

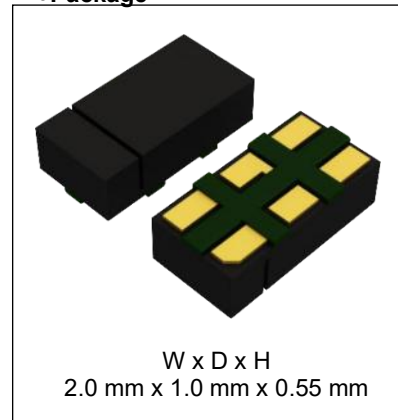
## •Construction

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<sup>2</sup>C 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<sub>VCSELA</sub> Max.4.5V@V<sub>CC</sub>=1.8V)
- 4) Detection range of proximity sensor is around 1 - 15mm (adjustable by I<sup>2</sup>C)
- 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



## •Application

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

**1. Absolute maximum ratings** (Ta = 25°C)

| Parameter                       | Symbol                                                          | Limits      | Units | Condition                  |
|---------------------------------|-----------------------------------------------------------------|-------------|-------|----------------------------|
| VCC Supply Voltage              | V <sub>CCmax</sub>                                              | 2.2         | V     | 4.5V < V <sub>VCSELA</sub> |
|                                 |                                                                 | 4.5         | V     | V <sub>VCSELA</sub> ≤ 4.5V |
| SDA, SCL, INT, Terminal Voltage | V <sub>SDAmax</sub> , V <sub>SCLmax</sub> , V <sub>INTmax</sub> | -0.3 to 4.5 | V     | -                          |
| VCSELA Terminal Voltage         | V <sub>VCSELAmax</sub>                                          | -0.3 to 6.0 | V     | V <sub>CC</sub> ≤ 2.0V     |
|                                 |                                                                 | -0.3 to 4.5 | V     | 2.0V < V <sub>CC</sub>     |
| INT, SCL, SDA Input Current     | I <sub>max</sub>                                                | 7           | mA    | -                          |
| Storage Temperature             | T <sub>stg</sub>                                                | -40 to 85   | °C    | -                          |
| Operating Temperature           | T <sub>opr</sub>                                                | -30 to 85   | °C    | -                          |

**2. Recommended operating conditions**

| Parameter                     | Symbol                                                 | Min. | Typ. | Max. | Units | Condition              |
|-------------------------------|--------------------------------------------------------|------|------|------|-------|------------------------|
| VCC Supply Voltage            | V <sub>CC</sub>                                        | 1.7  | 1.8  | 3.6  | V     | -                      |
| Input Voltage (INT, SCL, SDA) | V <sub>INT</sub> , V <sub>SCL</sub> , V <sub>SDA</sub> | 0    | -    | 3.6  | V     | -                      |
| Input Voltage (VCSELA)        | V <sub>VCSELA</sub>                                    | 2.7  | -    | 4.5  | V     | V <sub>CC</sub> ≤ 2.0V |
|                               |                                                        | 2.7  | -    | 3.6  | V     | 2.0V < V <sub>CC</sub> |

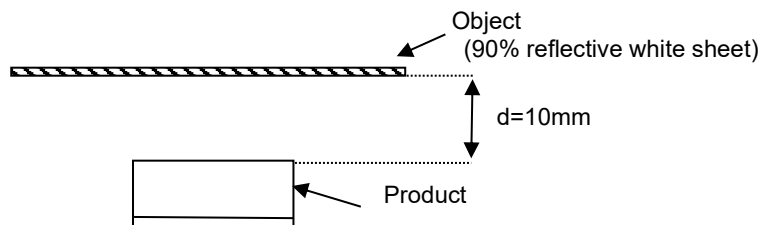
### 3. Electrical characteristics

(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 <sub>cc1</sub>   | -    | 16   | 35   | uA    | PS_EN=1<br>PS_PULSE=50μs mode                                                                                                        |
| Supply current<br>When driving VCSEL *1 | I <sub>cc2</sub>   | -    | 300  | 500  | uA    | -                                                                                                                                    |
| Standby current*1                       | I <sub>cc3</sub>   | -    | 0.7  | 5.0  | uA    | PS_EN=0                                                                                                                              |
| PS sensor out<br>(d=10mm*2)             | PS                 | 285  | 475  | 665  | count | IF=4mA<br>PS_GAIN =1x<br>PD_SEL =Far mode<br>PS_PULSE=50μs mode<br>Object:90% reflective white sheet<br>No glass above module        |
| PS sensor out<br>(No proximity object)  | PS <sub>LEAK</sub> | -    | -    | 205  | count | IF=4mA<br>PS_GAIN =1x<br>PD_SEL =Far mode<br>PS_PULSE=50μs mode<br>No glass above module<br>Ambient irradiance = 0uW/cm <sup>2</sup> |
| SCL SDA input 'H' Voltage               | V <sub>IH</sub>    | 0.84 | -    | -    | V     | -                                                                                                                                    |
| SCL SDA input 'L' Voltage               | V <sub>IL</sub>    | -    | -    | 0.45 | V     | -                                                                                                                                    |
| SCL SDA INT output 'L' Voltage          | V <sub>OL</sub>    | 0    | -    | 0.4  | V     | I <sub>OL</sub> = 3mA                                                                                                                |
| Input Current                           | I <sub>IHL</sub>   | -10  | -    | 10   | μA    | V <sub>INT</sub> , V <sub>SCL</sub> , V <sub>SDA</sub> = 0 to 3.6V                                                                   |

\*1 Does not include current of VCSEL

\*2 Measuring Condition



Object: 90% reflective white sheet (Kodak Gray Card Plus)

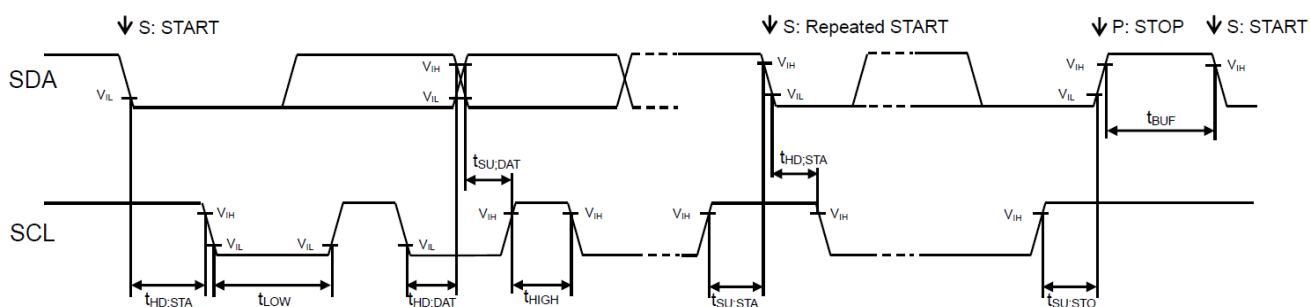
Distance between the object and the product is 10mm. No glass or apertures is above the product.

## 4. Transmitter Electrical characteristics ( Ta = 25°C, unless otherwise noted. )

| Parameter                      | Symbol      | Min. | Typ. | Max. | Units | Conditions |
|--------------------------------|-------------|------|------|------|-------|------------|
| VCSEL Peak Emission Wavelength | $\lambda_p$ | -    | 940  | -    | nm    | -          |

5. I<sup>2</sup>C bus timing characteristics ( V<sub>CC</sub>= 1.8V, Ta = 25°C, unless otherwise noted. )

| Parameter                                      | Symbol              | Min. | Typ. | Max. | Units | Conditions |
|------------------------------------------------|---------------------|------|------|------|-------|------------|
| I <sup>2</sup> C SCL Clock Frequency           | f <sub>SCL</sub>    | -    | -    | 400  | kHz   | -          |
| I <sup>2</sup> C START Condition Hold Time     | t <sub>HD,STA</sub> | 0.6  | -    | -    | us    | -          |
| I <sup>2</sup> C 'L' Period of the SCL Clock   | t <sub>LOW</sub>    | 1.3  | -    | -    | us    | -          |
| I <sup>2</sup> C 'H' Period of the SCL Clock   | t <sub>HIGH</sub>   | 0.6  | -    | -    | us    | -          |
| I <sup>2</sup> C S START Condition Set up time | t <sub>SU,STA</sub> | 0.6  | -    | -    | us    | -          |
| I <sup>2</sup> C Data Hold Time                | t <sub>HD,DAT</sub> | 0    | -    | -    | us    | -          |
| I <sup>2</sup> C Data Setup Time               | t <sub>SU,DAT</sub> | 100  | -    | -    | ns    | -          |
| I <sup>2</sup> C STOP Condition Set up Time    | t <sub>SU,STO</sub> | 0.6  | -    | -    | us    | -          |
| I <sup>2</sup> C Bus Free Time                 | t <sub>BUF</sub>    | 1.3  | -    | -    | us    | -          |
| Data Valid Time                                | t <sub>VD,DAT</sub> | -    | -    | 0.9  | us    | -          |
| Data Valid Acknowledge Time                    | t <sub>VC,ACK</sub> | -    | -    | 0.9  | us    | -          |

I<sup>2</sup>C bus F/S-mode timing diagram

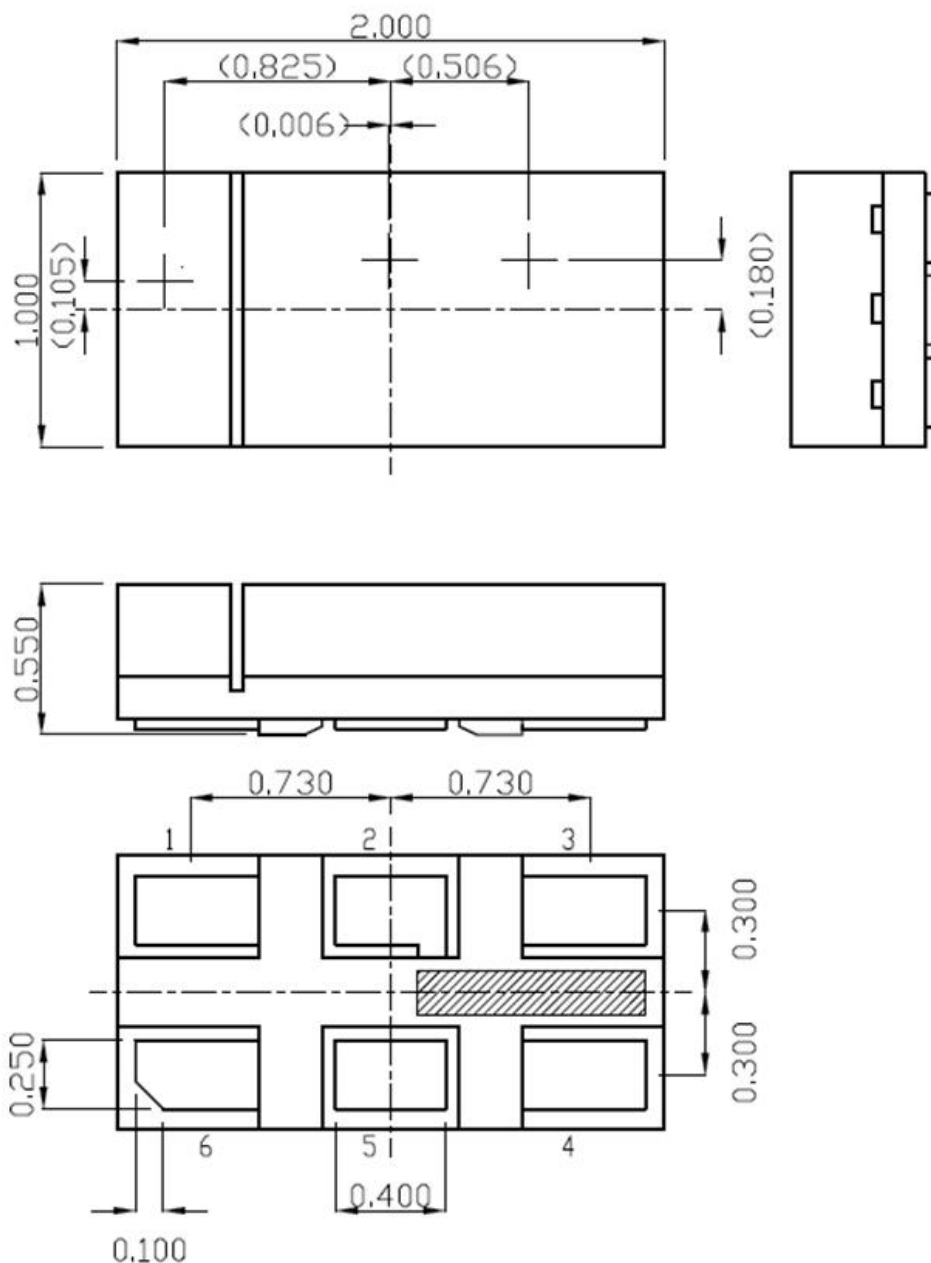
## 6. Package outlines

1) Unit: mm

2) Tolerance shall be  $\pm 0.10$ mm unless otherwise noted.

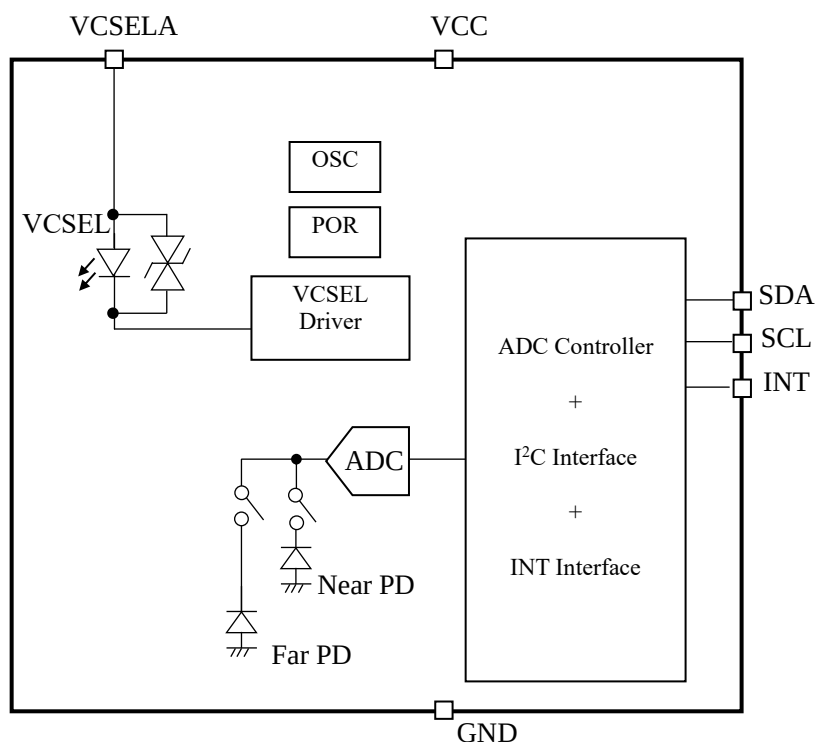
3) The values in ( ) are reference dimensions. (Not guaranteed)

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 <sup>2</sup> C Clock, Input              |
| 3          | SDA    | I <sup>2</sup> C Serial Data, Input/Output |
| 4          | INT    | PS Interrupt Pin, Open Drain               |
| 5          | VCC    | IC Supply Voltage                          |
| 6          | GND    | Ground                                     |

## 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.

## 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<br>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)<br>10 : PS GAIN ×2<br>Others : Forbidden                                  |
| PD_SEL   | 1 : 0 | RW   | 00 : No photodiode<br>01 : Far photodiode<br>10 : Near photodiode (default)<br>11 : Both photodiode |

default value 0x02

## • MODE\_CONTROL1 ( 0x42 )

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

## • PS\_DATA\_MSBs ( 0x45 )

| Field           | Bit   | TYPE | Description                                                           |
|-----------------|-------|------|-----------------------------------------------------------------------|
| PS_INT_TH_Flag  | 7     | R    | 0: PS_TH_HIGH is valid<br>1: PS_TH_LOW is valid                       |
| Ambient_Ir_Flag | 6     | R    | 0: Ambient infrared level is low<br>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 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> |

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      |



## • PS\_OFFSET\_LSBs ( 0x46 )

| Register       | TYPE | 7              | 6              | 5              | 4              | 3              | 2              | 1              | 0              |
|----------------|------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| PS_OFFSET_LSBs | RW   | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |

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 <sup>8</sup> |

## • INTERRUPT ( 0x4A )

| Field         | Bit   | TYPE | Description                                                                                                                                                                                                                                                                                                                          |
|---------------|-------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PS INT STAUTS | 7     | R    | 0 : PS interrupt signal inactive<br>1 : PS interrupt signal active                                                                                                                                                                                                                                                                   |
| Resereved     | 6     | R    | Ignored                                                                                                                                                                                                                                                                                                                              |
| PERSISTENCE   | 5 : 4 | RW   | PS interrupt persistence setting<br>00:Interrupt becomes active at each measurement end<br>01:Interrupt status is updated at each measurement end (default)<br>10:Interrupt status is updated if 4 consecutive threshold judgments are the same<br>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)<br>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 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |

default value 0xFF

## • PS\_TH\_HIGH\_MSBs ( 0x4C )

| Register        | TYPE | 7 | 6 | 5 | 4 | 3               | 2               | 1              | 0              |
|-----------------|------|---|---|---|---|-----------------|-----------------|----------------|----------------|
| PS_TH_HIGH_MSBs | RW   | - | - | - | - | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> |

default value 0x0F

## • PS\_TH\_LOW\_LSBs ( 0x4D )

| Register       | TYPE | 7              | 6              | 5              | 4              | 3              | 2              | 1              | 0              |
|----------------|------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| PS_TH_LOW_LSBs | RW   | 2 <sup>7</sup> | 2 <sup>6</sup> | 2 <sup>5</sup> | 2 <sup>4</sup> | 2 <sup>3</sup> | 2 <sup>2</sup> | 2 <sup>1</sup> | 2 <sup>0</sup> |

default value 0x00

• PS\_TH\_LOW\_MSBs ( 0x4E )

| Register       | TYPE | 7 | 6 | 5 | 4 | 3               | 2               | 1              | 0              |
|----------------|------|---|---|---|---|-----------------|-----------------|----------------|----------------|
| PS_TH_LOW_MSBs | RW   | - | - | - | - | 2 <sup>11</sup> | 2 <sup>10</sup> | 2 <sup>9</sup> | 2 <sup>8</sup> |

default value 0x00

• MANUFACT\_ID ( 0x92 )

| Field       | Bit   | TYPE | Description |
|-------------|-------|------|-------------|
| MANUFACT_ID | 7 : 0 | R    | 11100000    |

default value 0xE0

• I<sup>2</sup>C bus communication

1) Slave address "0111001" ( 0x39 )

2) Main write format

1. Case of "Indicating register address"

|   |               |        |     |                           |     |   |
|---|---------------|--------|-----|---------------------------|-----|---|
| S | Slave Address | W<br>0 | ACK | Indicate register address | ACK | P |
|---|---------------|--------|-----|---------------------------|-----|---|

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

|   |               |        |     |                           |     |
|---|---------------|--------|-----|---------------------------|-----|
| S | Slave Address | W<br>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<br>0 | ACK | Indicate register address | ACK |
|---|---------------|--------|-----|---------------------------|-----|

|   |               |        |     |                                          |     |
|---|---------------|--------|-----|------------------------------------------|-----|
| S | Slave Address | R<br>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<br>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

- Explanation of Accessing MODE\_CONTROL

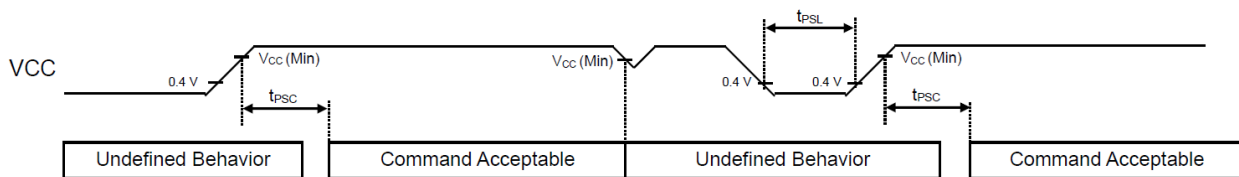
If master writes to MODE\_CONTROL0, MODE\_CONTROL1, MODE\_CONTROL2, INTERRUPT, PS\_OFFSET, PS\_TH\_HIGH and PS\_TH\_LOW registers, PS measurement currently in progress is interrupted immediately and re-started from the beginning. At this PS interrupt and PS persistence counter are cleared too.

- Power Supply Sequence (Unless otherwise specified  $V_{CC} = 1.8\text{ V}$ ,  $T_a = 25\text{ }^{\circ}\text{C}$ )

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 :  $t_{psc}$   
 $t_{psc} > 0.2\text{ ms}$

Power off time :  $t_{psl}$   
 $t_{psl} > 1\text{ ms}$



Command input is available after " $t_{PSC}$ " from  $V_{CC}$  is supplied.

If  $V_{CC}$  voltage is below the recommended operating voltage range, internal state is "Undefined Behavior".

In this case, once power down and power up again.

Keep  $V_{CC} < 0.4\text{ V}$  for " $t_{PSL}$ " or more before  $V_{CC}$  is supplied again.

### ● 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



## 9. Operational notes

### 1. Micro-slit

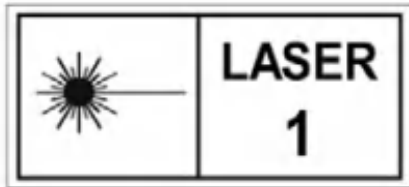
If foreign matter enters the micro-slit, the optical characteristics may be affected.

### 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.

**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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