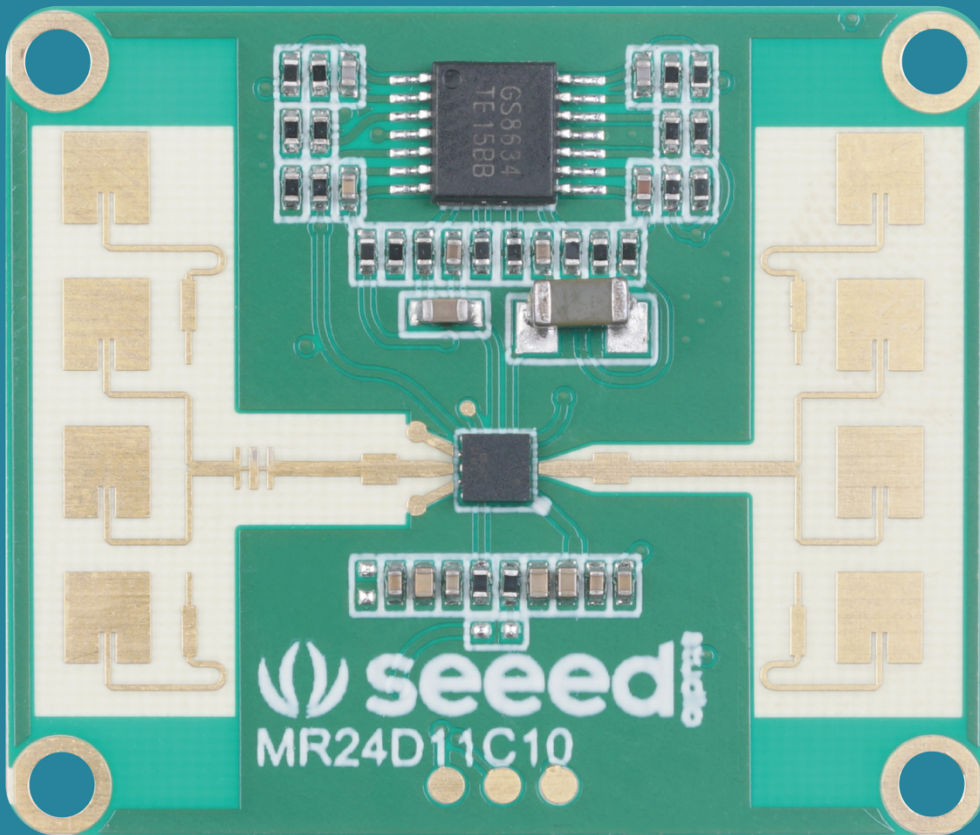


MR24FDB1

Fall Detection Radar User Manual



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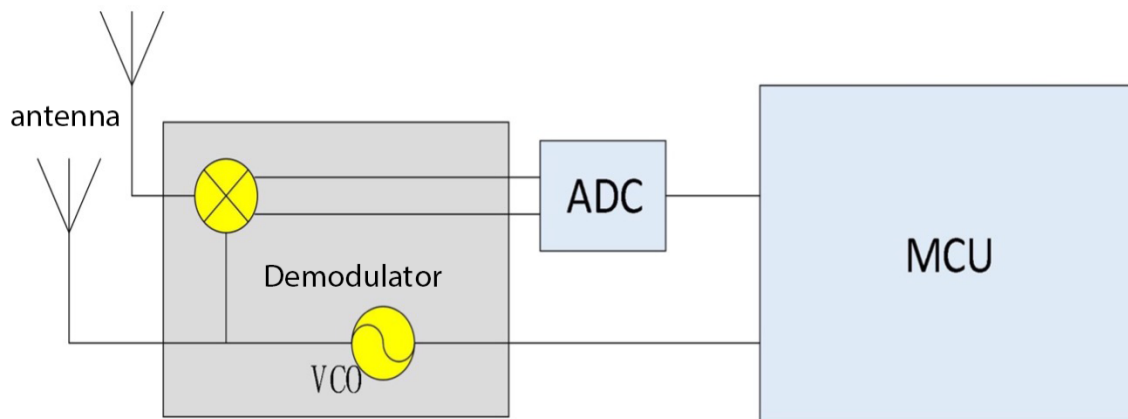
Overview

This document focuses on the use of the radar, the issues that need to be addressed at each stage to minimise 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.

1. 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.

2. 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 $\leq 100\text{mv}$.

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

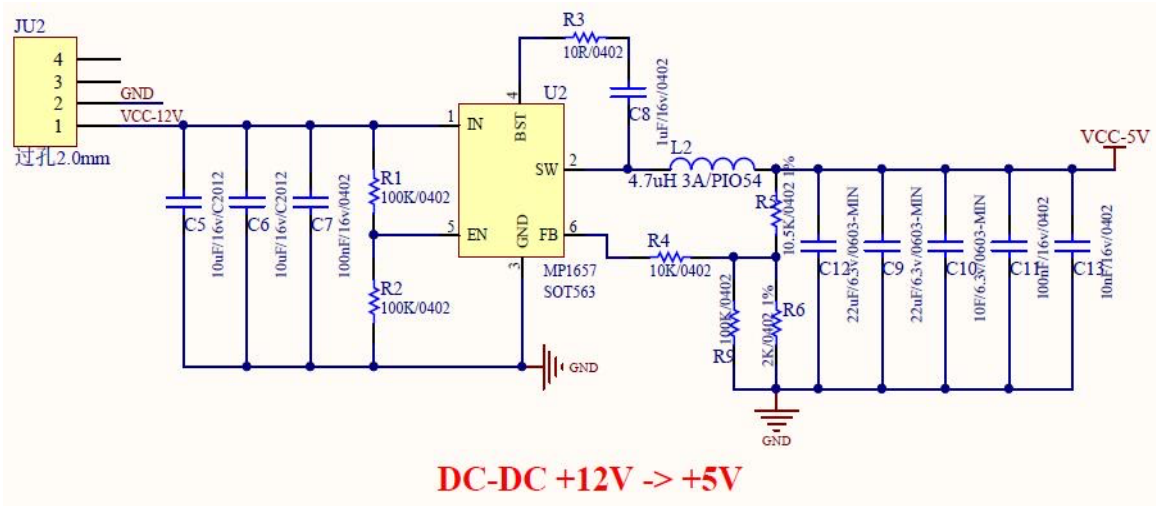


Fig. 1

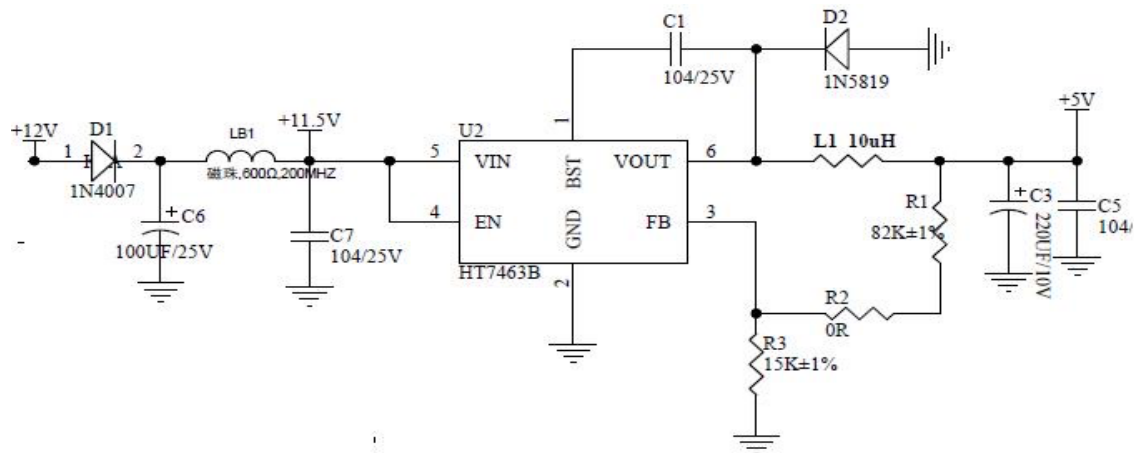


Fig. 2

2.2. using the wiring diagram

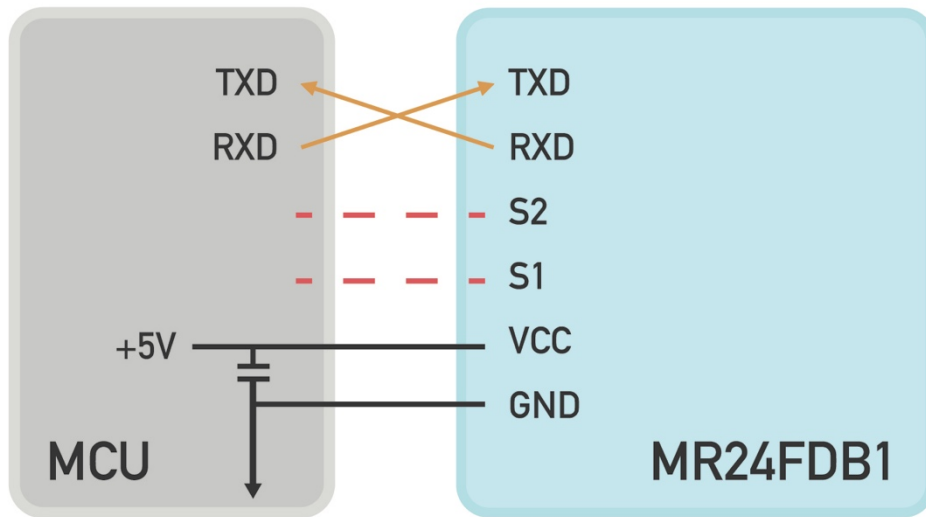


Fig. 3 Schematic diagram of the radar module and peripheral connections

3. Antenna and housing layout requirements

PCBA: the radar needs to be kept $\geq 1\text{mm}$ 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.

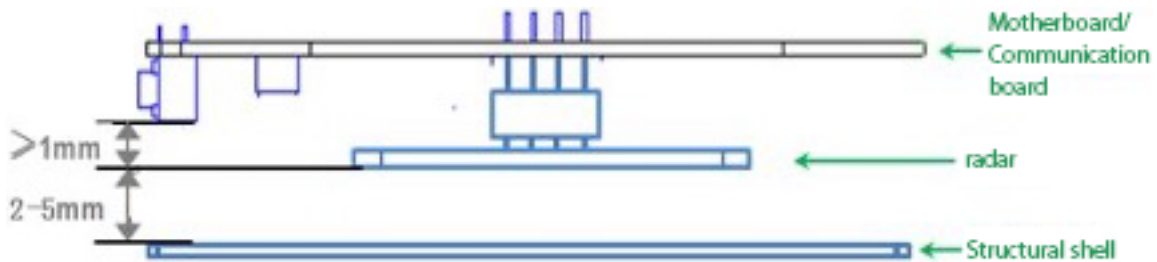


Fig. 4

4. 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 the radar sensor, please wear anti-static gloves if possible.

5. Functional disturbances

5.1 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.

A. 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 method: adjust the radar position so that it is not directly in front of the air conditioner or fan.

C. Shifting objects caused by air conditioning winds.

Adjustment method: cotton, non-metallic objects will not cause false alarms, metal objects need to be fixed.

D. The radar is not fixed, vibration causes false alarms.

Avoid supporting shaking and vibration.

E. 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.

F. Power supply interference, resulting in occasional false alarms.

Try to keep the power supply current stable and reduce ripple.

5.2 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.

A. 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.

B. 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.

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 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

Functions	Status change time/function explanation
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. Description of the agreement

This protocol is used to communicate between a 24G millimetre 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

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	
	Lenth_L	Lenth_H					Crc16_L	Crc16_H
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: Address code 1

indicates the function classification, address code 2 indicates the specific function.

See the description of address assignment and data information.

e. Data: n Byte

f. Checksum: 2 Byte, low byte before, high byte after.

CRC16 checksum is used, see Appendix 1 for reference code.

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		Marking search 0x01	Device ID 0x01		
2			Software version 0x02		
3			Hardware version 0x03		
4			Protocol version 0x04		

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
5	Read command 0x01	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 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			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

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
2		System parameters 0x04	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	
9				Reboot 0x04	
10		Fall function switch 0x0B	Off 0x00		
			On 0x01		
	copy order 0x02			Fall alarm time 0x0C	
				1min 0x00	
				2min 0x01	
				3min 0x02	
				4min 0x03	
				5min 0x04	
				6min 0x05	

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
		Other functions 0x05		7min 0X06	
				10min 0X07	
				15min 0X08	
				30min 0X09	
			Fall sensitivity setting 0X0E	0X01 1st gear	Default fall sensitivity is 4. The lower the gear, the less sensitive it is. The higher the gear, the more sensitive it is.
				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	
11			Start OTA upgrade 0X08	4byte Integer data (firmware package size) + nbyte (software version number)	
12	Upgrade package	Packet Offset (4byte)			

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
			transfer 0X09	+ 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			Device ID 0x01	12 Byte data	
2	Passive reporting of orders 0x03	Reporting module identification 0x01	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	Failure 0X00			
2			Upgrade Start 0X08	Success 0X01			
3			Feedback OTA transmission 0X09	Fixed characters 0X0F			
			Fall function switch 0X0B	Off 0X00			
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			

24G Bio-aware radar interface content					
	Function Code	Address code 1	Address code 2	Data	Notes
				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

24G Bio-aware radar interface content									
	Function Code	Address code 1	Address code 2	Data		Notes			
5			Approaching away state 0x07	Fixed character 0x01 0x01	None 0x01				
6					Close to 0x02				
7					Stay away 0x03				
				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 0x06	Alarm 0x01	Fall alarm 0x01	Suspected fall 0x00	
				Real falls 0x01	
				No falls 0x02	
2			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 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. {
3.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
4.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
5.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
6.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
7.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0x01, 0xC0, 0x80, 0x41,
8.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
9.     0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
10.    0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
11.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
12.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
13.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
14.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
15.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0x01, 0xC0, 0x80, 0x41,
16.    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
17.    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
18.    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
19.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
20.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
21.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
22.    0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
23.    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
24.    0x00, 0xC1, 0x81, 0x40
25. };
26.
27. const unsigned char cuc_CRCLo[256]=
28. {
29.     0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7,
30.     0x05, 0xC5, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E,
31.     0x0A, 0xCA, 0xCB, 0x0B, 0xCB, 0x0B, 0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9,
32.     0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC,
33.     0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
34.     0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32,
35.     0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35, 0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D,
36.     0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A, 0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38,
37.     0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF,
38.     0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
39.     0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x22, 0xE0, 0xA0, 0x60, 0x61, 0xA1,
40.     0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4,
41.     0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F, 0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB,
42.     0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA,
43.     0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
44.     0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0,
45.     0x50, 0x90, 0x91, 0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97,
46.     0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C, 0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E,
47.     0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98, 0x88, 0x48, 0x49, 0x89,
48.     0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
49.     0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83,
50.     0x41, 0x81, 0x80, 0x40
51. };
52.
53.
54. static unsigned short int us_CalculateCrc16(unsigned char *lpuc_Frame, unsigned short i
nt lus_Len)
55. {
56.     unsigned char luc_CRChi = 0xFF;
57.     unsigned char luc_CRCLo = 0xFF;
58.     int li_Index=0;

```

```
59.  
60.     while(lus_Len--)  
61.     {  
62.         li_Index = luc_CRCLo ^ *(lpuc_Frame++);  
63.         luc_CRCLo = (unsigned char)( luc_CRChi ^ cuc_CRChi[li_Index]);  
64.         luc_CRChi = cuc_CRCLo[li_Index];  
65.     }  
66.     return (unsigned short int )(luc_CRCLo << 8 | luc_CRChi);  
67. }
```

Appendix 2: Analysis codes for motor sign parameters

```
1. typedef union
2. {
3.     unsigned char Byte[4];
4.     float Float;
5. }Float_Byte;
6.
7. void main()
8. {
9.     Float_Byte fb;
10.    fb.Byte[0] = 0x9A;
11.    fb.Byte[1] = 0xFB;
12.    fb.Byte[2] = 0xE7;
13.    fb.Byte[3] = 0x3F;
14.    printf("%f\n",fb.Float);
15. }
```

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