**PixArt Imaging Inc.**

## PAW3602DH-NF CMOS LASER MOUSE SENSOR

## General Description

PAW3602DH-NF is a CMOS laser mouse sensor with DSP integration chip that serves as a non-mechanical motion estimation engine for implementing a computer mouse.

## Features

- ❑ **Single power supply**
- ❑ **Precise laser motion estimation technology**
- ❑ **Complete 2-D motion sensor**
- ❑ **No mechanical parts**
- ❑ **Accurate motion estimation over most of surfaces**
- ❑ **High speed motion detection up to 28 inches/sec and acceleration can be up to 20g**
- ❑ **High resolution up to 1600cpi**
- ❑ **Power down pin and register setting for low power dissipation**
- ❑ **Power saving mode during times of no movement**
- ❑ **Serial Interface for programming and data transfer**
- ❑ **Low power for wireless application**
- ❑ **Eye safety protection circuit**

## Key Specification

| | |
|---|---|
| **Power Supply** | **4.25V ~ 5.5V (VDD)** **3.0V~3.6V (VDDD, VDDA)** |
| **System Clock** | **27 MHz** |
| **Speed** | **28+ inches/sec** |
| **Acceleration** | **20g** |
| **Resolution** | **800/1600cpi** |
| **Frame Rate** | **6600 frames/sec** |
| **Operating Current (Sensor + LD)** | **17 mA @Mouse moving (Normal)** **5 mA @Mouse not moving (Sleep)** **200 uA @Shutdown mode** |
| **Package** | **Shrunk DIP20** |

## Ordering Information

| Order number | I/O | Resolution |
|---|---|---|
| PAW3602DH-NF | CMOS output | 800/1600 cpi |

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**PAW3602DH-NF**                                          **CMOS Laser Mouse Sensor**

## 1. Pin Description

| Pin No. | Name | Type | Definition |
|---------|------|------|------------|
| 1 | LD_P | PWR | LD control |
| 2 | LD_N | PWR | LD control |
| 3 | OSCOUT | OUT | Resonator output |
| 4 | OSCIN | IN | Resonator input |
| 5 | VDDD | PWR | Chip digital power, 3.3V |
| 6 | VSSD | GND | Chip digital ground |
| 7 | VSSA | GND | Chip analog ground |
| 8 | VDD | PWR | Chip power, 5V power supply |
| 9 | VDDA | PWR | Chip analog power, 3.3V |
| 10 | LDRES | IN | Connect to resistor input |
| 11 | YA | I/O | LD BIST mode input / YA quadrature output |
| 12 | YB | I/O | LD BIST mode input / YB quadrature output |
| 13 | XA | I/O | LD BIST mode input / XA quadrature output |
| 14 | XB | OUT | LD BIST mode fail output / XB quadrature output |
| 15 | CPI | IN | CPI select pin<br>➢ Pull-high to VDD: 800 cpi (Default)<br>➢ Pull-down to GND: 1600 cpi |
| 16 | LDTEST | IN | LD test pin<br>➢ Floating (Chip internal pull-down): Disable LD test mode<br>➢ Pull-high (3.3V ONLY) : Enable LD test mode |
| 17 | NC | - | No connection |
| 18 | SCLK | IN | Serial interface clock |
| 19 | SDIO | I/O | Serial interface bi-direction data |
| 20 | PD | IN | Power down pin, active high |
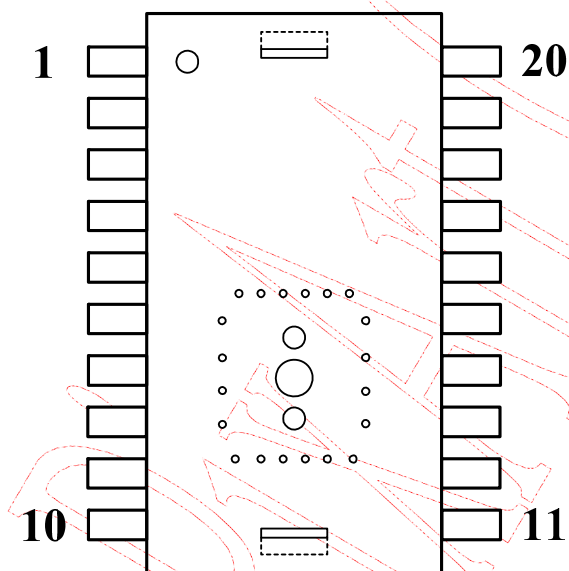


Figure 1. Top View Pinout
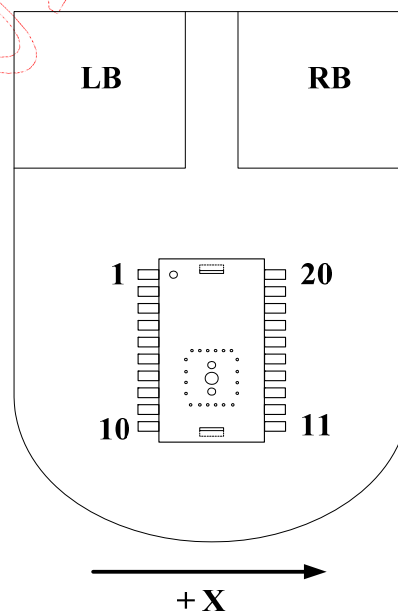


Figure 2. Top View of Mouse
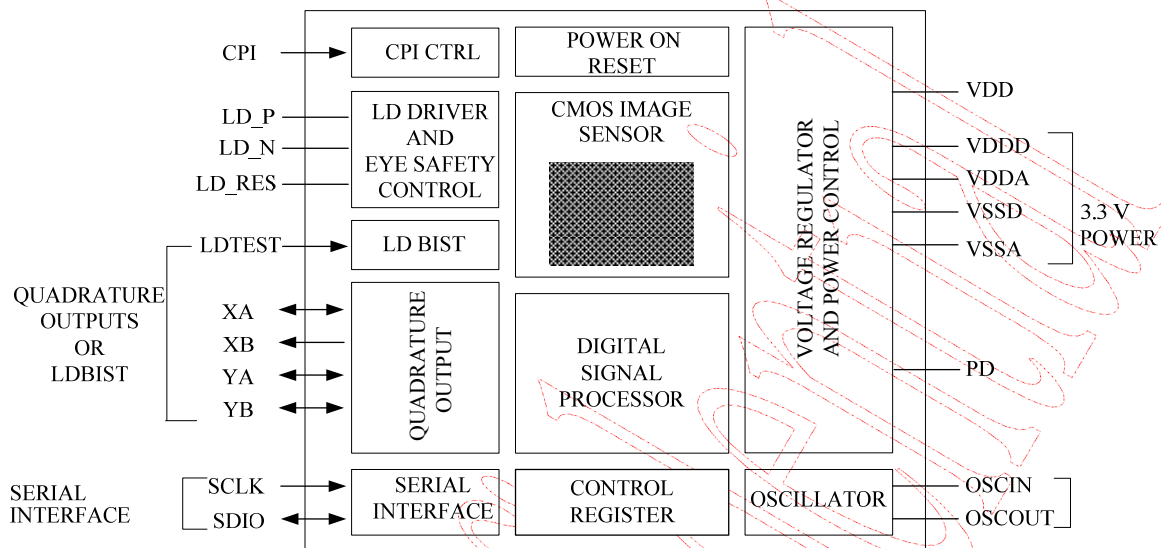
## 2. Block Diagram and Operation



**Figure 3. Block Diagram**

The PAW3602DH-NF is a high performance CMOS laser mouse sensor with DSP integration chip that serves as a non-mechanical motion estimation engine for implementing a computer mouse. It is based on new laser speckle navigation technology. In the laser mouse, it uses laser diode (LD), specially uses VCSEL (Vertical Cavity Surface Emitting Laser) as light source, where laser is one kind of coherent light. When this light illuminates on the working surface, the surface will reflect and diffuse the incident light and generates speckle pattern. The imaging sensor in the laser mouse chip detects the speckle pattern that generated from the working surface and determines the movement and direction. Since the speckle pattern can be generated on the most of the surface if this surface is not perfect smooth or transparent, the laser mouse can adapt on more surfaces as compared with traditional LED-based optical mouse.

The PAW3602DH-NF has an extra function, eye safety protection circuit. The embedded eye safety protection circuit will detect if LD_P pin is short to power, if LD_N pin is short to ground, or if LD_RES pin is short to ground to be a large LD power. And this will protect users from eye injured for large LD power. This mouse sensor is in a 20-pin optical package. The output format is two-channel quadrature (X and Y direction), which emulates encoder phototransistors. The current X and Y information are also available in registers accessed via a serial port. The word "mouse sensor," instead of PAW3602DH-NF, is used in the document.

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## 3. Registers and Operation

The mouse sensor can be programmed through registers, via the serial port, and DSP configuration and motion data can be read from these registers. All registers not listed are reserved, and should never be written by firmware.

### 3.1 Registers

| Address | Name | R/W | Default | Data Type |
|---------|------|-----|---------|-----------|
| 0x00 | Product_ID | R | 0x30 | Eight bits [11:4] number with the product identifier |
| 0x01 | Product_ID | R | 0x3N | Four bits [3:0] number with the product identifier Reserved [3:0] number is reserved for further |
| 0x02 | Motion_Status | R | - | Bit field |
| 0x03 | Delta_X | R | - | Eight bits 2's complement number |
| 0x04 | Delta_Y | R | - | Eight bits 2's complement number |
| 0x05 | Operation_Mode | R/W | - | Bit field |
| 0x06 | Configuration | R/W | - | Bit field |
| 0x07 | Image_Quality | R | - | Bit field |

### 3.2 Register Descriptions

| 0x00 | Product_ID | | | | | | | |
|------|---|---|---|---|---|---|---|---|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | PID[11:4] | | | | | | | |
| Usage | The value in this register can't change. It can be used to verify that the serial communications link is OK. | | | | | | | |

| 0x01 | Product_ID | | | | | | | |
|------|---|---|---|---|---|---|---|---|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | PID[3:0] | | | | Reserved [3:0] | | | |
| Usage | The value in this register can't change. PID[3:0] can be used to verify that the serial communications link is OK. Reserved[3:0] is a value between 0x0 and 0xF, it can't be used to verify that the serial communication. | | | | | | | |

| 0x02 | Motion_Status | | | | | | | |
|------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | Motion | Reserved[3:2] | | DYOVF | DXOVF | Reserved[1:0] | | RES |
| Usage | Register 0x02 allows the user to determine if motion has occurred since the last time it was read. If so, then the user should read registers 0x03 and 0x04 to get the accumulated motion. It also tells if the motion buffers have overflowed since the last reading. The current resolution is also shown.<br><br>Reading this register freezes the *Delta_X* and *Delta_Y* register values. Read this register before reading the *Delta_X* and *Delta_Y* registers. If *Delta_X* and *Delta_Y* are not read before the motion register is read a second time, the data in *Delta_X* and *Delta_Y* will be lost. | | | | | | | | |

| Notes | Field Name | Description |
|-------|-----------|-------------|
| | Motion | Motion since last report or PD<br>**0 = No motion (Default)**<br>1 = Motion occurred, data ready for reading in Delta_X and Delta_Y registers |
| | Reserved[3:2] | Reserved for future |
| | DYOVF | Motion Delta Y overflow, ΔY buffer has overflowed since last report<br>**0 = No overflow (Default)**<br>1 = Overflow has occurred |
| | DXOVF | Motion Delta X overflow, ΔX buffer has overflowed since last report<br>**0 = No overflow (Default)**<br>1 = Overflow has occurred |
| | Reserved[1:0] | Reserved for future |
| | RES | Resolution in counts per inch<br>0 = 1600<br>1 = 800 |

| 0x03 | Delta_X | | | | | | | |
|------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | X7 | X6 | X5 | X4 | X3 | X2 | X1 | X0 |
| Usage | X movement is counts since last report. Absolute value is determined by resolution. Reading clears the register. Report range –128~+127. | | | | | | | |

| 0x04 | Delta_Y | | | | | | | |
|------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | Y7 | Y6 | Y5 | Y4 | Y3 | Y2 | Y1 | Y0 |
| Usage | Y movement is counts since last report. Absolute value is determined by resolution. Reading clears the register. Report range –128~+127. | | | | | | | |

| 0x05 | Operation_Mode | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | LDsht_enh | XY_enh | Reserved | Slp_enh | Slp2au | Slp2mu | Slp1mu | Wakeup |
| Usage | Register 0x05 allows the user to change the operation of the sensor. Shown below are the bits, their default values, and optional values.<br><br>Operation_Mode[4:0]<br>"0xxxx"=Disable sleep mode<br>"10xxx"=Enable sleep mode[1]<br>"11xxx"=Enable sleep mode[2]<br>"1x100"=Force enter sleep2[3]<br>"1x010"=Force enter sleep1[3]<br>"1x001"=Force wakeup from sleep mode[3]<br><br>Notes:<br>1. Enable sleep mode, but disable automatic entering sleep2 mode, that is, only 2 modes will be used, normal mode and sleep1 mode. After 0.45 sec not moving during normal mode, the chip will enter sleep1 mode, and keep on sleep1 mode until moving is detected or wakeup is asserted.<br><br>2. Enable sleep mode full function, that is 3 modes will be used, normal mode, sleep1 mode and sleep2 mode. After 0.45 sec not moving during normal mode, chip will enter sleep1 mode, and keep on sleep1 mode until moving is detected or wakeup is asserted.<br><br>And after 27.3 sec not moving during sleep1 mode, the chip will enter sleep2 mode, and keep on sleep2 mode until detect moving or force wakeup to normal mode.<br><br>3. Only one of these three bits slp2mu_enh, slp1mu_enh, and wakeup can be set to 1 at the same time, others have to be set to 0. After a period of time, the bits, which was set to 1, will be reset to 0 by internal signal. | | | | | | | | |

| Notes | Field Name | Description |
|---|---|---|
| | LDsht_enh | LD shutter enable / disable<br>0 = Disable<br>**1 = Enable (Default)** |
| | XY_enh | XY quadrature output enable/disable<br>0 = Disable<br>**1 = Enable (Default)** |
| | Reserved | Reserved for future. Must be written to zero |
| | Slp_enh | Sleep mode enable/disable<br>0 = Disable<br>**1 = Enable (Default)** |
| | Slp2au | Automatic enter sleep2 mode enable/disable<br>**0 = Disable (Default)**<br>1 = Enable |
| | Slp2mu | Manual enter sleep2 mode, set "1" will enter sleep2 and this bit will be reset to "0" |
| | Slp1mu | Manual enter sleep1 mode, set "1" will enter sleep2 and this bit will be reset to "0" |
| | Wakeup | Manual wake up from sleep mode, set "1" will enter wakeup and this bit will be reset to "0" |

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| 0x06 | Configuration | | | | | | | |
|------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | Reset | Reserved[3:2] | | | PD | Reserved[1:0] | | RES |
| Usage | The Configuration register allows the user to change the configuration of the sensor. Shown below are the bits, their default values, and optional values. | | | | | | | |
| Notes | **Field Name** | **Description** | | | | | | |
|  | Reset | Reset full chip<br><br>**0 = Normal operation (Default)**<br><br>1 = Reset the fully chip | | | | | | |
|  | Reserved[3:2] | Reserved for future. Must be written to "00" | | | | | | |
|  | PD | Power down mode<br><br>**0 = Normal operation (Default)**<br><br>1 = Power down mode | | | | | | |
|  | Reserved[1:0] | Reserved for future. Must be written to "00" | | | | | | |
|  | RES | Output resolution setting. In the power-on initial state, the resolution is depend on the CPI IO trap select pin. If MCU write the register, it is depend on the register value.<br>0 = 1600<br>1 = 800 | | | | | | |

| 0x07 | Image_Quality | | | | | | | |
|------|------|------|------|------|------|------|------|------|
| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Field | Imgqa[7:0] | | | | | | | |
| Usage | Image Quality is a quality level of the sensor in the current frame. Report range 0~255. The minimum level for normally working is 45. | | | | | | | |
| Notes | **Field Name** | **Description** | | | | | | |
|  | Imgqa[7:0] | Image quality report range: 0(worst) ~ 255(best). | | | | | | |

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## 4. LD BIST (Built in Self Test) Mode

The mouse sensor can be performed the LD driver error detection function by manufactures to fit the LD power in eye safety rule. LD BIST mode is enabled by pull-high (3.3V ONLY) the LDTEST pin. Once LDTEST pin is pulled high, the XA, YB, YA pin are changed to be input pin and become the LD test mode input [XA ,YB ,YA] , XA is MSB and YA is LSB. At this moment, XB is also changed to LD test fail output.

| Pin Name | Description |
|---|---|
| LDTEST | LD Test Mode disable/enable<br>**0 = Disable (Default)**<br>1 = Enable |
| [XA , YB , YA] | " 000 " = Mode 0, Measure LD power, BIST if eye safety error detection function is fail in normal mode<br>" 001 " = Mode 1, BIST if LD_P error detection function is fail<br>" 010 " = Mode 2, BIST if LD_N error detection function is fail<br>" 011 " = Mode 3, BIST if LDRES pin is short to GND |
| XB | 0 = PASS<br>1 = FAIL |

## 5. Specifications

## 5.1 Absolute Maximum Ratings

Stresses above those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only. Functional operation of this device at these or any other conditions above those indicated in the operational sections of this specification is not implied and exposure to absolute maximum rating conditions for extended periods may affect device reliability.

| Symbol | Parameter | Min | Max | Unit | Notes |
|---|---|---|---|---|---|
| $T_{STG}$ | Storage Temperature | -40 | 85 | °C | |
| TA | Operating Temperature | -15 | 55 | °C | |
| $V_{DC}$ | DC Supply Voltage | -0.5 | $V_{dd1} + 0.3$ | V | |
| | | -0.5 | $V_{dd2} + 0.5$ | V | |
| $V_{IN}$ | DC Input Voltage | -0.5 | $V_{DC}$ | V | All I/O pin except LDTEST pin (LDTEST high is 3.3V only) |
| | Lead Solder Temp | | 260 | °C | For 10 seconds, 1.6mm below seating plane. |
| ESD | | | 2 | kV | All pins, human body model MIL 883 Method 3015 |

## 5.2 Recommend Operating Condition

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| $T_A$ | Operating Temperature | 0 | | 40 | °C | |
| $V_{dd1}$ | Power Supply Voltage | 3.0 | 3.3 | 3.6 | V | VDDD, VDDA short |
| $V_{dd2}$ | | 4.25 | 5 | 5.5 | | VDD |
| $V_N$ | Supply Noise | | | 80 | mV | Peak to peak within 0 - 80 MHz |
| Z | Distance from Lens Reference Plane to Surface | 2.3 | 2.4 | 2.5 | mm | |
| R | Resolution | | 800 | 1600 | CPI | |
| SCLK | Serial Port Clock Frequency | | | 10 | MHz | |
| $F_{CLK}$ | Clock Frequency | | 27 | | MHz | |
| FR | Frame Rate | | 6600 | | frames/s | |
| S | Speed | | 28 | | inches/s | |

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## 5.3 AC Operating Condition

Electrical Characteristics over recommended operating conditions. Typical values at 25 °C, $V_{dd1}$ = 3.3 V, $F_{CLK}$ = 27 MHz.

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| $t_{PDR}$ | PD Pulse Register | | | 152 | us | One frame time maximum after setting *PD_enh* bit in the *Configuration* register @6600frame/sec (refer to Figure 14). |
| $t_{PD}$ | Power Down | | 500 | | us | From PD↑ (refer to Figure 10) |
| $t_{PDW}$ | PD Pulse Width | 700 | | | us | Pulse width to reset the serial interface (refer to Figure 10). |
| $t_{PUPD}$ | Power Up from PD↓ | 8 | | 14.5 | ms | From PD↓ to valid quad signals. After $t_{PUPD}$, all registers contain valid data from first image after PD↓. Note that an additional 90 frames for Auto-Exposure (AE) stabilization may be required if mouse movement occurred while PD was high (refer to Figure 10). |
| $t_{PU}$ | Power Up from $V_{DD}$↑ | 8 | | 14.5 | ms | From $V_{DD}$↑ to valid quad signals. 500usec + 90 frames. |
| $t_{HOLD}$ | SDIO Read Hold Time | | 3 | | us | Minimum hold time for valid data (refer to Figure 9). |
| $t_{RESYNC}$ | Serial Interface RESYNC. | 1 | | | us | @6600 frame/sec (refer to Figure 11) |
| $t_{SIWTT}$ | Serial Interface Watchdog Timer Timeout | 1.7 | | | ms | @6600 frame/sec (refer to Figure 11) |
| $t_r$ , $t_f$ | Rise and Fall Times: SDIO | | 35, 25 | | ns | $C_L$ = 30 pF |
| $t_r$ , $t_f$ | Rise and Fall Times: XA, XB, YA, YB | | 30, 25 | | ns | $C_L$ = 30 pF |
| $t_r$ , $t_f$ | Rise and Fall Times: $I_{LD}$ | | 80, 30 | | ns | LD bin grade: P64; R1 = 13.2 Kohm |

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## 5.4 DC Operating Condition

Electrical Characteristics over recommended operating conditions. Typical values at 25 °C, $V_{dd1}$ = 3.3 V, $F_{CLK}$ = 27 MHz.

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| **Type: PWR** | | | | | | |
| $I_{DD}$ | Supply Current Mouse moving (Normal) | | 17 | | mA | Sensor + LD |
| $I_{DD}$ | Supply Current Mouse not moving (sleep1) | | 5 | | mA | Sensor + LD |
| $I_{DDPD}$ | Supply Current (Power Down) | | 200 | | uA | PD, SCLK, SDIO = high Sensor + LD |
| **Type: SCLK, SDIO, PD** | | | | | | |
| $V_{IH}$ | Input voltage HIGH | 2.0 | | | | |
| $V_{IL}$ | Input voltage LOW | | | 0.7 | V | |
| $V_{OH}$ | Output voltage HIGH | 2.4 | | | V | @$I_{OH}$ = 2mA (SDIO only) |
| $V_{OL}$ | Output voltage LOW | | | 0.6 | V | @$I_{OL}$ = 2mA (SDIO only) |
| **Type: LDTEST** | | | | | | |
| $V_{IH}$ | Input voltage HIGH | 2.0 | | | V | |
| $V_{IL}$ | Input voltage LOW | | | 0.7 | V | |
| **Type: XA, XB, YA, YB** | | | | | | |
| $V_{OH}$ | Output voltage HIGH | 2.4 | | | V | @$I_{OH}$ = 2mA |
| $V_{OL}$ | Output voltage LOW | | | 0.6 | V | @$I_{OL}$ = 2mA |

## 6. Quadrature Mode

The quadrature state of the mouse sensor tells mouse controller which direction the mouse is moving in. The output format is two channels quadrature (X and Y direction), which emulates encoder phototransistors. The DSP generates the Δx and Δy relative displacement values that are converted into two channel quadrature signals. The following diagrams show the timing for positive X motion, to the right or positive Y motion, up.

## 6.1 Quadrature Output Timing
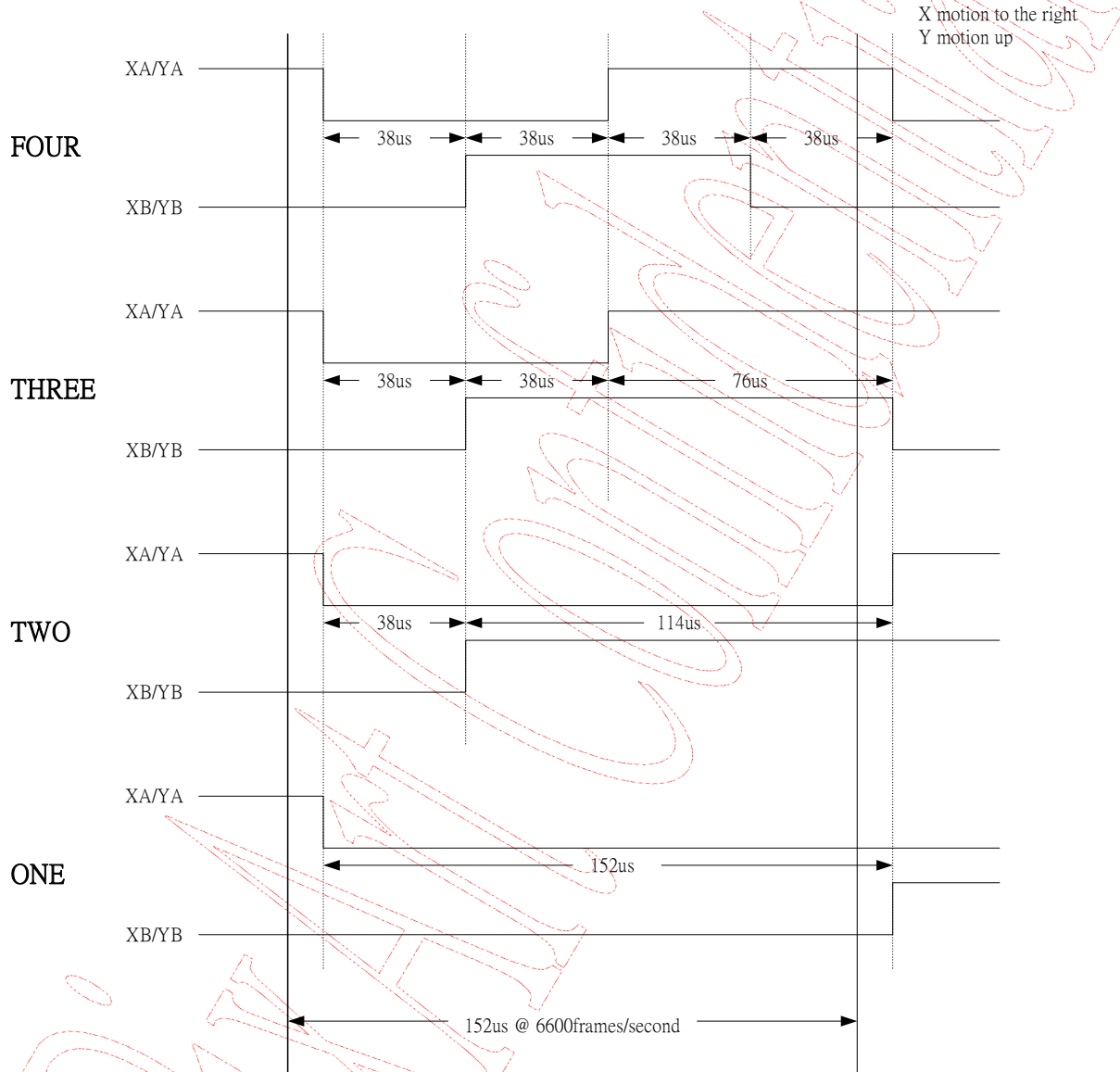


**Figure 4. Quadrature output timing**

## 6.2 Quadrature Output State Machine

The following state machine shows the states of the quadrature output pins. The three things to note are that state 0 is entered after a power on reset. While the PD pin is asserted, the state machine is halted. Once PD is de-asserted, the state machine picks up from where it left off. During times of mouse no movement will entry power saving mode, until mouse was moved.
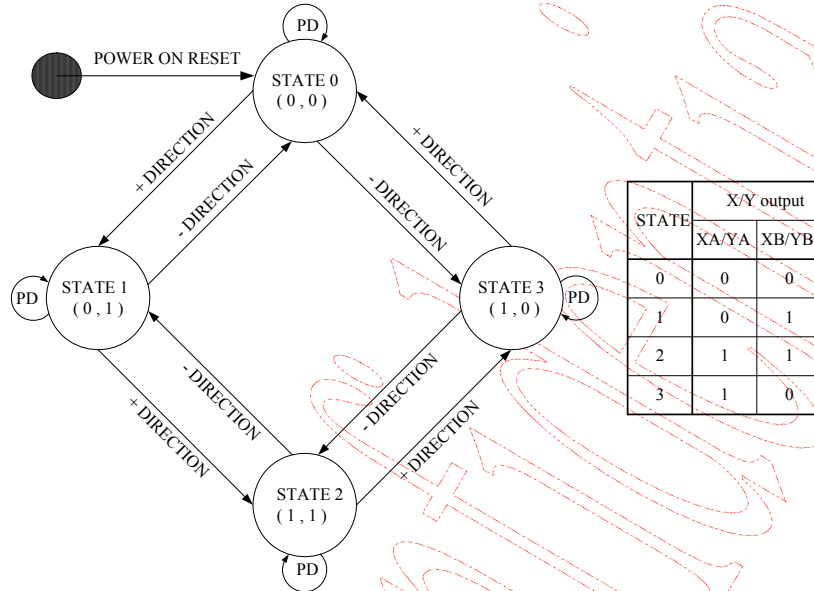


**Figure 5. State machine**

## 6.3 Quadrature Output Waveform

The following diagrams show the waveform of the two channel quadrature outputs. If the X, Y is motionless, the (XA, XB), (YA, YB) will keep in final state. Each state change (ex. STATE2 → STATE3) is one count.
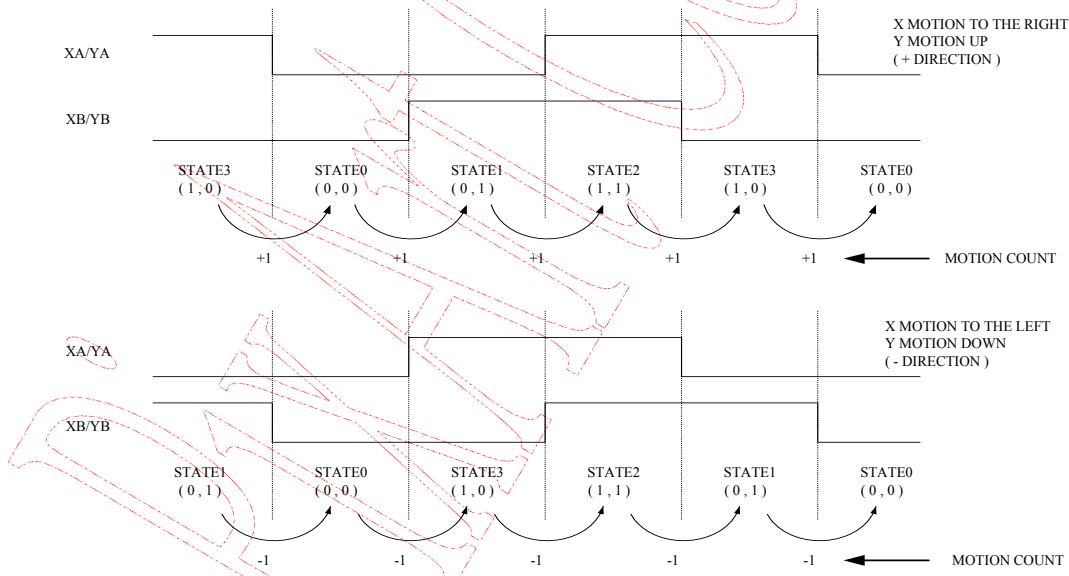


**Figure 6. Quadrature output waveform**

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## 7. Serial Interface

The synchronous serial port is used to set and read parameters in the mouse sensor, and can be used to read out the motion information instead of the quadrature data pins.

**SCLK:** The serial clock line. It is always generated by the host micro-controller.

**SDIO:** The serial data line used for write and read data.

**PD:**   A third line is sometimes involved. PD (Power Down pin) is usually used to place the mouse sensor in a low power mode to meet USB suspend specification. PD can also be used to force re-synchronization between the micro-controller and the mouse sensor in case of an error.

### 7.1 Transmission Protocol

The transmission protocol is a two-wire link, half duplex protocol between the micro-controller and mouse sensor. All data changes on SDIO are initiated by the falling edge on SCLK. The host micro-controller always initiates communication; the mouse sensor never initiates data transfers.

The transmission protocol consists of the two operation modes:

- Write Operation.

- Read Operation.

Both of the two operation modes consist of two bytes. The first byte contains the address (seven bits) and has a bit7 as its MSB to indicate data direction. The second byte contains the data.
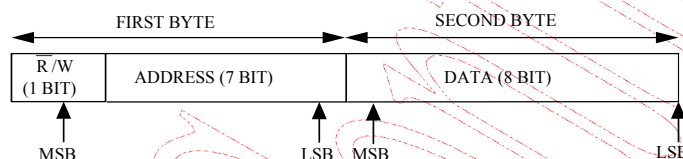


**Figure 7. Transmission protocol**

### 7.1.1 Write Operation

A write operation, which means that data is going from the micro-controller to the mouse sensor, is always initiated by the micro-controller and consists of two bytes. The first byte contains the address (seven bits) and has a "1" as its MSB to indicate data direction. The second byte contains the data. The transfer is synchronized by SCLK. The micro-controller changes SDIO on falling edges of SCLK. The mouse sensor reads SDIO on rising edges of SCLK.
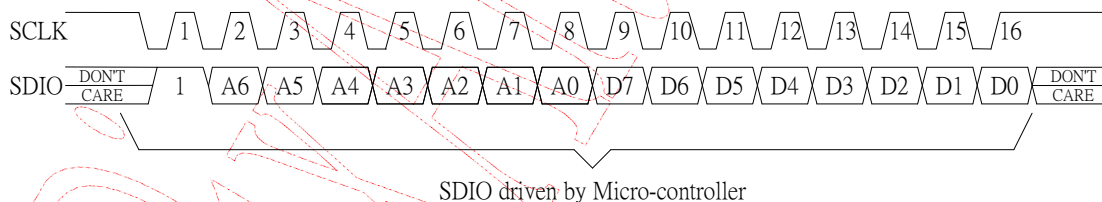


**Figure 8. Write operation**

## 7.1.2 Read Operation

A read operation, which means that data is going from the mouse sensor to the mouse controller, is always initiated by the mouse controller and consists of two bytes. The first byte contains the address, is written by the mouse controller, and has a "0" as its MSB to indicate data direction. The second byte contains the data and is driven by the mouse sensor. The transfer is synchronized by SCLK. SDIO is changed on falling edges of SCLK and read on every rising edge of SCLK. The mouse controller must go to a high Z state after the last address data bit. The mouse sensor will go to the high Z state after the last data bit.
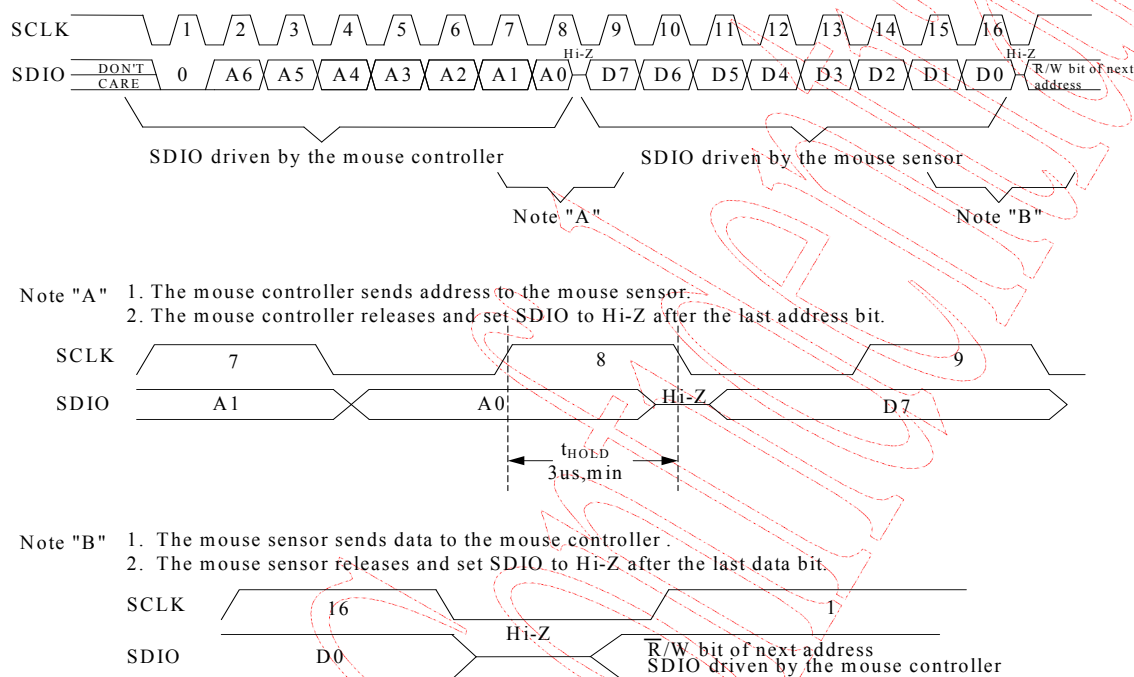


**Figure 9. Read Operation**

## 7.2 Re-Synchronous Serial Interface

If the mouse controller and the mouse sensor get out of synchronization, then the data either written or read from the registers will be incorrect. There are two different ways for re-synchronous serial interface.

- Re-synchronous serial interface using PD pin (see Section 7.2.1)
- Re-synchronous serial interface using watchdog timer timeout (see Section 7.2.2)

Note that "watchdog timer timeout" (see Section 7.2.2) function is disabled when the mouse sensor is in the power down mode. If the user uses this function during the power down mode, it will get out of synchronization. The mouse sensor and the mouse controller also might get out of synchronization due to following conditions.

- Power On Problem - The problem occurs if the mouse sensor powers up before the mouse controller sets the SCLK and SDIO lines to be output. The mouse sensor and the mouse controller might get out of synchronization due to power on problem. An easy way to solve this is to raise PD pin (see Section 7.2.1) or use watchdog timer timeout (see Section 7.2.2) for re-synchronous serial interface.

- ESD Events - The mouse sensor and the mouse controller might get out of synchronization due to ESD events. An easy way to solve this is to raise PD pin (see Section 7.2.1) or use watchdog timer timeout (see Section 7.2.2) for re-synchronous serial interface.

- USB suspend - Termination of a transmission by the mouse controller may be required sometimes (for example, due to a USB suspend interrupt during a read operation). An easy way to solve this is to raise PD pin (see Section 7.2.1) or use watchdog timer timeout (see Section 7.2.2) for re-synchronous serial interface.

### 7.2.1 Re-Synchronous Serial Interface Using PD Pin

The mouse controller raises PD line to reach re-synchronous serial interface after an incorrect read. The mouse sensor will reset the serial port but will not reset the registers and be prepared for the beginning of a new transmission. Note that using "PD pin" to reach re-synchronous is quicker than using "watchdog timer timeout".
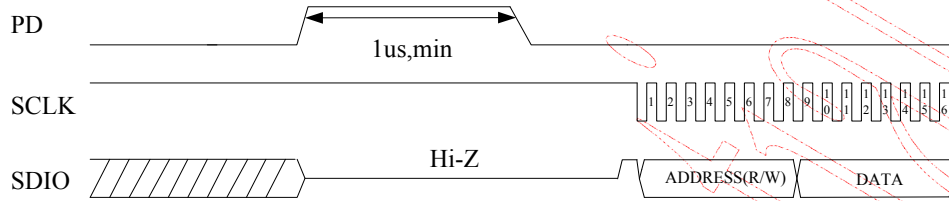
**Figure 10. Re-synchronous Serial Interface Using PD Pin**

### 7.2.2 Re-Synchronous Serial Interface Using Watchdog Timer Timeout

The mouse controller can toggle the SCLK line from high to low to high and wait at least $t_{SIWTT}$ to reach re-synchronous serial interface after an incorrect read. The mouse sensor will reset the serial port but will not reset the registers and be prepared for the beginning of a new transmission.
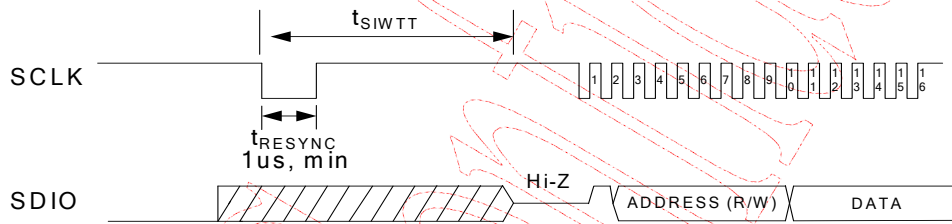
**Figure 11. Re-synchronous Serial Interface Using Watchdog Timer Timeout**

### 7.3 Collision Detection on SDIO

The only time that the mouse sensor drives the SDIO line is during a READ operation. To avoid data collisions, the micro-controller should release SDIO before the falling edge of SCLK after the last address bit. The mouse sensor begins to drive SDIO after the next falling edge of SCLK. The mouse sensor release SDIO of the rising SCLK edge after the last data bit. The micro-controller can begin driving SDIO any time after that. In order to maintain low power consumption in normal operation or when the PD pin is pulled high, the micro-controller should not leave SDIO floating until the next transmission (although that will not cause any communication difficulties).

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## 7.4 Power Down Mode

There are two different ways to entry power down mode, using the PD line or register setting.

### 7.4.1 PD Line Power Down Mode

To place the mouse sensor in a low power mode to meet USB suspend specification, raise the PD line at least 700us. Then PD line can stay high, with the mouse sensor in the shutdown state, or the PD pin can be lowered, returning the mouse sensor to normal operation.
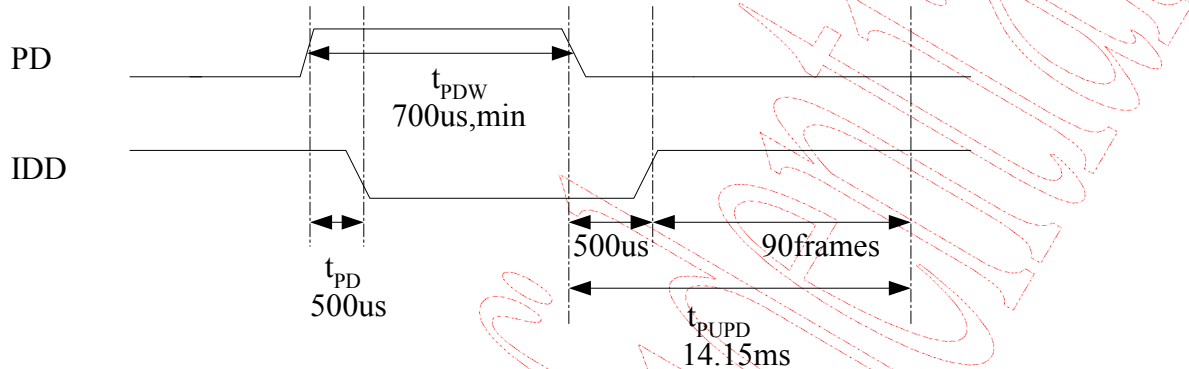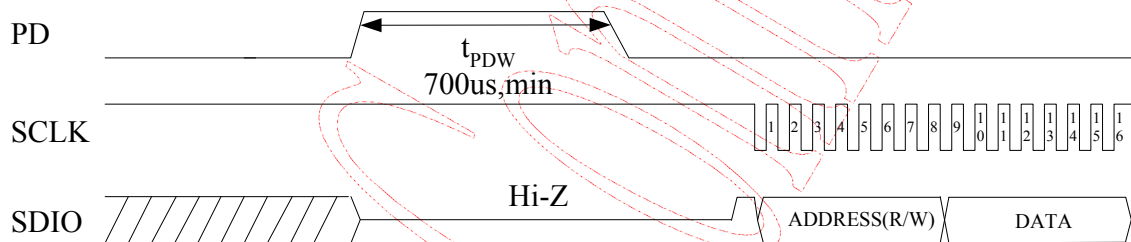


**Figure 12. Power down minimum pulse width**



**Figure 13. PD line power down mode**

### 7.4.2 Register Power Down Mode

The mouse sensor can be placed in a power down mode by setting *PD_enh* bit in the *configuration* register via a serial port write operation. After setting the *configuration* register, wait at least 1frame times. To get the chip out of the power down mode, clear *PD_enh* bit in the *configuration* register via a serial port write operation. In the power down mode, the serial interface watchdog timer is not available (see Section 7.2.2). But, the serial interface still can read/write normally. For an accurate report after leave the power down mode, wait about 3ms before the mouse controller is able to issue any write/read operation to the mouse sensor.
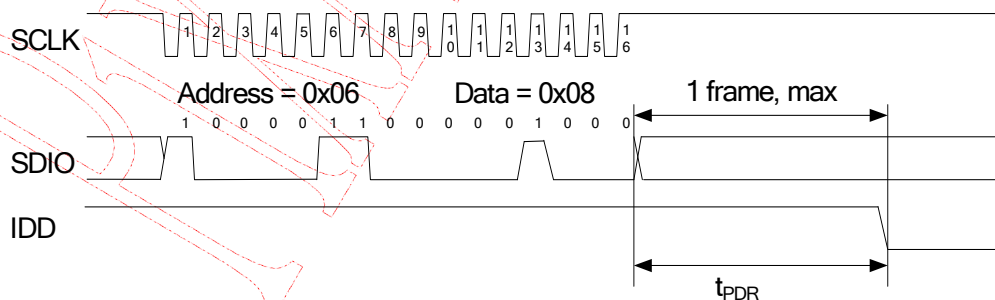


**Figure 14. Power-down Configuration Register Writing Operation**

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### 7.4.3 Register Power Down Mode

The mouse sensor can be placed in a power-down mode by setting bit 3 in the configuration register via a serial port write operation. After setting the configuration register, wait at least 1frame times. To get the chip out of the power-down mode, clear bit 3 in the configuration register via a serial port write operation. In power-down mode, the serial interface watchdog timer is not available. But, The serial interface still can read/write normally. For an accurate report after leave power down mode, wait about 3ms before the micro-controller is able to issue any write/read operation to the mouse sensor.
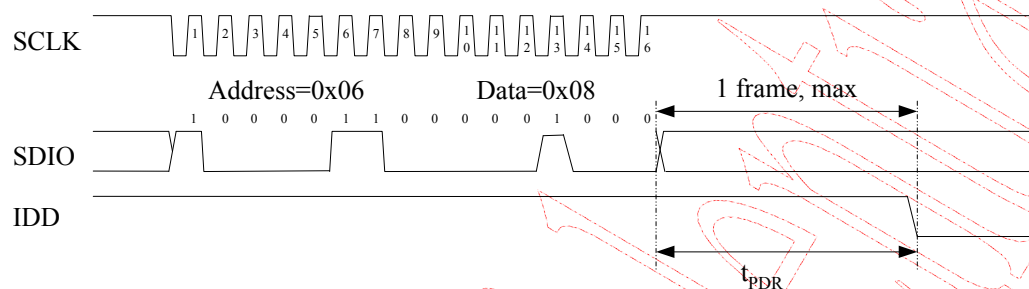
**Figure 15. Power-down configuration register writing operation**

### 7.5 Error Detection

1. The micro-controller can verify success of write operations by issuing a read command to the same address and comparing written data to read data.

2. The micro-controller can verify the synchronization of the serial port by periodically reading the product ID register.

# 8. Referencing Application Circuit

## 8.1 Typical Application using Serial Interface for Full Speed USB Wire Mouse
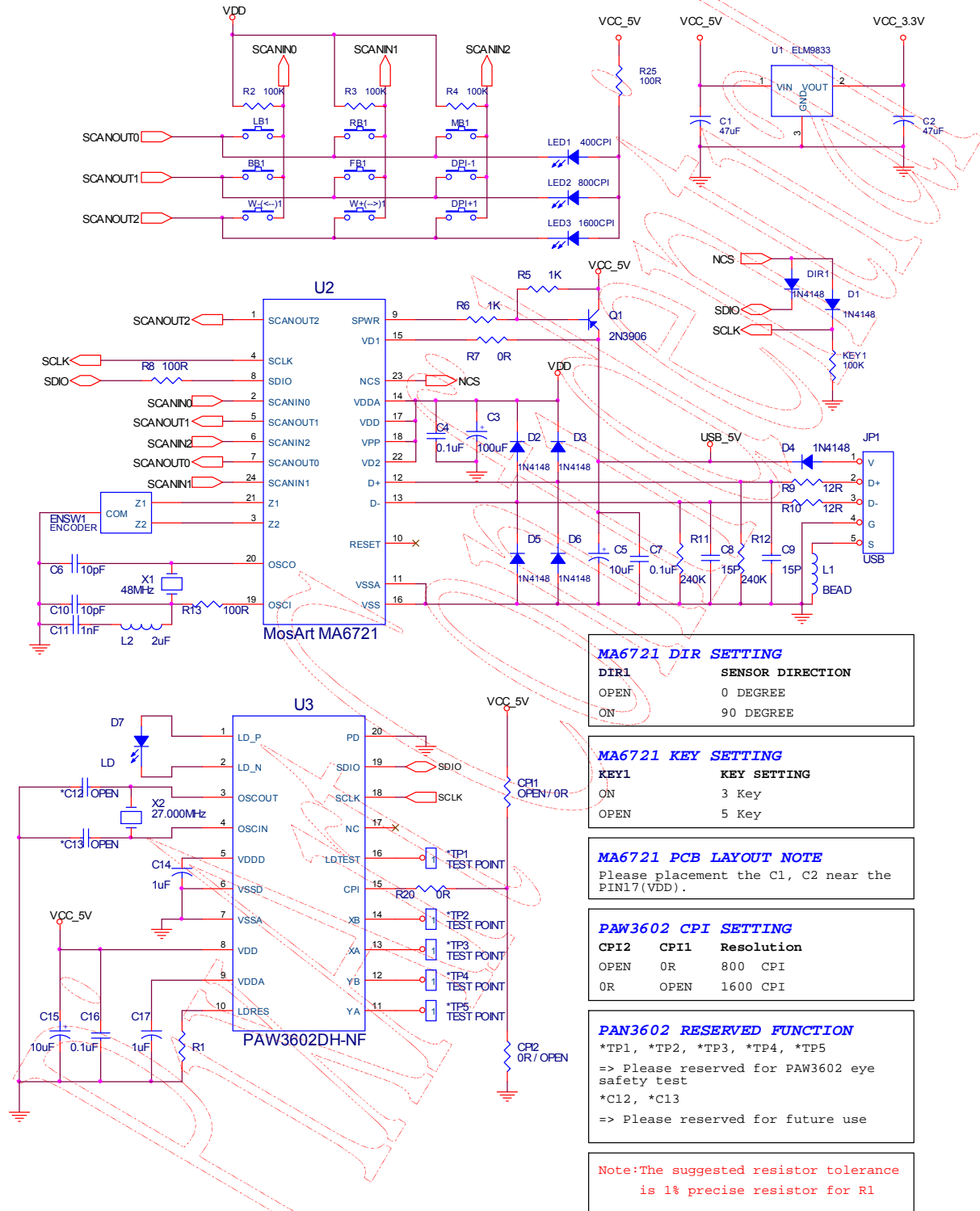
**MA6721 DIR SETTING**

| DIR1 | SENSOR DIRECTION |
|------|------------------|
| OPEN | 0 DEGREE |
| ON | 90 DEGREE |

**MA6721 KEY SETTING**

| KEY1 | KEY SETTING |
|------|-------------|
| ON | 3 Key |
| OPEN | 5 Key |

**MA6721 PCB LAYOUT NOTE**
Please placement the C1, C2 near the PIN17(VDD).

**PAW3602 CPI SETTING**

| CPI2 | CPI1 | Resolution |
|------|------|------------|
| OPEN | 0R | 800 CPI |
| 0R | OPEN | 1600 CPI |

**PAN3602 RESERVED FUNCTION**
*TP1, *TP2, *TP3, *TP4, *TP5
=> Please reserved for PAW3602 eye safety test
*C12, *C13
=> Please reserved for future use

Note:The suggested resistor tolerance is 1% precise resistor for R1

**Figure 16. Application Circuit Using Serial Interface with MosArt MA6721 (Full Speed USB)**

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## 8.2 Typical Application using Serial Interface for Low Speed USB Wire Mouse
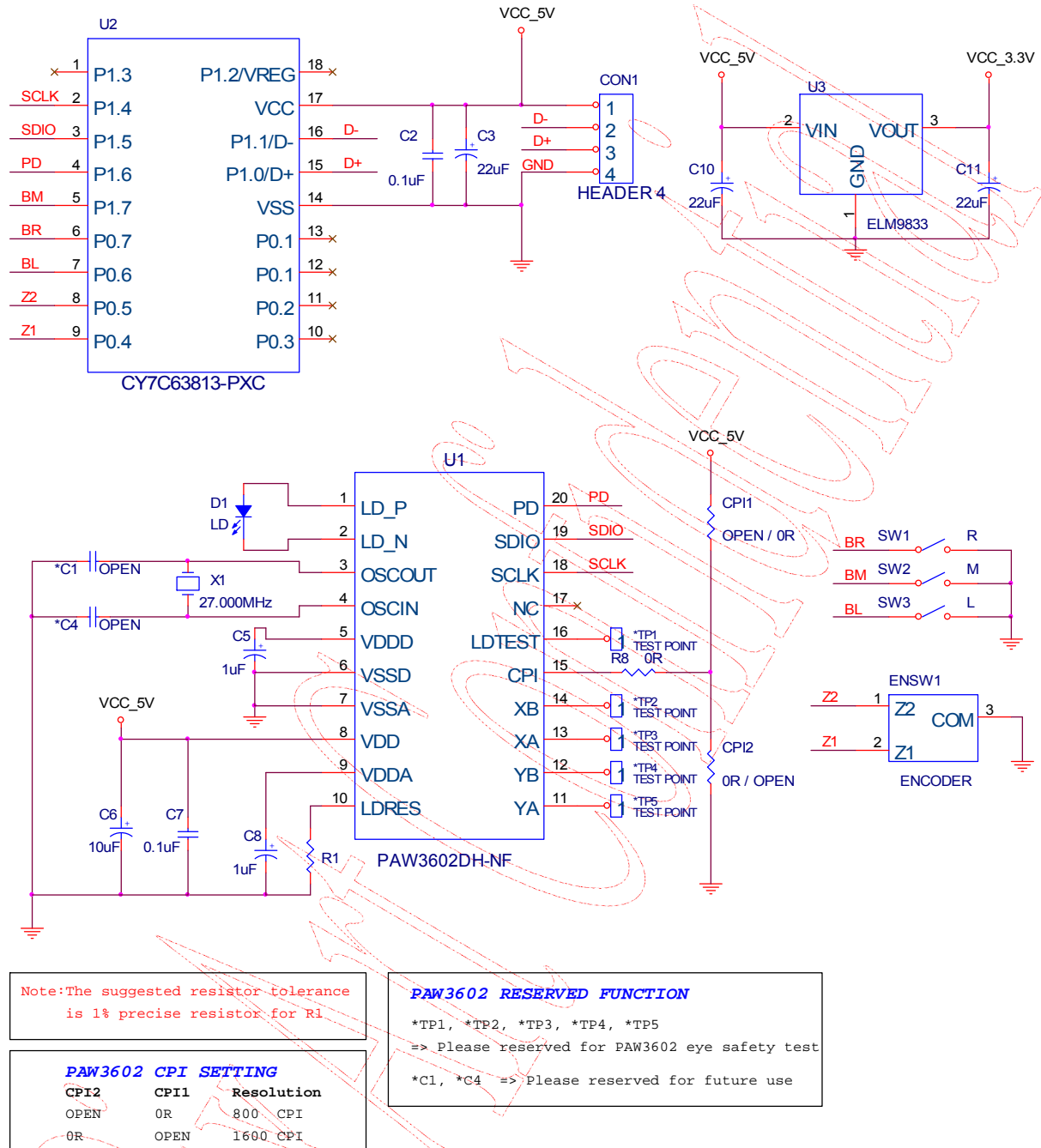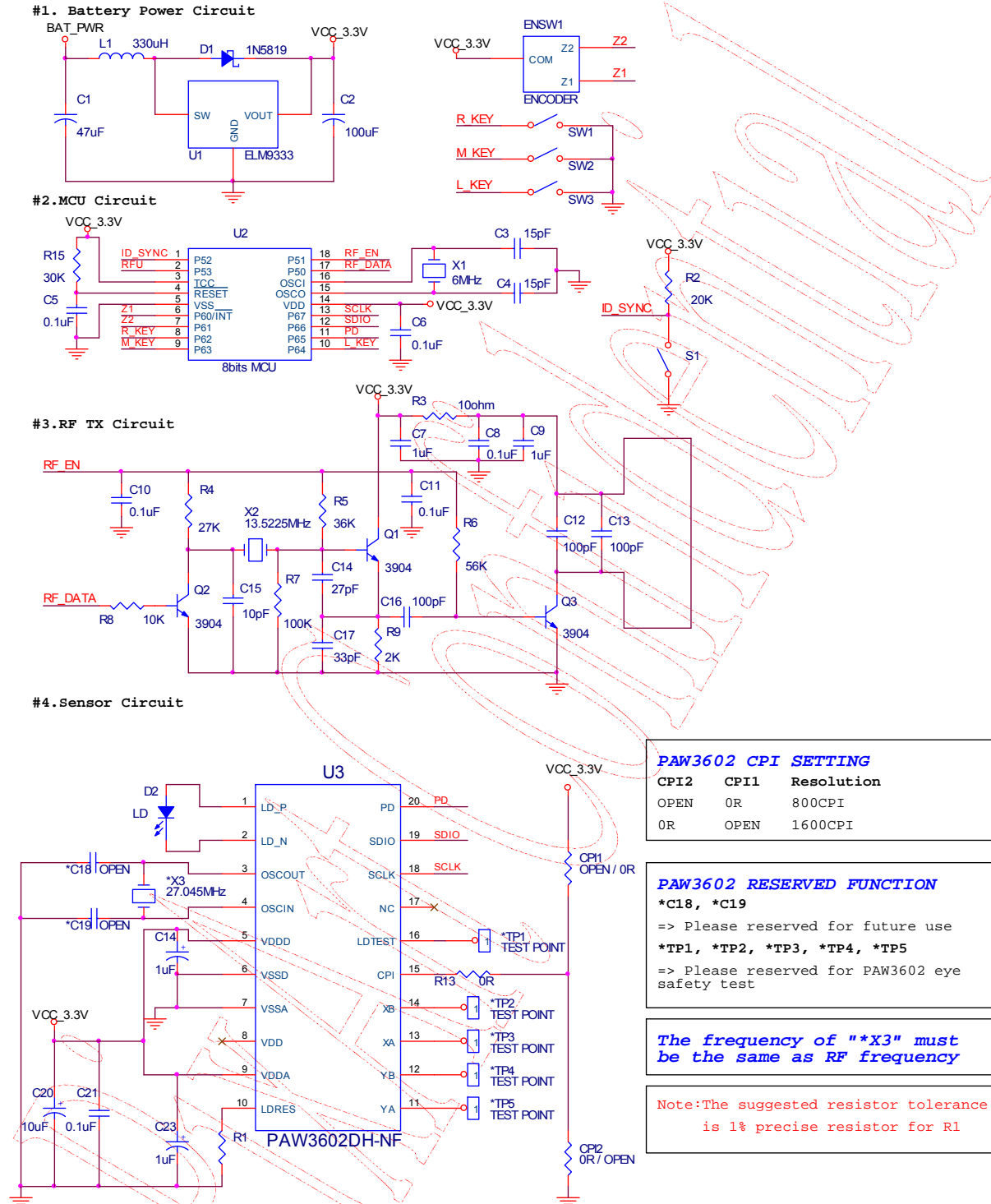


**Figure 17. Application circuit using serial interface with Cypress CY7C63813 (Low Speed USB)**

## 8.3 Typical Application for Wireless Laser Mouse, Power Source from Pin 5 & 9



**Figure 18. RF application circuit using pin 5 & 9 for power supply source**

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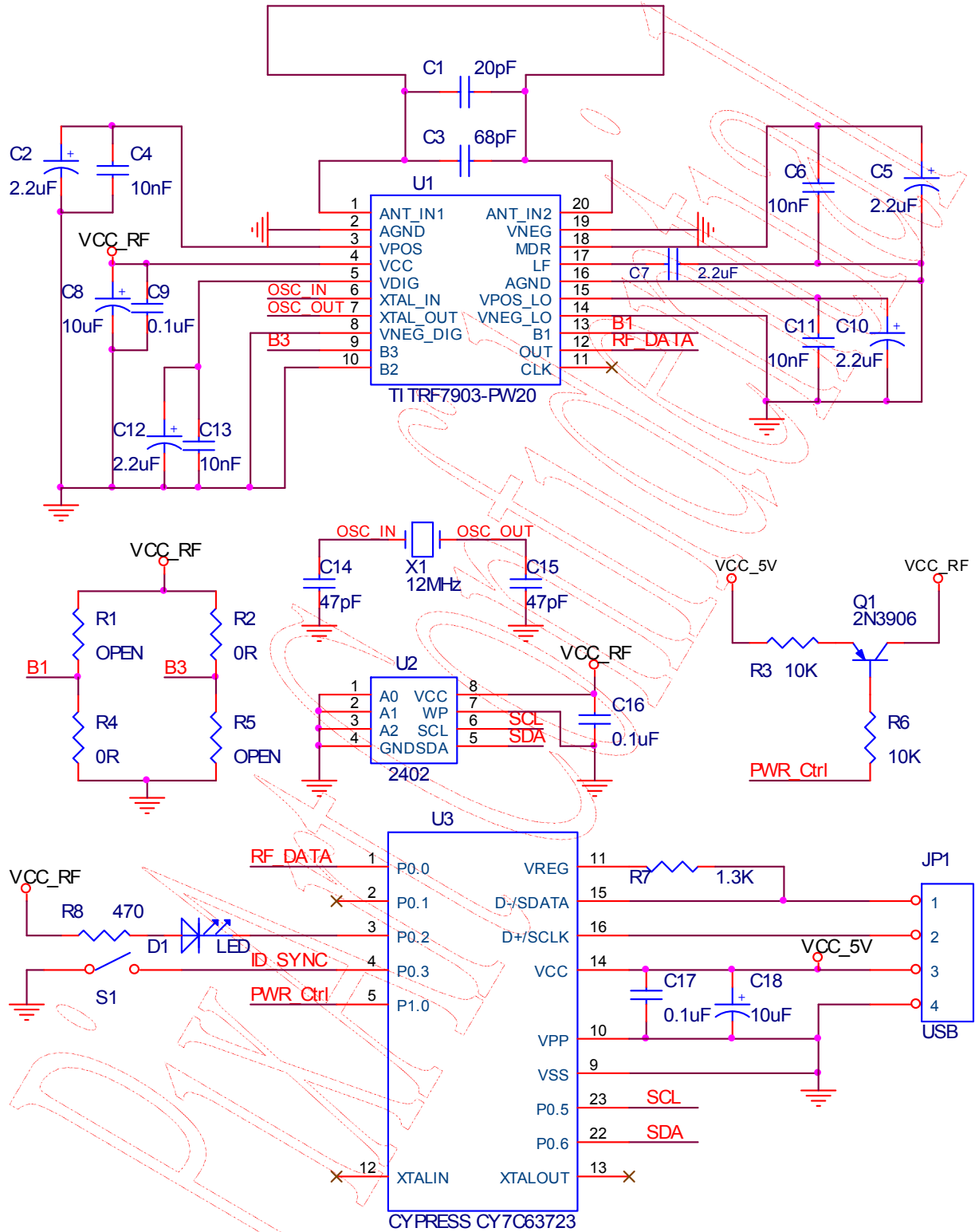## 8.4 Typical Application for RF Receiver



**Figure 19. Application circuit with Cypress CY7C63813 (Low speed USB)**

## 9. PCB Layout Consideration

1. Caps for pins 5, 8, 9 **MUST** have trace lengths **LESS** than **5mm**.
2. The trace lengths of OSCOUT, OSCIN must less than **6mm**.
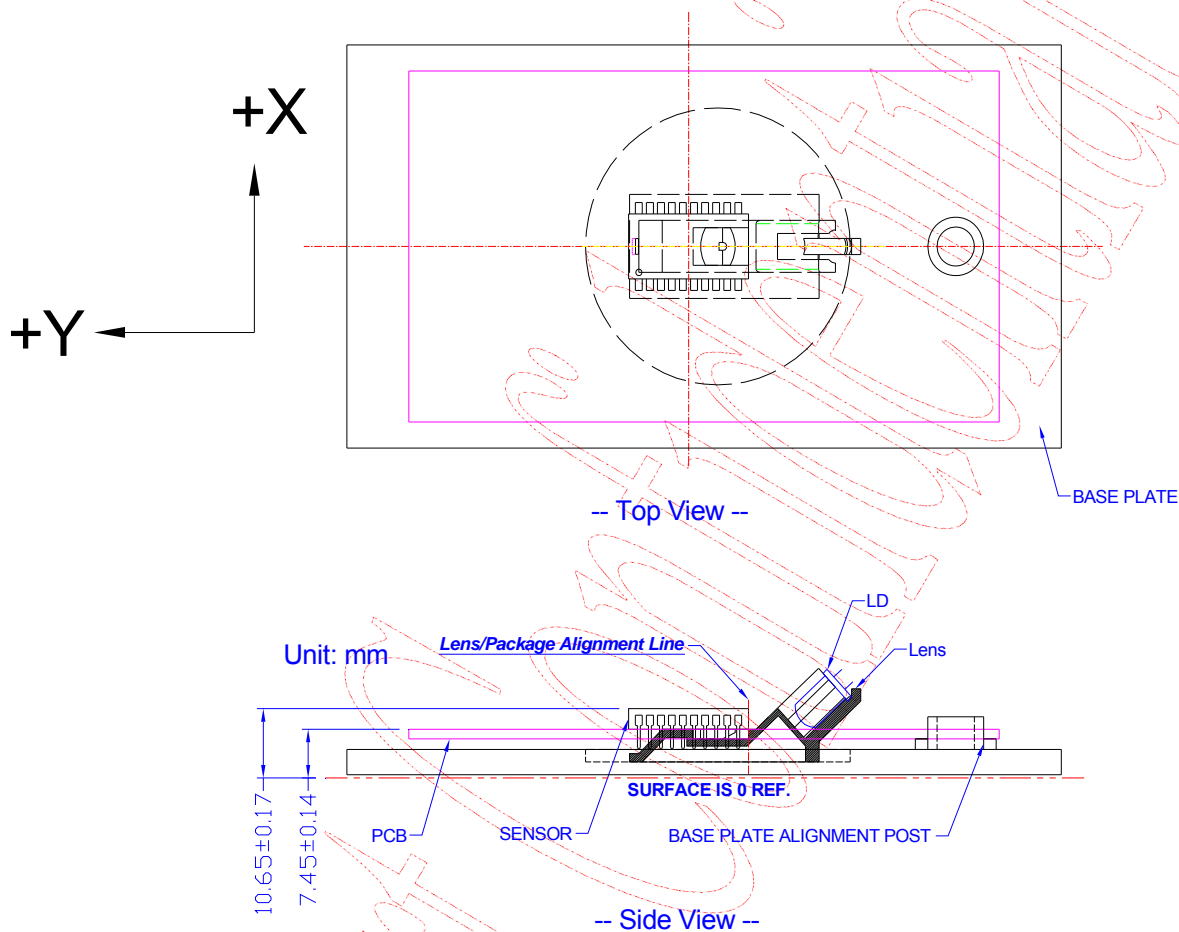
## 10. Z and 2D Assembly



**Figure 20. 2D Assembly**
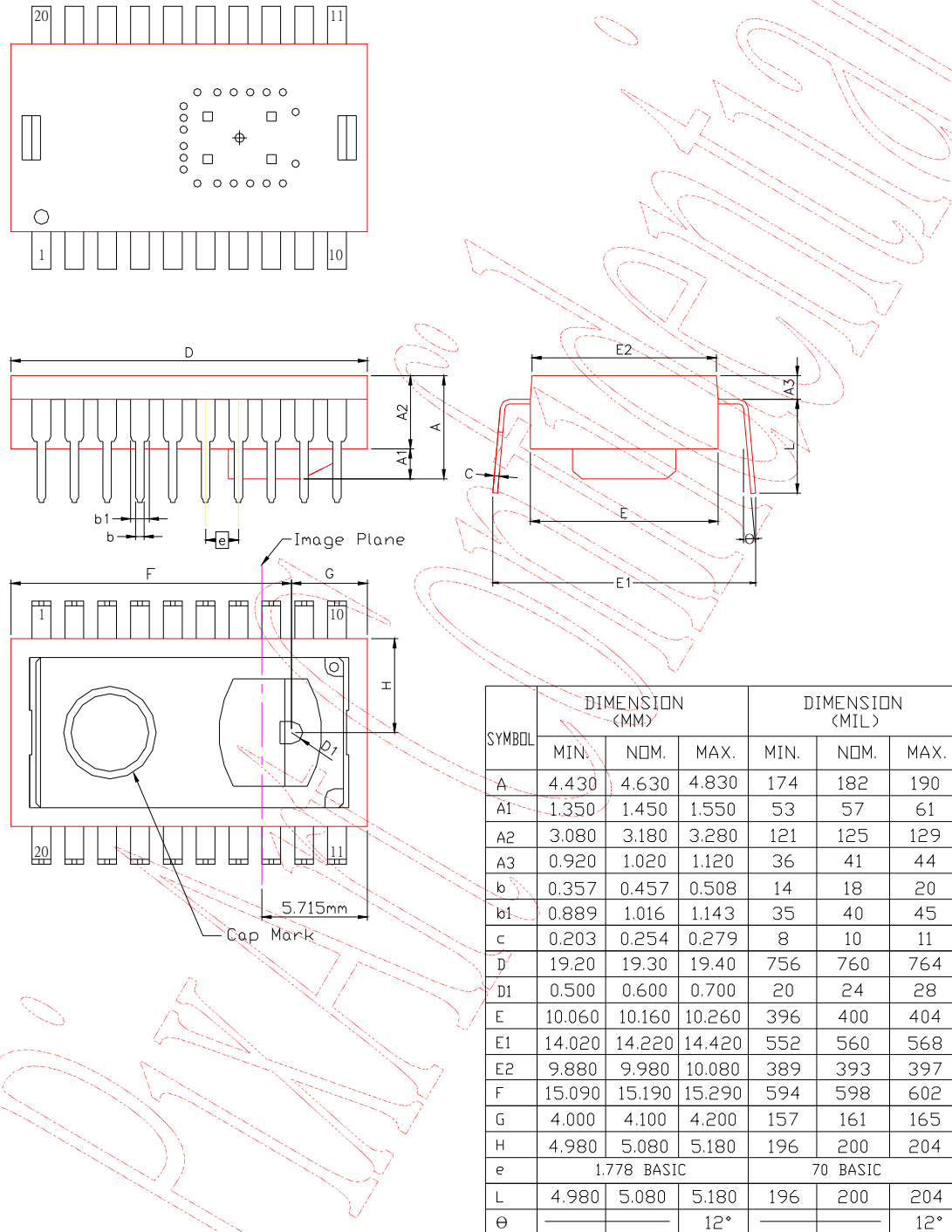
## 11. Package Information

## 11.1 Package Outline Drawing



| SYMBOL | DIMENSION (MM) | | | DIMENSION (MIL) | | |
|--------|------|------|------|------|------|------|
|        | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A      | 4.430 | 4.630 | 4.830 | 174 | 182 | 190 |
| A1     | 1.350 | 1.450 | 1.550 | 53 | 57 | 61 |
| A2     | 3.080 | 3.180 | 3.280 | 121 | 125 | 129 |
| A3     | 0.920 | 1.020 | 1.120 | 36 | 41 | 44 |
| b      | 0.357 | 0.457 | 0.508 | 14 | 18 | 20 |
| b1     | 0.889 | 1.016 | 1.143 | 35 | 40 | 45 |
| c      | 0.203 | 0.254 | 0.279 | 8 | 10 | 11 |
| D      | 19.20 | 19.30 | 19.40 | 756 | 760 | 764 |
| D1     | 0.500 | 0.600 | 0.700 | 20 | 24 | 28 |
| E      | 10.060 | 10.160 | 10.260 | 396 | 400 | 404 |
| E1     | 14.020 | 14.220 | 14.420 | 552 | 560 | 568 |
| E2     | 9.880 | 9.980 | 10.080 | 389 | 393 | 397 |
| F      | 15.090 | 15.190 | 15.290 | 594 | 598 | 602 |
| G      | 4.000 | 4.100 | 4.200 | 157 | 161 | 165 |
| H      | 4.980 | 5.080 | 5.180 | 196 | 200 | 204 |
| e      | 1.778 BASIC | | | 70 BASIC | | |
| L      | 4.980 | 5.080 | 5.180 | 196 | 200 | 204 |
| θ      | — | — | 12° | — | — | 12° |

**Figure 21. Package outline drawing**

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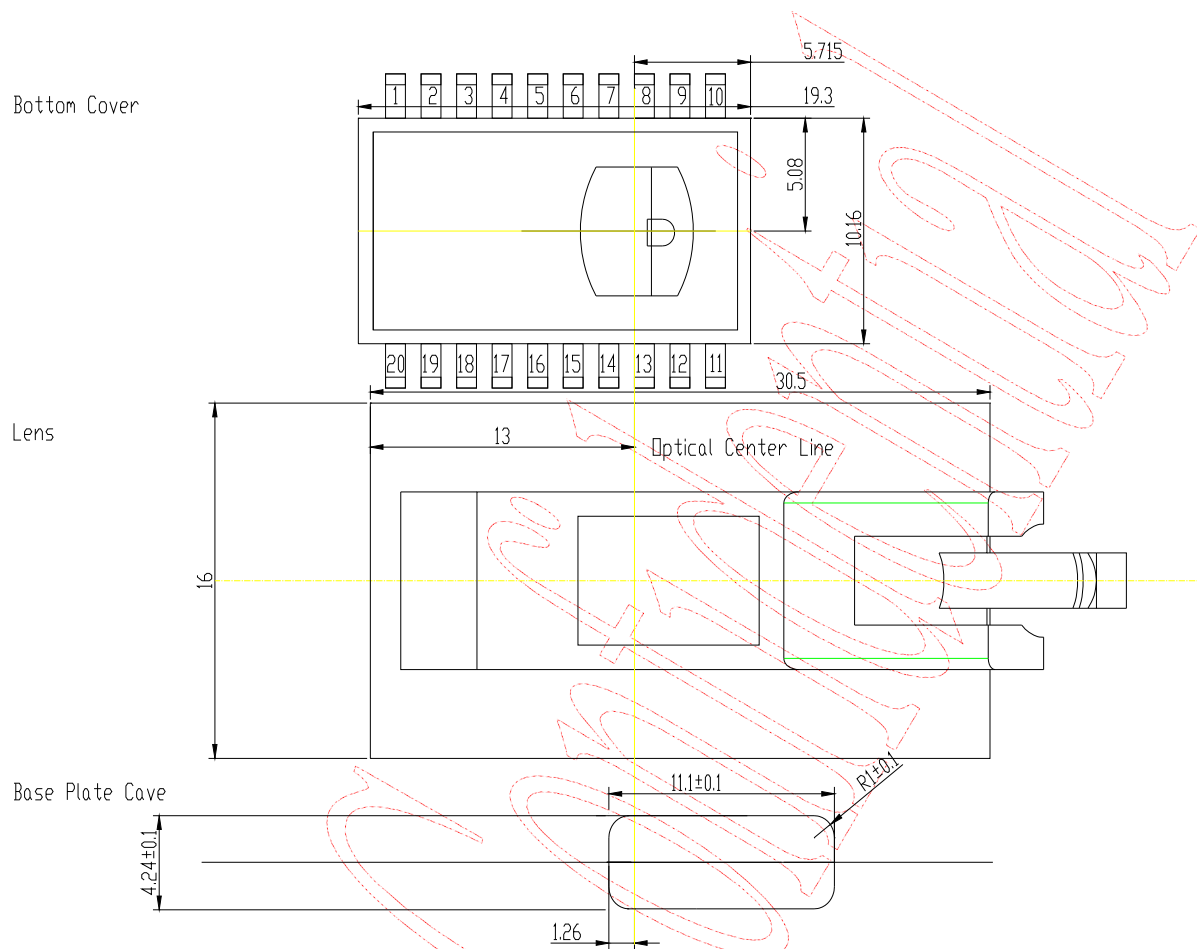## 11.2 Base Plate Modeling Dimension



**Figure 22. Base plate molding dimension**

## 11.3 Recommended PCB Mechanical Cutouts and Spacing
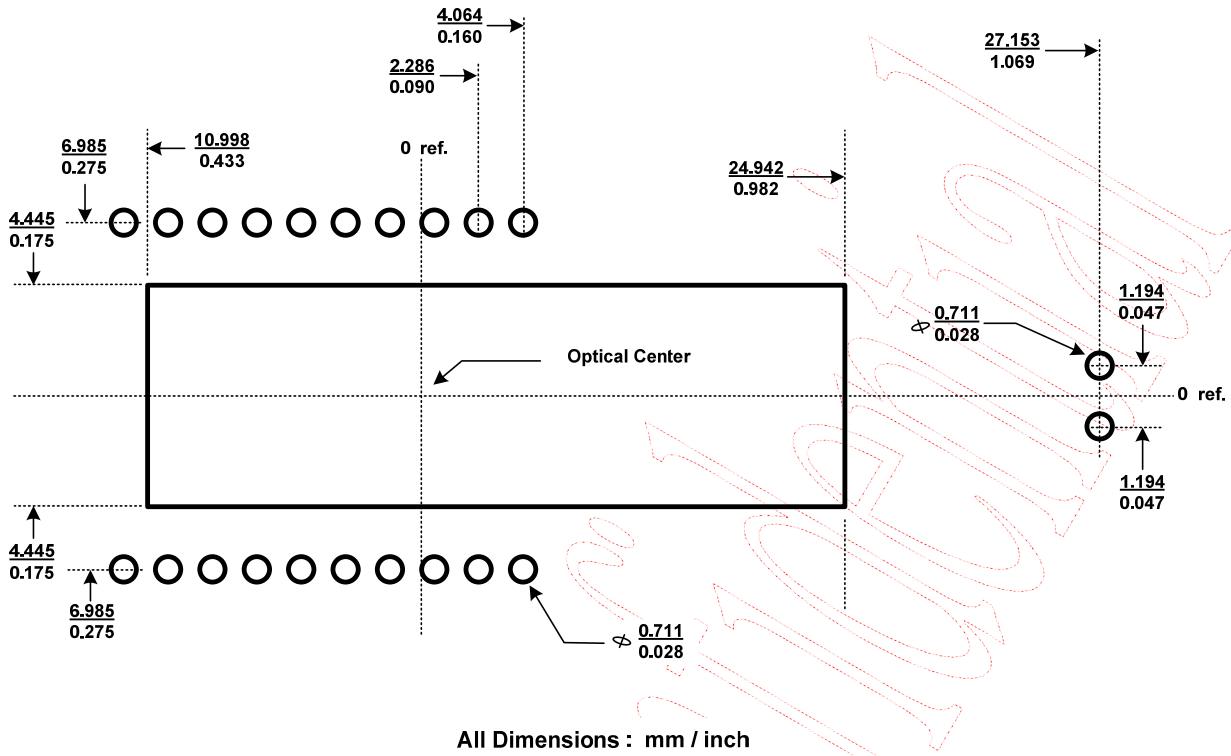


**Figure 23. Recommended PCB mechanical cutouts and spacing**

## 6. Update History

| Version | Update | Date |
|---------|--------|------|
| V1.0 | Creation, Preliminary 1st version | 06/28/2007 |
| | | |
| | | |

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# Vertical Cavity Surface Emitting Laser

# (VCSEL)

# Components Specification

**Distribution**

Internal Only                     ☐

External All                      ☐

External Restricted               ☐  If restricted, specify restricted to whom:

_____

**Document No.:**      **PNDR-00004**

**Revision:**          **Rev 2.50**

**Date:**              **2007/06/15**

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# Revision History

| Revision | Author | Date | Description |
|----------|--------|------|-------------|
| 1.0 | M.H.Chien | 2006/06/14 | Initial version |
| 1.5 | Chadwick | 2007/01/18 | Add VDD=2.7V and delete VDD=5.0V constraint resistor table |
| 2.0 | Chadwick | 2007/05/04 | Revise resistor table for higher CW radiant power 300uW ~550uW on Mouse operation ; Delete P32/ P64/ P68/ P72/ P76/ P80 six Grades |
| 2.5 | Chadwick | 2007/06/15 | Note PAN/PAW 3601DH-NF for constraint resistor table and add new constraint resistor table for  PAN/PAW 3602DH-NF |
|  |  |  |  |

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# PNDR-00004

## 850nm Epoxy molded VCSEL for Laser Mouse

**FEATURES**

- Epoxy Molded with round emission surface.
- Small divergence angle.

## ELECTRO-OPTICAL CHARACTERISTICS:

| PARAMETERS | SYMBOL | MIN | TYP | MAX | UNIT | TEST CONDITIONS |
|---|---|---|---|---|---|---|
| Output Power | $P_o$ | | 0.475 | 0.7 | mW | $I=I_F$ [1] |
| Wavelength | $\lambda_P$ | 830 | 850 | 860 | nm | $I_F$ = 6 mA |
| Forward Voltage | $V_F$ | 1.6 | 1.75 | 1.9 | V | $I_F$ = 6 mA |
| Series Resistance | $R_S$ | | 40 | 60 | Ω | $I_F$ = 6 mA |
| Breakdown voltage | $V_{BD}$ | 7 | 14 | | V | Ir = 10uA |
| Beam Divergence(1/e$^2$) | $\theta$ | | 8 | | degree | $I_F$ = 6 mA |

Notes :(1) Binning

## APPIY TO PAN3602DH-NF/ PAW3602DH-NF

Optical power at each of following nominal bin operating current and constrained resistor

| Bin grade | LD current (mA) | Single Constrain resistor :R(Ω) | Bin grade | LD current (mA) | Single Constrain resistor :R(Ω) |
|---|---|---|---|---|---|
| P36 | 3.6 | 18K | P50 | 5.0 | 13K |
| P40 | 4.0 | 15K | P52 | 5.2 | 13K |
| P42 | 4.2 | 15K | P54 | 5.4 | 12K |
| P44 | 4.4 | 15K | P56 | 5.6 | 12K |
| P46 | 4.6 | 15K | P58 | 5.8 | 12K |
| P48 | 4.8 | 13K | P60 | 6.0 | 10K |

**Warning! For Single constrain resistor( R ) , please using the recommend value, if resistor value is less than recommend value, there will be eye safety issue.**

**Note: The suggested resistor tolerance is 1% precise resistor for constrained resistor R.**
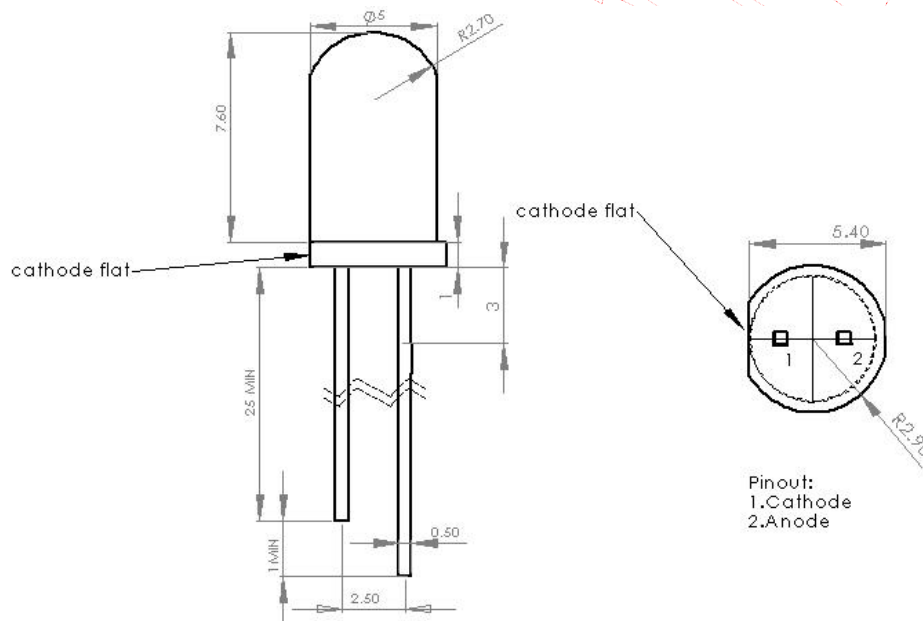
## ABSOLUTE MAXIMUM RATINGS:

| PARAMETERS | MIN | MAX | UNIT | Condition |
|---|---|---|---|---|
| Storage Temperature | -30 | 85 | °C | |
| Operating Temperature | -10 | 60 | °C | |
| Continuous Forward Current | | 12 | mA | |
| Continuous Reverse Voltage | | 7 | V | |
| Lead Solder Temperature | | 260 | °C | 10 seconds |

Fig. 1  Typical Optical Characteristics          Fig. 2  Typical Electrical Characteristics
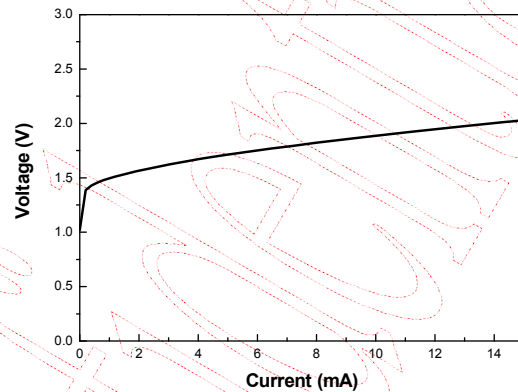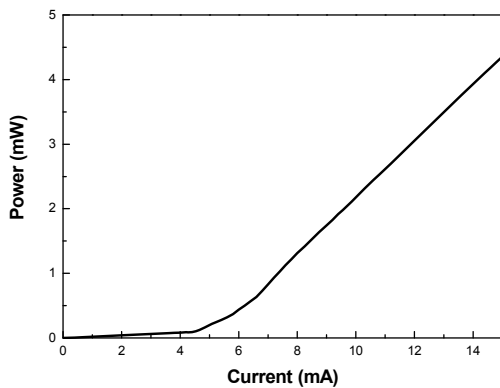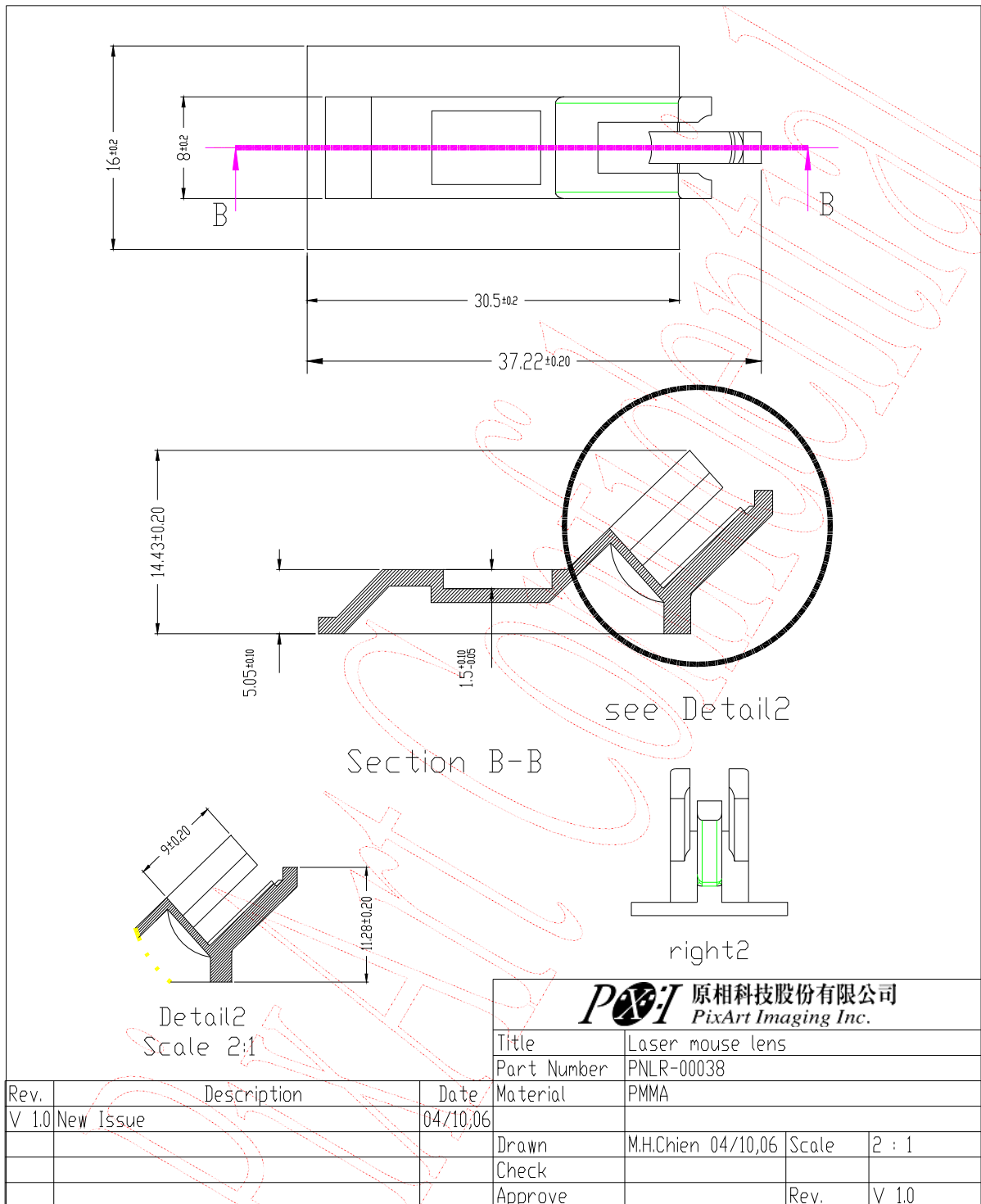


## OUTLINE DIMENSIONS:



Note: Unit is millimeters and Tolerance is ± 0.2 mm unless otherwise notes

## WARNING:

The VCSEL is a class IIIa laser in the safety
standard ANSI Z136.1 and should be treated
as a potential eye hazard.



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# PNLR-00038 Lens Dimensions



Section B-B

see Detail2

right2

Detail2
Scale 2:1

| PX:I 原相科技股份有限公司 PixArt Imaging Inc. | | | |
|---|---|---|---|
| Title | Laser mouse lens | | |
| Part Number | PNLR-00038 | | |
| Material | PMMA | | |
| | | | |
| Drawn | M.H.Chien 04/10,06 | Scale | 2 : 1 |
| Check | | | |
| Approve | | Rev. | V 1.0 |

| Rev. | Description | Date |
|---|---|---|
| V 1.0 | New Issue | 04/10,06 |
| | | |
| | | |
| | | |

Note:  The Part No. of the Mouse Product with Prefix "PAN" shall NOT be made, sold, offered to sell, imported or used in or into USA, Canada, Japan and EU.  For "PAN", PixArt has only gained territory-limited patent license from Avago.  Avago reserve right to take legal action against our customers who fails to comply the above term.  PLEASE NOTE THAT PixArt will NOT defend, indemnify, or provide any assistance to our customers who fail to comply the term.  IF YOU DO NOT AGREE THE TERM, PIXART WILL NOT DELIVER "PAN" PRODUCTS TO YOU.