Laser Diode / Temperature Controller

ITC4000 Series Operation Manual

2012

Version: 3.1
Date: 02.02.2012

Contents

We aim to develop and produce the best solution for your application in the field of optical measurement technique. To help us to live up to your expectations and improve 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 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 preceeded 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 these advices carefully!

1 General Information

This part of the operation manual contains specific information on how to operate the ITC4000 Series Laser Diode and Temperature Controller. A general description is followed by an explanation of how to operate the unit manually. The instrument provides a USB 2.0 Full Speed interface according to the USB 2.0 specification, the USBTMC specification and the USBTMC USB488 specification.

Related documents:

- LDC4000 Series Operation Manual available at www.thorlabs.com
- TED4000 Series Operation Manual available at www.thorlabs.com
- Series 4000 Programmers Reference Manual at www.thorlabs.com

1.1 At a glance

1.1.1 General remarks

The ITC4000 series is a high power precision laser diode and temperature controller series with a USB 2.0 interface for driving laser diodes up to 20A laser current.

Special highlights of the ITC4000 Series Laser Diode and Temperature Controllers are:

- Operate with anode- or cathode-grounded lasers and photodiodes
- Current (photodiode) and voltage (thermopile) feedback inputs
- The laser diodes can be operated in constant current as well as in constant power mode
- CW mode with modulation up to 100kHz
- Internal DDS generator for sine, square, triangle waveforms
- External modulation input
- QCW mode with pulse width down to 100µs
- QCW trigger input and trigger output
- Interlock for automatic switch off by an external emergency switch or by a cable interruption
- Laser Diode Enable input
- High power TEC with excellent temperature stability and PID Auto-Tune function
- Temperature loop monitoring for laser protection
- A wide variety of protection features safeguard the laser diode and the TEC element from damage.
- USB interface for remote operation supporting the USBTMC protocol
- SCPI compliant command set
- VXIpnp Instrument Drivers for various programming environments including NI-LabVIEW™, NI-LabWindows™/CVI and MS-Visual Studio
- Power efficient by active power management

1.1.2 Protection for laser diodes

To protect the user and the connected setup, the ITC4000 series includes the following protective features:

Key switch
The key switch will shutoff the laser output. This feature complies with the CDRH (Center for Devices and Radiological Health) requirements and prevents an unauthorized usage of the laser driver.

Switch on delay
The ITC4000 controllers are CDRH compliant with the user programmable switch on delay. The default setting is 3 seconds.

Softstart
The softstart function protects the laser diode against undesired peaks.

Laser current limit (hardware limit)
The maximum laser current can be adjusted by the laser current limit. The threshold can be set in the LD Source Setup menu.
(Refer to chapter Setting the LD source parameters 31)

Interlock
The interlock input realizes several protection functions simultaneously.
- Safety lock to prevent unintentional use
- Cable damage monitoring
- An external emergency switch may be connected
- To connect your external automatic protection equipment, e.g. for temperature monitoring
- Laser ON/OFF LED

(Refer to chapter Connecting the interlock and LD ON monitoring 19)
The laser can only be operated with the interlock input being closed.

Open circuit detection for the laser diode
If the connection to the laser is interrupted even for a short time during operation, an immediate emergency switch off occurs. The open circuit threshold can be set via the "Voltage Protection" feature.

(Refer to chapter Laser Output Configuration 29)

Electronic short-circuit switch for the laser diode
With the current module switched off, an electronic switch will short the laser diode so that no voltage is applied to the laser contacts.

Control LED for laser current ON
When the laser current is switched on, a green LED indicator in the LD ON switch lights up.

Temperature window protection of the laser diode
A laser operation in a specified temperature range can be realized in combination with the temperature protection function of the integrated TEC controller (Refer to chapters Temperature protection 56 and Laser output configuration 29). The laser output is switched off, if the temperature leaves the defined temperature window.

Over-temperature protection
The ITC4000 has an automatic over-temperature protection. If the allowed internal operating temperature should be exceeded, the outputs will be switched off. After a temperature drop of about 10 °C, the outputs of the ITC4000 can be switched on again.

Defined states after switch-on
When turning on the ITC4000 with the main switch, the laser and TEC outputs remain switched off.

Line failure monitoring
In case of line failure / line interruption the ITC4000 will restart anew as if it has been turned on. So the laser output remains switched off.

Mains filtering:
The installed power supply, with carefully dimensioned filters, provides low ripple and noise at the laser and TEC outputs.

1.2 Safety

Warning

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly.
Before applying power to your ITC4000 Series Instrument, 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!
The ITC4000 series laser diode and temperature controllers must not be operated in explosion endangered environments!
Do not remove covers!
Refer servicing to qualified personnel!

Warning

Laser modules can deliver up to several Watts of (maybe) invisible laser radiation!
When operated incorrectly, this can cause severe damage to your eyes and health!
Be sure to pay strict attention to the safety recommendations of the appropriate laser safety class! This laser safety class is marked on your external laser source used.

Attention

Laser output, sensor inputs, and control inputs and outputs must only be connected with duly shielded connection cables.

Do not obstruct the air ventilation slots in the housing!
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 must be shipped in its complete original packaging, including the plastic form parts. If necessary, ask for a replacement package.

Attention

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.
Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- **Reorient or relocate the receiving antenna.**
- **Increase the separation between the equipment and receiver.**
- **Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.**
- **Consult the dealer or an experienced radio/T.V. technician for help.**

Thorlabs GmbH is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs GmbH. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user.
The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

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).

1.3 Ordering codes and accessories

Ordering code	Short description
ITC4001	Laser Diode / Temperature Controller, LD current range 0 .. 1 A, TEC current 0 .. 8A
ITC4005	Laser Diode / Temperature Controller, LD current range 0 .. 5 A, TEC current 0 .. 15A
ITC4020	Laser Diode / Temperature Controller, LD current range 0 .. 20 A, TEC current 0 .. 15A
CAB4000	Shielded cable to connect the TEC output of the ITC4000 controller to a Thorlabs LM14S2, LDM21 or TCLDM9 laser diode mount (male 17W2 mixed DSUB connector to female 9 pin DSUB connector). The rated TEC current is 5A.
CAB4001	Shielded cable to connect the TEC output of the ITC4000 controller to a Thorlabs high power TEC mount or laser diode mount (male 17W2 mixed DSUB connector to male 17W2 mixed DSUB connector). The rated TEC current is 20A.
CAB4005	Shielded cable to connect the laser output of the ITC4000 controller to a Thorlabs LM14S2, LDM21 or TCLDM9 laser diode mount (male 13W3 mixed DSUB connector to male 9 pin DSUB connector). The rated LD current is 5A.
CAB4006	Shielded cable to connect the laser output of the ITC4000 controller to a Thorlabs high power laser diode mount (male 13W3 mixed DSUB connector to male 13W3 mixed DSUB connector). The rated LD current is 20A.
CON4001	Connector kit for the TEC output of the ITC4000 controllers, 20A: mixed DSUB connector type 17W2 (male) with two 20A high current contacts (male)
CON4005	Connector kit for the laser output of the ITC4000 controllers, 20A: mixed DSUB connector type 13W3 (male) with three 20A high current contacts (male)
CAL-ITC4000	Recalibration of an ITC4000 series controller

Please visit our homepage www.thorlabs.com for further information.

2 Getting started

2.1 Unpacking

Inspect the shipping container for damage.
If the shipping container appears to be damaged, keep it until you have checked the contents and you have inspected the ITC4000 controller mechanically and electrically.
Verify that you have received the following items:

- 1 ITC4001, ITC4005 or ITC4020
- 1 power cord, connector according to ordering country
- 1 USB cable (A-B)
- 1 ITC4000 series operation manual
- 1 Series 4000 instrumentation CD (containing manuals, drivers, tools and software)
- With ITC4001 or ITC4005: 1 CAB4000 shielded cable to connect the TEC controller to a Thorlabs LM14S2, LDM21 or TCLDM9 laser diode mount (male 17W2 mixed DSUB connector to female 9 pin DSUB connector), rated TEC current 5A
- With ITC4020: 1 CAB4001 shielded cable to connect the TEC controller to a Thorlabs high power laser diode mount (male 17W2 mixed DSUB connector to male 17W2 mixed DSUB connector), rated TEC current 20A
- With ITC4001 or ITC4005: 1 CAB4005 shielded cable to connect the laser diode controller to a Thorlabs LM14S2, LDM21 or TCLDM9 laser diode mount (male 13W3 mixed DSUB connector to male 9 pin DSUB connector), rated laser current 5A
- With ITC4020: 1 CAB4006 shielded cable to connect the laser diode controller to a Thorlabs high power laser diode mount (male 13W3 mixed DSUB connector to male 13W3 mixed DSUB connector), rated laser current 20A
- 1 Connector Kit CON4001 for ITC4000 series, rated TEC current 20A:
  - 1 Mixed DSUB connector type 17W2 (male) with 2 high current contacts (male)
  - 1 Mixed DSUB connector type 17W2 (female) with 2 high current contacts (female)
- 1 Connector Kit CON4005 for ITC4000 series, rated laser current 20A:
  - 1 Mixed DSUB connector type 13W3 (male) with 3 high current contacts (male)
  - 1 Mixed DSUB connector type 13W3 (female) with 3 high current contacts (female)

2.2 Preparation

Connect the mains connector (R10) of the unit to the line via the provided mains cable (refer to Figure 2, chapter Operating elements at the rear panel 12).

An external optical setup can be connected to ground potential via the connector jack of the chassis ground (R12).

2.3 Operating elements

2.3.1 Operating elements at the front panel

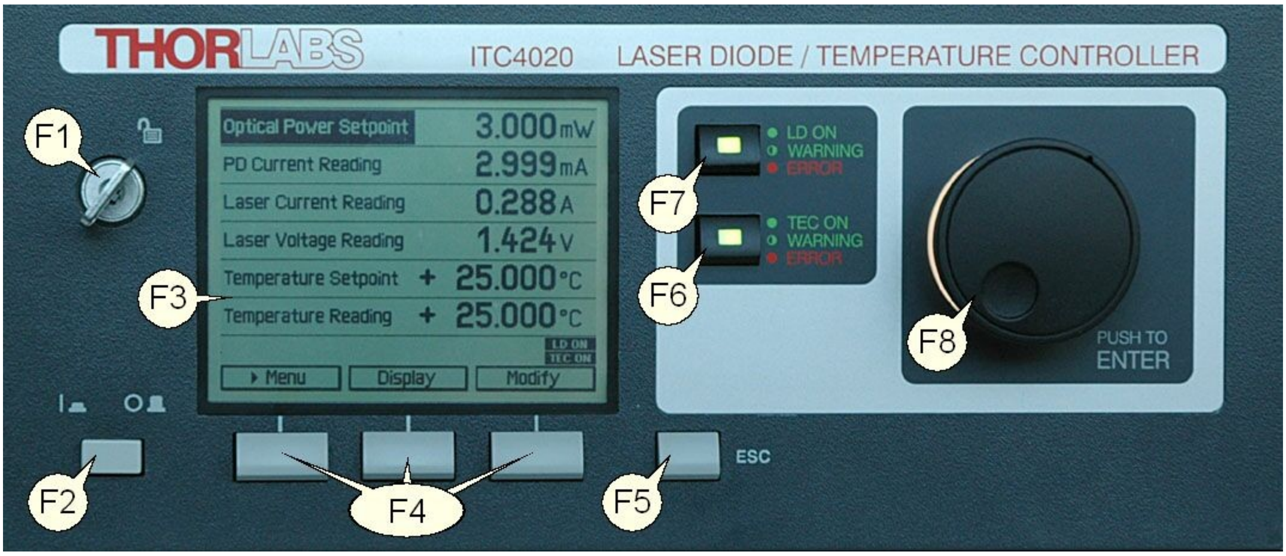


Figure 1 Operating elements at the front panel

F1		Key switch (Locked/Unlocked)
F2		Line switch (On/Off)
F3		LC display
F4		Softkeys for menu navigation
F5	ESC	Escape key
F6	TEC ON	On/Off button for TEC output with TEC ON LED (green) and ERROR LED (red)
F7	LD ON	On/Off button for LD output with LD ON LED (green) and ERROR LED (red)
F8		Adjustment knob to change set values, push to enter

2.3.2 Operating elements at the rear panel

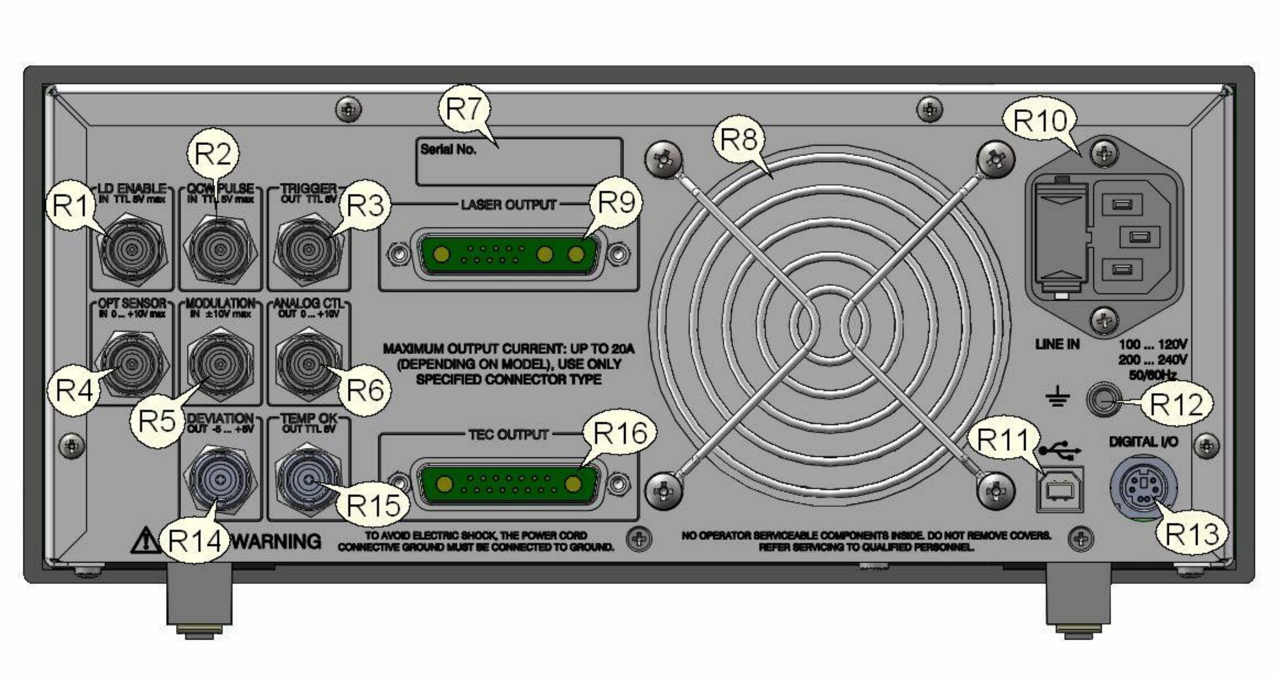


Figure 2 Operating elements at the rear panel

R1	LD ENABLE IN	Laser Enable input (high to enable laser ON), TTL 5 V max.
R2	QCW PULSE IN	Input for external trigger signal, TTL 5 V max.
R3	TRIGGER OUT	QCW pulse tracking output, TTL 5 V
R4	OPT SENSOR IN	Input for optical sensor, 0 ... +10 V max.
R5	MODULATION IN	Input for external modulation signal, -10 ... +10 V max.
R6	ANALOG CTL OUT	Output for laser current monitoring, 0 ... +10 V
R7	Serial No.	Serial number of the unit
R8		Cooling fan
R9	LASER OUTPUT	Laser diode output and optical sensor input (13W3 mixed DSUB jack)
R10	LINE IN	Mains connector and fuse holder
R11		USB connector
R12	⏚	4 mm banana jack for chassis ground
R13	DIGITAL I/O	MiniDin-6 jack for 4x digital I/O, I/O supply voltage (internal +12V) and GND
R14	DEVIATION OUT	Actual temperature deviation output, -5 ... +5 V
R15	TEMP OK OUT	Temperature OK output (high if inside temperature window), TTL 5 V
R16	TEC OUTPUT	TEC element output and temperature sensor input (17W2 mixed DSUB jack)

2.4 First operation

Warning

Prior to switching on your ITC4000, please read the safety instructions in chapter Safety 7 **carefully.**

Turn on the unit by means of the line switch (F2)
(see Figure 1, chapter Operating elements at the front panel 11).

After switching on the unit, the backlight of the display (F3) must get visible and the backlight behind the adjustment knob (F8) must light up.

If nothing is shown on the display, please check the line voltage (see chapter Line Voltage Settings 72) and the mains fuses (see chapter Replacing the mains fuses 72).
The ITC4000 series is immediately ready to use after turning on. The rated accuracy is reached, however, after a warming-up time of approx. 30 minutes.
After switching on the unit, the graphics display will show the device status, followed by the measurement screen.

By using the softkeys (F4) you can select the menu items, the set values and the measurement values to be displayed. You can change the set values by pressing the **Modify** button or the adjustment knob and then turning the adjustment knob (F8). Push this knob or the **Done** key to enter the adjusted value. If several menu items are displayed, you can select them also by turning and then pressing the adjustment knob.

If changing a parameter isn't permitted in the actual operating mode, or you arrive at the end of a parameter number range, entering is declined and a short beep is audible.

From any menu level, you can navigate to the next higher menu level using the **ESC** key (F5). The highest level is the measurement screen.
To leave the measurement screen and to enter the menu, press the **Menu** key or the **ESC** key.

2.5 System preferences

In the System Preferences menu you can select different settings concerning your ITC4000 system configuration, including Message Handling, Display Brightness, Display Contrast, Sound Signals, and Update Capability. To get into the System Preferences menu, turn the adjustment knob or press **Up / Down** until System Preferences is highlighted. Press **Enter** or the adjustment knob to confirm.

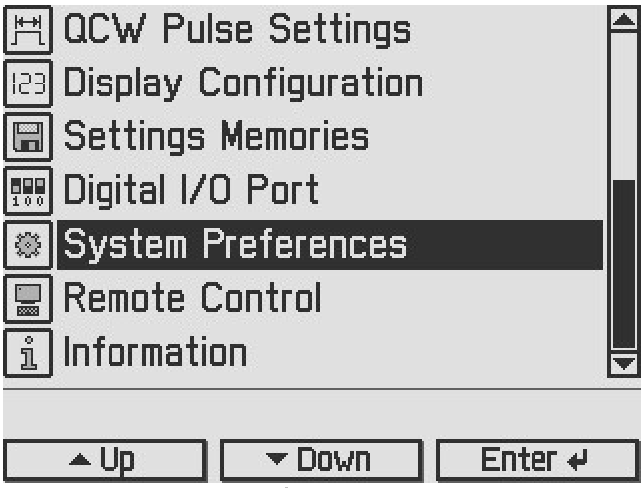


Figure 3
Main menu

Turn the adjustment knob or press **Up / Down** and select your desired menu item by pressing the **Modify** key or the adjustment knob. Make your necessary changes and confirm with the **Enter** key or by pressing the adjustment knob again.

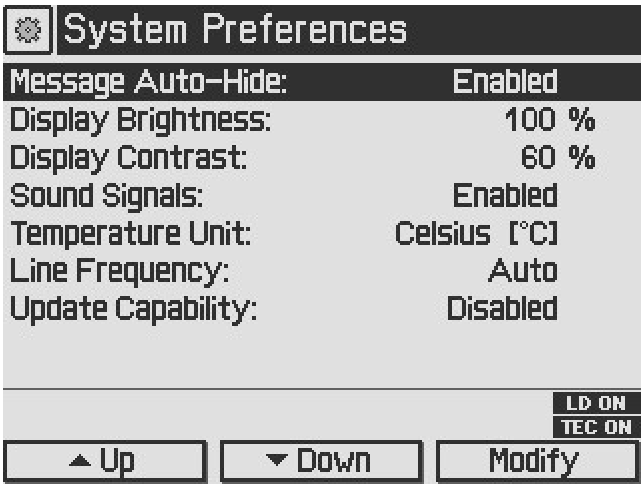


Figure 4
System preferences

Message Auto-Hide:
Message and error conditions which force the Laser output to switch off may disappear after a short time. So it may be preferable to keep the error messages displayed. You can choose the following settings:

Enabled (auto-hide): Error popup messages disappear after 10 seconds, you can close them instantly by pressing the ESC button (F5).
Disabled: Messages are displayed until they will be confirmed by pressing the ESC button.

Display Brightness, Display Contrast:
Both display parameters can be changed from 0% to 100%.
The brightness value also determines the illumination brightness of the adjustment knob.

NOTE

Please take care not to reduce the contrast value to a level making it impossible to read the display.

Sound Signals:
Here you can disable or enable the audibility of the error beeps and the menu navigation click response.

Temperature Unit:
The preferred temperature unit can be selected: °C (Celsius), °F (Fahrenheit), and K (Kelvin). The conversion between the units will be calculated automatically.

Line Frequency:
According to the mains properties, the line filter frequency can be set to 50 Hz or 60 Hz to suppress unwanted readout aliasing effects. The "Auto" function detects the line frequency automatically (default setting).

Update Capability:
Firmware updates can be performed by the user via the USB interface.
Three options are available:
Enabled: Firmware can be updated at any time.
Enabled once: Firmware can be updated once, afterwards this setting changes to disabled.
Disabled: Firmware update is inhibited (default setting).
For more information please refer to chapter Firmware Update 70.

3 Operating the ITC4000 series

3.1 Connecting components

3.1.1 Pin assignement of the laser output jack

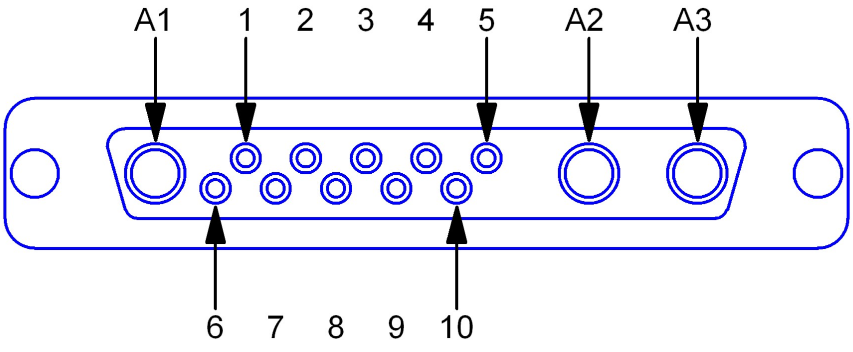


Figure 5
Pin assignment of the 13W3 DSUB laser output jack (rear panel view)

Pin	Connection
	Interlock and Status Indicator:
5	Output for interlock and status indicator "LASER ON/OFF" (+)
6	Ground pin for interlock and status indicator "LASER ON/OFF" (-)
	Monitor Input / Power Feedback Source:
1	(Thermo) voltage sensor input (+)
2	(Thermo) voltage sensor ground (-)
7	Photo current sensor input
8	Photo current sensor ground
	Laser Voltage Measurement:
4	Laser diode anode (+)
10	Laser diode cathode (-)
	Laser Diode:
A1	Laser diode ground
A2	Laser diode cathode (with polarity AG) (-)
A3	Laser diode anode (with polarity CG) (+)
3, 9	Not connected

Attention

The maximum laser output current for the ITC4020 is 20A. Use only the specified connector type: 13W3 mixed DSUB plug with high power contacts A1, A2, and A3 rated for at least 20A current. For wiring of A1, A2, and A3 use only wires rated for at least 20A current.

If Thorlabs laser diode mounts like TCLDM9, LDM21, or LM14S2 are used, the easiest way to connect them using a shielded cable CAB4005 (rated Laser current is 5A).
For use of other equipment's, a shielded cable with two 13W3 mixed DSUB plugs, CAB4006, (20A Laser current rating) is also available.

If using a custom-made cable, we recommend to use a shielded cable for the sensor inputs with twisted pairs. Use a separate shielded cable for the Laser current and Laser voltage measurement lines. The Laser current lines should be as short as possible and as close together as possible (e.g. twisted) to minimize inductance.

3.1.2 Connecting the laser diode

For CG polarity connect the laser diode with anode to A3 and with cathode to A1 (ground). For AG polarity, connect the laser diode with cathode to A2 and with anode to A1 (ground). Please refer to chapter Pin assignment of the laser output jack 16.

Attention

Take care to select the proper polarity for the connected laser diode. A wrong polarity may damage the laser diode.

We recommend using separate shielded lines drilled in pairs (twisted pair) for laser diode current and laser voltage measurement, as well as for the sensor inputs.

Some laser modules have a common ground pin for laser and photodiode. Figure 6 shows four wiring configurations for these modules.

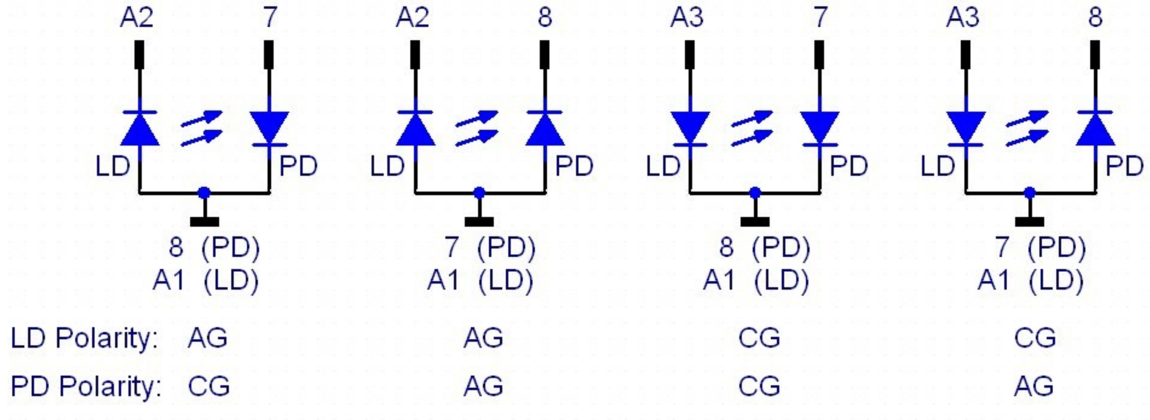


Figure 6
Connecting combined laser diode and photodiode modules

3.1.3 Connecting an optical sensor as a feedback source

The ITC4000 Laser Diode Controllers support optical current sensors (e.g. photodiodes) and optical voltage sensors (e.g. thermopiles) for monitoring the laser power output. Both sensor types can be used as a feedback source for a constant power loop to stabilize the laser output power.

3.1.3.1 Connecting a photodiode

The photodiode input circuit design is a trans-impedance amplifier with virtual ground (input impedance ~0 Ω).

The photodiode can be connected to the 13W3 DSUB jack "LASER OUTPUT" (R9) pins 7 and 8 or to the BNC jack "OPT SENSOR IN" (R4) at the rear panel of the ITC4000 (please refer to chapter Operating elements at the rear panel 12).

For more information about connecting modules with common laser and photodiode ground please refer to chapter Connecting the Laser Diode 17

The photodiode input parameters like input route, polarity, current range, BIAS state, BIAS voltage and response can be set via Setting the Photodiode Input Parameters 33.

We recommend using shielded “twisted pair“ wiring for the monitor diode current measurement.

Attention

Input voltage / current must not exceed 10V / 20mA!

3.1.3.2 Connecting a voltage feedback source

An optical voltage sensor (like thermopile) can be connected to the 13W3 DSUB jack "LASER OUTPUT" (R9) or to the BNC jack "OPT. SENSOR IN" (R4) at the rear panel. (refer to chapter Operating elements at the rear panel 12). Sensor amplifiers or power meters with voltage output can be connected here as well.

Attention

Prior to connecting an optical voltage sensor to the BNC jack "OPT. SENSOR IN", make sure that the thermopile sensor input route is set to rear panel BNC (refer to Setting the Thermopile Parameters 35**).**

The voltage sensor input parameters like input route, voltage range and response can be set via Setting the Thermopile Parameters 35.

We recommend using shielded “twisted pair“ wiring for the thermopile voltage measurement.

Attention

Input voltage must not exceed 10V!

3.1.4 Connecting the laser voltage meassurement

The ITC4000 controllers offer laser voltage measurements with standard accuracy or enhanced accuracy. Without additional wiring, the laser voltage is measured at the "LASER OUTPUT" jack (R9) at the rear panel of the unit (two terminal measurement). This leads to a measurement error due to the voltage drop along the "current" lines to the laser diode, so a slightly increased voltage will be displayed.
For an enhanced laser voltage measurement, two additional lines must be connected as close as possible to the laser diode pins (four terminal measurement). Connect the laser diode anode to pin 4 and the laser diode cathode to pin 10 of the "LASER OUTPUT" jack (R9) at the rear panel of the unit.

Attention

If the laser voltage measurement contacts (pin 4 and pin 10 of the "LASER OUTPUT" jack) are not used, they must be left unconnected to any other potential, otherwise the overvoltage protection may not work properly.

We recommend using separate shielded “twisted pair“ wiring for the Laser voltage measurement to minimize noise in the current- or voltage feedback measurement.

3.1.5 Connecting interlock and LD ON monitoring

The interlock function is realized using two pins that must be connected to each other as a precondition for switching on the laser.
These are pin 5 and pin 6 of the 13W3 DSUB "LASER OUTPUT" jack (R9) at the rear panel of the unit.

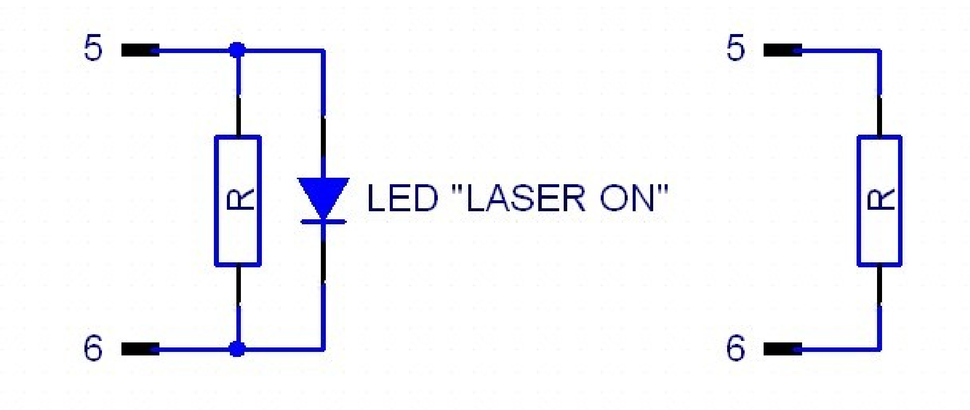


Figure 7
Connecting the laser Interlock with and without monitoring LED

Pin 5 and pin 6 must be connected externally by a wire (total resistance <430Ω). If this connection is opened while the laser is switched on, there will be an acoustic signal and the laser will be switched off immediately. If the two pins are not connected, the laser cannot be switched on.

Furthermore the red LED in the "LD-ON" key (F7) on the front panel of the ITC4000 and a corresponding error message on the display will indicate that the interlock is open.

A LED can be connected in parallel to a resistor (<430Ω) between pin 5 and pin 6. This LED lights up when the laser current is switched on (Laser ON indicator).

It is possible to connect several switches in series to the interlock pins, setting up a closed loop that can be opened by each switch. Thus different protective functions can be accomplished simultaneously via the interlock.

Examples of various protective interlock functions:

- An external emergency key (opener) is connected to the two pins of the interlock or in series to other interlock switches.
- If the laser is to be operated in a closed setup (lab) a switch can be installed in a suitable position interrupting when the setup (lab-door) is opened.
- If the interlock line is led in parallel to the laser current line a cable damage monitoring can be realized.

3.1.6 Laser protection "LD Enable" input

The ITC4000 has a "LD Enable" input for additional laser safety. Using this input, the laser diode can be switched off by an external TTL signal. Please connect this external "safety signal" to the BNC input jack "LD ENABLE IN" (R1) at the rear of the unit. The external signal should be low, in case of an error, to switch off the laser output.
The input is high active with an internal pull-up resistor, therefore, if no cable is connected, the input is at high level and the laser output is enabled.
In the Laser Output Configuration you can change the LD Enable functionality (please refer to chapter Laser Output Configuration 29 for more information).

For example, if the ITC4000 is used together with an additional temperature controller (TED4015 or TED350), you can use the BNC jack "LD ENABLE IN" (R1) as a temperature window input, to switch off the laser current, if the temperature leaves a predefined window.

Attention

The LD ENABLE Input voltage must not exceed TTL level (5V)

3.1.7 Pin assignement of the TEC output jack

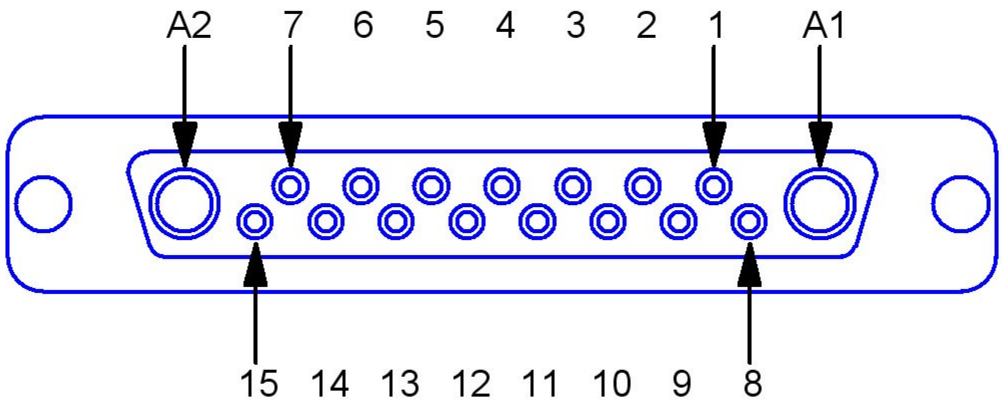


Figure 8
Pin assignment of the 17W2 DSUB TEC output jack (rear panel view)

Pin	Connection
	TEC element (Peltier element) [1)] :
A1	TEC element (+, when cooling)
A2	TEC element (-, when cooling) **Attention: Do not connect to Ground!**
2	Voltage measurement TEC element (+)
9	Voltage measurement TEC element (-)
	Open circuit monitoring, status indicator, external fan:
1	Interlock, TEC ON LED (+)
7	12V Output (for external fan; max. current = 500mA)
15	Ground for 12V Output and Interlock, TEC ON LED (-)
	Temperature sensor:
3	Thermistor (-), PT100/1000 (-), analog ground
4	Thermistor (+), PT100/1000 (+)
10	PT100/1000 (-), AD590/592 (-), LM35 out, LM135/235/335 (+)
11	PT100/1000 (+), AD590/592 (+), LM35/135/235/335 (+)
5,12	Analog ground, LM35/135/235/335 (-)
	other:
14	I/O 1-wire (currently not used)
6	Digital ground for I/O 1-wire
8, 13	Not connected

[1)] TEC element output pins and voltage measurement input pins are "ground-free". ***Do not connect*** any of these pins to Ground, otherwise the electronic circuit will be damaged!

Attention

The maximum TEC output current for the ITC4000 series is 15A. Use only the specified connector type: 17W2 mixed DSUB plug with high power contacts A1 and A2 rated for at least 15A current. For wiring of A1 and A2 use only wires rated for at least 15A current.

If Thorlabs laser diode mounts like TCLDM9, LDM21, or LM14S2 are used, the easiest way to connect them using a shielded cable CAB4000 (rated TEC current is 5A).
For use of other equipment, a shielded cable with two 17W2 mixed DSUB plugs, CAB4001, (20A current rating) is also available.

When using a custom-made cable, we recommend to use a shielded cable for the sensor inputs with twisted pairs. Use a separate shielded cable for the TEC current and TEC voltage measurement lines. The TEC current lines should be as short as and as close as possible to minimize inductance.

3.1.8 Connecting a TEC element

Attention

The TEC element output of the ITC4000 is a ground-free output. Do not connect the TEC element pins to any grounded pins (3, 5, 6, 12, 15) or to case ground, otherwise the electronic circuit will be damaged.
A TEC element connected with wrong polarity may lead to thermal runaway and damage of the connected components.

Connect the thermoelectric cooler (TEC or Peltier element) to the high current contacts A1 (TEC+) and A2 (TEC-) of the 17W2 DSUB jack (R16, see Figure 2 in chapter Operating elements at the rear panel 12).
When the Temperature controller is in cooling mode, current flows from TEC+ to TEC-. This is defined as positive current, and with the TEC element connected correctly, its active surface (which is in contact with the tempered object) gets colder.

Check the TEC polarity as follows:
Connect the TEC element and the temperature sensor to the 17W2 DSUB jack "TEC OUTPUT" (R16) (Refer to chapter Connecting the TEC element 21 and Connecting a temperature sensor 24). The sensor and the TEC element must be in good thermal contact to the thermal load. The use of thermal conducting grease is recommended. Please refer to chapter Setup and function of a temperature controller 46.

Turn on the ITC4000.

Select the appropriate sensor type by pressing **Menu.** Scroll to Temperature Sensor Setup by turning the adjustment knob. Switch into the the Temperature Settings by pressing the Enter button or the adjustment knob (F8) and select the appropriate sensor:
Menu / Temperature Sensor Setup / Temperature Sensor. Confirm by pressing **Done** or the adjustment knob (F8) again.

Adjust a suitable current limit for the TEC element by selecting
Menu / Temperature Source Setup / Current Limit. Confirm by pressing **Done** or the adjustment knob (F8). (refer to chapter Setting the TEC source parameters 41).

Switch the display back to the measurement screen and set the desired temperature by pressing and turning the adjustment knob (F8). Confirm the entered value by pressing the adjustment knob.

Switch on the ITC4000 TEC output current by pressing the key TEC ON (F6). The green LED in TEC ON key (F6) lights up (see Figure 1 at chapter Operating elements at the front panel 11). If the green LED in TEC ON key is flashing, the current temperature is out of the temperature window.

If the TEC module is connected with correct polarity, the difference between the temperature setpoint and the actual temperature will decrease. Provided that the control loop parameters are set properly (refer to chapter PID control loop 48), the actual temperature should be in accordance with the temperature setpoint rather quickly.

If the TEC module is connected with reversed polarity, the difference between the temperature setpoint and the actual temperature will increase continuously. In this case, switch off the TEC current by pressing key "TEC ON" (F6) and correct the TEC module wiring.

3.1.9 Connecting a temperature sensor

The temperature controller in the ITC4000 can be used with the following temperature sensors: NTC thermistor, AD590, AD592, LM35, LM335, LM235, LM135, PT100, and PT1000.

The setting and measurement range of thermistors is 100 Ω to 100 kΩ (Low range) and 1 kΩ to 1 MΩ (High range). The displayed temperature of the used thermistor and the temperature setpoint range are dependent on the sensor parameters.

If one of the other sensor types is used, the measurement range is -55°C to +150°C.
The actual control range and the accuracy of the displayed temperature depend on the operating range and the tolerance of the used sensor, and on the individual thermal setup.

The temperature sensor is connected to the 17W2 DSUB jack "TEC OUTPUT" (R16, Figure 2, chapter Operating elements at the rear panel 12). The wiring depends on the used sensor type.

Attention

Do not connect any sensor pin to the TEC element pins A1 or A2, otherwise the connected components may be damaged!

3.1.9.1 NTC thermistor

The thermistor is connected between pin 3 and pin 4 of the 17W2 mixed DSUB jack (R16, Figure 2 in chapter Operating elements at the rear panel 12). The polarity is unimportant if the thermistor is ungrounded. If one pin of the thermistor is grounded (for example in a laser module), this pin must be connected to pin 3.

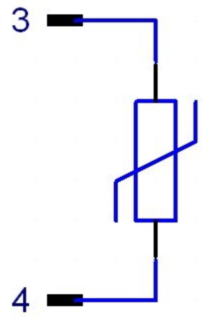


Figure 9
Connecting a thermistor

With a thermistor as temperature sensor, the resistance can be converted into the temperature by using the Exponential or the Steinhart-Hart calculation method.
Using the exponential method, the relation between temperature and NTC thermistor resistance (and vice versa) is approximated by the formulas:

$$R(T) = R_0 * e^{\beta(\frac{1}{T} - \frac{1}{T_0})} \Leftrightarrow T(R) = \frac{\beta * T_0}{T_0 * \ln(\frac{R}{R_0}) + \beta}$$

(temperatures in Kelvin)

with: R_0 Thermistor nominal resistance at temperature T_0
T_0 Nominal temperature (usually 298.15 K = 25° C)
β Thermistor constant (sensitivity index, B value)

For R_0, T_0 and β please refer to the data sheet of the thermistor.

Using linearization series resistors, the thermistor measurement circuit of the instrument is optimized for best resolution with R_0 = 10 kΩ (Low Range) and R_0 = 100 kΩ (High Range). Thermistors with other R_0 values can be used at the expense of a degraded resolution, depending on the actual sensor resistance.

If the exponential method parameters given in the thermistor data sheet are stored in the ITC4000 setup, the thermistor temperature can be shown on the display.

A further way of approximating the relation between temperature and thermistor resistance is the method according to Steinhart-Hart, described by the formula:

$$1/T = A + B * \ln(R) + C * (\ln(R))^3$$

(temperature in Kelvin)
with the Steinhart-Hart parameters A, B and C.
To select the calculation method and to enter the thermistor parameters, please refer to chapter Thermistor settings 44.

3.1.9.2 Current temperature sensors AD590 or AD592

If a temperature/current transducer AD590 or AD592 is used as temperature sensor, it has to be connected to pin 10 (-) and pin 11 (+) of the 17W2 mixed DSUB jack "TEC OUTPUT" (R16, Figure 2 in chapter Operating elements at the rear panel 12) at the rear of the unit.

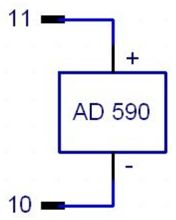


Figure 10
Connecting a
temperature sensor
AD590 or AD592

3.1.9.3 Voltage temperature sensor LM35

If the temperature/voltage transducer LM35 is used as temperature sensor, it must be connected to pin 10 (out), pin 11 (+) and pin 12 (-) of the 17W2 mixed DSUB jack "TEC OUTPUT" (R16, Figure 2 in chapter Operating elements at the rear panel 12) at the rear of the unit.

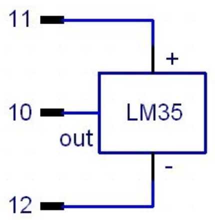


Figure 11
Connecting a
temperature sensor
LM35

3.1.9.4 Voltage temperature sensors LM335, LM235 or LM135

If the temperature/voltage transducer LM135, LM235 or LM335 is used as temperature sensor, it has to be connected to pin 10 (+), pin 11 (also +) and pin 12 (-) of the 17W2 mixed DSUB jack "TEC OUTPUT" (R16, Figure 2 in chapter Operating elements at the rear panel 12) at the rear of the unit.

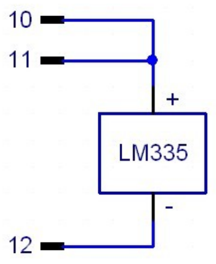


Figure 12
Connecting a
temperature sensor
LM335, LM235 or LM135

3.1.9.5 Platinum RTD temperature sensors PT100 or PT1000

Pin 3 and 4 of the DSUB Connector are the current source, Pin 10 and 11 are the voltage measurement pins for the 4-wire measurement setup.
One connector of the sensor has to be connected to pin 4 and 11 and the other to pin 3 and 10 of the 17W2 mixed DSUB jack "TEC OUTPUT" (R16, Figure 2 in chapter Operating elements at the rear panel 12) at the rear of the unit.

For optimum performance, use a separate wire for each pin of the DSUB connector and connect the corresponding wires only at the PT100 or PT1000, as close as possible to the sensor (see Figure 13).

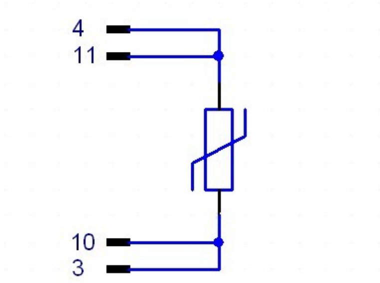


Figure 13
Connecting a temperature sensor PT100 or PT1000

3.1.10 Setting up the TEC voltage measurement

If the voltage of the TEC element shall be measured and displayed with enhanced accuracy, two additional cables must be connected directly from the two poles of the TEC element to pin 2 and 9 of the TEC OUTPUT jack (four terminal measurement, see Figure below).

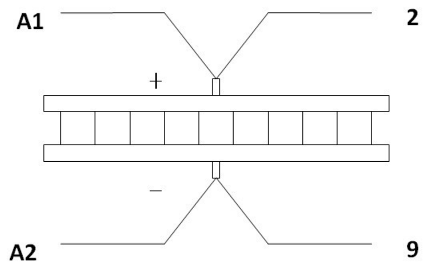


Figure 14
TEC voltage four terminal measurement

If pin 2 and pin 9 are left unconnected, the TEC voltage is measured internally at the contacts A1 and A2 of the TEC output jack (two terminal measurement). This leads to a measurement error due to the voltage drop along the lines to the TEC element, so a slightly increased voltage will be displayed.

3.1.11 Connecting interlock and TEC ON monitoring

Pin 1 and pin 15 of the "TEC OUTPUT" jack (R16) are test contacts to determine whether a TEC setup is connected or the connection has been interrupted. These pins must be connected externally by a wire (total resistance <430 Ω). When this “interlock” connection is opened, the ITC4000 switches off the TEC output current automatically. If the TEC output was off, it cannot be switched on and an error message “TEC cable connection fault” appears.
If a LED with a 1 kΩ parallel resistor is connected between pin 1 and pin 15 as shown in Figure 15, the interlock connection is interpreted as closed, too. The LED lights up when the TEC current output is switched on (TEC ON mode).

Figure 15
Connecting theTEC interlock with and without monitoring LED

NOTE

The ITC4000 Controllers don't support the “TEC lockout” feature of the Thorlabs laser diode mounts. Please install the shorting device in the interlock connector of the laser diode mount. For details please refer to the operating manual of the laser diode mount.

3.2 Power-up

Warning

Prior to switching on your ITC4000, please read the safety instructions in chapter Safety 7 **carefully.**

Turn on the unit by means of the line switch (F2, see Figure 1 in chapter Operating elements at the front panel 11).

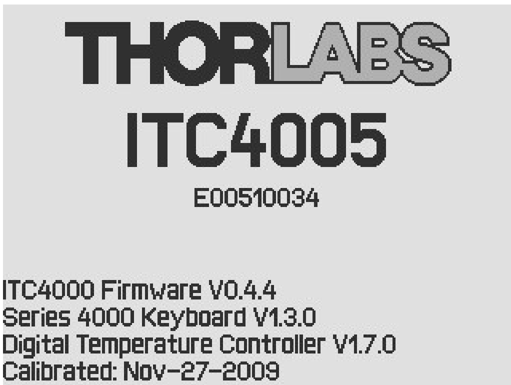


Figure 16
Device status screen

After switching on the unit, the graphics display will show the device status, followed by the measurement screen shown below. In the device status window, device specific information like device name, serial number, the installed firmware versions, and the calibration date will be shown. If any system error has occurred (please refer to chapter Error Messages 85), the ITC4000 display will stay in the device status window. You can switch to the measurement screen window by pressing the ESC key.

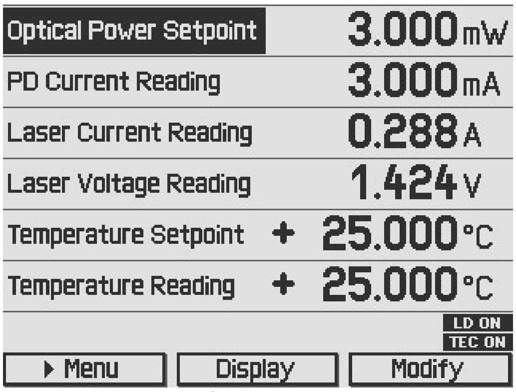


Figure 17
Measurement screen with 6 values

In the display configuration menu, the display can be configured to show two, four or six values. Factory setting is the six value screen.
To change a setpoint displayed on the screen, select it using the softkeys or turning the adjustment knob. Press the **Modify** button or the adjustment knob to get into the entry mode. Adjust the value by turning the adjustment knob. The entry position to be changed can be selected by the **Coarse** or **Fine** buttons. Confirm your entry by pressing the **Done** button or the adjustment knob again.
Please refer to chapter Display Configuration 58 for more information about selecting setpoints and measurement readings.

Switch into the menu by pressing the **Menu** button or the ESC key. In the ITC4000 menu you can change different ITC4000 settings described in the following chapters.
For a complete menu item listing, please refer to chapter Menu structure overview 81.

3.3 Laser output configuration

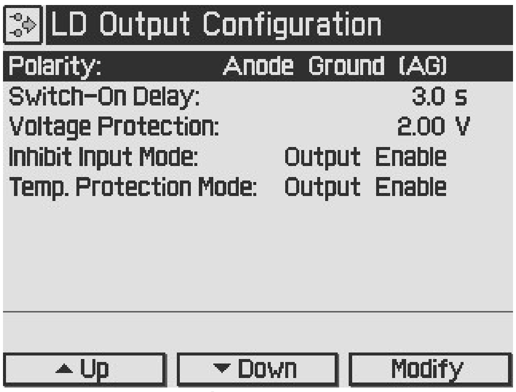


Figure 18
LD output configuration

In the Laser Output configuration you can set the polarity of the driven laser diode, the switch on delay time, the laser voltage protection and the inhibit input mode of the "LD Enable" input.

Polarity:
The laser polarity can be chosen between anode grounded (AG) and cathode grounded (CG) .

Attention

Take care to select the proper polarity for the connected laser diode. A wrong polarity may damage the laser diode.

Switch-On Delay:
With the CDRH Compliant Switch-On Delay option you can choose the time delay between pressing the "LD-ON" key and the point in time the laser output is switching on. A time delay from 0 til 60s is selectable. The default value is 3 seconds. This feature is required to conform several government requirements like the CDRH US21 CFR 1040.10.

Voltage Protection:
The voltage protection is an additional protection feature for the laser diode. It is recommended to set the voltage protection about 0.5V higher than the nominal laser voltage. If the protection voltage is reached the laser output will be switched off. Protection voltages from 1 V to 11 V can be set.

Inhibit Input Mode:
The Inhibit input mode predefines the behavior of your ITC4000 when using the "LD ENABLE IN" BNC jack as an error signal input.
You can choose between:

None	no action
Output enable	the laser output is switched off during a failure and will be switched on automatically, when the error condition will be fixed.
Protection	the laser output is switched off and can only be switched on by pressing the "LD ON" key again

Temp. Protection Mode:
The temperature protection of the ITC4000 offers an internal temperature window monitoring by the integrated TEC module.
You can choose between:

None	no action
Output enable	the laser Output is switched off during the temperature is out of the selected window and will be switched on automatically, if the temperature goes back into the specified temperature window range
Protection	the laser Output is switched off and can only be switched on by pressing the "LD-ON" key again

3.4 Setting the LD source parameters

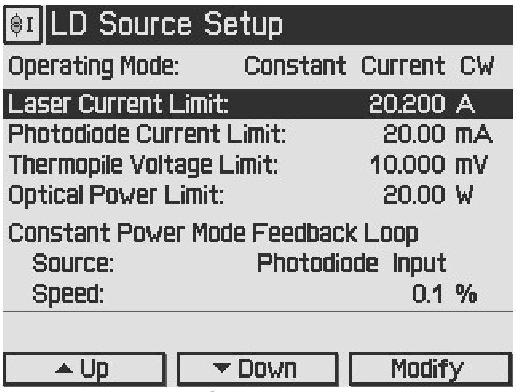


Figure 19
LD source setup

Setting the operating mode:
In the LD Source Setup menu you can change the operating mode of the ITC's laser current driver between Constant Current mode and Constant Power mode. In Constant Current mode an internal current loop to the laser will be closed. You can set the laser output current in Ampere, read back and display the actual laser current. In Constant Current mode a preselected pulse regime enabled in chapter QCW Pulse Settings 37 may work together with the internal laser current loop. In Constant Power mode a control loop will be closed via an external feedback source (current or voltage). A laser current dependent on the feedback value will be driven. The optical output power can be set in Watts, when the response of the connected feedback sensor is known and entered. Additionally you can set the corresponding feedback current for photodiodes or the feedback voltage for voltage sensors like thermopiles.

Setting the laser current limit:
In the LD Source Setup menu, the laser diode current limit can be set. This limit is active in the constant current mode and in the constant power mode, and protects the laser diode against excessive laser current. This value can be set from 1mA to 1.01A for an ITC4001, from 5mA to 5.05A for an ITC4005, and from 20mA to 20.2A for an ITC4020.

Setting the photodiode current limit:
The feedback photo current will be limited to this preselected value, so the optical output power will be clipped by a hardware circuit. This feature protects the optical setup against excessive optical power. If the photodiode range is switched from the high to the low range, the photodiode current limit will be constraint to the maximum value of the low range (if higher then the maximum before). When switching back to the high range, the constraint value will remain and must be increased if necessary.

Setting the thermopile voltage limit:
The feedback voltage will be limited to this preselected value, so the optical output power will be clipped by a hardware circuit. This feature protects the optical setup against excessive optical power. If the thermopile range is changed from a higher to a lower range, the thermopile voltage limit will be constraint to the maximum value of the lower range (if higher than the maximum before). When switching back to the higher range, the constrained value has to be increased if necessary.

Setting the optical power limit:
The optical power limit can be set in Watts if the responsivity of the connected sensor is known and entered. The resulting photodiode current or thermopile voltage will be calculated by the ITC4000 Firmware.

Note

The photodiode current, the thermopile voltage, and the power limit values shouldn't be set to zero, otherwise the laser current may be limited by these power limits in constant current mode. If a power limit gets active in constant current mode, the operation mode changes over to constant power mode.
The response time of these limits is dependent on the control rate of the power feedback loop. If the feedback loop speed is adjusted to a very low level, the limit reaction will be accordingly slow. If a quick reaction is desired, the feedback loop speed should be optimized as described below. In any case, the laser current limit should be set to an appropriate value as an additional safeguard for the laser.

The maximum limit values are dependent on the connected sensor and the selected range for this sensor:

Optical sensor type	**Measurement range**	**Limit range**
current	2mA	0 to 2.02 mA
current	20mA	0 to 20.2 mA
voltage	10mV	0 to 10.1 mV
voltage	100mV	0 to 101 mV
voltage	1V	0 to 1.01 V
voltage	10V	0 to 10.1 V

Setting the constant power feedback loop:
In this menu topic, the feedback source for the constant power loop (photodiode or thermopile) can be set. In addition, the feedback loop speed can be limited to minimize oscillation and overshoots. For DC operating laser diodes, the speed should be set to the minimum value (0.1%). For modulated laser applications with a photodiode as sensor, the optimum feedback loop speed can be identified by using an internal square wave modulation (100Hz 20% modulation depth). With an oscilloscope connected to the ANALOG CTL OUT jack, the resulting waveform can be evaluated. Increasing the feedback loop speed as long as no overshoots are visible at the square wave, should result in an optimized setup. When using a thermopile sensor, a quite slow feedback loop speed may be necessary to obtain a stable constant power control.

3.5 Setting the power feedback source parameters

To select the power feedback source please refer to chapter Setting the LD source parameters 31
Additional settings according to the selected sensor are described in the following two sub items.

3.5.1 Setting the photodiode parameters

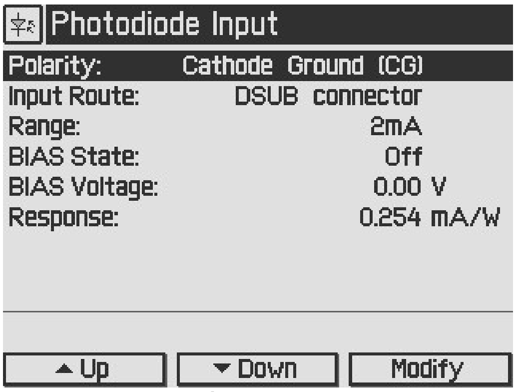


Figure 20
Photodiode input configuration

For current sensors like photodiodes the following parameters can be set:

Parameter	Selection	Description
Polarity	CG or AG	grounding of the used photodiode: CG: cathode grounded AG: anode grounded
Input Route	DSUB connector or Rear Panel BNC	configures which input connector is used
Range	2mA or 20mA	depending on nominal current of the used photodiode
BIAS State	On or Off	an applied reverse bias voltage is used to reduce the response time of the photodiode
BIAS Voltage	0 to ±10 V	reverse bias voltage value. The sign is depending on the selected polarity
Response	entered in mA/W	is used to display a calibrated power value

For using photodiode sensors in the constant power loop please choose photodiode input as power feedback source (please refer to chapter Setting the LD source parameters 31).

Polarity:
The polarity in the Photodiode Input configuration menu can be chosen between anode grounded (AG) and cathode grounded (CG). For connecting the photodiode please refer to chapter Connecting a photodiode 18

Attention

Take care to select the proper polarity of the connected photodiode. A wrong polarity may damage the photodiode, if a bias voltage is applied.

Input Route:
The Input Route determines the used photodiode input. The Input Route will be the contacts 7 and 8 of the 13W3 Mixed DSUB jack "LASER OUTPUT" (R9) or the BNC jack "OPT SENSOR" (R4) on the rear panel. For using the 13W3 "LASER OUTPUT" please select DSUB connector. Otherwise please select Rear panel BNC.

Note

If the thermopile sensor is configured to the Rear Panel BNC a settings conflict will be shown. In this case set the thermopile input route to DSUB connector.

Range:
The ITC4000 features two photo current input ranges. Please choose the 20mA range for higher photo currents and the 2mA range for higher sensitivity.

BIAS State:
The BIAS State switches the adjusted BIAS voltage On or Off. A BIAS voltage offers a shorter response time of the connected photodiode. For the maximum permitted reverse voltage please refer to the data sheet of the used photodiode.

BIAS Voltage:
The BIAS voltage can be adjusted from 0 to +10V with CG polarity and from 0 to -10V with AG polarity.

Response:
The photodiode responsivity value is used for a calibrated power adjustment. The adjustment range is 0.01mA/W to 10 A/W. With this parameter set correctly, the optical output power can be displayed in Watts. The resulting photodiode current setpoint will be calculated automatically by the ITC4000.

3.5.2 Setting the thermopile parameters

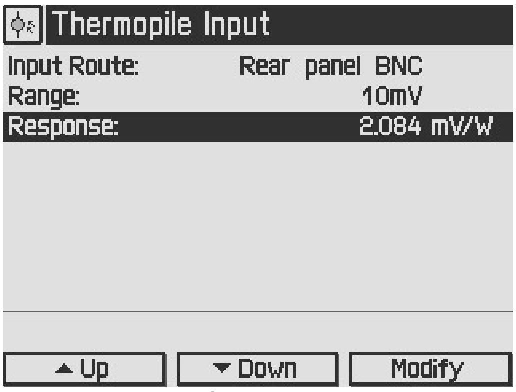


Figure 21
Thermopile input configuration

For voltage sensors like thermopiles the following parameters can be set:

Parameter	**Selection**	**Description**
Input Route	DSUB connector or Rear Panel BNC	configures which input connector is used
Range	10mV, 100mV, 1V or 10V	depending on nominal voltage of the used voltage sensor
Response	entered in mV/W	is used to display a calibrated power value

For using thermopile sensors please choose thermopile input as power feedback source described in chapter Setting the LD source parameters 31.

Input Route:
The Input Route determines the used thermopile input. The Input Route will be the contacts 1 and 2 of the 13W3 Mixed DSUB jack "LASER OUTPUT" (R9) or the BNC jack "OPT SENSOR IN" (R4) on rear. For using the 13W3 DSUB jack "LASER OUTPUT" please select DSUB connector. In other case please select Rear Panel BNC.

Note

If the photodiode input route is set to the Rear Panel BNC a settings conflict will be shown. In this case set the photodiode input route to DSUB connector.

Range:
Four voltage ranges from 10mV to 10V are offered. For thermopile sensors, the 10mV or 100mV ranges are recommended. For other voltage sensors, sensor amplifiers or power meters, you can also use the 1V or 10V ranges depending on the maximum output voltage.

Response:
The thermopile responsivity value is used for a calibrated power adjustment. The possible adjustment range is 0.01mV/W to 500 V/W. With this parameter set correctly, the optical output power can be displayed in Watts. The resulting sensor voltage setpoint will be calculated automatically by the ITC4000.

3.6 Laser diode modulation settings

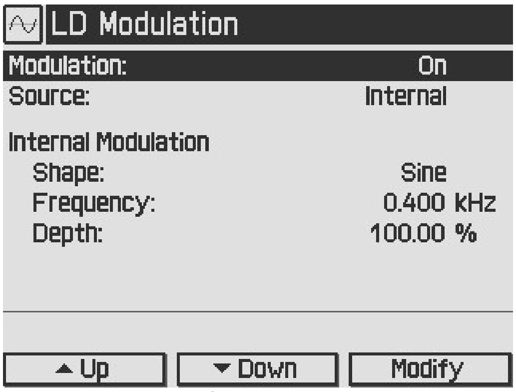


Figure 22
LD modulation settings

The ITC4000 provides a modulated operation of laser diodes in constant current and constant power mode. The modulation signal can be generated internally or by an external source.

An internal function generator offers an AC coupled sine, triangle or square signal. The modulation frequency range is 20 Hz to 100 kHz for the ITC4001 or the ITC4005 and 20 Hz to 50 kHz for the ITC4020. The modulation depth can be set from 0.1% to 100%. In constant current mode, this percentage refers to the peak to peak value of the output current in relation to the nominal maximum current of the laser diode controller.

Example: A DC current of 10 A (ITC4020) is modulated from 8A to 12 A with 20% modulation depth.

In constant power mode, the bandwidth may be limited by the constant power loop characteristics (for optimizing the speed of the constant power loop, please refer to chapter Setting the LD source parameters 31). In this mode, the percentage refers to the peak to peak value of the optical power in relation to the selected power range.

The external modulation input allows a precision power level control or a wavelength tuning of the laser.
When using an external modulation source, please connect the external source to the "MODULATION IN" BNC jack (R5) on rear of your ITC4000 and switch the modulation source to External. The modulation signal is DC coupled and added to the current setpoint (in constant current mode) or to the power setpoint (in constant power mode).

The resulting values for the laser current "I_{LD}", the photodiode current "I_{PD}" and the thermopile voltage „U_{TH}" are calculated as:

$I_{LD} = I_{LDset} + I_{LDmax} * U_{MOD} / 10V$ (in constant current mode)
$I_{PD} = I_{PDset} + I_{PDmax} * U_{MOD} / 10V$ (in constant power mode, photodiode sensor)
$U_{TH} = U_{THset} + U_{THmax} * U_{MOD} / 10V$ (in constant power mode, thermopile sensor)

with:

I_{LDmax} :	maximum laser current (e.g. 5A for a ITC4005)
I_{PDmax}:	maximum photodiode current (depending on selected range)
U_{THmax} :	maximum thermopile voltage (depending on selected range)
I_{LDset}:	set value in constant current mode
I_{PDset}:	set value in constant power mode, photodiode as sensor
U_{THset}:	set value in constant power mode, thermopile as sensor
U_{MOD}:	modulation voltage at "MODULATION IN BNC" jack (R5)

For example; you can add a bipolar (0...±5Vmax) modulation to an internal adjusted 50% current / power value or a unipolar modulation (0...10V) if the internal adjusted "DC" value is zero.

The laser current can be monitored at the “ANALOG CONTROL OUT” jack (R6) at the rear panel.

Note

If the laser current or the laser power reaches the adjusted limits, the status indicators "I LIMIT" or "P LIMIT" are shown and the green "LD ON" LED is flashing. The modulation will be clipped to the adjusted limit values.

Attention

The input voltage at the "Modulation Input" BNC jack must not exceed ±10V !

3.7 QCW pulse settings

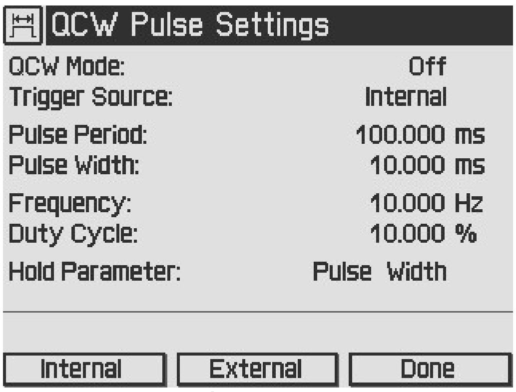


Figure 23
QCW pulse settings for internal triggering

The Quasi Continuous Wave (QCW) mode allows the laser output to be pulsed with an internal or an external trigger source. All necessary pulse parameters can be set in the QCW pulse settings menu.

QCW Mode

Off sets the ITC4000 to "CW" (continuous wave) mode. This is the default setting. **On** enables the "QCW" (quasi continuous wave) mode.

Changes in the state of the QCW mode (On/Off) are only possible if the laser output is switched off.
The QCW mode can only be enabled in constant current mode. Otherwise the error message "Wrong LD Source Operating Mode" will be shown. In this case please set the LD operating mode to constant current. (please refer to chapter Setting the LD source parameters 31)

Trigger Source
This parameter specifies the QCW pulse trigger source.
If set to Internal, current pulses are generated regularly with the specified period / frequency.
If set to external, a single current pulse is generated each time a rising edge is detected at the QCW Pulse input (R2) at the rear of the unit.

The parameters shown in the QCW pulse settings menu are dependent on the trigger source used. The upper screenshot shows the parameters for internal triggering.

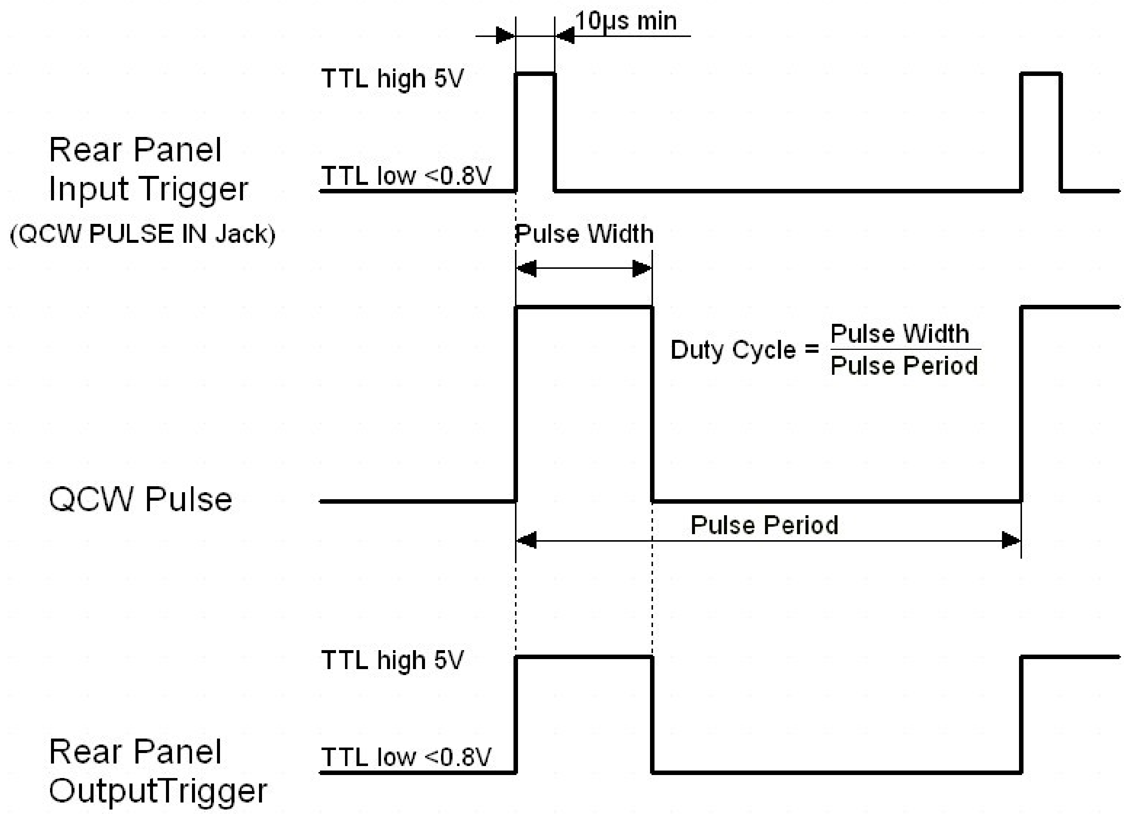


Figure 24
QCW pulse diagram

Pulse frequency / Pulse period
This is the pulse repetition rate in case of internal triggering. Pulse frequency is the reciprocal value of the pulse period. If you change one value the other will be readjusted automatically. The pulse period can be changed from 1ms to 5s, the pulse frequency accordingly from 1 kHz to 0.2 Hz.

Duty cycle
Means the duration of the QCW pulses in relation to the pulse period. It can be set from 0.002% to 99.999% depending on the used pulse period.

Pulse width
Means the duration of the QCW pulse and can be set from 100µs to 1s pulse width.

Hold parameter
Sets the parameter to be held constant when the pulse period or the frequency changes. The hold parameter can be the duty cycle or the pulse width.

If the trigger source is set to external, the following parameters will be shown.

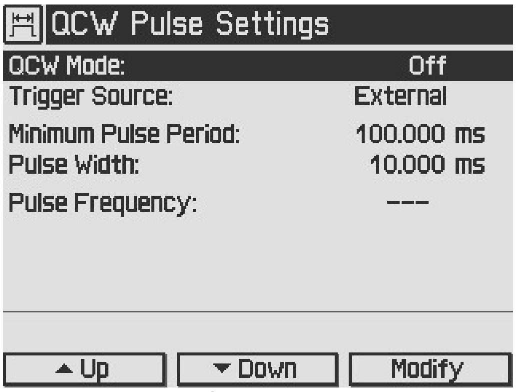


Figure 25
QCW pulse settings for external triggering

Minimum pulse period
The minimum pulse period indicates the minimum permitted time between the rising edges of two trigger pulses. Trigger pulses following after a time interval shorter than the minimum pulse period will be ignored.

Pulse width
Corresponding to the internal triggering the QCW pulse width can be changed from 100µs to 1s.

Pulse frequency
With an external trigger source, the pulse frequency is a measured value and therefore can't be set.

3.8 LD source setpoints

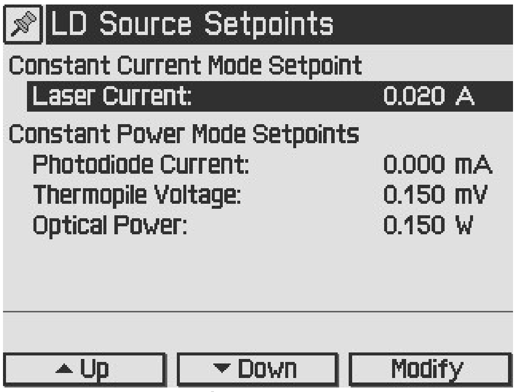


Figure 26
LD source setpoints

You can change the setpoint values for constant current or constant power mode depending on the selected operating mode. To select the operating mode please refer to chapter Setting the LD source parameters 31.

For constant current mode, only the laser current can be adjusted. This value can also be changed from the measurement screen, if one of the displayed values is the laser current setpoint.

In constant power mode you can adjust the photodiode current or the thermopile voltage depending on the power feedback source selected in chapter Setting the LD source parameters 31. If you have entered the response of your feedback source in mA/W (photodiode) or mV/W (thermopile) you can use the optical power setpoint to change the optical output power.

Note

In constant current mode, the constant power mode setpoints are ignored.

In constant power mode, the laser current setpoint is ignored. Only the setpoint for the selected power feedback source will be effective.

3.9 Setting the TEC source parameters

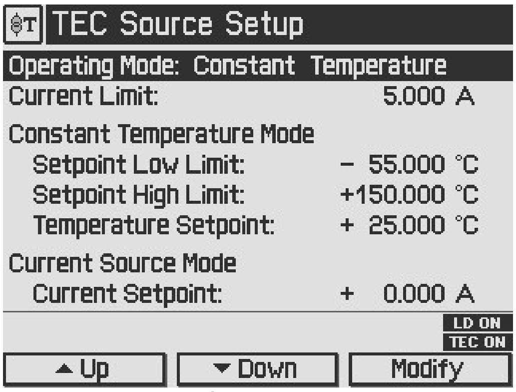


Figure 27
TEC source setup

Setting the operating mode:
In the TEC Source Setup menu, the temperature controller operating mode of your ITC4000 can be changed. It can be shifted between Current Source mode and Constant Temperature mode. In Current Source mode, an internal constant current loop is closed, and the TEC output current can be set in Ampere. In Constant Temperature mode a temperature control loop will be closed via an external feedback source (current, voltage or resistance temperature sensor). A TEC current depending on the feedback value will be driven. If the Exponential or Steinhart-Hart parameters of the connected thermistor sensor are known and entered, the ITC4000 offers a temperature control in Celsius, Fahrenheit or Kelvin.

Setting the TEC current limits:
In the TEC Source Setup menu, the TEC current limit for the constant current and the constant temperature mode can be set. This feature protects the TEC element against excessive TEC current.

Setting the temperature setpoint limits:
In the TEC Source Setup menu, the temperature setpoint limits for the constant temperature mode can be set. This feature protects the TEC setup against accidental excessive temperatures. The limit values can be set from -55°C to +150°C.

Setting the temperature setpoint:
Enables the temperature setting in constant temperature mode. Entries will be ignored in constant current mode.

Setting the constant current mode setpoint:
Offers a current setting in constant current mode. Entries will be ignored in constant temperature mode.

3.10 Temperature sensor setup

From the Main menu, select the Temperature Sensor Setup menu and press **Enter** or the adjustment knob.

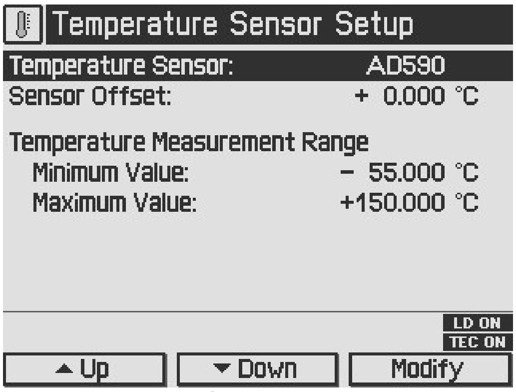


Figure 28
Temperature sensor setup

Select Temperature Sensor by pressing **Modify** or the adjustment knob.

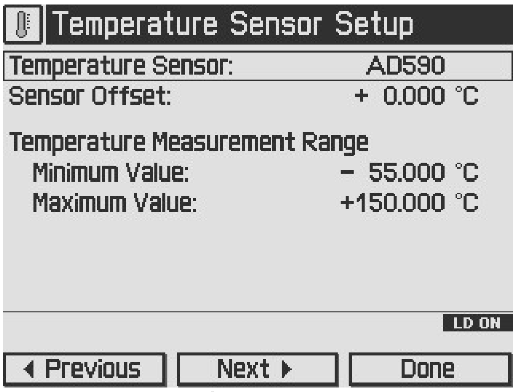


Figure 29
Changing the temperature sensor

The Temperature Sensor line is in entry mode, the border is flashing. By pressing **Previous** or **Next** or by turning the adjustment knob you can choose the appropriate temperature sensor:

AD590:	current sensor, means also AD592, 1 µA/K
Thermistor (low):	NTC Thermistors, measurement range 100 Ω to 100 kΩ
Thermistor (high):	NTC Thermistors, measurement range 1 KΩ to 1 MΩ
PT100:	Platinum RTD sensor, 100 Ω at 0°C
PT1000:	Platinum RTD sensor, 1000 Ω at 0°C
LM35:	Voltage sensor, 10 mV/°C, 0 V at 0 °C
LM335:	Voltage sensor, 10 mV/K, 0V at 0 K, means also LM235 / LM135

Confirm your choice with **Done** or by pressing the adjustment knob again.

For IC sensors, the calculation coefficients are predetermined by your ITC4000: 1µA/K for the current sensors AD59x, 10mV/°C for LM35 and 10mV/K for LMx35.

If no temperature sensor is connected or if the temperature sensor does not correspond to the selected sensor type, the red LED in the “TEC ON” key (F6, Figure 1 at chapter Operating elements at the front panel 11) lights up and in the the status line the indicator "SENSOR" is shown. If the TEC output is switched on and the sensor lines are broken the TEC output will be switched off immediately. An short beep and an error message “Temperature sensor failure detected” appears at the bottom of the measurement display.

The set temperature for all sensors can be entered in Celsius, Kelvin or Fahrenheit. You can set your favored temperature unit in the System Preferences Menu (see chapter System preferences 14).

The ITC4000 controllers offer an offset compensation for temperature sensors. The setting range is ±10 °C. Use a calibrated thermometer to verify the real sensor temperature. From this, subtract the temperature displayed by the ITC4000 (take care of the proper signs). Enter the result as Sensor Offset in the Temperature Sensor Settings Menu. The displayed actual temperature will be shifted by this amount and will give you an improved absolute accuracy.

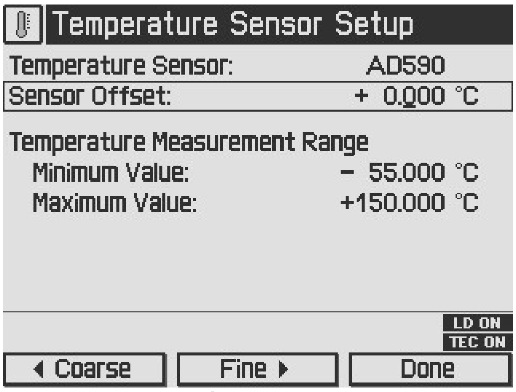


Figure 30
Adjusting the temperature sensor offset

3.11 Thermistor settings

In Thermistor Settings menu, the parameters for a thermistor temperature calculation may be set, if a thermistor is used as temperature sensor.

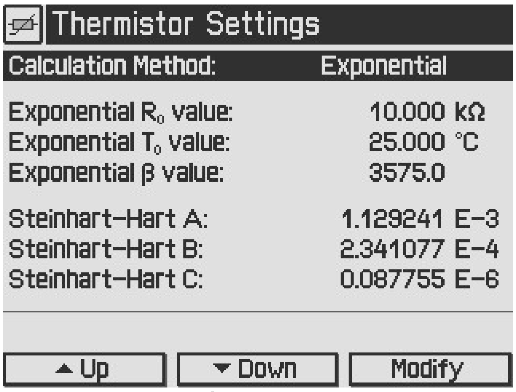


Figure 31
Thermistor settings

You can choose between two calculation methods, Exponential or Steinhart-Hart. The parameters for the respective method can be set in the two additional menu items as shown below:

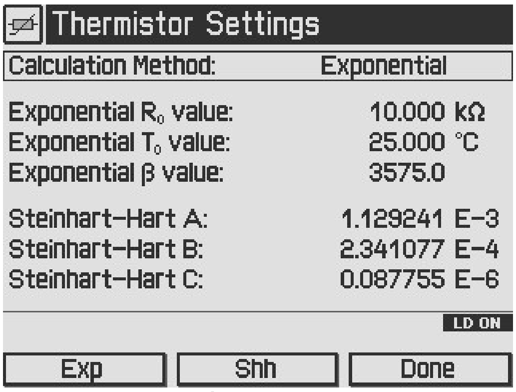


Figure 32
Selecting the calculation method

For the Exponential Method, the required parameters are R0, T0 and β. You can find these values in the data sheet of your thermistor. R0 is the resistance value at the nominal temperature T0, for most thermistors T0 is 25°C. The β value is a material-specific thermistor constant.

For the Steinhart-Hart calculation, you need the A, B and C parameters of your thermistor, indicated in some datasheets.

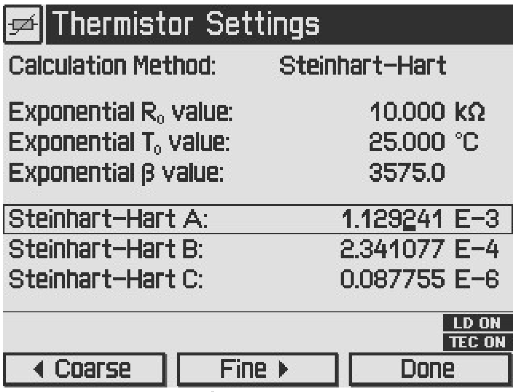


Figure 34
Changing the Steinhart-Hart parameters

3.12 Setup and function of a temperature controller

When devices are tempered normally, the following components are involved:

- The component to be tempered (i.e. a laser diode)
- A sensor measuring the temperature of the component
- A heat source or sink (air or water / cooling element)
- A heat conductor connecting the component to the source / sink (copper, aluminium)
- A "propulsion" to lead the flow of heat (TEC element)

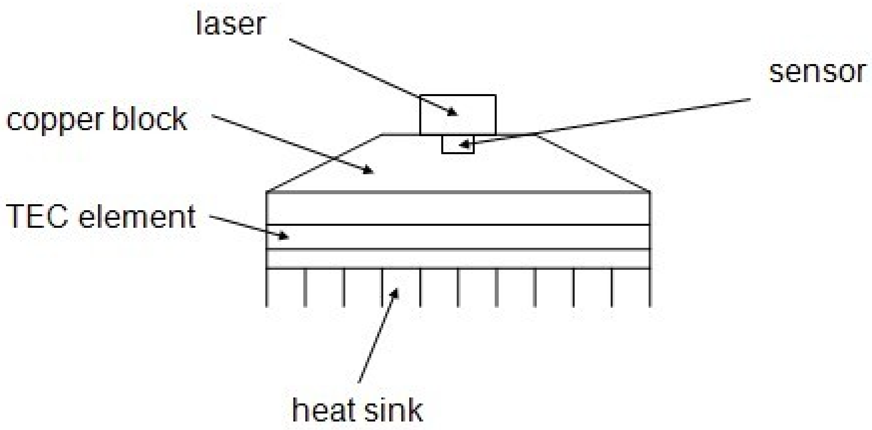


Figure 35
Typical thermal setup for temperature control

Statements and implications

- The temperature of the laser can be measured with the sensor.
- In the copper block, there is a heat flow between laser and TEC element.
- In the TEC element, there is a heat flow between copper block and heat sink.
- In the heat sink, there is a heat flow between TEC element and environment.
- The temperature difference in the TEC element can be controlled by the TEC current. This has a direct influence on the heat flow in the copper block and in the heat sink.

Hence the temperature of the laser can be influenced by the TEC current. The quantity of heat flowing from the laser into the copper block and the size of the block impacts the reaction speed of the setup.

Usually very small components (laser diodes) are tempered with relatively large cooling elements (TEC elements). Thus the dissipated power must be lead away quickly, and the components are to be kept at the same temperature as close as possible.

Demands to the ideal temperature control loop

1. Knowledge of the absolute laser temperature
2. Stability of the laser temperature under any influence
3. Immediate settling to a new laser temperature when changing the set value of the temperature

Influences on the real temperature control loop

To 1:
The sensor cannot be fixed to the laser chip in such a way that it will measure it's temperature exactly. The reason is, that the temperature in the heat sink has a gradient due to the heat flow. Further, even within the laser chip the temperature is not homogeneous.As for this, offset and gain errors of the sensor lead to deviation in laser temperature measurement.
Possible solution: sensor calibration

To 2.
If the internal power dissipation changes (e.g. the laser current is changed), the temperature gradient between laser and sensor changes as well. This results in a measurement error depending on the mechanical setup laser/sensor. Changes in the ambient temperature however will be compensated well by the control loop since they will almost only have an effect on the heat slope between TEC element and cooling element.
Possible solution: improved thermal design

To 3.
The transient response after setting a new temperature is limited since the heat transport in the heat sink is relatively slow. Furthermore the temperature slope in the heat sink must form anew. The sensor (which also possesses a significant heat capacity) must settle to the laser temperature.
Possible solution: PID controller adjustment

3.13 PID control loop

3.13.1 PID controller theory

The temperature controller in the ITC4000 series is using a digital proportional-integral-derivative controller (PID controller) to correct the difference between a measured temperature and a desired temperature setpoint. The temperature can be adjusted accordingly by calculating and then outputting a corrective current.

The PID controller calculation (algorithm) involves three separate parameters; the Proportional, the Integral and Derivative values. The Proportional value determines the reaction to the current temperature error, the Integral value determines the reaction based on the sum of recent temperature errors, and the Derivative value determines the reaction based on the rate at which the temperature error has been changing. The weighted sum of these three terms is used to adjust the temperature via the current supply of a cooling/heating element (Thermo Electric Cooler (TEC) – Peltier Element).

The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). Hence:

$$\mathrm{MV(t)} = P_{\mathrm{out}} + I_{\mathrm{out}} + D_{\mathrm{out}}$$

where P_{out}, I_{out}, and D_{out} are the contributions to the output from the PID controller from each of the three terms.

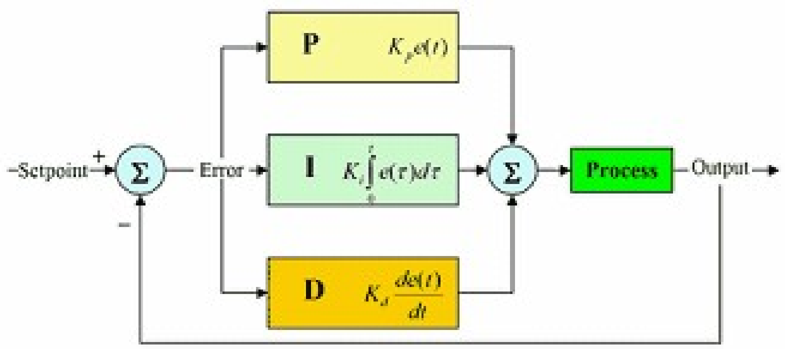


Figure 36
Block diagram of a PID controller

By "tuning" the three constants in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint and the degree of system oscillation.

You can set every constant (P, I, D) to zero to disable it. That means you can use the PID controller only as PI controller by setting the Derivative value to zero. This may be useful in an noisy environment since derivative action is very sensitive to measurement noise. On the other hand, the absence of an integral value may prevent the system from reaching its target temperature and is not recommended.

3.13.2 PID auto tune

A very simple method to adapt the PID parameters to the characteristics of your thermal setup is the use of the implemented PID Auto-Tune function. It is easy to use and gives good results after relatively short time (depending on the time response of your thermal setup).

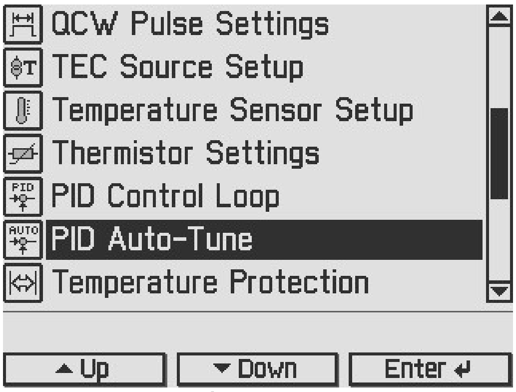


Figure 37
Get into the PID auto-tune setup

The implemented PID Auto-Tune algorithm is using the Ziegler-Nichols method. That means the I and D shares are set to zero and the algorithm is looking for the "critical gain" KC at which the output of the control loop starts to oscillate. The algorithm is optimized for finding good PID parameters as quick as possible.

The new parameters are displayed and you can set them active or discard them.

This gives a good transient oscillation to a new temperature setpoint, but it is more optimized to avoid influences of disturbances from outside, such as changes in ambient air temperature, changes in heat sink temperature, laser diode power (lost heat) and so on.

Strictly speaking, a set of PID parameters is valid only for the temperature setpoint active during PID Auto-Tuning. However, a new temperature setpoint not too far away will also lead to an adequate transient response. Therefore you will be able to control the temperature of your system effectively in a certain temperature range of many degrees (depending on your thermal setup).

If the system behavior for another temperature setpoint is not good enough, you can start the PID Auto-Tune function at the new temperature setpoint again. In this case, a quick 5 step Auto-Tune procedure is started under the following conditions:

- You already finished a PID Auto-Tuning successfully before
- You didn't change the PID parameters by hand in the meantime
- You didn't unplug the cable between the ITC4000 and your thermal setup (e.g. changing the mount).

To save time, the new quick PID Auto-Tune process tries only to readjust the PID parameters calculated before. It starts without changing the KP value and the oscillation period value.

Normally you will get better PID parameters for the new temperature setpoint after a shorter time. If the KP tuning has to be greater than the allowed range the re-adjusting fails and the complete PID Auto-tuning over the whole KP range is started automatically, giving you a better tuned PID-Controller at the end.

Sometimes the PID Auto-Tune function may not finish successfully. In that case, the KC of your system may be outside the possible tuning range (smaller than 0.1 or greater than 100). Please try it out by manually tuning the PID-Controller.

If the PID Auto-Tune function finishes very fast but gives bad results, your system might be too noisy, and the noise (maybe 50 or 60 Hz) could be interpreted as oscillations of your system. Eliminate the noise and try the PID Auto-Tune function again.

If you don't like the system performance given by the PID Auto-Tune function, you can tune the parameters manually (see chapter PID control loop settings 52).

When you found the ideal PID parameters for your system, you can save them together with many other settings (e.g. temperature setpoint, current limit…) into one of the eight memory locations (see chapter Saving and restoring setups 60).

Press Start to run the PID Auto-Tune procedure. The following screenshots show a selection from the 8 steps of a full range tuning. The green LED in the TEC ON key is flashing while the procedure is running. Press Cancel or the ESC key to abort the procedure.

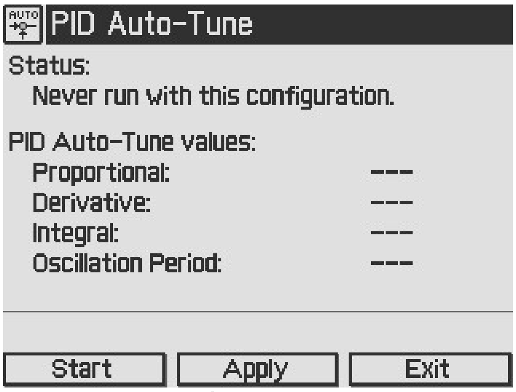


Figure 38
PID auto-tune never run

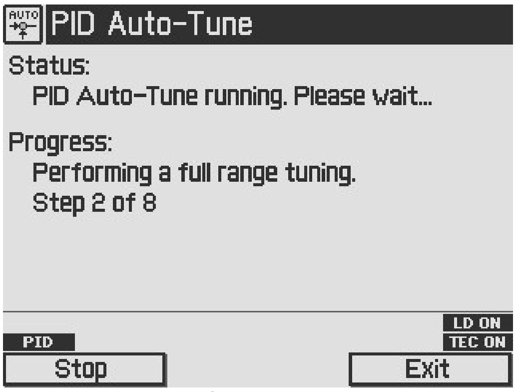


Figure 39
PID full range tuning

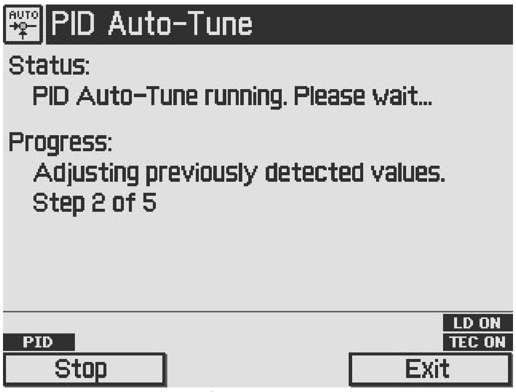


Figure 40
Adjusting previously detected values

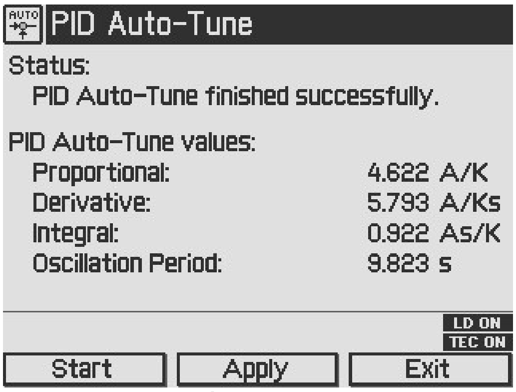


Figure 41
PID auto-tune finished successfully

3.13.3 PID control loop settings

Manual tuning:

By setting the control loop parameters of the PID control loop manually, the temperature controller of the ITC4000 can be adapted to the most different thermal loads.

Two different ways are possible to find the optimal parameters. A PID Auto-Tune function can help to find the optimal parameters easily (see chapter PID auto tune 49).

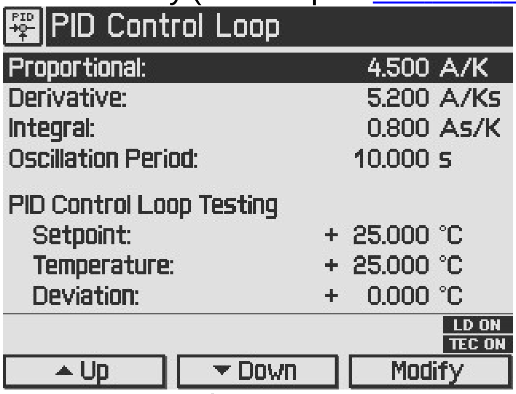


Figure 42
PID control loop settings

A manual tuning of the P, I and D parameter can be done with the following steps:

Set the Temperature Setpoint to your required temperature.

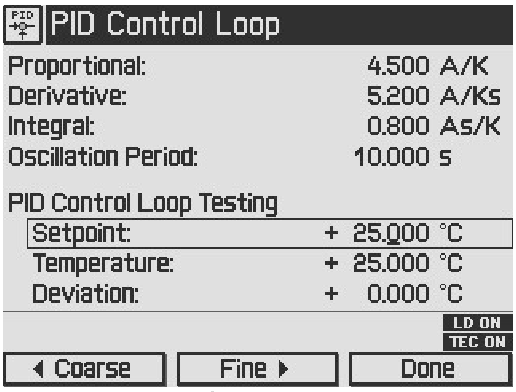


Figure 43
Adjusting the temperature setpoint

Set the Proportional parameter to a very low value (e.g. 0.2) and the Derivative and Integral parameters to minimum (0) in the PID control loop settings menu. Set the Oscillation Period to Minimum (0.2 s).

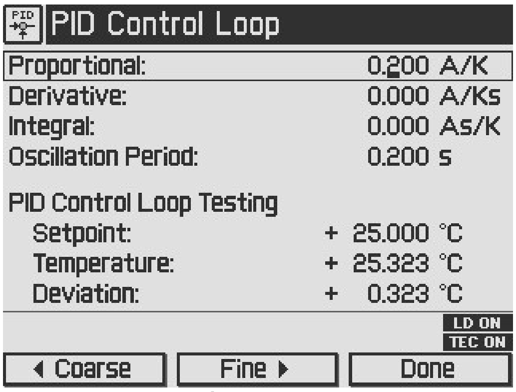


Figure 44
Adjusting the proportional value

NOTE

The settling behavior may be additionally observed at the DEVIATION OUT jack (R14, Figure 2 at chapter Operating elements at the rear panel 12) by means of an oscillo-scope (please refer to chapter TEC control outputs 57).

Switch on the TEC output with the switch " TEC ON" (F6, see Figure 1 at chapter Operating elements at the front panel 11). Watch the course of the actual measured temperature. If it oscillates continuously, or even builds up to increasing amplitude, switch the TEC output off immediately. Further decrease the Proportional parameter before switching the TEC output on again.

Proportional (P) parameter:

Repeatedly increase and decrease the Temperature Setpoint about 1…2C around your desired target temperature with the adjustment knob (F8). Watch the settling behavior of the actual measured temperature.

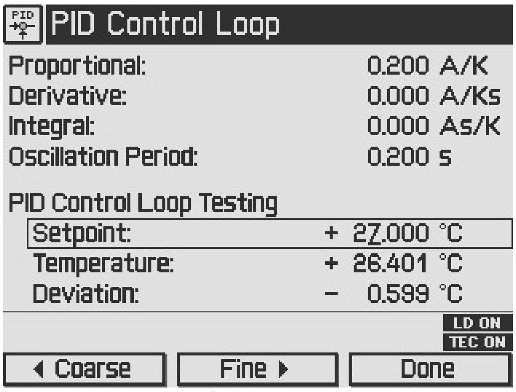


Figure 45
Increasing the temperature

Increase the P parameter gradually by turning the adjustment knob clockwise. Higher values will increase the settling speed. To high values will increase the amplitude and number of overshoots. This may lead to an unstable system (continuous oscillation or even increasing amplitude), which should be avoided. The P parameter is set correctly when the oscillation is notedly damped, this means the actual temperature approaches the setpoint with each overshoot having about half the amplitude of the previous overshoot. Due to the disabled

Integral constant, a temperature deviation may remain. Please evaluate the time span between the maximum temperature of a positive overshoot and the minimum temperature of the following negative overshoot = half of a full period (this is approximately equal to the full period time of a continuous, undamped oscillation). You will need this data to set the "oscillation period" value as described below.

Oscillation period:
The oscillation period value corresponds to the resonance frequency of the temperature control setup. The value entered here impacts the control cycle period of the digital PID control, which is determined as one-hundredth of the oscillation period. Enter the time span recorded in the previous section when you adjusted the P parameter and observed the settling behavior of the temperature.

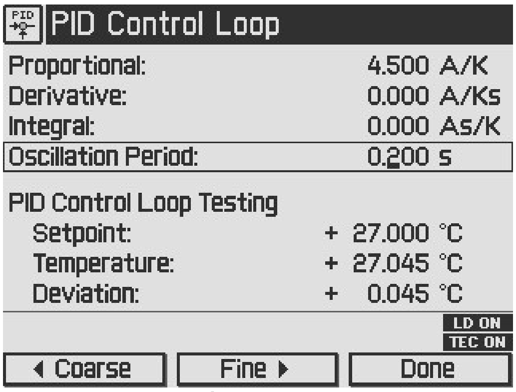


Figure 46
Adjusting the oscillation period

Derivative (D) parameter:
Change again repeatedly between temperature setpoints ±1...2°C around your desired target temperature while observing the settling behavior of the actual temperature.

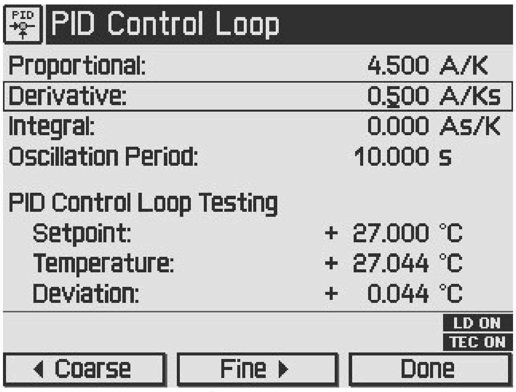


Figure 47
Adjusting the derivate value

Increase the D parameter gradually by turning the adjustment knob (F8) clockwise.
Higher values will decrease the amplitude and number of overshoots. To high values will increase again overshoot effects or will even lead to an unstable system. The D parameter is set correctly when the actual temperature settles at a value close to the temperature setpoint after a minimum of overshoots. Due to the disabled Integral constant, a temperature deviation

may remain.

Integral (I) parameter:
Change again repeatedly between set temperatures ±1...2°C around your desired target temperature.

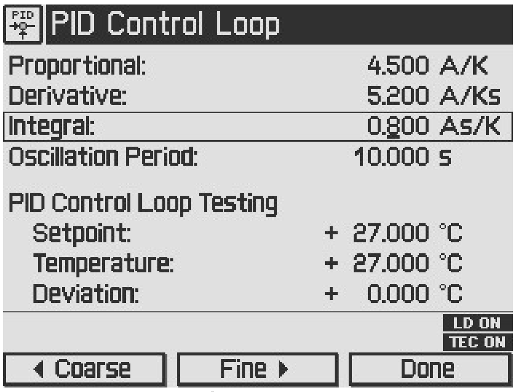


Figure 48
Adjusting the integral value

Increase the I parameter gradually by turning the adjustment knob (F8) clockwise.
Higher values will accelerate the settling to the set temperature. To high values will increase the amplitude and number of overshoots or will even make the system instable. The I parameter is set correctly when the actual temperature reaches the set temperature in a short time with a minimum of overshoots.

The following table summarizes the effects of increasing the P, D and I share:

Effects of increasing parameters				
Parameter	**Rise Time**	**Overshoot**	**Settling Time**	**Steady-state Error**
Proportional K_P	Decrease	Increase	Small Change	Decrease
Derivative K_D	Small Decrease	Decrease	Decrease	None
Integral K_I	Decrease	Increase	Increase	Eliminate

3.14 Temperature protection

The temperature controller of the ITC4000 provides an adjustable **Temperature Window** to monitor the correct function of the temperature control. The display shows a “plus / minus“ value, so if you select i.e. 5 °C, the window will reach from 5 °C below the temperature setpoint to 5 °C above the temperature setpoint.

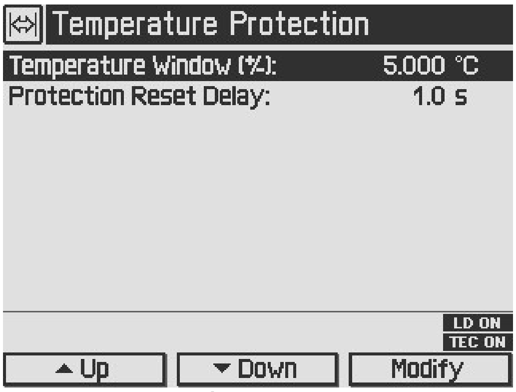


Figure 49
TEC temperature protection setup

If the actual temperature moves out of the preset window, the green LED in the TEC ON key (F6, see Figure 1 at chapter Operating elements at the front panel 11) is flashing and the temperature protection indicator flashes up. The behavior of the laser output is depending on the selected inhibit mode in the Laser output settings.

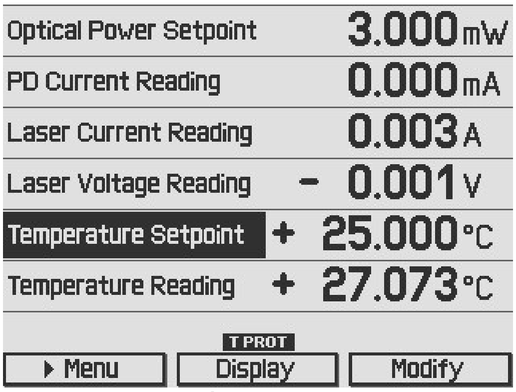


Figure 50
TEC temperature protection indicator

To avoid multiple sets and resets of the window protection error in transient oscillation or during tuning steps, you can adjust an appropriate **Protection Reset Delay**. A value between 50% and 100% of the oscillation period is recommended. With this setting, the window protection will reset only if the actual temperature remains inside the window for a sufficient time, indicating a stable settling to the temperature setpoint.

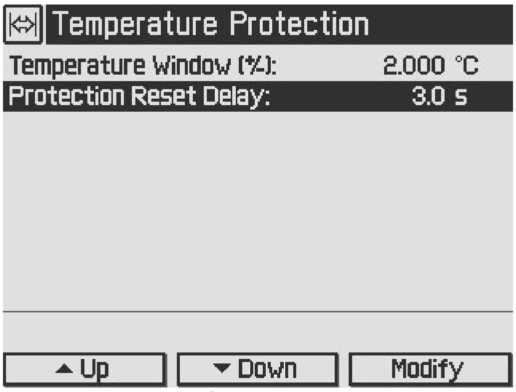


Figure 51
Adjusting the temperature protection behavior

3.15 LDC control outputs

Trigger Out:
The ITC4000 trigger output jack (R3) provides a tracking of the QCW pulse, preselected in QCW pulse settings. The output level is TTL5V.

Analog Control Out:
An Analog Control output (R1, see Figure 2 in chapter Operating elements at the rear panel 12) is provided at the rear of the unit for monitoring purposes, e.g. to watch the settling behavior of the constant power control loop by means of an oscilloscope. At this jack, a voltage proportional to the actual driven laser current, scaled to the maximum laser current of the unit is available. The voltage ranges from 0 V to +10 V.
The voltage formula is:

$$U_{out} = 10V \times \frac{I_{act}}{I_{max}}$$

3.16 TEC control outputs

Temperature OK output
This output (R15, see Figure 2 at chapter Operating elements at the rear panel 12) provides a TTL signal (+5 V), which gets low (0 V) when the window protection is active. Please refer to chapter Temperature protection 56.

This jack can be used to monitor the temperature of a laser diode when using a *Thorlabs* LDC340 or LDC200C series laser driver. Simply connect the corresponding plug of the laser driver to this output of the ITC4000. The laser will be switched off if the laser temperature moves out of the temperature window. Further details can be found in the operation manual of the respective laser driver.

Analog temperature deviation output

A temperature output "DEVIATION OUT" (R14, see Figure 2 at chapter Operating elements at the rear panel 12) is provided at the rear of the unit. At this jack, a voltage proportional to the actual temperature deviation, scaled to the adjusted temperature window is applied for monitoring purposes, e.g. to watch the settling behavior of the temperature control loop by means of an oscilloscope. The voltage ranges from -5 V to +5 V.

The voltage formula is:

$$U_{out} = 5V \times \frac{T_{set} - T_{act}}{T_{win}}$$

Example:

If the temperature setpoint is 25 °C and the temperature window is set to 2 °C, an actual temperature of

23 °C leads to -5 V at the output

25 °C leads to 0 V at the output

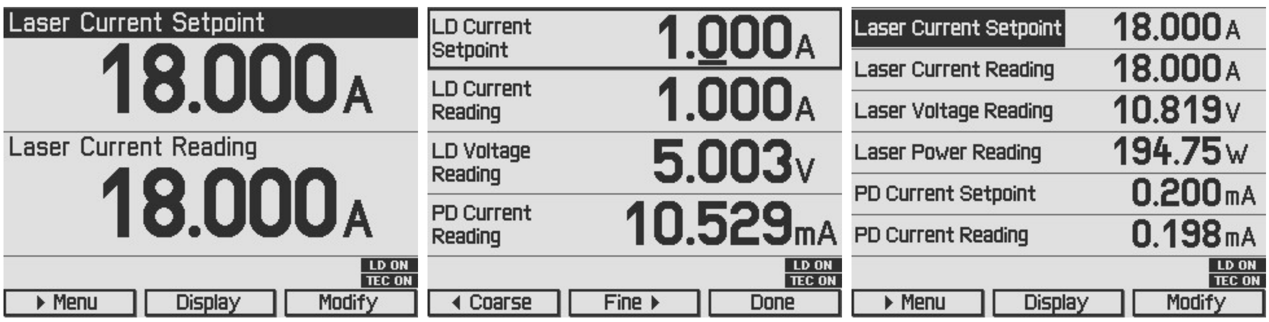
27 °C leads to +5 V at the output

(please refer to chapter Temperature protection 56).

The temperature deviation output "DEVIATION OUT" is grounded. Thus standard measurement equipment can be connected directly. Devices connected to this output should have an input resistance $\geq$ 10 kΩ.

3.17 Display configuration

The display can be configured to show two, four or six values on the screen. Factory setting is the six value screen.



You can select your favored measurement screen by pressing the **Display** button or in the Display Configuration menu. Press the **Menu** button, scroll to the Display Configuration and press the **Enter** button or the adjustment knob. You get the following display configuration:

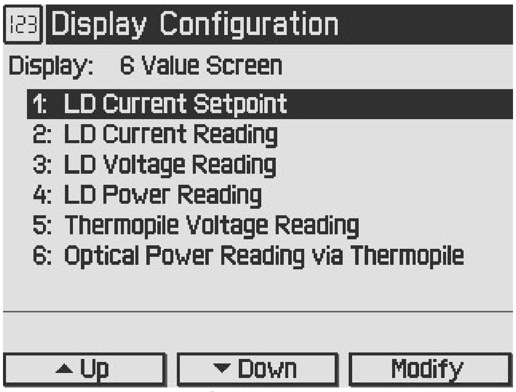


Figure 52
Display configuration menu

In the **Display configuration** menu you can select the favorite screen configuration with two, four or six values.

For each value number (depending on selected values per screen), you can choose one of the following setpoints or readings:

- LD Source Setpoint; shown value dependent on selected operating mode (LD Current Setpoint if constant current mode or LD Optical Power Setpoint if constant power mode)
- LD Current Setpoint
- LD Optical Power Setpoint
- Photodiode Current Setpoint
- Thermopile Voltage Setpoint
- TEC Source Setpoint
- Temperature Setpoint
- TEC Current Setpoint
- LD Current Reading
- LD Voltage Reading
- LD Power Reading
- Photodiode Current Reading
- Optical Power Reading via Photodiode
- Thermopile Voltage Reading
- Optical Power Reading via Thermopile
- Temperature Reading
- Temperature Deviation Reading
- Temperature Sensor Signal Reading
- TEC Current Reading
- TEC Voltage Reading
- TEC Power Reading

For choosing the desired values please select the appropriate line by turning the adjustment knob. Then press **Modify** or the adjustment knob and choose your desired value. Confirm your selection by pressing **Done** or the adjustment knob again.

3.18 Saving and restoring setups

With the exception of the “LD ON” and "TEC ON"state, all settings will be saved when the ITC4000 controller is powered down.
Additionally, the **Settings Memories** menu can be useful in saving several sets of specific settings like: current limits, power limits, temperature limits, polarities, sensor input settings etc. for the connected laser or TEC setup. Consequently, you can reload the saved setup parameters from one of the eight memory spaces in the **Settings Memories** menu.

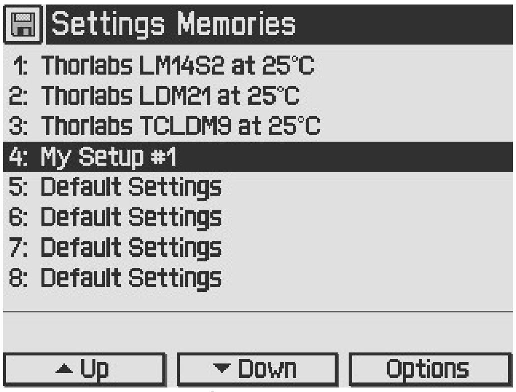


Figure 53
Settings memories

At the positions 1 … 3, the parameters (for a temperature setpoint of about 25°C) are pre-saved for the Thorlabs laser mounts. The parameter sets # 4…8 can be used to save your personal setups. If more space is required, and you don't need the pre-saved parameter sets # 1…3, you may overwrite them.

Select the desired data set by turning the adjustment knob or by pressing **Up / Down**. Enter the menu for the respective data set by pressing the **Options** key or the adjustment knob.

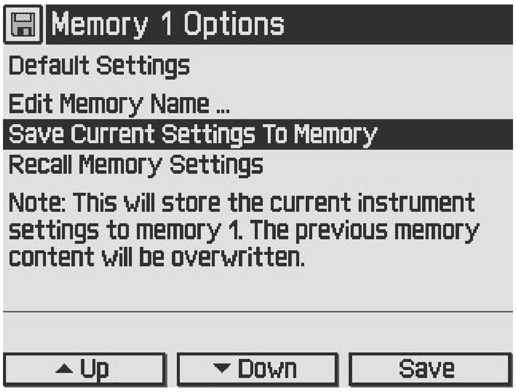


Figure 54
Save settings to memory

Save Current Settings To Memory allows to save all current laser controller settings. Note that this will overwrite the settings stored in the selected data set.

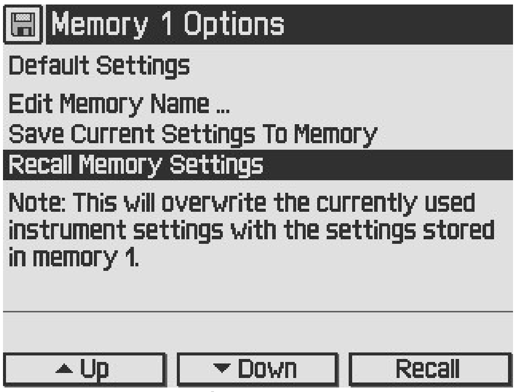


Figure 55
Recall settings from memory

Via **Recall Memory Settings** you can load a saved laser setup. Note that this will overwrite your currently used instrument settings.
Before recalling data from the memory, the laser and TEC outputs must be switched off (if on) by means of the LD ON / TEC ON buttons (F6 and F7, see Figure 1 in chapter [Operating elements at the front panel](#) 11).

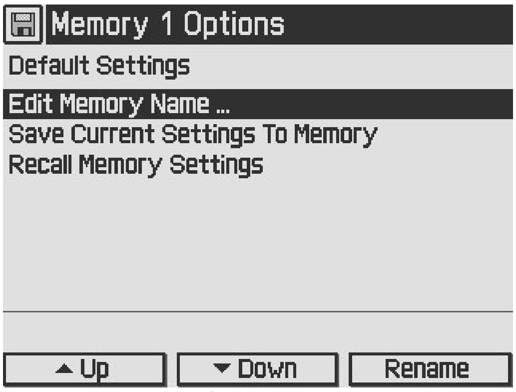


Figure 56
Edit memory name

The name of the data set can be changed in the **Edit Memory Name …** menu.

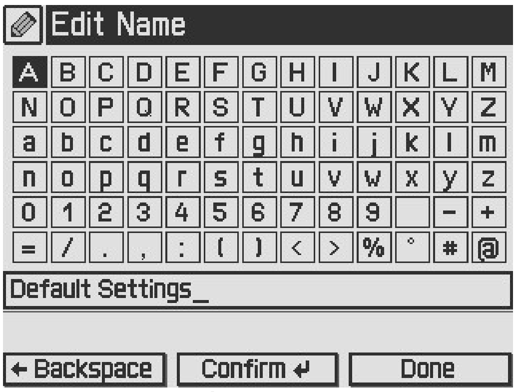


Figure 57
Letter panel for editing memory name

In the **Edit Memory Name…** menu you get a table of characters. Select a character by turning the adjustment knob (F8) and then press **Confirm**. The selected character will be inserted in the text field. Delete mistyped characters by pressing **Backspace**. When you are finished, confirm with **Done**.

3.19 Digital I/O ports

The laser diode controllers of the ITC4000 series have a very versatile digital port providing four separately configurable Input / Output lines. This feature allows control of external circuitry from the unit, or control of the unit from external circuitry (via PC software). Figure 58 shows the pin layout of the 6 pin Mini-DIN jack (R13, see Figure 2, chapter Operating elements at the rear panel 12).

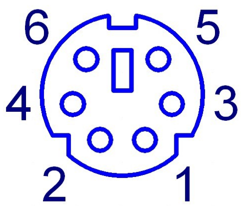


Figure 58
Digital I/O jack
(Mini-DIN 6, female, rear panel view)

Pin	Connection
1	I/O1
2	I/O2
3	I/O3
4	I/O4
5	GND
6	I/O Supply voltage (+12 V from internal or higher external voltage up to +24 V)

Figure 59 shows the I/O port basic circuit (applicable for each channel).

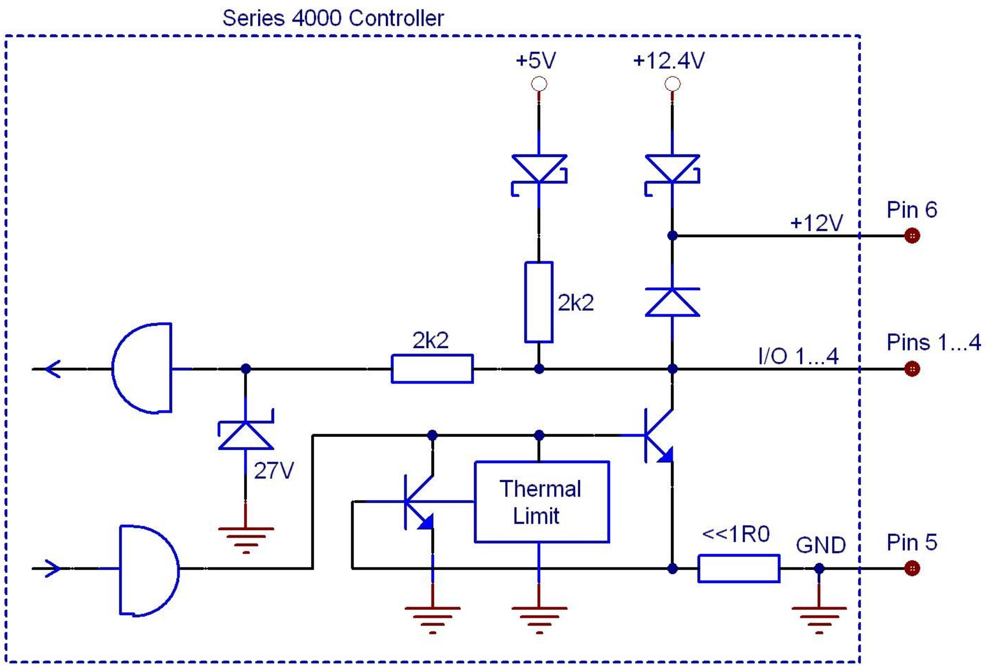


Figure 59
I/O port basic circuit

Any I/O line configured as input accepts TTL levels (0 V / +5 V) and is tolerant of higher voltages up to +24 V. When the input is left open, an internal +5 V pull-up resistor in series with a diode shifts the input to high level.

Any I/O line configured as output can source up to 2 mA when high (+5 V) and sink up to 400 mA when low.
The outputs are current-limited and infinitely short-circuit proof.

Additionally a +12 V supply output is provided to drive a relay or other external circuitry. The maximum output current is 500 mA. This supply output is current-limited and infinite short-circuit proof.

The following figures show three typical output configurations.

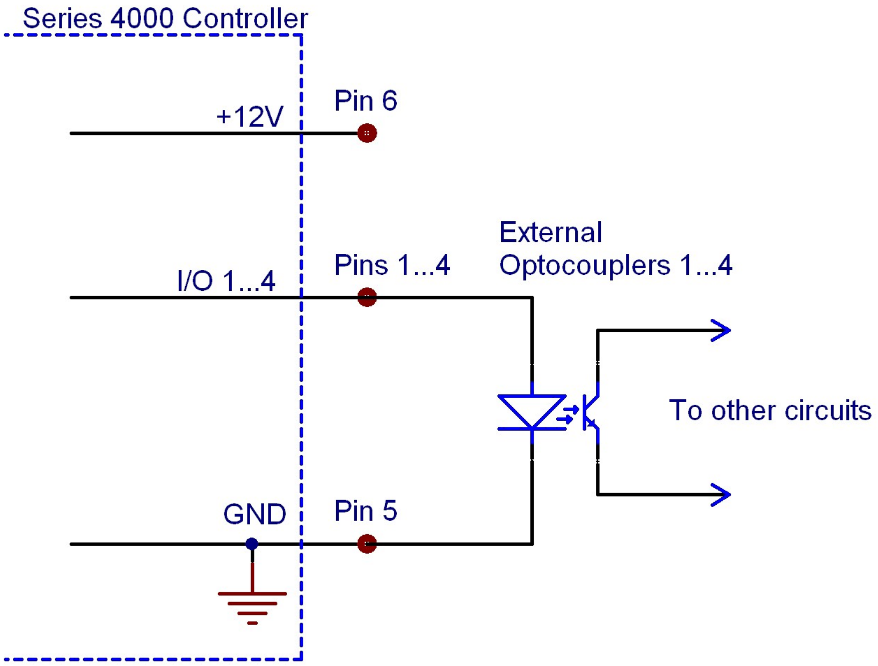


Figure 60
I/O port source operation

In Figure 60, the output drives an optocoupler in source operation. This component may be replaced by a LED or a switching transistor.

To switch the connected device to on-state, the output level of the digital I/O line must be set HIGH. The maximum source current is 2 mA.

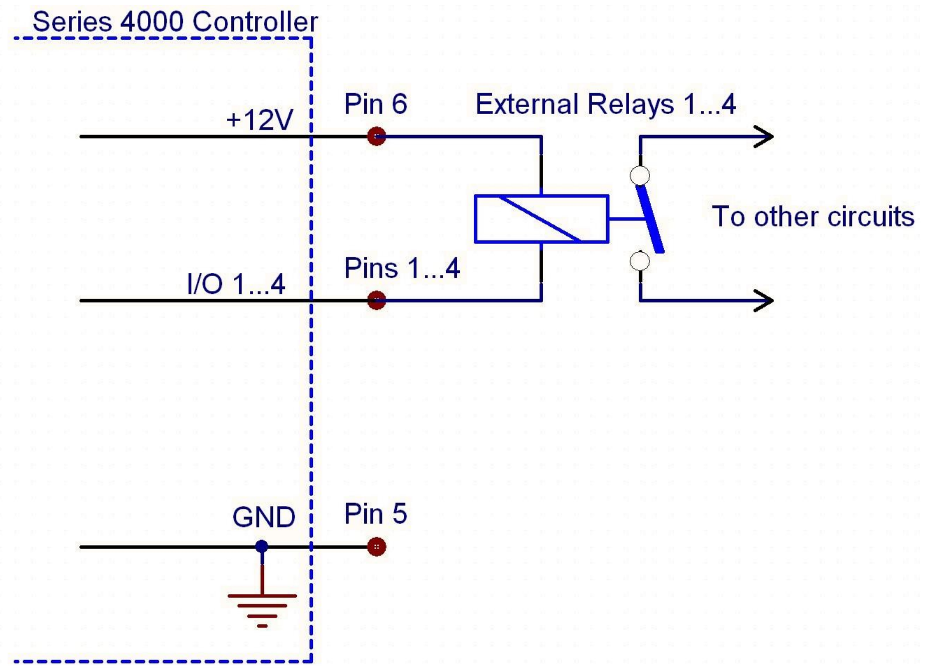


Figure 61
I/O port sink operation

In Figure 61, the output drives a relay in sink operation. Note that the external relay coil is connected between the digital I/O line (pins 1 …4) and +12 V (pin 6).

To energize the external relay, the output level of the digital I/O line must be set LOW. The maximum sink current is 400 mA.

If a lower supply voltage is required for the relay, a standard voltage regulator may be inserted between pin 6 and the relay coil contact.

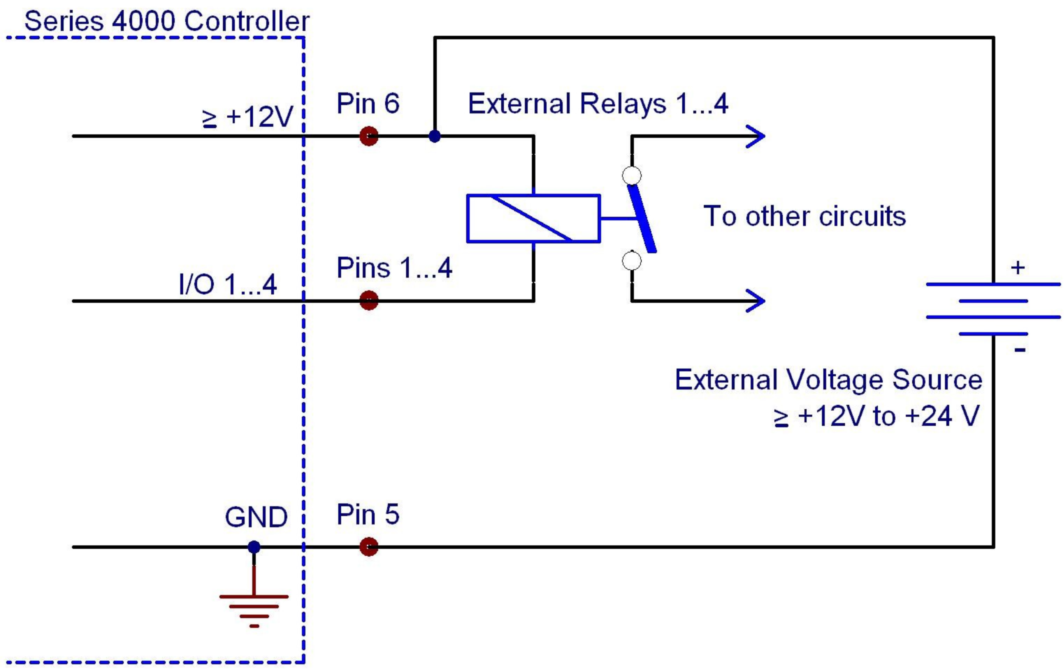


Figure 62
I/O port with external supply

In Figure 62, the output drives a relay in sink operation using a higher external voltage supply (= +12V to +24V). To energize the external relay, the output level of the digital I/O line must be set LOW. The maximum sink current is 400 mA.

When driving a relay, connect your external supply voltage also to pin 6 of the digital I/O jack in order to connect the internal de-spiking clamping diode in parallel to the relay coil. The internal +12 V supply (which passes a serial diode) is overridden and non-effective in this case.

In **Digital I/O Port** menu the direction of each port can be set to input or output.

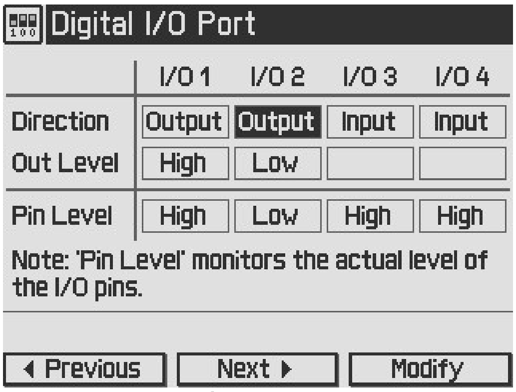


Figure 63
Digital I/O port settings

In addition the output level of each I/O port can be set, if configured as output. The actual pin level of each port pin is monitored and displayed in the third line.

For enhanced controlling, please use the remote control interface from an external PC or Laptop. See the *Thorlabs "Series 4000 Programmers Reference Manual"* on the included "Series 4000 Instrumentation CD".

4 Computer interface

4.1 Using the USB interface

The instrument provides a USB 2.0 Full Speed link according to the USB 2.0 specification, the USBTMC specification and the USBTMC USB488 specification. It allows sending commands from a host computer to the instrument. The connection to the PC is accomplished by a USB cable with a type 'A' connector at the PC side and a type 'B' connector on the instrument side.

When connecting the instrument to the PC the first time, on Windows systems the "New Hardware Found" wizard will be displayed. Proper installation requires a VISA library with USBTMC support to be installed on your system in advance (e.g. NI-VISA available at the National Instruments website www.ni.com or from the data carrier that comes with the instrument. Allow the installation and follow the dialog instructions).

Via the instrument's USB interface you may easily connect to third party data logging, data acquisition and data analysis software (e.g. MATLAB, NI LabVIEW Signal Express, Agilent VEE). For basic instrument communication you may also use the *Thorlabs Instrument Communicator 2* Software from the accompanying data carrier. Please see also the *SCPI Programmers Reference Manual* for a detailed description of the instrument's command set.

When receiving a command, the ITC4000 will enter its **Remote** mode.This will be indicated by the REMOTE Symbol in the Status Bar. The right softkey (F4) will serve as a Local button, which switches back from Remote mode to Local operations mode. In Remote mode, the front panel setup of the instrument is disabled to avoid accidental entries and settings conflicts. This also includes the LD ON key and the TEC ON key.

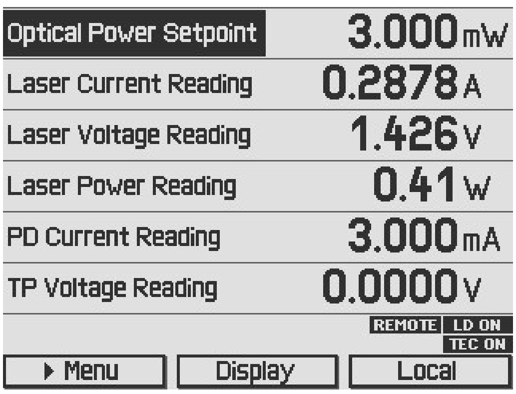


Figure 64
ITC4000 measuring screen in remote mode

4.2 Instrument driver installation

The software package that comes with the device contains a VXIpnp instrument driver. This instrument driver library simplifies the instrument control and reduces test program development time. It is suitable for various programming environments including NI-LabVIEW, NI-LabWindows/CVI and MS-Visual Studio.

Prior to connecting the instrument to a PC, please check if a VISA engine is installed on the PC, otherwise install the NI-VISA engine that is available for free from the National Instruments website www.ni.com or from the included data carrier.

Note

To complete the installation of the ITC4000 USB driver successfully, you must have Administrator privileges on the PC on which you are performing the installation.

After successfully installing the drivers connect the ITC4000 to a USB port of your PC. The PC will find a test and measurement device. Please follow the instructions of the dialog screens and allow the installation.

Various programming examples demonstrate how to use the instrument driver and how to communicate successfully with your instrument. The examples are installed with the instrument driver and may be found in the drivers installation directory.

4.3 Firmware update

Firmware upgrades can be accomplished by the user via the USB interface using the software "Thorlabs DFU Wizard".

NOTE

To install the Thorlabs DFU wizard successfully, you must have Administrator privileges on the PC, and the instrument must be powered down or disconnected from the USB.

Follow the instructions below to upgrade your instrument:

- Install the Thorlabs DFU Wizard on your PC.
- Download the new Firmware file from the Thorlabs web site (www.thorlabs.com).
- Switch on your instrument and connect it to a USB port of your PC.
- Make sure the Update Capability is “enabled” or “enabled once” in the System Preferences Menu (refer to chapter 2.5 System preferences 14)
- Launch the DFU Wizard from the start menu. Follow the DFU Wizard instructions.

Figure 65
DFU wizard

- During the process a new DFU capable device will be recognized by the PC. Make sure to install this device properly.
- If the following error message appears, click "Yes" to retry finding the device and continue the installation of the new firmware.

Figure 66
DFU wizard - error

NOTE

Do not switch off the instrument or disconnect the USB cable during the firmware download.

5 Maintenance and repair

5.1 General remarks

The ITC4000 controllers does not need regular maintenance by the user. It does not contain any modules that could be repaired by the user himself. If a malfunction occurs, the whole unit has to be sent back to *Thorlabs*. Do not remove covers!

If any disturbances in function occur, please refer first to chapter Troubleshooting 74.

If you don't find the error source by means of the trouble shooting list please first contact *Thorlabs* before sending the ITC4000 controller for checkup and repair to *Thorlabs* (refer to section Thorlabs Worldwide Contacts 95).

If highest precision of measurements is vital to you, you should have the ITC4000 controller recalibrated by *Thorlabs* about every two years.

General care
Protect the unit from adverse weather conditions. The ITC4000 controllers are not water resistant.

Attention

To avoid damage to the ITC4000 controllers, do not expose it to spray, liquids or solvents!

Cleaning
The unit and the display can be cleaned with a cloth dampened with water. You can use a mild 75% Isopropyl Alcohol solution for more efficient cleaning.

5.2 Line voltage settings

The ITC4000 series controllers operate with line voltages of 100 ... 120 V AC and 200 ... 240 V AC ±10%. The line frequency range is 50 ... 60 Hz.

Thus it can be operated worldwide without any adjustment or voltage setting.

5.3 Replacing the mains fuses

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

Warning

To avoid fire hazard, replace the two mains fuses with fuses of the specified type and rating only. Fuse Type: IEC60127-2/1 (High breaking capacity!), F10 H 250V, fast acting (F) 10 Amperes, size 5 x 20 mm

Instructions:

1. Power off the ITC4000 and disconnect the mains cable.
2. The fuse holder (R14, see Figure 62) is located below the 3-terminal power connector of the mains jack (R10). Release the fuse holder by bending its two plastic retainers with the aid of two small screwdrivers. The retainers must be pressed towards the center of the fuse holder.
3. Replace the defective fuses (R15). We recommend changing both fuses, even if only one fuse has opened.
   Press in the fuse holder into the mains jack until locked on both sides.
4. Switch on the unit. If it cannot be switched on, please contact your supplier or *Thorlabs*.

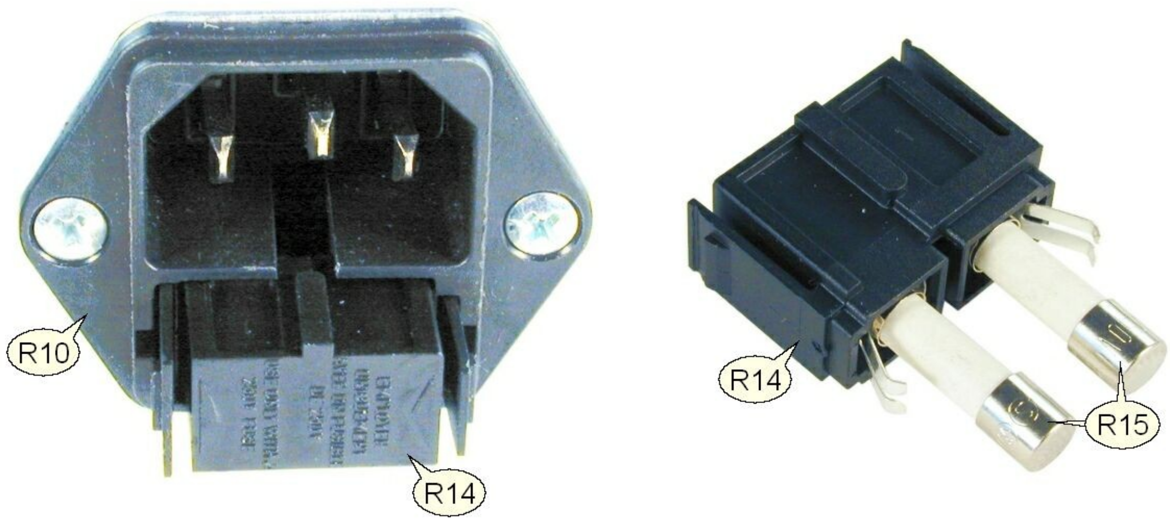


Figure 67
Replacing the mains fuses

5.4 Troubleshooting

In case that your ITC4000 shows malfunction, please check the following items:

Unit does not work at all (nothing is shown on the display at the front):

- Is the ITC4000 connected to the mains properly?
- Is the ITC4000 turned on?
- Check the fuses on the rear panel (see chapter Replacing the mains fuses 72). If blown, please replace the fuses by the correct type.
- Check via SCPI interface if the unit works (see chapter Computer Interface 69). If you can connect to the unit properly, please check display settings via remote control (brightness and contrast).

The display works, but you don't get the desired operation temperature, current or power:

- Have the corresponding hardware limits been set correctly? Please refer to chapter Setting the LD source parameters 31 or to chapter Setting the TEC source parameters 41
- Has the Laser diode / TEC setup been connected to the 13W3 DSUB jack 16 and the 17W2 DSUB jack 21 at the rear panel correctly?
- Has the interlock circuit been closed? Please refer to chapter Connecting Interlock and LD ON Monitoring 19.
- Has the Voltage Protection been set to a value grater than the nominal laser forward voltage? Please refer to chapter Laser Output Configuration 29.
- Please check all cables and the polarity settings. Please refer to chapter Connecting components 16, to chapter Laser Output Configuration 29 and to chapter Setting the Photodiode Parameters 33.
- Has the temperature sensor been connected properly, and has the sensor type been selected correctly? Check the corresponding connections and polarities of the temperature sensor (please refer to chapter Connecting a temperature sensor 24). Check the temperature sensor settings (please refer to chapter Temperature sensor setup 42)
- Check the TEC polarity (please refer to chapter Connecting a TEC element 22)
- The optical output power in constant power mode is oscillating. Please check the bandwidth for the constant power feedback loop in chapter Setting the LD source parameters 31.
- The temperature in constant temperature mode is oscillating. Please check the PID settings in chapter PID control loop settings 52
- If you don't find the error source with the help of the troubleshooting list, please contact the Thorlabs (see Thorlabs Worldwide Contacts 95 before sending the unit to Thorlabs for checkup and repair.

- Please check the error messages before calling.
- For information about the installed firmware, please check the current firmware versions on the Information screen before calling:.

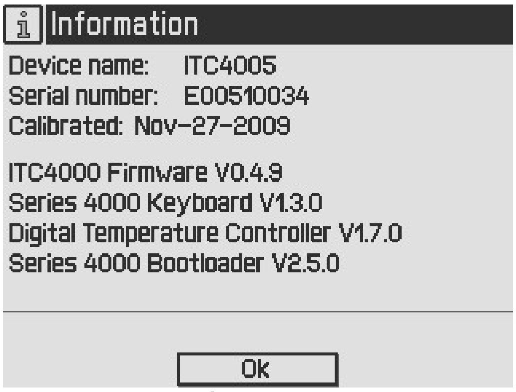


Figure 68
ITC4000 information screen

6 Appendix

6.1 Technical data

(All data related to accuracy is valid at 23 ± 5°C and 45 ±15% humidity)

General Data	
Line voltage	100 to 120V ±10% / 200 to 240V ±10%
Line frequency	50 to 60 Hz ±5%
Maximum power consumption[1)]	600 / 650 / 900 VA
Supply mains overvoltage	Category II (Cat II)
Operating temperature (non condensing)	0 to +40°C
Storage temperature	-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	30 min
Weight	5.3 kg
Dimensions (WxHxD) without operating elements	263 x 122 x 307 mm³
Dimensions (WxHxD) with operating elements	263 x 122 x 345 mm³

Laser current control	
Laser diode current range ITC4001	0 to 1 A
Laser diode current range ITC4005	0 to 5 A
Laser diode current range ITC4020	0 to 20 A
Compliance voltage	>10 V
Setting resolution ITC4001[2)]	0.1 mA / 16 µA
Setting resolution ITC4005 [2)]	1 mA / 80 µA
Setting resolution ITC4020 [2)]	1 mA / 320 µA
Measurement resolution ITC4001 [2)]	0.1 mA / 16 µA
Measurement resolution ITC4005 [2)]	1 mA / 80 µA
Measurement resolution ITC4020 [2)]	1 mA / 320 µA
Current accuracy ITC4001	±(0.1% reading + 0.5 mA)
Current accuracy ITC4005	±(0.1% reading + 2 mA)
Current accuracy ITC4020	±(0.1% reading + 8 mA)
Ripple and noise ITC4001 (10 Hz to 10 MHz, rms, typ.)	<15 µA
Ripple and noise ITC4005 (10 Hz to 10 MHz, rms, typ.)	<500 µA
Ripple and noise ITC4020 (10 Hz to 10 MHz, rms, typ.)	<10 mA
Drift, 24 hours ITC4001 (0 -10 Hz, typ., at Constant Ambient Temperature)	<100 µA
Drift, 24 hours ITC4005 (0 -10 Hz, typ., at Constant Ambient Temperature)	<300 µA
Drift, 24 hours ITC4020 (0 -10 Hz, typ., at Constant Ambient Temperature)	<1 mA
Temperature coefficient	= 50 ppm/°C

1) ITC4001 / ITC4005 / ITC4020

2) via front panel / remote control

Laser power control	
Photo current range 2 mA	0 to 2 mA
Photo current range 20 mA	0 to 20 mA
Setting resolution photo current range 2 mA [2)]	1 µA / 32 nA
Setting resolution photo current range 20 mA [2)]	10 µA / 320 µA
Measurement resolution photo current range 2 mA [2)]	1 µA / 32 nA
Measurement resolution photo current range 20 mA [2)]	10 µA / 320 µA
Accuracy photo current range 2 mA	±(0.08% reading +0.5 µA)
Accuracy photo current range 20 mA	±(0.08% reading +5 µA)
Photodiode reverse BIAS voltage	0 to 10 V
Photodiode input impedance	~0 Ω (Virtual Ground)
Thermopile range 10 V	0 to 10 V
Thermopile range 1 V	0 to 1 V
Thermopile range 100 mV	0 to 100 mV
Thermopile range 10 mV	0 to 10 V
Measurement resolution Thermopile range 10 V [2)]	1 mV / 160 µV
Measurement resolution Thermopile range 1 V [2)]	100 µV / 16 µV
Measurement resolution Thermopile range 100 mV [2)]	10 µV / 1.6 µV
Measurement resolution Thermopile range 10 mV [2)]	1 µV / 0.1 6µV
Accuracy Thermopile range 10 V	±(0.1% reading + 5 mV)
Accuracy Thermopile range 1 V	±(0.1% reading + 1 mV)
Accuracy Thermopile range 100 mV	±(0.1% reading + 100 µV)
Accuracy Thermopile range 10 mV	±(0.1% reading + 10 µV)

LD current limit	
Setting range ITC4001	0 to 1 A
Setting range ITC4005	0 to 5 A
Setting range ITC4020	0 to 20 A
Setting resolution ITC4001	0.1 mA / 16 µA
Setting resolution ITC4005	1 mA / 80 µA
Setting resolution ITC4020	1 mA / 320 µA
Accuracy ITC4001	±(0.12% reading + 0.8 mA)
Accuracy ITC4005	±(0.12% reading + 3 mA)
Accuracy ITC4020	±(0.12% reading + 12 mA)

PD current limit	
Photo current limit 2 mA range	5 µA to 2 mA
Photo current limit 20 mA range	50 µA to 20 mA
Photo current limit resolution 2 mA range [2)]	1 µA / 128 nA
Photo current limit resolution 20 mA range [2)]	10 µA / 1.28 µA
Photo current limit accuracy 2 mA range	± 20 µA
Photo current limit accuracy 20 mA range	± 200 µA

TH voltage limit	
Thermopile voltage limit 10 V range	0 to 10V
Thermopile voltage limit 1 V range	0 to 1V
Thermopile voltage limit 100 mV range	0 to 100 mV
Thermopile voltage limit 10 mV range	0 to 10 mV
Thermopile voltage limit resolution 10 V range [2)]	1 mV / 730 µV
Thermopile voltage limit resolution 1 V range [2)]	100 µV / 73 µV
Thermopile voltage limit resolution 100 mV range [2)]	10 µV / 7.3 µV
Thermopile voltage limit resolution 10 mV range [2)]	1 µV / 730 nV
Thermopile voltage limit accuracy 10 V range	± 10 mA
Thermopile voltage limit accuracy 1 V range	± 1 mA
Thermopile voltage limit accuracy 100 mV range	± 100 µA
Thermopile voltage limit accuracy 10 mV range	± 10 µA

2) via front panel / remote control

Laser voltage measurement	
Measurement principle	4-wire / 2-wire
Measurement range	0 to 14 V
Measurement resolution 2)	1 mV / 160 µV
Accuracy	±20 mV

Laser overvoltage protection	
Setting range	1 to 11 V
Resolution 2)	1mV / 650 µV
Accuracy	±100 mV

Internal laser modulation	
Waveforms	Sine, Square, Triangle
Frequency range ITC4001/ITC4005	20 Hz to 100 kHz
Frequency range ITC4020	20 Hz to 50 kHz
Modulation depth	0.1 to 100%

External laser modulation	
Input impedance	>10 kOhm
Small signal 3dB bandwidth, CC mode, ITC4001	DC to 100 kHz
Small signal 3dB bandwidth, CC mode, ITC4005	DC to 100 kHz
Small signal 3dB bandwidth, CC mode, ITC4020	DC to 50 kHz
Modulation coefficient, CC mode, ITC4001	100 mA/V ±5%
Modulation coefficient, CC mode, ITC4005	500 mA/V ±5%
Modulation coefficient, CC mode, ITC4020	2 A/V ±5%
Modulation coefficient, CP mode, Current Sensor 3)	200 µA/V / 2 mA/V ±5%
Modulation coefficient, CP mode, Voltage Sensor 3)	1 mV/V /10 mV/V / 100 mV/V / 1V/V ±5%

Analog control out	
Load resistance	>10 kOhm
Transmission coefficient ITC4001	10V/A ±5%
Transmission coefficient ITC4005	2 V/A ±5%
Transmission coefficient ITC4020	500 mV/A ±5%

QCW Mode	
Pulse width range	0.1 ms to 1 s
Pulse width resolution	1 µs
Repetition rate range	1 ms to 5 s (0.2 to 1000 Hz)
Repetition rate resolution	10 µs

Trigger	
Input	rising edge triggered, starts QCW pulse with internal adjusted width
Input level	TTL or 5 V CMOS
Output	active high, tracks pulse width
Output level	TTL or 5 V CMOS
Death time to next pulse	>10 µs

2) via front panel / remote control

3) depending on the selected range

TEC current control	
Current range ITC4001	-8 to +8 A
Current range ITC4005 & ITC4020	-15 to +15 A
Compliance voltage ITC4001	>12 V
Compliance voltage ITC4005 & ITC4020	>15 V
Max. TEC output power ITC4001	>96 W
Max. TEC output power ITC4005 & ITC4020	>225 W
Settings resolution [2)]	1 mA / 0.1 mA
Accuracy	±(0.2% reading + 20 mA)
Ripple and noise (10 Hz to 10MHz, rms, typ.)	<10 mA

TEC current limit	
Setting range ITC4001	0.1 to 8 A
Setting range ITC4005 & ITC4020	0.1 to 15 A
Resolution [2)]	1 mA / 0.1 mA
Accuracy	±(0.2% reading + 10 mA)

NTC thermistor sensors	
Resistance measurement range 100kΩ	100 Ω to 100kΩ
Resistance measurement range 1MΩ	1 kΩ to 1MΩ
Temperature control range (max) [4)]	-55°C to + 150°C
Resolution 100kΩ range [2)]	0.1 / 0.03 Ω
Resolution 1MΩ range [2)]	1 / 0.3 Ω
Accuracy [3)]	±(0.06% reading + 1Ω / 5 Ω)
Temperature stability (24 hours typ.) [4)]	<0.002°C
Temperature coefficient	<5 mK/°C

IC sensors	
Supported current temperature sensors	AD590, AD592
Supported voltage temperature sensors	LM35, LM335, LM235, LM135
Temperature control range AD590	-55 to +150°C
Temperature control range AD592	-25 to +150°C
Temperature control range LM35	-55 to +150°C
Temperature control range LM335	-40 to +100°C
Temperature control range LM235	-40 to +125°C
Temperature control range LM135	-55 to +150°C
Resolution [2)]	0.001 / 0.0001°C
Accuracy AD590 current	±(0.04% reading + 0.08 µA)
Accuracy LM335/LM35 voltage	±(0.03% reading + 1.5 mV)
Temperature stability (24 hours typ.)	<0.002°C
Temperature coefficient	<5 mK/°C

Pt100/Pt1000 RTD sensors	
Temperature control range	-55 to +150°C
Resolution [2)]	0.001 / 0.0003°C
Accuracy	± 0.3°C
Temperature stability (24 hours typ.)	<0.005°C
Temperature coefficient	<20 mK/°C

2) via front panel / remote control

3) depending on the selected range

4) control range and thermal stability dependent on thermistor parameters

TEC voltage measurement	
Measurement principle	4-wire / 2-wire
Measurement range	-16.5 to +16.5 V
Resolution [2)]	100 mV / 40 mV
Accuracy (4-wire)	± 50 mV

Temperature window protection	
Setting range T_{WIN}	0.01 to 100°C
Protection reset delay	0 to 600 s
Window protection output (TEMP OK)	BNC, TTL 5V

Temperature deviation output	
Load resistance	>10 kΩ
Transmission coefficient (temperature deviation scaled to temperature window)	ΔT * 5V / T ± 0.2%.

Digital I/O port	
Number of I/O lines	4 (separately configurable)
Input level	TTL or CMOS, Voltage Tolerant up to 24 V
Output level (sourece operation)	TTL or 5 V CMOS, 2 mA max.
Output level (sink operation)	open collector, up to 24 V, 400 mA max.

Interface	
USB 2.0	according to USBTMC/USBTMC-USB488 specification Rev. 1.0
Protocol	SCPI compliant command set
Drivers	VISA VXI pnp™, MS Visual Studio™, MS Visual Studio.net™, LabView™, Labwindos/CVI™

Connectors	
Connector for Laser, Photodiode, Interlock & Laser On Signal	13W3 mixed DSUB jack (female)
Connector for TEC element, thermo sensors, 12VDC	17W2mixed DSUB jack (female)
Connectors for LD enable, QCW pulse, Trigger out, Opt. sensor in, modulation in, Analog CTL out	BNC
Chassis ground connector	4 mm Banana jack
Connector for USB interface	USB type B
Digital I/O	Mini DIN 6
Mains input	IEC 60320

Safety features	
Switch ON delay	0 to 60 s
Keylock switch	yes
LDC interlock	yes
Over temperature protection	yes
Inhibit Input (LD Enable)	yes
LDC current and power limits LDC	yes
Adjustable overvoltage protection	yes
TEC current limit	yes
TEC open	yes
TEC no cable detection	yes

6.2 Menu structure overview

Menu topic	description
LD Output Configuration	Laser diode polarity, laser diode voltage protection, switch on delay, and inhibit input mode can be set
LD Source Setup	Operating mode, laser current limit, photodiode current limit, thermopile voltage limit, power feedback loop settings can be set
LD Source Setpoints	changes of different setpoints like the laser current (in constant current mode) or photodiode current, thermopile voltage, and optical power (in constant power mode) can be made
Photodiode Input	the photodiode parameters like input route (13W3 DSUB jack or BNC jack), current range, BIAS state, BIAS voltage and response can be set
Thermopile Input	the voltage sensor parameters like input route (13W3 D-Sub jack or BNC jack), voltage range or response can be set
LD Modulation	the modulation source (internal or external) and the settings for the internal modulation like shape, frequency and depth can be changed
QCW Pulse Settings	the trigger source and the QCW pulse parameters can be changed
TEC Source Setup	TEC current limit, Temperature setpoint limits, temperature setpoint, and current setpoint can be changed
Temperature Sensor Setup	a temperature sensor can be selected and the sensor offset can be adjusted
Thermistor Settings	the parameters for the thermistor temperature calculation can be entered
PID Control Loop	the PID control loop parameters can be shown and changed manually
PID Auto-Tune	the PID auto-tune process can be started and the found parameters can be applied to the PID control loop settings
Temperature Protection	the TEC's temperature protection window can be defined and the error behavior can be set
Display Configuration	two, four or six value measurement screen can be picked and the displayed setpoints or readings can be changed
Settings Memories	8 different Laser setups can be saved or reloaded
Digital I/O Port	the direction and the levels of the digital I/Os can be read or written

Menu topic	description
System Preferences	the system settings like message handling, display brightness and contrast, sound signal on/off, line frequency and update capability can be changed.
Remote Control	contains the address string for use of VISA remote control
Information	contains device specific information like device name, serial number, calibration date, and the current firmware version

6.3 Factory settings for Thorlabs ITC4000 controllers

set value	factory setting
LD Polarity	cathode grounded (CG)
Switch On Delay	3 seconds
LD Voltage Protection	1.0V
Inhibit Mode	Protection
Laser Current Limit	1mA (ITC4001) / 5mA (ITC4005) / 20mA (ITC4020)
Laser Current Setpoint	0A
PD Range	20mA
PD Polarity	CG
PD Input Route	DSUB connector
PD Sensitivity	1A/W
PD Current Limit	2mA
PD Current Setpoint	0mA
PD BIAS State	Off
PD BIAS Voltage	0V
Thermopile Voltage Range	10V
Thermopile Input Route	DSUB connector
Thermopile Sensitivity	1V/W
Thermopile Voltage Limit	1V
Thermopile Voltage Setpoint	0V
Feedback Source	Photodiode
Feedback Loop Speed	0.1%
Modulation	Off
Modulation Source	Internal
Shape	Sine
Frequency	1kHz
Depth	5%
QCW Trigger	internal
QCW Pulse Period	20ms
QCW Pulse Width	1ms
TEC Operating Mode	constant temperature
TEC Current Limit	0.1A
Setpoint Low Limit	-55°C
Setpoint High Limit	+150°C
Temperature Setpoint	+25°C

set value	factory setting
Current Setpoint	0A
Temperature Sensor	thermistor (low)
Sensor Offset	0°C
Exponential R0 value	10.000kΩ
Exponential T0 value	25.000°C
Exponential β value	3977
Steinhart-Hart parameter A	1.129241 EXP-3
Steinhart-Hart parameter B	2.341077 EXP-4
Steinhart-Hart parameter C	0.087755 EXP-6
PID Proportional value	1.000 A/K
PID Derivate value	0.1 A/Ks
PID Integral value	0.0 As/K
PID Oscillation Period	0.2 seconds
TEC Temperature Window	5.000°C
TEC Protection Reset Delay	1.0 second
Display	6 value screen
Display Value 1	LD Source Setpoint
Display Value 2	LD Current Reading
Display Value 3	LD Voltage Reading
Display Value 4	Photodiode Current Reading
Display Value 5	TEC Source Setpoint
Display Value 6	Temperature Reading
Display Brightness	100%
Display Contrast	65%
Sound Signals	Enabled
Line Frequency	Auto
Update Capability	Disabled

6.4 Error messages

6.4.1 LED status messages

LD ON switch LED	Description
Green	LD output ON
Green flashing	• Switch On Delay active • I-Limit / P-Limit • Inhibit Input Mode (Output Enable) active* • Temp. Protection Mode (Output Enable) active*
Red	Critical errors: • Keylock • LD open • Interlock • Inhibit Input Mode (Protection)* • Temperature Protection (Protection)*
Red flashing	Internal device overtemperature (OTP)

* Refer to chapter Laser Output Configuration 29

TEC ON switch LED	Description
Green	TEC output ON
Green flashing	• Temperature out of window (temperature protection) • PID Auto-Tune is running
Red	Critical errors: • No sensor • No cable • TEC open
Red flashing	Internal device overtemperature (OTP)

6.4.2 Status indicators

The ITC4000 has various status indicators in the bottom line.

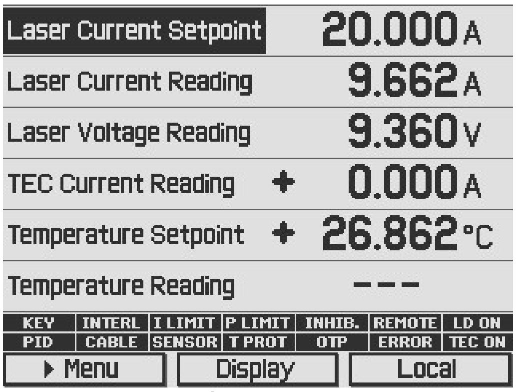


Figure 69
ITC4000 status indicators

The meanings are:

Status indicator	description
KEY	The key switch is in locked position to prevent unauthorized usage of the laser driver.
INTERL	The interlock is open because of an incorrect wiring or an open external switch; the laser output can't be switched on.
I LIMIT	The laser current is limited because the laser current limit value (adjusted in the LD Source Setup 31 menu) is reached
P LIMIT	The optical laser power is limited because one of the sensor limits is reached (photo current limit, voltage limit, or power limit, adjusted in the LD Source Setup 31 menu).
INHIB.	The LD-ENABLE input level is in disable state (low). The effect on the laser output is dependent on the selected Inhibit input mode in the LD Output configuration 29 menu.
OTP	The unit is internally overheated. The laser output and the TEC output are switched off and can be switched on again after a temperature drop of about 10 degrees
REMOTE	The unit is in remote operation
TMC-ID	The unit is in TMC identification (via remote)
LOCK	The unit is in remote operation and a local operation is locked.
ERROR	Interface error indicator. There are errors stored in the device's error queue. They can be read using the syst:err? command
PID	The PID auto-tune process is running
CABLE	Indicates an incorrect wiring to the TEC setup

Status indicator	description
SENSOR	A wrong sensor is selected or the sensor lines are broken
T PROT	The current TEC temperature is outside the preselected temperature window and the temperature protection is active. The effect on the laser output is depending on the Temp. protection mode setting in the LD Output configuration 29 menu.

6.4.3 Instrument errors

Table 1: Switch Off / Output Protection Errors

Error	Description
The instrument is too hot	The laser output and the TEC output were switched off because the instrument is internally overheated
LD output switched off due to Key switch	The laser output was switched off because the key switch was moved to “locked” position
Open interlock circuit detected	The laser output was switched off because the interlock connection was opened
LD inhibit input was tripped	The laser output was switched off because the level of the “LD ENABLE IN” input was changed to LOW
LD temperature protection detected	The laser output was switched off because the temperature protection was tripped
LD output voltage protection was tripped	The laser output is switched off. This can be caused by a too low laser voltage threshold or an incorrect laser diode wiring. Please check polarity, wiring, and the laser voltage protection
TEC output voltage protection was tripped	The TEC output was switched off because the output compliance voltage was exceeded
Temperature sensor failure detected	The TEC output was switched off because a temperature sensor error occured
TEC cable connection failure detected	The TEC output was switched off because the interlock connection was opened
PID Auto-Tune finished	The PID Auto-Tune procedure is finished, check the status information in the Auto-Tune Menu

Table 2: Other Instrument Errors

Error	Description
Instrument is overheated	The units internal temperature is too high. The laser output and the TEC output are switched off and can be switched on again after a temperature drop of about 10 degrees.

Error	Description
Not permitted with LD Output on	Operation is not allowed while the laser output is switched on. This applies to the laser current limit, the used sensor limits, and the sensor ranges.
Interlock circuit open	Operation is not allowed while the interlock protection is tripped. This can be caused by an incorrect wiring or an open external safety switch.
Key switch is in locked position	Operation is not possible, when locked by the front panel key switch. This avoids an unauthorized usage of the laser driver
LD inhibit is active	The Laser output is temporarily switched off until the status level on "LD ENABLE IN" jack will be switched to high level
LD temperature protection is active	The Laser output is disabled because of the "LD ENABLE IN" error and must be switched on manually
Not permitted with photodiode BIAS on	Operation is not allowed while the photodiode BIAS is switched on.
Not permitted with QCW mode on	The constant power mode is not allowed if the QCW mode is switched on, please set the QCW mode to off before using constant the power mode
Wrong LD source operating mode	The QCW mode is not allowed in constant power mode, please switch the operating mode to constant current before using the QCW mode.
Settings conflict	Only one feedback sensor (photodiode or thermopile) can be switched to the BNC jack "OPT SENSOR IN". If this message is shown please set the unused feedback sensor to the DSUB connector.
Value is not editable	The selected display item (e.g. measurement reading) can't be adjusted
Not editable with LD output on	Laser current limit, photo current limit, thermopile voltage limit, and power limit can't be set if the Laser output is on.
Not permitted with TEC output on	Operation is not allowed while the TEC output is switched on. This is valid e.g. for the TEC current limit and the temperature sensor selection.
Wrong TEC source operating mode	Operation is not allowed in current TEC source operating mode, please check the selected operating mode in the TEC source setup
PID auto-tune is currently running	Operation is not permitted during a running PID auto-tune process
PID auto-tune value error	The values of the PID auto-tune process are out of the specified range, please try a manuel tuning (refer to chapter PID control loop settings 52)
TEC open circuit detected	The connection to the TEC element is broken or the resistance of the TEC element is too high, the TEC output cannot be switched on.

Error	Description
Temperature sensor failure	In case of an incorrect wiring to the temperature sensor or the selected temperature sensor does not match
TEC cable connection failure	The TEC setup is not connected to the unit correctly
Value is out of range	A sent numerical value in remote mode is out of range, check the allowed min/max values for the parameter to be changed
Value minimum/maximum reached	Occurs when the range limits of the setpoints are reached
Operation is not applicable	Occurs in Edit Name menu if characters can't be deleted (with backspace) anymore
FPGA configuration error	A FPGA configuration failure has occurred during the boot procedure, please switch the unit off and on again. If this error is shown again contact the Thorlabs Hotline
Nonvolatile checksum error	A general EEPROM checksum error has occured, please switch the unit off and on again. If this error will be appeared again contact the Thorlabs Hotline
General keyboard bootloader error	The keyboard bootloader is not running after the boot procedure, please switch the unit off and on again. If this error is shown again contact the Thorlabs Hotline
Hardware error	A device internal hardware error has occurred, please switch the unit off and on again. If this error continues contact the Thorlabs Hotline
Calibration memory lost	The calibration data in the EEPROM is invalid, please switch the unit off and on again. If this error is still present contact the Thorlabs Hotline
Save/recall memory lost	The saved user setup data in the EEPROM is invalid, please switch the unit off and on again. If this error is shown again contact the Thorlabs Hotline
Configuration memory lost	The last saved setup before power down is invalid, please switch the unit off and on again. If this error is still present contact the Thorlabs Hotline
Self test failed	The device self test procedure has failed, please switch the unit off and on again. If this error continues contact the Thorlabs Hotline

6.5 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 [2,3]. Emission: complies with EN 55011 Class B Limits [2,3,4] 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)
	IEC 61000-4-5	Power Line Surge Immunity (Performance Criterion B)
	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 [5])
	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 [2,3,4].	
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 [6]	
	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) Compliance demonstrated with CAB4006 cable installed at the LD OUTPUT port with 20A resistor dummy attached to the other end and CAB4001 cable installed at TEC OUTPUT PORT with 15A resistor dummy attached to the other end.
4) Emissions, which exceed the levels required by these standards, may occur when this equipment is connected to a test object.
5) Performance Criterion C was reached at voltage interruptions test level 0% for 250 / 300 cycles and is permitted at this test level.
6) Replaces 73/23/EEC, amended by 93/68/EEC.

6.6 Warranty

Thorlabs warrants material and production of the ITC4000 controllers 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 (Germany)* or to a place determined by *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 return 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 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.

6.7 Copyright

6.8 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 70)
- 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.).

6.8.1 Waste treatment on our 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

6.8.2 Ecological backround

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 life products will thereby avoid negative impacts on the environment.

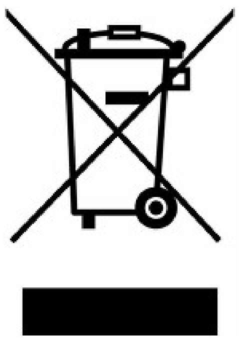


Figure 70
Crossed out
"wheelie bin"

6.9 Listings

6.9.1 List of acronyms

AC	Alternating Current
AG	Anode Grounded
CC	Constant Current
CG	Cathode Grounded
CDRH	Center for Devices and Radiological Health
CP	Constant Power
CW	Continuous Wave
DC	Direct Current
DDS	Digital Direct Synthesizer
ILD	I (current) Laser Diode
IPD	I (current) Photo Diode
LD	Laser Diode
LDC	Laser Diode Controller
LED	Light Emitting Diode
NTC	Negative Temperature Coefficient
OTP	Over Temperature
PC	Personal Computer
PD	Photo Diode
QCW	Quasi Continuous Wave
RF	Radio Frequency
RMS	Root Mean Square
TEC	Thermo Electric Cooler
TED	Thermo Electric Driver
USB	Universal Serial Bus
UTH	U (voltage) Thermoplie

6.9.2 Thorlabs Worldwide Contacts

USA, Canada, and South America
Thorlabs, Inc.
435 Route 206
Newton, NJ 07860
USA
Tel: 973-579-7227
Fax: 973-300-3600
www.thorlabs.com
www.thorlabs.us (West Coast)
Email: sales@thorlabs.com
Support: techsupport@thorlabs.com

Europe
Thorlabs GmbH
Hans-Böckler-Str. 6
85221 Dachau
Germany
Tel: +49-8131-5956-0
Fax: +49-8131-5956-99
www.thorlabs.de
Email: europe@thorlabs.com

UK and Ireland
Thorlabs Ltd.
1 Saint Thomas Place, Ely
Cambridgeshire CB7 4EX
Great Britain
Tel: +44-1353-654440
Fax: +44-1353-654444
www.thorlabs.com
Email: sales.uk@thorlabs.com
Support: techsupport.uk@thorlabs.com

France
Thorlabs SAS
109, rue des Côtes
78600 Maisons-Laffitte
France
Tel: +33-970 444 844
Fax: +33-811 381 748
www.thorlabs.com
Email: sales.fr@thorlabs.com

Scandinavia
Thorlabs Sweden AB
Box 141 94
400 20 Göteborg
Sweden
Tel: +46-31-733-30-00
Fax: +46-31-703-40-45
www.thorlabs.com
Email: scandinavia@thorlabs.com

Japan
Thorlabs Japan, Inc.
Higashi Ikebukuro
Q Building 1st Floor 2-23-2
Toshima-ku, Tokyo 170-0013
Japan
Tel: +81-3-5979-8889
Fax: +81-3-5979-7285
www.thorlabs.jp
Email: sales@thorlabs.jp

China
Thorlabs China
Room A101, No. 100
Lane 2891, South Qiliashan Road
Putuo District
Shanghai
China
Tel: +86-21-60561122
Fax: +86-21-32513480
www.thorlabs.hk
Email: chinasales@thorlabs.com