

**60G Millimeter Wave Radar Module
R60BFD1
Fall Alarm Radar
User Manual_v1.2**

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Notes:

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1. Product Overview

This document mainly describes precautions for using the radar and problems needing attention at each stage, so as to minimize the design cost, and improve the product stability and the project completion efficiency.

This document covers the reference design of hardware circuits, the layout requirements for radar antenna and shell, the way of interference discrimination and multi-functional standard UART protocol output.

This radar is a self-contained distance sensing sensor, which is a module composed of a radio frequency antenna, a radar chip and a high-clock rate MCU. Depending on a stable, flexible and superior algorithm framework core, it intends to satisfy various scene detection needs of users, and supports a master computer or a host computer to flexibly output detection status and data. The number of available GPIO groups can be customized and developed by users.

2. Operating Principle

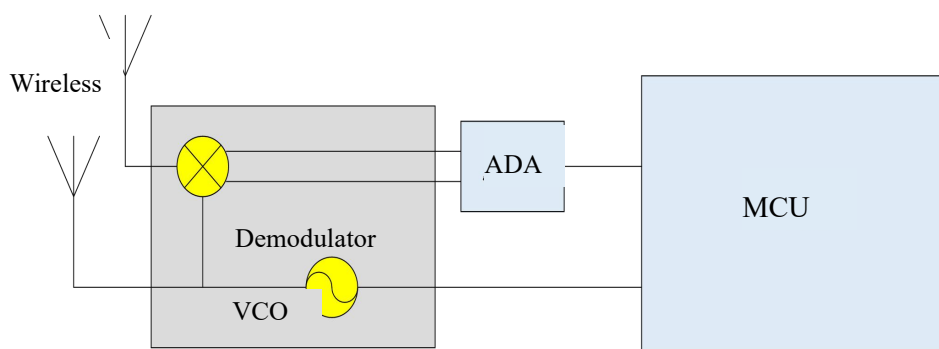


FIG. 1

The radar transmits a 60G band millimeter wave signal, and the detected target reflects an electromagnetic wave signal, which is demodulated according to the transmitted signal, and then processed by amplification, filtering, ADC, etc., to obtain the demodulated echo signal data. The MCU calculates information of amplitude, frequency and phase of the echo signal, and finally achieves measurement of target parameters (e.g., fall, standstill, motion, fine motion) and scene evaluation.

3. Precautions for Hardware Design

3.1 The power supply can refer to the following circuit designs



FIG. 4 Wiring schematic diagram of radar module and peripherals

4. Layout Requirements for Antenna and Shell

PCBA: It is necessary to keep the radar at least 1 mm higher than other surface mounting technology (SMT) devices.

Shell structure: it is necessary to keep the radar antenna surface 2 mm to 5 mm away from the shell surface.

Shell detection surface: a non-metallic shell, requiring a flat surface rather than a curve surface that affects the performance of the whole scanning area.

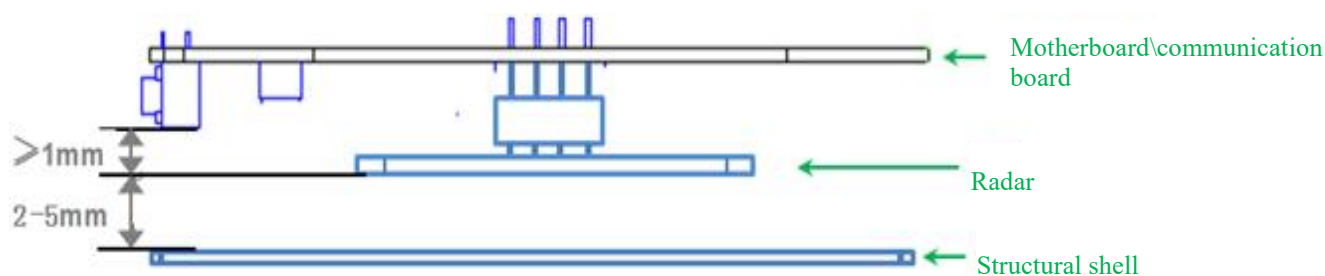


FIG. 5

5. Electrostatic Protection

The radar product has a built-in electrostatic-sensitive circuit, which are vulnerable to electrostatic hazards. Hence, it is necessary to take adequate measures for electrostatic protection during transportation, storage, operation and taking. You cannot touch or grasp the antenna surface and connector pins of the radar module by hand, but only touch the corners.

When operating the radar sensor, please wear anti-static gloves when possible.

6. Functional Details

6.1 Description of function points

Function points	State change time/function explanation
DP1: presence/absence	It reports 0.5 s after detecting a presence state from the previous absence state It outputs an absence state about 30 s after detecting an absence state from the previous presence state
DP2: fall alarm	It sends the alarm immediately in case that the fall alarm condition is met at its discretion.

DP3: standstill alarm	It sends the alarm in case of an abnormal standstill for 5 mins.
DP4: people counting	It detects people in the detection area in real time.

7. Protocol Description

This protocol is applicable to communication between the 60G millimeter-wave fall detection radar and the master computer.

This protocol provides an overview of the radar's work flow, briefly introduces the interface protocol architecture framework, and gives control commands and data necessary for related radar works. The serial communication is defined as follows:

- Interface level: TTL
- Baud rate: 115200 bps
- Stop bit: 1
- Data bit: 8
- Parity check: none

8. Communication Command and Parameter Definition

8.1 Definition and description of frame structure

A. Frame structure definition

Frame	Control field	Command field	Length identifier		Data	Check code	Frame tail
0X53 0X59	Control	Command	Lenth_H	Lenth_H	Data	sum	0X54 0X43
2 Byte	1 Byte	1 Byte	1 Byte	1 Byte	n Byte	1 Byte	2 Byte

B. Description of frame structure

- Frame header: 2 Byte, constant 0X53, 0X59;
- Control field: 1 Byte

(0X01- heartbeat identifier, 0X02- product information, 0X03-OTA upgrade, 0X05- working status, 0X06- installation method, 0X80- presence of human body, 0X83- fall detection)

- Command field: 1 Byte (identifying the current data content)
- Length identifier: 2 Bytes, equal the specific byte length of data
- Data: n Byte, defined based on practical function

- Check code: 1 Byte (check code calculation: frame header + control field + command field + length identifier + data, and take the lower eight bits after summation)
- Frame tail: 2 Byte, constant 0X54, 0X43;

8.2. Description of address assignment and data information

Product category	Function description	Transmissi on direction	Fram e heade r	Contro l field	Comm and field	Length identi fier	Data	Chec k field	Frame tail	Remarks	
System functions	Actively sending a heartbeat (1 min)	Reporting	5359	01	01	0001	0F	sum	5443		
	Module reset	Distributio n	5359	01	02	0001	0F	sum	5443		
		Reporting	5359	01	02	0001	0F	sum	5443		
Information query											
Product information	Product model query	Distributio n	5359	02	A1	0001	0F	sum	5443		
		Reply	5359	02	A1	len	len B product information	sum	5443		
	Product id query	Distributio n	5359	02	A2	0001	0F	sum	5443		
		Reply	5359	02	A2	len	len B product id	sum	5443		
	Hardware model query	Distributio n	5359	02	A3	0001	0F	sum	5443		
		Reply	5359	02	A3	len	len B hardware model	sum	5443		
	Firmware version query	Distributio n	5359	02	A4	0001	0F	sum	5443		
		Reply	5359	02	A4	len	len B firmware version	sum	5443		
	Working status	Information of initialization completion	Reporting	5359	05	01	0001	0F	sum	5443	

	Radar fault uploading	Reporting	5359	05	02	0001	00: Normal operation 01: abnormal radar chip 02: encryption exception ---	sum	5443	
Parameter query										
	Initialization completion query	Distribution	5359	05	81	0001	0F	sum	5443	
		Reply	5359	05	81	0001	01: completed 00: uncompleted	sum	5443	
Parameter setting										
Radar installation information	Mounting angle	Distribution	5359	06	01	0x0006	2B X-axis angel + 2B Y-axis angel + 2B Z-axis angel	sum	5443	
		Reply	5359	06	01	0x0006	2B X-axis angel + 2B Y-axis angel + 2B Z-axis angel	sum	5443	
	Mounting height	Distribution	5359	06	02	0002	2B height information	sum	5443	The height is in cm the step length is 1 cm
		Reply	5359	06	02	0002	2B height information	sum	5443	
	Parameter query									
Radar installation	Mounting angle query	Distribution	5359	06	81	0001	0F	sum	5443	Mounting angle query

information		Reply	5359	06	81	0006	2B X-axis angel + 2B Y -axis angel + 2B Z -axis angel	sum	5443	
	Mounting height query	Distributio n	5359	06	82	0001	0F	sum	5443	
		Reply	5359	06	82	0002	2B height informati on	sum	5443	
Active reporting of human body										
Presence function	On/off of presence function	Distributio n	5359	80	00	0001	01: on 00: off	sum	5443	
		Reply	5359	80	00	0001	01: on 00: off	sum	5443	
	Active reporting of presence information	Reporting	5359	80	01	0001	00: absence 01: presence	sum	5443	Reporting method: report when state changes.
	Active reporting of motion information	Reporting	5359	80	02	0001	00: none 01: stationary 02: active	sum	5443	Reporting method: report when state changes.
	Active reporting of body movement parameter	Reporting	5359	80	03	0001	1B body movemen t parameter	sum	5443	Reporting method: report at an interval of 1 s Numerical range:0-100
Information query										
	Presence on/off query	Distributio n	5359	80	80	0001	0F	sum	5443	
		Reply	5359	80	80	0001	01: on 00: off	sum	5443	
	Presence information query	Distributio n	5359	80	81	0001	0F	sum	5443	
		Reply	5359	80	81	0001	00: absence 01:	sum	5443	

							presence			
Motion information query	Distribution	5359	80	82	0001	0F	sum	5443		
	Reply	5359	80	82	0001	00: none 01: stationary 02: active	sum	5443		
Body movement parameter query	Distribution	5359	80	83	0001	0F	sum	5443	Numerical range:0-100	
	Reply	5359	80	83	0001	1B body movement parameter	sum	5443		
Body movement parameter on/off query	Distribution	5359	80	94	0001	0F	sum	5443		
	Reply	5359	80	94	0002	01: on 00: off	sum	5443		
Active reporting and setting of fall detection										
Fall detection function	Fall on/off monitoring function	Distribution	5359	83	00	0001	01: on 00: off	sum	5443	
		Reply	5359	83	00	0001	01: on 00: off	sum	5443	
	Fall state	Reporting	5359	83	01	0001	00: not fallen down 01: fallen down	sum	5443	Reporting method: report when state changes.
	Fall duration setting	Distribution	5359	83	0C	0004	4B length of time	sum	5443	Numerical range:0-3600 Unit: second
		Reply	5359	83	0C	0004	4B length of time	sum	5443	
	Standstill state	Reporting	5359	83	05	0x0001	00: no standstill 01: standstill exists	sum	5443	Report when state changes.

Standstill duration setting	Distribution	5359	83	0A	0004	4B length of time	sum	5443	Numerical range: 60-72000 Unit: second
	Reply	5359	83	0A	0004	4B length of time	sum	5443	
Standstill on/off setting	Distribution	5359	83	0B	0001	1B on/off	sum	5443	0: off 1: on
	Reply	5359	83	0B	0001	1B on/off 01: on 00: off	sum	5443	
Fall position reporting	Reporting	0x53 0x59	83	16	00 04	2B X-axis position information, 2B Y-axis position information	sum	5443	Unit: cm
Cancellation of fall position reporting	Reporting	0x53 0x59	83	17	00 04	2B X-axis position information, 2B Y-axis position information	sum	5443	Unit: cm
Automatic detection range limit setting	Distribution	5359	07	08	0001	01: turn on automatic detection 00: turn off automatic detection	sum	5359	Report the points in the unit time.
	Reply	5359	07	08	0001	01: turn on automatic detection 00: turn off automatic detection	sum	5359	
Radar detection range setting	Distribution	5359	07	09	0008	2B (positive-half X axis)+2B (negative-half X axis)+2B	sum	5359	Unit: cm

						(positive-half Y axis)+2B (negative-half Y axis)			
	Reply	5359	07	09	0008	2B (positive-half X axis)+2B (negative-half X axis)+2B (positive-half Y axis)+2B (negative-half Y axis)	sum	5359	
	Foreign object size setting in detection range	Distribution	5359	07	0A	len	sum	5359	Foreign object type: 00: door 01: window 02: desk 03: bed 04: couch 05: interference source 06: appliances
		Reply	5359	07	0A	len	sum	5359	Foreign object type: 00: door 01: window 02: desk 03: bed 04: couch 05: interference

						filtering or not (00: completely filtering 01: not filtering), 2B positive-half X axis, 2B negative-half X axis, 2B positive-half Y axis and 2B negative-half Y axis.			source 06: appliances
Automatic detection range limit setting	Automatic reporting	5359	07	0B	len	n*(2B X-axis position information + 2B Y-axis position information)	sum	5359	Report the points in the unit time.
Automatic detection range on/off setting	Distribution	5359	07	0C	0001	01: on 00: off	sum	5359	
	Reply	5359	07	0C	0001	01: on 00: off	sum	5359	
Information query									
Fall monitoring on/off query	Distribution	5359	83	80	0001	0F	sum	5443	
	Reply	5359	83	80	0001	01: on 00: off	sum	5443	
Fall state query	Distribution	5359	83	81	0001	0F	sum	5443	
	Reply	5359	83	81	0001	00: not fallen down 01: fallen down	sum	5443	
Fall duration query	Distribution	5359	83	8C	0001	0F	sum	5443	
	Reply	5359	83	8C	0004	4B length of time	sum	5443	

Standstill state query	Distribution	5359	83	85	0001	0F	sum	5443	
	Reply	5359	83	85	0001	00: no standstill 01: standstill exists	sum	5443	
Standstill duration query	Distribution	5359	83	8A	0001	0F	sum	5443	
	Reply	5359	83	8A	0004	4B length of time	sum	5443	
Standstill on/off query	Distribution	5359	83	8B	0001	0F	sum	5443	
	Reply	5359	83	8B	0001	1B on/off 01: on 00: off	sum	5443	
Radar detection range query	Distribution	5359	07	89	0001	0F	sum	5443	
	Reply	5359	07	89	0008	2B (positive-half X axis)+2B (negative-half X axis)+2B (positive-half Y axis)+2B (negative-half Y axis)	sum	5443	Unit: cm
Foreign object size query in detection range	Distribution	5359	07	8A	0001	OF	sum	5443	
	Reply	5359	07	8A	len	Distribute a plurality of foreign objects, and each target point has 1B index, 1B foreign object type, 1B filtering or not (00: complete)	sum	5443	Foreign object type: 00: door 01: window 02: desk 03: bed 04: couch 05: interference source 06: appliances

							y filtering 01: not filtering), 2B positive-h alf X axis, 2B negative- half X axis, 2B positive-h alf Y axis and 2B negative- half Y axis.			
		Distributio n	5359	07	8B	0001	0F	sum	5443	
	Automatic detection range limit query	Reply	5359	07	8B	len	n*(2B X-axis position informati on + 2B Y-axis position informati on)	sum	5443	Report the points in the unit time.
Trace reporting and setting										
Trace tracking function	Trace tracking on/off function	Distributio n	544 3	82	00	0001	01: on 00: off	sum	5443	
		Reply	544 3	82	00	0001	01: on 00: off	sum	5443	
	Total number of traces	Reporting	544 3	82	01	0001	1B total number of traces	sum	5443	Reporting method: report at an interval of 2 s Numerical range:0-255 Unit: trace
		Trace information	544 3	82	02	len	Report a plurality of target points, and each target point has 1B index, 1B target size, 1B target feature, 2B X-axis position informati	sum	5443	The position information may be positive or negative. If the first bit of 16-bit data is 0, it indicates positive; and the first bit is 1, it indicates positive.

							on, 2B Y-axis position informati on, 2B height informati on, 2B velocity and reserved informati on.			
Information query										
	Trace tracking on/off query	Distributio n	544 3	82	80	0001	0F	sum	5443	
		Reply	544 3	82	80	0001	01: on 00: off	sum	5443	
	Query of total number of traces	Distributio n	544 3	82	81	0001	0F	sum	5443	
		Reply	544 3	82	81	0001	1B total number of traces	sum	5443	
	Trace information query	Distributio n	544 3	82	82	0001	0F	sum	5443	
		Reply	544 3	82	82	len	Report a plurality of target points, and each target point has 1B index, 1B target size, 1B target feature, 2B X-axis position informati on, 2B Y-axis position informati on, 2B height informati on and 2B velocity.	sum	5443	The position information may be positive or negative. If the first bit of 16-bit data is 0, it indicates positive; and the first bit is 1, it indicates positive. Note: 1. Refer to the 2B height information for the height. 2. The number of people is calculated by dividing the total data length by the data length of one frame.
OTA										

OTA	Start OTA upgrade	Distribution	5359	03	01	0004	4B firmware package size	sum	5443	
		Reply	5359	03	01	0004	4B upgrade package size transmitted per frame	sum	5443	The master computer will determine the length of firmware package information to be distributed per frame according to the size replied here.
	Upgrade package transmission	Distribution	5359	03	02	1en+4	4B package offset address + lenB data packet	sum	5443	
		Reply	5359	03	02	0001	02: Receiving failed 01: Receiving succeeded	sum	5443	
	Finish OTA upgrade	Distribution	5359	03	03	0001	01: firmware package is sent 02: firmware package is not sent	sum	5443	
		Reply	5359	03	03	0001	0F	sum	5443	
		Distribution	5359	03	01	0004	4B firmware package size	sum	5443	
		Reply	5359	03	01	0004	4B upgrade package size transmitted per frame	sum	5443	The master computer will determine the length of firmware package information to be distributed per frame according to the size replied here.

Appendix 1: About Data Instruction Generation Routine

For instance: presence information query:

According to the above protocol table, the data structure for presence information query is confirmed as follows:

- Frame header: 0X53 0X59
- Control field: 0X80
- Command field: 0X81

- Length identifier: 0X00 0X01
- Data: 0X0F
- Check code: 1 Byte (sum)
- Frame tail: 0X54 0X43
- Combined into a complete instruction as follows: 53 59 80 81 00 01 0F sum 54 43
- Check code sum: $(0X53+0X59+0X80+0X81+0X00+0X01+0X0F) = 0X01BD$
- Take low byte to obtain sum = 0XBD
- Therefore, the complete presence information query instruction is: 53 59 80 81 00 01 0F BD 54 43

9. Revision History

Revision	Release Date	summary	Author
V1.0	November, 24, 2023	First draft	Jason
V1.1	January 22, 2024	Revision and supplementary of the problem of reporting the trace protocol	Jason
V1.2	June 4, 2024	Addition of protocol interface protocol	Jason