General Description

SIP3510 is a 3-in-1 light sensor module which integrates high performance ambient light sensor and IR proximity sensor inside, as well as an IR LED which wavelength peak is at 940nm. ALS is used to measure the illuminance of ambient light, proximity sensor is sensitive to the reflective light of objects to IR LED, the response values will be output via an I2C communication port.

There are two ALS channels in SIP3510. Two ultra-high sensitivity, low dark current photodiodes which have specific optical filters on them are key elements of ALS, they simulate the human eye response appropriately, and respond to various of light sources accurately. Precise timing control block and independent gain setting for different channels help to measure wide range of illuminance.

There is one proximity sensor in SIP3510, its proximity photodiode is covered by proper optical filters to match the 940nm IR LED emitter, as well as filtering out the noise of ambient light, the build-in signal chain also will do ambient light cancellation and noise suppression, make proximity sensor getting higher SNR response to the reflective light from objects. A configurable IR LED driver is designed into SIP3510, to drive the inside module 940nm IR LED emitter. The IR LED driver supports factory calibration to get better consistence of proximity response, and help to get better user experience at object detection application.

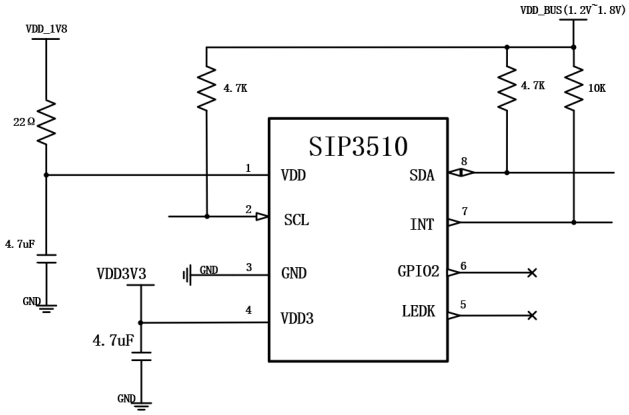
Key Features

- Sensor uses 1.8V power supply, IR LED emitter uses 3.3V supply, IO voltage is compatible to 1.2V and 1.8V
- ALS:
  - Photopic + IR two channels design
  - Ultra-high sensitivity, low noise, low dark current
  - Integration time is configurable, gain setting is independently for ALS channels
- IR proximity sensor:
  - High sensitivity, low noise
  - Ambient light cancellation, crosstalk compensation
  - Integrated IR LED driver and emitter
  - LED current, pulse length, pulse counts, gain are configurable
  - Filters for noise suppression
- 1MHz I2C communication frequency
- Low power consumption design:
  - IDLE mode
  - Sleep mode
- Operation temperature range: -40℃~85℃
- Moisture Sensitivity Level 3
- 8-pin WB LGA packaging， 4.0mm x 1.5mm x 1.0mm

Application

- Mobile phone, PAD display management
- Notebook PC, TV display management

Application Diagram



Content

1 System Description

1.1 Device overview

SIP3510 module includes a sensor die and an IR LED emitter. ALS and proximity sensor are integrated into single sensor die, supports two functions work serially or parallelly. VDD is the supply to sensor die, VDD3 is the supply to IR LED emitter, the IR LED is driven by an IR LED driver in sensor die, INT pin is used to output the internal interrupt events, such like data beyond thresholds event, I2C communication port is used for configuration as well as data output.

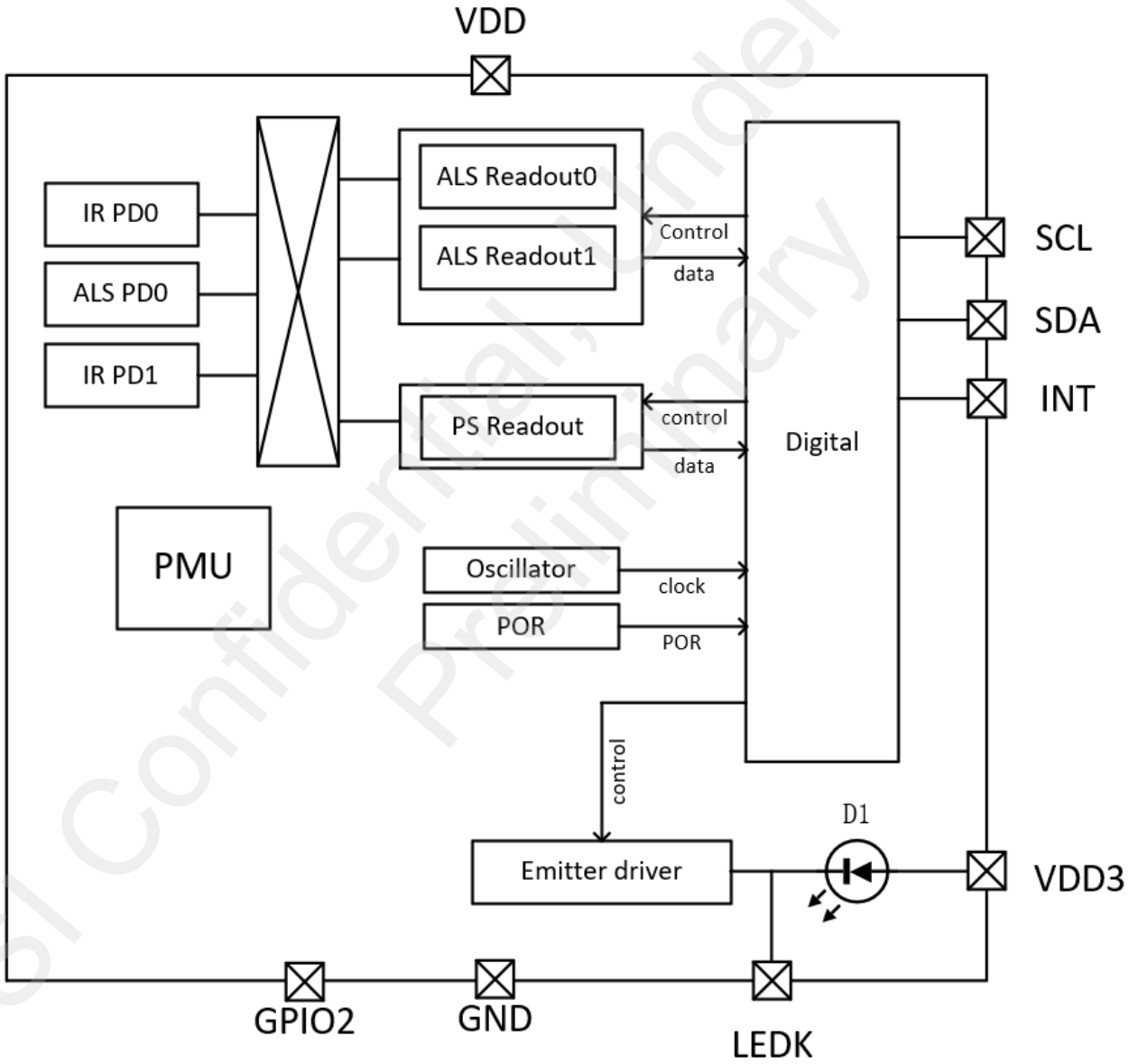


Figure 1-1Block diagram

1.2 Pin configuration and functions

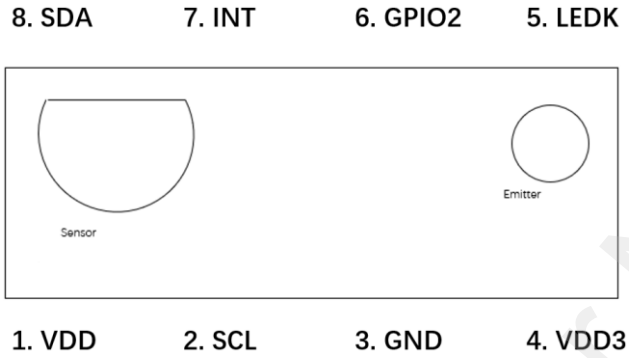


Figure 1-2-1 Pin configuration (top view)

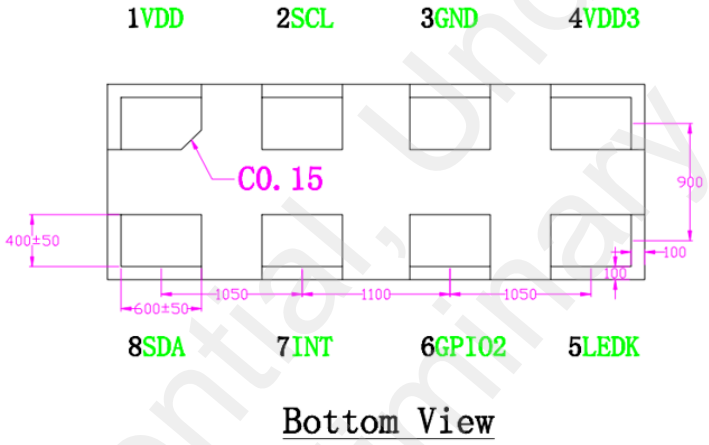


Figure 1-3-2 Pin configuration (bottom view)

Table 1-1Pins functions

#	Name	Direction	Comments
1	VDD	PWR	1.8V power supply
2	SCL	I	I²C serial clock input
3	GND	GND	Ground
4	VDD3	PWR	3.3V IR emitter supply. Connect to IR emitter anode
5	LEDK	O	IR emitter driver output. Connect to IR emitter cathode
6	GPIO2	O	Leave it NC or connect to ground.
7	INT	O	Interrupt output pin, open drain, default active low
8	SDA	I/O	I²C serial data input/output, open drain

1.3 Typical Application

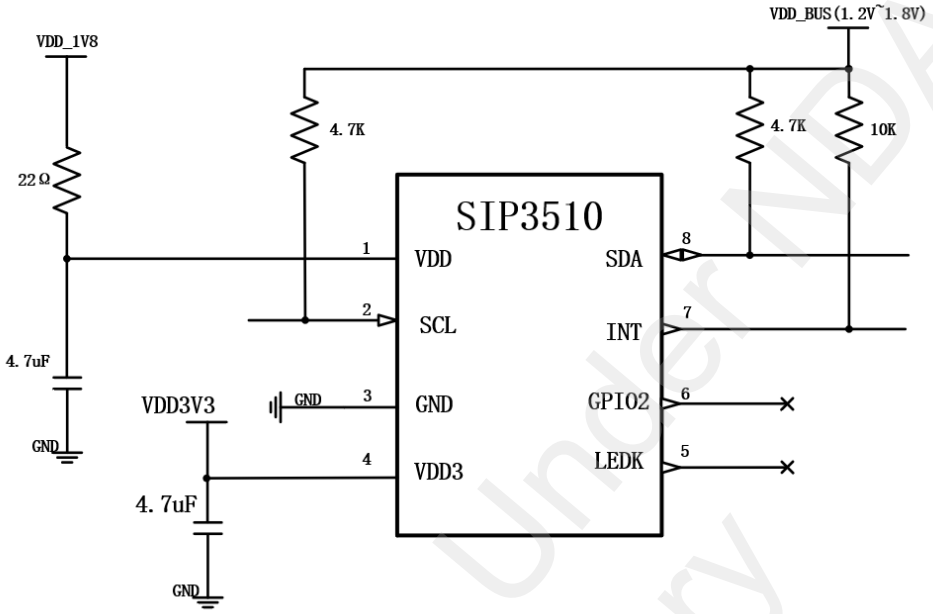


Figure 1-4 SIP3510 application circuits

2 Electrical Characteristics

2.1 Absolute Maximum Rating

Table 2-1 Absolute Maximum Rating

Parameters	Symbol	Min.	Typ.	Max.	Units
Supply voltage	VDD	-0.3		1.98	V
Emitter supply voltage	VDD3	-0.3		3.6	V
Digital Input/Output voltage	SCL, SDA, INT	-0.3		1.98	V
Storage Temperature Range	T_{STG}	-40		85	℃
Moisture Sensitivity Level	MSL		3		
Lead Temperature (Soldering 10 seconds)			260		℃

2.2 ESD Rating

Table 2-2 ESD Rating

Stress Test	Value	Units
Human-body mode (HBM), per ESDA/JEDEC JS-001-2017	±2000	V
Charged-device mode (CDM)， per ESDA/JEDEC JS-002-2018	±500	V

Latch-up	±100	mA

2.3 Recommended Operating Conditions

Parameters	Symbol	Condition	Min.	Typ.	Max.	Units
Supply Voltage	VDD		1.62	1.8	1.98	V
Emitter Supply Voltage	VDD3		2.9	3.3	3.6	V
Operating Ambient Temperature	T_A		-40		85	℃
I2C Com Frequency	f_{I2C}				400	KHz

2.4 Electrical Specifications

Table 2-3 Operating Characteristics with VDD=1.8V, VDD3=3.3V, T_A=25℃ (unless otherwise noted)

Parameters	Symbol	Condition	Min.	Typ.	Max.	Units
SDA, SCL input high voltage	V_{IH}		0.71			V
SDA, SCL input low voltage	V_{IL}				0.44	V
SDA, INT output low voltage	V_{OL}				0.12	V
Oscillator Frequency	f_{OSC}			8.1		MHz
Supply Current	I_{Sleep}	Sleep		0.7		μA
	I_{Idle}	Idle		45		μA
	I_{ALS}	ALS Active		220		μA
	$I_{Proximity}$	Proximity Active (Not include emitter, 1 pulses, pulse length 32μs in 1ms period)		360		μA
ALS characteristics						
CH0 ALS sensitivity			-10%		+10%	counts
CH1 ALS sensitivity			-10%		+10%	counts
ALS Integration Time	T_{ALS_inte}		2.72μ		712m	s
ALS Output Full Range					65535	counts

ALS Dark Current	DCR	Max gain, 100ms integration time		0	3	
ALS Noise		ALS_GAIN = 128x T_{ALS_inte} = 100ms		0.01		%(σ)
Proximity characteristics						
Response: gray card				TBD		Counts
Part to part variation					TBD	%
Response: no target				TBD		Counts
Proximity Noise					TBD	%
Proximity Output Full Range					1023	counts
LED sink current	$ILED_{SINK}$	Detailed equation see Note 1	3.125		246.875	mA

*Note1: $ILED_{SINK}$ = irdvr_rg_led_ctrl[7] *25mA + irdvr_rg_led_ctrl[6:4] *25mA + irdvr_rg_led_ctrl[3:0] *3.125mA

2.5 Optical Characteristics

Figure 2-4-1 SIP3510 ALS Angular Response

Figure 2-4-2 SIP3510 Spectral Responsivity

2.6 Power On Sequence

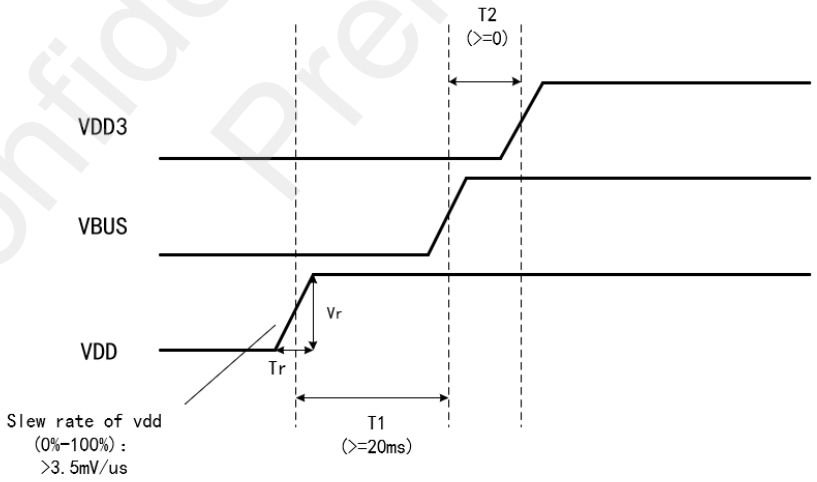


Figure 2-6-1 Recommended SIP3510 Power On Sequence

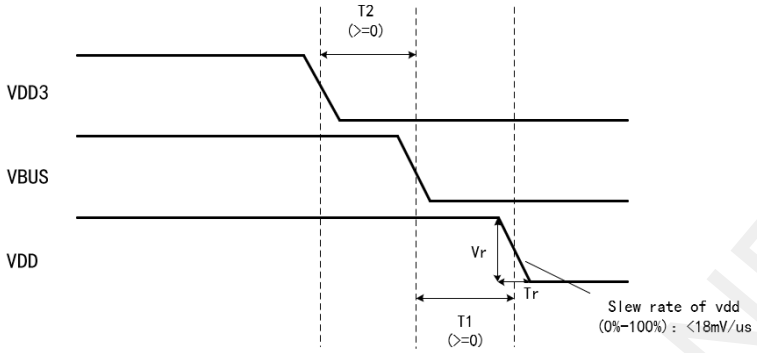


Figure 2-6-2 Recommended SIP3510 Power Down Sequence

2.7 General I²C Operation

The SIP3510 operates as an I²C slave, use 7-bit slave address 0x58.

The I²C bus employs two signals, SDA (data) and SCL (clock), to communicate between integrated circuits in a system. The corresponding pins on the SIP3510 for the two signals are SDA and SCL. The bus transfers data serially, one bit at a time. The address and data 8-bit bytes are transferred most-significant bit (MSB) first. In addition, each byte transferred on the bus is acknowledged by the receiving device with an acknowledge bit. Each transfer operation begins with the master device driving a start condition on the bus and ends with the master device driving a stop condition on the bus. The bus uses transitions on the data terminal (SDA) while the clock is at logic high to indicate start and stop conditions. A high-to-low transition on SDA indicates a start, and a low-to-high transition indicates a stop. Normal data-bit transitions must occur within the low time of the clock period.

The master generates the 7-bit slave address and the read/write (R/W) bit to open communication with another device and then waits for an acknowledge condition. The device holds SDA low during the acknowledge clock period to indicate acknowledgment. When this occurs, the master transmits the next byte of the sequence. Each device is addressed by a unique 7-bit slave address plus R/W bit (1 byte). All compatible devices share the same signals via a bi-directional bus using a wired-AND connection. Use external pull-up resistors for the SDA and SCL signals to set the logic-high level for the bus. Use pull-up resistors between 660 Ω and 4.7 kΩ. Do not allow the SDA and SCL voltages to exceed the device digital interface supply voltage, V_{DD}.

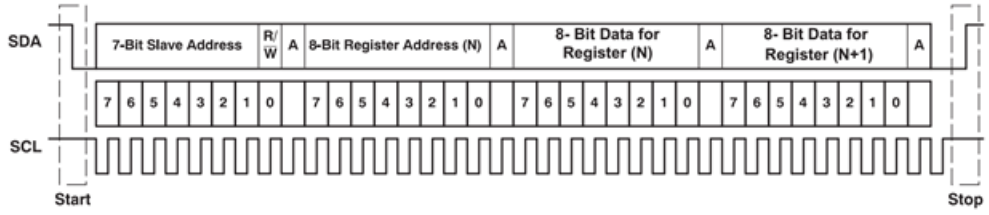


Figure 2-5-1 Typical I²C Sequence

There is no limit on the number of bytes that can be transmitted between start and stop conditions. When the last word transfers, the master generates a stop condition to release the bus. Figure 2-5-1 shows a generic

data transfer sequence.

2.7.1 Single-Byte and Multiple-Byte Transfers

The serial control interface supports both single-byte and multiple-byte read/write operations for all registers. During multiple-byte read operations, the SIP3510 responds with data, a byte at a time, starting at the register assigned, as long as the master device continues to respond with acknowledges. The SIP3510 supports sequential I²C addressing. For write transactions, if a register is issued followed by data for that register and all the remaining registers that follow, a sequential I²C write transaction has taken place. For I²C sequential write transactions, the register issued then serves as the starting point, and the amount of data subsequently transmitted, before a stop or start is transmitted, determines to how many registers are written.

2.7.2 Single-Byte Write

As shown in Figure 2-5-2, a single-byte data-write transfer begins with the master device transmitting a start condition followed by the I²C device address and the read/write bit. The read/write bit determines the direction of the data transfer. For a write-data transfer, the read/write bit must be set to 0. After receiving the correct I²C device address and the read/write bit, the SIP3510 responds with an acknowledge bit. Next, the master transmits the register byte corresponding to the device internal memory address being accessed. After receiving the register byte, the device again responds with an acknowledge bit. Finally, the master device transmits a stop condition to complete the single-byte data-write transfer.

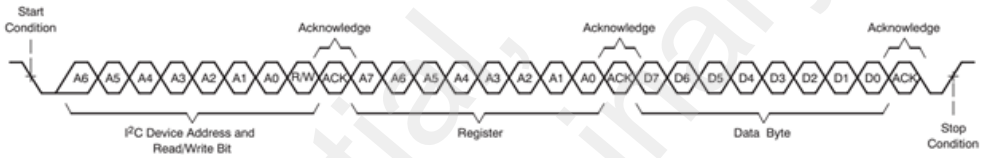


Figure 2-5-2 Single Byte Write transfer

2.7.3 Multiple-Byte Write and Incremental Multiple-Byte Write

A multiple-byte data write transfer is identical to a single-byte data write transfer except that multiple data bytes are transmitted by the master device to the SIP3510 as shown in Figure 2-5-3. After receiving each data byte, the device responds with an acknowledge bit.

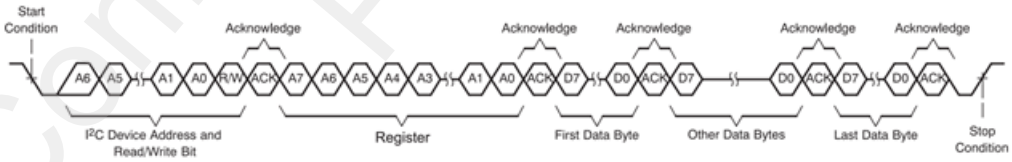


Figure 2-5-3 Multiple-Byte Write transfer

2.7.4 Single-Byte Read

As shown in Figure 2-5-4, a single-byte data-read transfer begins with the master device transmitting a start condition followed by the I²C device address and the read/write bit. For the data-read transfer, both a write followed by a read are actually done. Initially, a write is done to transfer the address byte of the internal memory address to be read. As a result, the read/write bit is set to a 0. After receiving the SIP3510 address and the read/write bit, the device responds with an acknowledge bit. The master then sends the internal memory address byte, after which the device issues an acknowledge bit. The master device transmits another start condition followed by the SIP3510 address and the read/write bit again. This time, the read/write bit is set to 1, indicating a read transfer. Next, the SIP3510 transmits the data byte from the memory address being read. After

receiving the data byte, the master device transmits a not-acknowledge followed by a stop condition to complete the single-byte data read transfer.

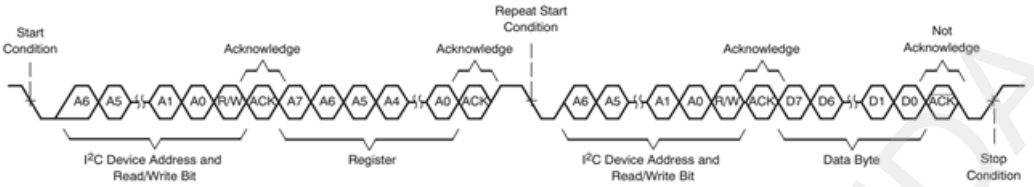


Figure 2-5-4 Single-Byte Read transfer

2.7.5 Multiple-Byte Read

A multiple-byte data-read transfer is identical to a single-byte data-read transfer except that multiple data bytes are transmitted by the SIP3510 to the master device as shown in Figure 2-5-5. With the exception of the last data byte, the master device responds with an acknowledge bit after receiving each data byte.

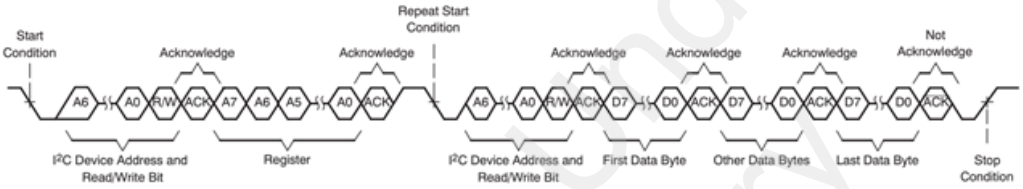


Figure 2-5-5 Multiple-Byte Read transfer

2.7.6 Timing Chart

Parameters	Symbol	Standard-Mode		Fast-Mode		Units
		Min	Max	Min	Max	
SCL clock frequency	f_{scl}	0	100	0	1000	kHz
Hold time (repeated) START condition. After this period, the first clock pulse is generated.	T_s_hd	4		0.6		us
LOW period of the SCL clock	T_low_scl	4.7		1.3		us
HIGH period of the SCL clock	T_high_scl	4		0.6		us
Setup time for a repeated START condition	T_rep_s_su	4.7		0.6		us
Data hold time: For I2C bus devices	T_s_hd	0	3.45	0	0.9	us
Data set-up time	T_s_su	250		100		ns
SDA and SCL Rise Time	Tr_scl		1000	20+0.1xCb	300	ns
SDA and SCL Fall Time	Tf_scl		300	20+0.1xCb	300	ns
Set-up time for STOP condition	T_t_su	4		0.6		us

Bus free time between a STOP and START condition	T_t_buf	4.7		1.3		us
Capacitive load for each bus line	Cb		400		400	pF

3 Fuction Description

3.1 ALS Operation

ALS is used to measure the illuminance of light. The response value is directly proportional to ambient light illuminance, ALS integration time and ALS gain setting. Once ALS is enabled, two ALS channels are doing accumulation simultaneously and periodically, but can have independent gain setting. Host gets two 16-bit ALS channel data from single integration time, and do calculation to generate illuminance result.

SIP3510 support various of ALS interrupts. ALS saturation interrupt, ALS timing error interrupt and ALS data beyond thresholds interrupt, a debounce filter designed for ALS data interrupt. If ALS data is greater than high threshold or lower than low threshold consecutively, and reach the number which is configured to the debounce filter, ALS_INT will be asserted.

3.2 Proximity Operation

Proximity sensor is used to measure the reflective light of detected object to IR emitter. The response is directly proportional to IR emitter power, reflectivity of detected object, and the gain setting of proximity sensor. The IR emitter produces light, when object getting close to SIP3510, the reflective light getting stronger, the proximity sensor can accumulate more energy, and convert to higher proximity data. But ambient light produces noise to proximity sensor response, and also optical stack might bring crosstalk. SIP3510 proximity sensor has design to do ambient light cancellation and crosstalk compensation. Proximity sensor detection consumes very short time, to save power consumption, most of time proximity sensor stays at idle state, proximity period time should be enabled once proximity function is enabled. To get better consistence, crosstalk calibration should be done to alleviate crosstalk caused by optical stack at proper time. And to get higher SNR, SIP3510 also provides two kinds of filter to attenuate the noise.

SIP3510 support various of proximity interrupts. Proximity saturation interrupt, proximity timing error interrupt, proximity data zero interrupt and proximity data beyond thresholds interrupt. If proximity data is greater than high threshold or lower than low threshold consecutively, and reach the number which is configured to the debounce filter, Px_INT will be asserted.

3.3 State machine diagram

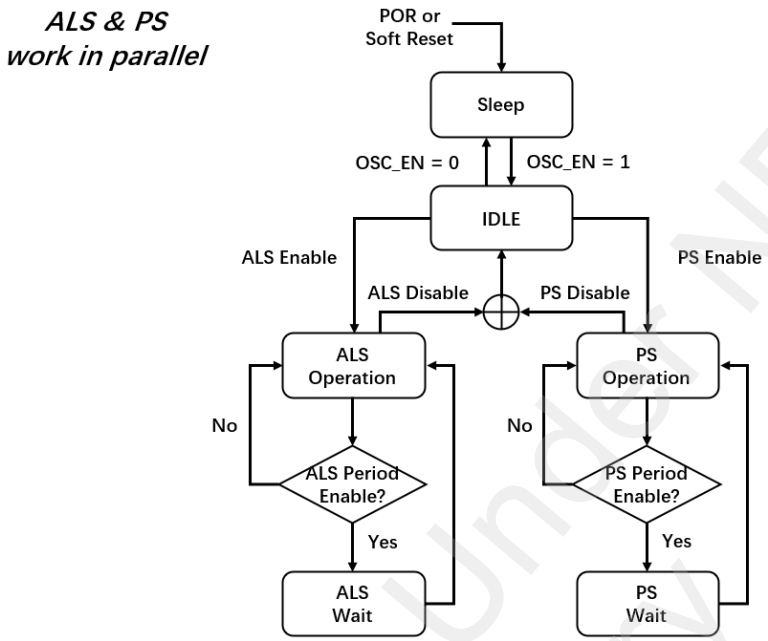


Figure 3-3-1 SIP3512 operation state diagram (parallel)

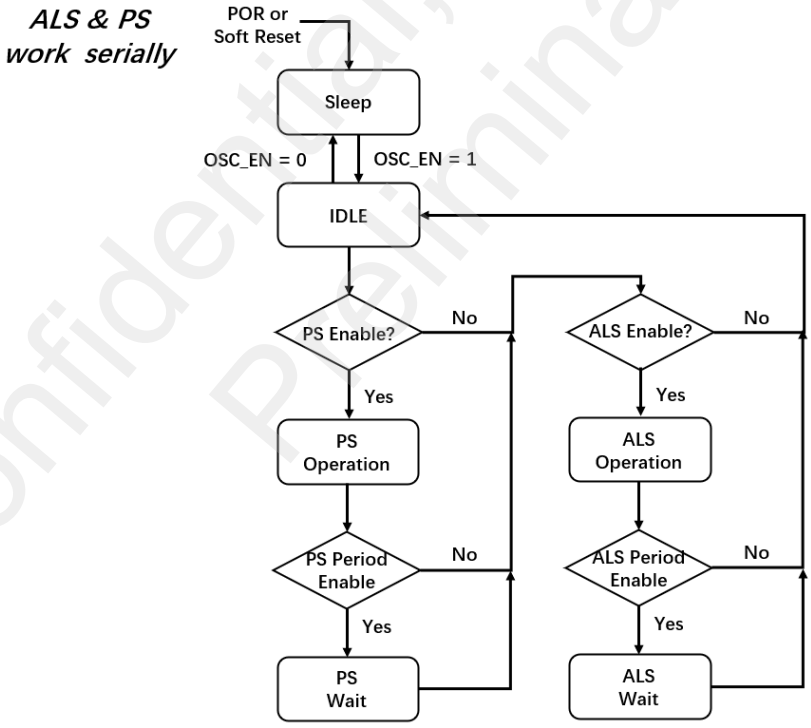
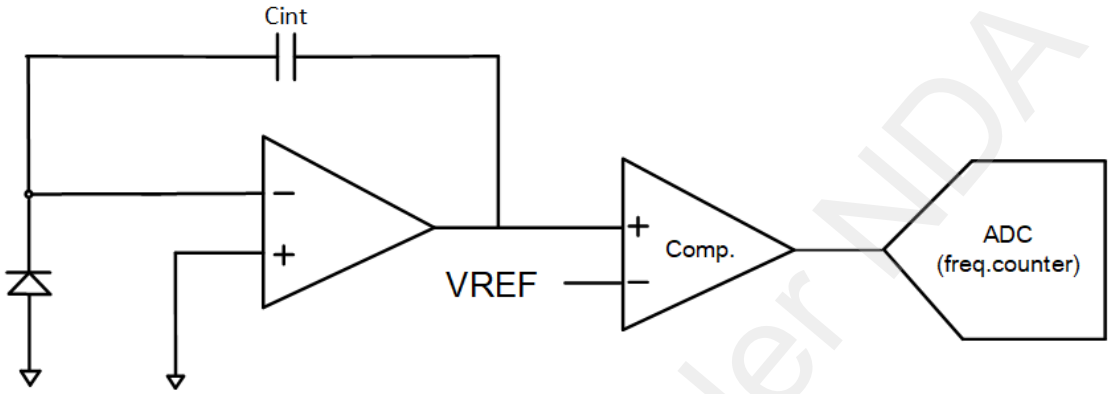


Figure 3-3-2 SIP3512 operation state diagram (serially)

3.4 ADC



A simplied block diagram of ADC architecture is shown above. Output current of light sensitive photodiode is integrated by a low noise integrator. When integrator‘s output exceeds its following comparator threshold, comparator will toggle and the amount of toggling events are recorded by a ripple counter. For proximity readout, a 10 bit ADC is used and for ambient light readout, a 16 bit ADC is used. ADC is designed to have ultra low noise, which can be used to quantize very small light variation.

4 Register Mapping

All communication with the device shall be performed by reading from and writing to the registers. Any reading or writing operation to this device can activate I2C communication mode.

Addr	Register name	R/W	Default	Description
0x02	CLKCTRL	RW	0x1F	Functions clock enable
0x03	ID	R	0x0C	Chip ID register
0x05	CTRL	RW	0x01	OSC enable and reset control
0x06	INTCTRL	RW	0x00	Working mode and INT control
0x08	PSOFFSET_EN	RW	0x00	Proximity offset compensation enable
0x0C	PSENABLE	RW	0x00	Proximity enables and calibration trigger
0x0D	PSCTRL0	RW	0x00	Proximity control register 0
0x0E	PSCTRL1	RW	0x00	Proximity control register 1
0x0F	PSCTRL2	RW	0x10	Proximity control register 2
0x10	P0_THLOW_H	RW	0x00	High data of proximity channel0 interrupt low threshold
0x11	P0_THLOW_L	RW	0x20	Low data of proximity channel0 interrupt low threshold
0x12	P0_THHIGH_H	RW	0x03	High data of proximity channel0 interrupt high threshold
0x13	P0_THHIGH_L	RW	0xD0	Low data of proximity channel0 interrupt high threshold
0x14	P0_GAIN	RW	0x00	Gain setting for proximity channel0
0x15	P0_PULSE	RW	0x10	Pulse number for proximity channel0 in single integration
0x22	PSINT_EN	RW	0xFF	Proximity interrupts enables
0x23	PS_CTRL3	RW	0xC1	Proximity control register 3
0x24	PSPERIOD_STEP	RW	0x00	Proximity period step configuration
0x26	PSPERIOD_TIME	RW	0x00	Proximity period time configuration
0x29	PSRATE_STEP_L	RW	0x00	Low data of proximity sample rate step configuration
0x2A	PSRATE	RW	0x00	Proximity sample rate configuration
0x2B	P0_PULSELEN_L	RW	0x40	Low data of pulse length for proximity channel0
0x2D	PS_PULSELEN_H	RW	0x00	High data of pulse length for proximity channel0
0x39	PSOFFSET_SEL	RW	0x00	Offset compensation selection for proximity
0x3A	PSCALI_CTRL	RW	0x00	Proximity offset calibration control register
0x3B	P0_OFFSET3_H	RW	0x00	High data of third offset value for proximity channel0
0x3C	P0_OFFSET3_L	RW	0x00	Low data of third offset value for proximity channel0

0x3D	P0_OFFSET2	RW	0x00	Second offset value for proximity channel0
0x3E	P0_OFFSET1	RW	0x00	First offset value for proximity channel0
0x48	IRDVR_RG_CTRL	RW	0x01	**LED enable**
0x4C	IRCURR_CTRL0	RW	0x05	Low data of IR current for proximity channel0
0x50	ALSENABLE	RW	0x00	ALS enables
0x51	ALS_CTRL0	RW	0x10	ALS control register 0
0x52	ALS_CTRL1	RW	0x10	ALS control register 1
0x54	ALS_THLOW_H	RW	0x00	High data of ALS interrupt low threshold
0x55	ALS_THLOW_L	RW	0x20	Low data of ALS interrupt low threshold
0x56	ALS_THHIGH_H	RW	0xFF	High data of ALS interrupt high threshold
0x57	ALS_THHIGH_L	RW	0xD0	Low data of ALS interrupt high threshold
0x5C	ALSPERIOD_STEP	RW	0x00	ALS period step configuration
0x5E	ALSPERIOD_TIME	RW	0x00	ALS period time configuration
0x5F	ALSINT_EN	RW	0x0F	ALS interrupts enables
0x60	ALS_GAIN	RW	0x00	Gain setting for ALS channel 0 and channel 1
0x61	ALSINTE_TIME_M	RW	0x8C	Middle data of ALS integration time
0x62	ALSINTE_TIME_L	RW	0xA0	Low data of ALS integration time
0x64	ALSAZ_CTRL	RW	0x00	ALS auto zero control
0x65	ALSAZ_EN	RW	0xF0	ALS auto zero enables
0x67	RESERVE1	RW	0x00	Reserved registers, should configured to 0x08
0x69	RESERVE2	RW	0x00	Reserved registers, should configured to 0x08
0x8D	PSINT_STATUS	RW	0x00	Proximity interrupts status
0x8E	ALSINT_STATUS	RW	0x00	ALS interrupts status
0xA0	P0DATA_H	R	0x00	High data of proximity channel0 data
0xA1	P0DATA_L	R	0x00	Low data of proximity channel0 data
0xA4	ALS0DATA_H	R	0x00	High data of ALS channel0 data
0xA5	ALS0DATA_L	R	0x00	Low data of ALS channel0 data
0xA6	ALS1DATA_H	R	0x00	High data of ALS channel1 data
0xA7	ALS1DATA_L	R	0x00	Low data of ALS channel1 data
0xA8	DATA_VALID	R	0x00	Data valid status of proximity and ALS

4.1 CLKCTRL (0x02) (default:0x1F)

Bit	Name	R/W	default	Description
7	---	---	0	Reserved and Unused
6	LOWPOWER_EN	RW	0	When write"1", will enable low power mode which can help to save more power when sensor is in wait state
5	---	---	0	Reserved and Unused
4	CLK_ALS_EN	RW	1	Clock enable for ALS function "0": disable "1": enable
3:2	CLK_PS_EN	RW	11	Clock enable for proximity function "0": disable "1": enable
1	Reserved	RW	1	Reserved, write "0" can help to save more power
0	CLK_DIG_EN	RW	1	Clock enable for digital; it is always required to be enabled unless sensor is in sleep or idle state "0": disable "1": enable

4.2 ID (0x03) (default:0x0C)

Bit	Name	R/W	default	Description
7:0	ID	R	00001100	SIP3515 ID value, 0x0C

4.3 CTRL(0x05) (default:0x01)

Bit	Name	R/W	default	Description
7:2	---	---	0	Reserved and Unused
1	OSC_EN	RW	0	Oscillator enable “0”: disable “1”: enable
0	SOFT_RST_N	RW	1	Soft reset trigger, this bit will be set to “1” after soft reset is completed. “0”: trigger soft reset “1”: normal operation

4.4 INTCTRL (0x06) (default:0x00)

Bit	Name	R/W	default	Description
7:5	---	---	0	Reserved and Unused
4	WORK_MODE	RW	0	Proximity and ALS working mode: “0”: serially “1”: parallelly
3	Reserved	RW	0	Must be set to “0” for normal operation
2	INT_EN	RW	0	INT pin output enable, it must be enabled if want to output internal interrupts to external “0”: disable “1”: enable
1	INT_POLARITY	RW	0	Output level polarity configuration “0”: output active low “1”: output active high
0	INT_CLR_MODE	RW	0	Interrupt clear mode. “0”: interrupts will be cleared after reading related status registers “1”: interrupts will be cleared after writing “1” to related status bit

4.5 PSOFFSET_EN (0x08) (default:0x00)

Bit	Name	R/W	default	Description
7:3	---	---	0	Reserved and Unused
2	P0_OFFSET3_EN	RW	0	The 3rd offset compensation analog enable for proximity channel0, it is fine offset compensation. “0”: disable “1”: enable

1	P0_OFFSET2_EN	RW	0	The 2nd offset compensation analog enable for proximity channel10 it is moderate offset compensation. “0”: disable “1”: enable
0	P0_OFFSET1_EN	RW	0	The 2nd offset compensation analog enable for proximity channel0, it is coarse offset compensation. “0”: disable “1”: enable

4.6 PSENABLE (0x0C) (default:0x00)

Bit	Name	R/W	default	Description
7:4	---	---	000	Reserved and Unused
3	OFFSET_CALI_EN	RW	0	Proximity offset calibration enable, write “1” to trigger calibration, write “0” to abort the calibration even the calibration is not completed
2	---	---	000	Reserved and Unused
1	P0_EN	RW	0	Proximity channel0 enable “0”: proximity channel1 disable “1”: proximity channel1 enable
0	PS_EN	RW	0	Proximity general switch enable “0”: proximity general switch disable “1”: proximity general switch enable

4.7 PSCTRL0 (0x0D) (default:0x00)

Bit	Name	R/W	Default	Description
7:5	---	---	000	Reserved and Unused
4	Reserved	RW	0	Must be set to “0” for normal operation
3	---	RW	0	Reserved and Unused
2	OFFSET_CALI_RATE_EN	RW	0	Proximity sample rate enable during proximity offset calibration. “0”: disable proximity sample rate control during proximity offset cabliration “1”: enable proximity sample rate control during proximity offset calibration
1	Reserved	RW	0	Reserved and Unused
0	PSPERIOD_EN	RW	0	Proximity period control enable, this should be enabled for normal operation to reduce power consumption. “0”: disable proximity period control “1”: enable proximity period control

4.8 PSCTRL1 (0x0E) (default:0x00)

Bit	Name	R/W	default	Description
7	---	---	0	Reserved and Unused
6:4	PS_AVG_WINDOW	RW	000	Window size setting for proximity window average filter. “0”: 1 data

				“1”: 2 data “2”: 4 data “3”: 8 data “4”: 16 data
3:2	---	---	00	Reserved and Unused
1:0	Reserved	RW	00	This must be set to “00” for normal operation.

4.9 PSCTRL2 (0x0F) (default:0x10)

Bit	Name	R/W	default	Description
7:4	PS_PERSIST_NUM	RW	0000	Debounce filter setting for proximity interrupt. Px_INT will be asserted only when proximity data beyond the thresholds for number of consecutive times. “0”: 0 time, Px_INT will be asserted every proximity cycle no matter the proximity data beyond the thresholds or not; “1”: 1 time, Px_INT will be asserted once proximity data beyond the thresholds; “2”: 2 times, Px_INT will be asserted when proximity data beyond the thresholds for 2 consecutive times; … “15”: 15 times, Px_INT will be asserted when proximity data beyond the thresholds for 15 consecutive times;
3	---	---	0	Reserved and Unused
2:0	CALI_TARGET	RW	000	Proximity target data value for proximity offset calibration. “0”: target proximity data is 3 “1”: target proximity data is 7 “2”: target proximity data is 15 “3”: target proximity data is 31 … “7”: target proximity data is 511

4.10 P0_THLOW_H (0x10) (default:0x00)

Bit	Name	R/W	default	Description
7:2	---	---	000000	Reserved and Unused
1:0	P0_TH_LOW_H	RW	00	2 MSB bits of proximity channel0 low data threshold

4.11 P0_THLOW_L (0x11) (default:0x20)

Bit	Name	R/W	default	Description
7:0	P0_TH_LOW_L	RW	00100000	8 LSB bits of proximity channel0 low data threshold

4.12 P0_THHIGH_H (0x12) (default:0x03)

Bit	Name	R/W	default	Description
7:2	---	---	000000	Reserved and Unused
1:0	P0_TH_HIGH_H	RW	11	2 MSB bits of proximity channel0 high data threshold

4.13 P0_THHIGH_L (0x13) (default:0xD0)

Bit	Name	R/W	default	Description
7:0	P0_TH_HIGH_L	RW	11010000	8 LSB bits of proximity channel0 high data threshold

4.14 P0_GAIN (0x14) (default:0x00)

Bit	Name	R/W	default	Description
7:6	---	---	00	Reserved and Unused
5:4	P0_GAIN1	RW	00	Gain1 setting for proximity channel0 “00”: 2.5x “01”: 5x “10”: Reserved “11”: 10x
3:2	---	---	00	Reserved and Unused
1:0	P0_GAIN0	RW	00	Gain0 setting for proximity channel0 “00”: 1x “01”: 2x “10”: 4x “11”: 8x

4.15 P0_PULSE (0x15) (default:0x10)

Bit	Name	R/W	default	Description
7:6	---	---	00	Reserved and Unused
5:0	P0_PULSE_CNT	RW	010000	Pulse counts in one proximity sample for proximity channel0 “0”: 1 pulse “1”: 2 pulses … “63”: 64 pulses

4.16 PSINT_EN (0x22) (default:0xFF)

Bit	Name	R/W	default	Description
7	PS_ERR_INT_EN	RW	1	Enable control of the interrupt status to indicate proximity timing error.

				Ex. Proximity period time is too short for proximity integration.
6	PS_ADC_SAT_INT_EN	RW	1	Enable control of the interrupt status to indicate proximity ADC saturation.
5	PS_REF_SAT_INT_EN	RW	1	Enable control of the interrupt status to indicate reflective light make proximity sensor saturated.
4	PS_AM_SAT_INT_EN	RW	1	Enable control of the interrupt status to indicate ambient light make proximity sensor saturated.
3	P1_ZINT_EN	RW	1	Enable control of the interrupt status to indicate proximity channel1 data reach to 0 count
2	P0_ZINT_EN	RW	1	Enable control of the interrupt status to indicate proximity channel0 data reach to 0 count
1	P1_INT_EN	RW	1	Enable control of the interrupt status to indicate proximity channel1 data beyond thresholds event
0	P0_INT_EN	RW	1	Enable control of the interrupt status to indicate proximity channel0 data beyond thresholds event

4.17 PS_CTRL3 (0x23) (default:0xC1)

Bit	Name	R/W	default	Description
7:6	Reserved	RW	11	These two bits must be set to “11” for normal operation.
5:1	IIR_A	RW	00000	“A” value of IIR filter, this filter achieve similar target with windows average filter, another method to reduce the noise of proximity output data.
0	PS_CALI_INT_EN	RW	1	Enable control of the interrupt status to indicate proximity offset calibration finished.

4.18 PSPERIOD_STEP (0x24) (default:0x00)

Bit	Name	R/W	default	Description
7:0	PS_PERIOD_STEP	RW	00000000	Proximity period time step setting. ps_period_step = PS_PERIOD_STEP * 126.4μs

4.19 PSPERIOD_TIME (0x26) (default:0x00)

Bit	Name	R/W	default	Description
7:0	PSPERIOD_TIME	RW	00000000	Proximity period time setting. ps_period_time = PSPERIOD_TIME * ps_period_step

4.20 PSRATE_STEP_L (0x29) (default:0x00)

Bit	Name	R/W	default	Description
7:0	PS_RATE_STEP_L	RW	00000000	Proximity sample rate time step setting, 8 LSB bits.

				ps_samplerate_step = ((PS_RATE_STEP_H << 8) | PS_RATE_STEP_L) * 246.9ns

4.21 PSRATE (0x2A) (default:0x00)

Bit	Name	R/W	default	Description
7:0	PS_RATE_TIME	RW	00000000	Proximity sample rate time setting. ps_samplerate_time = PS_RATE_TIME * ps_samplerate_step

4.22 P0_PULSELEN_L (0x2B) (default:0x40)

Bit	Name	R/W	default	Description
7:0	P0_PULSE_LEN_L	RW	01000000	LED pulse length setting for proximity channel0 integration. 8 LSB bits, default pulse length is 15.8μs

4.23 PS_PULSELEN_H (0x2D) (default:0x00)

Bit	Name	R/W	default	Description
7:4	---	---	000000	Reserved and Unused
3:0	P0_PULSE_LEN_H	RW	0000	LED pulse length setting for proximity channel0 integration. 4 MSB bits p0_pulse_length = ((P0_PULSE_LEN_H << 8) | P0_PULSE_LEN_L) * 246.9ns

4.24 PSOFFSET_SEL (0x39) (default:0x00)

Bit	Name	R/W	default	Description
7:6	---	---	00	Reserved and Unused
5	P1_OFFSET3_SEL	RW	0	Compensation code selection of 3rd offset for proximity channel1 “0”: use the code generated by proximity offset calibration, the code also can be read from register 0x3F and 0x40, if this bit set to “0” “1”: use the code writen to register 0x3F and 0x40.
4	P1_OFFSET2_SEL	RW	0	Compensation code selection of 2nd offset for proximity channel1 “0”: use the code generated by proximity offset calibration, the code also can be read from register 0x41, if this bit set to “0” “1”: use the code writen to register 0x41.
3	P1_OFFSET1_SEL	RW	0	Compensation code selection of 1st offset for proximity channel1 “0”: use the code generated by proximity offset calibration, the code also can be read from register 0x42, if this bit set to “0” “1”: use the code writen to register 0x42.

2	P0_OFFSET3_SEL	RW	0	Compensation code selection of 3rd offset for proximity channel0 "0": use the code generated by proximity offset calibration, the code also can be read from register 0x3B and 0x3C, if this bit set to "0" "1": use the code writen to register 0x3B and 0x3C.
1	P0_OFFSET2_SEL	RW	0	Compensation code selection of 2nd offset for proximity channel0 "0": use the code generated by proximity offset calibration, the code also can be read from register 0x3D, if this bit set to "0" "1": use the code writen to register 0x3D.
0	P0_OFFSET1_SEL	RW	0	Compensation code selection of 1st offset for proximity channel0 "0": use the code generated by proximity offset calibration, the code also can be read from register 0x3E, if this bit set to "0" "1": use the code writen to register 0x3E.

4.25 PSCALI_CTRL (0x3A) (default:0x00)

Bit	Name	R/W	default	Description
7:3	---	---	00000	Reserved and Unused
2	PS_OFFSET2_CALI_EN	RW	0	Enable control for 2nd offset compensation during proximity offset auto calibration. "0": won't search proper code for 2nd offset compensation during proximity offset auto calibration "1": will search proper code for 2nd offset compensation during proximity offset auto calibration
1	PS_OFFSET1_CALI_EN	RW	0	Enable control for 1st offset compensation during proximity offset auto calibration. "0": won't search proper code for 1st offset compensation during proximity offset auto calibration "1": will search proper code for 1st offset compensation during proximity offset auto calibration
0	PS_OFFSET_AUTO_ADJ_EN	RW	0	Enable control to do offset auto adjustment, everytime when observe proximity data reach "0", 3rd offset code will do self-attunuation. "0": won't do offset auto adjustment "1": do offset auto adjustment

4.26 P0_OFFSET3_H (0x3B) (default:0x00)

Bit	Name	R/W	default	Description
7:1	---	---	0000000	Reserved and Unused
1:0	P0_OFFSET3_SIGN	RW	0	The MSB of 3rd offset compensation code for proximity channel0, it is a sign bit. "0": positive, 3rd offset compensate the positive offset to get lower proximity data.

				"1": negative, 3rd offset compensate the negative offset to get higher proximity data. Note: This register stores the result of 3rd offset compensation code generated by proximity offset auto calibration if P0_OFFSET3_SEL is set to "0", OFFSET_CALI_CH is set to "0" If P0_OFFSET3_SEL is set to "1" P0_OFFSET3_EN is set to "1" Write code to this register to implement the 3rd offset compensation to proximity channel0.

4.27 P0_OFFSET3_L (0x3C) (default:0x00)

Bit	Name	R/W	default	Description
7:0	P0_OFFSET3_D	RW	00000000	The data value of 3rd offset compensation code for proximity channel0. See note in register 0x3B.

4.28 P0_OFFSET2 (0x3D) (default:0x00)

Bit	Name	R/W	default	Description
7:0	P0_OFFSET2_D	RW	00000000	The data value of 2nd offset compensation code for proximity channel0. It can only compensate the positive offset. This register stores the result of 2nd offset compensation code generated by proximity offset auto calibration if P0_OFFSET2_SEL is set to "0", PS_OFFSET2_CALI_EN is set to "1" OFFSET_CALI_CH is set to "0" If P0_OFFSET2_SEL is set to "1" P0_OFFSET2_EN is set to "1" Write code to this register to implement the 2nd offset compensation to proximity channel0.

4.29 P0_OFFSET1 (0x3E) (default:0x00)

Bit	Name	R/W	default	Description
7:0	P0_OFFSET1_D	RW	00000000	The data value of 1st offset compensation code for proximity channel0. It can only compensate the positive offset.

				This register stores the result of 1st offset compensation code generated by proximity offset auto calibration if P0_OFFSET1_SEL is set to ”0”, PS_OFFSET1_CALI_EN is set to “1” OFFSET_CALI_CH is set to “0” If P0_OFFSET1_SEL is set to ”1” P0_OFFSET1_EN is set to “1” Write code to this register to implement the 1st offset compensation to proximity channel0.

4.30 IRDVR_RG_CTRL (0x48) (default:0x01)

Bit	Name	R/W	default	Description
7:2	---	RW	---	RFU
1	LED_EN	RW	0	LED enable “0”: LED disable “1”: LED enable
0	---	RW	1	Keep default value for normal operation

4.31 IRCURR_CTRL0 (0x4C) (default:0x05)

Bit	Name	R/W	default	Description
7	---	---	0	Reserved and Unused
6:0	IRDVR_CURR_CH0	RW	00000101	IR driver current setting for IR emitter for proximity channel0. p0_led_current = IRDVR_CURR_CH0 * 2mA Support up to 190mA

4.32 ALSENABLE (0x50) (default:0x00)

Bit	Name	R/W	default	Description
7:3	---	---	00000	Reserved and Unused
2	ALS1_EN	RW	0	ALS channel1 enable “0”: ALS channel1 disable “1”: ALS channel1 enable
1	ALS0_EN	RW	0	ALS channel0 enable “0”: ALS channel0 disable “1”: ALS channel0 enable
0	ALS_EN	RW	0	ALS general switch enable “0”: ALS general switch disable “1”: ALS general switch enable

4.33 ALS_CTRL0 (0x51) (default:0x10)

Bit	Name	R/W	default	Description
7:6	---	---	00	Reserved and Unused
5:1	RESERVED	RW	01000	Keep default value for normal operation
0	ALSPERIOD_EN	RW	0	ALS period control enable, it will only be used when required ALS sample rate is low and lower power consumption requirement. “0”: disable ALS period control “1”: enable ALS period control

4.34 ALS_CTRL1 (0x52) (default:0x10)

Bit	Name	R/W	default	Description
7:4	ALS_PERSIST_NUM	RW	0000	Debounce filter setting for ALS interrupt. ALS_INT will be asserted only when ALS data beyond the thresholds for number of consecutive times. “0”: 0 time, ALS_INT will be asserted every ALS cycle no matter the ALS data beyond the thresholds or not; “1”: 1 time, ALS_INT will be asserted once ALS data beyond the thresholds; “2”: 2 times, ALS_INT will be asserted when ALS data beyond the thresholds for 2 consecutive times; … “15”: 15 times, ALS_INT will be asserted when proximity data beyond the thresholds for 15 consecutive times;
3:0	RESERVED	RW	0000	These 4 bits must be set to “0100” for normal operation.

4.35 ALS_THLOW_H (0x54) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS_TH_LOW_H	RW	00000000	Upper byte of ALS low data threshold

4.36 ALS_THLOW_L (0x55) (default:0x20)

Bit	Name	R/W	default	Description
7:0	ALS_TH_LOW_L	RW	00100000	Lower byte of ALS low data threshold

4.37 ALS_THHIGH_H (0x56) (default:0xFF)

Bit	Name	R/W	default	Description
7:0	ALS_TH_HIGH_H	RW	11111111	Upper byte of ALS high data threshold

4.38 ALS_THHIGH_L (0x57) (default:0xD0)

Bit	Name	R/W	default	Description
7:0	ALS_TH_HIGH_L	RW	11010000	Lower byte of ALS high data threshold

4.39 ALSPERIOD_STEP (0x5C) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS_PERIOD_STEP	RW	00000000	ALS period time step setting. als_period_step = ALS_PERIOD_STEP * 316.2μs

4.40 ALSPERIOD_TIME (0x5E) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALSPERIOD_TIME	RW	00000000	ALS period time setting. als_period_time = ALSPERIOD_TIME * ps_period_step

4.41 ALSINT_EN (0x5F) (default:0x0F)

Bit	Name	R/W	default	Description
7:4	---	---	0000	Reserved and Unused
3	ALS_ERR_INT_EN	RW	1	Enable control of the interrupt status to indicate ALS timing error. Ex. ALS period time is too short for ALS integration.
2	ALS_ANS_SAT_INT_EN	RW	1	Enable control of the interrupt status to indicate ALS analog saturation.
1	ALS_DIG_SAT_INT_EN	RW	1	Enable control of the interrupt status to indicate ALS digital saturation.
0	ALS_INT_EN	RW	1	Enable control of the interrupt status to indicate ALS data beyond thresholds event

4.42 ALS_GAIN (0x60) (default:0x00)

Bit	Name	R/W	default	Description
7:4	ALS1_GAIN	RW	0000	Gain setting for ALS channel1 “0000”: 1x “0001”: 2x “0010”: 4x … “1010”: 1024x
3:0	ALS0_GAIN	RW	0000	Gain setting for ALS channel0 “0000”: 1x

				“0001”: 2x “0010”: 4x … “1010”: 1024x

4.43 ALSINTE_TIME_M (0x61) (default:0x8C)

Bit	Name	R/W	default	Description
7:0	ALS_INTE_TIME_M	RW	10001100	ALS integration time setting, ALS_INTE_TIME[15:8]

4.44 ALSINTE_TIME_L (0x62) (default:0xA0)

Bit	Name	R/W	default	Description
7:0	ALS_INTE_TIME_L	RW	10100000	ALS integration time setting, ALS_INTE_TIME[7:0]

4.45 ALSAZ_CTRL (0x64) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS_AZ_NUM	RW	00000000	ALS auto zero setting. “0”: ALS auto zero is disabled “1”: ALS auto zero will be done once every ALS cycle “2”: ALS auto zero will be done once every two ALS cycles … “255”: ALS auto zero will be done only one time after ALS is enabled

4.46 ALSAZ_EN (0x65) (default:0xF0)

Bit	Name	R/W	default	Description
7:1	RESERVED	RW	1111000	Must be set to “1111000” for normal operation
0	ALS_AZ_EN	RW	0	ALS auto zero enable control. “0”: disable ALS auto zero “1”: enable ALS auto zero

4.47 RESERVE1 (0x67) (default:0x00)

Bit	Name	R/W	default	Description
7:0	RESERVED	RW	00000000	Must be set to “00001000” for normal operation

4.48 RESERVE2 (0x69) (default:0x00)

Bit	Name	R/W	default	Description
7:0	RESERVED	RW	00000000	Must be set to “00001000” for normal operation

4.49 PSINT_STATUS (0x8D) (default:0x00)

Bit	Name	R/W	default	Description
7	PS_CALI_INT	R	0	Interrupt status to indicate proximity offset calibration is completed.
6	PS_ADC_SAT_INT	R	0	Interrupt status to indicate proximity ADC saturation.
5	PS_REF_SAT_INT	R	0	Interrupt status to indicate reflective light make proximity sensor saturated.
4	PS_AM_SAT_INT	R	0	Interrupt status to indicate ambient light make proximity sensor saturated.
3	P1_ZINT	R	0	Interrupt status to indicate proximity channel1 data reach to 0 count
2	P0_ZINT	R	0	Interrupt status to indicate proximity channel0 data reach to 0 count
1	P1_INT	R	0	Interrupt status to indicate proximity channel1 data beyond thresholds event
0	P0_INT	R	0	Interrupt status to indicate proximity channel0 data beyond thresholds event

4.50 ALSINT_STATUS (0x8E) (default:0x00)

Bit	Name	R/W	default	Description
7:5	---	---	0000	Reserved and Unused
4	PS_ERR_INT	R	0	Interrupt status to indicate proximity timing error.
3	ALS_ERR_INT	R	0	Interrupt status to indicate ALS timing error.
2	ALS_ANS_SAT_INT	R	0	Interrupt status to indicate ALS analog saturation.
1	ALS_DIG_SAT_INT	R	0	Interrupt status to indicate ALS digital saturation.
0	ALS_INT	R	0	Interrupt status to indicate ALS data beyond thresholds event

4.51 P0DATA_H (0xA0) (default:0x00)

Bit	Name	R/W	default	Description
7:2	---	---	000000	Reserved and Unused
1:0	P0_DATA_H	R	00	2 MSB bits of proximity channel0 data, P0_DATA[9:8]

4.52 P0DATA_L (0xA1) (default:0x00)

Bit	Name	R/W	default	Description
7:0	P0_DATA_L	R	00000000	8 LSB bits of proximity channel0 data, P0_DATA[7:0]

4.53 ALS0DATA_H (0xA4) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS0_DATA_H	R	00000000	Upper byte of ALS channel0 data, ALS0_DATA[15:8]

4.54 ALS0DATA_H (0xA5) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS0_DATA_L	R	00000000	Lower byte of ALS channel0 data, ALS0_DATA[7:0]

4.55 ALS1DATA_H (0xA6) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS1_DATA_H	R	00000000	Upper byte of ALS channel1 data, ALS1_DATA[15:8]

4.56 ALS1DATA_H (0xA7) (default:0x00)

Bit	Name	R/W	default	Description
7:0	ALS1_DATA_L	R	00000000	Lower byte of ALS channel1 data, ALS1_DATA[7:0]

4.57 DATA_VALID (0xA8) (default:0x00)

Bit	Name	R/W	default	Description
7:3	---	---	00000	Reserved and Unused
2	ALS_DATA_VALID	R	0	Indicates new ALS data is refreshed into data registers after last reading, it will be cleared automatically after the new ALS data is read out.
1	P1_DATA_VALID	R	0	Indicates new proximity channel1 data is refreshed into data registers after last reading, it will be cleared automatically after the new proximity channel1 data is read out.
0	P0_DATA_VALID	R	0	Indicates new proximity channel0 data is refreshed into data registers after last reading, it will be cleared automatically after the new proximity channel0 data is read out.

5 Packaging Information

5.1 Marking information

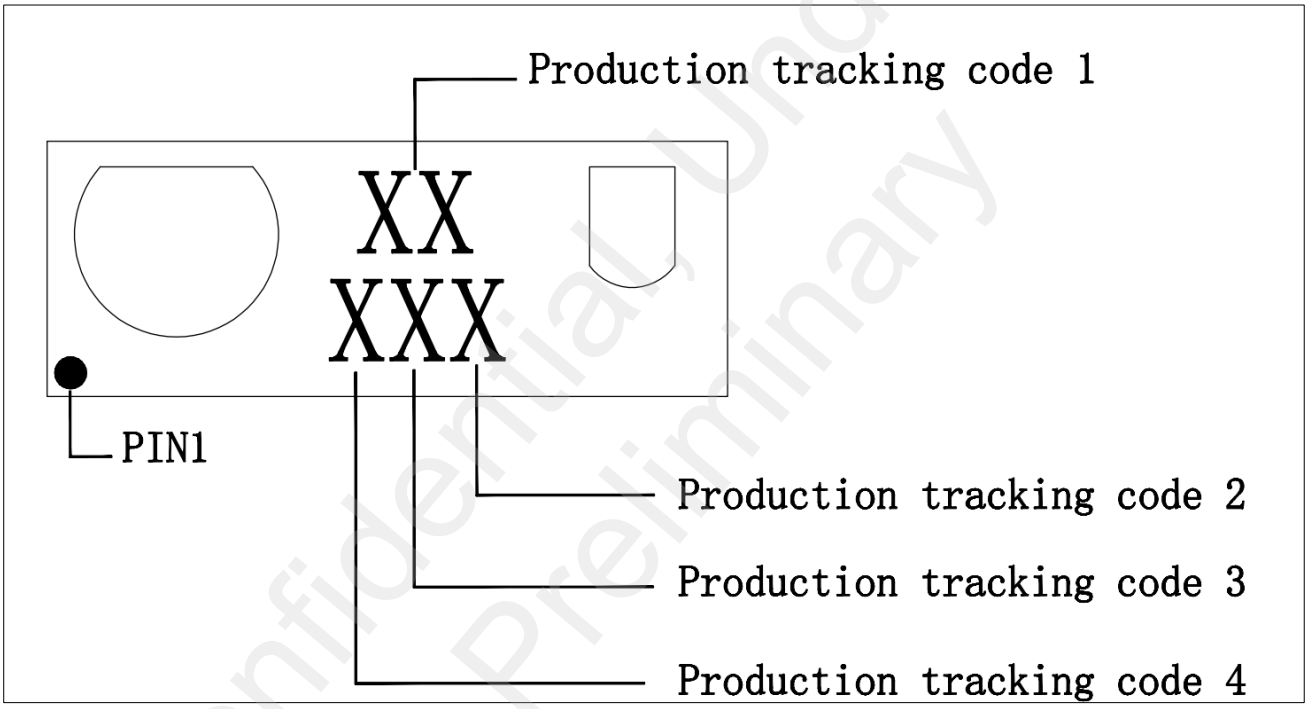
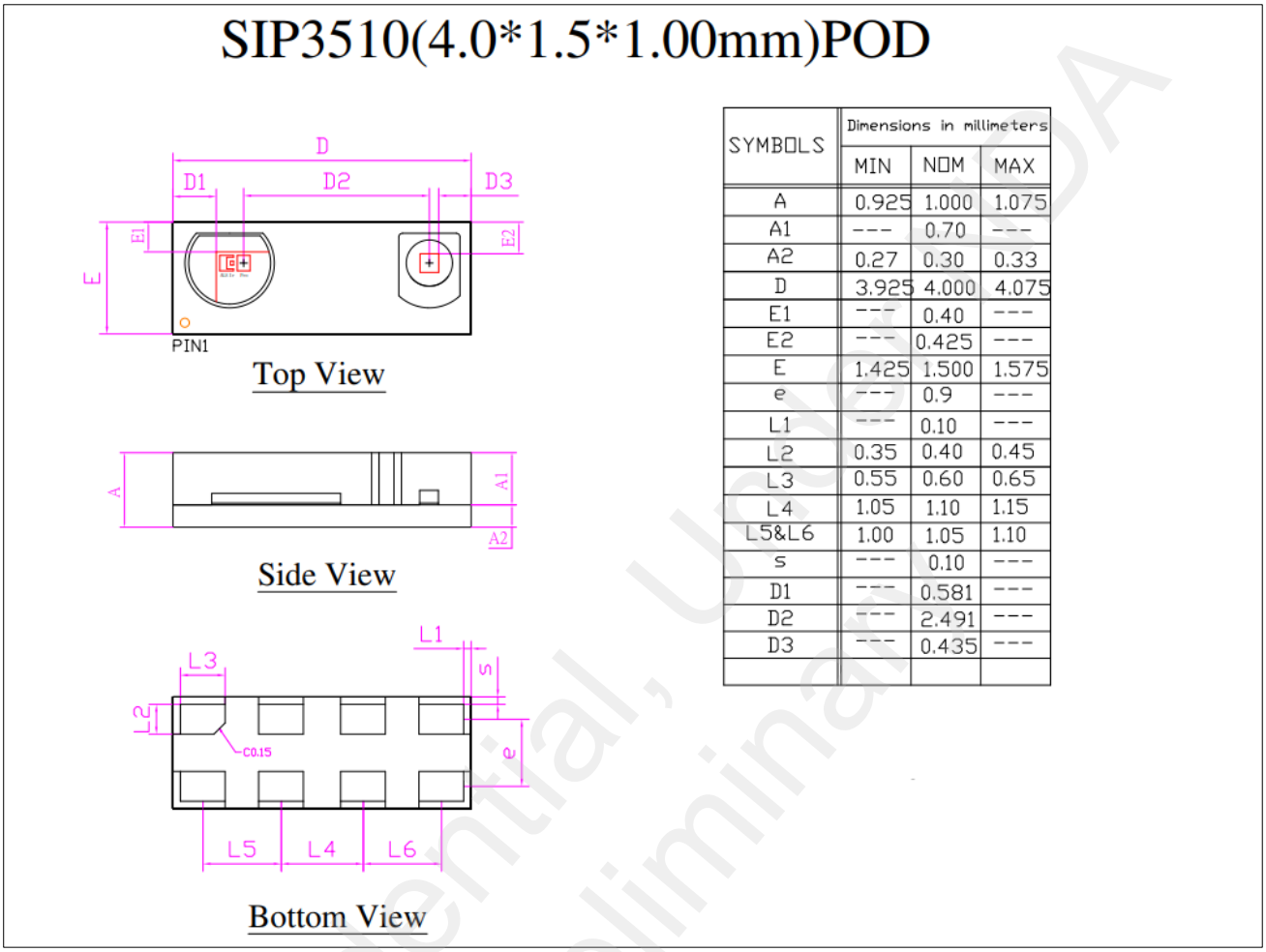


Figure 5-1Marking information

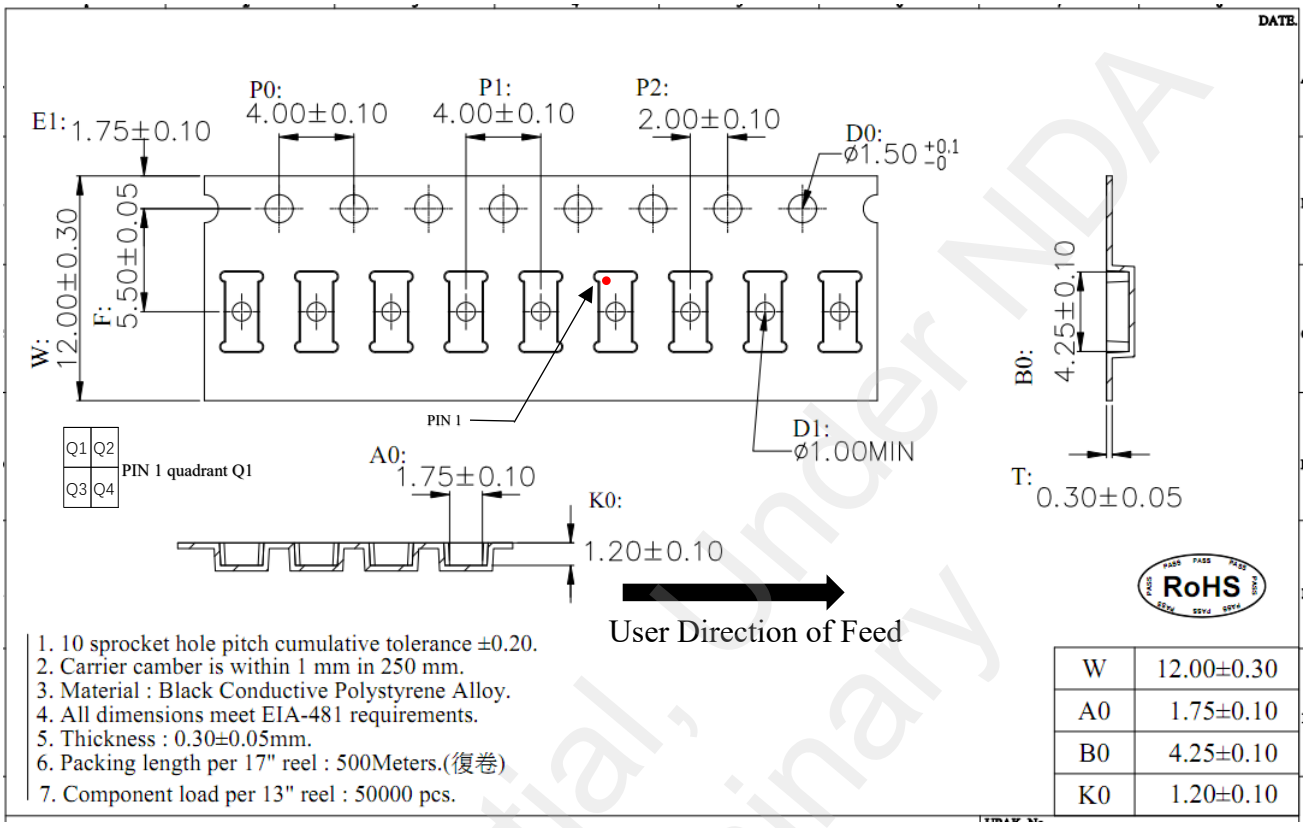
5.2 Package Dimension



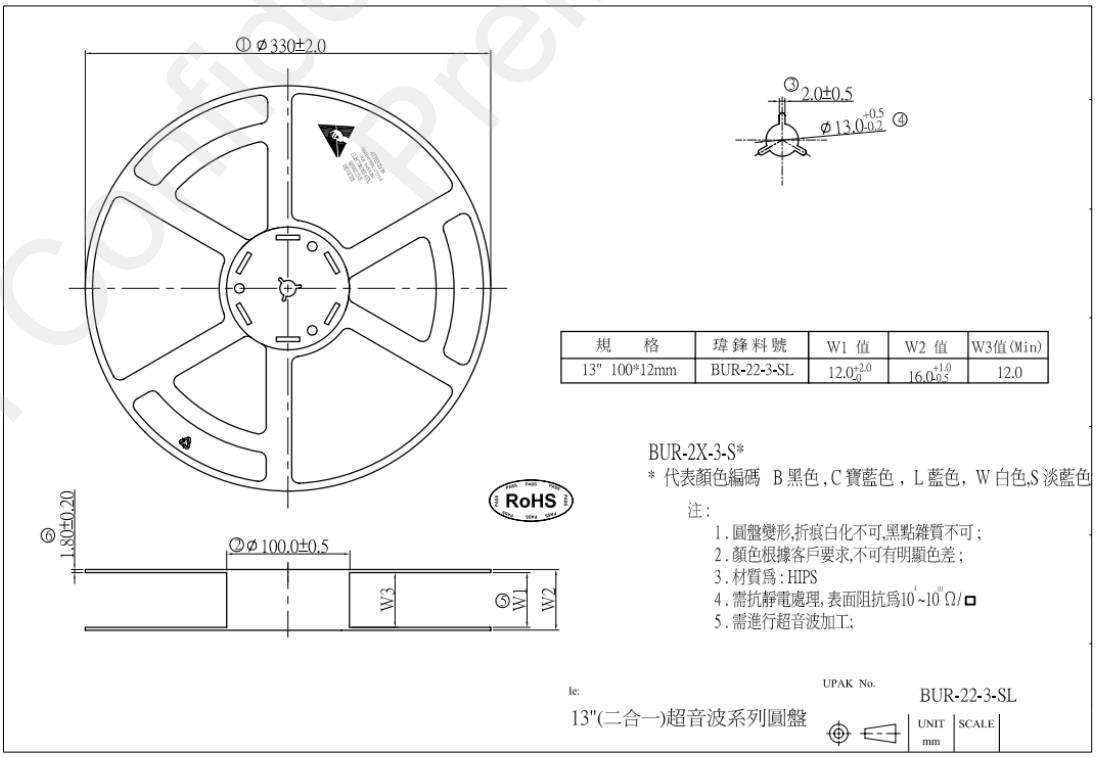
SYMBOLS	Dimensions in millimeters		
	MIN	NOM	MAX
A	0.925	1.000	1.075
A1	---	0.70	---
A2	0.27	0.30	0.33
D	3.925	4.000	4.075
E1	---	0.40	---
E2	---	0.425	---
E	1.425	1.500	1.575
e	---	0.9	---
L1	---	0.10	---
L2	0.35	0.40	0.45
L3	0.55	0.60	0.65
L4	1.05	1.10	1.15
L5&L6	1.00	1.05	1.10
s	---	0.10	---
D1	---	0.581	---
D2	---	2.491	---
D3	---	0.435	---

Figure 5-2 Package dimension

5.3 Tape Reel Information



W	12.00±0.30
A0	1.75±0.10
B0	4.25±0.10
K0	1.20±0.10



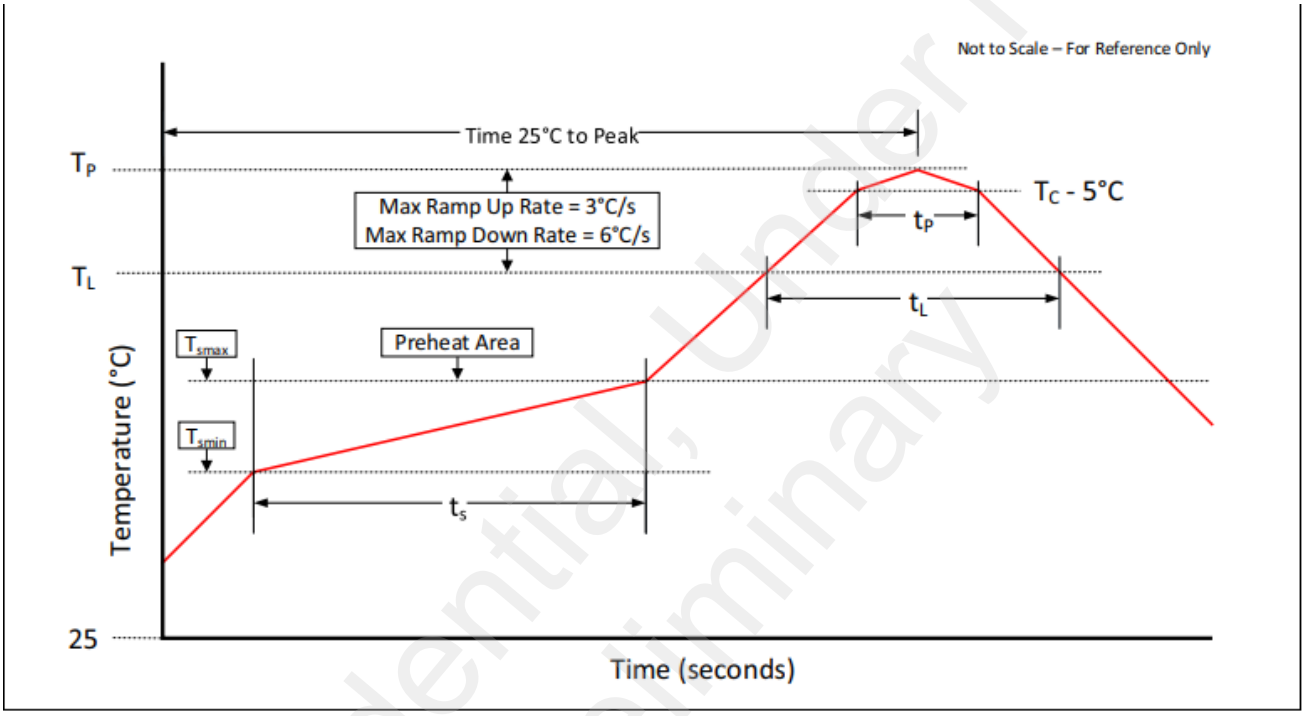
規 格	瑋鋒料號	W1 值	W2 值	W3值(Min)
13" 100*12mm	BUR-22-3-SL	$12.0^{+2.0}_{0}$	$16.0^{+1.0}_{0.5}$	12.0

Figure 5-3 Tape reel information

6 Solder Information

The module has been tested and has demonstrated an ability to be reflow soldered to a PCB substrate. The solder reflow profile describes the expected maximum heat exposure of components during the solder reflow process of product on a PCB. Temperature is measured on top of component. The components should be limited to a maximum of three passes through this solder reflow profil

Solder Flow Profile Graph



Solder Reflow Profile

Profile Feature Preheat/Soak	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Temperature Min (T_{smin})	100°C	150°C
Temperature Max (T_{smax})	150°C	200°C
Time (t_s) from (T_{smin} to T_{smax})	60-120 seconds	60-120 seconds
Ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Liquidous temperature (T_L) Time (t_L) maintained above T_L	183°C 60-150 seconds	217°C 60-150 seconds
Peak package body temperature (T_P)	For users T_P must not exceed the Classification temp of 235°C For suppliers T_P must equal or exceed the Classification temp of 235°C	For users T_P must not exceed the Classification temp of 260°C For suppliers T_P must equal or exceed the Classification temp of 260°C
Time (t_P)[1] within 5°C of the specified classification temperature (T_C)	20[1]seconds	30[1]seconds
Ramp-down rate (T_P to T_L)	6°C/second max.	6°C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.

7 Order Information

Table 7-1 Order Information

Product Part	Temp Range	Moisture Sensitivity Level	Package	Delivery Form
SIP3510LR	-40 ºC ~ +85ºC	MSL3	WB LGA	7000 pcs/reel

8 Reversion History

Table 8-1Reversion History

Version	Status	Date	Change Notice
0.1	Draft	Dec., 2021	Initial draft
0.2	Draft	Jan., 2022	Preliminary version
0.3	Preliminary	Apr., 2022	
0.4	Preliminary	Mar.,2023	Added register map