PAW3401 PS/2 OPTICAL MOUSE SENSOR

General Description

The PAW3401 is a CMOS process optical mouse sensor single chip 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 mechanical input
- Internal ± 10% accurate oscillator, external crystal-less

Key Specification

Power Supply	Wide operating supply range 4.5V ~ 5.5V
Interface	PS/2
Optical Lens	1:1
System Clock	24 MHz
Speed	28 inches/sec
Acceleration	20g
Resolution	400/800/1000 CPI
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
PAW3401DK	800
PAW3401DK-TD	400
PAW3401DK-TJ	1000

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

PixArt Imaging Inc.
E-mail: fae_service@pixart.com.tw

1. Pin Configuration

1.1 Pin Description

Pin #	Name	Type	Definition
1	BL	IN	Button left key input, normal pull-high (50k), 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, normal pull-high (50k), press connect to low
10	BM	IN	Button middle key input, normal pull-high (50k), press connect to low
11	Z2	IN	Z axis, support mechanical scroller input
12	Z1	IN	Z axis, support mechanical scroller input

1.2 Pin Assignment

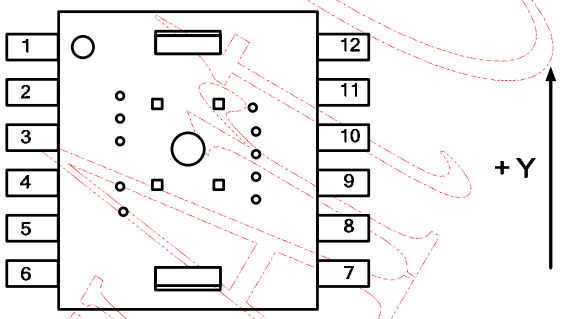


Figure 1. Top View Pinout

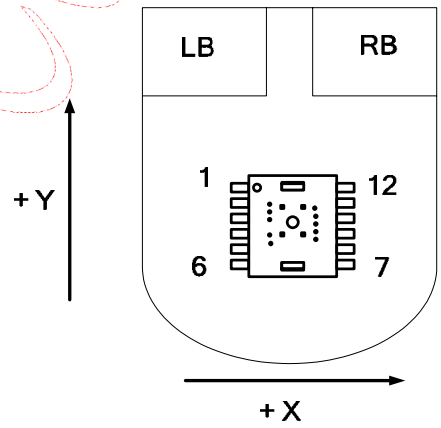


Figure 2. Top View of Mouse

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

PixArt Imaging Inc.
E-mail: fae_service@pixart.com.tw

2. Block Diagram and Operation

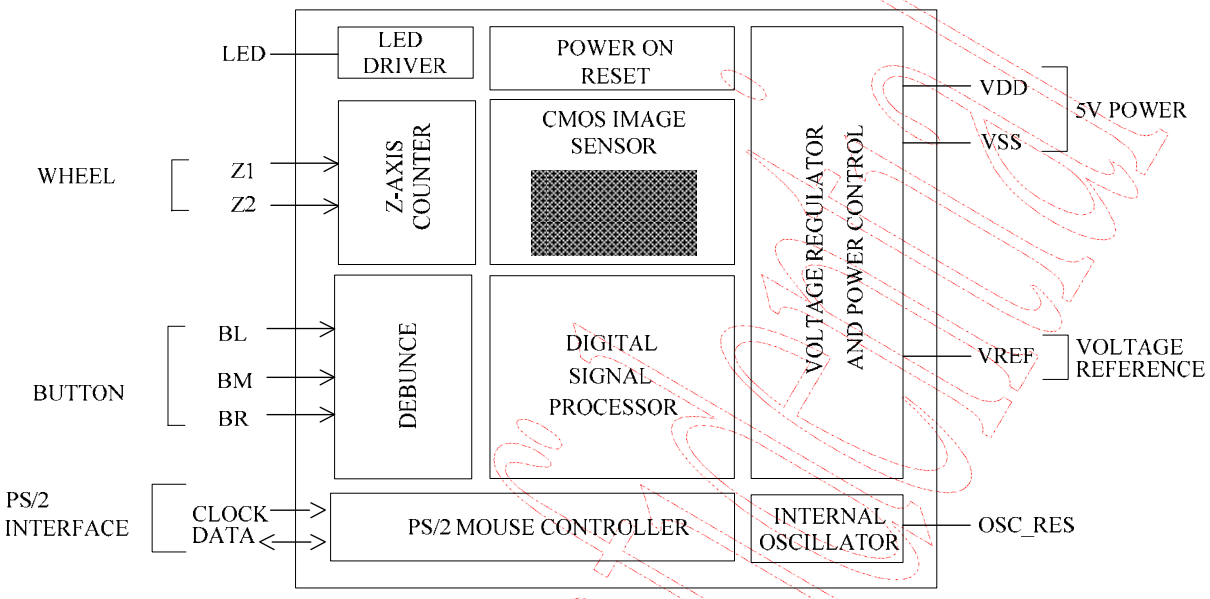


Figure 3. Block diagram

The PAW3401 is a CMOS process optical mouse sensor single chip 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 400/800/1000 counts per inch (CPI) and the rate of motion up to 28 inches per second. It is also featured crystal-less (Internal ± 10% accurate oscillator) to save customer's BOM cost. The PAW3401 includes PS/2 interface so that no mouse controller is needed to interface through PS/2. The PAW3401 can receive command and echo status or data format which are compatible with IBM PS/2 mouse and Microsoft 3D PS/2 mouse.

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

2. Specifications

2.1 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

2.2 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 - 100 MHz
Z	Distance from Lens Reference Plane to Surface	2.3	2.4	2.5	mm	
R	Resolution		800	1000	CPI	
A	Acceleration			20	g	
F_{CLK}	Clock Frequency		24		MHz	
FR	Frame Rate		3000		frames/s	
S	Speed	0		28	inches/sec	28 inches/sec @400CPI 16 inches/sec @800CPI 13 inches/sec @1000CPI *Base on data rate : 100 report/sec

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

2.3 AC Operating Condition

Electrical characteristics over recommended operating conditions. Typical values at 25 °C, V_{DD} = 5.0 V, F_{CLK} = 24 MHz

Symbol	Parameters	Min.	Typ.	Max.	Unit	Notes
Tmca	Mouse CLK Active Time	-	40	-	us	Refer to Figure 6,7
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	

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

2.4 DC Electrical Characteristics

Electrical characteristics over recommended operating conditions. Typical values at 25 °C, V_{DD} = 5.0 V, F_{CLK} = 24 MHz

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 (sleep1)	-	5	-	mA	
Type: BL, BM, BR, B4, B5						
R_{PH}	Internal Pull-up Resistance	-	50	-	Kohm	
Type: Z1, Z2						
R_{PD}	Internal Pull-down Resistance	-	50	-	Kohm	
Type: BL, BM, BR, B4, B5, 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}= 10mA
I_{OH}	Output Pull-up Current	-	700	-	uA	V_{OH} = 2.0V
Type: LED						
V_{OL}	Output Voltage LOW	-	-	360	mV	I_{OL} = 25mA

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

3. Z and 2D Assembly

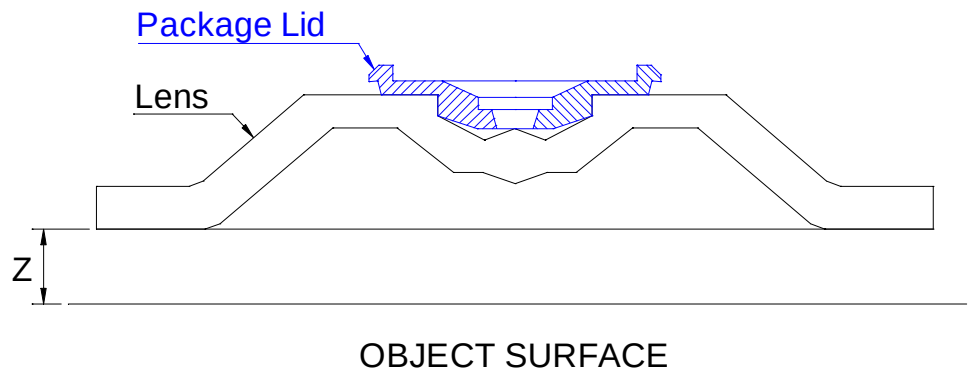


Figure 4. Distance from Lens Reference Plane to Surface

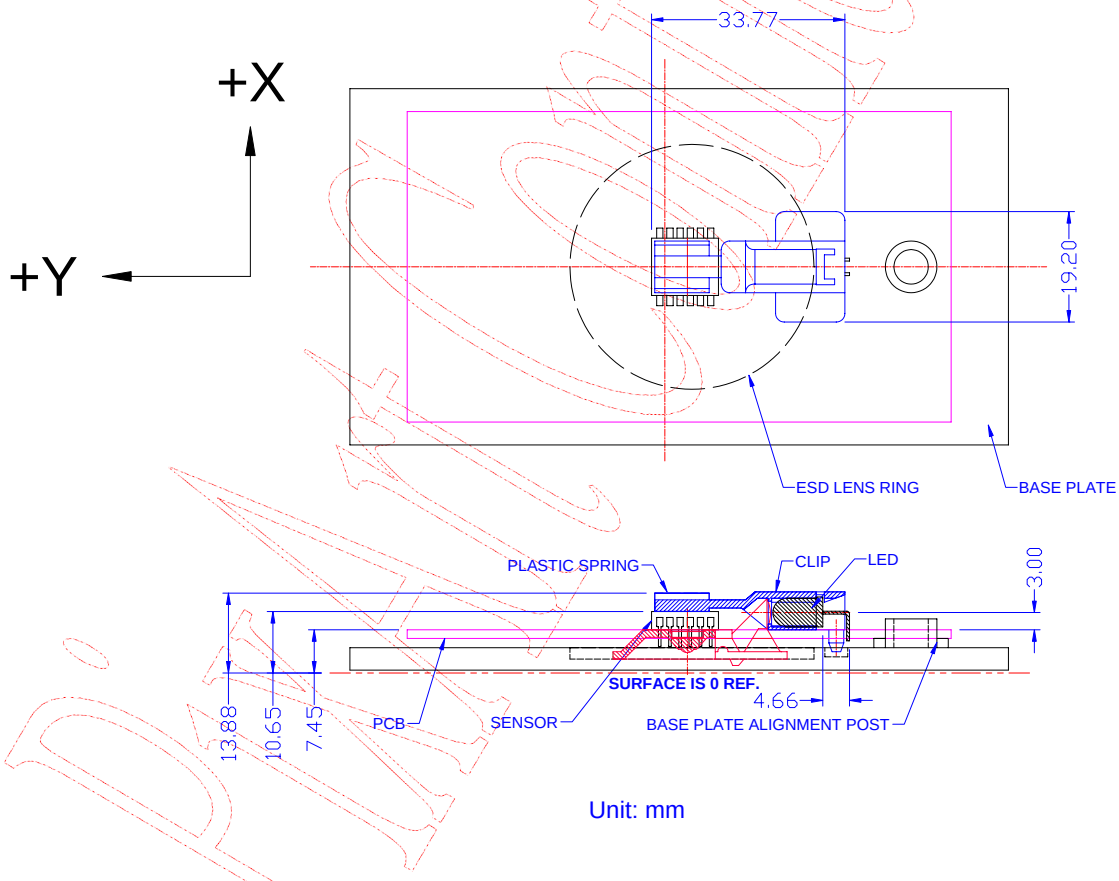


Figure 5. 2D Assembly

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

4. PS/2 Command Set Description

There are 16 valid commands that transmit between the system and The PAW3401. All other commands will cause an FE (*Resend*) response from the PAW3401. A second invalid command will cause an FC (error) response from the PAW3401.

4.1 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

4.2 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

4.3 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.

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

4.4 Set Resolution (E8, XX)

Second Byte XX	Resolution (counts/mm)
00	1
01	2
02	4
03	8

4.5 Set Scaling 2:1 (E7)

Input	Output
0	0
1	1
2	1
3	3
4	6
5	9
N (>=6)	2.0 * N

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

5. Data Format

The PAW3401 supports three different PS/2-compatible packet formats, depending upon the following operational modes:

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

5.1 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.

5.2 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.

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

6. 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

6.1 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.

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

7. PS/2 Data Transmission

7.1 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 PAW3401 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 PAW3401 checks 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 PAW3401 output after the PAW3401 has started a transmission. If this occurs prior to the rising edge of the tenth clock (parity bit), the PAW3401 internally stores 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 PAW3401 by holding CLK low until it can service the input or until the system receives a request to send a response if necessary.

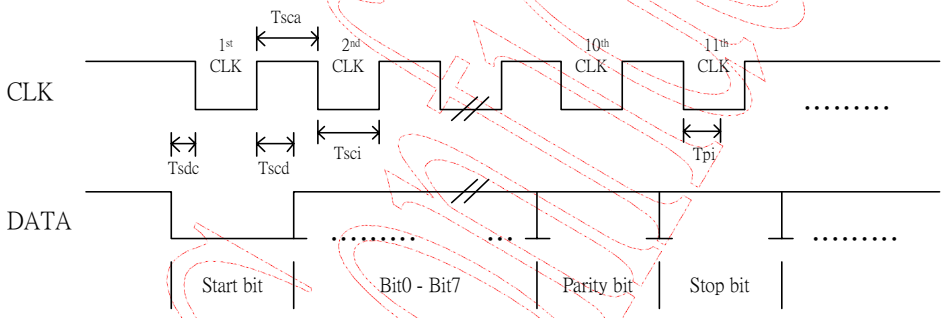


Figure 6. Mouse send data out to host

7.2 Mouse Receive Data from Host

System first check to see if the PAW3401 is transmitting data. If the PAW3401 is transmitting, the system can override the output forcing CLK to an inactive level prior to the tenth clock. If the PAW3401 transmission is beyond the tenth clock, the system receives the data. If the PAW3401 is not transmitting or if the system chooses to override the output, the system forces 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 PAW3401 clocks in 11 bits. Following the tenth clock, the PAW3401 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 PAW3401 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 PAW3401 that requires a response, the system must wait for the PAW3401 to response before sending its next output.

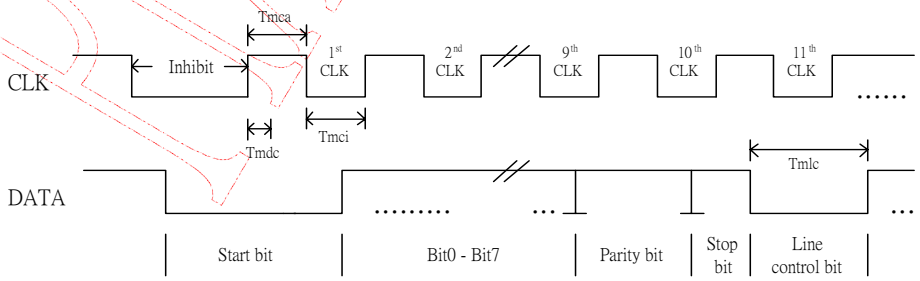
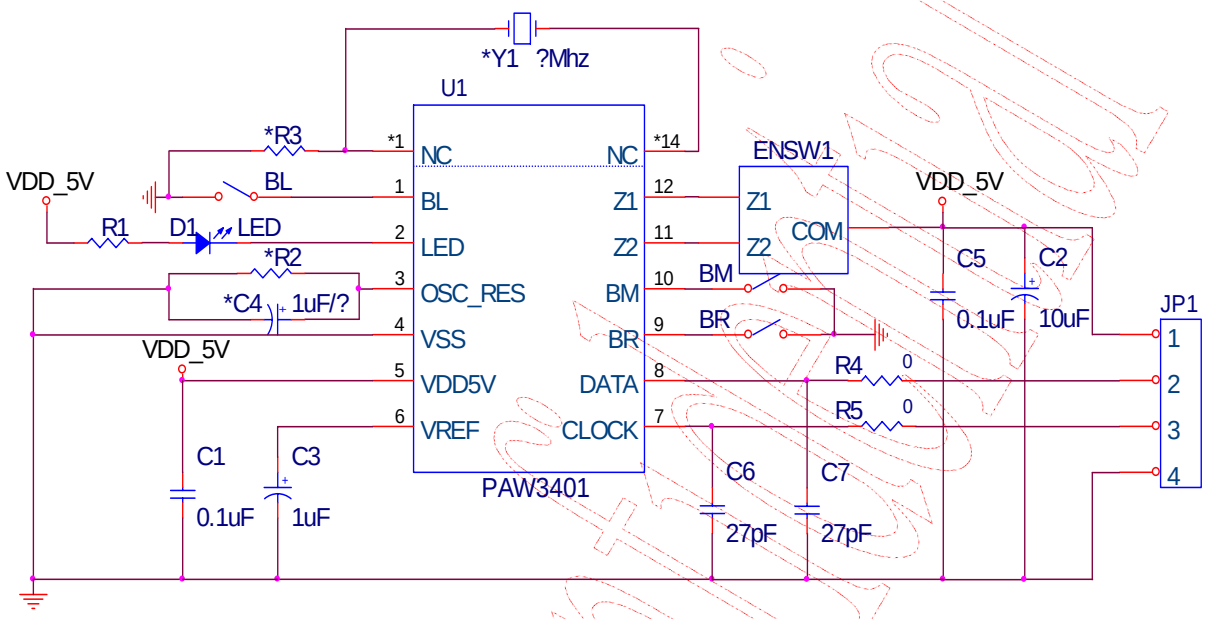


Figure 7. Mouse Receive Data from Host

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

6. Referencing Application Circuit



Note:
1. *R2 is left for 12 pin package
2. *C4 , *R3 and *Y1 is left for 14 pin package with USB interface

Figure 8. Application Circuit for PAW3401

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

7. 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 ± 15%

- R1 value (ohm), VDD = 5.0V (refer to Figure 8)

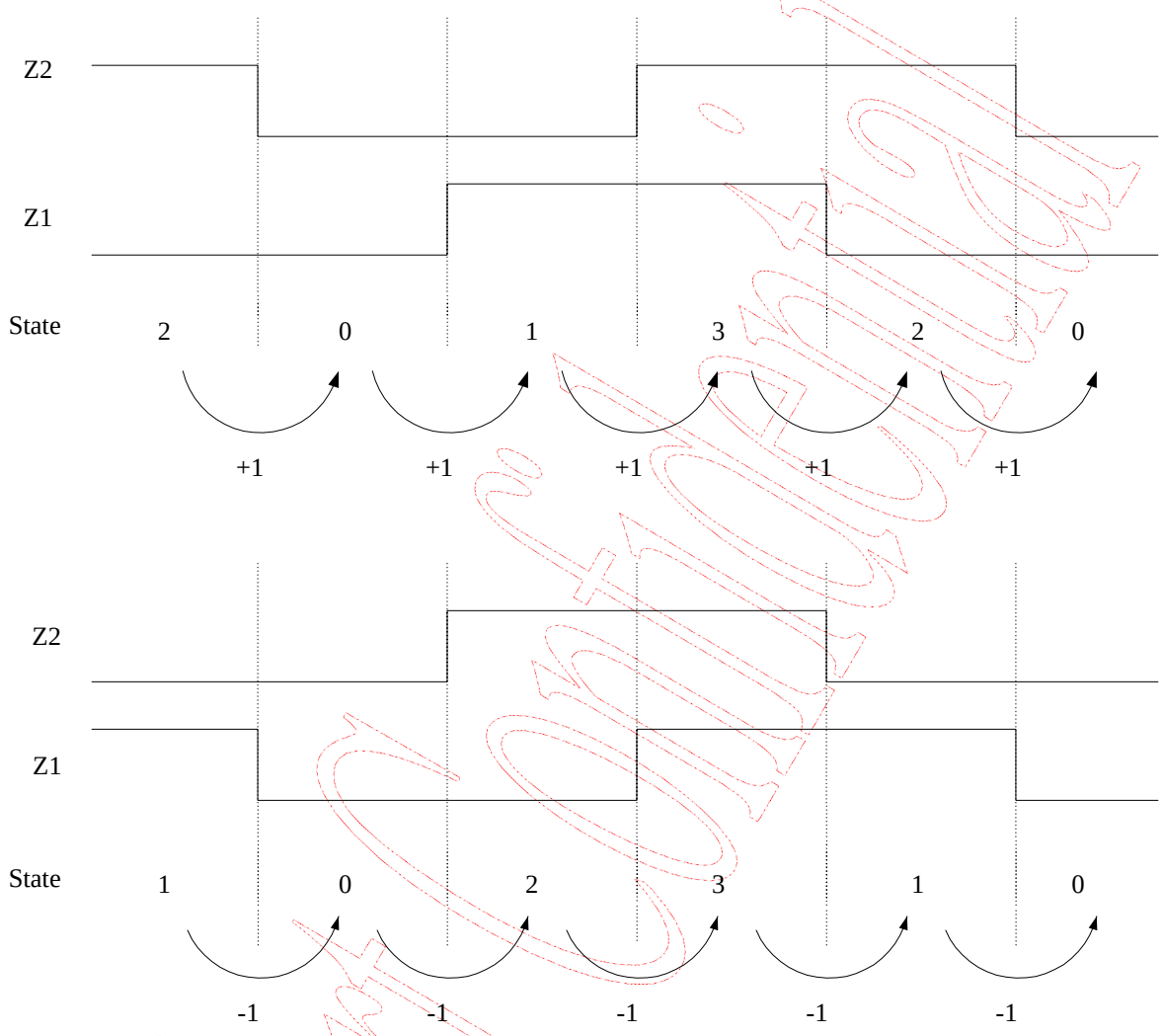
LED Bin Grade	Min.	Typ.	Max.
N	43	56	-
P	43	56	-
Q	43	56	-

PixArt Confidential

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

PixArt Imaging Inc.
E-mail: fae_service@pixart.com.tw

8. Z-axis Waveform



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

Figure 9. Z-axis Waveform

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

9. Package Information

9.1 Package Outline Drawing

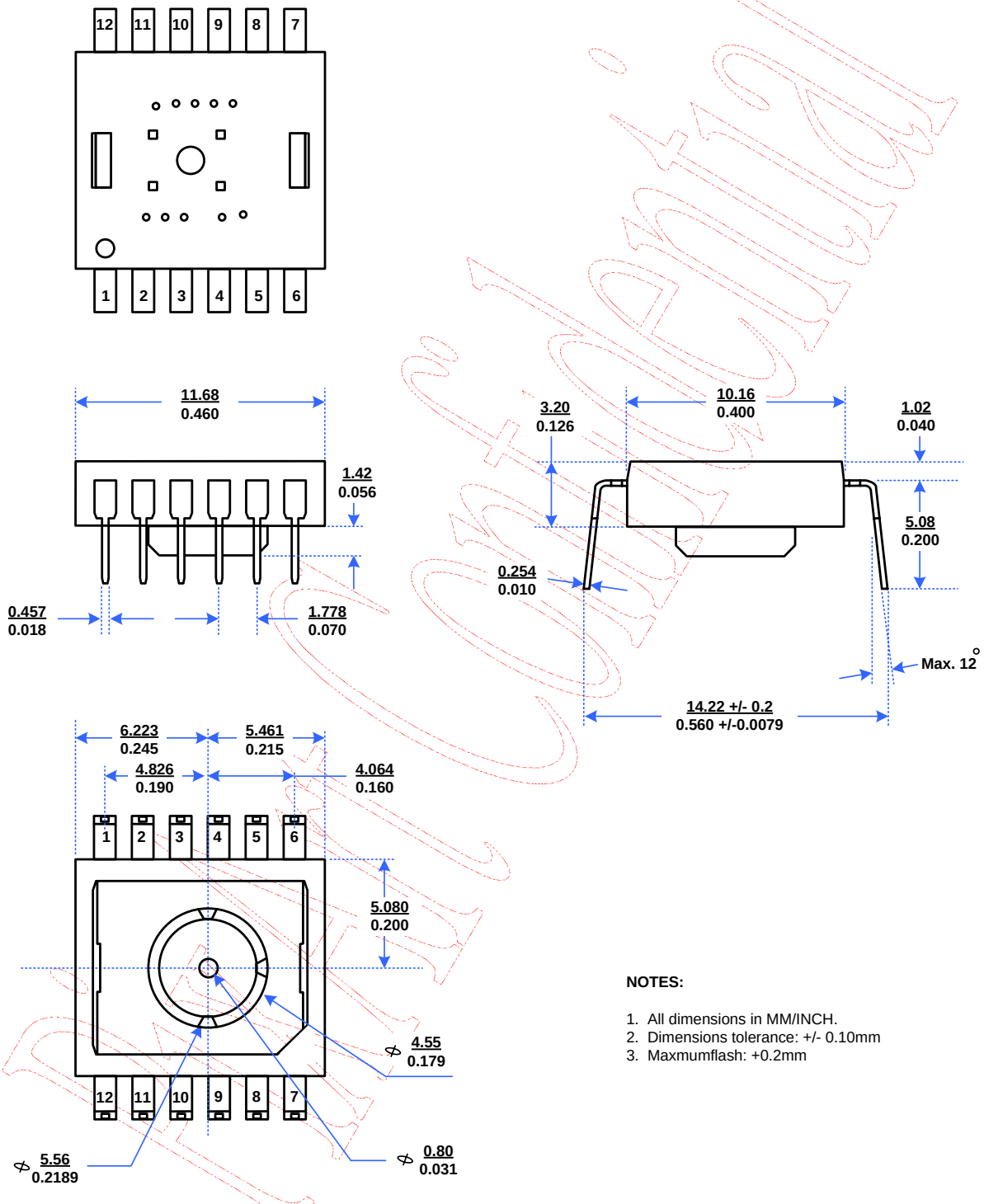


Figure 10. Package Outline Drawing

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.

9.2 Recommended PCB Mechanical Cutouts and Spacing

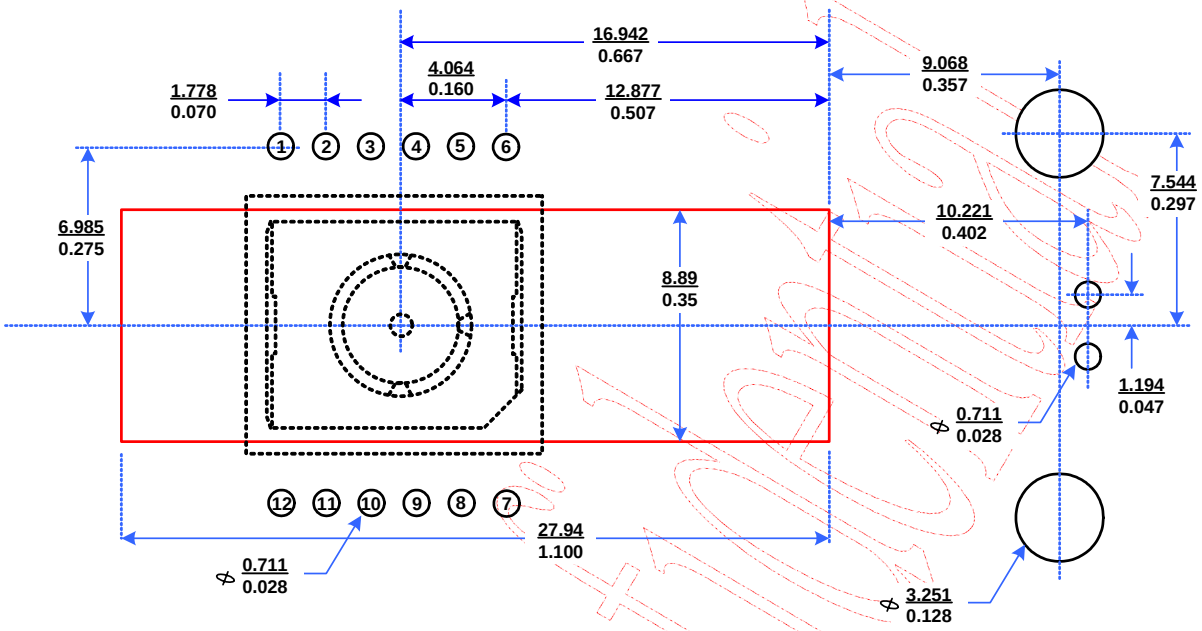


Figure 11. Recommended PCB Mechanical Cutouts and Spacing

10. Update History

Version	Update	Date
V1.0	Creation, Preliminary 1st version	09/14/2006
V1.1	Modify Referencing Application Circuit	12/29/2006

All rights strictly reserved any portion in this paper shall not be reproduced, copied or transformed to any other forms without permission.