

# PAA5101EW-M: Optical Tracking Miniature Chip

## General Description

The PAA5101EW is a high performance and high accurate optical tracking chip using PixArt LASER/LED hybrid optical navigation technology. It integrates an optical chip with a LASER light source in a single miniature package. When working with an external infrared LED and a PixArt designed companion lens LST0-217, the chip can track on a wide range of material surfaces from white glossy tiles to shag carpets. Besides, the sensor also provides a high DOF range to accommodate to uneven surfaces when tracking.

## Key Features

- Reflowable SMT package with built-in VCSEL LASER light source in a single package
- LASER/LED hybrid optical navigation technology
- Compliance to IEC/EN 60825-1:2014 Eye Safety with Class 1 LASER power output level
- Tracking on glossy surfaces (metal, tiles) by LASER and rough surface (cloth, carpets) by LED with a lens
- Wide DOF range of tracking
- High accuracy of tracking
- Tracking speed is up to 45 ips on glossy metal surfaces
- Support 3-wire SPI interface
- Programmable resolution

## Applications

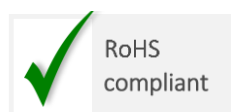
- Devices that requires tracking on surfaces with wide DOF working range
- Devices that requires tracking on surfaces with wide range of material surfaces
- Devices that requires detecting the speed and distance of moving surfaces

## Key Parameters

Parameter	Value
Supply Voltage	VDD : 2.7 ~ 3.6V
Control Interface	3-wire SPI
Companion lens	LST0-217
Light Source	Infrared 850nm LED Infrared 850nm LASER
Max .Tracking Speed	Up to 45ips (LASER mode) UP to 100ips (LED mode)
Operating current (@ VDD = 3.3V)	Run mode : 11.5mA (LASER mode) 44mA (LED mode) Power down : 15uA
Distance from chip top to tracking surface	5 cm
Package Size L x W x H	4.4 x 4.6 x 1.0 mm

## Ordering Information

Part Number	Package Type
PAA5101	LGA 10-pin



For any additional inquiries, please contact us at <http://www.pixart.com/contact.asp>

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## 1.0 Introduction

### 1.1 Overview

PAA5101 is a high performance CMOS-processed optical image chip with integrated digital image process circuits. It is based on PixArt LASER/LED hybrid optical navigation technology which measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the speed, the direction and the magnitude of motion. The displacement X and Y information are available in registers. A host controller can read and translate the displacement X and Y information from the SPI serial interface.

Since LASER and LED are not allowed to turn on at the same time, the host controller should also keep reading the Image Quality registers to determine whether if LASER or LED should be chosen to illuminate the surfaces. In general, when LASER is chosen for illumination, the Image Quality value is high when tracking on tiles and is low when tracking on carpets. On the contrary, when LED is chosen for illumination, the Image Quality is high when tracking on carpets and is low when tracking on tiles.

**Note:** Throughout this document PAA5101 is referred to as the chip.

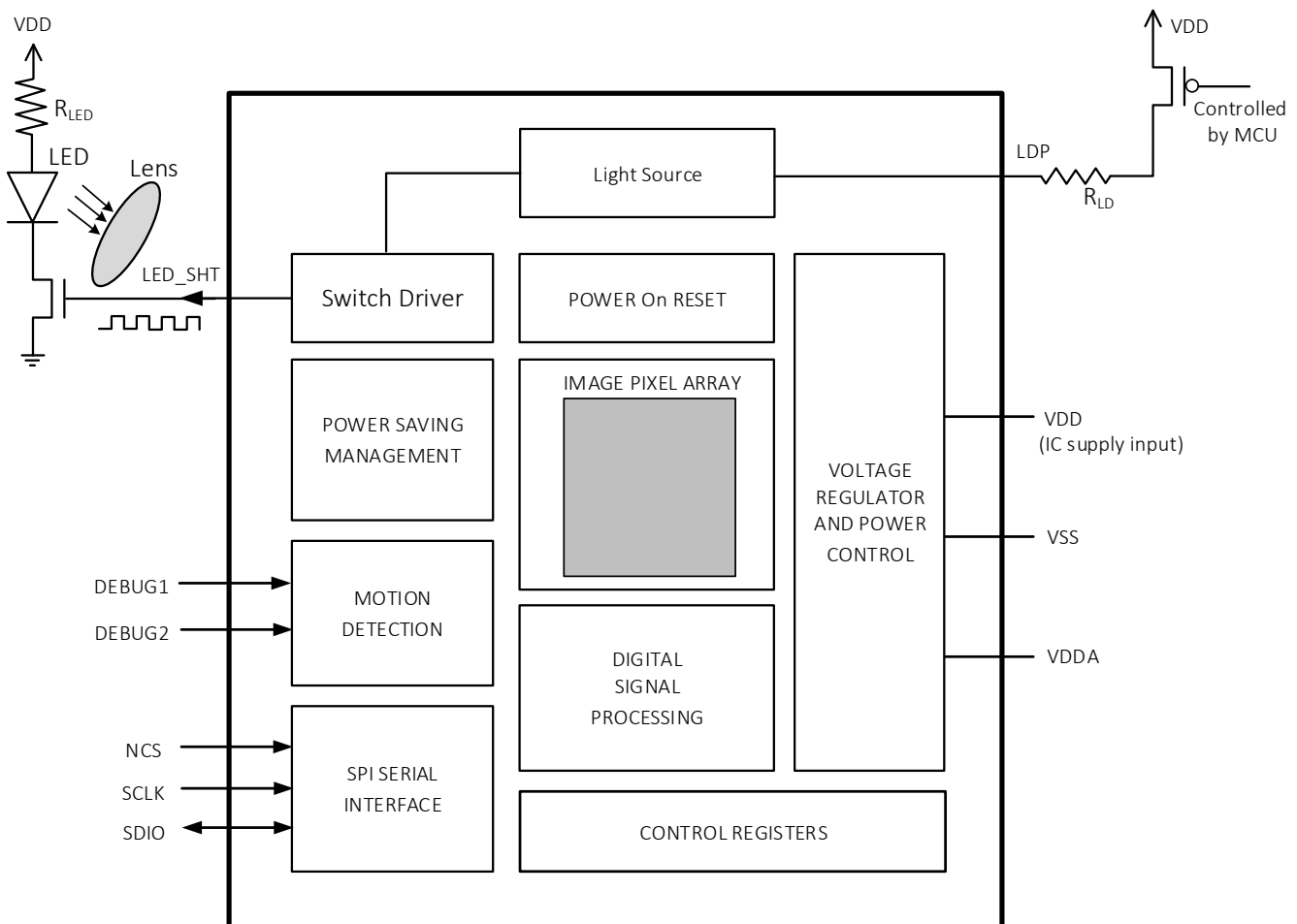


Figure 1. Chip Architecture Functional Block Diagram

## 1.2 Signal Description

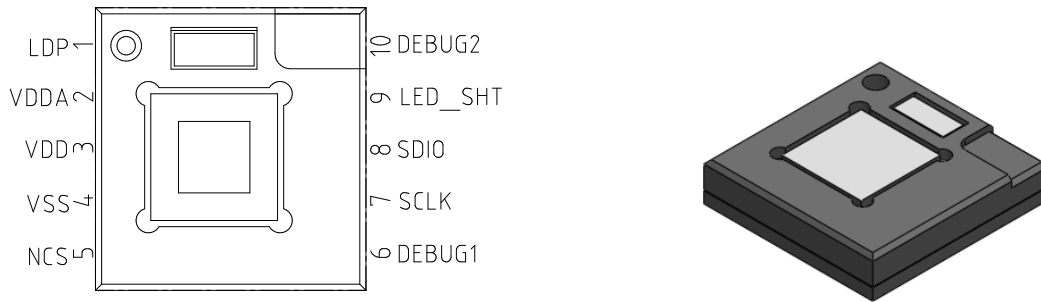


Figure 2. Pinout Configuration

Table 1. Signal Pins Description

Pin No.	Signal Name	Type	Description
1	LDP	PWR	Anode of the VCSEL LASER. This pin should be connected to VDD (2.7V - 3.6V) through a resistor ( $R_{LD}$ ).
2	VDDA	PWR	Internal 1.8V regulator output
3	VDD	PWR	Power supply for I/O and LASER, voltage range : 2.7V ~ 3.6V
4	VSS	GND	Chip ground
5	NCS	IN	Chip select for 3-wire SPI interface (active low)
6	DEBUG1	IN	This pin is for debug purpose and is only for PixArt internal use. In normal operation, this pin should connect a 100k ohm resistor to GND.
7	SCLK	IN	Clock input for SPI interface
8	SDIO	I/O	Bi-directional I/O for SPI interface
9	LED_SHT	OUT	LED Shutter. The shutter control for the external LED light source
10	DEBUG2	NC	This pin is for debug purpose and is only for PixArt internal use. In normal operation, this pin should connect a 100k ohm resistor to GND.

## 2.0 Mechanical Specifications

### 2.1 Package Mechanical Dimension

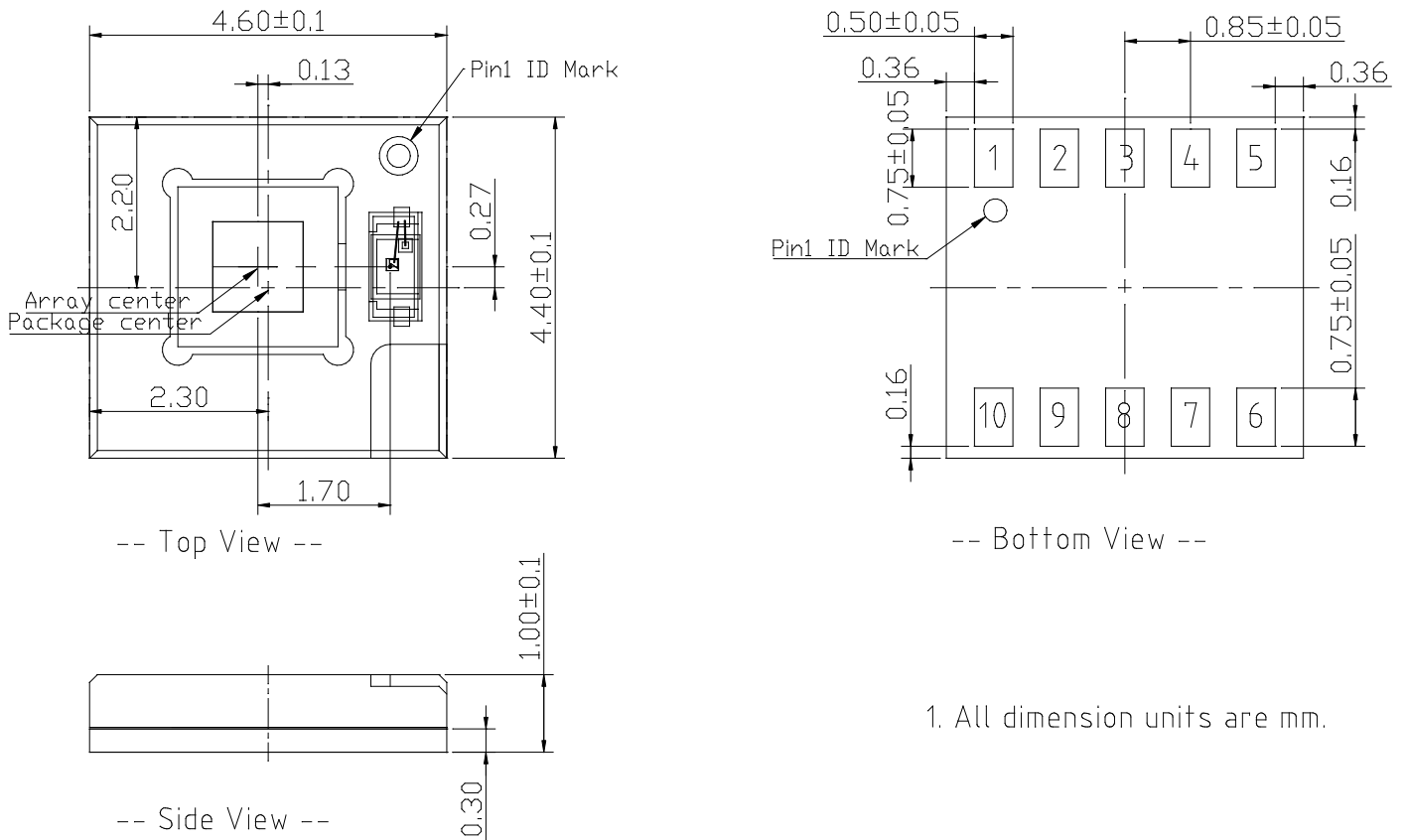


Figure 3. Chip Package Outline Diagram

## 2.2 Lens Mechanical Dimension

NOTES:

1.HAZARDOUS SUBSTANCES REQUIREMENTS: ROHS COMPLIANT,HALOGEN-FREE,REACH COMPLIANCE.

2.THE EJECTOR MARK MUST BE SUNKEN TYPE.

3.GENERAL TOLERANCE RULE IS  $\pm 0.1$

4.UNIT:mm

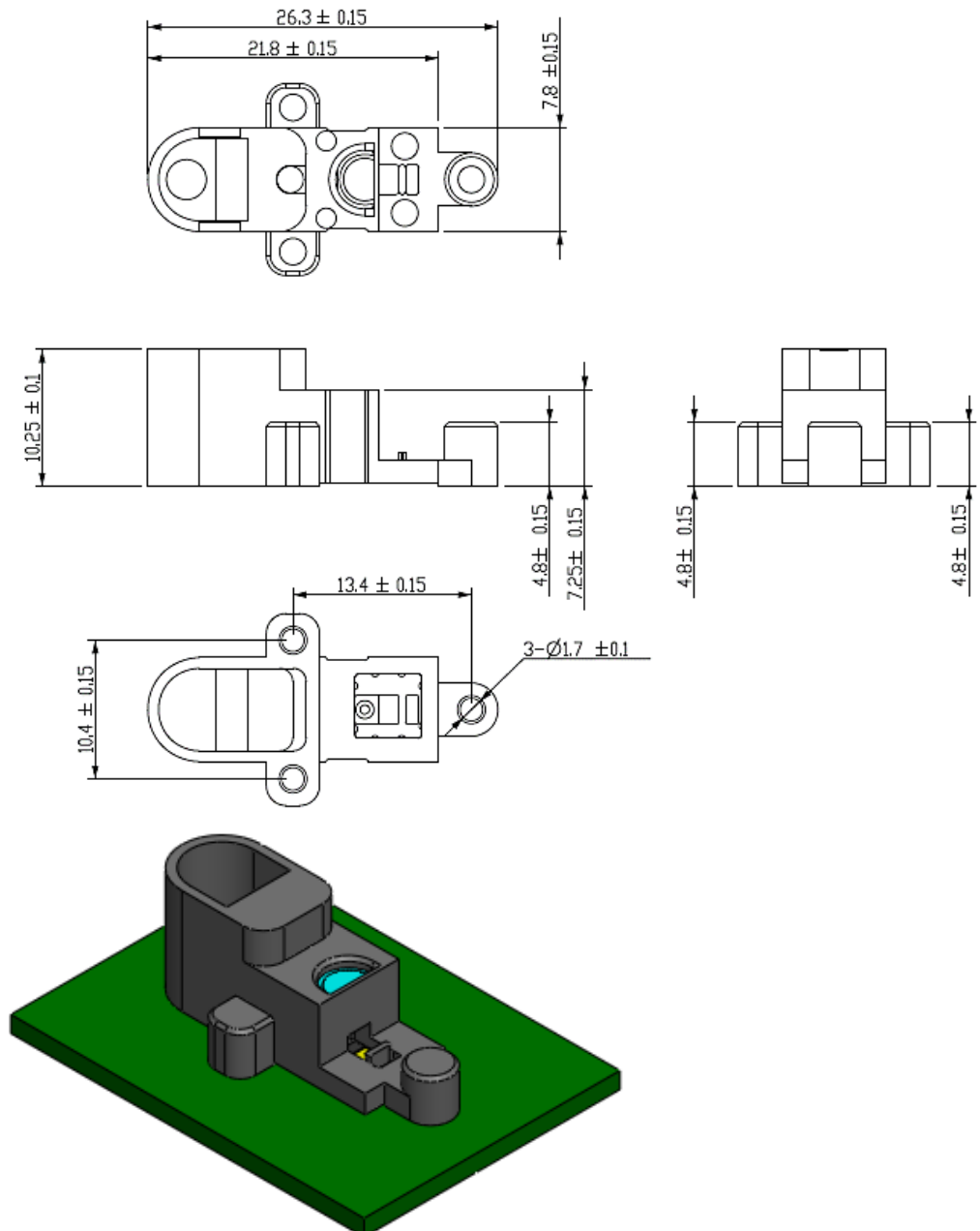


Figure 4. Lens Mechanical Dimensions

2.3 PCB Layout Guides

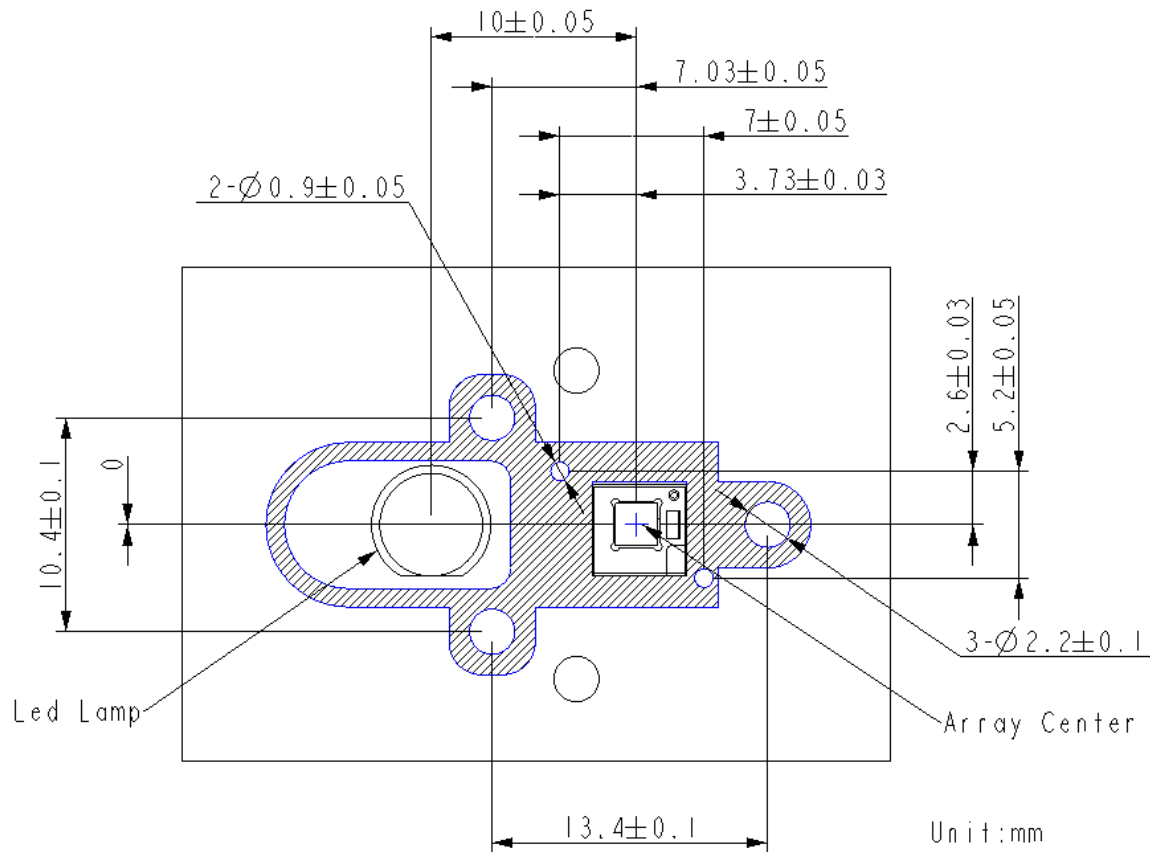
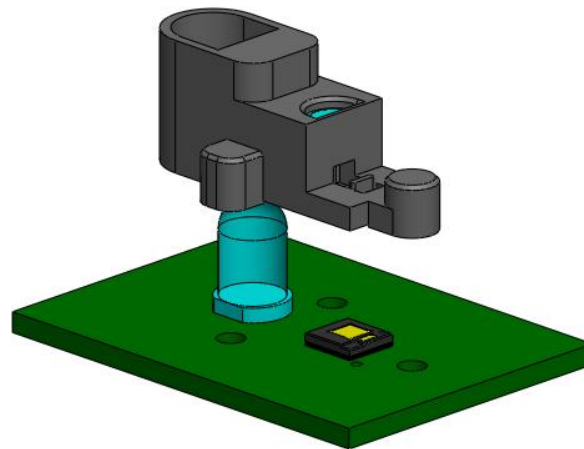


Figure 5. PCB Layout Guides



### 3.0 Operating Specifications

#### 3.1 Absolute Maximum Ratings

Table 2. Absolute Maximum Ratings

Parameters	Symbol	Min.	Max.	Unit	Notes
Supply Voltage	VDD	-0.3	3.9	V	I/O and LASER power
	VDDA	-0.2	2.3	V	Core circuitry power
ESD	ESD <sub>HBM</sub>		2	kV	Class 2 on all pins, as per human body model. JESD22-A114E with 15 sec zap interval.

**Notes:**

1. At room temperature.
2. Maximum Ratings are those values beyond which damage to the device may occur.
3. Exposure to these conditions or conditions beyond those indicated may adversely affect device reliability. Functional operation under absolute maximum-rated conditions is not implied.

#### 3.2 Recommended Operating Conditions

Table 3. Recommended Operating Conditions

Description	Symbol	Min.	Typ.	Max.	Unit	Notes
Storage Temperature	T <sub>STG</sub>	-40	-	85	°C	
Operating Temperature	T <sub>A</sub>	-20	25	60	°C	
Power Supply Voltage	VDD	2.7	3.3	3.6	V	I/O and LASER power supply
Supply Noise (peak to peak)	V <sub>pp</sub>	-	-	100	mV	Peak to peak voltage within 100KHz – 80MHz
SPI Clock Frequency	SCLK	-	-	2	MHz	
Tracking Speed	SP	-	-	45	IPS	on glossy metal surfaces
				100		on white copy paper
Laser Drive Current (DC)	I <sub>LD</sub>	5.0	7.0	8.0	mA	Configured via LD_SRC register

**Note:** PixArt does not guarantee the performance if the operating temperature is beyond the specified limit.

#### 3.3 DC Characteristics

Table 4. DC Electrical Specifications

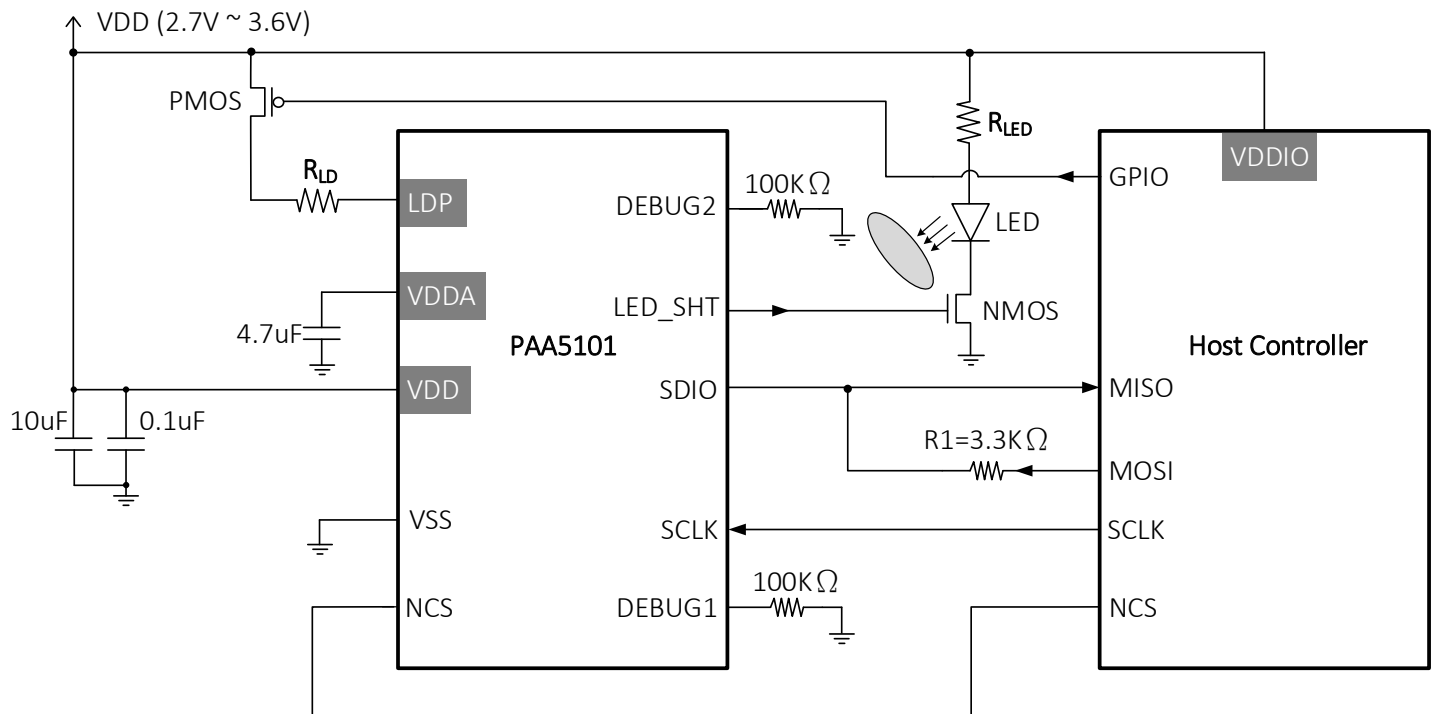
Parameters	Symbol	Min.	Typ.	Max.	Unit	Conditions
Power Consumption	I <sub>VDDRN</sub>	-	10.0 11.5 11.0	-	mA	LASER Run mode tested for: White Tile Black Tile Wooden Flooring
		-	44	-	mA	LED Run mode
	I <sub>VDDPD</sub>				mA	VDD current @power down
I/O Input High Voltage	V <sub>IH</sub>	0.7* V <sub>DD</sub>	-	-	V	
I/O Input Low Voltage	V <sub>IL</sub>	-	-	0.3* V <sub>DD</sub>	V	
I/O Output High Voltage	V <sub>OH</sub>	V <sub>DD</sub> -0.4	-	-	V	@I <sub>OH</sub> = 2mA
I/O Output Low Voltage	V <sub>OL</sub>	-	-	0.4	V	@I <sub>OL</sub> = 2mA

**Notes:** All the parameters are tested under operating conditions: V<sub>DD</sub> = 3.3V (including LASER current), T<sub>A</sub> = 25°C

## 4.0 Design Reference

### 4.1 Reference Application Schematics

The chip only supports simplified 3-wire SPI slave mode, while some host controllers may only support standard 4-wire SPI master mode. In this case, users can connect the host controller to the chip using the method shown below to communicate with each other. Take note that the 3.3K ohm resistor (R1) is for reference only and the resistance may have to be modified according to different I/O capability as per the specification of the host controllers. The resistor  $R_{LD}$  and  $R_{LED}$  are to restrict the current flowing through the LASER and LED. In order not to overdrive the LASER and LED, please adopt the resistance specified on the table.



VDD (Volt)	$R_{LD}(\text{ohm}) \pm 3\%$	$R_{LED}(\text{ohm}) \pm 3\%$
3.6	177	19
3.5	165	18
3.4	152	17
3.3	140	15
3.2	128	14
3.1	115	13
3.0	102	12
2.9	90	11
2.8	78	10
2.7	65	9

Figure 6. Reference Application Schematics

## 5.0 Registers

### 5.1 Registers Summary

Table 5. Registers List

Address	Register Name	Access	Reset	Brief Description
0x00	Product_ID1	R	0x31	Product Identifier [11:4]
0x01	Product_ID2	R	0x61	Upper 4 bits for Product Identifier, PID [3:0] Lower 4 bits for Product Version, VID [3:0]
0x02	Motion_Status	R	-	Motion Status information
0x03	Delta_XL	R	-	Low Byte of X-movement for 16-bit 2's complement data Delta_X[15:0] = {Delta_XH[7:0], Delta_XL[7:0]}
0x04	Delta_YL	R	-	Low Byte of Y-movement for 16-bit 2's complement data Delta_Y[15:0] = {Delta_YH[7:0], Delta_YL[7:0]}
0x06	Configuration	R/W	0x10	Software power down and reset
0x09	Write_Protect	R/W	0x00	Write Protect to avoid missed-writing registers
0x0D	RES_X	R/W	0x27	CPI resolution setting for X-direction
0x0E	RES_Y	R/W	0x2B	CPI resolution setting for Y-direction
0x11	Delta_XH	R	-	High Byte of X-movement for 16-bit 2's complement data Delta_X[15:0] = {Delta_XH[7:0], Delta_XL[7:0]}
0x12	Delta_YH	R	-	High Byte of Y-movement for 16-bit 2's complement data Delta_Y[15:0] = {Delta_YH[7:0], Delta_YL[7:0]}
0x15	Shutter	R	-	Shutter value[7:0]
0x17	Frame_Avg	R	-	Average brightness of a frame
0x51	LD_SRC	R/W	0x0E	Programmable current source for LASER
0x75	IQH	R	-	High byte of IQ (Image Quality) [15:8]
0x76	IQL	R	-	Low byte of IQ (Image Quality) [7:0]

### Document Revision History

Revision Number	Date	Description
0.5	28 May 2018	New creation. DS v0.5
0.6	24 Dec 2018	Modify current consumption