60G millimeter-wave radar

R60BMP1 People Counting Radar

Manual v1.0

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Contents

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1. Product introduction

This document mainly describes the use of radar, the problems that may be encountered at different stages, to minimize the design costs and increase the stability of the product, and to improve the efficiency of the project.

Hardware circuit reference design, radar antenna and housing layout requirements, how to distinguish between interference and multi-functional UART protocol output.

The radar is a self-contained space sensing sensor, which is composed of RF antenna, radar chip and high speed main frequency MCU. It relies on stable and flexible algorithm architecture core to provide solution for scene detections. It's equipped with upper computer or host computer to output detection status and data, and meet several groups of GPIO for user customization and development.

2. Theory of operation

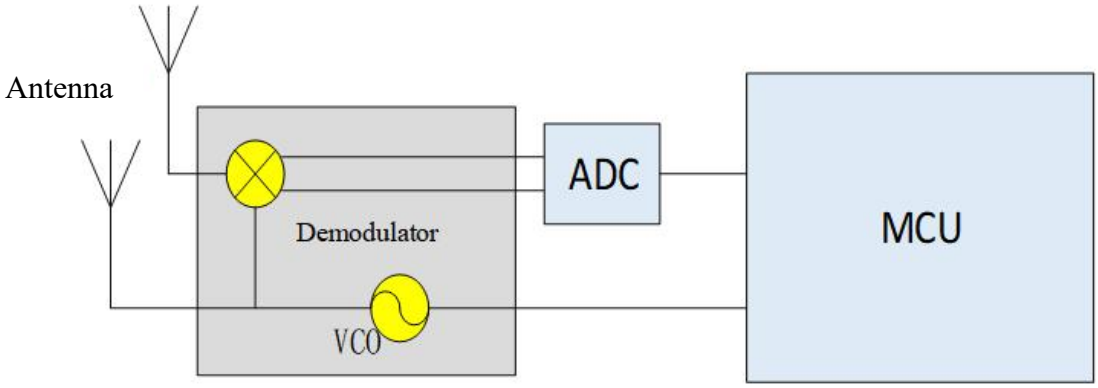

Fig. 1

The radar transmits 60G band millimeter wave signal, 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. Information about the amplitude, frequency, and phase of the echo signal is calculated in the MCU unit, thereby completing target parameter (people counting, accurate location, motion, and micro-motion) measurement and scene evaluation.

3. Notes for hardware design

The rated supply voltage of this radar shall be 4.9 - 6V, and in normal circumstances, the

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rated current shall be at least 200mA. Power supply design, power supply ripple shall be ≤ 100mv.

3.1 For the power supply, refer to the circuit design below

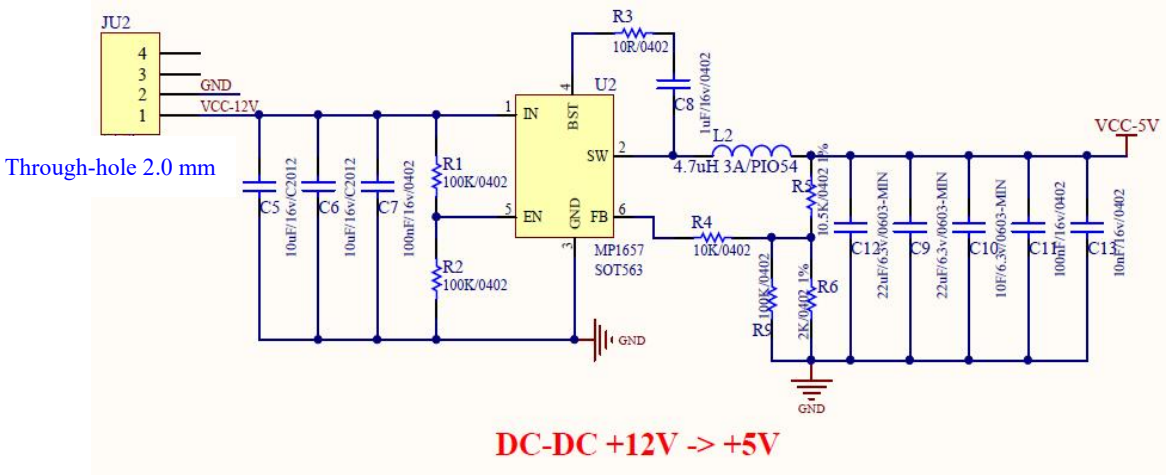

Fig. 2

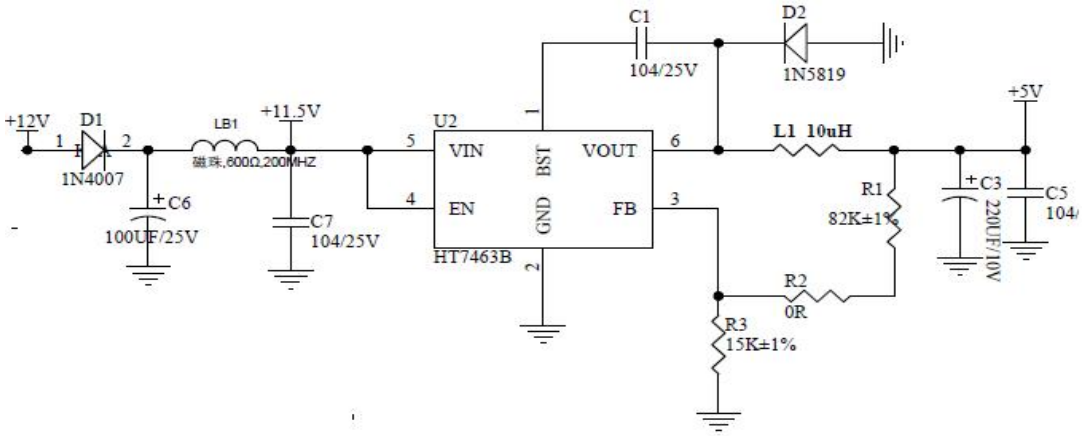

Fig. 3

3.2 Application wiring diagram

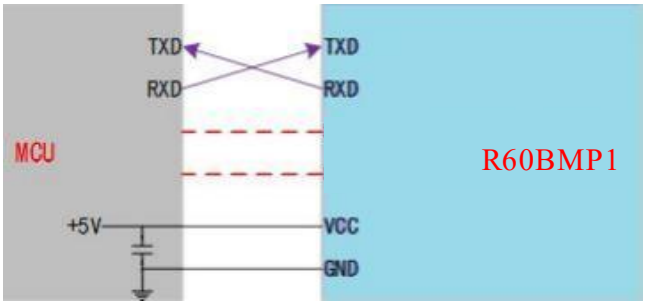

Fig. 4 Schematic diagram for connection between radar module and peripherals

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4. Requirements for antenna and housing layout

- PCBA: Mounting height for radar shall be ≥ 1mm compared with other components
- Housing structure: Radar antenna surface and housing surface shall be kept at a distance of 2 - 5mm
- Housing detection surface: Non-metallic shell shall be flat, otherwise it may affect the performance of the entire scanning surface

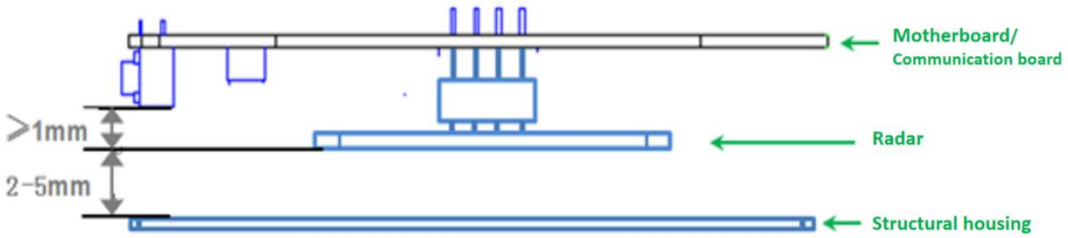

Fig. 5

5. Electrostatic protection

Radar products contain electrostatic sensitive circuits, and shall be protected from static electricity during transportation, storage, working and picking up. Do not touch the radar module antenna surface and connector pins. Hold the components by their edge.

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

6. Function description

6.1 Description of function point

Function point	State change time/function explanation
DP1: Presence/Non-presence	Report within 0.5s from non-presence to presence If there is no output in 30s, presence changes to non-presence
DP2: People counting	Within the detection zone, real-time personnel monitoring is conducted
DP3: Trajectory information	The system reports the positional coordinates, altitude information, and velocity data of the target points

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7. Protocol description

This protocol is applied to the communication between the 60G millimeter wave fall detection radar and the host computer.

This protocol outlines the radar workflow, gives a brief introduction to the interface protocol composition architecture, and explains the control commands and data required for radar operation. The serial communication is defined as follows:

- Interface level: TTL
- Baud rate: 115200bps
- Stop bit: 1
- Data bit: 8
- Parity check: N/A

8. Definition of communication command and parameter

8.1 Definition and description of frame structure

8.1.1 Definition of frame structure

Frame header	Control word	Command word	Length identification		Data	Check digit	Frame tail
0X53 0X59	Control Lenth_H	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

8.1.2 Description of frame structure

- Frame header: 2Byte, fixed to 0X53,0X59;
- Control word: 1 Byte

(0X01-heartbeat packet identification, 0X02-product information, 0X03-OTA upgrade, 0X05-working status, 0X06-installation mode, 0X80-human presence, 0X83-falling detection)

- Command word: 1Byte (identification of current data)
- Length identification: 2Byte, equal to the specific byte length of data
- Data: nByte, defined according to the actual function
- Check digit: 1 Byte (check digit calculation: (frame header + control word + command word + length identifier + data) take the lowest eight bits after summation)
- Frame end: 2Byte, fixed to 0X54, 0X43;

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Category	Function description	Transmission direction	Frame header	Control word	Command word	Length identification	Data	Verification field	Frame tail	Remarks
System functions	Heartbeat packet report (1min)	Report	5359	01	01	0001	0F	sum	5443	
Information query										
	Firmware version query	Issue	5359	02	A4	0001	0F	sum	5443	
		Reply	5359	02	A4	len	len B firmware version query	sum	5443	
Working status	Message of initialization complete	Report	5359	05	01	0001	0F	sum	5443	
Parameter query										
	Initialization progress query	Issue	5359	05	81	0001	0F	sum	5443	
		Reply	5359	05	81	0001	01: Completed 00: Not completed	sum	5443	
Parameter settings										
Radar installation information	Installation angle	Issue	5359	06	01	0006	2B X-axis angle + 2B Y-axis angle + 2B Z-axis angle	sum	5443	The angular range spans from -18000° to 18000° Step length 1° The X-axis and Y-axis are currently set to 0 degrees by default The Z-axis indicates the degree of downward tilt, which is set to a default downward tilt of 30
		Reply	5359	06	01	0006	2B X-axis angle + 2B Y-axis angle + 2B Z-axis angle	sum	5443	

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										degrees The data is transmitted with a 100-fold magnification
	Mounting height	Issue	5359	06	02	0002	2B height information	sum	5443	Height in cm Step length 1cm
		Reply	5359	06	02	0002	2B height information	sum	5443	
Parameter query										
Radar installation information	Installation angle query	Issue	5359	06	81	0001	0F	sum	5443	The data is transmitted with a 100-fold magnification
		Reply	5359	06	81	0006	2B X-axis angle + 2B Y-axis angle + 2B Z-axis angle	sum	5443	
	Installation height query	Issue	5359	06	82	0001	0F	sum	5443	
		Reply	5359	06	82	0002	2B height information	sum	5443	
	Gyroscope information	Proactive report	5359	06	04	0008	horizontal angle + 2B pitch angle + 2B horizontal standard deviation + 2B pitch standard deviation	sum	5443	
	Gyroscope abnormality	Proactive report	5359	06	05	0001	00: Normal 01: No sensor is detected 02: The measured angle deviates excessively from the preset angle	sum	5443	If the angle exceeds ± 5°, it will report code 02 within 5 min
Human presence report										
Human presence	Enable/disable	Issue	5359	80	00	0001	01: Enable 00: Disable	sum	5443	

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function	human presence function	Reply	5359	80	00	0001	01: Enable 00: Disable	sum	5443	
	Human presence information report	Report	5359	80	01	0001	00: Non-presence 01: Presence	sum	5443	Report method: Report on status changes
	Movement information report	Report	5359	80	02	0001	00: No 01: Static 02: Active	sum	5443	Report method: Report on status changes
Information query										
	Human presence switch query	Issue	5359	80	80	0001	0F	sum	5443	
		Reply	5359	80	80	0001	01: Enable 00: Disable	sum	5443	
	Presence information query	Issue	5359	80	81	0001	0F	sum	5443	
		Reply	5359	80	81	0001	00: Non-presence 01: Presence	sum	5443	
	Movement information query	Issue	5359	80	82	0001	0F	sum	5443	
		Reply	5359	80	82	0001	00: No 01: Static 02: Active	sum	5443	
		Reply	5359	80	83	0001	1B body movement parameters	sum	5443	
Detection zone query and setting										
People counting	Automatic detection range limit setting	Issue	5359	07	08	0001	01: Automatic detection is enabled 00: Automatic detection is disabled	sum	5443	
		Reply	5359	07	08	len	Enabling automatic detection reply: 01 Disabling automatic detection reply:	sum	5443	Report points within a unit time

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							1B (01) + n * (2B X-axis location information + 2B Y-axis location information)			
	Radar detection range setting	Issue	5359	07	09	0009	1B (00) + 2B (positive X-axis) + 2B (negative X-axis) + 2B (positive Y-axis) + 2B (negative Y-axis)	sum	5443	Unit: cm
		Reply	5359	07	09	0009	1B (00) + 2B (positive X-axis) + 2B (negative X-axis) + 2B (positive Y-axis) + 2B (negative Y-axis)	sum	5443	
	Whether the setting is used for automatic detection range	Issue	5359	07	0C	0001	01: Use 00: Not use	sum	5443	
		Reply	5359	07	0C	0001	00: Not use	sum	5443	
	Label setting	Issue	5359	07	11	0003	1B label type + 2B label radius	sum	5443	1B label type 0-4: Door 5-9: Sofa 10-14: Bed 15-19: Interference source 20-30: Reserved
		Reply	5359	07	11	0002	1B label type + 1B status value (01: Status is correct, start to reply 02: Label setting or label verificatio	sum	5443	

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							n is in progress 03: The current label index has not been set)			
	Label verification	Issue	5359	07	12	0001	1B label type	sum	5443	
		Reply	5359	07	12	0002	1B label type + 1B status value (01: Status is correct, start to reply 02: Label setting or label verification is in progress 03: The current label index is already in use)	sum	5443	
	Label clearance	Issue	5359	07	13	0001	FF	sum	5443	All labels are cleared
		Reply	5359	07	13	0001	FF	sum	5443	
	Report the label setting information proactively	Proactive report	5359	07	14	0008	1B label type + 1B status value (01: Status is correct 02: The number of trajectories is not 1 03: There is an excessive change in distance) + 2B X + 2B Y + 2B label radius	sum	5443	

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	Label verification information	Proactive report	5359	07	15	0008	1B label type + 1B status value (01: Status is correct 02: The number of trajectories is not 1 03: There is an excessive change in distance) + 2B X + 2B Y + 2B distance difference	sum	5443	
	Radar Z-axis detection range setting	Issue	5359	07	16	0004	2B (max. Z value) + 2B (min. Z value)	sum	5443	Unit: cm
		Reply	5359	07	16	0004	2B (max. Z value) + 2B (min. Z value)	sum	5443	
	Configuration file setting for detection range	Issue	5359	07	17	LEN	n*(2BX+2BY)	sum	5443	Unit: cm
		Reply	5359	07	17	LEN	n*(2BX+2BY)	sum	5443	
Information query										
	Radar detection range query	Issue	5359	07	89	0001	0F	sum	5443	
		Reply	5359	07	89	Len	Manual detection range setting reply: 1B (00) + 2B (positive X-axis) + 2B (negative X-axis) + 2B (positive Y-axis) +	sum	5443	Unit cm

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							2B (negative Y-axis) Automatic detection range setting reply: 1B (01) + n * (2B X-axis location information + 2B Y-axis location information)			
	Label query	Issue	5359	07	91	0001	0F	sum	5443	1B label type 00-4: Door 5-9: Sofa 10-14: Bed 15-19: Interference source 20-30: Reserved
		Reply	5359	07	91	Len	Reply all valid labels n* (1B label type + 2B X + 2B Y + 2B label radius	sum	5443	
	Radar Z-axis detection range query	Issue	5359	07	96	0001	0F	sum	5443	Unit: cm
		Reply	5359	07	96	0004	2B (max. Z value) + 2B (min. Z value)	sum	5443	
	Query on configuration file setting for detection range	Issue	5359	07	97	0001	0F	sum	5443	Unit: cm
		Reply	5359	07	97	LEN	n*(2BX+2BY)	sum	5443	
Trajectory reporting and setting										
Trajectory tracking function	Enable/disable trajectory tracking feature	Issue	5359	82	00	0001	01: Enable 00: Disable	sum	5443	
		Reply	5359	82	00	0001	01: Enable 00: Disable	sum	5443	

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	Trajectory information	Report	5359	82	02	len	Report multiple target points, each target point has 1B index, 1B target size, 1B target characteristics, 2B X-axis position information, 2B Y-axis position information, 2B height information, 2B velocity, and reserved information	sum	5443	Location information has positive and negative value, if the first 16 bits of data is 0, it indicates positive, if the first bit is 1, it indicates negative
信息查询 Information query										
	Trajectory tracking query switch	Issue	5359	82	80	0001	0F	sum	5443	
		Reply	5359	82	80	0001	01: Enable 00: Disable	sum	5443	
	Trajectory information query	Issue	5359	82	82	0001	0F	sum	5443	
		Reply	5359	82	82	len	Report multiple target points, each target point has 1B index, 1B target size, 1B target characteristics, 2B X-axis position information, 2B Y-axis position information, 2B height	sum	5443	Location information has positive and negative value, if the first 16 bits of data is 0, it indicates positive, if the first bit is 1, it indicates negative Note: 1. Height information is taken as 2B 2. The number of

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							information, and 2B velocity			people is obtained by dividing the total data length by the length of one frame of data
People counting query setting										
People counting	Real-time number of people	Proactive report	5359	86	0A	0002	1B (min real-time number of people) 1B (max real-time number of people)	sum	5443	Unit: S
	Real-time number of people reporting time setting	Issue	5359	86	0B	0004	4B reporting time	sum	5443	
		Reply	5359	86	0B	0004	4B reporting time	sum	5443	
	Accurate number of people	Proactive report	5359	86	0C	0002	1B (min accurate number of people) 1B (max accurate number of people)	sum	5443	
	Accurate number of people reporting time setting	Issue	5359	86	0D	0004	4B reporting time	sum	5443	
		Reply	5359	86	0D	0004	4B reporting time	sum	5443	
	Trajectory generation distance setting	Issue	5359	86	0E	0004	4B trajectory generation distance	sum	5443	Unit: cm
		Reply	5359	86	0E	0004	4B trajectory generation distance	sum	5443	
	False alarm elimination time length setting	Issue	5359	86	0F	0004	4B false alarm elimination time length	sum	5443	Unit: S
		Reply	5359	86	0F	0004	4B false alarm elimination time length	sum	5443	
	Information on	Issue	5359	86	11	0001	0F	sum	5443	

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	eliminated number of people	Reply	5359	86	11	0001	0F	sum	5443	
Information query										
	Real-time number of people query	Issue	5359	86	8A	0001	0F	sum	5443	Unit: S
		Reply	5359	86	8A	0002	1B (min real-time number of people) 1B (max real-time number of people)	sum	5443	
	Real-time number of people reporting time query	Issue	5359	86	8B	0001	0F	sum	5443	
		Reply	5359	86	8B	0004	4B reporting time	sum	5443	
	Accurate number of people query	Issue	5359	86	8C	0001	0F	sum	5443	
		Reply	5359	86	8C	0002	1B (min real-time number of people) + 1B (max real-time number of people)	sum	5443	
	Accurate number of people reporting time query	Issue	5359	86	8D	0001	0F	sum	5443	
		Reply	5359	86	8D	0004	4B reporting time	sum	5443	
	Trajectory generation distance query	Issue	5359	86	8E	0001	0F	sum	5443	Unit: cm
		Reply	5359	86	8E	0004	4B trajectory generation distance	sum	5443	
	False alarm elimination time query	Issue	5359	86	8F	0001	0F	sum	5443	Unit: S
		Reply	5359	86	8F	0004	4B false alarm elimination time length	sum	5443	
OTA										

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OTA	Start OTA upgrade	Issue	5359	03	01	0004	4B firmware package size	sum	5443	
		Reply	5359	03	01	0004	4B transmission upgrade packet size per frame	sum	5443	The host computer will determine the size of the firmware packet information to be issued per frame according to the reply
	Upgrade package transmission	Issue	5359	03	02	1en+4	4B packet offset address + lenB data packet	sum	5443	
		Reply	5359	03	02	0001	02: Failed to receive 01: Received	sum	5443	
	Stop OTA upgrade	Issue	5359	03	03	0001	01: Firmware package transmission completed 02: Firmware package transmission not completed	sum	5443	
		Reply	5359	03	03	0001	0F	sum	5443	

8.2 Description of address assignment and data information

Appendix 1: Example of data instruction generation

Example: Presence information query:

The data structure for confirming the presence information query according to the protocol form above:

- Frame header: 0X53 0X59
- Control word: 0X80

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- Command word: 0X81
- Length identification: 0X00 0X01
- Data: 0X0F
- Check digit: 1 Byte (sum)
- Frame end: 0X54 0X43
- Combined to a complete command as: 53 59 80 81 00 01 0F sum 54 43
- Check digit sum: (0X53 + 0X59 + 0X80 + 0X81 + 0X00 + 0X01 + 0X0F) = 0X01BD, taking the lower byte to get sum = 0XBD

So the complete presence information query command is: 53 59 80 81 00 01 0F BD 54 43

9. Updates history

Revision	Release Date	summary	Author
V1.0	2024/10/24	First draft	Jason

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