High-resolution non-contact

Position Sensing Detector Mount

PSDM

THORLABS

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We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to come up to your expectations and develop our products permanently we need your ideas and suggestions. Therefore, please let us know about possible criticism or ideas. We and our international partners are looking forward to hearing from you.

Thorlabs Sweden AB

Contents

1 Warranty

Thorlabs Sweden AB warrants material and production of the PSDM for a period of 12 months starting with the date of shipment. During this warranty period *Thorlabs Sweden AB* will see to defaults by repair or by exchange if these, are entitled to warranty.

For warranty repairs or service the unit must be sent back to *Thorlabs Sweden AB (Sweden)* or to a place determined by *Thorlabs Sweden AB*. The customer will carry the shipping costs to *Thorlabs Sweden AB,* in case of warranty repairs *Thorlabs Sweden AB* will carry the shipping costs back to the customer.

If no warranty repair is applicable the customer also has to carry the costs for back shipment.

In case of shipment from outside EU duties, taxes etc. which should arise have to be carried by the customer.

Thorlabs Sweden AB warrants the hard- and software determined by *Thorlabs Sweden AB* for this unit to operate fault-free provided that they are handled according to our requirements. However, *Thorlabs Sweden AB* does not warrant a faulty free and uninterrupted operation of the unit, of the soft- or firmware for special applications nor this instruction manual to be error free. *Thorlabs Sweden AB* is not liable for consequential damages.

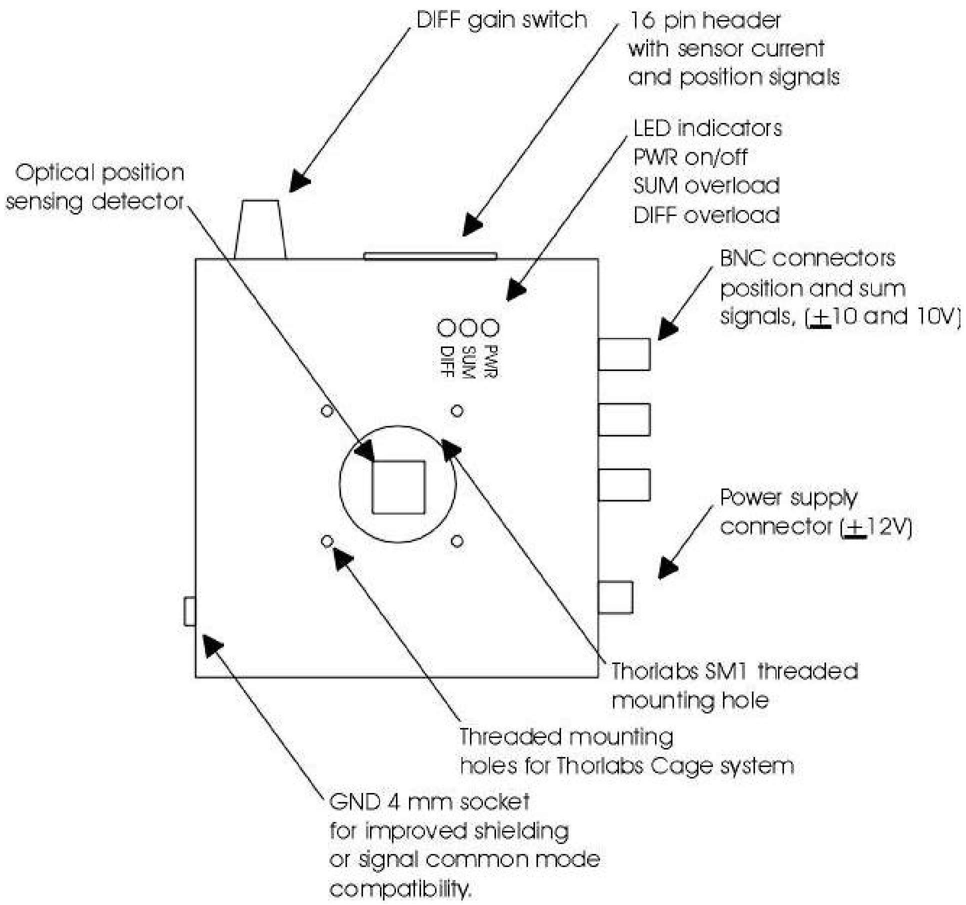
1.1 Restriction of warranty

The warranty mentioned before does not cover errors and defects being the result of improper treatment, software or interface not supplied by us, modification, misuse or operation outside the defined ambient conditions stated by us or unauthorized maintenance.

Further claims will not be consented to and will not be acknowledged. *Thorlabs Sweden AB* does explicitly not warrant the usability or the economical use for certain cases of application. *Thorlabs Sweden AB* reserves the right to change this instruction manual or the technical data of the described unit at any time.

2 Features

- *High resolution, (nm scale), non-contact position sensing in one or two dimensions*
- *Sensitive to wavelengths from 440 to1100nm, (lateral silicon photodiode detector), and 900 to 1700 nm, (quadrant InGaAs detector)*
- *Gain adjustable X and Y position signals*
- *SUM signal for source power indication, source power control feedback or setup alignment*
- *Stable mechanics enables long-term low drift measurements*
- *Mounting holes for Thorlabs Cage system and SM1 mechanics facilitates lens mounting*
- *16 pin header enables sampling of low level signals for fast external signal processing*
- *LEDs on the front panel indicate on/off, position signals limitation and power signal limitation*
- *The PSDM can be mounted to optical tables, posts or other mechanics through three M4 or three 8-32 threaded mounting holes*



3 Applications

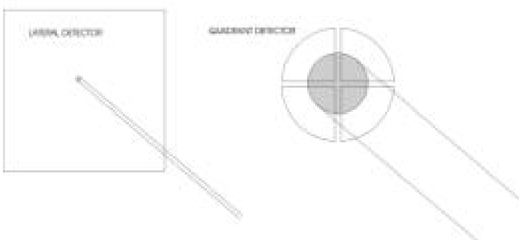
- *General position, angle and motion measurements*
- *Distance measurements through triangulation*
- *Surface measurements*
- *Spectral and color analysis*

4 Introduction

A radiation or light spot on an optical position-sensing detector generates currents that relate to spot position. A PSDM hosts a position-sensing detector and associated electronics that converts detector currents into signals proportional to optical spot position.

The detectors are of two types; lateral silicon photodiodes and quadrant InGaAs photodiodes. The lateral type consists of a single photodiode for continuous, (no pixels), high linearity position sensing and the quadrant of four photo diodes, each shaped as a circle quadrant which together form a circularly detection area. The quadrant detector is especially useful in alignment applications, where alignment target is detector mid position[1].

PSDM 1 to 4 has the lateral detector where detector dimensions increase with model number, whereas PSDM 5 has the quadrant detector. PSDM 1 to 4 can upon request be equipped with an UV enhanced lateral detector for a response down to 200nm.



Optical position detector types used in PSDM

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[1] See chapter 7.2.1

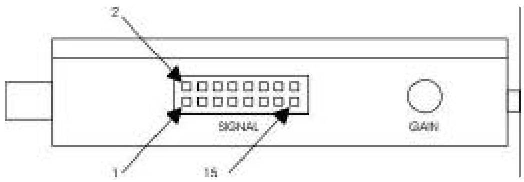
5 Output signals

The X and Y signals are proportional[2] to spot position.

The SUM signal is proportional to optical beam spot power. In order to make position signals independent of spot power, the SUM signal can be used to normalize[3] position with regard to power. Alternatively, use the SUM as a power source control feedback in order to achieve constant beam power.

X:A,B current and Y:A,B current are signals[4] proportional to detector currents, generated by current to voltage converters, (TIA). In order to cancel out offset errors, mainly due to the detector dark current, these signals can be sampled directly for external computation of position, (dark current offsets alone, can be pre measured when source power is blocked).

Signals can be connected through either BNC connectors; (X, Y and SUM only), or through a 16 pin male header



16 pin header seen from top

Signal	Pin
Reference/GND	1, 3, 5, 7..
X:A current	2
X:B current	4
Y:A current	6
Y:B current	8
SUM	10
DIFF X	14
DIFF Y	16

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[2] See chapter 7

3 See chapter 7

[4] See chapter 7

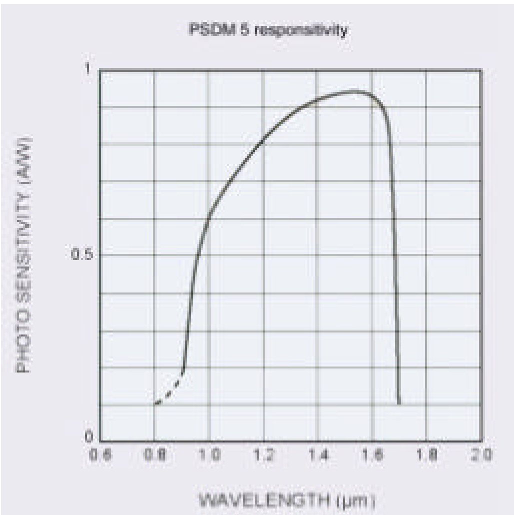
6 Technical data

6.1 Spectral response

6.1.1 Lateral detector PSDM 1 – 4

Lateral detector spectral response

6.1.2 Quadrant detector PSDM 5



Quadrant detector spectral response

6.2 Standard silicon lateral detector, PSDM 1 to 4

Parameter	Unit	Min	Typ	Max	Conditions
Dimensions					Housing
Length	mm		98		
Height	mm		98		
Width	mm		34		
Bottom to detector centre	mm		44		
Power consumption	W		<3		
Wavelength range[5]	nm	440	640	1100	
Detector dimensions PSDM 1 PSDM 2 PSDM 3 PSDM 4	 mm mm mm mm		 4 10 4 x 4 10 x 10		
Resolution[6] BW = 0.1 – 300Hz.			>100 000		Resolves change in position: $\Delta L < \frac{\det ector \dim}{\mathrm{Re}\, solution}$ Single mode beam, (TEM 00) Beam spot near mid position 5V < SUM < 10V
Detector non linearity PSDM 1 PSDM 2 PSDM 3 PSDM 4	 % % % %		 0.1 0.1 0.3 0.3	 0.2 0.2 0.8 0.8	Within 80% of detector dim.
Detector sensitivity[7]	A/W	0,10	0,40	0,69	

[5] See chapter 6.1.1

[6] See chapter 8.1

[7] See chapter 6.1.1

Parameter	Unit	Min	Typ	Max	Conditions
Detector dark current					
PSDM 1	nA		4	20	
PSDM 2	nA		8	50	
PSDM 3	nA		50	200	
PSDM 4	nA		100	500	
Transimpedans gain[8], TIA	V/A		50 000		
Optical power					
Damage threshold	W/cm^2		3		.
Detector current					
position any	uA			100	
position mid	uA			200	
@440 nm	uW			2000	Beam spot at mid pos.
@640 nm	uW			500	Beam spot at mid pos.
@780 nm	uW			350	Beam spot at mid pos.
Signal output range					
X:A and B current	Volt	-10		-5	>10Kohm, low capacitance load
Y:A and B current	Volt	5		10	>10Kohm, low capacitance load
DIFF X and Y	Volt	-10		10	>10Kohm, low capacitance load
SUM	Volt	0		10	>10Kohm, low capacitance load
Signal output bandwidth					
X and Y current	KHz		10		-3dB
DIFF X, Y and SUM	Hz		300		-3dB

[8] See chapter 7.1 and 8.2

6.3 InGaAs quadrant detector, PSDM 5

Parameter	Unit	Min	Typ	Max	Condition
Wavelength range (nm)	nm	900	1550	1700	
Dimension ∅	mm		2		
Optical sensitivity[9] (A/W)					Detector sensitivity
@1300 nm			0.90		
@1550 nm			0.95		
Transimpedans gain, TIA [10]	V/A		10 000		
Optical power					
Detector current					
position any	uA			500	
position mid	uA			2000	SUM signal: 1000 uA max
@1300 nm	mW			2.2	Beam at mid position
@1500 nm	mW			2.1	Beam at mid position
Signal output range					
X:A and B current	Volt	-10		0	>10Kohm, low cap. load
Y:A and B current	Volt	-10		0	>10Kohm, low cap. load
DIFF X and Y	Volt	-10		10	>10Kohm, low cap. load
SUM	Volt	0		10	>10Kohm, low cap. load

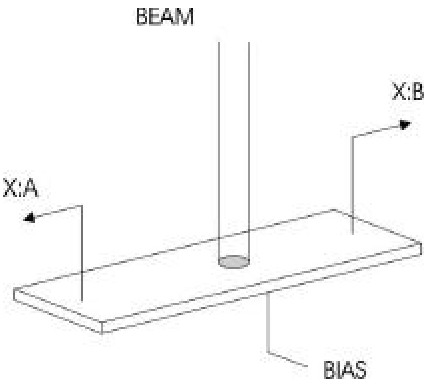
[9] See chapter 6.1.2

[10] See chapter 7

7 PSDM sensing principle

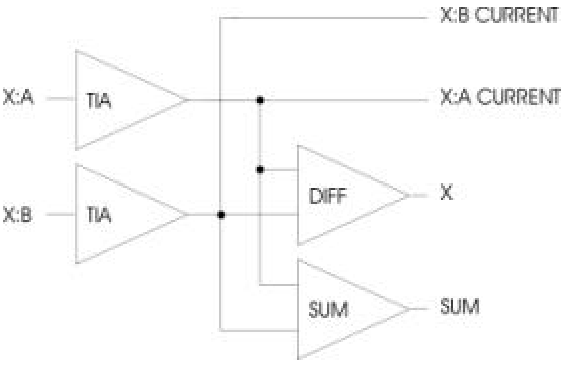
7.1 PSDM lateral detector

A beam spot generates currents through detector terminals X:A and X:B, (one dimensional detector).



One-dimensional lateral detector

The first amplifier stage converts detector currents to voltages after which difference and sum amplifiers generate X and SUM output signals.



PSDM amplifying principle

A normalized position, (independent of power level), can be computed externally either with an analogue division circuit or, if sampled for example by a data acquisition card, by software.

$$POS_{NORM} = \frac{XA - XB}{XA + XB} = \frac{X}{SUM}$$

7.2 PSDM quadrant detector

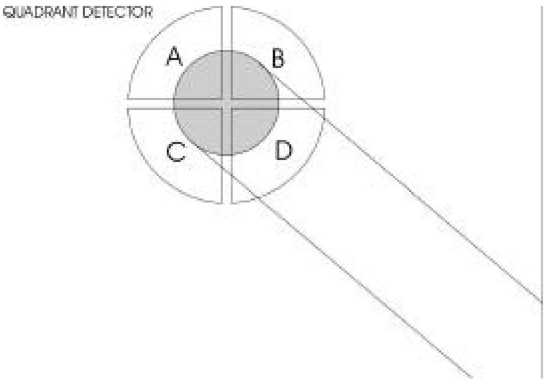
PSDM positions signals are processed according to

$$X = (B + D) - (A + C)$$

$$Y = (A + B) - (C + D)$$

$$SUM = A + B + C + D$$

A, B, C and D are signals proportional to currents from each of the photodiode elements.



Quadrant detector photodiode elements

Normalized position independent of power level can be computed externally by

$$POS_{NORM} = \frac{DIFF}{SUM} = \frac{X}{SUM} OR \frac{Y}{SUM}.$$

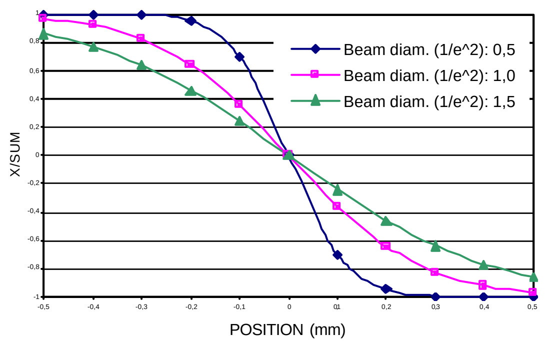
If using low level signals; X:A current etc, compute normalized position according to:

$$POS\_X_{NORM} = \frac{(XA + YA) - (XB + YB)}{XA + XB + YA + YB}$$

$$POS\_Y_{NORM} = \frac{(YA + XB) - (YB + XA)}{XA + XB + YA + YB}$$

7.2.1 Position response

Quadrant detectors for telecom wavelengths, (1300 and 1500 nm), are often used in applications where beams emerge from single mode fibres with a Gaussian intensity distribution. The PSDM position response depends highly on beam diameter, (here defined as where $I = \frac{I_{max}}{e^2}$), as can be seen in plots below.



Normalized quadrant X position signal as a function of actual position, (Gaussian spot)

8 Application information

8.1 Resolution

PSDM position signal resolution is in most cases restricted by beam spot quality, (diameter/focus, centre of gravity stability), and environment. To obtain the full potential of the PSDM, the optical setup should have a non-interfering level of ambient light. Also, the beam direction is sensitive to air currents as they create graded index of refraction in the beam path.

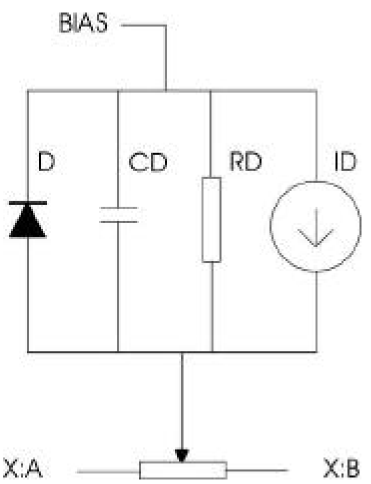
Noise inherent to amplifier electronics is less than 100uV ppk, (measured at X or Y from 0.1 to 300Hz), and the signal span 20V. For example the PSDM 1 and ideal ambient conditions would result in a position resolution better than 5/100000 = 50 nm, measured up to 300 Hz, (see technical data). If measuring with a spot at mid position, set maximum PSDM gain to overcome measuring equipment noise, (digital oscilloscopes can seldom resolve signals below 1 mV).

8.1.1 Beam spot power

A change in power will lead to a change in difference signals X and Y as long as spot position is not zero, (mid position). Consequently, power noise will show up as position noise, which increases with distance to detector mid position. If your measuring resolution is not satisfactory, try to lower power noise, position the spot in mid range or normalize the position with regard to power[11].

8.2 Lateral detector saturation

The lateral detector divides the photocurrent into two resistor sheets. Consequently the bias voltage across the PN-junction decreases with increasing photocurrent. As the bias decreases, photo generated charges will tend to worsen linearity as they will modulate/affect the resistor sheets, (charge build up). If measuring over a long time period, a position signal will tend to drift under such circumstances.



Electrical model of a one-dimensional lateral detector

[11] See chapter 7.1 or 7.2

The PSDM transimpedans gain, (TIA), was chosen to secure a certain amount of bias by not allowing more than 200 uA of detector current, as signals limit when exceeding this amount. A lower beam source power or on/off modulation[12] of beam power might, however, improve further on long-term stability.

8.3 Beam power modulation

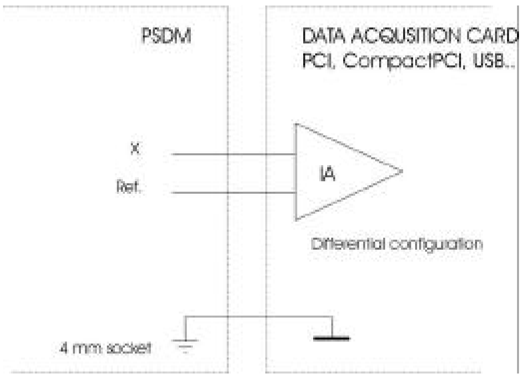
On/off modulation of beam power enables PSDM setups to measure under normal indoor ambient light conditions.

Preferably use electrical modulation of source power, (laser or LED current modulation). In applications where beam path length in air is limited or where high resolution is not required, an optical chopper can be used such as the Thorlabs MC1000.

Use the signals X:A and B[13] current and a modulation frequency of 500 – 1000 Hz.

8.4 Sampling techniques

When measuring several signals with a data acquisition card, preferably configure the card preamplifiers to measure differentially with no coupling to card ground. Connect PSDM GND to the card GND through the PSDM GND 4 mm socket, see figure below.



Recommended connection to data acquisition card

[12] See chapter 8.3

[13] See chapter 7