Laser Ranging Module

# BM42S5321-1

Revision: V1.00 Date: August 31, 2023

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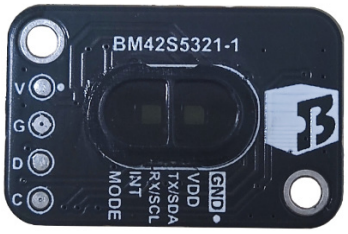
## Features




- Operating voltage: 3.0~5V
- Operating current: 16.3mA @ 5V
- Standby current: 560μA (Measure once in 500ms) @ 5V
- Sleep current: 1μA @ 5V (The module does not perform any action in the Sleep mode)
- Transmission method: I²C/UART (The default baud rate is 9600)
- Function effect: Single/continuous measurement, adjustable FoV, adjustable sample time, adjustable measurement period, set distance thresholds
- Measuring range: 4cm~400cm
- Size: 23mm×15mm×9mm

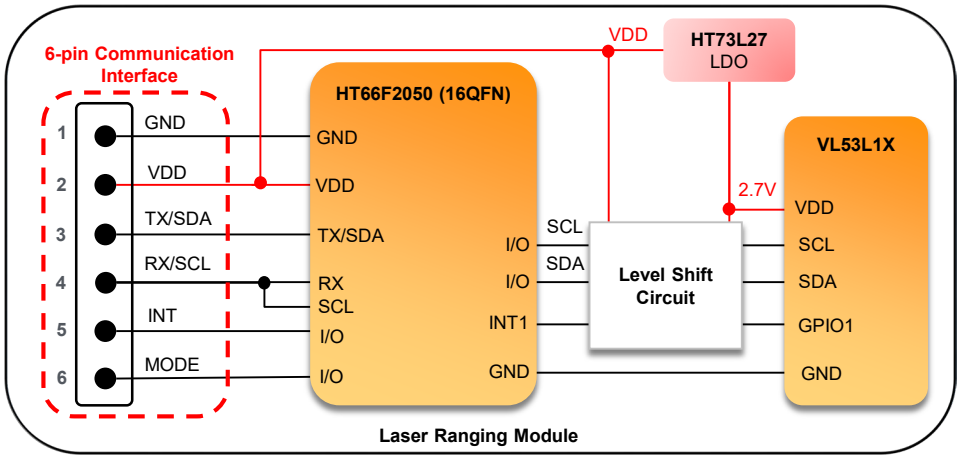
## General Description

The BM42S5321-1 is a laser ranging module, which can measure a range of 4cm~400cm. The module supports adjustable Sensing field of view (Fov) which ranges from 15° to 27°. The device has a variety of functions, including single/continuous measurement, adjustable cycle measurement, adjustable measurement time, and user-configurable distance thresholds that can trigger the INT output if a threshold is reached. The module provides one 6-pin interface, UART and I²C communication interfaces, to meet customer requirements for different applications.

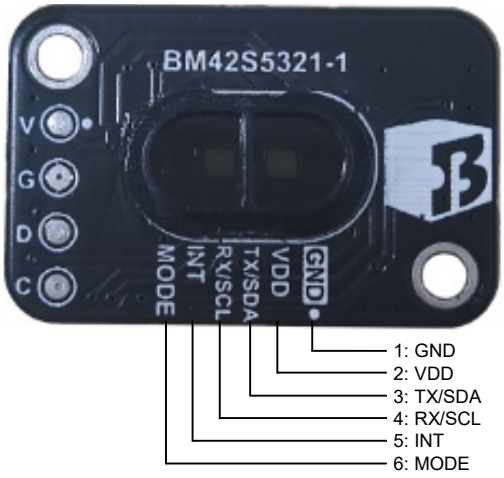
## Applications

- UAVs
- Car obstacle avoidance
- Camera-assisted focus

## Block Diagram



## Pin Assignment




## Pin Description

| Pin | Function | Description |
|---|---|---|
| 1 | GND | Negative power supply, ground |
| 2 | VDD | Positive power supply |
| 3 | TX/SDA | UART transmitting data line or $I^2C$ data line |
| 4 | RX/SCL | UART receiving data line or $I^2C$ clock line |
| 5 | INT | User-configurable distance threshold output pin |
| 6 | MODE | UART and $I^2C$ switch pin, 1=UART, 0=$I^2C$ |

## Technical Specifications

### Recommended Operation Conditions

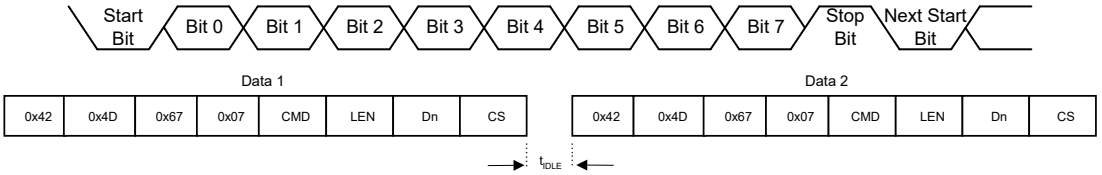
Ta=25°C

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Input Voltage | Module operating voltage | 3.0 | 5.0 | 5.5 | V |
| $I_{DD}$ | Operating Current | $V_{DD}$=5V | — | 16.3 | — | mA |
| | | $V_{DD}$=3.3V | — | 15.9 | — | mA |
| $I_{STB}$ | Sleep Current | The module stops operating @ 5V | — | 1 | — | μA |
| $I_{IDLE}$ | Standby Current | Measure once in 500ms @ 5V | — | 560 | — | μA |

### UART Interface

Ta=25°C

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| BDR | UART Baud Rate | — | — | 9600 | — | bps |
| | | — | — | 115200 | — | bps |
| $t_{IDLE}$ | Each Packet UART Data Transfer Interval | — | 6 | — | — | ms |
| $t_{FQR}$ | Power-on Initialisation | — | — | — | 400 | ms |

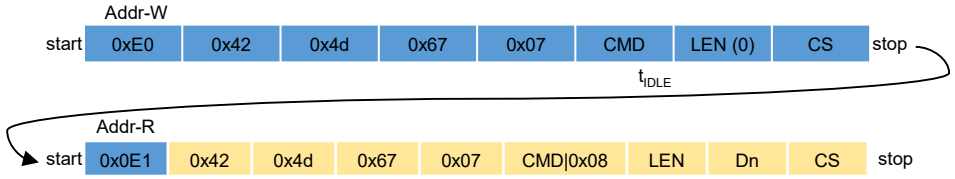



Note: During or just after power-on about 400ms, the module is in the initialisation stage and cannot respond to operation.

CS: It starts from the frame header, takes the lowest 8 bits of the sum of all data bytes and complements it.

### I²C Interface

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| | Communication Rate | — | — | — | 100 | Kbit/s |
| $t_{IDLE}$ | Each I²C Frame Interval | — | 6 | — | — | ms |
| $t_{FOR}$ | Power-on Initialisation | — | — | — | 400 | ms |




## Accuracy Description

### Repeatable Accuracy

- ±20mm or <2%

### Test Conditions

- Covers the full FoV (27°)
- Sample time is 500ms
- General lighting
- Long-range Mode

| Distance | 60mm | | 140mm | | 360mm | |
|---|---|---|---|---|---|---|
| Module No. | Black A4 Paper | White A4 Paper | Black A4 Paper | White A4 Paper | Black A4 Paper | White A4 Paper |
| 1 | 55 | 66 | 140 | 146 | 364 | 369 |
| 2 | 55 | 63 | 138 | 144 | 362 | 369 |
| 3 | 58 | 62 | 139 | 145 | 361 | 367 |
| 4 | 59 | 59 | 139 | 145 | 363 | 370 |
| 5 | 61 | 62 | 140 | 147 | 365 | 369 |
| 6 | 59 | 61 | 138 | 147 | 363 | 370 |
| 7 | 59 | 62 | 139 | 145 | 362 | 368 |
| 8 | 59 | 64 | 139 | 142 | 361 | 367 |
| 9 | 64 | 71 | 139 | 148 | 364 | 370 |
| 10 | 60 | 60 | 140 | 145 | 363 | 371 |
| Measurement Error | ±20mm | | ±20mm | | ±20mm | |

**Black and White A4 Paper Test**

| Distance | 1500mm | |
|---|---|---|
| Module No. | White A4 Paper | White Wall |
| 1 | 1574 | 1534 |
| 2 | 1577 | 1531 |
| 3 | 1568 | 1529 |
| 4 | 1565 | 1530 |
| 5 | 1572 | 1534 |
| 6 | 1570 | 1530 |
| 7 | 1572 | 1526 |
| 8 | 1572 | 1530 |
| 9 | 1566 | 1529 |
| 10 | 1565 | 1530 |

**FoV Coverage Test**

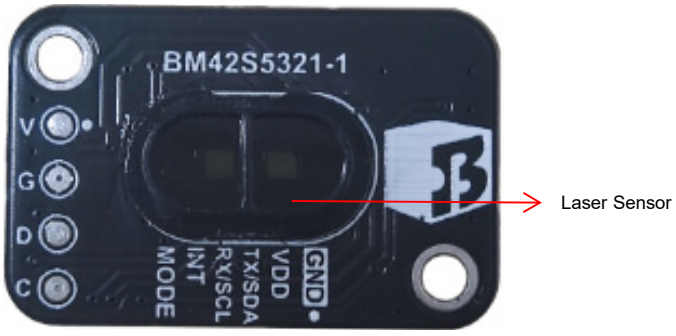
Note: The item to be measured must not cover the complete FoV (27°), otherwise the accuracy will deteriorate.

| Distance | 1500mm | 2000mm | 3000mm | 4000mm |
|---|---|---|---|---|
| Module No. | White Wall | White Wall | White Wall | White Wall |
| 1 | 1534 | 2036 | 3061 | 4075 |
| 2 | 1531 | 2031 | 3051 | 4080 |
| 3 | 1529 | 2039 | 3046 | 4060 |
| 4 | 1530 | 2035 | 3048 | 4070 |
| 5 | 1534 | 2036 | 3056 | 4080 |
| 6 | 1530 | 2034 | 3058 | 4076 |
| 7 | 1526 | 2030 | 3053 | 4055 |
| 8 | 1530 | 2035 | 3053 | 4074 |
| 9 | 1529 | 2031 | 3049 | 4065 |
| 10 | 1530 | 2033 | 3055 | 4065 |
| Measurement Error | ±2% | ±2% | ±2% | ±2% |

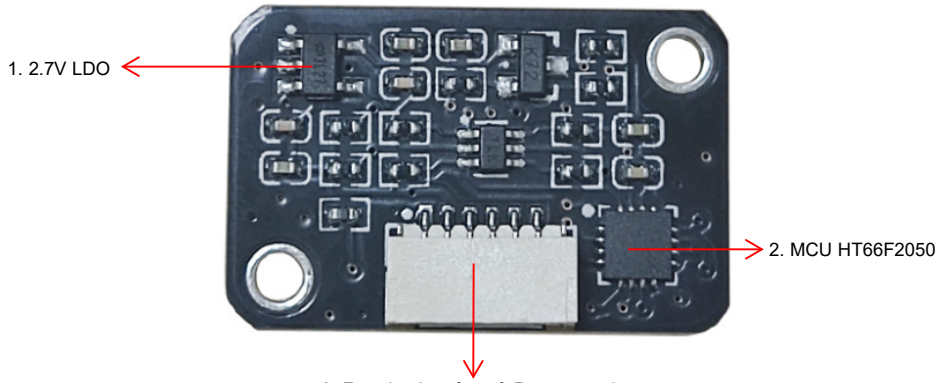
**White Wall Test**

Note: If measuring 400cm, it is recommended to set the sample time to 500ms to obtain the best accuracy.

## Hardware Overview




**PCBA Front View**




**PCBA Back View**

## Functional Description

The module uses laser sensors for ranging, which can achieve 4cm~400cm distance ranging, specific instructions are sent through UART or I²C interface. There are three operating modes, namely Normal operating mode, Standby mode and Sleep mode to adapt to different power consumption scenarios. These features are can help users to quickly develop products.

### Mode Selection

The MODE pin state should be determined before powering on,, the MODE pin defaults to the pull-up input to select the UART communication mode. The module will be in a state of waiting for instructions after power-on initialisation. To start ranging, the corresponding command need to be sent.

### Module Operating Modes

Normal operating mode: In this mode, the module is in a normal operating state and the module full performance can be obtained, the operating current is 16.3mA.

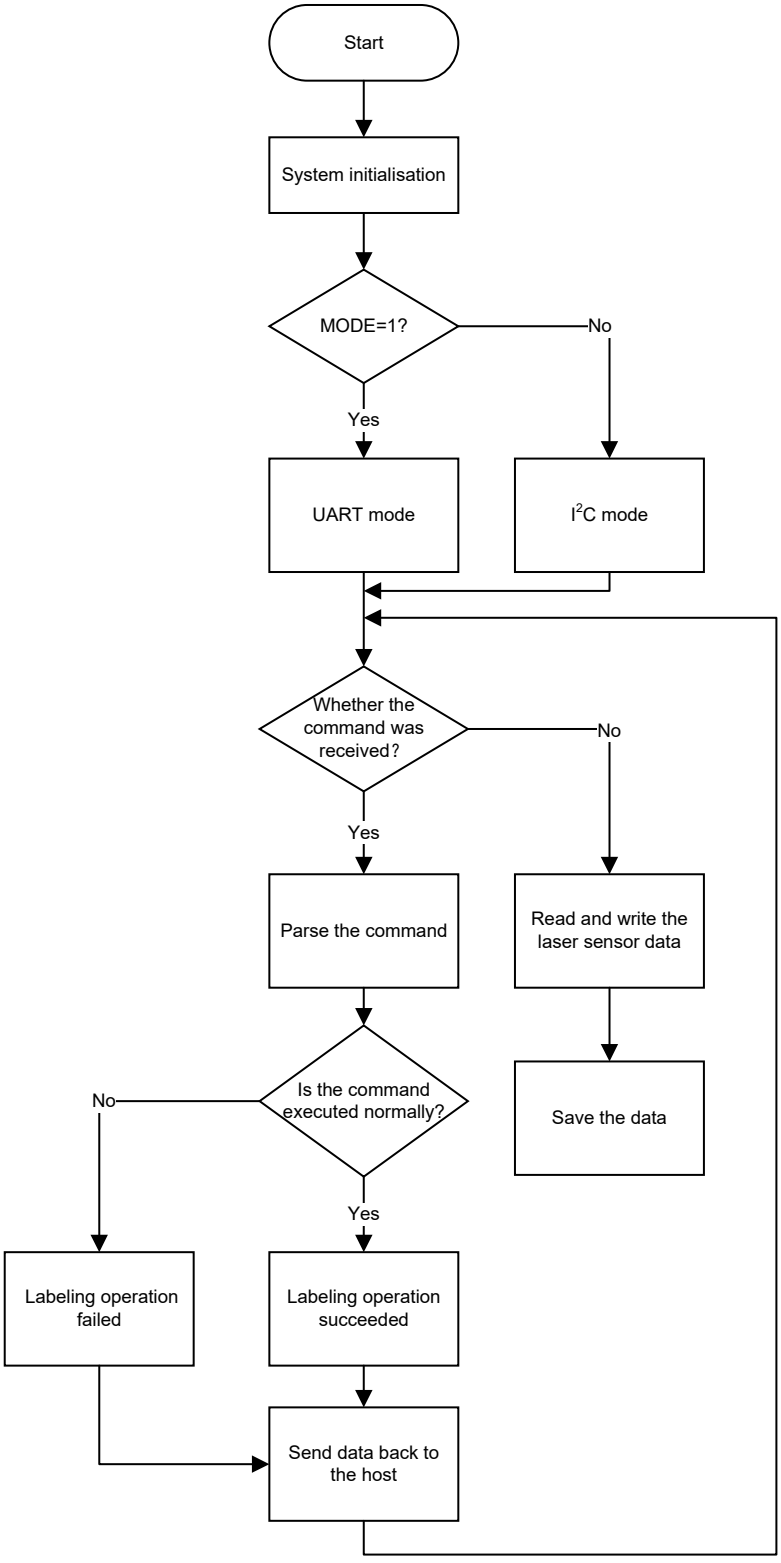
Standby mode: The module default measurement period is 100ms, the sample period is 20ms, the measurement error is large and the current is about 560μA.

Sleep mode: The module sleeps completely, does not perform any action, the current is about 1μA.

### Module Calibration

The module provides a calibration function to help users improve ranging accuracy. It is required to implement calibration in a calibration environment where the object to be measured is larger than 10cm×10cm and placed at 140mm.  Start calibration by using the calibration command, the calibration process lasts about 10s, do not touch the module during the calibration period.

## Functional Processes




**BM42S5321-1 Function Flowchart**

## UART Mode

- UART communication baud rate: 9600 or 115200
- Data bit: 8 bits, stop bit: 1 bit, parity bit: no
- After the host sends the command, the module will respond to the corresponding operation status regardless of whether the operation is successful or not.
- Communication frame format:
  - Host sending

| Frame Header (Header) | Module Type (MOD) | Module ID (ID) | Command (CMD) | Data Length (LEN) | Data (n) | Checksum |
|---|---|---|---|---|---|---|
| 2-byte | 1-byte | 1-byte | 1-byte | 1-byte | n-byte | 1-byte |

  - Module return

| Frame Header (Header) | Module Type (MOD) | Module ID (ID) | Command (CMD\|0x80) | Data Length (LEN) | Data (n) | Checksum |
|---|---|---|---|---|---|---|
| 2-byte | 1-byte | 1-byte | 1-byte | 1-byte | n-byte | 1-byte |

Description: The frame header is fixed as 0x42 or 0x4D.

The module type is fixed as 0x67.

The Module ID fixed as 0x07.

Command code: The command code returned by the slave is 0x80|CMD.

The LEN value is the data length of the data to be sent, if the LEN is filled with 0, the data can be left blank.

The checksum starts from the frame header, takes the lowest 8 bits of the sum of all data bytes and complements it.

## I²C Mode

- I²C communication rate: ≤100Kbit/s
- After the host sends the command, the module will respond to the corresponding operation status regardless of whether the operation is successful or not.
- The I²C slave address defaults to 0x07 (7-bit), the slave address + R/W is E1 and E0.
- Communication frame format:
  - Host sending

| Frame Header (Header) | Module Type (MOD) | Module ID (ID) | Command (CMD) | Data Length (LEN) | Data (n) | Checksum |
|---|---|---|---|---|---|---|
| 2-byte | 1-byte | 1-byte | 1-byte | 1-byte | n-byte | 1-byte |

  - Module return

| Frame Header (Header) | Module Type (MOD) | Module ID (ID) | Command (CMD\|0x80) | Data Length (LEN) | Data (n) | Checksum |
|---|---|---|---|---|---|---|
| 2-byte | 1-byte | 1-byte | 1-byte | 1-byte | n-byte | 1-byte |

Description:

The default slave address is 0x07, the slave address + R/W is E1 and E0.

The frame header is fixed as 0x42 or 0x4D.

The module type is fixed as 0x67.

The Module ID fixed as 0x07.

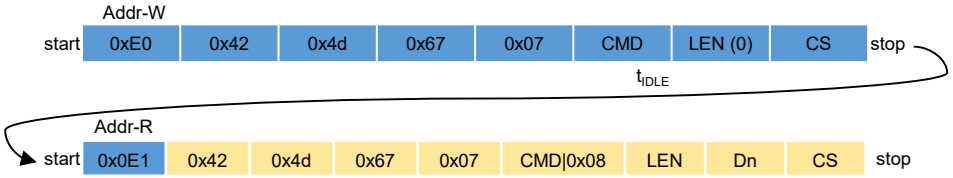
Command code: The command code returned by the slave is 0x80|CMD.

The LEN value is the data length of the data to be sent, if the LEN is filled with 0, the data can be left blank.

The checksum starts from the frame header, takes the lowest 8 bits of the sum of all data bytes and complements it.

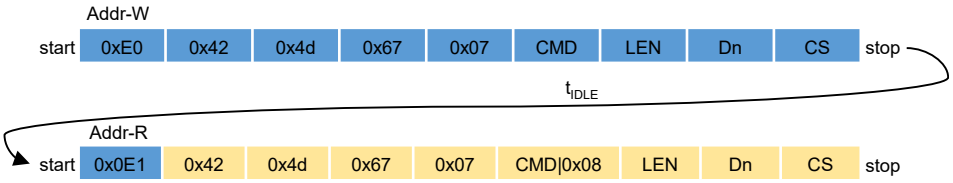
### I²C Host Read Operations

When the host reads data from the module, it does not need to send data, so the data length LEN is fixed fill in 0. The blue highlight represents the data sent by the host while the yellow highlight represents the data returned by the slave. When the host reads the data, it is necessary to determine how many data will be transmitted back after the module receives the CMD.




### I²C Host Write Operations

When the host writes data to the module, it sends the data directly after sending commands and LEN. The blue highlight represents the data sent by the host while the yellow highlight represents the data returned by the slave. When the master receives the slave's response, it must determine how many data to return from the slave to avoid omissions.




## Instruction Set

### Write Data Instruction Set

| No. | Command (CMD) | Data (DATA) | | Note |
|---|---|---|---|---|
| 1 | Set the range mode (0x01) | Command frame | 1-byte data:<br>DATA[0]<br>0: Long-range mode<br>1: Short-range mode | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 2 | Set the measure mode (0x02) | Command frame | 1-byte data:<br>DATA[0]<br>0: Continuous measurement<br>1: Single measurement<br>2: Low power measurement | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |

| No. | Command (CMD) | Data (DATA) | | Note |
|---|---|---|---|---|
| 3 | Set the sample time (0x03) | Command frame | 2-byte data:<br>DATA[0]: Single sample time high byte<br>DATA[1]: Single sample time low byte | The single sample time, the unit is ms. It can be set to 20, 33, 50, 100, 200, 500.<br>For example, 500ms, the data is 01 F4. |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 4 | Set the measurement period (0x04) | Command frame | 2-byte data:<br>DATA[0]: Measurement period high byte<br>DATA[1] Measurement period low byte | It is the time interval between two ranging measurements during continuous measurement, the unit is ms. It needs to be greater than the single sample time. The maximum setting is 5000ms |
| | | ACK frame | DATA[0]:<br>0: Successful<br>1: Failed | |
| 5 | Setup the sensor ROI (0x05) | Command frame | 1-byte data:<br>DATA[0]:<br>00: ROI array, 16×16<br>01: ROI array, 8×8<br>02: ROI array, 4×4 | ROI arrays affect signal reception and power consumption, the larger the ROI, the easier the signal is to be received and the greater the power consumption, it is usually unchanged |
| | | ACK frame | DATA[0]:<br>0: Successful<br>1: Failed | |
| 6 | Set the alarm lower and upper thresholds (0x06) | Command frame | 4-byte data:<br>DATA[0]: Lower threshold high byte<br>DATA[1]: Lower threshold low byte<br>DATA[2]: Upper threshold high byte<br>DATA[3]: Upper threshold low byte | If the value is below the lower threshold or above the upper threshold, the INT pin outputs a low level until it returns to the threshold value of 30mm.<br>For example, if the lower threshold is 1000mm and the upper threshold is 2000mm, the data is sent 03 E8 07 D0 |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 7 | Set the baud rate (0x07) | Command frame | 4-byte data:<br>DATA[0]: Baud rate Bit 31~23<br>DATA[1]: Baud rate Bit 23~16<br>DATA[2]: Baud rate Bit 15~8<br>DATA[3]: Baud rate Bit 7~0 | The baud rate only supports 9600 or 115200 |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 8 | Set the module address (0x08) | Command frame | 1-byte data:<br>DATA[0]: The new address of the module | The address needs to be in the range of 1~127 |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 9 | Start ranging (0x0A) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 10 | Stop ranging (0x0B) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 11 | Offset calibration (0x0C) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | DATA[0]<br>0: Start calibration<br>1: Setting failed | |

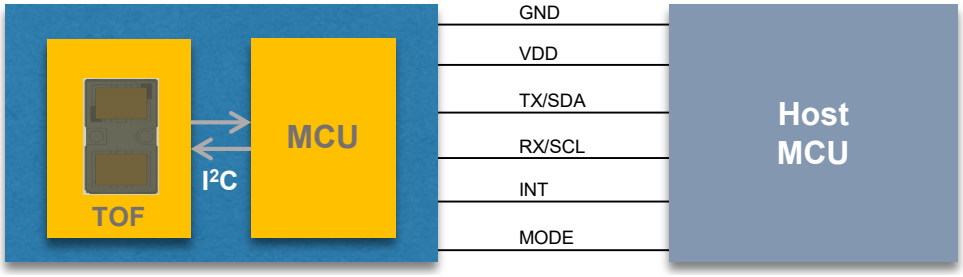
| No. | Command (CMD) | Data (DATA) | | Note |
|---|---|---|---|---|
| 12 | Save the relevant settings (0x21) | Command frame | No DATA, data length is 0 | The measurement mode, the ranging mode, the single sample time, the continuous measurement period, ROI, upper and lower thresholds, the baud rate, the module address and the user calibration parameters should be set |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 13 | Sleep (0x22) | Command frame | No DATA, data length is 0 | The sensor power is cut off, the MCU will enter the Sleep mode |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 14 | Wake up (0x23) | Command frame | No DATA, data length is 0 | Wake the MCU from the Sleep mode and power on the sensor |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 15 | Reset the MCU (0x23) | Command frame | No DATA, data length is 0 | The sensor does not have a reset function, so only the MCU is reset |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| 16 | Factory reset (0x25) | Command frame | No DATA, data length is 0 | It should be powered on again |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |

### Read Data Instruction Set

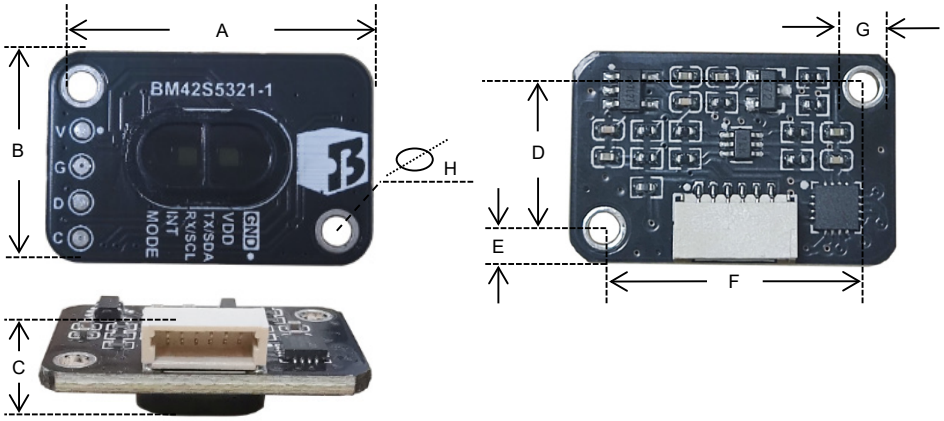
| No. | Command (CMD) | Data (DATA) | | Note |
|---|---|---|---|---|
| 1 | Obtain the distance (0x10) | Command frame | No DATA, data length is 0 | In the DATA[3] byte, 0x01 indicates a sigma error, 0x02 indicates that the signal received by the sensor is too low, 0x04 indicates that the sensor exceeds the threshold, and 0x07 indicates a surround error |
| | | ACK frame | DATA[0]: Distance length high byte<br>DATA[1]: Distance length low byte<br>DATA[2]<br>0: Currently updated data<br>1: No data update<br>DATA[3]<br>0: The data is reliable<br>Other values: The data is unreliable | |
| 2 | Obtain the measurement mode (0x11) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the measurement mode settings | |
| 3 | Obtain the ranging mode (0x12) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the ranging mode settings | |
| 4 | Obtain a single sample time (0x13) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the single sample time settings | |
| 5 | Obtain the measurement cycle (0x14) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the measurement period settings | |
| 6 | Obtain ROI (0x15) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the ROI settings | |

| No. | Command (CMD) | Data (DATA) | | Note |
|---|---|---|---|---|
| 7 | Obtain the upper and lower thresholds (0x16) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | Refer to the data in the upper and lower threshold settings | |
| 8 | Obtain the light intensity (0x17) | Command frame | No DATA, data length is 0 | The unit is Kcps, which requires starting ranging to obtain the light intensity. |
| | | ACK frame | DATA[0]: Light intensity high byte<br>DATA[1]: Light intensity low byte | |
| 9 | Obtain the calibration is complete or not (0x19) | Command frame | No DATA, data length is 0 | If the calibration is not completed, it is forbidden to set other functional parameters |
| | | ACK frame | DATA[0]<br>0: Calibration complete<br>1: Calibration is not complete | |
| 10 | Obtain the FW version number (0x1A) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | DATA[0]: Integer version number<br>DATA[1]: Decimal version number | For example 0x01, 0x02 indicates that the current version is 1.02 |
| 11 | Obtain the date (0x1B) | Command frame | No DATA, data length is 0 | For example: 0x20, 0x23, 0x04, 0x26 represent April 26, 2023 |
| | | ACK frame | DATA[0]: Year<br>DATA[1]: Year<br>DATA[2]: Month<br>DATA[3]: Day | |
| 13 | Obtain factory calibration values (0x1C) | Command frame | No DATA, data length is 0 | |
| | | ACK frame | DATA[0]: Calibration value high byte<br>DATA[1]: Calibration value low byte | |
| | | ACK frame | DATA[0]<br>0: Successful<br>1: Failed | |

## Application Circuit




## Dimensions




| Symbol | Unit | |
|---|---|---|
| | mm | inch |
| A | 23 | 0.905 |
| B | 15 | 0.590 |
| C | 9 | 0.354 |
| D | 10 | 0.393 |
| E | 2.5 | 0.098 |
| F | 18 | 0.708 |
| G | 3.048 | 0.120 |
| H | 2.184 | 0.085 |