

UMAIN

Harmless UWB Radar Sensor for 24-hours

UWB Radar Sensor Thunder Series

- Presence Detection
- Respiration Detection
- Sleep Detection
- Intrusion Detection
- Passenger Detection
- Activity Detection



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1. Introduction

Sensor "Thunder Series" is an impulse radar based on Ultra-Wide Band technology in high band areas (7GHz-9GHz), which can be used to detect the presence of person or animals within detection range. US Federal Communications Commission (FCC) authorized the definition of UWB and the use of frequency bands and limited uses in February 2002.

Using a very wide frequency band compared to conventional systems, low-power signal energy is distributed to spectra of several GHz bandwidth.

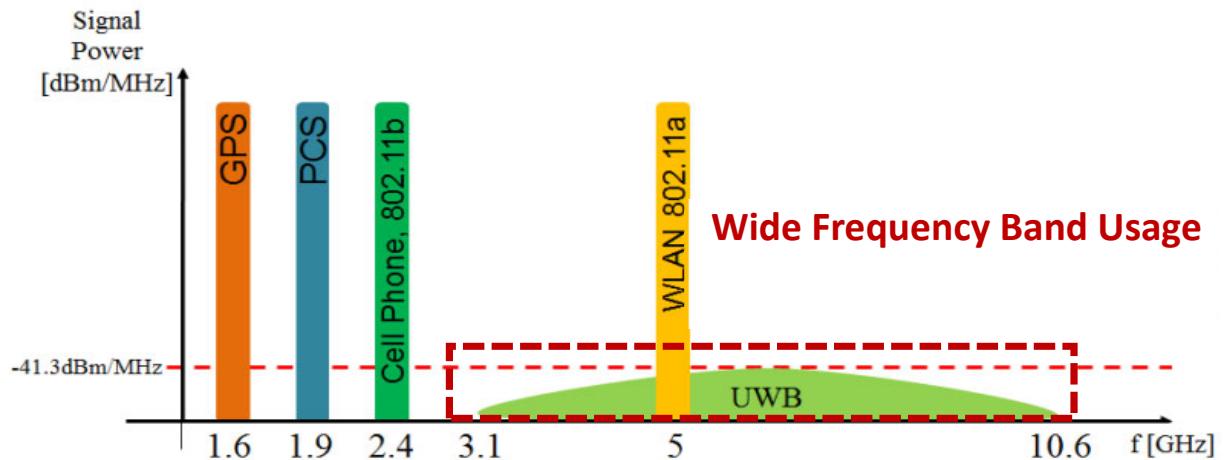
Sensors can detect a person's respiration signal also have reliable capture performance and are designed to reduce false alarms for commercial use.

For this purpose, sensor contain two fields in detection solution: Doppler detector and Vital Signal detector. Doppler detector allows to detect movements of person's inside of area, Vital Signal catch signals when body is unmoved (sleeping, reading book or watch tv etc.).

Sensor "Thunder Series" provides the data by Bluetooth Low Energy (BLE) and UART interfaces. Sensor's maximum working distance can be adjusted through UART interface or using IR remote controller.

Data that provided by sensor is indicating about area occupancy. Two numbers are representing motion detection and respiration detection.

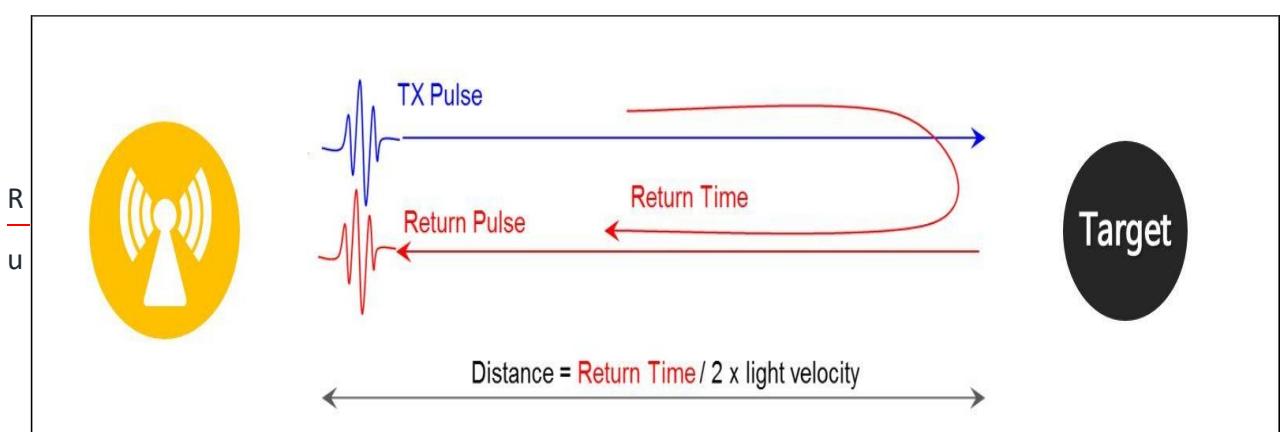
This device complies with Part 15.517 of the FCC Rules. This equipment may only be operated indoors. Operation outdoors is in violation of 47 U.S.C. 301 and could subject the operator to serious penalties.



1.1 IR-UWB Radar System

- IR-UWB Radar measures distance using time reflected from the detection object using nano-second or less pulse heat.
- The smaller pulse size, the more precise the measurement and the more information it can contain.
- The precision of the target is improved compared to normal radar and has less impact on the surrounding environment.
- Because it uses short pulses, it can also be used in the security field, and because of its high permeability, distance measurement is possible even if there are obstacles.
- To estimate the distance of an object, we need to eliminate background noise and compensate for signal attenuation

<System of UWB Radar>



If you look at the figure above, you can see the Tx pulse.

- For biometric purposes at close range (within 10 meters)
- Low power operation according to domestic and international standards
- Key technologies of the fourth industry used in biometric signal detection and human detection technologies at home and abroad, which are harmless to the human body (from 1/700 to 1/1,500 levels of first-class mobile phones)
- Small objects, small motion detection, and strength

1.2 UWB Technical Advantages

- **Radar technology is harmless to the human body for 24 hours a day (most important)**
- Low power of radio waves compared to other electronic devices
- The size of the pulse is very short, allowing precise measurements
- Use in security because of short pulses
- Good permeability, allowing distance measurements even with obstructions
- Low power output, available for low power use



High Resolution

Non-contact heart rate, biometric signals such as breathing can be detected

Anonymous Data

Sensing without camera function. Prevent personal information leakage and privacy breaches

Permeability

High permeability using high frequency bands. Not affected by external environment, such as mist, rain, snow, or darkness

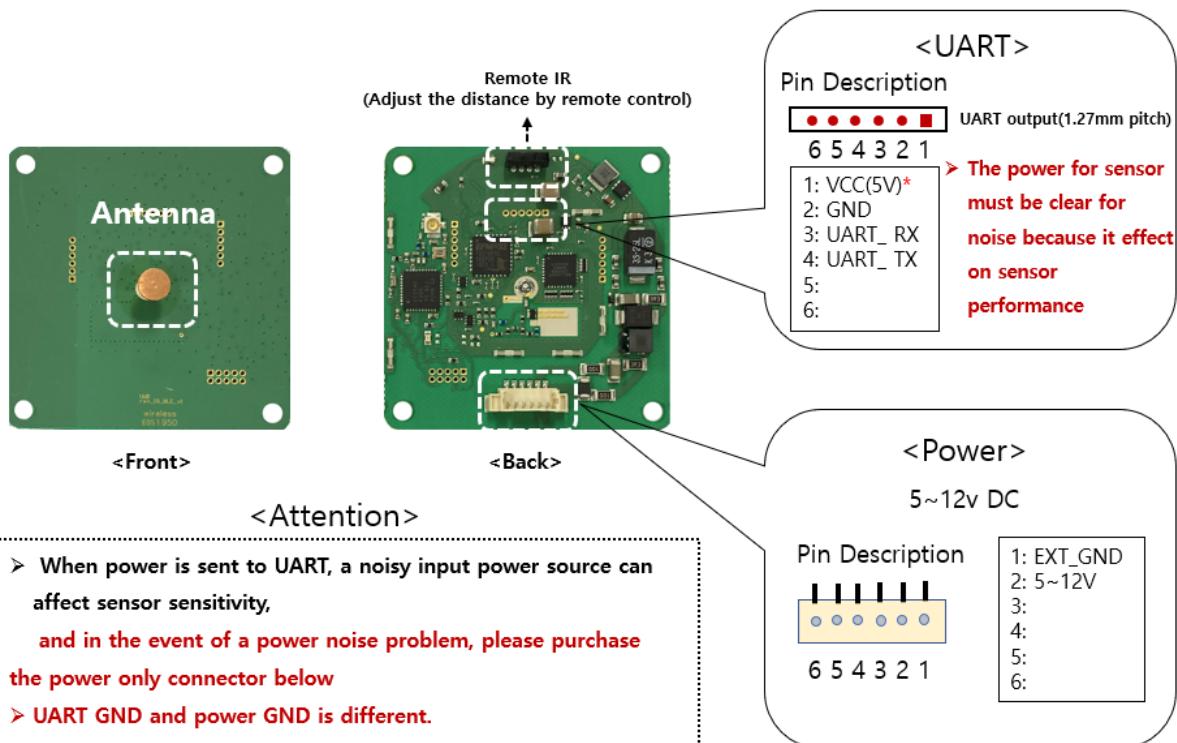


2. Product Specification

Hardware Specification	
RF central frequency	7.9GHz +/- 0.15GHz
RF bandwidth	>500MHz
RF power	<-42dBm/MHz
Antenna type	Omni directional, Directional
Range resolution	50cm
Detecting range	5m max
Detecting speed of motion	0.2 ~ 1.0m/s
Detecting vital signs	0.13 ~ 0.7Hz
Warm-up period	<30 sec (calibration time)
Alarm Delay	1sec (min)
Interface Specification	
Outputs (default/optional)	UART, BLE
Communication output (optional)	9600bps, 57600bps, 115200bps, 230400bps
Inputs (default/optional)	IR remote control
IR compatible decoder	NEC (10keys)

Communication input (optional)	Remote control
Wi-Fi	802.11b/g/n(2412~2462 MHz)
BLE	2402~2480 MHz
Electrical Specification	
Current supply	Standby 10mA / Max. 20mA
Voltage input	VDC 12V/Class B 9.6V ~ 14.4V
Functional Extra Low Voltage	VDC 5V (min)
Time of power interrupt	<1sec (max)

3. Terminal Information

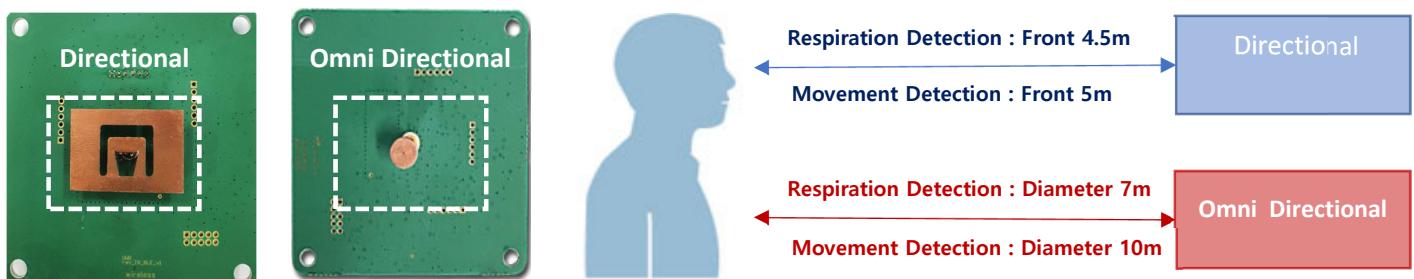


4. Difference between Omni Directional and Directional

There are two types of Thunder series products, Omni Directional and Directional. The table below shows the difference between Omni Directional and Directional based on the antenna specifications.

Parameter	Value	Value
Antenna Type	Omni directional	Directional
Antenna Angle	X-Z Plane: 360° Y-Z Plane: 60°	X-Z Plane: 50°~80° Y-Z Plane: 60°
Antenna Gain	XZ Plane: 4.91(min.) dBi YZ Plane: 4.66(min.) dBi	XZ Plane: 7(min.) dBi YZ Plane: 7(min.) dBi

Figure below shows the model of an Omni Directional antenna and Directional antenna and the difference in respiration detection distance.



5. UART interface

UART interface is available on 6-pin connector inside of the sensor PCB. Pinout of this connector is described on picture below:

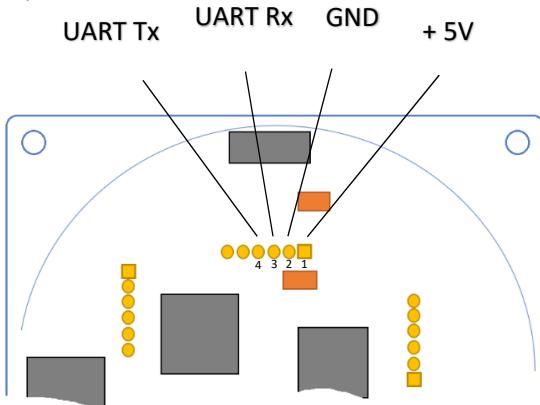


Fig. 1 – UART connector pinout

UART interface can be used for sensor's data receiving and for changing sensor's parameters as well. Result of sensor detection is represented in two values: "motion marker" and "respiration marker".

Table 1 – Description of sensor output variables

Situation:	Not occupied	Occupation detected (Motion detected)	Occupation detected (Respiration detected)
First value "Motion marker"	0	Min:100 Max:4800 Value represents how strong the environment was changed since previous measurements.	-
Second value "Respiration marker"	0	-	Min:6 Max:40 Value represents estimated respiration rate (BPM).

Default settings

By default, data provided in event driven mode. Which means that sensor sends the data when motion or respiration detected. The message after first detection is sending during 1 second. For continuous event sensor sends messages with delay around 3 second.

In case of no detection, sensor sends zero values every 1 minute to indicate that sensor is "online".

Data format is ASCII and represented as "*val1, val1*<CR><LF>". Default communication speed is 9600 bps. Default sensor's ID is 0x00.

Optional settings

Parameters of serial communication can be adjusted as follow:

- Communication speed:

- 1) 9600 bps.
- 2) 57600 bps.
- 3) 115200 bps.
- 4) 230400 bps.

- Sending method:

- 1) Event driven.

Sensor sends the data when motion or respiration detected. The message after first detection is sending during 1 second. For continuous event sensor sends messages with delay around 3 second. In case of no detection, sensor sends zero values every 1 minute.

- 2) Continuously sending.

Sensor sends the data continuously with fixed time interval from 1 to 180 seconds.

- 3) By request.

Sensor sends the data when host request it.

- Data format:

- 1) ASCII.

Data format is represented as "val1, val1<CR><LF>" (in C: `printf("%d, %d\n", val1, val2);`)

val1 is movement value and respiration value.

```
2020-05-20 16:10:07.970 [RX] - Motion Marker, BPM<CR><LF>
2020-05-20 16:10:08.583 [RX] - 0, 0<CR><LF>
2020-05-20 16:10:17.148 [RX] - 362, 0<CR><LF>
2020-05-20 16:10:29.764 [RX] - 481, 0<CR><LF>
2020-05-20 16:10:32.434 [RX] - 260, 0<CR><LF>
2020-05-20 16:10:35.114 [RX] - 209, 0<CR><LF>
2020-05-20 16:10:41.473 [RX] - 102, 0<CR><LF>
2020-05-20 16:10:50.410 [RX] - 170, 0<CR><LF>
2020-05-20 16:11:00.450 [RX] - 520, 0<CR><LF>
2020-05-20 16:11:04.230 [RX] - 325, 0<CR><LF>
```

In the figure above, the received data is in ASCII format, left values 362, 481 are movement values, and right values 0 are respiration values. Respiration is zero because it is an environment that measures the state of movement.

- 2) Hex format.

Data is packed in message that contains header, sensor id, motion and respiration markers and checksum:

0x6A	Sensor ID	0xC1	Value 1 MSB	Value 1 LSB	Value 2	CRC8
------	-----------	------	-------------	-------------	---------	------

```
2020-05-20 16:58:19.699 [RX] - 6A 00 C1 04 FF 00 90
2020-05-20 16:58:22.370 [RX] - 6A 00 C1 02 58 00 9E
2020-05-20 16:58:27.987 [RX] - 6A 00 C1 00 73 00 71
2020-05-20 16:59:30.178 [RX] - 6A 00 C1 00 00 00 EC
2020-05-20 17:00:10.643 [RX] - 6A 00 C1 00 DB 00 C1
2020-05-20 17:00:40.527 [RX] - 6A 00 C1 01 14 00 84
```

In the figure above, the data received is Hex format. For example "6A 00 C1 01 14 00 84" data has been received

1. 6A is always a common type of sensor
2. 00 is a default sensor ID (selectable, ref. P17)
3. C1 is alarm signals that the sensor has detected movement or respiration
4. 01,14 is the value of movement value
5. 00 is the respiration value
6. 84 is a CRC8 value

The sensor working range and option settings can be set using the command in hex format as follow:

Sensor type	Sensor ID	Command	Value	CRC8
0x6A	0x00	0xC2	0x01	0x09

5.1 Commands description

5.1.1 Sensor range

C4

Possible values:

- 0x00 – no changes, return current range
- 0x01 – set 1.5m
- 0x02 – set 2.0m
- 0x03 – set 2.5m
- 0x04 – set 3.0m
- 0x05 – set 3.5m
- 0x06 – set 4.0m
- 0x07 – set 4.5m
- 0x08 – set 5.0m

Comment:

Distance in meters means the maximum detection range from sensor.

As soon as sensor's detection range can be changed by IR remote controller as well, we would recommend controlling sensor's settings periodically by sending 0x00 value.

After changing of working range, the sensor starts to recalibrate.

Example:

Change range to 3.5m for sensor with id 0:

Host request: 0x6A 0x00 0xC4 0x06 0x62

Sensor reply: 0x6A 0x00 0xC4 0x06 0x62

5.1.2 Communication speed

Command:

C8

Possible values:

- 0x00 – no changes, return current speed
- 0x01 – set 9600
- 0x02 – set 57600
- 0x03 – set 115200
- 0x04 – set 230400

Comment:

Sensor replies on the same communication speed. Then communication speed is changed for requested one.

Example:

Change UART speed to 115200 for sensor with id 0:

Host request: 0x6A 0x00 0xC8 0x03 0x85

Sensor reply: 0x6A 0x00 0xC8 0x03 0x85

5.1.3 Sending method

Command:

CA

Possible values:

- 0x00 – no changes, return current setting
- 0x01 – event driven
- 0x02 – continuous sending with fixed interval
- 0x03 – sending by request

Comment:

- Event driven – sensor sends the data when motion or respiration detected. The message after first detection is sending during 1 second. For continuous event sensor sends messages with delay around 3 second. In case of no detection, sensor sends zero values every 1 minute.
- Continuously sending – sensor sends the data continuously with fixed time interval from 1 to 180 seconds. Time interval can be changed by command "CC"
- By request – sensor sends the data when host request it by command "CB".

The data format is set by command "C9".

Example:

Change sending method to "continuous sending" for sensor with id 0:

Host request: 0x6A 0x00 0xCA 0x02 0xA8

Sensor reply: 0x6A 0x00 0xCA 0x02 0xA8

5.1.4 Data format

Command:

C9

Possible values:

- 0x00 – no changes, return current setting
- 0x01 – ASCII
- 0x02 – Hex

Comment:

When ASCII format is set, sensor sends the header text "*Motion marker, respiration*<CR><LF>" after calibration finished.

Example:

Change data format to "Hex" for sensor with id 0:

Host request: 0x6A 0x00 0xC9 0x02 0x97

Sensor reply: 0x6A 0x00 0xC9 0x02 0x97

5.1.5 Continuous sending interval

Command:

CC

Possible values:

0x00 – no changes, return current setting

0x01...0xB4 – set interval value from 1 to 180 seconds, in seconds

Comment:

This parameter is meaningful only when sending type is "continuous sending" (command "CA").

The intervals less then 3 seconds are not recommended.

Example:

Change repetition interval to 5 seconds for sensor with id 0:

Host request: 0x6A 0x00 0xCC 0x05 0xC3

Sensor reply: 0x6A 0x00 0xCC 0x05 0xC3

5.1.6 Request send data

Command:

CB

Possible values:

Any

Comment:

Sensor replies to this command with data message. It is working only when sending type is "sending by request" (command "CA").

Example:

Change repetition interval to 5 seconds for sensor with id 0:

Host request: 0x6A 0x00 0xCB 0x00 0xB3

Sensor reply: 0x6A 0x00 0xC1 0x01 0x12 0x00 0xFA (Motion marker: 274, BPM: 0) 0x01, 0x12 = 274, 0x00 = 0

5.1.7 Change ID

Command:

C3

Possible values:

0x00 ... 0xFE – set sensor ID respectively

Comment:

This command changing sensor's id.

If the command refers to 0xFF and value field contains 0xFF then sensor will return current ID.

Example:

Change sensor ID from 0 to 1:

Host request: 0x6A 0x00 0xC3 0x01 0x1C

Sensor reply: 0x6A 0x01 0xC3 0x01 0x77

Get current ID:

Host request: 0x6A 0xFF 0xC3 0xFF 0xC3

Sensor reply: 0x6A 0xFF 0xC3 0x01 0x37

5.1.8 Ping

Command:

C2

Possible values:

Any

Comment:

Just returns the same message (To check the connection with the sensor)

Example:

Ping the sensor:

Host request: 0x6A 0x00 0xC2 0x00 0x0E

Sensor reply: 0x6A 0x00 0xC2 0x00 0x0E

5.1.9 Recalibrate the sensor

Command:

CD

Possible values:

Any

Comment:

This command pushes the sensor to recalibrate.

Example:

Recalibrate the sensor:

Host request: 0x6A 0x00 0xCD 0x00 0xCD

Sensor replies "0x6A 0x00 0xCD 0x00 0xCD" and starts to recalibrate

5.1.10 Wrong CRC

Command:

C7

Possible values:

This is one direction message. Only from sensor to host.

Comment:

If the CRC code in the host's message is wrong, then sensor returns this command. Value field of returned message contains CRC that calculated in sensor.

Example:

Change sensor ID from 0 to 1:

Host request: 0x6A 0x00 0xC3 0x01 0x53

Sensor reply: 0x6A 0x00 0xC7 0x1C 0x1B

(0x1C is the correct CRC part in the sensor response section)

5.2 Error-detecting code description

The last byte of message to and from sensor should contains error-detecting code calculated according to CRC8 rules.

CRC8 calculation parameters: initial value 0x00; polynomial value 0x07.

Computation code for reference:

```
crc = gencrc(&data[0], 4);

uint8_t gencrc(uint8_t * data, uint8_t len)
{
    uint8_t crc8 = 0x00;

    for (uint8_t i = 0; i < len; i++)
    {
        crc8 ^= *data;
        for (uint8_t j = 0; j < 8; j++)
        {
            if ((crc8 & 0x80) != 0)
                crc8 = (uint8_t)((crc8 << 1) ^ 0x07);
            else
                crc8 <<= 1;
        }

        data++;
    }

    return crc8;
}
```

For checking crc8 value you can refer to website <https://crccalc.com/>.

6. FCC Statement

Compliance Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: 1. This device may not cause harmful interference, and 2. This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Warning

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure

This portable transmitter with its antenna complies with FCC RF exposure limits for general population / uncontrolled exposure.

UWB devices may not be employed for the operation of toys. Operation onboard an aircraft, a ship or a satellite is prohibited.

This device complies with Part 15.517 of the FCC Rules. This equipment may only be operated indoors. Operation outdoors is in violation of 47 U.S.C. 301 and could subject the operator to serious penalties.

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