Artifex
Engineering

LIV120-400A-12V

(30.060.00049)

Laser Diode Characterization System

Read this instruction manual before performing any task!

Original Operating Instructions

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1 Product Overview

The LIV120 is a powerful test instrument for use in the lab and in production environments. This instrument is ideal for laser diode characterization and quality control. The main unit comprises the current source as well as the data acquisition and communication hardware.

The LIV120 supports two basic operating modes: LIV sweep (pulsed or CW current "staircase") and burst mode (pulsing or CW at constant current). During a measurement cycle, the instrument measures the optical power of the laser diode (L), the drive current (I) and the voltage drop across the laser diode (V). The photocurrent from a monitor photodiode may also be measured if present. Optionally, the wavelength spectrum can be simultaneously measured via a fibre optic port on the detector.

pulsed LIV sweep

CW LIV sweep

pulsed burst mode

CW burst mode
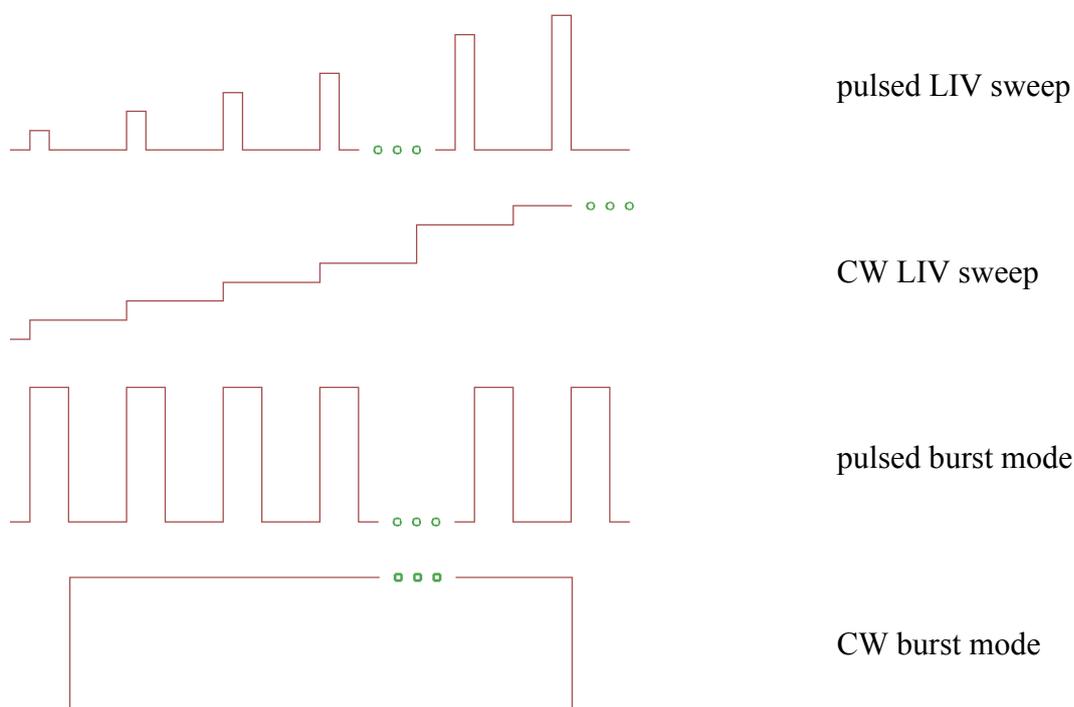
The LIV120 is controlled via a set of commands and parameters which are uploaded from the controlling computer. This is followed by the command to begin measurement. The LIV120 then autonomously completes the full measurement sweep and sends the complete data set to the control computer. A graphical software package is provided to ease use of the instrument in a lab environment.

The software development kit allows for easy integration of the LIV120 into a custom software environment.

2 About this manual

2.1 Information about this manual

This manual enables you to handle the device in a safe and efficient manner. This manual is part of the device and must be kept in its vicinity in order to ensure that it is available to the personnel at all times.

The personnel must have carefully read and understood this manual before commencing any work. The compliance with all safety information and instructions provided in this manual is essential for safe operation.

Furthermore, all local work protection and general safety regulations applicable at the device's place of installation must be observed.

The illustrations used throughout this manual are intended to provide a general understanding and may deviate from the actual model of the machine.

2.2 Explanation of symbols

Safety instructions

Safety instructions are marked with symbols in these instructions. The safety instructions are always introduced by signal words which express the extent of the danger.

DANGER!

This combination of symbol and signal word indicates an immediately-dangerous situation which could cause death or severe injuries if not avoided.

WARNING!

This combination of symbol and signal word indicates a possibly-dangerous situation which could cause death or severe injuries if it is not avoided.

CAUTION!

This combination of symbol and signal word indicates a possibly-dangerous situation which could cause slight injuries if it is not avoided.

NOTICE!

This combination of symbol and signal word indicates a possibly-dangerous situation which could cause property and environmental damage if it is not avoided.

Tips and recommendations

This symbol highlights useful tips and recommendations as well as information designed to ensure efficient and smooth operation.

Special safety instructions

The following symbols are used in the safety instructions to draw attention to specific dangers:

DANGER!

This combination of symbol and signal word indicates an immediately-dangerous situation due to electric shock. If an instruction so marked is not heeded, severe or even fatal injuries can be the consequence.

DANGER!

This combination of symbol and signal word indicates an immediately-dangerous situation due to laseremission. If an instruction so marked is not heeded, severe or even fatal injuries can be the consequence.

2.3 Copyright

The contents of these instructions are copyrighted. Their use is permitted in the context of using the device. Any use extending beyond this is not allowed without written permission from the manufacturer.

2.4 Customer service

Our customer service is available for technical information and service:

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We are also always interested in information and experiences gathered from use which could be valuable for the improvement of our products.

3 Safety

This section provides an overview of all safety aspects that are essential to the best possible protection of the personnel and the safe and trouble-free operation of the machine. Additional safety instructions for specific work tasks are contained in the sections regarding the individual life stages of the machine.

3.1 Intended use

The laser diode characterization system LIV120 is designed exclusively as a test system for the electro-optical characterization of laser diodes.

The intended use also includes adherence to all specifications in this manual.

Any use exceeding or differing from the intended use applies as misuse.

3.2 Basic dangers

The following section describes remaining risks which can arise from the device even with proper use.

In order to reduce risks of personal injury and property damage and avoid dangerous situations, the safety instructions listed here and the safety instructions in the other sections of these instructions must be followed.

Electrical current

DANGER!

Life-threatening danger from electrical current!

When touching live parts there is an immediate, life-threatening danger from electric shock. Damage to the housing as well as the cable can be life-threatening!

- Work on the electrical system in the interior of the unit may only be performed by the manufacturer.

- In the event of damage to the housing or the cable, immediately disconnect the voltage supply by pulling out the mains plug and initiate the repair process.

- When making high current connections, please observe the correct order of mounting in order to avoid undue heating of the connection. Mount the cable lug directly onto the contact and then secure with a washer, a lock washer and a nut in that order.

3.3   Responsibility of the owner

Owner:

The owner is any such person who operates the laser diode characterization system for commercial or economic purpose either itself or transfers it to a third party for use and bears the legal responsibility for the safety of the user, the personnel or third parties during the operation.

Owner's duties:

The laser diode characterization system is used in commercial applications. Therefore, the owner of the respective laser diode characterization system is subject to the statutory duties of work safety.

In addition to the safety instructions in this manual, the safety, work safety and environmental safety regulations applicable for the area in which the electronic ballast is used must be adhered to. In the process, the following applies in particular:

- The owner must remain updated on the applicable work safety regulations and determine, in the scope of a risk assessment, additional dangers which can arise due to the special working conditions at the place in which the electronic ballast is used. This must be implemented in the form of working instructions for the operation of the laser diode characterization system.

- During the entire period of use of the laser diode characterization system, the owner must check whether the working instructions meet the current status of the rules and regulations and to adapt them as necessary.

- The owner must clearly regulate and define responsibilities for the operation, fault rectification and cleaning.

- The owner must make sure that all persons who work with the laser diode characterization system have read and understood this manual. Moreover, the owner must train the personnel in regular intervals and inform them of the dangers.

- The owner must adhere to all statutory provisions in regard to the regular testing of electrical equipment and document this testing.

-

In addition, the owner is responsible for ensuring that the unit is always in a technically faultless condition.

3.4 Personnel requirements

Qualifications:

The various tasks described in this manual place different requirements on the qualification of the persons to whom these tasks are entrusted.

!

NOTICE!

Insufficiently qualified personnel can cause property damage!

Insufficiently qualified personnel cannot assess the risks when working with the unit.

- All work may only be performed by personnel who are qualified for this purpose.
- Keep insufficiently qualified personnel away from the work area.

Only persons who can be expected to reliably perform this work are permitted to carry out any work with this equipment. Persons whose ability to react is impaired by drugs, alcohol, medications, etc. are not permitted to work with this equipment.

In this manual the following qualifications listed for the personnel for the various tasks are specified:

User:

The user uses and operates the device for its intended purpose without other prior knowledge.

3.5 Symbols on the unit

The following symbols and instruction signs are affixed in the work area. These symbols and instruction signs refer to the immediate vicinity in which they are affixed.

WARNING!

Danger due to illegible signage!

- Over time, stickers and signs can get dirty or in some other manner become illegible, so that dangers cannot be recognized and necessary operating instructions cannot be followed. Thus an injury hazard occurs.

- Keep all safety, warning, and operating instructions that are affixed to the device in legible condition.

- Replace damaged signs or stickers immediately.

Observe the operating manual
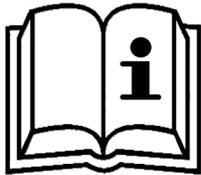
Do not use the indicated appliance until the operating manual has been read.

Do not dispose of with the household waste
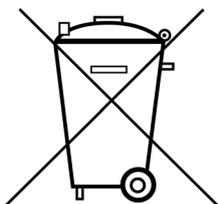
Notice that the laser diode characterization system may not be disposed of with the household waste. The worn out unit can be taken to an electronics and metal recycling service for disposal. The manufacturer also accepts old units for disposal.

3.6 Scope of delivery

Depending of the chosen model, the scope of delivery will vary:

- LIV120 current source and data acquisition unit
- Contact sockets, cards and/or cables
- Patch cables
- Integrating sphere or large area detector
- Power cable
- USB cable
- USB-Stick with Software, drivers and manual

3.7 Transport inspection

On receipt, immediately inspect the delivery for completeness and transport damage.

Proceed as follows in the event of externally apparent transport damage:

- Do not accept the delivery, or only accept it subject to reservation.
- Note the extent of the damage on the transport documentation or the shipper's delivery note.
- Initiate complaint procedures.

i *Issue a complaint in respect of each defect immediately following detection. Damage compensation claims can only be asserted within the applicable complaint deadlines.*

3.8 Packaging

About the packaging

The individual laser diode characterization system is packaged according to the expected transport conditions. Only environmentally friendly materials were used for the packaging.

The packaging should protect the individual laser diode characterization system from transport damage, corrosion and other types of damage. Therefore, do not destroy the packaging and save it for later transport and for storage.

Handling packaging materials

If the laser diode characterization system no longer has to be transported, dispose of the packaging materials in accordance with the respective statutory provisions and local regulations.

> **!**
>
> **NOTICE!**
>
> **Danger for the environment from improper disposal!**
>
> Packaging materials are valuable raw materials and can be reused in many cases or prepared and recycled. Dangers for the environment can arise through improper disposal of packaging material.

- Only dispose of packaging materials once it has been determined that the electronic ballast will no longer be transported.
- Dispose of packaging materials in an environmentally friendly manner.
- Observe the locally applicable disposal regulations. If necessary, commission a specialist company with the disposal.

3.9 Transporting

> **!**
>
> **NOTICE!**
>
> **Property damage from improper transport!**

Improper transport can damage the laser diode characterization system.

- Always transport the laser diode characterization system in the packaging provided for this purpose.
- Always proceed with caution with the transport of the laser diode characterization system in the packaging.
- Do not throw the laser diode characterization system.
- Protect the laser diode characterization system from vibrations and moisture.
- Do not let the laser diode characterization system fall.

3.10 Storage

Store the electronic ballasts in the packaging under the following conditions:

- Do not store outdoors.

- Store in a dry and dust-free area.

- Do not expose to any aggressive media.

- Protect from sun radiation.

- Avoid mechanical vibrations.

- Storage temperature: 15 to 35 °C.

- Relative air humidity: max. 60 %.

i *Under certain circumstances there are instructions for the storage on the packaging, which exceed the requirements specified here. Follow these accordingly.*

4   System Overview

An overview of a typical complete system is depicted in the figures below.
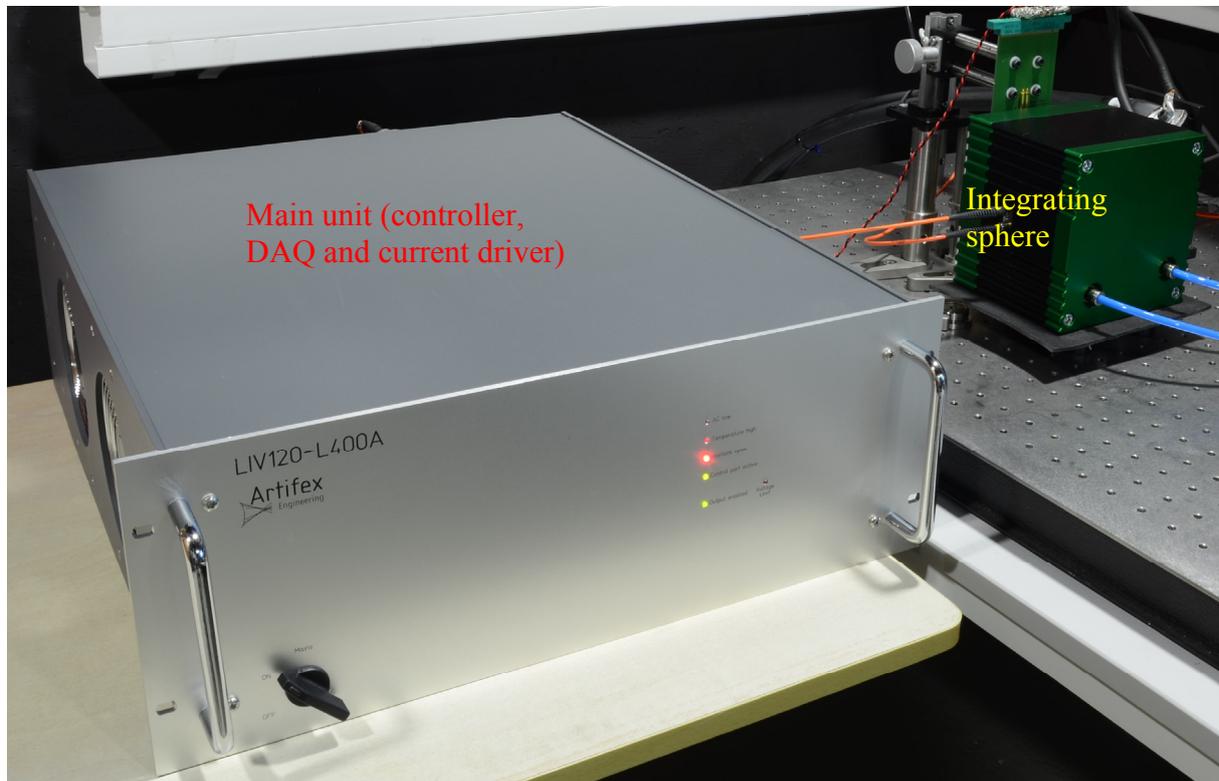
Figure 1: Overview of the LIV120-400A-12V system

The device under test is mounted on a TEC-controlled contact station or freely connected to the contact socket if temperature control is not required. An integrating sphere or a large area detector collects the light for the optical power measurement. In the case of the integrating sphere, a portion of this optical power is sampled at two ports by respective optical fibres. One sampled portion of the light is directed by a fibre to a photodiode detector connected to the DAQ system in the main enclosure of the LIV120 unit. The other fibre illuminates the input of a spectrometer as required.

i

Fibre bending

Please ensure that the optical fibres are not bent to a radius less than the specified minimum bending radius. Particularly in the case of the optical power measurement fibre, this will result in erroneous power measurements. If the minimum bending radius is observed, the power calibration will be independant of the placement of the fibre to within ±1%.

In the case of a large area detector, there may also be a fibre port for spectral measurement if required. All detectors from the OPM150 series of optical power meters are compatible with the LIV120 system. These detectors are recognized by the LIV120 allowing hot swapping for measuring various laser types and wavelengths.

The LIV120 provides sequences of software programmable currents to the laser. Details on these sequences are given in section 4.2 "Modes of Measurement" page 21. Four A/D channels in the DAQ system sample the output data during the measurement sequence. These channels are: 1) actual current driven, 2) voltage drop across the device under test, 3) optical power output from the device under test, 4) current from the monitor photodiode of the device under test (if applicable).

4.1 Description of Test Sequence

During a test sequence, the programmed currents are sequentially set via the controller interface of the LIV120. The first pulse or step of a staircase of a sequence is used internally to automatically set the optical power channel gain which depends on the output power of the device for the present measurement sequence. Thereafter the sequence will run with the parameters as set by the user. During each current step the four measurement channels (voltage, current, optical power, optionally monitor photodiode current) are acquired a given number of times for averaging.

When a new current is set, the device under test (DUT) will in general not be in thermal equilibrium anymore. The LIV120 system allows a user programmable delay period to allow thermalization of the DUT. The control software may terminate the sequence at any time by clicking the STOP button. The control system checks for a STOP command after each pulse / pause sequence. Thus, the maximum delay is the length of one pulse / pause sequence plus the internal delay of the control computer.

After thermalization, the waveforms are captured by the A/D circuitry and stored to buffer memory.

4.2 Modes of Measurement

The LIV120 supports a variety of modes to allow testing under a wide range of operating conditions. The essential variables available are the output current, pulse width and the pulse separation. The various modes of operation are described in the subsections below.

4.2.1 LIV Sweep

This mode performs an LIV sweep by stepping the pulse current from the minimum set value to the maximum set value in a number of equidistant currents as determined by the parameter "Number of currents". The voltage, current, optical power and monitor photodiode current are sampled at a rate of 40kS/s (25µs period) each. The drive current output may be run in CW mode or interupted between steps (pulsed mode). Schematically this appears as follows:
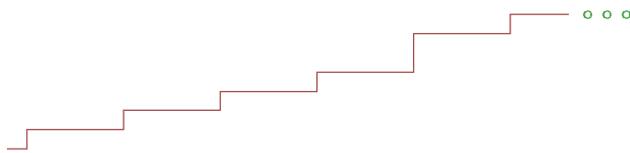
Figure 2: CW-LIV mode
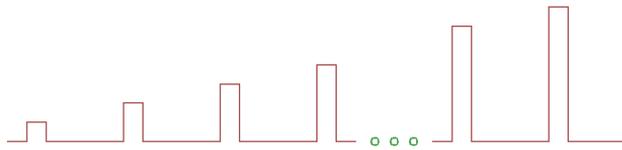
Figure 3: Pulsed LIV mode

When in CW-mode, the LIV120 is capable of running in the so-called soft pulse mode. This means that the current between pulses in pulsed mode operation does not drop down to zero, but rather to the value of the minimum current set by the operater.
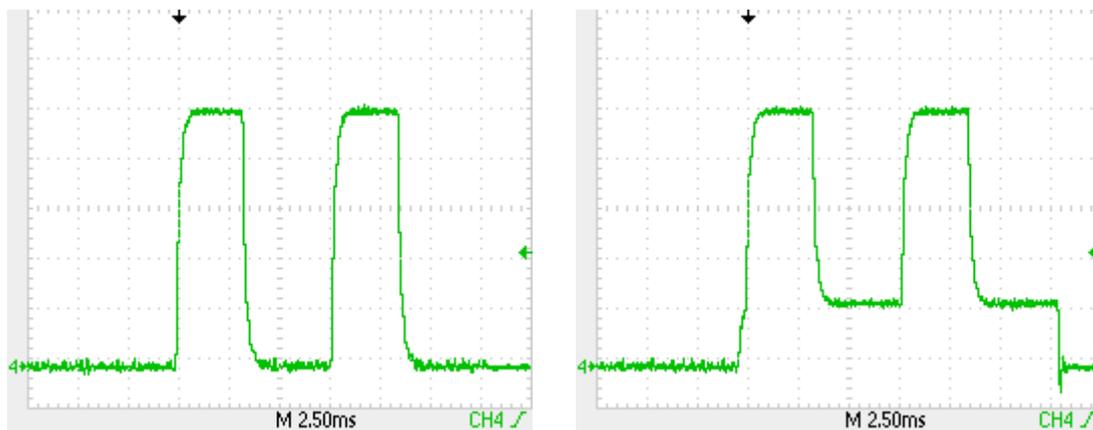
Figure 4: Current output (min. = 0)   *Current output (min. ≠0)*

!

NOTICE!

Selection of a non-zero value of the minimum current has the potential to damage the device under test since this current will flow constantly during the "pause time".

The current driver end stage is enabled only during the period of activity. Thereafter the end stage is disabled and the "Interlock open" LED on the front panel is lit. The "Interlock open" LED turns off during the enable period of the current driver.

The data acquisition unit (DAQ) begins sampling the measurement inputs after a fixed delay in order to allow the current to reach its final value during each pulse or step. The trigger output is activated only during the DAQ sampling period as depicted below:
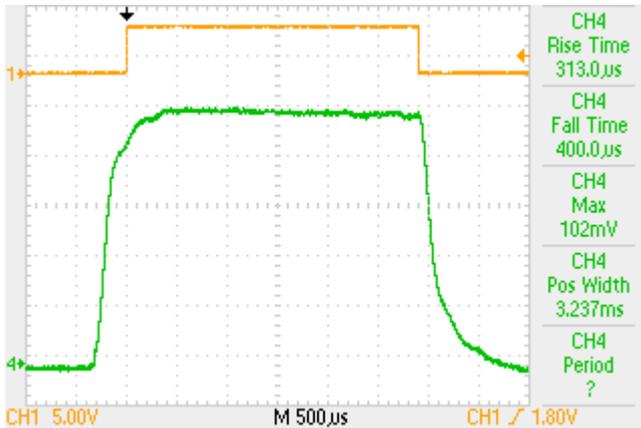
Figure 5: Trigger output (orange trace); Current output (green trace)

Pulse separation

Note that the pause between pulses cannot be zero due to the internal timing of the microcontroller in the drive unit. There is a minimum pulse separation of 480µs which appears as an offset to the pulse separation value input by the user. This is apparent in the following scope traces:
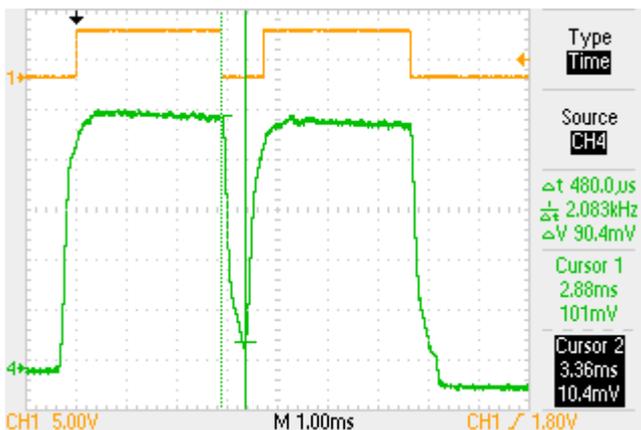
Figure 6: Pulse separation of 0.48ms at user input of 0ms
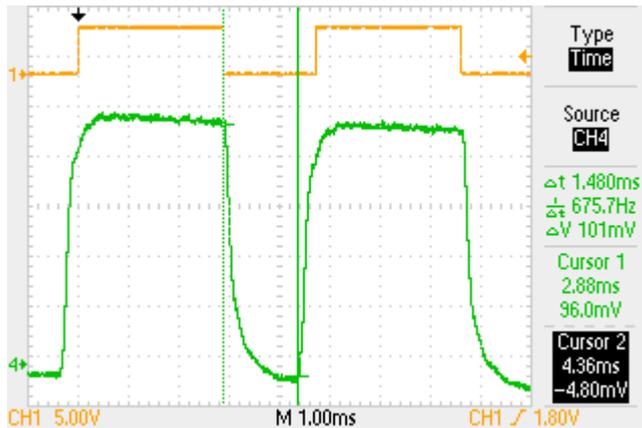
Figure 7: Pulse separation of 1.48ms at user input of 1ms

4.2.2   Burst mode

The burst mode is used to run the driver at constant current with a single pulse (or step) width and pulse separation during the whole burst. Schematically this appears as follows:

Figure 8: CW-burst mode
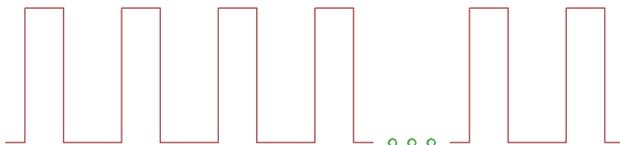
Figure 9: Pulsed burst mode

In pulsed mode, the current drops to zero between pulses. In CW mode, the current drops to the set minimum current between pulses. Therefore, in CW mode, the burst mode can be a soft pulse burst (min. current ≠ max. current) or it can be a true CW output (min. current = max. current).

The burst mode is useful for lifetime testing, checking the thermal contact on a device or for generating light for a certain length of time for other measurements such as smile, near field / far field patterns or spectra.

5 Specifications

5.1 Current Driver and DAQ Unit

Table 1: Specifications of the Current Driver and DAQ System

PARAMETER	CONDITIONS	RESOLUTION	MIN	TYP	MAX	UNITS
INPUTS: 2 x Transimpedance amplifier (1 x power input, 1 x monitor photodiode) 2 x A/D converter (current and voltage inputs)						
Sampling rate		n.a.		40		kS/s
A/D resolution				12		bit
Photodiode gain	optimum gain automatically selected			1 10 100		V/mA
Transimpedance amplifier rise time[1]	Input capacitance <1000pF, gain = 1 kΩ			20		µs
OUTPUT						
Pulse duration[2]		0.0235	1.02		6.88	ms
Rise time				400	500	µs
Current overshoot at maximum current[3]				0	5	%
Pulse separation		1	0.48		60 000	ms
Current range		0.1	0.1		400	A
D/A resolution				12		bit
Compliance voltage					12 [4]	V
Duty cycle		0.0017			100	%
SIGNAL PROCESSING						
Number of channels				3	4	
Number of cycles for averaging		1	1		250	
PC INTERFACE						
Type				USB; 100kB/s		
DIMENSIONS						
				483 x 500 x 177 mm (W x L x H) = 19" rack, 4U		mm
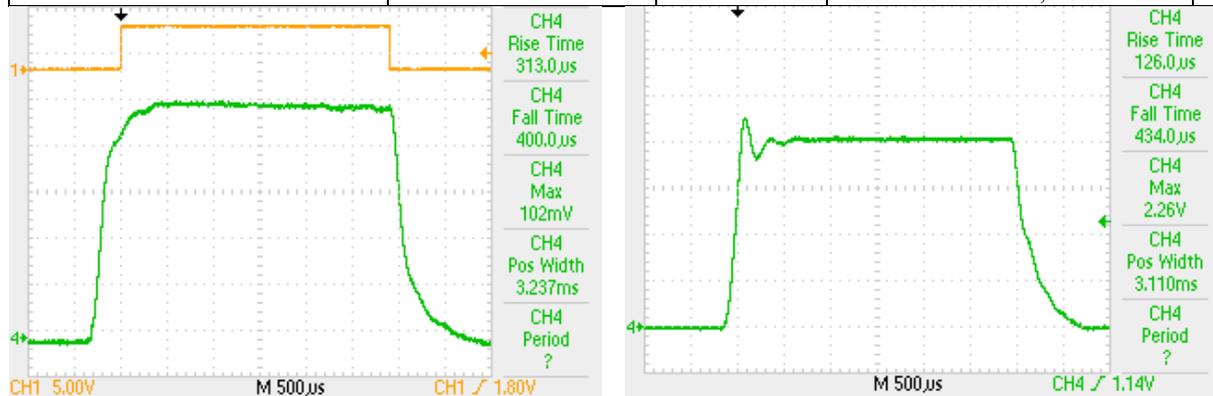
Figure 10: Pulse shape (20A)   *Pulse shape (400A)*

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[1] Per ANSI/IEEE Standard 181-1977: 10% - 90%
[2] Optimum sampling rate is automatically selected
[3] With cable supplied with the unit, no load matching required
[4] Dependant on the configuration of the connecting cable

6 Connections

6.1 Front Panel

Figure 11: Front Panel

The main ON-OFF switch as well as the status indication LEDs are mounted on the front panel.

6.1.1 On-Off Switch

Turn the switch to "ON" to turn the unit on. Turn the switch to "OFF" to turn the unit off.

6.1.2 Status LEDs

AC low [red]:   Error indication. Indicates that the mains power supply is too low.

Temperature high [red]:   Error indication. Indicates that the temperature of the driver is too high. Check for blockage of the air flow on the side panels.

Interlock [red]:   Possible error indication. Indicates that the interlock socket on the back panel has not been short-circuited or that the driver is presently disabled (no current being driven).

Voltage Limit [red]:   Error indication. Indicates that the driver reached its compliance limit during operation. The current did not reach its full set level.

Control port active [green]:   Indicates that the system control is active and ready for operation.

Output enabled [green]:   Indicates that the output of the current driver is ready for activation.

6.2 Back Panel

Figure 12: Back Panel

Figure 13: Back Panel, detailed view

6.2.1 Interlock

This three pin receptacle is used to connect an external safety interlock such as a door switch. The two outer pins of this receptacle must be short-circuited in order to be able to run the LIV unit. The middle pin is unused. Note that no voltage may be applied to any of these pins!

The unit is delivered with a short-circuit plug inserted into the interlock receptacle to be able to run the unit without an interlock switch connected (override).

WARNING!

It is dangerous to operate the unit with the interlock overrided. The LIV120-400A-12V is designed to drive class 4 lasers only.

6.2.2 Detector

The optical power is measured with an integrating sphere as the collecting element. The integrated optical power within the sphere is sampled at an optical port fitted with a fibre SMA receptacle. The sampled optical power is transmitted to the main system through a multimode optical fibre patch cable. The optical power port is a DB-9 receptacle compatible with the OPM150 series of optical power meters. The systems is delivered with an appropriately calibrated optical power head which must be connected to this receptacle. The LIV120 system reads the data from the connector (model, serial number and calibration file) for use during operation.

6.2.3   Monitor Photodiode

This BNC input is for a current input from a monitor photodiode if available. The signal is processed by a dedicated transimpedance amplifier of the same type as for the optical power detector.

6.2.4   Trigger Out

This BNC receptacle may be used for synchronizing external instruments. The output is TTL compatible. The output is HI when current is driven and the data acquisition unit is sampling. The output is LO otherwise.

6.2.5   USB

The communication with the LIV120 is via USB 2.0 with a baud rate of 1 000 000 bit/s. A hardware – handshake using RTS/CTS is employed to ensure secure communication. The system is fitted with a standard USB A-type receptacle. The appropriate USB cable is supplied with the system.

6.2.6   Voltage Input

The voltage input is via this BR2 type receptacle. This receptacle has the same form factor as BNC but is not compatible with BNC since the BR2 cable has two signal pins inside an outer shielding. Please use only the cable supplied with the unit for noise free measurement of the voltage drop across the device under test.

The polarity of the voltage input receptacle is as follows:

$+$ Connect to DUT anode $-$ Connect to DUT cathode

6.2.7 Current Output

The current output to drive the device under test is delivered from the two lugs in the middle of the back panel.
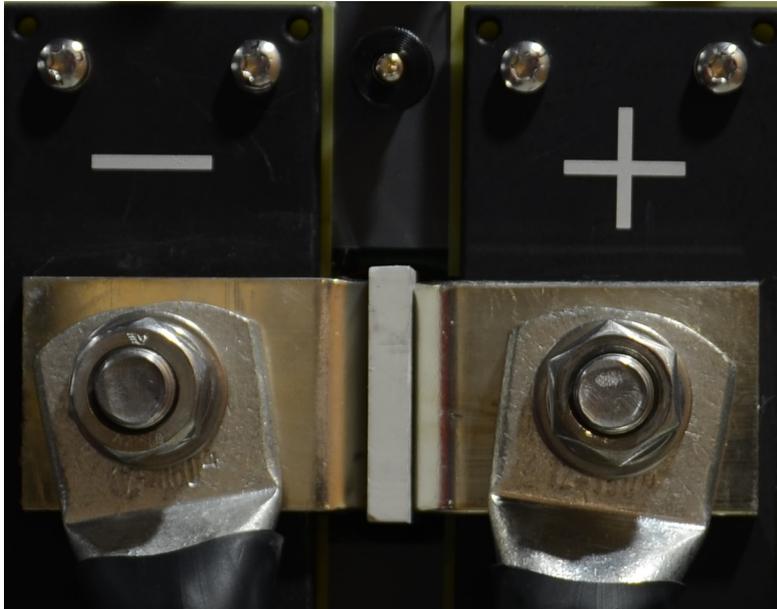
NOTICE!

The LIV120-400A-12V is designed to supply up to 400A of current. Even very small contact resistance can cause potentially damaging heating. Ensure that the current driver cables are securely fastened with the hardware provided. The order of mounting is: cable shoe, flat washer, locking washer, nut. The M12 nut should be tightened to 80N·m using an appropriate torque wrench.

Artifex Engineering provides full support to design and manufacture custom cables and connectors for contacting laser bars, chips, TO, C-Mount, CS-Mount, etc. Contact us for your requirements.
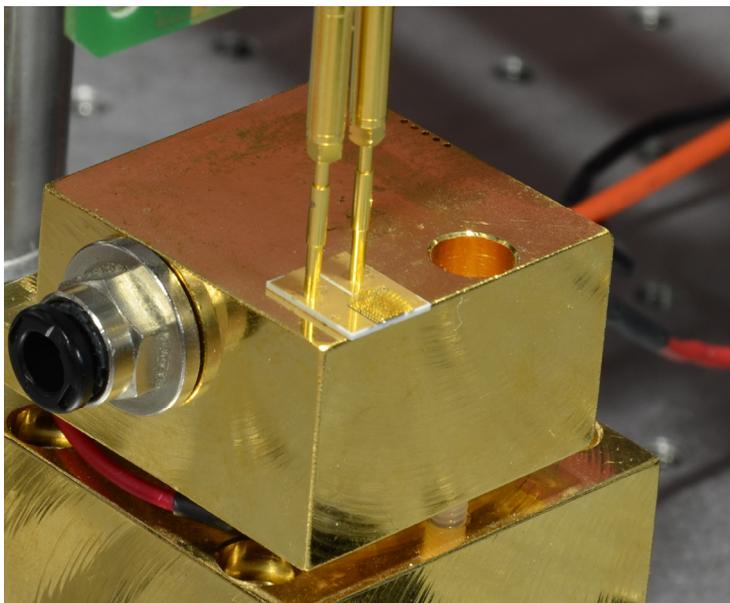
7 Using the Application Software

The graphical user interface is simple and easy to use. All of the important features can be reached directly in the main window. The main window comprises a pull down menu, a tool bar, the diagramme frame and a status bar.
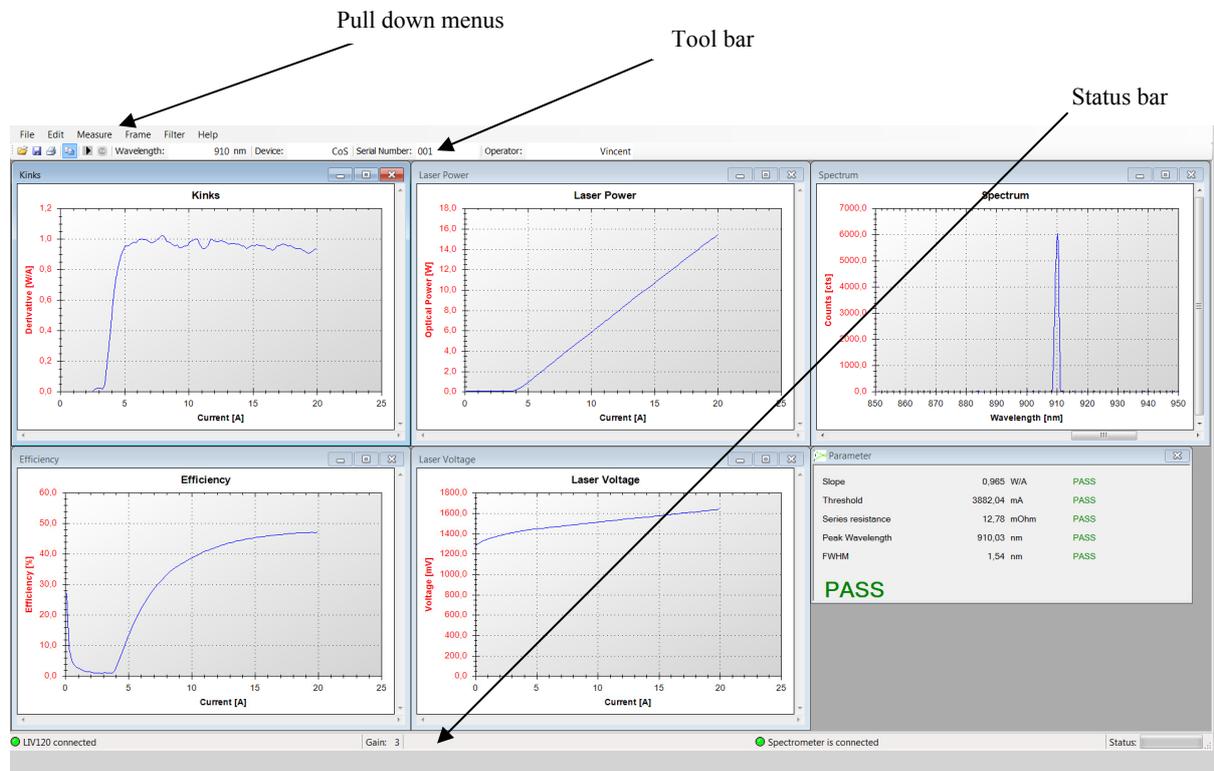
Figure 14: The Graphical User Interface (GUI)

7.1 The Functions of the Pull Down Menus

File: **Open** – Loads a *.LIV data format file or a *.WBD format parameter file. When opening an *.LIV file, ensure that the system is already in the same operation mode as that of the file (Edit/Settings: LIV or burst mode).

Save – Saves a *.LIV data format file or a *.WBD format parameter file. The *LIV format is specific for this application.

Save as – This function always prompts for the file name and folder. Otherwise identical to "Save".

Export – Exports the present data set as *csv or as a preconfigured pdf report. The *csv format is appropriate for exporting data into a format which can be read by Microsoft Excel and various other programmes. See "The *.csv Format", pg. 46 for further information on this data format.

Print – Prints the present graph frame using the printer selected in the following frame.

Page setup – Change the page formatting for the print.

Exit – Ends the programme.

Edit: **Copy** – Copies the present graph frame into the PCs intermediate storage for further use with other programmes. For example, the graph can now be inserted into a text document using the paste function.

Settings – Opens a new window in which various settings such as the pulse currents and user language can be made. For details, see „Settings" pg.34.

 DANGER!

Measure: **Measure** – Starts a measurement. The data are displayed in the open frames. Note that the LIV120-400A-12V is designed for testing class 4 lasers. Appropriate protection of all personnel must be observed before activating the measurement sequence.

Repeat Mode – Starts a series of measurements, the results of which are displayed until the next measurement in the series overwrites them. The number of measurement repetitions and the pause duration between them are set up in the "Settings" menu. This mode is useful when setting up a new system or measurement sequence.

Repeat Mode STOP – Aborts the repeat mode sequence before completing the full number of repetitions.

Manual Laser Control – Allow turning the current supply to the laser on and off without measurement. The current is run in constant current mode. This is useful for driving the laser for other applications such as spectral measurement with an OSA or for independent power measurement with an external power meter.

Frame: **Laser Power versus Current** – Opens the power versus drive current graph.

Voltage versus Current – Opens the voltage versus drive current graph.

Monitor Diode versus Current – Opens the monitor diode current versus drive current graph.

Efficiency versus Current – Opens the efficiency versus drive current graph.

Kinks – Opens the derivative of optical power versus drive current graph.

Laser Power versus Time – Opens the power versus time graph.

Voltage versus Time – Opens the voltage versus time graph.

Current versus Time – Opens the current versus time graph.

Monitor Diode versus Time – Opens the monitor diode current versus time graph.

Show parameter – Opens the table of calculated results (slope, threshold, series resistance, monitor diode slope, spectrum centre wavelength and spectrum FWHM).

Spectrum – Opens the optical spectrum graph.

Arrange frames horizontally – arranges the open frames horizontally within the screen window.

Arrange frames vertically – arranges the open frames vertically within the screen window.

Cascade frames – arranges the open frames in a cascade style.

Show all windows – opens all relevant graph frames for the type of measurement cycle chosen.

Filter: **Load Filter** – Loads a filter calibration file which is then used to correct the optical power data.

Delete Filter – Removes the filter file from the local memory of the GUI so that this file cannot be selected.

No Filter – Leaves the filter file in the local memory of the GUI but stops the programme from using the data for power value correction.

Help: **Info** – Shows information about this programme.

LIV Info – Shows information on the present instrument connected, including its model and serial numbers.

7.2 The Tool Bar

The tool bar allows for quick access to the most important functions.
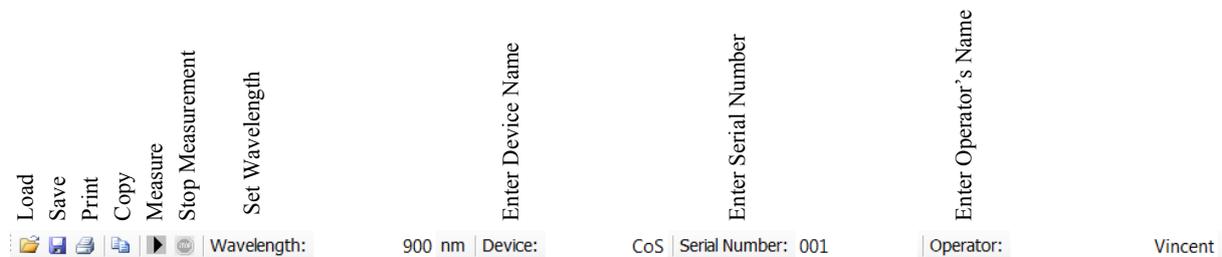
Figure 15: The Tool Bar

The file handling functions (Load, Save, Print, Copy,..) are identical to the corresponding sub menus in the pull down menus.

The following two symbols allow direct access to the measre and stop measurement functions.

 DANGER!

Measure : Starts a measurement. The data are displayed in the open frames. Note that the LIV120-400A-12V is designed for testing class 4 lasers. Appropriate protection of all personnel must be observed before activating the measurement sequence.

Stop : Stops a measurement. Use of this button leads to a premature abortion of the present measurement sequence. The data is lost and will not be displayed. A pop-up message box appears to inform the user that this function has been applied.
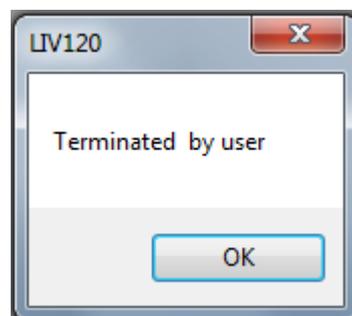
In addition, there are input fields for the wavelength the device and the operator's names.

Wavelength: The sensitivity of the detector head is dependant on wavelength. The individual calibration file is stored in the connector of each detector. Since the head cannot measure the wavelength of the light detected, this must be inputted by the user in order to allow the software to perform the appropriate correction calculation. The wavelength selection will only be accepted if it is within the range of calibration of the head.

Device: Model number of the device under test. This is useful for documentation and appears in the pdf report.

Serial Number: Serial number of the device under test. This is useful for documentation and appears in the pdf report.

Operator: Name of the operator. This is useful for documentation and appears in the pdf report.

7.3 The Status Bar

The most important status information is displayed here.
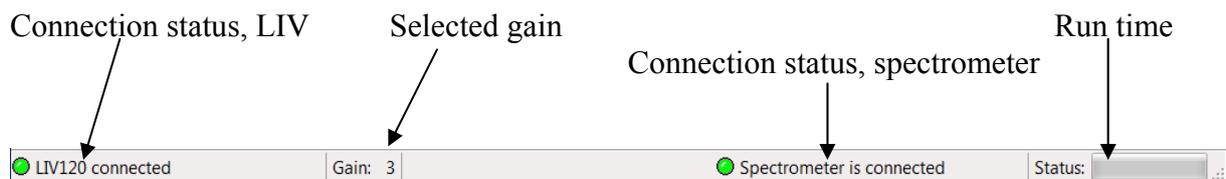
Figure 16: The Status Bar

Connection status, LIV: Indicates whether an LIV120 instrument is connected and all relevant connection parameters could be set properly. If a connection error occurs, the fault is indicated here and highlighted with a red virtual indicator lamp.

The programme will only function if the virtual indicator lamp is green and the status "LIV120 connected" appears. Disconnection will also be recognized and indicated during a running measurement.

Gain: Indicates the presently selected gain of the input amplifier for the optical power measurement. Possible gain settings are 0, 1 and 2 (low to high gain).

Connection status, spectrometer: Only present if the spectrometer is activated in the software (via the appropriate check-box on the spectrometer settings tab). Indicates whether a spectrometer is connected and all relevant connection parameters could be set properly. If a connection error occurs, the fault is indicated here and highlighted with a red virtual indicator lamp.

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The programme will only function if the virtual indicator lamp is green and the status "Spectrometer connected" appears. Disconnection will also be recognized and indicated during a running measurement.

Status: Coloured slider showing the run time status of the present measurement.

7.4 Settings

In addition to the settings in the tool bar, there are several which will not be required during normal operation and will usually be set once when first setting up the instrument. These settings are found in the pull down menu "Edit" under "Settings".

The following window then appears (with five tabs). The numbers in parentheses behind the paramter titles indicate the range and units of valid inputs. Inputs outside of the respective valid range will be automatically corrected to the next valid value.

On all tabs, the "OK" button saves the settings and exits the "Settings" menu. The "Abort" button exits the "Settings" menu without saving any of the settings on any of the tabs.

7.4.1 Tab "General"
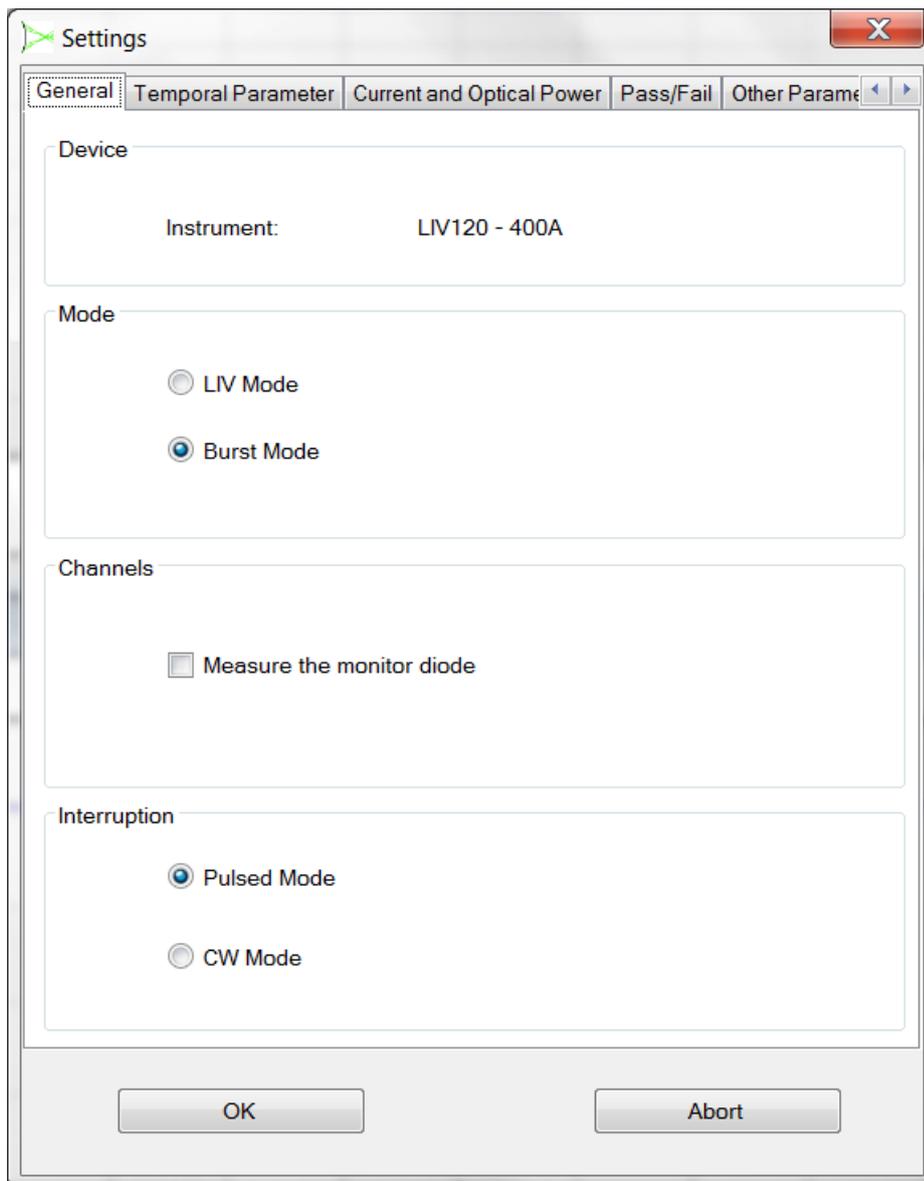
Figure 17: Tab "General"

Instrument:	Indicates the model of instrument.
Mode:	Radio buttons to choose the mode of operation. See section 4.2 "Modes of Measurement", page 21 for details.
Channels:	Check box to activate or deactivate measurement of the laser's monitor photodiode.
Interruption:	Radio buttons to select pulsed or CW mode.

7.4.2 Tab "Temporal Parameter"

Some fields are specifically for information only and cannot be editted in any operation modes. These are "Return Values" and are helpful in aiding in the choice of the selectable parameter values.
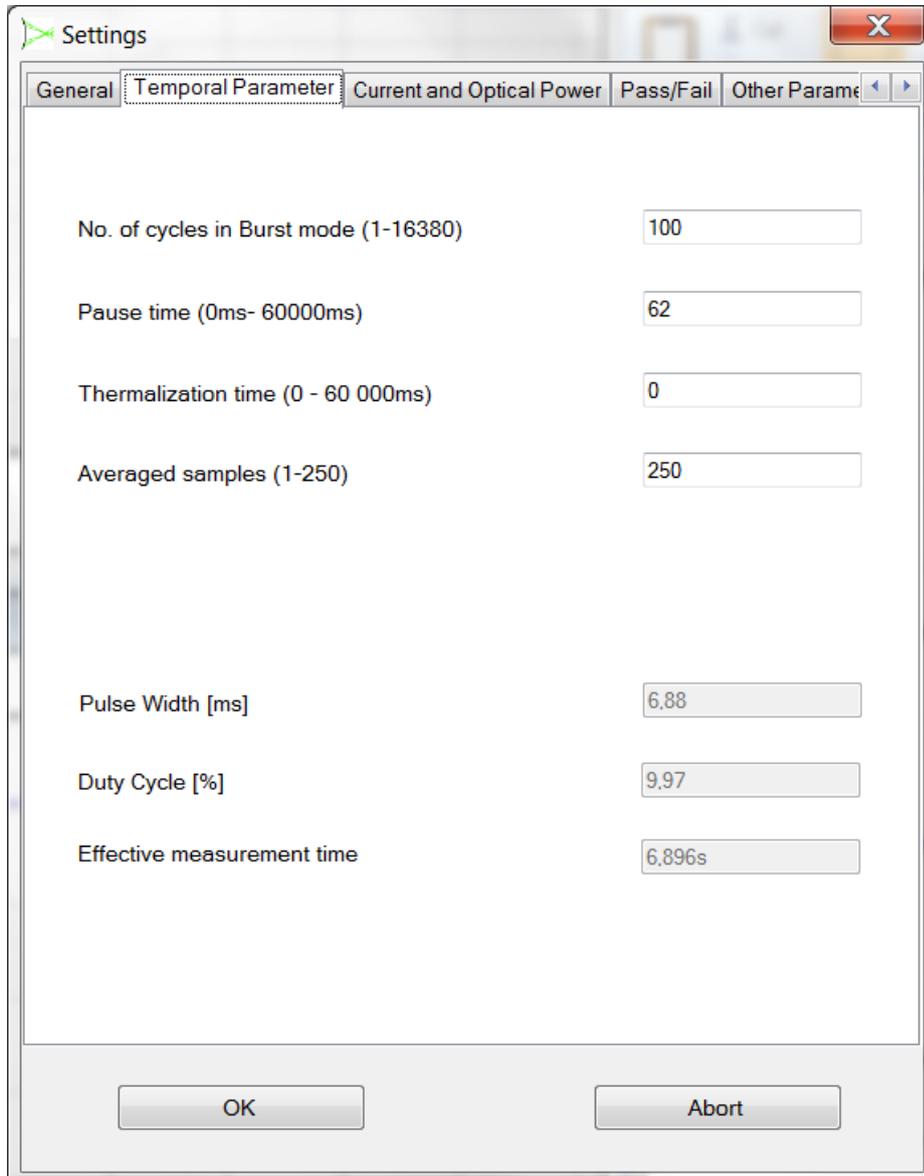
Figure 18: Tab "Temporal Parameter"

No. of cycles in Burst mode: Selects the number of cycles which will be performed in burst mode. This field is greyed out and inactive in LIV mode.

Pause time: Selects the separation between the falling edge of a pulse until the rising edge of the next pulse.[5]

---

[5] Therefore the period of the measurement cycle is given by (t_pulse + t_sep) and the repetition frequency is given by 1/(t_pulse + t_sep). Note that in fact the pause time is 480μs longer than the selected pause time. This is a fixed offset due to the microcontroller timing.

Thermalization time:	Selects the period of time during which current will flow before the data acquisition begins. This allows the user to select a period of time during which the device under test can reach thermal equilibrium before taking data.
Averaged samples:	Selects the number of samples to be acquired at each current step. Since the sampling rate is fixed and there is a fixed delay at each current before sampling, this parameter determines the length of each current pulse or step.

[Return Values]

Pulse Width:	Indicates the duration of the pulse or step width which results from the input under "Averaged samples". This is a non-editable field.
Duty Cycle [%]:	Indicates the duty cycle of the pulsing sequence in pulsed modes or of the data acquisition cycles in CW modes. The duty cycle is given by (100% $\cdot$ *pulse duration*)/(*pulse duration + pulse separation*). This is a non-editable field.

Effective measurement time [ms]:   Indicates the total duration of the data acquisition period. This is a non-editable field.

7.4.3 Tab "Current and Optical Power"

The appearance of the "Current and Optical Power" tab will depend on the settings on the "General" tab. Only those parameters which are relevant to the operation mode chosen on the "General" tab are active. All other parameters are greyed out and inactive.
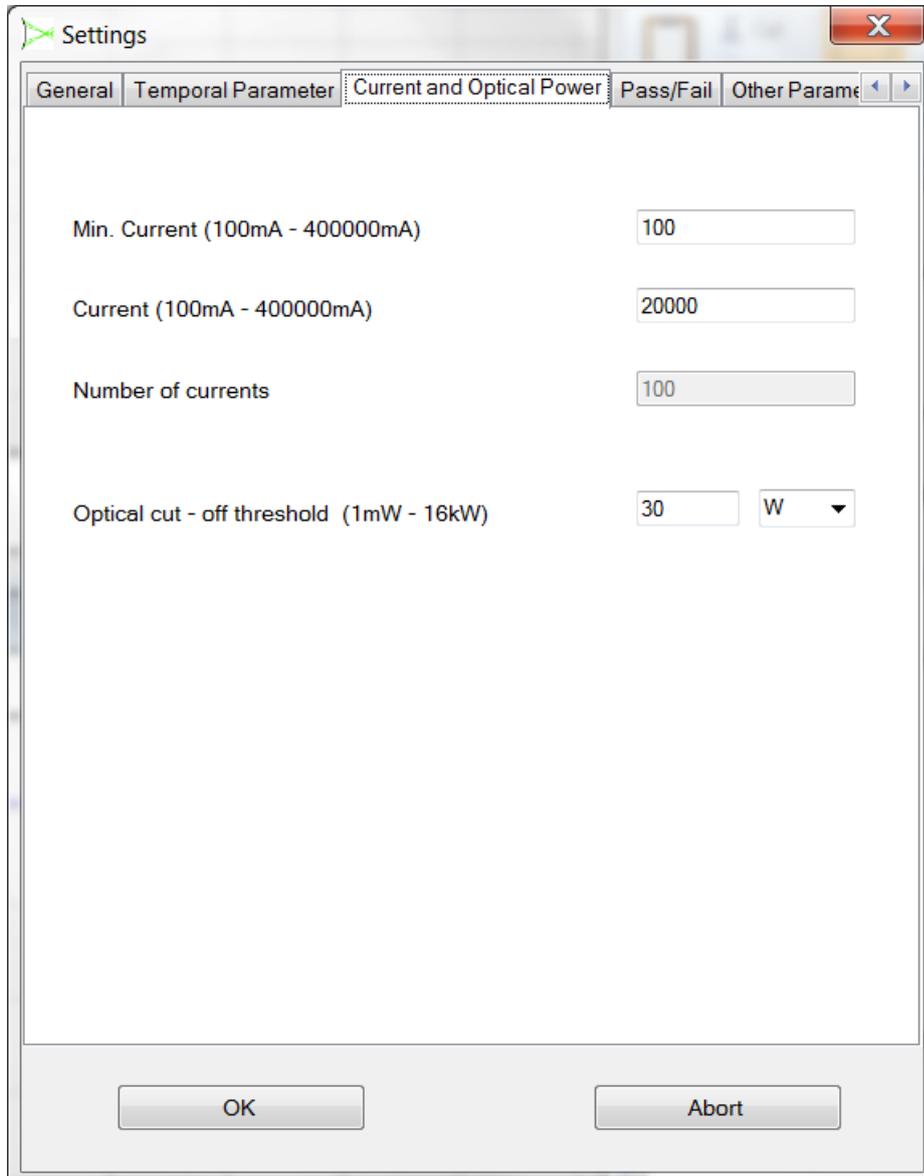
Figure 19: Tab "Current and Optical Power"

Min. Current:	Selects the minimum current for the LIV sweep and burst modes. Note that this is also the lower current level to which the output drops between current pulses. Thus, the LIV120 is capable of so-called soft pulsing.

NOTICE!

Selection of a non-zero value of the minimum current has the potential to damage the device under test since this current will flow constantly during the "pause time".

Max. Current:	Selects the maximum current for the LIV sweep and burst modes.
Number of current steps:	Selects the number of arithmetically equidistant steps for sweeping from the minimum to the maximum current in LIV mode. This is not the number of pulses in burst mode which should be set on the "Temporal Parameter" tab.
Optical cut-off threshold:	Selects the maximum optical power which the device under test is to emit. The input consists of a number and a unit which is selected via the drop-down menu. LIV sweeps will prematurely abort if this optical power limit is reached. In burst mode, the sequence will stop after the test pulse if the optical power is above this limit. In both cases a pop-up box appears to inform the user that the optical cut-off threshold was invoked.

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The maximum optical power parameter was exceeded!

OK
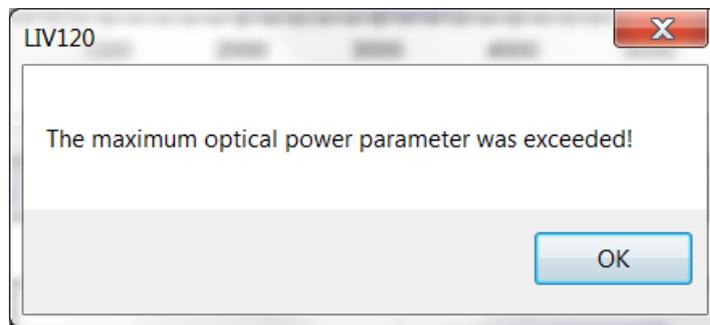
7.4.4 Tab "Pass/Fail"

The appearance of the "Pass/Fail" tab will depend on the settings on the "General" tab. Only those parameters which are relevant to the operation mode chosen on the "General" tab are active. All other parameters are greyed out and inactive.
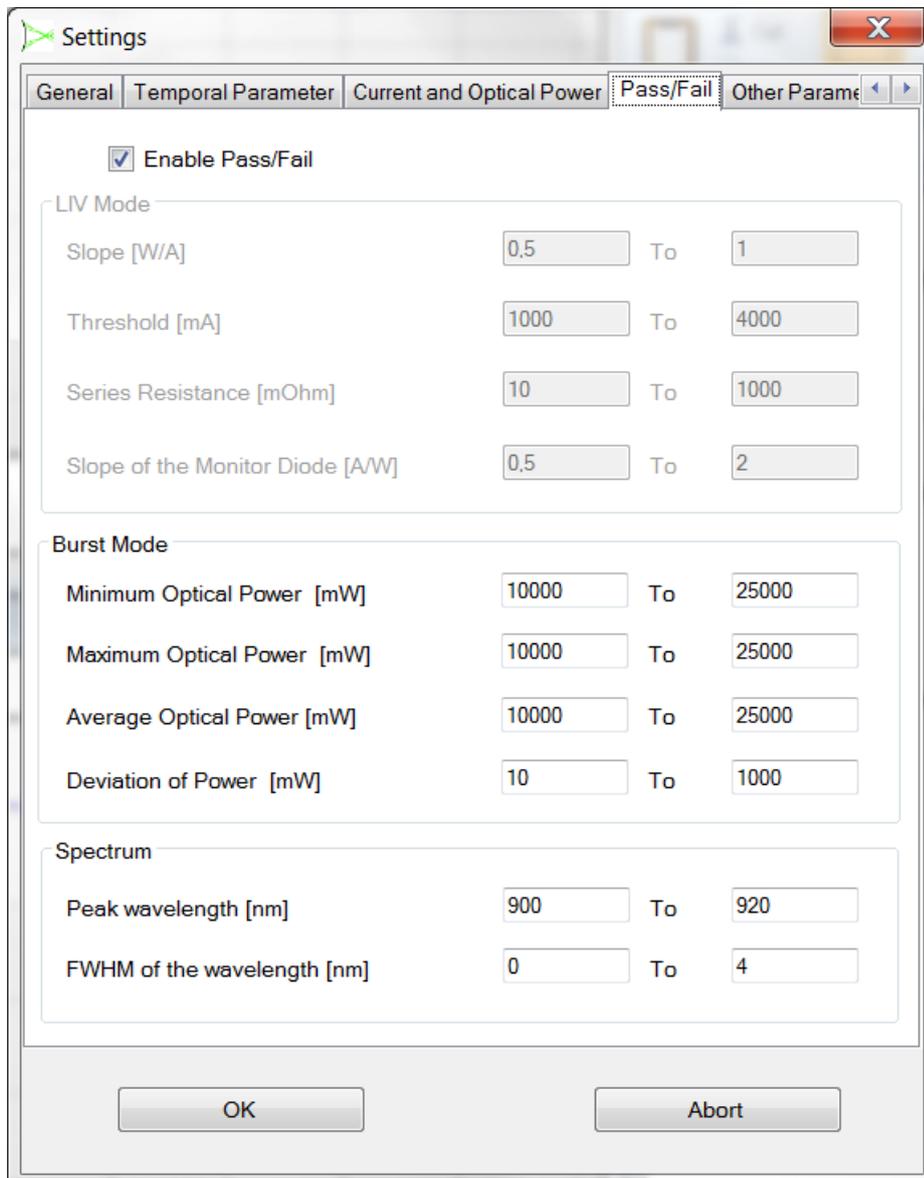
Figure 20: Tab "Pass/Fail"

Enable Pass/Fail: Check box to activate the pass/fail analysis. Each subsequent parameter has two input boxes representing the lower and upper valid limits of operation of the device under test. If the measured value during the sweep lies within the selected range, the relevant parameter will be evaluated as "Pass". Otherwise as "Fail". Only in the case that all parameters are evaluated as "Pass" will the device under test be evaluated as "Pass". Otherwise as "Fail".

[LIV Mode]

Slope: Slope of the optical power versus current curve.

Threshold: Threshold of the optical power versus current curve as determined by the threshold algorithm selected on the "Other Parameter" tab.

Series Resistance: Slope of the voltage versus current curve.

Slope of the Monitor Diode: Slope of the monitor current versus drive current curve. This selection is only valid if "Measure the monitor diode" is activated on the "General" tab.

[Burst Mode]

Minimum Optical Power: Lowest value of the optical power measured during the burst.

Maximum Optical Power: Highest value of the optical power measured during the burst.

Average Optical Power: Average value of the optical power measured during the burst.

Deviation of Power: Standard deviation of the optical power measured during the burst.

[Spectrum]

Peak wavelength: Wavelength at which the spectral data curve is maximum.

FWHM of the wavelength: Full width at half maximum (FWHM) of the spectral peak.

7.4.5   Tab "Other Parameter"
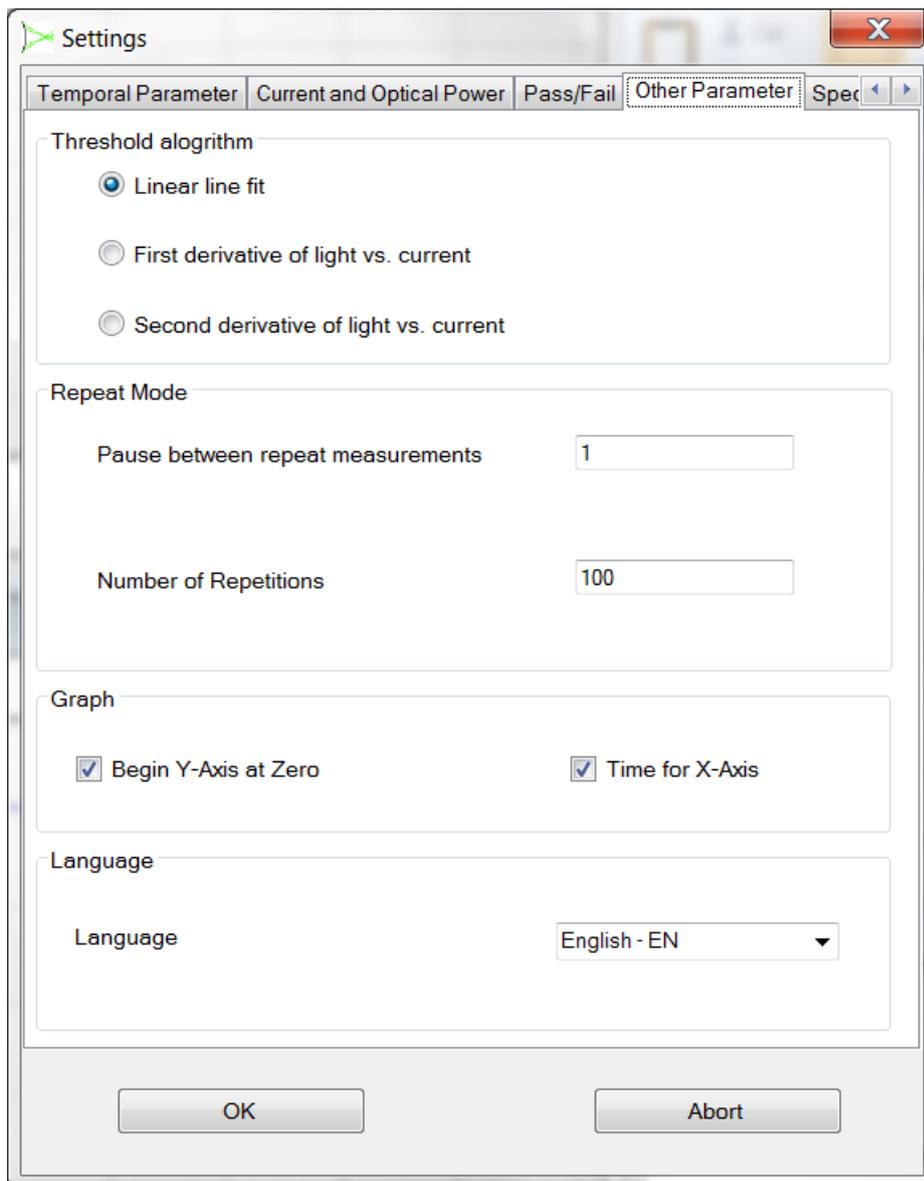
Figure 21: Tab "Other Parameters"

[Threshold algorithm]	Radio buttons to select the algorithm to be used for calculating the threshold.
Linear line fit:	fits the upper 10%-90% of the linear rising portion of the LI-curve. The threshold is calculated as the current of the X-axis intercept of this linear fit. This algorithm works best when there are very few data points or if the data is too noisy.
First derivative:	threshold is determined as the current at which the first derivative of the LI-curve reaches 50% of its maximum value. This algorithm works well if there is a large number of data points and the data is not too noisy. The minimum number of current steps for use of this algorithm is 27.

Second derivative:	threshold is determined as the current at which the second derivative of the LI-curve is a maximum. This is the algorithm recommended by Belcore. This algorithm only works well if there is a large number of data points and the data is not noisy. The minimum number of current steps for use of this algorithm is 27.
[Repeat Mode]	Parameter selection for the repeat mode.
Pause:	sets the pause (in seconds) between repetitions of the full measurement sequence.
Number:	sets the number of repetitions.
[Graph]	Radio buttons to select the graph settings.
Begin Y-Axis at zero:	forces scaling of the y-axes such that the lower end of the scale is zero.
Time for X-Axis:	selects the units for the x-axes to be time (instead of sample number). Note that the time scaling is not very accurate as it depends largely on the status of the computer being used
Language:	Pulls down menu to select the language of the GUI.

7.4.6 Tab "Spectrometer"

The LIV120 supports the integration of a diode array spectrometer. If the spectrometer is connected to a USB port on the same control computer as the GUI is running, it may be controlled by the GUI through selection of the data acquisition parameters on this tab.
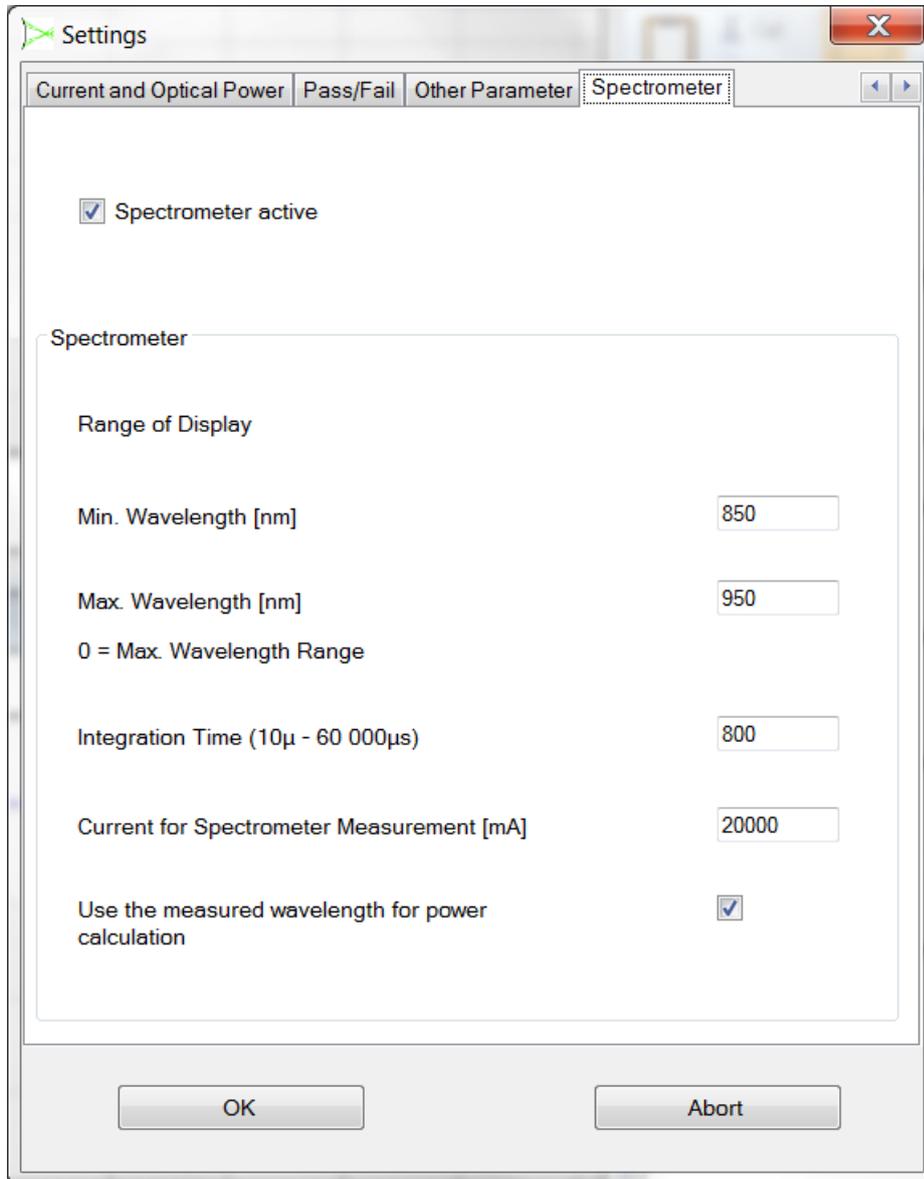
Figure 22: Tab "Spectrometer"

Spectrometer active:	Radio button to activate control of the spectrometer via the GUI. When activated, the status bar will show the connection status of the spectrometer. Note that the spectrometer must be connected to the USB port and its driver installed before activation on this tab.
Min. Wavelength:	Sets the lowest wavelength of the "Spectrum" graph in the user interface. This does not limit the range of the measurement, but only the display. The full range of wavelengths available to the spectrometer is stored in all cases. Entering "0" will cause the

display to begin at the lowest possible value for the spectrometer connected.

Max. Wavelength: Sets the highest wavelength of the "Spectrum" graph in the user interface. This does not limit the range of the measurement, but only the display. The full range of wavelengths available to the spectrometer is stored in all cases. Entering "0" will cause the display to end at the highest possible value for the spectrometer connected.

Integration Time: Sets the integration time of the spectrometer and the duration of the current pulse for the spectral measurement.

NOTICE!

This selection has the potential to damage the device under test since this current will flow constantly during the integration time. A pop-up warning will appear if the integration time of the spectrometer is selected to be longer than the pulse duration of the LIV sweep or burst.

Current for Spectrometer Measurement: Sets the current level to flow during the spectral measurement.

NOTICE!

This selection has the potential to damage the device under test since this current will flow constantly during the integration time. A pop-up warning will appear if the current level of the spectral measurement is selected to be higher than the maximum current of the LIV sweep or burst.

Use the measured wavelength for power calculation: The wavelength of the device under test must be known in order for the system to calculate the optical power measured. If a spectrometer is activated, the system can automatically obtain the wavelength from the spectral measurement if this check box is selected. Otherwise the user must manually enter the wavelength in the appropriate field of the tool bar on the main GUI frame.

7.5   Data Formats

7.5.1   The *.csv Format

The *.CSV format is useful for data export or use with other programmes. These files can be loaded directly into spread sheet programmes such as Excel®.

The data set is comprised of columns arranged as follows.

Sample No.	Current Set [mA]	Current Measured [mA]	Optical Power [μW]	Monitor Diode Current [μA]	Voltage [mV]

7.6   The Graphs

The LIV120 GUI displays the measurement results in graphical format for ease of interpretation.

The following frames are available for display.

7.6.1   Graphs in LIV Mode

A full screen in LIV mode may appear as follows.
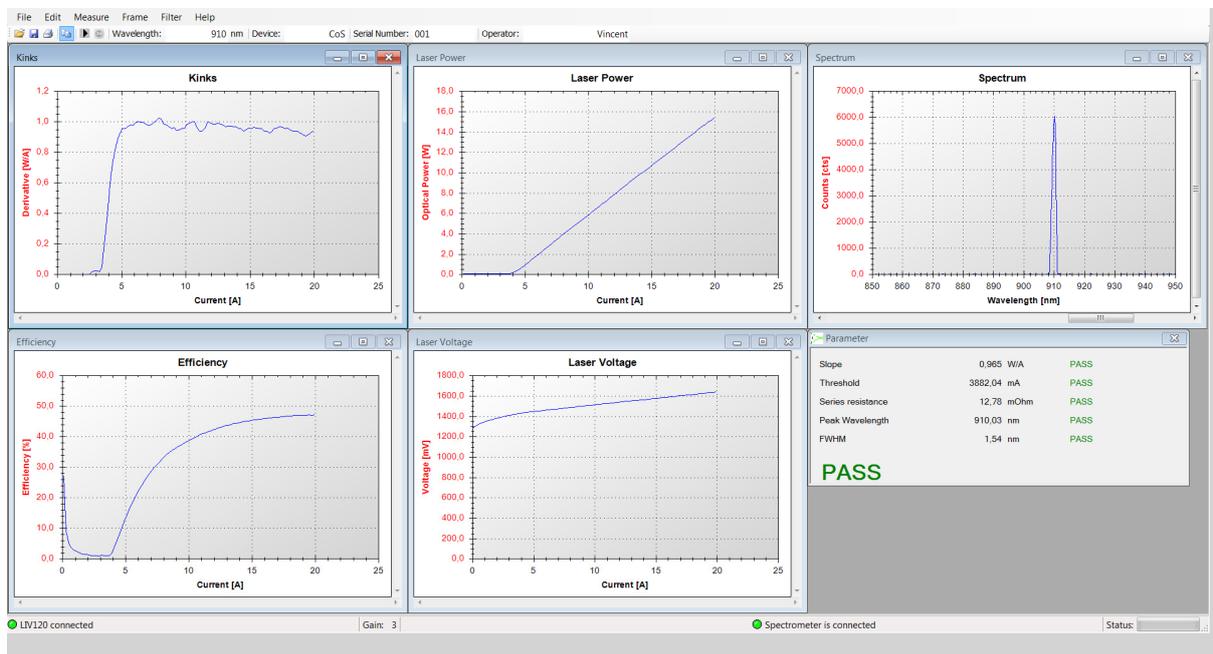
A report for archiving can be produced in any mode. An example is given on the following page.

® Excel is a registered trade mark of the Microsoft corporation.
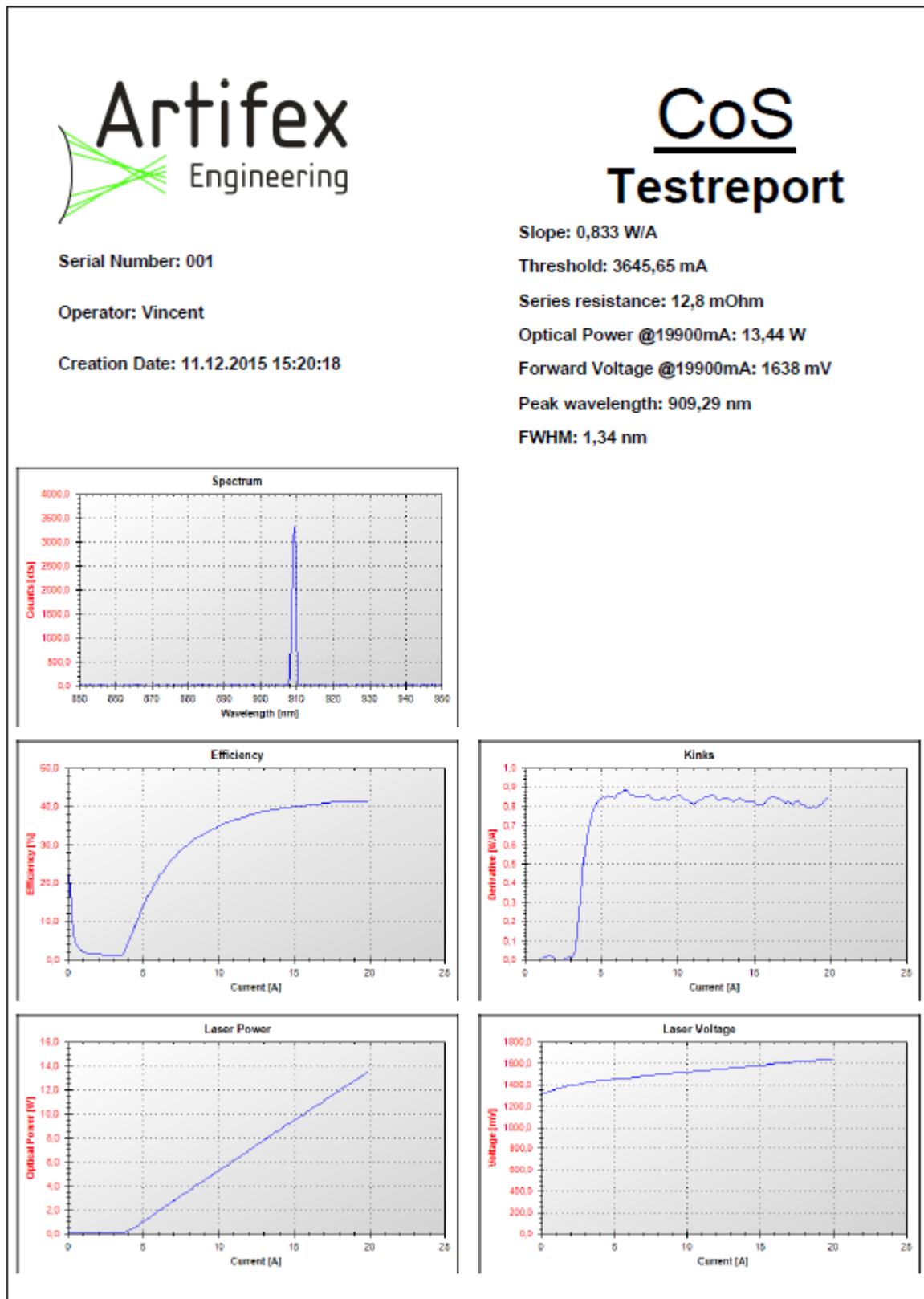
Figure 23: Example Test Report in LIV Mode

The laser power versus current graph is the main feature for the characterization of a good, functional laser diode. The slope efficiency and threshold current are determined from the information contained in this data set.
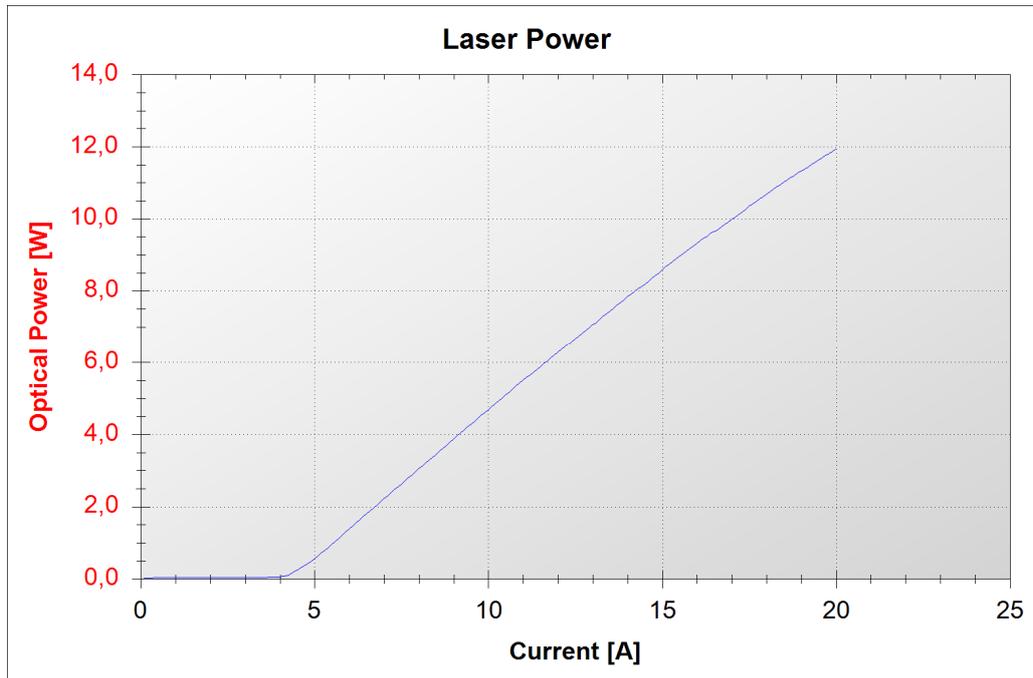
Figure 24: Optical Power vs. Current Graph

The laser voltage graph is useful to check for proper contacting and functionality of the laser diode.
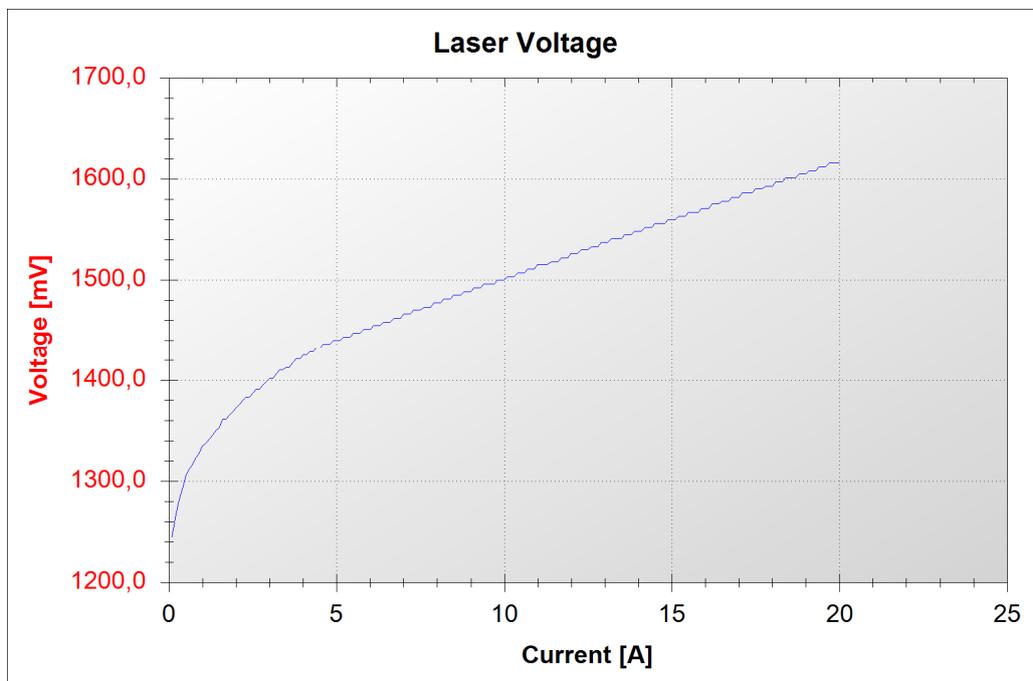
Figure 25: Voltage vs. Current Graph

The efficiency as defined here is the ratio of the optical output power to the input electrical power: $P_{optical}\Big/\left(V_{laser} \bullet I_{laser}\right)$ (= "wall plug efficiency").
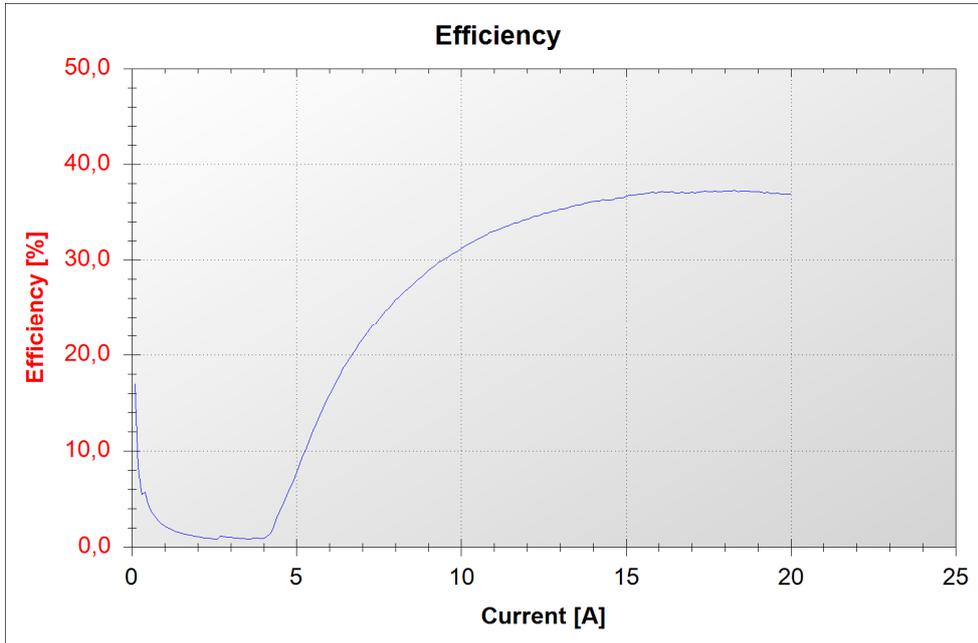
Figure 26: Efficiency vs. Current Graph

The "kinks" curve is the derivative of optical power with respect to current, dL/dI. This is useful to visualize changes in the slope of the L-I curve. Since the eye tends to follow the straight L-I line, slight changes in slope may not be readily recognizable in the L-I curve itself. Drop-outs in this curve indicate possible laser damage which will lead to reduced lifetime. Sinking of this curve at the high current end may indicate undue thermal loading of the laser diode. Data will only be displayed if there are at least 27 current steps in the LIV sweep.
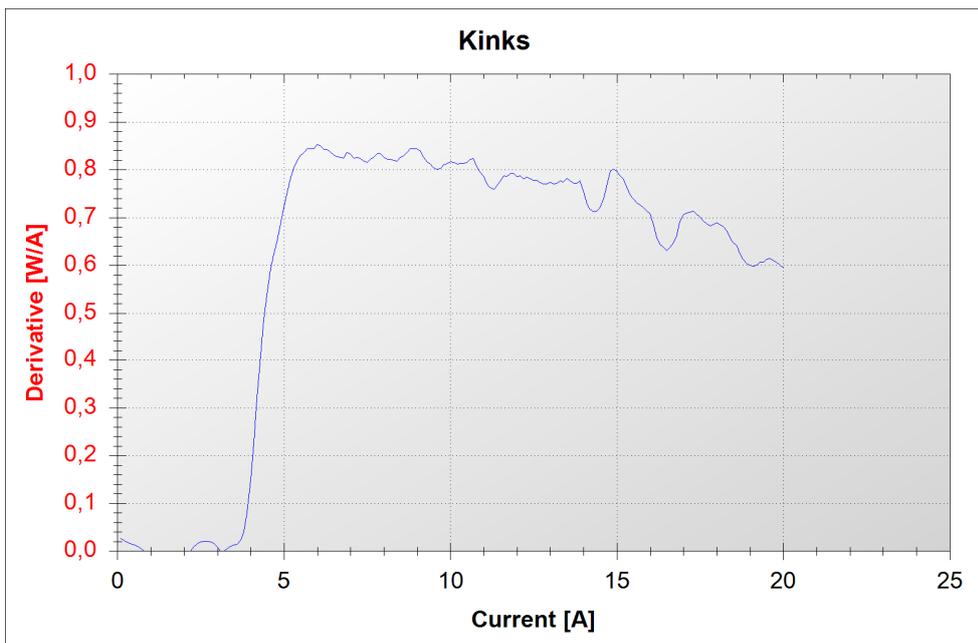
Figure 27: Kinks Graph

The "Spectrum" graph shows the optical power at each wavelength within the range selected on the Spectrometer settings tab.
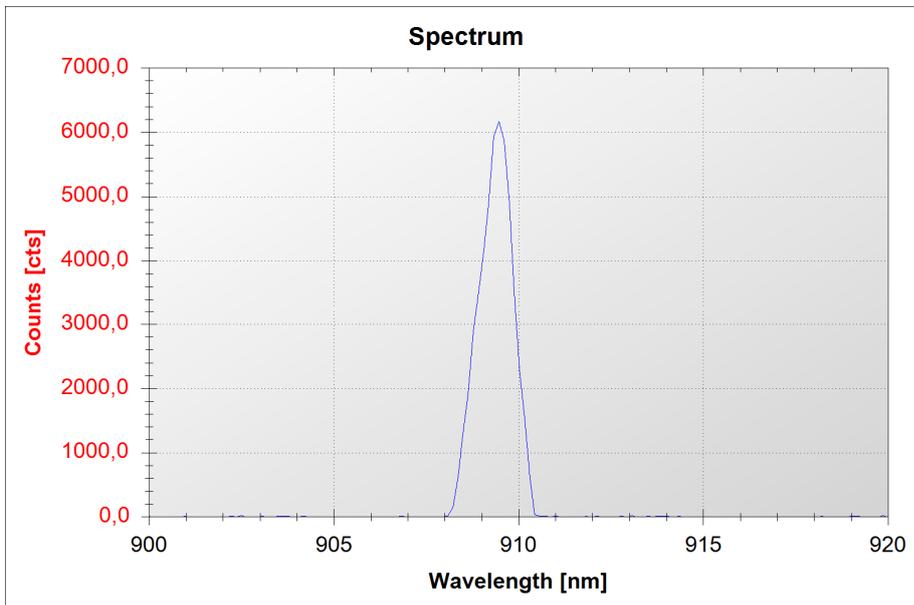
Figure 28: Spectrum Graph

The parameter window summarizes the results of the characterization calculations. In LIV mode the window shows the following information:

Figure 29: Parameter Window

Slope: slope efficiency of the laser diode. This is the rate of change of output optical power per change of input current within the straight, rising portion of the L-I curve. The slope efficiency is calculated via a linear least squares fit of the data within the range 10% to 90% of the maximum measured optical power.

Threshold: the laser threshold current is determined according to one of three selectable algorithms. These are described in section 7.4 "Settings" on page 34.

Series resistance: the series resistance is the dynamic resistance of the laser diode. This is calculated from the linear least squares fit of the slope of the V-I curve within the range 10% to 90% of the maximum measured voltage.

7.6.2 Graphs in Burst Mode

In the burst mode, the optical power, voltage and drive current as a function of samples (time) is documented. If a spectrometer is connected, the spectrum will also be graphed.
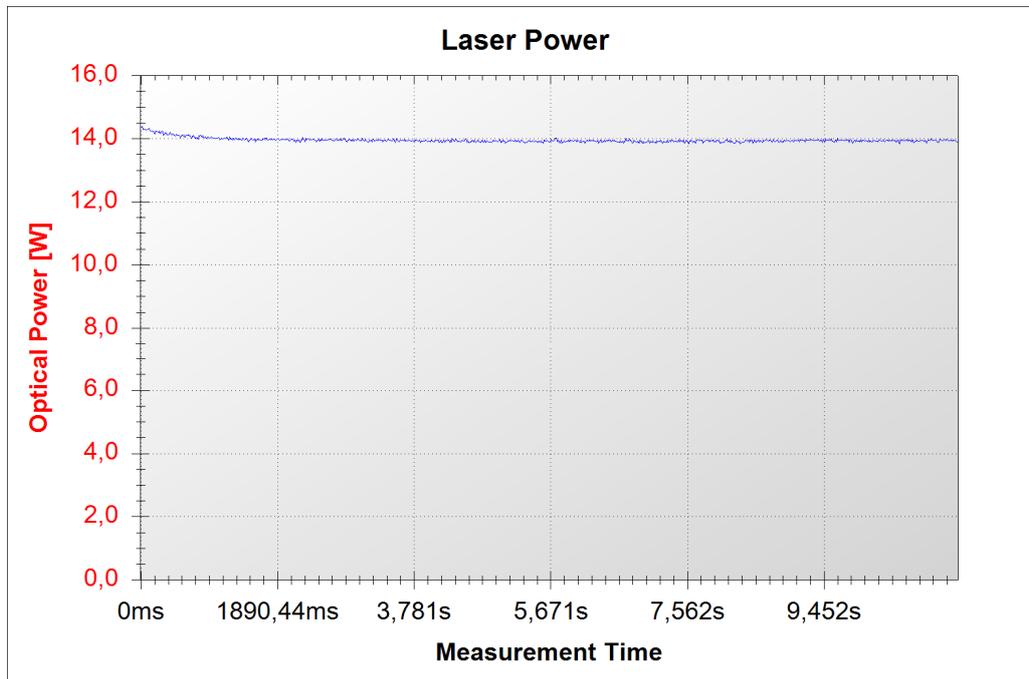
Figure 30: Optical Power vs. Time Graph
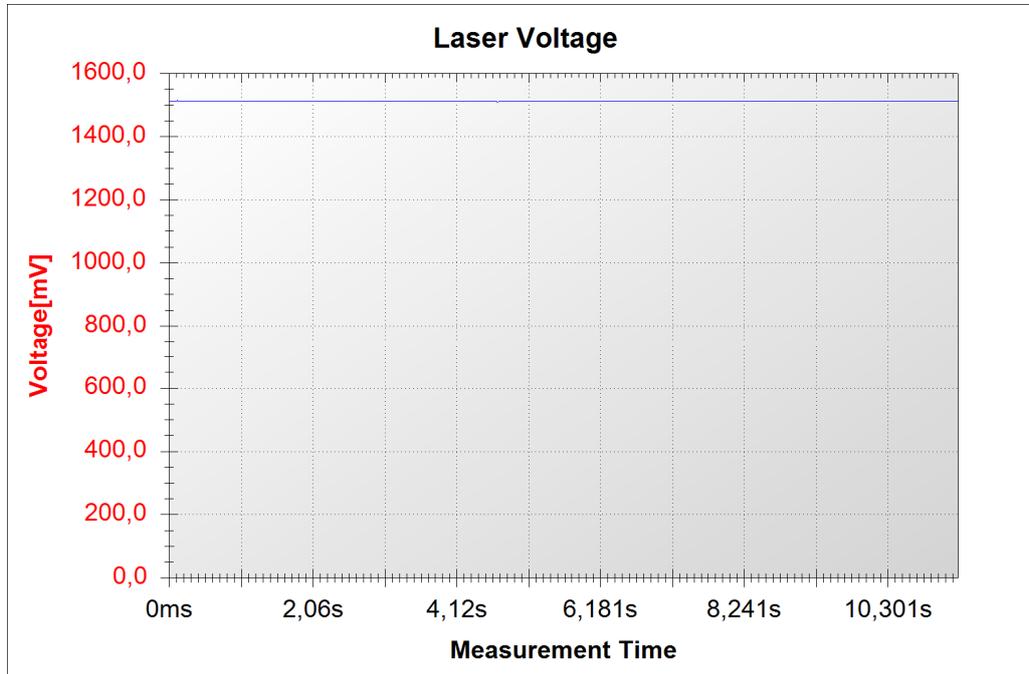
Figure 31: Voltage vs. Time Graph
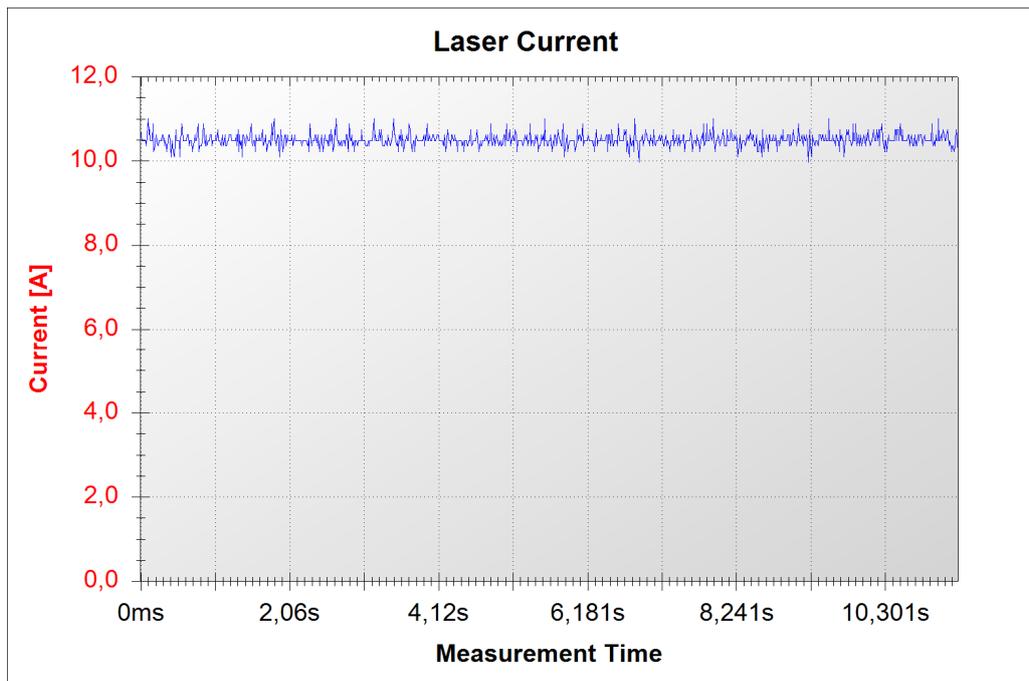
Figure 32: Drive Current vs. Time Graph
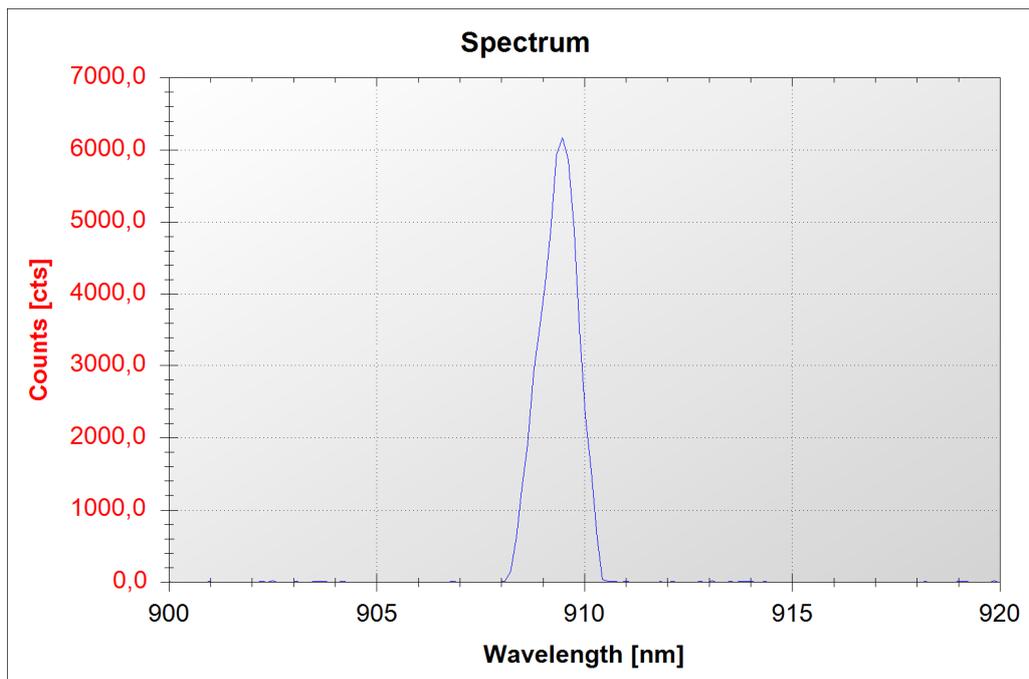
Figure 33: Spectrum vs. Wavelength

The parameter window in the burst mode shows the following information:

Minimum power: indicates the lowest power measured.

Maximum power: indicates the highest power measured.

Average power: indicates the average power measured.

Standard deviation: indicates the standard deviation of the power measurements.

Peak Wavelength: indicates the peak of the spectral measurement if the spectrometer is activated.

FWHM: indicates the width of the measured spectral peak if the spectrometer is activated.

7.6.3   Graph functions

A dynamic zoom can be activated by clicking in the graph window and dragging a box to the size of the desired zoom. If the automatic rescaling is activated, the next measurement will rescale the window to its previous representation. Therefore, if the zoom is to be kept active, the automatic rescaling must be deactivated first (context menu) or the measurement stopped. If the cursor is moved over a given sample in the graph, an information box will appear with the sample values:

This option can be activated and deactivated using the context menu.

7.6.4 The Context Menü

The context menu is opened by a right click within the graph frame.
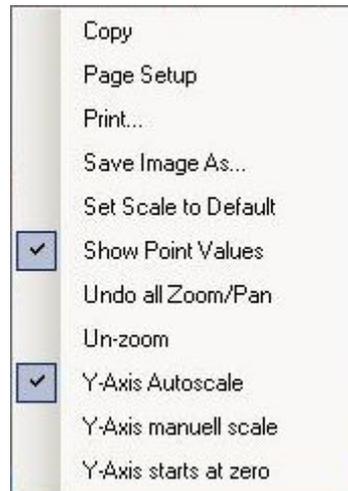
Figure 34: Graph Context Menu

Copy	A picture of the graph is stored to the PC's temporary storage. It may be copied into other programmes for documentation purposes.
Page Setup	Page setup for printing.
Print...	Opens the print control window for output to a printer.
Save Image As...	Saves a picture of the graph to a file.
Set Scale to Default	Resets the graph axes to their default values.
Show Point Values	Activates or deactivates the mouse-over pop-up box with the sample data information.
Undo all Zoom/Pan	Resets all zoom and pan settings.
Un-zoom	Resets the last zoom and pan setting.
Y-Axis Auto Scale	Activates automatic rescaling of the Y-axis (unless the „Y-Axis starts at zero" option is activated).
Y-Axis manual scale	Opens an input box in which the upper and lower limits of the Y-axis can be manually fixed. This deactivates the auto scaling.
Y-Axis starts at zero	Fixes the lower limit of the Y-axis to zero. This setting remains active in auto scaling mode, in which case only the upper limit is automatically rescaled.

8 Communication

The communication with the LIV120 is via USB 2.0.

The most recent USB driver for the MS Windows® operating system is included on the storage medium shipped with the device.

Following installation there will be two drivers in the device manager under "System Properties". One is in the communication ports (COM und LPT), the other is in the list of USB controllers.

The first driver generates a virtual COM port for ease of control. The communication can be realized via a terminal programme.

The second driver can be addressed directly without a port number for integration in custom software. An example programme with direct addressing is also included on the storage medium provided (folder "SDK").

8.1 Communication Protocol

Baud rate: 1 000 000 bit/s

Data bits: 8

Parity: none

Stop bits: 1

Flow control: Hardware

8.2 Parameter Upload

A complete parameter set must be uploaded to the LIV120 before a measurement can begin. The process involves uploading one byte to the LIV and then receiving the identical byte back (echo). The echo should be compared to the byte sent in order to ensure that valid data have been interpreted. All parameters must be uploaded, even if they will not be used for the chosen mode of operation. The parameter upload begins with the sequence @U, which is also echoed by the LIV.

The following table illustrates the upload parameters in the order of transmission. The numerical values must be separated into the respective bytes.

Following the upload sequence, the LIV performs a consistency check of the values received. If all of the parameter values are within their respective valid ranges, the LIV will send the word %U back to the computer.

In case of an overflow in any of the parameters, the LIV will send the byte ! followed by further bytes indicating the erroneous parameter. This sequence is terminated with byte 13 (CR). The list of error bytes is given in Table 3 and Table 4 on page 65.

Byte No.	Name	Range of Validity	Description and Calculations
1	Mode (Bit 0: monitor diode, Bit 1: Pulsed / CW mode , Bit 2: LIV / burst mode)	0-7	Bit 0 = no monitor diode included Bit 0 = 1 : monitor diode included Bit 1 = 0 CW mode Bit 1 = 1 Pulsed mode Bit 2 = 0 LIV mode Bit 2 = 1 Burst mode
2	Minimum current (High Byte)	1 - 4000	1bit = Max Current / 4000
3	Minimum current (Low Byte)		
4	Maximum current (High Byte)	1 – 4000	1bit = Max Current / 4000
5	Maximum current (Low Byte)		
6	Current step for sweeps (High Byte)	1 – 4000	1bit = Max Current / 4000
7	Current step for sweeps (Low Byte)		
8	Number of averages	1 - 250	1 bit = 1 average sample
9	No of burst pulses (High Byte)	1 - 16 380	1 bit = 1 pulse
10	No of burst pulses (Low Byte)		
11	Pause time in ms (High Byte)	0 - 60 000	1 bit = 1 ms
12	Pause time in ms (Low Byte)		
13	Thermalization time in ms (High Byte)	0 - 60 000	1 bit = 1 ms
14	Thermalization time in ms (Low Byte)		
15	Wavelength in nm (High Byte)	1 – 65 000	
16	Wavelength in nm (Low Byte)		
17	Filter transmission (High Byte)		Transmission value * 10 000
18	Filter transmission (Low Byte)		
19	Optical power cut off in mW (High Byte)	1 - 16 000 000	1mW - 16KW
20	Optical power cut off in mW (Middle Byte)		
21	Optical power cut off in mW (Low Byte)		

Table 2: Upload Parameters in the Order of Transmission

8.2.1   Pulse separation

This parameter sets the minimum separation between the end of one pulse and the beginning of the next. The resolution of this setting is 1ms. The maximum pulse separation is 60s (60,000 x 1ms).

8.2.2   Number of burst pulses

This parameter sets the number of pulses to be generated in burst mode. This parameter is only used in the burst mode, but the value uploaded must be valid, even when running in other modes of operation. The range of valid values is 1 to 16,380 pulses.

8.2.3   Minimum and maximum current, current step

The upload parameter for the current to be generated lies in the range 1 to 4,000. The value 4,000 corresponds to the maximum current of the unit. For example, an LIV120-400A can drive a maximum current of 400A (= upload parameter value 4000). The resolution of the driver is therefore (max. current)/4,000. For the LIV120-400A this would be 0.1A (=100mA).

The same principle applies for the current step. Therefore a step parameter of 100 uploaded to the LIV120-400A would create current steps of 10.0A difference.

In the "LIV" mode, the system begins with the minimum current for the first pulse. Then the current is increased by the step size and pulsed again. This is repeated until the set current would be higher than the set maximum current. The last pulse is the one before the maximum current is reached to prevent overdriving the device under test.

In "burst" mode the current pulses between the minimum and maximum currents. Thus soft pulsing is also possible by setting a non-zero minimum current.

8.2.4   Operational modes

Four operational modes are supported: pulsed LIV, CW LIV, pulsed burst and CW burst.

The upload value 0 in bit 2 selects the LIV mode and the value 1 selects the burst mode. The upload value 0 in bit 1 selects the corresponding CW mode and the value 1 selects the corresponding pulsed mode.

8.2.5   Thermalization

The LIV120 provides for a thermalization of the device under test during the LIV sweep. This involves driving the device a selected period of time with the same current as to be used for the next measurement. The valid range for the thermalization period is 1-60,000ms.

Schematic Representation of the Parameter Upload

Bytes ‚@' and ‚U'
before sending the
parameter list

Send next Byte of
the parameter list

Read Byte — Time out → Cancel

Compare Byte with sent Byte

Identical   Different → Cancel

Parameter list complete

No   Yes

Read Byte — Time out → Cancel

‚%'   ‚!'

Read Byte

Is Byte = ‚U'

Yes   No

Read Byte

Is Byte = (13)

Yes   No

Time out   Time out

End   Cancel   Cancel

Store Byte as
error code
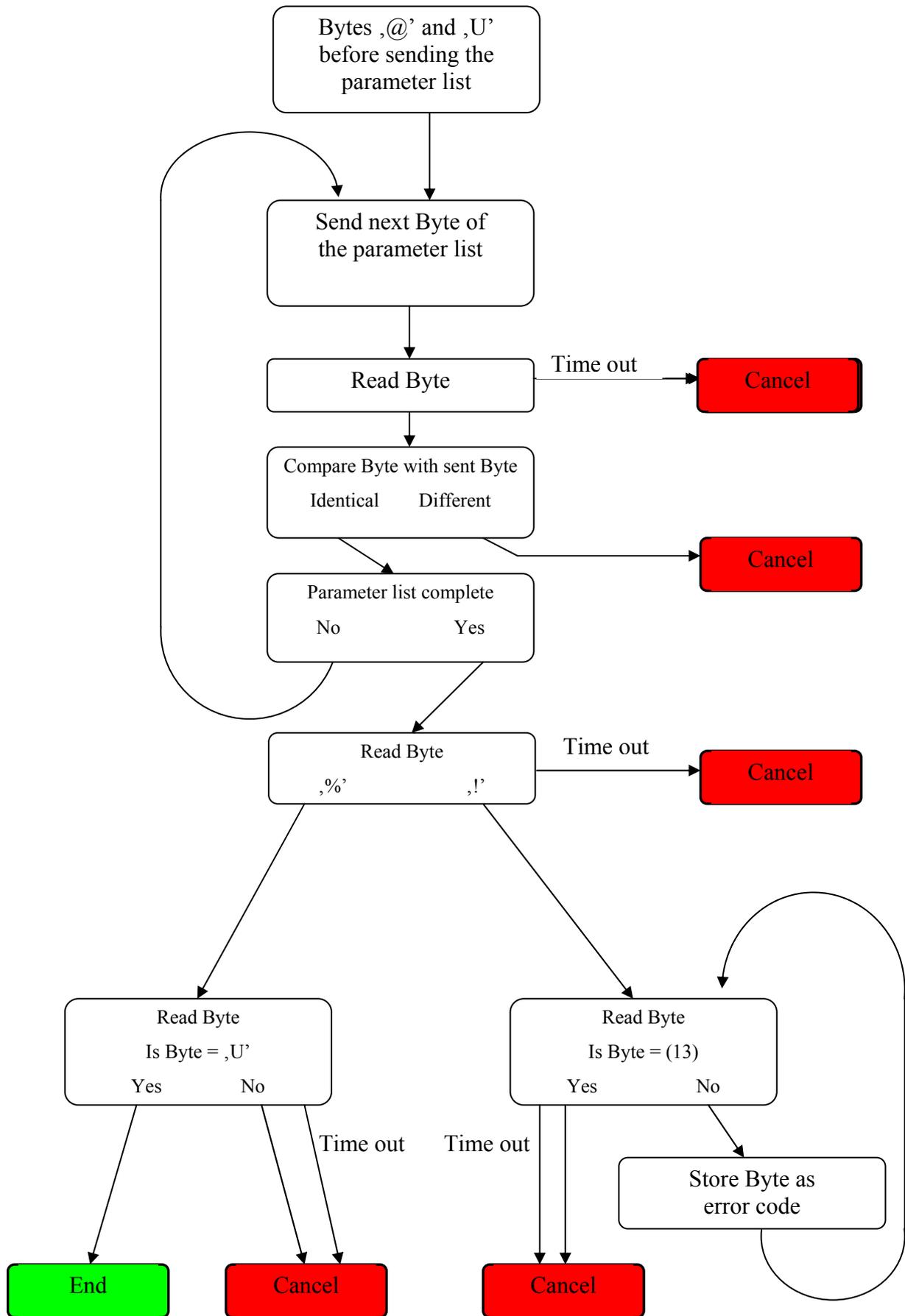
8.2.6 Start Measurement

Following the successful parameter upload, the measurement can now begin. The measurement is initiated with the bytes @g. If an error occurs during preparation, the LIV will send the byte ! back to the computer, followed by an error code byte and a status byte. If the preparation was successful, the LIV sends the bytes %g.

Prepation: Interlock check, read data from detector head, determine transimpedance amplifier gain, determine optical cut-off value, activate driver.
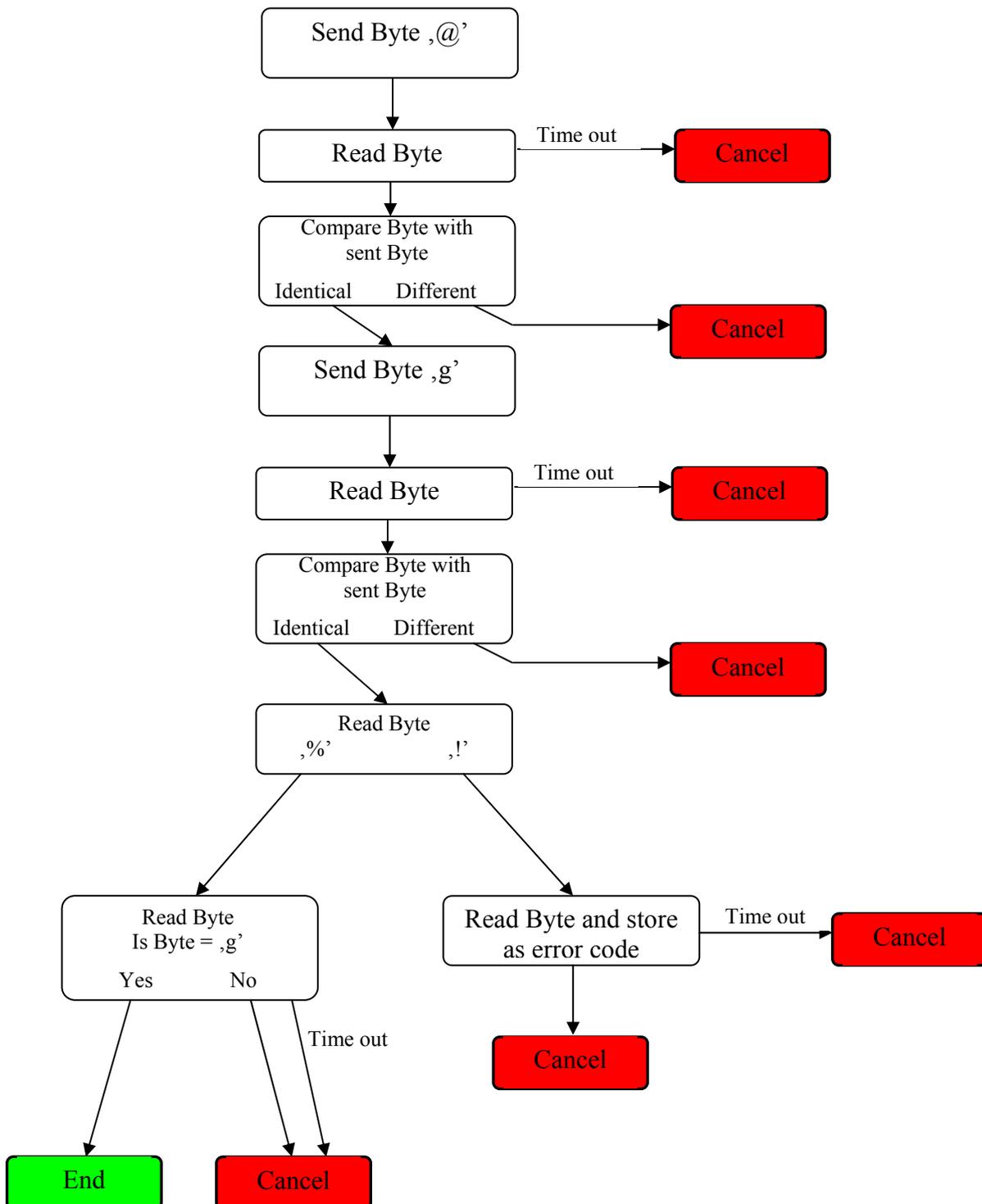
8.2.7 Read progress data

The LIV120 returns the value of the progress of the measurement in % during the measurement. The end of the measurement is indicated by the Byte 250.
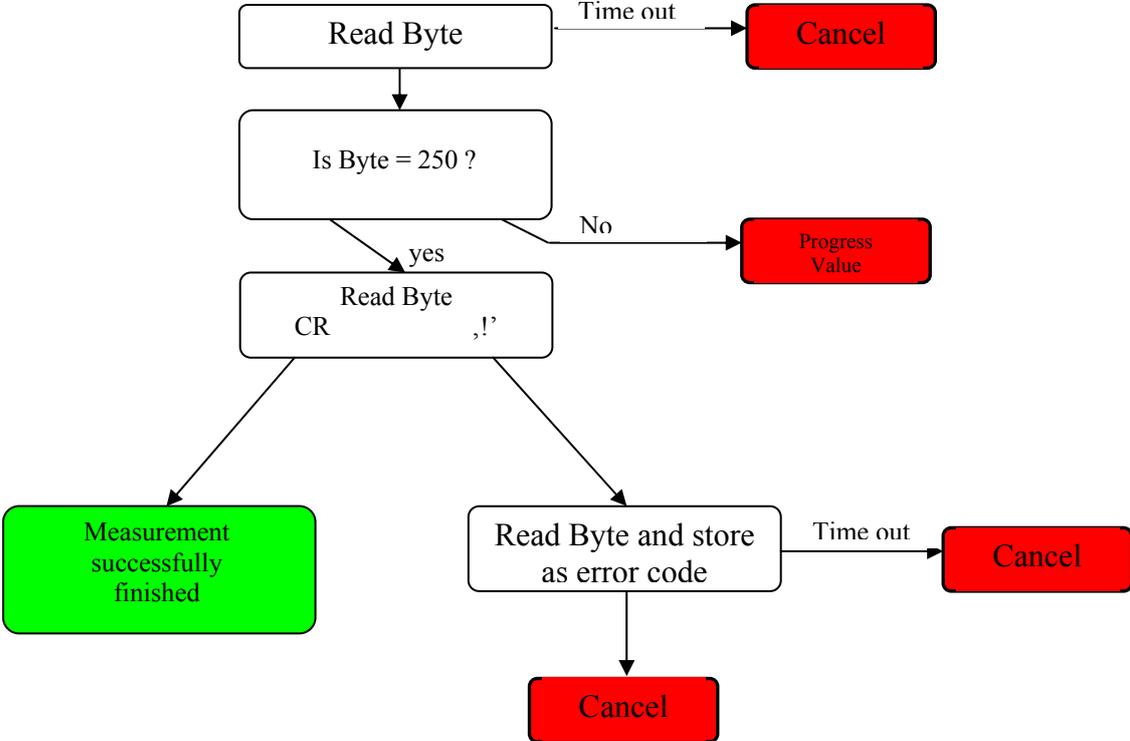
8.2.8 Read Sample Data

The download of the measurement data is initiated after measurement automatically. The following schematic depicts the initial process which is common to all modes.

The header of the data is sent first. The following schematic depicts reading the header containing 7 values.

```
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │(Gain optical Power)│             └──────────┘
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │(Gain monitor diode)│            └──────────┘
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │ (No of samples -│               └──────────┘
    │    High Byte)   │
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │ (No of samples -│               └──────────┘
    │    Low Byte)    │
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │ (No of channels)│               └──────────┘
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │(Wavelength correction│           └──────────┘
    │    - High Byte) │
    └─────────────────┘
            |
            v
    ┌─────────────────┐   Time out    ┌──────────┐
    │   Read Byte     │ ────────────> │  Cancel  │
    │(Wavelength correction -│         └──────────┘
    │    Low Byte)    │
    └─────────────────┘
            |
            v
    Further: Read Data
```

8.2.9 Read Sample Data – LIV Mode

The number of bytes to be received from the LIV is to be taken from the header. The following schematic depicts the procedure for reading the data in the correct order.
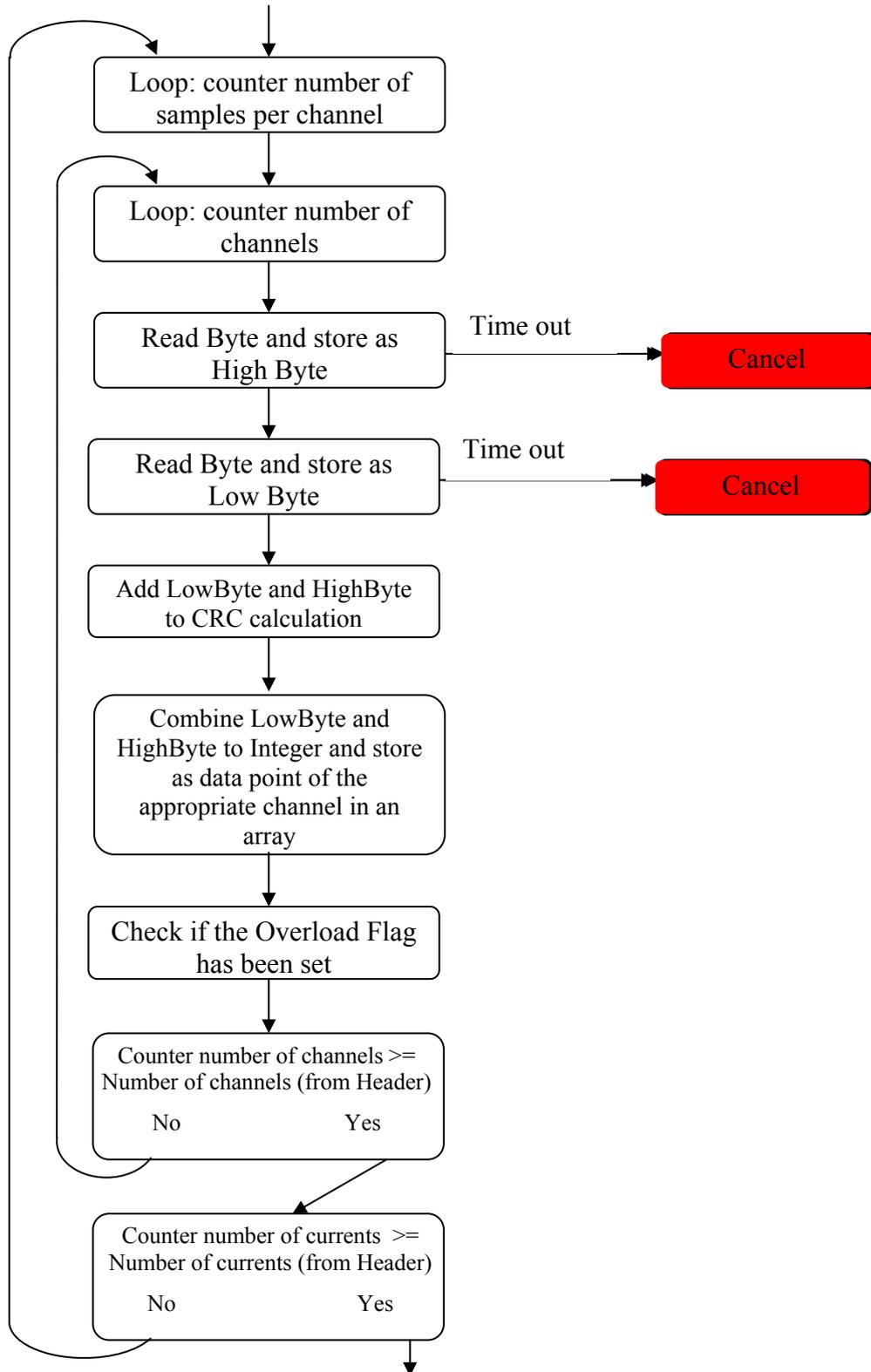
Further: CRC Check

The end of each read procedure involves a data integrity check via the CRC (cyclic redundancy check).
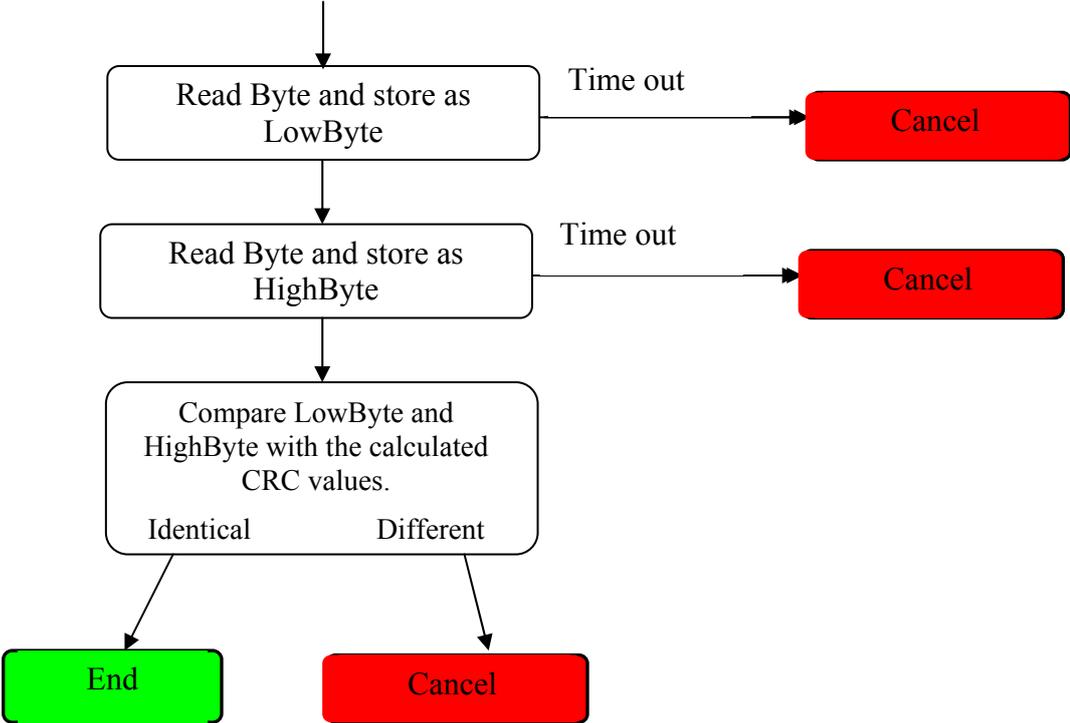
8.2.10 Calculation of the CRC value

In order to recognize data corruption, the LIV calculates a check sum (CRC = cyclic redundancy check) and sends this value to the host computer along with the measurement data. The host computer can now calculate its own CRC value from the measurement data and compare this with the CRC value received from the LIV. The measurement data should only be accepted when the two CRC values are identical.

```
  ┌─────────────────┐              ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  │ Global variable │               /    Input Byte    /
  │     ,CRC'       │              └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
  └─────────────────┘                       │
          │                         ┌────────────────┐
          │                         │  NByte * 256   │
          │                         └────────────────┘
          │                                 │
          ▼                                 ▼
  ┌───────────────────────────────────────────────────┐
  │            CRC = CRC XOR NByte                      │
  └───────────────────────────────────────────────────┘
                          │  I = 0
                          ▼
                        (  ○  )◄──────────────┐
                          │                   │
                          ▼                   │
                 ◇ MSB from CRC = 1 ? ◇───No──►┌──────────────┐
                          │                    │ CRC = 2 * CRC│
                          │ Yes                └──────────────┘
          ┌───────────────────────────┐              │
          │ CRC = (2 * CRC) XOR 4129   │              │
          └───────────────────────────┘              │
                          │  I = I + 1                │
      If I <= 8           ▼                           │
                        (  ○  )◄──────────────────────┘
                          │  If I >= 8
                          ▼
                      (  Exit  )
```
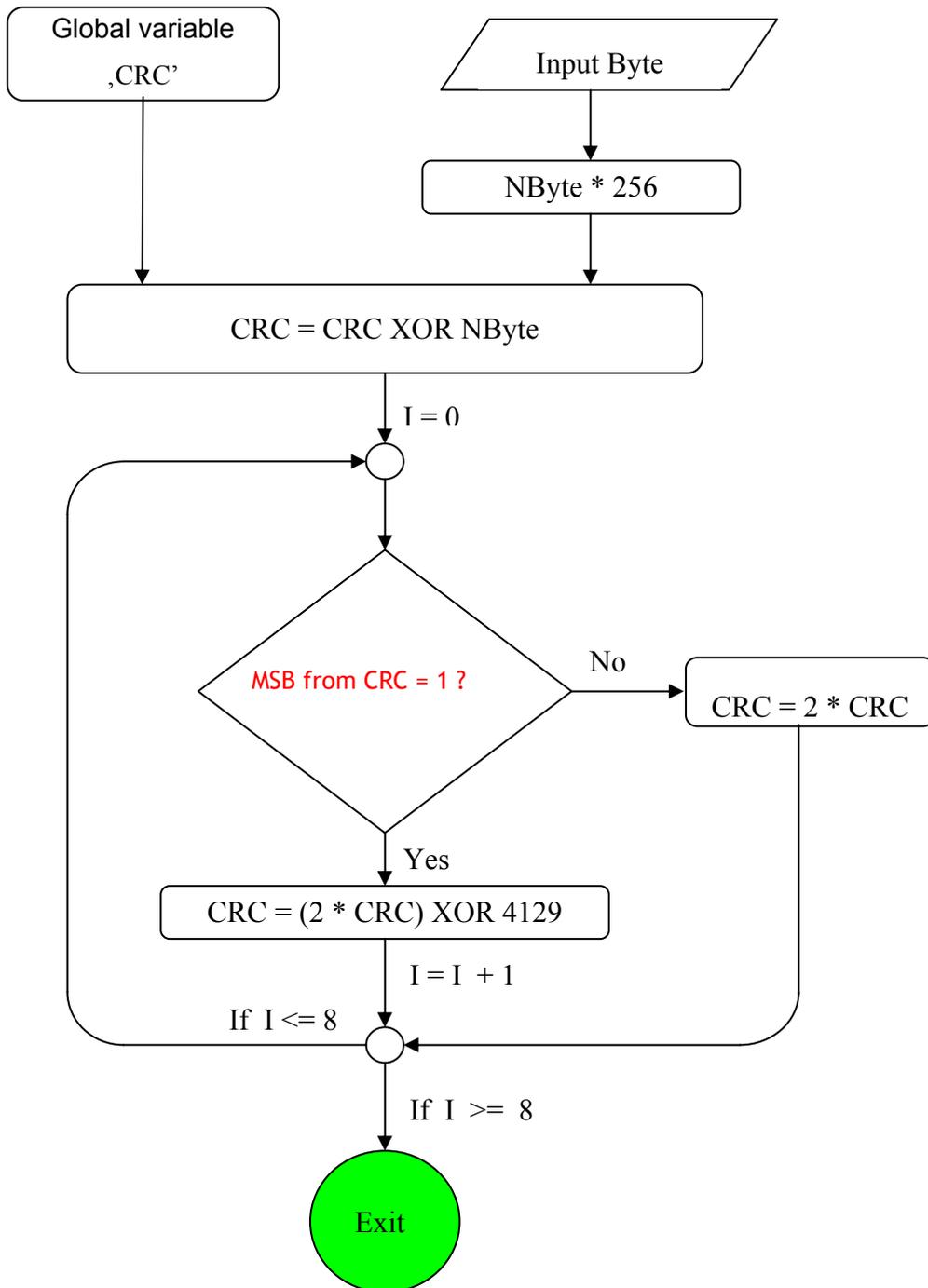
8.2.11 Error Codes

There are two principal categories of errors.

The first category involves the parameter selection. Each value is checked for range validity. In the case that any values are too high or too low, an error message will appear at the end of the parameter upload to indicate the erroneous parameter.

Table 3: Error Codes in Parameter Selection

Error Code (Byte)	Explanation
97	General error in parameter
98	Error in minimum current
99	Error in maximum current
100	Error in current step
101	Spectrometer integrating time out of range
102	Error in average parameter
103	Error in pause time
104	Error in no of burst pulses

The second category involves measurement errors and results in abortion of a measurement sequence.

Table 4: Error Codes in Measurement

Error Code (Byte)	Erroneous Parameter
48	Invalid data in memory
49	No detector available
50	Wavelength not in the detector range
51	Detector has a checksum error
52	Driver returns temperature exceeded
53	Driver returns not ready
54	Internal error
55	Timeout error in communication
56	Monitor current too low
57	Interlock failure
65	Optical power cut off released
66	Termination by user

8.2.12 Order of Data Values

a.) Optical power

b.) Monitor diode (if selected)

c.) Voltage

d.) Current

8.2.13 Calculation

Note: each ADC value must be right shifted by 2 bits (language C) or divided by 4 before use in calculations. Therefore the valid value range is -8192 to +8192 bit..

The following calculations are required in order to convert the bit values from the LIV120 to physical values.

8.2.13.1 Optical Power

P_{opt} = ADC Value / (S * R)

S = Sensitivity of the detection channel in A/W

R = Gain of the transimpedance amplifier:

G0 : 1000 Ohm

G1 : 10.000 Ohm

G2 : 100.000 Ohm

G3 : 1.000.000 Ohm

8.2.13.2 Monitor

I_{Mon} = ADC Value / R

R = Gain of the transimpedance amplifier:

G0 : 1000 Ohm

G1 : 10.000 Ohm

G2 : 100.000 Ohm

G3 : 1.000.000 Ohm

8.2.13.3 Current

Current: ADC Value * 1,31 * (Maximum Current / 4000)

8.2.13.4 Voltage

Voltage: 1mV/bit

8.2.13.5 Current Upload

I_{Out} = Maximum Current / 4000

9 Disposal

Do not dispose of the laser diode characterization system with the household waste. The worn out unit can be taken to an electronics and metal recycling centre for disposal. The manufacturer also accepts old units for disposal.

!

NOTICE!

Danger for the environment from improper disposal!

Dangers for the environment can arise through improper disposal.

- Never dispose of the electronic ballast with the household waste.

- Take the electrical scrap or electronic components to an approved specialist company for disposal.

- In case of doubt, contact the local authorities or a special disposal company for information about the environmentally compatible disposal.
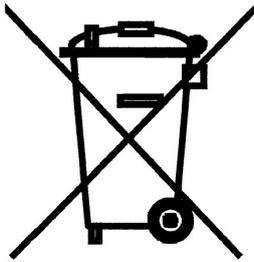
10 Type plate

The type plate is located on the back of the enclosure and includes the following information:

- Manufacturer
- Part number
- Serial number
- Manufacturing date

Artifex
Engineering   LIV120

Model No.:   LIV120
Ser. No.:
                         0011
www.artifex-engineering.com   CE

11 Notice

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Artifex Engineering does not approve use of this product in medical instrumentation or applications.

DANGER!   The LIV series of laser diode characterization systems is designed for use with lasers. Personnel who use this instrument must, therefore, be instructed in the safe use of lasers and laser beams.

Always wear the proper laser safety glasses designed for the laser in use!

Never allow the direct or reflected laser beam to impinge on the eyeball or to come into contact with the skin!