4. Introduction

The C4001(25m) millimeter-wave presence sensor utilizes a wavelength signal of 24GHz. It has a detection range of 100° horizontally, with a presence detection range of 16 meters and a motion detection and distance measurement range of 25 meters.

Human detection

Compared to other types of presence sensors such as infrared sensors and ultrasonic sensors, the C4001 millimeter-wave presence sensor has the advantage of being able to detect both stationary and moving objects. It also has relatively strong anti-interference capabilities, making it less susceptible to factors such as temperature changes, variations in ambient light, and environmental noise. Whether a person is sitting, sleeping, or in motion, the sensor can quickly and sensitively detect their presence.

	Millimeter-wave Presence Sensor	Infrared Sensor
Sensing Principle	TOF radar principle + Doppler radar sensing principle (active detection)	Pyroelectric infrared sensing principle (passive radiation)
Motion Sensitivity	Can detect presence, slight movement, and motion of human body	Can only detect motion and close-range slight movement of human body
Sensing Range	Can be adjusted to different sensing distances	Sensing range cannot be adjusted
Environmental Temperature Impact	Not affected by environmental temperature	Sensitivity decreases when temperature is close to human body temperature
Application Environment	Not affected by heat sources, light sources, air flow	Susceptible to heat sources and air flow
Penetration Ability	Can penetrate fabrics, plastics, glass, and other insulating materials	Can only penetrate some transparent plastics
Distance Measurement Support	Yes	No

Distance and velocity detection

The C4001(25m) millimeter-wave presence sensor utilizes Frequency Modulated Continuous Wave (FMCW) modulation for distance and speed measurement. It has a maximum measurement range of 25 meters for distance and a speed measurement range of 0.1 to 3 meters per second.

FMCW is a radar system based on Frequency Modulated Continuous Wave. Unlike traditional pulse radar, FMCW radar continuously emits a series of continuous wave signals with gradually changing frequencies while simultaneously receiving the reflected signals. By analyzing the received signals, measurements of parameters such as distance, velocity, and angle can be achieved.

Compared to traditional pulse radar technology, FMCW radar can continuously measure the distance of objects. By utilizing the Doppler effect, it can also obtain velocity information of the target objects. This makes it suitable for applications that require monitoring the motion status of target objects. Additionally, FMCW radar can achieve continuous frequency scanning, providing higher measurement resolution. Since it doesn't need to wait for the echo signal to return, it is suitable for applications that require real-time monitoring and tracking of target objects.

What is a millimeter-wave radar sensor?

Millimeter-wave radar technology is a non-contact sensing technology used to detect objects and provide information about their distance, velocity, and angle (in the case of humans, for example). The signals emitted by millimeter-wave sensors fall within the high-frequency spectrum with wavelengths between 24GHz and 300 GHz, also known as the millimeter (mm) range.

Characteristics

- Human detection: Detection range up to 16 meters and motion detection range up to 25 meters.

- Distance detection: Range from 1.2 meters to 25 meters.

- Velocity detection: Range from 0.1 meters per second to 3 meters per second.

- Strong anti-interference capability, unaffected by snow, haze, temperature, humidity, dust, light, noise, etc.

- High and low level output control through I/O ports.

- Input and output control via serial port.

- Small size, easy to integrate.

Technical Specifications

- Operating voltage: 3.3/5V

- Maximum detection range: 25m

- Beam angle: 100*40°

- Modulation mode: FMCW

- Operating frequency: 24GHz

- Operating temperature: -40~85℃

- Baud rate: 9600

- Size: 26*30mm

Interface Definitions

Definition	Explanation
VIN	Power Supply
GND	Ground
RX	Sensor Serial Port Receive
TX	Sensor Serial Port Transmit
OUT	Level Output

Installation method

The installation method of millimeter-wave human body sensors is sensitive, and improper installation can affect the performance and functionality of the sensor. Common installation methods for this module include top installation, bottom installation, horizontal installation, and downward tilt installation.
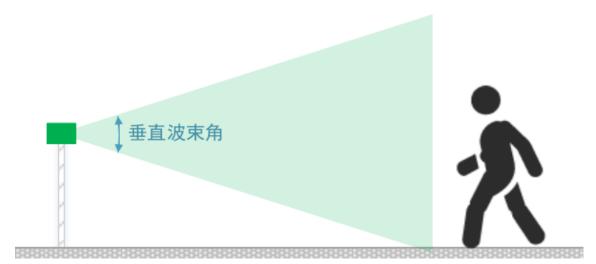
Top installation

Bottom installation

Horizontal installation

Communication protocol

If you use the C4001 millimeter wave presence sensor as a trigger switch, only using the OUT pin of the module, and when the configuration parameters meet the performance and functional requirements, you can omit the use of serial communication and do not need to worry about the communication protocol.

The C4001 millimeter wave presence sensor uses serial communication to interact with the module using ASCII code strings as data and commands, which are easy to understand and debug.

1. Serial port parameters:

   Default baud rate: 115200 bps, 1 stop bit, 8 data bits, no parity, no flow control.

2. Parameter configuration commands:

   In ASCII code string format, ending with a carriage return and line feed; commands and parameters, as well as parameters and parameters, are separated by one or more spaces.

3. Read configuration parameter commands:

   The response to reading parameters starts with the string "Response" and ends with a carriage return and line feed; commands and parameters, as well as parameters and parameters, are separated by one or more spaces.

4. Active data reporting:

   In ASCII code string format, starting with '$' and ending with '*', multiple parameters are separated by ',', and placeholder parameters (reserved) are represented by spaces.

Note:
(1) When configuring parameters, the module must be in a stopped state. After configuring the parameters, you must send the command to save the parameters to the module's Flash memory. Then, you can send the command to start the module, or the reset/restart command, or directly power off and restart. Only after these steps, the newly configured parameters will take effect.
(2) The "DFRobot:/>" mentioned in the following descriptions is just the command prompt printed by the module. The string after "DFRobot:/>" is the actual command.

1、Common configuration commands

Using modules is important, and the timing of module's read and write operations is crucial. For module parameter read and write intervals, it is recommended:

(1) After the module is powered on for more than 3 seconds, you can read the module to check if there is any response.

(2) After the module is powered on for 1 second, you can perform parameter read and write operations.

1.1、Configuration detection distance: setRange, getRange

Description:
- The C4001 millimeter wave presence sensor has a maximum detection distance of 0.6~25m;   - The C4001 millimeter wave presence sensor module has a 1m transition zone, which means that if the maximum detection distance is set to 3 meters, it is possible to detect targets between 3~25 meters. When approaching 25 meters, a significant movement is required to be detected, and it is also possible that the target cannot be detected at the 25-meter position (depending on the target characteristics). However, no targets will be detected beyond 25 meters, such as 27 meters. Therefore, users need to pay special attention to this feature when configuring the maximum distance parameter in order to accurately define the detection area.   Note: The C4001 millimeter wave presence sensor is not specifically designed for distance measurement. The distance is currently not calibrated in the current version, so the distance can only be used as a reference and may have some deviation or error.
Configuration Parameter Command:
Send command: setRange par1 par2
Read Configuration Parameter Command:
Send command: getRange Command response: Response par1 par2
Parameters:

par1	Minimum detection distance, in meters (m): Value range: 0.6~25; default 0.6m, not recommended to modify.
par2	Maximum detection distance, in meters (m): Value range: par1 < par2 ≤ 25; default 6m
Command Execution Result:	
Done	Command executed successfully
Error	Command execution failed
Examples:	
Configure detection distance to 0.6 ~ 6 meters	DFRobot:/> setRange 0.6 6
Configure detection distance to 0.6 ~ 12 meters	DFRobot:/> setRange 0.6 12
Configure detection distance to 0.6 ~ 2.8 meters	DFRobot:/> setRange 0.6 2.8

1.2、 Configuration trigger distance: setTrigRange, getTrigRange

Description:

- The trigger distance of the C4001 millimeter wave presence sensor refers to the distance at which it can trigger from no one to someone. For example, if the maximum detection distance is configured as 10 meters, and the trigger distance is set to 6 meters, the sensor will only display "someone" when someone is within 6 meters. If someone is between 6-10 meters, it will not be triggered as "someone". The trigger distance can be set within the range of 0-25m, with a default of 6m.

Note: Configuring the trigger distance can optimize the problem of false triggering caused by slight movements at the edge. The smaller the trigger distance, the closer you need to be to the center axis of the sensor to trigger it. The trigger distance value cannot be greater than the difference between the maximum and minimum detection distances.

This command only supports presence detection mode.

Configuration Parameter Command:	
Send command: setTrigRange par1	
Read Configuration Parameter Command:	
Send command: getTrigRange Command response: Response par1	
Parameters:	
par1	Trigger distance, in meters (m): Value range: 0~25m; default 6m.
Command Execution Result:	
Done	Command executed successfully
Error	Command execution failed
Examples:	
Configure trigger distance to 10m	DFRobot:/> setTrigRange 10

1.3、Configuration detection sensitivity: setSensitivity, getSensitivity

Description:	
   ○ The C4001 millimeter wave proximity sensor has two sensitivities: trigger sensitivity and hold sensitivity. Trigger sensitivity refers to the ease of triggering the sensor when entering the sensing area. Hold sensitivity refers to the sensitivity of continuous detection of the target after the sensor is triggered. Both trigger and hold sensitivities have 10 levels, with higher numbers indicating higher sensitivity and lower numbers indicating lower sensitivity. The default sensitivity value is 7. Note: Please configure the sensitivity according to the actual usage environment and requirements. Lower sensitivity requires larger movement amplitude and closer distance of the target to be detected. Higher sensitivity requires a higher demand for environmental interference. If there are interferences, it is more prone to false alarms. Setting the trigger sensitivity to 8 or 9 may cause a certain probability of false alarms, and it is mainly used in scenarios where false alarms are not sensitive. Generally, it is recommended to configure the trigger sensitivity between 2 and 6, with a value range of 0 to 9. This command only supports the detection mode.	

Configuration Parameter Command:	
Send command: setSensitivity par1 par2	

Read Configuration Parameter Command:	
Send command: getSensitivity Command response: Response par1 par2	

Parameters:	
par1	Hold sensitivity: Value range: 0 to 9; default is 7
Par2	Trigger sensitivity: Value range: 0 to 9; default is 5

Command Execution Result:	
Done	Command executed successfully

Error	Command execution failed
Examples:	
Configure trigger sensitivity as 3, keep hold sensitivity unchanged	DFRobot:/> setSensitivity 255 3
Configure hold sensitivity as 7, keep trigger sensitivity unchanged	DFRobot:/> setSensitivity 7 255
Configure hold sensitivity as 8, trigger sensitivity as 4	DFRobot:/> setSensitivity 8 4

1.4、Set output latency time: setLatency, get output latency time: getLatency

Description:

- Output latency configuration, confirmation latency: used to configure the confirmation time when "target detected"; disappearance latency: used to configure the confirmation time after "target disappears".

Note:

1. Confirmation latency: configuring the optimal parameter value can greatly reduce the false positive rate. Although a larger value is more reliable, the module will take longer to report the detection of the target when the real target appears;

2. Disappearance latency: the larger the configured parameter value, the easier it is to reduce the missed detection caused by the target accidentally disappearing. Although a larger value is more reliable, the module will take longer to report the target has disappeared after the target actually disappears.

This command only supports the existence detection mode.

Configuration parameter command:

Send command: setLatency par1 par2

Read configuration parameter command:

Send command: getLatency
Command response: Response par1 par2

Parameter:

par1	Confirmation latency; after detecting the target, output the target valid signal (OUT pin outputs high level) after par1 duration, in seconds (s): Value range: 0~100, default 0.050 seconds Note: For scenarios with low requirements for detection response speed, it is recommended to set it greater than 0.5 seconds, which can greatly reduce the false positive rate.
par2	Disappearance latency; after not detecting the target, output the invalid target signal (OUT pin outputs low level) after par2 duration, in seconds (s): Value range: 0.5~1500, default 15 seconds Note: For scenarios with low requirements for response speed after the target disappears, it is recommended to set it greater than 15 seconds, which can greatly reduce the missed detection rate. It can also be set longer, such as 30 seconds, 60 seconds, 90 seconds, etc.
Command execution result:	
Done	Command executed successfully
Error	Command execution failed
Example:	
Configure that the target needs to exist for at least 0.5 seconds to be considered as a target; if the target does not exist for 15 seconds, it is considered as no target.	DFRobot:/> setLatency 0.5 15

1.5、 Configuration of Inhibit Time: setInhibit, getInhibit

Description:

- Configuration blocking time, default blocking detection function is 1 second;

- After the module detects the target, the default blocking detection function is 1 second, and the OUT pin outputs a control signal. After the duration of the control signal, the default blocking detection function is 1 second before it can detect the target again.

- The blocking time is mainly used to solve the problem of power appliances such as relays, motors, fans, and lighting lamps causing power fluctuations, radiation, and other interference to the radar module when the control signal of the OUT pin changes. Within the blocking time, the target is not detected to avoid sudden interference. It is recommended to set the default configuration to 1 second when designing the relay and module PCB together.

  This command only supports the existence detection mode.

Configuration Parameter Command:	
Send command: setInhibit par1	
Read Configuration Parameter Command:	
Send command: getInhibit Command response: Response par1	
Parameters:	
par1	Blocking time in seconds: Value range: 0.1 to 255; default is 1.
Command Execution Result:	
Done	Command executed successfully
Error	Command execution failed
Examples:	
Set the blocking time to 0.5 seconds, which means not detecting the target for 0.5 seconds	DFRobot:/> setInhibit 0.5

Set the blocking time to 3 seconds, which means not detecting the target for 3 seconds	DFRobot:/> setInhibit 3

1.6、Set UART baud rate: setUart, get UART baud rate: getUart

Description:	
o After configuring the UART baud rate, the module needs to be reset and restarted (parameters need to be saved first) for the new configuration to take effect. After the configuration takes effect, the UART baud rate on the user's side also needs to be changed to the new baud rate for normal communication with the module. Note: To make the baud rate effective, you need to use the reset and restart command (resetSystem 0), not the start command (sensorStart).	
Configuration Parameter Command:	
Send command: setUart par1	
Read Configuration Parameter Command:	
Send command: getUart Command response: Response par1	
Parameters:	
par1	UART baud rate in bps: Value range: 4800 to 115200; default is 9600. Note: Do not exceed the maximum baud rate of the device you are using, otherwise you will not be able to reconnect to the module.
Command Execution Result:	
Done	Command executed successfully

Error	Command execution failed
Examples:	
Set the UART baud rate to 57600 bps	DFRobot:/> setUart 57600

1.7、 Set micro motion switch: setMicroMotion, get micro motion switch: getMicroMotion

Description:
Configure the sensor for micro motion detection in speed and distance measurement mode. Note: This command is only valid in speed and distance measurement mode.
Configuration Parameter Command:
Send command: setMicroMotion par1
Read Configuration Parameter Command:
Send command: getMicroMotion Command response: Response par1

Parameter:	
par1	Micro motion detection switch 0: Disable micro motion detection (default) 1: Enable micro motion detection
Command Execution Result:	
Done	Command executed successfully
Error	Command execution failed
Example:	
Enable micro motion detection	DFRobot:/> setMicroMotion 1

1.8、 Threshold factor configuration: setThrFactor, getThrFactor.

Description:	
o Threshold factor configuration: The larger the factor, the bigger the action and the larger the object that can be detected. Note: This command is only valid in speed and distance measurement mode.	
Configuration parameter command:	
Send command: setThrFactor par1	
Read configuration parameter command:	
Send command: getThrFactor Command response: Response par1	
Parameters:	
par1	Threshold factor configuration: The larger the factor, the bigger the action and the larger the object that can be detected. (Default: 5)
Command execution result:	
Done	Command executed successfully
Error	Command execution failed
Example:	
Set threshold factor to 3	DFRobot:/> setThrFactor 3

2、 Control class commands

2.1、 Stop： sensorStop

Description:	

- Stop the module while it is running.

Note: Before configuring parameters, you need to send the stop command to stop the module and enter the parameter configuration mode.

Command:	
sensorStop	
Parameters:	
None	No parameters
Response:	
Done	Command executed successfully
Error	Command execution failed, module is not in running state
Example:	
Stop the module	sensorStop

2.2、Start: sensorStart.

Description:	

- When the module is in a stopped state and the configured parameters have been saved, start the module to begin operation.

Note: After the parameter settings are completed and saved, the start command (sensorStart) needs to be sent to start the module with the new parameters. (The serial baud rate configuration requires the reset and restart command resetSystem 0)

Command:	
sensorStart	Start the module. The module will output "no one" first when starting, and then output "someone" when someone is detected.
sensorStart 1	Start the module with the same state as before stopping. If the state before stopping was "someone," it will first output "someone"; if it was "no one," it will first output "no one."
Parameters:	
None	No parameters
Response:	
Done	Command executed successfully
Error	Command execution failed, module is not in running state
Example:	
Start the module	sensorStart

2.3、Save configuration: saveConfig

Description:	

- After configuring the module parameters through the serial port, use this command to save the new configuration parameters to Flash.

Note: After configuring all the parameters, you must send this command, otherwise the new parameters will not take effect, and the new parameters will be lost after the module restarts.

Command:	
saveConfig	
Parameters:	
None	No parameters
Response:	
Done	Command executed successfully
Error	Command execution failed
Example:	
Save all configured parameters	saveConfig

2.4、 Restore factory configuration: resetCfg

Description:	
- Restore all current configuration parameter values of the module to the factory default values.	
Command:	

resetCfg	
Parameters:	
None	No parameters
Response:	
Done	Command executed successfully
Error	Command execution failed
Example:	
Restore configuration parameters to factory default values	resetCfg

2.5、 Reset and restart: resetSystem.

Description:	
○ The module performs a software reset and restarts.	
Command:	
resetSystem par1	
Parameters:	
par1	Run mode (optional, default is 0): 0: Normal software restart 1: Software restart and enter bootloader
Response:	
None	No string printed during normal software restart
reset enter bootloader!	Response when software restart enters bootloader
Example:	
Normal restart	resetSystem
Normal restart	resetSystem 0
Enter bootloader	resetSystem 1

2.6、 Switch working mode: setRunApp

Description:	
o Switch the module's working mode. Note: Before sending this command, use "sensorStop" to stop the module.	
Command:	
setRunApp par1	
Parameters:	
par1	Working mode: 0: Enter presence detection mode 1: Enter speed and distance measurement mode
Response:	
None	Once the command is recognized, the sensor will directly enter the corresponding working mode.
Example:	
Enter speed and distance measurement mode	setRunApp 1
Enter presence detection mode	setRunApp 0

3、 Active data reporting

3.1、 Presence detection result output: $DFHPD

Description:	

- The C4001 millimeter wave presence sensor outputs the detection result of whether there is a person in a fixed cycle or through passive querying.

Note: The output of the detection result is controlled by the configuration command setUartOutput, which can disable the output, set the output cycle, or enable output in query mode.

Response:	
$DFHPD,par1,par2,par3,par4*	
Parameters:	
par1	Detection result: 0: No person 1: Person detected (person present, stationary, moving, or slight movement, etc.)
par2	Placeholder: Reserved, use space instead
par3	Placeholder: Reserved, use space instead
par4	Placeholder: Reserved, use space instead
Example:	
Person detected	$DFHPD,1, , , *
No person detected	$DFHPD,0, , , *

3.2、 Distance and speed detection output: $DFDMD

Description:	

- The C4001 millimeter wave presence sensor provides real-time output of the detected target's speed and distance.

Note: $DFDMD can only output when the sensor is operating in distance measurement mode.

Response:
$DFDMD,par1,par2,par3,par4,par5,par6,par7*

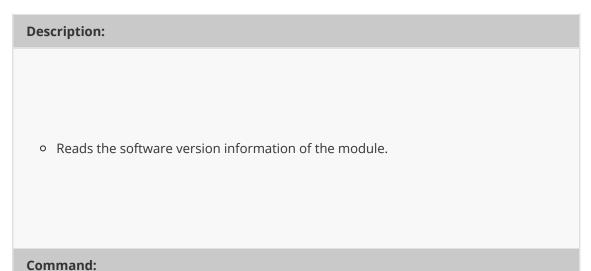| Parameters:	
par1	Number of targets: 0: No target detected 1: One target detected This module supports up to one target only
par2	Target number: When par1=1, par2=1; when par1=0, par2 is a placeholder using space
par3	Target distance, in meters (m): Range: 0-25 meters When par1=0, par3 is a placeholder using space
par4	Target speed, in meters per second (m/s): Range: 0-10 m/s When par1=0, par4 is a placeholder using space
par5	Target energy When par1=0, par5 is a placeholder using space
par6	Placeholder: Reserved, use space instead
par7	Placeholder: Reserved, use space instead

Example:	
Person detected Distance: 1.817 meters Speed: 0.129 m/s Energy: 15304	$DFDMD,1,1,1.817,0.129,15304, , *

4、Other commands

4.1、Reading hardware version information: getHWV

Description:	
○ Reads the hardware version information of the module.	
Command:	
getHWV	
Parameters:	
None	
Response:	
[Version information] Done	See example
Example:	
Read hardware version information	DFRobot:/> getHWV HardwareVersion:JYSJ_5807_A01 Done

4.2、Reading software version information: getSWV

Description:	
○ Reads the software version information of the module.	
Command:	

getSWV	
Parameters:	
None	
Response:	
[Version information] Done	See example
Example:	
Read software version information	DFRobot:/> getSWV SoftwareVersion:JYSJ_02.08.08.010827 Done

5、 Configuration Example: Complete Process

1. **Configure Detection Distance**

   Set the minimum detection distance to 0.6 meters and the maximum detection distance to 3 meters:

   ```
   DFRobot:/> sensorStop
   DFRobot:/> setRange 0.6 3
   Done
   DFRobot:/> saveConfig
   save cfg complete
   Done
   DFRobot:/> sensorStart
   Done
   ```

2. **Configure Hold Sensitivity and Trigger Sensitivity**

   Set the hold sensitivity to 6 and the trigger sensitivity to 5. The higher the number, the higher the hold and trigger sensitivity.

   ```
   DFRobot:/> sensorStop
   DFRobot:/> setSensitivity 6 5
   Done
   DFRobot:/> saveConfig
   save cfg complete
   Done
   DFRobot:/> sensorStart
   Done
   ```

3. **Configure delay time.**

   (1) Confirm that the delay setting is 2 seconds, meaning that the target needs to be present for 2 seconds continuously to be considered as having a target.

   (2) Confirm that the disappearance delay is set to 15 seconds, meaning that the target needs to be absent for 15 seconds continuously to be considered as having no target.

```
DFRobot:/> sensorStop
DFRobot:/> setLatency 2 15
Done
DFRobot:/> saveConfig
save cfg complete
Done
DFRobot:/> sensorStart
Done
```

4. **Multiple configuration parameter commands: such as simultaneously configuring sensitivity and delay time parameters.**

   (1) Sensitivity is configured as 5.

   (2) Delay time configuration: Confirm delay set to 0.5 seconds, disappearance delay set to 5 seconds.

```
DFRobot:/> sensorStop
DFRobot:/> setSensitivity 5
Done
DFRobot:/> setLatency 0.5 5
Done
DFRobot:/> saveConfig
save cfg complete
Done
DFRobot:/> sensorStart
Done
```