Operation Manual

Thorlabs Instrumentation

Balanced polarization diversity detector for PS-OCT

INT-POL-1300

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 hear from you.

Thorlabs GmbH

This part of the instruction manual contains every specific information on how to handle and use the INT-POL-1300. A general description is followed by explanations of how to operate the unit.

☝Attention☝

This manual contains "WARNINGS" and "ATTENTION" label in this form, to indicate danger for persons or possible damage of equipment.

Please read these advises carefully!

NOTE

This manual also contains "NOTES" and "HINTS" written in this form.

1 Overview

The Thorlabs INT-POL-1300 is a subassembly to be used in polarization sensitive swept source Fourier domain OCT systems and other applications. It contains two polarization beam splitters and two balanced detectors.

The S and P polarization states of the optical input signals are split using polarization beamsplitters (PBS). The split inputs are directed into two balanced detectors, one for each SOP. These balanced photodetectors subtract the two optical input signals from each other resulting in the cancellation of common mode noise.

The INT-POL-1300 enables to extract additional information about the birefringence of the sample by calculating the phase retardation between the two balanced outputs.

1.1 Ordering Codes and Customization

Ordering code:

INT-POL-1300

Please refer to www.thorlabs.com for new models.

1.2 Safety

☝ Attention ☝

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.

Before connecting the power supply to the mains make sure that the line voltage range marked on the power supply agrees with your local supply.

The unit must not be operated in explosion endangered environments!

Only with written consent from Thorlabs GmbH may changes to single components be carried out or components not supplied by Thorlabs GmbH be used.

This precision device is only dispatchable if duly packed into the complete original packaging including the plastic form parts. If necessary, ask for a replacement package.

☝ Attention ☝

Mobile telephones, handy phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to EN 50 082-1.

2 Getting Started Quickly

This section is intended to provide information how to quickly set up the INT POL-1300. More details and advanced features are described in further sections.

2.1 Unpacking

The INT-POL-1300 Balanced Polarization Diversity Detector consists of the following items:

- **INT-POL-1300** Balanced Polarization Diversity Detector
- Switchable Power supply (±12V, 250 mA) for 100 V, 120 V, or 230 V line voltage
- Operation manual

NOTE

Please check prior to operation, if the indicated line voltage on the power supply matches with your local mains voltage!

NOTE

If you want to use your own power supply, you can ask Thorlabs for an appropriate power connector cable.

2.2 Setup

- Carefully unpack the unit and accessories. If any damage is noticed, do not use the unit. Call Thorlabs and have us replace the defective unit.
- If necessary, mount the unit on your optical table or application.

- Switch the power supply to your local main voltage (100 VAC, 120 VAC or 230 VAC), see Figure 1.

Figure 1: *Switchable power supply for 100 V, 120 V, or 230 V*

- Plug the power connector cable into the **DC INPUT**.
- Plug the power supply into a 50-60 Hz, 100 VAC outlet (120 VAC, or 230 VAC resp.) and turn it on.
- Connect **RF OUTPUTs** and, if required, **MONITOR** outputs with coaxial cables to your data acquisition device.

2.3 First Operation

- Please note, that all fiber connectors must have a FC/APC connector!
- Connect the INT-POL-1300 to your OCT setup, for further details please refer to section 3.4 Basic Measurement Setup.
- For balanced operation (optimum noise suppression), the power at each detector pair has to be the same. This can be achieved by inserting polarization controllers previous both optical inputs and change the SOP so that both diodes are balanced. The monitor outputs helps to adjust the power to the same level.
- The maximum **RF-OUTPUT** voltage swing is ±3.6 V for high impedance loads (±1.8 V into 50 Ω loads). The **RF OUTPUT** signal should not exceed this maximum output voltage to avoid saturation. If necessary, reduce optical input power at input ports.
- The maximum **MONITOR** voltage swing is +10 V for high impedance loads (+1.5 V into 50 Ω loads). The **MONITOR** signal should not exceed this maximum output voltage to avoid saturation. If necessary, reduce optical input power at input ports.

NOTE

Clean all connectors before plug-in into the module. Please make sure that used connector style is FC/APC.

NOTE

To prevent saturation of the amplifier keep the optical input power less than the saturation power listed in specification.

☝ Attention ☝

Refer to the specification and pay attention to the optical damage threshold!

Exceeding these values will permanently destroy the detectors!

3 Detailed Description

3.1 General Principle of Operation

The Thorlabs INT-POL-1300 is a subassembly to be used in polarization sensitive swept source Fourier domain OCT systems and other applications. It contains two polarization beam splitters and two balanced detectors.

The S and P polarization states of the optical input signals are split using polarization beamsplitters (PBS). The split inputs are directed into two balanced detectors, one for each SOP. These balanced photodetectors subtract the two optical input signals from each other resulting in the cancellation of common mode noise. This allows small changes on the signal path to be extracted from the interfering noise floor for each SOP independently.

The INT-POL-1300 enables to extract additional information about the birefringence of the sample by calculating the phase retardation between the two balanced outputs.

The INT-POL-1300 is powered by the included external power supply (±12 V, 250 mA) via a PICO M8 power connector.

Figure 2 shows a functional block diagram of the INT-POL-1300.

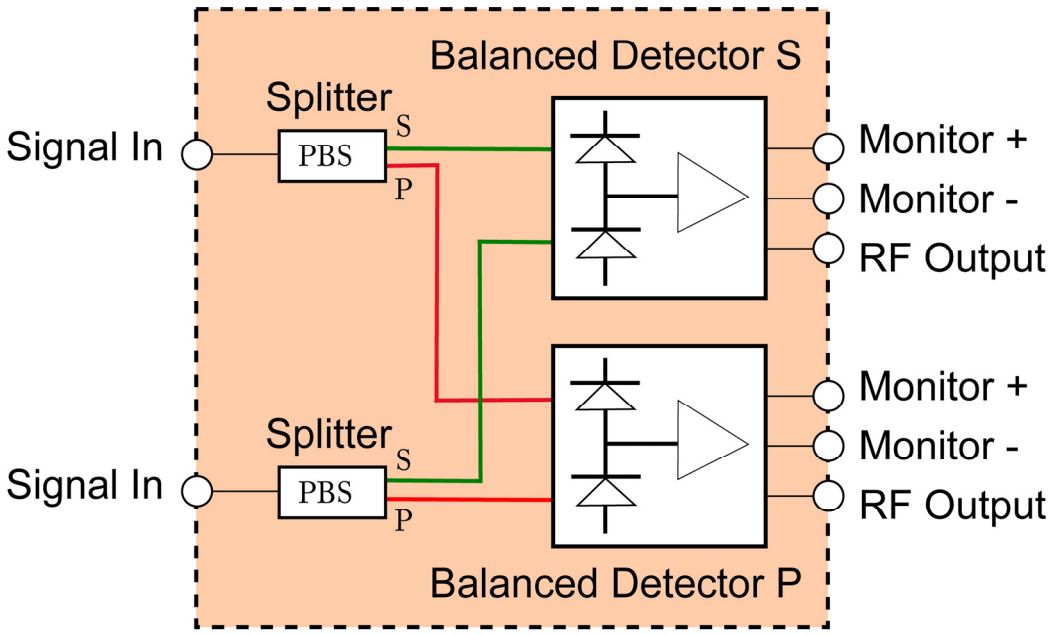


Figure 2: *Functional block diagram of the INT-POL-1300*

3.2 Optical Input and Detector Response

The INT-POL-1300 Balanced Polarization Diversity Detector subassembly is equipped with two FC/APC adaptors to be connected to your application. Corning SMF-28™ single mode fiber is used for internal fiber network. Input polarization has to be adjusted in order to achieve a desired polarization splitting ratio. Depending on input polarization typical insertion loss for each optical path is about 0.5 dB.

NOTE

FC/APC connectors must be used for all INPUT and OUTPUT connectors. Carefully clean the connectors prior to connection.

The internal fiber network is carefully length-matched for both SOP to achieve maximum possible common mode rejection ratio CMRR (maximum noise suppression).

INT-POL-1300 uses pigtailed InGaAs PIN photodiodes. Figure 3 shows a typical responsivity curve for this photodiode type.

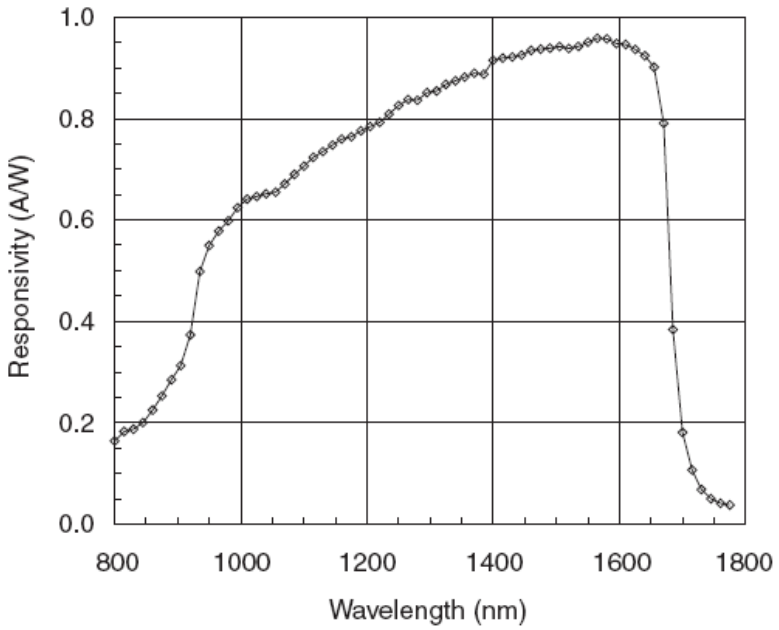


Figure 3: *INT-POL-1300 detector responsivity*

This wavelength dependency affects the output signal amplitude. In order to compensate this responsivity, the measured electrical signal must be multiplied by the normalized wavelength dependent responsivity.

3.3 Electrical Outputs

The INT-POL-1300 contains two separate balanced detectors. Each balanced detector has three SMA output connectors carrying monitoring signals (**MONITOR+ / MONITOR-**) and the balanced output signal (**RF OUTPUT**).

RF-OUTPUT delivers an output voltage proportional to the difference between the photocurrents in the two photodiodes, i.e. the two optical input signals P_{1OPT} and P_{2OPT}, detectors responsivity $\Re(\lambda)$ and transimpedance gain *G* given by:

$$V_{RF\,OUTPUT} = \left(P_{1OPT} - P_{2OPT}\right) \cdot \Re(\lambda) \cdot G$$

The responsivity $\Re(\lambda)$ for a given wavelength can be read from Figure 3 to estimate the RF-OUTPUT voltage. The amplifier's transimpedance gain *G* is $50x10^3$V/A. Please note, that RF-OUTPUT voltage is reduced by a factor of 0.5 if connected to a 50Ω load.

The maximum output voltage swing of the RF-OUTPUT is ±3.6 V for high impedance loads (±1.8 V into 50 Ω). Depending on wavelength responsivity $\Re(\lambda)$ of the detectors the amplifier will reach saturation if the difference between the optical input powers at the detector pair is greater than 80µW. The output signal should not exceed the maximum output voltage to avoid saturation. Please note, that the individual power at each detector can be significantly higher, but not higher than damage threshold listed in Specifications. The power differene can be adjusted by changing the input polarization an each optical input.

The amplifier offset voltage is factory set to zero at 23°C ambient temperature. A small drift during a short warm-up period (~5min) may occur. For exact DC light level measurements a constant temperature environment is recommended.

The 3 dB bandwidth of the **RF OUTPUT** signal is DC-15 MHz. Figure 4 shows a typical frequency response curve of INT-POL-1300 **RF OUTPUT** signal. For this measurement a test signal was applied to one input port only.

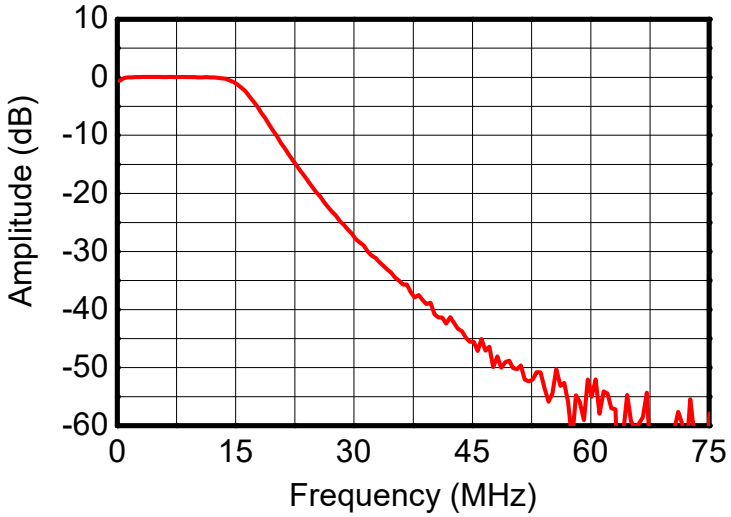


Figure 4: *INT-POL-1300* ***RF*** **OUTPUT** *frequency response*

The balanced detector RF-OUTPUT includes an active filter section to suppress the generation of aliasing frequencies in the digitized fringe signal, which would degrade the quality of the OCT image. The active filter is designed for a sample rate of 50 Msample/sec. Signal frequencies beyond 25 MHz are suppressed by more than 20 dB. For different sample rates, the filter design can be modified accordingly - please contact Thorlabs GmbH for details.

The signal monitor outputs (MONITOR+ and MONITOR-) allow observation of the power levels on each detector and can be used as independent power meters for each channel. The conversion gain of the monitor outputs is 5V/mW. The maximum output voltage swing of the MONITOR output is +10 V for high impedance loads (+1.5 V into 50 Ω). Saturation of MONITOR outputs will occur at optical power level greater than 2 mW, reaching the detector. The power level on each detector depends on PBS splitting ratio, i.e. input polarization. To achieve same power levels polarization controllers previous the optical inputs are needed.

The 3 dB bandwidth of the **MONITOR** signal is DC-5 MHz. Figure 4 shows a typical frequency response curve of INT-POL-1300 **MONITOR** signal. For this measurement a test signal was applied to one input port only. **MONITOR** outputs can be used to measure RF modulated signals on each detector separately.

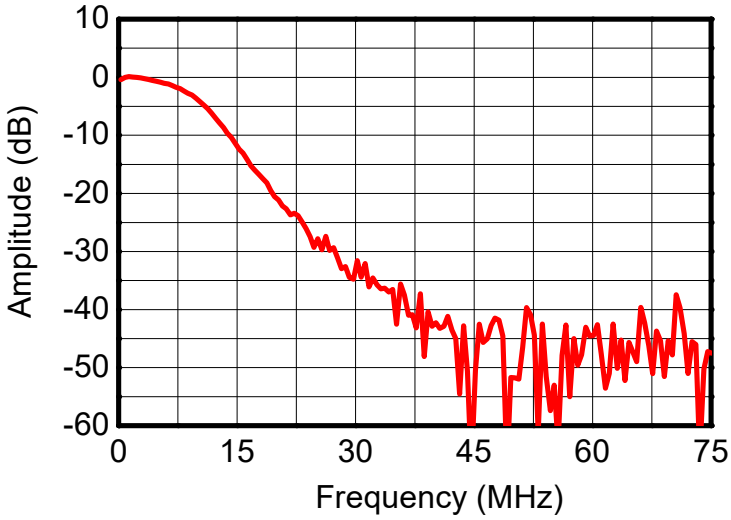


Figure 5: *INT-POL-1300* ***MONITOR*** *output frequency response*

3.4 Basic Measurement Setup

A measurement setup for Polarization Sensitive OCT is shown in Figure 6.

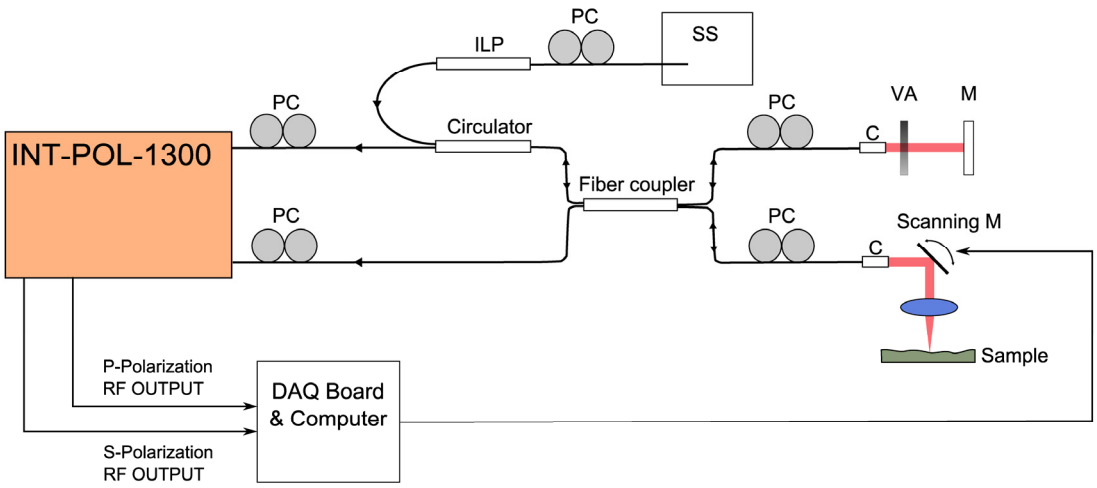


Figure 6 *Schematic setup for PS-OCT*

C Collimator; ILP: in-line polarizer; PC: Polarization Controller; M: Mirror; SS Swept Source, VA Variable Attenuator

As OCT enables high resolution cross sectional imaging by measuring light intensity from the sample, PS-OCT enables to extract additional information about the birefringence of the sample. It uses depth dependent polarization changes of the signal to determine the birefringence of the sample.

The inline polarizer ensures a stable polarization of the input light, here a swept source. The experimental set up is based on a Michelson Interferometer composed by a fiber coupler, a reference and sample arm. The fiber coupler acts as a polarization independent beam splitter and combiner. For individual polarization control of sample and reference arm a PC is build into each interferometer arm. The PC in the sample arm is used to optimize the detection of birefringence of the sample. With the PC in the reference arm it is possible to match the SOP of signal from the reference and sample.

The focused beam is scanned over the sample with a scanning mirror. The reference beam is reflected by a mirror and can be attenuated with a variable attenuator to match the intensity of the back reflected light of the sample.

The polarization controller in front of the input enables polarization adjustment of the signal to balance it at the S- and P- balanced detector. Data processing calculates the phase retardation between the two channels at different sample depth.

4 Maintenance and Repair

☝ Attention ☝

Do not try to open the power supply or the unit! Dangerous or even lethal voltages inside.

To avoid damage, do not expose it to spray, liquids or solvents!

4.1 General Care

Protect the INT-POL-1300 from adverse weather conditions. The INT-POL-1300 is not water resistant.

4.2 Cleaning

To clean the INT-POL-1300 housing, use a mild detergent and damp cloth. Do not soak the unit in water or use solvent based cleaners.

It is not recommended to remove FC adaptors to clean the inner FC/APC connectors. If you suspect a contaminated connector please contact Thorlabs GmbH for a solution. When cleaning FC/APC connectors, please remember that these are sensitive optical devices. Wipe gently with an optic tissue wetted with propane or use a commercial optical fiber connector cleaner.

☝ Attention ☝

To avoid damage, do not remove the FC adaptors and do not try to open the unit!

4.3 Repair

There are no serviceable parts in the INT-POL-1300 or power supply. The INT-POL-1300 does not contain any components to be repaired by the user. If any malfunction should occur or you suspect a problem, please contact Thorlabs GmbH for repair return instructions.

5 Appendix

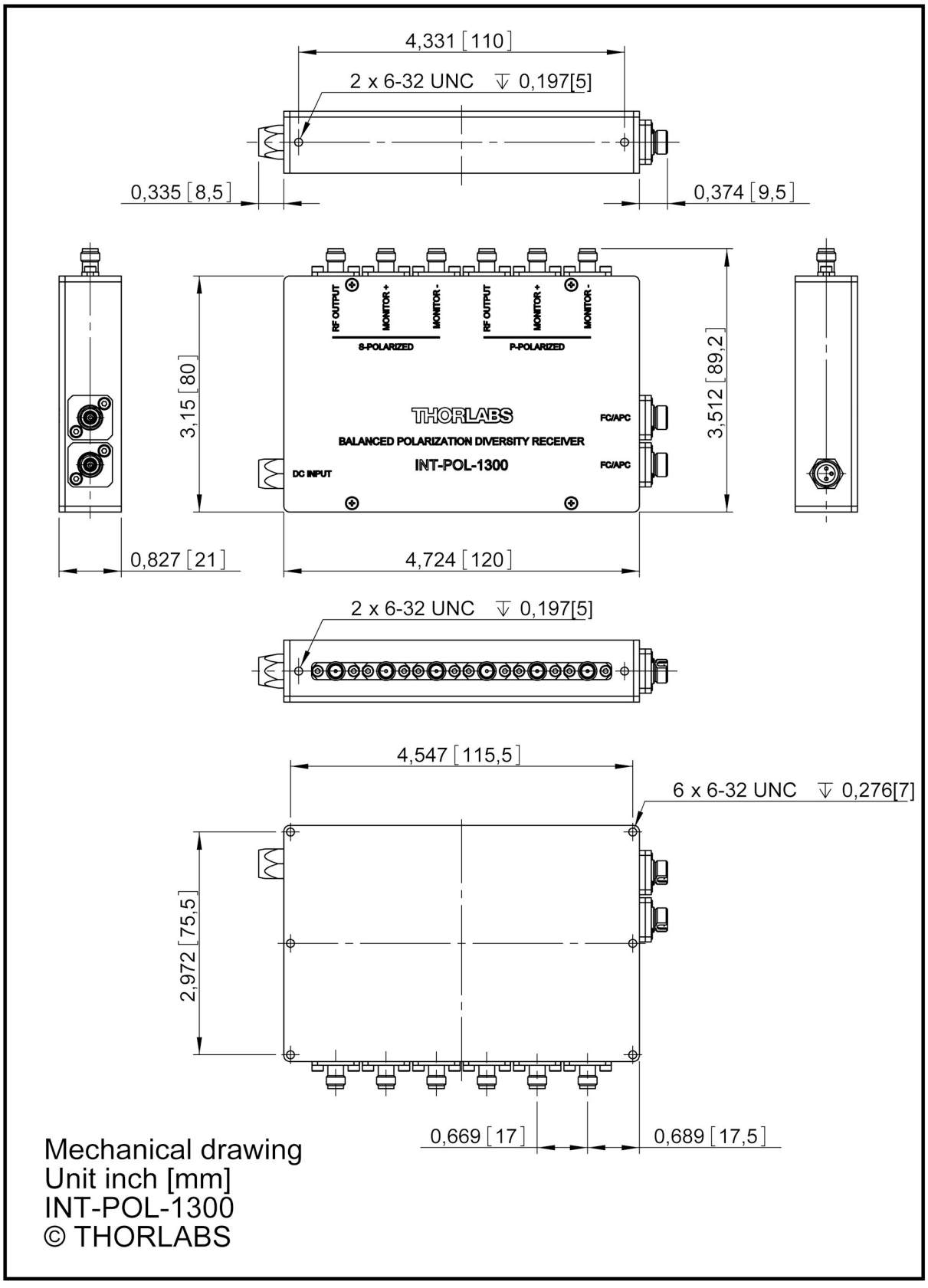
5.1 Technical Data

Model	INT-POL-1300
Optical Parameters	
Wavelength Range	1270 - 1350 nm
Fiber Type	Corning SMF-28
Optical Connectors	FC/APC
Extinction Ratio (PBS)	22 dB
Detector Material/Type	InGaAs / PIN
Detector Wavelengthrange	800 - 1700 nm
Typical Max. Responsitivity	1.0 A/W
Detector Damage Threshold	20 mW
Electrical Parameter	
Output Bandwidth RF Output	DC - 15 MHz
Output Bandwidth Monitor Output	DC - 5 MHz
Transimpedance Gain	50 x 10^3 V/A
Conversion Gain Monitor Outputs	5 V/mW
CW Saturation Power *	80 µW @ 1300 nm
Electrical Output /Impedance	SMA, 50 Ω
DC Offset	±10 mV (max.)
Power Supply	±12 V, 250 mA

***difference between two optical powers on a detector pair**

All accuracy data are valid at 23 ± 5°C and 45 ±15% humidity

5.2 Mechanical Drawings



5.3 Warranty

Thorlabs GmbH warrants material and production of the INT-POL-1300 for a period of 24 months starting with the date of shipment. During this warranty period *Thorlabs GmbH* 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 GmbH (Germany)* or to a place determined by *Thorlabs GmbH*. The customer bears the shipping costs to *Thorlabs GmbH ,* in case of warranty repairs *Thorlabs GmbH* will pay for return shipment back to the customer.
If no warranty repair is applicable the customer bears the costs for return shipment as well.
In case of shipment from outside EU applying customs fees, taxes etc. shall be paid by the customer.

Thorlabs GmbH warrants the hard- and software determined by *Thorlabs GmbH* for this unit to operate fault-free provided that they are handled according to our requirements. However, *Thorlabs GmbH* 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 GmbH* is not liable for consequential damages.

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 GmbH* does explicitly not warrant the usability or the economical use for certain cases of application.

Thorlabs GmbH reserves the right to change this instruction manual or the technical data of the described unit at any time.

5.4 Certifications and compliances

Certifications and compliances

Category	Standards or description	
EC Declaration of Conformity – EMC	Meets intent of Directive 2004/108/EC [1] for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326-1:2006	Electrical Equipment for Measurement, Control and Laboratory Use – EMC Requirements – Part 1: General Requirements: Immunity: complies with basic immunity test requirements [2]. Emission: complies with EN 55011 Class B Limits [2,3] IEC 61000-3-2 and IEC 61000-3-3.
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance Criterion A)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance Criterion A)
	IEC 61000-4-4	Electrical Fast Transient / Burst Immunity (Performance Criterion A)
FCC EMC Compliance	Emissions comply with the Class B Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B [2,3].	
EC Declaration of Conformity - Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Communities: Low Voltage Directive 2006/95/EC [4]	
	EN 61010-1:2001	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
U.S. Nationally Recognized Testing Laboratory Listing	UL 61010-1 2nd ed.	
	ISA-82.02.01 2nd ed.	
Canadian Certification	CAN/CSA C22.2 No. 61010-1 2nd ed.	
Additional Compliance	IEC 61010-1:2001	
Equipment Type	Test and measuring	
Safety Class	Class I equipment (as defined in IEC 60950-1:2001)	

[1] Replaces 89/336/EEC.

[2] Compliance demonstrated using high-quality shielded interface cables shorter than or equal to 3 meters.

[3] Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.

[4] Replaces 73/23/EEC, amended by 93/68/EEC.

5.5 Thorlabs “End of Life” Policy (WEEE)

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return “end of life” units without incurring disposal charges.

This offer is valid for Thorlabs electrical and electronic equipment

- sold after August 13th 2005
- marked correspondingly with the crossed out “wheelie bin” logo (see Figure 7)
- sold to a company or institute within the EC
- currently owned by a company or institute within the EC
- still complete, not disassembled and not contaminated

As the WEEE directive applies to self contained operational electrical and electronic products, this “end of life” take back service does not refer to other Thorlabs products, such as

- pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- components
- mechanics and optics
- left over parts of units disassembled by the user (PCB’s, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

5.5.1 Waste treatment on your own responsibility

If you do not return an “end of life” unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

5.5.2 Ecological background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.
The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of live products will thereby avoid negative impacts on the environment.

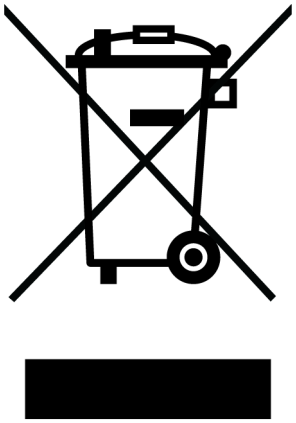


Figure 7: *Crossed out "wheelie bin" symbol*

5.6 List of Figures

5.7 List of Acronyms

The following acronyms are used in this manual:

BW	Bandwidth
C	Collimator
DAQ	Data Acquisition
G	Galvano Scanner
ILP	In Line Polarizer
M	Mirror
NEP	Noise-equivalent Power
OCT	Optical Coherence Tomography
PBS	Polarization Beam Splitter
PC	Polarization Controller
PS-OCT	Polarization Sensitive Optical Coherence Tomography
RF	Radio Frequency
SOP	State Of Polarization
SS	Swept Source
VA	Variable Optical Attenuator

5.8 Addresses

Our company is also represented by several distributors and sales offices throughout the world.

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