5.8GHz Radar Sensor Module

BM22S4421-1

Revision: V1.10 Date: June 20, 2024

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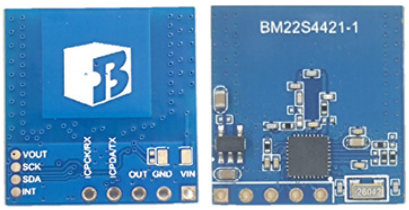
Features



- Operating frequency band: 5.8GHz ISM
- Operating voltage: 4.0V~12.0V (UART voltage: 3.3V)
- Operating current
  - 80μA @ 5m
  - 1.3mA @ 14m
- Horizontal forward sensing distance(5V, 25°C): 5m~14m
- Operating temperature: -40°C~85°C
- Supports the standard UART serial port protocol
- Reserves lighting control component positions
- Compatible with FCC/CE
- Interface:5-pin straight hole
- Size: 20.0mm(L)×20.5mm(W)×2.8mm(H)

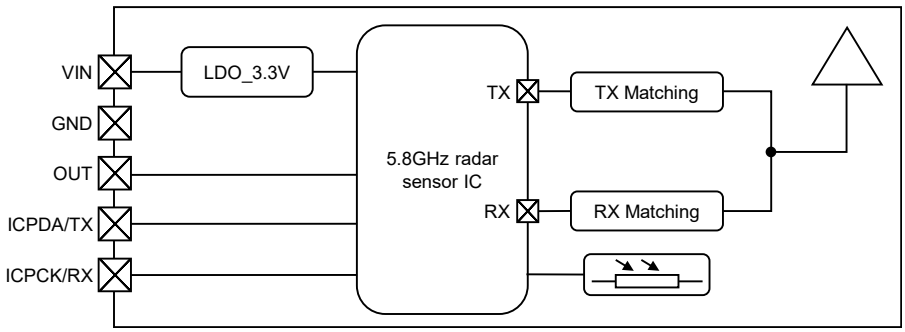
General Description

The BM22S4421-1 is a low power consumption, high performance and low cost 5.8GHz radar sensor module designed based on the 5.8GHz radar sensor IC. Users can flexibly adjust the module performance using the UART serial port communication. This module has a sensing distance of up to 14m, a minimum average operating power consumption of 80μA and a reserved position for a photosensitive resistance.

Applications

- Smart lighting
- Smart home
- Anti-intrusion detection

Block Diagram



Pin Assignment

Pin Description

Pin	Function	Type	Description
1	VIN	PWR	Positive power supply
2	GND	PWR	Negative power supply, GND
3	OUT	DO	Radar sensor trigger output
4	ICPDA/TX	DO	ICPDA: ICP data/address TX: UART TX serial data output
5	ICPCK/RX	DI	ICPCK: ICP clock RX: UART RX serial data input

Legend: PWR: power; DI: digital input; DO: digital output

Technical Specifications

Absolute Maximum Ratings

Supply Voltage ..... V_{SS}-0.3V~V_{SS}+12V

Input Digital Voltage ..... V_{SS}-0.3V~3.3V+0.3V

Storage Temperature..... -60℃~150℃

Operating(ambient) Temperature ..... -40℃~85℃

ESD HBM ..... >±2kV

Note: this module is ESD sensitive. HBM(Human Body Mode) is based on MIL-STD-883.

D.C. Electrical Characteristics

Ta=25°C, V_{DD}=5.0V, with matching circuit and antenna, unless otherwise specified

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage	—	4.0	5.0	12.0	V
V_{IL}	I/O Low Level Input Voltage	—	0	—	0.6	V
V_{IH}	I/O High Level Input Voltage	—	2.6	—	3.3	V
T_{OP}	Operating Temperature	—	-40	—	85	°C
Current Consumption						
I_{SLP}	Deep Sleep Current	WDT off RF Deep Sleep mode	—	4	—	μA

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{DD}	Operating Current	RF Duty mode Maximal sensing distance=5m	—	0.08	—	mA
		RF Duty mode Maximal sensing distance=14m	—	1.3	—	mA
I_{OL}	I/O Port Sink Current	—	16	32	—	mA
I_{OH}	I/O Port Source Current	—	-0.7	-1.5	—	mA
R_{PH}	I/O Port Pull-high Resistance	—	20	60	100	kΩ

A.C. Electrical Characteristics

Ta=25°C, V_{DD}=5.0V, with matching circuit and antenna, unless otherwise specified

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
f_{RF}	RF Frequency	—	5725	5800	5875	MHz
P_{OUT}	Output Power	—	—	10	—	dBm
	Sensing Distance	Horizontal forward, 1.2m above the ground	5	—	14	m
$S.E._{TX}$	TX Spurious Emission Power	f<1GHz	—	—	-36	dBm
		47MHz<f<74MHz	—	—	-54	dBm
		87.5MHz<f<118MHz				dBm
		174MHz<f<230MHz				dBm
		470MHz<f<862MHz				dBm
		2^{nd}, 3^{rd} harmonic	—	—	-30	dBm
		1.8GHz~1.9GHz	—	—	-47	dBm
		5.1GHz~5.3GHz	—	—	-47	dBm
Crystal	Crystal Frequency	—	—	32.768	—	kHz
	Crystal Tolerance	—	-20	—	+20	ppm

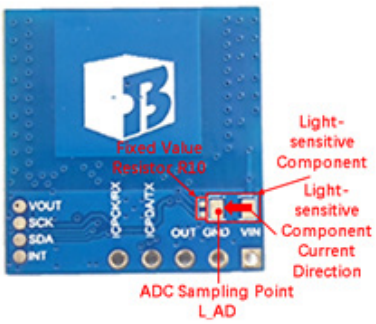
Software Default Parameters

Parameter	Default Value
TX Frequency	5800MHz
Sensing Distance	14m
Maximum Sensing Radius with 3m Suspension Height	4m
OUT Pin Output Level	Outputs 0V in silence and outputs 3.3V during sensing
Sensing Output Delay	3s
Lighting Control Function	Disabled
Lighting Control Method	Triggered when sampling value is less than threshold value
Lighting Control Threshold Value(AD value)	37

Note:for the default lighting control threshold value of the software, the test conditions are RT1 = ambient lighting sensor PT1206, R10 = 1kΩ and lighting intensity judgment = 10Lux. For details of the lighting control circuit, refer to the "Lighting Control Circuit Principle" section.

Lighting Control Circuit Principle

Enabling the lighting control function: only after the lighting control has been triggered, the radar sensor is triggered. This allows that the radar sensor will be triggered by the module only in dark/light environment. As shown in the figure below, the module has reserved several positions for lighting control circuit components, and users can solder a light-sensitive component and a resistor to form a lighting control circuit.



The lighting control circuit principle is shown below.

RT1 is a light-sensitive component (if using a lighting sensor, attention should be paid to the current direction);

R10 is a fixed value resistor;

VCC33 is 3.3V;

L_AD is the ADC sampling point;

L_EN is the control pin of the lighting control function. When the lighting control is enabled, L_EN=0V.

Note:

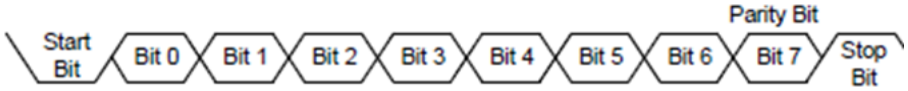
1. The A/D converter is 12-bit, with a maximum value of 4095.
2. The L_AD sampling value = RT1/(RT1+R10)×4095 = (L_AD voltage value/VCC33)×4095.
3. The trigger conditions of the lighting control, such as the trigger method and lighting control threshold value, can be set. Refer to the communication section for details. Users can flexibly adjust the conditions based on the actual used component specifications and ambient brightn

Software Parameter Adjustment Method

UART Communication

After the module is powered on and waiting for 1.2 seconds, users can use an external MCU or the serial port assistant to set the module software parameter values using the UART communication. Note that the MCU communication pin high level should be set to 3.3V or the serial port assistant voltage should be set to 3.3V. After setting the “sensing distance” and “TX frequency” items, it is necessary to repower the module or turn off the RF function and restart it to make the settings take effect. Other settings will take effect in real time. The setting values of all items will be stored and do not need to be re-configured when the module is powered on again.

- UART waveform: the baud rate is 4800bps using the 8-bit data format and LSB sent first.



8-bit data format

- Packet format: as shown below, the interval between two consecutive bytes should be greater than

0.4ms and less than 8ms. Wait for the module to reply before sending the next packet.

Wake-up Code 1 Byte	Start Code 1 Byte	Command Code 1 Byte	Parameter Value 1~2 Bytes	Check Code 1 Byte

- Wake-up code: 0x00
- Start code: 0x42(write), 0x43(read)
- Check code: command code+parameter value+4

Item	Command Code	Parameter Value	Note
Sensing Distance	0x01	1~7	5m, 9m, 10m, 11m, 12m, 13m, 14m
OUT Pin Output Mode	0x02	1, 2	1: outputs a low level during sensing and outputs a high level when not sensing 2: outputs a high level during sensing and outputs a low level when not sensing
OUT Pin Output Delay	0x03	1~250	Unit: s
Enable Control of Lighting Control Function	0x04	1, 2	1: disable the lighting control function 2: enable the lighting control function
Trigger Method of Lighting Control Function	0x05	1, 2	1: when the AD sampling value is less than the threshold value, the lighting control will be triggered 2: when the AD sampling value is greater than the threshold value, the lighting control will be triggered
Lower Eight Bits of Lighting Control Threshold Value	0x06	0~255	Parameter value of a combined 16-bit number is 0~4095
Higher Eight Bits of Lighting Control Threshold Value	0x07	0~15	
TX Frequency	0x08	1~51	×3+5722(MHz)
RF Function Enable Control	0x14	1, 2	When the module is powered on, the RF function is enabled by default. This parameter setting takes effect only when the module is in use and will not be saved 1: disable the RF function 2: enable the RF function
Module Version	0x15	0x10	Read only and 0x10 indicates V1.0 version
Read AD Value at L_AD Point of Lighting Control Circuit	0x17	0~4095	Read only, with a 2-byte parameter value and the higher eight bits in the front. Check code=the higher eight bits of AD value+the lower eight bits of AD value+4. This function is supported by V1.1 version or above but not by V1.0.

Reply data:

Item	Reply Data	Note
Write Operation	0x65	Communication is failed
	0x6A	Communication is successful
Read Operation	Wake-up code+start code+command code+parameter value+check code	Parameter value indicates the current module status

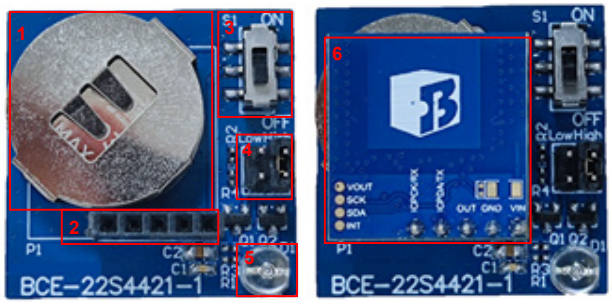
Software Parameter Introduction

1. **Sensing distance**: used to set the module horizontal forward sensing distance. There are seven levels, 1/2/3/4/5/6/7, corresponding to seven sensing distances of 5m/9m/10m/11m/12m/13m/14m.
2. **OUT pin output mode**: used to set the module OUT pin output.

3. **OUT pin output delay**: used to set the delay time of the OUT pin outputting a valid level after the module does not detect a moving object.
4. **Enable control of lighting control function**: used to set whether the module needs to enable the lighting control function. The lighting control function cannot be used independently and is effective only when the RF function is enabled.
5. **Trigger method of lighting control function**: used to set the trigger method of the lighting control function. Users can determine that this function is triggered whether when the AD sampling value is greater than the preset threshold value or less than the preset threshold value.
6. **Lower eight bits of lighting control threshold value**: used to set the lower eight bits of the lighting control trigger threshold value and these eight bits are combined with the higher eight bits of the lighting control trigger threshold value to form a 16-bit number ranging from 0 to 4095.
7. **Higher eight bits of lighting control threshold value**: used to set the higher eight bits of lighting control trigger threshold value and these eight bits are combined with the lower eight bits of the lighting control trigger threshold value to form a16-bit number ranging from 0 to 4095.
8. **TX frequency**: used to set the module TX frequency and there are 51 frequency points for users to select. The available frequency can be calculated by n×3+5722MHz, where n has a range of 1~51 and is selected according to actual requirements(such as regulations, etc.).
9. **RF function enable control**: used to enable/disable the RF function. This parameter value is not stored and takes effect only when the module is running. The RF function will be enabled by default when the module is powered on.
10. **Module version**: used to read the module version and cannot be written. If 0x10 is read, the current module version is V1.0.
11. **AD Value at L_AD Point of Lighting Control Circuit**:the AD sampling value ranging from 0 to 4095. Read only, with a 2-byte parameter value and the higher eight bits in the front.

Demo Board Operations

Demo Board Introduction



1. **Battery holder**: uses two CR2032 button batteries to supply power to the demo board.
2. **Pin headers for external connection**: used to connect the 5.8GHz radar sensor module to the demo board and it provides a convenient way for users to change different modules for test.
3. **Power supply switch**: the module is powered on by sliding the switch to the ON side.
4. **Indicator lighting level selection**: if the Low side two pin headers are shorted, the indicator will be on when the OUT pin outputs a low level. If the High side two pin headers are shorted, the indicator will be on when the OUT pin outputs a high level.
5. **Status indicator**: used to display the output status of the 5.8GHz radar sensor module. When the

5.8GHz radar sensor module detects a moving object, the status indicator will be on, and when there is no moving object, the status indicator will be off.

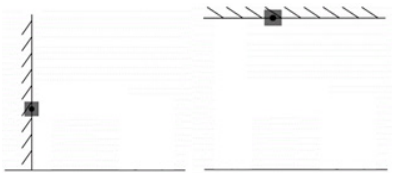
6. **5.8GHz radar sensor module**: used to detect whether there is a moving object in front of the module.

Moving Object Detection

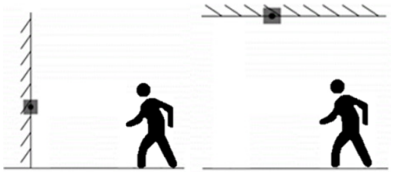
1. Insert two CR2032 button batteries into the holder and make the negative electrode face to the PCB.

2. Install the radar module, make the antenna face outward and slide the power supply switch to the ON side.

3. Use a double-sided sponge tape or similar adhesive tape to attach the demo board to the wall, ceiling, or stable objects (refer to the considerations when installing) and make the module antenna face to the test area.

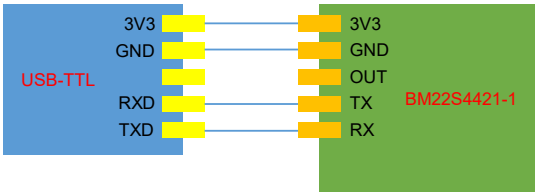


4. If the radar module detects a moving object in the test area, the indicator will be on. When the moving object leaves the detection area or the object stops moving, no moving object is detected and the indicator will be off after delaying for a period of time which can be adjusted.

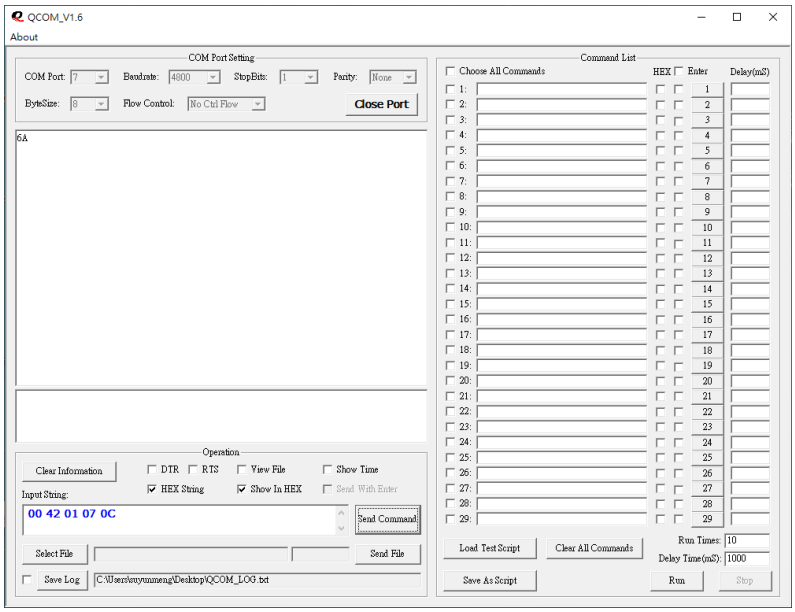


Adjust Software Parameters Using UART

1. Connect the computer to the USB serial port assistant. Remove the module and connect the USB serial port assistant to the module using Dupont lines. The connection diagram is shown below.



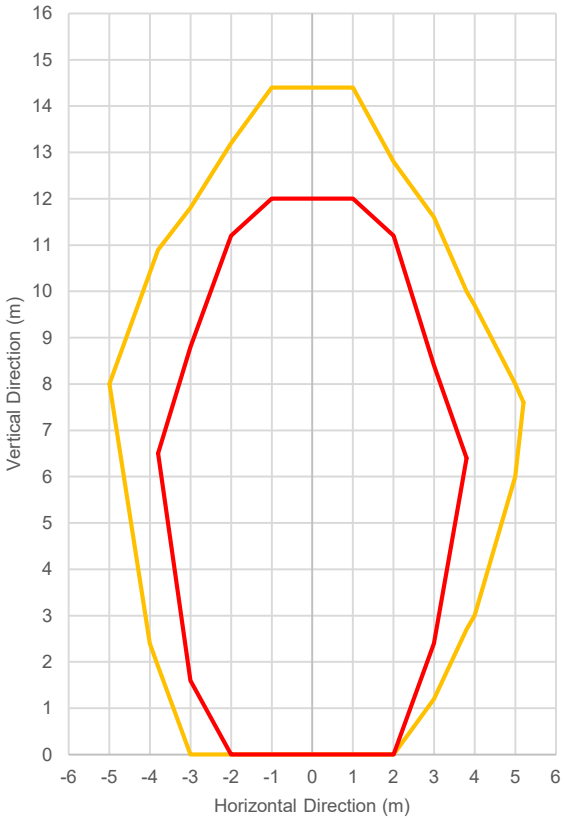
2. Open the serial port assistant software. Set the port, baud rate, data bits, stop bits and parity. Open the serial port. Set the auxiliary operation. Clear the sending and receiving area. Enter the UART command in the sending area(refer to the software parameter adjustment method), click “Send Command” and then view the receiving area.



3. After setting all the parameters that need to be set, remove the module and reinstall it to the demo board for normal test.

Detection Range

The following figure shows the detection range of the radar module. The sensitivity used for testing is 14m and the detection range varies with different sensitivities. The area within the red line is the strong sensing area where an object can be detected by moving only about 10cm. The area between the red and orange lines is the weak sensing area where larger moving distances are required and an object can be detected by moving greater than 40cm.

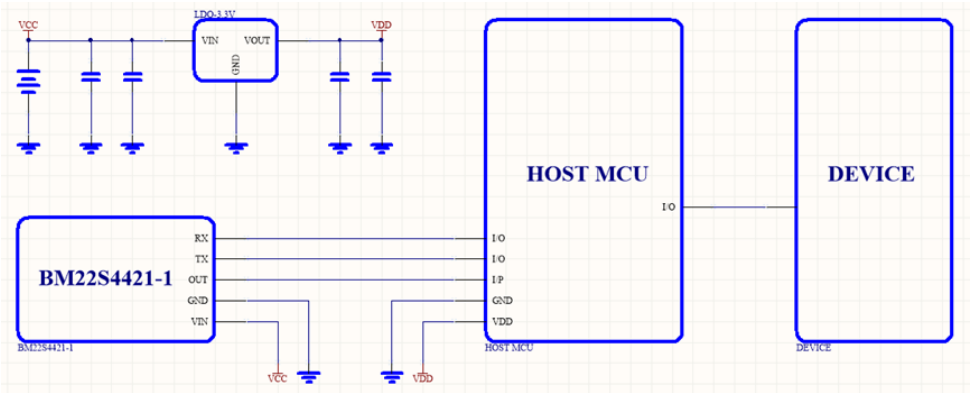

16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Vertical Direction (m)
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6
Horizontal Direction (m)

Considerations

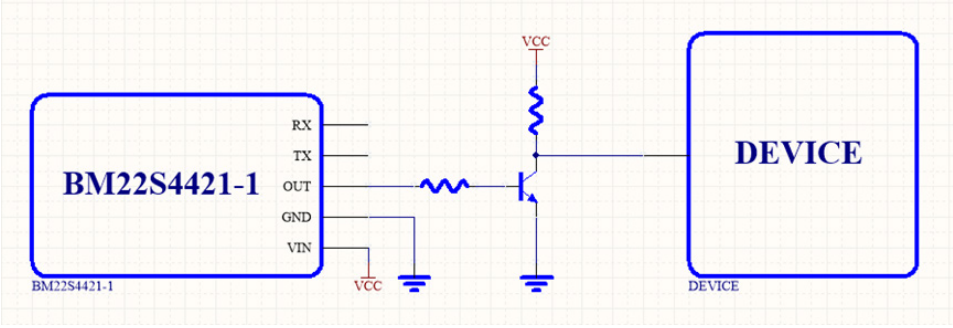
1. When using or installing the module, the module antenna should face to the detection direction.
2. Large metal equipment or pipelines should not be placed in front of the module antenna.
3. During the product installment, metal shells/components or components that are prone to shaking should not be placed in front of the module antenna.
4. Non-metallic obstructions can be placed in front of the module antenna but a suitable clearance area must be reserved in front of the antenna with a distance of at least 5mm.
5. The module should be as far as possible from components with strong radiation interference. This can avoid interference signals being coupled into the intermediate frequency signal and prevent the module erroneous trigger.
6. The module can filter out the power frequency signals but it still needs to avoid interference from power frequency signals as far as possible.

Application Circuits

Control with MCU

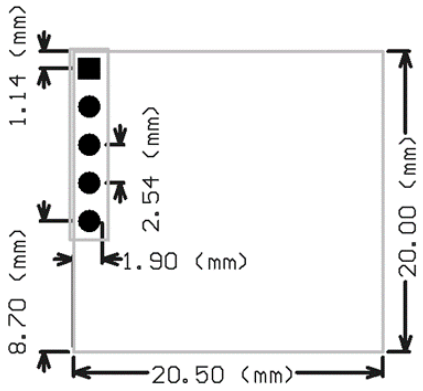


Control without MCU

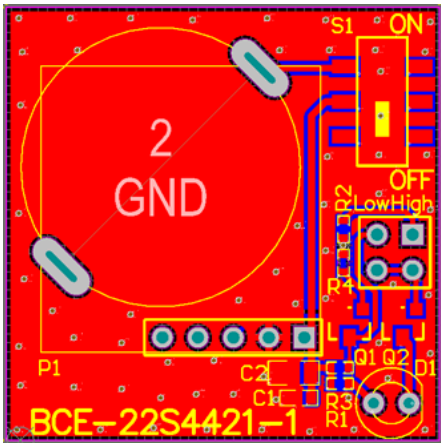


Layout Description

PCB Footprint

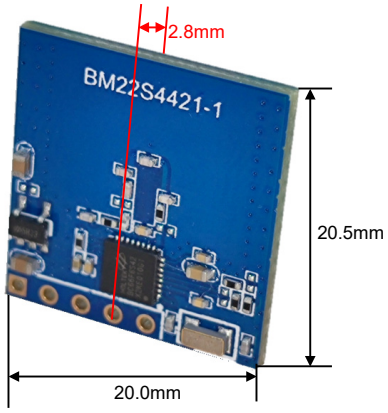


Layout Example



Note: if the OUT pin is set to output a high level when the module is triggered, the High side pin headers should be shorted. If the OUT pin is set to output a low level when the module is triggered, the Low side pin headers should be shorted.

Dimensions



Reference Information

Modification History

Date	Author	Issue	Modification Information
2023.09.27	苏运猛	V1.00	First Version
2024.05.30	苏祎斐	V1.10	1.Addition of Lighting Control Circuit Description 2.Addition of 0x17 Command Code

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