24G Millimeter Wave Radar Module
R24ETT1 Multifunction Radar

User manual（Ver.1.2）

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Contents

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

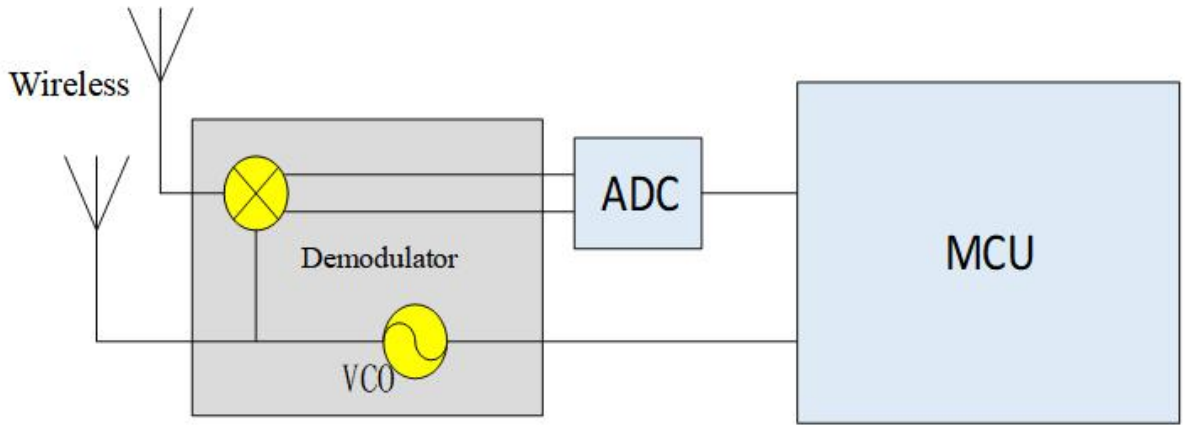

Figure 1

The radar transmits 24G 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 (fall, static stationary, 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 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

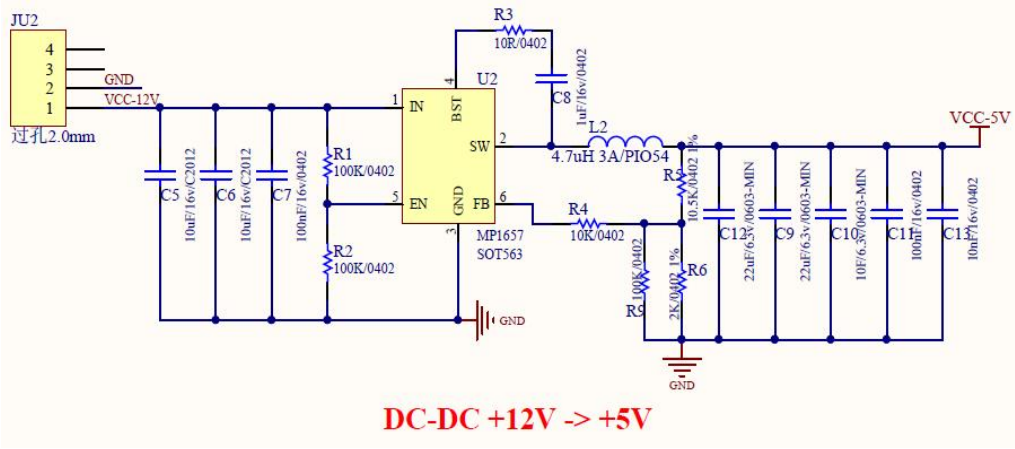

Figure 2

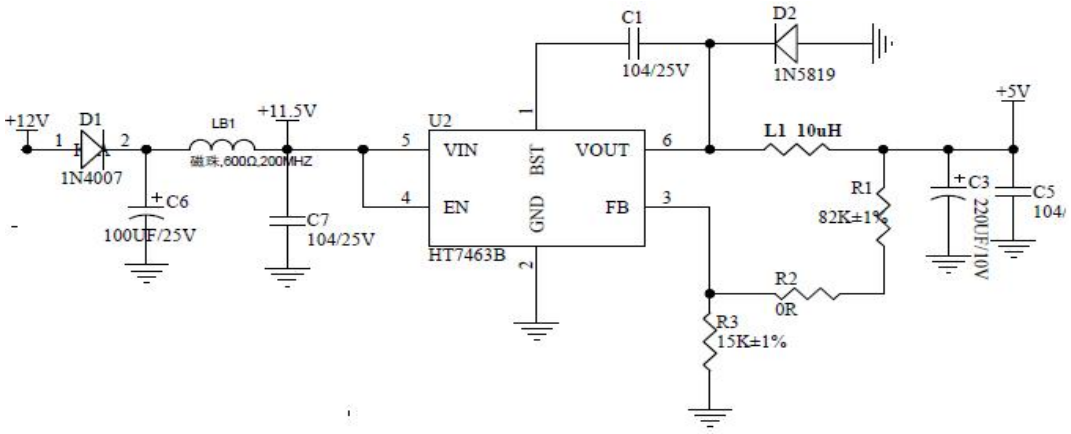

Figure 3

3.2 Application wiring diagram

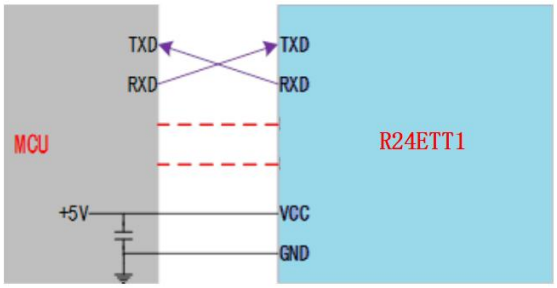

Figure 4 Schematic diagram for connection between radar module and peripherals

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

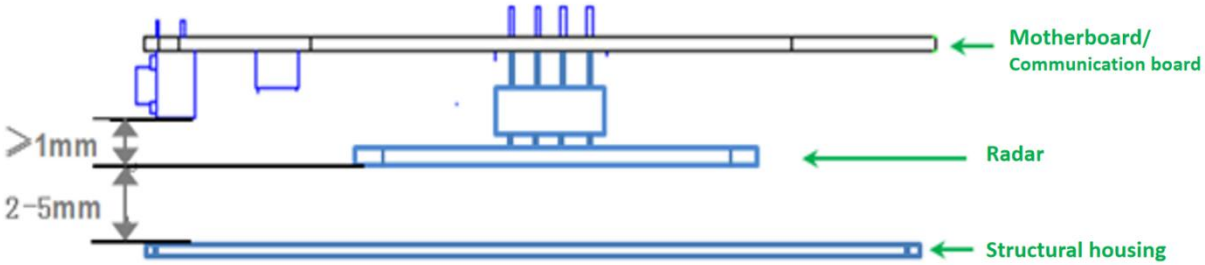

Figure 5

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: Active/Still/None	Report within 0.5s from static to active Report within 2s from active to static Report non-presence state when no one is present
DP3: Body movement parameter amplitude	Report method: Output data every 1 second. Body movement range: 0~100 [Refer to description of body motion amplitude parameter output for details]
DP4: Static energy report	Value range: 0-100
DP5: Trajectory information	The radar reports target size, target characteristics, position, altitude, and speed when it detects the movement of the target
DP6: Zoning	Set the detection coverage
DP7: Direction identification	Identify the trajectory status of the target, from left to right, and right to left.
DP8: People count information	People count of entry, people count of exit, and people count in the detection coverage; reported when the state changes.
DP9: Rectangular zone setting	Set the coordinates for the 4 points of the rectangle. Input (x0, y0) first.
DP10: People count resetting	Reset the people count as 0
DP11: x and y threshold setting for line crossing	x-axis threshold, and y-axis threshold
DP12: Direction setting of line crossing count	X-axis by default, counted from the left to the right.

7. Protocol description

This protocol is applied to the communication between the 24G millimeter wave human presence 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

Definition of frame structure

Frame	Control word	Command word	Length identification		Data	Check digit	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

Definition 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 method, 0x80-human presence, 0X83-fall 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: 1Byte (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;

8.2 Description of address assignment and data information

Category	Function description	Transmission direction	Frame header	Control word	Command word	Length identification	Data	Verification field	Frame tail	Remarks
System functions	Heartbeat package Report	Report	5359	01	01	0001	0f	sum	5443	
	Heartbeat package query	Issue	5359	01	80	0001	0f	sum	5443	
		Reply	5359	01	80	0001	0f	sum	5443	
	Module reset	Issue	5359	01	02	0001	0f	sum	5443	
		Report	5359	01	02	0001	0f	sum	5443	
Information query										
Product Info	Product model query	Issue	5359	02	A1	0001	0f	sum	5443	
		Reply	5359	02	A1	len	len B product information	sum	5443	
	Product id query	Issue	5359	02	A2	0001	0f	sum	5443	
		Reply	5359	02	A2	len	len B product id	sum	5443	
	Hardware model query	Issue	5359	02	A3	0001	0f	sum	5443	
		Reply	5359	02	A3	len	len B hardware model	sum	5443	
	Firmware version query	Issue	5359	02	A4	0001	0f	sum	5443	
		Reply	5359	02	A4	len	len B firmware version query	sum	5443	
	Message of initialization complete	Report	5359	05	01	0001	0f	sum	5443	
	Upload of radar failure	Report	5359	05	02	0001	01: Radar chip exception 02: Encryption exception ---	sum	5443	

Parameter query										
Working status	Initialization progress query	Issue	5359	05	81	0001	0f	sum	5443	
		Reply	5359	05	81	0001	01: Completed 00: Not completed	sum	5443	
		Reply	5359	06	02	0002	2B height information	sum	5443	
		Reply	5359	06	82	0002	2B height information	sum	5443	
Human presence report										
Human presence function	Enable/disable human presence function	Issue	5359	80	00	0001	01: Enable 00: Disable	sum	5443	
		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
	Body movement parameter report	Report	5359	80	03	0001	1B body movement parameters	sum	5443	Report method: Report every 1s Value range: 0-100
	Static energy report	Report	5359	80	04	0001	1B energy value	sum	5443	Value range: 0-100
	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	
	Body movement parameter query	Issue	5359	80	83	0001	0f	sum	5443	
		Reply	5359	80	83	0001	1B body movement parameters	sum	5443	Value range: 0-100
	Static energy query	Issue	5359	80	84	0001	0f	sum	5443	
		Reply	5359	80	84	0001	1B energy value	sum	5443	Value range: 0-100
Active report and setting of trajectory information										
	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	
	Total trajectories	Report	5359	82	01	01	1B Total trajectories	sum	5443	Report method: Reported once every 2 s. Value range: 0-255 Unit: pcs
	Active report of trajectory information (Cartesian coordinates	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	sum	5443	Location/angle/speed information has positive and negative values. The value is positive/negativ

	)						information, 2B height information, and 2B velocity (it can also be used to indicate approaching/leaving away information, in which case a positive value means approaching, and a negative one means leaving away)			e if the first bit of the 16-bit data is 0/1.
	Zoning	Issue	5359	82	09	0006	1B front 1B rear 2B left 2B right	sum	5443	Range: y-axis: 0-127 X-axis: -127-128 Unit: dm
		Reply	5359	82	09	0006	1B front 1B rear 2B left 2B right	sum	5443	
	Direction identification	Report	5359	82	0B	0002*n	1B*n: trajectory index 1B*n: direction status corresponding to the index Direction status 00: No 01: Left to right 02: Right to left	sum	5443	
Trajectory 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	
	Query of total trajectories	Issue	5359	82	81	0001	0f	sum	5443	
		Reply	5359	82	81	0001	1B Total trajectories	sum	5443	
	Trajectory information query	Issue	5359	82	82	0001	0f	sum	5443	Location information has positive and negative value, if the first 16 bits of data is 0, it indicates
		Reply	5359	82	82	len	Report multiple target points, each target point has 1B index, 1B target size, 1B target	sum	5443	

							characteristics, 2B X-axis position information, 2B Y-axis position information, 2B height information, and 2B velocity			positive, if the first bit is 1, it indicates positive
	Query of trajectory mode (Cartesian coordinates)	Issue	5359	82	83	0001	0f	sum	5443	
		Reply	5359	82	83	0001	00: Multiple persons 01: Single person	sum	5443	
	Zoning query	Issue	5359	82	89	0001	0f	sum	5443	
		Reply	5359	82	89	0006	1B front 1B rear 2B left 2B right	sum	5443	Range: y-axis: 0-127 X-axis: -127-128 Unit: dm
	Direction identification query	Issue	5359	82	8B	0001	0f	sum	5443	
		Reply	5359	82	8B	0006	1B*n: trajectory index 1B*n: direction status corresponding to the index Direction status 00: No 01: Left to right 02: Right to left	sum	5443	
Function points of active report and setting										
People counting	Enable/disable people counting feature	Issue	5359	86	00	0001	01: Enable 00: Disable	sum	5443	
		Reply	5359	86	00	0001	01: Enable 00: Disable	sum	5443	

Report People count information report	Report	5359	86	01	0007	1B: Mode 2B: People count of entry 2B: people count of exit 2B: People count in the detection coverage	sum	5443	Report Report on state change
Rectangular zone setting	Issue	5359	86	02	0011	1B is the bit of mode setting: 01 2B: x0 coordinate 2B: y0 coordinate 2B: x1 coordinate 2B: y1 coordinate 2B: x2 coordinate 2B: y2 coordinate 2B: x3 coordinate 2B: y3 coordinate	sum	5443	Input (x0, y0) first, and then (x1, y1), (x2, y2), and (x3, y3)
	Reply	5359	86	02	0011	1B is the bit of mode setting: 01 2B: x0 coordinate 2B: y0 coordinate 2B: x1 coordinate 2B: y1 coordinate 2B: x2 coordinate 2B: y2 coordinate 2B: x3 coordinate 2B: y3 coordinate	sum	5443	
People count resetting	Issue	5359	86	05	01	0f	sum	5443	
	Reply	5359	86	05	01	00: failure 01: success	sum	5443	
Setting of counting	Issue	5359	86	06	0001	00: X axis 01: Y axis	sum	5443	

	direction	Reply	5359	86	06	0001	00: X axis 01: Y axis	sum	5443	
	X and y threshold setting for line crossing	Issue	5359	86	07	0002	1B: X-axis threshold 1B: Y-axis threshold	sum	5443	
		Reply	5359	86	07	0002	1B: X-axis threshold 1B: Y-axis threshold	sum	5443	
	Direction setting of line crossing count	Issue	5359	86	08	0001	Oriented to radar 00: (when the counting direction is x: counting is from the left to the right) (When the counting direction is y: counting is from the front to the rear) 01: (when the counting direction is x: counting is from the right to the left) (When the counting direction is y: counting is from the rear to the front)	sum	5443	X-axis by default, from the left to the right.
		Reply	5359	86	08	0001	Oriented to radar 00: (when the counting direction is x: counting is from the left to the right) (When the counting direction is y: counting is from the front to the rear) 01: (when the counting direction is x: counting is from the right to the left) (When the counting direction is y: counting is from the rear to the front)	sum	5443	
	Setting of people counting	Issue	5359	86	09	0001	00: Line crossing counting 01: Rectangular detection	sum	5443	

	mode						counting 02: Round detection counting 03: Sector detection counting 04: Entire radar detection zone counting			
		Reply	5359	86	09	0001	00: Line crossing counting 01: Rectangular detection counting 02: Round detection counting 03: Sector detection counting 04: Entire radar detection zone counting	sum	5443	
Information query										
	People count query switch	Issue	5359	86	80	0001	0f	sum	5443	
		Reply	5359	86	80	0001	01: Enable 00: Disable	sum	5443	
	People count information query	Issue	5359	86	81	0001	0f	sum	5443	
		Reply	5359	86	81	0001	1B: Mode 2B: People count of entry 2B: people count of exit 2B: People count in the detection coverage	sum	5443	
	Rectangula	Issue	5359	86	82	0001	0f	sum	5443	

r zone query	Reply	5359	86	82	0007	1B is the bit of mode setting: 01 2B: x0 coordinate 2B: y0 coordinate 2B: x1 coordinate 2B: y1 coordinate 2B: x2 coordinate 2B: y2 coordinate 2B: x3 coordinate 2B: y3 coordinate	sum	5443	
Counting direction query	Issue	5359	86	85	0001	0f	sum	5443	
	Reply	5359	86	85	0001	00: X axis 01: Y axis	sum	5443	
Query of x and y threshold setting for line crossing	Issue	5359	86	87	0001	0f	sum	5443	
	Reply	5359	86	87	0002	Oriented to radar 00: (when the counting direction is x: counting is from the left to the right) (When the counting direction is y: counting is from the front to the rear) 01: (when the counting direction is x: counting is from the right to the left) (When the counting direction is y: counting is from the rear to the front)	sum	5443	Range of x: -127-+128 Range of y: 0-+255 Unit: dm
Query of line crossing counting direction	Issue	5359	86	88	0001	0f	sum	5443	

		Reply	5359	86	88	0001	00: Line crossing counting 01: Rectangular detection counting 02: Round detection counting 03: Sector detection counting 04: Entire radar detection zone counting	sum	5443	
OTA										
O T A	Start OTA upgrade	Issue	5359	03	01	0013	4B firmware package size+15B Firmware version	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 here
	Upgrade package transmission	Issue	5359	03	02	len+4	4B packet offset address + len B packet	sum	5443	
		Reply	5359	03	02	0001	01: Received 02: Failed to receive	sum	5443	
	Stop OTA upgrade	Issue	5359	03	03	0x0001	01: Firmware package transmission completed 02: Firmware package transmission not completed	sum	5443	
		Reply	5359	03	03	0x0001	0f	sum	5443	

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
Command word: 0X81
Length identification: 0X00 0X01
Data: 0X0f
Check digit: 1Byte (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
Take 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_0423	2023/04/23	First draft	Jason
V1.1_0530	2023/5/30	Remove useless function settings such as installation angle	Mark
V1.2_08310	2023/8/31	Delete part of the remark information of the track function	Mark