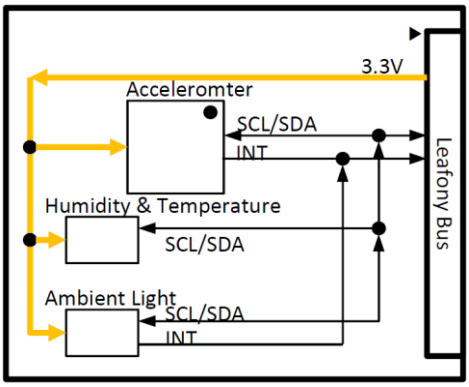
# AI01 4-Sensors

## 1. Description

This is a leaf which Temperature and huminity sensor, Illuminance sensor and acceleration sensor installed.
This is connected by I2C with MCU leaf.

## 2. Leaf specification

### 2-1. Block diagram




### 2-2. Power supply specification

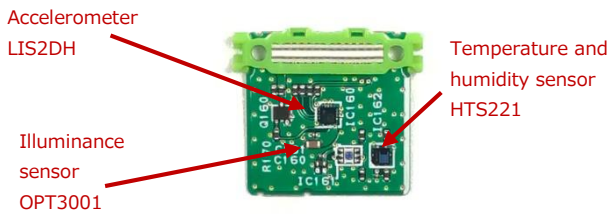
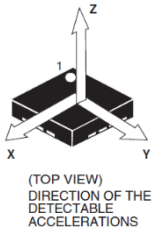
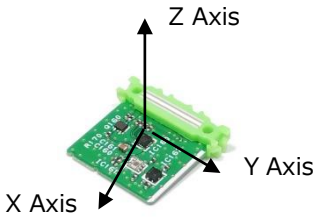
| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Vdd | Power Supply Voltage | – | 1.71V | 3.3V | 3.6V |
| Idd | Operating current | Active | - | 16uA | - |
| | | Sleep | - | 1.4uA | - |

### 2-3. Main parts

| Reference No. | Part name | Part number | Vendor name | note |
|---|---|---|---|---|
| IC162 | Temperature and huminity sensor | HTS221 | ST Microelectronics | I2C adress : 0x5F |
| IC161 | Illuminance sensor | OPT3001 | Texas Instruments | I2C adress : 0x45( Can be altered to 0x44 by changing the chip resestance.) |
| IC160 | Acceleration sensor | LIS2DH | ST Microelectronics | I2C adress : 0x19 |

※I2C Address is 7 bits.

2-4. Appearance

| Top Side | Back Side |
|---|---|
|  <br>※Accerleration sensor（LIS2DH）<br>X axis, Y axis and Z axis on substrate are at bellow<br>  <br>  |  |

2-5. Pinout

| Name | Function |
|---|---|
| SCL | I2C Communication Clock |
| SDA | I2C Communication Data |
| D3 | INT : Interrupt Output signal  L : Interruption |
| 3V3 | 3.3V Input |
| GND | GND |

# 3. Temperature and huminity sensor(HTS221) Specifications

3-1. Description

| Item | Description |
|---|---|
| Relative Temperature range | -40～120℃ |
| Temperature accuracy | ±0.5°C (15 to +40°C) |
| Relative humidity range | 0 to 100% |
| Humidity accuracy | 3.5% rH (20 to +80% rH) |
| Interfaces | I2C |

3-2. Electrical characteristics

・ Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| Operating Temperature | -40℃ to +120℃ |
| Maximum Operation Voltage | 4.8V |

・ Electrical characteristics

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Vdd | supply voltage | Internal Oscillator | 1.71V | 2.5V | 3.6V |
| Idd | Normal mode | 1Hz, 2.5V | - | 2uA | - |
| | Power down mode | 2.5V | - | 0.5uA | - |

3-3. Link destination of data sheet

https://www.st.com/ja/mems-and-sensors/hts221.html

3-4. Main functions and libraries

3-4-1. Unified sensor driver

include file:Adafruit_Sensor.h

https://github.com/adafruit/Adafruit_Sensor

| Definition | Description |
|---|---|
| – | Necessary, in order to use Adafruit's sensor library. |

3-4-2. Obtainting the data of temperature and huminity sensor

include file:HTS221.h

https://github.com/ameltech/sme-hts221-library

| Definition | Description |
|---|---|
| smeHumidity.begin() | Initialize the temperature and huminity senor.<br>【Parameter】<br>None<br>【Return value】<br>true: succeed<br>false: fail |
| smeHumidity.readTemperature() | Read the temperature from temperature and huminity sensor.<br>【Parameter】<br>None<br>【Return value】<br>Temperature data |
| smeHumidity.readHumidity() | Read the huminity from temperature and huminity sensor.<br>【Parameter】<br>None<br>【Return value】<br>Huminity data |
| smeHumidity.deactivate() | Migrate to low energy mode.<br>【Parameter】<br>None<br>【Return value】<br>true: succeed |

| | |
|---|---|
| smeHumidity.activate() | Retern from low energy mode.<br>【Parameter】<br>none<br>【Return value】<br>true: succeed |

3-5. Register

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| WHO_AM_I | 0Fh | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |

WHO_AM_I description

| | |
|---|---|
| WHO_AM_I[7:0] | Device identification=BCh(reading only) |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| AV_CONF | 10h | Reserved | Reserved | AVGT2 | AVGT1 | AVGT0 | AVGH2 | AVGH1 | AVGH0 |

WHO_AM_I description

| | |
|---|---|
| AV_CONF[7:6] | Reserved |
| AV_CONF[5:3] | AVGT2-0: To select the numbers of averaged temperature samples (2 - 256). |
| AV_CONF[2:0] | AVGH2-0: To select the numbers of averaged humidity samples (4 - 512). |

Humidity and temperature average configuration

| AVGx2:0 | Nr. internal average | | Noise (RMS) | | $I_{DD}$ 1 Hz |
|---|---|---|---|---|---|
| | Temperature (AVGT) | Humidity (AVGH) | Temp (°C) | rH % | µA |
| 000 | 2 | 4 | 0.08 | 0.4 | 0.80 |
| 001 | 4 | 8 | 0.05 | 0.3 | 1.05 |
| 010 | 8 | 16 | 0.04 | 0.2 | 1.40 |
| 011 | 16 | 32 | 0.03 | 0.15 | 2.10 |
| 100 | 32 | 64 | 0.02 | 0.1 | 3.43 |
| 101 | 64 | 128 | 0.015 | 0.07 | 6.15 |
| 110 | 128 | 256 | 0.01 | 0.05 | 11.60 |
| 111 | 256 | 512 | 0.007 | 0.03 | 22.50 |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG1 | 20h | PD | Reserved | Reserved | Reserved | Reserved | BDU | ODR1 | ODR0 |

CTRL_REG1 description

| | |
|---|---|
| CTRL_REG1[7] | PD: power-down control<br>(0: power-down mode; 1: active mode) |
| CTRL_REG1[6:3] | Reserved |
| CTRL_REG1[2] | BDU: block data update<br>(0: continuous update; 1: output registers not updated until MSB and LSB reading) |
| CTRL_REG1[1:0] | ODR1, ODR0: output data rate selection |

Output data rate configuration

| ODR1 | ODR0 | Humidity (Hz) | Temperature (Hz) |
|---|---|---|---|
| 0 | 0 | One-shot | |
| 0 | 1 | 1 Hz | 1 Hz |
| 1 | 0 | 7 Hz | 7 Hz |
| 1 | 1 | 12.5 Hz | 12.5 Hz |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG2 | 21h | BOOT | Reserved | Reserved | Reserved | Reserved | Reserved | Heater | ONE_SHOT |

CTRL_REG2 description

| | |
|---|---|
| CTRL_REG2[7] | BOOT: Reboot memory content<br>(0: normal mode; 1: reboot memory content) |
| CTRL_REG2[6:2] | Reserved |
| CTRL_REG2[1] | Heater<br>(0: heater disable; 1: heater enable) |
| CTRL_REG2[0] | One-shot enable<br>(0: waiting for start of conversion; 1: start for a new dataset) |

Typical power consumption with heater ON

| $V_{DD}$ [V] | I [mA] |
|---|---|
| 3.3 | 33 |
| 2.5 | 22 |
| 1.8 | 12 |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG3 | 22h | DRDY_H_L | PP_OD | Reserved | Reserved | Reserved | DRDY | Reserved | Reserved |

CTRL_REG3 description

| | |
|---|---|
| CTRL_REG3[7] | DRDY_H_L: Data Ready output signal active high, low (0: active high - default;1: active low) |
| CTRL_REG3[6] | PP_OD: Push-pull / Open Drain selection on pin 3 (DRDY) (0: push-pull - default; 1: open drain) |
| CTRL_REG3[5:3] | Reserved |
| CTRL_REG3[2] | DRDY_EN: Data Ready enable<br>(0: Data Ready disabled - default;1: Data Ready signal available on pin 3) |
| CTRL_REG3[1:0] | Reserved |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| STATUS_REG | 27h | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved | H_DA | T_DA |

STATUS_REG description

| | |
|---|---|
| STATUS_REG[7:2] | Reserved |
| STATUS_REG[1] | H_DA: Humidity data available.<br>(0: new data for humidity is not yet available; 1: new data for humidity is available) |

| | |
|---|---|
| STATUS_REG[0] | T_DA: Temperature data available.<br>(0: new data for temperature is not yet available; 1: new data for temperature is available)<br>H_DA is set to 1 whenever a new humidity sample is available. H_DA is cleared anytime HUMIDITY_OUT_H (29h) register is read.<br>T_DA is set to 1 whenever a new temperature sample is available.<br>T_DA is cleared anytime TEMP_OUT_H (2Bh) register is read. |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| HUMIDITY_OUT_L | 28h | HOUT7 | HOUT6 | HOUT5 | HOUT4 | HOUT3 | HOUT2 | HOUT1 | HOUT0 |

HUMIDITY_OUT_L description

| | |
|---|---|
| HUMIDITY_OUT_L[7:0] | HOUT7 - HOUT0: Humidity data LSB |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| HUMIDITY_OUT_H | 29h | HOUT14 | HOUT13 | HOUT12 | HOUT11 | HOUT10 | HOUT9 | HOUT8 | HOUT7 |

HUMIDITY_OUT_H description

| | |
|---|---|
| HUMIDITY_OUT_H[7:0] | HOUT15 - HOUT8: Humidity data MSB |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| TEMP_OUT_L | 2Ah | TOUT7 | TOUT6 | TOUT5 | TOUT4 | TOUT3 | TOUT2 | TOUT1 | TOUT0 |

TEMP_OUT_L description

| | |
|---|---|
| TEMP_OUT_L[7:0] | TOUT7 - TOUT0: Temperature data LSB |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| TEMP_OUT_H | 2Bh | TOUT15 | TOUT14 | TOUT13 | TOUT12 | TOUT11 | TOUT10 | TOUT9 | TOUT8 |

TEMP_OUT_H description

| | |
|---|---|
| TEMP_OUT_H[15:8] | TOUT15 - TOUT8: Temperature data MSB. |

### 3-6. Power saving control

Data from the sensor can be obtain by setting MCU to sleeping mode to wakeup mode in every fixed time.

In order to set the temperature and huminity sensor to low energy mode, set the sensor chip to power-down mode.

The sensor is on Power-down mode when it is turned on.

The function needed in order to migrate to power-down mode.

```
smeHumidity.deactivate()
```

The function needed in order to migrate to active.

```
smeHumidity.activate()
```

# 4. Illuminance sensor (OPT3001) Specifications

## 4-1. Overview

| Item | 内容 |
|---|---|
| Measurement range | 0.01 lux to 83 k lux |
| IR Rejects | > 99% (typ) |
| Interfaces | I2C |

## 4-2. Electrical characteristics

・ Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| Operating Temperature | -40℃ to +85℃ |
| Maximum Operation Voltage | 6V |

・ 定格

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Vdd | supply voltage | Internal Oscillator | 1.6V | - | 3.6V |
| Vdd_IO | IO pin supply voltage | – | 1.6V | - | 5.5V |
| Idd | Active | Dark,VDD=3.6V | - | 1.8uA | 2.5uA |
| | | Full-scale lux,VDD=3.6V | - | 3.7uA | - |
| | Shutdown | Dark,VDD=3.6V | - | 0.3uA | 0.47uA |
| | | Full-scale lux,VDD=3.6V | - | 0.4uA | - |

## 4-3. Link destination of data sheet

http://www.tij.co.jp/product/jp/OPT3001

## 4-4. Main functions and libraries

### 4-4-1. Unified sensor driver

include file:Adafruit_Sensor.h

https://github.com/adafruit/Adafruit_Sensor

| Definition | 概要 |
|---|---|
| – | Necessary, in order to use Adafruit’s sensor library. |

### 4-4-2. Obtainting the data of illuminance sensor 照度センサーデータ取得

include file:ClosedCube_OPT3001.h

https://github.com/closedcube/ClosedCube_OPT3001_Arduino

| Definition | 概要 |
|---|---|
| light.begin(address) | Initialize the temperature and huminity sensor.<br>【Parameter】<br>address : 7bit I2C slave adress<br>【Return value】<br>Error Code |

| | |
|---|---|
| light.writeConfig(newConfig) | Writes the data on the illuminance sensor’s confrigeration register.<br>【Parameter】<br>newConfig : Setting data<br>【Return value】<br>Error Code |
| light.readConfig() | Reads the data from confrigeration register of illuminance sensor.<br>【Parameter】<br>なし<br>【Return value】<br>Register value |
| light.readResult() | Reads the data of illuminance sensor【Parameter】<br>none<br>【Return value】<br>luminance、measured value、error code |

4-5. Register

| Name | Add | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 |
|---|---|---|---|---|---|---|---|---|---|
| Result | 00h | E3 | E2 | E1 | E0 | R11 | R10 | R9 | R8 |
| | | **D7** | **D6** | **D5** | **D4** | **D3** | **D2** | **D1** | **D0** |
| | | R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 |

Result Register Field Descriptions

| Field | Description |
|---|---|
| E[3:0] | **Exponent.**<br>These bits are the exponent bits. Full-Scale Range and LSB Size as a Function of Exponent Level provides further details. |
| R[11:0] | **Fractional result.**<br>These bits are the result in straight binary coding (zero to full-scale). |

Full-Scale Range and LSB Size as a Function of Exponent Level

| E3 | E2 | E1 | E0 | FULL-SCALE RANGE (lux) | LSB SIZE (lux per LSB) |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 40.95 | 0.01 |
| 0 | 0 | 0 | 1 | 81.90 | 0.02 |
| 0 | 0 | 1 | 0 | 163.80 | 0.04 |
| 0 | 0 | 1 | 1 | 327.60 | 0.08 |
| 0 | 1 | 0 | 0 | 655.20 | 0.16 |
| 0 | 1 | 0 | 1 | 1310.40 | 0.32 |
| 0 | 1 | 1 | 0 | 2620.80 | 0.64 |
| 0 | 1 | 1 | 1 | 5241.60 | 1.28 |
| 1 | 0 | 0 | 0 | 10483.20 | 2.56 |
| 1 | 0 | 0 | 1 | 20966.40 | 5.12 |
| 1 | 0 | 1 | 0 | 41932.80 | 10.24 |
| 1 | 0 | 1 | 1 | 83865.60 | 20.48 |

| Name | Add | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 |
|---|---|---|---|---|---|---|---|---|---|
| Configuration | 01h | RN3 | RN2 | RN1 | RN0 | CT | M1 | M0 | OVF |
| | | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| | | CRF | FH | FL | L | POL | ME | FC1 | FC0 |

Configuration Register Field Descriptions

| Field | Description |
|---|---|
| RN[3:0] | **Range number field (read or write)**.<br>The range number field selects the full-scale lux range of the device. The format of this field is the same as the result register exponent field (E[3:0]). When RN[3:0] is set to 1100b (0Ch), the device operates in automatic full-scale setting mode. In this mode, the automatically chosen range is reported in the result exponent (register 00h, E[3:0]).<br>The device powers up as 1100 in automatic full-scale setting mode. Codes 1101b, 1110b, and 1111b (0Dh, 0Eh, and 0Fh) are reserved for future use. |
| CT | **Conversion time field (read or write).**<br>The conversion time field determines the length of the light to digital conversion process. The choices are 100 ms and 800 ms. A longer integration time allows for a lower noise measurement.<br>The conversion time also relates to the effective resolution of the data conversion process. The 800-ms conversion time allows for the fully specified lux resolution. The 100-ms conversion time with full-scale ranges above 0101b for E[3:0] in the result and configuration registers also allows for the fully specified lux resolution. The 100-ms conversion time with full-scale ranges below and including 0101b for E[3:0] can reduce the effective result resolution by up to three bits, as a function of the selected full-scale range. Range 0101b reduces by one bit. Ranges 0100b, 0011b, 0010b, and 0001b reduces by two bits. Range 0000b reduces by three bits.<br>The result register format and associated LSB weight does not change as a function of the conversion time.<br>0 = 100 ms<br>1 = 800 ms |

| | |
|---|---|
| M[1:0] | **Mode of conversion operation field (read or write).**<br>The mode of conversion operation field controls whether the device is operating in continuous conversion, single-shot, or low-power shutdown mode. The default is 00b (shutdown mode), such that upon power-up, the device only consumes operational level power after appropriately programming the device.<br>When single-shot mode is selected by writing 01b to this field, the field continues to read 01b while the device is actively converting. When the single-shot conversion is complete, the mode of conversion operation field is automatically set to 00b and the device is shut down.<br>When the device enters shutdown mode, either by completing a single-shot conversion or by a manual write to the configuration register, there is no change to the state of the reporting flags (conversion ready, flag high, flag low) or the INT pin. These signals are retained for subsequent read operations while the device is in shutdown mode.<br>00 = Shutdown (default) 01 = Single-shot<br>10, 11 = Continuous conversions |
| OVF | **Overflow flag field (read-only).**<br>The overflow flag field indicates when an overflow condition occurs in the data conversion process, typically because the light illuminating the device exceeds the programmed full-scale range of the device. Under this condition OVF is set to 1, otherwise OVF remains at 0. The field is reevaluated on every measurement.<br>If the full-scale range is manually set (RN[3:0] field < 1100b), the overflow flag field can be set while the result register reports a value less than full-scale. This result occurs if the input light has a temporary high spike level that temporarily overloads the integrating ADC converter circuitry but returns to a level within range before the conversion is complete. Thus, the overflow flag reports a possible error in the conversion process. This behavior is common to integrating-style converters.<br>If the full-scale range is automatically set (RN[3:0] field = 1100b), the only condition that sets the overflow flag field is if the input light is beyond the full-scale level of the entire device.<br>When there is an overflow condition and the full-scale range is not at maximum, the OPT3001 aborts its current conversion, sets the full-scale range to a higher level, and starts a new conversion. The flag is set at the end of the process. This process repeats until there is either no overflow condition or until the full-scale range is set to its maximum range. |
| CRF | **Conversion ready field (read-only).**<br>The conversion ready field indicates when a conversion completes. The field is set to 1 at the end of a conversion and is cleared (set to 0) when the configuration register is subsequently read or written with any value except one containing the shutdown mode (mode of operation field, M[1:0] = 00b). Writing a shutdown mode does not affect the state of this field. |

| | |
|---|---|
| FH | **Flag high field (read-only).**<br>The flag high field (FH) identifies that the result of a conversion is larger than a specified level of interest. FH is set to 1 when the result is larger than the level in the high-limit register (register address 03h) for a consecutive number of measurements defined by the fault count field (FC[1:0]). |
| FL | **Flag low field (read-only).**<br>The flag low field (FL) identifies that the result of a conversion is smaller than a specified level of interest. FL is set to 1 when the result is smaller than the level in the low-limit register (register address 02h) for a consecutive number of measurements defined by the fault count field (FC[1:0]). |
| L | **Latch field (read or write).**<br>The latch field controls the functionality of the interrupt reporting mechanisms: the INT pin, the flag high field (FH), and flag low field (FL). This bit selects the reporting style between a latched window-style comparison and a transparent hysteresis-style comparison.<br>0 = The device functions in transparent hysteresis-style comparison operation, where the three interrupt reporting mechanisms directly reflect the comparison of the result register with the high- and low-limit registers with no user-controlled clearing event.<br>1 = The device functions in latched window-style comparison operation, latching the interrupt reporting mechanisms until a user-controlled clearing event. |
| POL | **Polarity field (read or write).**<br>The polarity field controls the polarity or active state of the INT pin.<br>0 = The INT pin reports active low, pulling the pin low upon an interrupt event.<br>1 = Operation of the INT pin is inverted, where the INT pin reports active high, becoming high impedance and allowing the INT pin to be pulled high upon an interrupt event. |
| ME | **Mask exponent field (read or write).**<br>The mask exponent field forces the result register exponent field (register 00h, bits E[3:0]) to 0000b when the full-scale range is manually set, which can simplify the processing of the result register when the full-scale range is manually programmed. This behavior occurs when the mask exponent field is set to 1 and the range number field (RN[3:0]) is set to less than 1100b. Note that the masking is only performed to the result register. When using the interrupt reporting mechanisms, the result comparison with the low-limit and high-limit registers is unaffected by the ME field. |
| FC[1:0] | **Fault count field (read or write).**<br>The fault count field instructs the device as to how many consecutive fault events are required to trigger the interrupt reporting mechanisms: the INT pin, the flag high field (FH), and flag low field (FL). The fault events are described in the latch field (L), flag high field (FH), and flag low field (FL) descriptions.<br>00 = One fault count (default) 01 = Two fault counts<br>10 = Four fault counts 11 = Eight fault counts |

### 4-6. Power saving control

Data from the sensor can be obtain by setting MCU to sleeping mode to wakeup mode in every fixed time.

In order to set the illuminance sensor to low energy mode, set the sensor chip to shutdown mode. The sensor is on shutdown mode when it is turned on.

By altering the mode of conversion operation field of configuration register field, it can swich between active mode and shutdown mode.

00 = Shutdown mode (default)
01 = Single-shot
10, 11 = Continuous conversions

It should be set from the library like bellow.

1)Active モード

```
newConfig.ModeOfConversionOperation = B11;
light.writeConfig(newConfig);
```

However, it should be set like bellow when setting to active mode because the rest of configuration register's contents alter.

```
newConfig.RangeNumber = B1100;                //automatic full scale
newConfig.ConvertionTime = B1;                //convertion time = 800ms
newConfig.ModeOfConversionOperation = B11;    //continous conversion
newConfig.Latch = B1;                         //latch window styl

light.writeConfig(newConfig);
```

2)Shutdown mode

```
ClosedCube_OPT3001 light;
OPT3001_Config newConfig;

newConfig.ModeOfConversionOperation = B00;
light.writeConfig(newConfig);
```

## 5. Acceleration sensor (LIS2DH) Specifications

### 5-1. Overview

| Item | Description |
|---|---|
| Measurement range | ±2g/±4g/±8g/±16g (selectable) |
| Function | 6D/4D orientation detection<br>Freefall detection<br>Motion detection |
| Interfaces | I2C |

## 5-2. Electrical characteristics

### 5-2-1. Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| Operating Temperature | -40℃ to +85℃ |
| Maximum Operation Voltage | 4.8V |

### 5-2-2. Electrical characteristics

| Symbol | Parameter | Condition | Min. | Typ. | Max. |
|---|---|---|---|---|---|
| Vdd | supply voltage | Internal Oscillator | 1.71V | 2.5V | 3.6V |
| Vdd_IO | IO pin supply voltage | – | 1.71V | - | Vdd+0.1V |
| Idd | Current consumption | normal mode 50Hz | - | 11uA | - |
| | | normal mode 1Hz | - | 2uA | - |
| | | low power mode 50Hz | - | 6uA | - |
| IddPdn | Current consumption | Power down mode | - | 0.5uA | - |

## 5-3. Link destination of data sheet

https://www.st.com/ja/mems-and-sensors/lis2dh.html

## 5-4. Main functions and libraries

### 5-4-1. Unified sensor driver

include file:Adafruit_Sensor.h

https://github.com/adafruit/Adafruit_Sensor

| Definition | 概要 |
|---|---|
| – | Necessary, in order to use Adafruit's sensor library. |

### 5-4-2. Obtaining the acceleration sensor data

Adafruit_LIS3DH.h

https://github.com/adafruit/Adafruit_LIS3DH

| Definition | 概要 |
|---|---|
| Adafruit_LIS3DH accel = Adafruit_LIS3DH(); | Adafruit_LIS3DH Setting the communication mode and making the instance of library.<br>【Parameter】<br>accel : the name of instance (accel)<br>= communincation mode（Adafruit_LIS3DH()) |
| accel.begin(address) | Initialize acceleration sensor<br>【Parameter】<br>address: 7bit I2C slave address<br>【Return value】<br>true: succeed<br>false: fail |

| | |
|---|---|
| accel.writeRegister8(<br>register_address,<br>value) | Writes the value on register of acceleration sensor<br>【Parameter】<br>register_address :<br>LIS3DH_REG_CTRL1 CTRL_REG1 (20h)<br>LIS3DH_REG_CTRL2 CTRL_REG2 (21h)<br>LIS3DH_REG_CTRL3 CTRL_REG3 (22h)<br>LIS3DH_REG_CTRL4 CTRL_REG4 (23h)<br>LIS3DH_REG_CTRL5 CTRL_REG5 (24h)<br>LIS3DH_REG_CTRL6 CTRL_REG5 (25h)<br>LIS3DH_REG_INT1CFG INT1_CFG (30h)<br>LIS3DH_REG_INT1THS INT1_THS (32h)<br>LIS3DH_REG_INT1DUR INT1_DURATION (33h)<br>【Return value】<br>none |
| accel.setDataRate(val<br>ue) | Sets the data ratio of acceleration sensor<br>【Parameter】<br>value :<br>LIS3DH_DATARATE_400_HZ 400Hz<br>LIS3DH_DATARATE_200_HZ 200Hz<br>LIS3DH_DATARATE_100_HZ 100Hz<br>LIS3DH_DATARATE_50_HZ 50Hz<br>LIS3DH_DATARATE_25_HZ 25Hz<br>LIS3DH_DATARATE_10_HZ 10 Hz<br>LIS3DH_DATARATE_1_HZ 1 Hz<br>【Return value】<br>none |
| accel.read() | Writes the value of acceleration sensor<br>【Parameter】<br>none<br>【Return value】<br>none<br>The results will be saved like bellow.<br>accel.x_g the value of x axis<br>accel.y_g the value of y axis<br>accel.z_g the value of z axis |

5-5. Register

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG1 | 20h | ODR3 | ODR2 | ODR1 | ODR0 | LPen | Zen | Yen | Xen |

CTRL_REG1 description

| | |
|---|---|
| ODR[3:0] | Data rate selection. Default value:<br>(0000:Power Down mode; Others: Refer to "Data Rate Configuration") |

| | |
|---|---|
| LPen | Low power mode enable. Default value: 0<br>(0: Normal mode, 1: Low power mode) |
| Zen | Z axis enable. Default value: 1<br>(0: Z axis disabled; 1: Z axis enabled) |
| Yen | Y axis enable. Default value: 1<br>(0: Y axis disabled; 1: Y axis enabled) |
| Xen | X axis enable. Default value: 1<br>(0: X axis disabled; 1: X axis enabled) |

Data Rate Configuration

| ODR3 | ODR2 | ODR1 | ODR0 | Power mode selection |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Power down mode |
| 0 | 0 | 0 | 1 | HR / normal / Low power mode (1 Hz) |
| 0 | 0 | 1 | 0 | HR / normal / Low power mode (10 Hz) |
| 0 | 0 | 1 | 1 | HR / normal / Low power mode (25 Hz) |
| 0 | 1 | 0 | 0 | HR / normal / Low power mode (50 Hz) |
| 0 | 1 | 0 | 1 | HR / normal / Low power mode (100 Hz) |
| 0 | 1 | 1 | 0 | HR / normal / Low power mode (200 Hz) |
| 0 | 1 | 1 | 1 | HR/ normal / Low power mode (400 Hz) |
| 1 | 0 | 0 | 0 | Low power mode (1.620 kHz) |
| 1 | 0 | 0 | 1 | HR/ normal (1.344 kHz);<br>Low power mode (5.376 kHz) |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG2 | 21h | HPM1 | HPM0 | HPCF2 | HPCF1 | FDS | HPCLICK | HPIS2 | HPIS1 |

CTRL_REG2 description

| | |
|---|---|
| HPM[1:0] | High Pass filter Mode Selection. Default value: 00<br>Refer to "High pass filter mode configuration" |
| HPCF[2:1] | High Pass filter Cut Off frequency selection |
| FDS | Filtered Data Selection. Default value: 0<br>(0: internal filter bypassed; 1: data from internal filter sent to output register and FIFO) |
| HPCLICK | High Pass filter enabled for CLICK function.<br>(0: filter bypassed; 1: filter enabled) |
| HPIS2 | High Pass filter enabled for AOI function on Interrupt 2,<br>(0: filter bypassed; 1: filter enabled) |
| HPIS1 | High Pass filter enabled for AOI function on Interrupt 1,<br>(0: filter bypassed; 1: filter enabled) |

High pass filter mode configuration

| HPM1 | HPM0 | High Pass filter Mode |
|---|---|---|
| 0 | 0 | Normal mode (reset reading) |
| 0 | 1 | Reference signal for filtering |
| 1 | 0 | Normal mode |
| 1 | 1 | Autoreset on interrupt event |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG3 | 22h | I1_CLICK | I1_AOI1 | I1_AOI2 | I1_DRDY1 | I1_DRDY2 | I1_WTM | I1_ OVERRUN | -- |

CTRL_REG3 description

| | |
|---|---|
| I1_CLICK | CLICK interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_AOI1 | AOI1 interrupt on INT1 pn. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_AOI2 | AOI2 interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_DRDY1 | DRDY1 interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_DRDY2 | DRDY2 interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_WTM | FIFO Watermark interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |
| I1_OVERRUN | FIFO Overrun interrupt on INT1 pin. Default value 0.<br>(0: Disable; 1: Enable) |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG4 | 23h | BDU | BLE | FS1 | FS0 | HR | ST1 | ST0 | SIM |

CTRL_REG4 description

| | |
|---|---|
| BDU | Block data update. Default value: 0<br>(0: continuos update; 1: output registers not updated until MSB and LSB have been read) |
| BLE | Big/Little Endian data selection. Default value:0;<br>(0: data LSb at lower address; 1: data MSb at lower address)<br>The BLE function can be activated only in High Resolution mode |
| FS[1:0] | Full Scale selection. Default value: 00<br>(00: +/- 2G; 01: +/- 4G; 10: +/- 8G; 11: +/- 16G) |
| HR | Operating mode selection |
| ST[1:0] | Self Test Enable. Default value: 00<br>(00: Self Test Disabled; Other: See Table ) |
| SIM | SPI Serial Interface Mode selection. Default value: 0<br>(0: 4-wire interface; 1: 3-wire interface). |

Self test mode configuration

| ST1 | ST0 | Self test mode |
|---|---|---|
| 0 | 0 | Normal mode |
| 0 | 1 | Self test 0 |
| 1 | 0 | Self test 1 |
| 1 | 1 | -- |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG5 | 24h | BOOT | FIFO_EN | -- | -- | LIR_ INT1 | D4D_ INT1 | LIR_ INT2 | D4D_ INT2 |

CTRL_REG5 description

| | |
|---|---|
| BOOT | Reboot memory content. Default value: 0<br>(0: Normal mode; 1: reboot memory content) |
| FIFO_EN | FIFO enable. Default value: 0<br>(0: FIFO disable; 1: FIFO Enable) |
| LIR_INT1 | Latch interrupt request on INT1_SRC register, with INT1_SRC register cleared by reading INT1_SRC itself. Default value: 0.<br>(0: interrupt request not latched; 1: interrupt request latched) |
| D4D_INT1 | 4D enable: 4D detection is enabled on INT1 pin when 6D bit on INT1_CFG is set to 1. |
| LIR_INT2 | Latch interrupt request on INT2_SRC register, with INT2_SRC register cleared by reading INT2_SRC itself. Default value: 0.<br>(0: interrupt request not latched; 1: interrupt request latched) |
| D4D_INT2 | 4D enable: 4D detection is enabled on INT2 pin when 6D bit on INT2_CFG is set to 1. |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| CTRL_REG6 | 25h | I2_ CLICKen | I2_ INT1 | I2_ INT2 | BOOT_ I2 | P2_ ACT | -- | H_ LACTIVE | -- |

CTRL_REG6 description

| | |
|---|---|
| I2_CLICKen | Click interrupt on INT2 pin. Default value: 0<br>(0: disable; 1: enable) |
| I2_INT1 | Interrupt 1 function enabled on INT2 pin. Default value: 0<br>(0: function disable; 1: function enable) |
| I2_INT2 | Interrupt 2 function enabled on INT2 pin. Default value: 0<br>(0: function disable; 1: function enable) |
| BOOT_I2 | Boot on INT2 pin enable. Default value: 0<br>(0: disable; 1:enable) |
| P2_ACT | Activity interrupt enable on INT2 pin. Default value: 0.<br>(0: disable; 1:enable) |
| H_LACTIVE | interrupt active. Default value: 0.<br>(0: interrupt active high; 1: interrupt active low) |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| INT1_CFG | 30h | AOI | 6D | ZHIE/ ZUPE | ZLIE/ ZDOWNE | YHIE/ YUPE | YLIE/ YDOWNE | XHIE/ XUPE | XLIE/ XDOWNE |

INT1_CFG description

| | |
|---|---|
| AOI | And/Or combination of Interrupt events. Default value: 0. Refer to "Interrupt mode" |
| 6D | 6 direction detection function enabled. Default value: 0. Refer to "Interrupt mode" |

| | |
|---|---|
| ZHIE/ ZUPE | Enable interrupt generation on Z high event or on Direction recognition. Default value: 0<br>(0: disable interrupt request;1: enable interrupt request) |
| ZLIE/ ZDOWNE | Enable interrupt generation on Z low event or on Direction recognition. Default value: 0<br>(0: disable interrupt request;1: enable interrupt request) |
| YHIE/ YUPE | Enable interrupt generation on Y high event or on Direction recognition. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request.) |
| YLIE/ YDOWNE | Enable interrupt generation on Y low event or on Direction recognition. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request.) |
| XHIE/ XUPE | Enable interrupt generation on X high event or on Direction recognition. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request.) |
| XLIE/XDOWNE | Enable interrupt generation on X low event or on Direction recognition. Default value: 0<br>(0: disable interrupt request; 1: enable interrupt request.) |

Interrupt mode

| AOI | 6D | Interrupt mode |
|---|---|---|
| 0 | 0 | OR combination of interrupt events |
| 0 | 1 | 6 direction movement recognition |
| 1 | 0 | AND combination of interrupt events |
| 1 | 1 | 6 direction position recognition |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| INT1_THS | 32h | 0 | THS6 | THS5 | THS4 | THS3 | THS2 | THS1 | THS0 |

INT1_THS description

| | |
|---|---|
| THS[6:0] | Interrupt 1 threshold. Default value: 000 0000<br>1LSb = 16mg @FS=2g<br>1LSb = 32 mg @FS=4g<br>1LSb = 62 mg @FS=8g<br>1LSb = 186 mg @FS=16g |

| Name | Add | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---|---|---|---|---|---|---|---|---|---|
| INT1_DURATION | 33h | 0 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

INT1_DURATION description

| | |
|---|---|
| D[6:0] | Duration value. Default value: 000 0000 1 LSb = 1/ODR |

5-6. Power saving control

Data from the acceleration sensor can be obtained by setting MCU to sleeping mode to wakeup mode in every fixed time. Also, in acceleration sensor, it can be obtained by interrupting when there is a vibration lager the certain amount. This is able because the sensor collects the vibration in sleeping mode.

In order to set the acceleration sensor to low energy mode, set the sensor chip to power-down mode. The sensor is on power-down mode when it is turned on.

Migration of Power-down mode and Active mode is able in the function bellow.

Function

lis3dh.setDataRate(parameter) : Data Rate configuration function(parameter)

Reading of library

#include < Adafruit_LIS3DH.h >

| Data Rate Parameters | Operation |
|---|---|
| LIS3DH_DATARATE_50_HZ | normal mode 50Hz : Acrtion at Data rate 50Hz |
| LIS3DH_DATARATE_1_HZ | normal mode 1Hz : Actioin at Data rate 1Hz |
| LIS3DH_DATARATE_POWERDOWN | Power Down mode : doesn't act |

Example of scetch

```
#include <Adafruit_LIS3DH.h>
Adafruit_LIS3DH lis3dh = Adafruit_LIS3DH();
void setup() { }
void loop() {
    lis3dh.setDataRate (LIS3DH_DATARATE_POWERDOWN);
}
```

## 6. Revision history

Rev A1.0: First edition, August 2019