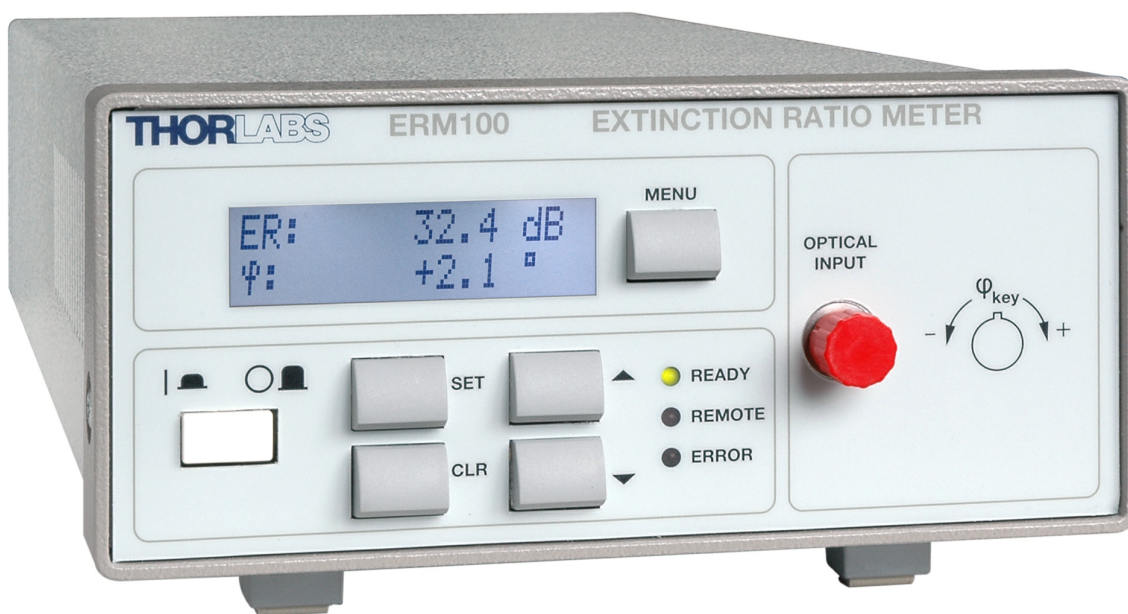




## Extinction Ratio Meter

# ERM100 Operation Manual



2018

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Version: 1.2

Date: 10-Jul-2018

Item No.: M0009-510-309

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*Thorlabs GmbH*

### **Warning**

Sections marked by this symbol 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 explain hazards that could damage the instrument and the connected equipment or may cause loss of data.

### **Note**

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

Please read this advice carefully!

# 1 General Information

The ERM100 Benchtop Extinction Ratio Meter is designed to analyze the ER of laser light in a polarization maintaining fiber for any kind of alignment applications like connectorization of PM fibers or pigtailling of laser diodes with PM fibers.

The easy to use interface combined with a fast USB device interface open a wide range of applications in Manufacturing, Quality Control, Quality Assurance, and R&D.

Drivers for LabVIEW and C are available and makes it easy to integrate the instrument in test and measurement systems

## 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.

The ER meter ERM100 must not be operated in explosion endangered environments!

Before applying power to your ERM100 system, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth contact of the socket outlet!

Improper grounding can cause electric shock with damages to your health or even death!

All modules must only be operated with proper shielded connection cables.

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

Do not obstruct the air ventilation slots in housing!

Do not remove covers!

Refer servicing to qualified personal!

This precision device is only serviceable if properly packed into the complete original packaging including the plastic foam sleeves. If necessary, ask for a replacement package.

### Attention

Mobile telephones, cellular 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 IEC 61326-1.

This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

**Vous pouvez trouver les traductions françaises des paragraphes ayant trait à la sécurité d'utilisation de ce produit sur le lien suivant:**

[http://www.thorlabs.com/thorcat/17500/ERM100-CSADocument\(Français\).pdf](http://www.thorlabs.com/thorcat/17500/ERM100-CSADocument(Français).pdf)

**Vous pouvez aussi simplement scanner le code QR**



## 1.2 Ordering Codes and Accessories

Ordering code	Short description
ERM100	ERM100 Benchtop Extinction Ratio Meter

Please visit our homepage <http://www.thorlabs.com> for further information.

## 1.3 Requirements

### 1.3.1 Hardware Requirements

CPU: 1 GHz or higher  
RAM: 256 MB  
Graphic card with at least 32 MB memory  
Hard disc with at least 100 MB free storage space  
Free USB2.0 port  
USB cable according the USB 2.0 specification

### 1.3.2 Software Requirements

The ERM100 software (CD1.1) is compatible with Windows<sup>®</sup> XP (32-bit) SP3 operating system. A NI-VISA engine V4.2 or higher must be installed. This NI-VISA engines comes with the Thorlabs ERM100 installation CD.

In order to operate the ERM100 under

- Windows<sup>®</sup> Vista (32-bit, 64-bit)
- Windows<sup>®</sup> 7 (32-bit, 64-bit)

a NI-VISA version 5.0.3 or higher is required. It can be downloaded also from National Instruments' website [www.ni.com](http://www.ni.com).

## **2 Installation**

### **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 ERM100 mechanically and electrically.

Verify that you have received the following items within the package:

1. 1 ERM100
2. 1 power cord, connector according to ordering country
3. 2 Replacement mains fuses
4. 1 operation manual
5. 1 CD Rom
6. 1 USB Cable

### **2.2 Getting Started**

Connect the ERM100 to the power outlet.

Turn the unit on by pressing the power switch at the front.

After switching on the unit, the display will show the device version and then jump to the operation screen.

The ERM100 is immediately ready to use after turning on. The rated accuracy is reached, however, after a warming-up time of approx. 15 minutes.

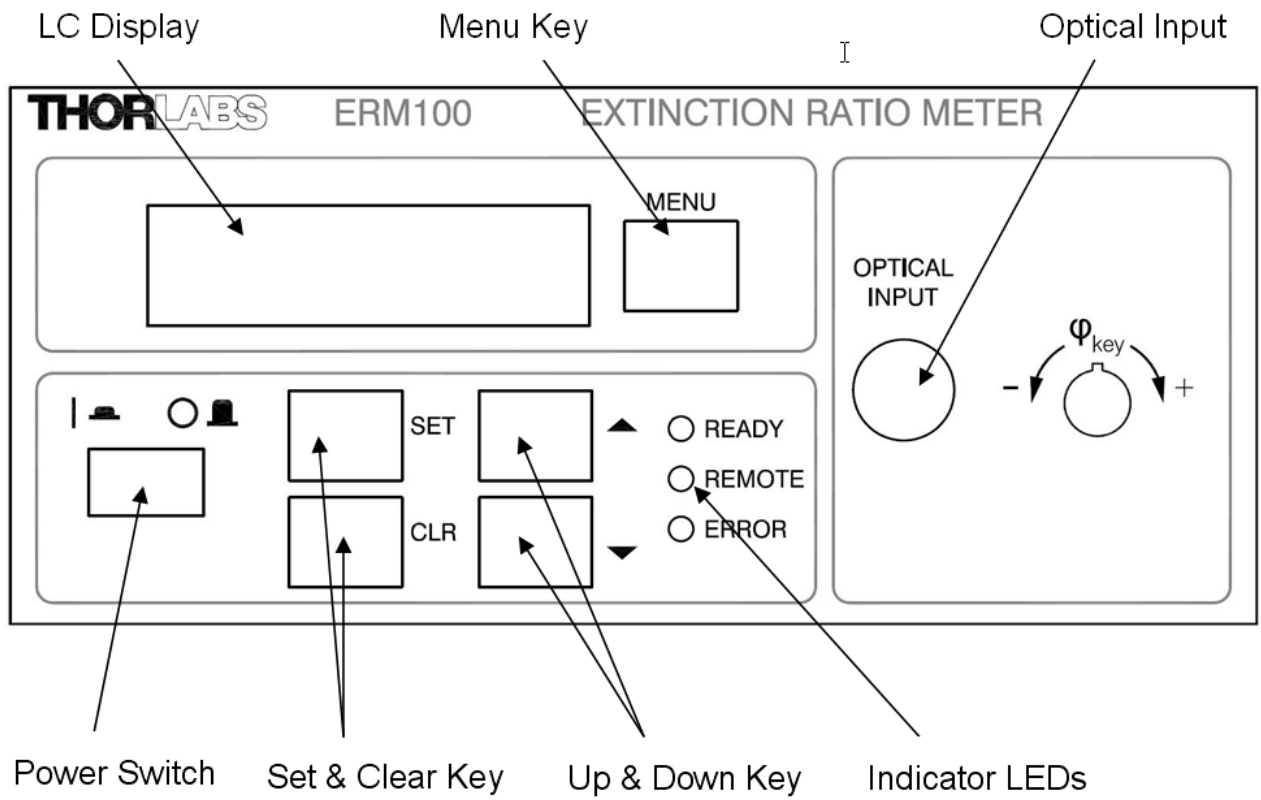
The chassis ground can be connected to ground potential via the banana connector jack to the external optical build-up, if required.



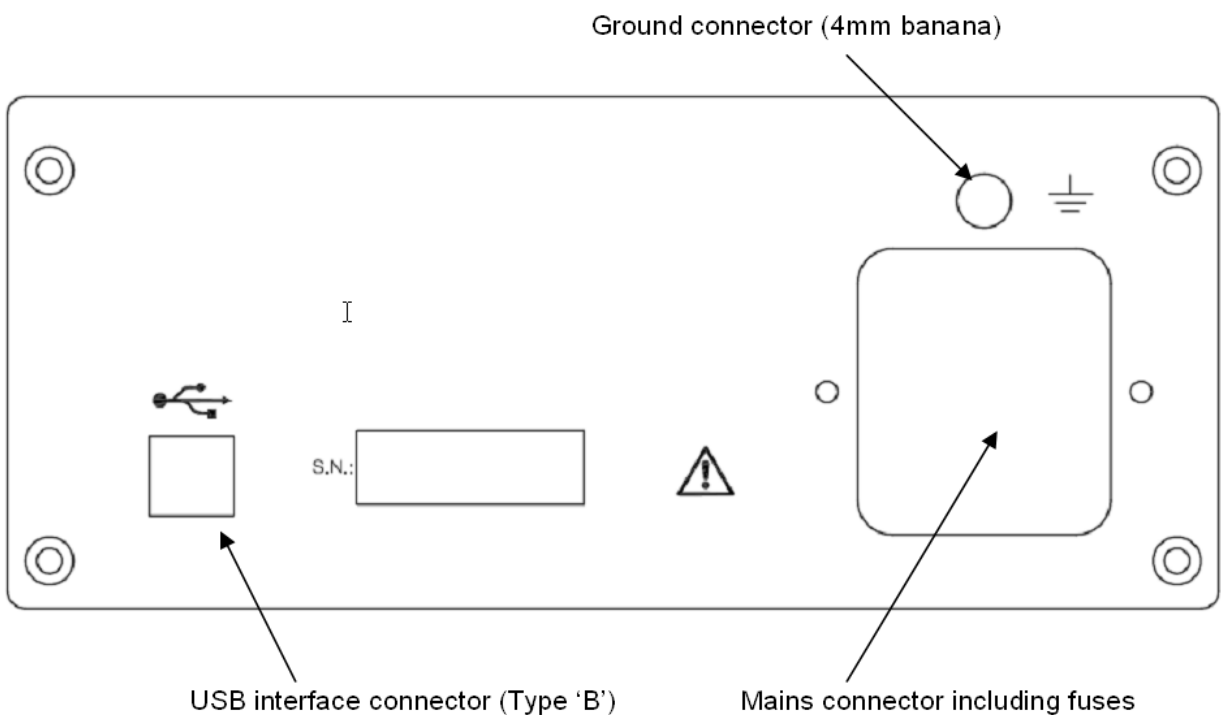
### 3 Operating Instruction

#### 3.1 Operating Elements

##### Front Panel



##### Rear Panel



## 3.2 Operation and Settings

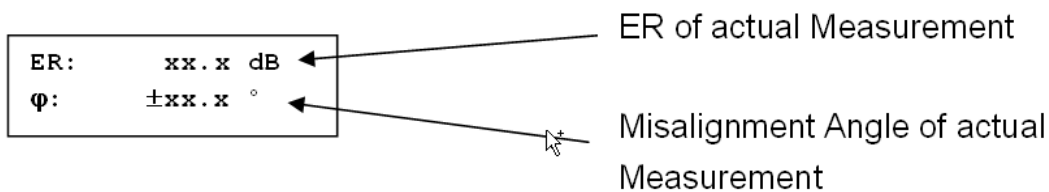
The ERM100 is controlled by five buttons on the front. A LC display on the front panel shows all measurement data in various display configurations. All necessary settings can be easily done using the control buttons and will be shown on the display.

There are two display modes. In 'Main Display Mode' the actual measurement data is displayed. In 'Menu Mode' additional measurement parameters can be modified and system information will be shown. The button 'MENU' is used to toggle between these two modes.

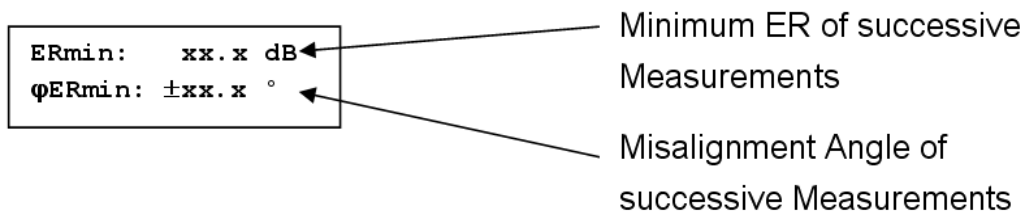
### 3.2.1 Main Displays

There are three different measurement screens. The 'SET' button is used to toggle between these displays:

The **ER display** presents the current ER measurement value in dB as well as the current misalignment angle in degree:

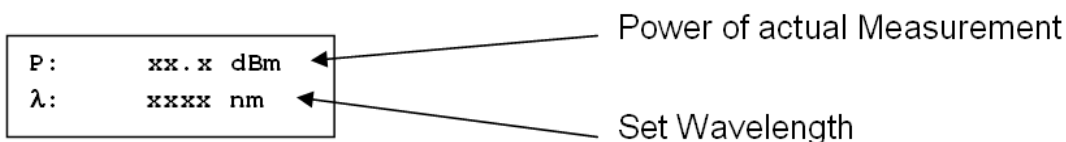


The **ER<sub>min</sub> display** shows the minimum ER in dB since the last ER<sub>min</sub>-Monitor reset and the corresponding misalignment angle in degree:



Pressing the button 'CLR' (Clear) while in 'Main Display Mode' resets the minimum ER monitor and the minimum ER value measured from that moment is displayed in the ER<sub>min</sub> display.

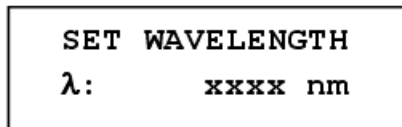
The last screen is the **power display**. It shows the power in dBm and the wavelength in nm:



### Setting the Wavelength

Setting the wavelength is necessary to determine the correct power. This set value will impact only the power value but no other measurement values.

- Press the 'SET' button until the power and wavelength menu is displayed.
- Press 'UP' and 'DOWN' buttons once: The "Set Wavelength" display comes up for about 2 seconds.



```
SET WAVELENGTH
λ:      xxxx nm
```

- Press within these 2 sec. 'UP' or 'DOWN' buttons to set the desired wavelength. This mode will be left automatically 2 sec. after the last key-press and the new wavelength is stored.

### 3.2.2 Menu

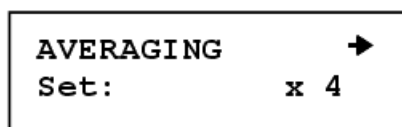
Additional settings but the wavelength can be accessed in the 'Menu Mode'. This mode can be entered by pressing the 'MENU' button. To return to 'Main Display Mode' press the 'MENU' button again. The ERM100 being in 'Menu Mode' is indicated by an arrow in the upper right corner of the display pointing to the 'MENU' button.

To navigate in the 'Menu Mode' use the 'UP' and 'DOWN' buttons. If the value of a menu entry is editable the word 'Set' is displayed in the lower left corner of the Display. Pressing the 'SET' button enters the edit mode of the selected menu entry. If a menu point is in edit mode, the 'UP' and 'DOWN' buttons are used to modify the value and the 'SET' button is used to save the new value. If a menu entry is in edit mode a cursor flashes at the position the value will be edited.

The following menu functions are accessible:

#### 3.2.2.1 Averaging

The ERM100 gains 10 samples per second. With AVERAGING up to 16 samples can be averaged for the display values. A higher AVERAGING value will result in lower display rate. The AVERAGING value has no effect on the measurement data transferred by the remote interface.



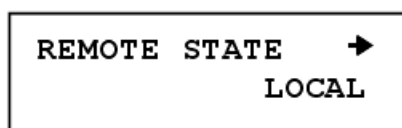
```
AVERAGING      →
Set:           x 4
```

#### 3.2.2.2 Remote State

This menu entry displays the remote state. The following states are possible:

##### Local

The ERM100 is operated by the front panel. The 'REMOTE' LED on the ERM100 front is off. This remote state is not editable.



```
REMOTE STATE   →
                LOCAL
```

## Remote

The ERM100 is operated by the remote interface. The **'REMOTE'** LED on the ERM100 front is on. The front panel can not change settings but this menu entry can be used to switch back to local mode.

```
REMOTE STATE  →  
Set:         REMOTE
```

To switch back to local mode press the **'SET'** button to enter the edit mode of the 'REMOTE STATE' menu entry. Then toggle the menu entry value with the **'UP'** or **'DOWN'** button from 'REMOTE' to 'Go to Local'. Pressing the **'SET'** button again switches the ERM100 to 'LOCAL' state. The display changes to the local state display and the **'REMOTE'** LED goes off.

## Remote with Local Lockout

The ERM100 is operated by the remote interface. The **'REMOTE'** LED on the ERM100 front is on. The front panel can not change settings. The 'Go to Local' function of this menu entry is locked by a remote command. Therefore this remote state is not editable. The front panel can only regain access by an unlock command over the remote interface or by power on reset of the ERM100.

```
REMOTE  
LOCAL LOCKOUT
```

### 3.2.2.3 Serial Number

The serial number of the ERM100. This value is not editable.

```
SERIAL NUMBER  →  
M00510202
```

### 3.2.2.4 Firmware Version

The version of the ERM100 firmware. This value is not editable.

```
FIRMWARE VERS. →  
V1.0.0
```

### 3.2.2.5 Bootloader Version

The version of the ERM100 bootloader. The bootloader software is a special part of the ERM100 firmware. It is used to transfer a new firmware version to the ERM100. This value is not editable.

```
LOADER VERSION →  
V1.0.0
```

### 3.2.3 Remote Mode

If the ERM100 is in remote control state by the USB interface this is shown by **'REMOTE'** LED on. In remote state no settings can be changed by the front panel. If you try to change any setting for 3 seconds a remote message display is shown.

```
REMOTE  
'CLR' for LOCAL
```

If the **'CLR'** (Clear) button is pressed within these 3 seconds, the instrument is set to local mode.

If the ERM100 is in remote control state with local lockout and you try to change any setting for 3 seconds a remote with local lockout message display is shown.

```
REMOTE  
LOCAL LOCKOUT
```

In 'Remote with Local Lockout' mode the 'Go to Local' function is disabled by a remote command. See also menu entry ['Remote State'](#).

### 3.2.4 Error Messages

If there is an error and the 'Main Display Mode' is active an error message will be displayed. If there occur more than one error the most important error message is shown. The error displays look like that:

```
SYSTEM ERROR:  
Motor rotation
```

```
INPUT ERROR:  
Input power high
```

### 3.3 Measurement Procedure

Depending on the alignment task there exist different measurement setups and measurement procedures. For example the alignment of a laser diode to a PM fiber pigtail has different requirements than the testing of PM fiber patch cords.

The ERM100 can be used to couple linear polarized light into the slow (or fast) axis of a polarization maintaining (PM) fiber as well as align the connectors key to the slow (or fast) axis of the PM fiber.

### 3.4 Measurement Principle

The ERM100 is based on a rotating polarizer. A polarizer transmits only the polarized part of the light which is parallel to its transmission axis. The transmitted power is not only dependent on the input polarization but also on the degree of polarization (DOP). A photo diode after the spinning polarizer detects the power.

If the input light is completely linear polarized and the DOP is 100% the measured photo current is sinusoidal with its minimum at zero. If the minimum is not equal to zero it can be due to an elliptical input polarization or due to a DOP less than 100%. There are also more factors which can influence the measurement data like dark current and noise of the photo diode but let us assume perfect optical elements for our considerations.

If the input light is circularly polarized with a DOP of 100% a DC photo current would be the result. A purely unpolarized input light would also generate a DC photo current.

Both properties the ellipticity as well as the DOP will affect the measurement result. This should be considered when measurements with the ERM100 are performed.

### 3.5 Coupling of linear polarized light into a main axis of a PM fiber

If linear polarized light is coupled to one of the main axis (slow or fast) of a PM fiber the linear polarization will be maintained in the fiber. Light with an elliptical polarization or linear polarized light which is not parallel to one of the main axis will not preserve its polarization state along the fiber. The output polarization state is not predictable. It depends on the current conditions like bends and stress of the fiber.

There are several ways to set up an ER measurement. The light source is one of the key elements. Using a broadband source like an ASE or SLED will simplify the alignment procedure compared to a narrow band source like a DFB laser.

#### Narrow bandwidth light source (DFB laser)

It is not sufficient to measure a single ER value to characterize the quality of an PM fiber alignment. The output polarization can be linear with a misaligned linear polarization at the input or even with an elliptical polarization entered into the input. There are many different output polarizations possible. The worst case has to be found to characterize this fiber.

An easy way to generate the worst case is to stress the fiber by pulling it gently. Stress is induced and the output polarization will be changed. The ERM100 stores the worst case / minimum ER value and displays this data in the ER<sub>min</sub> screen.

#### ASE Source

Instead of a laser diode a SLED (super-luminescent diode) or an ASE is used as light source. A SLED has a 3dB bandwidth of 10nm to >60nm and an ASE source typically more than 100nm. As larger the bandwidth as better suitable is a broadband source for this ER measurement on PMF method.

In general the polarization of a broadband source is not known. It is necessary to generate a linear polarization for the complete spectrum. A fiber bench with a polarizer is convenient to perform this task. The polarizer can be mounted with its transmission axis vertical orientated to

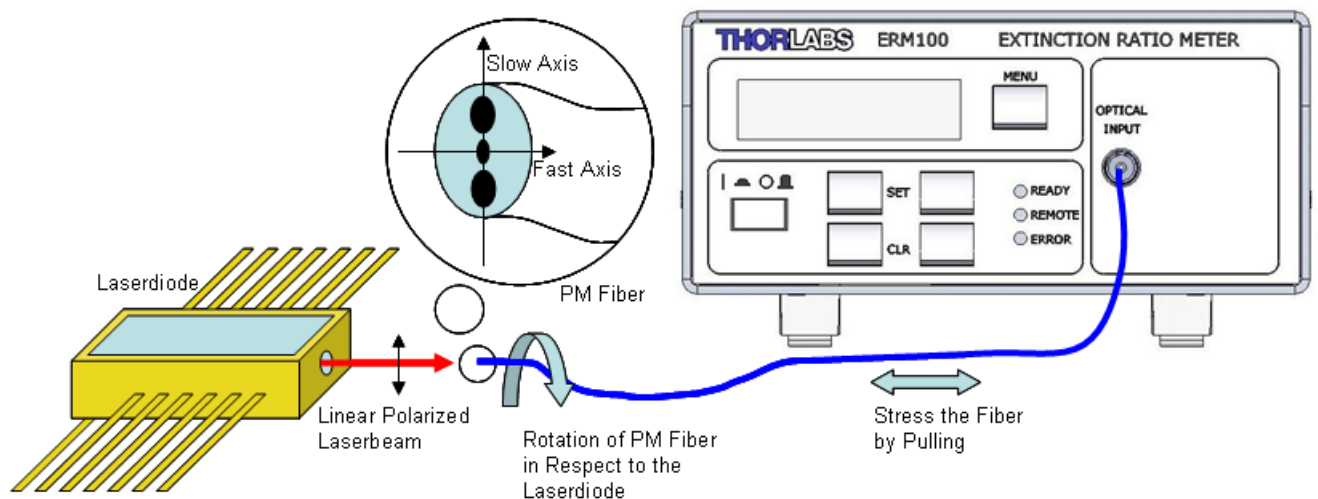
the base plate. Now the incident light from the SLED or ASE is linear polarized. This light is fed into the slow axis of the PM fiber if the slow axis is orientated to the connectors key and the key is vertical aligned.

As long as the linear polarized light of the broadband source travels along the slow (or fast) axis the polarization is maintained and the ERM100 will show a high Extinction Ratio. Values between 20dB and 30dB are desired. If the linear polarized light is not coupled into one of the main axes of the PM fiber the linear polarized light is separated into two parts. One is traveling along the fast and the other along the slow axis. Both parts will travel with different speeds. Depending on the birefringence of the fiber, its length and the induced stress for example by bending or temperature the output polarization is not predictable and can vary over time. Furthermore, the birefringence is wavelength dependent. The output of each certain wavelength of the spectrum of the broadband source will be different. This leads to a depolarization of the complete light. In this case the ERM100 will detect a low Extinction ratio.

### 3.6 Alignment of a Laser Diode to a PM Fiber

The alignment of a laser diode to a PM fiber can be done in the following way:

1. The output of the fiber is entered to the input of the ERM100 and the unit is switched on.
2. Toggle to the ER display by pressing the button 'SET'.
3. Rotate the PM fiber in respect to the laser diode until a maximum ER value is displayed. Typically values between 20dB and 30dB are desired.
4. Change to the  $ER_{min}$  display and reset the minimum ER value by pressing the button 'CLR'.
5. Gently pull the fiber.
6. The shown ER value in the  $ER_{min}$  display represents the minimum ER value.
7. The coupling efficiency can be increased by a trial and error method. Rotate the fiber only slightly in respect to the laser diode in one direction and repeat step 4 to 6. If the  $ER_{min}$  value increases try the same direction again otherwise try the opposite direction.



#### Note

The ERM100 cannot distinguish between the fast and slow axis of a PM fiber. A preadjustment to the desired main axis has to be performed to align the DUT to the slow (or fast) axis of the PM fiber.

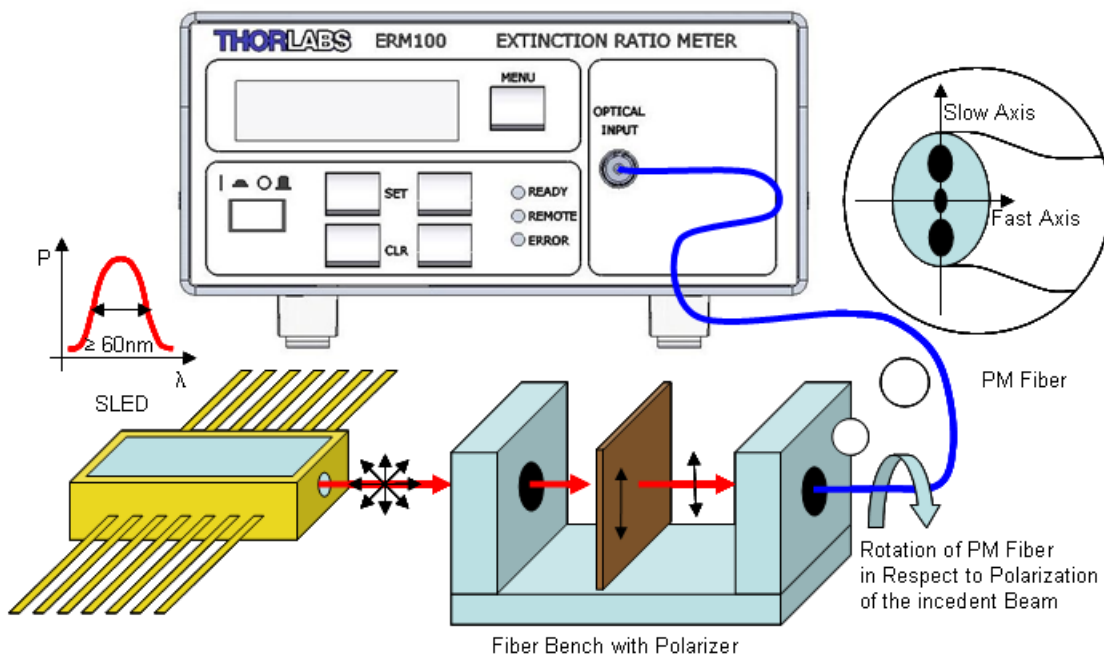
### 3.7 Alignment of a PMF Patchcord

The alignment of a PMF patchcord can be performed also with a narrow bandwidth laser source. However, there are two disadvantages using such a light source. The first is the manual handling which is divided into a rotating and a pulling (stress) part. The second and main disadvantage is that with this method fibers which have a loose tube are difficult to handle.

Loose tube means that the fiber itself and the buffer (tube) are not fixed to each other over the entire length. If someone pulls the buffer the fiber inside is not necessarily stressed in the same way like the buffer.

Therefore, a broadband source like a SLED or ASE is more suitable for this task. The Extinction Ratio measurement of a PM fiber with a SLED can be done in the following way:

1. The output of the PM fiber is entered to the input of the ERM100 and the ERM100 is switched on.
2. Connect the SLED to the input of the fiber bench with the polarizer.
3. Connect the input of the PM fiber to the output of the fiber bench.
4. Toggle to the ER display by pressing the button 'SET'.
5. Rotate the input of the PM fiber in respect to the fiber bench until a maximum ER value is displayed. Typically values between 20dB and 30dB are desired.
6. The shown ER value in the ER display represents the minimum ER value.



### 3.8 Aligning the connectors key to a main axis of a PM fiber

The alignment of the connectors key can also be done using the ERM100. There are several ways to perform this alignment depending on the type of connector and the equipment used to assemble a connector to a fiber.

Assuming the connector is already assembled to fiber and the key can still be moved the aligning can be performed as follows:

1. Couple linear polarized light into the main axis which has to be aligned to the connectors key.
2. Toggle to the ER display by pressing the 'SET' button.
3. Rotate the connector until the displayed misalignment angle shows 0°.

Lock the key in the respect to the connector with adhesive or another adequate method.



### 3.9 Measurement consideration

The method based on the rotating polarizer does not only take the polarized light into account for the determination of the ER but also the unpolarized part. Therefore, even if the light with linear polarization but with a DOP less than 100% enters the rotating polarizer the calculated ER value depends strongly on the DOP. The following table shows the measured ER value in relation to the DOP assuming a ideal linear polarization.

DOP [%]	90.0	98.0	99.0	99.8	99.9	99.94	99.98	99.99	99.998
ER [dB]	12.8	20.0	23.0	30.0	33.0	35.0	40.0	43.0	50.0

If the DOP is a problem for the ER measurement a more complex measurement system like Thorlabs' Polarization Measurement System PAX57xx is required.

## 4 Remote Operation

The ERM100 optical power meter provides a USB 2.0 Full Speed link that allows to remote control the instrument by a host computer (USBTMC Interface) or upgrade the instrument firmware (DFU Interface). The connection between PC and ERM100 is accomplished by a USB cable with a male type 'A' connector at the PC side and a type 'B' connector on the instrument side.

### USBTMC Interface:

The USB link provides an interface according to the **USBTMC** specification (Universal Serial Bus Test and Measurement Class Specification (USBTMC) Revision 1.0 April 14, 2003) and the **USBTMC-USB488** specification (Universal Serial Bus Test and Measurement Class, Sub-class USB488 Specification (USBTMC-USB488) Revision 1.0 April 14, 2003).

There are two categories of command types:

- Set commands that bring the ERM100 to the desired configuration
- Query commands that get data from the ERM100. These commands are always terminated by a question mark (?).

These commands are described in chapter 'Command Reference' of this document.

Additionally the ERM100 USB driver comes with a VISA Instrument Driver DLL. Details please see in section [Write Your Own Application](#)

### Attention

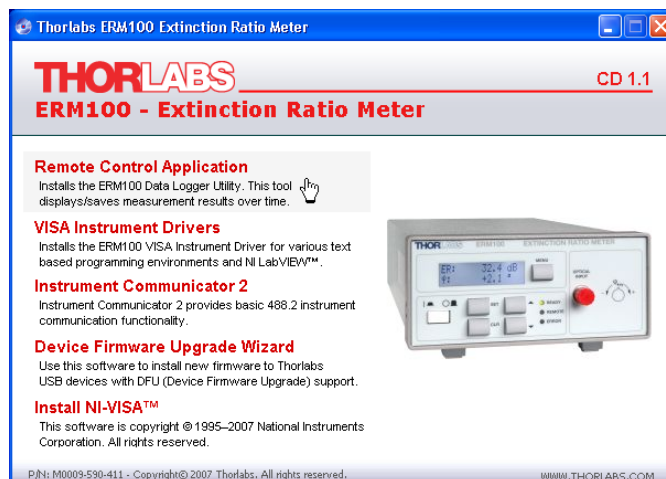
Prior to connect the ERM100 first time to a PC, please install the software from the delivered with the ERM100 CD! Otherwise, a proper operation is impossible.

## 4.1 Installing Software

The delivered with ERM100 CD includes:

- [Remote Control Application](#): an application to display and record data over time
- [VISA Instrument Drivers](#): These are drivers to write your own application.
- [Instrument Communicator](#): Basic communication with the instrument
- [Device Firmware Upgrade Wizard](#): Upload a ERM100 firmware update to the instrument
- [Install NI VISA](#): NI VISA Runtime is mandatory to remotely control the ERM100.

Hereinafter the software installation to a Windows XP operating system is described.



### Note

For remote operation the NI-VISA engine is required. Please check, if you have installed a NI-VISA Runtime on your PC.

### Attention

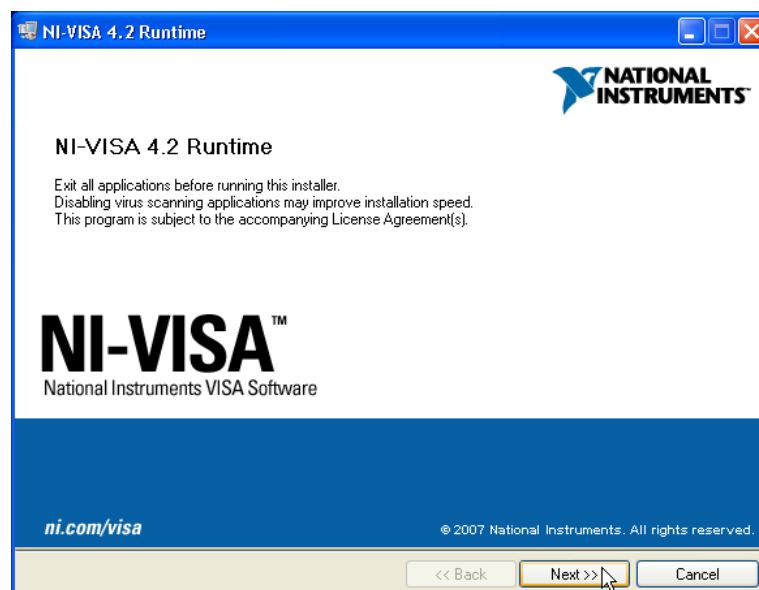
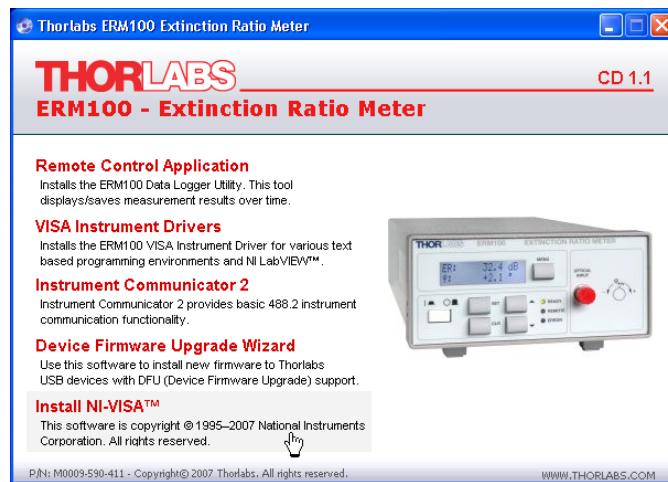
From the delivered CD 1.1 the version **4.2** can be installed. This works on **Windows XP® systems only**.

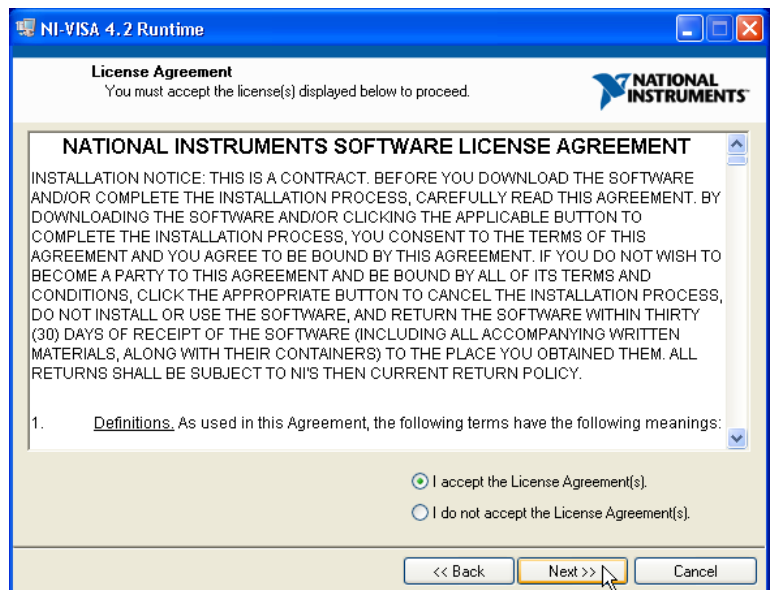
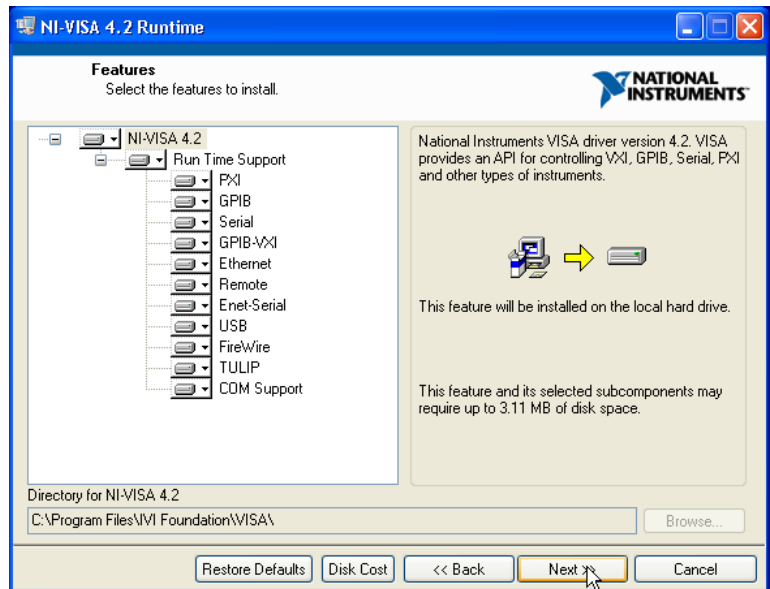
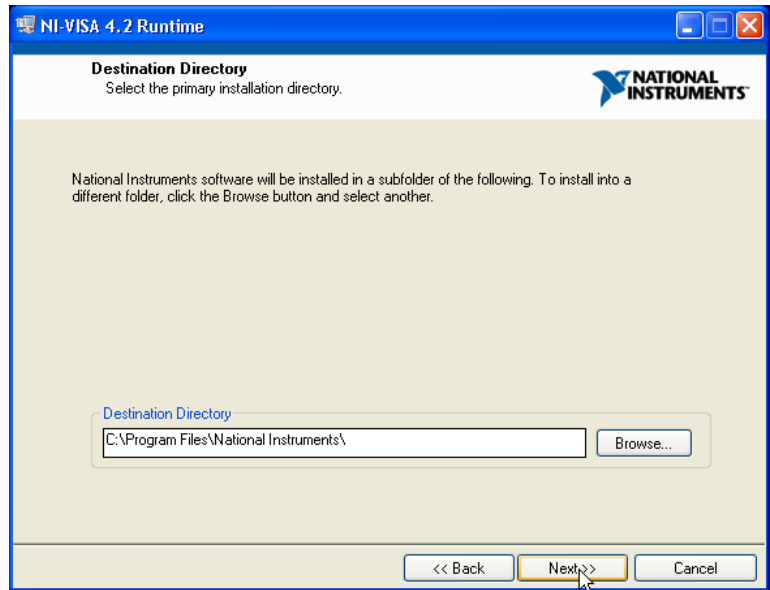
If you want to operate the ERM100 from a **Windows Vista®** or **Windows 7®** operating system, you need to install a NI VISA Runtime, version **5.0.2 or higher**. You can download it from National Instruments' web site [www.ni.com/visa/](http://www.ni.com/visa/).

If you have installed already an appropriate NI VISA version, the software installation description continues in section [Install Remote Control Application](#).

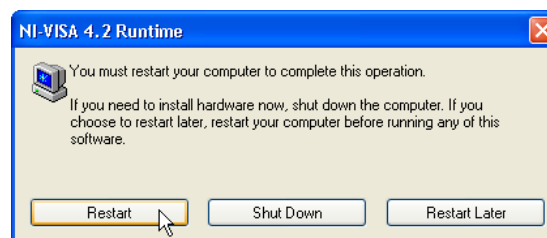
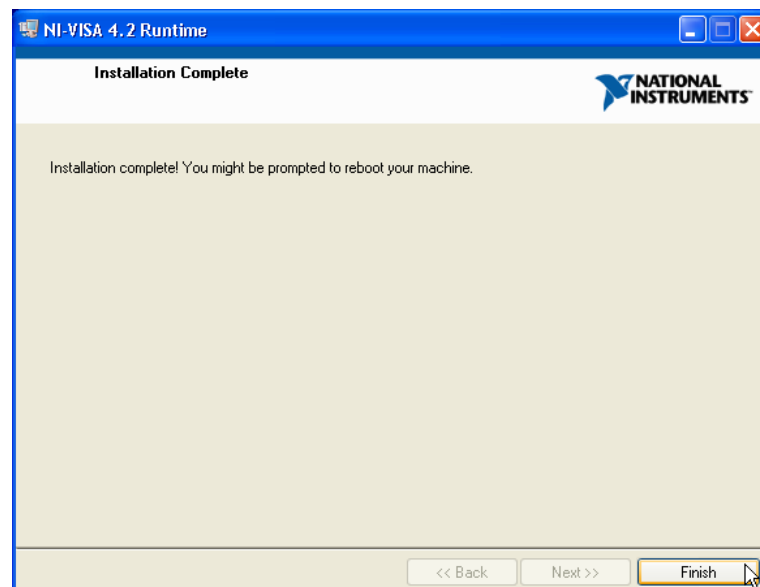
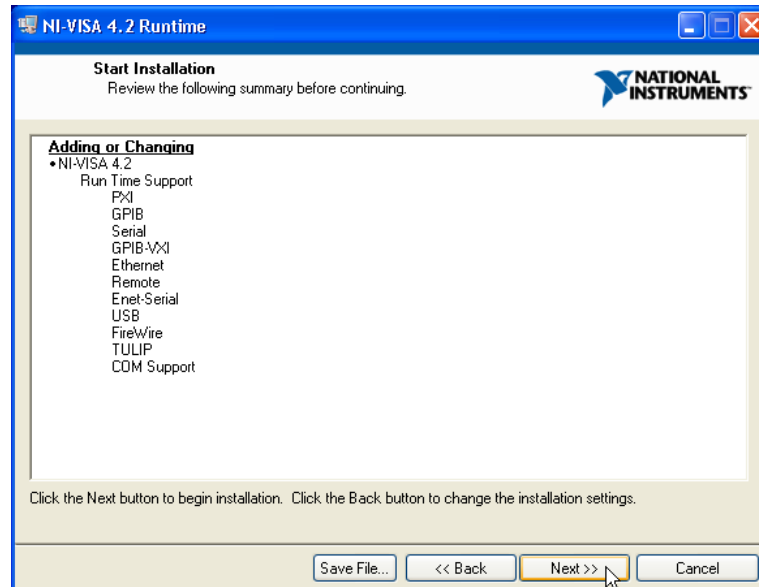
## 4.1.1 Install NI Visa 4.2

The installation is simple - just follow the recommendation as per the screen shots:





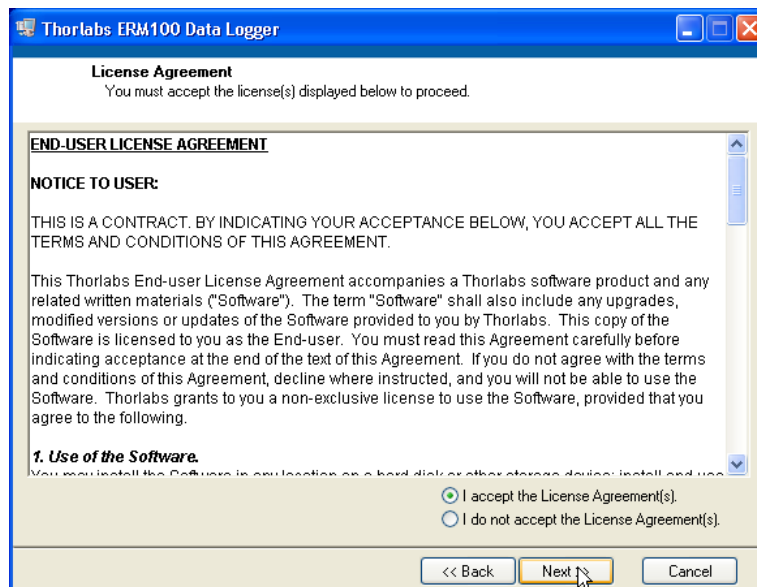
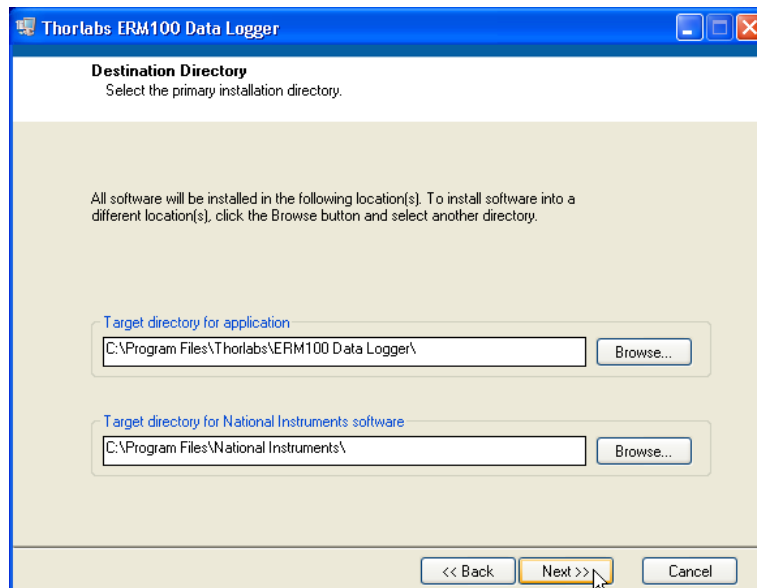
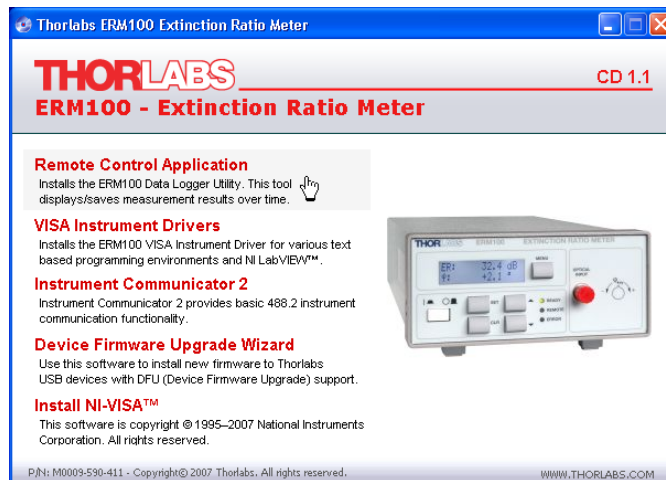
Click "I accept..." if you do so, then click "Next >>":



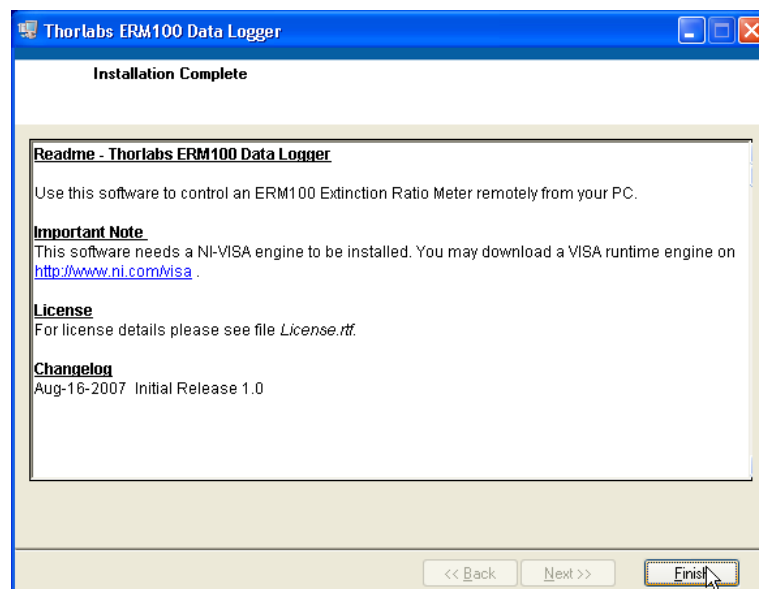
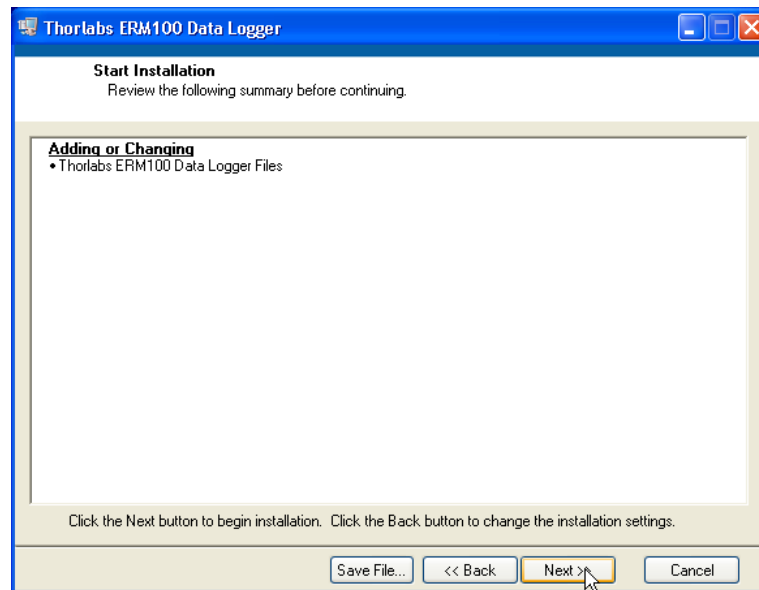
### Note

You may choose "Restart later" and continue with the installation of [Remote Control Application](#), however you need to restart the computer prior to connect the ERM100 first time for a proper operation. Otherwise, the ERM100 won't be recognized in a correct way.

## 4.1.2 Install Remote Control Application



Click "I accept..." if you do so, then click "Next >>":

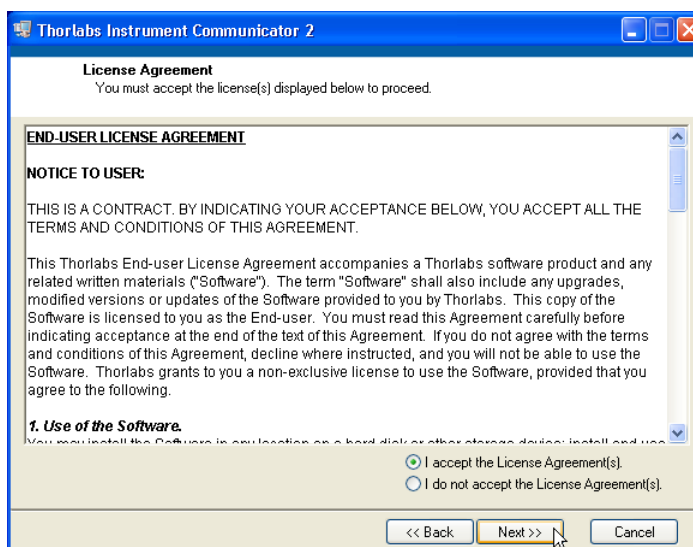
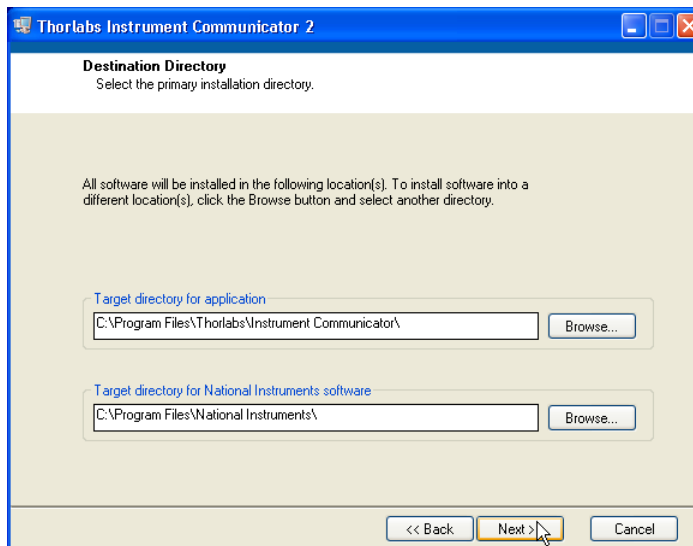
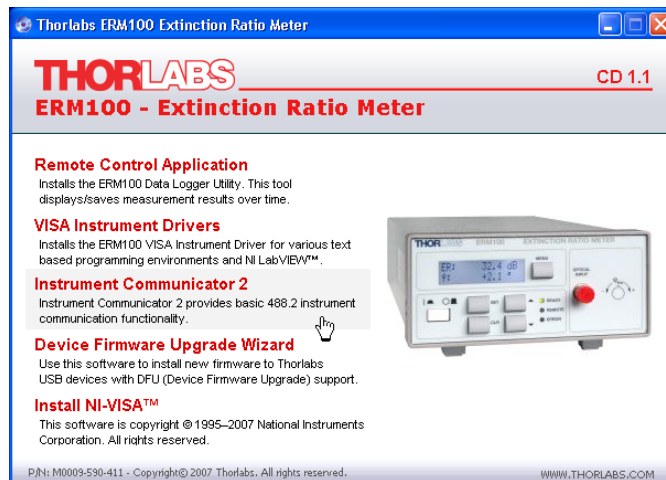


Click "Finish" to complete the installation.

### Note

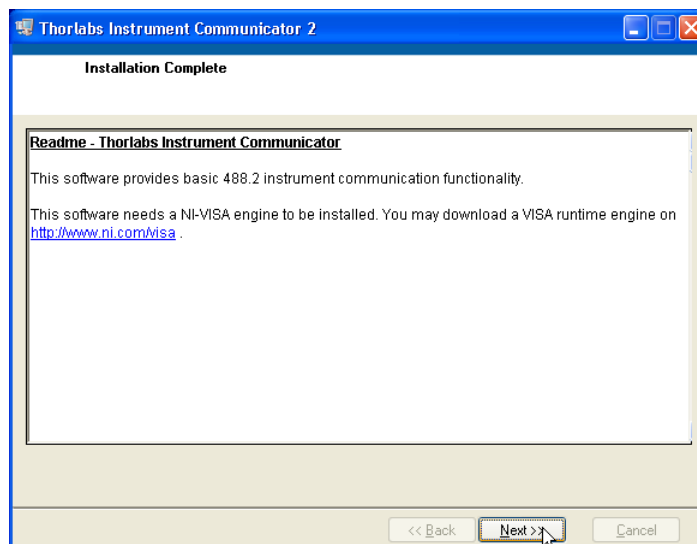
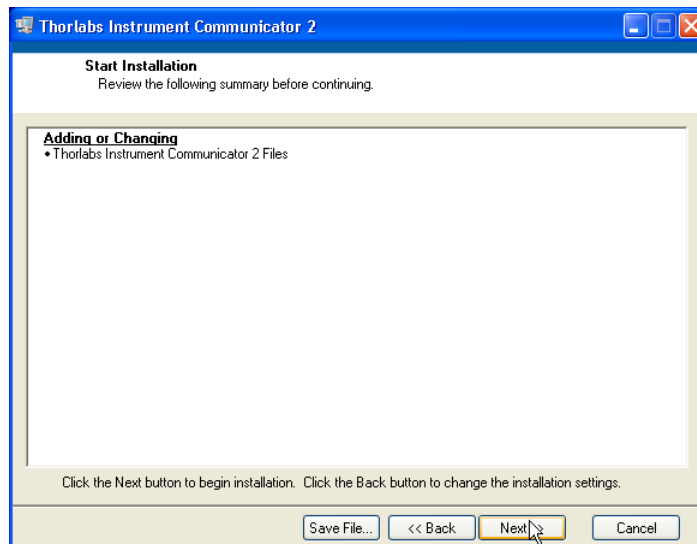
If the computer has not been restarted after NI VISA installation, please reboot now.

## 4.1.3 Install Instrument Communicator



Click "I accept..." if you do so, then click "Next >>":

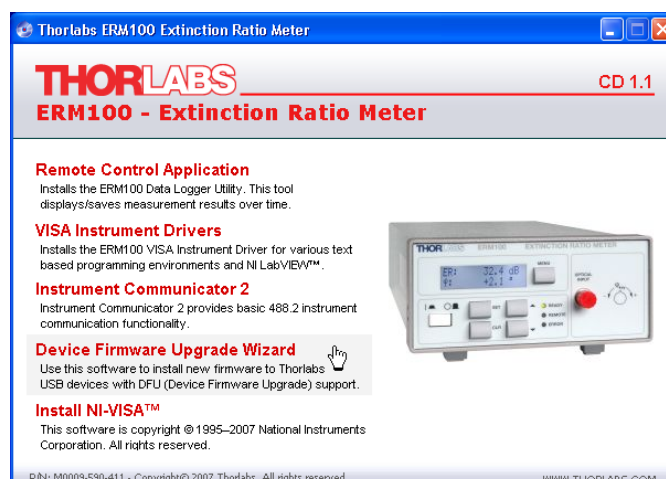


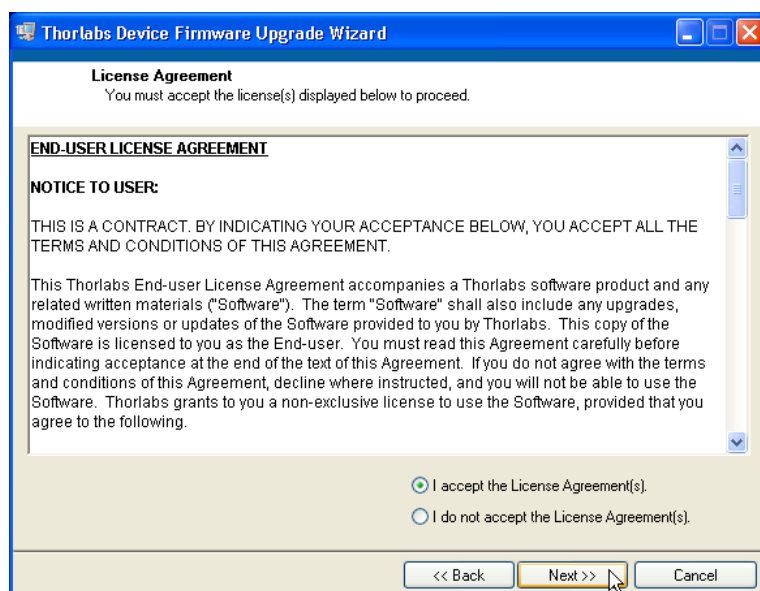
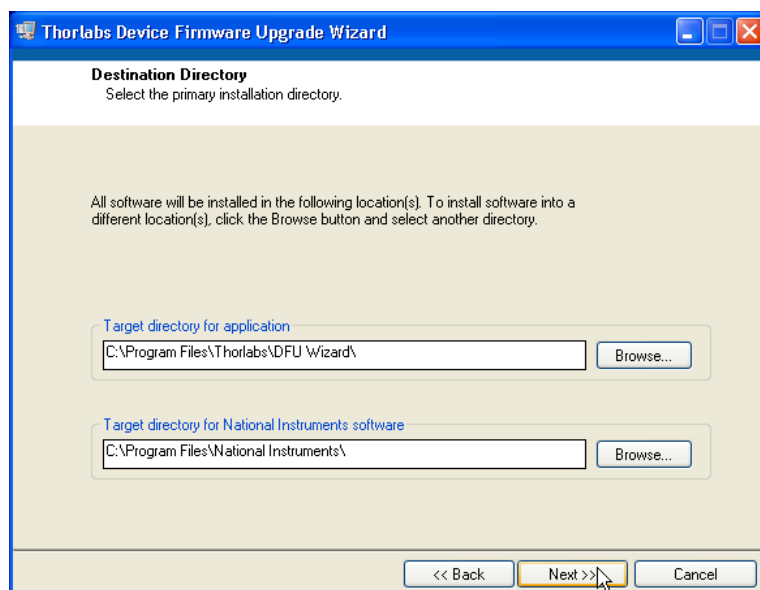


Click "Next >>" to finish the installation.

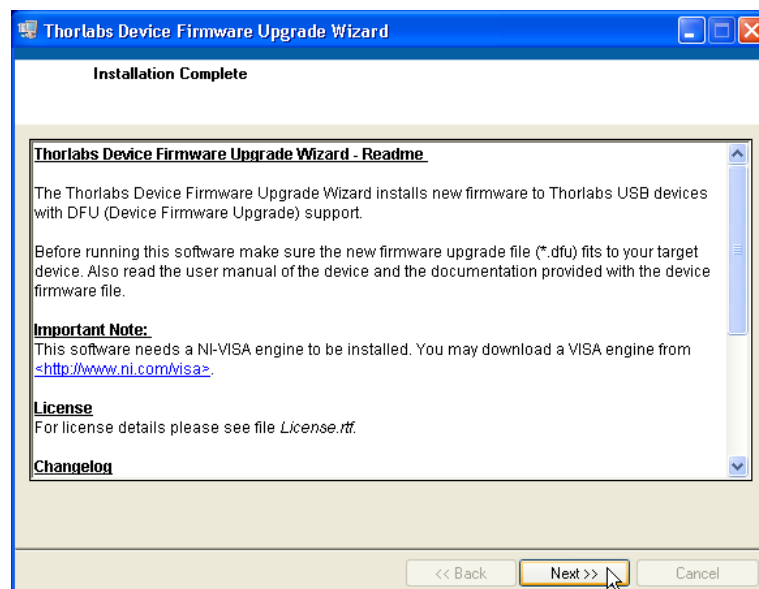
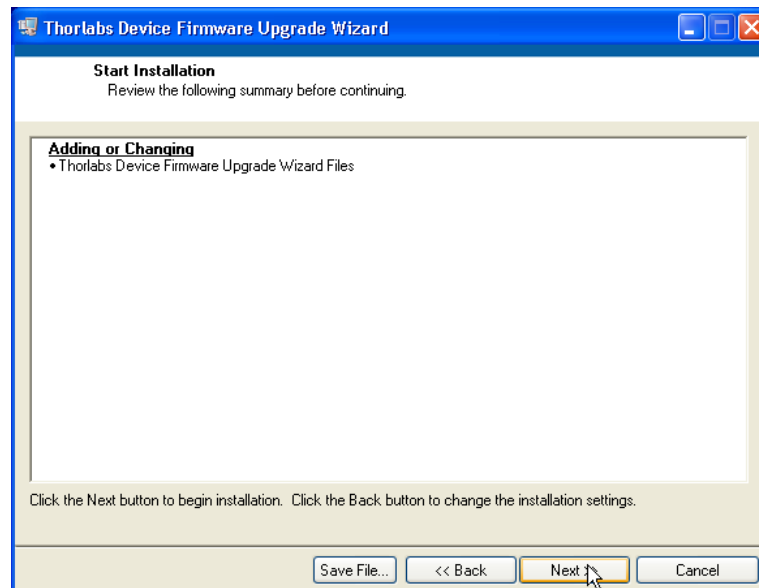
#### 4.1.4 Install Firmware Upgrade Wizard

This wizard is an easy-to-use tool for uploading a new firmware version.





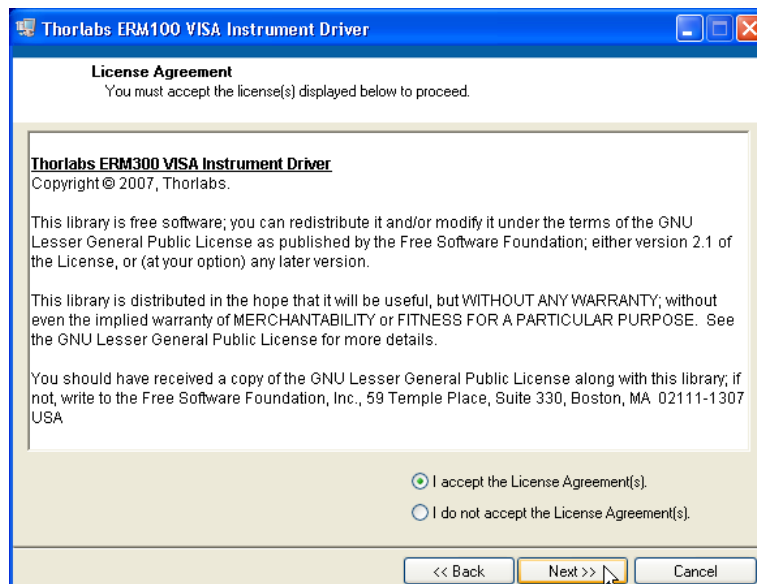
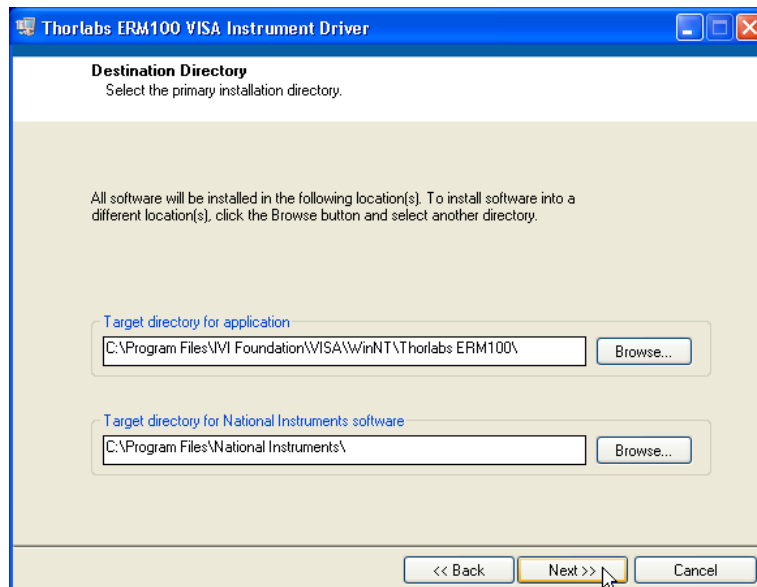
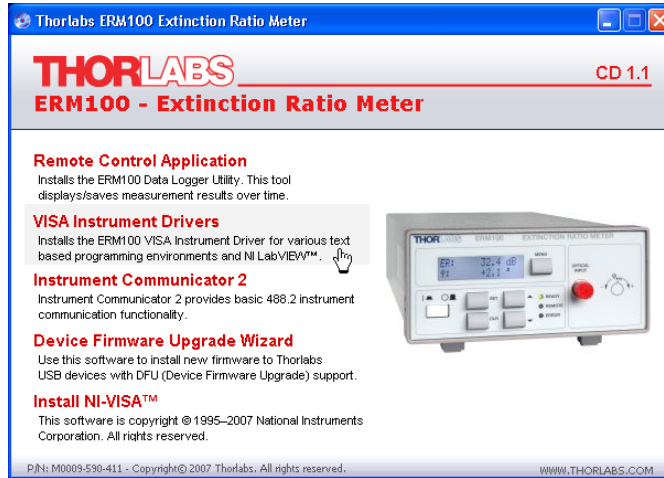
Click "I accept..." if you do so, then click "Next >>":



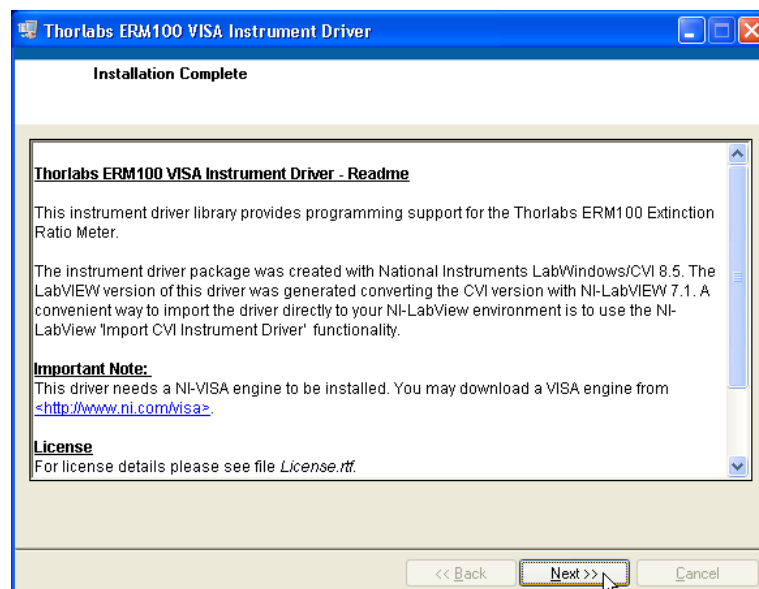
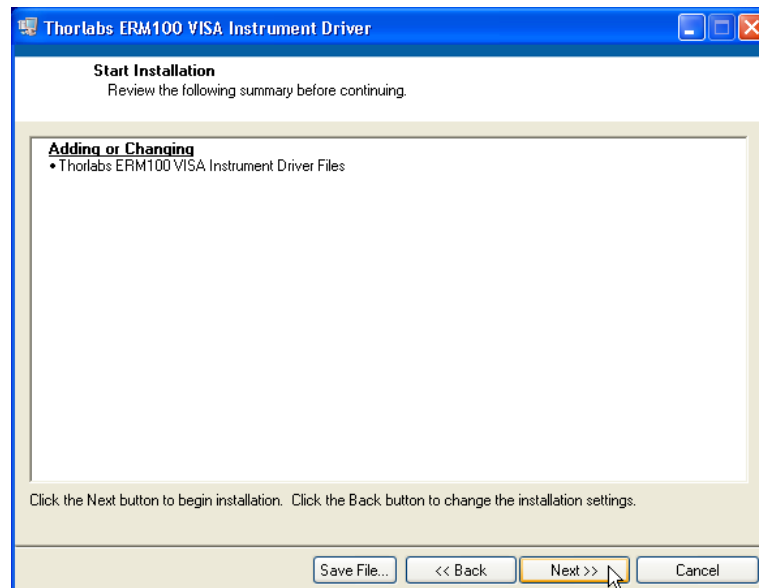
Click "Next >>" to finish the installation.

## 4.1.5 Install NI Instrument Drivers

This topic installs ERM100 instrument drivers for different programming interfaces. For details, please see section [Write Your Own Application](#).



Click "I accept..." if you do so, then click "Next >>":



Click "Next >>" to finish the installation.

## 4.2 Connect the ERM100

### Note

Please make sure, you have installed a NI VISA runtime on your computer prior to connect the ERM100 first time.

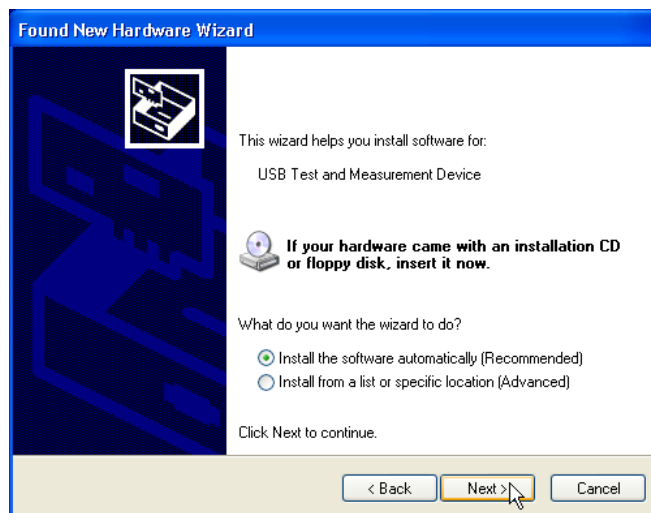
- Switch on the ERM100
- Connect the ERM100 to the PC using the provided USB 2.0 cable (A to B).

The Found New Hardware Wizard comes up. It will recognize the ERM100 twice - as a USBTMC (USB Test and Measurement Class) and as a DFU (Device Firmware Upload) capable device.

Below are the screen shots in case of a Windows® XP operating system.

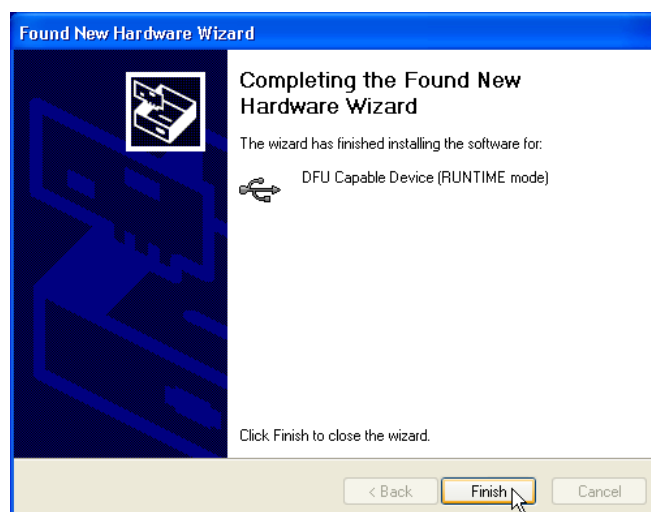
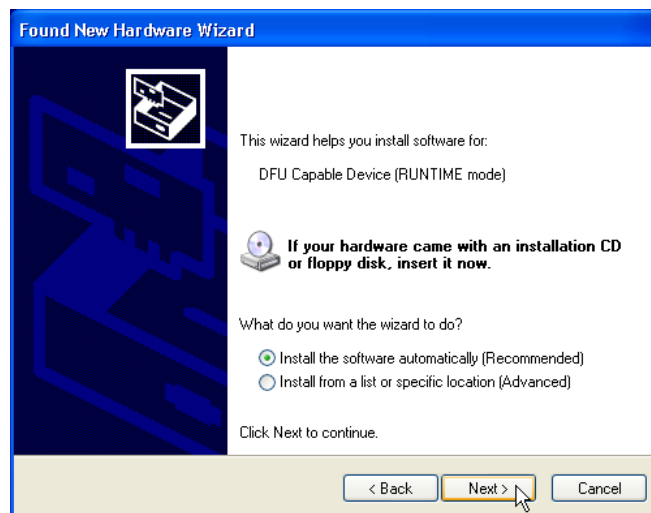


Check the box "No, not this time", then "Next >>" to continue

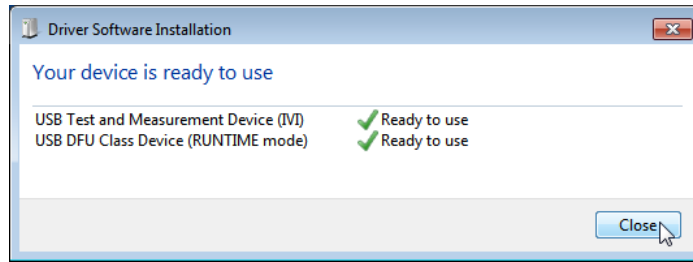




Check the box "No, not this time", then "Next >>" to continue



Under Windows® 7 operating system, the device recognition and driver install is more simple - after connect, a single screen appears during driver installation, after completion it states:

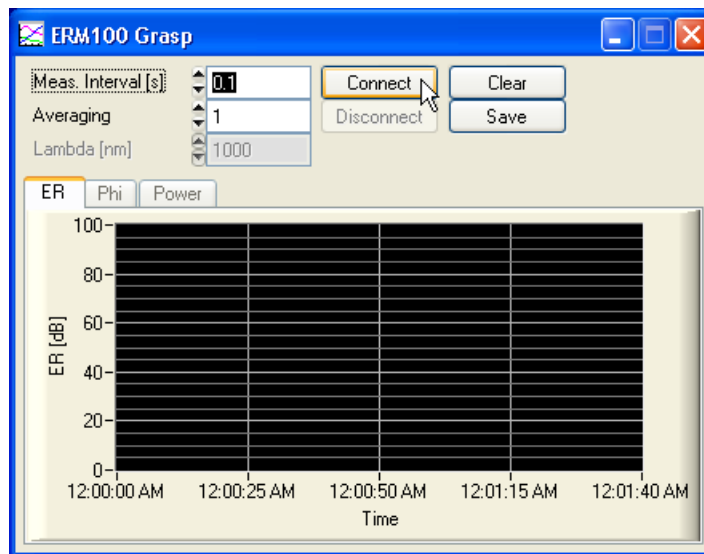


The ERM100 drivers are installed now and your device is ready to be remotely operated.

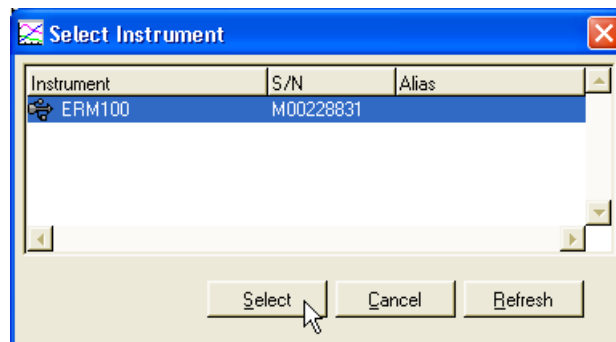
### 4.3 Remote Control Application

The Remote Control Application is an easy-to-use simple data logger.

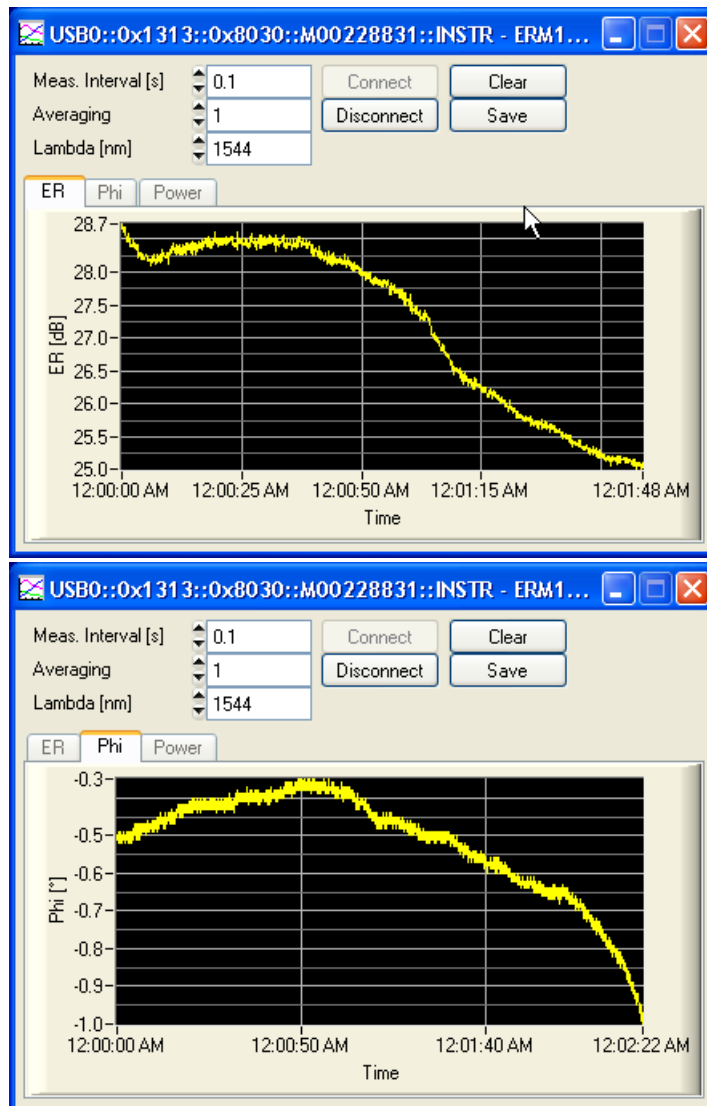
Make sure the ERM100 is connected and recognized. Start the application from the "Start" button:



Click "Connect", a dialog screen comes up. Select the instrument and click "Select":







The logged data can be saved in \*.csv file format.

## 4.4 Write Your Own Application

After installing NI instrument drivers, all necessary tools can be found at following locations:

### NI VISA instrument driver

C:\Program Files\IVI Foundation\VISA\WinNT\Bin\ERM100\_Drv\_32.dll

#### Note

This instrument driver is required for all development environments!

### NI VISA instrument driver online help:

C:\Program Files\IVI Foundation\VISA\WinNT\Thorlabs ERM100>manual\ERM100\_Drv.hlp

C:\Program Files\IVI Foundation\VISA\WinNT\Thorlabs ERM100>manual\ERM100\_Drv.txt

C:\Program Files\IVI Foundation\VISA\WinNT\Thorlabs ERM100>manual\ERM100\_Drv\_VB.txt

### Matlab / LabVIEW programming

Function Panel

C:\Program Files\IVI Foundation\VISA\WinNT\Thorlabs ERM100\ERM100\_Drv.fp

Driver

C:\Program Files\IVI Foundation\VISA\WinNT\Bin\ERM100\_Drv\_32.dll

### LabVIEW container file

C:\Program Files\National Instruments\LabVIEW\instr.lib\ERM100\_Drv\ERM100\_Drv.llb

### C++

Header file

C:\Program Files\IVI Foundation\VISA\WinNT\include\ERM100\_Drv.h

Static library

C:\Program Files\IVI Foundation\VISA\WinNT\lib\msc\ERM100\_Drv.lib

## 5 Maintenance and Service

Protect the ERM100 from adverse weather conditions. The ERM100 is not water resistant.

### Attention

**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 for return instructions.

Do not remove covers!

In order to ensure the specified measurement accuracy, the recommended factory recalibration interval is 12 months.

### 5.1 Firmware Upgrade

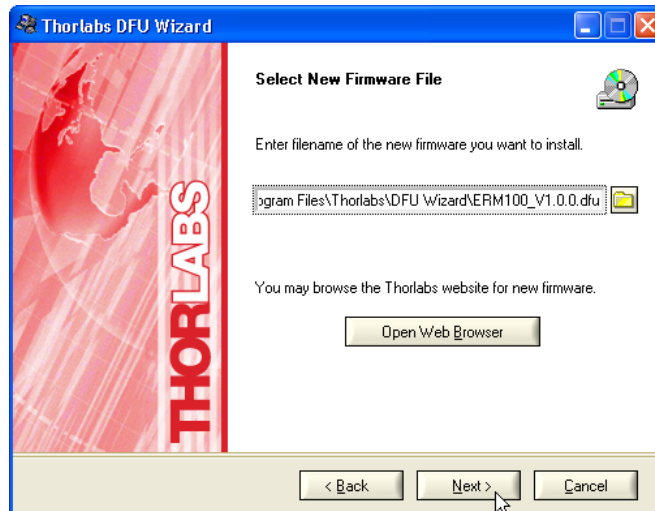
Prior to start the firmware upgrade, please download the new version from our website, unzip it and save it to a convenient to remember location on your PC.

Firmware upgrades can be done by the user via the USB interface. Therefore [install the DFU \(device firmware upgrade\) wizard](#) from the distribution CD.

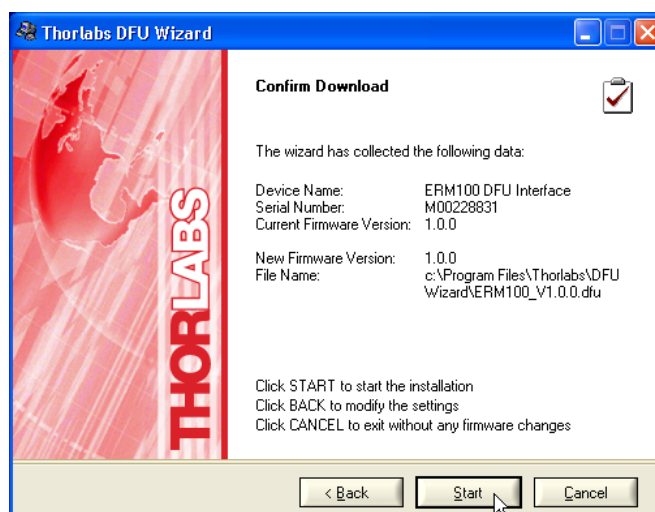
Connect the ERM100 to a USB port of your PC, switch it on and launch the DFU wizard from the Start button:

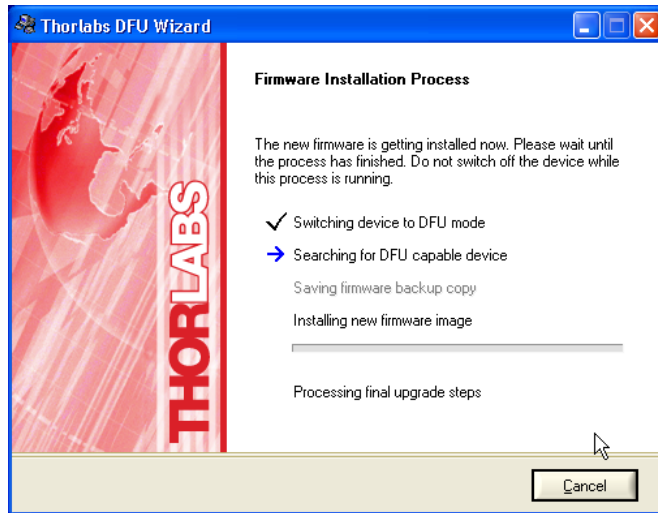


Click "Next >" to continue:

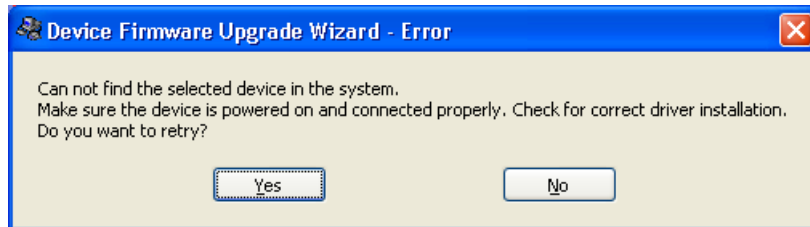


Select the ERM100 firmware file, click "Next >":



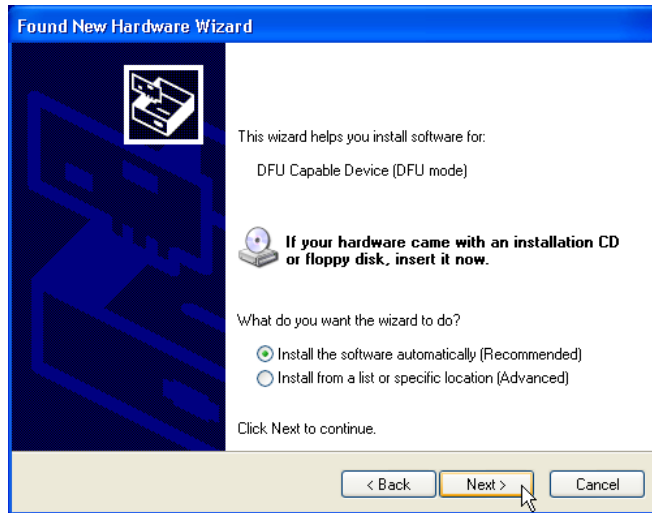


The wizard has switched the ERM100 to DFU mode, but so far no DFU device driver has been installed yet. As for this reason, the wizard cannot find a DFU device and an Error message comes up. Don't click nor to Yes nor to No!

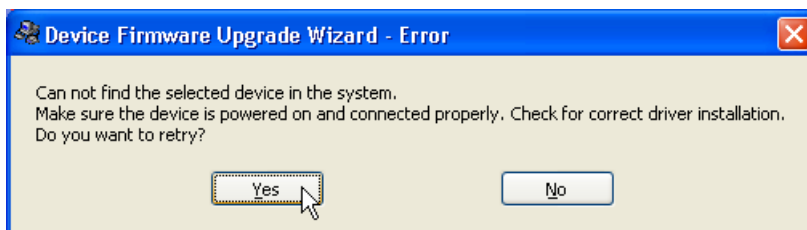


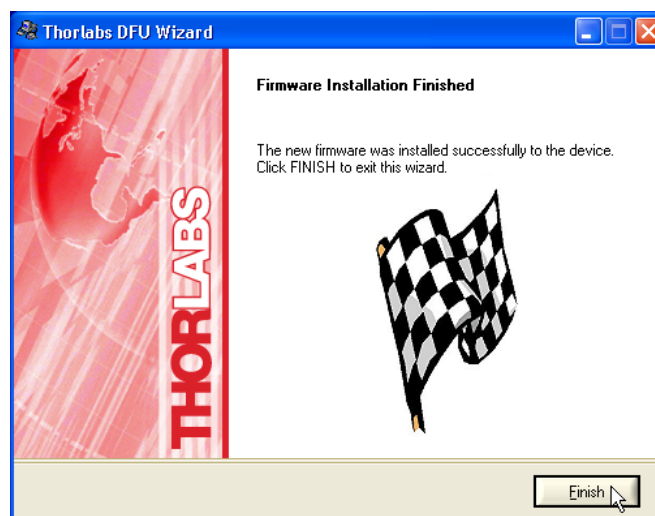
Please note, that at the same time in the background a "Found New Hardware Wizard" came up - please bring it in front and proceed as shown in the screen shots below:





After finishing the DFU driver installation, the above screen closes this way getting you back to Error screen - now click "Yes" to continue.





Firmware update was carried out successfully.

## 5.2 Version Information

The software version can be found on the [CD start screen](#).

The ERM100 menu provides the information on

- [serial number](#)
- [firmware version](#)
- [bootloader version](#)

from the display. Prior to contact Thorlabs, please retrieve this information and keep it ready.

## 5.3 Troubleshooting

In case that your ERM100 shows malfunction please check the following items:

Unit does not work at all (no display at the front):

- **ERM100 connected properly to the mains?**

- Check the mains cable.
- **ERM100 turned on?**
  - Turn on your ERM100 with the mains-switch.
- **Check the fuses at the rear panel.**
  - If blown replace the fuses by the correct type, please refer to section [Replacing Mains Fuses](#).

### Display shows 'INPUT ERROR: Input power low'

- **Is a fiber connected to the optical input of the ERM100?**
  - Connect the fiber to the optical input of the ERM100.
  - Check if the optical connection from the light source to the optical input of the ERM100.
- **Is the light source (laser diode, SLED, ASE) switched on?**
  - Check Switch the light source on.

### Display shows 'System ERROR: Motor speed low'

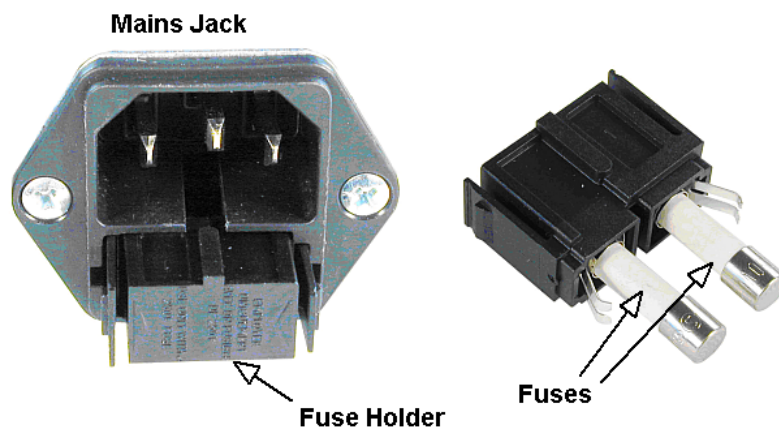
- **The motor speed is low for more than 10 seconds.**
  - The motor is defective. Please contact Thorlabs.

If you don't find the error source by means of the trouble shooting list please first contact Thorlabs prior to return the ERM100 for checkup and repair.

## 5.4 Replacing Mains Fuses

The ERM100 optical power meter operates at a line voltage range of 90 V ... 264 V.

The two power input fuses are externally accessible. If they have opened due to line distortions or other causes, they can be replaced from the rear without opening the unit.



1. Turn off the ERM100 and disconnect the mains cable.



2. The fuse holder (see Figure 24) is located below the 3-pole power connector of the mains jack. Release the fuse holder by pressing its plastic retainers with the aid of a small screwdriver. The retainers are located on the right and left side of the holder and must be pressed towards the center.
3. Replace the defective or wrong fuses and press in the fuse holder until locked on both sides.

**Fuse type**

T0.8A 250V (800 mA, time-lag, 250V)

**Note**

The fuses must meet IEC specification 60127-2/III, time characteristic: time-lag (T), 250V AC, size 5 x 20 mm.

## 6 Appendix

### 6.1 Technical Data

<b>Optical Specifications</b>	
Wavelength range	800 .. 1700 nm
Maximum ER 1)	>40 dB
ER Accuracy 1)	0.5 dB
ER Resolution	0.1 dB
Angle Accuracy 1)	0.5 °
Angle resolution	0.1 °
Dynamic range 2)	50 dB
<b>Connectors</b>	
Optical input	FC/PC narrow key <sup>3)</sup>
USB	USB 2.0 Type B
Chassis ground	4 mm banana jack
Mains input	IEC 60320
<b>Power Supply</b>	
Line voltage	90...264V AC
Line frequency	50 ... 60 Hz
Power consumption (max.)	20 VA
Supply mains over voltage	Category II (Cat II)
<b>General</b>	
Operating Temperature Range 4)	+5C ... +40 °C
Storage Temperature Range	-40 to 70 °C
Relative Humidity	Max. 80 % up to 31 °C, decreasing to 50% at 40 °C
Pollution Degree (indoor use only)	2
Operation altitude	< 2000 m
Warm-up time for rated accuracy	10 min
Dimensions (W x H x D) without operating elements with operating elements	146 x 66 x 290 mm <sup>3</sup> 146 x 77 x 320 mm <sup>3</sup>
Weight	≤ 3 kg

1) for input power > -30dBm

2) Dynamic range depends on specific wavelength

3) others on request

4) non condensing

All technical data are valid at 23 ± 5°C and 45 ± 15% rel. humidity (non condensing)

## 6.2 Instrument Driver Command Reference

### 6.2.1 Common IEEE488.2 Commands

The device supports several IEEE488.2 common commands and queries. Additional descriptive information may be found in the IEEE488.2-1992-§10 standard.

#### Command List

Command	Description
<b>*IDN?</b>	Identification query. (IEEE488.2-1992-§10.14)
<b>*TST?</b>	Selftest query. (IEEE488.2-1992-§10.38)
<b>*OPC</b>	Operation complete command. (IEEE488.2-1992-§10.18)
<b>*OPC?</b>	Operation complete query. (IEEE488.2-1992-§10.19)
<b>*WAI</b>	Wait command. (IEEE488.2-1992-§10.39)
<b>*RST</b>	Reset command. (IEEE488.2-1992-§10.32)
<b>*SRE</b>	Service Request Enable command. (IEEE488.2-1992-§10.34)
<b>*SRE?</b>	Service Request Enable query. (IEEE488.2-1992-§10.35)
<b>*STB?</b>	Read Status Byte query. (IEEE488.2-1992-§10.36)
<b>*ESE</b>	Standard Event Status Enable command. (IEEE488.2-1992-§10.10)
<b>*ESE?</b>	Standard Event Status Enable query. (IEEE488.2-1992-§10.11)
<b>*ESR?</b>	Standard Event Status Register query. (IEEE488.2-1992-§10.12)
<b>*CLS</b>	Clear Status command. (IEEE488.2-1992-§10.3)

#### Descriptions

##### Identification Query

Command syntax: **\*IDN?**

Response syntax: **<ARBITRARY ASCII RESPONSE DATA>**

Description: Identification query (see also IEEE488.2-1992-§10.14). The response is organized into four fields separated by commas. (Manufacturer, Model, Serial number, Firmware level)

##### Self test Query

Command syntax: **\*TST?**

Response syntax: **<NR1 NUMERIC RESPONSE DATA>**

Description: Selftest query (see also IEEE488.2-1992-§10.38 and chapter 'Selftest Results' in this document). A return value of '0' means success.

##### Operation Complete Command

Command syntax: **\*OPC**

Description: Sets the 'OPC' bit in the 'Standard Event Status Register' (see also IEEE488.2-1992-§10.18).

### Operation Complete Query

Command syntax: **\*OPC?**

Response syntax: **<NR1 NUMERIC RESPONSE DATA>**

Description: The Operation Complete Query places a '1' into the device's output queue (see also IEEE488.2-1992-§10.19).

### Wait Command

Command syntax: **\*WAI**

Description: This command is required for IEEE488 compatibility and has no effect. (see also IEEE488.2-1992-§10.39).

### Reset Command

Command syntax: **\*RST**

Description: This command resets the device. (see also IEEE488.2-1992-§10.32).

### Service Request Enable Command

Command syntax: **\*SRE <DECIMAL NUMERIC PROGRAM DATA>**

Description: Sets the device's Service Request Enable Register (see also IEEE488.2-1992-§10.34 and chapter 'Status Reporting' in this document).

---

### Service Request Enable Query

Command syntax:            **\*SRE?**  
Response syntax:            **<NR1 NUMERIC RESPONSE DATA>**  
Description:                Queries the device's Service Request Enable Register (see also IEEE488.2-1992-§10.35 and chapter 'Status Reporting' in this document).

### Read Status Byte Query

Command syntax:            **\*STB?**  
Response syntax:            **<NR1 NUMERIC RESPONSE DATA>**  
Description:                Queries the device's Status Byte (see also IEEE488.2-1992-§10.36 and chapter 'Status Reporting' in this document).

### Standard Event Status Enable Command

Command syntax:            **\*ESE <DECIMAL NUMERIC PROGRAM DATA>**  
Description:                Sets the device's Standard Event Status Enable Register (see also IEEE488.2-1992-§10.10 and chapter 'Status Reporting' in this document).

### Standard Event Status Enable Query

Command syntax:            **\*ESE?**  
Response syntax:            **<NR1 NUMERIC RESPONSE DATA>**  
Description:                Queries the device's Standard Event Status Enable Register (see also IEEE488.2-1992-§10.11 and chapter 'Status Reporting' in this document).

### Standard Event Status Register Query

Command syntax:            **\*ESR?**  
Response syntax:            **<NR1 NUMERIC RESPONSE DATA>**  
Description:                Queries the device's Standard Event Status Register (see also IEEE488.2-1992-§10.12 and chapter 'Status Reporting' in this document).

### Clear Status Command

Command syntax:            **\*CLS**  
Prerequisite:                None  
Description:                Clears the following device's status registers (see also IEEE488.2-1992-§10.3):

- Standard Event Status Register
- Device Error Event Register
- Device Operation Event Register
- Device Error Queue

## 6.2.2 Measurement Commands

### Command List

Command	Description
<code>:MEAS:VAL?</code>	Query the measurement data
<code>:MEAS:EXT?</code>	Query extreme value monitor
<code>:MEAS:EXR?</code>	Query extreme value monitor and reset extreme values

### Description

#### Measurement Query

Command syntax: `:MEAS:VAL?`

Response syntax: Extinction ratio [dB] <NR3 NUMERIC RESPONSE DATA>, Key angle [°] <NR3 NUMERIC RESPONSE DATA>, Optical power [dBm] <NR3 NUMERIC RESPONSE DATA>

Description: Queries the measurement result.  
Note: If a power overflow occurs, the value '+Inf' or '-Inf' is returned for the optical power value.

#### Extreme Value Query

Command syntax: `:MEAS:EXT?`

Response syntax: Extinction ratio minimum value [dB] <NR3 NUMERIC RESPONSE DATA>, Key angle maximum value [°] <NR3 NUMERIC RESPONSE DATA>

Description: Queries the extreme values of the measurement results. If there was no new measurement since last monitor reset the values '+Inf' for the ER and '0.0' for the angle are returned and an error is insert into the error queue.

#### Extreme Value Query With Reset

Command syntax: `:MEAS:EXR?`

Response syntax: Extinction ratio minimum value [dB] <NR3 NUMERIC RESPONSE DATA>, Key angle maximum value [°] <NR3 NUMERIC RESPONSE DATA>

Description: Queries the extreme values of the measurement results and re-sets the extreme value monitor. If there was no new measurement since last monitor reset the values '+Inf' for the ER and '0.0' for the angle are returned and an error is insert into the error queue. The reset sets the ER value to '+Inf' and the angle to '0.0'.

## 6.2.3 Device Setup Commands

### Command List

Command	Description
<code>:WAVEL:VAL</code>	Set the wavelength
<code>:WAVEL:VAL?</code>	Query the currently used wavelength
<code>:WAVEL:RNG?</code>	Query the wavelength range

### Description

#### Set Wavelength

Command syntax: `:WAVEL:VAL <DECIMAL NUMERIC PROGRAM DATA>`  
 Description: Sets the wavelength [nm] to use for calculating the sensor sensitivity.

#### Query Wavelength

Command syntax: `:WAVEL:VAL?`  
 Response syntax: currently used wavelength `<NR3 NUMERIC RESPONSE DATA>`  
 Description: Queries the currently used wavelength [nm].

#### Query Wavelength Range

Command syntax: `:WAVEL:RNG?`  
 Response syntax: minimum settable wavelength [nm]:  
`<NR3 NUMERIC RESPONSE DATA>`,  
 maximum settable wavelength [nm]:  
`<NR3 NUMERIC RESPONSE DATA>`,  
 currently used wavelength [nm]:  
`<NR3 NUMERIC RESPONSE DATA>`  
 Description: Queries wavelength range.

## 6.2.4 Device Status Commands

### Command List

Command	Description
<code>:STAT:ERR:CND?</code>	Query the Device Error Condition register.
<code>:STAT:ERR:EVT?</code>	Query the Device Error Event register.
<code>:STAT:ERR:ENA?</code>	Query the Device Error Event Enable register.
<code>:STAT:ERR:ENA</code>	Set the Device Error Event Enable register.
<code>:STAT:OPER:CND?</code>	Query the Device Operation Condition register.
<code>:STAT:OPER:EVT?</code>	Query the Device Operation Event register.
<code>:STAT:OPER:ENA?</code>	Query the Device Operation Event Enable register.
<code>:STAT:OPER:ENA</code>	Set the Device Operation Event Enable register.

### Description

#### Query Device Error Condition Register

Command syntax: `:STAT:ERR:CND?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Error Condition Register (see also chapter ['Status Reporting'](#) in this document).

#### Query Device Error Event Register

Command syntax: `:STAT:ERR:EVT?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Error Event Register (see also chapter ['Status Reporting'](#) in this document).

#### Set Device Error Event Enable Register

Command syntax: `:STAT:ERR:ENA <DECIMAL NUMERIC PROGRAM DATA>`

Description: Sets the device's Error Event Enable Register (see also chapter ['Status Reporting'](#) in this document).

#### Query Device Error Event Enable Register

Command syntax: `:STAT:ERR:ENA?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Error Event Enable Register (see also chapter ['Status Reporting'](#) in this document).

#### Query Device Operation Condition Register

Command syntax: `:STAT:OPER:CND?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Operation Condition Register (see also chapter ['Status Reporting'](#) in this document).



### Query Device Operation Event Register

Command syntax: `:STAT:OPER:EVT?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Operation Event Register (see also chapter '[Status Reporting](#)' in this document).

### Set Device Operation Event Enable Register

Command syntax: `:STAT:OPER:ENA <DECIMAL NUMERIC PROGRAM DATA>`

Description: Sets the device's Operation Event Enable Register (see also chapter '[Status Reporting](#)' in this document).

### Query Device Operation Event Enable Register

Command syntax: `:STAT:OPER:ENA?`

Response syntax: `<NR1 NUMERIC RESPONSE DATA>`

Description: Queries the device's Operation Event Enable Register (see also chapter '[Status Reporting](#)' in this document).

## 6.2.5 General System Commands

### Command List

Command	Description
<code>:SYST:ERR?</code>	Query the device's error queue.
<code>:SYST:INFO?</code>	Query descriptive device information.

### Description

#### Error Query

Command syntax: `:SYST:ERR?`

Response syntax: Error number `<NR1 NUMERIC RESPONSE DATA>`,  
Error text `<ARBITRARY ASCII RESPONSE DATA>`

Description: Queries the device's error queue (see also: chapter 'Error Reporting' in this document).

#### Query Descriptive Device Information

Command syntax: `:SYST:INFO?`

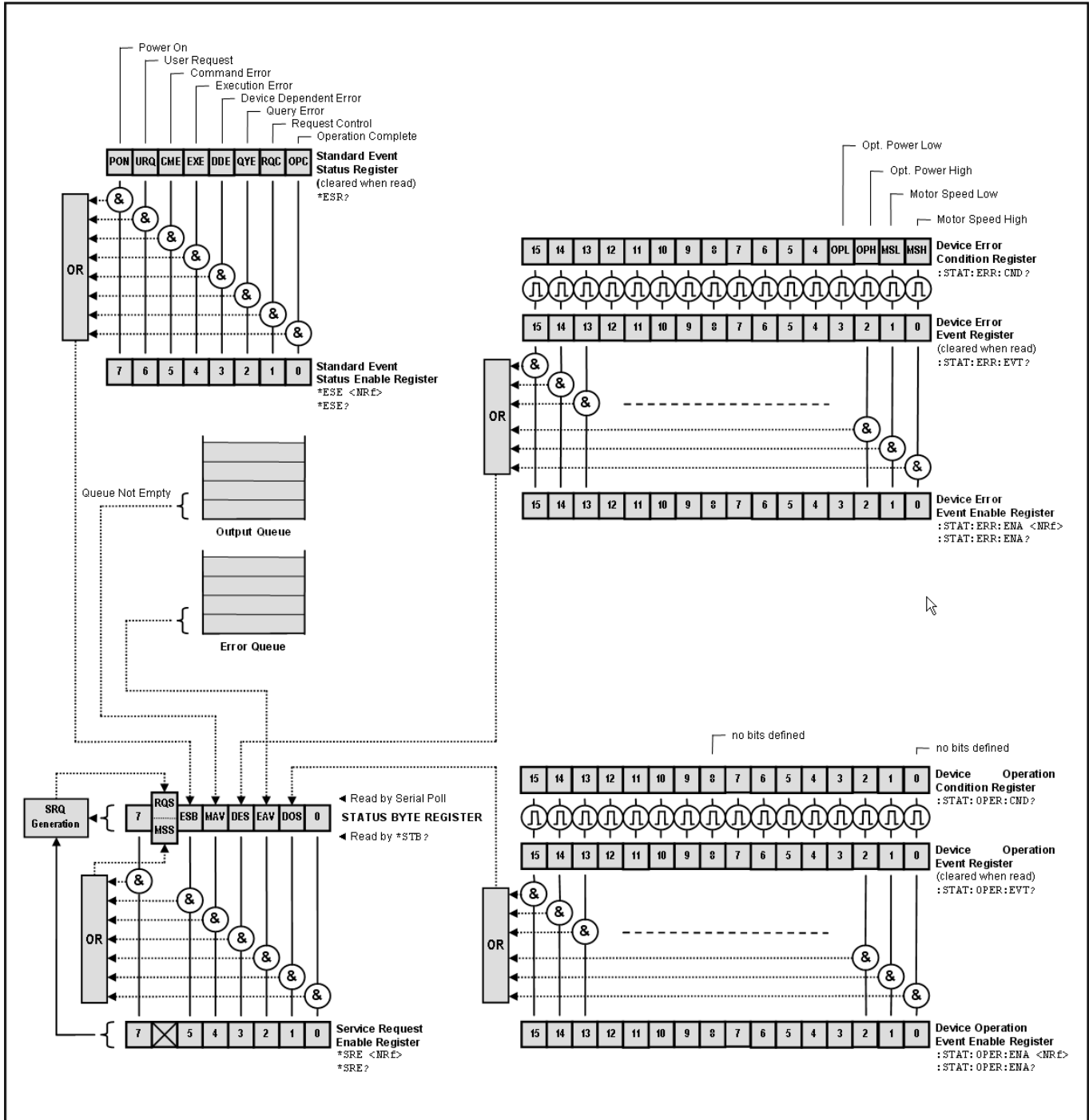
Response syntax: `<ARBITRARY ASCII RESPONSE DATA>`

Description: Queries descriptive device information.

## 6.3 Status Reporting

### 6.3.1 Status Structure

The device uses a status reporting structure like it is defined in IEEE488.2-1992-§11. The figure below shows the complete structure.



## 6.3.2 Register Description

### Status Byte Register

The Status Byte Register gives a summary of all underlying status structures. See also IEEE488.2-1992-§11.2.

Bit #	Mnemonic	Description
7		reserved
6	<b>RQS/MSS</b>	Request Service / Master Summary Status
5	<b>ESB</b>	Standard Event Status Bit
4	<b>MAV</b>	Message Available. There is response data available for readout
3	<b>DES</b>	Device Error Status Structure Summary Bit
2	<b>EAV</b>	Error Available. There is at least one error in the error queue.
1	<b>DOS</b>	Device Operation Status Structure Summary Bit
0		Reserved

### Standard Event Status Structure

The Standard Event Status Structure is described in IEEE488.2-1992-§11.5.

### Device Error Status Structure

The Device Error Status Structure reflects asynchronous device errors. Bits in the according event register are rising and falling edge triggered.

Bit #	Mnemonic	Description
15..4		reserved
3	<b>OPL</b>	Optical input power low
2	<b>OPH</b>	Optical input power high
1	<b>MSL</b>	Sensor motor speed low
0	<b>MSH</b>	Sensor motor speed high

### Device Operation Status Structure

The Device Operation Status Structure reflects device states. Bits in the according event register are rising edge and falling edge triggered.

Bit #	Mnemonic	Description
15..0		reserved

## Error Reporting

The device stores errors in a queue containing up to 30 entries. The error queue may be read out by the ``:SYST:ERR?'` command. The following table lists all error numbers and the according descriptive messages.

Error	Description
0	No error
1	General system failure
2	Floating point error - domain
3	Value out of range
4	Mainboard not supported
5	Feature not supported
6	Measurement in progres
7	Measurement interrupted
13	Timeout occurred while setting bootloader address
40	Timeout occurred while accessing onboard EEPROM
41	Checksum error reading EEPROM
42	Attempt to read from unknown EEPROM
43	EEPROM out of space
50	Response message buffer overflow
60	Error queue overflow
61	Command message buffer overflow
62	Unknown command
63	Invalid number of command parameters
64	Erroneous decimal command parameter
65	Erroneous nondecimal command parameter
66	Erroneous char/string command parameter
67	Invalid character program data value
70	Adjustment data invalid
71	Adjustment data set invalid by user
72	Device setup data corrupt
80	Internal calculation error
100	Authentication required for operation
101	Authentication failed
110	Operation is not allowed in SERVICE-MODE
111	Operation is allowed in SERVICE-MODE only
123	Erroneous HEX record
124	Erroneous sensor checksum
125	Erroneous converter adjustment checksum

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<b>Error</b>	<b>Description</b>
<b>126</b>	Erroneous key offset checksum
<b>130</b>	I <sup>2</sup> C: Illegal START/STOP condition
<b>131</b>	I <sup>2</sup> C: Slave adress not acknowledged (Not a valid bus adress?)
<b>132</b>	I <sup>2</sup> C: Incomplete write operation (Slave rejected to receive all data in the buffer)
<b>133</b>	I <sup>2</sup> C: Arbitration lost

## 6.4 Certifications and Compliances

Category	Standards or description	
EC Declaration of Conformity - EMC	Meets intent of Directive 2004/108/EC <sup>1</sup> for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:	
	EN 61326:1997 +A1:1998 +A2:2001 +A3:2003	Electrical equipment for measurement, control and laboratory use – EMC requirements: Immunity: complies with immunity test requirements for equipment intended for use in industrial locations <sup>2</sup> . Emission: complies with EN 55011 Class B Limits <sup>2,3</sup> , IEC 610003-2 and IEC 61000-3-3.
	IEC 61000-4-2	Electrostatic Discharge Immunity (Performance Criterion B)
	IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity (Performance Criterion A)
	IEC 61000-4-4	Electrical Fast Transient / Burst Immunity (Performance Criterion A)
	IEC 61000-4-5	Power Line Surge Immunity (Performance Criterion A)
	IEC 61000-4-6	Conducted RF Immunity (Performance Criterion A)
	IEC 61000-4-11	Voltage Dips, Short Interruptions and Voltage Variations Immunity (Performance Criterion A/C <sup>4</sup> )
	IEC 61000-3-2	AC Power Line Harmonic Emissions
IEC 61000-3-3	Voltage Fluctuations and Flicker	
FCC EMC Compliance	Emissions comply with the Class B Limits of FCC Code of Federal Regulations 47, Part 15, Subpart B <sup>2,3</sup> .	
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 <sup>5</sup>	
	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 2 <sup>nd</sup> ed.	
	ISA-82:02.01	
Canadian Certification		
Additional Compliance	CAN/CSA C22.2 No. 61010-1	
Equipment Type	Test and Measuring	
Safety Class	Class I equipment (as defined in IEC 60950-1:2001)	
<sup>1</sup> Replaces 89/336/EEC. <sup>2</sup> Compliance demonstrated using high-quality shielded interface cables shorter than or equal to 3 meters. <sup>3</sup> Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object. <sup>4</sup> Performance Criterion C was reached at additional test levels according to EN 61326-1:2006 table 2. <sup>5</sup> Replaces 73/23/EEC, amended by 93/68/EEC		

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## 6.5 Warranty

Thorlabs warrants material and production of the ERM100 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 entitled to warranty.

For warranty repairs or service the unit must be sent back to Thorlabs. The customer will carry the shipping costs 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 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 warrants the hard- and/or software determined by Thorlabs for this unit to operate fault-free provided that they are handled according to our requirements. However, Thorlabs does not warrant a fault free and uninterrupted operation of the unit, of the software or firmware for special applications nor this instruction manual to be error free. Thorlabs 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 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 instruction manual or the technical data of the described unit at any time.

## 6.6 Copyright and Exclusion of Reliability

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## 6.7 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 13<sup>th</sup> 2005
- marked correspondingly with the crossed out “wheelie bin” logo (see figure 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.).

### 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.

WEEE Number (Germany) : DE97581288

### Ecological background

It is well known that waste treatment 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-life products will thereby avoid negative impacts on the environment.



*Crossed out  
"Wheelie Bin" symbol*

## 6.8 List of Acronyms

The following acronyms and abbreviations are used in this manual:

ASE	Amplified Spontaneous Emission
DC	Direct Current
DFB	Distributed Feedback (laser)
DFU	Device Firmware Update
DOP	Degree Of Polarization
DUT	Device Under Test
ER	Extinction Ration
PM	Polarization-Maintaining
PMF	Polarization-Maintaining Fiber
SLED	Super-Luminescent Emitting Diode
USB	Universal Serial Bus

## 6.9 Thorlabs Worldwide Contacts

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



### USA, Canada, and South America

Thorlabs, Inc.  
[sales@thorlabs.com](mailto:sales@thorlabs.com)  
[techsupport@thorlabs.com](mailto:techsupport@thorlabs.com)

### Europe

Thorlabs GmbH  
[europe@thorlabs.com](mailto:europe@thorlabs.com)

### France

Thorlabs SAS  
[sales.fr@thorlabs.com](mailto:sales.fr@thorlabs.com)

### Japan

Thorlabs Japan, Inc.  
[sales@thorlabs.jp](mailto:sales@thorlabs.jp)

### UK and Ireland

Thorlabs Ltd.  
[sales.uk@thorlabs.com](mailto:sales.uk@thorlabs.com)  
[techsupport.uk@thorlabs.com](mailto:techsupport.uk@thorlabs.com)

### Scandinavia

Thorlabs Sweden AB  
[scandinavia@thorlabs.com](mailto:scandinavia@thorlabs.com)

### Brazil

Thorlabs Vendas de Fotônicos Ltda.  
[brasil@thorlabs.com](mailto:brasil@thorlabs.com)

### China

Thorlabs China  
[chinasales@thorlabs.com](mailto:chinasales@thorlabs.com)