenario detection needs, which can be equipped with a host computer or host computer to flexibly output detection status and data, meeting several groups of GPIOs for custom development.

Principle of operation



The radar transmits a millimetre wave signal in the 24G band, the measured target reflects the electromagnetic wave signal and demodulates the transmitted signal, which is then amplified, filtered and processed by ADC to obtain the echo demodulated signal data. The amplitude, frequency and phase of the echo signal are decoded in the MCU unit, which ultimately enables the measurement of target parameters (breathing, movement, micro-motion, etc.) and scene evaluation.

Hardware Design Considerations

The radar needs to have a rated supply voltage of 4.9 – 6V and a rated current requirement of 200mA or more input under normal operating conditions. The power supply must be designed for a supply ripple of ≤ 100mv.

The power supply can be designed with the following circuit in mind

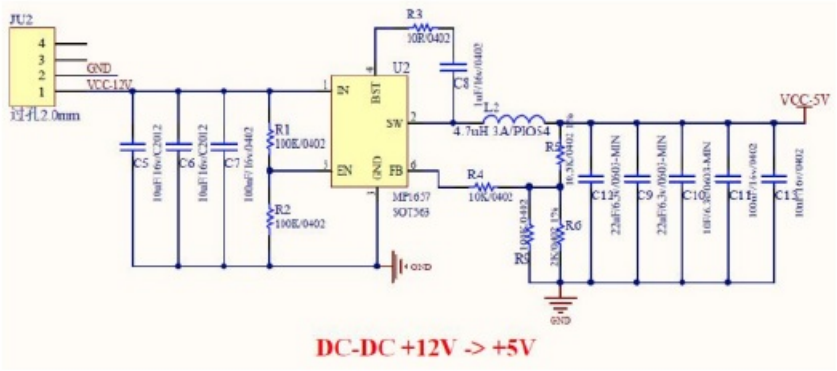


Fig. 1

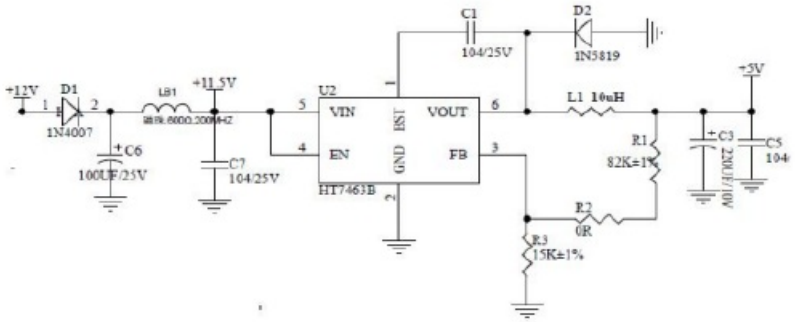


Fig. 2

using the wiring diagram

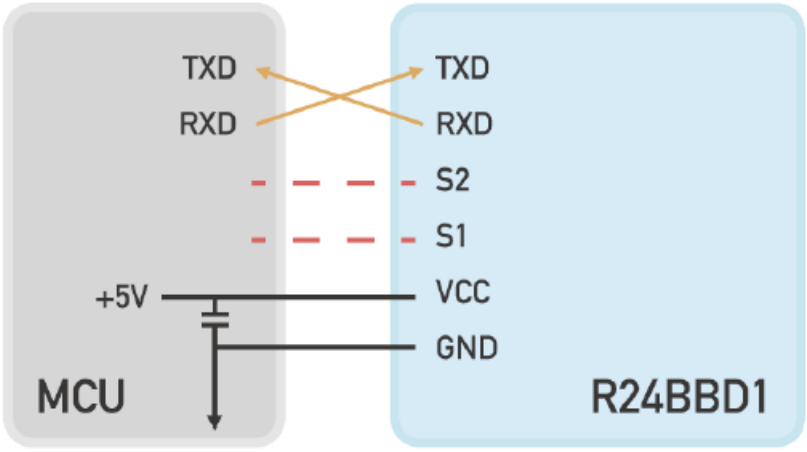


Fig. 3 Schematic diagram of the radar module and peripheral connections

Antenna and housing layout requirements
PCBA: the radar needs to be kept ≥ 1mm higher than the other components Housing construction: need to maintain a distance of 2 – 5mm between the radar antenna face and the housing face
Housing detection surface: non-metallic housing, needs to be flat and straight to avoid curved surfaces which can affect the performance of the entire swept surface area.

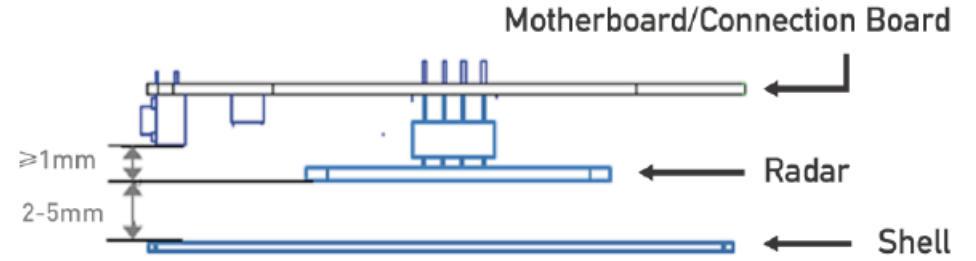


Fig. 4 Schematic diagram of the radar module and peripheral connections

Static Protection
Radar products have electrostatic sensitive circuitry and are susceptible to electrostatic hazards, therefore they need to be adequately protected from static electricity during transport, storage, work and handling. When handling radar sensors, please wear anti-static gloves if possible.

Functional disturbances

Unoccupied state, abnormal output occupied
In normal conditions, the radar will accurately determine the presence of a sitting or sleeping body and output information on falls, breathing, vital signs etc.

- Radar scanning area is large, doorway, boarded wall next door movement is detected
  Adjustment method: reduce radar sensitivity, radar provides scene setting B. Radar underneath is facing a running air conditioner or fan Adjustment: adjust the radar position so that it is not directly in front of the air conditioner or fan
- Shifting objects caused by air conditioning winds
  Adjustment method: cotton, non-metallic objects will not cause false alarms, metal objects need to be fixed
- The radar is not fixed, vibration causes false alarms
  Avoid supporting shaking and vibration

- Occasional moving objects such as pets, birds, etc.
  As the radar measures micro-movements, the sensitivity is very high and this interference cannot be excluded
- Power supply interference, resulting in occasional false alarms
  Try to keep the power supply current stable and reduce ripple

Manned status, abnormal output unoccupied
Radar determines the presence of a human body by sending and receiving electromagnetic waves. The closer you are to the radar, the more accurate it is.

- Human body out of radar range
  Radar scanning range with adjustment of mounting angle. Radar measurement range, in different environments with different electromagnetic wave reflection areas, the scanning area will vary slightly.
- False output due to metal occlusion
  Excessively thick desks and chairs, metal seats. It will block the electromagnetic wave penetration and cause misinterpretation. C. Differences in scanning angles
  The radar does not scan the torso area. This can lead to false positives. D. Radar sensitivity is too low
  The radar offers parameter adjustment to increase sensitivity for improvement.

Functions in detail

Function point descriptions

Functions	Status change time/function explanation
DP1: occupied/unoccupied	No one to occupied, report within 0.5s Manned to unoccupied, no status output in 1- 2 minutes or so
DP2: Some people are stationary / Some people are active	Static dynamic switching, reporting within 0.5 seconds
DP3: Someone close to the device / someone moving away from the device / someone moving without direction	Status output once every 2 seconds

Functions	Status change time/function explanation
DP4: Body movement amplitude parameter 0 – 100	Data output once every 5 seconds Reference (description of output of body motion amplitude parameters)
DP5: Sensitivity setting 1 – 10 steps	Default scene mode, adapted to 10 positions of adjustment
DP6: Scene modes (bed, bathroom, hotel, bedroom, office, default mode)	Adapted to different scenarios according to the size of the area
DP7: No false alarm confirmation prompt	
DP8: Sleep parameter switch	Off by default, sleep function only works when on
DP9: Bed entry/exit	Output status in 3S clock
DP10: Number of bed entries/exits	Count the number of times you enter/leave bed in a day
DP11: Stationary dwell alarms	Outputs in three states, once every 10 minutes
DP12: Length of Sobriety	
DP13: Length of light sleep	
DP14: Length of deep sleep	
DP15: Breathing rate	Normal number of breaths can be tested
DP16: Breathing rate detection signal	If there are factors such as distance, range and other effects, output breath-holding abnormalities, good signals, abnormal movements, abnormal states of shortness of breath
DP17: Sleep scoring (optional, users can rate according to their own way)	Combined day’s sleep rating

Description of the output of the body motion amplitude parameter

Body movement amplitude parameters		
0%	None	Environmental unmanned
1%	Stationary (sleep)	Only breathing without body mov ement
2% – 30%	Micro-Movements	Only minor head or limb moveme nts Movement
31% – 60%	Walking/fast body movements	Slower body movements
61% – 100%	Running/close range big moves	Rapid body movement

Description of the agreement

This protocol is used to communicate between a 24G millimeter wave sleep detection radar and a host computer. This protocol outlines the radar workflow, provides a brief introduction to the interface protocol component architecture and gives the control commands and data required for the operation of the relevant radar, with the serial communication defined as follows.

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

Communication commands and parameter definitions

Definition and description of the frame structure

- Frame structure definition
- Description of the frame structure
    - Start code: 1 Byte, fixed to 0X55.
    - Data length: 2 Byte, low byte before, high byte after.
      Length = Data Length + Function Code + Address Code 1 + Address Code 2 + Data + Checksum.
    - Function code: 1 Byte
    - Read command: 0X01 Write command: 0X02
      Passive report command: 0X03
      Active report command: 0X04
- Address code: Address code 1
  indicates the function classification, address code 2 indicates the specific function.
  See the description of address assignment and data information.
- Data: n Byte
- Checksum: 2 Byte, low byte before, high byte after.
  CRC16 checksum is used, see Appendix 1 for reference code.

Description of address assignment and data information

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
1			Device ID 0X01		
2		Marking	Software version 0x02		
		search			
3		0x01	Hardware version 0x03		
4			Protocol version 0x04		
5		Radar Information	Environmental status 0X05		
		Search			
6	Read command	0x03	Signs parameters 0x06		
	0x01				
7			Threshold gear 0x0C		
		System			
8		parameter	Scene setting 0x10		
		search			
		0x04	Forced into unoccupied		
			gear 0X12		
		Other			Enquiry
9		information enquiries	Sleep detection parameter switch 0X0D		Current sleep detection
		0X05			switch status

24G Bio-aware radar interface content					
1	copy order 0x02	System parameters 0x04	Threshold gear 0x0C	Enumeration range1~10	Corresponding to1 2 3 4 5 6 7 8 9 10 gears (default 7) The higher the gear, the more sensitive it is
2			Scene setting 0x10	Default mode 0x00	
3				Area detection (top loading) 0x01	
4				Bathroom (top mounted) 0x02	
5				Bedroom (top loading) 0x03	
6				Living room (top mounted) 0x04	
7				Office (top loading) 0x05	
8				Hotel (top loading) 0x06	
			Forced into unoccupied gear 0X12	No forced access to the unoccupied function 0X00	
				10s 0X01	
				30s 0X02	
				1min 0X03	
				2min 0X04	
				5min 0X05	
				10min 0X06	
				30min 0X07	
				60min 0X08	

24G Bio-aware radar interface content

9		Other functions 0X05	Reboot 0X04		
10			Sleep function s witch 0x0D	Off 0x00	
				On 0x01	
			Start OTA upgrade 0X08	4byte Integer data (firmware package size)+ nbyte (software version number)	
			Upgrade packag e transfer 0X09	Packet Offset (4byte) + Packet (1024 byte)	
			End of upgrade i nformation 0X0A	Fixed characters 0X0F	

24G Bio-aware radar interface content						
1	Passive		Device ID 0x01	12 Byte data		
2	reportin g of orders	Reporting modul e identification 0 X01	Software version 0x02	10 Byte data		
3			Hardware version 0x03	8 Byte data		
4	0x03		Protocol version 0x04	8 Byte data		

24G Bio-aware radar interface content					
1	Passive reporting of orders 0x03	Upload Radar Info 0x03	Environment status 0x05	Nobody 00 FF FF	
2				Static 01 00 FF	
3				Movement 01 01 01	
4			Signs parameters 0x06	4 Byte Float data (see Appendix 2)	
5		Reporting system parameters 0X04	Threshold gear 0X0C	Current gear value (0X01~0X0a)	
6			Scene setting 0x10	Default mode 0x00	
7				Area detection (top loading) 0x01	
8				Bathroom (top mounted) 0x02	
9				Bedroom (top loading) 0x03	
10				Living room (top mounted) 0x04	
11				Office (top loading) 0x05	
12				Hotel (top loading) 0x06	
			Forced into unoccupied gear 0 X12	No forced access to the unoccupied function 0X00	
				10s 0X01	
				30s 0X02	
				1min 0X03	
				2min 0X04	
				5min 0X05	
				10min 0X06	
				30min 0X07	
				60min 0X08	

13		Other functions 0X05	Sleep function switch 0x0D	Off 0x00	
				On 0x01	
14			Start OTA upgrade 0X08	Failed 0X00	
15				Success 0X01	
16			Upgrade package transfer 0X09	Fixed characters 0X0F	

24G Bio-aware radar interface content						
1	Proactive reporting of commands 0X04	Report radar information 0x03	Environment status 0x05	Unoccupied 00 FF FF		
2				Someone is stationary 01 00 FF		
3				U Some people exercise 01 01 01		
4			Motor signs parameters 0X06	4Byte Float data		
5			Approaching away state 0x07	Fixed characters 0x01 0x01	None 0x01	
					Approach 0x02	
					Far away 0x03	
6		Report other information 0X05	Heartbeat Pack 0X01	Unoccupied 00 FF FF		
7				Someone is stationary 01 00 FF		
8				Some people exercise 01 01 01		

24G Bio-aware radar interface content					
9			Abnormal reset 0X02	0X0F	When the radar is resta rted or re- powered, an abnormal reset comma nd is reported before th e initialisation process begins and a successful initialisation command is reported.
			Initialisation suc cessful 0X0A	0X0F	
					This means that the rad ar has been initialized successfully.
					Start of normal operatio ns.

24G Bio-aware radar interface content					
1	Sleeping		Breathing rate 0x0 1	1Byte integer data	
	radar	Breathing		Breath-holding	
	data reporti ng 0x05	parameters 0x 01	Detection signal 0x 04	abnormality 0x01	
				No 0X02	
				Normal 0x00	

24G Bio-aware radar interface content					
				Movement abnormalities 0X04	When large movements of the person occur, abnormal movements are indicated, informing the user that large movements may affect the radar's detection of breathing
				Shortness of breath abnormal 0X05	
2		Scenario assessment 0x03	In/out of bed 0x07	Out of bed 0X00	
3				In bed 0X01	
				None 0x02	Sleep switch off shows none
4			Sleep state assessment	Awake 0x00	
5				Light sleep 0x01	
6				Deep sleep 0x02	
7				None 0x03	Sleep switch off shows none
8		Duration parameter 0x04	Duration of wakefulness 0x01	4Byte integer data	Unit min
			Length of light sleep 0x02	4Byte integer data	
			Length of deep sleep 0x03	4Byte integer data	

24G Bio-aware radar interface content					
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

Description.

1. The read/write command is for the upper computer to send commands to the radar.
2. The report command is for the radar to send information to the upper computer.
3. Fall sensitivity is 1~10, default is 4, the higher the level, the more sensitive it is
4. Human body sensitivity is 1~10 steps, default 7 steps, the higher the step, the more sensitive it is

Appendix 1: CRC check digit reference parsing codes

```
1. const unsigned char  cuc_CRCHi[256]=
2. {
```

```
    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, 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, 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,
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    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
};
```

```
1.  static unsigned short int  us_CalculateCrc16(unsigned char *lpuc_Frame, unsi
    gned short int  lus_Len)
2.  {
3.    unsigned char luc_CRCHi = 0xFF;
4.    unsigned char luc_CRCLo = 0xFF;
5.    int li_Index=0;
6.
7.    while(lus_Len--)
8.    {
9.        li_Index = luc_CRCLo ^ *( lpuc_Frame++);
10.       luc_CRCLo = (t_BYTE)( luc_CRCHi ^ cuc_CRCHi[li_Index]);
11.       luc_CRCHi = cuc_CRCLo[li_Index];
12.   }
13.   return (unsigned short int )(luc_CRCLo << 8 | luc_CRCHi);
14. }
```

Appendix 2: Analysis codes for motor sign parameters

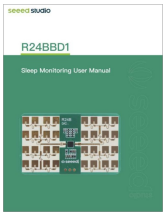
```
typedef union
{
    unsigned char Byte[4];
    float Float;
}Float_Byte;

 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);
}
```

Historical version update notes

Revision	Release Data	Summary
V1.0_0212	2020/02/12	First draft
V1.1_0319	2021/03/19	Readjustment
V1.2_0628	2021/6/28	Add Human sensitivity explained and fall sensitivity explained
V1.3_0906	2021/9/06	Human sensitivity revised from 0-9 to 1-10
V1.5_0210	2022/2/10	Add initialization success command protocol
V1.6_0221	2-22/2/21	Adding a forced entry unmanned gear protocol
V1.7_0224	2022/2/24	Addition of a “none” protocol in the entry and exit states and a protocol for reporting heart rate data

Documents / Resources

	**seed studio MR24BSD1 24GHz mmWave Module** [pdf] User Manual MR24BSD1, 24GHz mmWave Module, mmWave Module, MR24BSD1, Module