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Reflective Type Photosensor

Miniature Proximity Sensor

RPR-0720

Datasheet

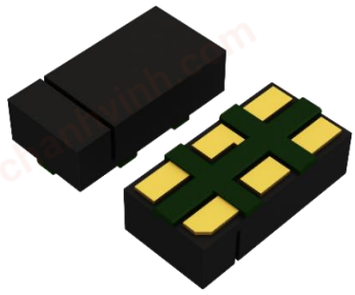
●Construction

RPR-0720 is a digital optical proximity sensor (PS) equipped with infrared VCSEL (IrVCSEL) and IC with I2C interface. This IC has a built-in infrared receiver and VCSEL driver. Proximity sensor (PS) detects the human or object approaching by the reflection of IrVCSEL light.

●Features

1) Compatible to I^2C bus interface (f/s mode support)
2) Compatible to 1.8V or 3.3V logic interface
3) Directly connected to the IrVCSEL input power supply battery
   (V_{VCSELA} Max.4.5V@V_{CC}=1.8V)
4) Detection range of proximity sensor is around 1 - 15mm (adjustable by I^2C)
5) Built-in constant current configurable IrVCSEL driver
6) Equipped with Ambient light canceling function
7) Low light leakage inside the product using micro slit

●Package



W x D x H
2.0 mm x 1.0 mm x 0.55 mm

●Application

Wireless Ear buds, Hearing aids, Smart phone, Mobile phone, Game machine, Wearable device, AR/VR device, Digital Still Camera, etc.

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1. Absolute maximum ratings (Ta = 25℃)

Parameter	Symbol	Limits	Units	Condition
VCC Supply Voltage	V_{CC}max	2.2	V	4.5V < V_{VCSELA}
		4.5	V	V_{VCSELA} ≦ 4.5V
SDA, SCL, INT, Terminal Voltage	V_{SDA}max, V_{SCL}max, V_{INT}max	-0.3 to 4.5	V	-
VCSELA Terminal Voltage	V_{VCSELA}max	-0.3 to 6.0	V	V_{CC} ≦ 2.0V
		-0.3 to 4.5	V	2.0V < V_{CC}
INT, SCL, SDA Input Current	Imax	7	mA	-
Storage Temperature	Tstg	-40 to 85	℃	-
Operating Temperature	Topr	-30 to 85	℃	-

2. Recommended operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
VCC Supply Voltage	V_{CC}	1.7	1.8	3.6	V	-
Input Voltage (INT, SCL, SDA)	V_{INT}, V_{SCL}, V_{SDA}	0	-	3.6	V	-
Input Voltage (VCSELA)	V_{VCSELA}	2.7	-	4.5	V	V_{CC} ≦ 2.0V
		2.7	-	3.6	V	2.0V < V_{CC}

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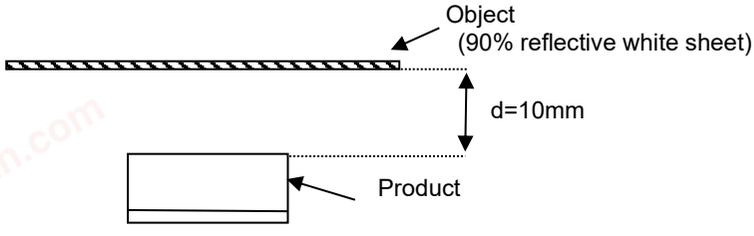
3. Electrical characteristics

(Unless otherwise specified, VCC = 1.8 V, Ta = 25 °C, MEAS_TIME=100ms mode,
PS_GAIN = 1x mode, PS_PULSE = 200 µs mode, PD_SEL=Far mode)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply current*1	$I_{CC}1$	-	16	35	uA	PS_EN=1 PS_PULSE=50µs mode
Supply current When driving VCSEL*1	$I_{CC}2$	-	300	500	uA	-
Standby current*1	$I_{CC}3$	-	0.7	5.0	uA	PS_EN=0
PS sensor out (d=10mm*2)	PS	285	475	665	count	IF=4mA PS_GAIN =1x PD_SEL =Far mode PS_PULSE=50µs mode Object:90% reflective white sheet No glass above module
PS sensor out (No proximity object)	PS_{LEAK}	-	-	205	count	IF=4mA PS_GAIN =1x PD_SEL =Far mode PS_PULSE=50µs mode No glass above module Ambient irradiance = 0uW/cm^2
SCL SDA input 'H' Voltage	V_{IH}	0.84	-	-	V	-
SCL SDA input 'L' Voltage	V_{IL}	-	-	0.45	V	-
SCL SDA INT output 'L' Voltage	V_{OL}	0	-	0.4	V	I_{OL} = 3mA
Input Current	I_{IHL}	-10	-	10	µA	V_{INT}, V_{SCL}, V_{SDA} = 0 to 3.6V

*1 Does not include current of VCSEL

*2 Measuring Condition



Object: 90% reflective white sheet (Kodak Gray Card Plus)
Distance between the object and the product is 10mm. No glass or apertures is above the product.

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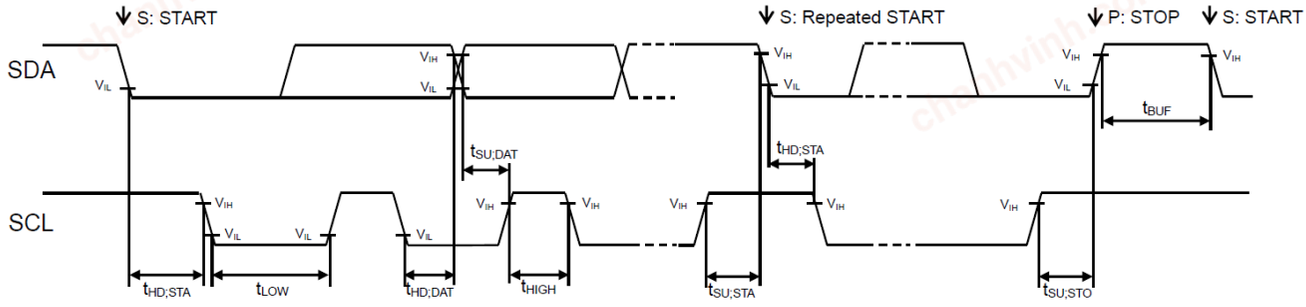
4. Transmitter Electrical characteristics (Ta = 25℃, unless otherwise noted.)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
VCSEL Peak Emission Wavelength	λp	-	940	-	nm	-

5. I²C bus timing characteristics (V_{CC}= 1.8V, Ta = 25℃, unless otherwise noted.)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
I²C SCL Clock Frequency	f_{SCL}	-	-	400	kHz	-
I²C START Condition Hold Time	$t_{HD;STA}$	0.6	-	-	us	-
I²C 'L' Period of the SCL Clock	t_{LOW}	1.3	-	-	us	-
I²C 'H' Period of the SCL Clock	t_{HIGH}	0.6	-	-	us	-
I²C S START Condition Set up time	$t_{SU;STA}$	0.6	-	-	us	-
I²C Data Hold Time	$t_{HD;DAT}$	0	-	-	us	-
I²C Data Setup Time	$t_{SU;DAT}$	100	-	-	ns	-
I²C STOP Condition Set up Time	$t_{SU;STO}$	0.6	-	-	us	-
I²C Bus Free Time	t_{BUF}	1.3	-	-	us	-
Data Valid Time	$t_{VD;DAT}$	-	-	0.9	us	-
Data Valid Acknowledge Time	$t_{VC;ACK}$	-	-	0.9	us	-

I²C bus F/S-mode timing diagram

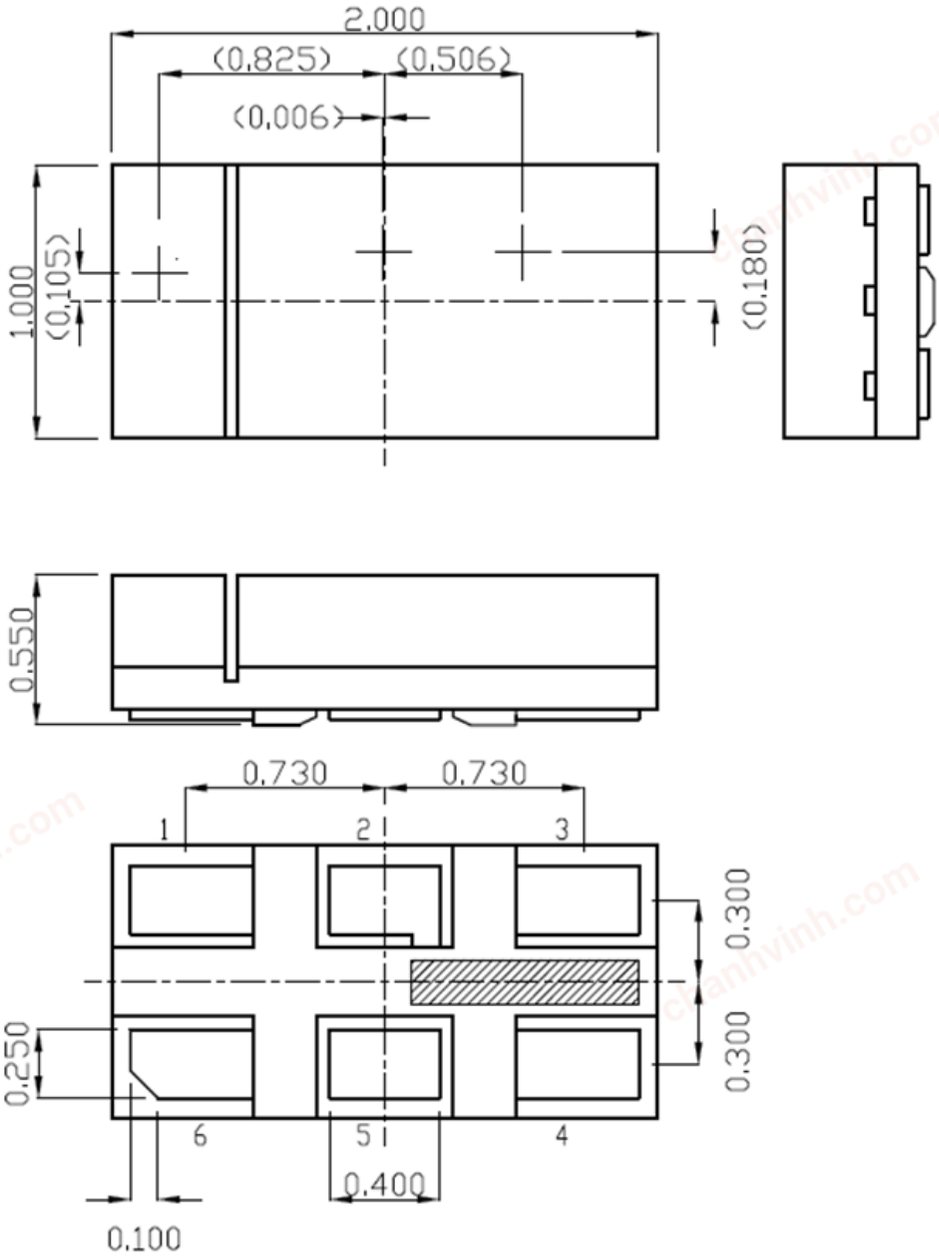


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6. Package outlines

1) Unit: mm
2) Tolerance shall be ±0.10mm unless otherwise noted.
3) The values in () are reference dimensions. (Not guaranteed)
4) A mark is printed in the shaded area. (Manufacture year, week and Factory)

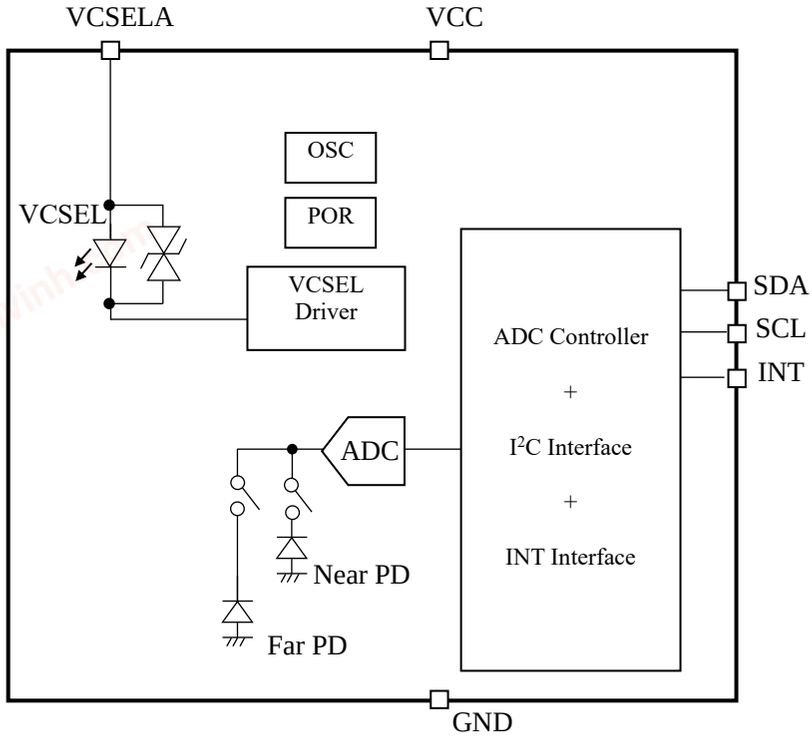


PIN Number	Symbol	Description
1	VCSELA	VCSEL Supply Voltage
2	SCL	I^2C Clock, Input
3	SDA	I^2C Serial Data, Input/Output
4	INT	PS Interrupt Pin, Open Drain
5	VCC	IC Supply Voltage
6	GND	Ground

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7. Block diagram and block explanation



● Description of Blocks

- Near PD : Photodiode near to VCSEL.
- Far PD : Photodiode far to VCSEL.
- ADC : AD converter for obtaining digital data
- ADC Controller + I2C Interface + INT Interface : ADC control logic and Interface logic.
- OSC : Oscillator for clock of internal logic.
- POR : Power ON Reset. All registers are reset after VCC is supplied
- VCSEL Driver : Constant current driver for VCSEL.

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8. Command set

Address	Type	default	Register name	Register function
0x40	RW	0x1C	SYSTEM_CONTROL	System control
0x41	RW	0x02	MODE_CONTROL0	Photodiode selection, Gain, Period, Pulse width, VCSEL current
0x42	RW	0x00	MODE_CONTROL1	
0x43	RW	0x00	MODE_CONTROL2	
0x44	R	0x00	PS_DATA_LSBs	PS data low byte
0x45	R	0x00	PS_DATA_MSBs	PS data high byte, PS Threshold Frag, Ambient Ir Frag
0x46	RW	0x00	PS_OFFSET_LSBs	PS offset low byte
0x47	RW	0x00	PS_OFFSET_MSBs	PS offset high byte
0x4A	RW	0x10	INTERRUPT	Interrupt control
0x4B	RW	0xFF	PS_TH_HIGH_LSBs	PS upper threshold low byte
0x4C	RW	0xFF	PS_TH_HIGH_MSBs	PS upper threshold high byte
0x4D	RW	0x00	PS_TH_LOW_LSBs	PS lower threshold low byte
0x4E	RW	0x00	PS_TH_LOW_MSBs	PS lower threshold high byte
0x92	R	0xE0	MANUFACT_ID	MANUFACT ID

● SYSTEM_CONTROL (0x40)

Field	Bit	TYPE	Description
SW reset	7	RW	0 : initial reset is not started 1 : initial reset is started
Part ID	6 : 0	R	0011100

default value 0x1C

● MODE_CONTROL0 (0x41)

Field	Bit	TYPE	Description
Reserved	7 : 4	R	Ignored
PS_GAIN	3 : 2	RW	00 : PS GAIN ×1 (default) 10 : PS GAIN ×2 Others : Forbidden
PD_SEL	1 : 0	RW	00 : No photodiode 01 : Far photodiode 10 : Near photodiode (default) 11 : Both photodiode

default value 0x02

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● MODE_CONTROL1 (0x42)

Field	Bit	TYPE	Description
Reserved	7	R	Ignored
Period	6 : 4	RW	000 : typ 10ms (default) 001 : typ 50ms 010 : typ 100ms 011 : typ 500ms 100 : typ 5ms Others : Forbidden
PS_PULSE	3 : 2	RW	00 : VCSEL pulse width is typ 50us (default) 01 : VCSEL pulse width is typ 100us 10 : VCSEL pulse width is typ 200us 11 : VCSEL pulse width is typ 400us
VCSEL CURRENT	1 : 0	RW	00 : 3mA 01 : 4mA 10 : 5mA

default value 0x00

● MODE_CONTROL2 (0x43)

Field	Bit	TYPE	Description
Reserved	7: 1	R	Ignored
PS_EN	0	RW	0 : PS Standby (default) 1 : PS Enable

default value 0x00

● PS_DATA_LSBs (0x44)

Register	TYPE	7	6	5	4	3	2	1	0
PS_DATA_LSBs	R	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

● PS_DATA_MSBs (0x45)

Field	Bit	TYPE	Description
PS_INT_TH_Flag	7	R	0: PS_TH_HIGH is valid 1: PS_TH_LOW is valid
Ambient_Ir_Flag	6	R	0: Ambient infrared level is low 1: Ambient infrared level is high
Reserved	5 : 4	R	Ignored
PS_DATA_MSBs	3 : 0	R	Shown in table below

default value 0x00

Register	TYPE	7	6	5	4	3	2	1	0
PS_DATA_MSBs	R	-	-	-	-	2^{11}	2^{10}	2^9	2^8

Table 1. PS measurement result

PS_PULSE	Data Range	Error Code
00 : 50 us mode	0x000 to 0x3FE	0xFFF
01 : 100 us mode	0x000 to 0x3FE	0xFFF
10 : 200 us mode	0x000 to 0x7FE	0xFFF
11 : 400 us mode	0x000 to 0xFFE	0xFFF

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● PS _OFFSET_LSBs (0x46)

Register	TYPE	7	6	5	4	3	2	1	0
PS_OFFSET_LSBs	RW	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

default value 0x00

● PS _OFFSET_MSBs (0x47)

Field	Bit	TYPE	Description
Resereved	7 : 1	R	Ignored
PS_OFFSET_MSBs	0	RW	Shown below

default value 0x00

Register	TYPE	7	6	5	4	3	2	1	0
PS_OFFSET_MSBs	RW	-	-	-	-	-	-	-	2^8

● INTERRUPT (0x4A)

Field	Bit	TYPE	Description
PS INT STAUTS	7	R	0 : PS interrupt signal inactive 1 : PS interrupt signal active
Resereved	6	R	Ignored
PERSISTENCE	5 : 4	RW	PS interrupt persistence setting 00:Interrupt becomes active at each measurement end 01:Interrupt status is updated at each measurement end (default) 10:Interrupt status is updated if 4 consecutive threshold judgments are the same 11:Interrupt status is updated if 16 consecutive threshold judgments are the same
Resereved	3 : 1	R	Ignored
INT TRIG	0	RW	0 : INT pin is inactive (default) 1 : INT pin is triggered by PS measurement.

default value 0x10

● PS_TH_HIGH_LSBs (0x4B)

Register	TYPE	7	6	5	4	3	2	1	0
PS_TH_HIGH_LSBs	RW	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

default value 0xFF

● PS_TH_ HIGH _MSBs (0x4C)

Register	TYPE	7	6	5	4	3	2	1	0
PS_TH_HIGH_MSBs	RW	-	-	-	-	2^{11}	2^{10}	2^9	2^8

default value 0x0F

● PS_TH_ LOW _LSBs (0x4D)

Register	TYPE	7	6	5	4	3	2	1	0
PS_TH_LOW_LSBs	RW	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

default value 0x00

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● PS_TH_ LOW_MSBs (0x4E)

Register	TYPE	7	6	5	4	3	2	1	0
PS_TH_LOW_MSBs	RW	-	-	-	-	2^{11}	2^{10}	2^{9}	2^{8}

default value 0x00

● MANUFACT_ID (0x92)

Field	Bit	TYPE	Description
MANUFACT_ID	7 : 0	R	11100000

default value 0xE0

● I^2C bus communication

1) Slave address “0111001”(0x39)

2) Main write format

1. Case of “Indicating register address”

S	Slave Address	W 0	ACK	Indicate register address	ACK	P

2. Case of "writing data register after indicating register address"

S	Slave Address	W 0	ACK	Indicate register address	ACK

Data specified at register address field	ACK

ACK	Data specified at register address field + N	ACK	P

3) Main read format

1. Case of “Reading data after indicating register address” (Master issues restart condition)

S	Slave Address	W 0	ACK	Indicate register address	ACK

S	Slave Address	R 1	ACK	Data specified at register address field	ACK

Data specified at register address field + 1	ACK

ACK	Data specified at register address field + N	NACK	P

2. Case of “Reading data from specified register address”

S	Slave Address	R 1	ACK	Data specified at register address field	ACK

Data specified at register address field + 1	ACK

ACK	Data specified at register address field + N	NACK	P

from master to slave

from slave to master

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● Explanation of Accessing MODE_CONTROL

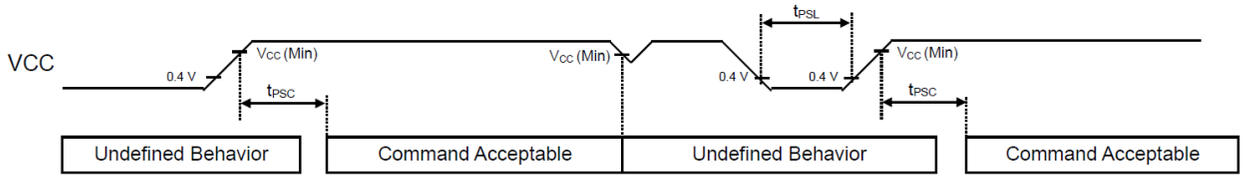
If master writes to MODE_CONTROL0, MODE_CONTROL1, MODE_CONTROL2, INTERRUPT, PS_OFFSET, PS_TH_HIGH and PS_TH_LOW registers, PS measurement currently in progress is interrupted immediately and re-started from the beginning. At this PS interrupt and PS persistence counter are cleared too.

● Power Supply Sequence (Unless otherwise specified VCC = 1.8 V, Ta = 25 °C)

RPR-0720 have power on reset function. By operating this function, all of registers are reset when the power is supplied. Please note followings and design the application.

Power on time : tpsc
tpsc > 0.2ms

Power off time :tpsl
tpsl > 1ms



Command input is available after “tPSC” from VCC is supplied.
If VCC voltage is below the recommended operating voltage range, internal state is “Undefined Behavior”.
In this case, once power down and power up again.
Keep V_{CC} < 0.4 V for “t_{PSL}” or more before V_{CC} is supplied again.

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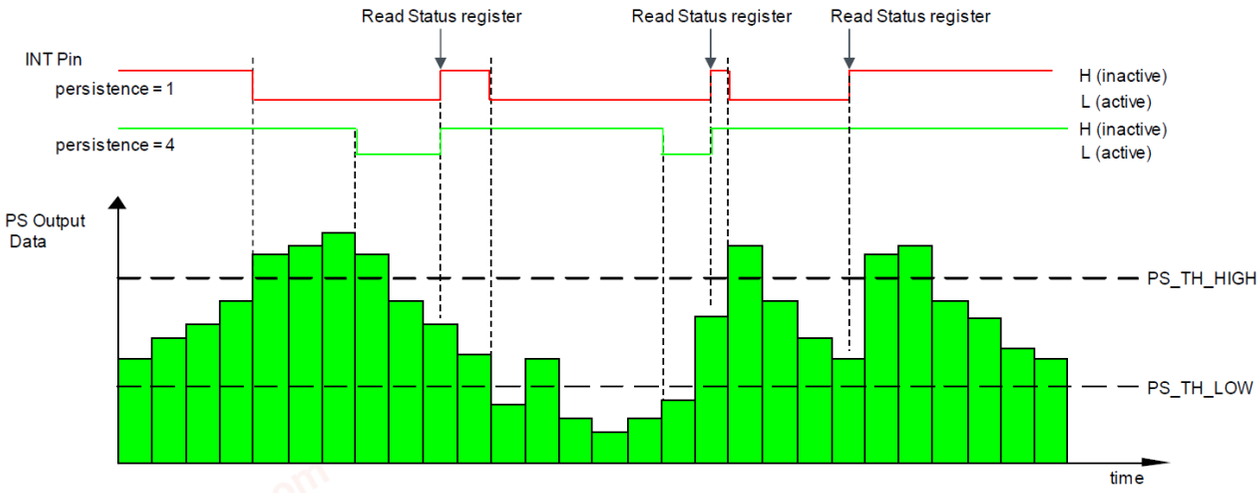
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- Proximity Sensor Interrupt Function

Interrupt function compares the PS measurement data and threshold values. Operation of proximity interrupt is window hysteresis mode. There are 2 thresholds for upper and lower side (“PS_TH_HIGH” and “PS_TH_LOW”), and H and L detection mode change alternately. (Initial is H detection mode)
In H detection mode, when PS measurement data exceeds “PS_TH_HIGH”, interrupt become active and mode shift to L detection mode. In L detection mode, when PS measurement data is below “PS_TH_LOW”, interrupt become active and mode shift to H detection mode.
When power-up, INT pin status is inactive (high impedance state).

To clear interrupt after once it becomes active.
1) Read status register (INTERRUPT)
2) Send software reset command
3) Write to MODE_CONTROL0, MODE_CONTROL1, MODE_CONTROL2, PS_OFFSET, INTERRUPT, PS_TH_HIGH and PS_TH_LOW registers

Ex) Example of interrupt behavior



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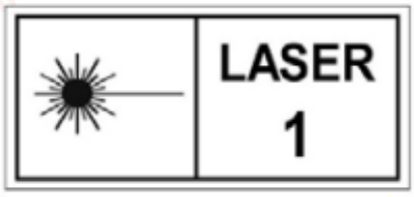
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9. Operational notes

1.Micro-slit
If foreign matter enters the micro-slit, the optical characteristics may be affected.

2.Laser eye safety
RPR-0720 is designed to meet the Class 1 laser safety limits including single faults in compliance with IEC/EN 60825-1:2014.

In an end application system environment, the system may need to be tested to ensure it remains compliant.
The system must not include any additional lens to concentrate the laser light or parameters set outside of the recommended operating conditions or any physical modification to the module during development could result in hazardous levels of radiation exposure.



3.Foreign matter on the top of the package
If foreign matter adheres to the top surface of the package, it may affect the optical characteristics.

4.Reverse Connection of Power Supply
Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

5.Power Supply Lines
Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

6.Ground Voltage
Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

7.Ground Wiring Pattern
When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

8.Recommended Operating Conditions
The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

9.Inrush Current
When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

10.Testing on Application Boards
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

11.Inter-pin Short and Mounting Errors
Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

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12.Regarding the Input Pin of the IC

In the construction of this IC, P-N junctions are inevitably formed creating parasitic diodes or transistors. The operation of these parasitic elements can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions which cause these parasitic elements to operate, such as applying a voltage to an input pin lower than the ground voltage should be avoided. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. Even if the power supply voltage is applied, make sure that the input pins have voltages within the values specified in the electrical characteristics of this IC.

13.Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

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