60G Millimeter Wave Radar Module

R60ABD1-Sleep monitoring radar module

User manual（Ver.2.3）

Micradar Technology (Shenzhen) Co. Ltd.

Contents

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Overview

This document mainly describes how to use the module of R60ABD1 to develop a product and explain the problems should be paid attention to during the process. The manual can help to reduce the design cost and increase the stability of the product, which can improve the efficiency of development.

From the hardware circuit reference design, the layout requirements of the radar antenna and the housing, how to distinguish the interference and the multi-function standard UART protocol output.

This module is a self-developed air sensing device, which is composed of a radio frequency antenna, radar chip and high-speed main frequency MCU. It relies on a stable, flexible and superior algorithm architecture to solve users' various detecting requirements. It can be used with a host computer software or a host to flexibly output detection status and data. It contains several groups of GPIOs, which can satisfy user-customized development requirements.

1. Working principle
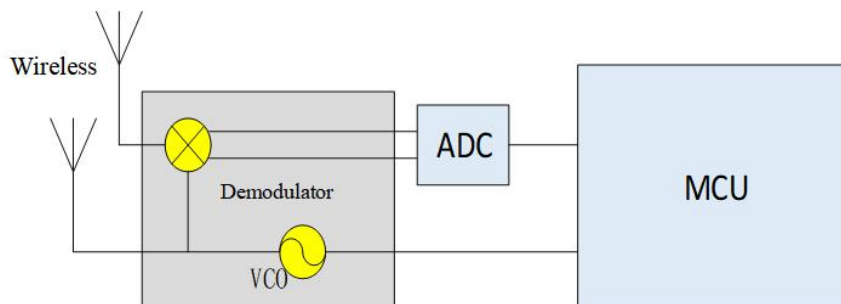
radar transmits a 60 G-band millimeter wave signal, and the measured target reflects the electromagnetic wave signal,and demodulates the transmitted signal, and then processes it through amplification, filtering, and ADC to obtain echo demodulated signal data. In the MCU unit, the amplitude, frequency, and phase of the echo signal are calculated, and the target parameters (sleep quality, breathing, turning over, body movement , etc.) are measured and the scene evaluation is finally realized.

2. Hardware Design Considerations

The radar's rated power supply voltage needs to meet 4.9 - 6V, and under normal working conditions, the rated current requires an input of more than 200mA. Power supply design, power supply ripple should be≤ 100mv.

2.1. The power supply can refer to the following circuit design

DC-DC +12V -> +5V

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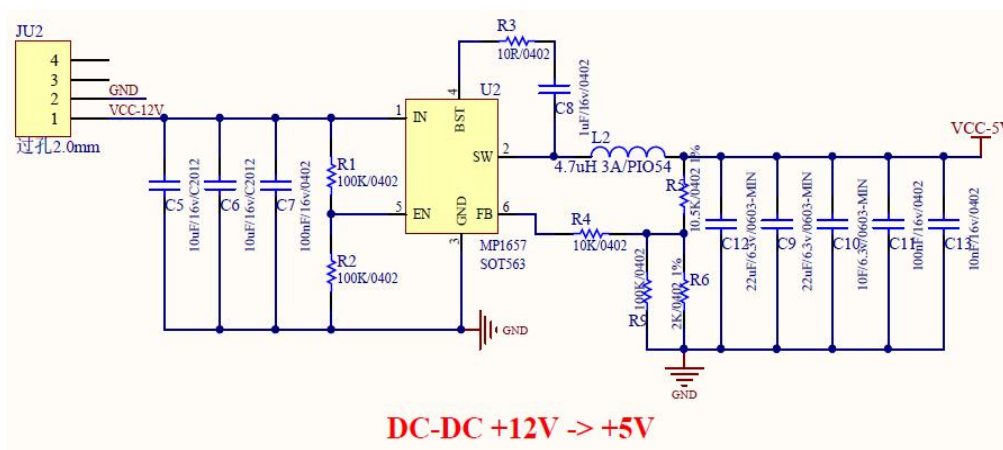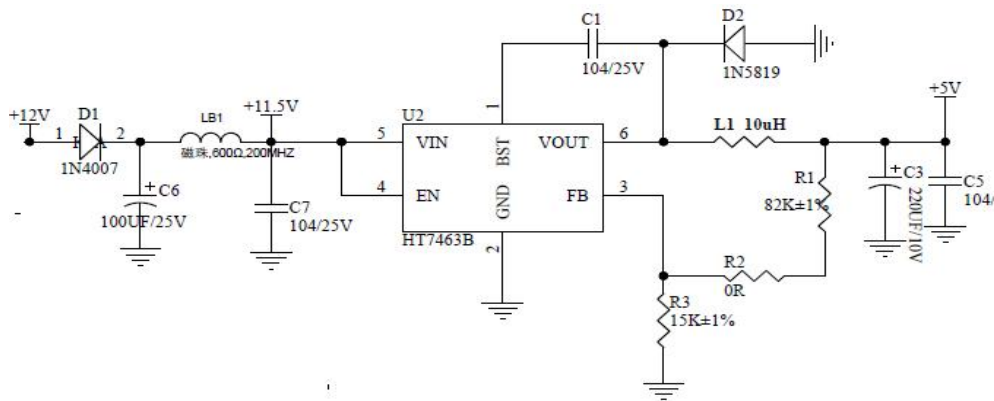
figure 1

figure 2

2.2. Use wiring diagrams
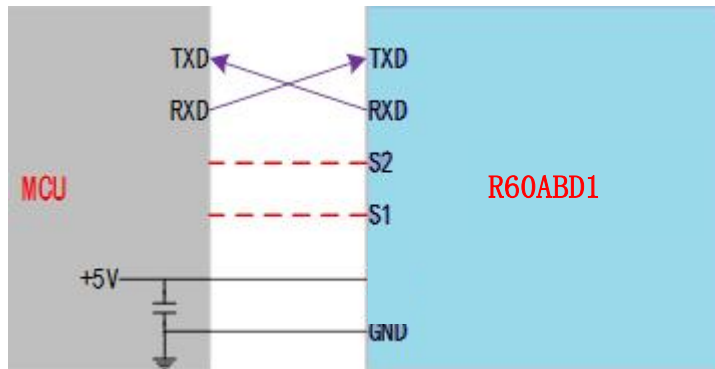
Figure 3 Schematic diagram of the connection between the radar module and the peripherals

3. Layout Requirements for Antenna and Housing

PCBA: Need to keep the height of the radar patch ≥ 1mm than other devices

Shell structure: It is necessary to maintain a distance of 2 - 5mm between the radar antenna surface and the shell surface

Shell detection surface: non-metallic shell, need to be straight to avoid curved surface, affecting the performance of the entire scanning area

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Figure 4

4. Static Protection

Radar products have static-sensitive circuits inside, which are prone to electrostatic hazards. Therefore, it is necessary to fully protect against static electricity during transportation, storage, work and handling. Do not touch and grab the radar module antenna surface and connector pins. Only touch its corners.

Wear anti-static gloves as much as possible when handling the radar sensor.

5. Detailed function

5.1. Function point description

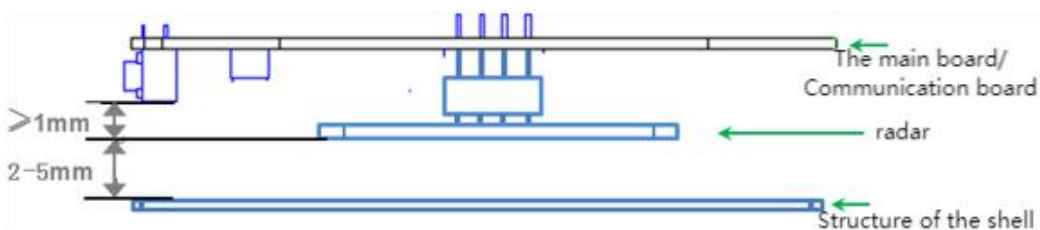| function points	State change time/function explanation
DP1: Someone/Nobody	No one to someone, report within 0.5s From someone to no one, 40 s output no one state
DP2: Someone is stationary / Someone is active	Static and dynamic switching, reporting within 0.5 seconds
DP3: Heartbeat rate	Output data once every 3 seconds, the unit is times/minute
DP4: Body Motion Amplitude Parameter 0 – 100	Output data once every 5 seconds [Reference: Description of Body Motion Amplitude Parameter Output]
DP5: Getting in/Out of bed	From getting out of bed to getting in bed, someone exists to report within 1 minute From bed entry to bed exit, the exit state is output in about 40s
DP6: Sleep state (awake/light/deep)	When in bed, judge and report the sleep state once every 10 minutes
DP7: Sleep Quality Score	At the end of the sleep process, report the score of this segment of sleep, with a score ranging from 0 to 100 points.
DP8: Respiratory/Heart Rate Rate	Output data once every 3 seconds, the unit is times/minute

6. Protocol description

This agreement applies to60G Communication between the millimeter wave breathing and sleep detection radar and the host computer.

This protocol briefly introduces the radar workflow, briefly introduces the structure of the interface protocol, and gives the control commands and data required for the related radar work. The serial port communication is defined as follows:

Interface level: TTL

Baud rate: 115200 bps

Stop bit: 1

Data bits: 8

Parity: None

7. Communication command and parameter definition

7.1. Frame structure definition and description

A. frame structure definition

frame header	control word	Command word	length identification		data	check code	end of frame
0X53 0X59	Control	Command	Lenth_H	Lenth_H	Data	Sum	0X54 0X43
2 Bytes	1 Byte	1 Byte	1 Byte	1 Byte	nByte	1 Byte	2 Bytes

B. frame structure description

a. Frame header: 2Byte, fixed at 0X53, 0X59;

b. Control word : 1 Byte

(0x0 1 - heartbeat packet identification, 0x0 2 - product information, 0x0 3 - OTA upgrade, 0x05 - working status, 0x07 - radar detection range information, 0x8 0 - human presence, 0x81 - breathing detection, 0x84 - sleep monitoring, 0x85 - heart rate monitoring)

c. Command word : 1Byte (identify the current data content)

d. Length identification : 2Byte, equal to the specific byte length of the data

e. Data: nByte, defined according to the actual function

f. Check code: 1 Byte,

(Check code calculation: frame header + control word + command word + length identifier + data) After summing, take the lower eight bits)

g. Frame end : 2 Byte, fixed at 0X54, 0X43;

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7.2. Address allocation and data information description

Product Category	Function Description	Transmission direction	frame header	control word	Command word	length identification	data	check field	end of frame	Remark
System functions	Heartbeat packet report	report	5359	01	01	0001	OF	sum	5443	
	Heartbeat packet query	Issued	5359	01	80	0001	OF	sum	5443	
		Reply	5359	01	80	0001	OF	sum	5443	
	Module reset	Issued	5359	01	02	0001	OF	sum	5443	
		report	5359	01	02	0001	OF	sum	5443	
	Product model report	report	5359	02	01	len	len B product information	sum	5443	
	Product ID report	report	5359	02	02	len	len B product id	sum	5443	
	Hardware model report	report	5359	02	03	len	len B hardware model	sum	5443	
	Firmware version report	report	5359	02	04	len	len B firmware version	sum	5443	
Information query										
	Product model query	Issued	5359	02	A1	0001	OF	sum	5443	
		Reply	5359	02	A1	len	len B Product Information	sum	5443	
	product	Issued	5359	02	A2	0001	OF	sum	5443	

product information	id query	Reply	5359	02	A2	len	len B product id	sum	5443	
	Hardware model query	Issued	5359	02	A3	0001	OF	sum	5443	
		Reply	5359	02	A3	len	len B hardware model	sum	5443	
	Firmware version query	Issued	5359	02	A4	0001	OF	sum	5443	
		Reply	5359	02	A4	len	len B firmware version	sum	5443	
working status	Initialization complete information	report	5359	05	01	0001	OF	sum	5443	
	Whether the initialization completes the query	Issued	5359	05	81	0001	OF	sum	5443	
		Reply	5359	05	81	0001	01: Completed 02: Not completed	sum	5443	
Radar detection range information	Location out-of-bounds status report	report	5359	07	07	0001	00: Out of range 01: In range	sum	5443	Reporting method: when the status changes
	Location out-of-bounds status query	Issued	5359	07	87	0001	OF	sum	5443	
		Reply	5359	07	87	0001	00: Out of range 01: In range	sum	5443	
human body report										
	Switch the	Issued	5359	8 0	00	0001	01: On 00: Off	sum	5443	

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	human presence function	Reply	5359	8 0	00	0001	01: On 00: Off	sum	5443	
human body function	Actively report existence information	report	5359	80	01	0001	00: no one 01: no one	sum	5443	Reporting method: report when the status changes
	Active reporting of sports information	report	5359	80	02	0001	00: None 01: Still 02: Active	sum	5443	Reporting method: report when the status changes
	Active reporting of physical activity parameters	report	5359	80	03	0001	1B Body Movement Parameters	sum	5443	Reporting method: report once every 1s Value range: 0-100
	Active reporting of human distance	report	5359	80	04	0002	2B Human distance	sum	5443	Reporting method: Report once every 2 s Value range: 0-65535 Unit: cm
	Active reporting of body position	report	5359	80	05	000 6	6B (2B:x, 2B:y, 2B:Z) Body Orientation	sum	5443	Reporting method: report once every 2s Unit: cm position information has positive and negative, the first 0 of 16-bit data means positive, and the first 1 means positive
Information query										
Query the human presence switch		Issued	5359	8 0	80	0001	OF	sum	5443	
		Reply	5359	85	80	0001	01: On	sum	5443	

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							00: Off		
Human existence information query	Existence information query	Issued	5359	80	81	0001	OF	sum	5443	
		Reply	5359	80	81	0001	00: no one 01: no one	sum	5443	
	Sports information query	Issued	5359	80	82	0001	OF	sum	5443	
		Reply	5359	80	82	0001	00: None 01: Still 02: Active	sum	5443	
	Body Motion Parameter Query	Issued	5359	80	83	0001	OF	sum	5443	
		Reply	5359	80	83	0001	1B Body Movement Parameters	sum	5443	Value range: 0-100
	Human body distance query	Issued	5359	80	84	0001	OF	sum	5443	
		Reply	5359	80	84	0002	2B Human distance	sum	5443	Value range: 0-65535 Unit: cm
	Human body orientation query	Issued	5359	80	85	0001	OF	sum	5443	
		Reply	5359	80	85	000 6	6B (2B:x, 2B:y, 2B:Z) Body Orientation	sum	5443	Unit: cm position information has positive and negative, the first 0 of 16-bit data means positive, and the first 1 means positive
Heart rate monitoring active reporting and settings										
Heart rate monitoring function	Switch the heart rate monitoring function on and	Issued	5359	85	00	0001	01: On 00: Off	sum	5443	
		Reply	5359	85	00	0001	01: On 00: Off	sum	5443	

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off								
Heart rate value	report	5359	85	02	0001	1B Heart rate value	sum	5443	Reporting method: Report once every 3 s Value range: 0 - 100
Heart rate waveform	report	5359	85	05	0005	5B Heart Rate Waveform	sum	5443	Reporting method: Report once every 1 s Value range: 0-2 28 5 bytes represent 5 values in real-time 1s, which is the real value + 128
Information query								
Querying the heart rate monitor switch	Issued	5359	85	80	0001	OF	sum	5443	
	Reply	5359	85	80	0001	01: On 00: Off	sum	5443	
Heart rate value query	Issued	5359	85	82	0001	OF	sum	5443	
	Reply	5359	85	82	0001	1B Heart rate value	sum	5443	Value range: 0-100
Heart rate waveform query	Issued	5359	85	85	0001	OF	sum	5443	
	Reply	5359	85	85	0005	3B Heart Rate Waveform	sum	5443	Reporting method: report once every 1 second Value range: 0-255 5 bytes represent 5 values within 1 second in real time, the waveform is sine wave data, and the central axis is 128, which means that when the heart rate intensity is equal to 0, it will be displayed as 128

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Active reporting and setting of respiratory monitoring									
Breath detection function	Switch breathing monitoring function on and off	Issued	5359	81	00	0001	01: On 00: Off	sum	5443	
		Reply	5359	81	00	0001	01: On 00: Off	sum	5443	
	breathing information	report	5359	81	01	0001	01: Normal 02: Breathing too high 03: Breathing too low 04: None	sum	5443	Reporting method: report when the status changes
	Breath value	report	5359	81	02	0001	1B Respiratory value	sum	5443	Reporting method: Report once every 3 s Value range: 0- 25
	Respiratory waveform	report	5359	81	05	0005	5B Respiratory waveform	sum	5443	Reporting method: report once every 1 second Value range: 0-255 5 bytes represent 5 values within 1 second in real time, the waveform is sine wave data, and the central axis is 128, which means that when the heart rate intensity is equal to 0, it will be displayed as 128
	Information query									
	Querying the respiration monitorin	Issued	5359	81	80	0001	OF	sum	5443	
		Reply	5359	81	80	0001	01: On 00: Off	sum	5443	

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g switch								
Respiratory information query	Issued	5359	81	81	0001	OF	sum	5443	
	Reply	5359	81	81	0001	01: Normal 02: Breathing too high 03: Breathing too low 04: None	sum	5443	
Respiratory value query	Issued	5359	81	82	0001	OF	sum	5443	
	Reply	5359	81	82	0001	1B Respiratory value	sum	5443	Value range: 0-30
Respiratory waveform query	Issued	5359	81	85	0001	OF	sum	5443	
	Reply	5359	81	85	0005	5B Respiratory waveform	sum	5443	Value range: 0-255
Active reporting and setting of sleep monitoring									
Switch the sleep monitoring function on and off	Issued	5359	84	00	0001	01: On 00: Off	sum	5443	
	Reply	5359	84	00	0001	01: On 00: Off	sum	5443	

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Sleep detection function	Bed in / out of bed	report	5359	84	01	0001	0x00: get out of bed 0x01: get into bed 0x02: None (displayed in real-time detection mode)	sum	5443	Reporting method: report when the status changes
	Sleep state	report	5359	84	02	0001	0x00: deep sleep 0x01: light sleep 0x02: awake 0x03: none (reported when getting out of bed /in real-time detection mode)	sum	5443	Reporting method: report every ten minutes
	Awake time	report	5359	84	03	0002	2Byte awake time	sum	5443	Reporting method: In the state of bed, follow the sleep state of 10 minutes to output the latest data of the corresponding duration. Value range: 0-65535 Unit: minutes
	light sleep duration	report	5359	84	04	0002	2Byte light sleep duration	sum	5443	Reporting method: In the state of bed, follow the sleep state of 10 minutes to output the latest data of the corresponding duration. Value range: 0-65535 Unit: minutes

deep sleep time	report	5359	84	05	0002	2Byte deep sleep time	sum	5443	Reporting method: In the state of bed, follow the sleep state of 10 minutes to output the latest data of the corresponding duration. Value range: 0-65535 Unit: minutes
Sleep Quality Score	report	5359	84	06	0001	1B Sleep Score	sum	5443	Reporting method: report at the end of the sleep process Value range: 0-100 Unit: minutes
Sleep status report	report	5359	84	0C	0008	1B Existing 1B Sleeping state 1B Average breathing 1B Average heartbeat 1B Turnover times 1B Large-scale body movements 1B Small-scale movements 1B Apnea times	sum	5443	Status reporting method: report once every ten minutes Existence: 1 someone 0 no one Sleeping: 3 getting out of bed (no one) 2 awake 1 light sleep 0 deep sleep The number of rollovers in sleep or deep sleep The ratio of large-scale body movements: the value is 0~100 The ratio of small-scale body movements: the value is 0~100 Apnea times: output the number of apnea in 10 minutes
Sleep quality analysis report	report	5359	84	0D	000C	1B Sleep quality score2B Total sleep duration1B Awake duration 1B Light sleep duration 1B Deep sleep	sum	5443	When it is judged that the sleep process is over , report the sleep statistics of the whole night 1B Sleep quality score numerical range: 0~100 2B Numerical range of total sleep duration: 0~65535 Unit: minute 1B Awake time proportion

						duration 1B Getting out of bed1B Number of getting out of bed1B Number of turning over1B Average breathing1B Average heartbeat1B Number of apnea (reserved parameter)		Numerical range: 0~100 1B Light Value range of sleep duration ratio: 0~100 1B Value range of deep sleep duration ratio: 0~100 1B Value range of time out of bed: 0~ 255 1B Value range of number of getting out of bed: 0~ 255 255 1B Value range of average respiration: 0~ 25 1B Value range of average heartbeat: 0~1 0 0 1B Value range of apnea times: 0~10 (not available)
Abnormal sleep report	report	5359	84	0E	0001	0x00 Sleep time is less than 4 hours 0x01 Sleep time is more than 12 hours 0x02 Abnormal long time no one 0x03 None	sum	5443	When the sleep duration is less than 4 hours or more than 12 hours, the abnormal sleep state is reported and there is no one detected for a long time, and the abnormality is reported.
Reporting mode selection	Issued	5359	84	OF	0001	0x00: Real-time data transmission 0x01: Sleep state transmission	sum	5443	

	Reply	5359	84	OF	0001	0x00: Real-time data transmission 0x01: Sleep state transmission	sum	5443	
Sleep quality rating report	Report	5359	84	10	0001	0x00 None 0x01 High sleep quality 0x02 medium sleep quality 0x03 Poor sleep quality	sum	5443	Output when sleep status ends
Abnormal struggling status report	Report	5359	84	11	0001	0x00 None 0x01 Normal status 0x02 Abnormal strugelling status	sum	5443	
Unoccupied timing status report	Report	5359	84	12	0001	0x00 None 0x01 Normal 0x02 Abnormal	sum	5443	
Abnormal struggling state switch setting	Issued	5359	84	13	0001	0x00 On 0x01 Off	sum	5443	
	Reply	5359	84	13	0001	0x00 On 0x01 Off	sum	5443	
Unoccupied timing status report switch setting	Issued	5359	84	14	0001	0x00 Off 0x01 On	sum	5443	
	Reply	5359	84	14	0001	0x00 Off 0x01 On	sum	5443	

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Timing duration setting in unoccupied situations	Issued	5359	84	15	0001	1B Time	sum	5443	Value range：30-180 Unit：minute Duration：10 minute
	Reply	5359	84	15	0001	1B Time	sum	5443	
Enter stop-sleeping state timing setting	Issued	5359	84	16	0001	1B Time	sum	5443	Value range: 5~120 Unit：Minute
	Reply	5359	84	16	0001	1B Time	sum	5443	
Information query									
Query the sleep monitoring switch	Issued	5359	84	80	0001	OF	sum	5443	
	Reply	5359	84	80	0001	01: On 00: Off	sum	5443	
Enquiry of bed entry/exit status	Issued	5359	84	81	0001	OF	sum	5443	
	Reply	5359	84	81	0001	0x00: get out of bed 0x01: get into bed	sum	5443	
Sleep state query	Issued	5359	84	82	0001	OF	sum	5443	
	Reply	5359	84	82	0001	0x00: deep sleep 0x01: light sleep 0x02: awake 0x03: none	sum	5443	
awake time query	Issued	5359	84	83	0001	OF	sum	5443	
	Reply	5359	84	83	0002	2Byte awake time	sum	5443	
Light	Issued	5359	84	84	0001	OF	sum	5443	

	sleep duration query	Reply	5359	84	84	0002	2Byte light sleep duration	sum	5443	
	Deep sleep time query	Issued	5359	84	85	0001	OF	sum	5443	
		Reply	5359	84	85	0002	2Byte deep sleep time	sum	5443	
	Sleep quality score query	Issued	5359	84	86	0001	OF	sum	5443	
		Reply	5359	84	86	0002	1B Sleep Score	sum	5443	
	Report mode query	Issued	5359	84	8C	0001	OF	sum	5443	
		Reply	5359	84	8C	0001	0x00: Real-time data transmission 0x01: Sleep state transmission	sum	5443	
	Sleep comprehensive state query	Issued	5359	84	8D	0001	OF	sum	5443	
		Reply	5359	84	8D	000 8	1B Existing 1B Sleeping state 1B Average breathing 1B Average heartbeat 1B Turnover times 1B Large-scale body movements 1B Small-scale movements 1B Apnea times	sum	5443	

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		Issued	5359	84	8E	0001	OF	sum	5443	
Sleep exception query		Reply	5359	84	8E	000C	0x00 Sleep duration is less than 4 hours 0x01 Sleep duration is greater than 12 hours 0x02 Abnormal long time no one 0x03 None	sum	5443	When the sleep duration is less than 4 hours or more than 12 hours, the abnormal sleep state is reported and there is no one detected for a long time, and the abnormality is reported.
	Sleep	Issued	5359	84	8F	0001	OF	sum	5443	

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statistics query	Reply	5359	84	8F	000C	1B Sleep quality score 2B Total sleep duration 1B Awake duration 1B Light sleep duration 1B Deep sleep duration 1B Getting out of bed 1B Number of getting out of bed 1B Number of turning over 1B Average breathing 1B Average heartbeat 1B Number of apnea (reserved parameter)	sum	5443	When it is judged to wake up and get out of bed, start reporting the sleep statistics of the whole night 1B Sleep quality score numerical range: 0~100 2B Numerical range of total sleep duration: 0~65535 Unit: minutes 1B Numerical range of awake time proportion: 0~100 1B Value range of light sleep duration: 0~100 1B Value range of deep sleep duration: 0~100 1B Value range of time out of bed: 0~100 Range: 0~40 1B Average respiration range: 0~30 1B Average heartbeat range: 0~150 1B Apnea count range: 0~10
Sleep Quality Rating Query	Issued	5359	84	90	0001	OF	sum	5443	
	Reply	5359	84	90	0001	0x00 None 0x01 High sleep quality 0x02 normal sleep quality 0x03 weak sleep quality	sum	5443	
Abnorma	Issued	5359	84	91	0001	OF	sum	5443	

l struggelling status query	Reply	5359	84	91	0001	0x00 None 0x01 Normal status 0x02 Abnormal struggelling status	sum	5443	
Timing status query in unoccupied status	Issued	5359	84	92	0001	OF	sum	5443	
	Reply	5359	84	92	0001	0x00 None 0x01 normal 0x02 Abnormal	sum	5443	
Abnormal struggling status switch query	Issued	5359	84	93	0001	OF	sum	5443	
	Reply	5359	84	93	0001	0x00 Off 0x01 On	sum	5443	
Inquiry of timing function switch in unoccupied state	Issued	5359	84	94	0001	OF	sum	5443	
	Reply	5359	84	94	0001	0x00 Off 0x01 On	sum	5443	
Query the timing duration of no one state	Issued	5359	84	95	0001	OF	sum	5443	Value range 30-180 Unit：minute
	Reply	5359	84	95	0001	1B Time	sum	5443	
Inquiry of time of entering stop-sleeping state	Issued	5359	84	96	0001	OF	sum	5443	Value range 5~120 Unit: minute
	Reply	5359	84	96	0001	1B Time	sum	5443	

OTA									
O T A	Start OTA upgrade	Issued	5359	03	01	0013	4B firmware package size + 15B firmware version number	sum	5443	
		Reply	5359	03	01	0004	4B Transfer upgrade package size per frame	sum	5443	The host computer will determine how long the firmware package information needs to be sent for each frame according to the size of the reply here
	Upgrade package transfer	Issued	5359	03	02	len+4	4B packet offset address + len B packet	sum	5443	
		Reply	5359	03	02	0001	01: Received successfully 02: Received failed	sum	5443	
	End OTA upgrade	Issued	5359	03	03	0x0001	01: Firmware package sending completed 02: Firmware package sending not completed	sum	5443	
		Reply	5359	03	03	0x0001	OF	sum	5443	

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Appendix 1 : About Data Command Generation Routines

Example: Existence information query:

The data structure that confirms the existence of information query through the above protocol table is:
Frame header: 0X53 0X59
Control word: 0X80
Command word: 0X81
Length identification: 0X00 0X01
Data: 0XOF
Check code: 1Byte (SUM)
Frame end: 0X54 0X43

Combined into a complete command:
53 59 80 81 00 01 OF sum 54 43
Check code sum:
(0X53+0X59+0X80+0X81+0X00+0X01+0XOF) = 0X01BD
Take the low byte to get sum = 0XBD
Therefore, the complete existence information query command is: 53 59 80 81 00 01 OF BD 54 43

8. Historical version update instructions

Revision	Release Date	Summary
V1.0_ 0 623	202 2/06/23	first draft
V1.1_0720	2022/7/20	Added detection mode query command, adjusted detection mode setting command
V1.2_0720	2022/7/20	Fix the problem of the active reporting protocol of human body orientation
V1.3_0729	2022/7/29	1: Added "Sleep Synthetic Status Query" to Sleep Radar 2、 Modified the length identification of "human body orientation query" and "human body orientation active reporting" to "0006" 3. Modified the data content of "sleep state" and "sleep state query", from the original "0x02 deep sleep 0x00 awake" to "0x02 awake 0x00 deep sleep"
V1.4_0801	2022/8/1	Modify the protocol for initializing query replies Change the original "01 not completed 02 completed" to "00 not completed 01 completed"
V1.5_0905	2022/9/5	1: Increase the state value "0x03---None" in the abnormal sleep state; 2: Added sleep abnormal state query function
V1.6_1008	2022/10/8	Added human presence switch settings and query functions
V1.7_1115	2022/11/15	Revise the instructions on the display of the respiratory and heartbeat waveform values. The value is a sine wave value, and the central axis is 128 [0~128	128~255]
V1.8_1128	2022/11/28	Added a heartbeat packet active reporting command, which requires firmware version 1.0.7 or newer to apply.
V1.9_1204	2022/12/4	Optimize the protocol problem of heartbeat packet query command
V2.0_0221	2023/2/21	Adjust typography
V2.1_0405	2023/4/5	Added functions such as unmanned timing/abnormal

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		struggle/sleep rating
V2.2_0527	2023/5/27	Added sleep cut-off time setting and query
V2.3_0728	2023/7/28	Added product information (product model, product id, hardware version, firmware version active reporting protocol)