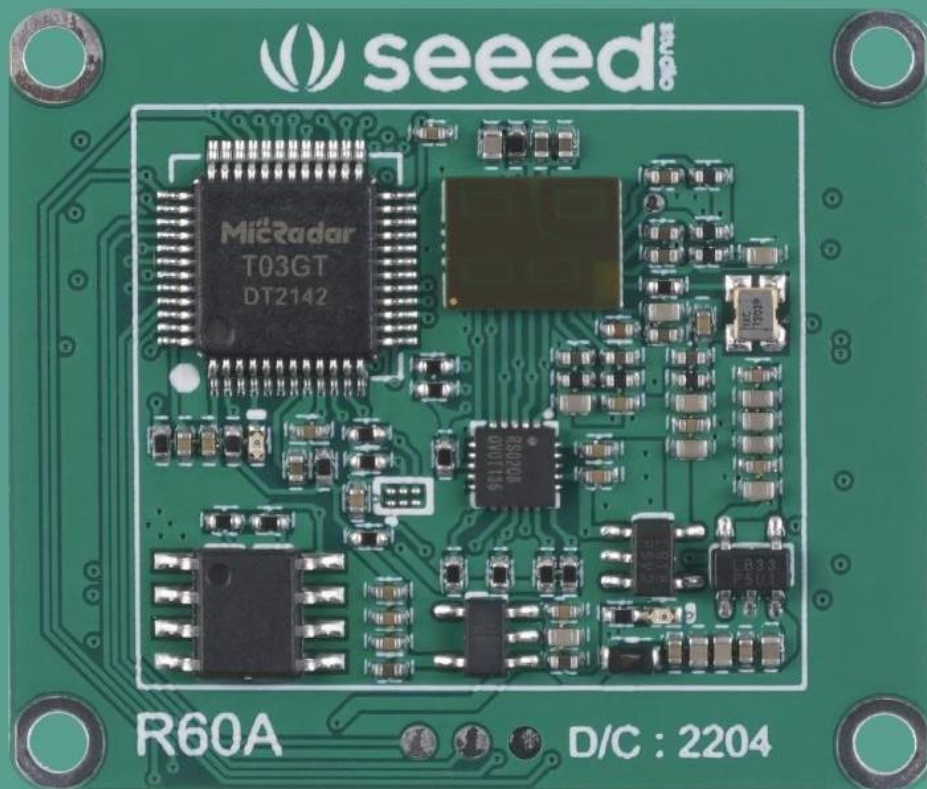


MR60BHA1

60GHz mmWave Module - Respiratory
Heartbeat Detection

Sensor User Manual (V1.9)



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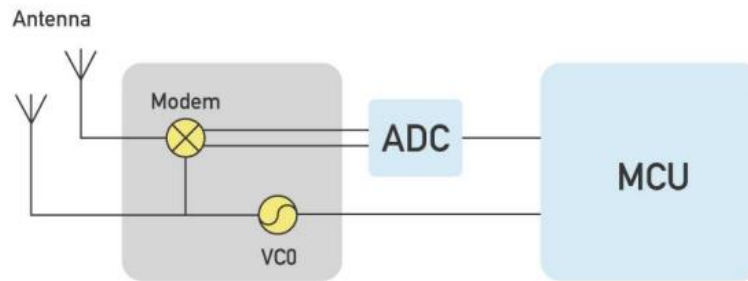
Overview

This document focuses on the use of the radar, the issues that need to be paid attention to in each phase, to minimize the design cost and increase the stability of the product, and to improve the efficiency of the project completion. This document focuses on the issues that need to be taken into account in each phase, in order to minimize the design cost and increase the stability of the product, and to improve the efficiency of the project completion.

From hardware circuit reference design, radar antenna and housing layout requirements, how to distinguish interference and multi-functional standard UART protocol output. The radar is a self-contained system.

This radar is a self-contained space sensing sensor, which consists of RF antenna, radar chip and high speed MCU. The radar is a self-contained sensor with a combination of RF antenna, radar chip and high-speed main frequency MCU. It can be equipped with a host computer or host computer to flexibly output detection status and data, and meet the needs of several groups of GPIOs. It can be equipped with a host computer or a host computer to flexibly output detection status and data, and meet several groups of GPIOs for user customization and development.

1. Working Principle



The radar transmits a 60G band millimeter wave signal, and the target reflects the electromagnetic wave signal, and demodulates it from the transmitted signal. The signal is demodulated, then amplified, filtered, ADC and other processing to obtain the echo demodulation signal data. In the MCU unit, the amplitude, frequency and phase of the echo signal are decoded, and the target signal is finally decoded. The target parameters (sleep quality, respiration, tossing, body movement, etc.) are measured and evaluated in the MCU.

2. Hardware Design Considerations

The rated supply voltage of the radar needs to meet 4.9 - 6V, and the rated current needs to be 200mA or more input is required. The power supply is designed to have a ripple of $\leq 100\text{mv}$.

2.1 Power supply can refer to the following circuit design

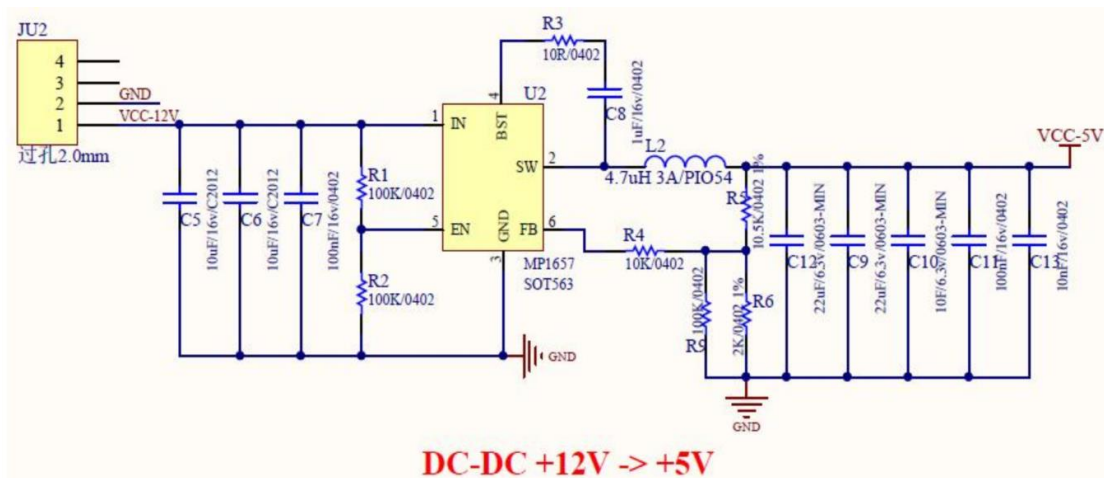


Figure 1



The diagram shows the connection between an MCU (Microcontroller Unit) and an MR60BHA1 module. The MCU is represented by a grey box on the left, and the MR60BHA1 module is represented by a light blue box on the right. The connections are as follows:

- TXD:** The TXD pin of the MCU is connected to the RXD pin of the MR60BHA1 module.
- RXD:** The RXD pin of the MCU is connected to the TXD pin of the MR60BHA1 module.
- S2:** A dashed red line indicates a connection between the S2 pin of the MCU and the S2 pin of the MR60BHA1 module.
- S1:** A dashed red line indicates a connection between the S1 pin of the MCU and the S1 pin of the MR60BHA1 module.
- +5V:** The +5V pin of the MCU is connected to the VCC pin of the MR60BHA1 module.
- GND:** The GND pin of the MCU is connected to the GND pin of the MR60BHA1 module.

Figure 3 Module and peripheral wiring diagram

3. Antenna and housing layout requirements

Housing structure: need to keep the radar antenna surface and the housing surface have 5mm distance

Housing detection surface: non-metallic housing, need to be straight to avoid bending surface, affect the performance of the whole sweep surface area Performance

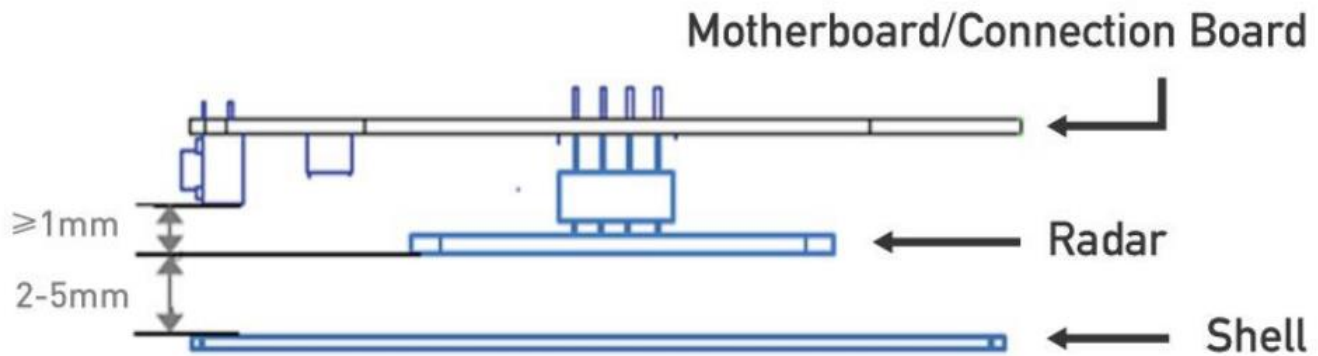


Figure 4

4. Electrostatic protection

Radar products with electrostatic sensitive circuitry inside, vulnerable to electrostatic hazards, so need to be in transport, storage, work and handling process to do a good job of electrostatic protection, do not touch the grasp of the radar hands. Therefore, it is necessary to do a good job in the transportation, storage, work and picking up process of static protection, do not touch and grab the radar module antenna surface and connector pins, only touch the corners. Do not touch the surface of the radar module antenna and connector pins with your hands, only touch the corners.

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

5. Detailed explanation of functions

5.1 Function Description

Function	Status change time/function explanation
DP1: occupied/unoccupied	From unoccupied to occupied, report within 0.5s From occupied to unoccupied, report within 40 s
DP2: Some people are stationary / Some people are active	Static dynamic switching, report within 0.5 seconds
DP3: Heart rate	Outputs data once every 3 seconds, in units of times/minute

DP4: Body movement parameters 0 - 100	Output data once every 5 seconds [Refer to: Body motion amplitude parameter output instructions].
DP5: In-bed/out-of-bed	From bed-out to bed-in, 1 minute report in the presence of someone From bed-in to bed-out, about 40s output of bed-out status
DP6: Sleep state (awake/light sleep/deep sleep)	In the bed state, 10 minutes to determine and report sleep status once
DP7: Sleep quality score	At the end of the sleep process, a score of 0 to 100 is reported for the sleep period
DP8: Respiratory/heart rate rate	Outputs data once every 3 seconds, in units of times/minute

6. Protocol Description

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

This protocol outlines the radar workflow, briefly introduces the interface protocol composition architecture, and The interface protocol structure is briefly introduced, and the related radar work requires control commands and data.

Interface level: TTL

Baud rate: 115200bps

Stop bit: 1

Data bits: 8

Parity check: None

7. Communication command and parameter definition

7.1 Frame structure definition and description

7.1.1 Definition of frame structure

Frame header	Control word	Command word	Length identifier		Data	Checksum	End of frame
0x53 0x59	Control	Command	Lenth_H	Lenth_L	Data	Sum	0x54 0x43
2 Byte	1 Byte	1 Byte	1 Byte	1 Byte	n Byte	1 Byte	2 Byte

7.1.2 Description of the frame structure

a. Frame header: 2 Byte, fixed to 0x53,0x59;

b. Control word: 1 Byte

(0x01 - heartbeat packet identification, 0x02 - product information, 0x03 - OTA upgrade, 0x05 - operation status, 0x07 - radar detection range information, 0x80 - human presence, 0x81 - breath detection, 0x84 - sleep monitoring, 0x85 - heart rate monitoring)

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

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

e. Data: n Byte, defined according to the actual function

f. Checksum: 1 Byte. (Calculation method of checksum: “frame header + control word + command word + length identifier + data” summed to the lower eight bits)

g. End of frame: 2Byte, fixed to 0x54,0x43;

7.2 Description of address assignment and data information

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
System Functions	Heartbeat Pack Report	Report	0x53 0x59	0x01	0x01	0x00	0x01	0F	sum	0x54 0x43	
	Heartbeat Package Inquiry	Send	0x53 0x59	0x01	0x80	0x00	0x01	0F	sum	0x54 0x43	
		Response	0x53 0x59	0x01	0x80	0x00	0x01	0F	sum	0x54 0x43	
	Module Reset	Send	0x53 0x59	0x01	0x02	0x00	0x01	0F	sum	0x54 0x43	
		Response	0x53 0x59	0x01	0x02	0x00	0x01	0F	sum	0x54 0x43	
	Information Inquiry										
Product Information	Product Model	Send	0x53 0x59	0x02	0xA1	0x00	0x01	0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA1	0x00	len	len B Product Info	sum	0x54 0x43	
	Product ID	Send	0x53 0x59	0x02	0xA2	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA2	0x00	len	len B Product ID	sum	0x54 0x43	
	Hardware Model	Send	0x53 0x59	0x02	0xA3	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA3	0x00	len	len B Hardware model	sum	0x54 0x43	
	Firmware Version	Send	0x53 0x59	0x02	0xA4	0x00	0x01	0F	sum	0x54 0x43	
		Response	0x53 0x59	0x02	0xA4	0x00	len	len B Firmware version	sum	0x54 0x43	

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Working Status	Initialization completion message	Report	0x53 0x59	0x05	0x01	0x00	0x01	0x0F	sum	0x54 0x43	
	Query if initialization is complete	Send	0x53 0x59	0x05	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x05	0x81	0x00	0x01	0x01: Completed 0x02: Incomplete	sum	0x54 0x43	
Radar detection range info	Out-of-bounds status reporting	Report	0x53 0x59	0x07	0x07	0x00	0x01	0x00: Out of range 0x01: Within range	sum	0x54 0x43	Report when status changes
	Query out-of-bounds status	Send	0x53 0x59	0x07	0x87	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x07	0x87	0x00	0x01	0x00: Out of range 0x01: Within range	sum	0x54 0x43	
Proactive reporting of human presence information											
	Human presence detection function switch	Send	0x53 0x59	0x80	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
Human presence detection function	Human existence information	Report	0x53 0x59	0x80	0x01	0x00	0x01	0x00: Occupied 0x01: Unoccupied	sum	0x54 0x43	Report when status changes
	Human movement information	Report	0x53 0x59	0x80	0x02	0x00	0x01	0x00: None 0x01: Stationary 0x02: Active	sum	0x54 0x43	Report when status changes
	Body movement parameters	Report	0x53 0x59	0x80	0x03	0x00	0x01	1B Body movement parameters	sum	0x54 0x43	Reported once in 1 second, value range 0-100
	Human distance information	Report	0x53 0x59	0x80	0x04	0x00	0x02	2B Human distance	sum	0x54 0x43	Reported once in 2 seconds, value range 0-65535, unit cm
	Human orientation information	Report	0x53 0x59	0x80	0x05	0x00	0x06	2B x 2B y 2B z	sum	0x54 0x43	Reported once in 2 seconds, in centimeters, with positive and negative position
	Query human presence monitoring function switch	Send	0x53 0x59	0x80	0x80	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x85	0x80	0x00	0x01	0x00: Occupied 0x01: Unoccupied	sum	0x54 0x43	
Human Presence Information Inquiry	Human Existence Inquiry	Send	0x53 0x59	0x80	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x81	0x00	0x01	0x00: Occupied 0x01: Unoccupied	sum	0x54 0x43	
	Movement Information Inquiry	Send	0x53 0x59	0x80	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x82	0x00	0x01	0x00: None 0x01: Stationary 0x02: Active	sum	0x54 0x43	
	Body movement parameter Inquiry	Send	0x53 0x59	0x80	0x83	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x83	0x00	0x01	1B Body movement parameters	sum	0x54 0x43	Value range 0-100
	Human Distance Inquiry	Send	0x53 0x59	0x80	0x84	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x84	0x00	0x02	2B Human distance	sum	0x54 0x43	Value range 0-65535, unit cm
	Human orientation Inquiry	Send	0x53 0x59	0x80	0x85	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x80	0x85	0x00	0x06	2B x 2B y 2B z	sum	0x54 0x43	In centimeters, with positive and negative position
Respiratory and heart rate monitoring active reporting and setup											
Heart rate monitor function	Heart rate monitoring function switch	Send	0x53 0x59	0x85	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
		Response	0x53 0x59	0x85	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Heart rate values	Report	0x53 0x59	0x85	0x02	0x00	0x01	1B Heart rate	sum	0x54 0x43	Reported once every 3 seconds, value range 0-100
	Heart rate waveform	Report	0x53 0x59	0x85	0x05	0x00	0x05	5B Heart rate waveform	sum	0x54 0x43	Reported once in 1 second, value range 0-255 5 bytes represent 5 values in 1s in real time, and the waveform is a sine wave with a median of 128, i.e. when the heart rate intensity is equal to 0, it will be displayed as 128

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Heart rate monitor function	Information Inquiry										
	Checking heart rate monitoring switch status	Send	0x53 0x59	0x85	0x80	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x85	0x80	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Heart rate query	Send	0x53 0x59	0x85	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x85	0x82	0x00	0x01	1B Heart rate	sum	0x54 0x43	value range 0-100
	Heart rate waveform query	Send	0x53 0x59	0x85	0x85	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x85	0x85	0x00	0x05	5B Heart rate waveform	sum	0x54 0x43	value range 0-255
Respiratory monitoring report and setup											
Respiratory monitoring function	Respiratory monitoring function switch	Send	0x53 0x59	0x81	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
		Response	0x53 0x59	0x81	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Breathing Information	Report	0x53 0x59	0x81	0x01	0x00	0x01	0x01: Normal 0x02: Fast breathing 0x03: Slow breathing 0x04: None	sum	0x54 0x43	Report when status changes
	Breathing values	Report	0x53 0x59	0x81	0x01	0x00	0x01	1B Breathing value	sum	0x54 0x43	Reported once every 3 seconds, value range 0-25
	Breathing waveform	Report	0x53 0x59	0x81	0x02	0x00	0x05	5B Breathing waveform	sum	0x54 0x43	Reported once in 1 second, value range 0-255 5 bytes represent 5 values in 1s in real time, and the waveform is a sine wave with a median of 128, i.e. when the heart rate intensity is equal to 0, it will be displayed as 128
	Information Inquiry										
	Inquiry respiratory monitoring function switch	Send	0x53 0x59	0x81	0x80	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x81	0x80	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Query Breathing Information	Send	0x53 0x59	0x81	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x81	0x81	0x00	0x01	0x01: Normal 0x02: Fast breathing 0x03: Slow breathing 0x04: None	sum	0x54 0x43	
	Query breathing values	Send	0x53 0x59	0x81	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x81	0x82	0x00	0x01	1B Breathing value	sum	0x54 0x43	value range 0-25
	Query respiratory waveform	Send	0x53 0x59	0x81	0x85	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x81	0x85	0x00	0x05	5B Breathing waveform	sum	0x54 0x43	value range 0-255
Sleep monitoring reporting and setup											
Sleep monitoring function	Sleep monitoring function switch	Send	0x53 0x59	0x84	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x00	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Bed-in/bed-out status	Report	0x53 0x59	0x84	0x01	0x00	0x01	0x00: Bed-out 0x01: Bed-in 0x02: None (Displayed when real-time data transfer mode is on)	sum	0x54 0x43	Report when status changes
	Sleep status	Report	0x53 0x59	0x84	0x02	0x00	0x01	0x00: Deep sleep 0x01: Light sleep 0x02: Awake 0x03: None (Displayed when out of bed/real time data transfer mode is on)	sum	0x54 0x43	Reported once every 10 minutes
	Duration of sobriety	Report	0x53 0x59	0x84	0x03	0x00	0x02	2 Byte Awake time	sum	0x54 0x43	Into bed state, follow 10 minutes of sleep state output corresponding to the length of time. Value range: 0-65535, unit: min

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Sleep monitoring function	Duration of light sleep	Report	0x53 0x59	0x84	0x04	0x00	0x02	2 Byte light sleep time	sum	0x54 0x43	Into bed state, follow 10 minutes of sleep state output corresponding to the length of time. Value range: 0-65535, unit: min
	Duration of deep sleep	Report	0x53 0x59	0x84	0x05	0x00	0x02	2 Byte deep sleep time	sum	0x54 0x43	Into bed state, follow 10 minutes of sleep state output corresponding to the length of time. Value range: 0-65535, unit: min
	Sleep quality score	Report	0x53 0x59	0x84	0x06	0x00	0x01	1B sleep quality score	sum	0x54 0x43	Reported at the end of sleep, value range 0-100, unit: minutes.
	Sleep integrated state	Report	0x53 0x59	0x84	0x0C	0x00	0x08	1B Human exists 1B Sleep state 1B Average breathing 1B Average heart rate 1B Number of turning 1B Percentage of significant body movements 1B Percentage of small body movements 1B Number of respiratory pauses	sum	0x54 0x43	Reported every 10 minutes Human exists: 0x01 occupied, 0x00 unoccupied Sleep state: 0x03 out of bed, 0x02 awake, 0x01 light sleep, 0x00 deep sleep Average heart rate and respiration: average over 10 minutes Number of turning: The number of rolls in light or deep sleep Percentage of body movements: value range 0-100 Number of respiratory pauses: Number of pauses in breathing in 10 minutes
	Analysis of sleep quality	Report	0x53 0x59	0x84	0x0D	0x00	0x0C	1B Sleep quality score 2B Total hours of sleep 1B Percentage of waking hours 1B Percentage of light sleep 1B Percentage of deep sleep 1B Length of time out of bed 1B Number of times out of bed 1B Number of turning 1B Average breathing 1B Average heart rate 1B Number of respiratory pauses (reserved parameter)	sum	0x54 0x43	Report sleep statistics for the entire night when the sleep process is judged to be over. Sleep quality score: 0-100 Total hours of sleep: 0-65535 units: min Percentage of wake/light/deep sleep: 0-100 Length of time out of bed: 0-255 Number of times out of bed/turning: 0-255 Average breathing: 0-25 Average heart rate: 0-100 Number of respiratory pauses: 0-10 (Not available)
	Abnormal sleep conditions	Report	0x53 0x59	0x84	0x0E	0x00	0x01	0x00: Less than 4 hours of sleep 0x01: More than 12 hours of sleep 0x02: No one detected for a long time 0x03: None	sum	0x54 0x43	When the sleep duration is less than 4 hours or more than 12 hours the abnormal state is reported. If there is no one in the sleep state for a long time, the abnormal status is reported.
	Reporting mode selection	Report	0x53 0x59	0x84	0x0F	0x00	0x01	0x00: Real-time data transfer mode 0x01: Sleep state transmission mode	sum	0x54 0x43	
		Report	0x53 0x59	0x84	0x0F	0x00	0x01	0x00: Real-time data transfer mode 0x01: Sleep state transmission mode	sum	0x54 0x43	
	Information Inquiry										
	Query sleep monitoring function switch status	Send	0x53 0x59	0x84	0x80	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x80	0x00	0x01	0x01: On 0x00: Off	sum	0x54 0x43	
	Query Bed-in/bed-out status	Send	0x53 0x59	0x84	0x81	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x81	0x00	0x01	0x00: Bed-out 0x01: Bed-in	sum	0x54 0x43	

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification		Data	Checksum field	End of frame	Note
Sleep monitoring function	Query Sleep status	Send	0x53 0x59	0x84	0x82	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x82	0x00	0x01	0x00: Deep sleep 0x01: Light sleep 0x02: Awake 0x03: None	sum	0x54 0x43	
	Query duration of sobriety	Send	0x53 0x59	0x84	0x83	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x83	0x00	0x02	2 Byte Awake time	sum	0x54 0x43	
	Query duration of light sleep	Send	0x53 0x59	0x84	0x84	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x84	0x00	0x02	2 Byte light sleep time	sum	0x54 0x43	
	Query duration of deep sleep	Send	0x53 0x59	0x84	0x85	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x85	0x00	0x02	2 Byte deep sleep time	sum	0x54 0x43	
	Query sleep quality score	Send	0x53 0x59	0x84	0x86	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x86	0x00	0x01	1B sleep quality score	sum	0x54 0x43	
	Query reporting mode	Send	0x53 0x59	0x84	0x8C	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x8C	0x00	0x01	0x00: Real-time data transfer mode 0x01: Sleep state transmission mode	sum	0x54 0x43	
	Query sleep integrated state	Send	0x53 0x59	0x84	0x8D	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x8D	0x00	0x08	1B Human exists 1B Sleep state 1B Average breathing 1B Average heart rate 1B Number of turning 1B Percentage of significant body movements 1B Percentage of small body movements 1B Number of respiratory pauses	sum	0x54 0x43	
	Query abnormal sleep conditions	Send	0x53 0x59	0x84	0x8E	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x8E	0x00	0x01	0x00: Less than 4 hours of sleep 0x01: More than 12 hours of sleep 0x02: No one detected for a long time 0x03: None	sum	0x54 0x43	
	Query sleep statistics	Send	0x53 0x59	0x84	0x8F	0x00	0x01	0x0F	sum	0x54 0x43	
		Response	0x53 0x59	0x84	0x8F	0x00	0x0C	1B Sleep quality score 2B Total hours of sleep 1B Percentage of waking hours 1B Percentage of light sleep 1B Percentage of deep sleep 1B Length of time out of bed 1B Number of times out of bed 1B Number of turning 1B Average breathing 1B Average heart rate 1B Number of respiratory pauses (reserved parameter)	sum	0x54 0x43	

Function Category	Function Description	Transfer direction	Frame header	Control word	Command word	Length Identification	Data	Checksum field	End of frame	Note
OTA (This feature is not yet available)										
OTA	Start OTA upgrade	Send	0x53 0x59	0x03	0x01	0x00	0x13	4B Firmware package size + 15B Firmware version number	sum	0x54 0x43
		Response	0x53 0x59	0x03	0x01	0x00	0x04	4B Transfer upgrade package size per frame	sum	0x54 0x43 The host computer will follow this the size of the response at this point to determine how long the how long a firmware packet needs to be sent information
	Upgrade package transmission	Send	0x53 0x59	0x03	0x02	0x00	len+4	4B Package offset address + len B Data Packages	sum	0x54 0x43
		Response	0x53 0x59	0x03	0x02	0x00	0x01	0x01: Received successfully 0x00: Receive Failure	sum	0x54 0x43
	Ending the OTA upgrade	Send	0x53 0x59	0x03	0x03	0x00	0x01	0x01: Firmware package delivery completed 0x00: Firmware package delivery not completed	sum	0x54 0x43
		Response	0x53 0x59	0x03	0x03	0x00	0x01	0x0F	sum	0x54 0x43

Appendix 1: About the calculation of check digit

Let's take the command to send a human presence information query as an example.

The data construction for the presence information query confirmed by the protocol table above is

Frame header: 0x53 0x59

Control word: 0x80

Command word: 0x81

Length identifier: 0x00 0x01

Data: 0x0F

Checksum: 1Byte (SUM)

End of frame: 0x54 0x43

Combined into a complete instruction as follows

53 59 80 81 00 01 0F sum 54 43

Check digit sum : $0x53 + 0x59 + 0x80 + 0x81 + 0x01 + 0x0F$

$(0x53 + 0x59 + 0x80 + 0x81 + 0x00 + 0x01 + 0x0F) = 0x01BD$

The lower byte is sum = 0xBD

So the complete existence information query instruction is: 53 59 80 81 00 01 0F BD 54