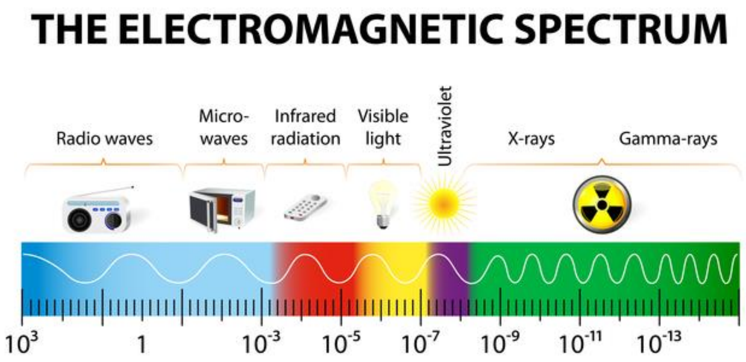
# Motion Sensor survey (electronic work) [Which is the 1st place? ]

- Understand the mechanism of motion sensors and programming
- Practical data of electronic work used in ESP32

# Table of Contents

# 1. Pyroelectric infrared (human) sensor

[Reference URL]
https://www.murata.com/ja-jp/products/sensor/infrared/overview/basic/about

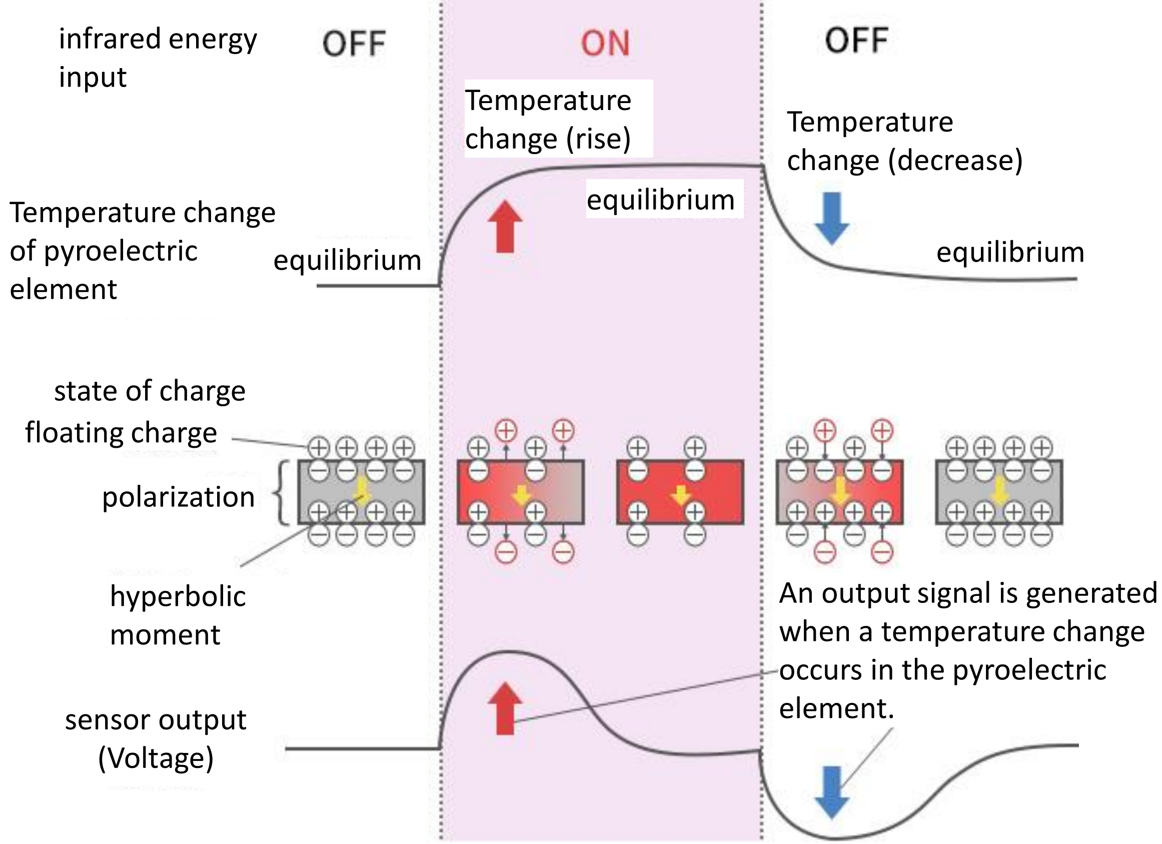


*1：https://k-comfort.co.jp/post-knowledge-infrared-1/

Infrared
(A kind of electromagnetic wave, same as light)

All objects from hot to cold emit infrared radiation
(Wavelength varies depending on temperature)

Pyroelectric effect:
the movement of the charge is the output of the sensor



An output signal is generated when a temperature change occurs in the pyroelectric element.

Infrared wavelength changes due to temperature change of the object

Pyroelectric element changes temperature by infrared rays

Change in sensor voltage output

# 2-1. Motion sensor to investigate

Selection criteria (IT Taro survey)
- 3.3V/5V compatible
- Selected from the lowest price of the same type

| NO | Item | Manufacturer | Model number | Image | Shop-URL | Price | Voltage I/ | Max dista | Angle | Delay time | Standby c | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pyroelectric infrared (human detection) sensor module SB412A | Nanyang Senba Optical&Electronic | SB412A |  | https://akizukidenshi.com/catalog/g/gM-09002/ | 500 | 3.5-12V<br>3V | 3~5m | ~115 | 2.3 sec<br>~80 min | 20μA<br>以下 | |
| 2 | Pyroelectric infrared sensor PaPIRs (VZ) 5m EKMC1601112 | Panasonic | EKMC1601112 |  | https://akizukidenshi.com/catalog/g/gM-12313/ | 500 | 3~6V<br>Vin-0.5 | ~5m | 82-94 | - | 170~<br>300μA | NG at 4.5V output with 5V input<br>Must be 3.3V input |
| 3 | Pyroelectric infrared sensor PaPIRs (VZ) 12m EKMC1603111 | Panasonic | EKMC1603111 |  | https://akizukidenshi.com/catalog/g/gM-09751/ | 520 | 3~6V<br>Vin-0.5 | ~12m | 92-102 | - | 170~<br>300μA | NG at 4.5V output with 5V input<br>Must be 3.3V input |
| 4 | Grove Digital PIR Motion Sensor | Seeed Studio | 101020793 |  | https://akizukidenshi.com/catalog/g/gM-16767/ | 480 | 3~5V<br>3.3V | 3.2m<br>~12m | ~120 | ~ 1 Sec | 100~<br>150μA | |
| 5 | Pyroelectric infrared sensor D203B | Nanyang Senba Optical&Electronic | D203B |  | https://akizukidenshi.com/catalog/g/gI-05711/ | 100 | 3~15V<br>Vin-(0.3-1.2) | ~5m | 120 - 144 | - | - | |
| 6 | Pyroelectric infrared sensor AKE-1 (RE-210) | Japanese ceramic | AKE-1<br>(RE-210) |  | https://akizukidenshi.com/catalog/g/gI-00243/ | 100 | 3~10V<br>2.5V~(4.0V) | - | 135-138 | - | - | NG at 4.5V output with 5V input<br>Must be 3.3V input |
| 7 | Pyroelectric infrared sensor D205B | Nanyang Senba Optical&Electronic | D205B |  | https://akizukidenshi.com/catalog/g/gI-05712/ | 150 | 3~15V<br>Vin-(0.3-1.2) | ~5m | 120 - 144 | - | - | |
| 8 | M5-StackC-PIR-HAT | M5-Stack | PIR_AS312 |  | https://shop.m5stack.com/collections/m5-sensor/products/m5stickccompatible-hat-pir-sensor | 594<br>($3.5) | 3.3V | ~0.5m | ~100 | 2 sec | ~60uA | Buy at a nearby store, not online |

# 2-2. Motion sensor to investigate (Summary of specifications)

We will check the differences between "modularized products with added resistance", "integrated lens", and “Sensor only".

| Type | Content | Price | How to Use | Note |
|---|---|---|---|---|
| Modularization<br>[SB412A、Grove-PIR、M5Stack-PIR]<br> | Products in which capacitors and resistors are integrated | Equivalent<br>(Same as sensor only, because lens and amplifier are required) | readily available<br>(3V output when sensing)<br>○<br>Output terminal can be used as it is | |
| Integrated lens<br>[EKMC1601112、EKMC1603111]<br> | Products integrated with lenses | | readily available<br>(3V output when sensing)<br>○<br>Pull down the output terminal and use it | |
| Sensor only<br>[D203B、AKE-1、D205B]<br> | Sensor only | | Circuit required<br>(not readily available)<br>✕<br>Amplified and detected by an operational amplifier | Purchase and install a Fresnel lens separately |

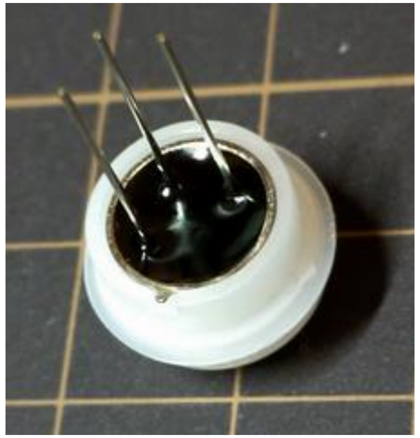
# 2-3. Fresnel lens attached (sensor only)

For sensor-only products, the "Fresnel lens" must be purchased separately, attached, and measured.

Fresnel lens S9001

[manufacturer]
Nanyang Senba Optical&Electronic Co.,Ltd.

- ■Size: 12.7mmΦ
- ■ Focal length: 6mm
- ■ Detection distance: 5m
- ■Horizontal viewing angle: 100°
- ■Materials: HDPE (high-density polyethylene)
- ■ Price: 40 yen / piece



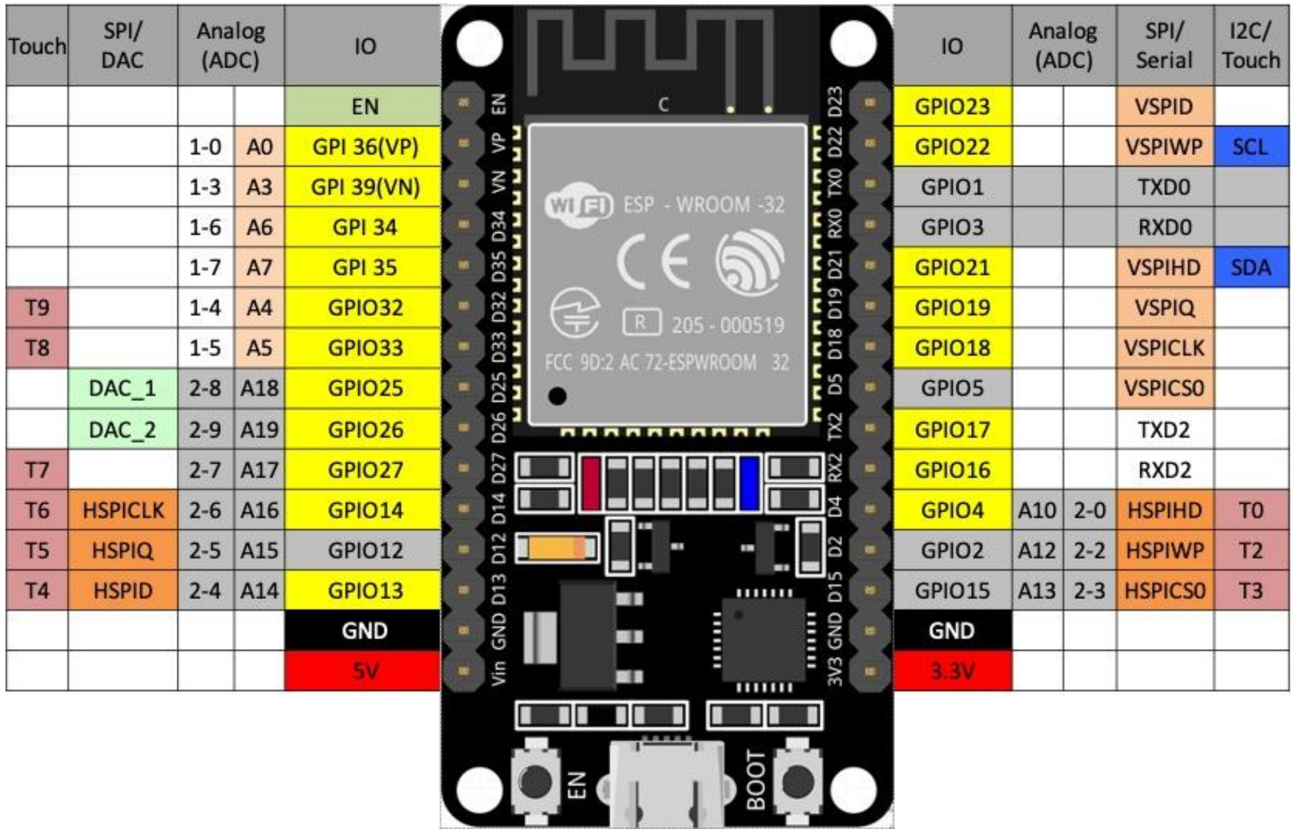
A lens that fits the sensor for a detection distance of 5m

https://akizukidenshi.com/catalog/g/gP-09003/

I installed it on D203B, AKE-1, and D205B, and all three were the perfect size.

# 3-1. ESP32 port

- ESP32 port configuration

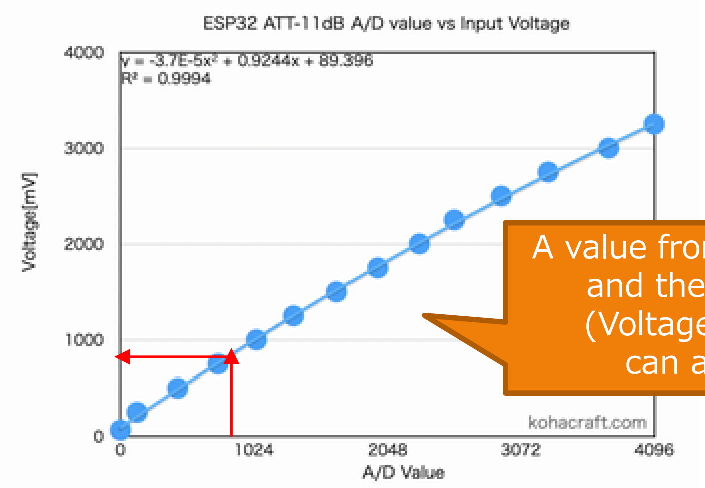


| Touch | SPI/ DAC | Analog (ADC) | | IO |
|---|---|---|---|---|
| | | | | EN |
| | | 1-0 | A0 | GPI 36(VP) |
| | | 1-3 | A3 | GPI 39(VN) |
| | | 1-6 | A6 | GPI 34 |
| | | 1-7 | A7 | GPI 35 |
| T9 | | 1-4 | A4 | GPIO32 |
| T8 | | 1-5 | A5 | GPIO33 |
| | DAC_1 | 2-8 | A18 | GPIO25 |
| | DAC_2 | 2-9 | A19 | GPIO26 |
| T7 | | 2-7 | A17 | GPIO27 |
| T6 | HSPICLK | 2-6 | A16 | GPIO14 |
| T5 | HSPIQ | 2-5 | A15 | GPIO12 |
| T4 | HSPID | 2-4 | A14 | GPIO13 |
| | | | | GND |
| | | | | 5V |

| IO | Analog (ADC) | | SPI/ Serial | I2C/ Touch |
|---|---|---|---|---|
| GPIO23 | | | VSPID | |
| GPIO22 | | | VSPIWP | SCL |
| GPIO1 | | | TXD0 | |
| GPIO3 | | | RXD0 | |
| GPIO21 | | | VSPIHD | SDA |
| GPIO19 | | | VSPIQ | |
| GPIO18 | | | VSPICLK | |
| GPIO5 | | | VSPICS0 | |
| GPIO17 | | | TXD2 | |
| GPIO16 | | | RXD2 | |
| GPIO4 | A10 | 2-0 | HSPIHD | T0 |
| GPIO2 | A12 | 2-2 | HSPIWP | T2 |
| GPIO15 | A13 | 2-3 | HSPICS0 | T3 |
| GND | | | | |
| 3.3V | | | | |

- ADC (Analog to Digital Converter) terminal
  [Voltage can be measured]

・Two ADC circuits are installed.
・Attenuation of 11dB is set as standard, so measurement from 0 to 3.3V is possible.
・The resolution is 9 to 12 bits. Since it is 12bit by default, it is output in 0 to 4095.
(It is also possible to output the voltage-converted value. This time, we will use this function.)
・Wi-Fi is not available when using ADC2



A value from 0 to 4095 is output and the voltage is grasped (Voltage-converted values can also be obtained)

https://kohacraft.com/archives/202202091047.html

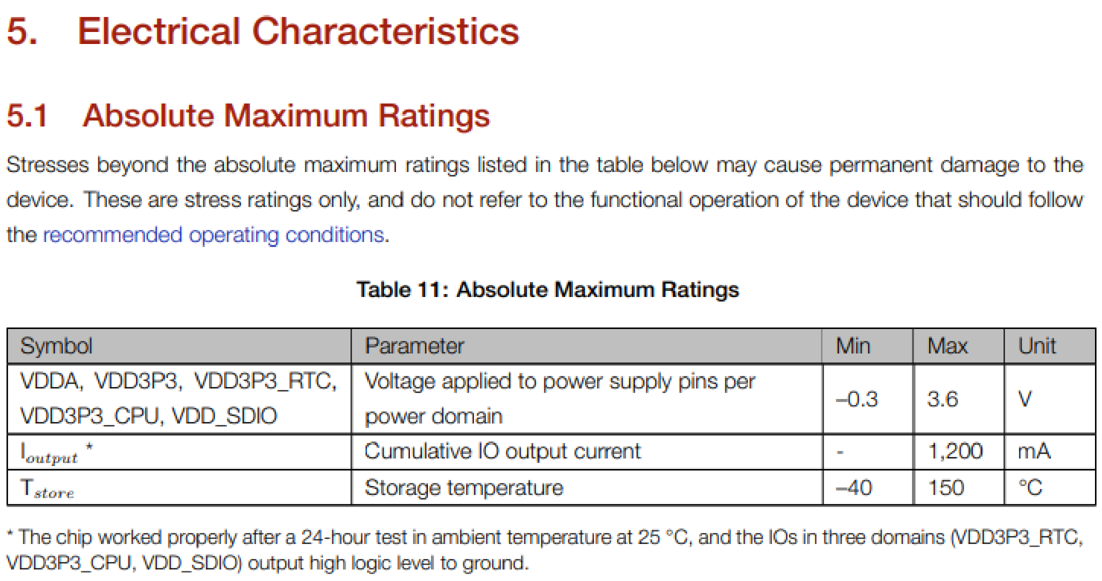
- GPIO terminal

An abbreviation for General Purpose Input/Output, this is a general-purpose I/O port with normal terminals.
For the 3V voltage output type, HIGH/LOW identification is sufficient, so use this GPIO terminal.

# 3-2. ESP32 input terminal

- Espressif Official ESP32

https://www.espressif.com/sites/default/files/documentation/esp32-pico-d4_datasheet_en.pdf



## 5. Electrical Characteristics

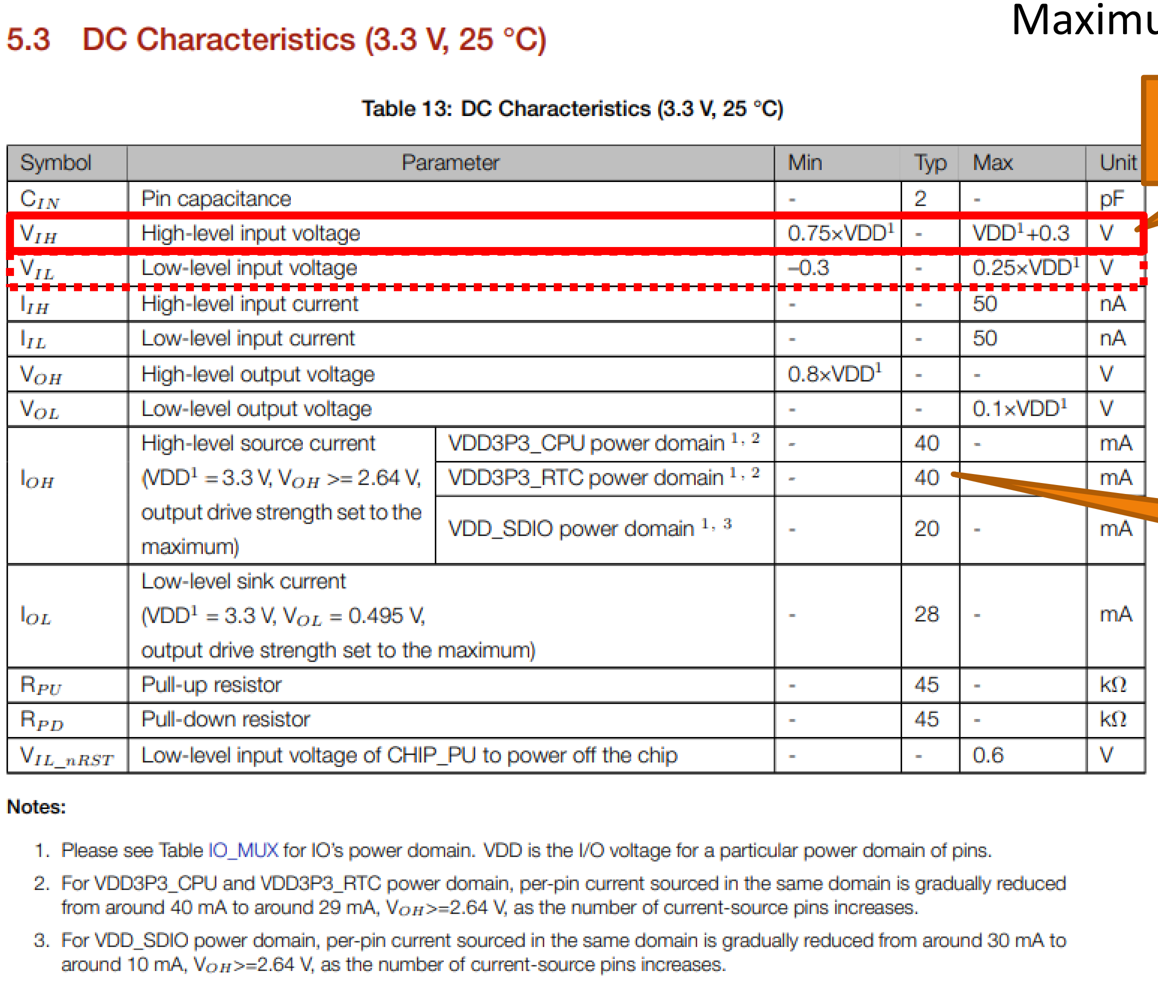
### 5.1 Absolute Maximum Ratings

Stresses beyond the absolute maximum ratings listed in the table below may cause permanent damage to the device. These are stress ratings only, and do not refer to the functional operation of the device that should follow the recommended operating conditions.

**Table 11: Absolute Maximum Ratings**

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| VDDA, VDD3P3, VDD3P3_RTC, VDD3P3_CPU, VDD_SDIO | Voltage applied to power supply pins per power domain | –0.3 | 3.6 | V |
| $I_{output}$ * | Cumulative IO output current | - | 1,200 | mA |
| $T_{store}$ | Storage temperature | –40 | 150 | °C |

* The chip worked properly after a 24-hour test in ambient temperature at 25 °C, and the IOs in three domains (VDD3P3_RTC, VDD3P3_CPU, VDD_SDIO) output high logic level to ground.



### 5.3 DC Characteristics (3.3 V, 25 °C)

**Table 13: DC Characteristics (3.3 V, 25 °C)**

| Symbol | Parameter | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $C_{IN}$ | Pin capacitance | | - | 2 | - | pF |
| $V_{IH}$ | High-level input voltage | | 0.75×VDD[1] | - | VDD[1]+0.3 | V |
| $V_{IL}$ | Low-level input voltage | | –0.3 | - | 0.25×VDD[1] | V |
| $I_{IH}$ | High-level input current | | - | - | 50 | nA |
| $I_{IL}$ | Low-level input current | | - | - | 50 | nA |
| $V_{OH}$ | High-level output voltage | | 0.8×VDD[1] | - | - | V |
| $V_{OL}$ | Low-level output voltage | | - | - | 0.1×VDD[1] | V |
| $I_{OH}$ | High-level source current (VDD[1] = 3.3 V, $V_{OH}$ >= 2.64 V, output drive strength set to the maximum) | VDD3P3_CPU power domain [1, 2] | - | 40 | - | mA |
| | | VDD3P3_RTC power domain [1, 2] | - | 40 | | mA |
| | | VDD_SDIO power domain [1, 3] | - | 20 | - | mA |
| $I_{OL}$ | Low-level sink current (VDD[1] = 3.3 V, $V_{OL}$ = 0.495 V, output drive strength set to the maximum) | | - | 28 | - | mA |
| $R_{PU}$ | Pull-up resistor | | - | 45 | - | kΩ |
| $R_{PD}$ | Pull-down resistor | | - | 45 | - | kΩ |
| $V_{IL\_nRST}$ | Low-level input voltage of CHIP_PU to power off the chip | | - | - | 0.6 | V |

**Notes:**

1. Please see Table IO_MUX for IO's power domain. VDD is the I/O voltage for a particular power domain of pins.
2. For VDD3P3_CPU and VDD3P3_RTC power domain, per-pin current sourced in the same domain is gradually reduced from around 40 mA to around 29 mA, $V_{OH}$>=2.64 V, as the number of current-source pins increases.
3. For VDD_SDIO power domain, per-pin current sourced in the same domain is gradually reduced from around 30 mA to around 10 mA, $V_{OH}$>=2.64 V, as the number of current-source pins increases.

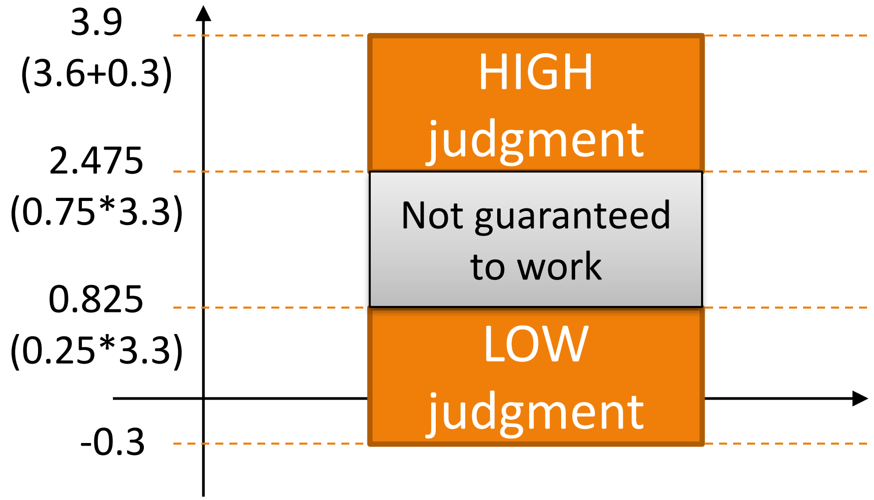
IO-Pin
Maximum input voltage

3.9（3.6+0.3）

IO-Pin
Output Current

40mA

- Input HIGH/LOW judgment of ESP32



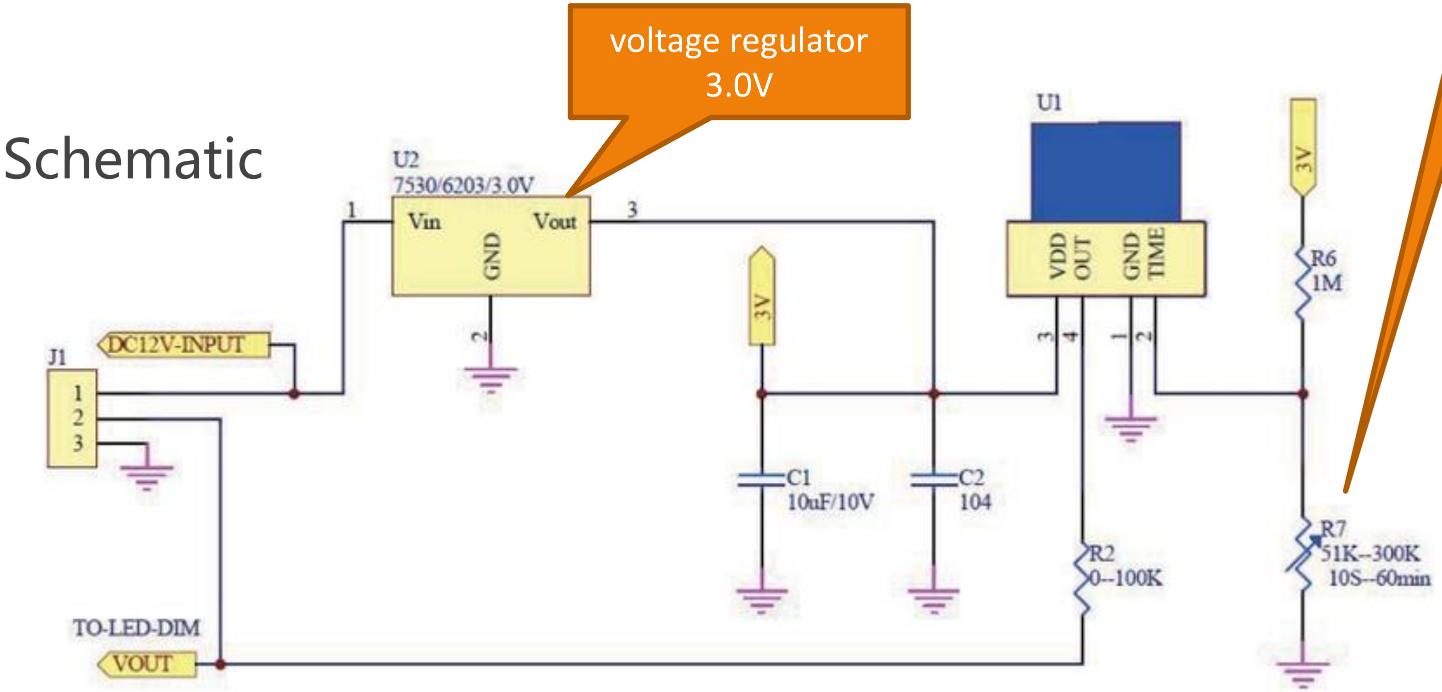
Since the input is up to MAX3.9V,
it is impossible to input a 5V signal.

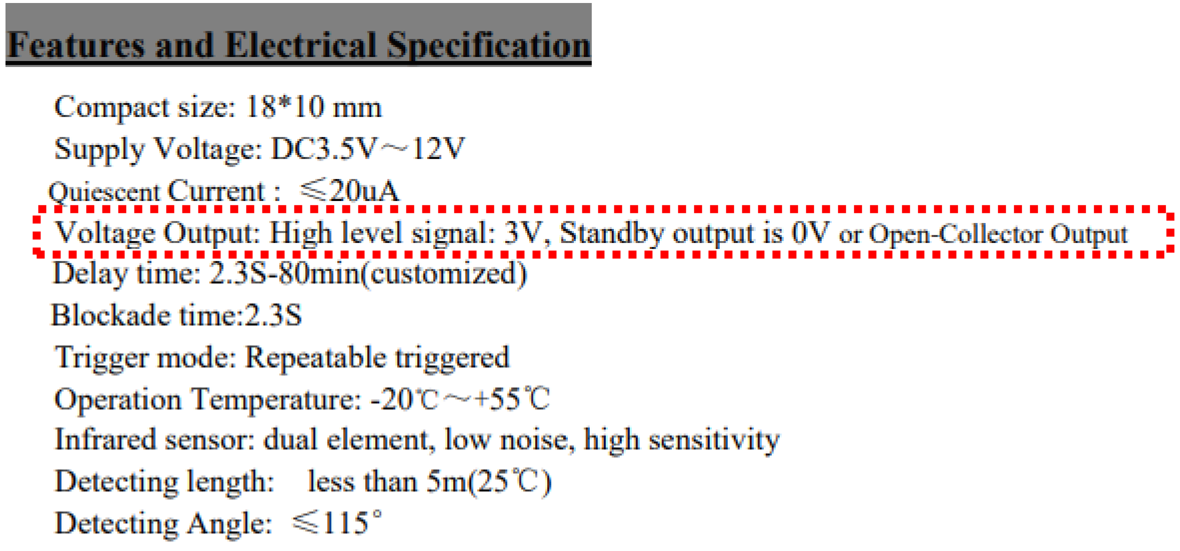
# 4-1. SB412A

《 Reference URL》
https://akizukidenshi.com/download/ds/senba/SB412A_20210413.pdf

variable resistor
Detection output retention time:
about 2 seconds to 60 minutes

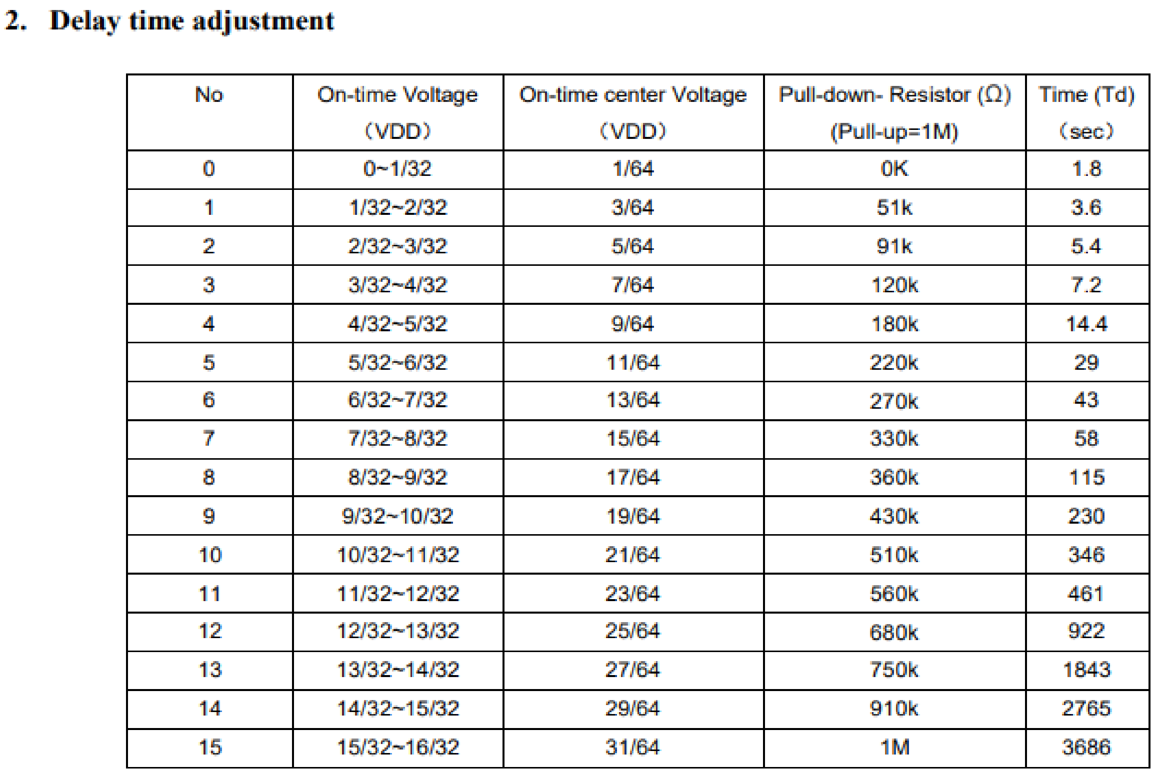
## Schematic





**Features and Electrical Specification**

Compact size: 18*10 mm
Supply Voltage: DC3.5V～12V
Quiescent Current : ≤20uA
Voltage Output: High level signal: 3V, Standby output is 0V or Open-Collector Output
Delay time: 2.3S-80min(customized)
Blockade time:2.3S
Trigger mode: Repeatable triggered
Operation Temperature: -20℃～+55℃
Infrared sensor: dual element, low noise, high sensitivity
Detecting length: less than 5m(25℃)
Detecting Angle: ≤115°



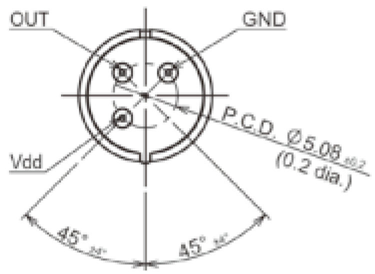
**2. Delay time adjustment**

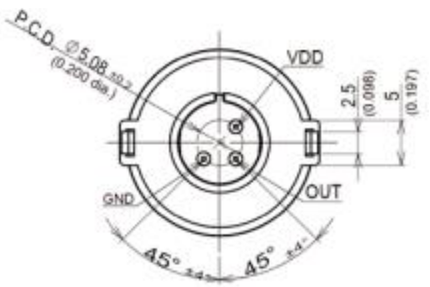
| No | On-time Voltage （VDD） | On-time center Voltage （VDD） | Pull-down- Resistor (Ω) (Pull-up=1M) | Time (Td) （sec） |
|---|---|---|---|---|
| 0 | 0~1/32 | 1/64 | 0K | 1.8 |
| 1 | 1/32~2/32 | 3/64 | 51k | 3.6 |
| 2 | 2/32~3/32 | 5/64 | 91k | 5.4 |
| 3 | 3/32~4/32 | 7/64 | 120k | 7.2 |
| 4 | 4/32~5/32 | 9/64 | 180k | 14.4 |
| 5 | 5/32~6/32 | 11/64 | 220k | 29 |
| 6 | 6/32~7/32 | 13/64 | 270k | 43 |
| 7 | 7/32~8/32 | 15/64 | 330k | 58 |
| 8 | 8/32~9/32 | 17/64 | 360k | 115 |
| 9 | 9/32~10/32 | 19/64 | 430k | 230 |
| 10 | 10/32~11/32 | 21/64 | 510k | 346 |
| 11 | 11/32~12/32 | 23/64 | 560k | 461 |
| 12 | 12/32~13/32 | 25/64 | 680k | 922 |
| 13 | 13/32~14/32 | 27/64 | 750k | 1843 |
| 14 | 14/32~15/32 | 29/64 | 910k | 2765 |
| 15 | 15/32~16/32 | 31/64 | 1M | 3686 |

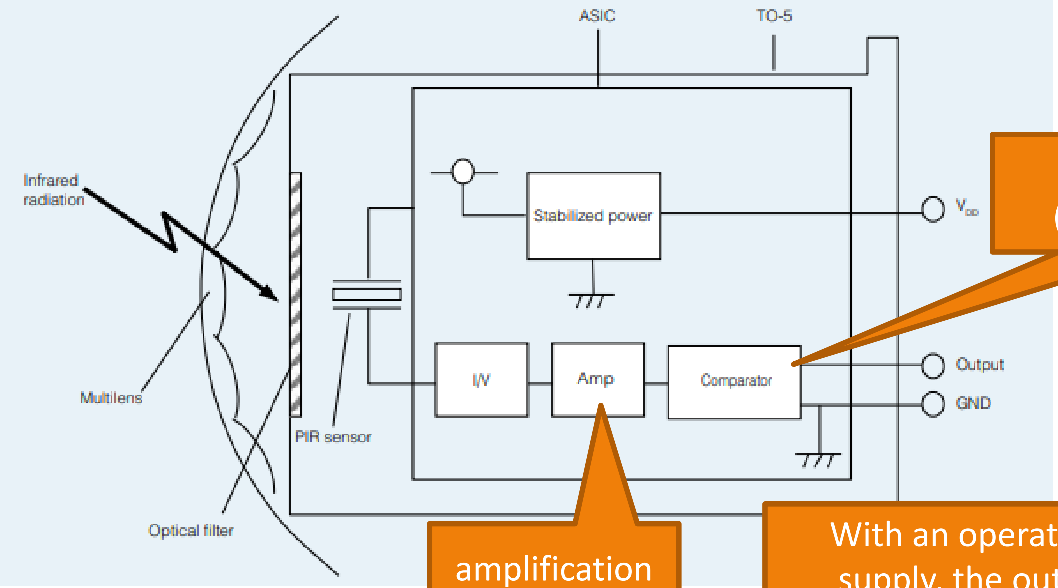
# 4-2/4-3. EKMC1601112/EKMC1603111

**Panasonic**

《 Reference URL》
https://akizukidenshi.com/download/ds/panasonic/vz.pdf
https://www.mouser.jp/datasheet/2/315/PANA_S_A0009105372_1-2560853.pdf



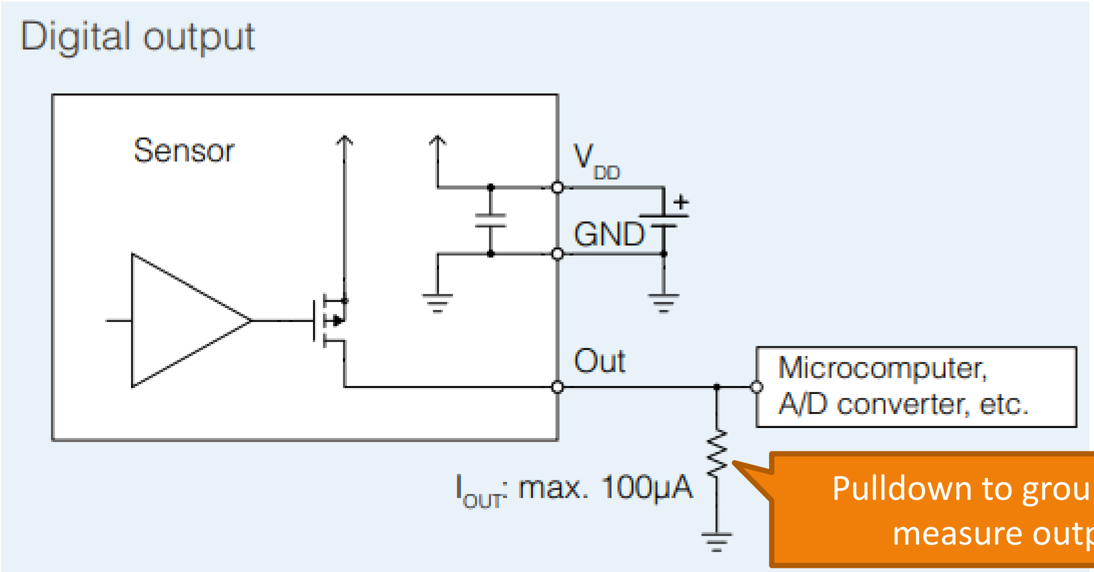




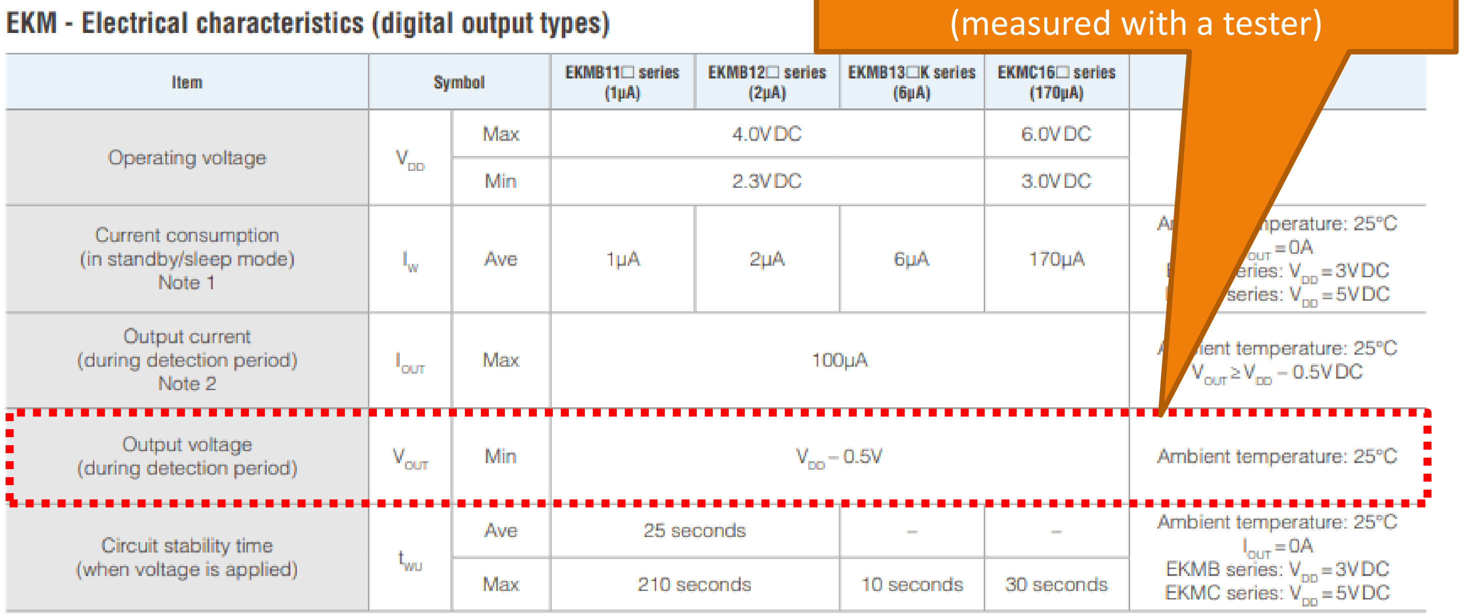
Comparator (Digital Convertor)

amplification

With an operating voltage of 3.3V supply, the output at the time of sensing is confirmed to be about 2.8V (measured with a tester)



Pulldown to ground and measure output



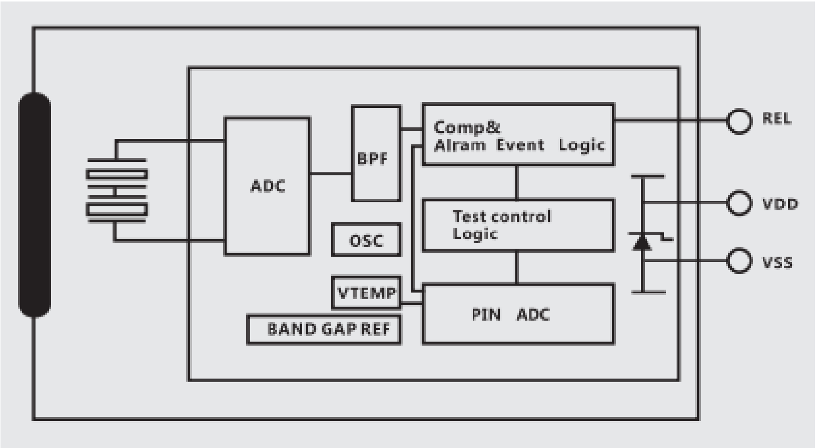
**EKM - Electrical characteristics (digital output types)**

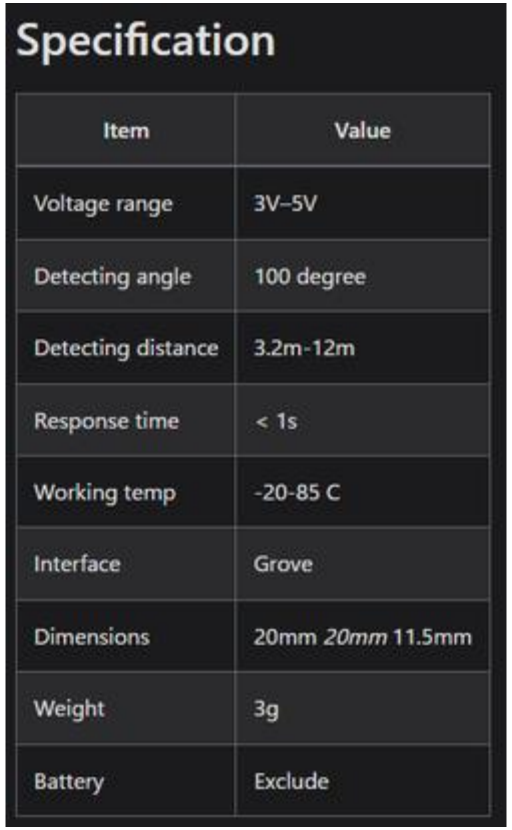
| Item | Symbol | | EKMB11☐ series (1μA) | EKMB12☐ series (2μA) | EKMB13☐K series (6μA) | EKMC16☐ series (170μA) | |
|---|---|---|---|---|---|---|---|
| Operating voltage | $V_{DD}$ | Max | 4.0V DC | | | 6.0V DC | |
| | | Min | 2.3V DC | | | 3.0V DC | |
| Current consumption (in standby/sleep mode) Note 1 | $I_W$ | Ave | 1μA | 2μA | 6μA | 170μA | A nperature: 25°C<br>OUT=0A<br>eries: $V_{DD}$=3VDC<br>series: $V_{DD}$=5VDC |
| Output current (during detection period) Note 2 | $I_{OUT}$ | Max | 100μA | | | | A ient temperature: 25°C<br>$V_{OUT} \geq V_{DD} - 0.5$VDC |
| Output voltage (during detection period) | $V_{OUT}$ | Min | $V_{DD} - 0.5$V | | | | Ambient temperature: 25°C |
| Circuit stability time (when voltage is applied) | $t_{WU}$ | Ave | 25 seconds | | – | – | Ambient temperature: 25°C<br>$I_{OUT}$=0A<br>EKMB series: $V_{DD}$=3VDC<br>EKMC series: $V_{DD}$=5VDC |
| | | Max | 210 seconds | | 10 seconds | 30 seconds | |

# 4-4. Grove - Digital PIR Motion Sensor [101020793]

《 Reference URL》
https://wiki.seeedstudio.com/Grove-Digital-PIR-Sensor
https://files.seeedstudio.com/products/101020793/document/Hardware_Schematic_SCH.pdf

## Interior Diagram [BS312]



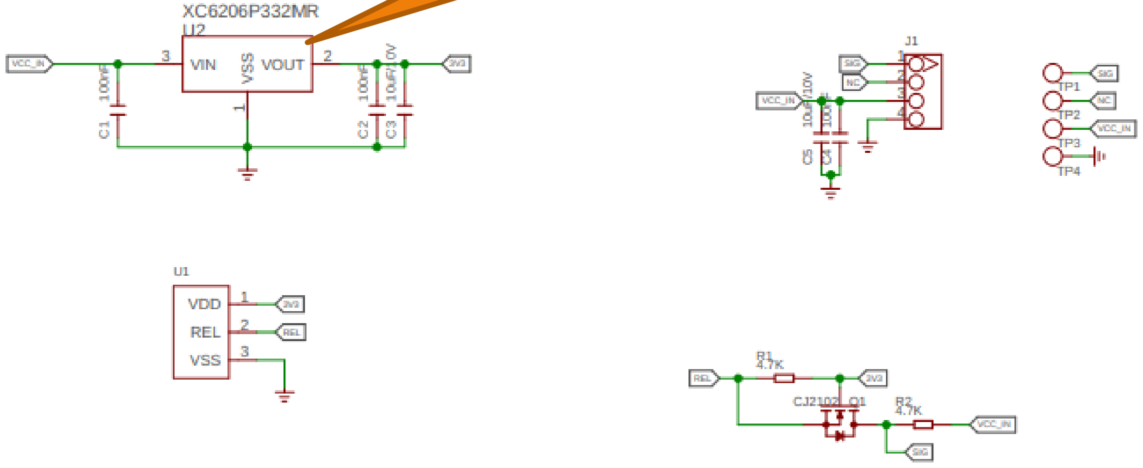


## Specification

| Item | Value |
|---|---|
| Voltage range | 3V–5V |
| Detecting angle | 100 degree |
| Detecting distance | 3.2m-12m |
| Response time | < 1s |
| Working temp | -20-85 C |
| Interface | Grove |
| Dimensions | 20mm *20mm* 11.5mm |
| Weight | 3g |
| Battery | Exclude |

## Schematic

3.3V
voltage regulator

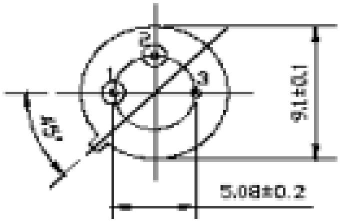


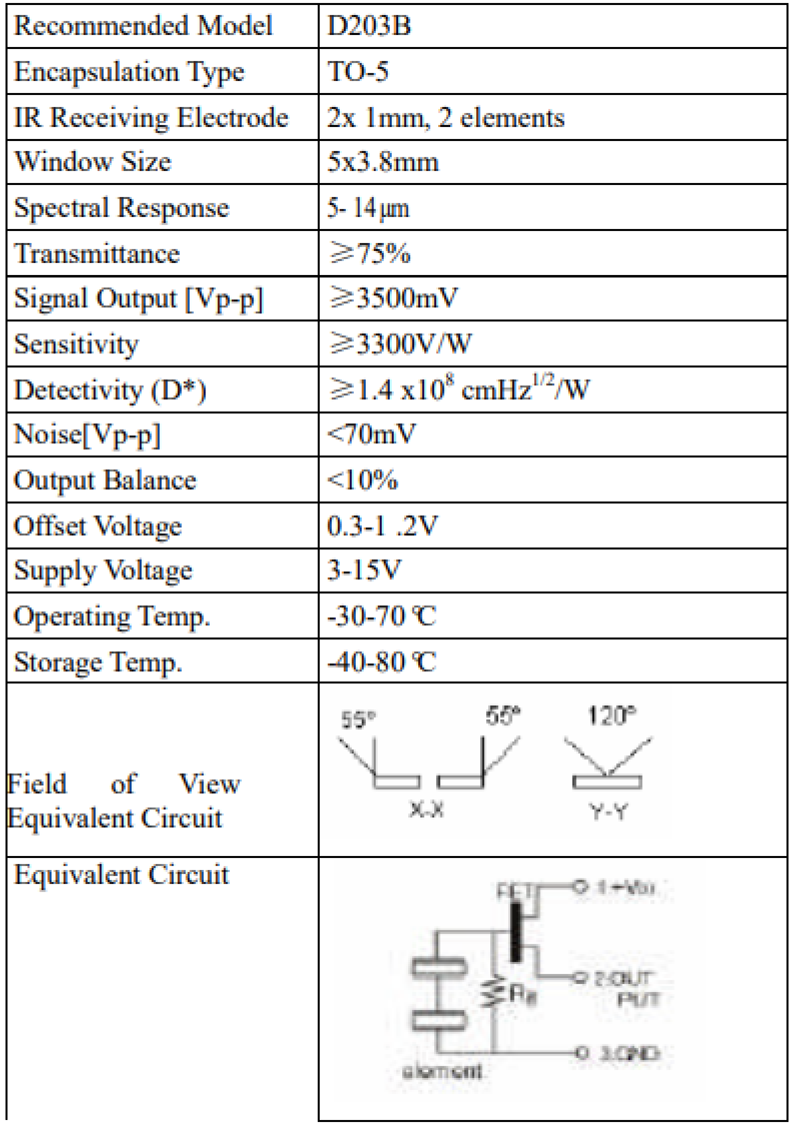
## Programing

```
pinMode(digital_pir_sensor,INPUT); // set Pin mode as input
digitalRead(digital_pir_sensor);
```

# 4-5. Pyroelectric infrared sensor D203B

《Reference URL》
https://akizukidenshi.com/download/ds/senba/D203B.pdf

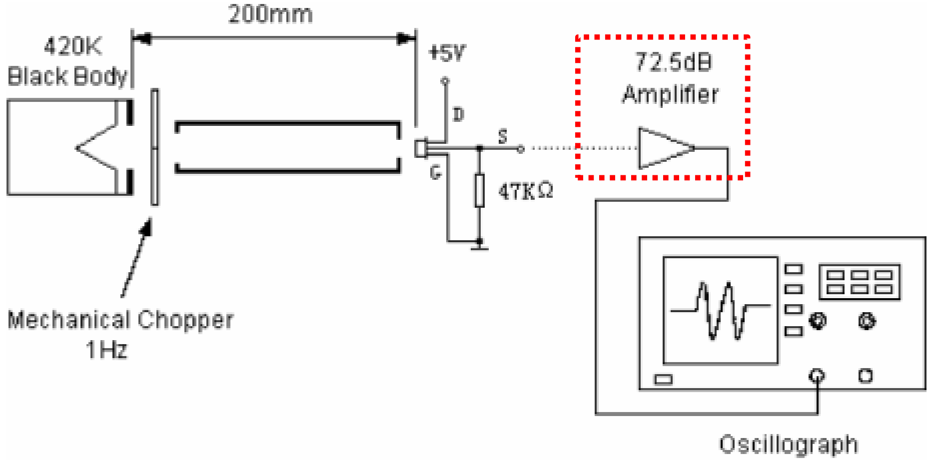




| | |
|---|---|
| Recommended Model | D203B |
| Encapsulation Type | TO-5 |
| IR Receiving Electrode | 2x 1mm, 2 elements |
| Window Size | 5x3.8mm |
| Spectral Response | 5- 14μm |
| Transmittance | ≥75% |
| Signal Output [Vp-p] | ≥3500mV |
| Sensitivity | ≥3300V/W |
| Detectivity (D*) | ≥1.4 x10$^8$ cmHz$^{1/2}$/W |
| Noise[Vp-p] | <70mV |
| Output Balance | <10% |
| Offset Voltage | 0.3-1 .2V |
| Supply Voltage | 3-15V |
| Operating Temp. | -30-70 ℃ |
| Storage Temp. | -40-80 ℃ |
| Field of View Equivalent Circuit | |
| Equivalent Circuit | |

## Test Method

Amplifier 72.5dB (about 4000 times)



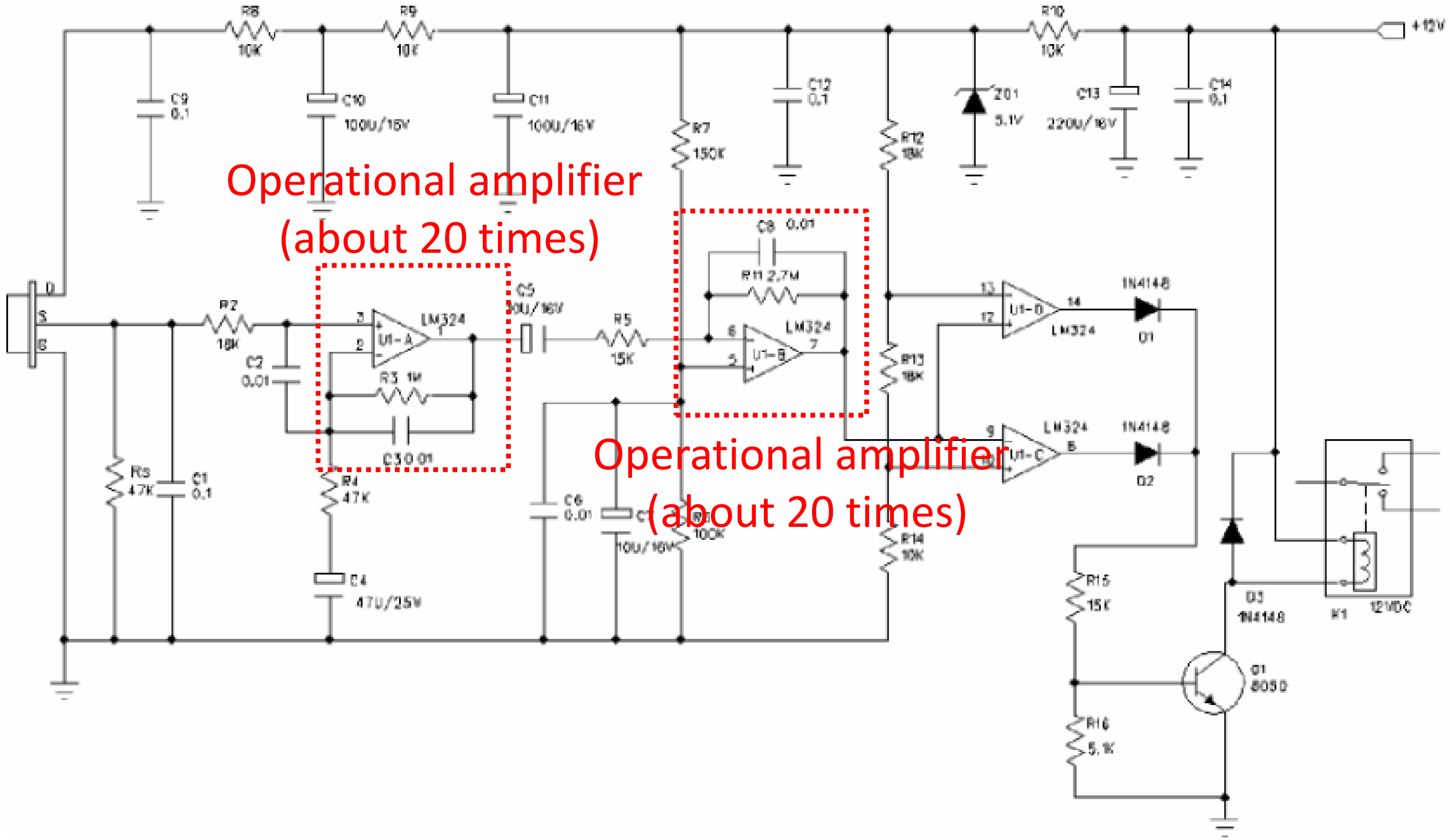
- 3.3V power supply
- Vout is used by pulling down to GND (connected with 47KΩ)

# 4-5. Pyroelectric infrared sensor D203B

《 Reference URL》
https://akizukidenshi.com/download/ds/senba/D203B.pdf

In a typical application, we recommend using a two-stage operational amplifier and amplifying it by about 72.5 dB (about 4000 times).
If you are considering using only one in the camera like this time, you usually do not use such a circuit in terms of cost and work, so consider whether it is possible to simply measure a few millivolt fluctuations and use it. To do.

- Typical Application

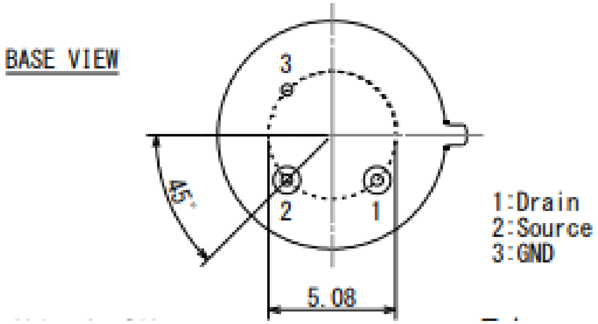


Operational amplifier (about 20 times)

Operational amplifier (about 20 times)

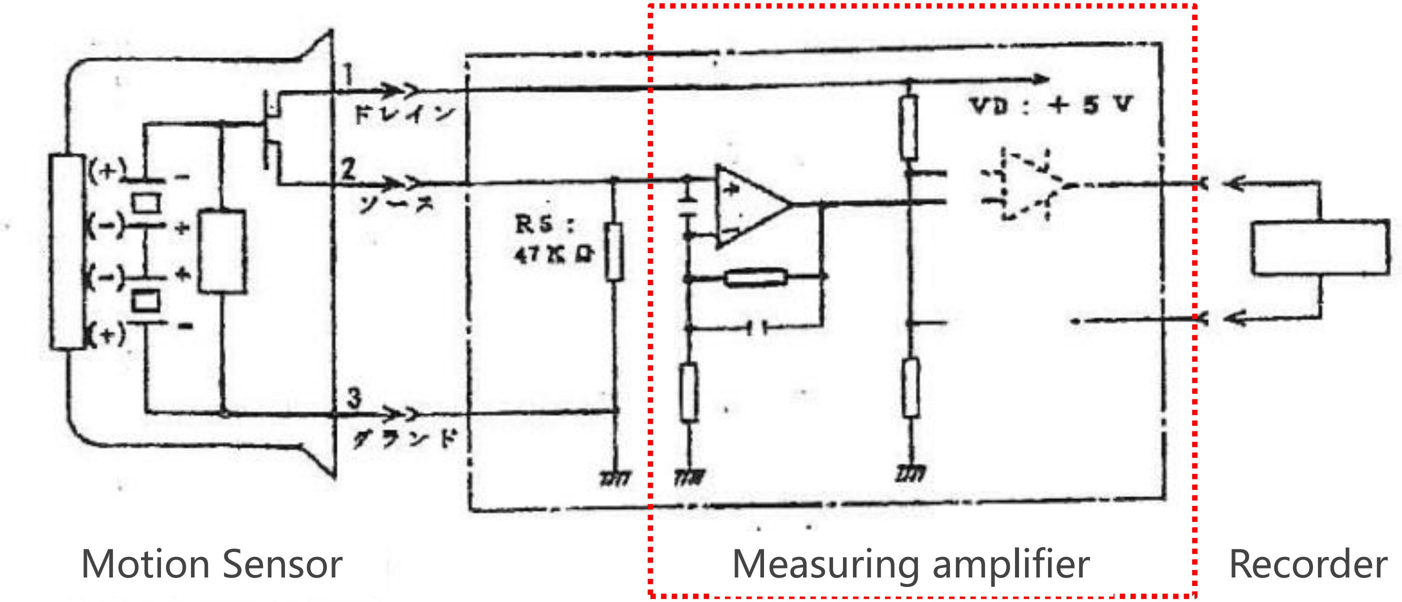
# 4-6.  Pyroelectric infrared sensor AKE-1 (RE-210)

《 Reference URL》
https://akizukidenshi.com/download/ds/nicera/ake-1_re-210.pdf



## Test Method

Amplifier



Motion Sensor

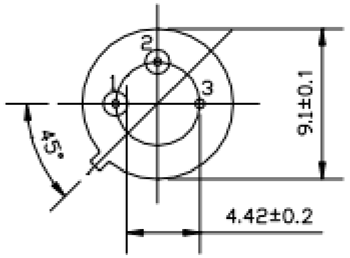
Measuring amplifier

Recorder

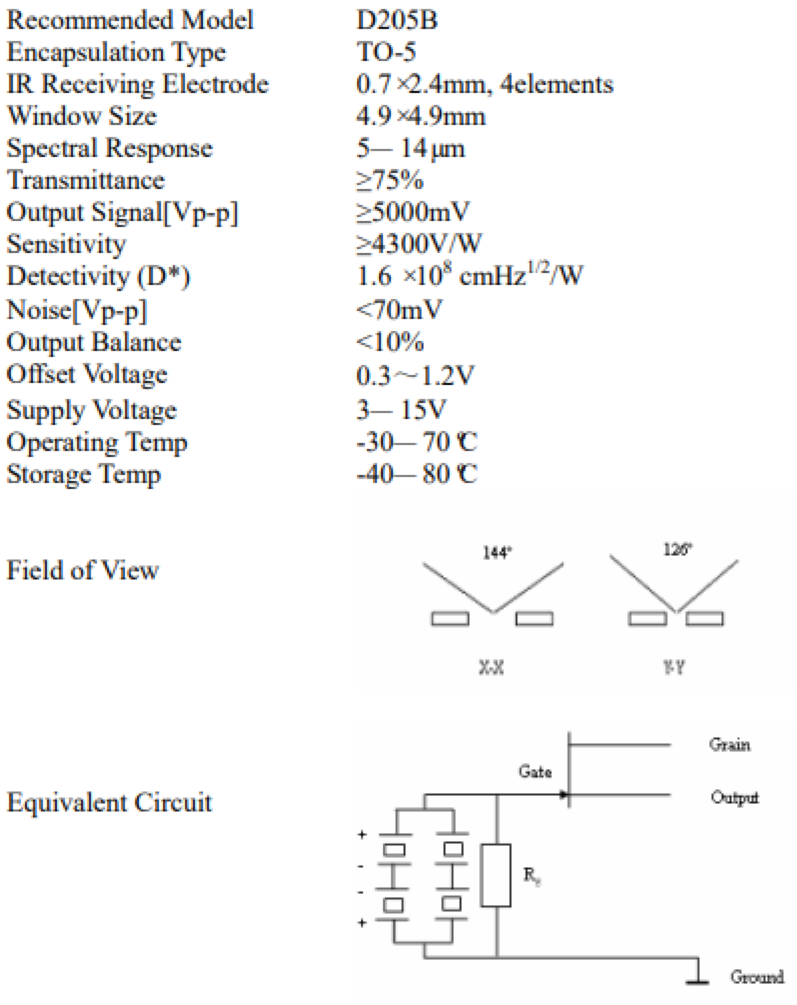
- 3.3V power supply
- Vout is used by pulling down to GND (connected with 47KΩ)

# 4-7. Pyroelectric infrared sensor D205B

《 Reference URL》
https://akizukidenshi.com/download/ds/senba/D205B.pdf
https://micmodshop.ir/wp-content/uploads/2021/10/D205B-DataSheet.pdf



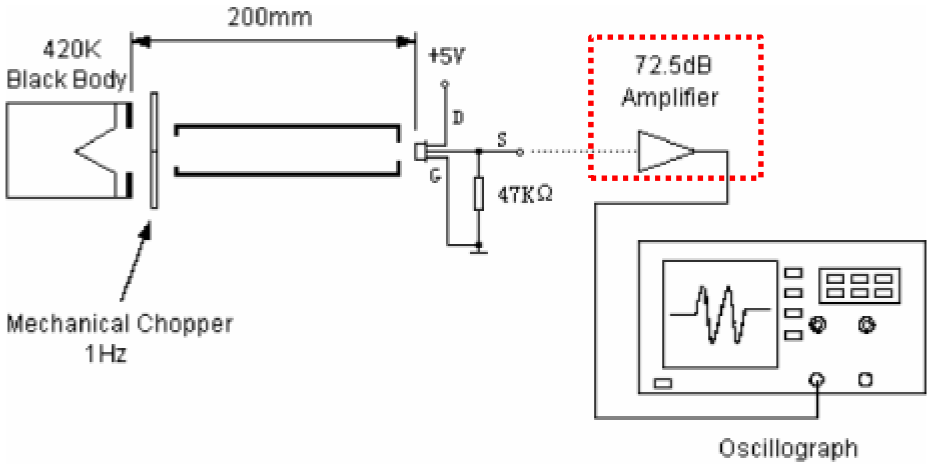
1. Drain
2. Source
3. Ground



| | |
|---|---|
| Recommended Model | D205B |
| Encapsulation Type | TO-5 |
| IR Receiving Electrode | 0.7 ×2.4mm, 4elements |
| Window Size | 4.9 ×4.9mm |
| Spectral Response | 5— 14 μm |
| Transmittance | ≥75% |
| Output Signal[Vp-p] | ≥5000mV |
| Sensitivity | ≥4300V/W |
| Detectivity (D*) | 1.6 $\times 10^8$ cmHz$^{1/2}$/W |
| Noise[Vp-p] | <70mV |
| Output Balance | <10% |
| Offset Voltage | 0.3～1.2V |
| Supply Voltage | 3— 15V |
| Operating Temp | -30— 70 ℃ |
| Storage Temp | -40— 80 ℃ |
| Field of View | |
| Equivalent Circuit | |

## Test Method

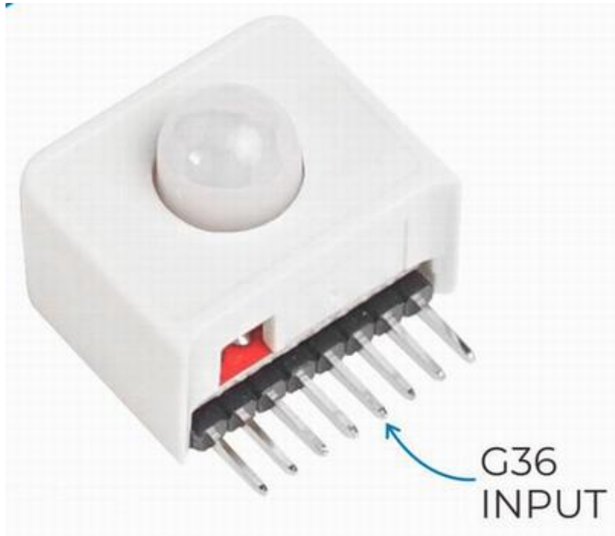
Amplifier 72.5dB (about 4000 times)

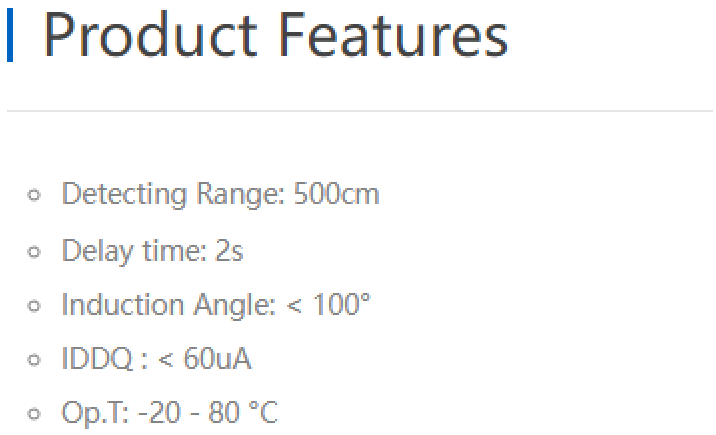


- 3.3V power supply
- Vout is used by pulling down to GND (connected with 47KΩ)

# 4-8. M5-Stack PIR AS312

《 Reference URL》
https://docs.m5stack.com/en/hat/hat-pir

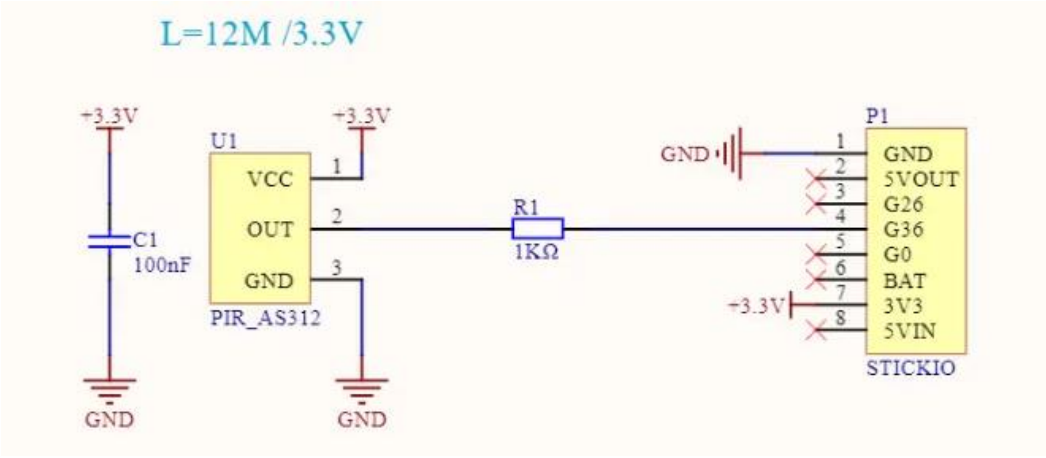




## Product Features

- Detecting Range: 500cm
- Delay time: 2s
- Induction Angle: < 100°
- IDDQ : < 60uA
- Op.T: -20 - 80 °C

## Schematic



## Programing

《Pin Setting》
pinMode(36, INPUT_PULLUP);
《Status》
digitalRead(36)

- 3.3V power supply
- Vout is used by pullUp (Program setting)

# 4-9. Summary of usage

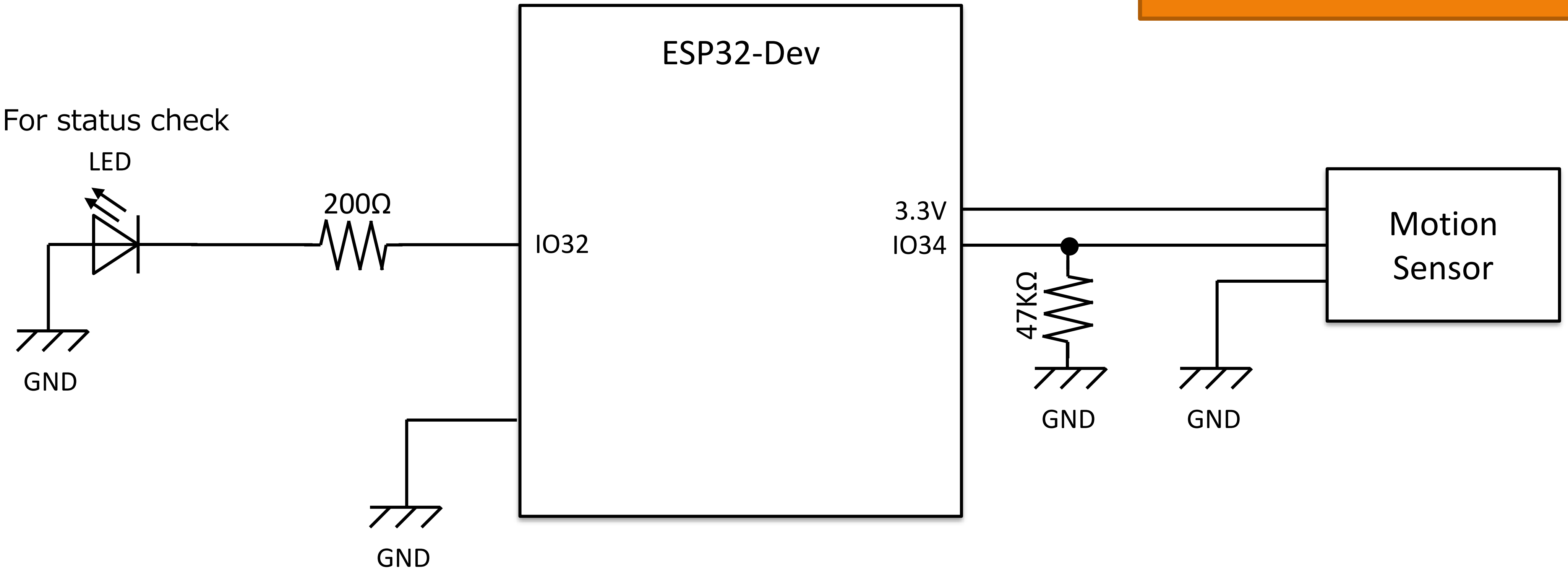
"Supply voltage" and "PullDown/PullUp setting of detection output terminal" for each sensor are as follows.

| NO | Model | イメージ | Vin(Spec) | Vin | Pull Up/Down | Vout(Spec) | Distance | Angle | Delay time | Note |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SB412A |  | 3.5-12V | 5 V | - | 3V | 3～5m | ～115 | 2.3 sec<br>～80 min |  |
| 2 | EKMC1601112 |  | 3~6V | 3.3 V | PullDown | Vin-0.5 | ～5m | 82-94 | - |  |
| 3 | EKMC1603111 |  | 3~6V |  |  | Vin-0.5 | ～12m | 92-102 | - |  |
| 4 | Grove-PIR 101020793 |  | 3~5V |  | - | 3.3V | 3.2m<br>～12m | ～120 | ～ 1 Sec |  |
| 5 | D203B |  | 3~15V |  | PullDown | Vin-(0.3-1.2) | ～5m | 120 - 144 | - |  |
| 6 | AKE-1 (RE-210) |  | 3~10V |  |  | 2.5V～(4.0V) | - | 135-138 | - |  |
| 7 | D205B |  | 3~15V |  |  | Vin-(0.3-1.2) | ～5m | 120 - 144 | - |  |
| 8 | M5Stack-PIR PIR_AS312 |  | 3.3V |  | PullUp | - | ～0.5m | ～100 | 2 sec | pinMode(PIN_IN, INPUT_PULLUP); |

# 5-1. Simple usage survey of sensor only type (circuit)

Supply 3.3V to the sensor unit product [D203B/AKE-1/D205B] and install a PullDown resistor to investigate whether simple measurement is possible

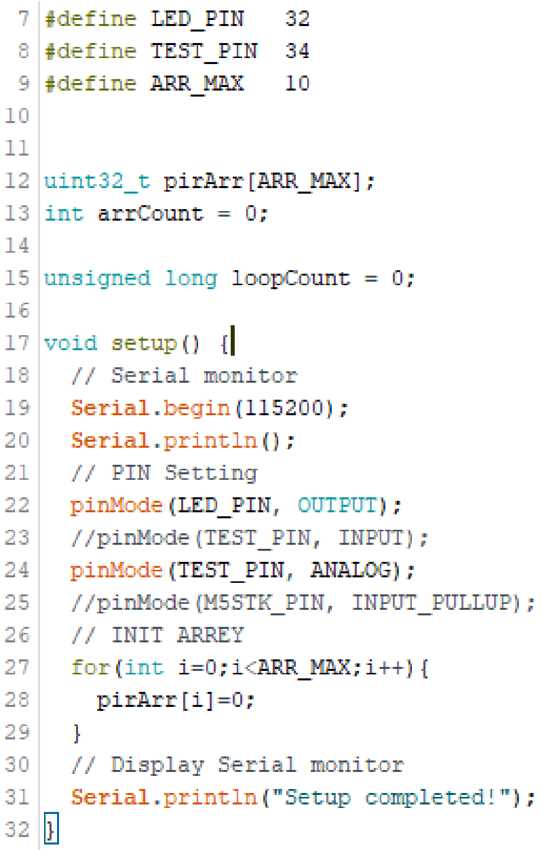
Motion Sensor
[D203B/AKE-1/D205B]



Note) D203B/AKE-1/D205B set the IO34 pin to ADC (ANALOG) and measure the output voltage.

# 5-2. Simple usage survey of sensor only type (program)

For the sensor unit [D203B, AKE-1, D205B] products, the LED lights up when the voltage fluctuates from the average value of the past 10 times. (The following is designed to detect when it changes by 7mV)



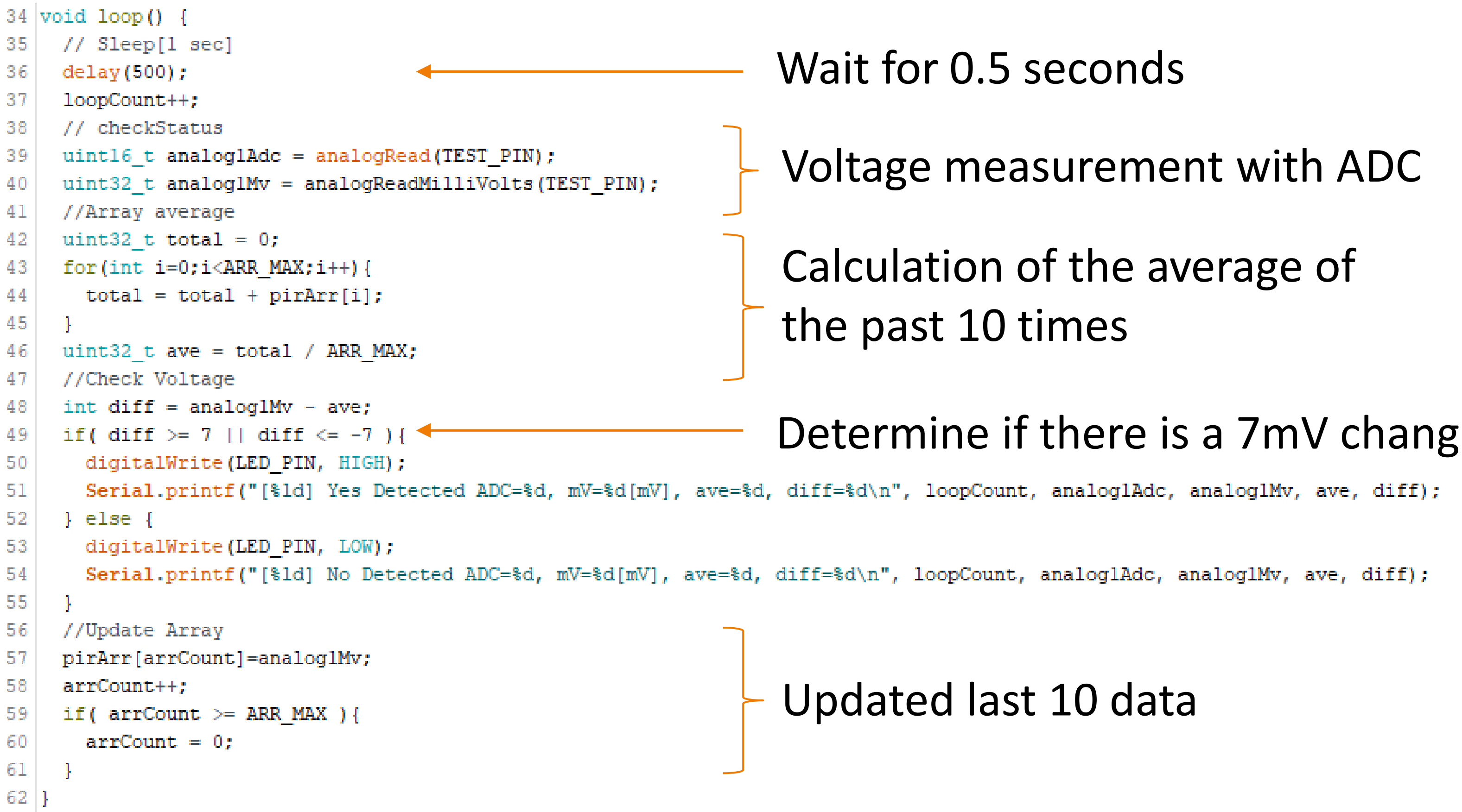
```
#define LED_PIN   32
#define TEST_PIN  34
#define ARR_MAX   10


uint32_t pirArr[ARR_MAX];
int arrCount = 0;

unsigned long loopCount = 0;

void setup() {
  // Serial monitor
  Serial.begin(115200);
  Serial.println();
  // PIN Setting
  pinMode(LED_PIN, OUTPUT);
  //pinMode(TEST_PIN, INPUT);
  pinMode(TEST_PIN, ANALOG);
  //pinMode(M5STK_PIN, INPUT_PULLUP);
  // INIT ARREY
  for(int i=0;i<ARR_MAX;i++){
    pirArr[i]=0;
  }
  // Display Serial monitor
  Serial.println("Setup completed!");
}
```

ESP32
terminal setting



```
void loop() {
  // Sleep[1 sec]
  delay(500);
  loopCount++;
  // checkStatus
  uint16_t analog1Adc = analogRead(TEST_PIN);
  uint32_t analog1Mv = analogReadMilliVolts(TEST_PIN);
  //Array average
  uint32_t total = 0;
  for(int i=0;i<ARR_MAX;i++){
    total = total + pirArr[i];
  }
  uint32_t ave = total / ARR_MAX;
  //Check Voltage
  int diff = analog1Mv - ave;
  if( diff >= 7 || diff <= -7 ){
    digitalWrite(LED_PIN, HIGH);
    Serial.printf("[%ld] Yes Detected ADC=%d, mV=%d[mV], ave=%d, diff=%d\n", loopCount, analog1Adc, analog1Mv, ave, diff);
  } else {
    digitalWrite(LED_PIN, LOW);
    Serial.printf("[%ld] No Detected ADC=%d, mV=%d[mV], ave=%d, diff=%d\n", loopCount, analog1Adc, analog1Mv, ave, diff);
  }
  //Update Array
  pirArr[arrCount]=analog1Mv;
  arrCount++;
  if( arrCount >= ARR_MAX ){
    arrCount = 0;
  }
}
```

Wait for 0.5 seconds

Voltage measurement with ADC

Calculation of the average of
the past 10 times

Determine if there is a 7mV change

Updated last 10 data

# 5-3. Simple usage survey of sensor only type（Result）

For the products of the single sensor type [D203B, AKE-1, D205B], we determined whether the difference from the average of the past 10 times can be easily detected without an operational amplifier.
Since several mV cannot be measured accurately and erroneous detection may occur,
**it seems that a simple method is not practical**.

```
[450] No Detected ADC=759, mV=756[mV], ave=757, diff=-1
[451] No Detected ADC=759, mV=760[mV], ave=757, diff=3
[452] No Detected ADC=759, mV=761[mV], ave=757, diff=4
[453] No Detected ADC=763, mV=759[mV], ave=757, diff=2
[454] No Detected ADC=758, mV=757[mV], ave=757, diff=0
[455] No Detected ADC=762, mV=757[mV], ave=757, diff=0
[456] No Detected ADC=763, mV=758[mV], ave=757, diff=1
[457] No Detected ADC=759, mV=757[mV], ave=757, diff=0
[458] No Detected ADC=762, mV=757[mV], ave=757, diff=0
[459] No Detected ADC=765, mV=759[mV], ave=757, diff=2
[460] No Detected ADC=758, mV=763[mV], ave=758, diff=5
[461] No Detected ADC=766, mV=757[mV], ave=758, diff=-1
[462] No Detected ADC=763, mV=759[mV], ave=758, diff=1
[463] No Detected ADC=761, mV=759[mV], ave=758, diff=1
[464] Yes Detected ADC=761, mV=765[mV], ave=758, diff=7
[465] No Detected ADC=757, mV=759[mV], ave=759, diff=0
[466] No Detected ADC=757, mV=757[mV], ave=759, diff=-2
[467] Yes Detected ADC=745, mV=749[mV], ave=759, diff=-10
[468] Yes Detected ADC=745, mV=746[mV], ave=758, diff=-12
[469] Yes Detected ADC=742, mV=745[mV], ave=757, diff=-12
[470] Yes Detected ADC=747, mV=748[mV], ave=755, diff=-7
[471] No Detected ADC=752, mV=752[mV], ave=754, diff=-2
[472] No Detected ADC=755, mV=756[mV], ave=753, diff=3
[473] Yes Detected ADC=766, mV=761[mV], ave=753, diff=8
[474] Yes Detected ADC=768, mV=762[mV], ave=753, diff=9
[475] Yes Detected ADC=765, mV=762[mV], ave=753, diff=9
[476] No Detected ADC=759, mV=758[mV], ave=753, diff=5
[477] No Detected ADC=761, mV=757[mV], ave=753, diff=4
```

Since a difference of 7mV or more occurs when approaching, consider whether it can be distinguished at about 7mV

```
[421] No Detected ADC=765, mV=760[mV], ave=761, diff=-1
[422] No Detected ADC=766, mV=761[mV], ave=761, diff=0
[423] No Detected ADC=763, mV=759[mV], ave=761, diff=-2
[424] No Detected ADC=763, mV=762[mV], ave=761, diff=1
[425] No Detected ADC=762, mV=761[mV], ave=761, diff=0
[426] No Detected ADC=761, mV=760[mV], ave=761, diff=-1
[427] No Detected ADC=762, mV=762[mV], ave=761, diff=1
[428] No Detected ADC=763, mV=761[mV], ave=761, diff=0
[429] No Detected ADC=762, mV=759[mV], ave=761, diff=-2
[430] No Detected ADC=759, mV=757[mV], ave=760, diff=-3
[431] Yes Detected ADC=764, mV=750[mV], ave=760, diff=-10
[432] No Detected ADC=763, mV=759[mV], ave=759, diff=0
[433] No Detected ADC=764, mV=757[mV], ave=759, diff=-2
[434] No Detected ADC=764, mV=760[mV], ave=758, diff=2
[435] No Detected ADC=761, mV=757[mV], ave=758, diff=-1
[436] No Detected ADC=759, mV=757[mV], ave=758, diff=-1
[437] No Detected ADC=759, mV=756[mV], ave=757, diff=-1
[438] No Detected ADC=762, mV=761[mV], ave=757, diff=4
[439] No Detected ADC=761, mV=757[mV], ave=757, diff=0
[440] No Detected ADC=759, mV=757[mV], ave=757, diff=0
[441] No Detected ADC=759, mV=757[mV], ave=757, diff=0
[442] No Detected ADC=759, mV=757[mV], ave=757, diff=0
[443] No Detected ADC=759, mV=759[mV], ave=757, diff=2
[444] No Detected ADC=759, mV=759[mV], ave=757, diff=2
[445] No Detected ADC=759, mV=757[mV], ave=757, diff=0
[446] No Detected ADC=758, mV=756[mV], ave=757, diff=-1
[447] No Detected ADC=758, mV=754[mV], ave=757, diff=-3
[448] No Detected ADC=760, mV=757[mV], ave=757, diff=0
```

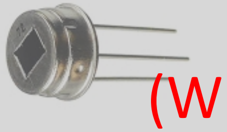
Even if left unattended, **7mV or more often occurs, resulting in false detection.**

Judgment is made with a difference of 7mV, but if it is larger than that, the normal sensing reaction will deteriorate.
Smaller values result in more false positives.

Originally, it is assumed that it is necessary to **accurately judge a difference of several mV** that is smaller than 7 mV.

# 5-4. Simple usage survey of sensor only type（Conclusion ）

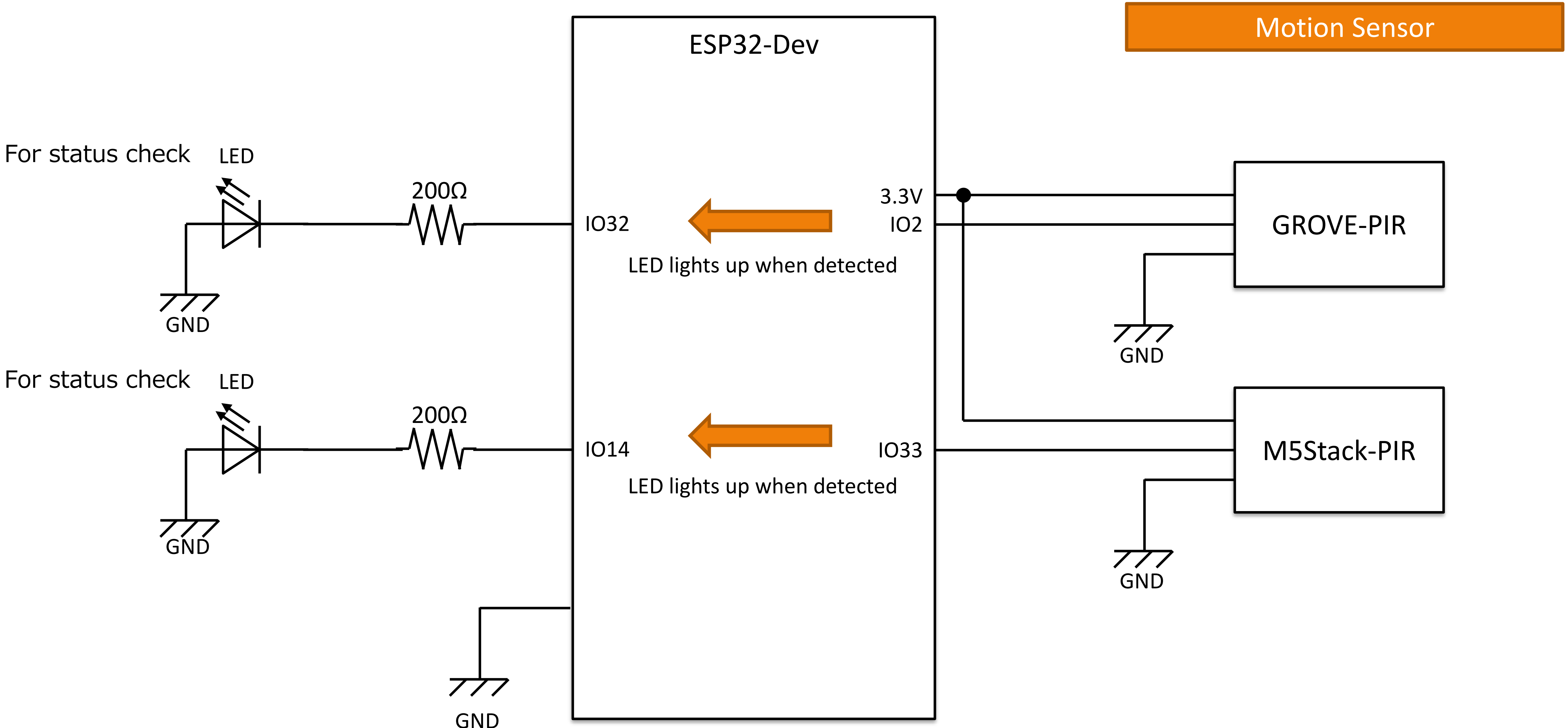
Since it is difficult to use the single sensor [D203B, AKE-1, D205B] with a simple method,
the remaining 5 sensors are measured.

| NO | Model | イメージ | Vin(Spec) | Vin | Pull Up/Down | Vout(Spec) | Distance | Angle | Delay time | Note |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SB412A |  | 3.5-12V | 5 V | - | 3V | 3～5m | ～115 | 2.3 sec<br>～80 min | |
| 2 | EKMC1601112 |  | 3~6V | | PullDown | Vin-0.5 | ～5m | 82-94 | - | |
| 3 | EKMC1603111 |  | 3~6V | | | Vin-0.5 | ～12m | 92-102 | - | |
| 4 | Grove-PIR<br>101020793 |  | 3~5V | | - | 3.3V | 3.2m<br>～12m | ～120 | ～ 1 Sec | |
| 5 | D203B |  | 3~15V | 3.3 V | | Vin-(0.3-1.2) | ～5m | 120 - 144 | - | |
| 6 | AKE-1<br>(RE-210) |  | 3~10V | | PullDown | 2.5V～(4.0V) | - | 135-138 | - | |
| 7 | D205B |  | 3~15V | | | Vin-(0.3-1.2) | ～5m | 120 - 144 | - | |
| 8 | M5Stack-PIR<br>PIR_AS312 |  | 3.3V | | PullUp | - | ～0.5m | ～100 | 2 sec | pinMode(PIN_IN, INPUT_PULLUP); |

Difficult to use with a simple method
(When using, a regular operational amplifier is required.)

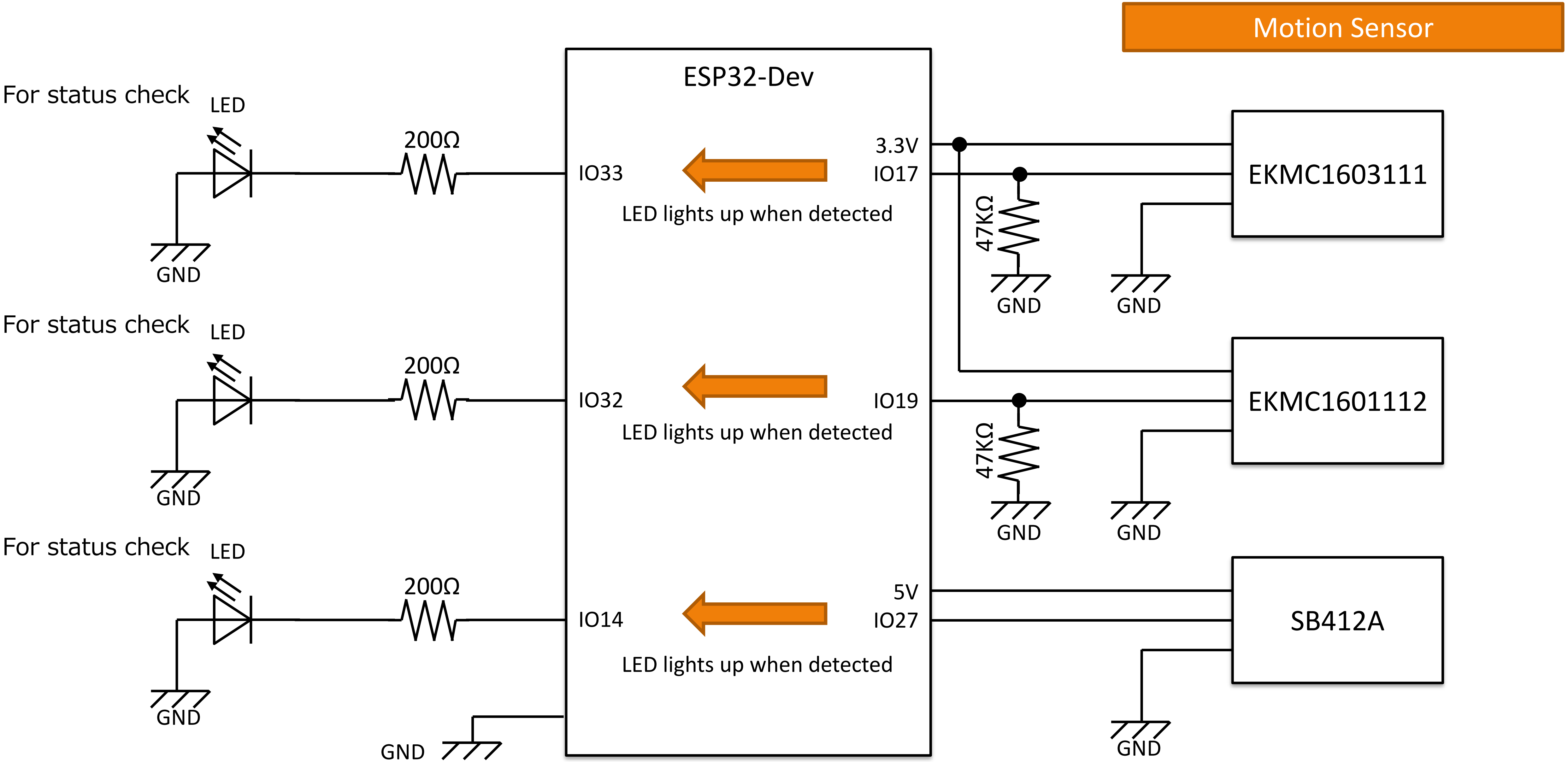
# 6-1. Circuit 1

Connect two motion sensors to ESP32 and make a circuit so that the status can be checked with LEDs when sensing.



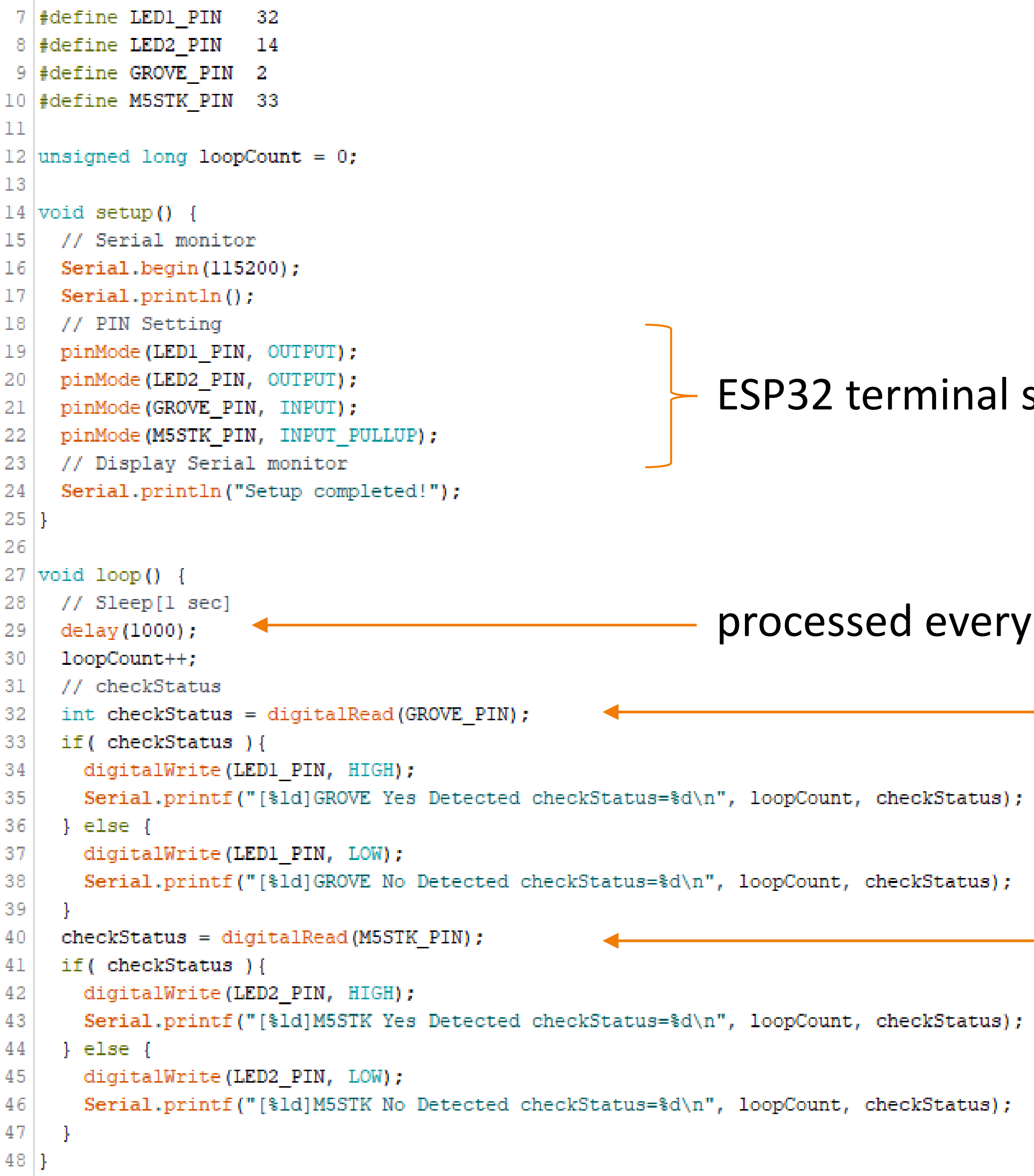
# 6-2. Circuit 2

Connect 3 human sensors to ESP32 and make a circuit so that you can check the status with LEDs when sensing



# 7. Program

When a high signal is detected at the Vout pin, the LED lights up.



```
#define LED1_PIN   32
#define LED2_PIN   14
#define GROVE_PIN  2
#define M5STK_PIN  33

unsigned long loopCount = 0;

void setup() {
  // Serial monitor
  Serial.begin(115200);
  Serial.println();
  // PIN Setting
  pinMode(LED1_PIN, OUTPUT);
  pinMode(LED2_PIN, OUTPUT);
  pinMode(GROVE_PIN, INPUT);
  pinMode(M5STK_PIN, INPUT_PULLUP);
  // Display Serial monitor
  Serial.println("Setup completed!");
}

void loop() {
  // Sleep[1 sec]
  delay(1000);
  loopCount++;
  // checkStatus
  int checkStatus = digitalRead(GROVE_PIN);
  if( checkStatus ){
    digitalWrite(LED1_PIN, HIGH);
    Serial.printf("[%ld]GROVE Yes Detected checkStatus=%d\n", loopCount, checkStatus);
  } else {
    digitalWrite(LED1_PIN, LOW);
    Serial.printf("[%ld]GROVE No Detected checkStatus=%d\n", loopCount, checkStatus);
  }
  checkStatus = digitalRead(M5STK_PIN);
  if( checkStatus ){
    digitalWrite(LED2_PIN, HIGH);
    Serial.printf("[%ld]M5STK Yes Detected checkStatus=%d\n", loopCount, checkStatus);
  } else {
    digitalWrite(LED2_PIN, LOW);
    Serial.printf("[%ld]M5STK No Detected checkStatus=%d\n", loopCount, checkStatus);
  }
}
```

ESP32 terminal setting

processed every second

Get GROVE sensor detection information

LED control and serial information display according to sensing results

Get M5Stack sensor detection information

LED control and serial information display according to sensing results

# 8-1. Measurement result 1 (cold object)

Investigate whether cold objects can also be detected. Can be detected without problems with all sensors.

| Type | Product | Measuring method | Measurement result | Note |
|---|---|---|---|---|
| Modularization | SB412A  | Measure whether the chilled ice pack can be detected at a distance of about 1m<br>(Put it in a plastic bag and move it in front of the sensor with a stick.)<br> | ○ Even cold objects can be detected without problems | measured indoors (temperature is about 10° C) |
| | Grove-PIR  | | | |
| | M5Stack-PIR  | | | |
| Integrated lens | EKMC1601112  | | | |
| | EKMC1603111  | | | |

# 8-2. Measurement result 2 (small object)

《Drone Purchase URL》
https://www.amazon.co.jp/gp/product/B096DW2XJ6

Measure whether even small moving objects can be detected.
Toy drones can be detected at about 50 cm or less in front

| Type | Product | Measuring method | Measurement result | Note |
|---|---|---|---|---|
| Modularization | SB412A  | Operate the drone (9*9*3cm) and measure whether it can be detected  | Detectable within about 50cm from the front<br>(See measurement video for details) | measured indoors (temperature is about 10° C) |
| | Grove-PIR  | | | |
| | M5Stack-PIR  | | | |
| Integrated lens | EKMC1601112  | | | |
| | EKMC1603111  | | | |

# 8-3. Measurement result 3 (outdoor: park)

EKMC1601112/EKMC1603111 are available.
Other sensors are falsely detected within 1 minute and cannot be measured.

| Type | Product | Measuring method | Measurement result | Note |
|---|---|---|---|---|
| Modularization | SB412A  | Measured in a park in clear weather<br>(clear weather with no clouds, a breeze of about 1 m/s, and a temperature of about 20° C) | × Not measurable<br>(False detection within 1 minute) | |
| | Grove-PIR  | | | |
| | M5Stack-PIR  | | | |
| Integrated lens | EKMC1601112  | | ○ Detectable<br>(See next page for details) | |
| | EKMC1603111  | | | |

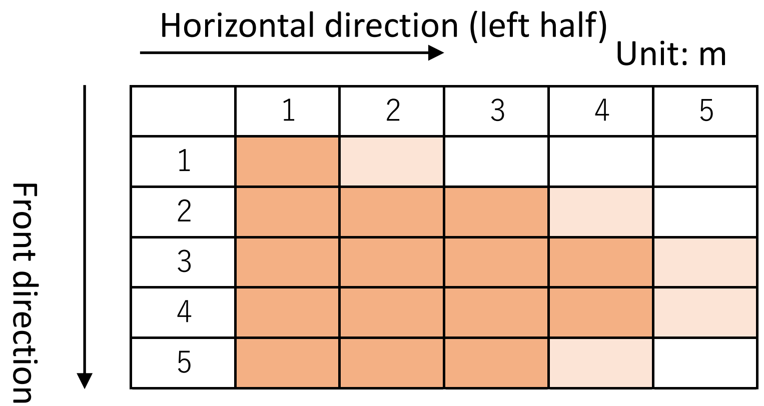
# 8-3. Measurement result 3 (outdoor: park)

**EKMC1601112/EKMC1603111 can be detected almost as specified**

Measurement method:
Move one step (about 50 cm) and check if it can be detected.
(However, the accuracy of the horizontal and vertical installation standards is low due to visual measurements.)

▓ : Detected at 80% or more
░ : Detected at 50% or more

**EKMC1601112**

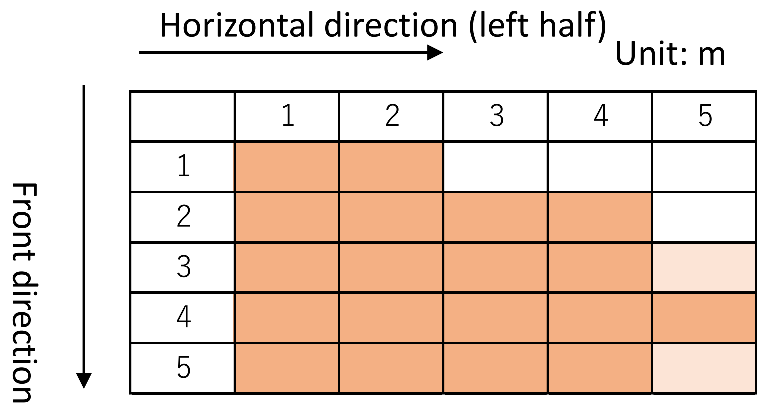


Unit: m

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | ▓ | ░ |  |  |  |
| 2 | ▓ | ▓ | ▓ | ░ |  |
| 3 | ▓ | ▓ | ▓ | ▓ | ░ |
| 4 | ▓ | ▓ | ▓ | ▓ | ░ |
| 5 | ▓ | ▓ | ▓ | ░ |  |

Up to 12m can be measured in the front direction

**EKMC1603111**



Unit: m

|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | ▓ | ▓ |  |  |  |
| 2 | ▓ | ▓ | ▓ | ▓ |  |
| 3 | ▓ | ▓ | ▓ | ▓ | ░ |
| 4 | ▓ | ▓ | ▓ | ▓ | ▓ |
| 5 | ▓ | ▓ | ▓ | ▓ | ░ |

Up to 15m can be measured in the front direction

# 8-4. Measurement result 4 (outdoor: under the roof)

I installed the sensor in the shadow under the roof and measured it,
but the result was the same as when I was in the park.

| Type | Product | Measuring method | Measurement result | Note |
|---|---|---|---|---|
| Modularization | SB412A  | Measurements were taken by installing the sensor under the roof in clear weather (clear weather with no clouds, a breeze of about 1m/s, and a temperature of about 20° C).<br>(measures distances up to 5m) | ✕<br>Not measurable<br>(False detection within 1 minute) | |
| | Grove-PIR  | | | |
| | M5Stack-PIR  | | | |
| Integrated lens | EKMC1601112  | | ○<br>Detectable<br>(The result is omitted because it is the same as the time of the park) | |
| | EKMC1603111  | | | |

# 8-5. Measurement result 5 (indoor)

As a result of indoor measurement, all sensors can detect up to 2m without any problem.
At 3 m, the sensor confirmed the difference in sensitivity.

| Type | Product | Measuring method | Measurement result | Note |
|---|---|---|---|---|
| Modularization | SB412A  | Measured at 1, 2, and 3m in the front direction indoors<br>Move one step to the side (about 50 cm) and measure if it can be detected | △ Up to 2m can be detected without problems<br>(3m is about 50%) | temperature is about 10° C |
|  | Grove-PIR  |  |  |  |
|  | M5Stack-PIR  |  | △ Up to 2m can be detected without problems<br>(3m is almost undetectable) |  |
| Integrated lens | EKMC1601112  |  | ○ Detectable |  |
|  | EKMC1603111  |  |  |  |

# 8-6. Summary of measurement results

According to the measurement results, the first place was "EKMC1603111" and the second place was "EKMC1601112".

| Type | Product | Cold Objects | Small Objects | Outdoors | Indoor | Note |
|---|---|---|---|---|---|---|
| Modularization | SB412A  | detect without problems | Detected at about 50 cm or less | Not measurable | OK up to 2m (3m is about 50%) | |
| | Grove-PIR  | | | | | |
| | M5Stack-PIR  | | | | OK up to 2m (3m is almost impossible) | |
| Integrated lens | EKMC1601112  | | | According to specifications (About 12m long) | 3m OK (Not measured over 4m) | |
| | EKMC1603111  | | | According to specifications (About 15m long) | | Accurate detection even at short distances |