PAW3501UI USB OPTICAL MOUSE SENSOR SINGLE CHIP

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

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

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)

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1. Pin Configuration

1.1 Pin Assignment

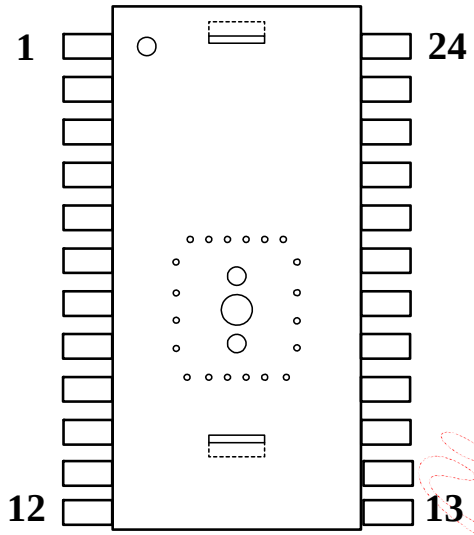


Figure 1. Top View Pinout

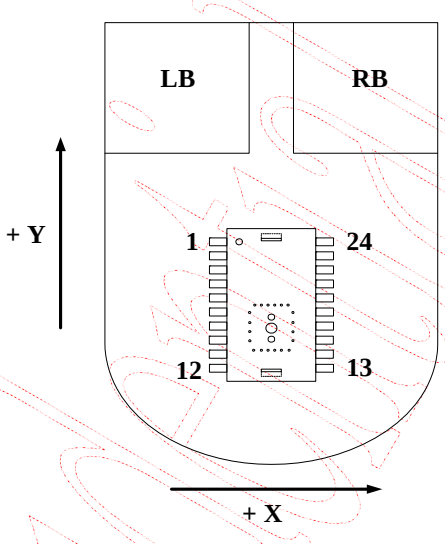


Figure 2. Top View of Mouse

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	OSCOUT	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

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2. Block Diagram and Operation

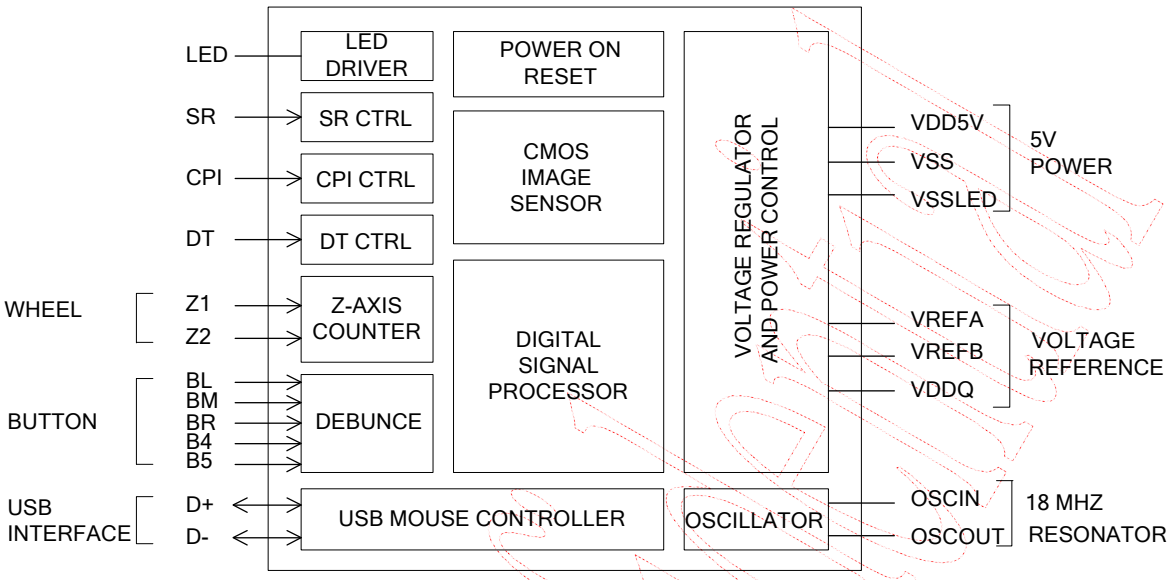


Figure 3. Block Diagram

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® spec V1.1 and USB HID spec V1.1 compatibility. It is also a cost effective solution to support USB Mouse.

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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, 1.6 mm 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	4.25	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	Refer to Figure 4.
R	Resolution	400	600	800	CPI	
A	Acceleration			20	g	
F_{CLK}	Clock Frequency		18.000		MHz	
FR	Frame Rate		3000		frames/sec	
S	Speed	0		28	inches/sec	

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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
Type: USB Mouse PWR						
I_{DD}	Supply Current Mouse Moving (Normal)		12		mA	
I_{DD}	Supply Current Mouse Not Moving (Sleep1)		8		mA	
I_{DD}	Supply Current Suspend Current (Suspend)			480	uA	
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	PAW3501UI built-in internal pull-down resistance. PAW3501UI-PX needs external pull-down resistance.
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: USB DP, DN						
R_{PH}	Internal Pull-up Resistance		1.5		Kohm	
V_{OL}	Output Low Voltage			0.3	V	
Type: OSCIN						
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
Type: LED						
V_{OL}	Output Voltage LOW			360	mV	I_{OL} = 25 mA

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4. Z and 2D Assembly Z and

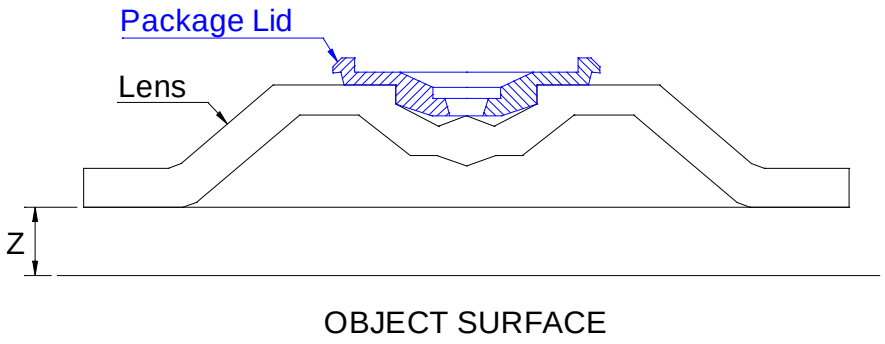


Figure 4. Distance from Lens Reference Plane to Surface

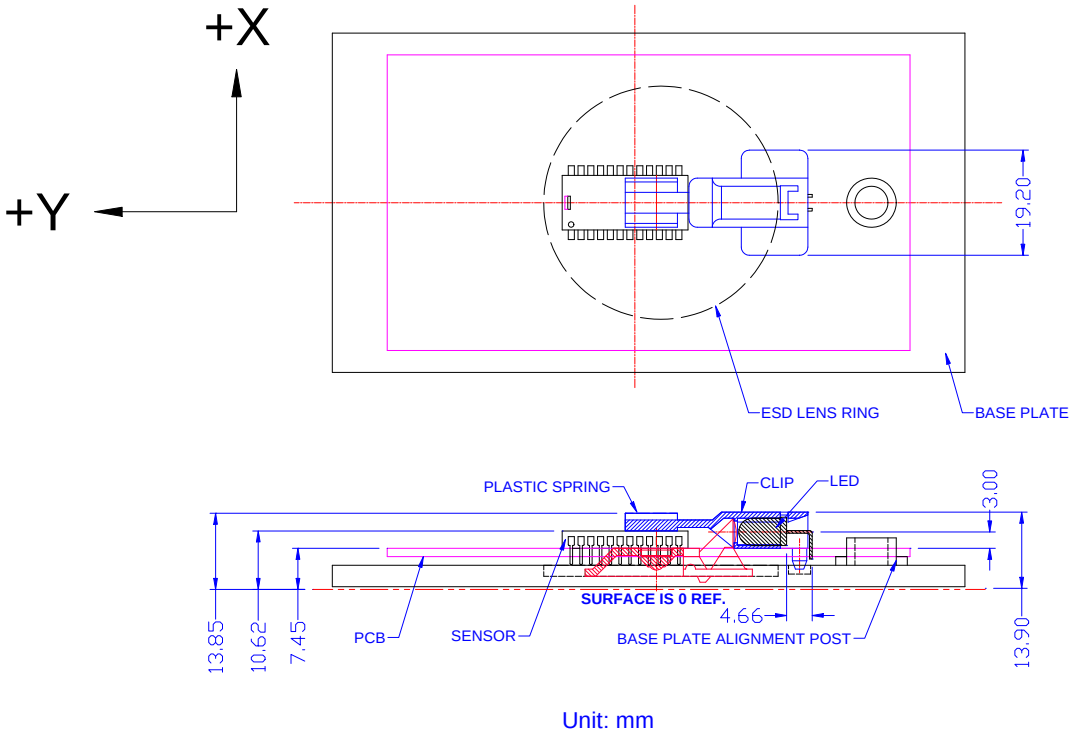


Figure 5. 2D Assembly

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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.

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5.2.2 USB Report Protocol

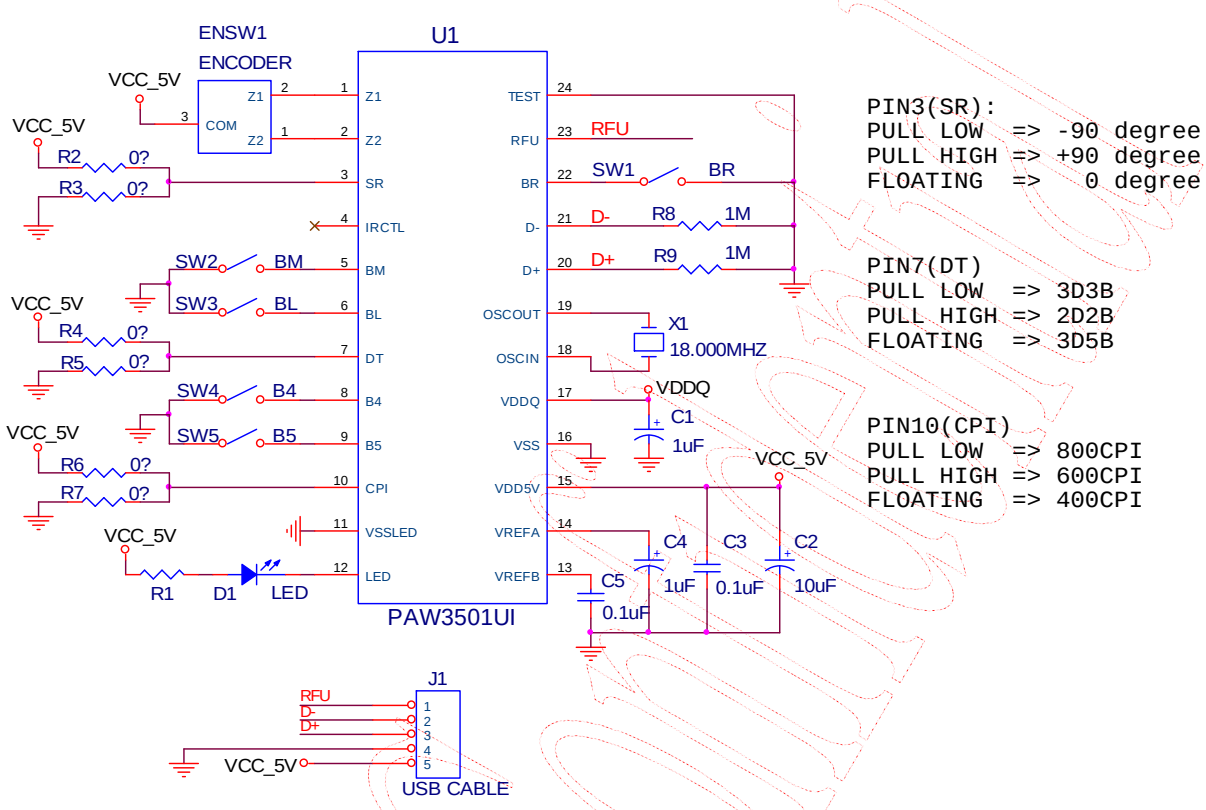
Byte	Bit	Symbol	Description
1	0	BL	1 = Left button pressed
	1	BR	1 = Right button pressed
	2	BM	1 = Middle button pressed
	3	B4	1 = B4 button pressed
	4	B5	1 = B5 button pressed
	5 ~ 7	NC	Reserved
2	0 - 7	X0 ~ X7	X data (D0 - D7). A positive value indicates motion to the right; a negative value indicates 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 ±7. Bit 0 = LSB.

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6. Referencing Application Circuit

6.1 Typical Application for PAW3501UI with Mechanical Encoder

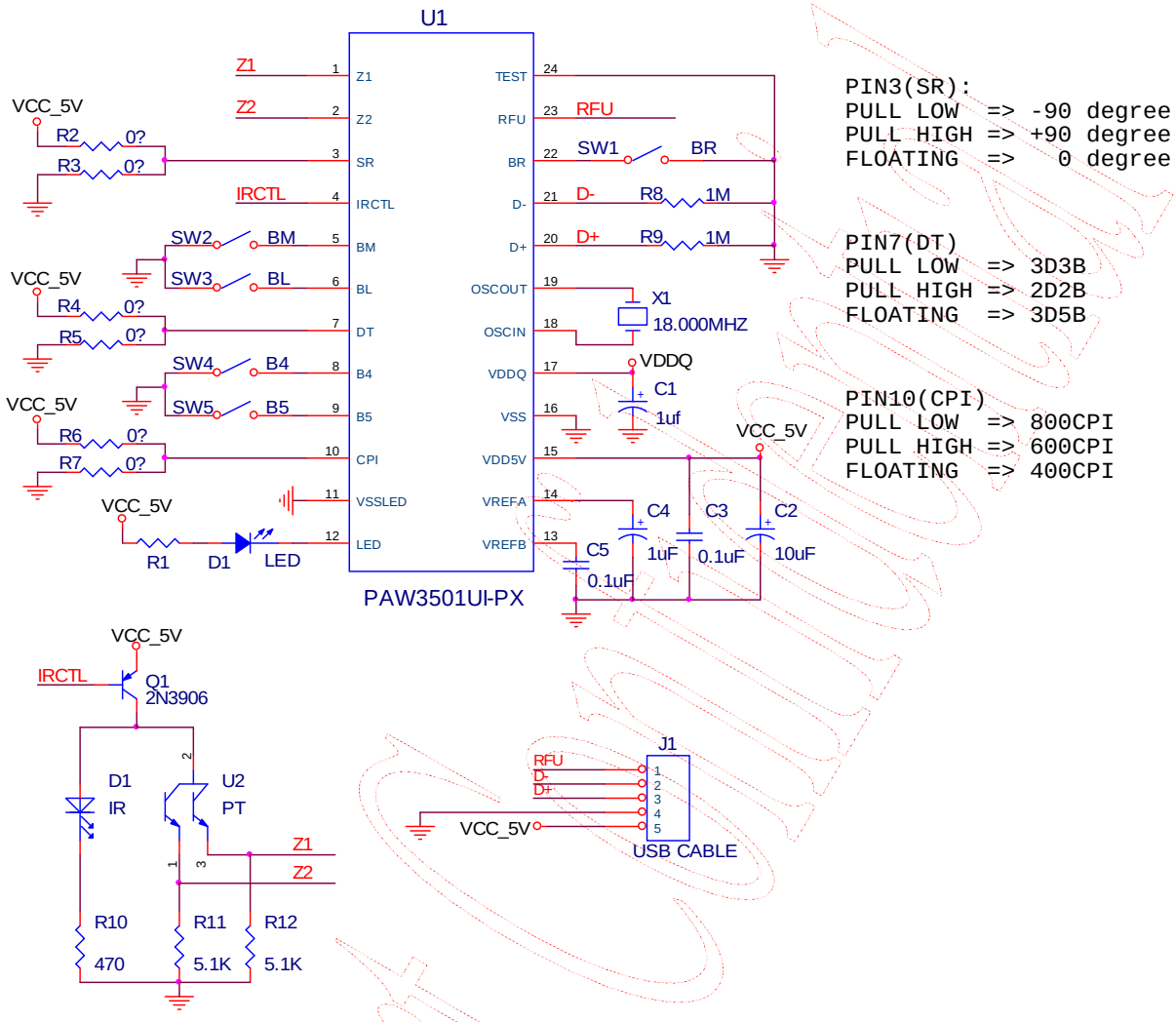



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Note:
Please connect the RFU pin to USB connector shell  for future use,
PAW3501UP used the pin to switch USB or PS/2.
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Figure 6. Application Circuit for PAW3501UI (Mechanical Encoder)

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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)

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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 ± 15%

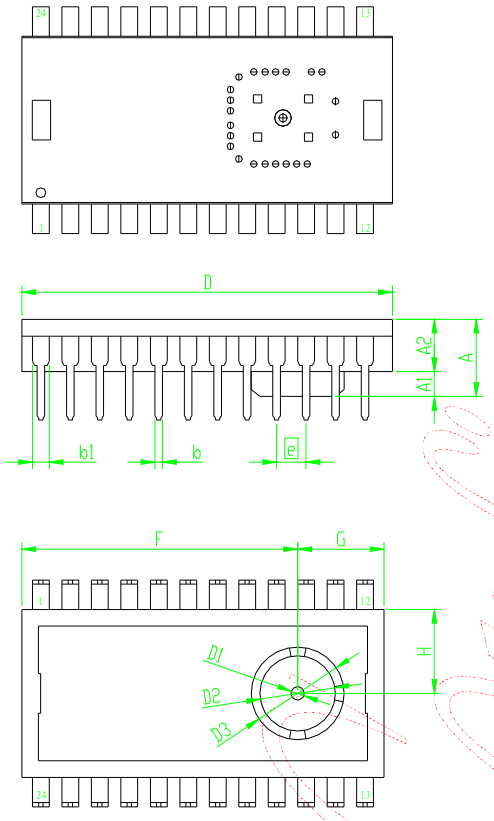
- R1 value (ohm), VDD = 5.0V

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

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7. Package Information

7.1 Package Outline Drawing



SYMBOL	DIMENSION (MM)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	4.470	4.670	4.870	176	184	192
A1	1.400	1.500	1.600	55	59	63
A2	3.070	3.170	3.270	121	125	129
A3	0.920	1.020	1.120	36	40	44
b	0.357	0.457	0.508	14	18	20
b1	0.889	1.016	1.143	35	40	45
c	0.203	0.254	0.279	8	10	11
D	21.74	21.84	21.94	856	860	864
D1	0.700	0.800	0.900	28	32	36
D2	4.450	4.550	4.650	175	179	183
D3	5.500	5.600	5.700	217	221	224
E	10.060	10.160	10.260	396	400	404
E1	14.020	14.220	14.420	552	560	568
E2	9.880	9.980	10.080	389	393	397
F	16.537	16.637	16.737	651	655	659
G	5.107	5.207	5.307	201	205	209
H	4.980	5.080	5.180	196	200	204
e	1.778 BASIC			70 BASIC		
L	4.980	5.080	5.180	196	200	204
θ	———	———	12°	———	———	12°

Figure 8. Package Outline Drawing

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7.2 Recommended PCB Mechanical Cutouts and Spacing

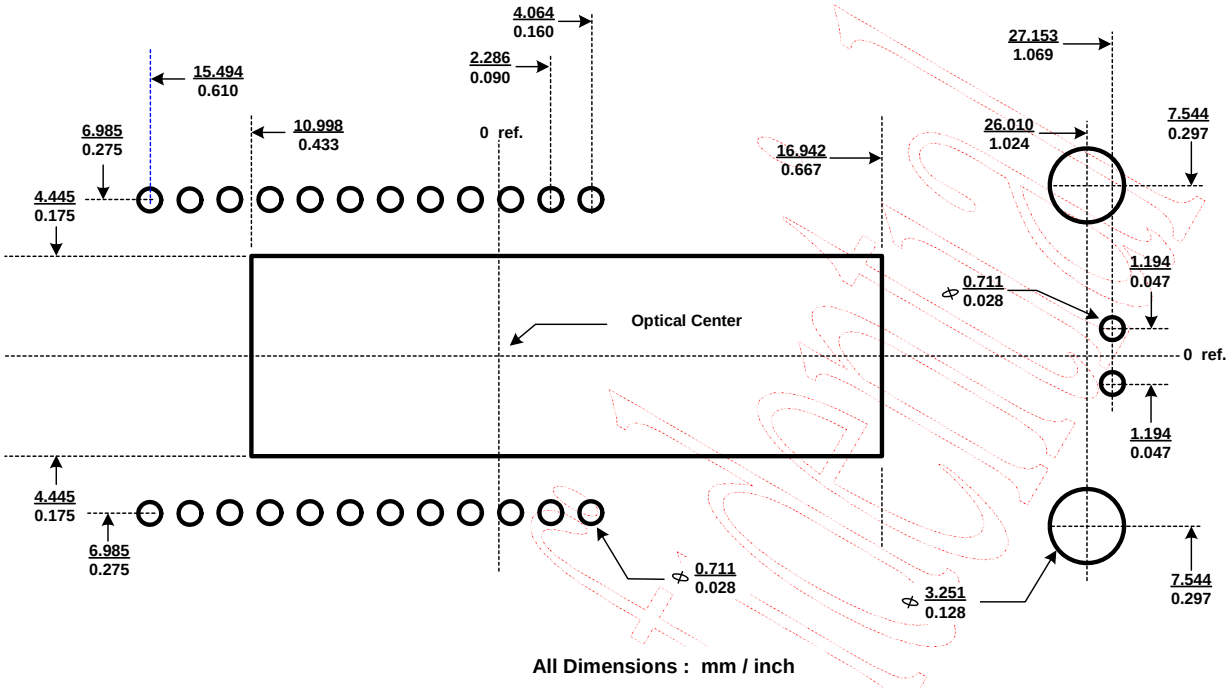


Figure 9. Recommended PCB Mechanical Cutouts and Spacing

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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 1st 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

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