2D IR Gesture Control Digital Module

BM32S4021-1

Revision: V1.00 Date: July 03, 2024

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Features

- 2D gesture recognition: Forward and backward, left and right, up and down, hover
- Operating voltage: 3.0V~5.5V
- Operating current: 4.5mA @ 3.3V
- Sleep current:
  - 85μA @ 3.3V & Detection cycle = 128ms
  - Adjustable detection cycle
- Operating range:
  - Z-axis distance: 1cm~25cm
  - X/Y-axis distance: Greater than -4.0cm~+4.0cm
- Communication Interface: UART+INT
- Size: 20×20×11.5mm

General Description

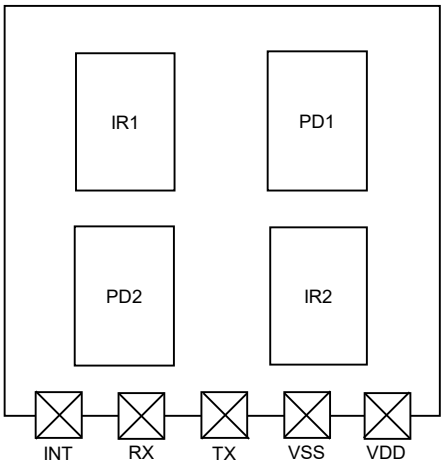
The BM32S4021-1 is a 2D infrared gesture sensing module, which is designed for products with gesture detection function. When hands or objects enter the detection range, the reflected energy of the infrared will change. Gesture or object movement direction is determined by detecting changes in reflection between two infrared emitters and two infrared receiver tubes. This module supports detection at a distance from 1cm to 25cm.

The module provides a UART interface. The module parameters can be adjusted using the host. The module supports two modes: operating mode and sleep mode. In sleep mode, there are multiple detection cycles for users to configure to reduce power consumption, which can meet the application requirements of different power design products. This modular design has an advantage of implementing fast and convenient product development, which can be used to reduce product development period.

Applications

- Lighting control
- Sound products
- Game controllers
- Automatic doors
- Intelligent center console

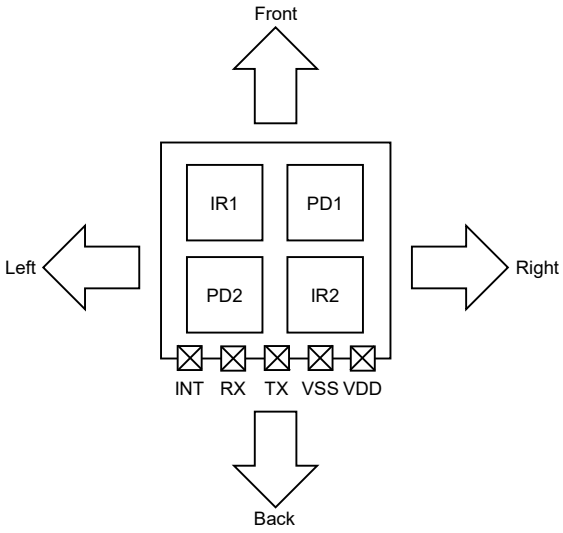
Pin Assignment



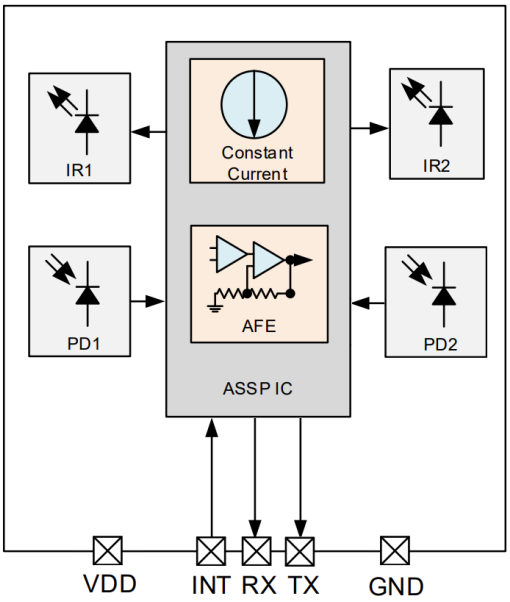
Pin Description

Pin Symbol	Type	Functional Description
INT	DO	Gesture detection trigger pin
RX	DI	UART (9600bps) receiving pin
TX	DO	UART (9600bps) transmitting pin
VSS	PWR	Ground
VDD	PWR	Positive power supply

Schematic Diagram



Block Diagram



Technical Specifications

Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.3V~6.0V

Input Voltage ..... V_{SS}-0.3V~V_{DD}+0.3V

Operating Temperature ..... -25°C~50°C

Storage Temperature ..... -30°C~70°C

Total Power Consumption 500mW

Note: These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

D.C. Electrical Characteristics

Ta=25°C

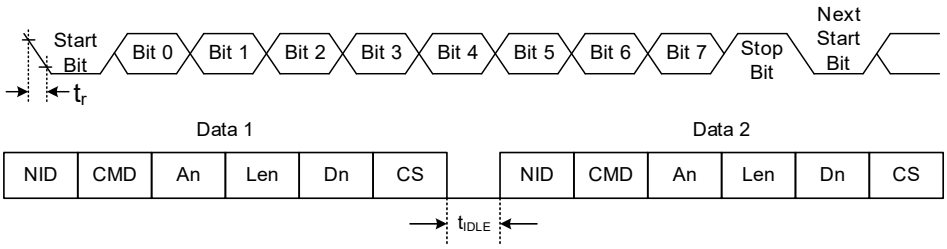
Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	3.0	—	5.5	V
I_{DD}	Operating Current	3.3V	—	—	3.80	4.50	mA
		5V		—	4.50	5.50	
Imax	Transient Current	—	—	—	—	200	mA
I_{STB}	Sleep Current	3.3V	Detection Cycle=8ms	—	920	—	μA
		5V		—	1150	—	
		3.3V	Detection Cycle=16ms	—	550	—	
		5V		—	700	—	
		3.3V	Detection Cycle=32ms	—	310	—	
		5V		—	380	—	
		3.3V	Detection Cycle=64ms	—	165	—	
		5V		—	210	—	
		3.3V	Detection Cycle=128ms (default)	—	85	—	
		5V		—	105	—	
		3.3V	Detection Cycle=256ms	—	45	—	
		5V		—	55	—	
		3.3V	Detection Cycle=512ms	—	25	—	
		5V		—	30	—	
		3.3V	Detection Cycle=1024ms	—	12	—	
		5V		—	16	—	

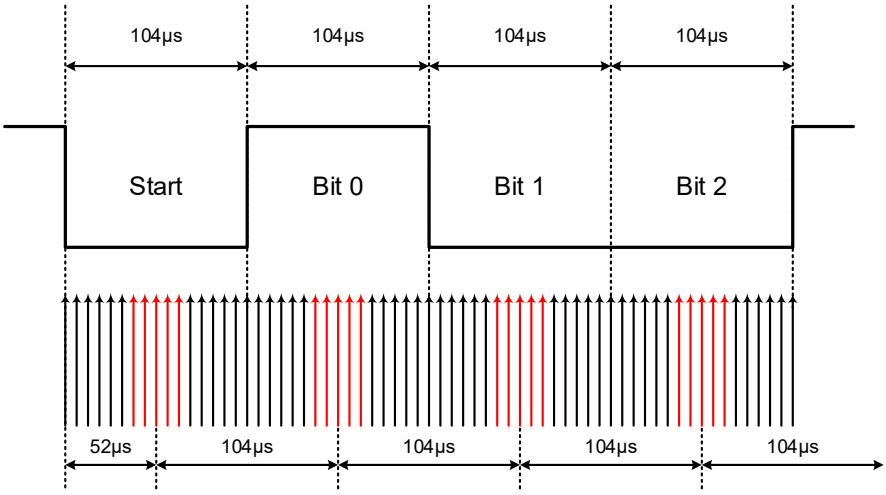
A.C. Electrical Characteristics

UART Interface

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
BDR	UART Baud Rate	—	—	—	9600	—	bps
t_{IDLE}	Interval of each UART Data Transmission	—	—	20	—	—	ms





UART Timming Chart

Functional Description

System Description

The module can achieve stable front/back, left/right, up/down and hover gesture detection with adjustable detection distance. There are two modes for users to configure: operating mode and sleep mode. The system defaults to sleep mode, with a detection cycle of 128ms. If there is an object approaching , the module will enter the operating mode. About 2s after the object leaves, the module will enter the sleep mode again. In the sleep mode, it is recommended to approach to wake up the module first and then swing gestures.

Operating Description

The BM32S4021-1 executes initialisation after the system is powered on, then it starts detection cycle by cycle. When a gesture has setup, the INT pin will output a low pulse for a certain time (default 200ms), and the host can determine the object gesture status using the UART.

Reading Gesture Method

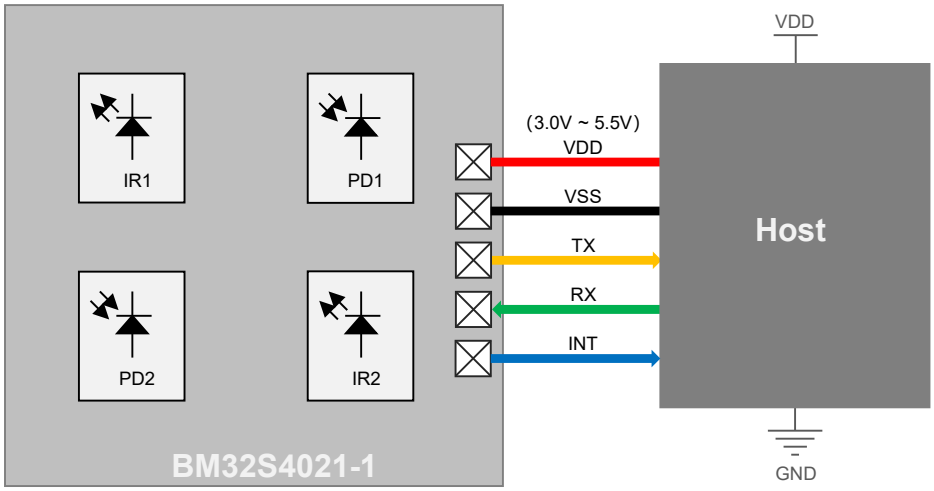
The module has two modes: active sending mode (default) and passive sending mode.

Active sending mode: When the module detects a forward, backward, left, right, up or down gesture is setup (Hover gesture requires to be read using the serial port), it will actively send gesture data to the host. When the module transmits the data back to the host device, the module will automatically clear the gesture sensing status. This mode can be disabled by modifying the Bit 0 of version high byte using the serial port.

Passive sending mode: The host device can directly read the module gesture sensing status data (including the hover time) via the corresponding UART command. When the gesture sensing has setup for more than the INT pin output timeout (default 200ms) time, the module will automatically clear the gesture status.

Communication Method	Minimum Continuous Reading Interval Time	Unit
UART	20	ms

Application Circuits



Application Circuit

UART Communication Interface

In the UART communication mode, after power-on for 0.5s, the host device can communicate with the module normally, read the parameter and device information, or modify the parameters, The UART protocol content is as follows:

1. NID: 0x55
2. Command: CMD

   0x80: read parameters from module.

   0xC0: write parameters to module.
3. Register address:An
4. Data length: Len (the maximum data length is 4)
5. Data: Dn
6. CheckSum (CS): CS=NID+CMD+An+LEN+Dn (take the lower 8 bits of the checksum)

NID	Command	Register Address	Data lentgh	Data	CheckSum
0x55	CMD	An	Len	Dn	CS
1	2	3	4	5	6

Special Commands

No.	NID	CMD	CS	Content
1	0x55	0x10	0x65	Module Reset. Module does not response.
2	0x55	0x20	0x75	Module Enters Calibration Mode. Place the test object at the calibration distance, the module will automatically adjust based on the distance of the obstruction. After the calibration is completed, a command will be sent to indicate whether it is successful. Start learning response: 0x55, Ack, CS. Learning completed response: 0x55, 0xC0, 0x01, 0x01, Dn, CS. Dn: Calibration result Bit 6: 0 – Calibration succeeded; 1 – Calibration failed.

Read Commands

No.	NID	CMD	An	Len	CS	Content
1	0x55	0x80	0x00	0x01	0xD6	Version number: Low byte. Dn1: Version low byte. Module Response: 0x55, 0xC0, 0x00, 0x01, Dn1, CS.
2	0x55	0x80	0x01	0x01	0xD7	Version number: High byte. Dn2: Version high byte. Bit 0: Active sending mode when it is 1 Bit 0: Passive sending mode when it is 0 Module Response: 0x55, 0xC0, 0x01, 0x01, Dn2, CS.
3	0x55	0x80	0x02	0x01	0xD8	Gesture Sensing Status. Dn: Status bit of 1 indicates that the corresponding gesture has setup Bit 0: Left swipe gesture Bit 1: Right swipe gesture Bit 2: Forward swipe gesture Bit 3: Backward swipe gesture Bit 4: Up gesture Bit 5: Down gesture Bit 6: Calibration result 0 – Calibration succeeded; 1 – Calibration failed. Module Response: 0x55, 0xC0, 0x02, 0x01, Dn, CS.
4	0x55	0x80	0x03	0x01	0xD9	Cumulative continuous swipe, automatically clear to zero when timeout occurs. Dn: Cumulative times. (0~255) Module Response: 0x55, 0xC0, 0x03, 0x01, Dn, CS.
5	0x55	0x80	0x04	0x01	0xDA	IR1 Reference Value. Dn: IR1 snd PD1 reference value. Module Response: 0x55, 0xC0, 0x04, 0x01, Dn, CS.
6	0x55	0x80	0x05	0x01	0xDB	IR2 Reference Value. Dn: IR2 and PD2 reference value. Module Response: 0x55, 0xC0, 0x05, 0x01, Dn, CS.
7	0x55	0x80	0x06	0x01	0xDC	Infrared Proximity Debounce Times (Noise Filter). Dn: 0~255 (default 2). Filter time calculation formula: Dn×5ms, (default 2×5ms=10ms) Module Response: 0x55, 0xC0, 0x06, 0x01, Dn, CS.
8	0x55	0x80	0x07	0x01	0xDD	Gesture Trigger Threshold Value. Dn: 10~255 (default 16). Module Response: 0x55, 0xC0, 0x07, 0x01, Dn, CS.
9	0x55	0x80	0x08	0x01	0xDE	IRQ trigger time when gesture is setup, INT pin sends a low pulse. Dn: 0~255 (default 40). IRQ trigger time calculation formula: Dn×5ms, (default 40×5ms=200ms) Module Response: 0x55, 0xC0, 0x08, 0x01, Dn, CS.
10	0x55	0x80	0x09	0x01	0xDF	Cumulative continuous swipe time. Dn: 0~255 (default 30). Continuous swipe time calculation formula: Dn×64ms, (default 30×64ms=1.92s) Module Response: 0x55, 0xC0, 0x09, 0x01, Dn, CS.
11	0x55	0x80	0x0A	0x01	0xE0	Fastest gesture detected time. Dn: 0~200 (default 0). Fastest gesture time calculation formula: 20+Dn×5ms, (default 20+0×5ms=20ms) Module Response: 0x55, 0xC0, 0x0A, 0x01, Dn, CS.
12	0x55	0x80	0x0B	0x01	0xE1	Slowest gesture detected time. Dn: 0~200 (default 80). Slowest gesture time calculation formula: Dn×25ms, (default 80×25ms=2.0s) Module Response: 0x55, 0xC0, 0x0B, 0x01, Dn, CS.

No.	NID	CMD	An	Len	CS	Content
13	0x55	0x80	0x0C	0x01	0xE2	Gesture Hover Time (recount when gesture status changes). Dn: 0~255 Hover time calculation formula: Dn×100ms, (100×100ms=10s) Module Response: 0x55, 0xC0, 0x0C, 0x01, Dn, CS.
14	0x55	0x80	0x21	0x01	0xF7	Enter the sleep time counter (only valid in the sleep mode, when there is no object approaching, the counter will be start). Dn: 10~255 Wake up operating time calculation formula: Dn×40ms, (default 100×40ms=4.0s) Module Response: 0x55, 0xC0, 0x21, 0x01, Dn, CS.
15	0x55	0x80	0x22	0x01	0xF8	Sleep detection cycle. Dn: 0~8 Sleep detection cycle calculation formula: Dn=0: No sleep, continuous operating Dn>0:2^(Dn-1)×8ms Module Response: 0x55, 0xC0, 0x22, 0x01, Dn, CS.
16	0x55	0x80	0x23	0x01	0xF9	IR1 Emission Current. Dn: 0~31 Emission current calculation formula: Dn≤15: Iisink=1+1×Dn (mA), 1mA/step Dn>15: Iisink=16+11+11×(Dn-16) (mA), 11mA/step Module Response: 0x55, 0xC0, 0x23, 0x01, Dn, CS.
17	0x55	0x80	0x24	0x01	0xFA	IR2 Emission Current. Dn: 0~31 Emission current calculation formula: Dn≤15: Iisink=1+1×Dn (mA), 1mA/step Dn>15: Iisink=16+11+11×(Dn-16) (mA), 11mA/step Module Response: 0x55, 0xC0, 0x24, 0x01, Dn, CS.

Continuous Read Commands (LEN length up to 4 data)

No.	NID	CMD	An	Len	CS	Content
1	0x55	0x80	0x00	0x04	0xD9	Reading the version low byte, version high byte, gesture sensing status and swipe times in the same direction at once. D1: Version low byte D2: Version high byte D3: Gesture sensing status D4: Cumulative times (0~255) Module Response: 0x55, 0xC0, 0x00, 0x04, D1~D4, CS.

Write Commands

No.	NID	CMD	An	Len	Dn	CS	Content
1	0x55	0xC0	0x01	0x01	Dn	CS	Version high byte. Dn: 0x00~0x01 (default 0x01). 0x01 is the active sending mode 0x00 is the passive sending mode Module Response: 0x55, Ack, CS.
2	0x55	0xC0	0x06	0x01	Dn	CS	Infrared Proximity Debounce Times (Noise Filter). Dn: 0~255 (default 2). Filter time calculation formula: Dn×5ms, (default 2×5ms=10ms) Module Response: 0x55, Ack, CS.
3	0x55	0xC0	0x07	0x01	Dn	CS	Gesture Trigger Threshold Value. Dn: 10~255 (default 16). Module Response: 0x55, Ack, CS.

No.	NID	CMD	An	Len	Dn	CS	Content
4	0x55	0xC0	0x08	0x01	Dn	CS	IRQ trigger time when gesture is setup. Dn: 0~255 (default 40). IRQ trigger time calculation formula: Dn×5ms, (default 40×5ms=200ms) Module Response: 0x55, Ack, CS.
5	0x55	0xC0	0x09	0x01	Dn	CS	Cumulative continuous swipe time. Dn: 0~255 (default 30). Continuous swipe time calculation formula: Dn×64ms, (default 30×64ms=1.92s) Module Response: 0x55, Ack, CS.
6	0x55	0xC0	0x0A	0x01	Dn	CS	Fastest gesture detected time. Dn: 0~200 (default 0). Fastest gesture time calculation formula: 20+Dn×4ms, (default 20+0×5ms=20ms) Module Response: 0x55, Ack, CS.
7	0x55	0xC0	0x0B	0x01	Dn	CS	Slowest gesture detected time. Dn: 0~200 (default 80). Slowest gesture time calculation formula: Dn×25ms, (default 80×25ms=2.0s) Module Response: 0x55, Ack, CS.
8	0x55	0xC0	0x21	0x01	Dn	CS	Enter the sleep time counter (only valid in the sleep mode, when there is no object approaching, the counter will be start). Dn: 10~255 (default 100) Wake up operating time calculation formula: Dn×40ms, (default 100×40ms=4.0s) Module Response: 0x55, Ack, CS.
9	0x55	0xC0	0x22	0x01	Dn	CS	Sleep detection cycle. Dn: 0~8 (default 5) Sleep detection cycle calculation formula: Dn=0: No sleep, continuous operating Dn>0:2^(Dn-1)×8ms, (default 16×8ms=128ms) Module Response: 0x55, Ack, CS.
10	0x55	0xC0	0x23	0x01	Dn	CS	IR1 Emission Current. Dn: 0~31 Emission current calculation formula: Dn≤15:Iisink=1+1×Dn (mA), 1mA/step Dn>15:Iisink=16+11+11×(Dn-16) (mA), 11mA/step Module Response: 0x55, Ack, CS.
11	0x55	0xC0	0x24	0x01	Dn	CS	IR2 Emission Current. Dn: 0~31 Emission current calculation formula: Dn≤15:Iisink=1+1×Dn (mA), 1mA/step Dn>15:Iisink=16+11+11×(Dn-16) (mA), 11mA/step Module Response: 0x55, Ack, CS.

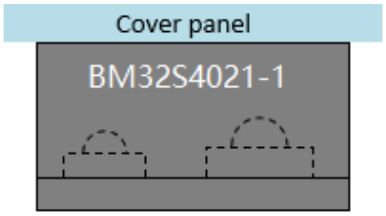
Module Responses

No.	NID	Ack	CS	Content
1	0x55	0x7F	D4	Completed
2	0x55	0x7E	D3	Failed

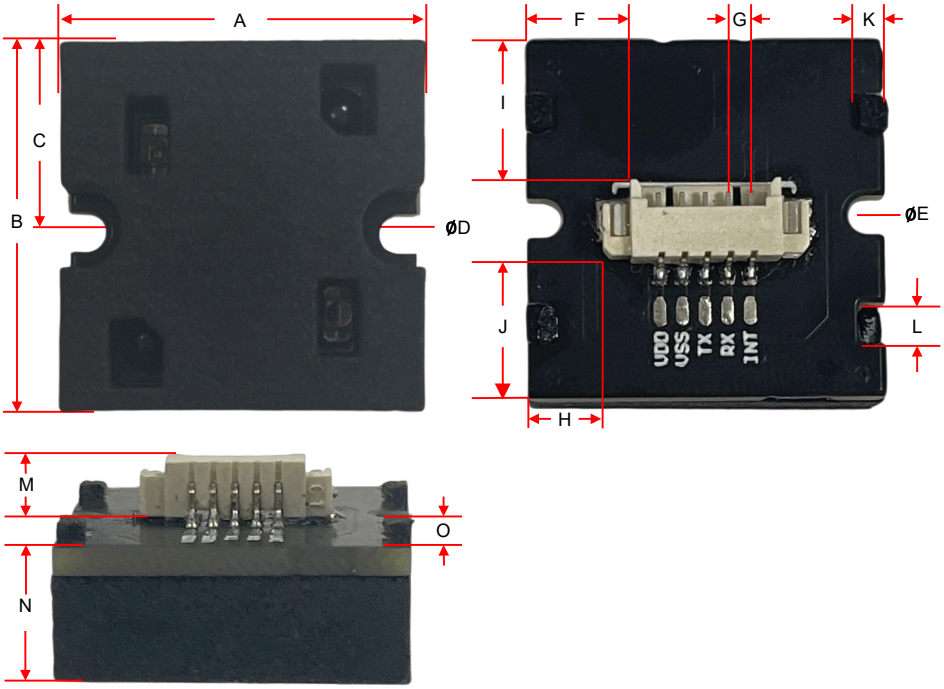
Application Considerations

The BM32S4021-1 implements the gesture recognition function by emitting/receiving 940nm infrared. To protect the optical sensitive part of the infrared receiver tube, it is recommended to pay attention to the following points when designing the cover panel:

- Recommend select PMMA or glass as the panel material, with a light transmittance of not less than 90%;
- PMMA thickness ≤ 3mm, glass thickness ≤ 5mm;
- The panel and module should be as close as possible, with a gap of ≤ 0.1mm.



Dimensions



No.	Unit	
	mm	inch
A	20.0	0.787
B	20.0	0.787
C	10.0	0.394
ØD	3.0	0.118
ØE	2.0	0.079
F	5.0	0.197
G	1.25	0.049

No.	Unit	
	mm	inch
H	3.9	0.154
I	8.2	0.323
J	8.0	0.315
K	1.4	0.055
L	2.0	0.079
M	3.45	0.138
N	7.6	0.299
O	1.0	0.039

Note: PCB dimensional tolerance±0.5mm, cover dimensional tolerance±0.3mm. Pin connector: 1.25mm 5-pin

Reference Information

Modification History

Data	Author	Issue	Modification Information
2024.07.02	姚尊宇	V1.00	First Version

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