Digital Type Ambient Light Sensor

Description

WH81120UF is a light to digital converter which combines photodiodes, current amplifiers, analog circuit and digital signal processor.

Ambient light sensor (ALS) built-in an optical filter for IR rejection, and providing a spectrum which is close to the human eye's response. ALS can work from dark to direct sunlight, the selectable detect range is about 40dB. Dual-channel output (human eye), so it has excellent light ratio under different light conditions. ALS has excellent light ratio under different light conditions.

WH81120UF has programmable interrupt function with high / low threshold.

Features

- Compact surface mount package 2.0x2.0x0.7mm
- I^2C interface (Fast Speed Mode at 400kHz/s)
- Dedicated Interrupt Pin
- Supply Voltage Range from 1.7V to 3.6V
- Operating Temperature Range from-40°C to +85°C
- Ambient Light Sensor
  - Close to human eyes responsibility
  - Up to 16-bit Digital Output
  - Programmable Dynamic Range Ratio = x1 : x4 : x16: x64: x256
  - Linear Output Code for Dynamic Range Selection
  - Eliminate 50 / 60 Hz Filter by Programmable Integrated Time
  - Fluorescent light flicker immunity

Applications
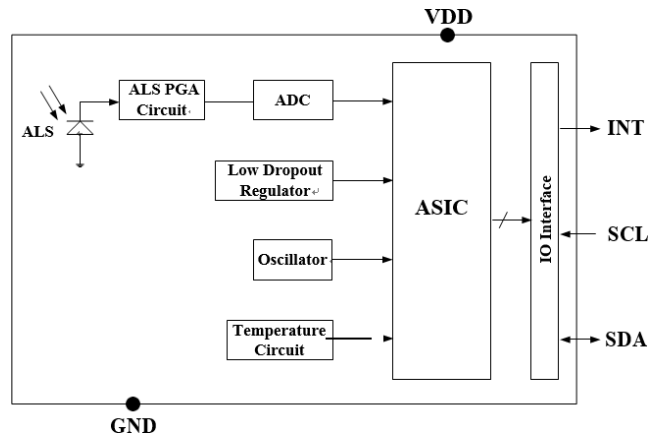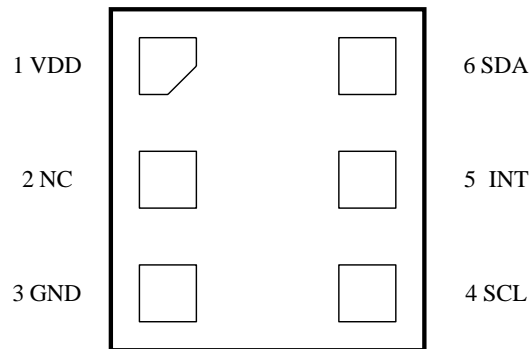
- Cell Phone and LCD display backlight control
- Notebook/Monitor Security
- Automatic Menu Pop
- Digital Camera light meter

Block Diagram

Fig. 1 Block Diagram

I/O Pins Configuration

Pin	I/O Type	Pin Name	Description
1		VDD	Power supply
2		NC	NO Connect
3		GND	Ground
4	I	SCL	I^2C serial clock line
5	O	INT	Interrupt pin
6	I/O	SDA	I^2C serial data line

Absolute Maximum Ratings*

| Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	4.5	V
I²C Bus Pin Voltage	V_{SCL}, V_{SDA}, V_{INT}	-0.2 to 4.5	V
I²C Bus Pin Current	I_{SCL}, I_{SDA}, I_{INT}	10	mA
LDR Pin Voltage	V_{LEDC}	-0.2V to VDD + 0.5V	V
Operating Temperature	T_{ope}	-40 to +85	˚C
Storage Temperature	T_{stg}	-45 to +100	˚C
ESD Rating	Human Body Mode	2	KV

*Note : Exceeding these ratings could cause damage to the device. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.

Recommended Operation Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage [Note1,2]	V_{DD}	1.7		3.6	V	
I²C Bus Pin Voltage [Note2]	V_{Bus}		VDD			VDD=VBUS
Operating Temperature	T_{ope}	-40		+85	˚C	
I²C Bus Input High Voltage [Note2]	V_{IH_SCL}, V_{IH_SDA}	VDD *0.7			V	
I²C Bus Input Low Voltage [Note2]	V_{IL_SCL}, V_{IL_SDA}			VDD *0.3	V	
SDA Output Low Voltage	V_{OL_SDA}	0		0.4	V	3mA sinking current
		0		0.6	V	6mA sinking current
INT Output Low Voltage	V_{OL_INT}	0		0.4	V	3mA sinking current

Notes:

1. The power supply need to make sure the VDD slew rate at least 0.5V/ms. WH81120UF have power on reset function. When VDD drops below 1.4V under room temp, the IC will be reset automatically. Then power back up at the requirement slew rate, and write registers to the desired values.

2. The IC power supply sequence is shown in below

3. The specs are defined under VDD=3.3V, T=25°C

T_stable > 1ms

VDD

$VDD \geq V_{SDA}, V_{SCL}$

SDA, SCL
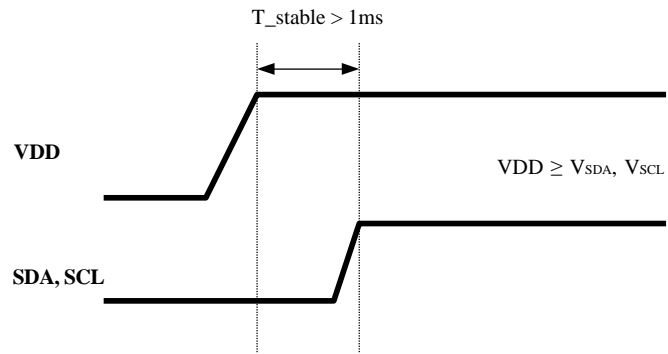
Electrical & Optical Specifications

Unless otherwise specified, the following specifications apply over the operating ambient temperature T=25°C, VDD = 3.3V, and measure the output current by white light LED.

| Electrical Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Active Supply Current	I_{DD1}		40		Ev=0 , Note 1	µA
	I_{DD2}		8		Ev=0 , Note 2	µA
	I_{PD}		2		Sleep mode ,Ev=0, Brown out disable	µA
Device Boot Time	T_{boot}		20		Note 3	ms

Notes :

1. ALSCONV=1, INTE_TIME=64, WUNIT=1T(8ms), WSTEP=64
2. ALSCONV=1, INTE_TIME=64, WUNIT=8T(64ms), WSTEP=62
3. The Device Boot Time (T_{boot}) is the delay time that the host can send the first I2C command after the VDD ready

ALS Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Sensing Gain, relative to x1 setting	AGAIN		4/16/64/256			
ALS ADC integration time step size			1.17			ms
ALS ADC number of integration unit	ALSCONV	1		16		unit
ALS ADC number of integration steps	INTE_TIME	1		64		step
Full scale ADC counts per step				1023		count
Full scale ADC counts value				65535		count
Dark count(white LED , Ev=0 lux)	ALS_L		0	5	AGAIN=256 ATIME=64	count
ALS ADC count value (white LED , Ev=100lux)	ALS_L		10680		AGAIN=256 ATIME=64	count
ALS ADC count value (white LED , Ev=100lux)	ALS_L		106		AGAIN=256 ATIME=64 1 * INT_TIME	Count/lux
Digital Resolution			0.008		IT=100ms , AGAIN=256	Lux/count
Detectable Min. Illuminance			0.01		IT=100ms , AGAIN=256	lux
Detectable Max. Illuminance			110000		IT=100ms , AGAIN=1~256	lux

State Machine

There is one prime operation mode ALS. The state machine is shown below:
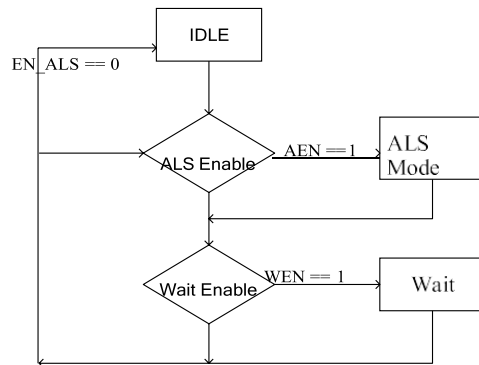
Typical Characteristics Curves

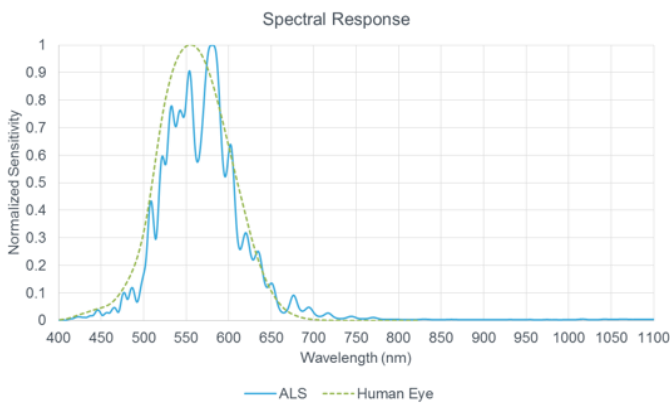Unless otherwise specified, the following specifications apply over the operating ambient temperature T = 25°C, VDD = 3.3V.

Fig. 1 Spectral Response

Fig. 2 Angular Response
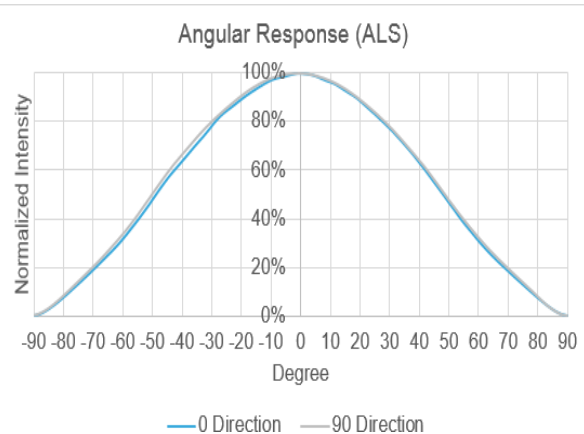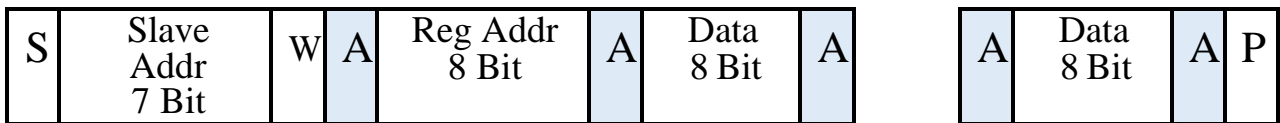
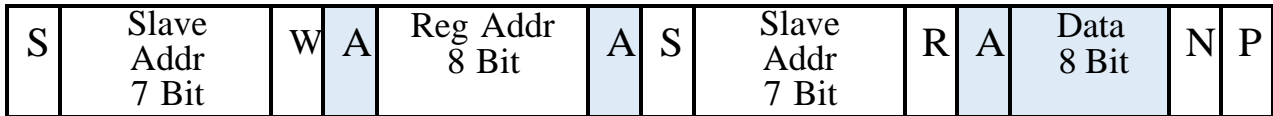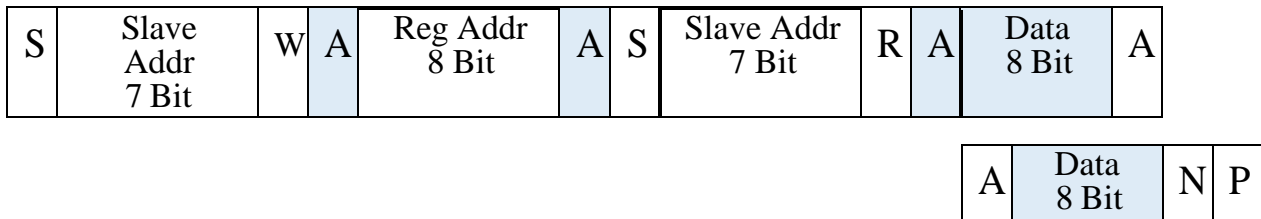## I²C Write

S	Slave Addr 7 Bit	W	A	Reg Addr 8 Bit	A	Data 8 Bit	A	P

I²CBlock Write

S	Slave Addr 7 Bit	W	A	Reg Addr 8 Bit	A	Data 8 Bit	A		A	Data 8 Bit	A	P

I²CRead

S	Slave Addr 7 Bit	W	A	Reg Addr 8 Bit	A	S	Slave Addr 7 Bit	R	A	Data 8 Bit	N	P

I²CBlock Read

S	Slave Addr 7 Bit	W	A	Reg Addr 8 Bit	A	S	Slave Addr 7 Bit	R	A	Data 8 Bit	A

A	Data 8 Bit	N	P

☐ Master to Slave

☐ Slave to Master

| S | Start Condition, 1 Bit Stop Condition, |

| P | 1 Bit |

| W | Write, Set 0 for write, 1 Bit |

| R | Read, Set 1 for read, 1 Bit |

| A | Acknowledge(ACK), Set 0, 1 |

| N | Bit |

Non acknowledge(NACK), Set 1, 1 Bit

I²C Slave Address and R/W bit

This address is seven bits long followed by an eighth bit which is a data direction bit (R/W). A '0' indicates a transmission (WRITE), a '1' indicates a request for data (READ). The slave address of this device is 0x38.

Register Set

The WH81120UF is operated over the I2C bus with registers that contain configuration, status, and result information. All registers are 8 bits long.

Address	Name	Type	Default value	Description
0x00	SYSM_CTRL	R/W	0x00	ALS/PS/CALIB operation mode control, waiting mode control, SW reset
0x01	INT_CTRL	R/W	0x01	Interrupt pin control, interrupt persist control
0x02	INT_FLAG	R/W	0x00	Interrupt flag, error flag, power on reset(POR) flag
0x03	WAIT_TIME	R/W	0x00	Waiting time setting
0x04	ALS_GAIN	R/W	0x00	ALS analog gain setting
0x05	ALS_TIME	R/W	0x03	ALS integrated time setting
0x0B	PERSISTENCE	R/W	0x01	ALS persistence setting
0x0C	ALS_THRES_LL	R/W	0x00	ALS low interrupt threshold - LSB
0x0D	ALS_THRES_LH	R/W	0x00	ALS low interrupt threshold - MSB
0x0E	ALS_THRES_HL	R/W	0xFF	ALS high interrupt threshold - LSB
0x0F	ALS_THRES_HH	R/W	0xFF	ALS high interrupt threshold - MSB
0x17	DATA_STATUS	R/W	0x00	Data status
0x1E	ALS_DATA_L	R	0x00	ALS channel output data - LSB
0x1F	ALS_DATA_H	R	0x00	ALS channel output data - MSB
0xBC	PROD_ID_L	R	0x11	Product ID - LSB
0xBD	PROD_ID_H	R	0x10	Product ID - MSB

0x00 SYSM_CTRL

0x00	SYSM_CTRL, System Control (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	SWRST	EN_ WAIT	EN_ FRST	0	0	0	EN_ ONCE	EN_ ALS

SWRST： Software reset. Reset all register to default value.

    0: (Default)

    1: Reset will be triggered.

EN_WAIT：Waiting time will be inserted between two measurements.

    0: Disable waiting function. (Default)

    1: Enable waiting function.

EN_FRST：

    0: Enable (Brown out Reset circuit enable). (Default)

    1: Disable (Brown out Reset circuit disable).

EN_ONCE ： Enables ALS function once.

    0: Disable ALS function. (Default)

    1: Enable ALS function.

EN_ALS： Enables ALS function.

    0: Disable ALS function. (Default)

    1: Enable ALS function

0x01 INT_CTRL

0x01	Interrupt Pin Control (Default = 0x01)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	ALS_ SYNC	0	0	0	EN_ AINT

ALS_SYNC ： **Measurement is pended when ALS interrupt is triggered. Until clear the interrupt then start the next measurement.**

    0: Disable pending ALS function.(Default)

    1: Enable pending ALS function.

EN_AINT : The ALS interrupt (INT_ALS) flag can trigger the INT pin to low.

    0: Disable **INT_ALS** effect INT pin.

    1: Enable **INT_ALS** effect INT pin. (Default)

0x02 INT_FLAG

0x02	INT_FLAG, System Control (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	INT_ POR	DATA_ FLAG	0	0	0	0	0	INT_ALS

INT_POR : Power-On-Reset Interrupt flag trigger the INT pin when the flag sets to one. Write zero to clear the flag.

    0:

    1: This bit will be set to one when it satisfy one of the following conditions:

- Power On
- VDD < 1.4V
- SWRST

DATA_FLAG : It shows if any data is invalid after completion of each conversion cycle. This bit is read-only.
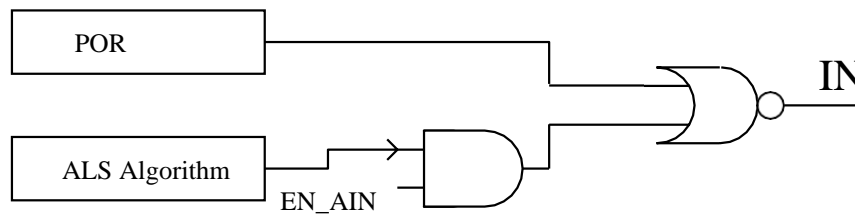
    0: Data valid.

    1: Data invalid.

INT_ALS : ALS Interrupt flag. It correlation with CH0/1 data and ALS high/low threshold. Write zero to clear the flag.

    0: ALS interrupt not triggered or be cleared.

    1: ALS interrupt triggered

Interrupt Behavior

The interrupt pin will be pulled low when POR occur or ALS interrupt trigger.

ALS Interrupt Algorithm

Correlative register:

The ALS Interrupt (**INT_ALS, register 0x02, bit0).**

The ALS Persistence (**PRS_ALS**, register 0x0B, bit0 to bit3),

The ALS Data (**ALS channel data**, register 0x1E to 0x1F),

The ALS Low Threshold (**ALS_THRES_L**, register 0x0C to 0x0D),

The ALS High Threshold (**ALS_THRES_H**, register 0x0E to 0x0F)

INT_ALS triggered condition:

1. Rule of active interrupt: **DATA**>**ALS_THRES_H** or **DATA**<**ALS_THRES_L.**
2. If the **DATA** meets the rule, the **interrupt** count increases one.
   If the **DATA** fails in the rule, the interrupt count will be clear.
3. When the **interrupt** count equal to **PRS_ALS setting**, **INT_ALS** will be triggered and reset the interrupt counter.
4. If **PRS_ALS** is set to zero, **threshold** will be ignored and **DATA** will meets the active interrupt rule forcibly.
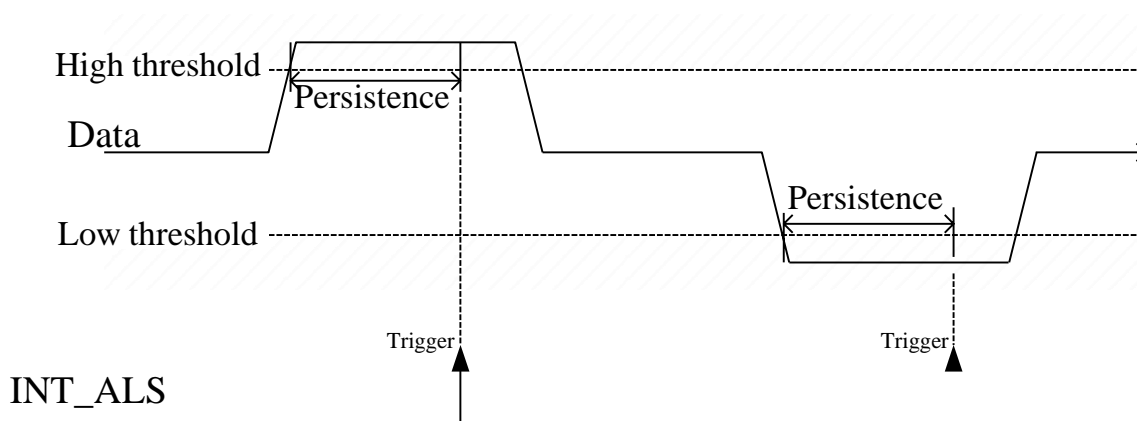
0x03 WAIT_TIME

0x03	WAIT_TIME, waiting time (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	WTIME_UNIT		WTIME					

WTIME_UNIT   :   This register controls the waiting time unit of waiting state which is inserted between any two measurements. It is 8 ms per time unit.

0x0: 1 time unit. (Default)

0x1: 2 time units.

0x2: 4 time units.

0x3: 8 time units.

WTIME_STEP   :   This register controls the time step of waiting state. It is increase one WTIME_UNIT per step.

0x00: 1 WTIME_UNIT. (Default)

0x01: 2 WTIME_UNIT.

0x3f: 64 WTIME_UNIT.

Total waiting time = **WTIME_STEP x WTIME_UNIT**

0x04 ALS_GAIN

0x04	ALS_GAIN, ALS analog gain (Default = 0x01)							
BIT	7	6	5	4	3	2	1	0
R/W	PD_SEL	0	0	PGA_ALS				

PD_SEL   :   PD gain select.

0x00: x1 (Default)

0x01: x2

PGA_ALS   :   ALS sensing gain.

0x01: x1 (Default)

0x02: x4

0x04: x16

0x08: x64

0x10: x256

0x05 ALS_TIME

0x05	ALS_TIME, ALS integrated time (Default = 0x03)							
BIT	7	6	5	4	3	2	1	0
R/W	ALSCONV				0	0	INT_TIME	

ALSCONV：This register controls the conversion time of AD converter at ALS mode (T_{ALS}), and the resolution of output dat.

    0x0: T_{ALS} = 1* INT_TIME (Default)

    0x1: T_{ALS} = 2 * INT_TIME

    0xf: T_{ALS} = 16 * INT_TIME

INT_TIME：This register controls the integrated time.

    0x0: INT_TIME (T) = 1.171 ms, the maximum count of **output data is** 1023.

    0x1: INT_TIME (4T) = 4.683 ms, the maximum count of **output data is** 4095.

    0x2: INT_TIME (16T) = 18.731 ms, the maximum count of **output data is** 16383.

    0x3: INT_TIME (64T) = 74.923 ms, the maximum count of **output data is** 65535. (Default)

    The conversion time of ALS function (T_{ALS}) is decided by **ALSCONV and INT_TIME**.

    T_{ALS}= **INT_TIME** x (**ALSCONV** + 1)   (ms)

    EX:

    Setting INT_TIME= 0x01 (4T UNIT) and ALSCONV = 0x01

    The maximum count of **output data is** minimum of

    [1024 x [INT_TIME * (ALSCONV+1)] - 1 , 65535]

    = [1024 x [4 * (1+1)] - 1, 65535].

0x0B PERSISTENCE

0x0B	PERSISTENCE, ALS persistence setting (Default = 0x01)							
BIT	7	6	5	4	3	2	1	0
R/W	0			INT_SRC	PRS_ALS			

INT_SRC ： **This register sets to select the ALS data for the ALS Interrupt algorithm.**

    0x00: Select ALS_DATA. (Default)

    0x01: Select COMP_DATA.

PRS_ALS：This register sets the numbers of similar consecutive ALS interrupt events before the interrupt pin is triggered.

0x0: Every ALS conversion is done.

0x1: 1 ALS interrupt event is asserted. (Default)

0xf: 15 consecutive ALS interrupt events are asserted.

0x0C/0x0D ALS_THRES_L

0x0C 0x0D	ALS_THRES_L, ALS low interrupt threshold (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R/W	ALS_THRE_LL							
R/W	ALS_THRE_LH							

This register sets the lower threshold value of ALS interrupt. The interrupt algorithm compares the selected ALS data and ALS threshold value.

ALS_THRE_LL：ALS lower interrupt threshold value, LSB. (Reg. 0x0C)

ALS_THRE_LH：ALS lower interrupt threshold value, MSB. (Reg. 0x0D)

0x0E/0x0F ALS_THRES_H

0x0E 0x0F	ALS_THRES_H, ALS high interrupt threshold (Default = 0xFFFF)							
BIT	7	6	5	4	3	2	1	0
R/W	ALS_THRE_HL							
R/W	ALS_THRE_HH							

This register sets the high threshold value of ALS interrupt. The interrupt algorithm compares the selected ALS data and ALS threshold value.

ALS_THRE_HL：ALS high interrupt threshold value, LSB. (Reg. 0x0E)

ALS_THRE_HH：ALS high interrupt threshold value, MSB. (Reg. 0x0F)

0x17 DATA_STATUS

0x17	DATA_STAT_0, Data status							
BIT	7	6	5	4	3	2	1	0
R	DATA_ REDY	0	0	0	0	0	SAT_ ALS	SAT_ COMP

This register indicates the ALS data status.

The data ready flag will set to one when the data register is updated. After read the data register, the data ready flag will clear to zero.

If the ALS data is outside of measurable range, the corresponding saturation flag will set to one. That means the data is invalid.

0x1E/0x1F ALS_DATA

0x1E 0x1F	ALS_DATA, ALS channel output data.							
BIT	7	6	5	4	3	2	1	0
R	ALS_DATA_L							
R	ALS_DATA_H							

The result of ALS sensor is written into ALS_DATA when ALS conversion is done.

For insuring the data in the register comes the same measurement, the high byte data will be latched when the low byte data has being accessed until the high byte data has be read..

I²C Interface Timing Characteristics

This section will describe the protocol of the I²C bus. For more details and timing diagrams please refer to the I²C specification.
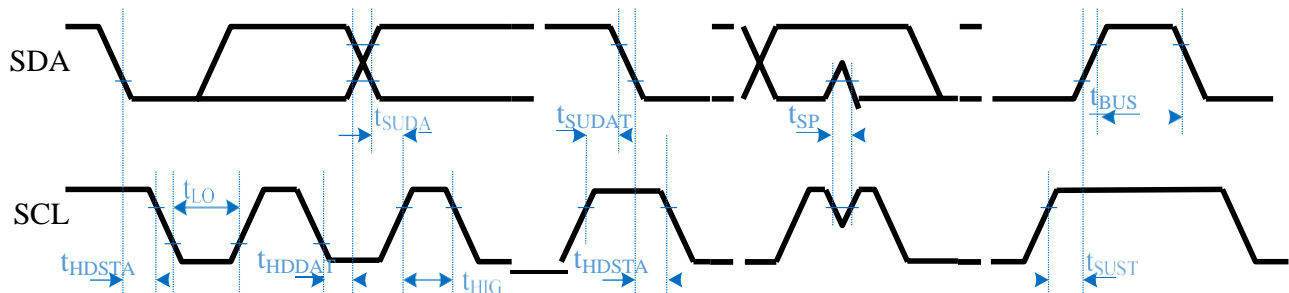
Parameter (*)	Symbol	Fast mode		Unit
		Min	Max	
SCL clock frequency	f_{SCL}	100	400	kHz
Bus free time between STOP condition and START condition	t_{BUS}	1.3	--	µs
LOW period of the SCL clock	t_{LOW}	1.3	--	µs
HIGH period of the SCL clock	t_{HIGH}	0.6	--	µs
Hold time (repeated) START condition	t_{HDSTA}	0.6	--	µs
Set-up time (repeated) START condition	t_{SUSTA}	0.6	--	µs
Set-up time for STOP condition	t_{SUSTO}	0.6	--	µs
Data hold time	t_{HDDAT}	50	--	ns
Data set-up time	t_{SUDAT}	100	--	ns
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	0	50	ns
Rise time of both SDA and SCL signals		20 x VDD/5.5	300	ns
Fall time of both SDA and SCL signals		20 x VDD/5.5	300	ns

(*) Specified by design and characterization; not production tested.

(**) All specifications are at V_{Bus} = 3.3V, T_{ope}=25ºC, unless otherwise noted.

Note:

I²CBus Clear

In the unlikely event where the clock (SCL) is stuck LOW, the preferential procedure is to reset the bus using the HW reset signal if your I2C devices have HW reset inputs. If theI2C devices do not have HW reset inputs, cycle power to the devices to activate the mandatory Internal Power-On Reset (POR) circuit.

If the data line (SDA) is stuck LOW, the master should send nine clock pulses. The device that held the bus LOW should release it sometime within those nine clocks.

I²C General Call Software Reset

Following a General Call, (0000 0000), sending 0000 0110 (06h) as the second byte causes software reset. This feature is optional and not all devices will respond to this command. On receiving this 2-byte sequence, all devices designed to respond to the general call address will reset and take in the programmable part of their address.

Precautions have to be taken to ensure that a device is not pulling down the SDA or SCL line after applying the supply voltage, since these low levels would block the bus.

Application Circuit
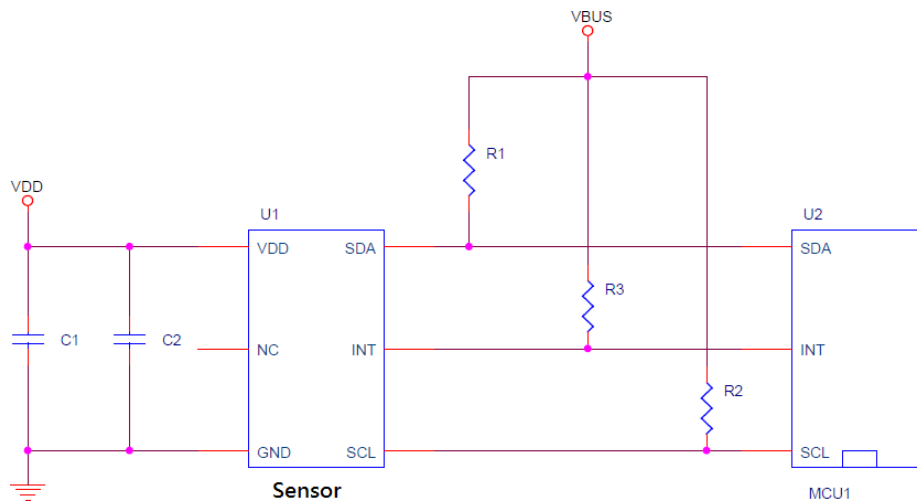
The capacitors (C1, C2) are required for power supply. The capacitors should be placed as close as possible to the device. The high frequency AC noises can be shunted to the ground by the capacitors. The transient current caused by digital circuit switching also can be handled by the capacitors. A typical value 0.1 / 1 µF can be used.
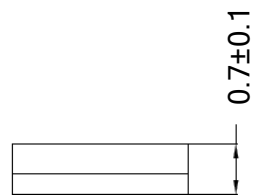
The pull-up resistors (R1, R2) are required for I²C communication. At fast speed mode (400kHz/s) and VBUS = 3.3V, 2.2kΩ resistors can be used. The pull-up resistor (R3) is also required for the interrupt, a typical value between 10 kΩ and 100 kΩ can be used.

Package Outline Drawing

Top View

2.0±0.1

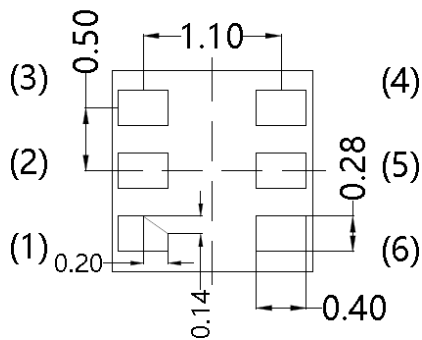PD

(1)

(2)   PD Center

(3)

(6)

(5)

(4)

2.0±0.1

Front View

0.7±0.1
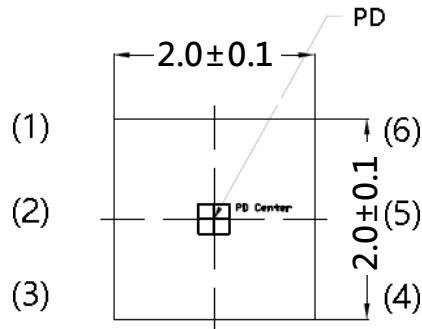
Right Side View

Bottom View

0.50

1.10

(3)

(2)

(1) 0.20

(4)

(5)

(6)

0.28

0.14

0.40

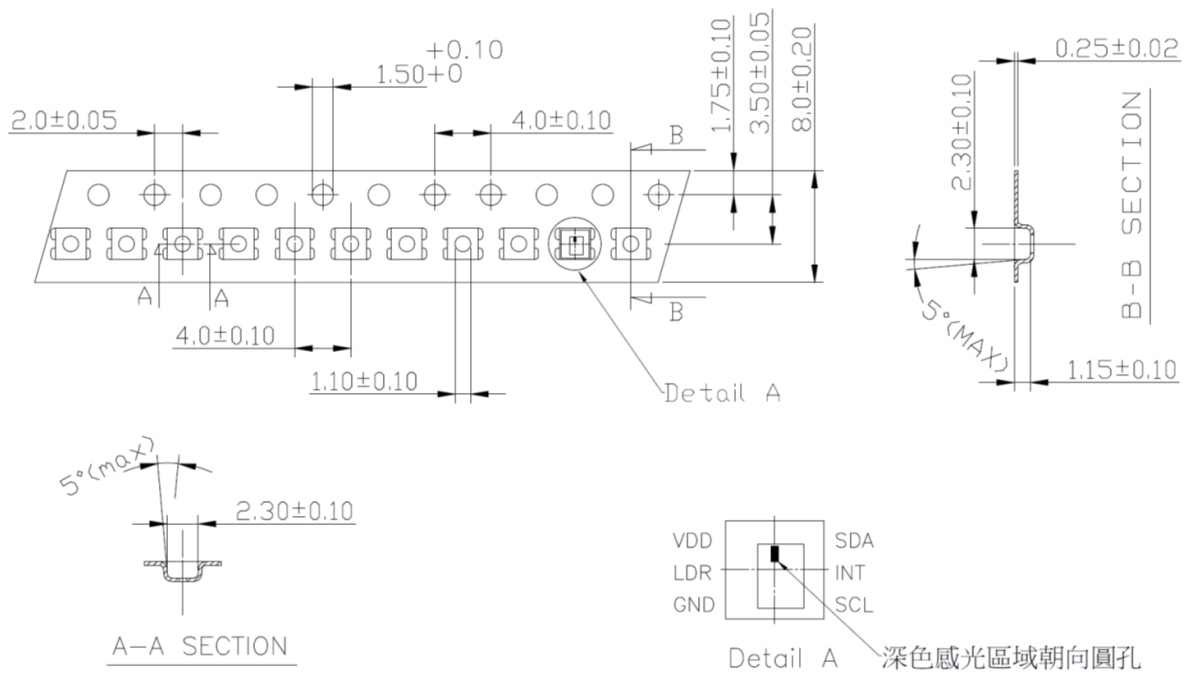| Pin-out	Name
(1)	VDD
(2)	NC
(3)	GND
(4)	SCL
(5)	INT
(6)	SDA

Recommended Land Pattern
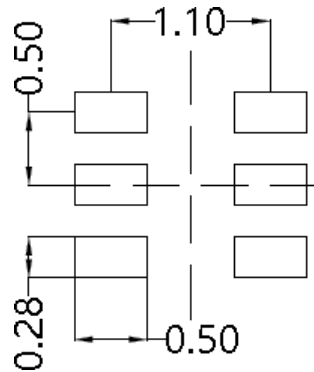
Notes :

1. All dimensions in millimeters.
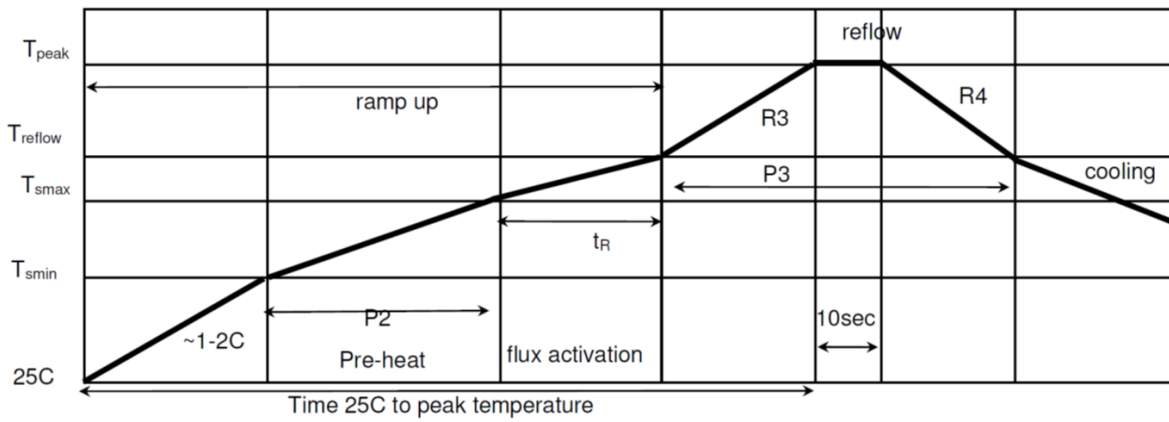
2. Dimension tolerance is ± 0.1mm unless otherwise noted

   .

Package Tape and Reel

Unit: mm

12.0±0.5
(measured at hub)

60±0.50

9.50±0.5
(measured at hub)

Ø178±1

EIAJ-RRM08B

1.50±0.10

1.20±0.10

W₃ =9.75±1.25
(8-11)

17.4±0.2

Ø13.5±0.5

2±0.5

Recommended Reflow Profile

	Peak temperature (Tpeak)	255-260C (max) ; 10sec
Pre-Heat	Temperature min (Tsmin) Temperature max (Tsmax) P2: (Ts min to Ts max)	150C 2C/sec 150C-217C 100s to 180s 90-110s
Time maintain above	Temperature (Treflow) Time (P3) R3 slope (from 217C -> peak) R4 slope (from peak -> 217C)	217C 60-90sec 2C/sec [typ] -> 2.5C/sec (max) -1.5C/sec [typ]-> -4C/sec (max)
	Time to peak temperature	480s max
	Cooling down slope (peak to 217C)	2-4C/ sec