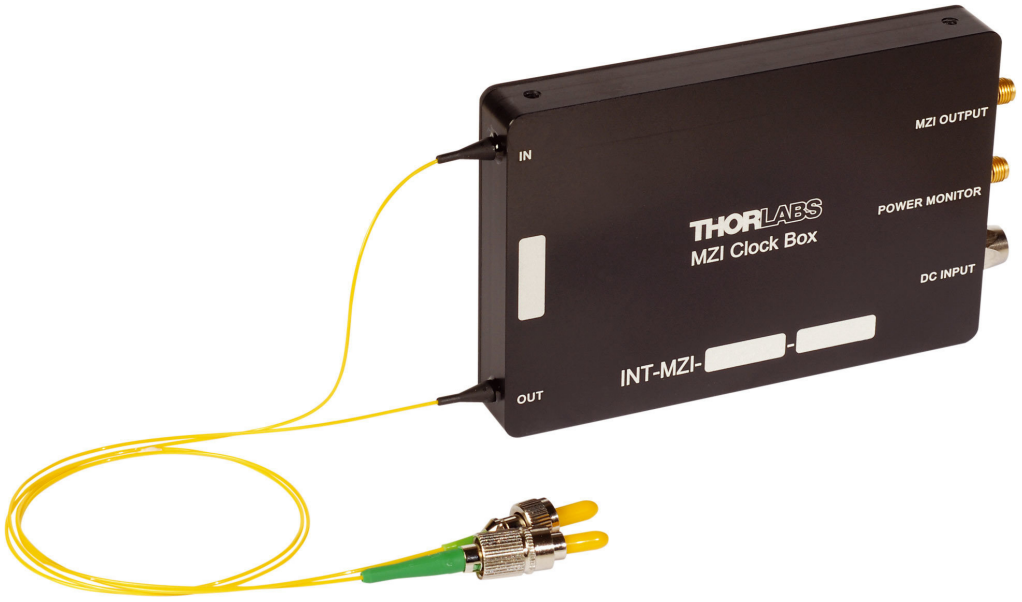
THORLABS

Mach - Zehnder - Interferometer Clock Box

INT-MZI-xxx Series Operation Manual



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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

WARNING

Sections marked with this heading explain dangers that might result in personal injury or death. Always read the associated information carefully before performing the indicated procedure.

ATTENTION

Paragraphs preceded by this symbol in the manual explain hazards that could damage the instrument and connected equipment or may cause loss of data.

NOTE

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

1 General Information

The Thorlabs INT-MZI-xxx series MZI Clock Box is a subassembly to be used in swept source OCT systems and other applications. It contains a fusion coupler network to provide a Power Monitor signal as well as a k-Clock signal to monitor output power and wavelength of a swept laser source. The used fusion couplers are optimized for flat wavelength response and very low PDCR (polarization dependent coupling ratio change) to make the Power Monitor signal nearly independent of input polarization changes.

The “Getting Started Quickly” section below gives an overview of how to set up the INT-MZI-xxx series MZI Clock Box. Subsequent sections contain detailed information about principle of operation, operating suggestions and technical specifications.

1.1 Safety

Attention

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

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

This precision device is only transportable if duly packed into the complete original packaging. If necessary, ask for a replacement package.

1.2 Ordering Codes and Accessories

The following models of INT-MZI-xxx series are available:

INT-MZI-1300	MZI-Clock-Box, 1225-1375nm, FSR 103,3 GHz
INT-MZI-850	MZI-Clock-Box, 780-900nm, FSR 103,3 GHz

Different wavelength ranges can be ordered on request, as well as different Free Spectral Ranges (FSR).

For the standard version, mounting holes are located on the small edges of the enclosure. An alternative cover with four mounting holes as well as a customized cover can be ordered on request.

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

2 Getting Started

2.1 Parts List

Inspect the shipping container for damage. If the shipping container seems to be damaged, keep it until you have inspected the contents and you have inspected the INT-MZI-xxx mechanically and electrically.
Verify that you have received the following items within the package:

- INT-MZI-xxx
- LDS12B Power supply (±12V, 250 mA), 100V, 120V, or 230V line voltage
- Operation manual

2.2 Optional Accessories

Thorlabs offers a DC power supply cable to INT-MZI, the PDA-C-72. This cable has a connector on one end and open wires at the other.

2.3 Setting Up

- If necessary, mount the unit on your optical table or application. The unit has four tapped 6-32 mounting holes (see section 3.5 for details).
- 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, 120 VAC, or 230 VAC outlet, turn power supply on.
- Use coaxial cables with SMA connectors for Power Monitor and MZI Output.

2.4 First Operation

- Connect the INPUT pigtail to the optical source. Make sure that the connector of the source is FC/APC style.
- Connect the OUTPUT pigtail to your application. Make sure that the connector is FC/APC as well.
- The maximum output voltage swing of the Power Monitor output is +3,6 V for high impedance loads (+1.8 V for 50 Ω loads). The output signal should be below this maximum output voltage to avoid saturation. Saturation of the Power Monitor output may occur at optical input power > 50 mW.
- The maximum MZI-Output voltage swing is ±3.6 V for high impedance loads (±1.8 V for 50 Ω loads). The MZI-Output signal should be below this maximum output voltage to avoid saturation. Saturation of the MZI-Output may occur at optical input power > 50 mW.

NOTE
Please note, that the fiber connector style is FC/APC!

NOTE
To prevent saturation of the amplifier keep the optical input powers 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 Operating the INT-MZI-xxx

3.1 General Principle of Operation

The Thorlabs INT-MZI-xxx series MZI Clock Box is a subassembly to be used in swept source OCT systems and other applications. It contains a fusion coupler network and ultra-low noise, high-speed transimpedance amplifiers with low output impedance to provide a Power Monitor signal as well as a k-Clock signal to monitor both the output power and wavelength of a swept laser source. The used couplers are optimized for flat wavelength response and very low PDCR (polarization dependant coupling ratio change) to make the Power Monitor signal nearly independent to input polarization changes.
The INT-MZI-xxx series is powered by the included external mains power supply (±12 V, 250 mA) via a PICO M8 power connector.
Figure 2 shows the functional block diagram of the INT-MZI-xxx series MZI Clock Box.

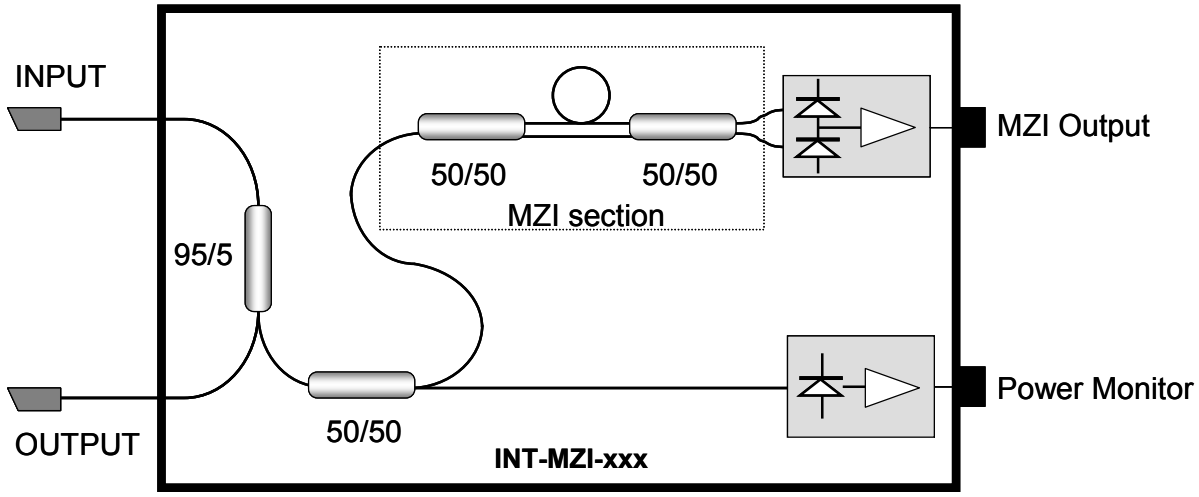


Figure 2: Functional block diagram of the INT-MZI-xxx series

3.2 Optical Input and Output, Fiber Network

The INT-MZI-xxx MZI Clock Box subassembly is equipped with ~50 cm long INPUT and OUTPUT pigtails with FC/APC connectors to be connected to your application. Model INT-MZI-1300 uses Corning SMF28™ single mode fiber. Model INT-MZI-850 uses Nufern 780-HP™ single mode fiber.

NOTE
FC/APC connectors are used for INPUT and OUTPUT pigtails!

Saturation of the electrical outputs may occur at optical input power > 50 mW. The optical damage threshold is 250 mW. Exceeding this value may permanently destroy photo detectors!

An internally fiber network is used to tap ~5% of the input light to generate Power Monitor and k-Clock signals. The remaining light is transmitted to the Output pigtail. Insertion loss (Input to Output) is less than 1 dB (model INT-MZI-1300), including connector losses. This tap coupler is designed for nearly flat transmission wavelength response (see Figure 3).
The sophisticated design of the 50/50 fusion coupler provides a Power Monitor output signal with flat wavelength response, which is nearly insensitive to input polarization changes. Figure 4 shows the typical spectral behavior of the INT-MZI-1300 measured from Input to Power Monitor output port.

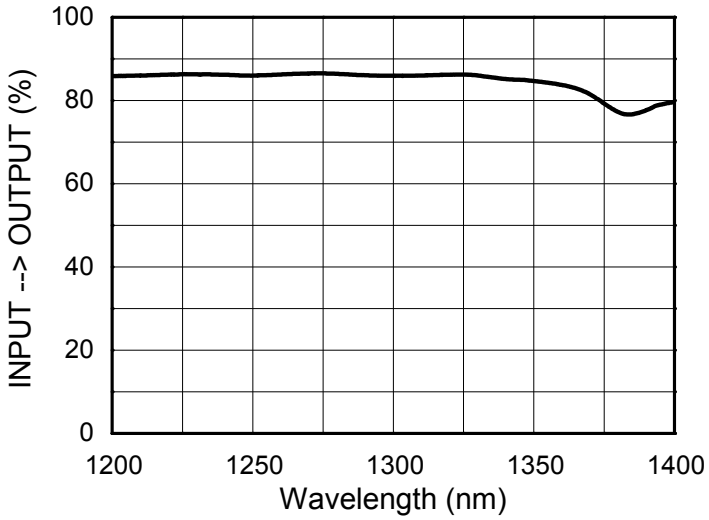


Figure 3: INT-MZI-1300 coupling ratio from INPUT to OUTPUT

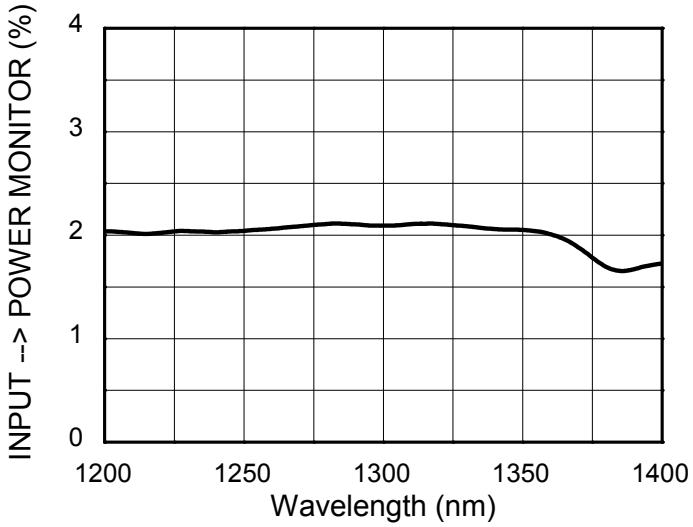


Figure 4 : INT-MZI-1300 coupling ratio from INPUT to POWER MONITOR

The tapped light is split into the Power Monitor signal and the k-Clock signal. The k-Clock signal is generated by an Mach-Zehnder interferometer section. Path length difference of the MZI section is about 2 mm to achieve 100 GHz free spectral range. Figure 5 shows a typical measurement of the MZI section.

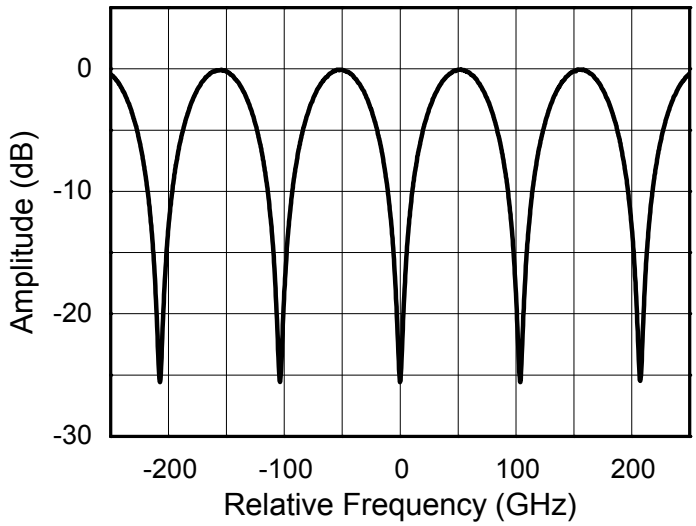


Figure 5: INT-MZI-1300 spectral behavior of the MZI section

Please note, that the INT-MZI-xxx can also operate outside the specified wavelength range. It will generate expedient output signals, but Specifications cannot be guaranteed.

3.3 Electrical Outputs

The INT-MZI-xxx series has two output SMA connectors carrying monitoring signals of the Power Monitor and the k-Clock signal (MZI Output).

3.3.1 Power Monitor

Power Monitor output delivers an output voltage proportional to optical input power. The Power Monitor signal is detected by a photodiode and amplified by an ultra-low noise, high-speed transimpedance amplifier. The maximum output voltage swing of the Power Monitor output is +3,6 V for high impedance loads (+1.8 V for 50 Ω loads). The output signal should be below this maximum output voltage to avoid saturation. Saturation of the Power Monitor output may occur at optical input power > 50 mW. The 3 dB bandwidth of the Power Monitor output is typically in excess of 200 MHz. Figure 6 shows a typical frequency response curve of the Power Monitor output of an INT-MZI-1300.

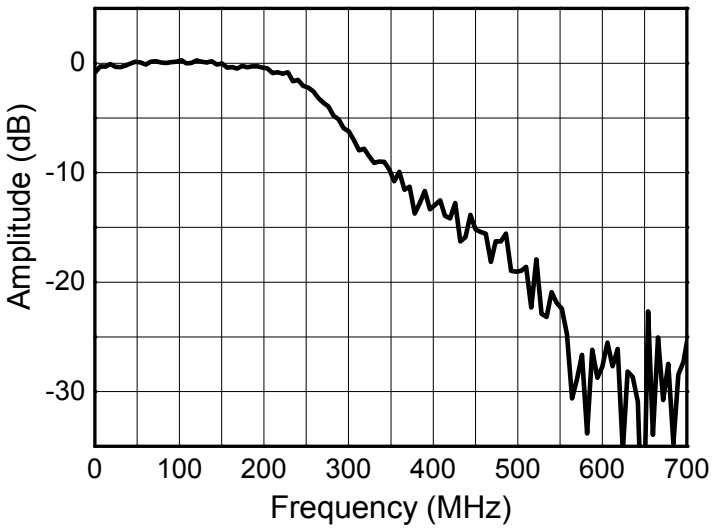


Figure 6: INT-MZI-1300 POWER MONITOR frequency response

3.3.2 MZI Output

MZI Output generates a periodical signal if the wavelength of the INPUT signal is changing. This signal shows maxima and minima which are equally spaced in optical frequency domain (k-space). The difference between two maxima is defined by the FSR, here 103.3 GHz (please refer to 5.1 Technical Data). As a practical application, the zero-crossing of MZI Output signal can be used to detect (trigger) a change of input frequency, equal to the FSR. For example, in OCT imaging applications rapidly swept laser sources are used, typically with sinusoidal tuning elements, to achieve the required very fast optical frequency sweep speed. As for this reason, a reliable and accurate recalibration of the OCT signal is required in order to achieve data points equidistant in frequency.
The amplitude of MZI Output is proportional to optical input power. Both output signals of the MZI section are fed into two well-matched photodiodes representing a balanced detector; the balanced signal is amplified by an ultra-low noise, high-speed transimpedance amplifier. The maximum output voltage swing of the MZI Output is ±3,6 V for high impedance loads (±1.8 V for 50 Ω loads). The output signal should be below this maximum output voltage to avoid saturation. Saturation of the MZI Output may occur at optical input power > 50 mW. The 3 dB bandwidth of the MZI Output is typically in excess of 200 MHz. Figure 7 shows typical frequency response curves of the MZI Output for model INT-MZI-1300.

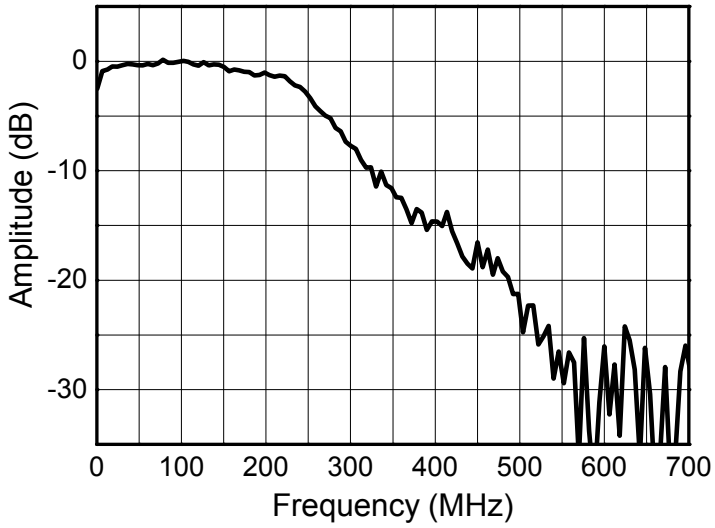


Figure 7: INT-MZI-1300 MZI OUTPUT frequency response

3.4 Detector Responsivity

Model INT-MZI-850 uses silicon PIN photodiodes while model INT-MZI-1300 uses InGaAs PIN photodiodes. Figure 8 and Figure 9 show typical responsivity curves for each photodiode type.

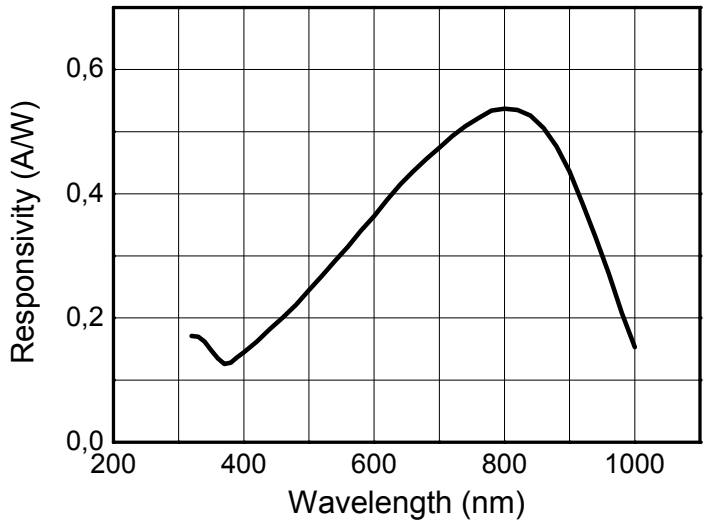


Figure 8: INT-MZI-850 detector responsivity

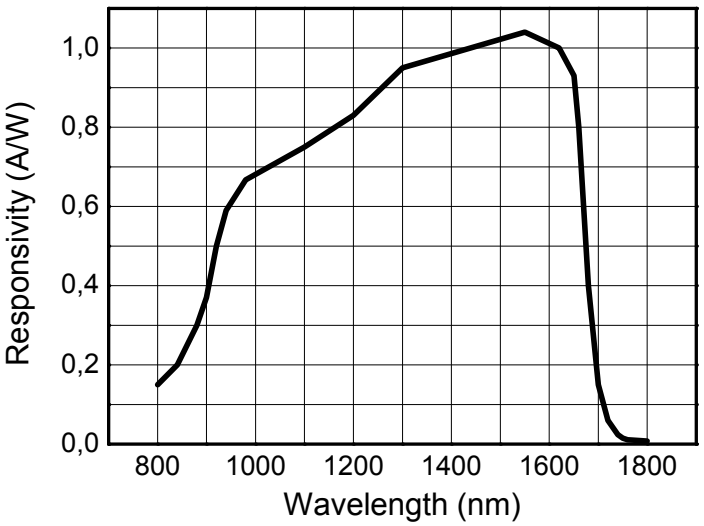


Figure 9: INT-MZI-1300 detector responsivity

The photodiodes responsivity affects both the Power Monitor output and the MZI Output amplitude. To compensate the photodiode wavelength responsivity, measured electrical signals should be multiplied by the normalized wavelength dependent responsivity.

3.5 Mounting the INT-MZI-xxx series

The INT-MZI-xxx series is housed in a rugged 120x80x16 mm shielded aluminum enclosure. The unit can be attached to the side surface (small edges) by 6-32 screws, see Figure 10. The thread is 6 mm deep.

An alternative cover with four mounting holes or a customized cover can be ordered on request, see Figure 11.

Figure 10: Possible mounting points for INT-MZI-xxx

Figure 11: INT-MZI-xxx with alternative cover

3.6 Recommendations

It has been observed, that some combinations of FC/APC patch cords and FC adaptors from different vendors may lead to different insertion loss values. Thorlabs is checking the insertion loss specification with its own FC/APC patch cords as well as with FC/APC patch cords from Diamond. If insertion loss of the INT-MZI-xxx seems to high (higher than listed in specifications), please try another FC/APC patch cord and/or adapter combination.

Due to the smaller core diameter of the 780-HP fiber used for INT-MZI-850, a higher connector coupling loss may occur. Even smallest mechanical tolerances remarkably impact the insertion loss. In such cases it is recommended to loose and fit the connectors to find a optimal value.

A further reduction of insertion loss, especially for INT-MZI-850, can be achieved using fusion splices instead of FC/APC connectors. For details please contact Thorlabs.

Although the Power Monitor signal is nearly independent to input polarization changes, a stable input polarization during measurement is recommended in order to increase accuracy. Fixing the input fiber to the optical table surface is sufficient in most cases.

Please note, that the INT-MZI-xxx can also operate outside the specified wavelength range. It will generate expedient output signals, but specifications cannot be guaranteed.

4 Maintenance and Repair

Protect the INT-MZI-xxx from adverse weather conditions. The INT-MZI-xxx is not water resistant.
To avoid damage to the instrument, do not expose it to spray, liquids or solvents**!**
The unit does not need a regular maintenance by the user. It does not contain any modules and/or components that could be repaired by the user himself. If a malfunction occurs, please contact Thorlabs (see section 5.7. Thorlabs Worldwide Contacts, page 19) for return instructions.
Do not remove covers!

4.1 Cleaning

To clean the INT-MZI-xxx series housing, use a mild detergent and damp cloth. Do not soak the unit in water or use solvent based cleaners.
When cleaning the FC/APC connectors, please remember that is a sensitive optical device. Wipe gently with an optic tissue wetted with propane or use a commercial optical fiber connector cleaner.

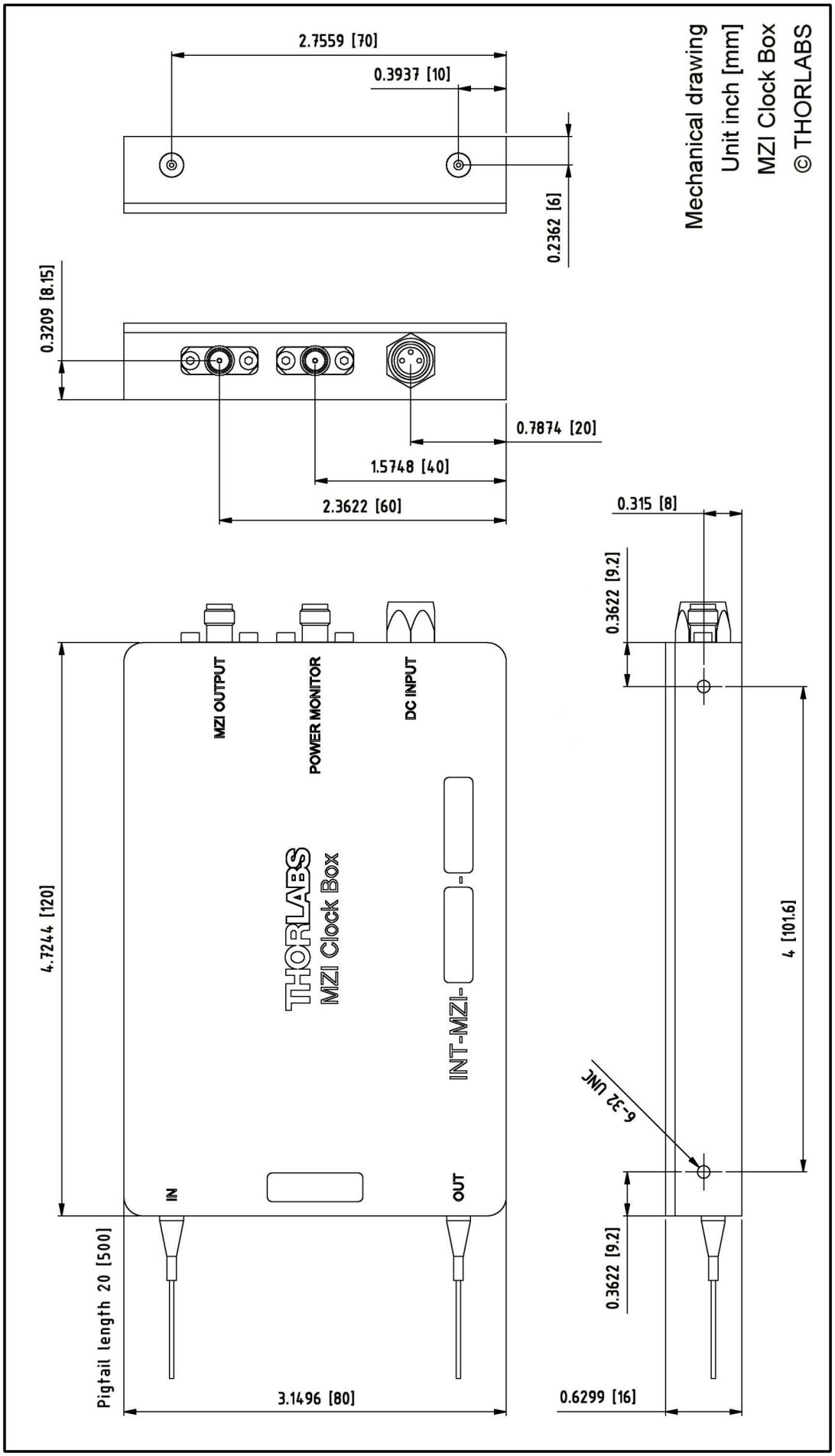
5 Appendix

5.1 Technical Data

Specification	INT-MZI-850	INT-MZI-1300
Optical Parameters		
Wavelength Range	780 - 925nm	1225 - 1375nm
Free Spectral Range MZI Output	103.3GHz ±5%	103.3GHz ±5%
Fiber Type	Nufern 780-HP™	Corning SMF28™
Optical Input, Output	FC/APC pigtail, 50cm long	
Insertion Loss*	< 1.5dB typical 3.0dB max.	< 0.7dB typical 1.0dB max.
Electrical Parameters		
Detector Material/Type	Si / PIN	InGaAs / PIN
Detector Wavelength Range	320 - 1000nm	800 - 1700nm
Typical Max. Responsivity	0.53A/W	1.0A/W
Bandwidth (3dB) Power Monitor, MZI-Output	DC - 200MHz	
Conversion Gain Power Monitor**	30V/W ±25%	60V/W ±25%
Conversion Gain MZI Output**	±30V/W ±25%	±60V/W ±25%
Saturation Power	100mW @ 850nm	50mW @ 1300nm
Max. Input Power (photodiode damage threshold))	250mW	
Electrical Outputs, Impedance	SMA, 50Ω	
DC-offset Electrical Outputs	< ± 5mV	
Others		
Size	120x80x16mm³	
Power Supply	±12V, 250mA	

All accuracy data are valid at 23 ± 5°C and 45 ±15% humidity
* includes connector losses of the Input and Output pigtail, measured at center wavelength
** referred to the output power; high impedance load, half value with 50 Ohm load

5.2 Mechanical Drawing



5.3 Certifications and Compliances

Category	Standards or description	
EC Declaration of Conformity - EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance is given to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326	EMC requirements for Class A electrical equipment for measurement, control and laboratory use, including Class A Radiated and Conducted Emissions[1] and Immunity.[2]
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance criterion C)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance criterion B) [2]
Australia / New Zealand Declaration of Conformity - EMC	Complies with the Radiocommunications Act and demonstrated per EMC Emission standard[1,2,3]:	
	AS/NZS 2064	Industrial, Scientific, and Medical Equipment: 1992
FCC EMC Compliance	Emissions comply with the Class A Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B[1].	

[1] Using high-quality shielded interface cables.

[2] Minimum Immunity Test requirement.

5.4 Warranty

Thorlabs warrants material and production of the INT-MZI-xxx for a period of 24 months starting with the date of shipment. During this warranty period *Thorlabs* will see to defaults by repair or by exchange if these are still entitled to warranty. For warranty repairs or service the unit must be sent back to *Thorlabs Germany* or to a place determined by *Thorlabs*. The customer will carry the shipping costs back to *Thorlabs,* in case of warranty repairs *Thorlabs* will carry the shipping costs back to the customer. If no warranty repair is applicable the customer will also carry the costs for back shipment. If the unit is sent back to *Thorlabs* from abroad the customer will carry all shipping costs, duties etc. which should arise for sending the goods back to *Thorlabs*.

Thorlabs warrants the hardware and software determined by *Thorlabs* for this unit to operate without fault provided that they are handled according to our statements. However, *Thorlabs* does not warrant a fault free or uninterrupted operation of the unit, of the software or firmware for special applications nor this operation manual to be fault free. We will not carry responsibility for ensuing damages.

Restriction of warranty

The aforementioned warranty does not cover errors and defects being the result of improper treatment, software and 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* does explicitly not warrant the usability or the economical use for certain cases of application.

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

5.5 Copyright

Thorlabs GmbH has taken every possible care in preparing this Operation Manual. We however assume no liability for the content, completeness or quality of the information contained therein. The content of this manual is regularly updated and adapted to reflect the current status of the software. We furthermore do not guarantee that this product will function without errors, even if the stated specifications are adhered to.

Under no circumstances can we guarantee that a particular objective can be achieved with the purchase of this product.

Insofar as permitted under statutory regulations, we assume no liability for direct damage, indirect damage or damages suffered by third parties resulting from the purchase of this product. In no event shall any liability exceed the purchase price of the product.

Please note that the content of this User Manual is neither part of any previous or existing agreement, promise, representation or legal relationship, nor an alteration or amendment thereof. All obligations of *Thorlabs GmbH* result from the respective contract of sale, which also includes the complete and exclusively applicable warranty regulations. These contractual warranty regulations are neither extended nor limited by the information contained in this User Manual. Should you require further information on this product, or encounter specific problems that are not discussed in sufficient detail in the User Manual, please contact your local *Thorlabs* dealer or system installer.

Status: 2012

5.6 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 below)
- 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

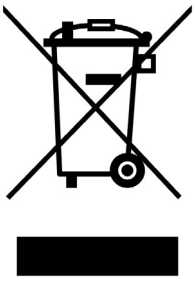
As the WEEE directive applies to self contained operational electrical and electronic products, this “end of life” take back service does not refer to other Thorlabs products, such as

- 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.

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.

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.



Crossed out “wheelie bin” symbol

5.7 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at www.thorlabs.com/contact for our most up-to-date contact information.

USA, Canada, and South America
Thorlabs, Inc.
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