JSA-1228

Proximity Sensor

Data Sheet

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Proximity Sensor

JSA-1228

1. Description

The JSA-1228 integrates a proximity sensor (PXS), a 940nm IR VCSEL and an SMBus compatible I2C Interface into one chip.

Proximity sensor detects the human or object approach by reflection of IR light. It built in algorithm auto to calibrate the crosstalk between the IR VCSEL and sensor. The wide dynamic range also allows for operation in short distance detection behind dark glass.

2. Features

- I^2C interface (Fast Speed Mode at 400kHz/s)
- Dedicated Interrupt Pin
- Supply voltage (to sensor) range from 1.7 V to 3.6 V
- Supply voltage (to VCSEL) range from 2.7 V to 3.6 V
- Operating temperature from -40°C to +85°C
- Proximity Sensor
  - Selectable ADC Output, up to 12-bit.
  - Auto calibration cross-talk.
  - 4 Programmable VSCEL Current Output, up to 20mA
  - Pulse Width Selection, PGA Gain Selection and Pulse Count Selection
- Small package size : 2.0 x 2.0 x 0.60 (mm)

3. Applications

- True Wireless Stereo
- Wearable device
- Smart phone

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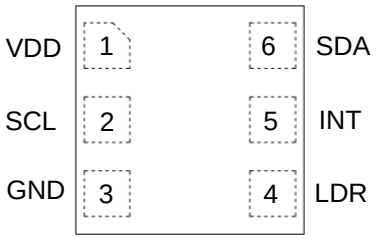
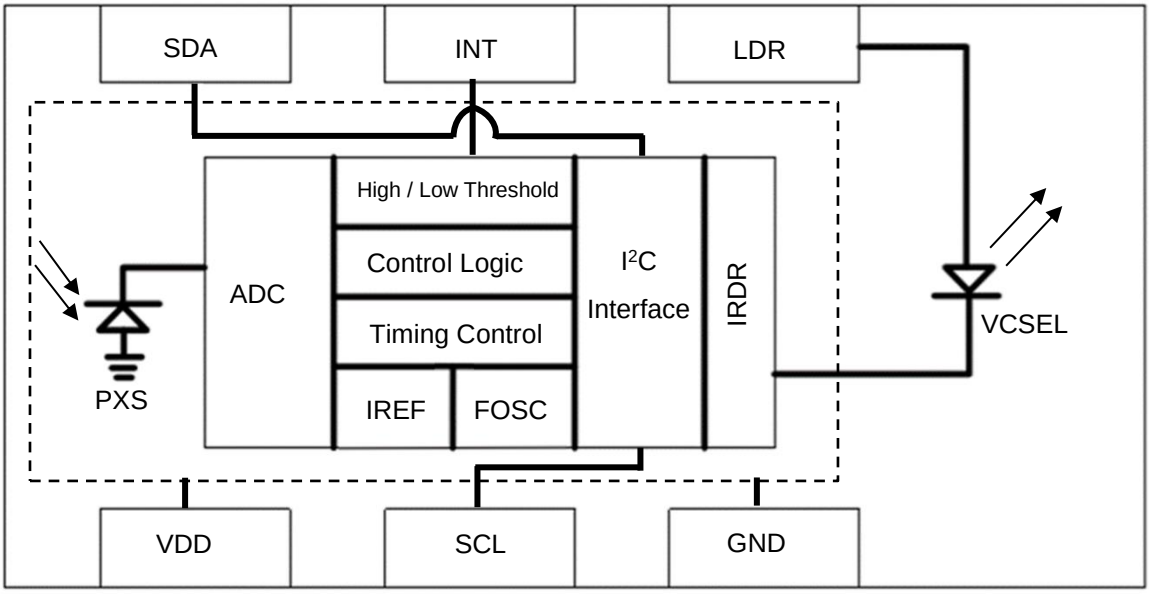
4. Pin Configuration



Pin Number	Pin Name	Description
1	VDD	Positive supply: 1.7V to 3.6V
2	SCL	I^2C serial clock signal
3	GND	Ground
4	LDR	IR VCSEL driver for proximity emitter ; V_{LDR} : 2.7V to 3.6V
5	INT	Interrupt pin
6	SDA	I^2C serial data signal

5. Function Block Diagram



6. Ordering Information

Part Number	Slave Address	Package Size	Quantity
JSA-1228	0x38	2.0 x 2.0 x 0.6 (mm)	2000 per reel

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7. Absolute Maximum Ratings

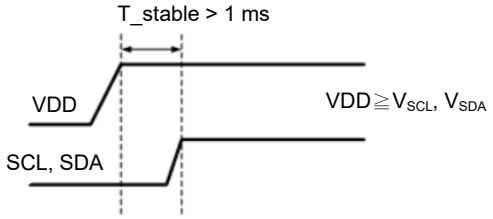
Parameter	Rating	Unit
V_{DD} Supply Voltage	+4.5	V
I^2C Bus Pin Voltage (SCL, SDA, INT)	-0.2 to +4.5	V
I^2C Bus Pin Current (SCL, SDA, INT)	+10	mA
LDR Pin Voltage	-0.2V to VDD + 0.5V	V
ESD Rating (HBM)	2	kV
Operating Temperature	-40 to +85	°C
Storage Temperature	-45 to +100	°C
CAUTION: Exceeding these ratings could cause damage to the device. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.		

8. Electrical Characteristics (Ta = +25°C)

Parameter	Descriptions	Condition	Min	Typ	Max	Unit
V_{DD}	Supply voltage to sensor	*Note 1,2	1.7	--	3.6	V
V_{LDR}	Supply voltage to VCSEL		2.7	--	3.6	V
V_{BUS}	I^2C bus supply Voltage	$V_{BUS} \leqq V_{DD}$	1.62	1.8	V_{DD}	V
V_{DD_slew}	V_{DD} power slew rate		0.5	--	--	V/ms
I_{PD1}	Shutdown current	Sleep mode, Ev=0 EN_FRST = 1	--	1	--	uA
I_{PD2}	Shutdown current	Sleep mode, Ev= 0 I^2C inactive	--	2.2	--	uA
I_{DD}	Active current	V_{DD} = 3.3V, *Note 3	--	33	--	uA
T_{boot}	Device Boot Time	*Note 4	10	--	--	ms

*Notes:

1. The power supply need to make sure the VDD slew rate at least 0.5V/ms. JSA-1228 have power on reset function. When VDD drops below 1.2V 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. EN_WAIT=1, EN_PS=1, NUM_AVG=0, WTIME=8 (55.7ms)
4. The Device Boot Time (Tboot) is the delay time that the host can send the first I^2C command after the VDD ready.

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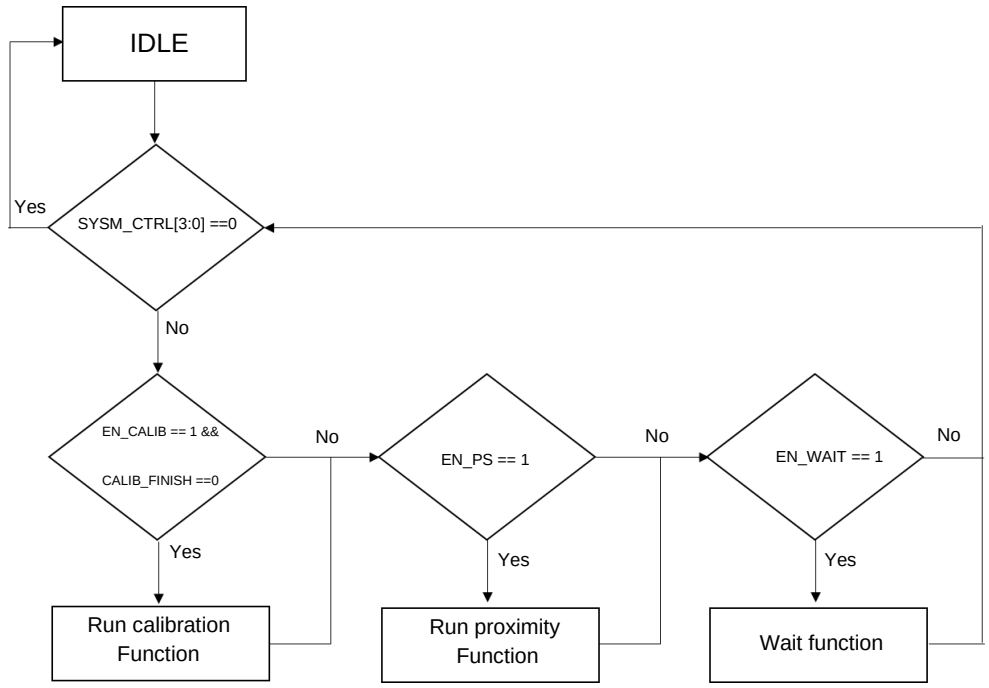
9. Optical Characteristics (V_{DD} = 3.3V, Ta = +25°C)

PS Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Sensing Gain, relative to x1 setting	**PGAIN**	--	2	--	--	--
		--	4	--	--	--
PS ADC integration time step size	**PStep**	--	0.256	--	--	ms
PS ADC number of integration unit	**PTIME**	1	--	16	--	Unit
Full ADC counts per step	--	--	--	255	--	count
Full scale ADC counts value	--	--	--	4095	--	count
LED pulse period	**ITW_PS**	0.016	--	4.096	--	ms
LED pulse count	**ITC_PS**	1	--	16	--	pulse
LED Driving Current	**IRDR_SEL**	--	5	--	--	mA
		--	10	--	--	
		--	15	--	--	
		--	20	--	--	
IR Peak Wavelength			940		--	nm

9.1 State Machine

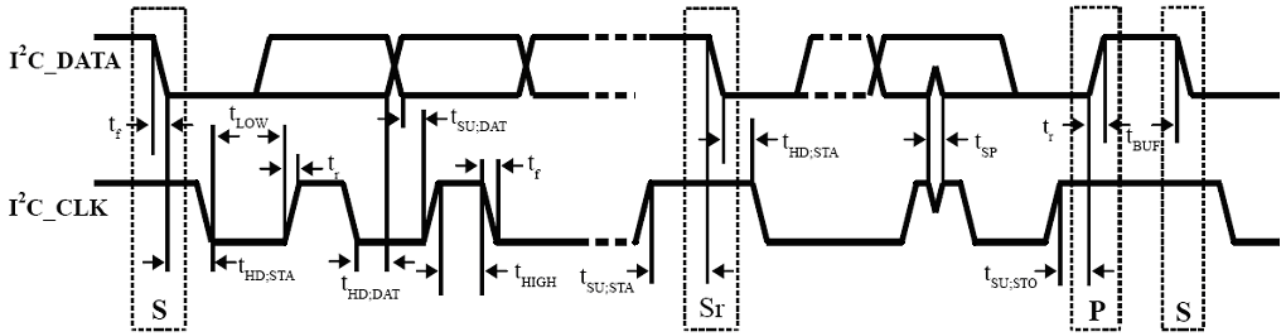
There are two operation mode , PS and Calibration mode. The state machine is shown below:



10. I²C Electrical Specifications (V_{DD} = 3.3V, Ta = +25°C)

Parameter	Description	Min	Typ	Max	Unit
f_{SCL}	SCL clock frequency	100	--	400	KHz
V_{IL}	I²C Bus Input Low Voltage	--	--	0.5	V
V_{IH}	I²C Bus Input High Voltage	1.4	--	--	V
$R_{pull-up}$	SDA and SCL system bus pull-up reistor	--	10	--	KΩ
t_{BUF}	Bus free time between a STOP and START condition	1.3	--	--	μs
$t_{HD;STA}$	Hold time (repeated) START condition. After this period, the first clock pulse is generated	0.6	--	--	μs
t_{LOW}	LOW period of the SCL clock	1.3	--	--	μs
t_{HIGH}	HIGH period of the SCL clock	0.6	--	--	μs
$t_{SU;STA}$	Set-up time for a repeated START condition	0.6	--	--	μs
$t_{SU;STO}$	Set-up time for STOP condition	0.6	--	--	μs
t_r	Rise time of both SDA and SCL signal	20 x VDD/5.5	--	300	ns
t_f	Fall time of both SDA and SCL signal	20 x VDD/5.5	--	300	ns
$t_{HD;DAT}$	Data hold time	50	--	--	ns
$t_{SU;DAT}$	Data setup time	100	--	--	ns
t_{SP}	Pulse width of spikes which must be suppressed by the input filter	0	--	50	ns

11. I²C Timing Diagram



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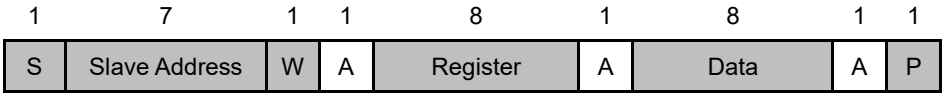
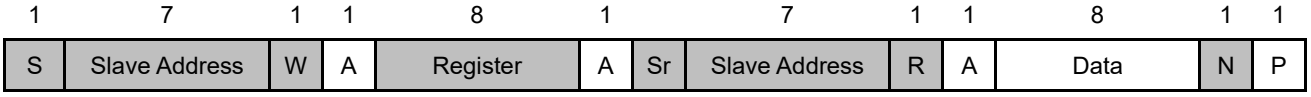
12. I²C Protocol

I²C Write



I²C Read



A	Acknowledge (0 for an ACK)	N	Non-Acknowledge(1 for an NACK)
S	Start condition	Sr	Repeated start condition
P	Stop condition		
W	Write (0 for writing)	R	Read (1 for read)
■	Master to Slave	□	Slave to Master

13. Register Description

The JSA-1228 is operated over the I²C bus with registers that contain configuration, status, and result information. All registers are 8 bits long.

13.1 Overall

Address	Name	Type	Default value	Description
0x00	SYSM_CTRL	R/W	0x00	PS/CALIB operation mode control, waiting mode control, SW reset
0x01	INT_CTRL	R/W	0x07	Interrupt pin control, interrupt persist control
0x02	INT_FLAG	R/W	0x80	Interrupt flag, error flag, power on reset(POR) flag
0x03	WAIT_TIME	R/W	0x00	Waiting time setting
0x06	PS_GAIN	R/W	0x00	PS analog gain setting
0x07	PS_PULSE	R/W	0x00	PS number of LED pulse
0x08	PSPD_CONFIG	R/W	0x04	PS PD setting
0x09	PS_TIME	R/W	0x00	PS integrated time setting
0x0A	PS_FILTER	R/W	0xBF	PS low pass filter setting
0x0B	PERSISTENCE	R/W	0x11	PS persistence setting
0x10	PS_THRES_LL	R/W	0x00	PS lower interrupt threshold - LSB
0x11	PS_THRES_LH	R/W	0x00	PS lower interrupt threshold - MSB
0x12	PS_THRES_HL	R/W	0xFF	PS higher interrupt threshold - LSB
0x13	PS_THRES_HH	R/W	0xFF	PS higher interrupt threshold - MSB
0x14	PS_OFFSET_L	R/W	0x00	PS offset level - LSB
0x15	PS_OFFSET_H	R/W	0x00	PS offset level - MSB
0x17	ERROR_FLAG	R	0x00	Error flag
0x1A	PS_DATA_L	R	0x00	PS output data - LSB
0x1B	PS_DATA_H	R	0x00	PS output data - MSB
0x26	CALIB_CTRL	R/W	0x0F	PS calibration control
0x28	CALIB_STAT	R	0x00	PS calibration status
0x2A	MANU_CDAT_L	R/W	0x00	Manual calibration data - LSB
0x2B	MANU_CDAT_H	R/W	0x00	Manual calibration data - MSB
0x2C	AUTO_CDAT_L	R	0x00	Automatic calibration data - LSB
0x2D	AUTO_CDAT_H	R	0x00	Automatic calibration data - MSB
0x2E	PS_PIPE_THRES	R/W	0x10	PS pipeline threshold
0xBC	Product ID	R	0x11	Product ID lower byte
0xBD		R	0x42	Product ID higher byte

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13.2 Register 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	EN_CALIB	EN_PS	0

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 detection function. (Default)

1: Disable Brown out detection function.

EN_CALIB：Enables calibration (CALIB) function.

0: Disable CALIB function. (Default)

1: Enable CALIB function.

EN_PS：Enables IR function.

0: Disable PS function. (Default)

1: Enable PS function.

13.3 Register 0x01 – INT_CTRL

0x01	INT_CTRL, interrupt pin control (Default = 0x07)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	PS_ SYNC	0	0	EN_ CALIBINT	EN_PINT	1

PS_SYNC：Measurement is pended when PS interrupt is triggered. Until clear the interrupt then start the next measurement.

0: Disable pending PS function (default).

1: Enable pending PS function.

EN_CALIBINT：The CALIB interrupt (INT_CALIB) flag can trigger the INT pin to low. conversion cycle.

0: Disable INT_CALIB effect INT pin.

1: Enable INT_ CALIB effect INT pin. (Default)

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EN_PINT：The PS interrupt (INT_PS)flag can trigger the INT pin to low.

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

1: Enable **INT_PS** effect INT pin(default)

13.4 Register 0x02 – INT_FLAG

0x02	INT_FLAG, System Control (Default = 0x80)							
BIT	7	6	5	4	3	2	1	0
R/W	INT_POR	DATA_ FLAG	OBJ	0	0	INT_ CALIB	INT_PS	0

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 satisfies one of the following conditions:

- Power On
- VDD < 1.2V
- 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.

OBJ：Object Detection Bit. It shows the position of the object. This bit is read only.

0: object disappear.

1: object appear.

INT_CALIB：CALIB interrupt flag. Write zero to clear the flag.

0: CALIB Interrupt not triggered or be cleared.

1: CALIB Interrupt triggered.

INT_PS：PS interrupt flag. It correlation with **PS_DATA** and PS high/low threshold. Write zero to clear the flag.

0: PS Interrupt not triggered or be cleared.

1: PS Interrupt triggered.

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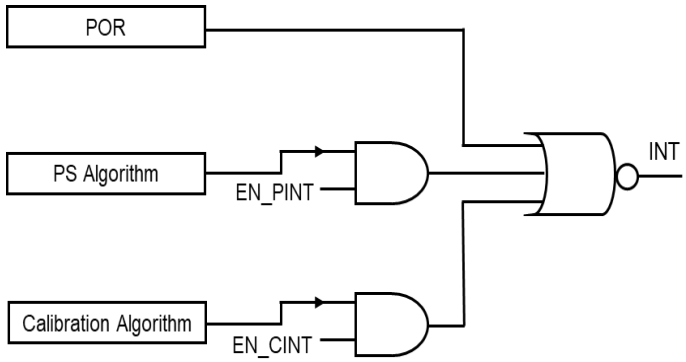
Interrupt Behavior :



PS Interrupt Algorithm

Correlative register:

The PS Interrupt (**INT_PS**, register 0x02, bit1),

The PS Persistence (**PRS_PS**, register 0x0B, bit4 to bit7),

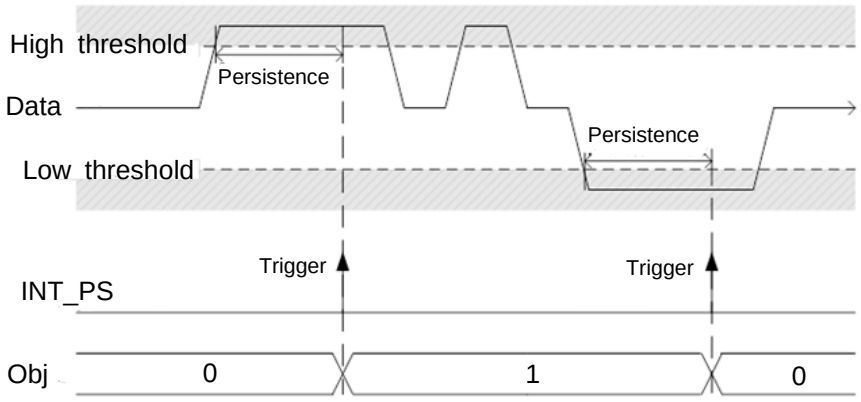
The PS Data (**PS_DATA**, register 0x1A to 0x1B),

The PS Low Threshold (**PS_THRES_L**, register 0x10 to 0x11),

The PS High Threshold (**PS_THRES_H**, register 0x12 to 0x13).

INT_PS triggered condition:

1. Rule of active interrupt:
   i. When **OBJ** is zero, **PS_DATA**>**PS_THRES_H.**
   ii. When **OBJ** is one, **PS_DATA**<**PS_THRES_L.**
2. If **PS_DATA** meets the rule, the interrupt **counter** increases one.
   If **PS_DATA** fails in the rule, the interrupt **counter** will be cleared.
3. When the counter value equal to **PRS_PS**, the **OBJ** flag will be inverted, **INT_PS** will be triggered, and clear interrupt counter.
4. If **PRS_PS** is set to zero, the **threshold** setting will be ignored and **DATA** will meets the active interrupt rule forcibly.



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13.5 Register 0x03 – WAIT_TIME

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

WTIME： This register controls the time unit of waiting state which is inserted between any two measurements. It is 6.5 ms per time unit.

0x00: 1 time unit. (Default)

0x01: 2 time unit.

……

0xFF : 256 time unit.

13.6 Register 0x06 – PS_GAIN

0x06	PS_GAIN, PS analog gain and LED control (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	IRDR_SEL		0	0	PGA_PS	

IRDR_SEL： It configures the peak current of the internal LED driver.

0x0: 5mA (Default)

0x1: 10mA

0x2: 15mA

0x3: 20mA

PGA_PS：PS sensing gain.

0x0: x1 (default)

0x1: x2

0x2: x4

13.7 Register 0x07 – PS_PULSE

0x07	PS_PULSE, PS integration pulse configure(Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	0	ITW_PS			

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ITW_PS：It controls LED pulse width in PS function mode. Pulse width is 16us per unit.

0x00: 1T (default).

0x01: 2T

……

0x0F: 16T

13.8 Register 0x08 – PSPD_CONFIG

0x08	PSPD_CONFIG, PS PD configure(Default = 0x04)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	0	0	EN_PSPD		0

EN_PSPD：PS PD select.

0x0：None

0x1：Select PD1

0x2：Select PD2 (Default)

0x3：Select PD1 and PD2

13.9 Register 0x09 – PS_TIME

0x09	PS_TIME, PS integrated time (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	ITC_PS				PSCONV			

ITC_PS： It controls the number of LED pulse in PS function mode.

0x0: 1 pulse. (Default)

0x1: 2 pulses.

……

0xF: 16 pulses.

PSCONV：This register controls the integrated time of AD converter at PS mode (T_{PS}), and the resolution of output data (PS_DATA, IR_DATA).

0x0: The maximum count of **output data** is 255, 1 time unit (default).

0x1: The maximum count of **output data** is 511, 2 time units.

……

0xF: The maximum count of **output data** is 4095, 16 time units.

The maximum count of **output data** is 256 x (time unit -1).

The conversion time of PS function (T_{PS}) is decided by ITW_PS, ITC_PS and PSCONV.

T_{PS} = 1.251 + 0.0005 x (ITC_PS + 1) x [144 + 64 x(ITW_PS+1)] + 0.256 x (PSCONV+1) (ms)

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13.10 Register 0x0A – PS_FILTER

0x0A	PS_FILTER, PS integrated time (Default = 0xBF)							
BIT	7	6	5	4	3	2	1	0
R/W	1	0	1	1	NUM_AVG			

NUM_AVG：This register sets the numbers of data to do average before output.

0x0: The output data is the average data of one time.

0x1: The output data is the average data of two times.

……

0xF: The output data is the average data of sixteen times. (Default)

The total conversion time (T_{TOTAL}) of device is decided by T_{PS}, and NUM_AVG.

T_{TOTAL} = (NUM_AVG + 1) * T_{PS} (ms)

13.11 Register 0x0B – PERSISTENCE

0x0B	PERSISTENCE, PS persistence setting (Default = 0x11)							
BIT	7	6	5	4	3	2	1	0
R/W	PRS_PS				0	0	0	1

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

0x0: Every PS conversion is done.

0x1: 1 PS interrupt event is asserted.

……

0xF: 15 consecutive PS interrupt events are asserted.

13.12 Register 0x10 to 0x11 – PS_THRES_L

0x10 0x11	PS_THRES_L, PS low interrupt threshold (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_THRE_LL							
R/W	PS_THRE_LH							

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

PS_THRE_LL：PS lower interrupt threshold value, LSB. (Reg. 0x10)

PS_THRE_LH：PS lower interrupt threshold value, MSB. (Reg. 0x11)

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13.13 Register 0x12 to 0x13 – PS_THRES_H

0x12 0x13	PS_THRES_H, PS high interrupt threshold (Default = 0xFFFF)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_THRE_HL							
R/W	PS_THRE_HH							

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

PS_THRE_HL：PS high interrupt threshold value, LSB. (Reg. 0x12)

PS_THRE_HH：PS high interrupt threshold value, MSB. (Reg. 0x13)

13.14 Register 0x14 to 0x15 – PS_OFFSET

0x14 0x15	PS_OFFSET, PS offset level (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_OFFSET_L							
R/W	PS_OFFSET_H							

This register used to calibrate the device's cross talk. The **PS_DATA** should be closed to zero with no object. The PS_OFFSET is subtracted from the measured data before it output to **PS_DATA**.

PS_OFFSET_L：PS offset level value, LSB. (Reg. 0x14)

PS_OFFSET_H：PS offset level value, MSB. (Reg. 0x15)

13.15 Register 0x17 – ERROR_FLAG

0x17	ERROR_FLAG, Error flag status							
BIT	7	6	5	4	3	2	1	0
R	PS_ REDY	0	0	ERR_ PSD	ERR_ PSL	0	0	0

This register indicates the PS data status. If the PS data is outside of measurable range, the corresponding error flag will set to one. That also means the data is invalid. Every PS conversion is done, the PS_REDY flag will set to 1. It notifies the user that the sensor data is updated.

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13.16 Register 0x1A to 0x1B – PS_DATA

0x1A 0x1B	PS_DATA, PS output data.							
BIT	7	6	5	4	3	2	1	0
R	PS_DATA _L							
R	PS_DATA_H							

The PS conversion result is written into PS_DATA.

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

13.17 Register 0x26 – CALIB_CTRL

0x26	CALIB_CTRL, PS calibration control (Default = 0x0F)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	CALIB_ BIN_SEL	1	1	1	1

CALIB_BIN_SEL：It select calibration bin-search source.

0x0: Automatic calibration (Default).

0x1: Manual.

13.18 Register 0x28 – CALIB_STAT

0x28	CALIB_STAT, PS calibration status (Default = 0x20)							
BIT	7	6	5	4	3	2	1	0
R	0	0	1	0	0	0	PS_ CALIB_SAT	CALIB_ FINISH

PS_CALIB_SAT： It shows if calibration bin-search result equal to 0xFF.

CALIB_FINISH：It shows the calibration function is done. Write zero to clear the flag.

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13.19 Register 0x2A to 0x2B – MANU_CDAT

0x2A 0x2B	MANU_CDAT, Manual calibration data. (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R/W	MANU_CDAT_L							
R/W	0	0	0	0	0	0	0	MANU_CDAT_H

The manual calibration data is setting by user to do crosstalk calibration.

13.20 Register 0x2C to 0x2D – AUTO_CDAT

0x2C 0x2D	AUTO_CDAT, Automatic calibration data.							
BIT	7	6	5	4	3	2	1	0
R	AUTO_CDAT_L							
R	0	0	0	0	0	0	0	AUTO_CDAT_H

The automatic calibration data is setting by chip to do crosstalk calibration. When calibration function is finished, the calibration data will show on this register.

13.21 Register 0x2E – PS_PIPE_THRE

0x2E	PS_PIPE_THRE, PS pipeline filter threshold (Default = 0x10)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_PIPE_THRE							

This register sets the pipeline filter threshold that controls the slew rate of the filter. When the PS data is large or less than before data over threshold, the filter will update to the new PS data.

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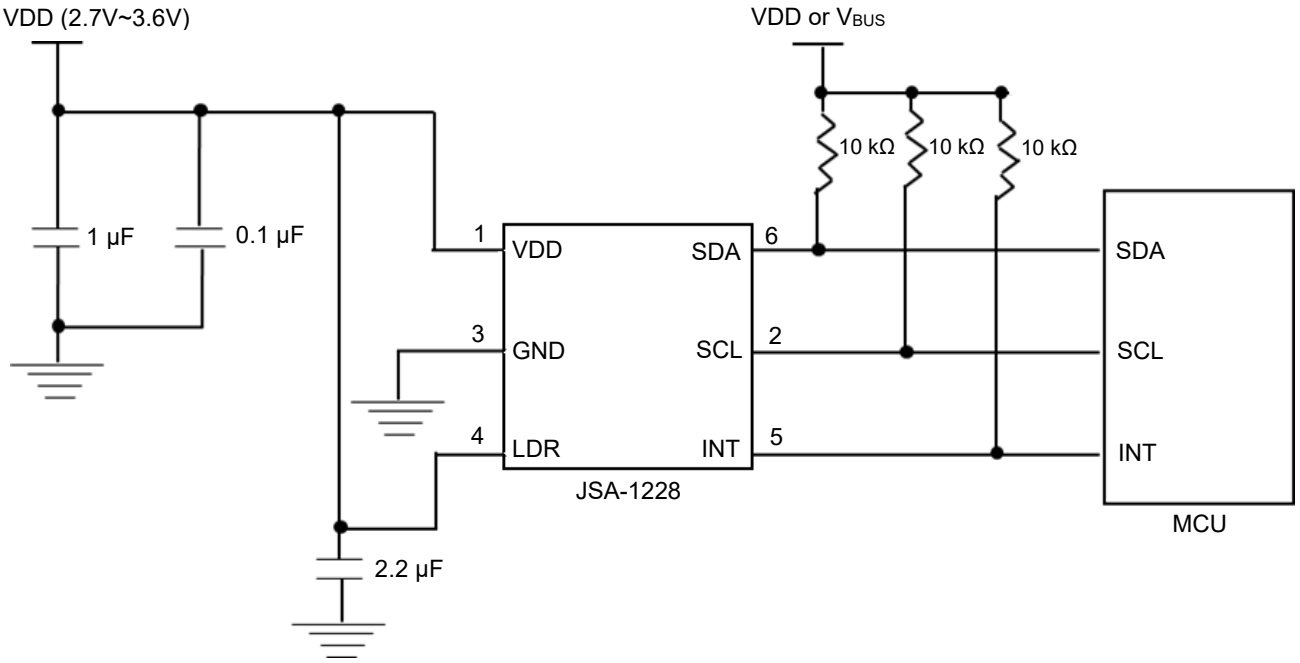
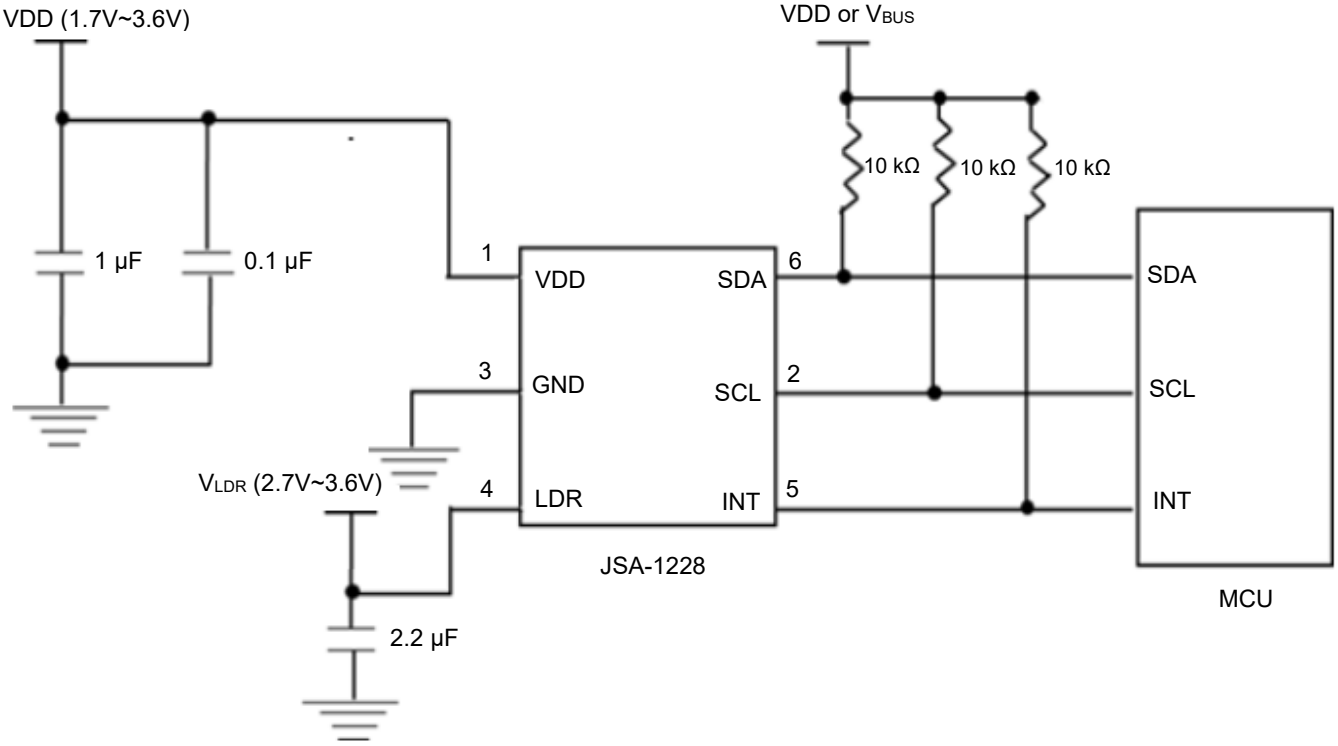
14. Application Circuit

Single Power Supply:

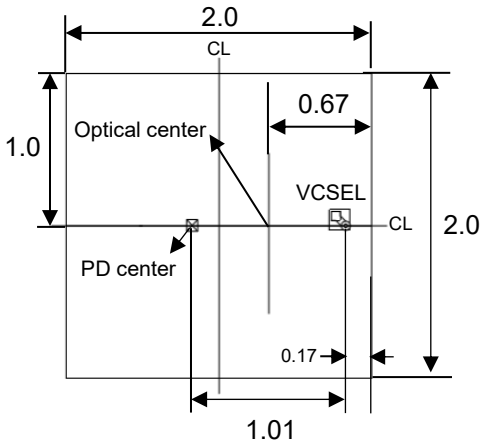


Separate power supplies:

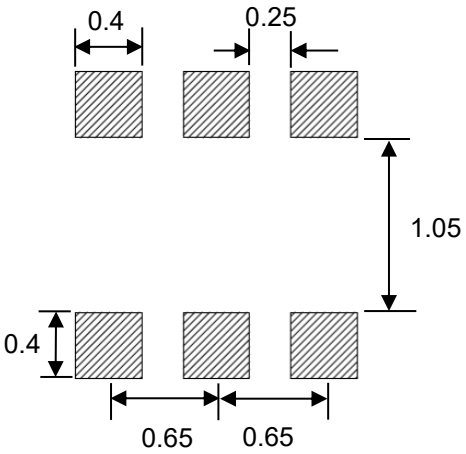


15. Package Outline

Top View

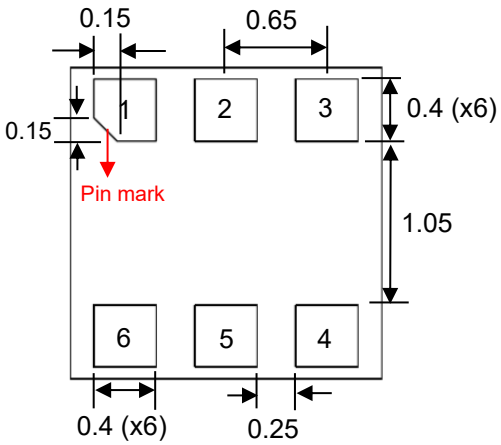


PAD Layout Reference



Side View

Bottom View



Pin Define

1. VDD
2. SCL
3. GND
4. LDR
5. INT
6. SDA

Notes:

1. All dimensions are in millimeters.
2. All tolerances are ±0.1mm (0.004 inch) unless otherwise noted.

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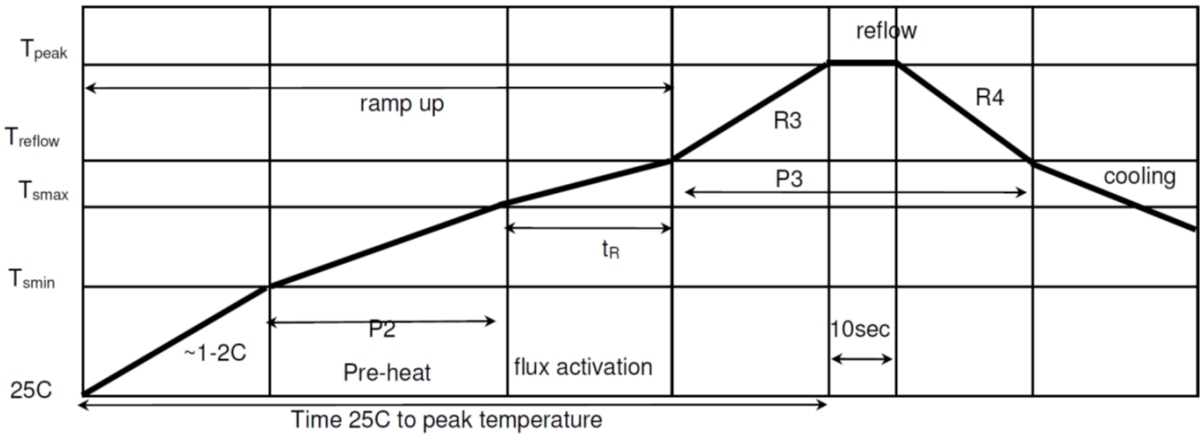
16. Recommended Reflow Profile



	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 (T_{reflow}) 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

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17. Notice

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