

PAW3402 /PAW3412 PS/2 OPTICAL MOUSE SOC
General Description

PAW3402 / PAW3412 is a CMOS process optical mouse SOC with PS/2 interface that serves as a non-mechanical motion estimation engine for implementing a computer mouse.

Features

- ❑ **Single 5.0 volt power supply**
- ❑ **Compatible with Microsoft Intelli 3D PS/2 and IBM PS/2 mouse**
- ❑ **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 1000 CPI**
- ❑ **Power saving mode during times of no movement**
- ❑ **Support three buttons (R, M, L) and three axes (X, Y, Z)**
- ❑ **Z axis support two kinds of input—
opto-mechanical and mechanical**
 - PAW3402 support mechanical input
 - PAW3412 support opto-mechanical input
- ❑ **Internal $\pm 10\%$ accurate oscillator, external resonator-less**

Key Specification

Power Supply	Wide operating supply range 4.5V ~ 5.5V
Interface	PS/2
Optical Lens	1:1
Speed	28 inches/sec
Acceleration	20g
Resolution	500 / 800 / 1000
Frame Rate	3000 frames/sec
Operating Current	12 mA @Mouse moving (Normal) 5 mA @Mouse not moving (Sleep)
Package	Shrunk DIP12

Ordering Information

Part Number	CPI	Sensor Rotate	Wheel Type	Device Type
PAW3402DK	800	0°	Mechanical	2D3B/3D3B
PAW3402DK-LH	800	-90°	Mechanical	2D3B/3D3B
PAW3402DK-TJ	1000	0°	Mechanical	2D3B/3D3B
PAW3412DK-TE	500	0°	Opto-Mechanical	2D3B/3D3B

1. Pin Configuration

1.1 Pin Description

Pin #	Name	Type	Definition
1	BL	IN	Button left key input, internal pull-up 50K ohm, press connect to low
2	LED	OUT	LED control
3	OSC_RES	IN	Connect to resistor input
4	VSS	GND	Chip ground
5	VDD5V	PWR	Chip power VDD, 5.0V
6	VREF	BYPASS	Analog voltage reference
7	CLOCK	I/O	PS/2 mouse clock line
8	DATA	I/O	PS/2 mouse data line
9	BR	IN	Button right key input, internal pull-up 50K ohm, press connect to low
10	BM	IN	Button middle key input, internal pull-up 50K ohm, press connect to low
11	Z2	IN	Z axis, support mechanical encoder input (internal pull-down 50K ohm) or optical encoder input (needs external pull-down resistor)
12	Z1	IN	Z axis, support mechanical encoder input (internal pull-down 50K ohm) or optical encoder input (needs external pull-down resistor)

1.2 Pin Assignment For Sensor Rotate 0°

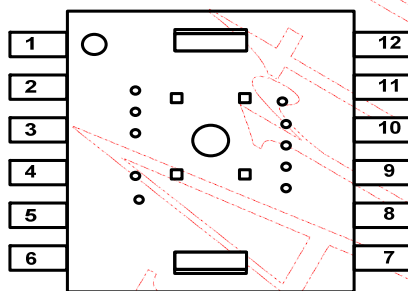


Figure 1. Top View Pinout

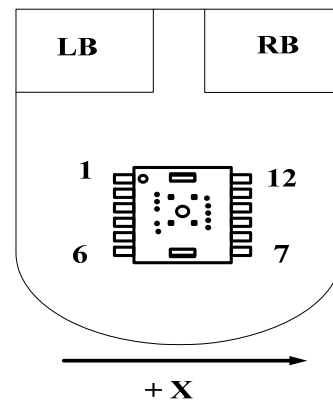


Figure 2. Top View of Mouse

1.3 Pin Assignment For Sensor Rotate -90°

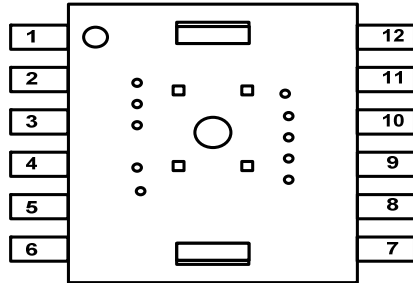


Figure 3. Top View Pinout

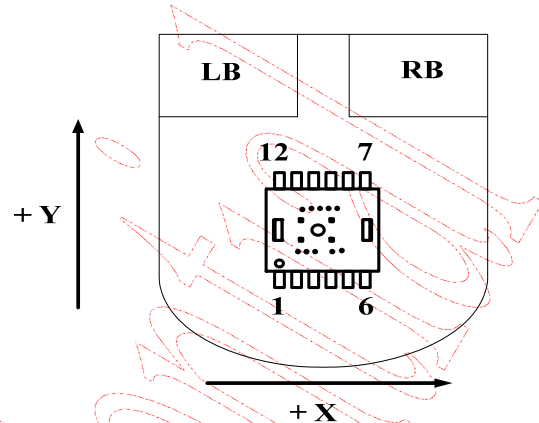


Figure 4. Top View of Mouse

2. Block Diagram and Operation

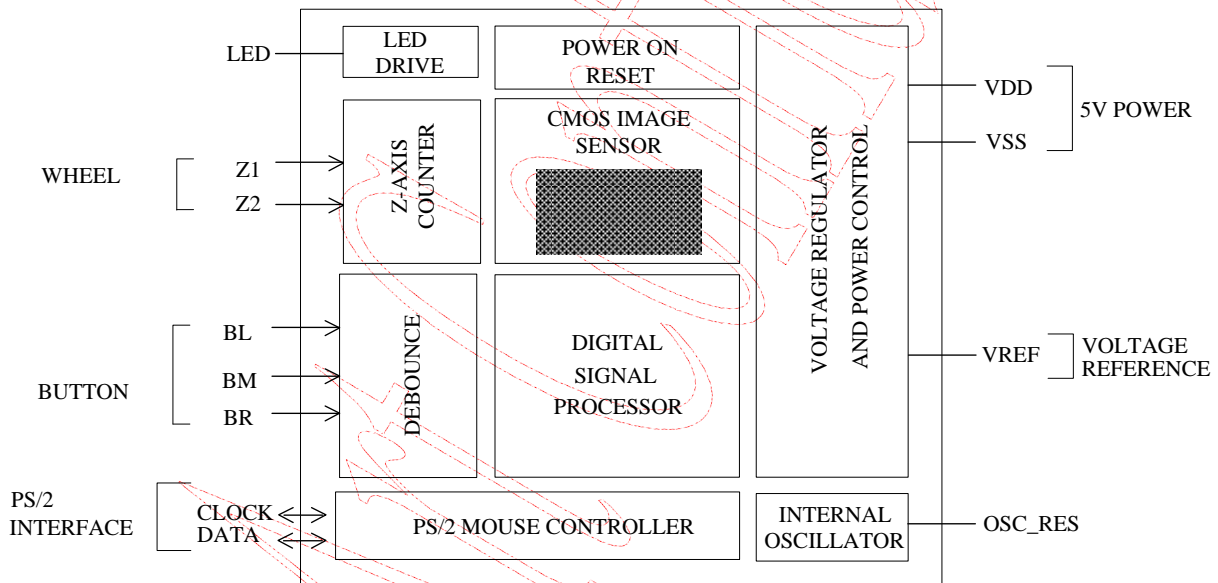


Figure 5. Block diagram

PAW3402 / PAW3412 is a CMOS process optical mouse SOC with PS/2 interface 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 sensor is in a 12-pin optical package and comes with the resolution of 500 / 800 / 1000 counts per inch (cpi) and the rate of motion up to 28 inches per second. It is also featured resonator-less (Internal $\pm 10\%$ accurate oscillator) to save customer's BOM cost. PAW3402 / PAW3412 include PS/2 interface so that no mouse controller is needed to interface through PS/2. PAW3402 / PAW3412 can receive command and echo status or data format which are compatible with IBM PS/2 mouse and Microsoft 3D PS/2 mouse.

* The word "PS/2 Mouse", instead of "PAW3402 / PAW3412", is used in the document.

3. Specifications

3.1 Absolute Maximum Ratings

Exposure to absolute maximum rating 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.
ESD			2	kV	All pins, human body model MIL 883 Method 3015
V _{DC}	DC Supply Voltage	-0.5	5.5	V	
V _{IN}	DC Input Voltage	-0.5	5.5	V	All I/O pin

3.2 Recommend Operating Condition

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T _A	Operating Temperature	0		40	°C	
V _{DD}	Power Supply Voltage	4.5	5.0	5.5	V	
V _N	Supply Noise			100	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	500	800	1000	CPI	
FR	Frame Rate		3000		frames/s	
S	Speed	0		28	inches/sec	25 inches/sec @ 500CPI 16 inches/sec @ 800CPI 13 inches/sec @ 1000CPI *Base on data rate : 100 report/sec

3.3 AC Operating Condition

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

Symbol	Parameters	Min.	Typ.	Max.	Unit	Notes
Tmca	Mouse CLK Active Time	-	40	-	us	Refer to Figure 9,10
Tmci	Mouse CLK Inactive Time	-	40	-	us	
Tmdc	Time that Mouse Sample DATA from CLK Rising Edge	-	14	-	us	
Tsca	System CLK Active Time	-	40	-	us	
Tsci	System CLK Inactive Time	-	40	-	us	
Tsdc	Time from DATA Transition to Falling Edge of CLK	-	12	-	us	
Tscd	Time from Rising Edge of CLK to DATA Transition	-	28	-	us	

3.4 DC Electrical Characteristics

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

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
Type: PWR						
I_{DD}	Supply Current Mouse moving (normal)	-	12	-	mA	
I_{DD}	Supply Current Mouse not moving (sleep)	-	5	-	mA	
Type: BL, BM, BR						
R_{PH}	Internal Pull-up Resistance	-	50	-	Kohm	
Type: Z1, Z2						
R_{PD}	Internal Pull-down Resistance	-	50	-	Kohm	Only mechanical Z input built-in internal pull-down resistance, optical Z input needs external pull-down resistance
Type: BL, BM, BR, Z1, Z2						
V_{IH}	Input High Voltage	2.0	-	-	V	
V_{IL}	Input Low Voltage	-	-	0.8	V	
Type: CLOCK, DATA						
R_{PH}	Internal Pull-up Resistance	-	5	-	Kohm	
V_{OL}	Output Low Voltage	-	-	0.6	V	$I_{OL} = 1mA$
I_{OH}	Output Pull-up Current	-	1	-	mA	$V_{OH} = 2.0V$
Type: LED						
V_{OL}	Output voltage LOW	-	-	300	mV	$I_{OL} = 25mA$

4. Z and 2D/3D Assembly

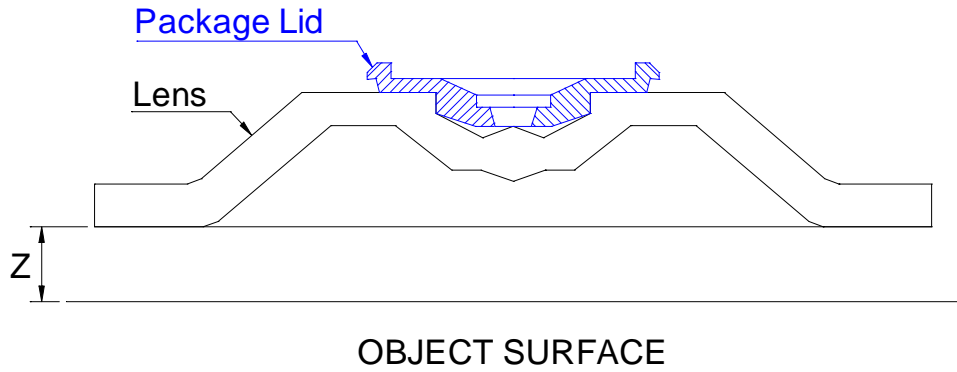


Figure 6. Distance from Lens Reference Plane to Surface

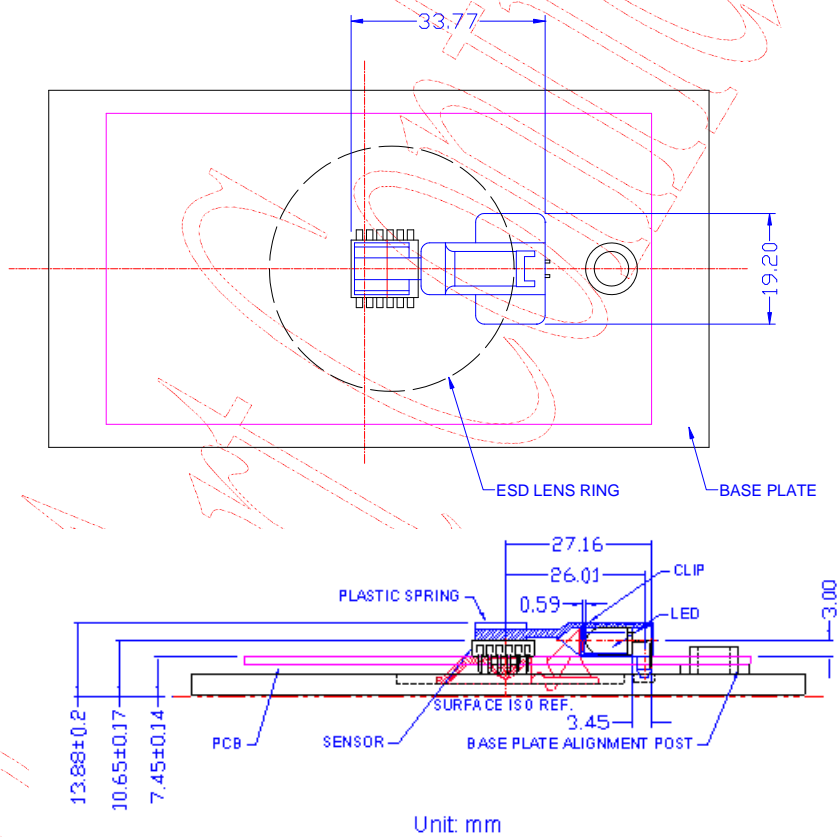


Figure 7. 2D Assembly

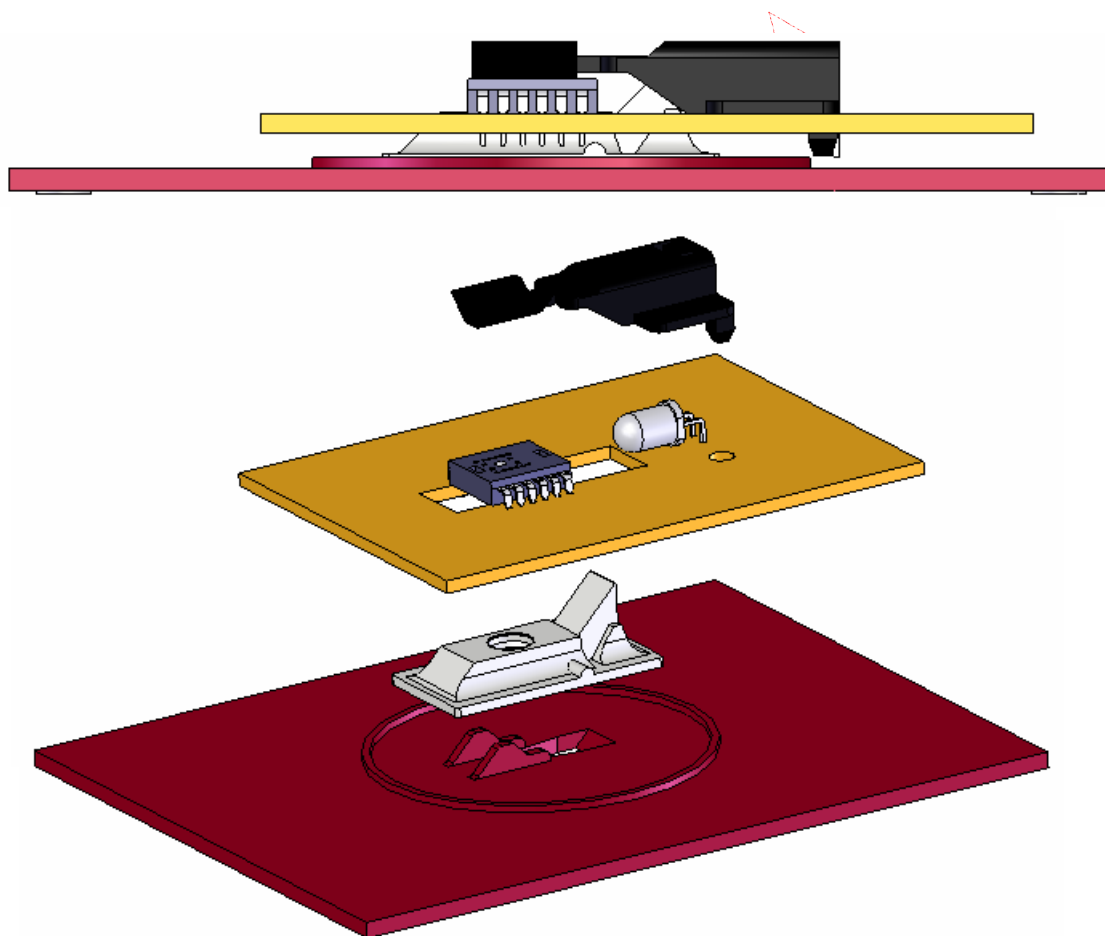


Figure 8. 3D Assembly for Mounting Instructions

DRAFT

5. PS/2 Command Set Description

There are 16 valid commands that transmit between the system and the PS/2 Mouse. All other commands will cause an FE (*Resend*) response from the PS/2 Mouse. A second invalid command will cause an FC (error) response from the PS/2 Mouse.

5.1 PS/2 Command Set

Hex Code	Command	Response
FF	Reset	FA, AA, 00
FE	Resend	XX, (XX, XX)
F6	Set Default	FA
F5	Disable	FA
F4	Enable	FA
F3, XX	Set Sampling Rate	FA, FA
F2	Read Device Type	FA, 00
F0	Set Remote Mode	FA
EE	Set Wrap Mode	FA
EC	Reset Wrap Mode	FA
EB	Read Data	FA, XX, XX, XX
EA	Set Stream Mode	FA
E9	Status Request	FA, XX, XX, XX
E8, XX	Set Resolution	FA, FA
E7	Set Scaling 2:1	FA
E6	Reset Scaling	FA

5.2 Set Sampling Rate (F3, XX)

Second Byte Hex Value (XX)	Sampling Rate
0A	10/sec
14	20/sec
28	40/sec
3C	60/sec
50	80/sec
64	100/sec
C8	200/sec

5.3 Status Request (E9)

Byte	Bit	Symbol	Description
1	0	BR	1 = Right button pressed.
	1	BM	1 = Middle button pressed.
	2	BL	1 = Left button pressed.
	3	0	Always = 0, reserved for future use.
	4	Scaling	0 = Scaling 1:1; 1 = Scaling 2:1.
	5	Enabled	0 = Disabled; 1 = Enabled.
	6	Remote mode	0 = Stream mode; 1 = Remote mode.
	7	0	Always=0, reserved for future use.
2	0-7	Resolution	Current resolution setting. Bit 0=LSB.
3	0-7	Sampling rate	Current sampling rate. Bit 0=LSB.

6. Data Format

The PS/2 Mouse support two different PS/2-compatible packet formats, depending upon the following operational modes:

- Standard 2D mode (2D3B)
- Standard 3D mode (3D3B)

6.1 Standard 2D Mode Format

A standard 2D PS/2-compatible mouse motion report consists of a 3-byte packet defined as below.

Byte	Bit	Symbol	Description
1	0	BL	1 = Left button pressed
	1	BR	1 = Right button pressed
	2	BM	Always = 0, reserved for middle button
	3	1	Always = 1, reserved for future use
	4	Xs	X data sign, 1 = negative
	5	Ys	Y data sign, 1 = negative
	6	X _{OV}	X data overflow, 1 = overflow
	7	Y _{OV}	Y data overflow, 1 = overflow
2	0-7	X0~X7	X data (D0 - D7). A positive value indicates motion to the right; a negative value indicates motion to the left. Bit 0=LSB.
3	0-7	Y0~Y7	Y data (D0 - D7). A positive value indicates device motion upward; a negative value indicates motion downward. Bit 0=LSB.

6.2 Standard 3D Mode Format

A standard 3D PS/2-compatible mouse motion report consists of a 4-byte packet defined as below.

Byte	Bit	Symbol	Description
1	0	BL	1 = Left button pressed
	1	BR	1 = Right button pressed
	2	BM	1 = Middle button pressed
	3	1	Always = 1, reserved for future use
	4	Xs	X data sign, 1 = negative
	5	Ys	Y data sign, 1 = negative
	6	X _{OV}	X data overflow, 1 = overflow
	7	Y _{OV}	Y data overflow, 1 = overflow
2	0-7	X0~X7	X data (D0 - D7). A positive value indicates motion to the right; A negative value indicates motion to the left. Bit 0=LSB.
3	0-7	Y0~Y7	Y data (D0 - D7). A positive value indicates device motion upward; A negative value indicates motion downward. Bit 0=LSB.
4	0-7	Z0~Z7	Z-wheel motion data (D0 - D7). A positive value indicates device motion downward; a negative value indicates motion upward. The Z0-Z7 limit value is ± 7 . Bit 0=LSB.

7. Mouse Mode Selection

The *Set Sampling Rate* command is used to set the device operating modes. Whenever the mouse received command 'FF', it will reset to standard mode (2D3B) mode. After power-on reset is initiated, the mouse is set to standard PS/2 mode.

The Device ID is available through the *PS/2 Read Device Type* (0xF2) command. For a device in standard 2D mode, the device will report an ID of 0x00. For a device in standard 3D mode, the device will report an ID of 0x03.

Mode	Device ID
Standard 2D mode (2D3B)	0x00
Standard 3D mode (3D3B)	0x03

● Standard 3D Mouse (3D3B) Command Sequence

After *Reset*, the device will be in standard 2D mode. By sending the *Set Sampling Rate* command series as follows, the device is set to standard 3D mode.

Command	Response
F3	FA
C8	FA
F3	FA
64	FA
F3	FA
50	FA
F2	FA, 03

Notice that the *Set Sampling Rate* commands are valid, and the device report rate will be the value of the last command; that is, 0x50 after this series of commands.

8. PS/2 Data Transmission

8.1 Mouse Send Data Out to Host

When the mouse is ready to transmit data, it must first check for mouse “inhibit” or system “request to send” status on clock and data lines. If CLK is low (inhibit status), data shall be continuously updated in the mouse and no transmissions shall be started. If CLK is high and DATA is low (request-to-send), data is updated. Data is received from the system and no transmission are started by the PS/2 Mouse until CLK and DATA both high.

If CLK and DATA are both high, the transmission is ready. DATA is valid prior to the falling edge of CLK and beyond the rising edge of CLK. During transmission, The PS/2 Mouse check for line contention by checking for an inactive level on CLK at intervals not to exceed 100 microseconds. Contention occurs when the system lowers CLK to inhibit the PS/2 Mouse output after PS/2 Mouse has started a transmission. If this occurs prior to the rising edge of the tenth clock (parity bit), The PS/2 Mouse internally store the data package in its buffer and return DATA and CLK to an active level. If the contention does not occur by the tenth clock, the transmission is complete.

Following a transmission, the system can inhibit the PS/2 Mouse by holding CLK low until it can service the input or until the system receives a request to send a response if necessary.

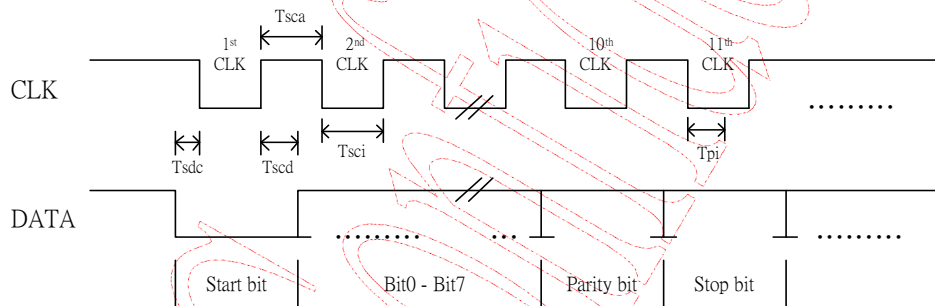


Figure 9. Mouse send data out to host

8.2 Mouse Receive Data from Host

System first check to see if the PS/2 Mouse is transmitting data. If the PS/2 Mouse is transmitting, the system can override the output forcing CLK to an inactive level prior to the tenth clock. If the PS/2 Mouse transmission is beyond the tenth clock, the system receives the data. If the PS/2 Mouse is not transmitting or if the system chooses to override the output, the system force CLK to an inactive level for a period of not less than 100 microseconds while preparing for output. When the system is ready to output “0” start bit, it allows CLK to go to active level. If “request-to-send” is detected, the PS/2 Mouse clocks in 11 bits. Following the tenth clock, the PS/2 Mouse checks for an active level on the DATA line, and if found, force DATA low (line control bit), and clock once more. If occurs framing error, the PS/2 Mouse continue to clock until DATA is high, then clock the line control bit and request a resend.

For each system command or data transmission to the PS/2 Mouse that requires a response, the system must wait for the PS/2 Mouse to response before sending its next output.

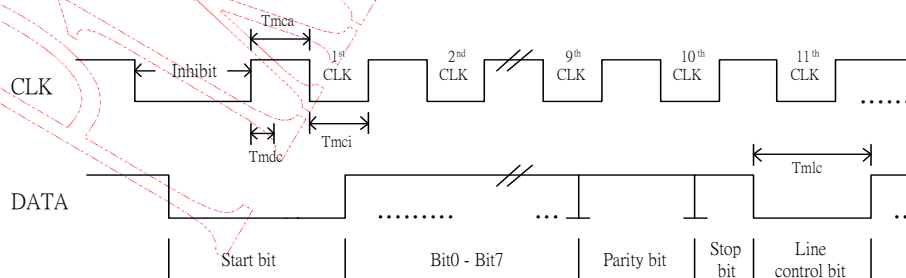
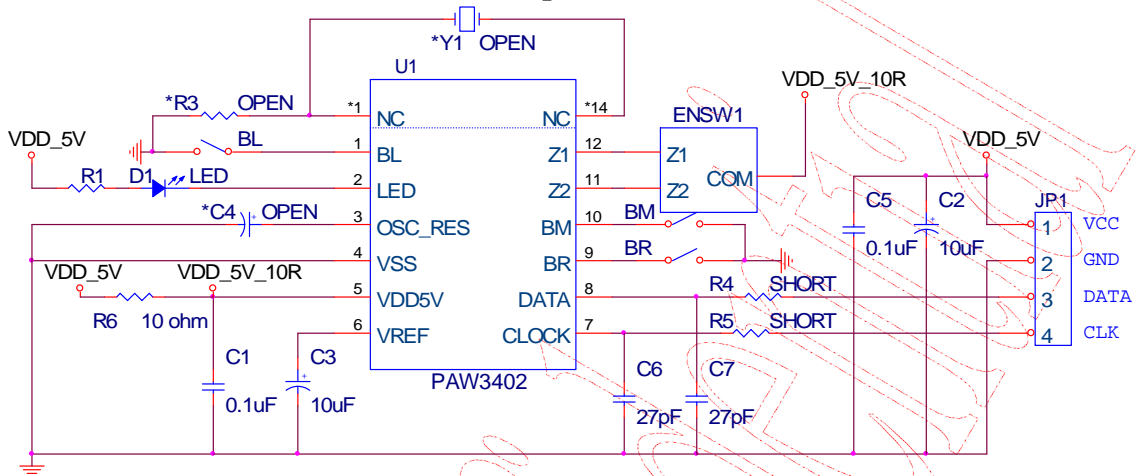


Figure 10. Mouse Receive Data from Host

9. Referencing Application Circuit

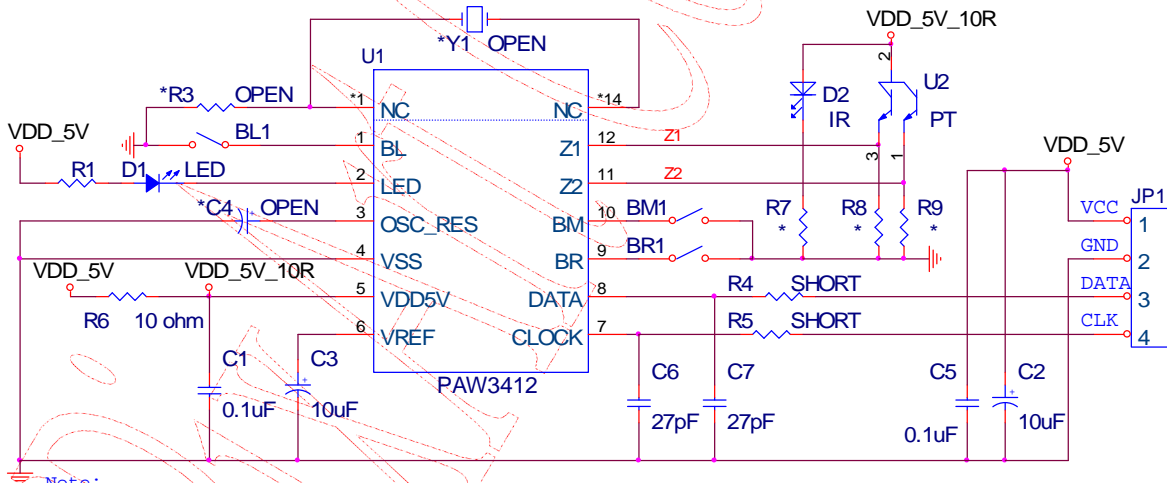
9.1 PAW3402 with Mechanical Encoder Input



- Note:
- *C4 , *R3 and *Y1 is left for PAW3502 with USB interface
 - PS/2 connector JP1 is suggested to has the pin sequence like this: VCC, GND, DATA, CLK.
 - R4, R5, C6, C7 are for EMC immunity
- Warning:
- If PCBA has dual layout for PAW3402 and PAW3502, please DO NOT mount PAW3402 in PAW3502's pin pads *1 and *14

Figure 11. Application Circuit for PAW3402 (Mechanical Encoder Input)

9.2 PAW3412 with Optical Encoder Input



- Note:
- *C4 , *R3 and *Y1 is left for PAW3502 with USB interface
 - PS/2 connector JP1 is suggested to has the pin sequence like this: VCC, GND, DATA, CLK.
 - R4, R5, C6, C7 are for EMC immunity
 - For resistor value selection, refer to high or low input level of Z1 and Z2 in the D.C. Electrical Characteristics table. The recommended value for R7 is 470ohm. The recommended value for R8/R9 is 5.1Kohm.

Warning:

If PCBA has dual layout for PAW3412 and PAW3502, please DO NOT mount PAW3412 in PAW3502's pin pads *1 and *14

Figure 12. Application Circuit for PAW3412 (Optical Encoder Input)

10. Recommended Value for R1

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

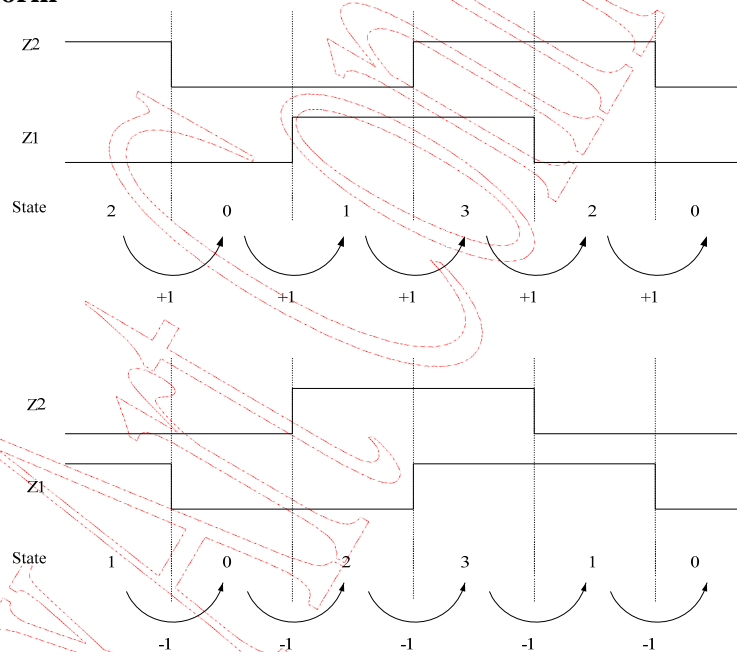
LED Bin Grade	Min.	Typ.	Max.
N	14.7	-	17.7
P	17.7	-	21.2
Q	21.2	-	25.4

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

R1 value (ohm), VDD=5.0V

LED Bin Grade	Min.	Typ.	Max.
N	43	56	-
P	43	56	-
Q	43	56	-

11. Z-axis Waveform



STATE	Z-axis input	
	Z2	Z1
0	0	0
1	0	1
2	1	0
3	1	1

Figure 13. Z-axis Waveform

12. Package Information

12.1 Package Outline Drawing

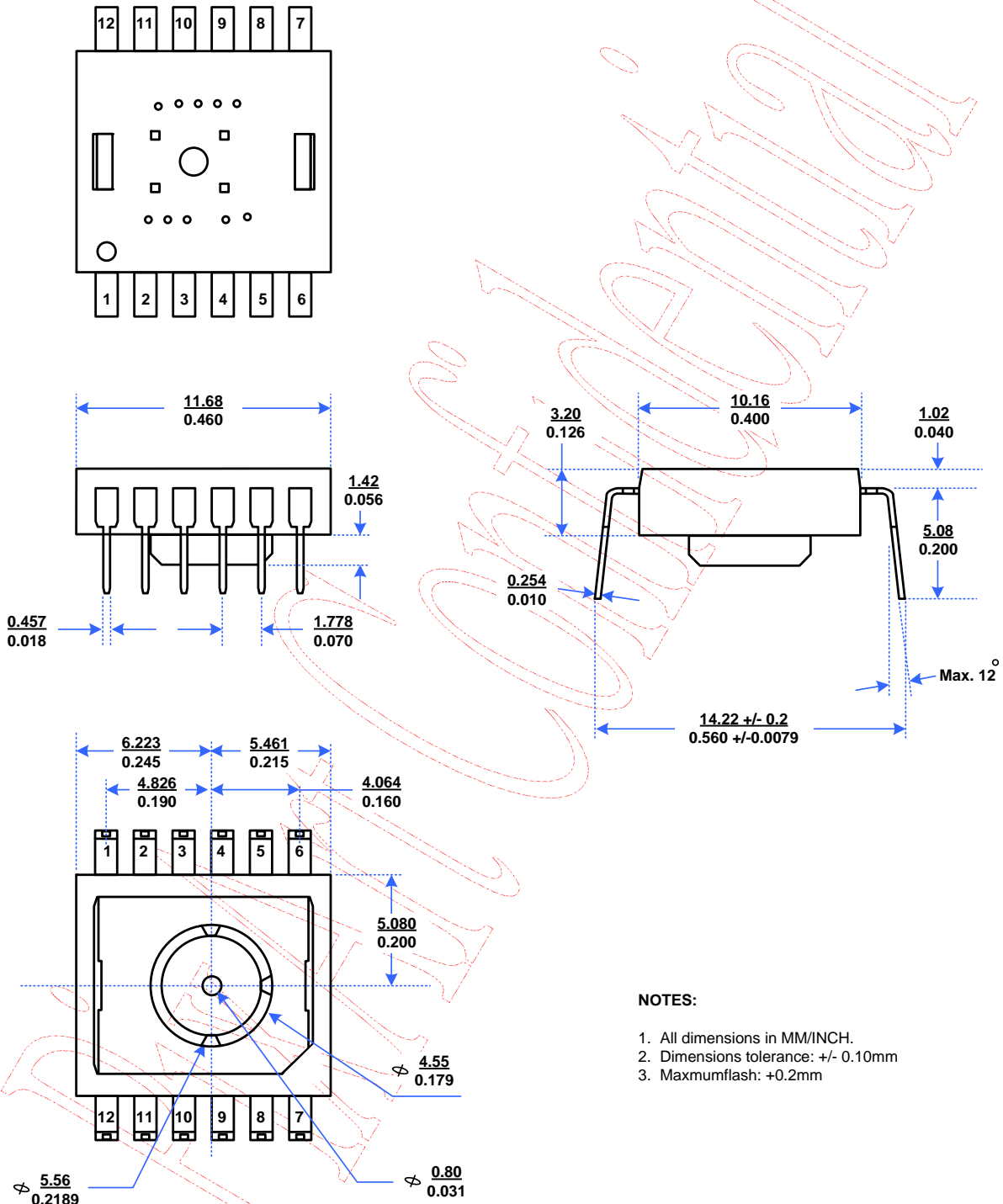
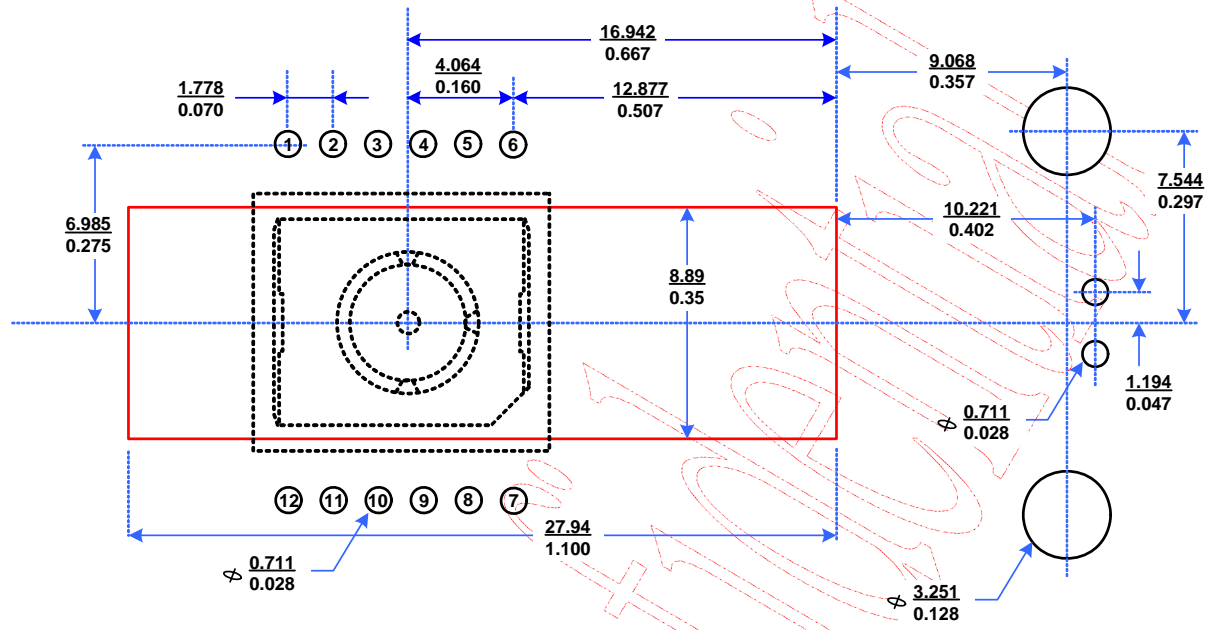


Figure 14. Package Outline Drawing

12.2 Recommended PCB Mechanical Cutouts and Spacing



All Dimension : mm/inch

Back Side

Figure 15. Recommended PCB Mechanical Cutouts and Spacing

13. Update History

Version	Update	Date
V0.1	Creation, Preliminary 1 st version	02/01/2008

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