

1. Description

Polarimeter measures the polarization state of light. The sensor's output is four 12-bit relative intensity values to be recalculated into the normalized Stokes vector parameters. Typical applications include on-line material uniformity inspection or complex refractive index measurement. SMA adapter for optical fiber with C-mount connection is available as an accessory. Sensor can be interfaced to any serial port, digital I/O or controller via four single-ended signals, or the PCI or EISA add-on boards are available with respective software.

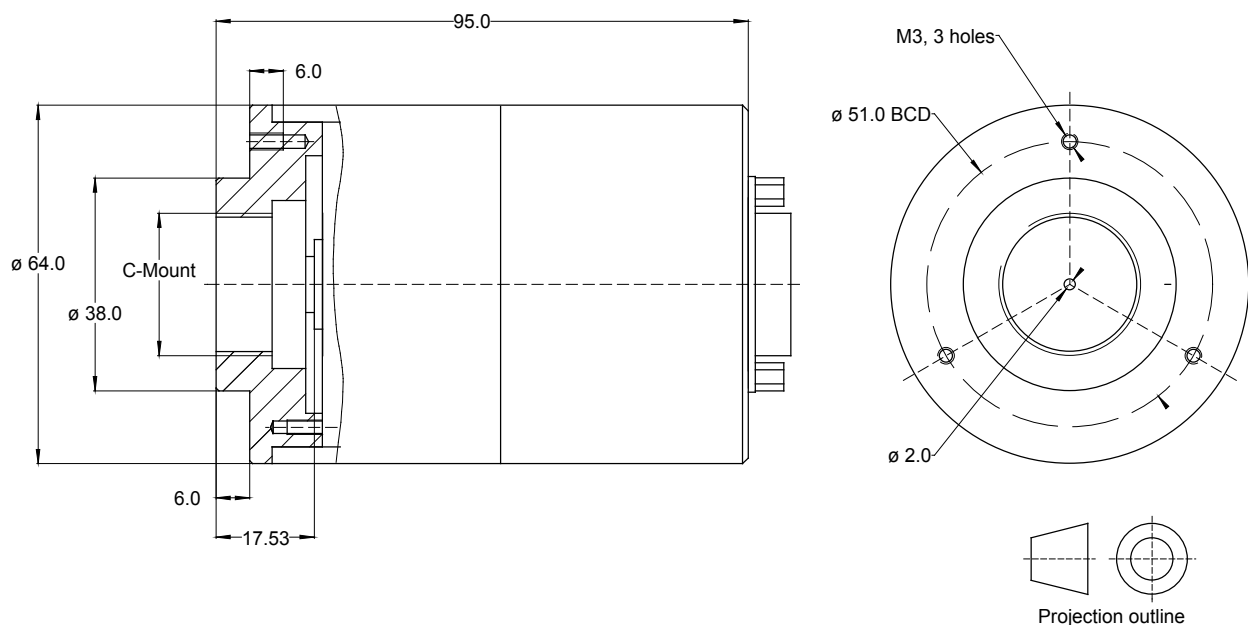
2. Optical specifications

Parameter	Value	Units
Accuracy for the degree-of-polarization	1.0	%
Accuracy for the azimuth angle	0.2	degrees
Accuracy for the ellipticity	0.01	-
Spectral operating range	500-800	nm
Input aperture diameter	2	mm
Measurement rate	up to 50	Hz
Input aperture diameter	2	mm
Spatial reception sensitivity	3	degrees

Polarimeter utilizes the method of rotating a 1/4-wavelength phase plate. Device reports four 12-bit intensity values to be recalculated into the normalized Stokes vector parameters. Signal descriptions and mathematical relations are shown below. Although the recalculation process is not complicated, customers are advised to purchase a PC-interfacing board with respective software to avoid problems with calibration of the device.

3. Mechanical specifications

Parameter	Value	Units
Flange mounting diameter tolerance	-0.05 .. +0.00	mm
Flange mounting depth tolerance	-0.05 .. +0.00	mm
Weight	200	grams
Housing material	Aluminum, anodized flat black	-
Attachment thread	C-mount type (1"x32TPI)	-
Operating temperature range	+10 .. +70	Celsius deg
Protection	IP 54	-
Maximum allowable shock	3	G
Maximum allowable relative humidity	Up to 90% permissible	%
Output connector	9-pin D, male	-



4. Signal conditioning for Polarimeter

Note: A PC board with complete software (see the list of accessories) provides a convenient alternative to intensive math calculations procedures described below.

Getting normalized Stokes vector parameters

Each of four intensity signals I_i returned by the device is represented as following (1), (2):

$$I_i = I_p + I_{np} = (k_{1i} \cdot S_1 + k_{2i} \cdot S_2 + k_{3i} \cdot S_3) + I_{np} \quad (1)$$

$$\begin{cases} k_{1i} = \frac{1}{2} \cdot \sin^2 2\varphi_i \cdot (\cos \Delta - 1) \\ k_{2i} = \frac{1}{4} \cdot \sin 4\varphi_i \cdot (1 - \cos \Delta) \\ k_{3i} = \frac{1}{2} \cdot \sin 2\varphi_i \cdot \sin \Delta \end{cases} \quad (2)$$

- i -current number of measurement, from 1 to 4
- I_p -intensity of the polarized component of light
- I_{np} -intensity of the unpolarized component of light
- S_1, S_2, S_3 -normalized Stokes vector parameters
- k_{1i}, k_{2i}, k_{3i} -coefficients that depend on the current azimuth of the turning phase plate φ and its phase retardation angle Δ

By the polarimeter's design, measurements 1..4 are taken at the following values of ϕ :

- $\phi_1 = 26$ degrees
- $\phi_2 = 52$ degrees
- $\phi_3 = 78$ degrees
- $\phi_4 = 104$ degrees

To obtain the S_1, S_2, S_3 , customer must solve the matrix equation (3) along with the condition (4):

$$\begin{pmatrix} k_{11} & k_{21} & k_{31} & 1 \\ k_{12} & k_{22} & k_{32} & 1 \\ k_{13} & k_{23} & k_{33} & 1 \\ k_{14} & k_{24} & k_{34} & 1 \end{pmatrix} \cdot \begin{pmatrix} S_1 \\ S_2 \\ S_3 \\ I_{np} \end{pmatrix} = \begin{pmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{pmatrix} \quad (3)$$

$$\sqrt{S_1^2 + S_2^2 + S_3^2} + I_{np} = 1 \quad (4)$$

Calibration of the polarimeter

The exact value of the phase retardation angle D depends on the ambient temperature and wavelength of the light being measured. Calibration of the device is essentially a procedure of finding the value Δ . First, expose the device to light with known polarization state. Then calculate the value of Δ using (1), (2).

Example:

To calibrate the polarimeter, linearly polarized light at the azimuth angle of 0 degrees is applied. Then,

$$\begin{cases} S_1 = 1 \\ S_2 = 0 \\ S_3 = 0 \end{cases}$$

Equations (1) will get simplified to (5)

$$\begin{aligned} I_1 &= k_{11} = \frac{1}{2} \cdot \sin^2 2\phi_1 \cdot (\cos \Delta - 1) \\ I_2 &= k_{12} = \frac{1}{2} \cdot \sin^2 2\phi_2 \cdot (\cos \Delta - 1) \\ I_3 &= k_{13} = \frac{1}{2} \cdot \sin^2 2\phi_3 \cdot (\cos \Delta - 1) \\ I_4 &= k_{14} = \frac{1}{2} \cdot \sin^2 2\phi_4 \cdot (\cos \Delta - 1) \end{aligned} \quad (5)$$

Then, any of the (5) can be used to calculate Δ .

4. Electrical specifications and interface

Connection (9-pin D-type connector, male)

Pin #	Function	Description
1	GND	Signal and power supply ground, isolated from the sensor's housing
2	+V	Power supply
3	NC	Not connected
4	NC	Not connected
5	NC	Not connected
6	Signal Latch IN	Input, initiates a measurement session
7	Data OUT	Output, serial synchronous data
8	Clock IN	Input, serial clock
9	Ready OUT	Output, rising edge denotes the end of a measurement session

Electrical parameters

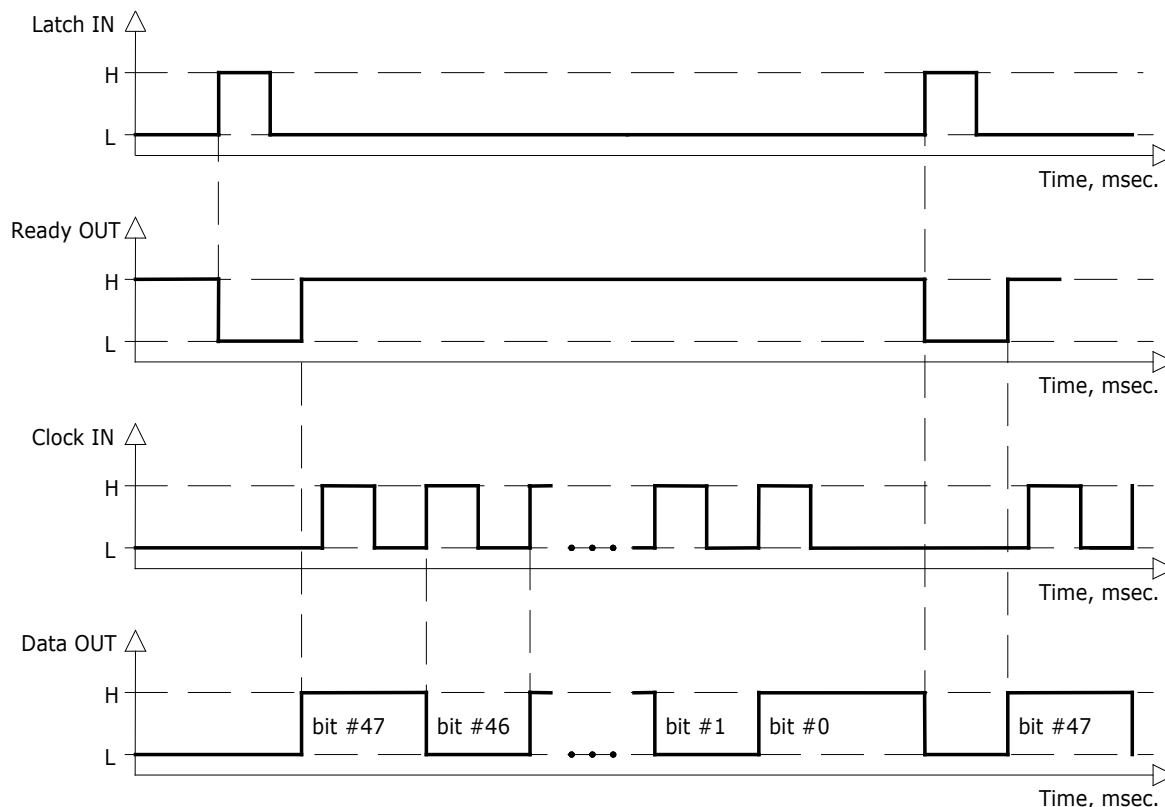
Parameter	Value	Units
Power supply +V	+5 ... +24	Volts
Electrical signal levels for data exchange	RS-232, single-ended	-
Total power consumption	0.3	Watts
Maximum cable length	40	ft
Storage temperature range	-20 .. +80	Celsius deg

Device reports 48 bits of information. The 48-bit data package contains four 12-bit values that must be recalculated later into normalized Stokes vector parameters. Most significant bits for all four values come first.

The Ready OUT cannot be omitted because it relates to the timing of the turning phase retarder in the device.

Timing diagrams

To start a measurement, the Latch IN must be asserted high for at least 1 msec. Then data can be clocked out after the raising edge of the Ready OUT signal. Data clock rate can be up to 500 kHz. Bits are shifted out on the rising edge of the Clock IN signal. First bit of the data package is asserted/valid on the rising edge of the Ready OUT.



5. Available accessories

1. SMA-to-C mount adapter for optical fiber
2. Device-to-PC interface kit. Includes:
 - EISA or PCI add-on board, interfaces up to 4 sensors
 - Power/data cable
 - Data acquisition module for DOS - OBJ-file
 - Data acquisition module for Windows - DLL-unit

Notice

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