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 ± 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

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

Ordering Information

Order Number	I/O	Resolution
PAW3102DB	CMOS output	1000 CPI

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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

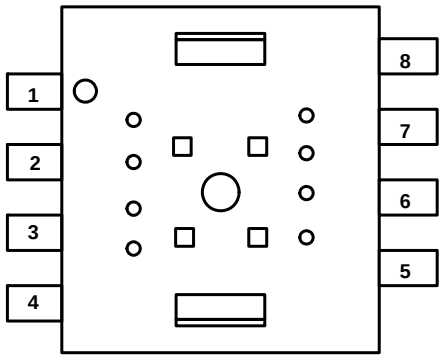

Figure 1. Top View Pinout

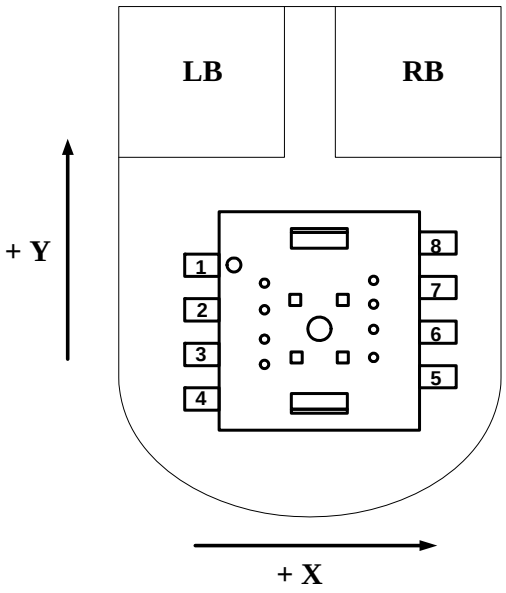

Figure 2. Top View of Mouse

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2. Block Diagram and Operation

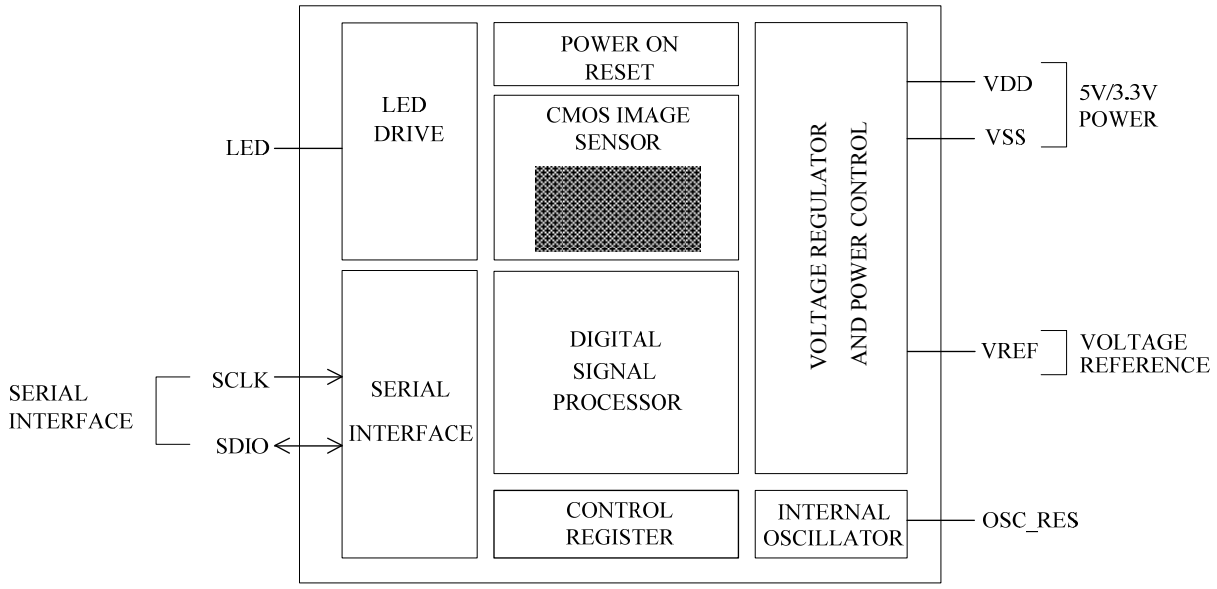

Figure 3. Block Diagram

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.

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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_Mode1**							
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 ***Slp_enl*** = 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	**Field Name**	**Description**						
	Reset	Full chip reset **0 = Normal operation mode (Default)** 1 = Full chip reset						
	PD_enh	Power down mode **0 = Normal operation mode (Default)** 1 = Power down mode						
	Bit [5:1]	MUST always be **00000**						
	Slp_enl	Sleep mode enable/disable **0 = Enable (Default)** 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	**Field Name**	**Description**						
	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.							

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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 ***Write_Protect*** function is disabled, users can write register 0x1A, 0x1B. After writing registers, users have to enable the ***Write_Protect*** 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 **00000 = Enable (Default)**, 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.							

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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	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. 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 **0 = No motion (Default)** 1 = Motion occurred, data ready for reading in ***Delta_X*** and ***Delta_Y*** registers
	Reserved[2:1]	Reserved for future use
	DYOVF	Motion Delta Y overflow, ΔY buffer has overflowed since last report **0 = No overflow (Default)** 1 = Overflow has occurred
	DXOVF	Motion Delta X overflow, ΔX buffer has overflowed since last report **0 = No overflow (Default)** 1 = Overflow has occurred
	Reserved[0]	Reserved for future use
	RES[1:0]	Resolution in counts per inch **0 = 1000 (Default)** 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.							

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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	Register 0x1A allows the user to change the operation of the mouse sensor. Shown below are the bits, their default values, and optional values. **Operation_Mode2[2:0]** "0xx" = Disable sleep mode "110" = Force enter sleep "101" = Force wakeup from sleep mode 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 ***Slpmu_enh*** and ***Wakeup*** 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.							
Notes	**Field Name**	**Description**						
	Reset	Full chip reset **0 = Normal operation mode (Default)** 1 = Full chip reset						
	PD_enh	Power down mode **0 = Normal operation mode (Default)** 1 = Power down mode						
	CPI[1:0]	Output resolution setting **0 = 1000 (Default)** 1 = 1200 2 = 1600 3 = 800						
	LEDsht_enh	LED shutter enable/disable 0 = Disable **1 = Enable (Default)**						
	Slp_enh	Sleep mode enable/disable 0 = Disable **1 = Enable (Default)**						
	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"						

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<table>
<tr><td>0x1B</td><td colspan="8">Configuration</td></tr>
<tr><td>Bit</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Field</td><td>XY_exch</td><td>Y_inv</td><td>X_inv</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Usage</td><td colspan="8">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.
Configuration[7:5]
“011” = Typical direction 0°
“110” = The mouse sensor turn -90°
“101” = The mouse sensor turn +90°
Notes:
When write Configuration[7:5], users have to keep Configuration[4:0] values. So the only way to do this is read Configuration[7:0] first, set/clear the desired bits of Configuration[7:5] and keep the same value of Configuration[4:0] , then write Configuration[7:0].</td></tr>
<tr><td rowspan="5">Notes</td><td colspan="2">Field Name</td><td colspan="6">Description</td></tr>
<tr><td colspan="2">XY_exch</td><td colspan="6">X and Y direction exchange function
0 = Disable (Default)
1 = Enable (X and Y direction exchange)</td></tr>
<tr><td colspan="2">Y_inv</td><td colspan="6">Y direction inverse function
0 = Enable(Y direction inverse)
1 = Disable (Default)</td></tr>
<tr><td colspan="2">X_inv</td><td colspan="6">X direction inverse function
0 = Enable (X direction inverse)
1 = Disable (Default)</td></tr>
<tr><td colspan="2">Bit [4:0]</td><td colspan="6">Must always be 00100</td></tr>
</table>

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_{STG}	Storage temperature	-40	85	°C	
TA	Operating Temperature	-15	55	°C	
	Lead Solder Temp		260	°C	For 10 seconds, 1.6mm below seating plane.
V_{DC}	DC supply voltage	-0.5	5.5	V	
ESD			2	kV	All pins, human body model MIL 883 Method 3015
V_{IN}	DC input voltage	-0.5	V_{DC}	V	SDIO, SCLK, VDD

4.2 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	VDD, VREF short
V_{dd2}		4.25	5.0	5.5		VDD only
V_N @ V_{dd1}	Supply noise			50	mV	Peak to peak within 0 - 80 MHz
V_N @ V_{dd2}				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 ***Operation_Mode*** 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}↑	3		30.5	ms	From V_{DD}↑ to valid motion data. @3000 frame/sec

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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	
Type: PWR						
I_{DDN}	Supply Current Mouse moving (Normal)		10		mA	SCLK, SDIO = no load
I_{DDS1}	Supply Current Mouse not moving (sleep1)		5		mA	
I_{DDPD}	Supply Current (Power Down)		100		uA	SCLK, SDIO = high
Type: SCLK, SDIO						
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: LED						
V_{OL}	Output voltage LOW			150	mV	@I_{OL} = 25mA

5. Z and 2D/3D Assembly

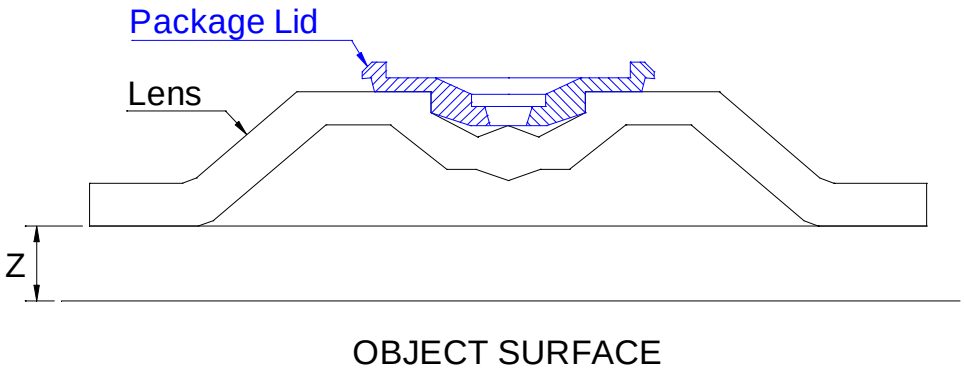

Figure 4. Distance from Lens Reference Plane to Surface

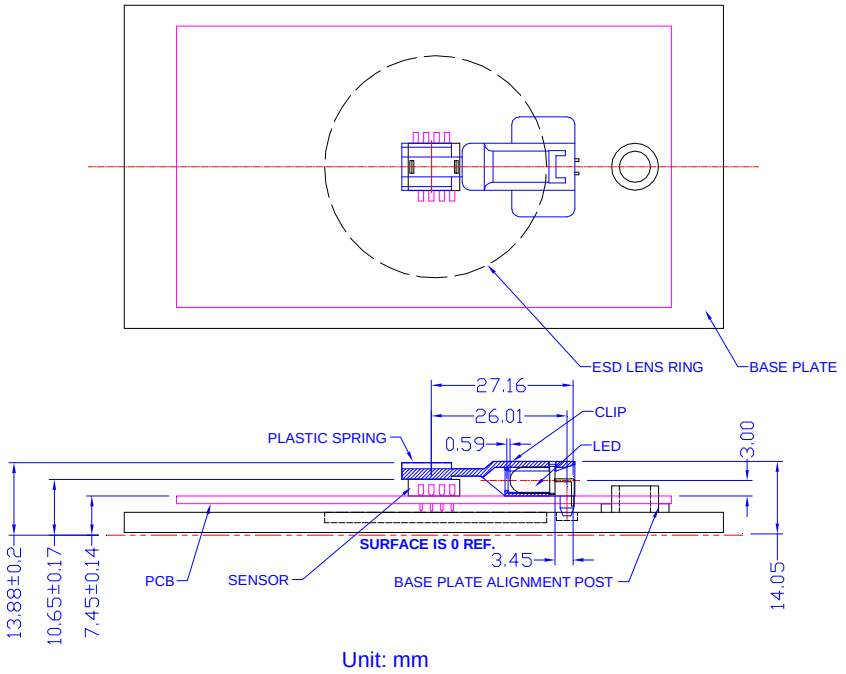

Figure 5. 2D Assembly

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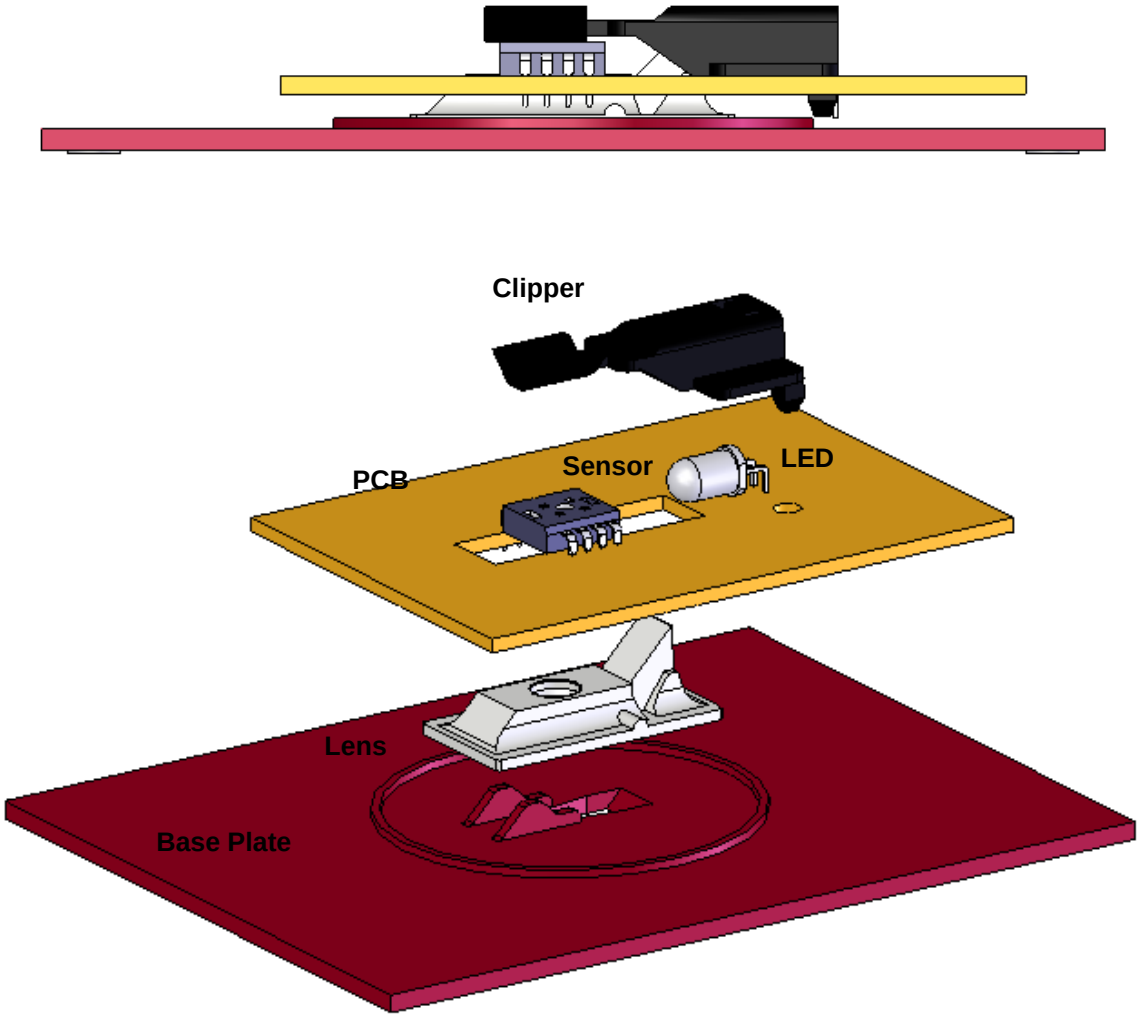

Figure 6. 3D Assembly for Mounting Instructions

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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 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.

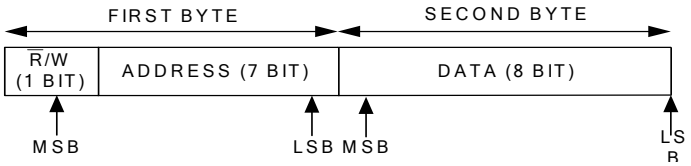

Figure 7. Transmission Protocol

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.

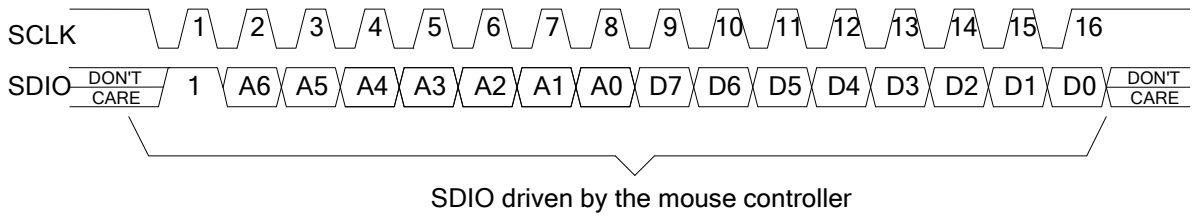

Figure 8. Write Operation

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.

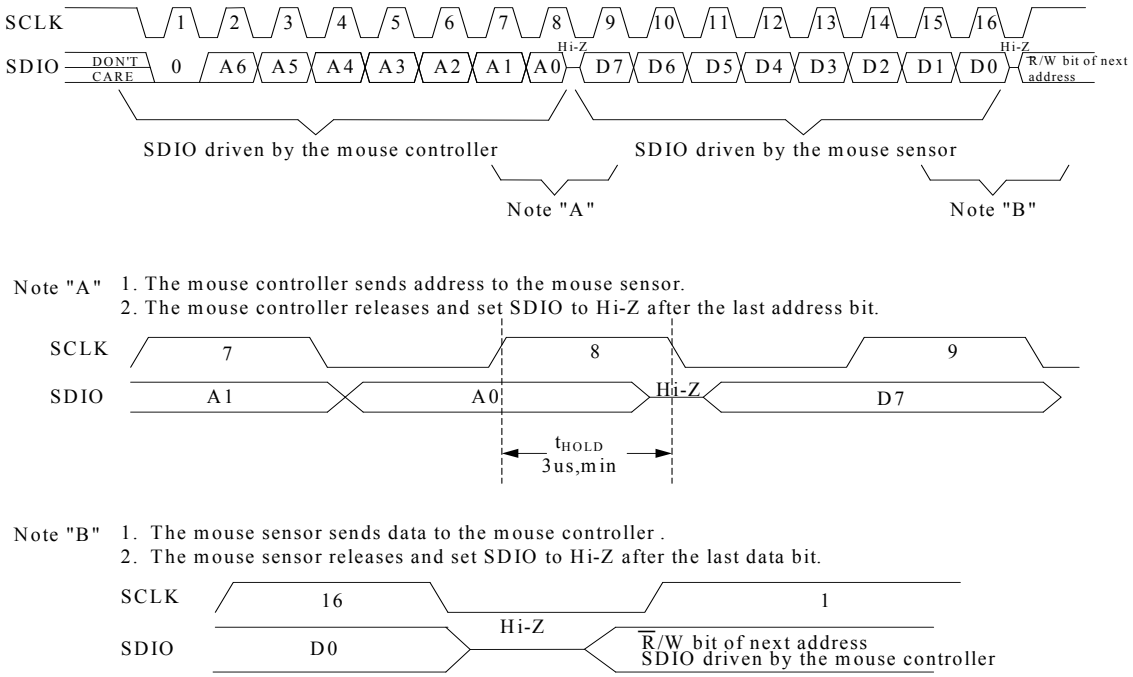

Figure 9. Read Operation

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.

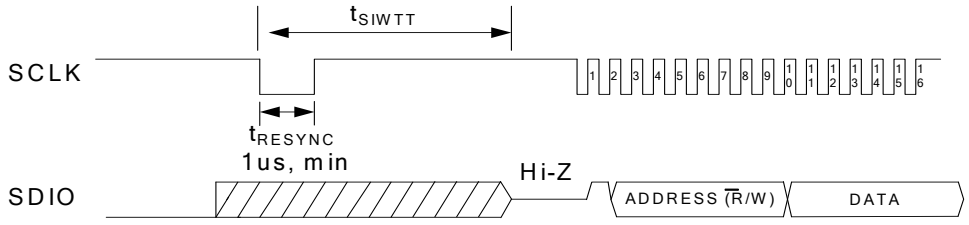

Figure 10. Re-synchronous Serial Interface Using Watchdog Timer Timeout

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.

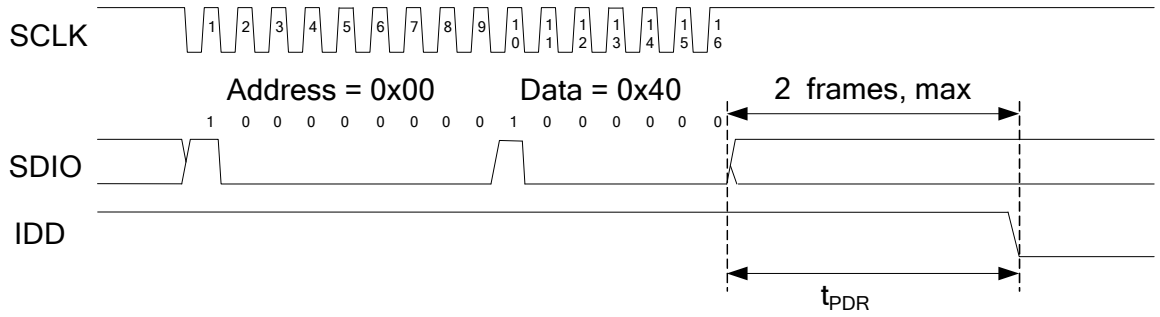

Figure 11. Power-down Configuration Register Writing Operation

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

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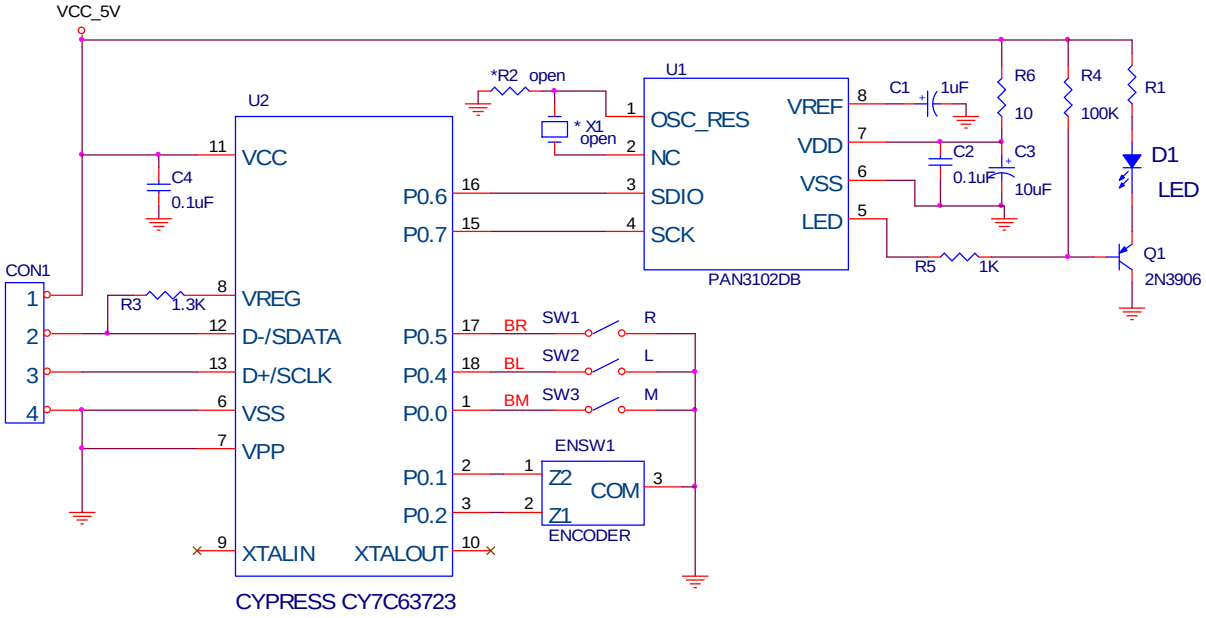
7. Referencing Application Circuit

7.1 Recommended Typical Application using External LED Control (5Volt)

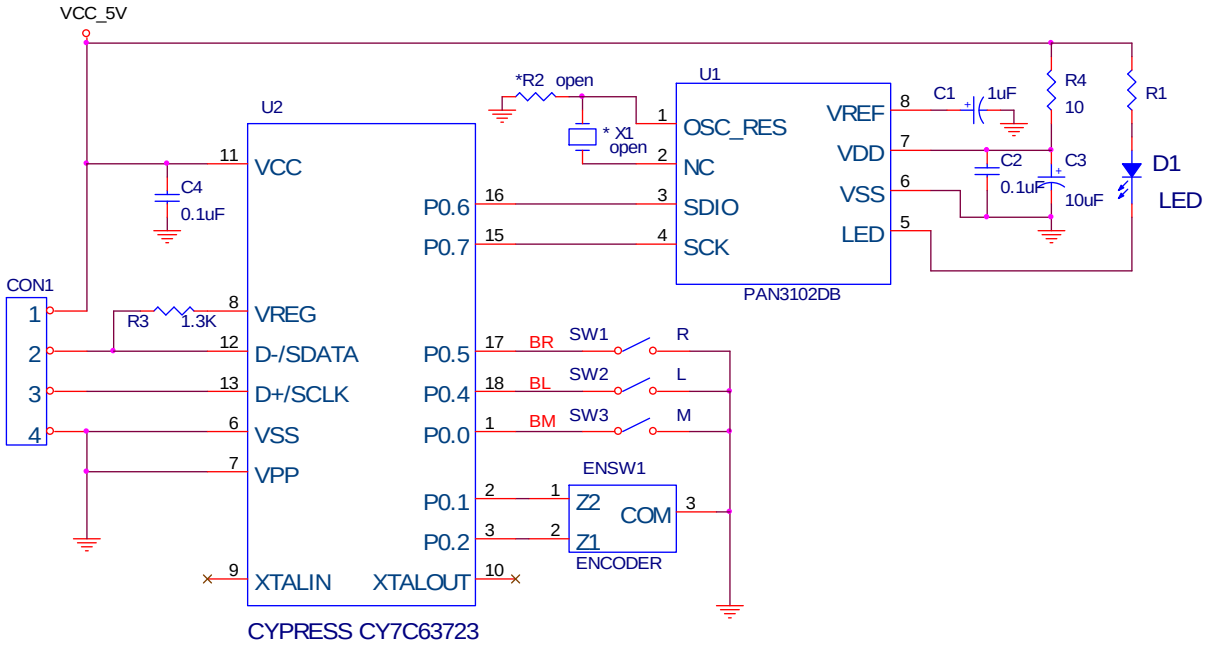


Note:

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

Figure 12. Application Circuit Using External LED (5Volt)

7.2 Recommended Typical Application using Internal LED Control (5Volt)



Note:

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

Figure 13. Application Circuit Using Internal LED (5Volt)

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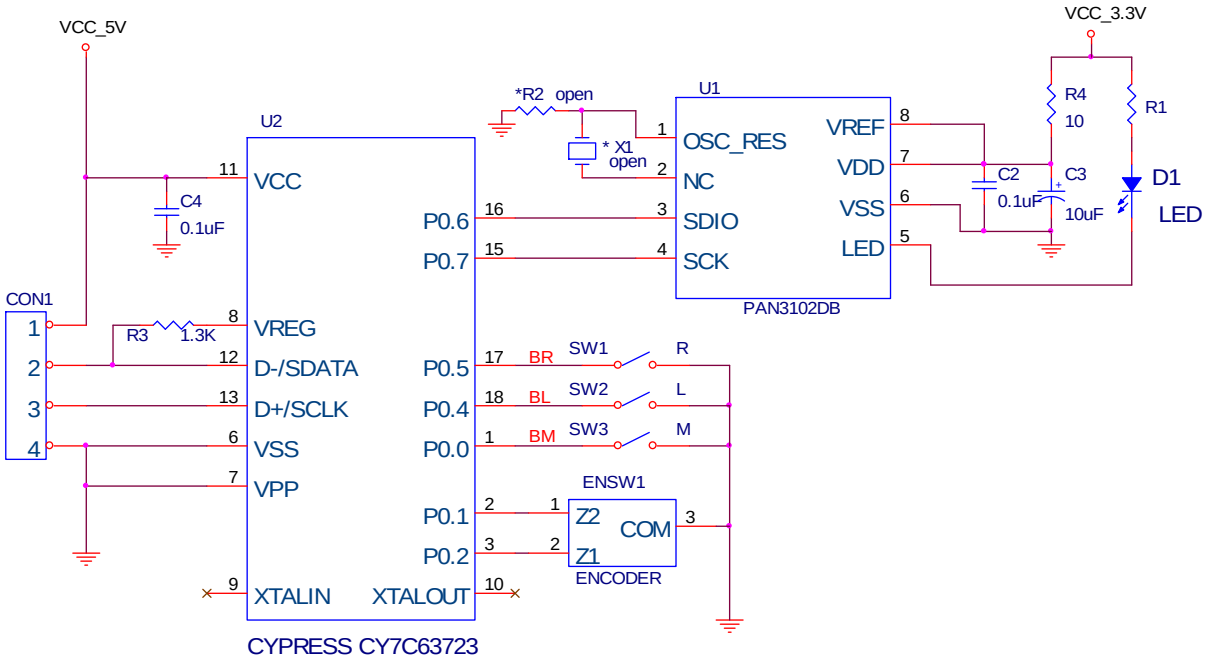
7.3 Recommended Typical Application using Internal LED Control (3.3Volt)



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 ± 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	

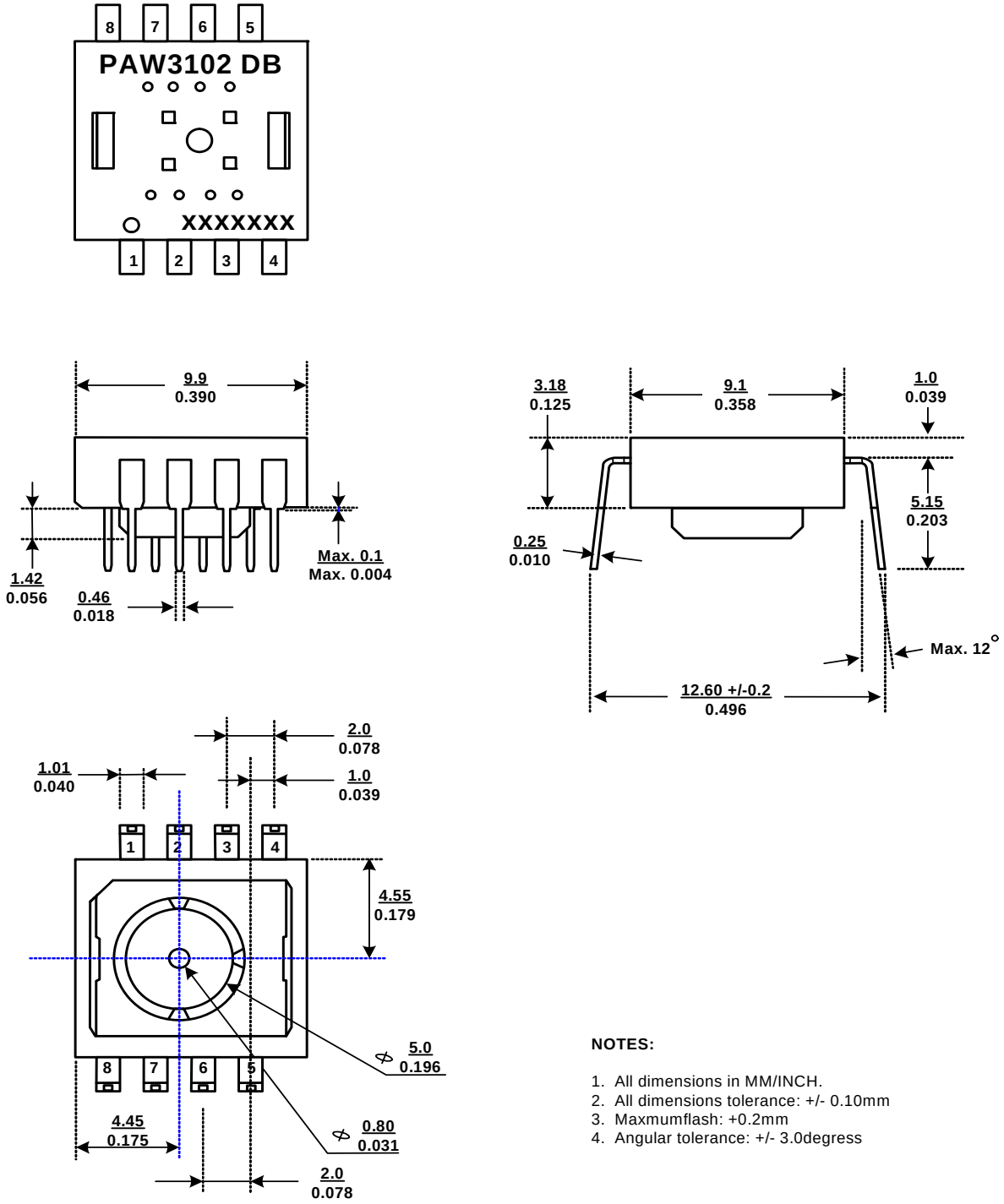
7.5.2 Application for 3.3V

- 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



NOTES:

1. All dimensions in MM/INCH.
2. All dimensions tolerance: +/- 0.10mm
3. Maxmumflash: +0.2mm
4. Angular tolerance: +/- 3.0degress

Figure 15. Package Outline Drawing

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8.2 Recommended PCB Mechanical Cutouts and Spacing

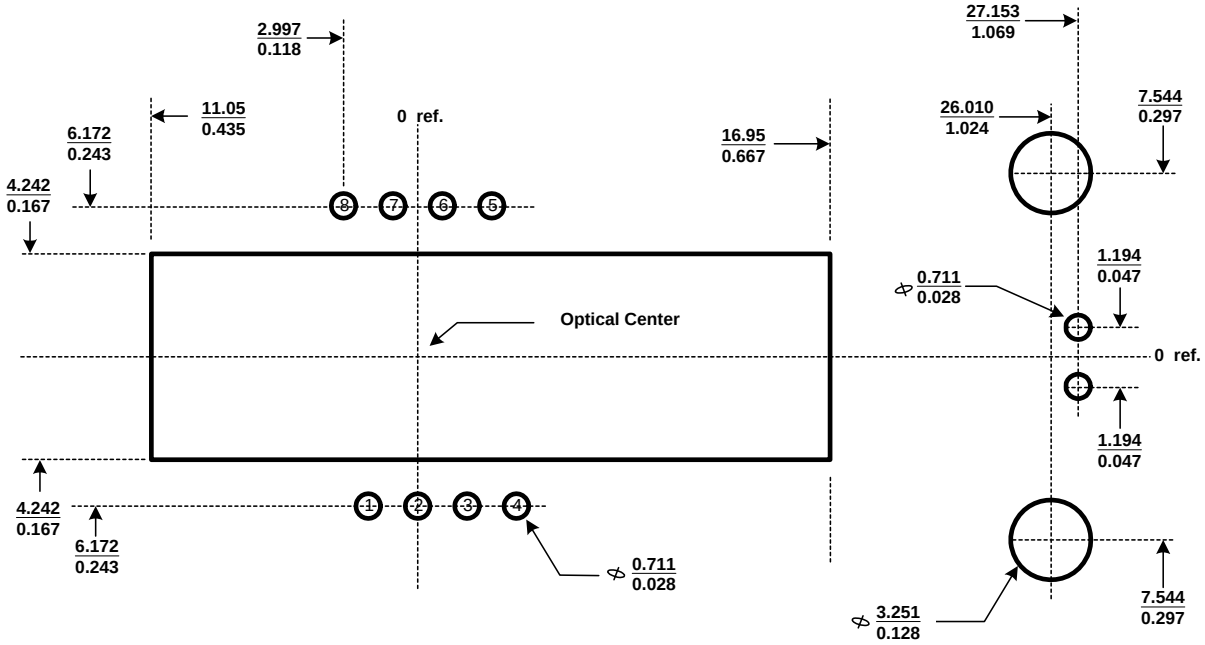

Figure 16. Recommended PCB Mechanical Cutouts and Spacing

9. Update History

Version	Update	Date
V1.0	Creation, Preliminary 1st version	09/12/2006
V1.1	3.2 Register Descriptions. 4.3 AC Operating Condition 5 Z and 2D/3D Assembly 6.4 Power Down Mode 7.3 PCB Layout Consideration 7.4 Recommended Value for R1	07/27/2007
V3.0	Content revise	10/23/2008
V4.0	Add 3.3Volt work range and relative information	01/16/2009
V4.1	Added patent announcement per page-end	03/03/2010

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