PAW3515DB SERIES USB OPTICAL MOUSE SINGLE CHIP

General Description

The PAW3515DB is an ultra low cost CMOS process optical mouse sensor single chip with USB interface that serves as a non-mechanical motion estimation engine for implementing a computer mouse. The PAW3515DB also embedded internal RC function to replace external resonator for BOM cost reduction and supported flexibility function change by programmer for easy and fast production.

Features

- **USB interface**
- **Single power supply**
- **Optical motion estimation technology**
- **Complete 2-D motion sensor**
- **Accurate motion estimation over a wide range of surfaces**
- **High speed motion detection up to 30 inches/sec**
- **Power saving mode during times of no movement**
- **Supports three buttons (R, M, L) and three axes (X, Y, Z) output**
- **Z-axis support mechanical input**
- **Internal RC oscillation without external resonator**
- **USB spec.**
  - **Complete Universal Serial Bus specs V2.0 compatibility**
  - **Compliant to the USB specification version 2.00**
  - **Complete USB HID specs V1.11 compatibility**
  - **Integrated USB transceiver and 1.5Mbps USB serial interface engine**
- **Flexibility function change(details as item 6)**
  - **Interface: USB / PS2**
  - **CPI resolution: 400~1600**
  - **Sensor rotation: 0, +90, -90, 180**
  - **USB report format: 8bit / 16bit**
  - **USB P_string: xxxxxxxxxx USB Optical Mouse**
  - **USB PID/VID: xxxx / xxxx**

Key Specification

Power Supply	**Wide operating supply range 4.25V ~ 5.5V**
Interface	**USB**
Optical Lens	**1:1**
Speed	**Up to 30 inches/sec**
Acceleration	**Up to 8g**
Resolution	**400/500/600/800/1000(default)/ 1200/1600**
Frame Rate	**3300 frames/sec**
Operating Current	**10mA @Mouse moving (Normal) 5mA @Mouse not moving (Sleep) 480uA @USB suspend (Suspend)**
Package	**Staggered DIP8 type**

Ordering Information

PixArt Imaging Inc.
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Sensor Part Number	CPI	Type	Interface
PAW3515DB-VJZA	1000	3D3B	U+P
PAW3515DB-VJYA	1000	3D3B	U

1. Pin Configuration

1.1 Pin Description

Pin #	Name	Type	Definition
1	MFIO_1 (LED)	I/O	Share pin for LED power/BM
2	VDD5V	PWR	Chip power VDD, 5.0V
3	Z1	I/O	Z axis, support mechanical scroller input
4	Z2	I/O	Z axis, support mechanical scroller input
5	MFIO_2 (SW)	I/O	Share pin for LED control pin/BL/BR
6	VSS	GND	Chip ground
7	D-/DATA	I/O	USB D- or PS/2 mouse data line
8	D+/CLK	I/O	USB D+ or PS/2 mouse clock line

1.2 Pin Assignment for Sensor Rotate 0˚, +90˚, -90˚, 180˚

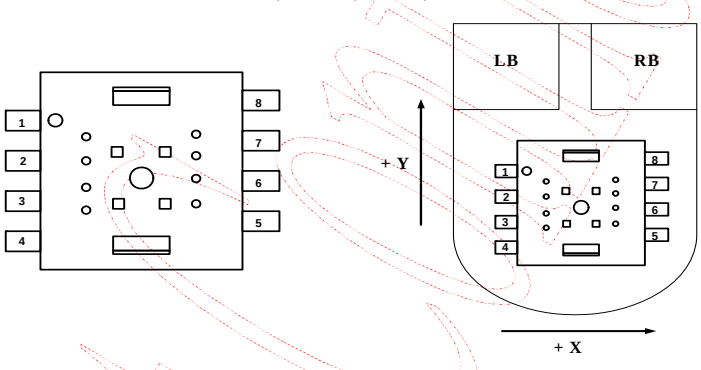

Figure 1. Top View Pinout

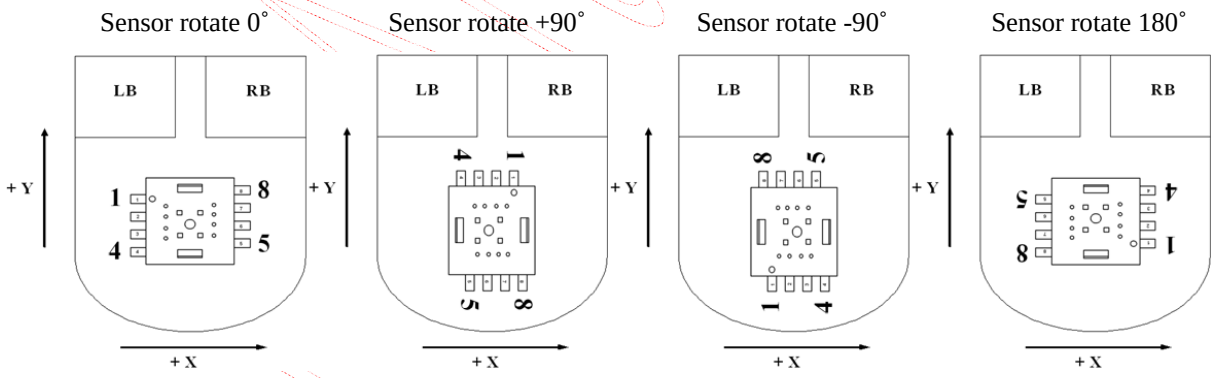

Figure 2. Top View of Mouse

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2. Block Diagram and Operation

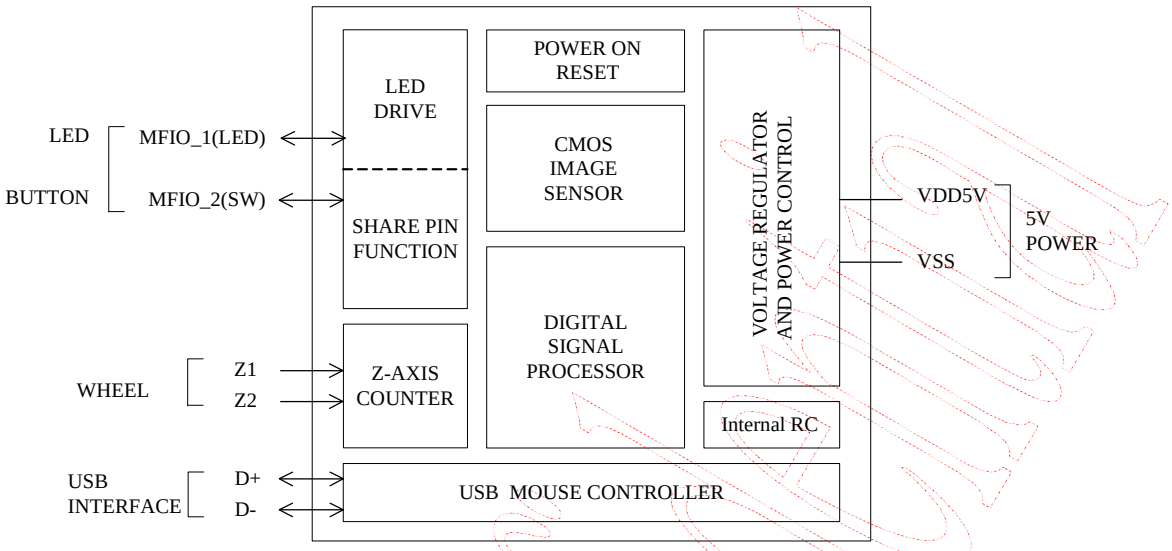

Figure 3. Block Diagram

The PAW3515DB supports X, Y, Z three axes, and L, R, M three 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.

The PAW3515DB is in a 8-pin optical package and comes with the resolution of 1000 counts per inch (CPI) and the rate of motion up to 30 inches per second. It includes USB interface so that no mouse controller is needed to interface through USB. The PAW3515DB can receive command and echo status or data format, both complete Universal Serial Bus® spec V2.0 and USB HID spec V1.11 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_{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_{Npp}	Supply Noise			150	mV	Peak to peak within 10K - 80 MHz
Z	Distance from Lens Reference Plane to Surface	2.3	2.4	2.5	mm	Refer to Figure 4 and Figure 5.
R	Resolution		1000		CPI	
A	Acceleration			8	g	
FR	Frame Rate		3300		frames/sec	
S	Speed	0	15	30	inches/sec	USB report format 8-Bit: 30 inches/sec @400CPI **15 inches/sec @1000CPI(default)** USB report format 16-Bit: 30 inches/sec @ all CPI
I_{R_LED}	LED reverse current			10	uA	LED reverse voltage @ 5V

3.3 AC Electrical Characteristics

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

Symbol	Parameters	Min.	Typ.	Max.	Unit	Notes
T_B	Mouse Button Debounce Time	-	10.24	-	ms	
Tz	Mouse Z Wheel Debounce Time	-	1.024	-	ms	

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: USB Mouse PWR						
I_{DD}	Supply Current Mouse moving (Normal)	-	10	-	mA	
I_{DD}	Supply Current Mouse not moving (Sleep)	-	5	-	mA	
I_{DD}	Supply Current USB suspend current	-	480	-	uA	
Type: MFIO_1/MFIO_2 share function for LED						
MFIO_1	Voh	VDD-0.7		-	V	Base on DC current 50mA
MFIO_2	Vol	-		VSS+0.4	V	Base on DC current 50mA
Type: Z1, Z2(Mechanical)						
V_{IH}	Input High Voltage	VDD*0.7	-	-	V	
V_{IL}	Input Low Voltage	-	-	VDD*0.3	V	
Type: USB DP, DN						
R_{PH}	Internal Pull Up Resistance	-	1.5	-	Kohm	

4. Z and 2D/3D Assembly

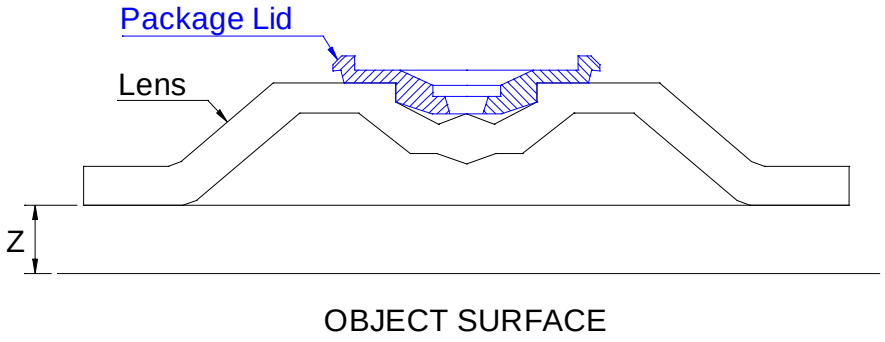

Figure 4. Distance from Lens Reference Plane to Surface

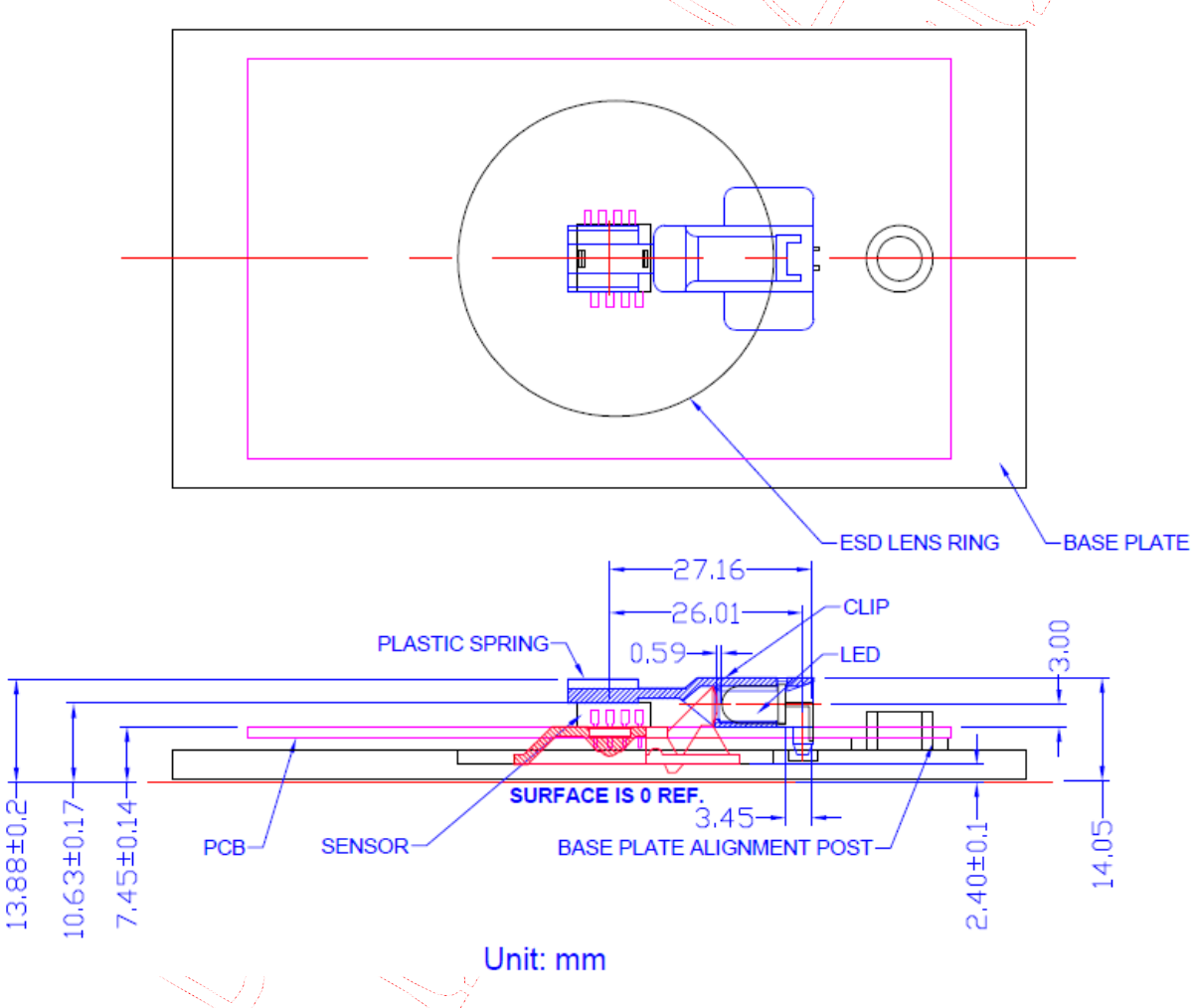

Figure 5. 2D Assembly

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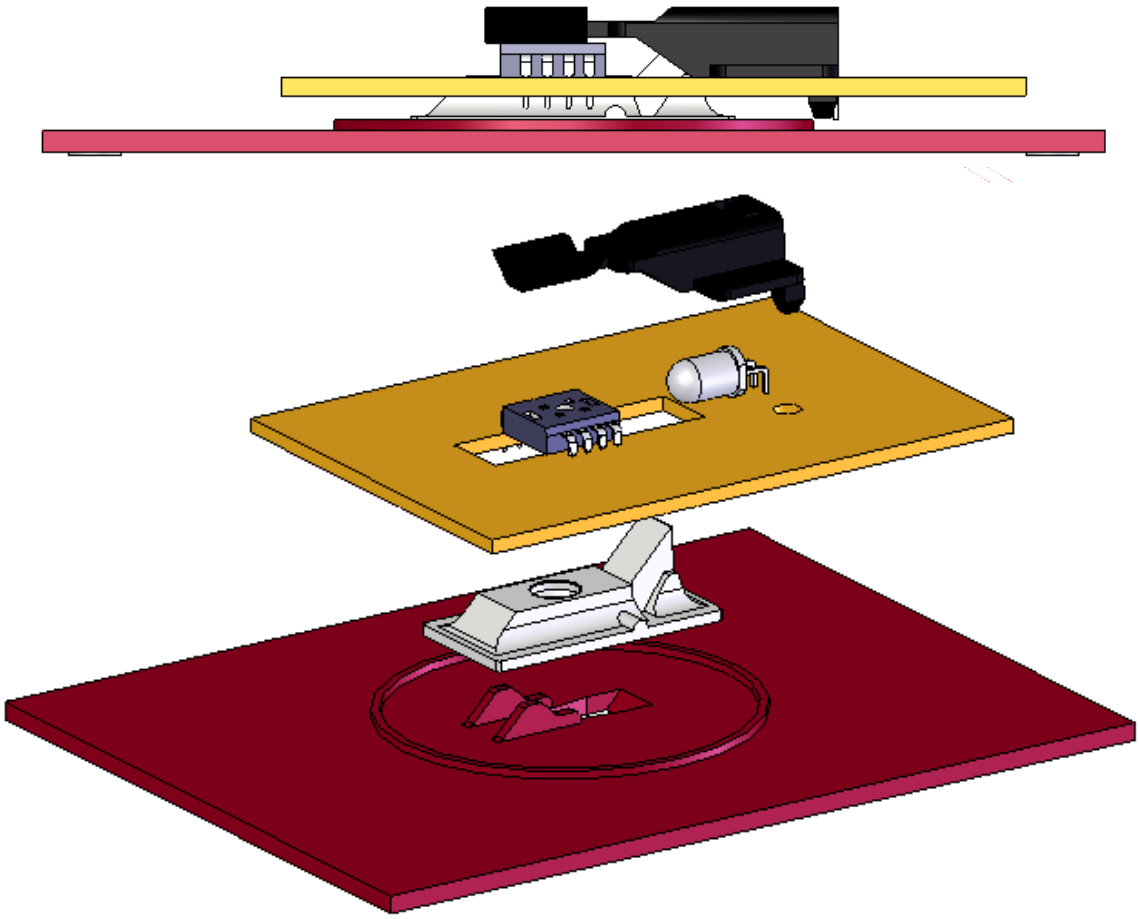


Figure 6. 3D Assembly for Mounting Instructions

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.

■ USB Descriptors for 3D3B, 8-Bit XY Device

Descriptor Type	Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Device Descriptor (18 bytes)	12	01	00	02	00	00	00	08
	3A	09	10	25	00	01	01	02
	00	01						
Configuration Descriptor (9 bytes)	09	02	22	00	01	01	00	A0
	32							
Interface Descriptor (9 bytes)	09	04	00	00	01	03	01	02
	00							
Human Interface Device Descriptor (9 bytes)	09	21	11	01	00	01	22	2E
	00							
Endpoint Descriptor (7 bytes)	07	05	81	03	04	00	0A	
Human Interface Device Report Descriptor (46 bytes, 3D3B)	05	01	09	02	A1	01	09	01
	A1	00	05	09	19	01	29	03
	15	00	25	01	95	08	75	01
	81	02	05	01	09	30	09	31
	09	38	15	81	25	7F	75	08
	95	03	81	06	C0	C0		
Language String Descriptor (4 bytes)	04	03	09	04				
Manufacture String Descriptor	PixArt							
Product String Descriptor	USB Optical Mouse							

■ USB Descriptors for 3D3B, 16-Bit XY Device

Descriptor Type	Byte	Byte	Byte	Byte	Byte	Byte	Byte	Byte
Device Descriptor (18 bytes)	12	01	00	02	00	00	00	08
	3A	09	10	25	00	01	01	02
	00	01						
Configuration Descriptor (9 bytes)	09	02	22	00	01	01	00	A0
	32							
Interface Descriptor (9 bytes)	09	04	00	00	01	03	01	02
	00							
Human Interface Device Descriptor (9 bytes)	09	21	11	01	00	01	22	2E
	00							
Endpoint Descriptor (7 bytes)	07	05	81	03	04	00	0A	
Human Interface Device Report Descriptor (79 bytes, 3D3B)	05	01	09	02	A1	01	09	01
	A1	00	05	09	19	01	29	03
	15	00	25	01	75	01	95	03
	81	02	75	05	95	01	81	03
	06	00	FF	09	40	95	02	75
	08	15	81	25	7F	81	02	05
	01	09	38	15	81	25	7F	75
	08	95	01	81	06	09	30	09
	31	16	01	80	26	FF	7F	75
	10	95	02	81	06	C0	C0	
Language String Descriptor (4 bytes)	04	03	09	04				
Manufacture String Descriptor	PixArt							
Product String Descriptor	USB Optical Mouse							

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 5.2.1. The other kind of data format is USB report protocol format which includes 8(default)/16 bit XY and Z-wheel movement data as 5.2.2. If the Z-wheel is scrolled upward the corresponding report data will be 01H. If the Z-wheel is scrolled downward the corresponding report data will be FFH. And the report data will be 00H if Z-wheel is idle.

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	BM	1 = Middle button pressed
	3 ~ 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

■ USB report protocol for 3D3B, 8-Bit XY Device.

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	Reserved
	4	B5	Reserved
	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.

■ USB report protocol for 3D3B, 16-Bit XY Device.

Byte	Bit	Symbol	Description
1	7 – 3	NC	Reserved
	2	BM	1 = Middle button pressed
	1	BR	1 = Right button pressed
	0	BL	1 = Left button pressed
2	7 – 0	X7 – X0	X data (D7 – D0). A positive value indicates motion to the right; a negative value indicates motion to the left. Bit 0 = LSB.
3	7 – 0	Y7 – Y0	Y data (D7 – D0). A positive value indicates device motion upward; a negative value indicates motion downward. Bit 0 = LSB.
4	7 – 0	Z7 – Z0	Z-wheel motion data (D7 – D0). A positive value indicates device motion downward; a negative value indicates motion upward. The Z7 – Z0 limit value is

			±7. Bit 0 = LSB.
5	7 – 0	X7 – X0	X data (D7 – D0). A positive value indicates motion to the right; a negative value indicates motion to the left. Bit 0 = LSB.
6	7 – 0	X15 – X8	X data (D15 – D8). A positive value indicates motion to the right; a negative value indicates motion to the left. Bit 0 = LSB.
7	7 – 0	Y7 – Y0	Y data (D7 – D0). A positive value indicates device motion upward; a negative value indicates motion downward. Bit 0 = LSB.
8	7 – 0	Y15 – Y8	Y data (D15 – D8). A positive value indicates device motion upward; a negative value indicates motion downward. Bit 0 = LSB.

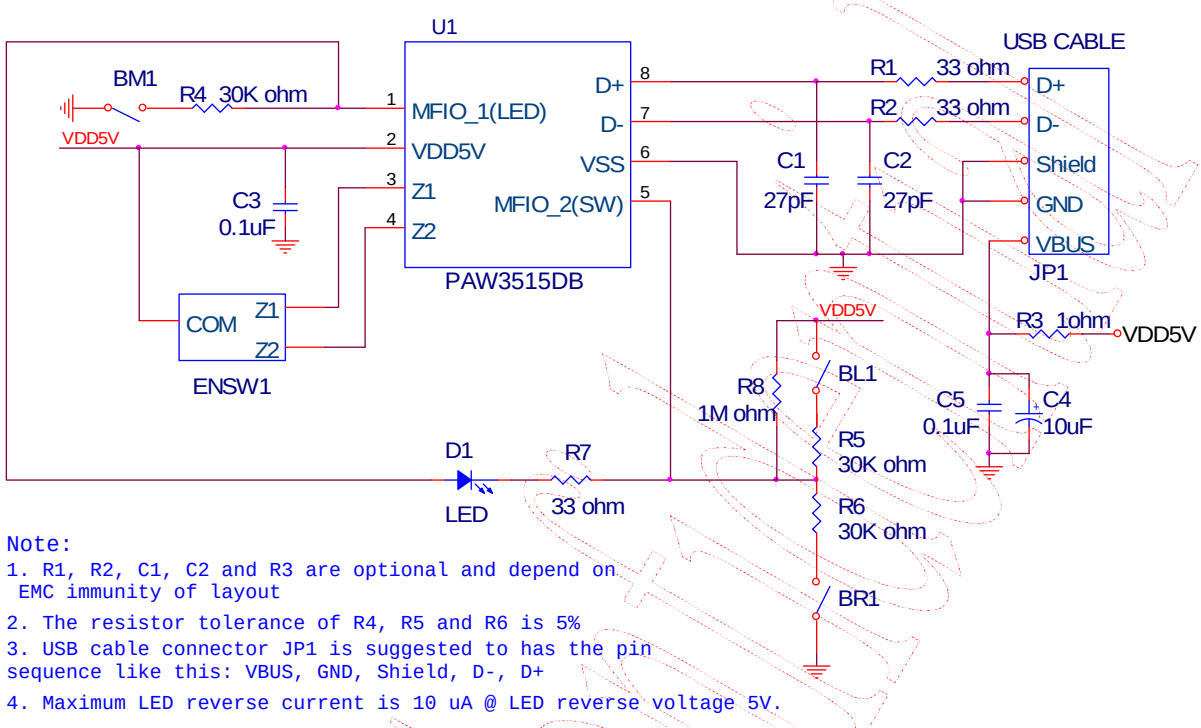
6. Flexibility Function Change

The PAW3515DB supports specific function change by PixArt provided programmer. That can speed up project production to meet time to market! Detail programmable items as below table.

Programmable Item	Specific Function	Remark
Interface	USB only, PS/2 only	
CPI resolution	400, 500, 600, 800, **1000**(default), 1200, 1600	
Sensor rotation	**0**(default), +90, -90, 180	
USB report format	**8bit**(default) /16bit	
USB P_string	**USB Optical Mouse**(default), xxxxxxxxxx USB Optical Mouse	x: Support 10 words totally. Specific character as **0~9**, **a~z**, **A~Z, ., space**
USB PID	**2510**(default), xxxx	x: Support any Hex code except FFFF.
USB VID	**093A**(default), xxxx	x: Support any Hex code except FFFF.

7. Referencing Application Circuit

7.1 3D3B Application Circuit



Note:
1. R1, R2, C1, C2 and R3 are optional and depend on EMC immunity of layout
2. The resistor tolerance of R4, R5 and R6 is 5%
3. USB cable connector JP1 is suggested to has the pin sequence like this: VBUS, GND, Shield, D-, D+
4. Maximum LED reverse current is 10 uA @ LED reverse voltage 5V.

Figure 7. Application Circuit for PAW3515DB

7.2 PCB Layout Guideline

The following guidelines apply to component placement and routing on the PCB. That will get an optimum EMC solution and tracking performance.

7.2.1 Key Components Placement Rules

1. Place bulk capacitor (C4) and bypass (C5) near the USB CABLE.
2. Place C3 near SENSOR pin 2.
3. The C1/C2 and R1/R2 should be placed as close to the USB CABLE.

7.2.2 Routing Rules

1. Caps for pin2 trace length must be less than 5 mm.

7.3 Recommended Value for R7

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

LED Bin Grade	Min	Typ	Max	Unit
Q	21.2	-	25.4	mW/Sr

Note: Tolerance for each bin will be ± 15%

R7 value (ohm), V_{DD} =5.0V

LED Bin Grade	Min	Typ	Max	Unit
Q	33	-	-	ohm

8. Optical Criterion

8.1 Recommended Red LED Angle Criterion

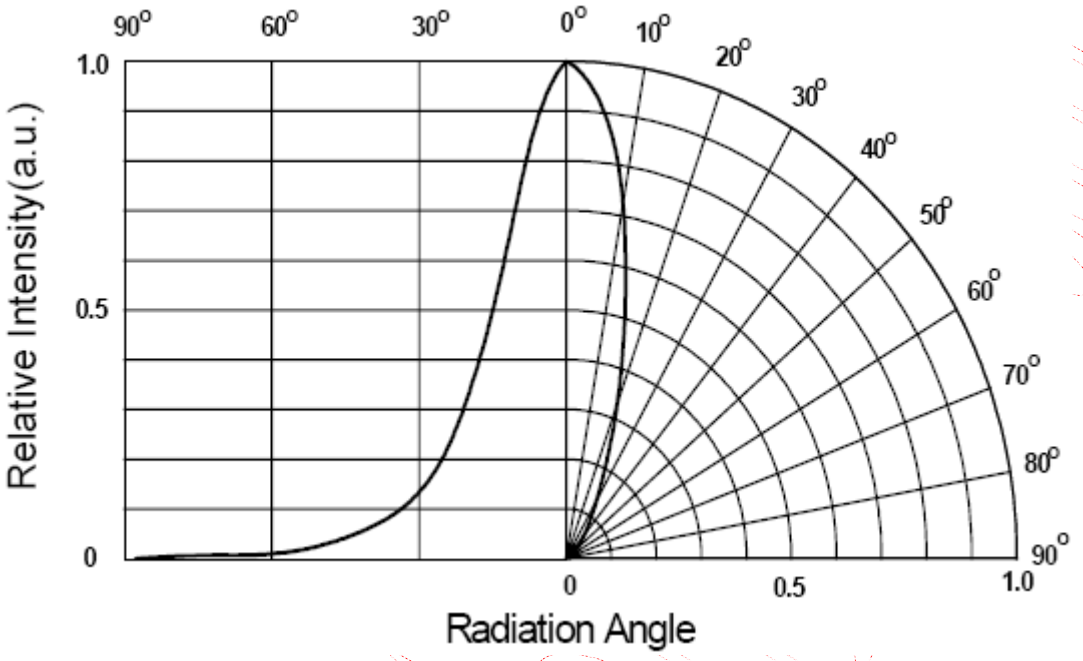


Figure 8. Radiation Characteristics

LED Viewing Angle	Min.	Typ.	Max.
$2\theta_{1/2}$	24	30	36

- Recommended using Chang-Yu LED goniophotometer V110 to measure the LED viewing angle.

8.2 Recommended Value for Optical Power

- In order to tracking performance of PAW3515DB are acceptable and lower power consumption of LED, PixArt recommended value for optical power. By selecting LED bin grade or changing R7 value, optical power can be adjust. Optical power is measured from base plate rectangle hole. LED is DC mode. (Please see optical power measurement method AP note). Recommended using ADCMT power meter 8230E to measure the optical power.

Parameter	Min.	Typ.	Max.	Unit
Optical Power	3000	-	5500	uW

9. Package Information

9.1 Package Outline Drawing

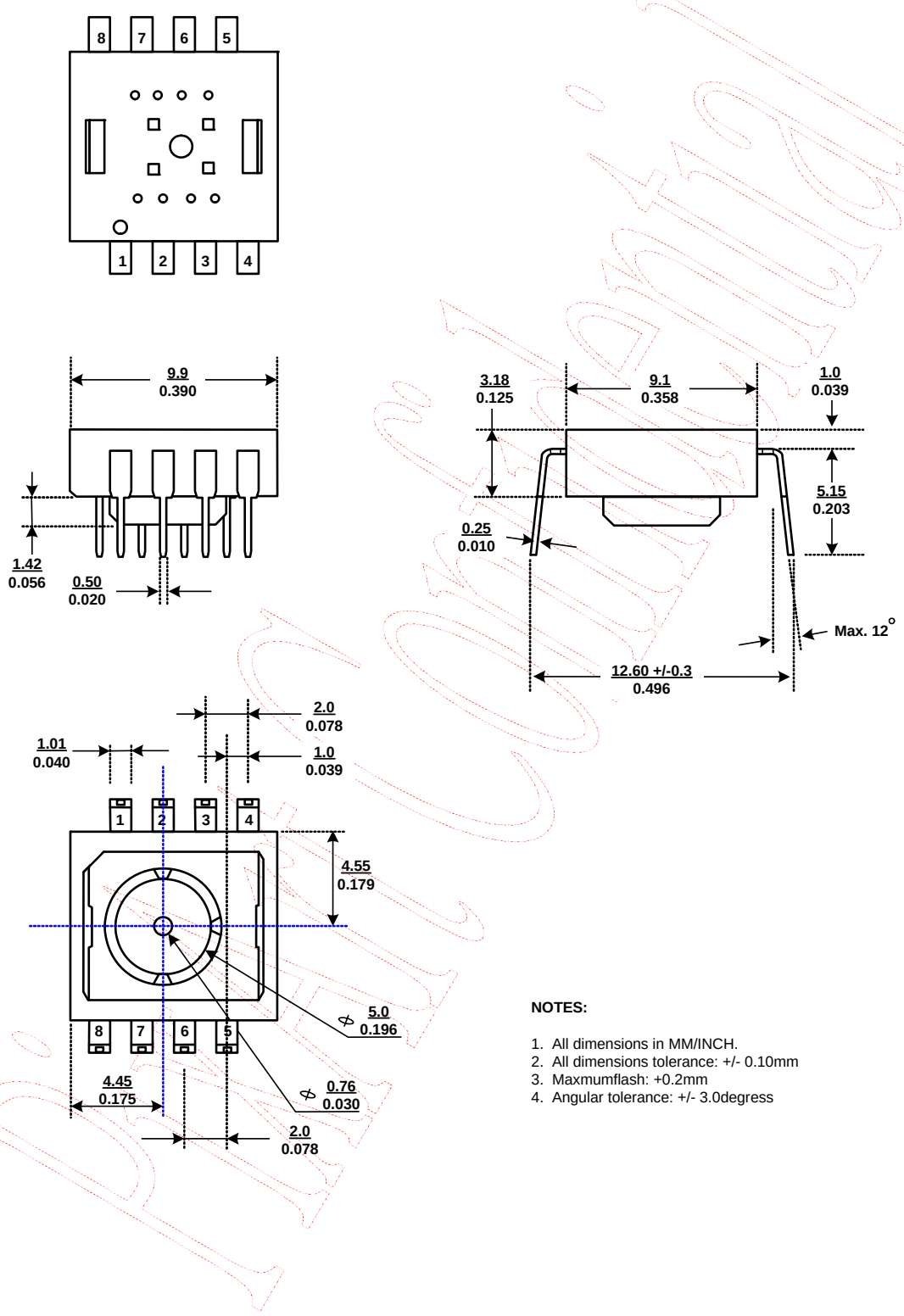


Figure 9. Package Outline Drawing

9.2 Recommended PCB Mechanical Cutouts and Spacing

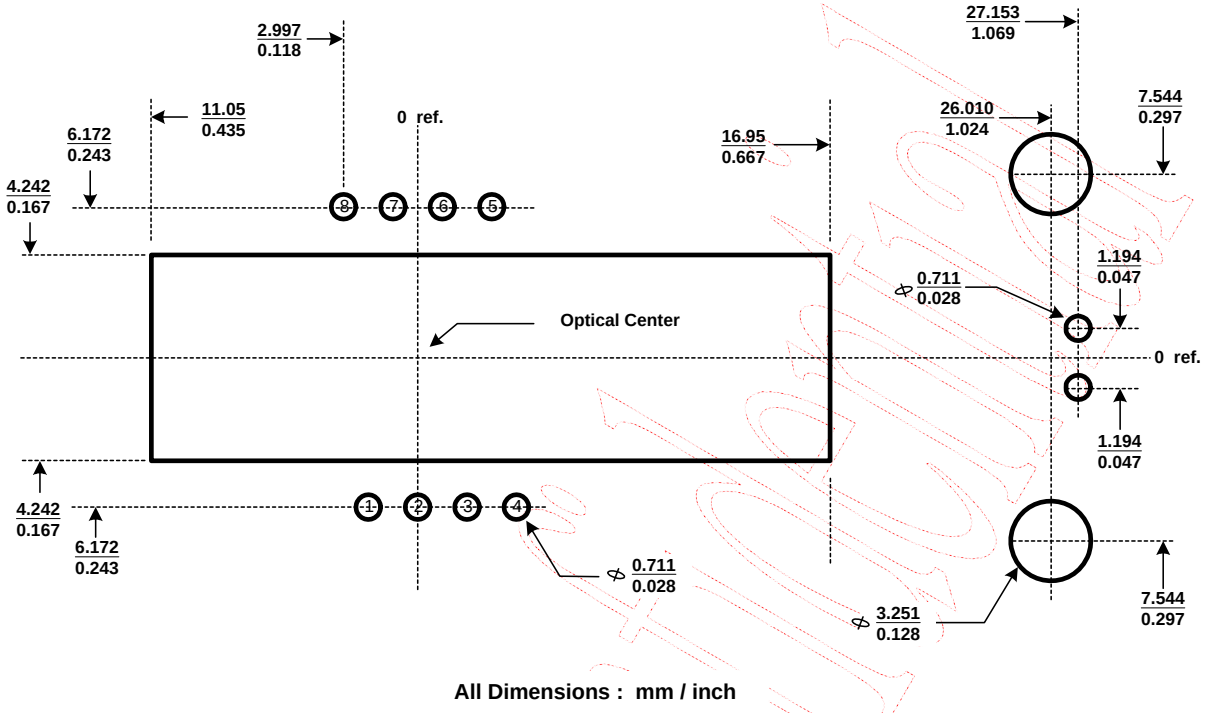


Figure 10. Recommended PCB Mechanical Cutouts and Spacing

10. Update History

Version	Update	Date
V1.0	Creation, Preliminary 1st version	Apr/23/2013