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**PAW3501UI USB OPTICAL MOUSE SENSOR SINGLE CHIP**


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**General Description**

PAW3501UI is a CMOS process optical mouse sensor single chip with USB interface that serves as a non-mechanical motion estimation engine for implementing a computer mouse.

**Features**

- ❑ USB interface
- ❑ Single 5.0 volt power supply
- ❑ Compatible with Microsoft® Windows 2000® and 5-button Wheel Mouse
- ❑ Optical motion estimation technology
- ❑ Complete 2-D motion sensor
- ❑ Accurate motion estimation over a wide range of surfaces
- ❑ High speed motion detection up to 28 inches/sec
- ❑ High resolution up to 800 CPI
- ❑ Power saving mode during times of no movement
- ❑ Supports five buttons (R, M, L, B4, B5) and three axes (X, Y, Z) output
- ❑ Z-axis can support two kinds of scroller input (Opto-mechanical and mechanical).
- ❑ Complete Universal Serial Bus® spec V1.1 compatibility
- ❑ Complete USB HID spec V1.1 compatibility
- ❑ Integrated USB transceiver and 1.5 Mbps USB serial interface engine

**Key Specification**

|                          |  |
|--------------------------|--|
| <b>Power Supply</b>      | <b>Wide operating supply range<br/>4.25V ~ 5.5V</b>  |
| <b>Interface</b>         | <b>USB</b>   |
| <b>Optical Lens</b>      | <b>1:1</b>   |
| <b>System Clock</b>      | <b>18.000 MHz</b>  |
| <b>Speed</b>             | <b>28 inches/sec</b>   |
| <b>Acceleration</b>      | <b>20g</b>   |
| <b>Resolution</b>        | <b>400/600/800 CPI</b>   |
| <b>Frame Rate</b>        | <b>3000 frames/sec</b>   |
| <b>Operating Current</b> | <b>12 mA @Mouse moving (Normal)<br/>8 mA @Mouse not moving (Sleep)<br/>480 uA @USB suspend (Suspend)</b> |
| <b>Package</b>           | <b>Shrunk DIP24</b>  |

**Ordering Information**

| Part Number  | CPI         | Sensor Rotate | Device Type    | Z-axis Type      |
|--------------|-------------|---------------|----------------|------------------|
| PAW3501UI    | 400/600/800 | 0°/+90°/-90°  | 2D2B/3D3B/3D5B | Mechanical (Z/2) |
| PAW3501UI-P2 | 400/600/800 | 0°/+90°/-90°  | 2D2B/3D3B/3D5B | Optical (Z/2)    |
| PAW3501UI-P4 | 400/600/800 | 0°/+90°/-90°  | 2D2B/3D3B/3D5B | Optical (Z/4)    |

## 1. Pin Configuration

### 1.1 Pin Assignment

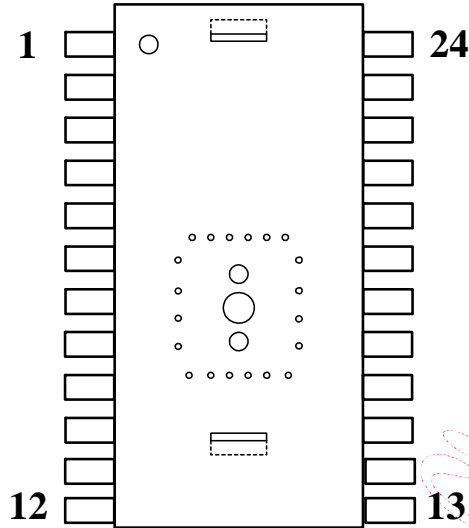


Figure 1. Top View Pinout

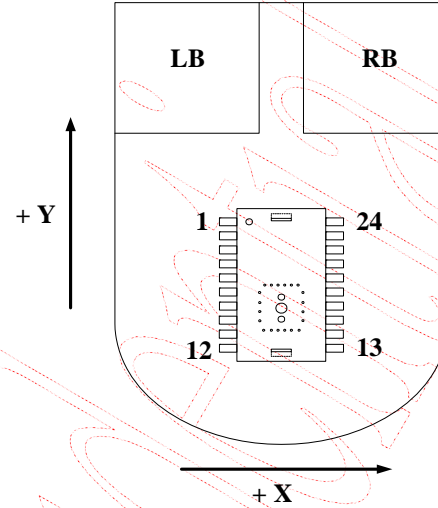


Figure 2. Top View of Mouse

### 1.2 Pin Description

| Pin # | Name   | Type   | Definition  |
|-------|--------|--------|---|
| 1     | Z1     | IN     | Z axis, support two kinds of scroller input, opto-mechanical and mechanical |
| 2     | Z2     | IN     | Z axis, support two kinds of scroller input, opto-mechanical and mechanical |
| 3     | SR     | IN     | Sensor rotate (0, 1, floating) => (-90°, +90°, 0°), 3-states input          |
| 4     | IRCTL  | OUT    | IR LED control  |
| 5     | BM     | IN     | Button middle key input, normal pull-high (50k), press connect to low       |
| 6     | BL     | IN     | Button left key input, normal pull-high (50k), press connect to low         |
| 7     | DT     | IN     | Device type (0, 1, floating) => (3D3B, 2D2B, 3D5B), 3-states input          |
| 8     | B4     | IN     | Button 4 key input, normal pull-high (50k), press connect to low            |
| 9     | B5     | IN     | Button 5 key input, normal pull-high (50k), press connect to low            |
| 10    | CPI    | IN     | CPI select to (0, 1, floating) => (800, 600, 400), 3-states input           |
| 11    | VSSLED | GND    | LED ground  |
| 12    | LED    | I/O    | LED control   |
| 13    | VREFB  | BYPASS | Analog voltage reference  |
| 14    | VREFA  | BYPASS | Analog voltage reference  |
| 15    | VDD5V  | PWR    | Chip power VDD, 5.0V  |
| 16    | VSS    | GND    | Chip ground   |
| 17    | VDDQ   | BYPASS | IO voltage reference  |
| 18    | OSCIN  | IN     | Oscillator input, connect to 18.000MHz crystal or resonator                 |
| 19    | OSCOU  | OUT    | Oscillator output, connect to 18.000MHz crystal or resonator                |
| 20    | D+     | I/O    | USB D+  |
| 21    | D-     | I/O    | USB D-  |
| 22    | BR     | IN     | Button right key input, normal pull-high (50k), press connect to low        |
| 23    | RFU    | IN     | Reserve for future use, PAW3501UP used the pin to switch USB or PS/2        |
| 24    | TEST   | IN     | Test pin. It is needed to connect to GND in normal operation mode           |

2. Block Diagram and Operation

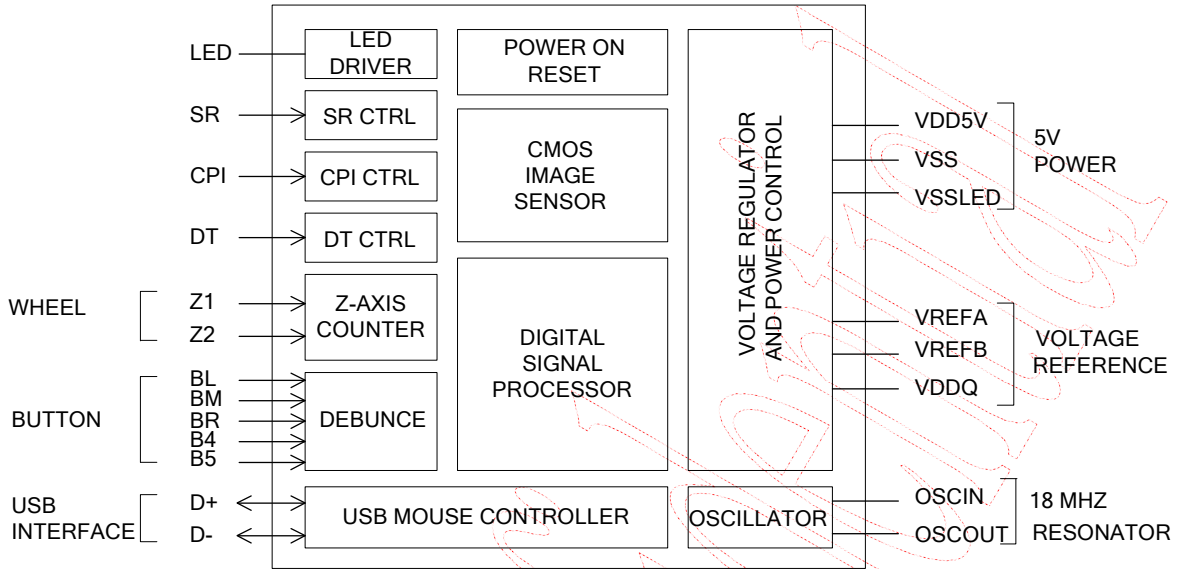


Figure 3. Block Diagram

PAW3501UI supports X, Y, Z three axes, and L, R, M, B4, B5 five buttons under USB mode. It is a CMOS process optical mouse sensor single chip with USB interface that serves as a non-mechanical motion estimation engine for implementing a computer mouse.

PAW3501UI is in a 24-pin optical package and comes with the resolution of 400/600/800 counts per inch (cpi) and the rate of motion up to 28 inches per second. It includes USB interface so that no mouse controller is needed to interface through USB. PAW3501UI can receive command and echo status or data format, both complete Universal Serial Bus<sup>®</sup> spec V1.1 and USB HID spec V1.1 compatibility. It is also a cost effective solution to support USB Mouse.

### 3. Specifications

#### 3.1 Absolute Maximum Ratings

Exposure to absolute maximum rating may affect device reliability.

| Symbol           | Parameter             | Min. | Max. | Unit | Notes  |
|------------------|-----------------------|------|------|------|--|
| T <sub>STG</sub> | Storage Temperature   | -40  | 85   | °C   |  |
| TA               | Operating Temperature | -15  | 55   | °C   |  |
|                  | Lead Solder Temp      |      | 260  | °C   | For 10 seconds, 1.6 mm below seating plane.    |
| ESD              |                       |      | 2    | kV   | All pins, human body model MIL 883 Method 3015 |
| V <sub>DC</sub>  | DC Supply Voltage     | -0.5 | 5.5  | V    |  |
| V <sub>IN</sub>  | 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 <sub>A</sub>   | Operating Temperature                         | 0    |        | 40   | °C         |                                 |
| V <sub>DD</sub>  | Power Supply Voltage                          | 4.25 | 5.0    | 5.5  | V          |                                 |
| V <sub>N</sub>   | 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         | Refer to Figure 4.              |
| R                | Resolution                                    | 400  | 600    | 800  | CPI        |                                 |
| A                | Acceleration                                  |      |        | 20   | g          |                                 |
| F <sub>CLK</sub> | Clock Frequency                               |      | 18.000 |      | MHz        |                                 |
| FR               | Frame Rate                                    |      | 3000   |      | frames/sec |                                 |
| S                | Speed   | 0    |        | 28   | inches/sec |                                 |

### 3.3 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   |
|---|---|------|------|------|------|---|
| <b>Type: USB Mouse PWR</b>              |   |      |      |      |      |   |
| $I_{DD}$                                | Supply Current<br>Mouse Moving (Normal)     |      | 12   |      | mA   |   |
| $I_{DD}$                                | Supply Current<br>Mouse Not Moving (Sleep1) |      | 8    |      | mA   |   |
| $I_{DD}$                                | Supply Current<br>Suspend Current (Suspend) |      |      | 480  | uA   |   |
| <b>Type: BL, BM, BR, B4, B5</b>         |   |      |      |      |      |   |
| $R_{PH}$                                | Internal Pull-up Resistance                 |      | 50   |      | Kohm |   |
| <b>Type: Z1, Z2</b>                     |   |      |      |      |      |   |
| $R_{PD}$                                | Internal Pull-down Resistance               |      | 50   |      | Kohm | PAW3501UI built-in internal pull-down resistance. PAW3501UI-PX needs external pull-down resistance. |
| <b>Type: BL, BM, BR, B4, B5, Z1, Z2</b> |   |      |      |      |      |   |
| $V_{IH}$                                | Input High Voltage                          | 2.0  |      |      | V    |   |
| $V_{IL}$                                | Input Low Voltage                           |      |      | 0.8  | V    |   |
| <b>Type: USB DP, DN</b>                 |   |      |      |      |      |   |
| $R_{PH}$                                | Internal Pull-up Resistance                 |      | 1.5  |      | Kohm |   |
| $V_{OL}$                                | Output Low Voltage                          |      |      | 0.3  | V    |   |
| <b>Type: OSCIN</b>                      |   |      |      |      |      |   |
| $V_{IH}$                                | Input High Voltage                          | 2.0  |      |      | V    | When driving from an external source  |
| $V_{IL}$                                | Input Low Voltage                           |      |      | 0.5  | V    | When driving from an external source  |
| <b>Type: LED</b>                        |   |      |      |      |      |   |
| $V_{OL}$                                | Output Voltage LOW                          |      |      | 360  | mV   | $I_{OL} = 25$ mA  |

4. Z and 2D Assembly Z and

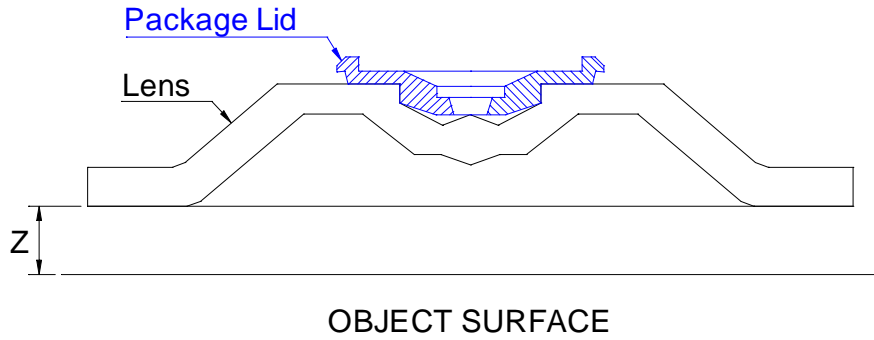


Figure 4. Distance from Lens Reference Plane to Surface

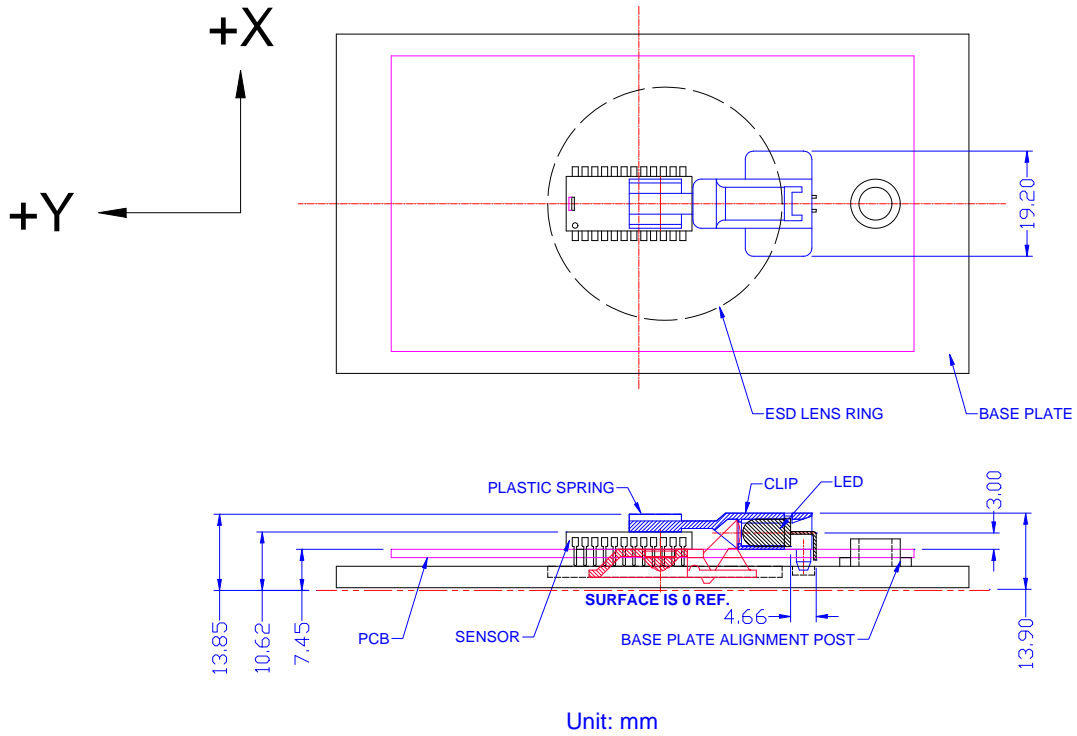


Figure 5. 2D Assembly

## 5. USB Interface

### 5.1 USB Command Set Description (USB Descriptor)

The USB HOST detects USB mouse device plug-in and assigns a new unique address to the USB mouse device, then asking USB mouse device for information about the device description, configuration description, and assigning a configuration value for USB mouse device during enumeration period. After enumeration, the USB mouse device is able to transfer motion and button value to the USB host.

| Descriptor Type   | Byte | Byte | Byte | Byte | Byte | Byte | Byte | Byte |
|---|------|------|------|------|------|------|------|------|
| Device Descriptor (18 bytes)                              | 12   | 01   | 10   | 01   | 00   | 00   | 00   | 08   |
|   | 3A   | 09   | 00   | 25   | 00   | 01   | 01   | 02   |
|   | 00   | 01   |      |      |      |      |      |      |
| Configuration Descriptor (9 bytes)                        | 09   | 02   | 22   | 00   | 01   | 01   | 04   | A0   |
|   | 32   |      |      |      |      |      |      |      |
| Interface Descriptor (9 bytes)                            | 09   | 04   | 00   | 00   | 01   | 03   | 01   | 02   |
|   | 00   |      |      |      |      |      |      |      |
| Human Interface Device Descriptor (9 bytes)               | 09   | 21   | 10   | 01   | 00   | 01   | 22   | 48   |
|   | 00   |      |      |      |      |      |      |      |
| Endpoint Descriptor (7 bytes)                             | 07   | 05   | 81   | 03   | 04   | 00   | 0A   |      |
| Human Interface Device Report Descriptor (72 bytes, 3D3B) | 05   | 01   | 09   | 02   | A1   | 01   | 05   | 09   |
|   | 19   | 01   | 29   | 03   | 15   | 00   | 25   | 01   |
|   | 95   | 03   | 75   | 01   | 81   | 02   | 95   | 01   |
|   | 75   | 05   | 81   | 03   | 05   | 01   | 09   | 01   |
|   | A1   | 00   | 09   | 30   | 09   | 31   | 15   | 81   |
|   | 25   | 7F   | 75   | 08   | 95   | 02   | 81   | 06   |
|   | C0   | 09   | 38   | 95   | 01   | 81   | 06   | 09   |
|   | 3C   | 15   | 00   | 25   | 01   | 75   | 01   | 95   |
|   | 01   | B1   | 22   | 95   | 07   | B1   | 01   | C0   |

### 5.2 USB Data Report Format

The USB report has two data formats, depending on boot or report protocol is selected. One kind of data format is the boot protocol used in legacy environment as 4.2.1. The other kind of data format is USB report protocol format which includes Z-wheel movement data in the fourth byte as 4.2.2. The Z-wheel is moved forward the fourth byte data is 01H, the Z-wheel is moved backward the fourth byte data is FFH, and the Z-wheel is idle the fourth byte data is 00H.

#### 5.2.1 USB Boot Protocol for Legacy Operation

| Byte | Bit   | Symbol  | Description   |
|------|-------|---------|---|
| 1    | 0     | BL      | 1 = Left button pressed   |
|      | 1     | BR      | 1 = Right button pressed  |
|      | 2 ~ 7 | NC      | Reserved  |
| 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.   |

**5.2.2 USB Report Protocol**

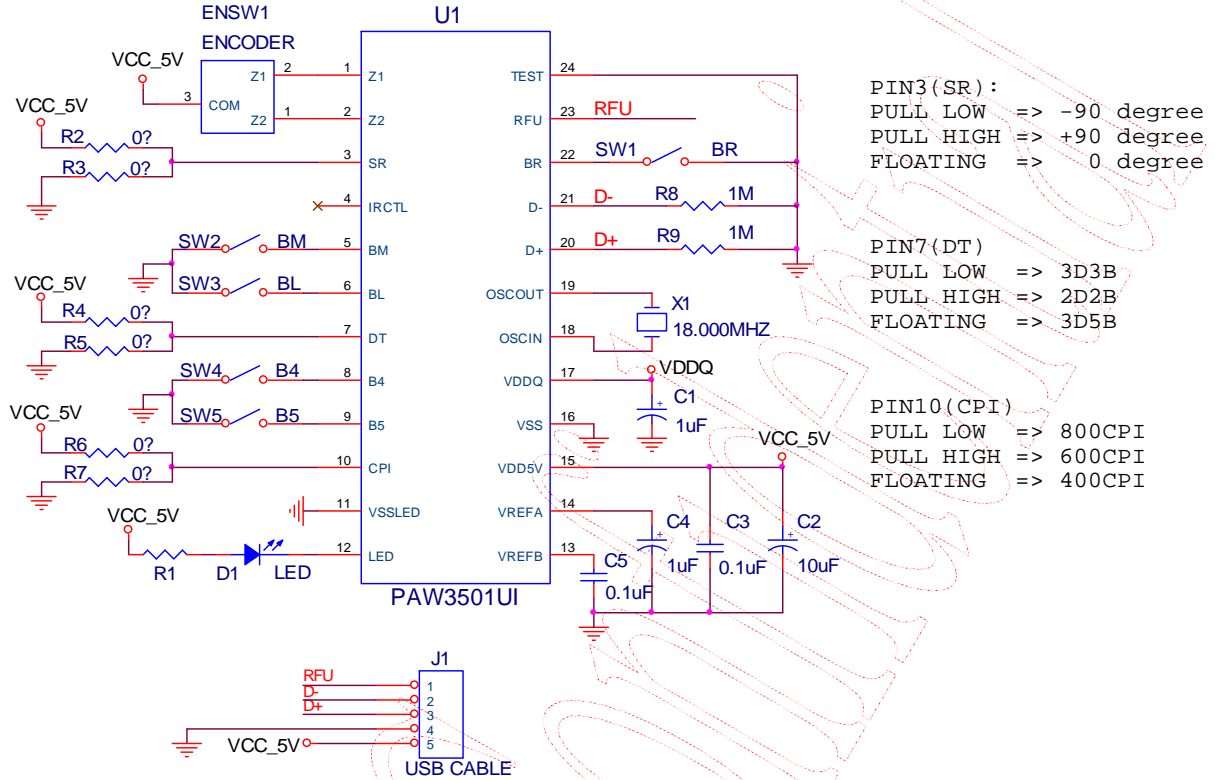
| Byte | Bit   | Symbol  | Description   |
|------|-------|---------|---|
| 1    | 0     | BL      | 1 = Left button pressed   |
|      | 1     | BR      | 1 = Right button pressed  |
|      | 2     | BM      | 1 = Middle button pressed   |
|      | 3     | B4      | 1 = B4 button pressed   |
|      | 4     | B5      | 1 = B5 button pressed   |
|      | 5 ~ 7 | NC      | Reserved  |
| 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 $\pm 7$ . Bit 0 = LSB. |





6. Referencing Application Circuit

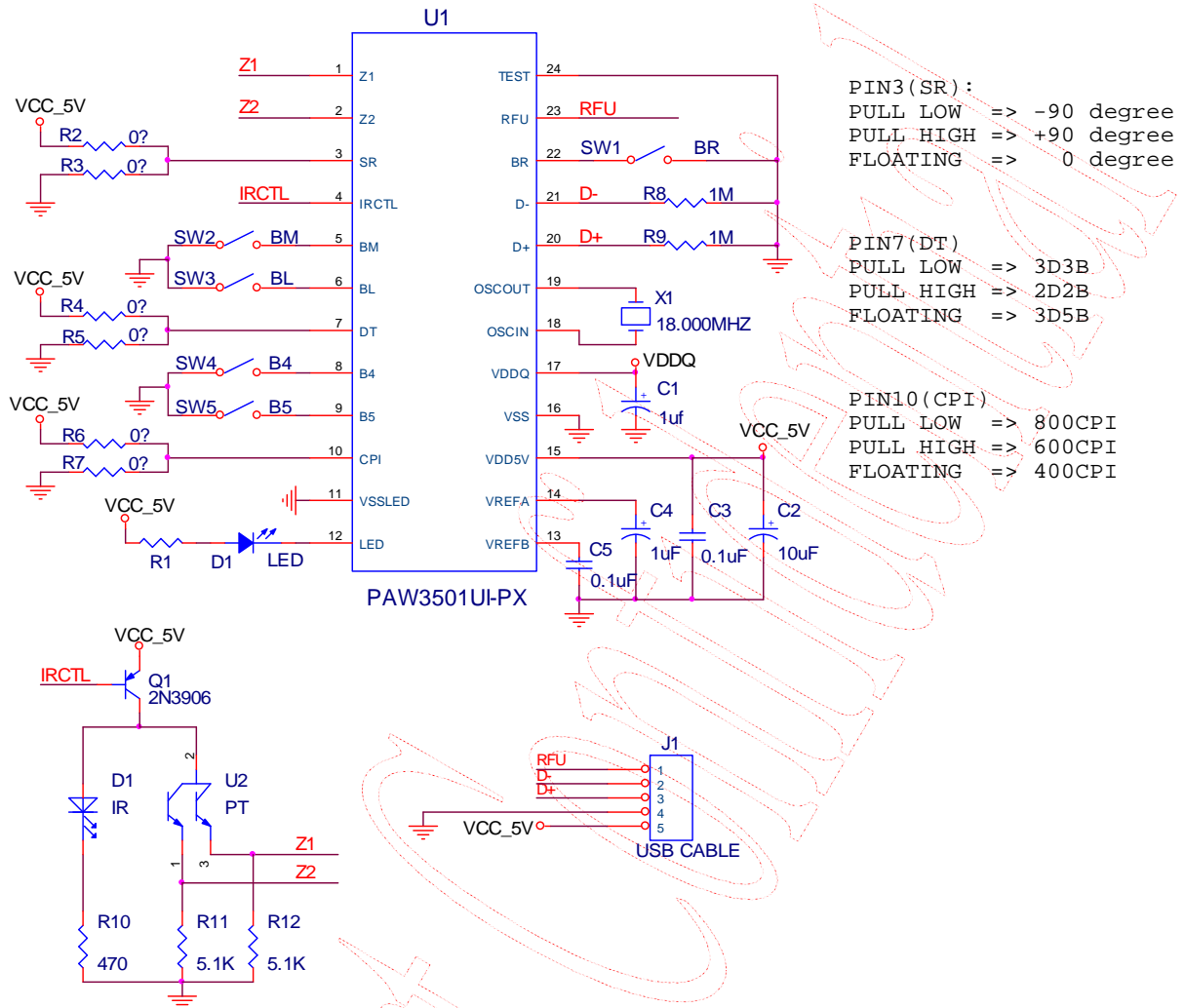
6.1 Typical Application for PAW3501UI with Mechanical Encoder



Note:  
Please connect the RFU pin to USB connector shell for future use, PAW3501UP used the pin to switch USB or PS/2.

Figure 6. Application Circuit for PAW3501UI (Mechanical Encoder)

6.2 Typical Application for PAW3501UI-PX with Optical Encoder



Note:

1. Please connect the RFU pin to USB connector shell for future use, PAW3501UP used the pin to switch USB or PS/2.
2. 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 R10 is 470ohm. The recommended value for R11/R12 is 5.1Kohm.

Figure 7. Application Circuit for PAW3501UI-PX (Optical Encoder)

### 6.3 PCB Layout Consideration

- Caps for pins 13, 14, 17 must have trace lengths less than **5mm**.
- The trace lengths of OSCOUT, OSCIN must less than **6mm**.

### 6.4 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  $\pm 15\%$

- R1 value (ohm), VDD = 5.0V

| LED Bin Grade | Min. | Typ. | Max. |
|---------------|------|------|------|
| N             | 51   | 100  |      |
| P             | 51   | 100  |      |
| Q             | 51   | 100  |      |

7. Package Information

7.1 Package Outline Drawing

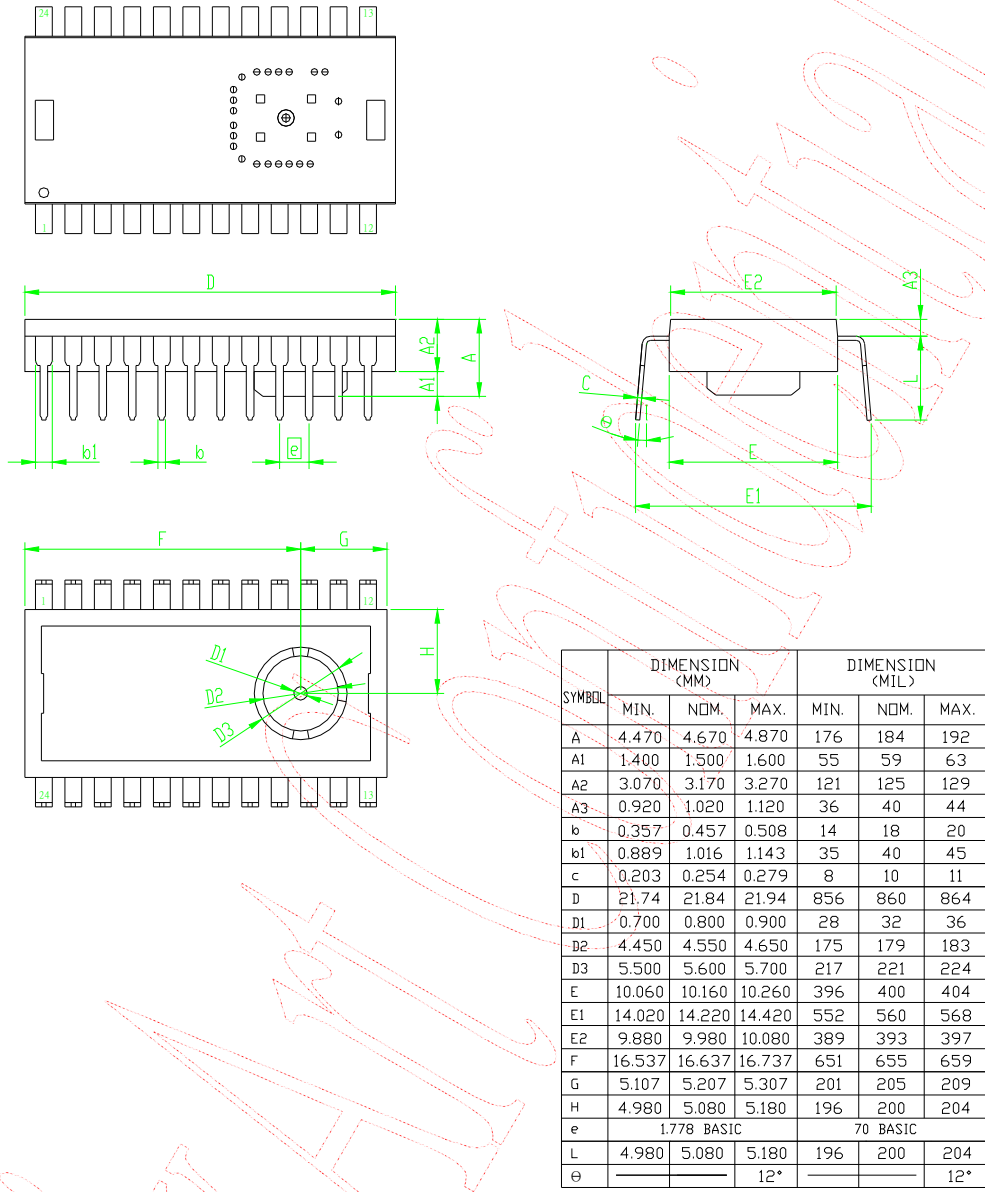


Figure 8. Package Outline Drawing

### 7.2 Recommended PCB Mechanical Cutouts and Spacing

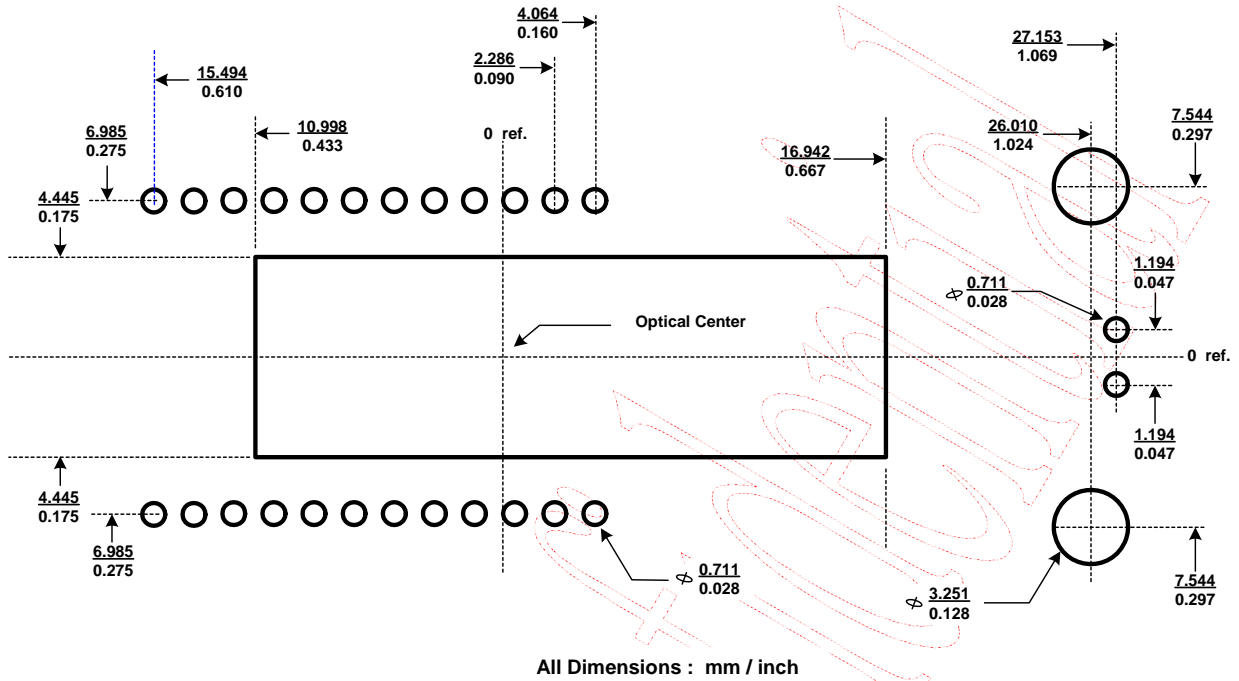


Figure 9. Recommended PCB Mechanical Cutouts and Spacing

### 8. NSTL Compatibility Test

PAW3501UI has passed the NSTL Compatibility Test Program, which conducts an objective quality assurance test suite to verify correct operation, functionality, and compatibility of system products. "The NSTL standard testing methodologies assessed the compatibility of PAW3501UI at the NSTL/ALLION Labs testing facility. And, it shows that it is getting along great and operated correctly with various software applications and add-on devices under a variety of Operating Systems." cited from the NTSL Test Report. Accordingly, PAW3501UI fully meets NTSL Compatibility Test Standard and is able to carry the NTSL Seal.

### 9. Update History

| Version | Update   | Date       |
|---------|--|------------|
| V1.0    | Creation, Preliminary 1 <sup>st</sup> version                                | 08/18/2006 |
| V2.0    | Modify Application Circuit for PAW3501UI-PX with Optical Encoder (Figure 7.) | 07/18/2007 |
| V2.1    | Content revise   | 04/18/2008 |
|         |  |            |

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.