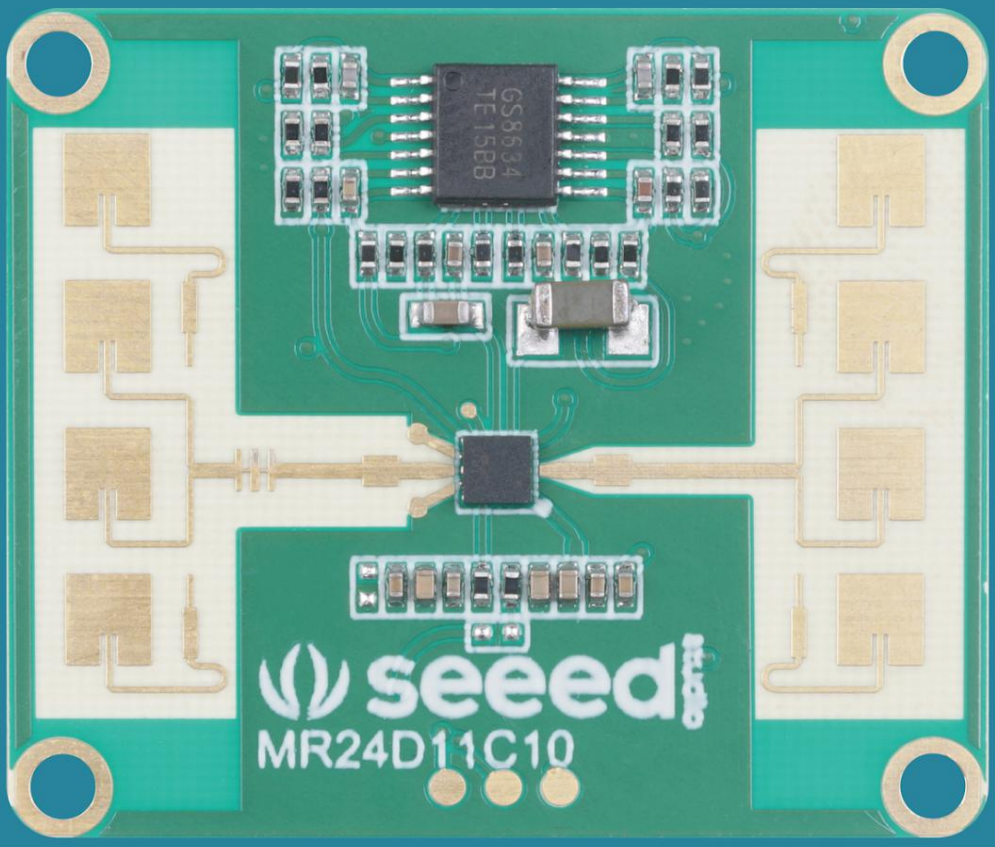
MR24FDB1

Fall Detection Radar User Manual



CONTENTS

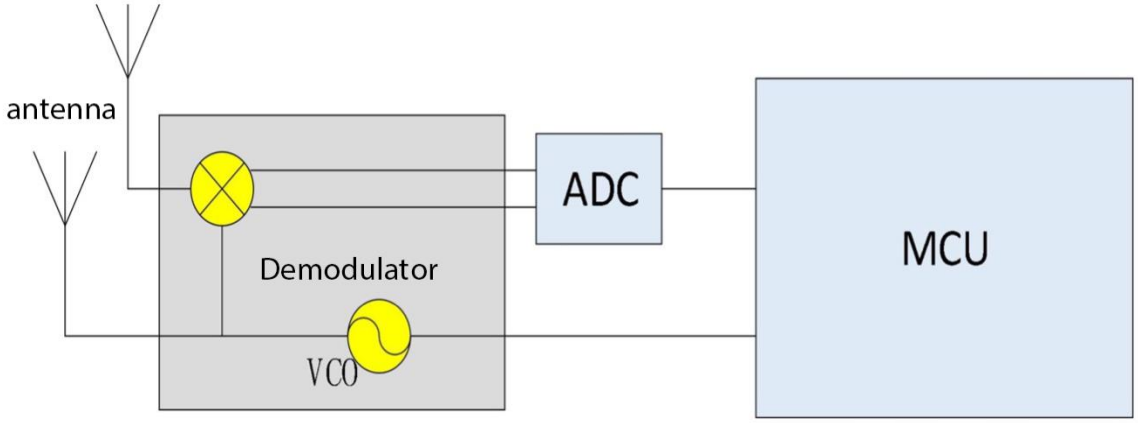
Overview

This manual primarily describes the practical application of the radar system and the issues that should be addressed at each stage to minimize design costs, increase product stability, and improve project efficiency.

This manual talks about the hardware circuit reference design, the radar antenna and shell layout requirements, and the use of a multifunctional standard UART protocol.

The radar is a self-contained space sensing module comprising an RF antenna, radar chip, and high-speed main frequency processing unit. The system's core relies on a stable, flexible, and superior algorithm architecture to meet the user's diverse scene detection requirements. It can operate with a local computer or host computer to output detection statuses and data. In addition, it has several groups of GPIOs for user customization and development.

1. Principle of operation



The radar transmits a 24G band millimeter-wave signal, the measured target reflection electromagnetic wave signal, demodulates the transmitted signal, and then obtains echo demodulation signal data through amplification, filtering, ADC, and other processes. The echo signal's amplitude, frequency, and phase are decoded in the MCU unit, which ultimately enables the measurement of the target parameters (breathing, motion, tiny motions, etc.).

2. Hardware Design Considerations

The standard voltage power supply and input current of the radar under normal circumstances should be 4.9–6V and 200 mA, respectively. Power supply design, power ripple ≤ 100mV.

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

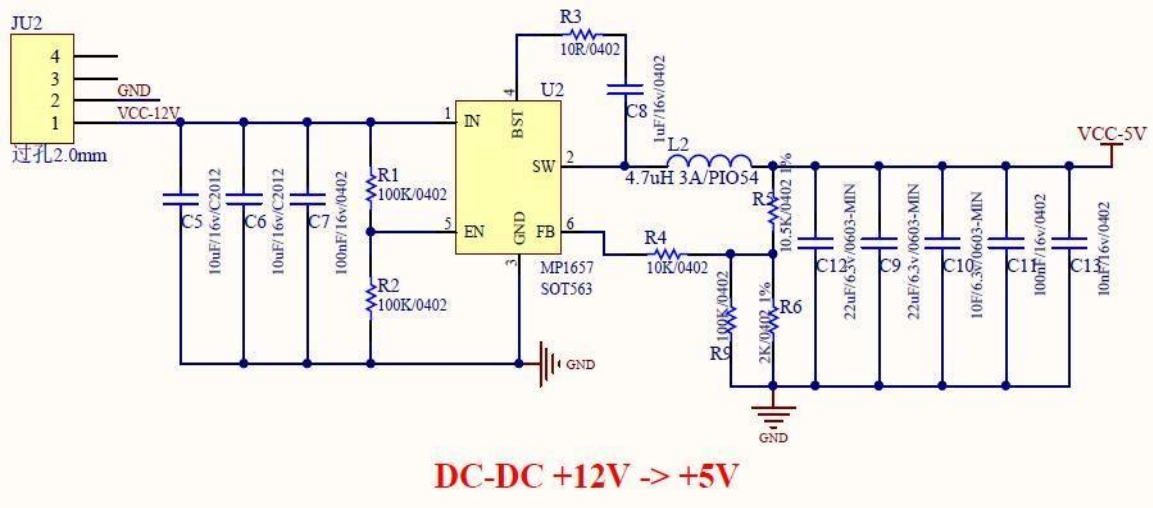


Fig. 1

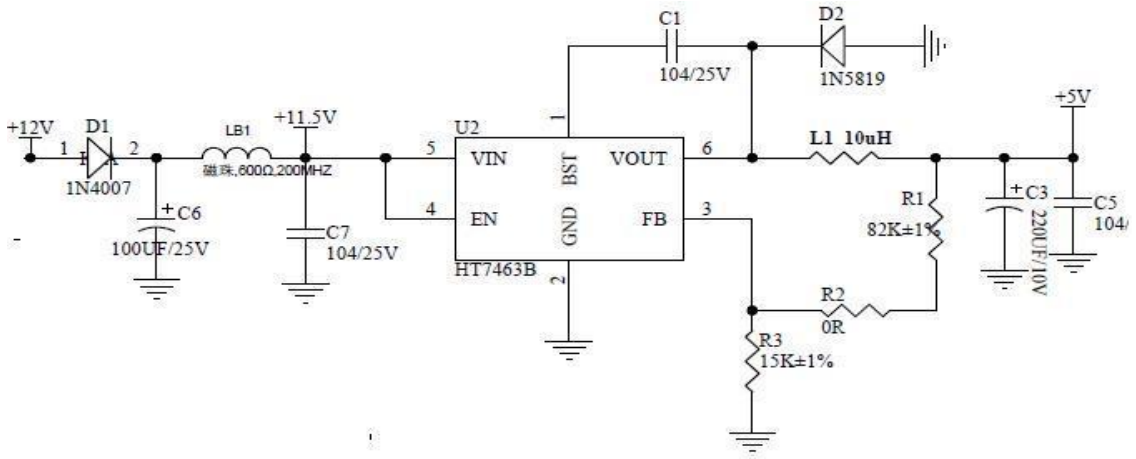


Fig. 2

2.2. using the wiring diagram

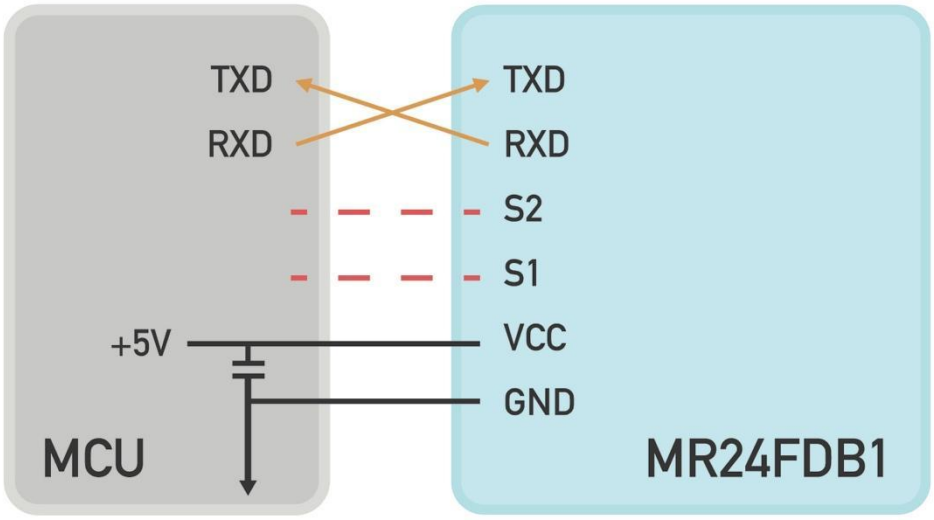


Fig. 3 Schematic diagram of the radar module and peripheral connections

3. Antenna and housing layout requirements

PCBA: Mount the radar ≥1mm higher than the other devices.

Case: Keep 2-5mm between the radar antenna and other shell surfaces.
Case detection surface: To avoid coverage area performance, keep the non-metallic case flat and straight to avoid bending.

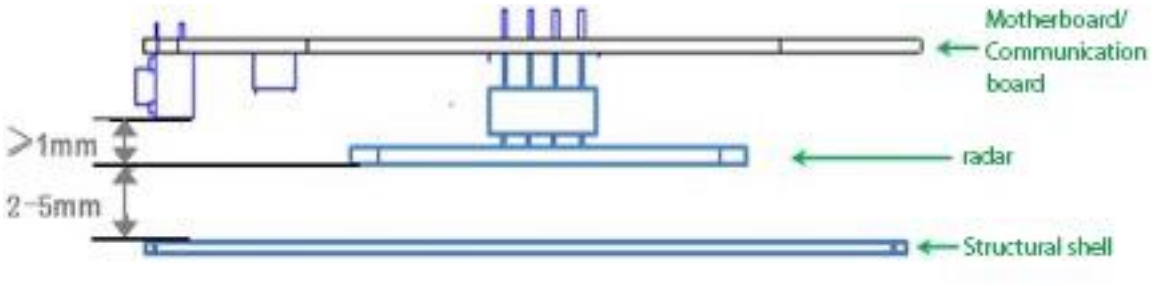


Fig. 4

4. Static Protection

Radar modules contain electrostatic-sensitive circuits, so they risk electrostatic shocks. Thus, it is essential to maintain proper electrostatic protection throughout the process of

transportation, storage, work, and handling. Avoid touching the radar module's antenna surface and connector pins, but hold the corners. We recommend that you wear anti-static gloves during the operation of the radar sensor.

5. Functional disturbances

5.1 Unoccupied state, abnormal output occupied

When the radar is in its normal state, it will accurately determine the existence of human sitting or sleeping states and will output fall data, breathing information, vital signs, etc.

a. Radar scanning covers a large area. You can detect movement around the doorway and the next door in the wooden wall.
   Adjustment method: Reduce radar sensitivity; the radar has scene settings

b. When the radar is facing toward the air conditioner and fan when it is operating
   Adjustment method: Position the radar so it doesn't directly face the air conditioner and fan

c. Object shaking caused by air conditioning wind
   Adjustment method: Cotton and non-metallic items do not cause false alarms. Metal items should be well-positioned to avoid interference.

d. If the radar is not fixed, vibration may cause false alarms. To prevent this from occurring, support the radar in a fixed position to avoid vibrations and shakes.

e. Occasional moving objects, such as pets, birds, or other animals.
   Because of the high sensitivity of the radar's detection of micromotions, this interference cannot be eliminated.

f. Power supply interference can interfere with judgment, resulting in occasional errors.
   Maintain a stable current power supply and minimize ripple.

5.2 Manned status, abnormal output unoccupied

Radar can determine whether a human body exists by transmitting and receiving electromagnetic waves. The closer the body is to the radar, the higher the accuracy is.

a. The human body is out of radar’s range.
   Adjust the installation angle to fit the range of the radar.

Measurement range: the electromagnetic wave reflection area is different in different environments, and the scanning area may be slightly different.

b. Output error due to metal shielding
Thick office desks and chairs and metallic seats. This will block electromagnetic waves from penetrating and causing inaccurate judgments.

c. The difference in scanning angle.
When the radar fails to detect the body part (torso area), it can cause errors.

d. The radar's sensitivity is too low
The radar can be adjusted in order to improve sensitivity.

6. Functions in detail

6.1. 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
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

Functions	Status change time/function explanation
	positions of adjustment
DP7: Scene modes (bed, bathroom, hotel, bedroom, office, default mode)	Adapted to different scenarios according to the size of the area
DP8: No false alarm confirmation prompt	
DP9: Fall switch	Off by default, fall function only works when on
DP10: Fallen state	Two level judgement "suspected fall", "fall alarm" Suspected fall – target fall detected Output status Fall alarm – alarm reported after time T is stationary
DP11: fall alarm reporting time T	Default 3 minutes, divided into 1–30 minute setting steps
DP12: Stationary dwell alarms	Reported in four time grades

6.2. 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 movement

2% – 30%	Micro-Movements	Only minor head or limb movements Movement
31% – 60%	Walking/fast body movements	Slower body movements
61% – 100%	Running/close range big moves	Rapid body movement

7.Protocol Specifications

This protocol is used for communications between a millimeter-wave sleep detection radar and a host computer. The protocol outlines the radar's workflow, describes the interface protocol's composition architecture, and provides the commands and data necessary for the relevant radar function. The serial port is defined as the following:
Interface level: TTL
Baud rate: 9600bps
Stop bits: 1
Data bits: 8
Parity: None

8. Communication commands and parameter definitions

8.1 Definition and description of the frame structure

A. Frame structure definition

Starting Code	Length of data		Function codes	Address code 1	Address code 2	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. Description of the frame structure

a. Start code: 1 Byte, fixed to 0X55.
b. Data length: 2 Byte, low byte before, high byte after. Length = Data Length + Function Code + Address Code 1 + Address Code 2 + Data + Checksum.
c. Function code: 1 Byte

Read command: 0X01
Write command: 0X02
Passive report command: 0X03
Active report command: 0X04

d. Address code:
The address code 1 indicates the function classification.
The address code 2 indicates the specific function.
Refer to the address assignment and data information description.
e. Data: n Byte
f. Checksum: 2 Byte, low byte before, high byte after.
CRC16 checksum is used. Refer to Appendix 1 for reference codes

8.2. Description of address assignment and data information

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Read command 0x01	Marking search 0x01	Device ID 0x01		
2			Software version 0x02		
3			Hardware version 0x03		
4			Protocol version 0x04		
5		Radar Information Search 0x03	Environmental status 0x05		
6			Signs parameters 0x06		
7		System parameter search 0x04	Threshold gear 0x0C		
8			Scene setting 0x10		
9		Other information enquiries 0X05	Fall function switch 0X0B		Enquiry Current fall function switch

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
					status
10			Fall alarm time query 0X0C		Enquiry Current fall alarm time
			Fall sensitivity query 0X0E		Enquiry Current fall sensitivity

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1		System parameters 0x04	Threshold gear 0x0C	Enumeration range1~10	Corresponding to 1 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	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
6	copy order 0x02			Living room (top mounted) 0x04	
7				Office (top loading) 0x05	
8				Hotel (top loading) 0x06	
9			Reboot 0x04		
10			Fall function switch 0x0B	Off 0x00	
				On 0x01	
			Fall alarm time 0X0C	1min 0X00	
				2min 0X01	
				3min 0X02	
				4min 0X03	
				5min 0X04	
				6min 0X05	
				7min 0X06	
				10min 0X07	
				15min 0X08	
				30min 0X09	
			Fall sensitivity setting	0X01 1st gear	Default fall sensitivity is 4. The lower the gear,
				0X02 2nd gear	
				0X03 3rd gear	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
		Other functions 0x05	0X0E	0X04 4th gear	the less sensitive it is. The higher the gear, the more sensitive it is.
				0X05 5th gear	
				0X06 6th gear	
				0X07 7th gear	
				0X08 8th gear	
				0X09 9th gear	
				0X0a 10th gear	
11			Start OTA upgrade 0X08	4byte Integer data (firmware package size) + nbyte (software version number)	
12			Upgrade package transfer 0X09	Packet Offset (4byte) + Packet (1024byte)	
13			End of upgrade information 0X0A	Fixed characters 0X0F	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Passive reporting of orders 0x03	Reporting module identification 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 Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Passive reporting of orders 0x03	Report radar information 0x03	Environment status 0x05	Unoccupied 00 FF FF	
2				Someone is stationary 01 00 FF	
3				Some people exercise 01 01 01	
4			Signs parameters 0x06	4 Byte Float data (see appendix 2)	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Passive reporting of orders 0x03	Reporting system information 0x04	Threshold gear 0x0C	Current gear value (0x01~0x0a)	
2			Scene setting 0x10	Default mode 0x00	
				Area detection (top loading) 0x01	
				Bathroom (top mounted) 0x02	
				Bedroom (top loading) 0x03	
				Living room (top mounted) 0x04	
				Office (top loading) 0x05	
				Hotel (top loading) 0x06	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Passive reporting of orders 0x03	Report additional information 0X05	Feedback OTA Upgrade Start 0X08	Failure 0X00	
2				Success 0X01	
3			Feedback OTA transmission 0X09	Fixed characters 0X0F	
			Fall function switch	Off 0X00	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
			0X0B	On 0X01	
4			Fall alarm time 0X0C	1min 0X00	
				2min 0X01	
				3min 0X02	
				4min 0X03	
				5min 0X04	
				6min 0X05	
				7min 0X06	
				10min 0X07	
				15min 0X08	
				30min 0X09	
			Response to fall sensitivity setting 0X0E	0X01 1st gear	
				0X02 2nd gear	
				0X03 3rd gear	
				0X04 4th gear	
				0X05 5th gear	
				0X06 6th gear	
				0X07 7th gear	
				0X08 8th gear	
				0X09 9th gear	
				0X0a 10th gear	

24G Bio-aware radar interface content

	Function Code	Address code 1	Address code 2	Data		Notes
1	Proactive reporting of commands 0x04	Reporting module identification 0X01	Software Version 0X02			The OTA will report once when the upgrade is completed/ repowered
3		Report radar information 0x03	Environment status 0x05	Unoccupied 00 FF FF		
4				Someone is stationary 01 00 FF		
3				Some people exercise 01 01 01		
4			Motor signs parameters 0x06	4 Byte Float data		
5			Approaching away state 0x07	Fixed character 0x01 0x01	None 0x01	
6					Close to 0x02	
7					Stay away 0x03	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
		Report other information 0x05	Heartbeat Pack 0x01	Unoccupied 00 FF FF	
				Someone is stationary 01 00 FF	
				Some people exercise 01 01 01	
			Abnormal reset 0x02	0x0F	

24G Bio-aware radar interface content					
	Function Code	**Address code 1**	**Address code 2**	**Data**	**Notes**
1	Fall radar data reporting	Alarm 0x01	Fall alarm 0x01	Suspected fall 0x00	
				Real falls 0x01	
				No falls 0x02	

2	0x06		Dwell alarm 0X02	None 0x00	Alarm time points: 5min/10min/30 min/ 60min
				First time 0X01	
				Second 0x02	
				Third 0X03	
				Fourth 0X04	

Description.

1. The read-write command is the command that is transmitted from the host computer to the radar.

2. The reporting command is when the radar transmits information to the host computer.
3. The fall sensitivity is 1 to 10 levels, and the default is 4. The larger the lever, the more sensitive it is.

4. Human body sensitivity is 1-10 levels, and the default is 7. The higher the level, the more sensitive it is.

Appendix 1: CRC check digit reference parsing codes

```
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, 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,
        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 short int us_CalculateCrc16(unsigned char *lpuc_Frame, unsigned 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 = (unsigned char)( luc_CRCHi ^ cuc_CRCHi[li_Index]);
        luc_CRCHi = cuc_CRCLo[li_Index];
    }
    return (unsigned short int )(luc_CRCLo << 8 | luc_CRCHi);
}
```

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_0528	2021/5/28	Plus fall sensitivity adjustment
V1.3_0628	2021/6/28	Add Human sensitivity explained and fall sensitivity explained
V1.4_0906	2021/9/06	Human sensitivity revised from 0–9 to 1–10 Fall sensitivity revised from 0–9 to 1–10 Fall alarm time added 10min, 15min, 30min