

## PAW3102DB HIGH RESOLUTION CMOS OPTICAL MOUSE SENSOR

### General Description

The PAW3102DB is a high resolution CMOS process optical mouse sensor with DSP integration chip that serves as a non-mechanical motion estimation engine for implementing a computer mouse.

#### Features

- Single 5.0/3.3 volt power supply
- Built-in  $\pm 10\%$  accurate oscillator, external crystal-less
- Precise optical motion estimation technology
- Complete 2-D motion sensor
- No mechanical parts
- Accurate motion estimation over a wide range of surfaces
- High speed motion detection up to 28 inches/sec
- High resolution up to 1600 CPI
- Register setting for low power dissipation
- Power saving mode during times of no movement
- Serial Interface for programming and data transfer
- I/O pin 5.0 volt tolerance
- EFT enhancement

#### Key Specification

<b>Power Supply</b>	<b>Wide operating supply range 3.0V ~ 3.6V (VDD, VREF) 4.25V ~ 5.5V (VDD)</b>
<b>Optical Lens</b>	<b>1:1</b>
<b>Speed</b>	<b>28 inches/sec</b>
<b>Resolution</b>	<b>800/1000(default)/1200/1600 CPI</b>
<b>Frame Rate</b>	<b>3000 frames/sec</b>
<b>Operating Current</b>	<b>10 mA @Mouse moving (Normal) 5 mA @Mouse not moving (Sleep) 100 uA @Power down mode</b>
<b>Package</b>	<b>Staggered DIP8</b>

### Ordering Information

<b>Order Number</b>	<b>I/O</b>	<b>Resolution</b>
PAW3102DB	CMOS output	1000 CPI

**1. Pin Configuration**

**1.1 Pin Description**

Pin No.	Name	Type	Definition
1	OSC_RES	IN	Internal RC oscillator for system clock without external resistor
2	NC	-	No connect
3	SDIO	I/O	Serial interface bi-direction data (5.0 volt tolerance and 3.3V output)
4	SCLK	IN	Serial interface clock (5.0 volt tolerance)
5	LED	OUT	LED control
6	VSS	GND	Chip ground
7	VDD	PWR	Chip power, 3.0V ~ 3.6V( $V_{dd1}$ ) or 4.25V ~ 5.5( $V_{dd2}$ )
8	VREF	BYPASS	Voltage reference, 3.3V

**1.2 Pin Assignment**

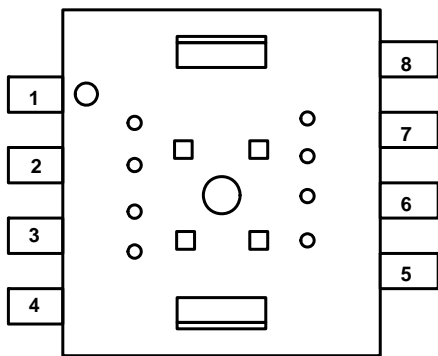


Figure 1. Top View Pinout

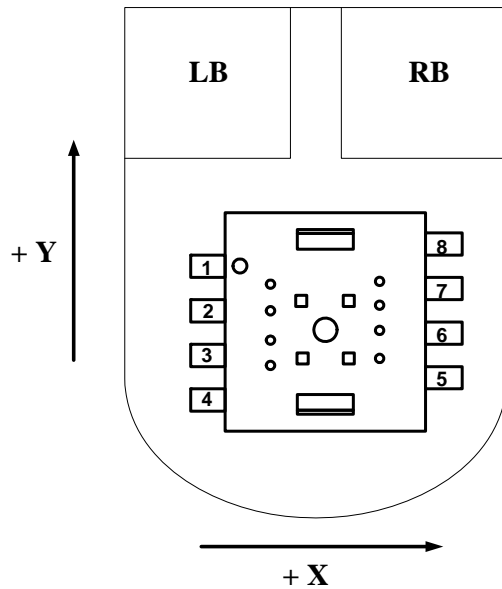


Figure 2. Top View of Mouse

## 2. Block Diagram and Operation

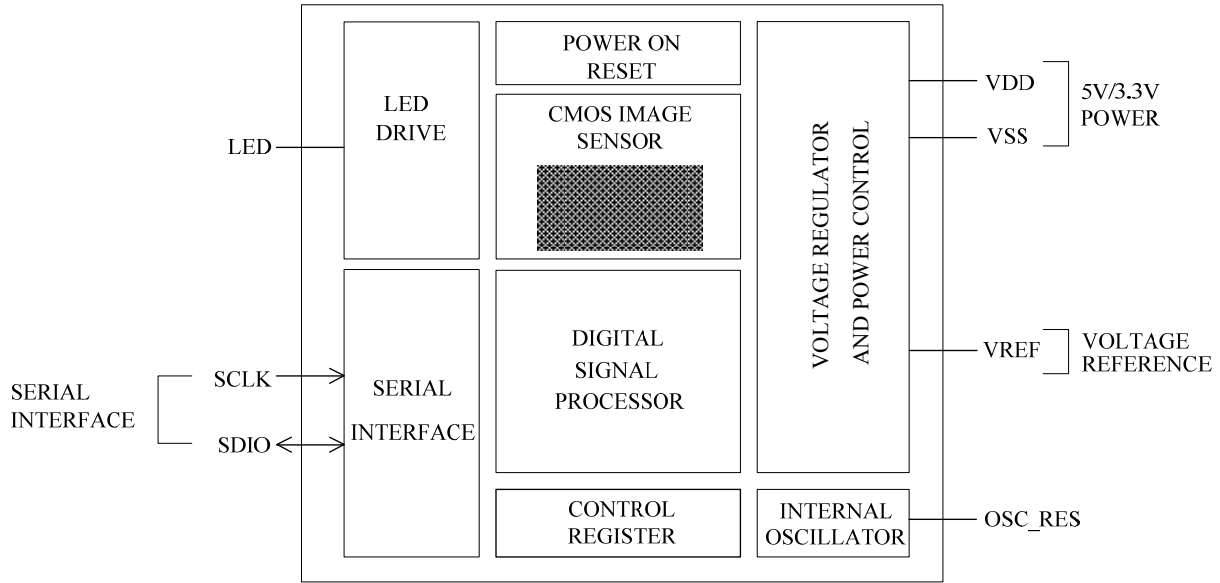


Figure 3. Block Diagram

The PAW3102DB is a high resolution CMOS-process optical 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 optical navigation technology, which measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the direction and magnitude of movement. The mouse sensor is in an 8-pin optical package. The current X and Y information are available in registers accessed via a serial port. The word "mouse sensor," instead of PAW3102DB, is used in the document.

### 3. Registers and Operation

The released registers of the mouse sensor can be programmed via a serial port interface. The user can modify released DSP configuration and read motion data from these registers. Some registers not being listed are reserved not allowed to be modified.

#### 3.1 Registers

Address	Name	R/W	Reset Value	Data Type
0x00	Operation_Mode1	R/W	0x00	Bit field
0x01	Product_ID1	R	0x01	Bit field
0x02	Delta_Y	R	-	Eight bits 2's complement number
0x03	Delta_X	R	-	Eight bits 2's complement number
0x04	Image_Quality	R	-	Eight bits unsigned integer
0x05   0x11	-	-	-	Reserved for future use
0x12	Write_Protect	W	-	Bit field
0x13	-	-	-	Reserved for future use
0x14	Product_ID2	R	0x10	Eight bits [11:4] number with the product identifier
0x15	Product_ID3	R	0x2N	Four bits [3:0] number with the product identifier Reserved [3:0] number is reserved for future
0x16	Motion_Status	R	-	Bit field
0x17	Delta_X	R	-	Eight bits 2's complement number
0x18	Delta_Y	R	-	Eight bits 2's complement number
0x19	Image_Quality	R	-	Eight bits unsigned integer
0x1A	Operation_Mode2	R	0x0C	Bit field
0x1B	Configuration	R	0x64	Bit field
0x1C   0x3F	-	-	-	Reserved for future use

3.2 Register Descriptions

0x00	Operation_Model1							
Bit	7	6	5	4	3	2	1	0
Field	Reset	PD_enh	0	0	0	0	0	Slp_enl
Usage	Register 0x00 allows the user to change the operation of the mouse sensor. Shown below are the bits, their default values, and optional values.  If <i>Slp_enl</i> = 0, After 1 sec not moving during normal mode, the mouse sensor will enter sleep mode, and keep on sleep mode until moving is detected or wakeup is asserted.							
Notes	<b>Field Name</b>	<b>Description</b>						
	Reset	Full chip reset <b>0 = Normal operation mode (Default)</b> 1 = Full chip reset						
	PD_enh	Power down mode <b>0 = Normal operation mode (Default)</b> 1 = Power down mode						
	Bit [5:1]	MUST always be <b>00000</b>						
	Slp_enl	Sleep mode enable/disable <b>0 = Enable (Default)</b> 1 = Disable						
0x01	Product_ID1							
Bit	7	6	5	4	3	2	1	0
Field	PID1[2:0]			Reserved[3:0]				Opstate
Usage	Product ID of mouse sensor and operation state of the mouse sensor.							
Notes	<b>Field Name</b>	<b>Description</b>						
	PID1[2:0]	The product ID is 000						
	Reserved[3:0]	Reserved for future use						
	Opstate	Operation state 0 = Sleep state 1 = Normal state						
0x02	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.							

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		Image_Quality						
Bit	7	6	5	4	3	2	1	0
Field	Imgqa[7:0]							
Usage	Image Quality is a quality level of the mouse sensor in the current frame. Report range 0 ~ 255.							
Notes	Field Name	Description						
	Imgqa[7:0]	Image quality report range: 0(worst) ~ 255(best).						
0x12		Write_Protect						
Bit	7	6	5	4	3	2	1	0
Field	Reserved[2:0]			WP[4:0]				
Usage	Write protect for the register 0x1A, 0x1B. Note: When <b>Write_Protect</b> function is disabled, users can write register 0x1A, 0x1B. After writing registers, users have to enable the <b>Write_Protect</b> function for EFT issue.							
Notes	Field Name	Description						
	Reserved[2:0]	Reserved for future use. Must be written to zero.						
	WP[4:0]	Write protect enable/disable for 0x1A, 0x1B <b>00000 = Enable (Default)</b> , register 0x1A, 0x1B is read only 10101 = Disable, register 0x1A, 0x1B can be read/written						
0x14		Product_ID2						
Bit	7	6	5	4	3	2	1	0
Field	PID2[11:4]							
Usage	The value in this register is fixed. It can be used to verify if the status of the serial communications link is OK.							
0x15		Product_ID3						
Bit	7	6	5	4	3	2	1	0
Field	PID2[3:0]				Reserved[3:0]			
Usage	The value in this register is fixed. PID2[3:0] can be used to verify if the status of the serial communications link is OK. Reserved[3:0] is a value between 0x0 and 0xF, but it can't be used to verify the status of the serial communications.							

0x16		Motion_Status						
Bit	7	6	5	4	3	2	1	0
Field	Motion	Reserved[2:1]		DYOVF	DXOVF	Reserved[0]		RES[1:0]
Usage	<p>Register 0x16 allows the user to determine if motion has occurred since the last time it was read. If so, then the user should read registers 0x17 and 0x18 to get the accumulated motion. It also tells if the motion buffers have overflowed since the last reading. The current resolution is also shown.</p> <p>Reading this register freezes the <i>Delta_X</i> and <i>Delta_Y</i> register values. Read this register before reading the <i>Delta_X</i> and <i>Delta_Y</i> registers. If <i>Delta_X</i> and <i>Delta_Y</i> are not read before the motion register is read a second time, the data in <i>Delta_X</i> and <i>Delta_Y</i> will be lost.</p>							
Notes	Field Name	Description						
	Motion	Motion since last report or PD <b>0 = No motion (Default)</b> 1 = Motion occurred, data ready for reading in <i>Delta_X</i> and <i>Delta_Y</i> registers						
	Reserved[2:1]	Reserved for future use						
	DYOVF	Motion Delta Y overflow, ΔY buffer has overflowed since last report <b>0 = No overflow (Default)</b> 1 = Overflow has occurred						
	DXOVF	Motion Delta X overflow, ΔX buffer has overflowed since last report <b>0 = No overflow (Default)</b> 1 = Overflow has occurred						
	Reserved[0]	Reserved for future use						
	RES[1:0]	Resolution in counts per inch <b>0 = 1000 (Default)</b> 1 = 1200 2 = 1600 3 = 800						
0x17		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.							
0x18		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.							

0x19	Image_Quality							
Bit	7	6	5	4	3	2	1	0
Field	Imgqa[7:0]							
Usage	Image Quality is a quality level of the mouse sensor in the current frame. Report range 0 ~ 255.							
Notes	Field Name	Description						
	Imgqa[7:0]	Image quality report range: 0(worst) ~ 255(best).						
0x1A	Operation_Mode2							
Bit	7	6	5	4	3	2	1	0
Field	Reset	PD_enh	CPI[1:0]		LEDsht_enh	Slp_enh	Slpmu_enh	Wakeup
Usage	<p>Register 0x1A allows the user to change the operation of the mouse sensor. Shown below are the bits, their default values, and optional values.</p> <p><b>Operation_Mode2[2:0]</b>                      “0xx” = Disable sleep mode                      “110” = Force enter sleep                      “101” = Force wakeup from sleep mode</p> <p>Notes:                      1. After 1 sec not moving during normal mode, the mouse sensor will enter sleep mode, and keep on sleep mode until moving is detected or wakeup is asserted.                      2. Only one of these two bits <i>Slpmu_enh</i> and <i>Wakeup</i> can be set to 1 at the one time, and the other one has to be set to 0. Note that these bits are self-clear.</p>							
Notes	Field Name	Description						
	Reset	Full chip reset <b>0 = Normal operation mode (Default)</b> 1 = Full chip reset						
	PD_enh	Power down mode <b>0 = Normal operation mode (Default)</b> 1 = Power down mode						
	CPI[1:0]	Output resolution setting <b>0 = 1000 (Default)</b> 1 = 1200 2 = 1600 3 = 800						
	LEDsht_enh	LED shutter enable/disable 0 = Disable <b>1 = Enable (Default)</b>						
	Slp_enh	Sleep mode enable/disable 0 = Disable <b>1 = Enable (Default)</b>						
	Slpmu_enh	Manual enter sleep mode, set “1” will enter sleep 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”						

0x1B	Configuration							
Bit	7	6	5	4	3	2	1	0
Field	XY_exch	Y_inv	X_inv	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>
Usage	<p>Register 0x1B allows the user to change the XY direction of the mouse sensor. Shown below are the bits, their default values, and optional values.</p> <p><b>Configuration[7:5]</b>                      “011” = Typical direction 0°                      “110” = The mouse sensor turn -90°                      “101” = The mouse sensor turn +90°</p> <p>Notes:                      When write <b>Configuration[7:5]</b>, users have to keep <b>Configuration[4:0]</b> values. So the only way to do this is read <b>Configuration[7:0]</b> first, set/clear the desired bits of <b>Configuration[7:5]</b> and keep the same value of <b>Configuration[4:0]</b> , then write <b>Configuration[7:0]</b>.</p>							
Notes	<b>Field Name</b>	<b>Description</b>						
	XY_exch	X and Y direction exchange function <b>0 = Disable (Default)</b> 1 = Enable (X and Y direction exchange)						
	Y_inv	Y direction inverse function 0 = Enable(Y direction inverse) <b>1 = Disable (Default)</b>						
	X_inv	X direction inverse function 0 = Enable (X direction inverse) <b>1 = Disable (Default)</b>						
	Bit [4:0]	Must always be <b>00100</b>						

## 4. Specifications

### 4.1 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 <sub>STG</sub>	Storage temperature	-40	85	°C	
T <sub>A</sub>	Operating Temperature	-15	55	°C	
	Lead Solder Temp		260	°C	For 10 seconds, 1.6mm below seating plane.
V <sub>DC</sub>	DC supply voltage	-0.5	5.5	V	
ESD			2	kV	All pins, human body model MIL 883 Method 3015
V <sub>IN</sub>	DC input voltage	-0.5	V <sub>DC</sub>	V	SDIO, SCLK, VDD

### 4.2 Recommend Operating Condition

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T <sub>A</sub>	Operating Temperature	0		40	°C	
V <sub>dd1</sub>	Power Supply Voltage	3.0	3.3	3.6	V	VDD, VREF short
V <sub>dd2</sub>		4.25	5.0	5.5		VDD only
V <sub>N @ V<sub>dd1</sub></sub>	Supply noise			50	mV	Peak to peak within 0 - 80 MHz
V <sub>N @ V<sub>dd2</sub></sub>				100		
Z	Distance from lens reference plane to surface	2.3	2.4	2.5	mm	Refer to Figure 4.
R	Resolution	800	1000	1600	CPI	
A	Acceleration			20	g	
SCLK	Serial Port Clock Frequency			10	MHz	
FR	Frame Rate		3000		frames/sec	
S	Speed	0		28	inches/sec	

### 4.3. AC Operating Condition

Electrical Characteristics over recommended operating conditions. Typical values at 25 °C,  $V_{DD} = 5.0$  V.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
$t_{HOLD}$	SDIO read hold time		3		us	Minimum hold time for valid data. (Refer to Figure 9)
$t_{RESYNC}$	Serial Interface RESYNC.	1			us	@3000frame/sec (Refer to Figure 10)
$t_{SIWTT}$	Serial Interface Watchdog Timer Timeout	1.7			ms	@3000frame/sec (Refer to Figure 10)
$t_{PDR}$	PD Pulse Register			666	us	Two frames time maximum after setting bit 6 in the <i>Operation Mode</i> register @3000frame/sec. (Refer to Figure 11)
$t_{PUPD}$	Power Up from deactivate the Power Down mode	3		30.5	ms	From deactivate power down mode to valid motion data. After $t_{PUPD}$ , all registers contain valid data from first image after deactivate power down mode. Note that an additional 90 frames for Auto-Exposure (AE) stabilization may be required if mouse movement occurred while PD bit in register was high. @3000 frame/sec
$t_{PU}$	Power Up from $V_{DD}\uparrow$	3		30.5	ms	From $V_{DD}\uparrow$ to valid motion data. @3000 frame/sec

#### 4.4. DC Operating Condition

Electrical Characteristics over recommended operating conditions. Typical values at 25 °C,  $V_{DD} = 5.0$  V.

Symbol	Parameter	Min.	Typ.	Max.	Unit	
<b>Type: PWR</b>						
$I_{DDN}$	Supply Current Mouse moving (Normal)		10		mA	SCLK, SDIO = no load
$I_{DDSI}$	Supply Current Mouse not moving (sleep1)		5		mA	
$I_{DDPD}$	Supply Current (Power Down)		100		uA	SCLK, SDIO = high
<b>Type: SCLK, SDIO</b>						
$V_{IH}$	Input voltage HIGH	2.0				
$V_{IL}$	Input voltage LOW			0.7	V	
$V_{OH}$	Output voltage HIGH	2.4			V	@ $I_{OH} = 2$ mA (SDIO only)
$V_{OL}$	Output voltage LOW			0.6	V	@ $I_{OL} = 2$ mA (SDIO only)
<b>Type: LED</b>						
$V_{OL}$	Output voltage LOW			150	mV	@ $I_{OL} = 25$ mA

5. Z and 2D/3D Assembly

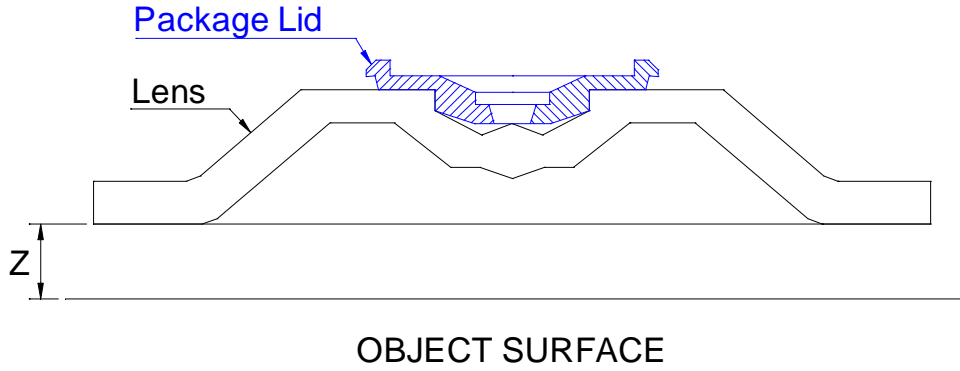


Figure 4. Distance from Lens Reference Plane to Surface

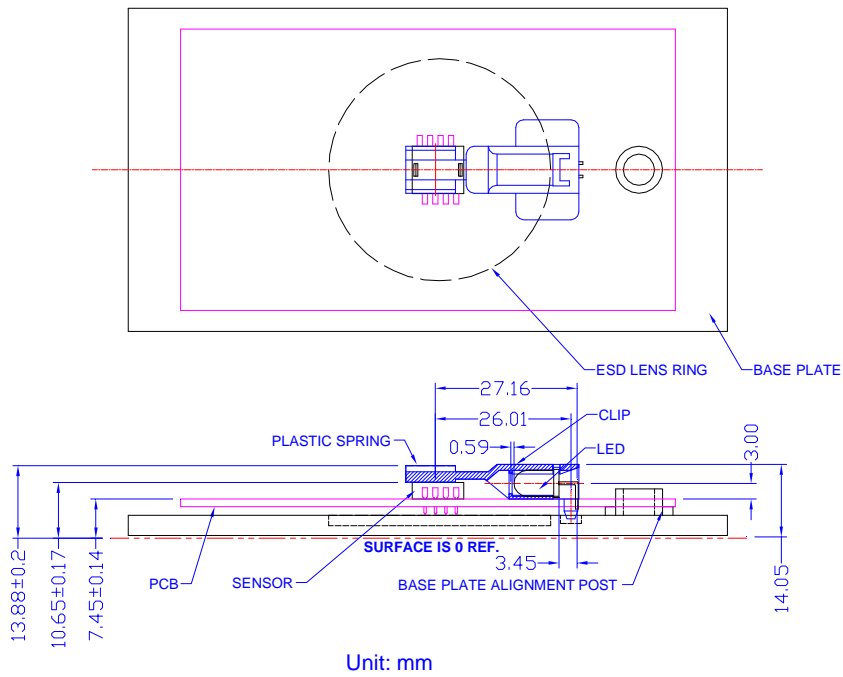


Figure 5. 2D Assembly

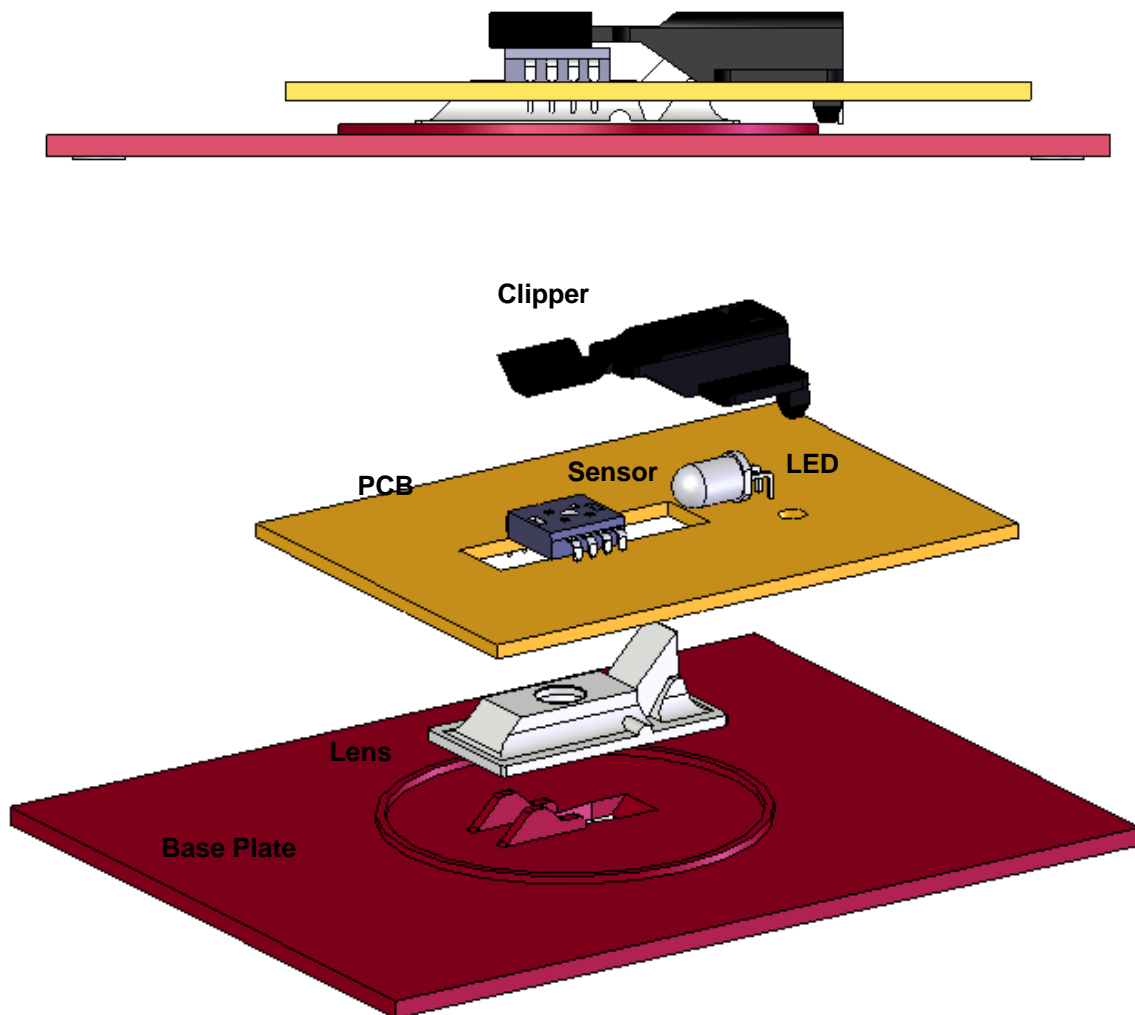


Figure 6. 3D Assembly for Mounting Instructions

## 6. Serial Interface

The synchronous serial port is used to set and read parameters in the mouse sensor.

**SCLK:** The serial clock line. It is always generated by the mouse controller.

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

### 6.1 Transmission Protocol

The transmission protocol is a two-wire link, half duplex protocol between the mouse controller and the mouse sensor. All data changes on SDIO are initiated by the falling edge on SCLK. The mouse controller instead of the mouse sensor has the ability to initiate 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.

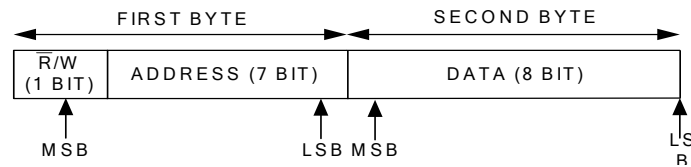


Figure 7. Transmission Protocol

#### 6.1.1 Write Operation

A write operation, which means that data is going from the mouse controller to the mouse sensor, is always initiated by the mouse 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 mouse controller changes SDIO on falling edges of SCLK. The mouse sensor reads SDIO on rising edges of SCLK.

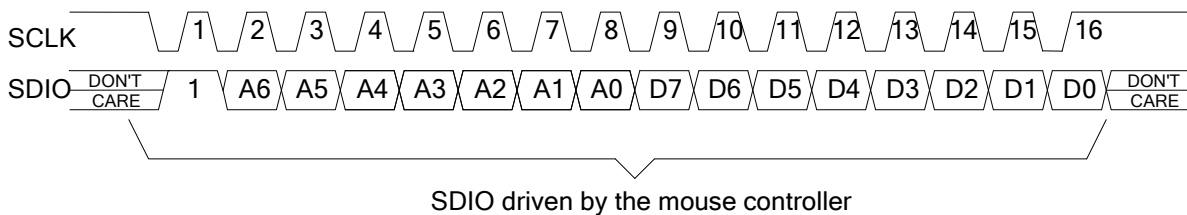
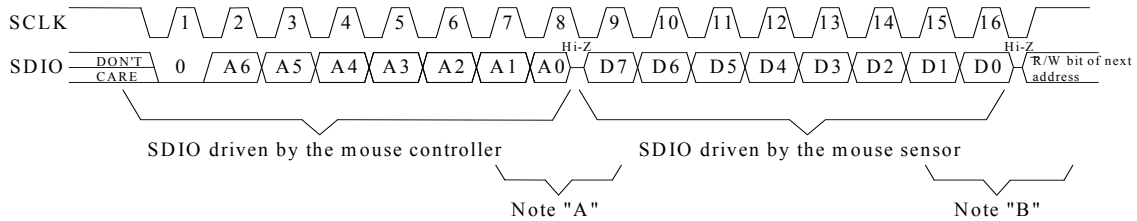


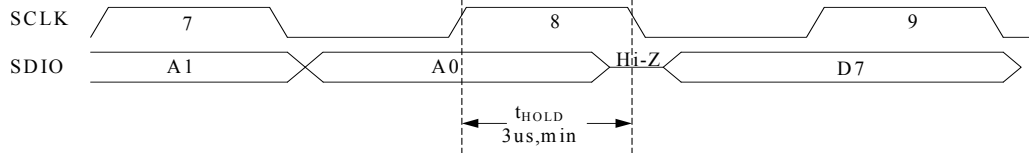
Figure 8. Write Operation

### 6.1.2 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.



- Note "A" 1. The mouse controller sends address to the mouse sensor.  
 2. The mouse controller releases and set SDIO to Hi-Z after the last address bit.



- Note "B" 1. The mouse sensor sends data to the mouse controller .  
 2. The mouse sensor releases and set SDIO to Hi-Z after the last data bit.

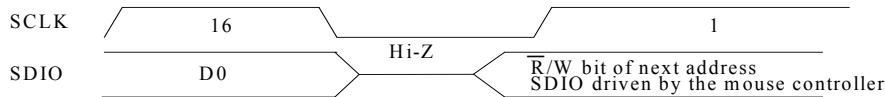


Figure 9. Read Operation

### 6.2 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. In such a case, an easy way to solve this condition is to toggle the SCLK line from high to low for least  $t_{RESYNC}$ , and then MUST toggle it from low to high to wait at least  $t_{SIWTT}$  to reach re-synchronous the serial port. This method is called by “watchdog timer timeout”. The mouse sensor will reset the serial port without resetting the registers and be prepared for the beginning of a new transmission.

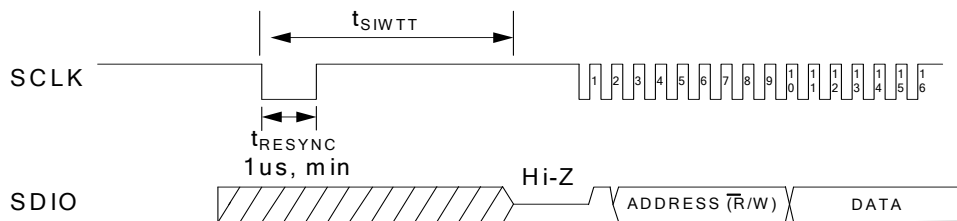


Figure 10. Re-synchronous Serial Interface Using Watchdog Timer Timeout

Note that this 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 use “watchdog timer timeout”.
- 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 use “watchdog timer timeout”.

### 6.3 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 mouse 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 releases SDIO of the rising SCLK edge after the last data bit. The mouse controller can begin driving SDIO any time after that. In order to maintain low power consumption in normal operation, the mouse controller should not leave SDIO floating until the next transmission (although that will not cause any communication difficulties).

### 6.4 Power Down Mode

The mouse sensor can be placed in a power-down mode by setting *PD\_enh* bit in the *Operation\_Mode* register via a serial port write operation. After setting the *Operation\_Mode* register, wait at most 2 frames times. To get the chip out of the power down mode, clear *PD\_enh* bit in the *Operation\_Mode* register via a serial port write operation. In the power down mode, the serial interface watchdog timer (see Section 6.2) is not available. 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.

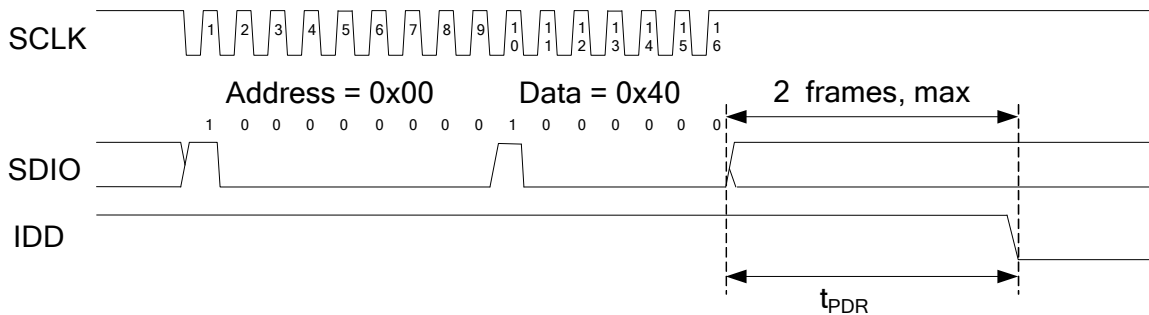


Figure 11. Power-down Configuration Register Writing Operation

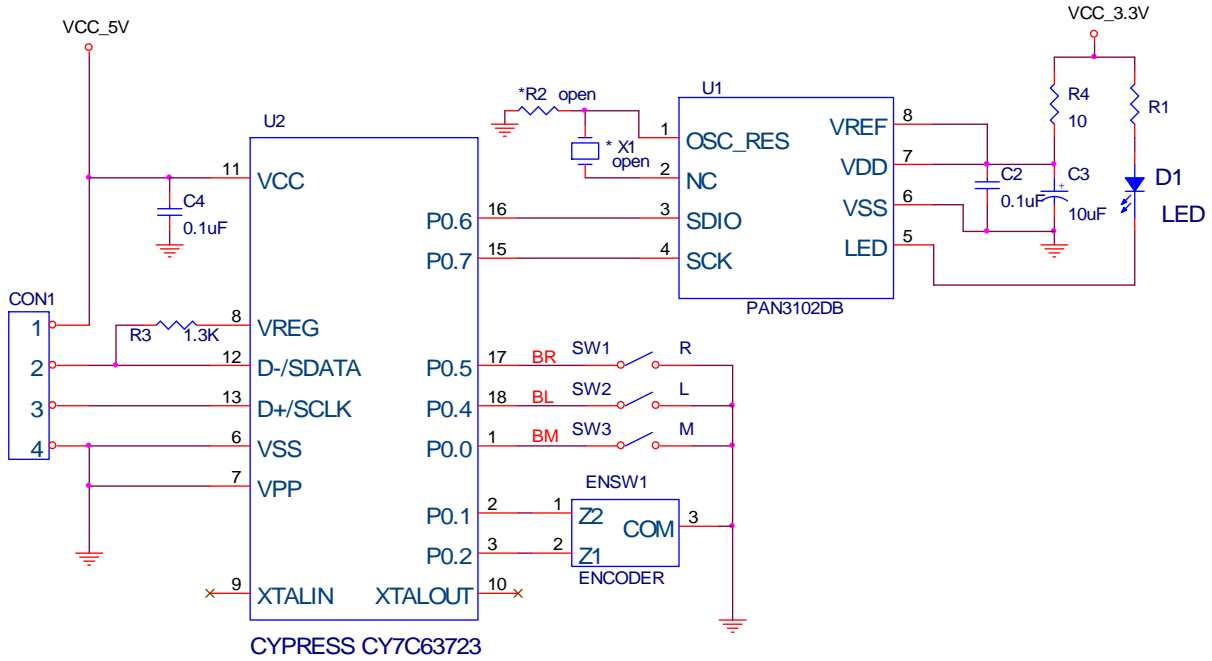
### 6.5 Error Detection

1. The mouse 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 mouse controller can verify the synchronization of the serial port by periodically reading the product ID register





7.3 Recommended Typical Application using Internal LED Control (3.3Volt)



Note:

1. \*R2 is left for future use
2. \*X1 is left for PAN3101DB

Figure 14. Application Circuit Using Internal LED (3.3Volt)

### 7.4 PCB Layout Consideration

- Caps for pins 7, 8 must have trace lengths less than **5 mm**.
- The trace lengths of OSC\_RES, NC must less than **6 mm**.

### 7.5 Recommended Value for R1

- Radiometric intensity of LED  
Bin limits (mW/Sr at 20 mA)

LED Bin Grade	Min.	Typ.	Max.
N	14.7		17.7
P	17.7		21.2
Q	21.2		25.4

Note: Tolerance for each bin will be  $\pm 15\%$

#### 7.5.1 Application for 5V

- R1 value (ohm) for external LED control, VDD = 5.0V (refer to Figure 12)

LED Bin Grade	Min.	Typ.	Max.
N	27	36	
P	27	36	
Q	27	36	

- R1 value (ohm) for internal LED control, VDD = 5.0V (refer to Figure 13)

LED Bin Grade	Min.	Typ.	Max.
N	47	100	
P	47	100	
Q	47	100	

#### 7.5.2 Application for 3.3V

- R1 value (ohm) for internal LED control, VDD = VREF = VDD\_LED = 3.3V (refer to Figure 14)

LED Bin Grade	Min.	Typ.	Max.
N	22	100	
P	22	100	
Q	22	100	

8. Package Information

8.1 Package Outline Drawing

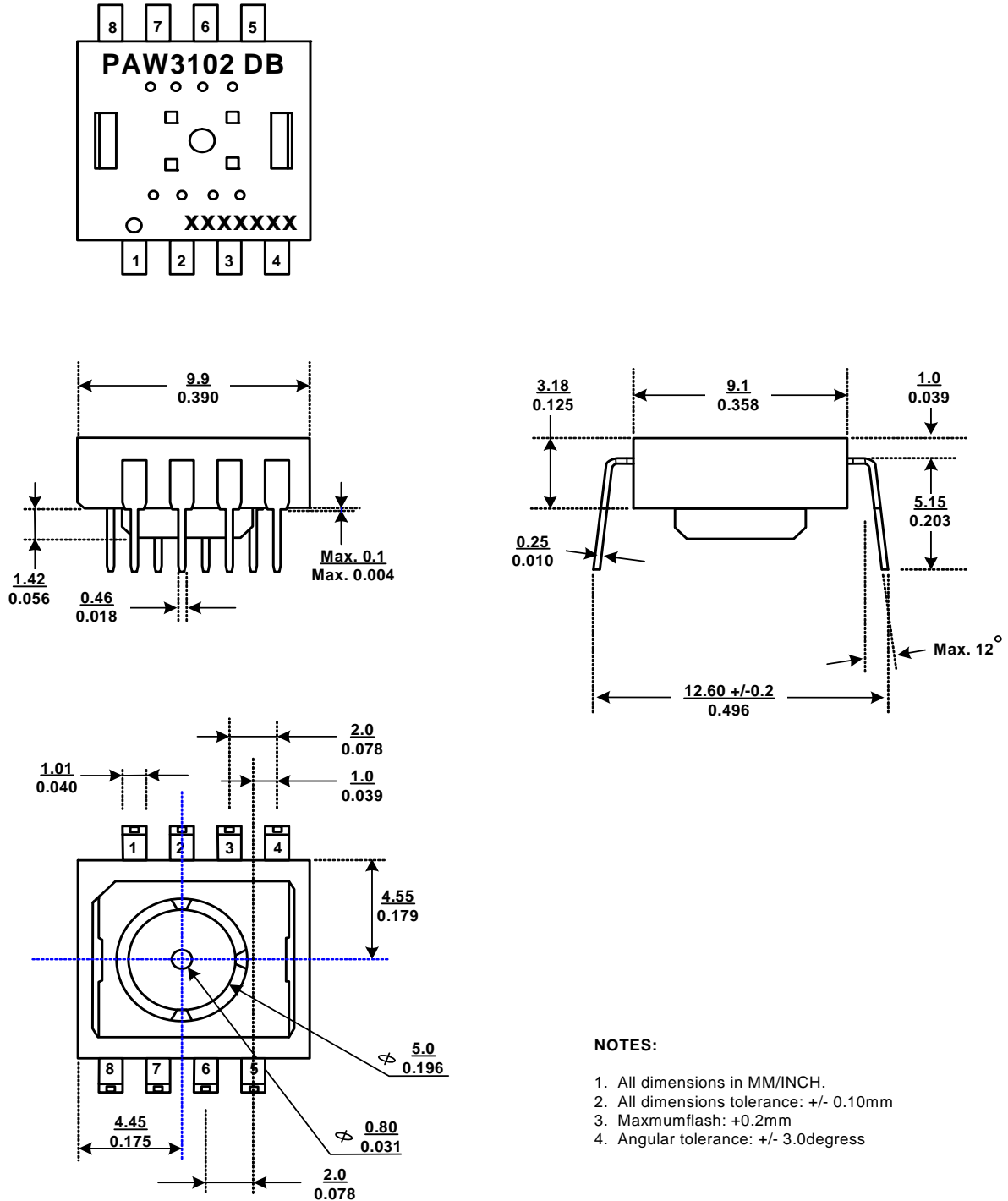


Figure 15. Package Outline Drawing

