

**Read this instruction manual before performing any task!**

Validity: FW2.3; S/N 0053 and higher

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# Original Operating Instructions

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## 1 Product Overview

The LIV100 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 a current source as well as data acquisition and communication hardware. Thus the functionality of several instruments has been combined into one compact, dedicated instrument for LIV testing. The block diagramme of the instrument is shown in the figure below.

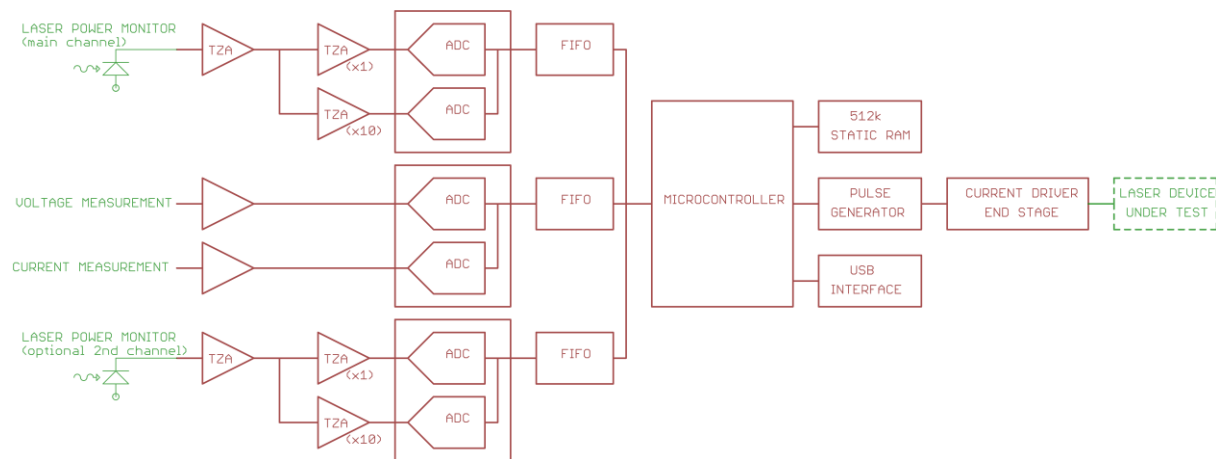
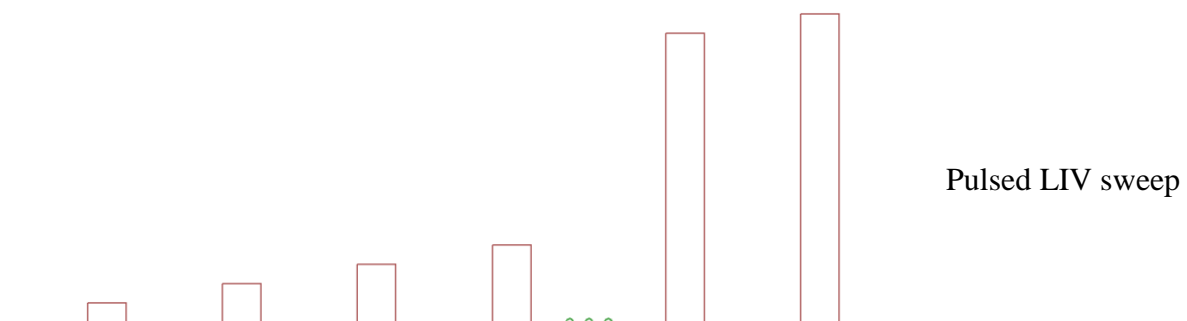
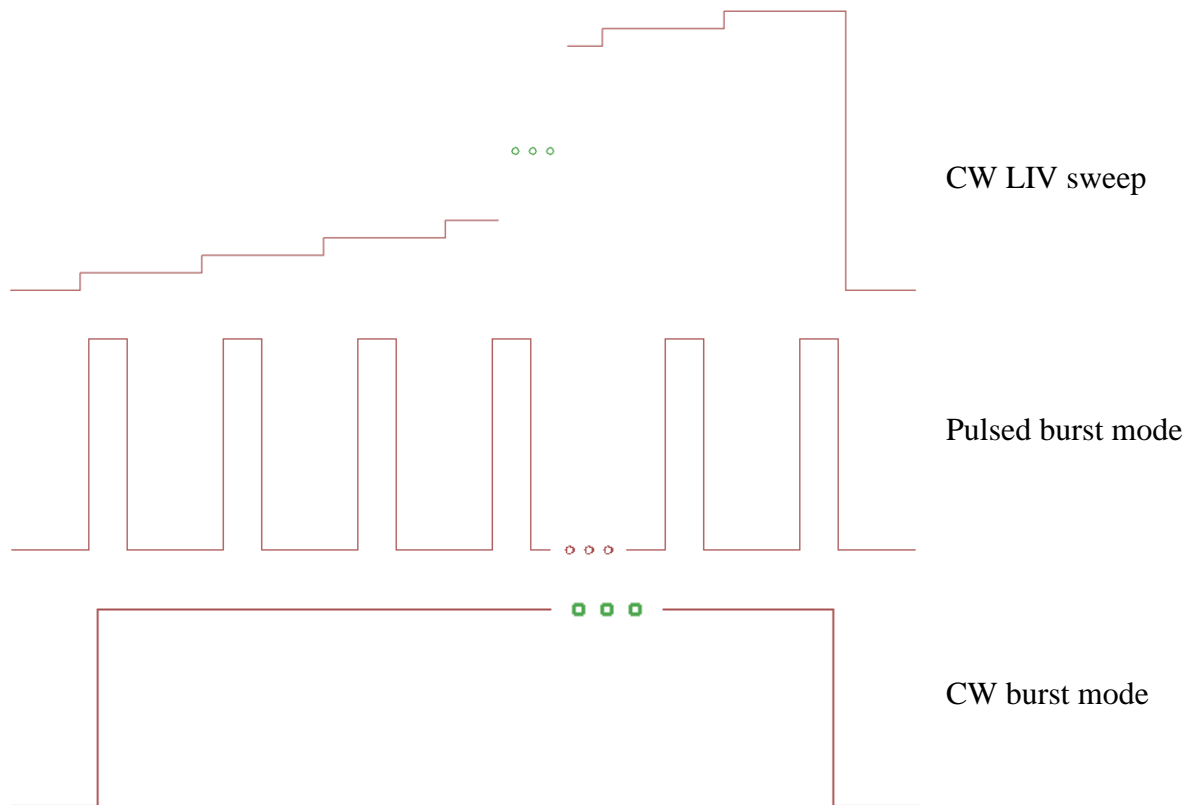


Figure 1: LIV100 Block Diagramme

The LIV100CW 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 LIV100CW supports various operating modes: LIV sweep (pulsed or CW current “staircase”), burst mode (pulsing at constant current) and CW mode. During a current sweep, the instrument measures the optical power of the laser diode (L), the drive current (I) and the voltage drop across the laser diode (V). In the burst or CW modes, only the optical power of the laser diode (L) is measured.





The LIV100CW 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 LIV100CW then autonomously completes the full measurement sweep and sends the complete data set to the control computer. The software development kit allows for easy integration of the LIV100CW into a custom software environment. A graphical software package is provided to ease use of the instrument in a lab environment.

Typical results of an LIV sweep are depicted below.

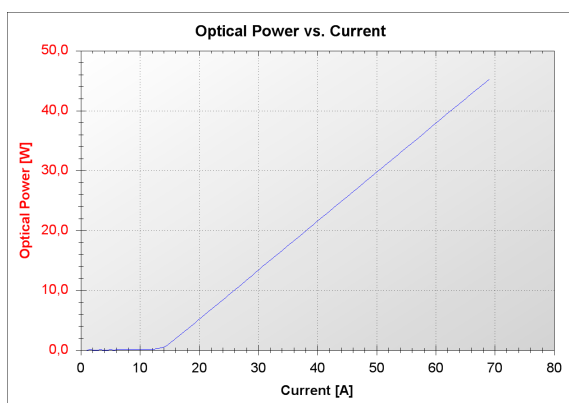
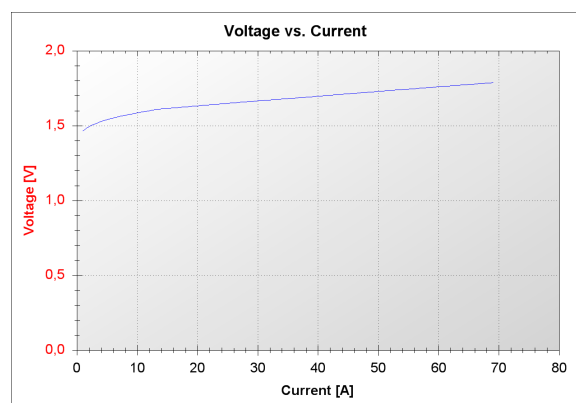


Figure 2: Optical Power vs. Current Graph



Voltage vs. Current Graph

## 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:

**Artifex Engineering GmbH & Co. KG**  
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**Internet:** [www.artifex-engineering.com](http://www.artifex-engineering.com)

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 LIV100CW 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!



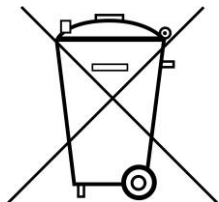
- Over time, stickers and signs can get dirty or in some other manner become illegible, so that dangers cannot be recognized and necessary operating instructions cannot be followed. Thus an injury hazard occurs.
- Keep all safety, warning, and operating instructions that are affixed to the device in 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:

- LIV100CW current source and data acquisition unit
- Contact card(s)
- Patch cables
- Integrating sphere
- 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.



*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 %.



*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 figure below.

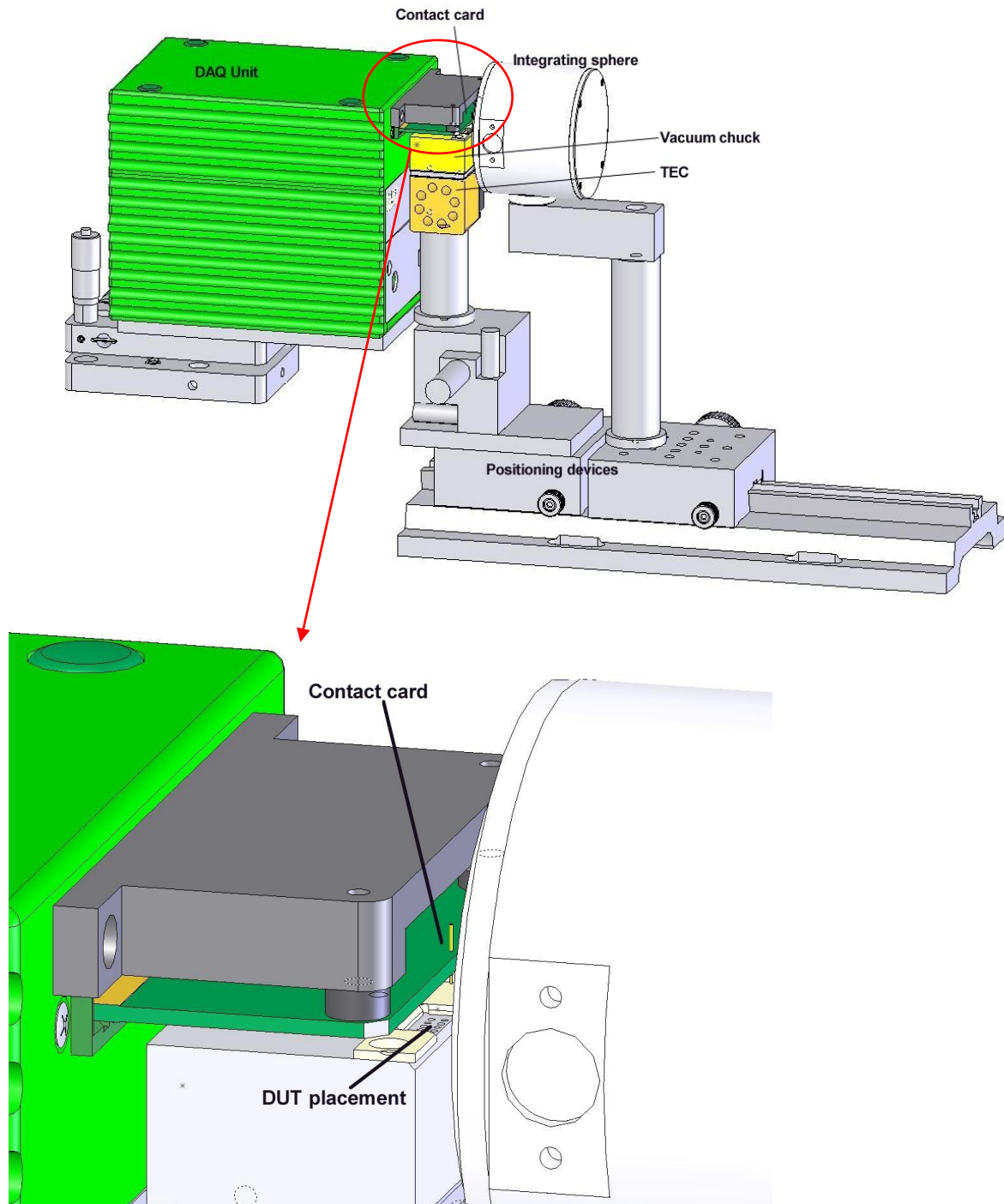


Figure 3: System Overview

The device under test is mounted on a TEC-controlled contact station. The contact station provides for high current contacts to drive the laser as well as further contacts to measure the voltage drop across the device during operation. An integrating sphere collects the light for the optical power measurement. 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 mounted in the DAQ system in the main enclosure of the LIV100CW unit. The other fibre illuminates the input of a spectrometer as required.

The LIV100CW provides sequences of software programmable currents to the laser. Details on these sequences are given in section 4.2 “Modes of Measurement” page 23. Three 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 from the integrating sphere.

## 4.1 Description of Test Sequence

During a test sequence, the programmed currents are sequentially set via the controller interface of the LIV100CW. The first pulse of a sequence is used internally to automatically set the amplifier gains which depend on the output power of the device for the present measurement sequence. In LIV mode, a second initialization pulse is fired to determine the optimum plateau region of the pulses for data analysis. Thereafter the sequence will run with the parameters as set by the user. During each current step the three measurement channels (voltage, current, optical power) 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 LIV100CW system allows a user programmable minimum delay period to allow thermalization of the DUT. This thermalization period is determined by selecting a number of current cycles to be driven without measurement. This number may be freely chosen between 1 – 65 000 current cycles. Note that each current cycle is defined by the parameters “pulse width” and “pulse separation”. Therefore the temporal value of the thermalization period is determined by these parameters as well. Note that this time may be extremely long and so care should be exercised when choosing a value for this parameter. For example with “pulse separation” set to the maximum value of 500ms and the thermalization sequence set at the maximum value of 65 000, the thermalization period will be 9 hours! The control software may terminate the sequence at any time by sending the “abort” command (=ESC). The control system checks for an ESC command after each pulse / pause sequence. Thus, the maximum delay is the length of one pulse / pause sequence (100µs to 500ms) plus the internal delay of the control computer.

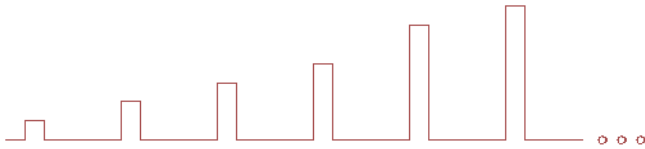
After thermalization, the waveforms are captured by the A/D circuitry and stored to buffer memory.

## 4.2 Modes of Measurement

The LIV100CW supports a variety of modes to allow testing under a wide range of operating conditions. The unit may be driven in CW or pulsed mode. The essential variables available are the output current, pulse width (or data acquisition time per sample in CW mode) and the pulse separation (or data acquisition “blind” time per sample in CW mode). The various modes of operation are described in the subsections below.

### 4.2.1 LIV Sweep (pulsed)

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 current steps”. Schematically this appears as follows:



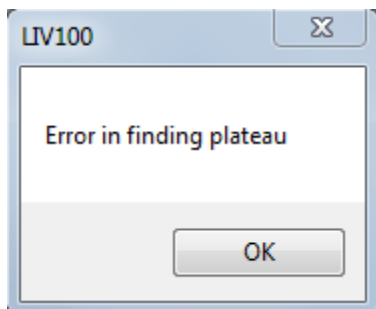
During a test sequence, the programmed currents are sequentially set via the controller interface of the LIV100. Prior to running the specified sequence, the LIV sets a test pulse at a user specified current. This pulse is used internally to automatically set up the system for high speed measurement during the sweep. This test pulse serves to determine the plateau region of the pulse according to an algorithm based on user input of the required flatness of the region to be analysed. This is discussed in detail under 9.4.4 Tab “LIV-Mode”, pg.59.

**NOTICE!**

**Note that the current strength selected for this test pulse is critical!**

If the maximum current of the sweep is large enough to damage or destroy the laser, then this test pulse may also be strong enough to damage or destroy the laser.

If the plateau determination is successful, the unit will continue with the measurement. If the plateau determination is not successful, the unit will abort the measurement and display the following warning message in a pop-up frame:

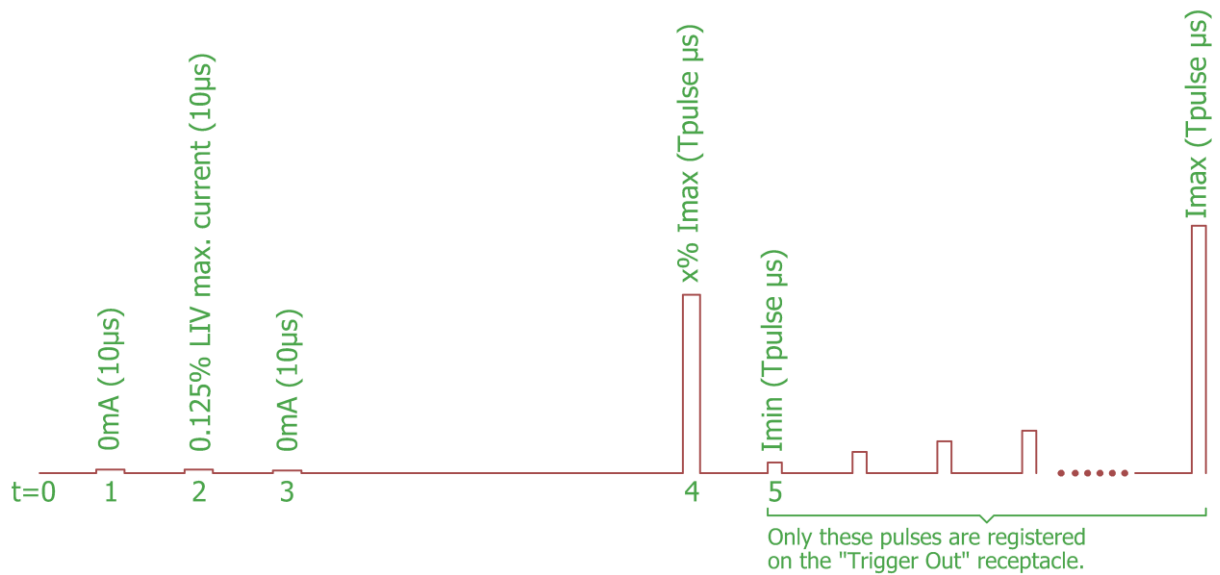


Reasons for not finding a plateau may be incorrect input parameters for the determination of the plateau region or poor signal quality. It may be useful to inspect the pulse signals using the scope mode if the plateau test is failed.

Further test pulses occur at currents negligible for any laser safety considerations. A complete description of the test pulse sequence is given in the diagramme below.



## LIV Mode



1: Test pulse to determine the offset compensation of the measurement channels.  
Current =  $0mA$ ; duration =  $10\mu s$ .

2: Test of contact between contact card and DUT.  
Current =  $0.125\%$  of LIV maximum current; duration =  $10\mu s$ .

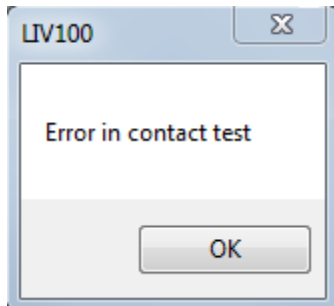
3: Test pulse to calculate the safe operating area (SOA).  
Current =  $0mA$ ; duration =  $10\mu s$ .

4: Test pulse at user defined current level to determine the plateau region to be analysed for each pulse.  
The duration of the pause following this pulse is not deterministic.  
Current =  $x\%$  of max. sweep current; duration = sweep pulse duration.

5: LIV sweep with user defined parameters of currents, pulse duration and pulse separation.

Figure 4: Test Pulse Sequence in LIV Mode

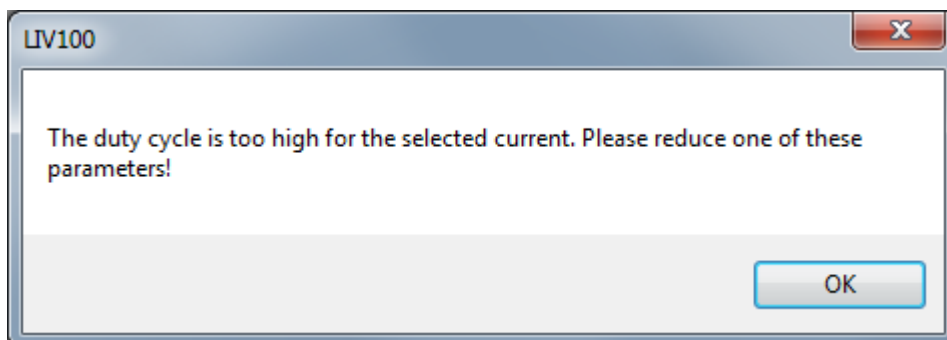
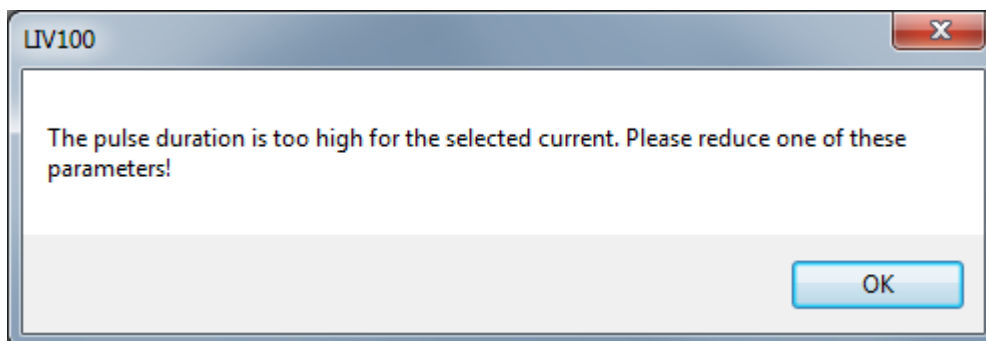
The contact test pulse serves to ensure that the DUT has been sufficiently securely contacted so as to give reliable test results. The result of this test is a voltage measurement which is compared to the range window as selected by the user under the settings tab 9.4.4 Tab “LIV-Mode” as described in detail on pg.59. If the contact test is successful, the unit will continue with the measurement. If the test is not successful, the unit will abort the measurement and display the following warning message in a pop-up frame:



The SOA test pulse measures the voltage drop across the DUT at essentially zero current flow. This represents the largest possible power dissipation in the driver end stage which is the worst case situation. From this value the safe operating area is calculated and compared with the parameters uploaded for the LIV sweep. If the SOA will not be exceeded by the parameters chosen, the unit will continue with the measurement. If the SOA would be exceeded, the unit will abort the measurement and display a warning message in a pop-up frame. There are two possible violations of the SOA:

1. the pulse duration is too long for the current chosen or
2. the duty cycle is too high for the selected current.

In either case, the choice of parameters must be modified in order to continue with the LIV sweep.



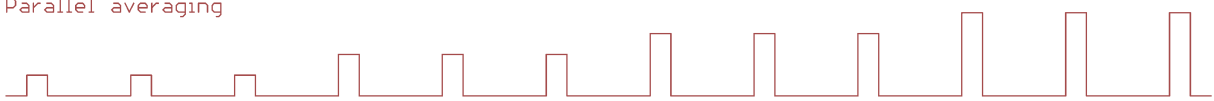
Once the test pulse sequence has been passed, the unit makes one final pre-sequence pulse, again at 0mA and 10 $\mu$ s duration. During this pulse, all measurement channels are sampled and the data stored internally as zero point offset values. These values are then subtracted from the subsequent measurement data.

Thereafter the sequence will run with the parameters as set by the user. During each current step the three measurement channels (voltage, current, optical power) are acquired a given number of times for averaging. There are three modes of averaging: no averaging, parallel averaging and serial averaging. The number of pulses to be averaged may be set in the range 1-250. The pulse sequence for each type of averaging is described in the following figure.

No averaging



Parallel averaging



Serial averaging



Figure 5: Averaging Modes for LIV Sweeps

The voltage, current and optical power are sampled at a rate of 1MS/s to 20MS/s each. The sampling rate is automatically determined internally in order to maximize the number of samples within each pulse. The maximum number of samples per pulse is thereby limited to 2000. All samples within the pulses (as well as 4 samples each before the rise time begins and after the pulse is shut off) are stored in a volatile memory. Finally, the average of the sample values within the plateau region<sup>1</sup> is calculated and stored internally. The individual sample values are deleted before the next pulse takes place. Only these averaged values are downloaded to the control computer at the end of the full measurement sequence.

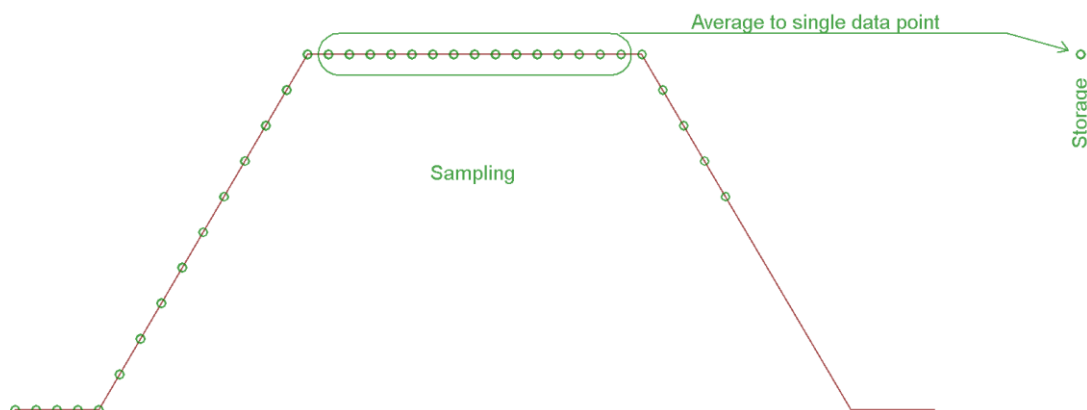


Figure 6: Sampling in LIV mode

<sup>1</sup> The plateau region is that region of the pulse determined by the flatness algorithm and the test pulse described above.

When a new current is set, the device under test (DUT) will in general not be in thermal equilibrium anymore. The LIV100 system allows a user programmable minimum delay period to allow thermalization of the DUT. This thermalization period is determined by selecting a number of current cycles to be driven without measurement. This number may be freely chosen between 1 – 65 000 current cycles. Note that each current cycle is defined by the parameters “pulse width” and “pulse separation”. Therefore the temporal value of the thermalization period is determined by these parameters as well. Note that this time may be extremely long and so care should be exercised when choosing a value for this parameter. For example with “pulse separation” set to the maximum value of 500ms and the thermalization sequence set at the maximum value of 65 000, the thermalization period will be 9 hours per current! The control software may terminate the sequence at any time by sending the “abort” command (=ESC). The control system checks for an ESC command after each pulse / pause sequence. Thus, the maximum delay is the length of one pulse / pause sequence (100 $\mu$ s to 500ms) plus the internal delay of the control computer. After thermalization, the waveforms are captured by the A/D circuitry and stored to buffer memory. The thermalization sequence is described in the following diagramme.

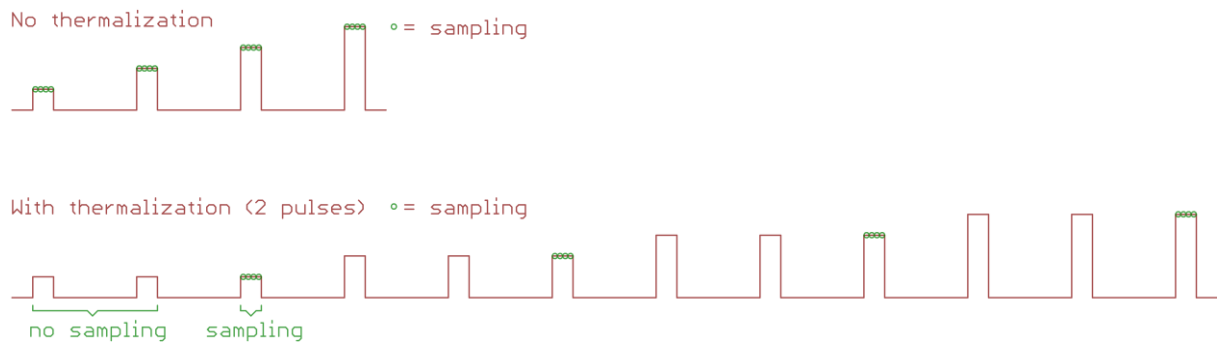


Figure 7: Thermalization Sequence in LIV mode

Following completion of the LIV sweep, the results are displayed in various graphs as selected by the user. Typical results are depicted in the following figure.

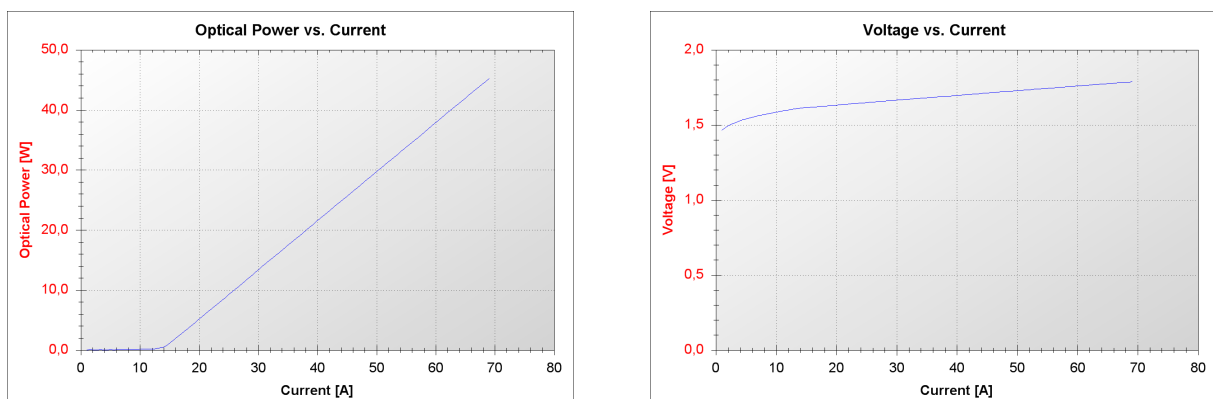
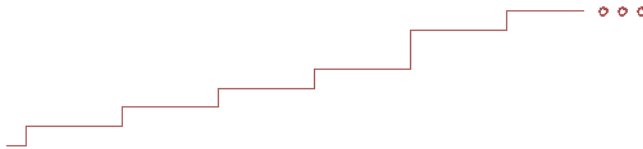


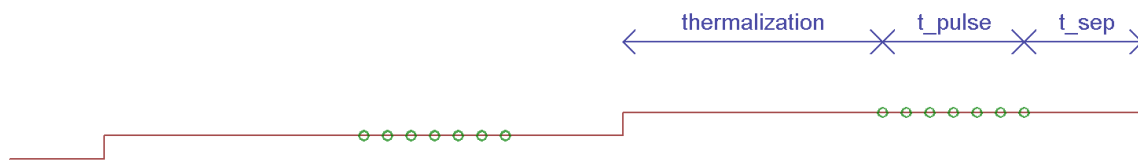
Figure 8: Typical Results of an LIV Mode Measurement Sequence

### 4.2.2 LIV Sweep (CW)

This mode performs an LIV sweep by stepping the current from the minimum set value to the maximum set value in a number of equidistant currents as determined by the parameter “Number of current steps”. The voltage, current and optical power are sampled at a rate of 1-20MS/s (50ns-1 $\mu$ s sampling period) each. All samples within the pulses (as well as 4 samples each before the rise time begins and after the pulse shut-off) are stored. Schematically this appears as follows:



Note that in the CW-sweep mode that the DAQ unit only samples and stores data during the period  $t_{\text{pulse}}$  and not during the period  $t_{\text{sep}}$  (pulse separation). The current remains on, however during  $t_{\text{sep}}$ . This is depicted in the figure below:



All other details concerning test pulses and data acquisition are identical to the pulsed LIV sweep mode.

### 4.2.3 Scope mode (pulsed or CW)

The scope mode is useful for setting up the system, testing the security of the high-current electrical connections and for evaluating the validity of the pulse parameters chosen. This mode performs sweeps as per the settings and descriptions given in the LIV sweeps. The difference lies in the way the data are stored. During LIV sweeps, the individual data samples within each sampling period as set up by the parameter “pulse width” are averaged and stored as a single data point.<sup>2</sup>

The scope mode on the other hand stores all of the points sampled and displays them in the respective graphs. The voltage, current and optical power are sampled at a rate of 1MS/s to 20MS/s each depending on the settings chosen. The sampling rate is automatically determined internally in order to maximize the number of samples within each pulse. The maximum number of samples per pulse is thereby limited to 2000. All samples within the pulses (as well as 4 samples each before the rise time begins and after the pulse is shut off) are stored and represented graphically. The difference between these two storage modi is indicated in the figures below.

<sup>2</sup> Not all samples are used in this average. Rather, the system employs an intelligent plateau algorithm to determine that part of the sample set which meets the criteria set up by the user on the Tab “LIV-Mode” of the “Settings” menu.

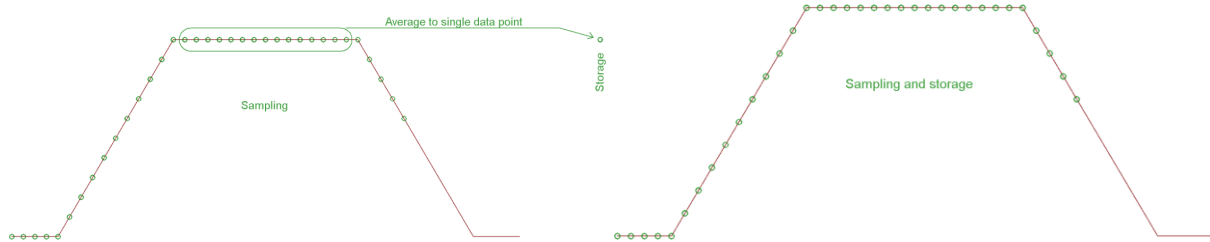
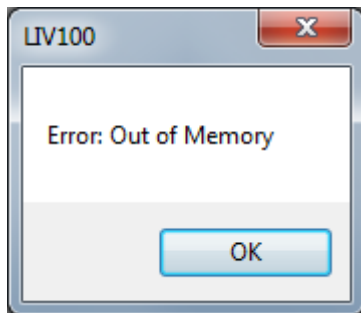


Figure 9: Sampling in LIV

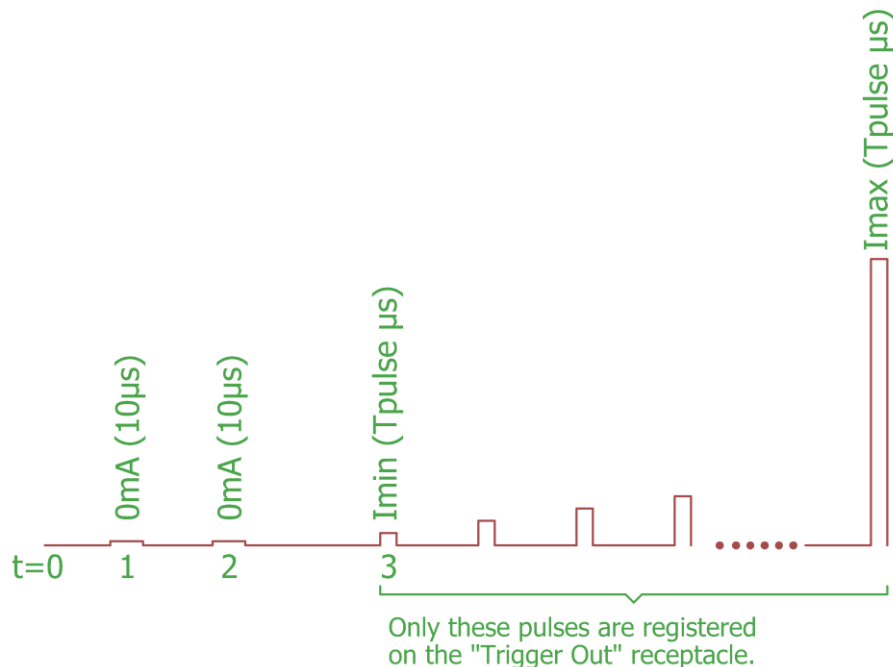
and scope modes

Since the scope mode stores all of the sample data, the size of the data set is much larger than in LIV mode. The storage of the LIV100 is limited to 512kB and for some settings in scope mode, the available on board memory is not sufficient to perform the sweep. In such cases, the LIV returns an error message resulting in the following warning in a pop-up frame:



As for the LIV sweep, the sweep in scope mode also requires test pulses to ensure proper operation of the device. A complete description of the test pulse sequence is given in the diagramme below.

## Scope Mode



1: Test pulse to determine the offset compensation of the measurement channels.  
Current =  $0\text{mA}$ ; duration =  $10\mu\text{s}$ .

2: Test pulse to calculate the safe operating area (SOA).  
Current =  $0\text{mA}$ ; duration =  $10\mu\text{s}$ .

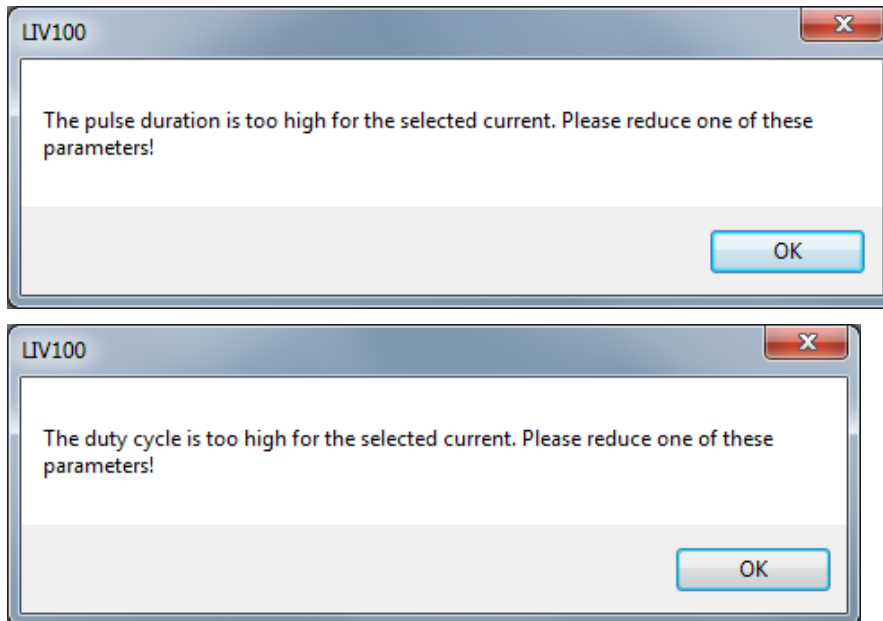
3: LIV sweep with user defined parameters of currents,  
pulse duration and pulse separation.

Figure 10: Test Pulse Sequence in Scope Mode

The SOA test pulse measures the voltage drop across the DUT at essentially zero current flow. This represents the largest possible power dissipation in the driver end stage which is the worst case situation. From this value the safe operating area is calculated and compared with the parameters uploaded for the scope sweep. If the SOA will not be exceeded by the parameters chosen, the unit will continue with the measurement. If the SOA would be exceeded, the unit will abort the measurement and display a warning message in a pop-up frame. There are two possible violations of the SOA:

1. the pulse duration is too long for the current chosen or
2. the duty cycle is too high for the selected current.

In either case, the choice of parameters must be modified in order to continue with the scope sweep.



Once the test pulse sequence has been passed, the unit makes one final pre-sequence pulse, again at 0mA and 10 $\mu$ s duration. During this pulse, all measurement channels are sampled and the data stored internally as zero point offset values. These values are then subtracted from the subsequent measurement data.

Thereafter the sequence will run with the parameters as set by the user. During each current step the three measurement channels (voltage, current, optical power) are acquired and stored internally until the sweep is completed. Following completion of the scope sweep, the results are displayed in various graphs as selected by the user. Note that no data is acquired during the “pulse separation” period. Therefore, the graphs show only the periods of data acquisition and do not indicate the actual temporal separation of the pulses. This results in a graph which seems to show essentially 100% duty cycle, whereas physically the duty cycle is as set up by the user. Typical results are depicted in the following figure.

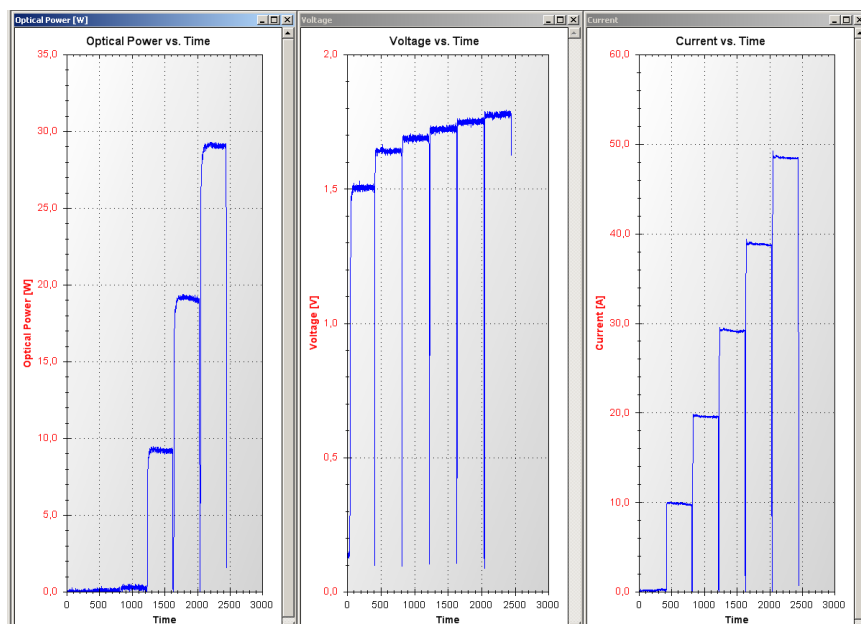
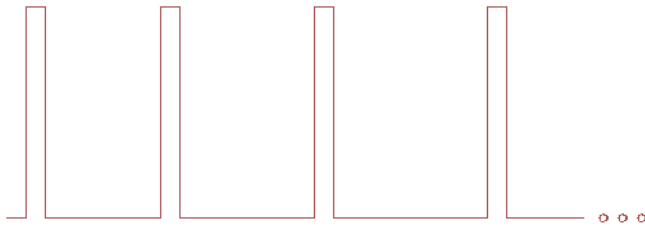


Figure 11: Typical Results of a Scope Mode Measurement Sequence



#### 4.2.4 Burst mode (pulsed)

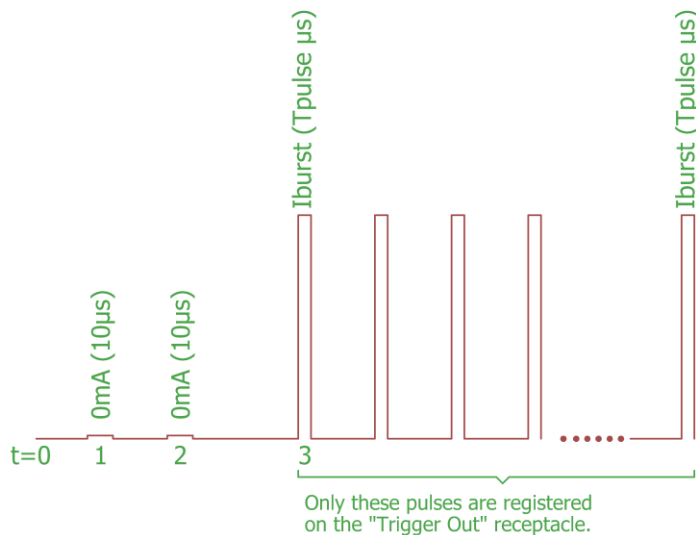
The burst mode is used to pulse the driver at constant current with a single pulse width and pulse separation during the whole burst.



Only the optical power at a single data point near the end of the pulse is measured in this mode. The drive current and the voltage drop across the DUT are not measured. 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. For such purposes, a trigger output receptacle is provided on the back side of the instrument to synchronize measurements with external equipment.

As for the LIV and scope sweeps, the burst mode also requires test pulses to ensure proper operation of the device. A complete description of the test pulse sequence is given in the diagramme below.

#### Burst Mode



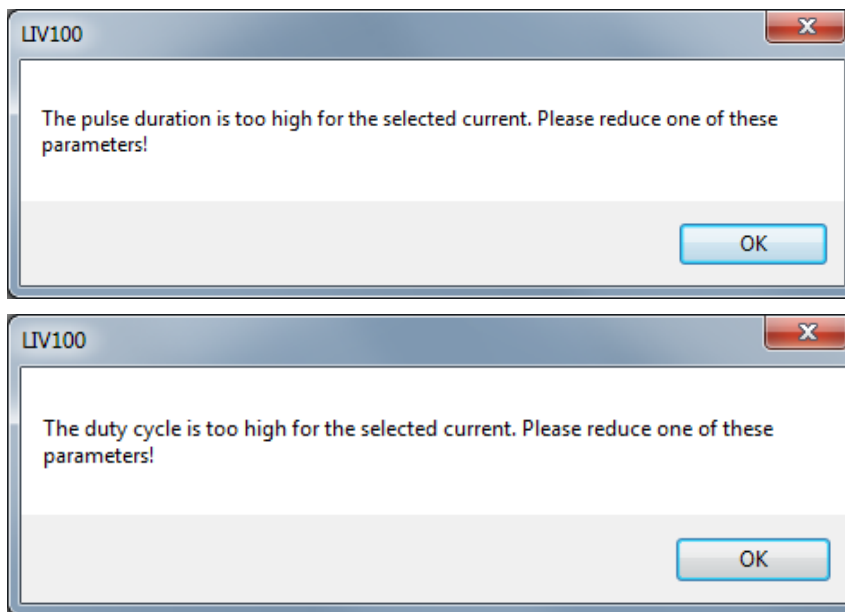
- 1: Test pulse to determine the offset compensation of the measurement channels.  
Current = 0mA; duration = 10µs.
- 2: Test pulse to calculate the safe operating area (SOA).  
Current = 0mA; duration = 10µs.
- 3: LIV sweep with user defined parameters of currents, pulse duration and pulse separation.

Figure 12: Test Pulse Sequence in Burst Mode

The SOA test pulse measures the voltage drop across the DUT at essentially zero current flow. This represents the largest possible power dissipation in the driver end stage which is the worst case situation. From this value the safe operating area is calculated and compared with the parameters uploaded for the burst mode. If the SOA will not be exceeded by the parameters chosen, the unit will continue with the measurement. If the SOA would be exceeded, the unit will abort the measurement and display a warning message in a pop-up frame. There are two possible violations of the SOA:

1. the pulse duration is too long for the current chosen or
2. the duty cycle is too high for the selected current.

In either case, the choice of parameters must be modified in order to continue with the burst.



Once the test pulse sequence has been passed, the unit makes one final pre-sequence pulse, again at 0mA and 10 $\mu$ s duration. During this pulse, all measurement channels are sampled and the data stored internally as zero point offset values. These values are then subtracted from the subsequent measurement data. Thereafter the sequence will run with the parameters as set by the user. Typical results are depicted in the following figure.

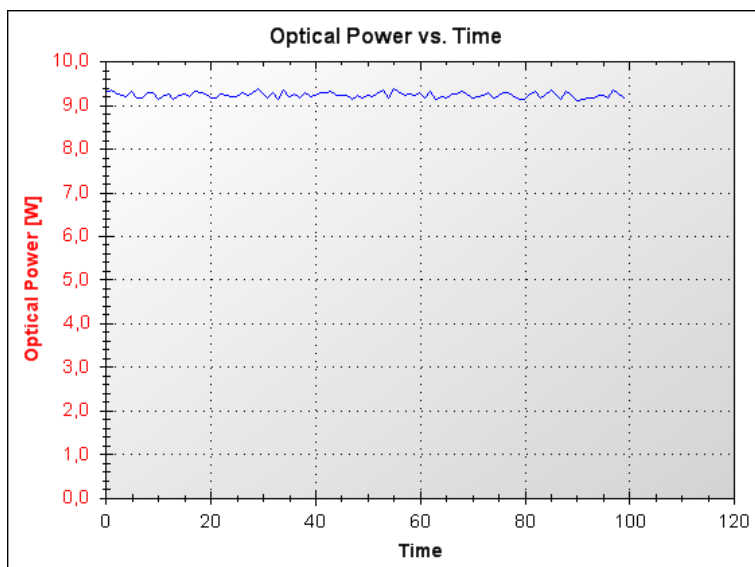
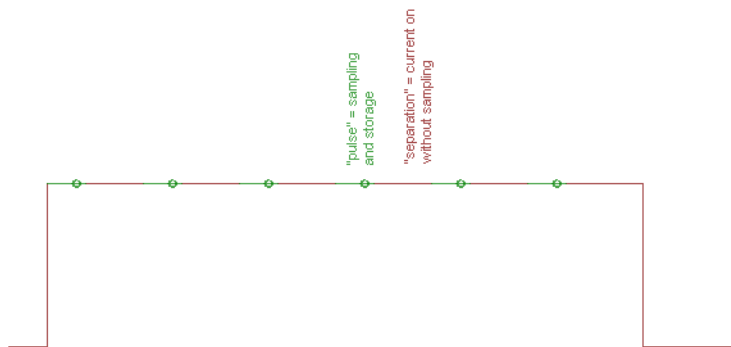


Figure 13: Typical Results of a Burst Mode Measurement Sequence

### 4.2.5 Burst mode (CW)

The CW burst mode is used to drive the output at constant current for a certain period of time.



Only the optical power at a single data point near the end of the “pulse width” period is measured in this mode. Data is acquired during the time periods set up with the parameter “pulse width”. During the “pulse separation” periods the current is still on, but no data is acquired. The CW 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.

All other details concerning test pulses and data acquisition are identical to the pulsed LIV sweep mode.



## 6 Specifications

### 6.1 Current Driver and DAQ Unit

Table 2: Specifications of the Current Driver and DAQ System

PARAMETER	CONDITIONS	RESOLUTION	MIN	TYP	MAX	UNITS
<b>INPUTS</b>						
Sampling rate	Selectable: 20/n MS/s with n=1 .. 20		1		20	MS/s
A/D resolution				13		bit
Photodiode gain	optimum gain automatically selected		1 10 100			V/mA
Transimpedance amplifier rise time <sup>4</sup>	Input capacitance <20pF, gain = 1 kΩ			50		ns
<b>OUTPUT</b>						
Pulse duration <sup>5</sup>	20MS/s sampling, F-version 20MS/s sampling, L-version 20MS/s sampling, XL-version 1MS/s sampling rate	0.05 0.05 0.05 1	0.15 2 5 1		100 100 100 2000	μs
Rise time	F-version L-version XL-version			50 500 1000	70 700 1500	ns
Current overshoot at maximum current <sup>6</sup>				0	5	%
Pulse separation		50	100		500 000	μs
Current range	LIV100-F005-CW LIV100-L010-CW	0.00125 0.0025	0.025 0.05		5 10	A
D/A resolution				12		bit
Compliance voltage	F-Version L, XL-Version				20 <sup>7</sup> 10	V
Duty cycle			0.0001		100	%
<b>SIGNAL PROCESSING</b>						
Depth of storage				512		kB
Number of channels				3		
Number of cycles for averaging		1	1		250	
<b>PC INTERFACE</b>						
Type				USB; 100kB/s		
<b>DIMENSIONS</b>						
Dimensions	DAQ unit DAQ unit with base plate		114 x 150 x 125 mm (W x L x H) 165 x 150 x 135 mm (W x L x H)			mm
Mass				3.5		kg
<b>OTHER</b>						
Cooling	Water			0.3 – 1		l/min

<sup>4</sup> Per ANSI/IEEE Standard 181-1977: 10% - 90%

<sup>5</sup> Optimum sampling rate is automatically selected

<sup>6</sup> With optimized strip line connector, no load matching required

<sup>7</sup> Dependant on the configuration of the connecting cable

## 6.2 Typical Current Pulse Forms

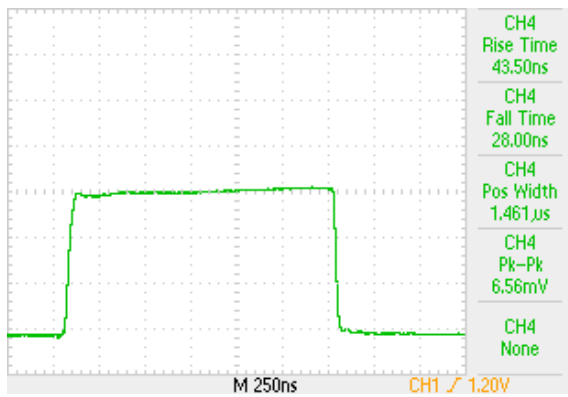


Figure 14: LIV100-F040, 1.5µs pulse shape

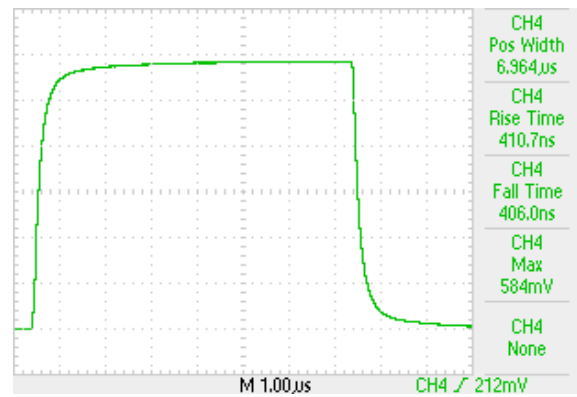


Figure 15: LIV100-L120, 7µs pulse shape

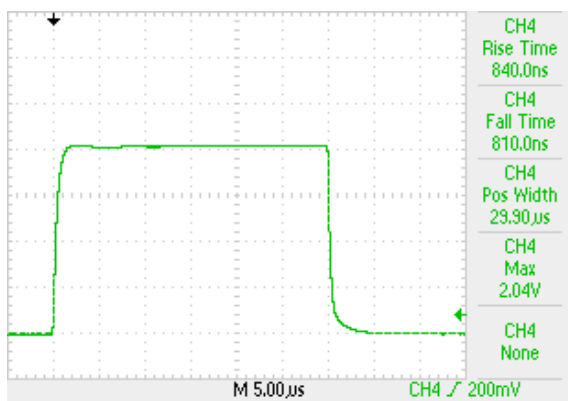
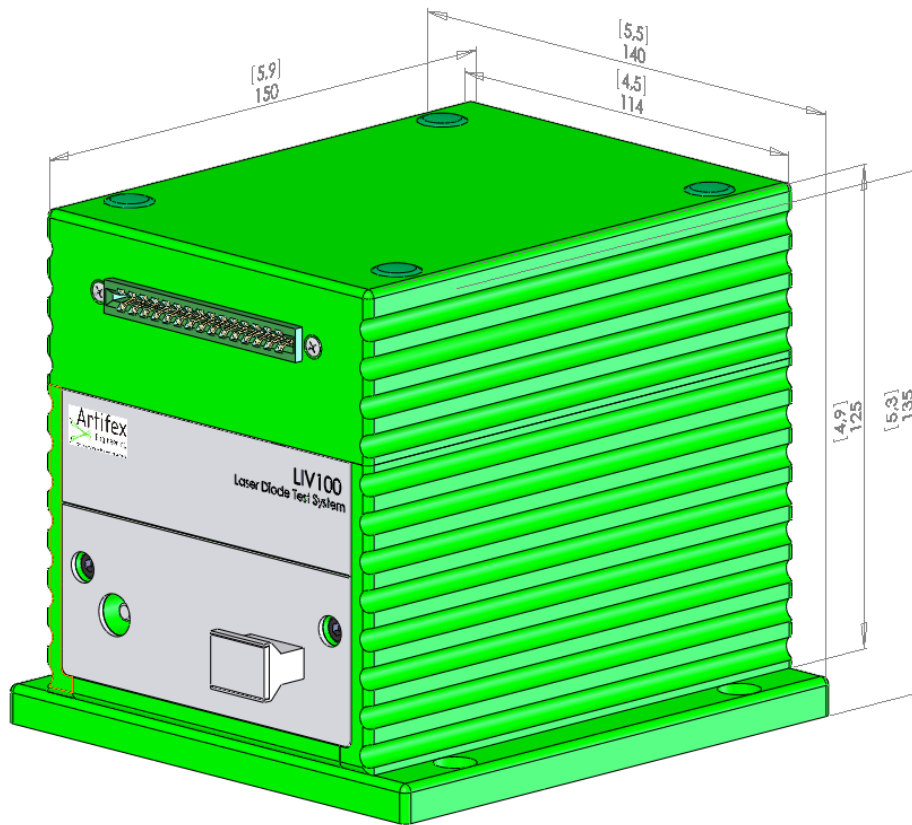


Figure 16: LIV100-XL400, 30µs pulse shape

### 6.3 Case Dimensions (mm [inch])



## 7 Connections

### 7.1 Front Panel

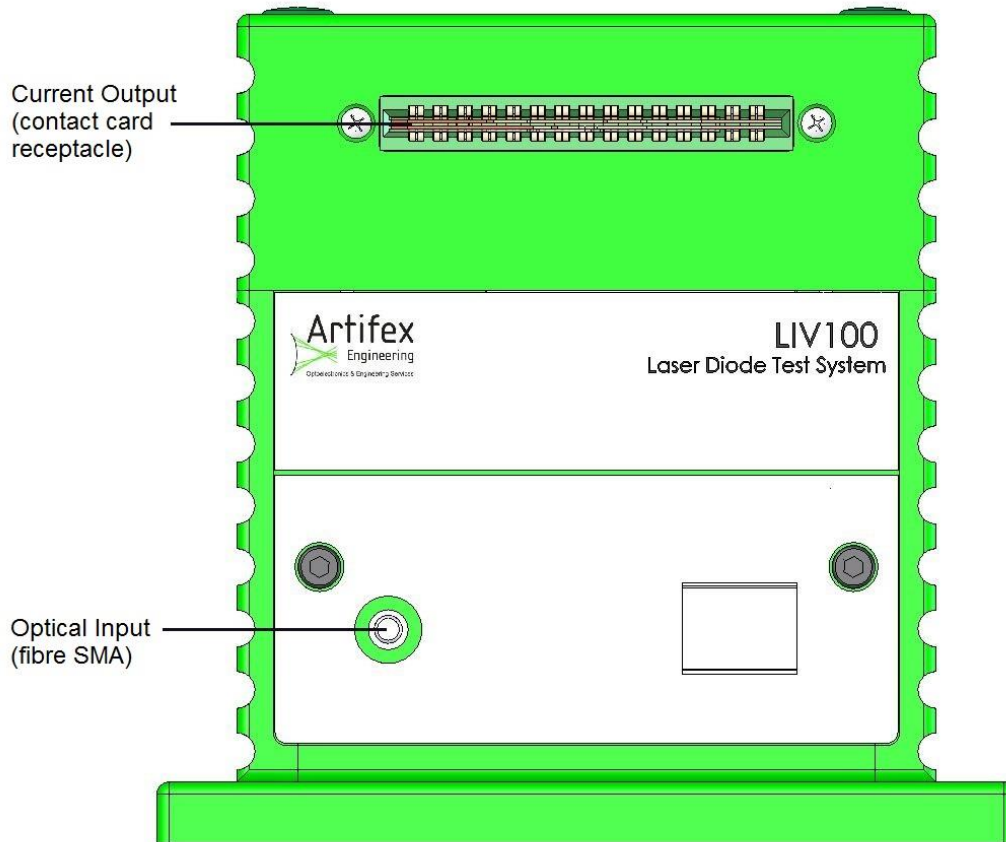


Figure 17: Front Panel

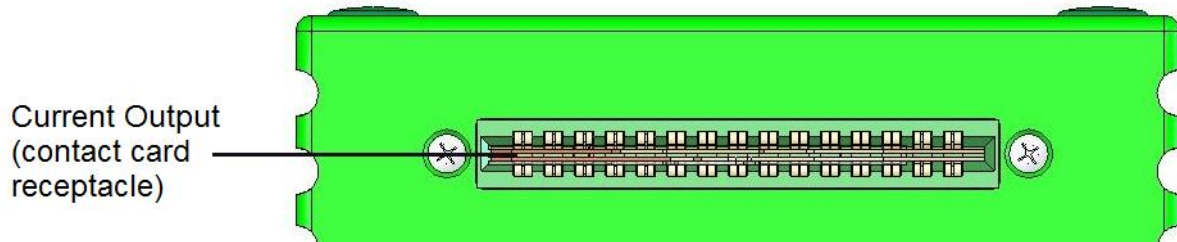
#### 7.1.1 Optical Measurement

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 where it is measured with a photodiode and transimpedance amplifier within the enclosure of the LIV100 unit. The complete optical chain (integrating sphere – optical fibre – photodiode – transimpedance amplifier) is calibrated as a unit before shipping.



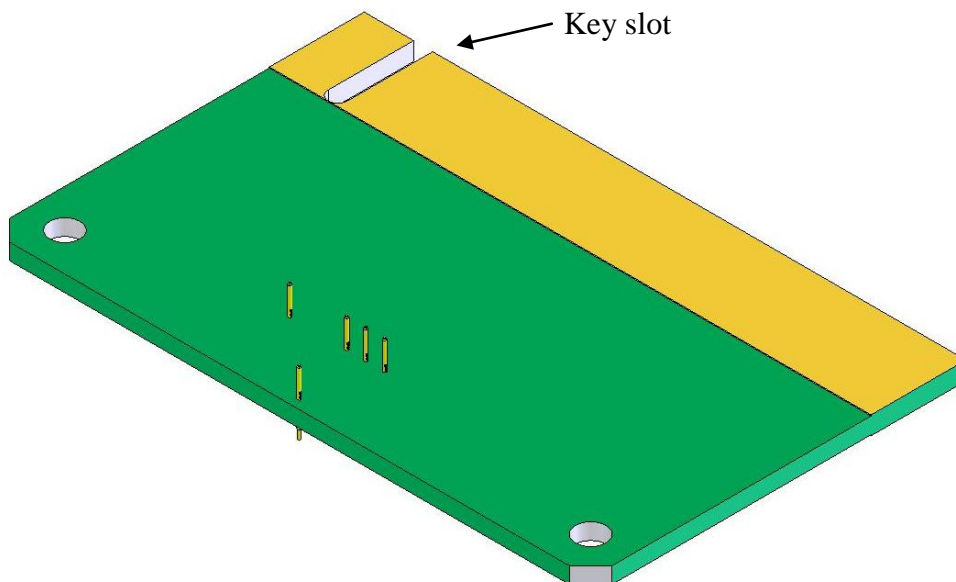
### 7.1.2 Current Output

The current output to drive the DUT is delivered from the slot receptacle at the top of the front panel.



Artifex Engineering provides full support to design and manufacture custom strip line contact cards for contacting laser bars, chips, TO, C-Mount, CS-Mount, etc. Contact us for your requirements.

The contact card is inserted into the card receptacle with the key slot on the left hand side of the receptacle. The correct polarity is guaranteed through the key slot in the card.



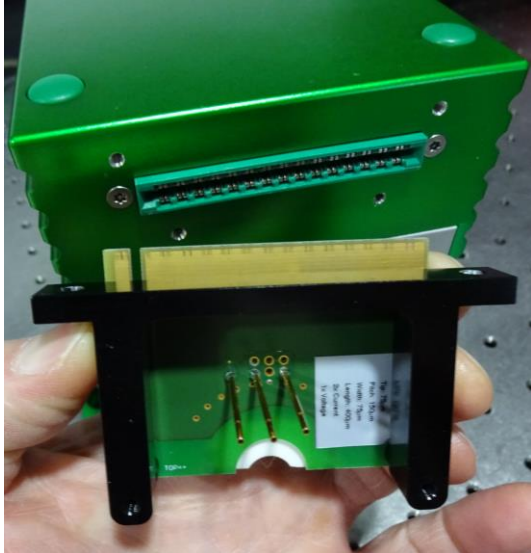
#### **NOTICE!**

The needles and pogo pins (laser contact pins) are sensitive. Do not touch the pins with your fingers or tools under any circumstance.

### 7.1.3 Mounting the Contact Card

Artifex Engineering provides two kinds of contact card assemblies: simple cards on a support frame and temperature controlled mounts.

Simple cards are mounted with two screws located above the current output receptacle. The assembly is as follows:



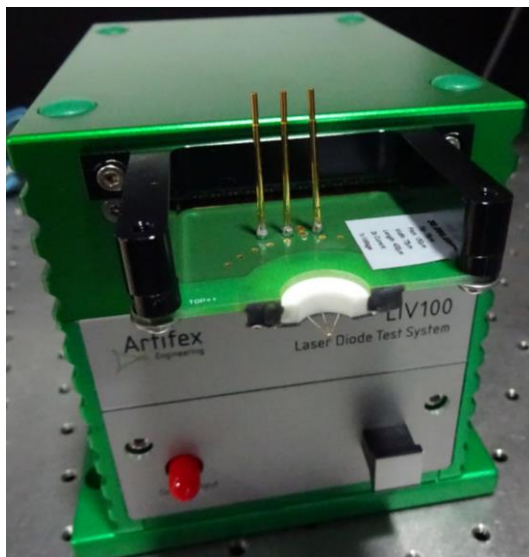
Correct orientation.



Insert the card in the contact slot.

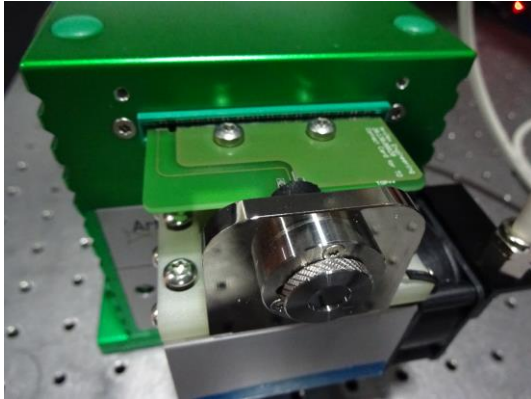


Insert the screws and tighten evenly.

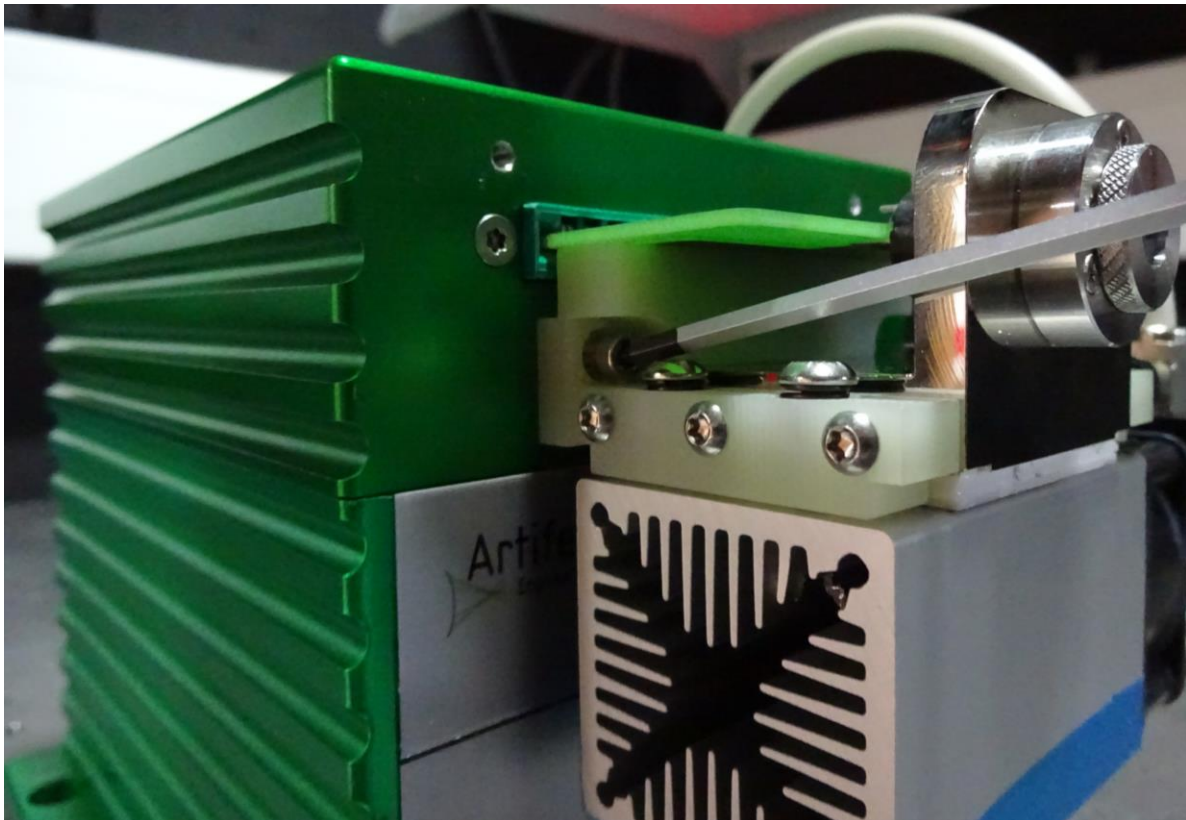


Finished mounting.

For temperature controlled contact mount assemblies, the mounting screw holes are located below the current output connector slot. Proceed as follows:

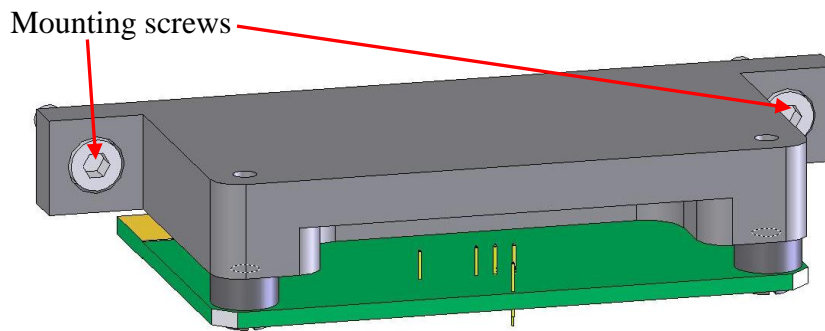


Insert the contact card into the current output slot.

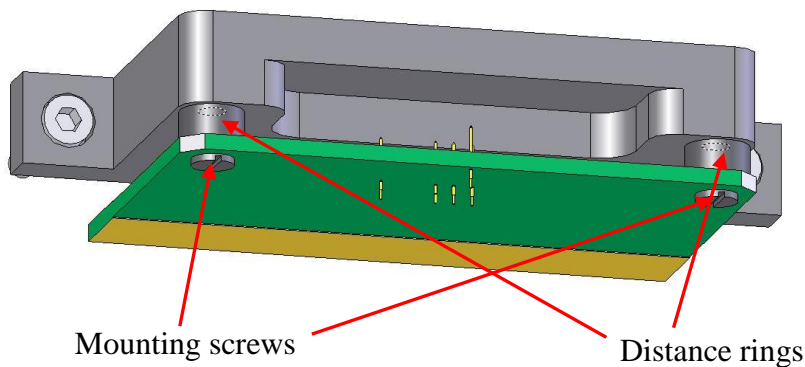


Insert the two screws and tighten evenly.

The contact card is fitted with a card support when delivered. If for any reason you need to exchange cards on the support, remove the two screws holding the card support to the LIV unit and remove the complete card assembly in order to change cards.



Now turn the card holder over and remove the two screws holding the card onto the card holder.

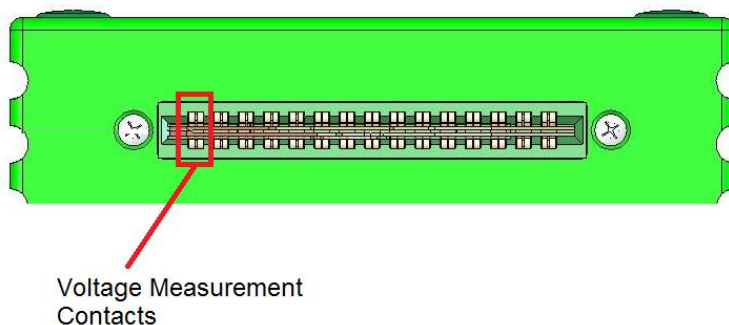


*Figure 18: Mounting a New Contact Card*

When reassembling, be sure the distance rings between the contact card and the card holder are in place.

#### 7.1.4 Voltage Measurement

The voltage measurement is also performed via the contact card inserted into the receptacle at the top of the front panel. The left two contacts are reserved for this measurement and are separated from the current driving contacts via a plastic key. This key also prevents accidental reversal of the contact card when inserting.



*Figure 19: Voltage Measurement Contacts*

## 7.2 Back Panel

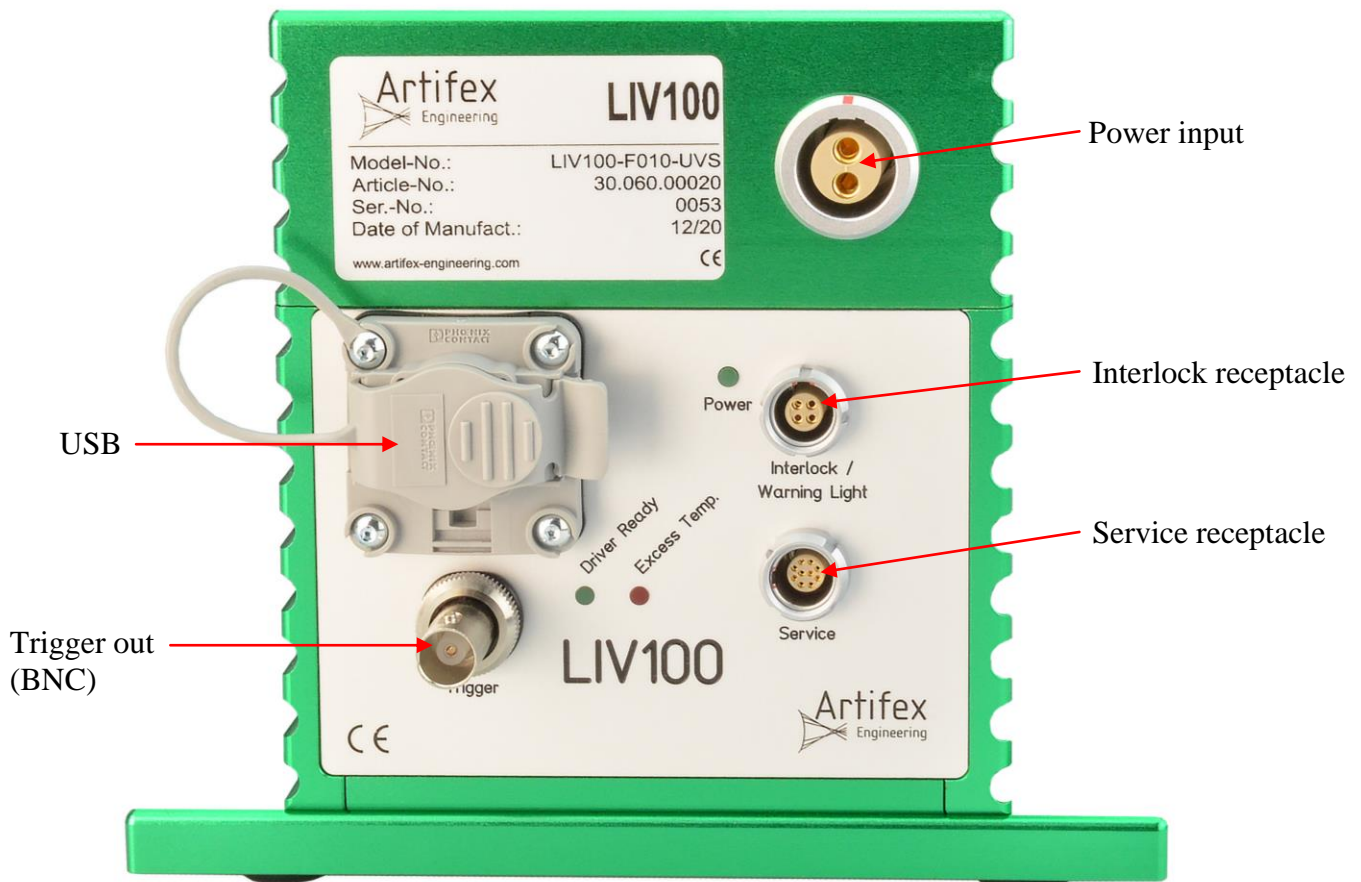


Figure 20: Back Panel

### 7.2.1 USB

The communication with the LIV100 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 an industrial (clip fastened) USB receptacle to ensure connection at all times. The appropriate industrial USB cable is supplied with the system. The standard cable length is 2m. A 5m cable may be supplied upon request.

### 7.2.2 Power Supply

This receptacle connects the mains power input to the control system. The connector is key coded to prevent insertion in the wrong direction. The red marks on the connector and the receptacle must be aligned in order to insert the connector.

The universal switching power supply delivered with the unit is mains input rated at 85-264VAC, 48-62Hz. Please use only the power supply delivered with the unit. The mains input cable to the power supply may be removed and replaced with an appropriate cable to fit the mains receptacle in the country of use.

### 7.2.3 Power LED

This LED (green) indicates the status of the power supply to the LIV100. The LED is lit when the unit is properly powered.

### 7.2.4 Trigger

This BNC receptacle may be used for synchronizing external instruments such as the standard diode array spectrometer option. The output is TTL compatible: HI=+5V; LO=0V. The output is HI when current is driven and LO when not. There is no trigger output during the pre-measurement test pulses, but rather only during the measurement test pulses. See details under 4.2 “Modes of Measurement” pg. 23ff.

Several external instruments may be connected to this receptacle by use of T- or Y-adapters. The outer electrode (shield electrode) is at the internal ground potential of the LIV100 instrument. Only instruments at the same ground potential may be connected to this receptacle.

#### **NOTICE!**



#### **Note that neither end of the DUT is at ground potential!**

The DUT connected to the current output receptacle of the LIV100 is at a floating, high potential. The anode of the DUT is at the potential of the power supply (typically +12V or +24V). The cathode of the DUT is actively “pulled down” when driving current to the potential required to drive the current in question. Thus, it is not possible to connect a single-ended oscilloscope probe to the DUT and trigger the oscilloscope from the “Trigger Out” receptacle. Doing so will cause a short circuit and may damage the power supply and/or the LIV100 unit.

### 7.2.5 Driver Ready

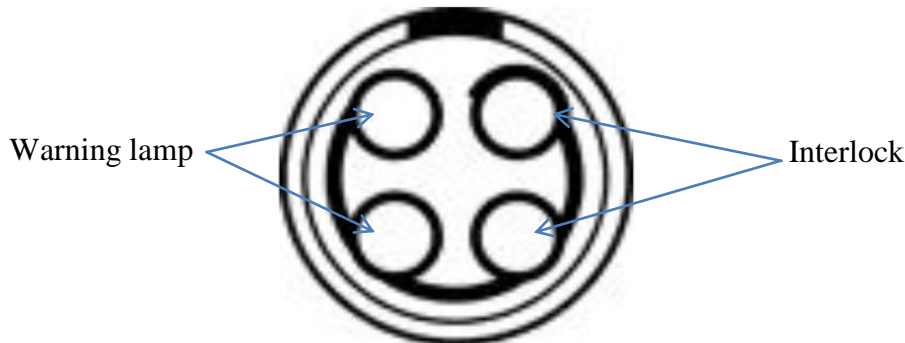
This LED (green) indicates the status of the current driver end stage. If the end stage is functioning properly, the LED will be lit. If this LED is not lit up when the “Power” LED is lit, then the end stage is not in a ready status. In this case, close the control software, remove the power supply and wait for the “Power” LED to go dark. Then repower the unit. If the “Driver Ready” LED still does not light, the unit must be serviced. In this case, please contact Artifex Engineering or your service representative.

### 7.2.6 Excess Temp

This LED (red) indicates the status of the temperature of the current driver end stage. If the end stage is too hot, the LED will be lit (error condition) and the driver will shut down. The graphical interface will indicate this condition through a pop-up frame. In this case, close the control software, remove the power supply and wait approximately ten minutes. Then repower the unit. If the “Excess Temp” LED still lights up, the unit must be serviced. In this case, please contact Artifex Engineering or your service representative.

### 7.2.7 Interlock Receptacle

This multipole receptacle is for connection of an interlock safety circuit and a warning lamp. The receptacle (Lemo EYG.1B.304.CLN) has four contacts.



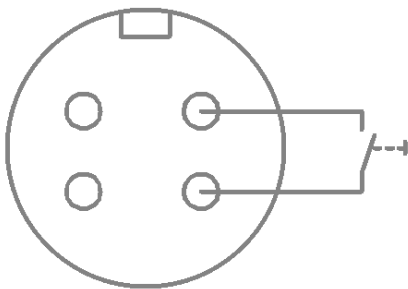
The interlock safety circuit should safeguard people and objects from damage due to optical irradiation. If the interlock connection is opened before starting a measurement, then the measurement cannot be initiated. Opening the interlock connection during a measurement leads to an immediate halt of the measurement and the output of the current driver. In this case, the software generates an error message and the ESD protection circuit (low impedance connection of the current output electrodes) is activated. The instrument itself remains active.

The interlock connection must be connected through a potential-free switch, for example a door switch.



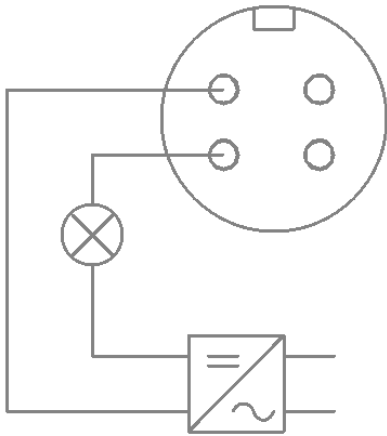
#### **NOTICE!**

External voltage or current inputs could lead to permanent damage of the device!



If an external interlock switch is not to be used, the two interlock pins can be shorted together. A preconfigured connector is delivered with the instrument for this purpose.

The “warning lamp” pins are used to connect a visual or acoustic warning system. During measurement, an internal relays connects the two pins in order to close an external electrical circuit (see diagramme below):



The output is potential-free and is rated at 2A / 24V.



**NOTICE!**

Voltages >30V on these pins will lead to permanent damage of the LIV device!

### 7.2.8 Service Connector

This multipole receptacle is for firmware updating. This receptacle is not intended for customer use and should only be accessed by Artifex Engineering service personnel or their representatives.



## 8 Installation of the Software Package

The installation of the software package is described in a separate document provided with the instrument.

## 9 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.

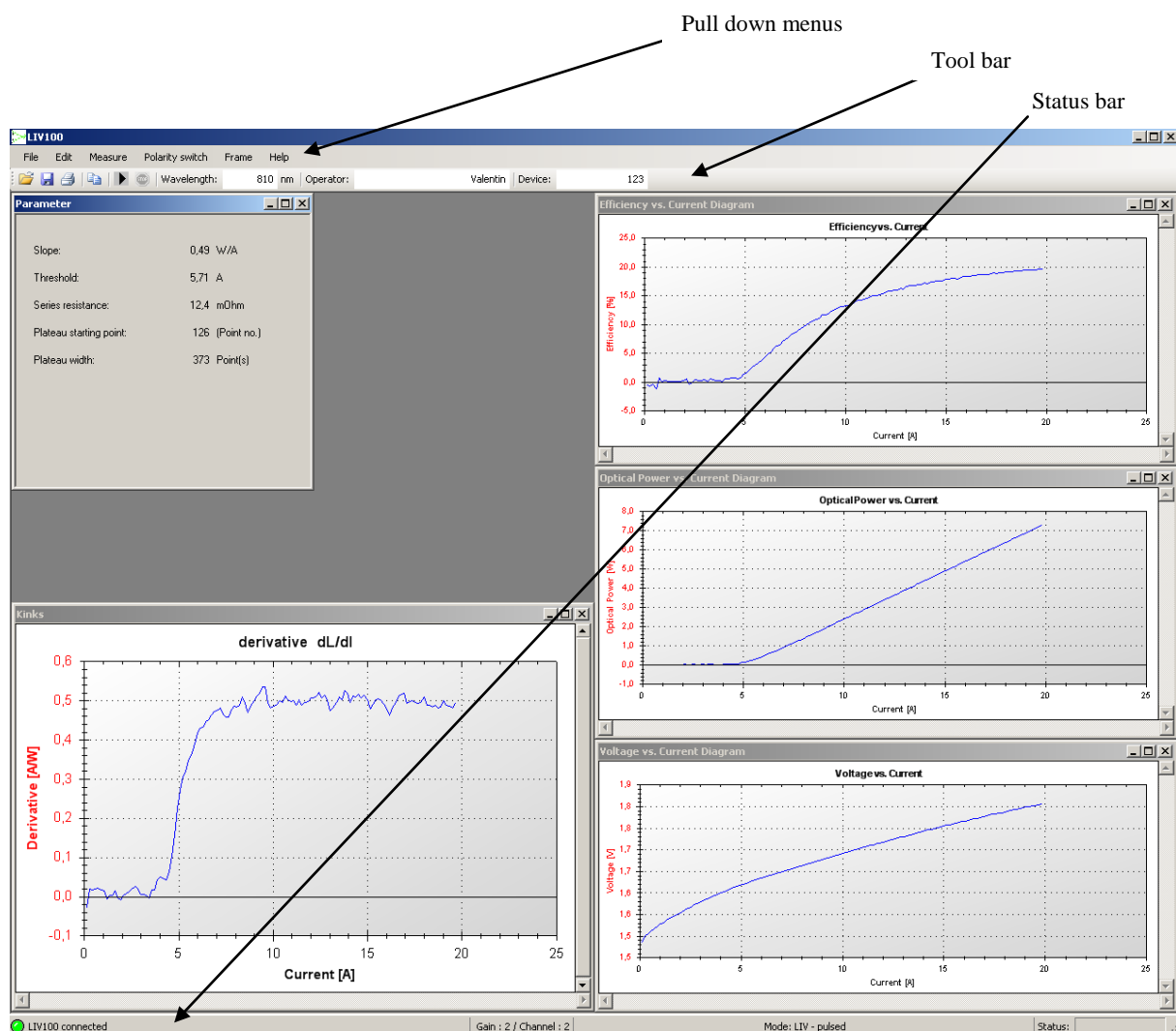


Figure 21: The Graphical User Interface (GUI)

## 9.1 The Functions of the Pull Down Menus

**File:** **Open** – Loads a \*.liv data format file or a \*.wbd format parameter file. The \*.liv file contains all of the measurement data information in a binary form and is specific for this application. The data in these files can only be viewed with the LIV100 graphical software and cannot be displayed in other programmes. 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). The \*.wbd file contains the setup parameters for a measurement sequence. These files are useful for repeated setup of different sequences for different devices or applications.

### **NOTICE!**



#### **The correct choice of \*WBD file for a measurement is critical!**

If an incorrect settings file (\*.wbd format) is chosen, the device under test may be subjected to currents, pulse durations or duty cycles beyond the safe operating conditions of that DUT. This may lead to damage or destruction of the DUT.

**Save** – Saves a \*.liv data format file or a \*.wbd format parameter file. The \*.liv file contains all of the measurement data information in a binary form and is specific for this application. The data in these files can only be viewed with the LIV100 graphical software. The \*.wbd file contains the setup parameters for a measurement sequence. These files are useful for repeated setup of different sequences for different devices or applications.

**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. 70 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.

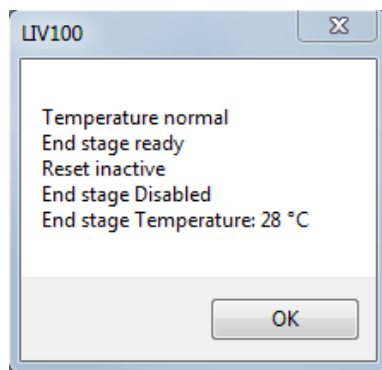
**Edit:** **Copy** – Copies the present graph frame into the PC's intermediate storage for further use with other programmes. For example, the graph can now be inserted into a text document using the paste function.

**Settings** – Opens a new window in which various settings such as the pulse currents and timing can be made. For details, see „Setting“ pg.54ff.


**DANGER!**

**Measure:** **Measure** – Starts a measurement. The data are displayed in the open frames. **Danger:** immediately after starting a measurement, the unit will begin to produce current pulses driving the device under test. Ensure that all personell within the working area are informed and are wearing suitable protection eyewear.

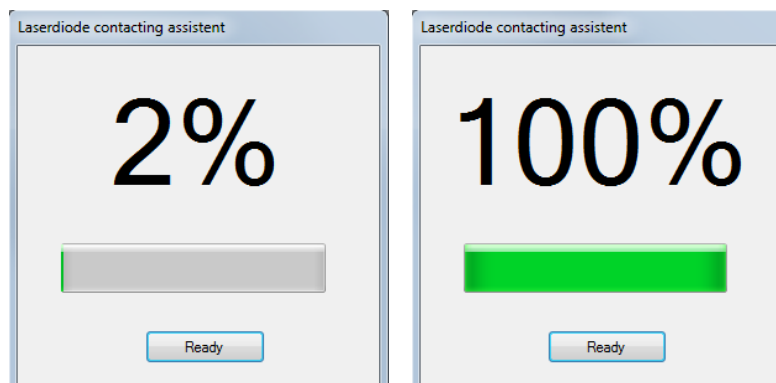
**Driver Info** – Opens a frame showing information on the status of the driver end stage.



**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. The repeat mode may also be aborted using the  stop button.

**Laser Diode Contacting Assistant** – Opens a frame showing a bar graph which indicates when the contact card is in full contact with the DUT. Use of this function is not mandatory, but may be of use in manual contacting of single emitters with fine needle cards. This assistant will only function properly when the cathode of the laser is contacted and the







- Frame:**
- Diagramme I-t** – Opens the current versus time (sample number) graph. This graph is valid in scope mode only.
  - Diagramme U-t** – Opens the voltage versus time (sample number) graph. This graph is valid in scope mode only.
  - Diagramme L-t** – Opens the optical power versus time (sample number) graph. This graph is valid in the scope and burst modes only.
  - Diagramme U-I** – Opens the voltage versus current graph. This graph is valid in LIV mode only.
  - Diagramme L-I** – Opens the optical power versus current graph. This graph is valid in LIV mode only.
  - Diagramme Efficiency-I** – Opens the efficiency versus current graph. This graph is valid in LIV mode only.
  - Kinks** – Opens the derivative of optical power versus current graph. This graph is valid in LIV mode only.
  - Show parameter** – Opens the table of calculated results (slope, threshold, series resistance and monitor diode slope). This frame is valid in LIV mode only.
  - Spectrum** – Opens the optical spectrum graph. This graph is only valid if the spectrometer is enabled on the Tab “Spectrometer”(see pg. 66).
  - TEC** – Opens a frame showing status information on the TEC driver and the measured temperature at the device mounting point. This frame is only valid if the TEC control is enabled on the Tab “Temperature Control” (see pg. 69).
  - 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 frames for the type of measurement cycle chosen.
- Help:**
- Info** – Shows information about this programme including the version number.
  - LIV Info** – Shows information on the present instrument connected, including its model and serial numbers as well as the firmware version of the unit.

## 9.2 The Tool Bar

The tool bar allows for quick access to the most important functions.



Figure 22: The Tool Bar

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



### DANGER!

#### Measure



Starts a measurement. The data are displayed in the open frames.

Danger: immediately after starting a measurement, the unit will begin to produce current pulses driving the device under test. Ensure that all personell within the working area are informed and are wearing suitable protection eyewear.

#### Stop



Aborts the measurement sequence before completion. All accumulated data are lost and will not be displayed.

In addition, there are input fields for the wavelength, the device name and the device serial number.

**Wavelength:** The sensitivity of the detector head is dependant on wavelength. The individual calibration file is stored in the programme folder of the control computer. The wavelength of the device to be measured must be inputted by the user in oder to allow the software to perform the appropriate calculation of the optical power. The wavelength selection will only be accepted if it is within the range of the calibration file. If a spectrometer is connected and the appropriate check box selected, then the system will measure the spectrum first and automatically select the wavelength for the power measurement. This option is described under, Tab "Spectrometer"pg. 66.

**Device:** Model number or description of the device under test. This is useful for documentation and appears in the pdf report. A maximum of 25 characters max be entered in this field.

**Serial:** Serial number of the device under test. This is useful for documentation and appears in the pdf report. A maximum of 25 characters max be entered in this field.

### 9.3 The Status Bar

The most important status information is displayed here.

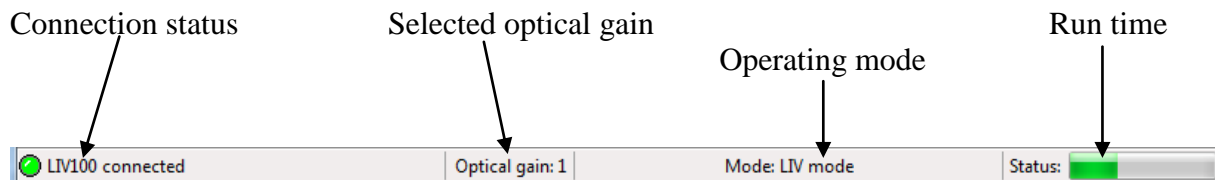



Figure 23: The Status Bar

**Connection status:** Indicates whether an LIV100 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:  LIV 100 not connected

The programme will only function if the virtual indicator lamp is green and the status “LIV100 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 and 1 (transimpedance gain  $10^3\text{V/A}$  and  $10^4\text{V/A}$  respectively).

**Mode:** Indicates the presently selected operating mode (LIV, scope or burst).

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

### 9.4 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 parameter 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.

### 9.4.1 Tab “General”

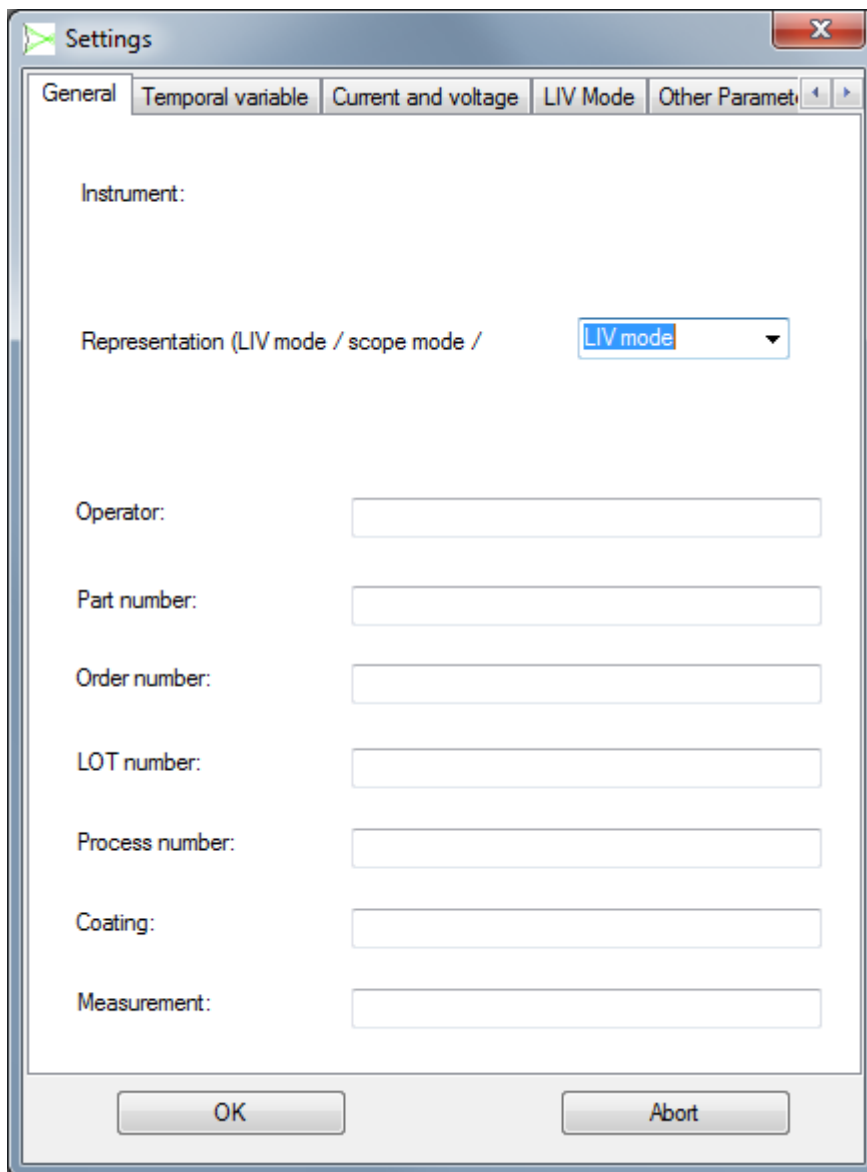


Figure 24: Tab “General”

Instrument:	Indicates the model of instrument.
Mode:	Pull down menu to choose the mode of operation. See section 4.2 “Modes of Measurement”, page 23 for details.
Operator, etc:	Fields to input the name of the operator, etc.. This is useful for documentation and appears in the pdf report. A maximum of 25 characters max be entered in these fields.

## 9.4.2 Tab “Temporal”

The appearance of the “Temporal variable” 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.

Some fields are specifically for information only and are greyed out and cannot be edited. These are “return values” and are helpful in aiding in the choice of the selectable parameter values.

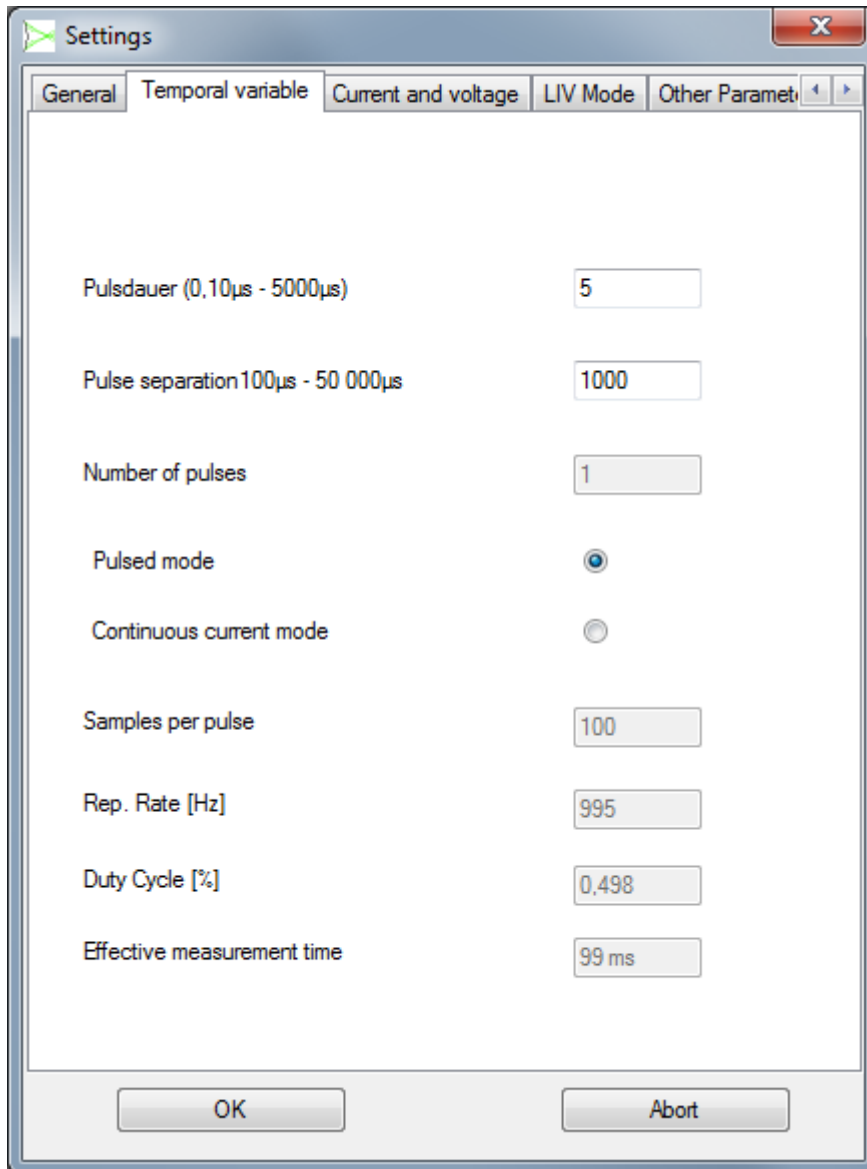


Figure 25: Tab “Temporal Variable”

**Pulse duration:** Selects the pulse duration in all pulsed modes. In all CW modes, this parameter selects the duration of the data acquisition period as detailed in section 4.2.2 “LIV Sweep (CW)”, page 29.

**Pulse separation:** In all pulsed modes, this parameter selects the separation between the falling edge of a pulse until the rising edge of the



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	next pulse. <sup>8</sup> In all CW modes, this parameter selects the duration of the pause between data acquisition periods as detailed in section 4.2.2 “LIV Sweep (CW)”, page 29.
Number of pulses:	Selects the number of pulses in burst mode. This is in addition to any pulses which may be activated by the “Thermalization” parameter on the “Other Parameters” tab.
[Radio Buttons]	
Pulsed Mode:	Selects pulsed mode.
Continuous current mode:	Selects continuous current (CW) mode.
[Return Values]	
Samples per pulse:	Indicates the number of samples which will be obtained during each data acquisition period. This is a non-editable field. The voltage, current and optical power are sampled during a measurement at a rate of 1MS/s to 20MS/s each. The sampling rate is automatically determined internally in order to maximize the number of samples within each pulse. The maximum number of samples per pulse is thereby limited to 2000.
Rep. Rate [Hz]:	Indicates the repetition rate of the pulsing sequence in pulsed modes or the rate of the data acquisition cycles in CW modes. This is a non-editable field. The repetition frequency is given by:
	$\frac{1}{("pulse\ duration" + "pulse\ separation")}$
Duty Cycle [%]:	Indicates the duty cycle of the pulsing sequence in pulsed modes or of the data acquisition cycles in CW modes. This is a non-editable field. The duty cycle is given by:
	$(100\% \cdot "pulse\ duration") / ("pulse\ duration" + "pulse\ separation")$
Effective measurement time [ms]:	Indicates the total duration of the data acquisition period. This includes the effects of “pulse duration”, “pulse separation”, “averaging” and the thermalization parameter.

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<sup>8</sup> 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).

### 9.4.3 Tab “Current and Voltage”

The appearance of the “Current” 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.

Some fields are specifically for information only and cannot be edited in any operation modes. These are the “Return Values” on the “Current” tab and the last three values on the “Spectrometer” tab. These return values are helpful in aiding in the choice of the selectable parameter values.

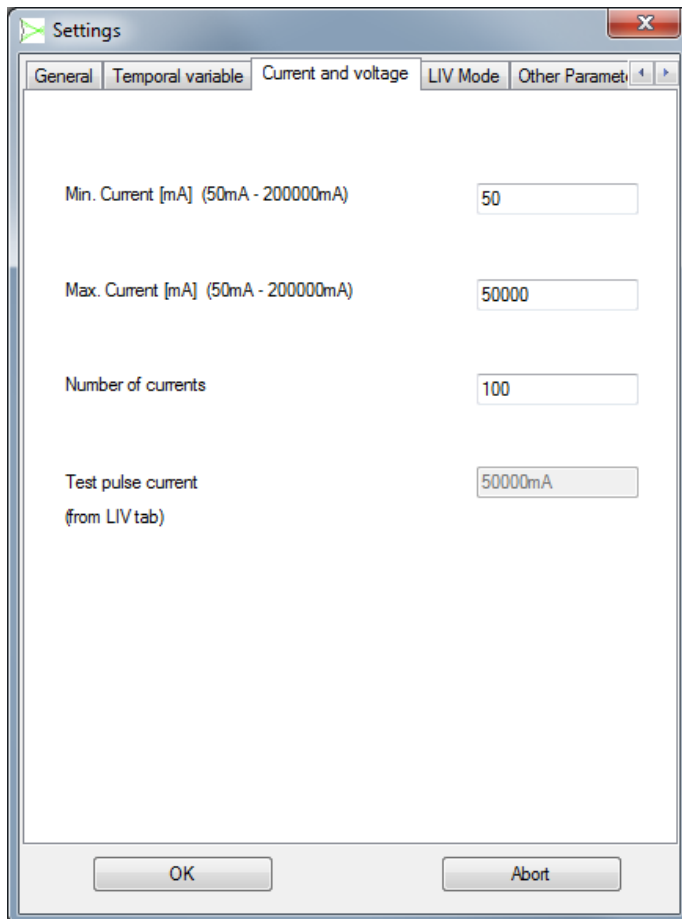


Figure 26: Tab “Current”

Min. Current:	Selects the minimum current for the LIV sweep.
Max. Current:	Selects the maximum current for the LIV sweep.
Number of current steps:	Selects the number of arithmetically equidistant steps for sweeping from the minimum to the maximum current.
Test pulse current:	Indicates the current which will be used for the test pulses to set the gain and for the plateau algorithm. This is a non-editable field calculated from the corresponding user input on the Tab “LIV-Mode” (see pg. 59).

#### 9.4.4 Tab “LIV-Mode”

This tab is only active if one of the LIV-modes has been selected on the “General” tab.

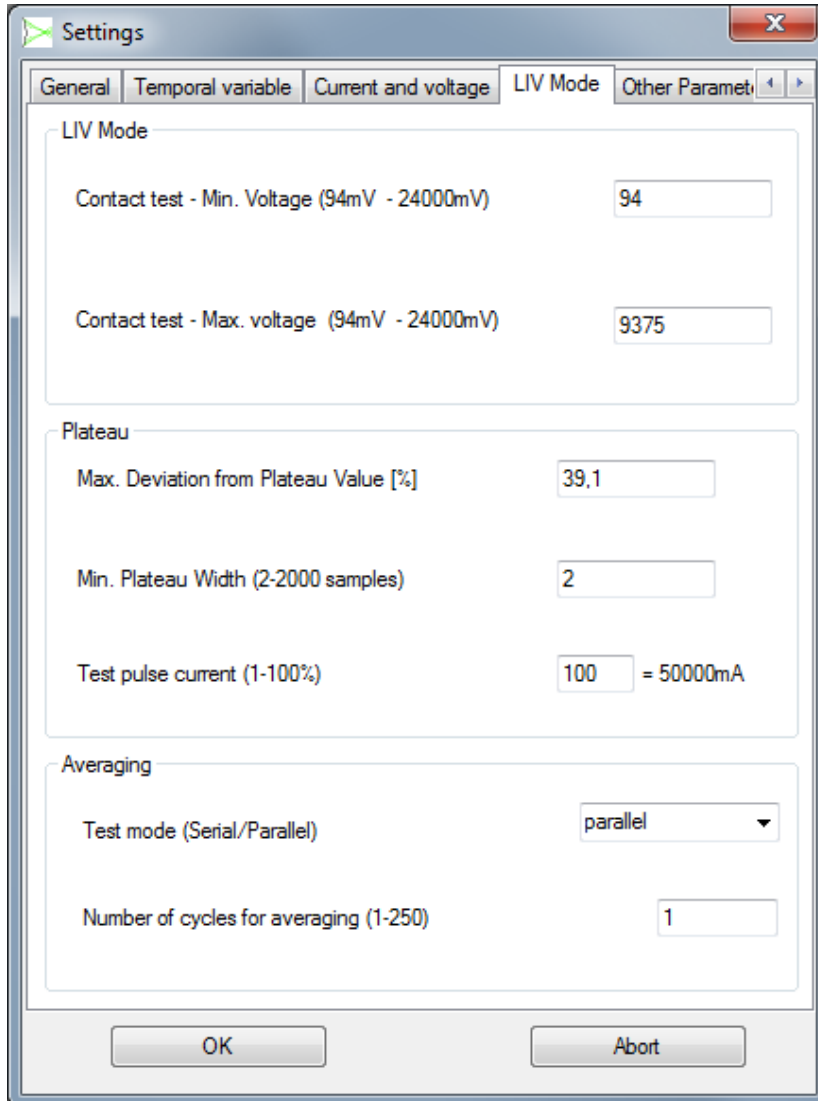
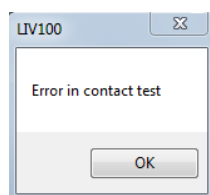


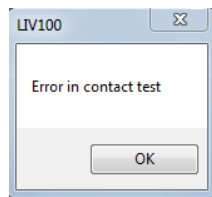
Figure 27: Tab “LIV-Mode”

[Contact test] Before a measurement cycle begins, the LIV100 automatically sets a low current test pulse to check if the DUT has been contacted properly.

Contact Test Min. Voltage: Selects the minimum value of the voltage which must be measured across the DUT during the contact test. If this criterium is not met, the measurement cycle will be aborted and an error message will appear:

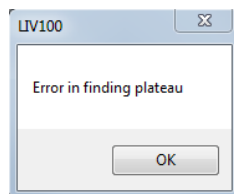


**Contact Test Max. Voltage:** Selects the maximum value of the voltage which must be measured across the DUT during the contact test. If this criterium is not met, the measurement cycle will be aborted and an error message will appear:

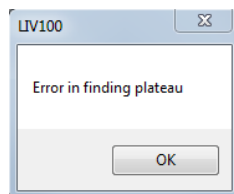


**[Plateau]** The LIV100 employs an intelligent algorithm for selecting the subset of the measured data points which will be used for calculating the final data values. Only those contiguous points which do not deviate by more than the selected value from the average of this data subset are considered valid for further calculations.

**Max. Deviation from Plateau Value [%]:** Selects the maximum deviation of any data point within the valid data subset from the average value of this subset. The range of valid upload values is 1-255 corresponding to 0.4% to 100%. If this criterium cannot be fulfilled, the measurement cycle will be aborted and an error message will appear:



**Plateau Width:** Selects the minimum number of valid, contiguous data points which must appear within the plateau as determined by the parameter “Max. Deviation from Plateau Value”. The valid range of the upload parameter depends on the chosen pulse width, as this affects the total number of samples within the pulse. If this number of data points is not found, the measurement cycle will be aborted and an error message will appear:



**Test pulse current:** Sets the current which will be used for the test pulses to set the gain and for the plateau algorithm. The input is in % of the maximum current setting from the Tab “Current and Voltage” (see pg. 58). The absolute value is then shown to the right of the input field.

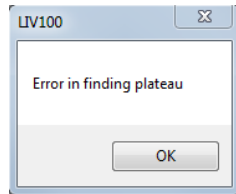
### NOTICE!

**Note that the current strength selected for this test pulse is critical!**



If the maximum current of the sweep is large enough to damage or destroy the laser, then this test pulse may also be strong enough to damage or destroy the laser.

If the plateau determination is successful, the unit will continue with the measurement. If the plateau determination is not successful, the unit will abort the measurement and display the following warning message in a pop-up frame:



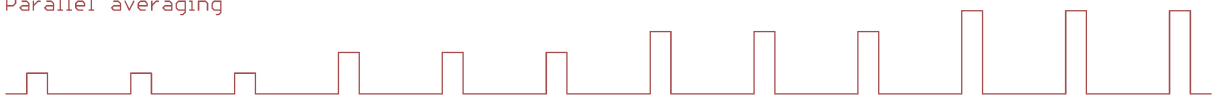
### [Averaging]

Test mode (Serial/Parallel): Selects the order of current stepping for averaging. Serial = sweep current from min. to max. and repeat cycle for averaging. Parallel = pulse min. current for averaging, then set next current and pulse for averaging, etc. up to max. current.

No averaging



Parallel averaging



Serial averaging



Figure 28: Averaging Modes for LIV Sweeps

Number of cycles for averaging: Selects the number of measurement cycles to be averaged in order to calculate one data point. Note that this parameter has a significant effect on the total measurement time as indicated by the “Effective measurement time” return value on the Tab “Temporal”(see pg. 56).

### 9.4.5 Tab “Other Parameters”

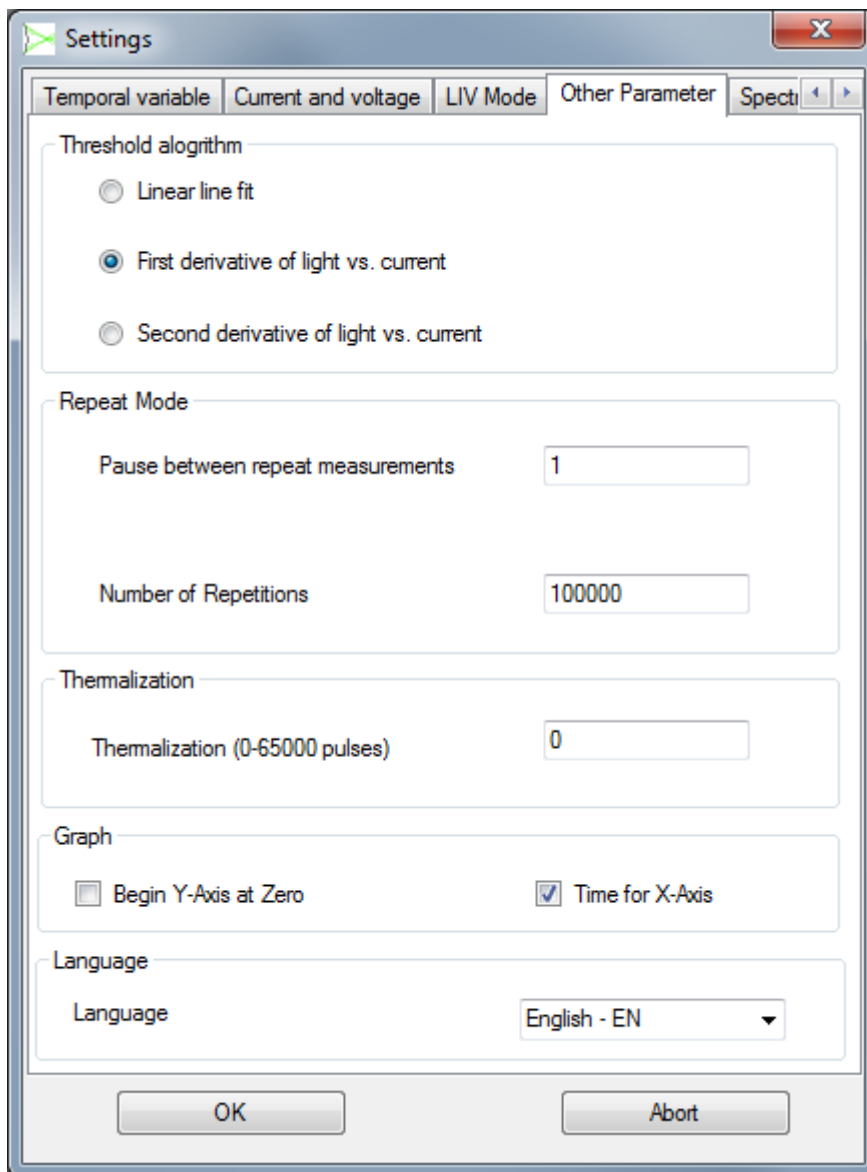


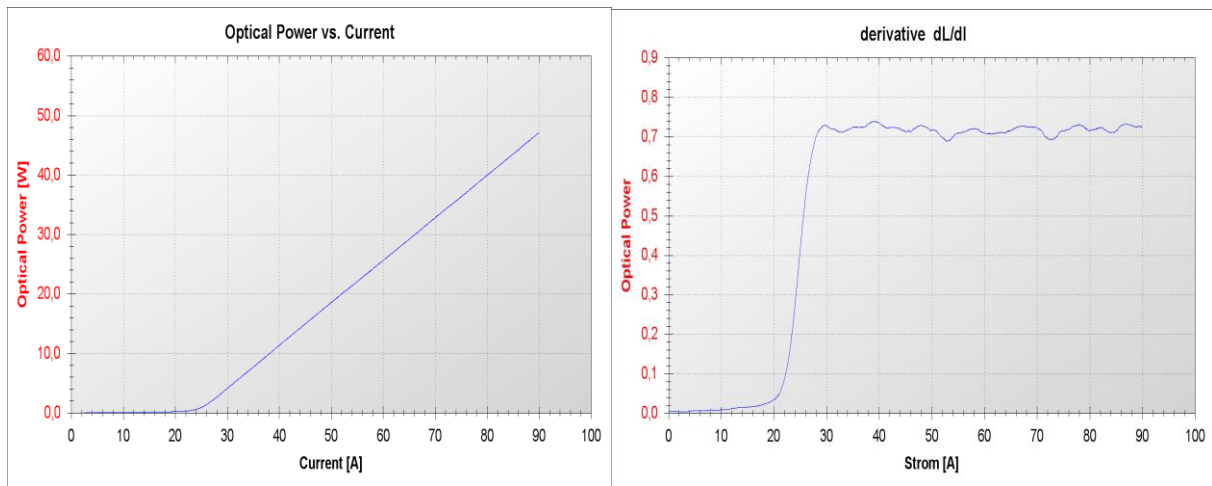
Figure 29: Tab “Other Parameters”

[Threshold algorithm]	Radio buttons to select the algorithm to be used for calculating the threshold. Further information on the choice of algorithm is presented in 9.4.5.1 Threshold Algorithm, pg. 64.
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.
First derivative:	Threshold is determined as the current at which the first derivative of the LI-curve reaches 50% of its maximum value. Note: a minimum of 27 current steps is required to use this algorithm. If less than 27 current steps are selected, the threshold will not be calculated and the corresponding result in the parameter frame is empty.

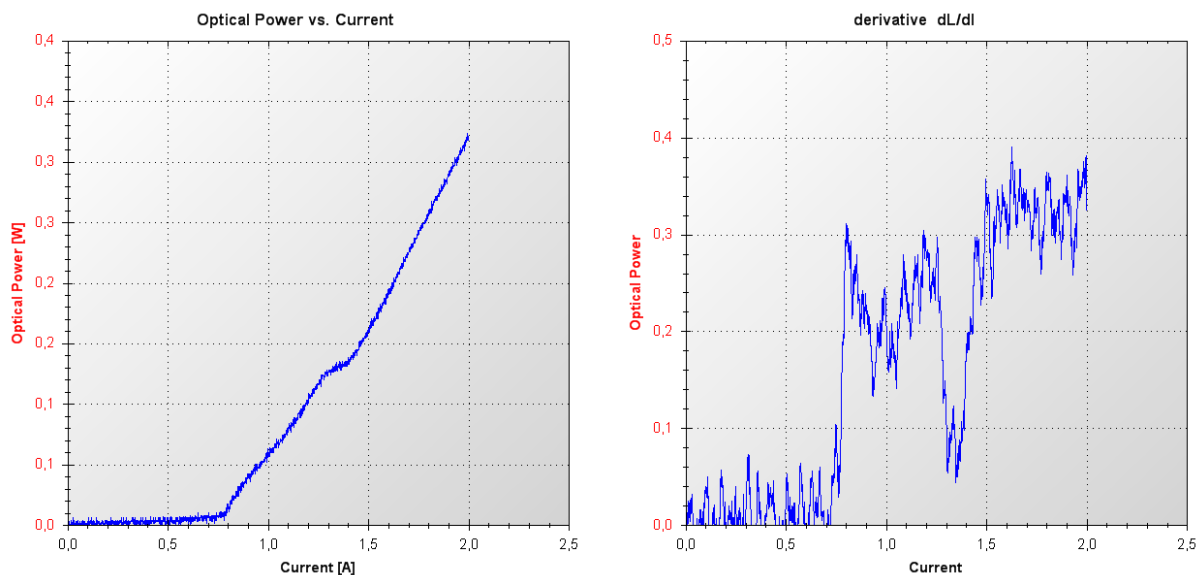
Second derivative:	Threshold is determined as the current at which the second derivative of the LI-curve is a maximum. This is the algorithm recommended by Belcore. Note: a minimum of 27 current steps is required to use this algorithm. If less than 27 current steps are selected, the threshold will not be calculated and the corresponding result in the parameter frame is empty.
[Repeat Mode]	Parameter selection for the repeat mode. The 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 following input fields. This mode is useful when setting up a new system or measurement sequence.
Pause:	Sets the pause (in seconds) between repetitions of the full measurement sequence.
Number:	Sets the number of repetitions.
[Thermalization]	Parameter selection for the thermalization period. When a new current is set, the device under test (DUT) will in general not be in thermal equilibrium anymore. The LIV100 system allows a user programmable minimum delay period to allow thermalization of the DUT. This thermalization period is determined by selecting a number of current cycles to be driven without measurement. Note that each current cycle is defined by the parameters “pulse width” and “pulse separation”. Therefore the temporal value of the thermalization period is determined by these parameters as well. Note that this time may be extremely long and so care should be exercised when choosing a value for this parameter.
Thermalization:	Sets the number of cycles (“Pulse duration” plus “Pulse separation”) to be repeated in order to bring the device under test into thermal equilibrium. The valid range is 0 – 65 000 current cycles.
[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 particularly accurate as it depends largely on the status of the computer being used.
Language:	Pulls down menu to select the language of the GUI.

### 9.4.5.1 Threshold Algorithm

The choice of algorithm has an impact on the accuracy and reproducibility of the determination of the threshold. Belcore recommends use of the second derivative algorithm. However, this algorithm works well only if the LIV sweep involves a large number of current steps and the optical power measurement is noise free. An indication of the noise of the optical power measurement may be obtained from the “Kinks” frame which is a graph of the derivative of the optical power with respect to current ( $dL/dI$ ). If the power level is a reasonable fraction of the rated level of the optical power measurement channel and the laser is in good condition, then the L-I curve should be clean and free of kinks. This situation is required for sensible use of the second derivative threshold algorithm, an example of which is shown here.



If the laser power is too low for the system or the laser is defective, the L-I curve will be noisy and possibly kinked. This situation is not suitable for use of the second derivative threshold algorithm.

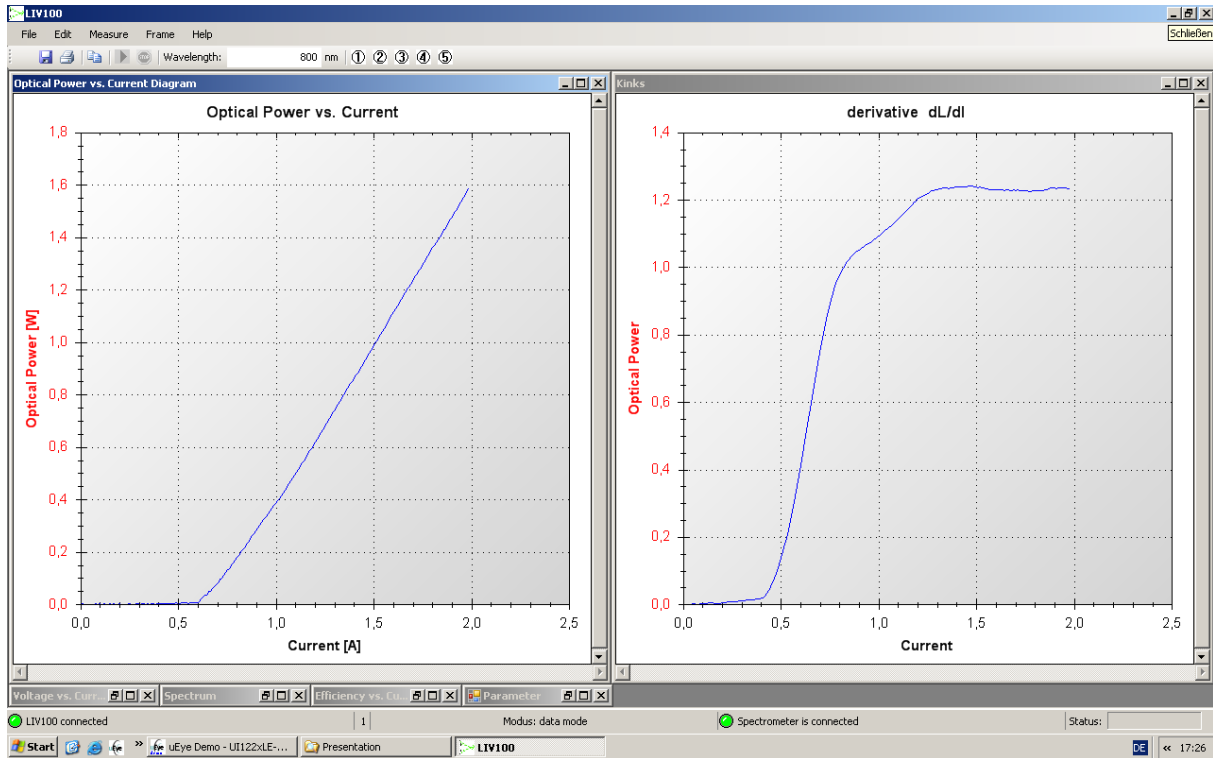


Even in the case that the L-I curve is clean and kink free, if the number of current steps is low then the second derivative algorithm will result in poor reproducibility of the threshold measurement. This is because the second derivative of a function is inherently noisier than the



first derivative. In such cases, the first derivative algorithm may be chosen. In either case, when using the first or second derivative algorithms, the results will be more reliable if averaging is used Tab “LIV-Mode” (see, pg. 59).

The linear line fit will produce results under all conditions. However, this algorithm is the least reliable. This is because any curvature of the L-I curve will result in an error in the determination of the threshold. Such curvature can occur if the laser is heated during operation or if the laser shows a slope dip just after threshold as in the following figure. In this case, the linear line fit will be inaccurate, whereas the first derivative or second derivative algorithms will generate reproducible results.



### 9.4.6 Tab “Spectrometer”

The LIV100-CW supports the integration of a diode array spectrometer. This is not a universal support option, but rather is limited to use of compatible devices provided by Artifex Engineering. If these auxiliary instruments are connected to USB ports on the same control computer as the GUI is running, they may be controlled by the GUI through selection of the parameters on this tab.

In order to control these devices, they must be activated by selecting the appropriate check box on this tab. This also modifies the status bar to include the status of these devices.

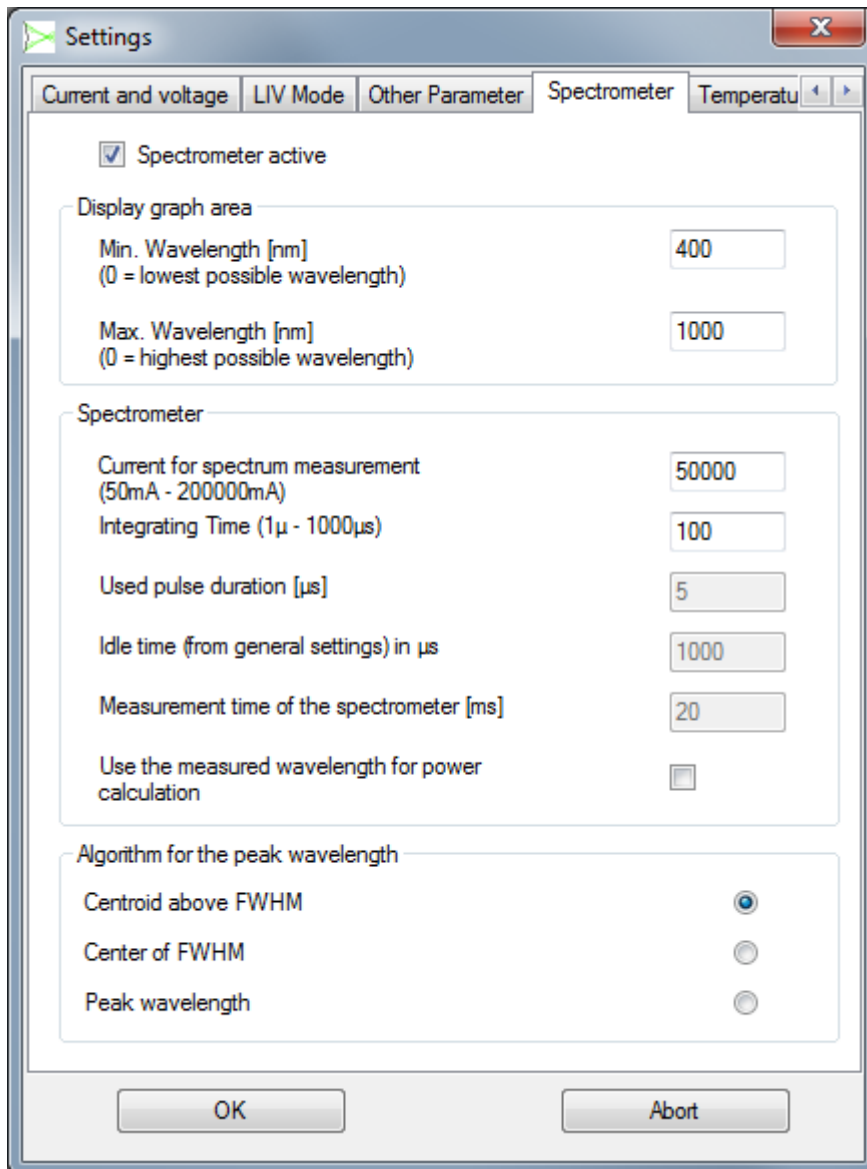
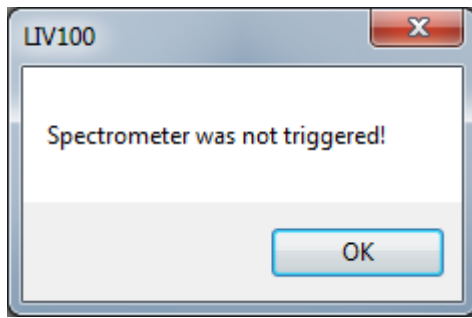


Figure 30: Tab “Spectrometer”

**Spectrometer active:** Radio button to activate control of the spectrometer via the GUI. The spectrometer must be connected to a USB port on the same computer as the LIV100 is running on. The spectrometer control port must be connected to the “Trigger Out” BNC receptacle of the LIV100 via the cable provided with the unit. If a measurement is attempted without the spectrometer connected to the trigger receptacle, a pop-up frame will appear as follows:



Further external instruments may also be connected to the trigger receptacle as long as they all share the same common ground.

The spectral measurement takes place during a current pulsing sequence which is performed in the style of a burst mode sequence: the current is pulsed at the current selected by the parameter “Current for spectrum” on this tab with the same pulse width and duration as selected on the Tab “Temporal”(pg. 56). This sequence takes place prior to the measurement sequence selected (LIV, scope or burst). All of the test pulses relevant to the burst mode are performed prior to the spectral measurement.

[Spectrometer]

**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.

**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.

#### **NOTICE!**



#### **The current strength selected for this measurement is critical!**

The current used for the spectral measurement may be large enough to damage or destroy the laser. 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, scope sweep or burst.

**Current for spectrum:** Sets the current to be generated during the burst period used to collect spectral data. This input does not affect the maximum current selected on the “Current and Voltage” tab.

#### **NOTICE!**



#### **The integration time selected for this measurement is critical!**

The burst mode used for the spectral measurement may be long enough to damage or destroy the laser through undue heating.

**Integrating Time:** Sets the effective integration time of the spectrometer by forcing the system to drive the device under test for a number of cycles (“pulse duration” plus “pulse separation”) until the duration during which current is driven is equal to the selected “Integration time”. It is not possible *a priori* to determine the

optimum integration time. It should be determined empirically for a given laser type and settings of maximum current, pulse duration and pulse separation. From a point of signal-to-noise ratio, it is best to choose a setting which will give a maximum signal at about 50-80% of saturation of the spectrometer (ie: 8 000 to 13 000 counts).

Used pulse duration: Indicates the setting of the “Pulse duration” in [ $\mu$ s] from the Tab “Temporal”(pg. 56). This is for information only to aid in setting up the spectrometer integration time. This is a non-editable field.

Idle time: Indicates the setting of the “Pulse separation” in [ $\mu$ s] from the Tab “Temporal”(pg. 56). This is for information only to aid in setting up the spectrometer integration time. This is a non-editable field.

Measurement time of the spectrometer: Indicates the calculated total measurement time (real time) of the spectrometer. This is for information only to aid in setting up the spectrometer integration time.

Use the measured wavelength...: Radio button. When active, the software will use the result of the spectral measurement to automatically select the wavelength for power calibration. This overrides any manual input in that respective field in the tool bar on the main graphical interface.

[Algorithm for the peak wavelength]      Radio buttons to select algorithm

Centroid above FWHM      Calculates the centroid (weighted average) of the spectral data. Only those data points which are within the calculated FWHM are used for this calculation.

Center of FWHM      Calculates the centre (mean) of the spectral data. Only those data points which are within the calculated FWHM are used for this calculation.

Peak wavelength      Finds the wavelength for the maximum measured power in the spectrum.

### 9.4.7 Tab “Temperature Control”

The LIV100-CW supports the integration of a TEC driver. This is not a universal support option, but rather is limited to use of devices manufactured by Artifex Engineering. If these auxiliary instruments are connected to USB ports on the same control computer as the GUI is running, they may be controlled by the GUI through selection of the parameters on this tab.

In order to control these devices, they must be activated by selecting the appropriate check box on this tab. This also modifies the status bar to include the status of these devices.

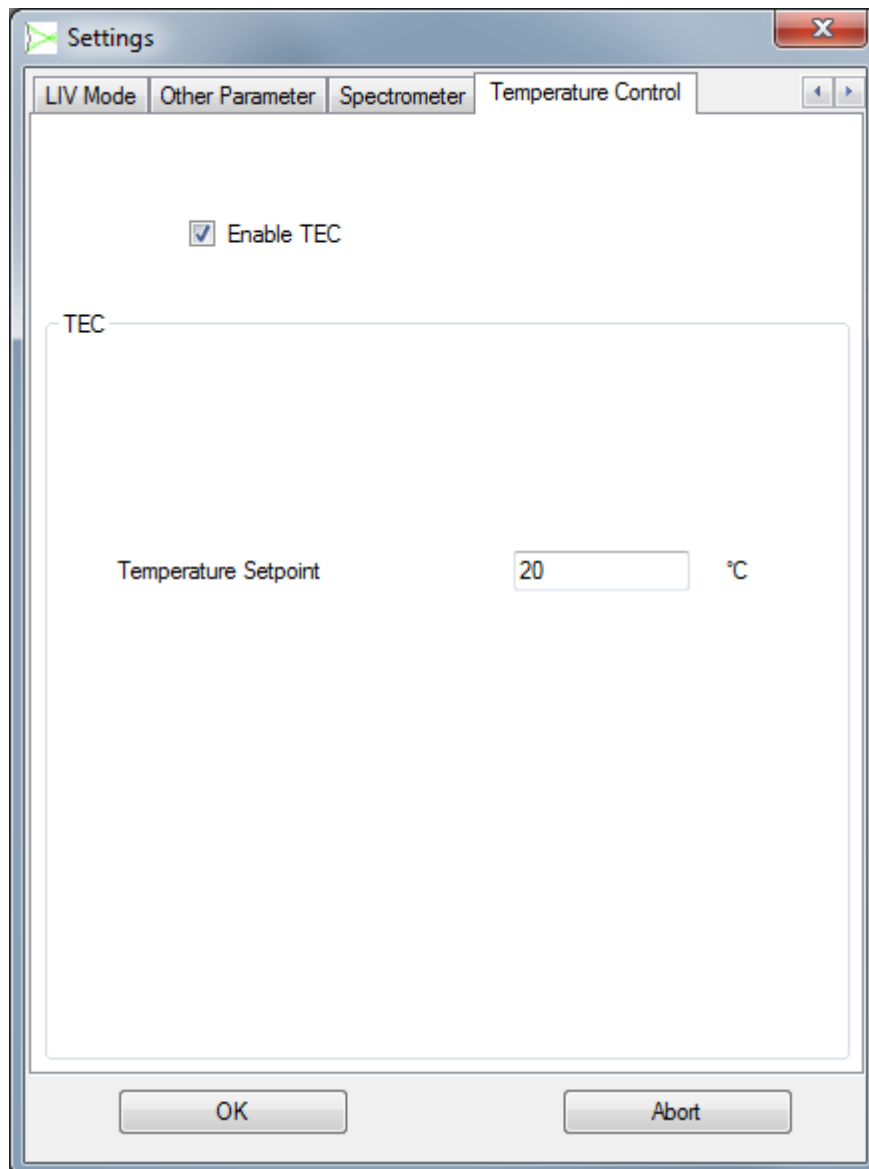


Figure 31: Tab “Temperature Control”

**Enable TEC:** Radio button to activate control of the TEC driver via the GUI. The TEC driver must be connected to a USB port on the same computer as the LIV100 is running on.

[TEC]

When the TEC control is enabled, the following menu becomes activated.

**Temperature Setpoint:** Sets the desired temperature of the device mounting plate.

## 9.5 Data Formats

### 9.5.1 The \*.liv Format

The \*.liv format is used for storage of measurement data in a binary form and is specific for this application. The data in these files can only be viewed with the LIV100 graphical software and cannot be displayed in other programmes.

### 9.5.2 The \*.wbd Format

The \*.wbd file contains the setup parameters for a measurement sequence. These files are useful for repeated setup of different sequences for different devices or applications.

#### NOTICE!



#### The correct choice of \*.wbd file for a measurement is critical!

If an incorrect settings file (\*.wbd format) is chosen, the device under test may be subjected to currents, pulse durations or duty cycles beyond the safe operating conditions of that DUT. This may lead to damage or destruction of the DUT.

### 9.5.3 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<sup>®</sup>. Each file comprises a header containing archiving information followed by the data columns. The header information is as follows:

Date (including time = computer internal clock time)

Operator (as input in the tool bar)

Device (as input in the tool bar)

Current (in “Burst” mode only, as here the current is constant)

The data set is comprised of columns arranged as follows. The wavelength and spectral data are only included if a spectrometer is connected and activated.

LIV mode:

Sample No.	Voltage [V]	Set Current [A]	Measured Current [A]	Optical Power [W]	Wavelength [nm]	Spectrum [counts]
------------	----------------	--------------------	----------------------------	-------------------------	--------------------	----------------------

Scope mode:

Sample No.	Voltage [V]	Measured Current [A]	Optical Power [W]	Wavelength [nm]	Spectrum [counts]
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Burst mode:

Sample No.	Optical Power [W]	Wavelength [nm]	Spectrum [counts]
------------	----------------------	--------------------	----------------------

<sup>®</sup> Excel is a registered trade mark of the Microsoft Corporation.

### 9.5.4 The \*pdf Format

A pdf-format report for archiving or use as a data sheet can be produced in any mode. An example is given below. When purchasing an LIV100, the user may provide Artifex Engineering with a suitable logo file to be used in this report instead of the logo shown:

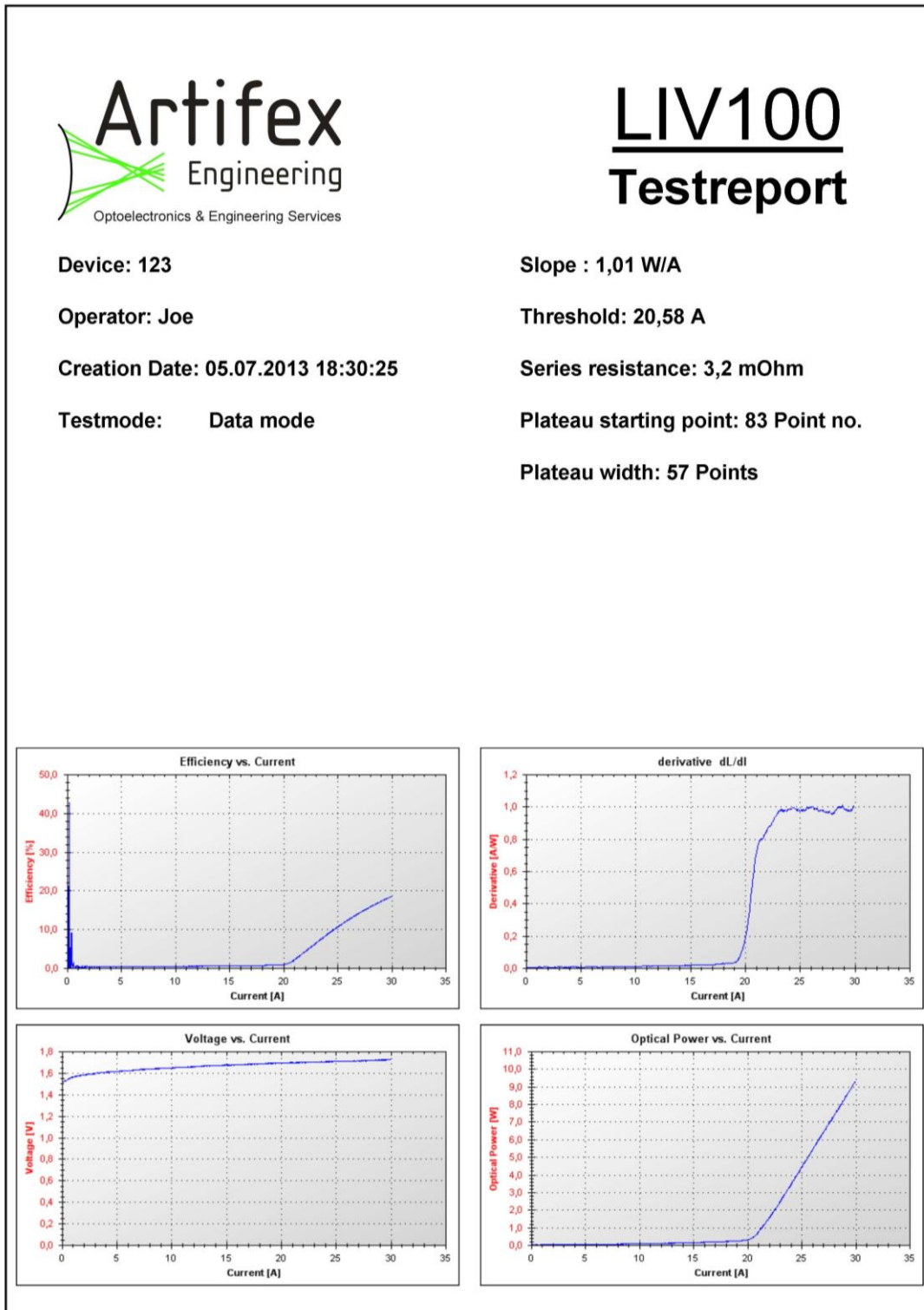


Figure 32: Example Test Report in LIV Mode

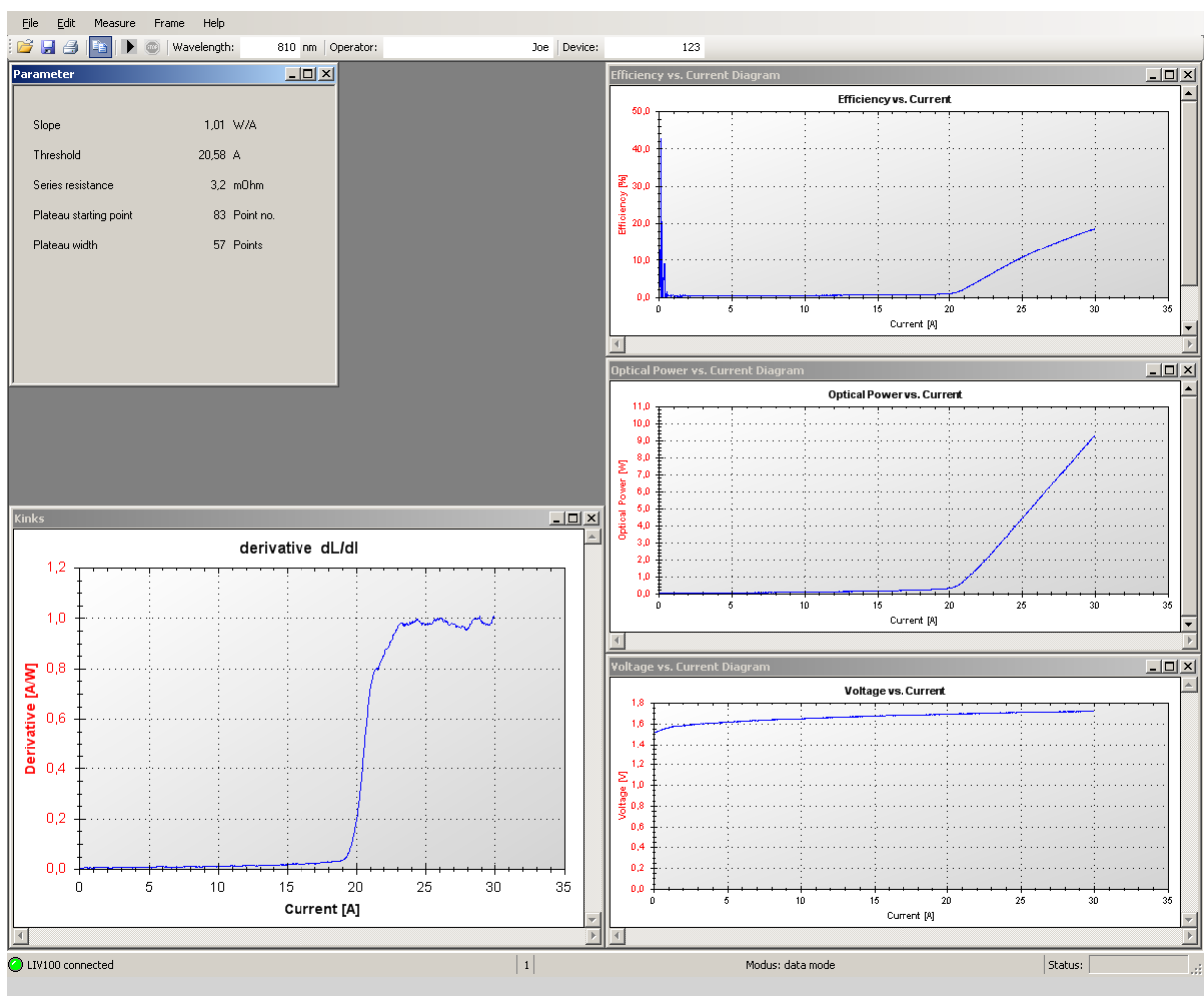
## 9.6 The Graphs

The LIV100 GUI displays the measurement results in graphical format for ease of interpretation.

The frames available for display are described in the following subsections.

### 9.6.1 Graphs in LIV Mode

A full screen in LIV mode may appear as follows. The graphs may be freely scaled and arranged within the main frame. The “Frame” pull-down menu provides selection fields to individually select frames, or all frames at once. Three automatic frame arrangements are also available in the “Frame” pull-down menu: arrange horizontally, vertically or cascaded.



A pdf-format report for archiving can be produced in any mode. An example is shown under 9.5.4 The \*pdf Format, pg. 71.



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.

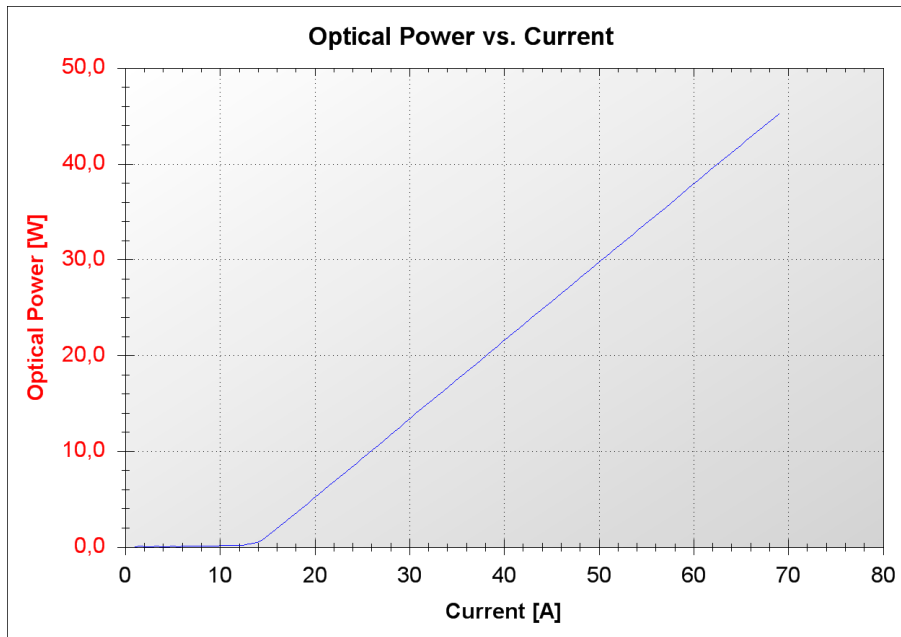


Figure 33: Optical Power vs. Current Graph

The laser voltage graph is useful to check for proper contacting and functionality of the laser diode.

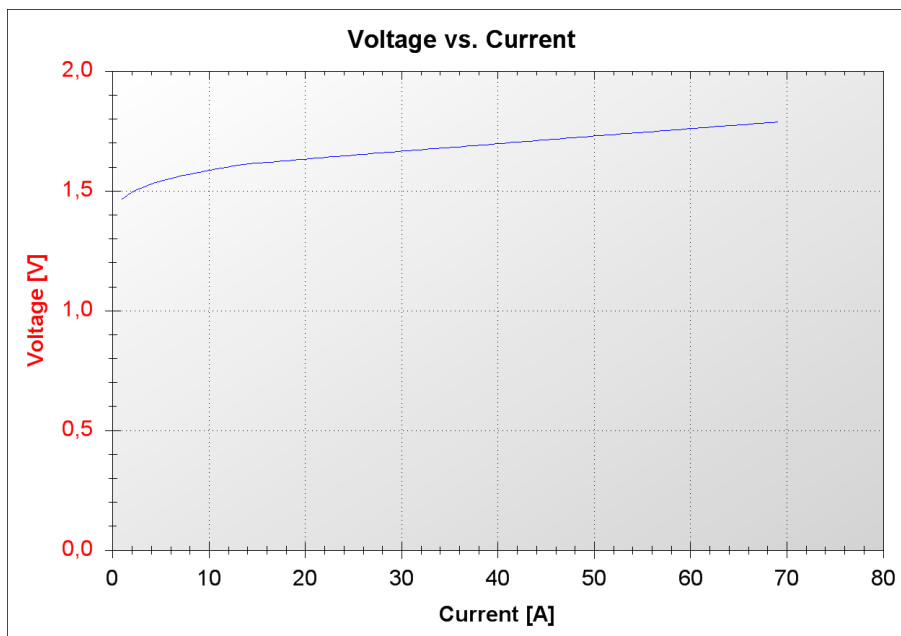


Figure 34: Voltage vs. Current Graph

The LIV100 card connector receptacle provides separate connectors for the current output and the voltage input to allow a proper 4-point connection of the DUT. A 4-point connection ensures that the voltage measurement gives a true indication of the voltage drop across the DUT. However, in most practical cases, it is difficult or impossible to actually implement a 4-

point contact on the DUT itself. The Artifex Engineering needle cards have provision for separate current and voltage contacts. When used together with our standard vacuum chuck, the voltage and current return paths are both connected to the vacuum chuck resulting in a three point contact scheme. When using the standard full bar stripline contact card, only a 2-point contact can be realized because the p-side of the bar is covered by the strip contact.

Thus, in most practical cases the voltage measurement will include the voltage drop across the DUT as well as the ohmic voltage drop corresponding to one or two contact sides. Typically these contact resistances will lie in the mΩ range leading to errors of some mV per Amp of drive current. The contact resistance depends on the size and form of the contact as well as the pressure used for contacting.

The efficiency as defined here is the ratio of the optical output power to the input electrical

power:  $\frac{P_{optical}}{(V_{laser} \bullet I_{laser})}$ , otherwise known as “wall plug efficiency”.

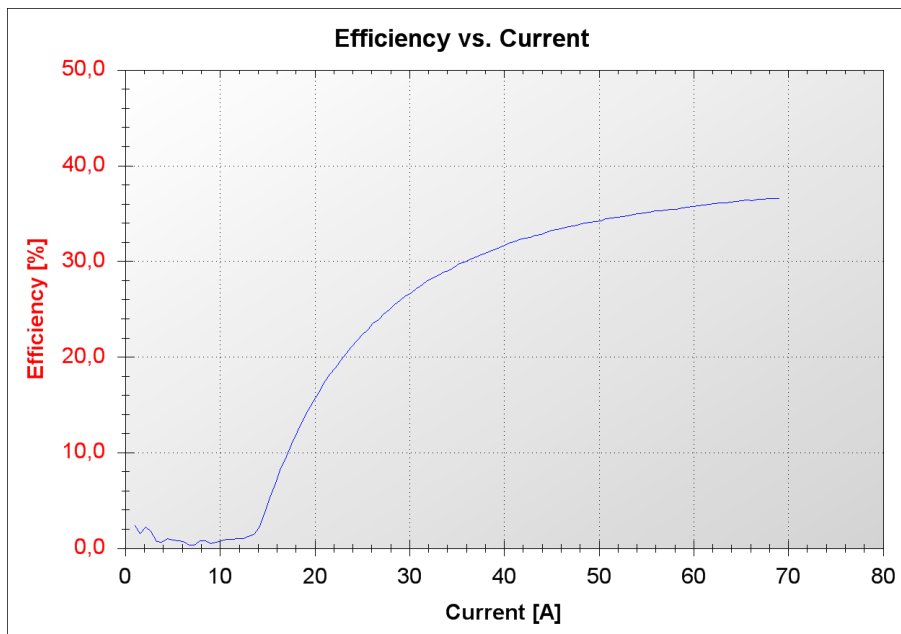


Figure 35: Efficiency vs. Current Graph

The derivative of optical power with respect to current,  $dL/dI$  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.

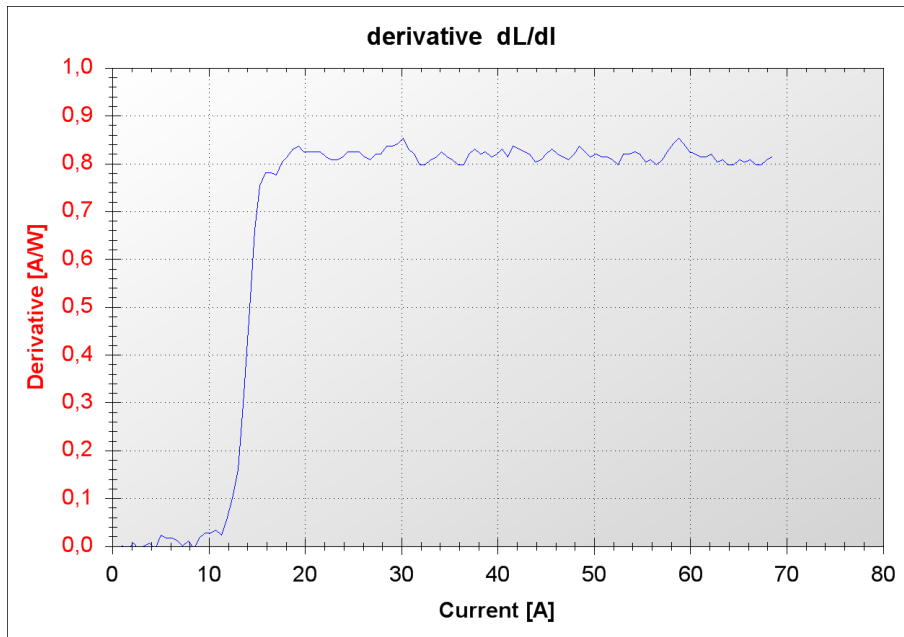


Figure 36: Derivative Graph

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

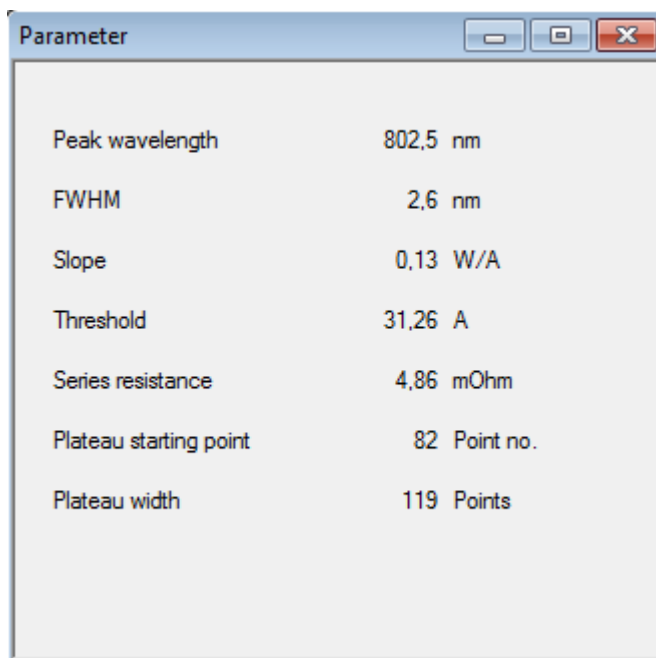


Figure 37: Parameter Window

**Peak wavelength** This value appears only when a spectrometer is connected and activated. The peak wavelength is assigned to the maximum value point in the measured spectrum.

**FWHM** Full Width at Half Maximum. This value appears only when a spectrometer is connected and activated. This is a standard calculation showing the width of the main spectral peak within the measured

	spectrum. The value shown is the difference of the the two data points nearest, but above, the half-maximum values on either side of the spectral peak.
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. See Tab “Other Parameters”, pg. 62.
Series resistance	The series resistance is the dynamic resistance of the laser diode. This is calculated as the slope of the V-I curve between the current at which the optical power is 10% and 90% respectively of the maximum measured optical power.
Plateau starting point	This value indicates the number of the data point at the beginning of the plateau region which was automatically determined for the evaluation of the data for each pulse. See 10.2.8 Plateau algorithm, pg. 86 for details.
Plateau width	This value indicates the number of the data points within the plateau region which was automatically determined for the evaluation of the data for each pulse. See 10.2.8 Plateau algorithm, pg. 86 for details.

## 9.6.2 Graphs in Scope Modes (pulsed and CW)

In the pulsed and CW scope modes, the output current, laser power, and voltage drop across the laser are displayed as a function of samples (time).

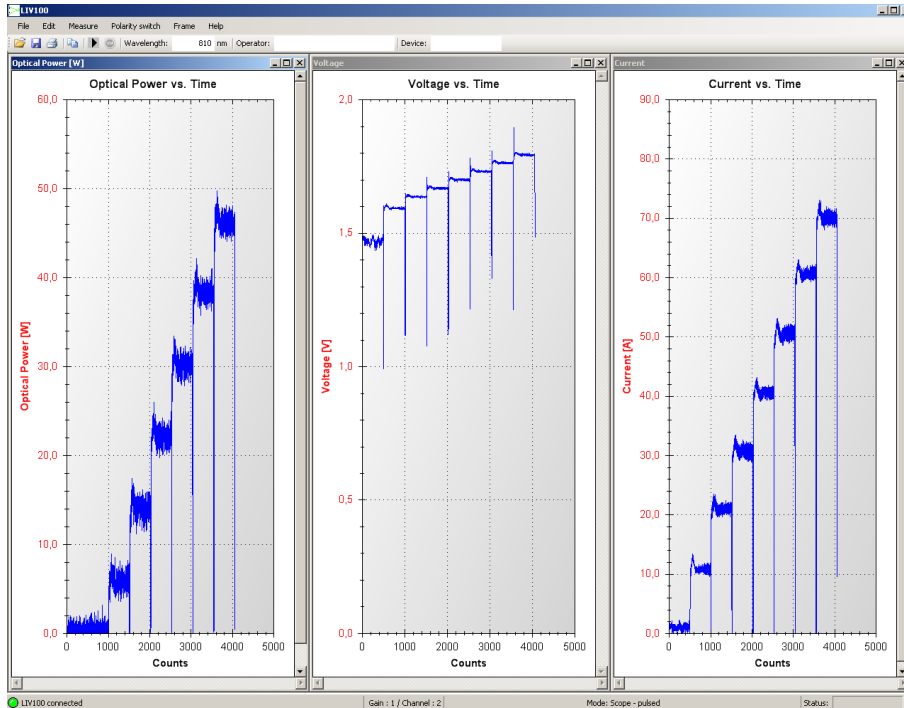


Figure 38: Scope (pulsed) Mode Graphs

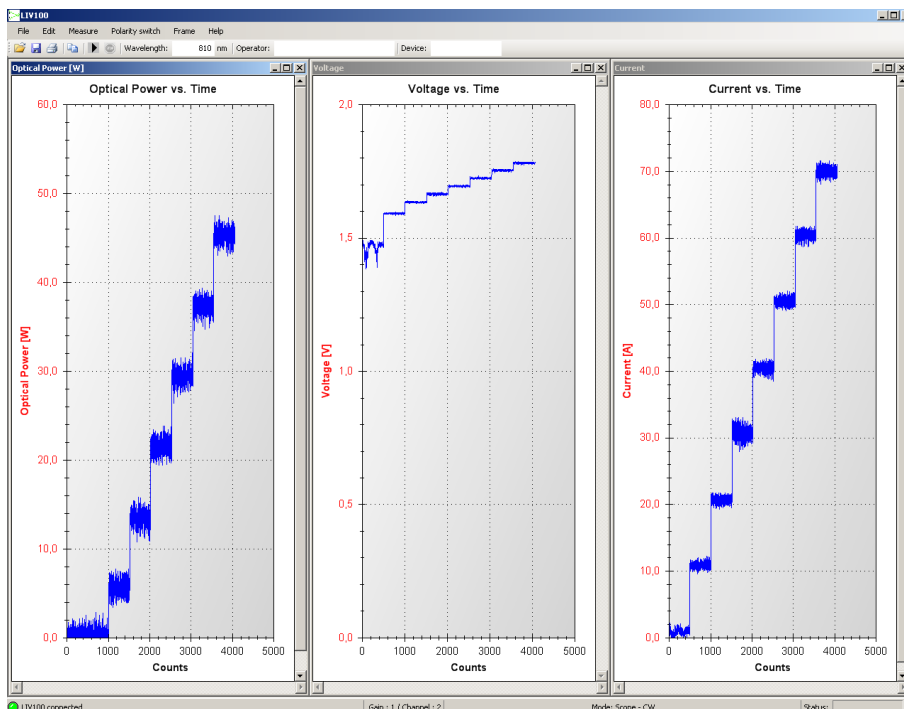


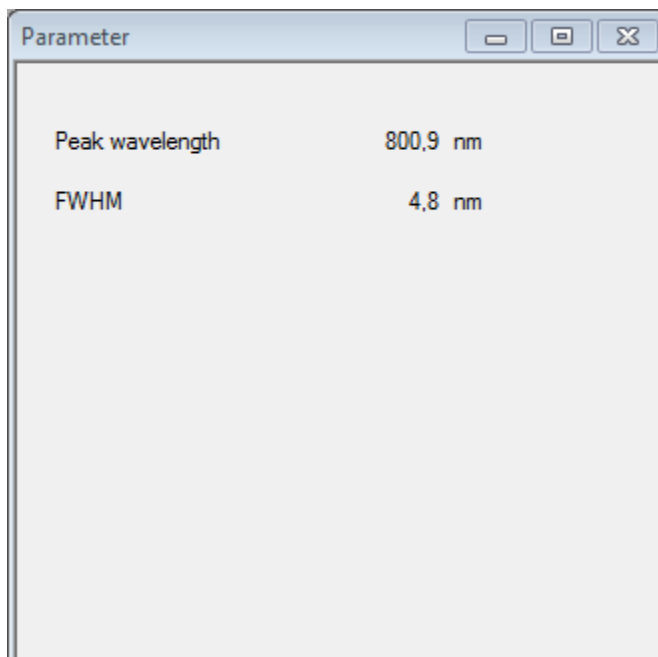
Figure 39: Scope (CW) Mode Graphs

These graphs display the raw sampled data of each pulse, omitting the information during the “pulse separation” periods which is not acquired by the system. This representation is useful to ensure that a setup is working properly and that the device under test is well contacted and showing acceptable behaviour.

Strong peaking in the current or optical outputs, oscillations, unexpectedly long rise times or sudden degradation in output may be indicators that the setup is not correct or that the device under test is defective. In this case, the system should be analysed before proceeding with LIV sweeps.

Strong peaks in the voltage graphs in pulsed mode are normal, especially at high currents. This is due to the fact that the device under test has some natural self inductance ( $L$ ) which opposes the sharp rise in current during the pulse transient. The voltage therefore peaks during this time according to  $V = L \cdot dI/dt$ .

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



**Peak wavelength** This value appears only when a spectrometer is connected and activated. The peak wavelength is assigned to the maximum value point in the measured spectrum.

**FWHM** Full Width at Half Maximum. This value appears only when a spectrometer is connected and activated. This is a standard calculation showing the width of the main spectral peak within the measured spectrum. The value shown is the difference of the the two data points nearest, but above, the half-maximum values on either side of the spectral peak.

### 9.6.3 Graphs in Burst and CW Modes (pulsed and CW)

In the burst and CW modes, only the laser power as a function of samples (time) is documented. The system generates pulses and samples one single value for the optical power near the end of each pulse.

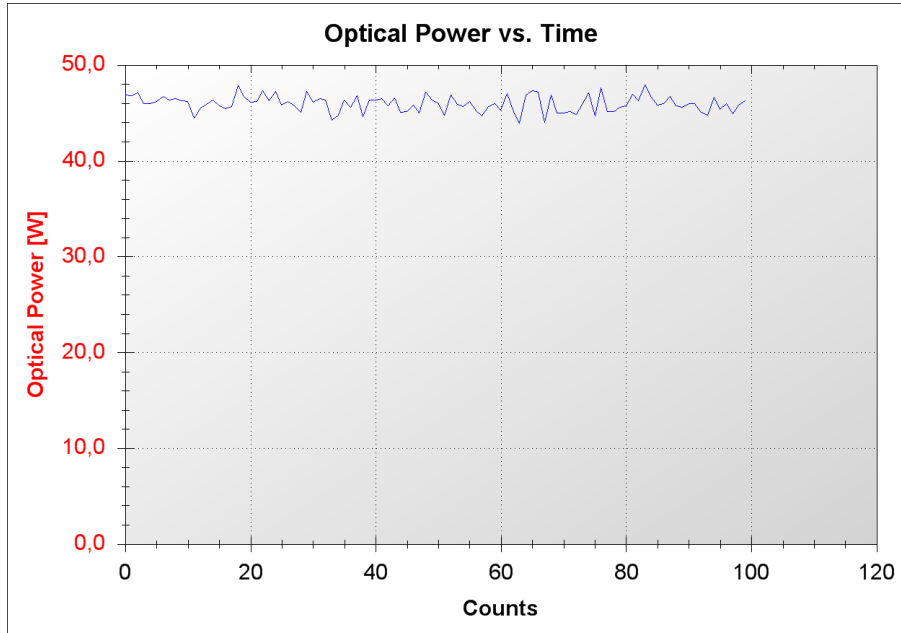


Figure 40: Optical Power vs. Time Graph

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

Parameter	
Peak wavelength	800,9 nm
FWHM	4,8 nm
Minimum power	1,64 W
Maximum power	1,72 W
Average power	1,68 W
Standard deviation	0,015 W

Peak wavelength

This value appears only when a spectrometer is connected and activated. The peak wavelength is assigned to the maximum value point in the measured spectrum.

---

FWHM	Full Width at Half Maximum. This value appears only when a spectrometer is connected and activated. This is a standard calculation showing the width of the main spectral peak within the measured spectrum. The value shown is the difference of the the two data points nearest, but above, the half-maximum values on either side of the spectral peak.
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.

#### 9.6.4 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:

X=5550mA Y=1,9W

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

#### 9.6.5 The Context Menü

The context menu is opened by a right click within the graph frame.

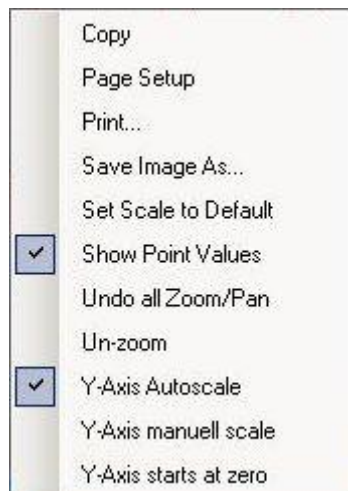


Figure 41: Graph Context Menu



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 Autoscale	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 autoscaling.
Y-Axis starts at zero	Fixes the lower limit of the Y-axis to zero. This setting remains active in autoscaling mode, in which case only the upper limit is automatically rescaled.

## 10 Communication

The communication with the LIV100CW 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”).

### 10.1 Communication Protocol

Baud rate: 1 000 000 bit/s

Data bits: 8

Parity: none

Stop bits: 1

Flow control: Hardware

### 10.2 Parameter Upload

A complete parameter set must be uploaded to the LIV100CW 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 @p, 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 \$p 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 6 and Table 7 on page 99.

Table 3: Upload Parameters in the Order of Transmission

Byte No.	Name	Range of Validity	Description and Calculations
1	Sampling rate	1 - 20	1 => 20MS/s ... 20 => 1MS/s
2	Number of samples (High Byte)	1 – 2,000	50ns ... 100µs (at 20MS/s)
3	Number of samples (Low Byte)		1µs ... 2,000µs (at 1MS/s)
4	Pulse separation (High Byte)	1 – 10,000	50µs ... 500ms (scope and LIV)
5	Pulse separation (Low Byte)		1-10,000x pulse duration (burst)
6	Number of burst pulses (High Byte)	1 – 131,072	
7	Number of burst pulses (Middle Byte)		
8	Number of burst pulses (Low Byte)		
9	Minimum current (High Byte)	1 – 4,000	$\frac{I_{\max}}{4000} \dots I_{\max}$
10	Minimum Current (Low Byte)		
11	Maximum Current (High Byte)	1 – 4,000	See “Minimum Current”
12	Maximum Current (Low Byte)		
13	Current step for sweeps (High Byte)	1 – 4,000	See “Minimum Current”
14	Current step for sweeps (Low Byte)		
15	Number of Averages	1 - 250	
16	Averaging Modus	0 – 1	0: Parallel Mode 1: Serial Mode
17	Function Selection	0 – 2	0: LIV mode 1: Scope mode 2: Burst mode
18	Contact Test – Minimum valid voltage	1 – 255	0.094V ... 24V
19	Contact Test – Maximum valid voltage	1 – 255	0.094V ... 24V
20	Plateau algorithm: tolerance range [%]	1 – 255	0.4% ... 100% of average value determined
21	Plateau algorithm: minimum width (High Byte)	2– 2,000	Minimum number of contiguous valid data samples
22	Plateau algorithm: minimum width (Low Byte)		
23	Current of Plateau Test Pulse	1 -100	% of maximum current
24	Thermalization cycles (High Byte)	1 – 65,000	Number of pulses
25	Thermalization cycles (Low Byte)		

### 10.2.1 Sampling rate and number of samples

The pulse width depends on the sampling rate and the number of samples per pulse. The sampling rate is set in units of MS/s (millions of samples per second). The maximum sampling rate is 20MS/s which corresponds to 50ns per sample. The minimum sampling rate is 1MS/s corresponding to 1µs per sample.

The upload parameter is a divisor for the base sampling rate of 20MS/s in order to slow the sampling rate as required. Thus sampling rate = (20MS/s)/(sampling rate parameter) as shown in the following table:

Table 4: Correlation of sampling parameter to sampling rate and period

Upload Parameter	Sampling rate [MS/s]	Sampling period [ns]	Upload Parameter	Sampling rate [MS/s]	Sampling period [ns]
1	20.00	50	11	1.82	550
2	10.00	100	12	1.67	600
3	6.66	150	13	1.53	650
4	5.00	200	14	1.42	700
5	4.00	250	15	1.33	750
6	3.33	300	16	1.25	800
7	2.86	350	17	1.18	850
8	2.50	400	18	1.11	900
9	2.22	450	19	1.05	950
10	2.00	500	20	1.00	1000

The parameter „Number of samples“ sets the number of samples which will be measured for each pulse. This value together with the sampling period selected above determine the pulse duration.

For example, 10 samples at 50ns sampling period results in a pulse duration of 500ns. For a given pulse duration, several combinations of sampling period and number of samples may generally be found.

### 10.2.2 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 50µs. The maximum pulse separation is 50ms (10,000 x 50µs).

### 10.2.3 Number of burst pulses

This parameter sets the number of pulses to be generated in burst mode. In this mode, only one sample is taken for each pulse. 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 131,072 pulses.

#### **10.2.4 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 LIV100-L120 can drive a maximum current of 120A (= upload parameter value 4,000). The resolution of the driver is therefore (max. current)/4,000. For the LIV100-L120 this would be 0.03A (=30mA).

The same principle applies for the current step. Therefore a step parameter of 100 uploaded to the LIV100-L120 would create current steps of 3.0A difference.

In the “scope” and “LIV” modes, 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 maximum chosen current is set for all pulses. Thus the minimum current and step size are irrelevant in this mode and the corresponding input fields on the settings tab are greyed out.

#### **10.2.5 Averaging**

Two modes of averaging are supported. In „parallel“ mode (upload value 0) each current is repeated the chosen number of times for averaging before the next current is set. In „serial“ mode (upload value 1) each current „staircase“ is fully completed and then repeated the chosen number of times for averaging.

The valid range for the averaging parameter is 1-250.

#### **10.2.6 Operational modes**

Three operational modes are supported.

The upload value 0 selects the LIV mode. The samples of each pulse are averaged to produce one data point on the characteristic LIV curves.

The upload value 1 selects the scope mode. In this mode each data sample is stored to allow the user to analyze the pulse forms. This mode is useful for setting up an experiment or for debugging.

The upload value 2 selects the burst mode. In this mode, only one current value is set. The driver pulses this current the selected number of times. One data sample is measured for each optical pulse. The voltage and current measurement channels are not sampled in this mode.

#### **10.2.7 Contact test**

The contact test detects defective or insufficiently contacted lasers before the full measurement routine is performed. The user selects the valid voltage range for the diode. The upload value is in the range 1 to 255 which results in a resolution of 96mV. For example, if the voltage across the laser diode should be within the range 1.8 to 2.1V, the user should upload the values 19 (minimum; results in 1.79V) and 22 (maximum; results in 2.07V).

The contact test is only run in the LIV mode.

### 10.2.8 Plateau algorithm

A plateau algorithm runs internally to select the appropriate sample data of each pulse in the LIV mode. To this end, the user inputs the parameters “maximum deviation from plateau” and “minimum plateau width”.

The maximum deviation from plateau is the maximum value that any of the selected data samples is allowed to deviate from the average value of the whole plateau. The range of valid upload values is 1-255 corresponding to 0.4% to 100%.

The minimum plateau width determines the minimum number of consecutive data samples which must be within the maximum deviation value from the plateau average. The valid range of the upload parameter depends on the chosen pulse width, as this affects the total number of samples within the pulse. An error message is fed back if the uploaded value of minimum plateau width is larger than the total pulse width.

### 10.2.9 Current of Plateau Test Pulse

The determination of the plateau range using the algorithm described above is applied to one single test pulse before the LIV sweep begins. The duration of the test pulse is the same as that chosen for the LIV sweep. The test current is set by the user via an upload parameter with valid range 1-100. This value represents the percent of the maximum current of the LIV sweep. For example, if the sweep is 30mA – 120A and the test pulse is set at 70%, then the test pulse will be 84A.

#### **NOTICE!**



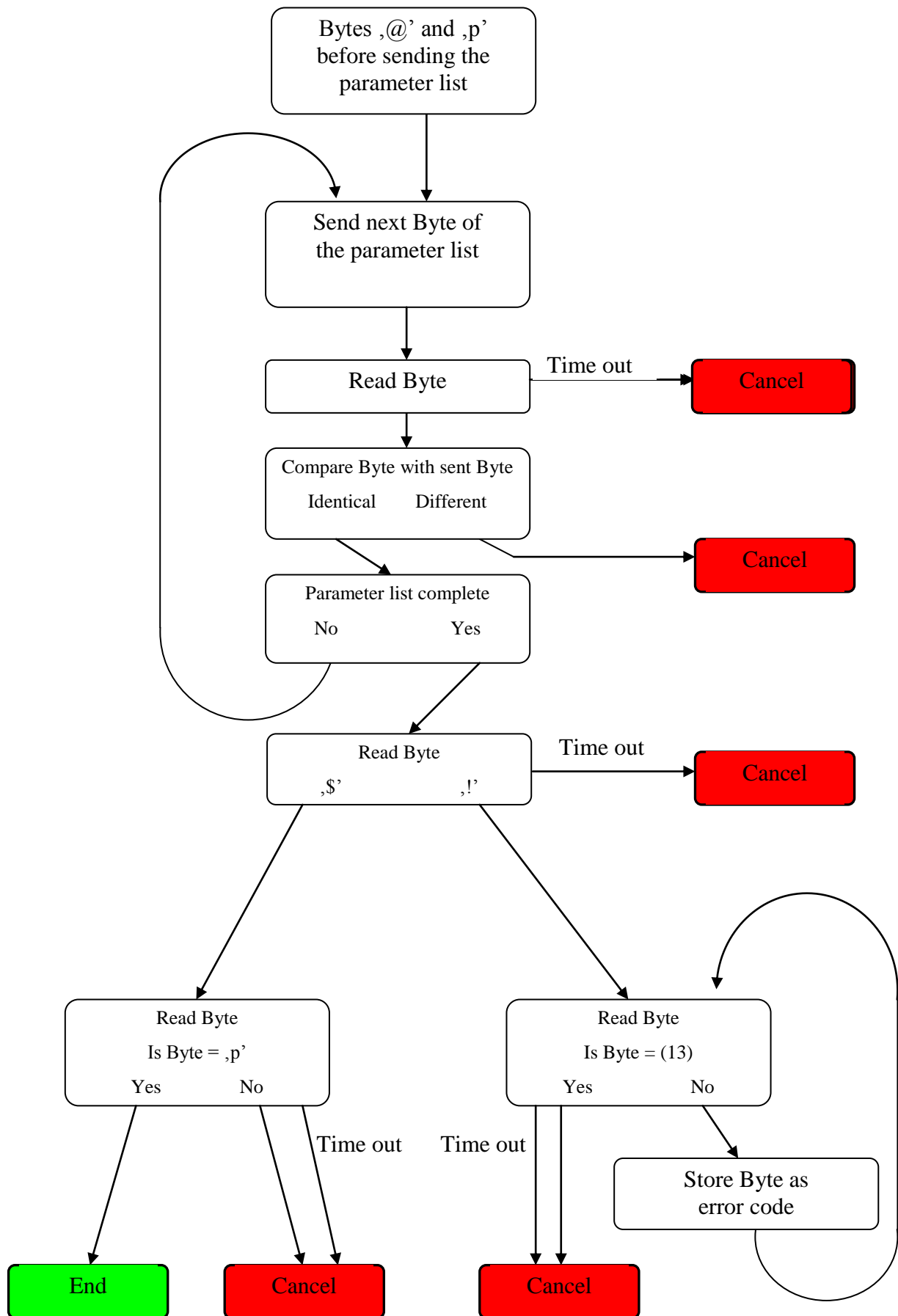
#### **Note that the current strength selected for this test pulse is critical!**

If the maximum current of the sweep is large enough to damage or destroy the laser, then this test pulse may also be strong enough to damage or destroy the laser.

### 10.2.10 Thermalization

The LIV100 provides for a thermalization of the device under test during the LIV sweep. This involves pulsing the device a selected number of times with the same current as to be used for the next measurement. The valid range for the number of thermalization pulses is 1-65,000.

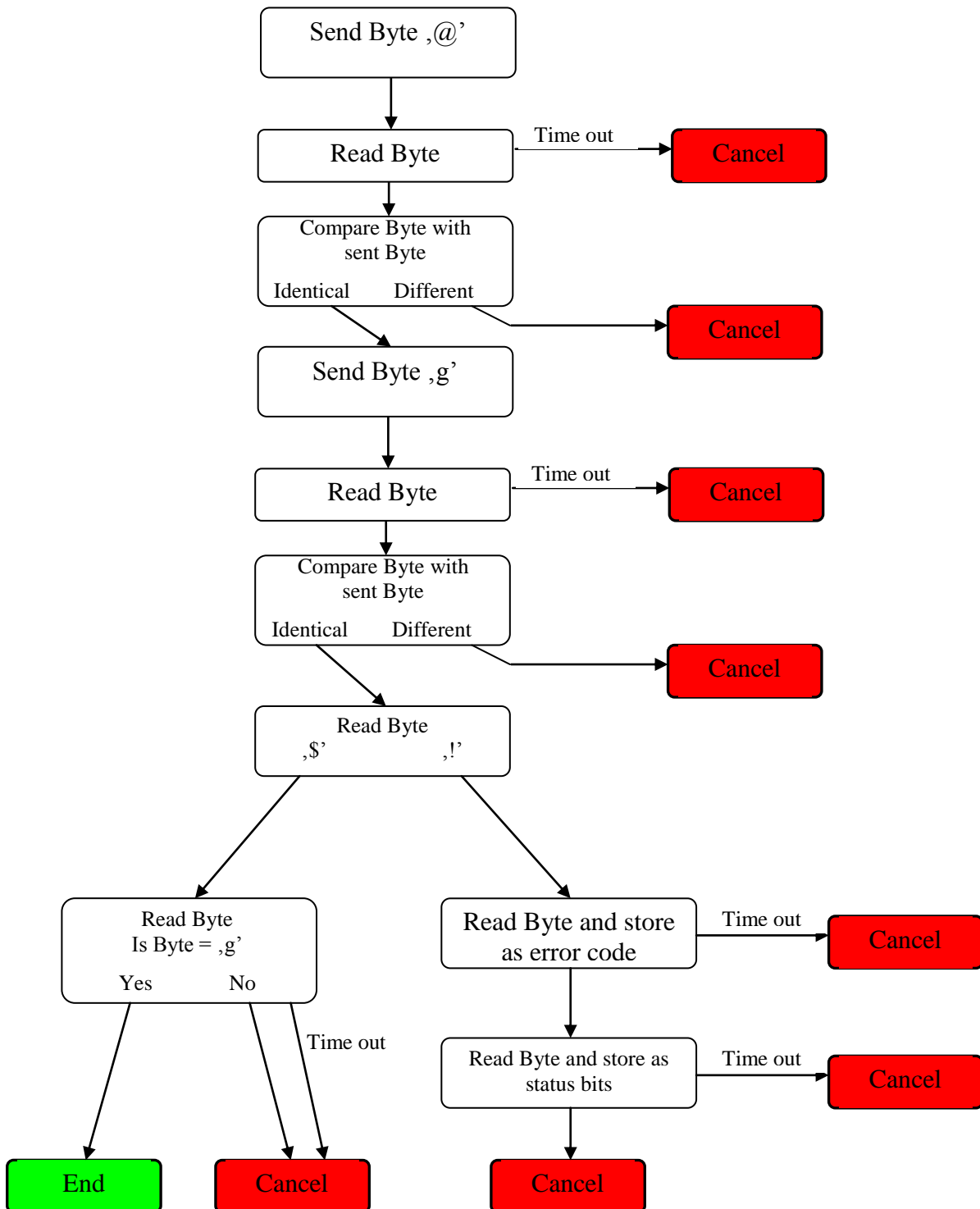
10.2.11 Schematic Representation of the Parameter Upload



**10.2.12 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 measurement, the LIV will send the byte ! back to the computer, followed by an error code byte and a status byte. If the measurement was successful, the LIV sends the bytes \$g.

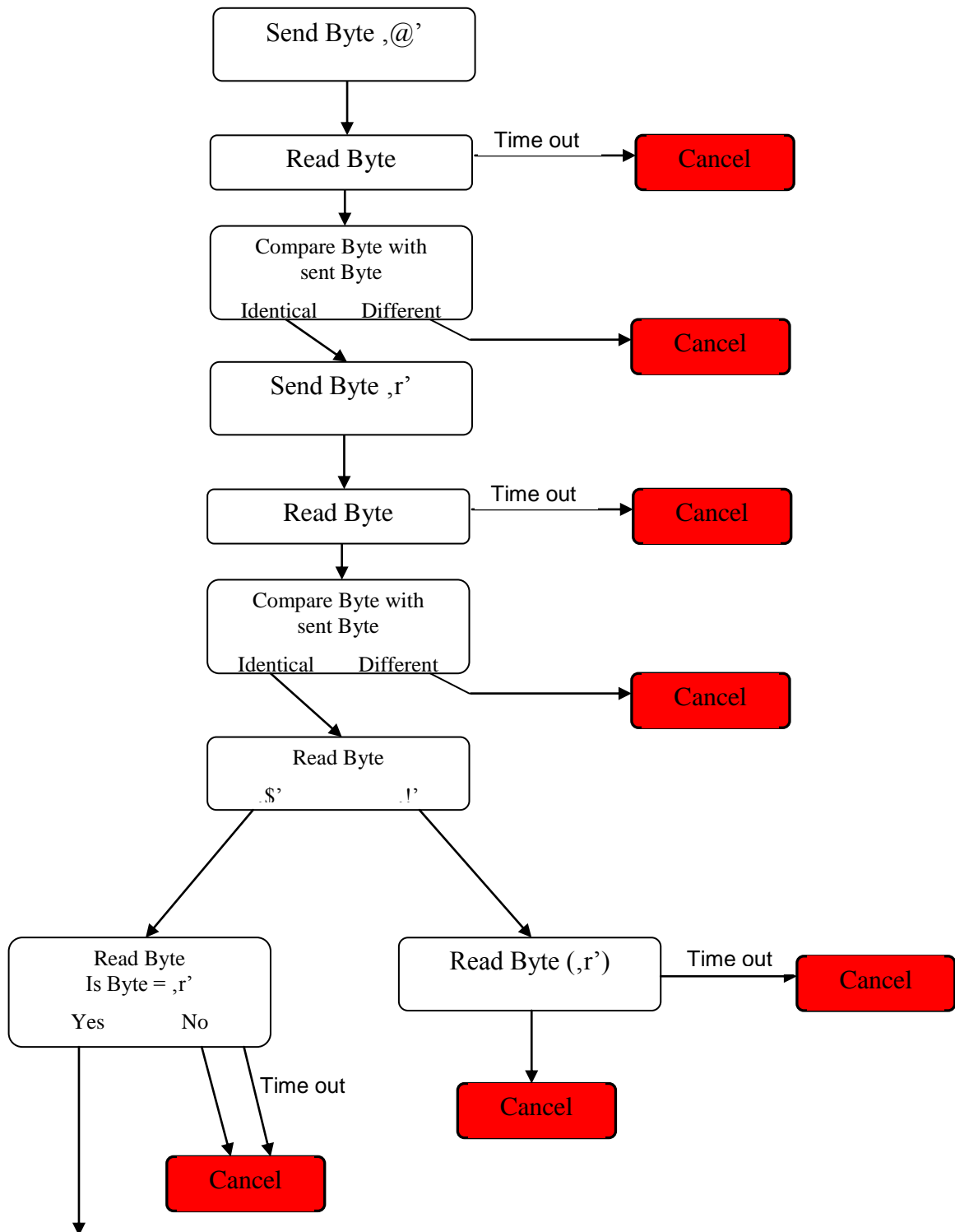
If a further measurement is to be performed with the identical parameter set, then the measurement can be reinitiated with @g without uploading the parameter set again. The measurement sequence is depicted schematically below.





### 10.2.13 Read Measurement Data

The download of the measurement data is initiated with the command @r. The process depends on the measurement mode (LIV, Scope and Burst/CW). The following schematic depicts the initial process which is common to all modes. After the bytes @r have been sent, the LIV responds either with \$r (data are being sent) or with !r (error).



Further: Read Header

The header of the data set is dependant on the operation mode. The following schematic depicts reading a header containing 8 values. The actual number and meaning of the parameters is summarized in table 2.

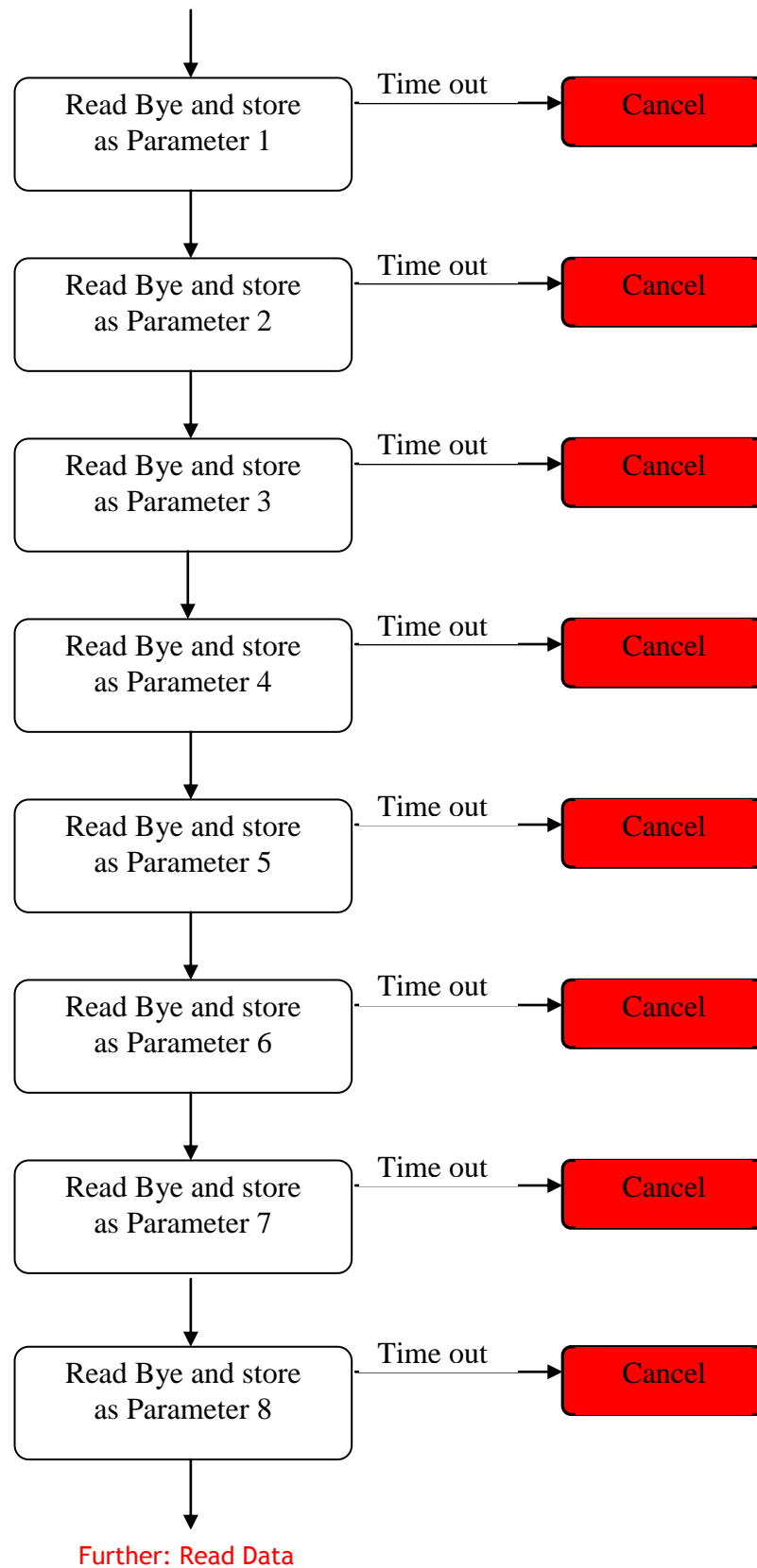
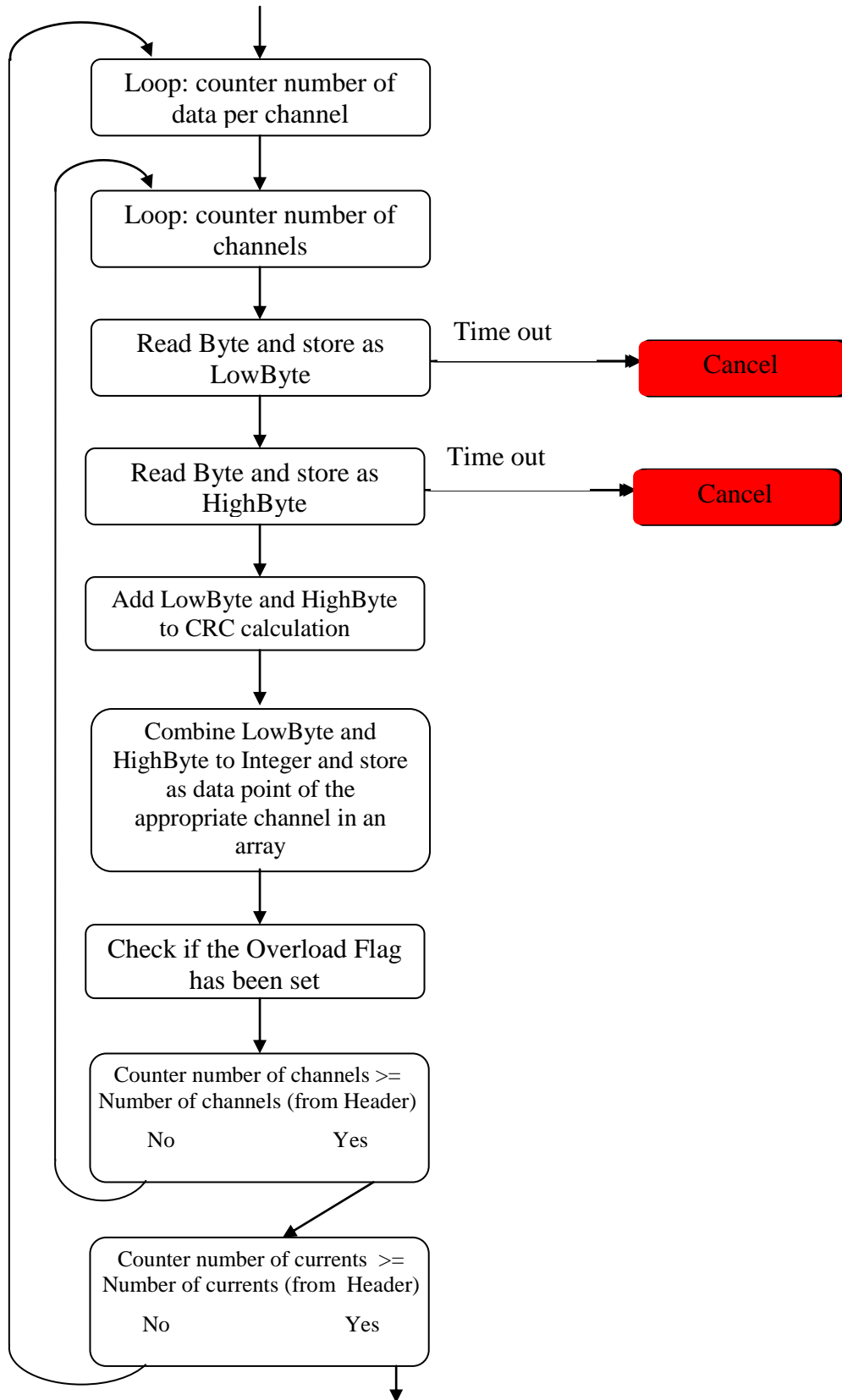


Table 5: Header Parameters for the Various Modes of Operation

Parameter No.	Scope Mode	LIV Mode	Burst Mode
1	Number of measurement data per pulse (Low Byte)	Number of measurement data on the plateau (Low Byte)	Number of measurement data per pulse (Low Byte)
2	Number of measurement data per pulse (High Byte)	Number of measurement data on the plateau (High Byte)	Number of measurement data per pulse (High Byte)
3	Number of channels	Number of channels	Number of channels
4	Number of Currents (Low Byte)	Number of Currents (Low Byte)	Number of Pulses (High Byte)
5	Number of Currents (Low Byte)	Number of Currents (Low Byte)	Number of Pulses (Middle Byte)
6	Gain of optical channel 1 0: 1k $\Omega$ 1: 10k $\Omega$	Averages	Number of Pulses (Low Byte)
7	Gain of optical channel 2 0: 1k $\Omega$ 1: 10k $\Omega$	Gain of optical channel 1 0: 1k $\Omega$ 1: 10k $\Omega$	Reserve
8	Reserve	Gain of optical channel 2 0: 1k $\Omega$ 1: 10k $\Omega$	Gain of optical channel 1 0: 1k $\Omega$ 1: 10k $\Omega$
9		Position of plateau begin (Low Byte)	Gain of optical channel 2 0: 1k $\Omega$ 1: 10k $\Omega$
10		Position of plateau begin (High Byte)	Number of measured pulses (High Byte)
11		Reserve	Number of measured pulses (Middle Byte)
12			Number of measured pulses (Low Byte)

### 10.2.14 Read Measurement 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

Example of a read routine for the LIV mode in C++

```

for(int i = 0; i < currents; i++) // loop on all currents
{
    for(int k = 0; k < par->NumberOfChannels; k++) // loop on all channels
    {
        short x;
        lo = p.GetByte(); // get LSB
        UpdateCRC(lo); // update CRC
        hi = p.GetByte(); // get LSB
        UpdateCRC(hi); // update CRC
        x = lo;
        if (lo & 1) par->OverRange[k] = 1; // check for out of range
        x |= hi << 8; // build the 16-bit data
        //put data in array. Scale[k] is the correction fraction for this channel.
        par->data[k][i] = par->Scale[k] * x/32768.0; // convert to quantity
    }
}
lo = p.GetByte(); // read CRC lo calculated in the instrument
hi = p.GetByte(); // read CRC hi calculated in the instrument
if (hi * 256 + lo != CRC_acc) par->CRC_Error++; // compare the two CRCs

```

### 10.2.15 Read Measurement Data – Scope Mode

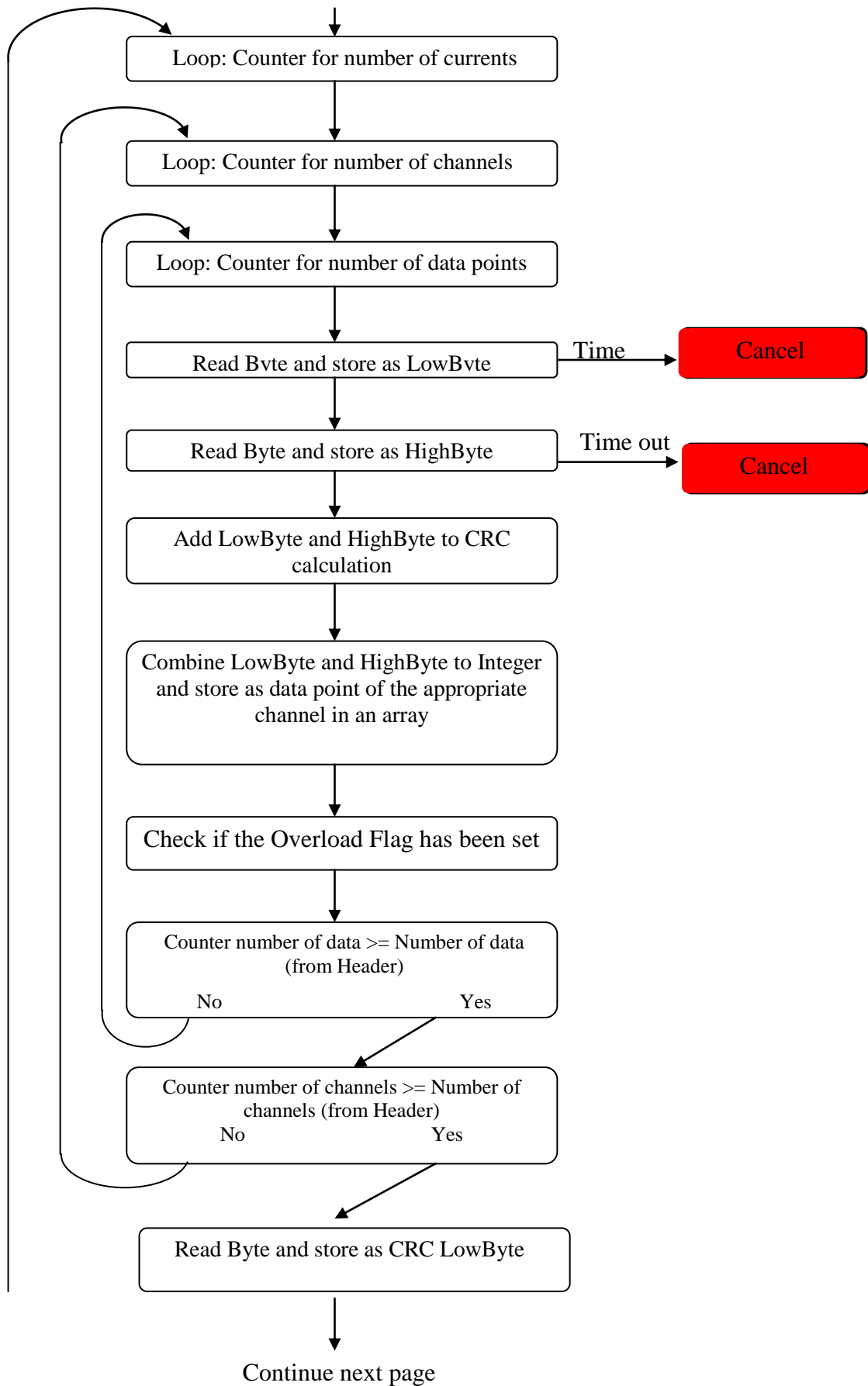
Again, the header provides all of the necessary information for correct receipt of the data. A further loop is necessary in this mode in order to assign the data correctly. The CRC check takes place for each operating point. The pulse duration sweep is noteworthy as the number of data points per operating point changes for each subsequent operating point. Therefore, a further parameter “Number of additional data points per operating point” is available for the calculation of the number of data points. This value must be added to the number of data points for each subsequent operating point. This value is 0 in all other modes.

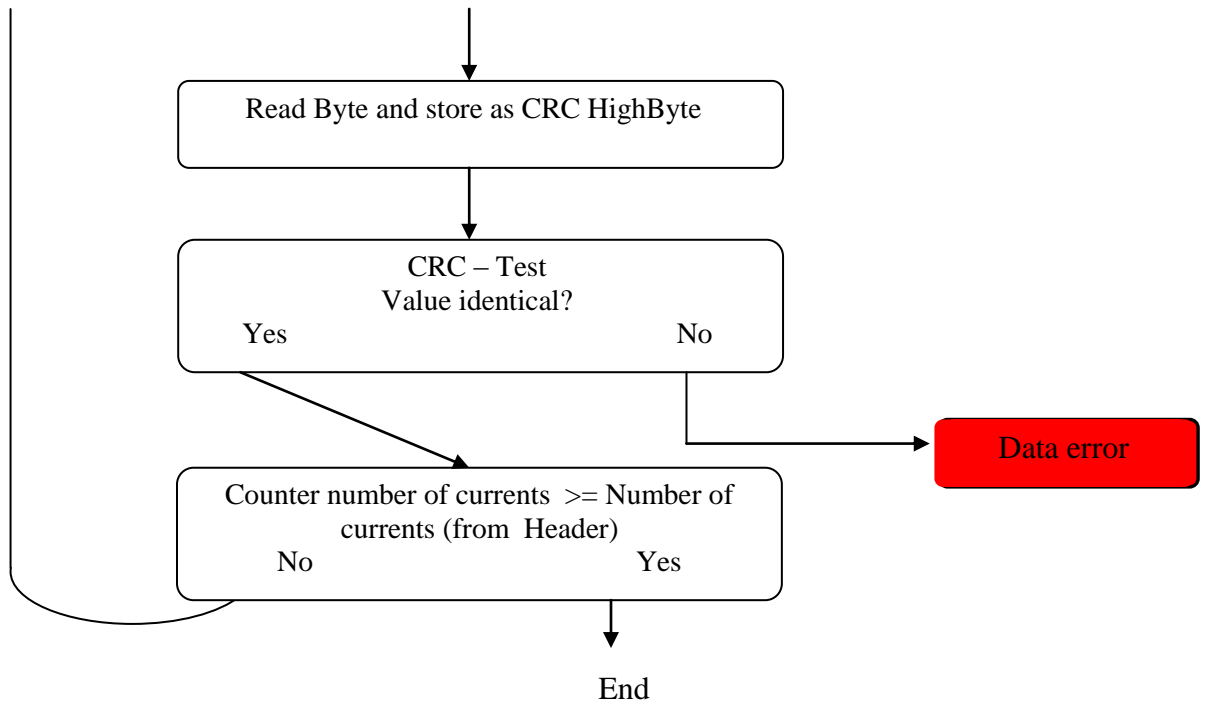
The number of data points per channel (n) is calculated as follows:

$$n = \text{Points} * \text{Currents} + \left( (\text{Currents} - 1) * \frac{\text{Currents}}{2} * \text{Additional\_Points} \right)$$

Points:	Number of data points per pulse (header bytes 1 and 2)
Currents:	Number of currents (header bytes 6 and 7)
Additional Points:	Number of additional data points per operating point (header bytes 4 and 5)

The following schematic shows the read process and the order of the bytes.





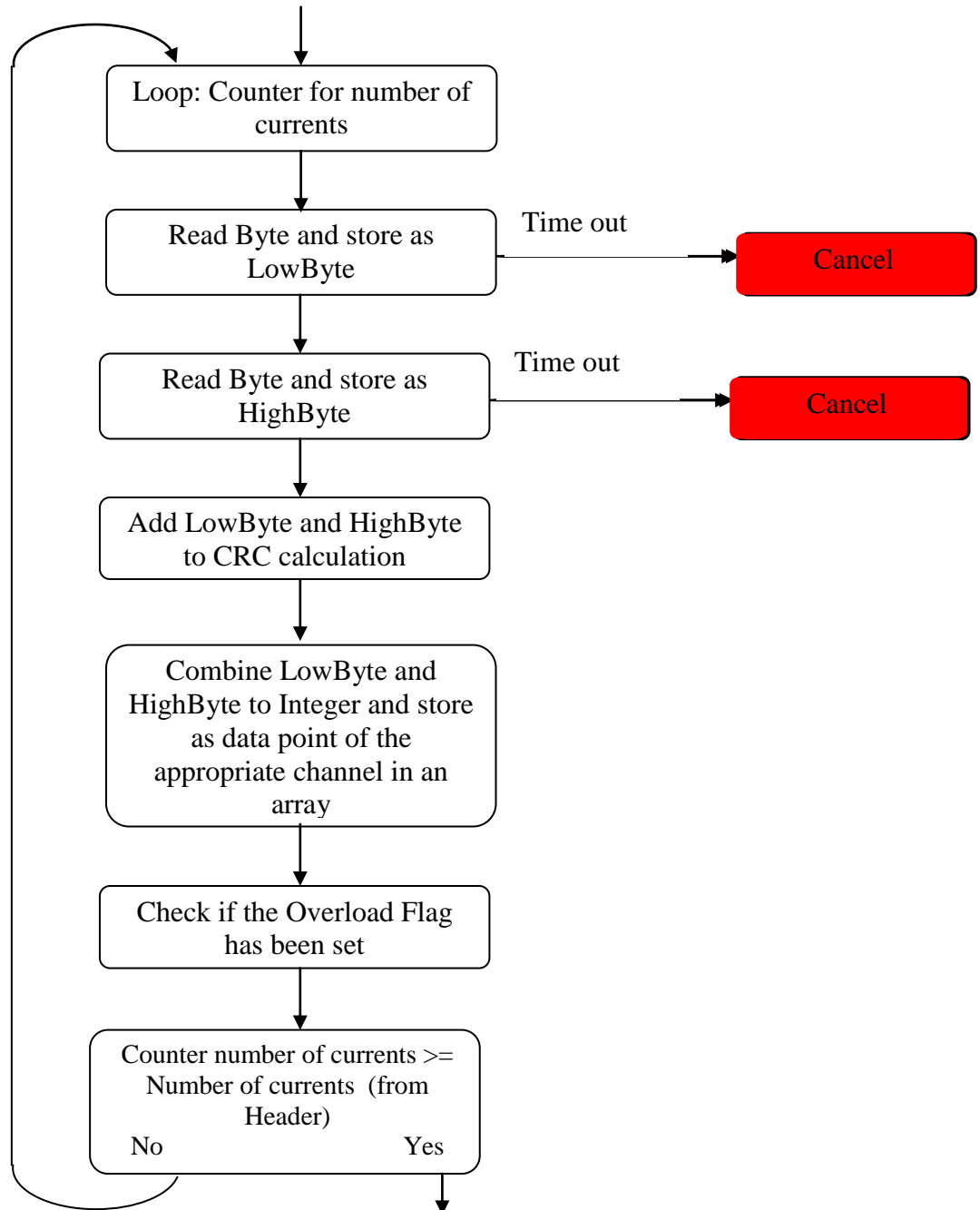
Example of a read routine for the scope mode in C++

```

for(int c=0; c<currents; c++)           // loop on all currents
{
    CRC_acc=0;                          // initialise CRC calculation for each current
    for(int k = 0; k < par->NumberOfChannels; k++) // loop on all channels
    {
        for(int i = 0; i < points; i++)    // loop on all points for a pulse
        {
            short x;
            lo = p.GetByte();              // read lo byte of data
            UpdateCRC(lo);                 // update CRC
            hi = p.GetByte();              // read hi byte of data
            UpdateCRC(hi);                 // update CRC
            x = lo;
            if (lo & 1) par->OverRange[k] = 1; // check for out of range
            x |= hi << 8;                  // build the 16-bit value
            \\put data in array. Scale[k] is the correction faction for this channel.
            par->data[k][c*points+i] = par->Scale[k]* x / 32768.0 ;
        }
    }
    lo=p.GetByte();                       // read CRC lo calculated in the instrument
    hi=p.GetByte();                       // read CRC hi calculated in the instrument
    if (hi*256+lo!=CRC_acc) par->CRC_Error++; // compare the two CRCs
}
  
```

## 10.2.16 Read Measurement Data – Burst and CW Modes

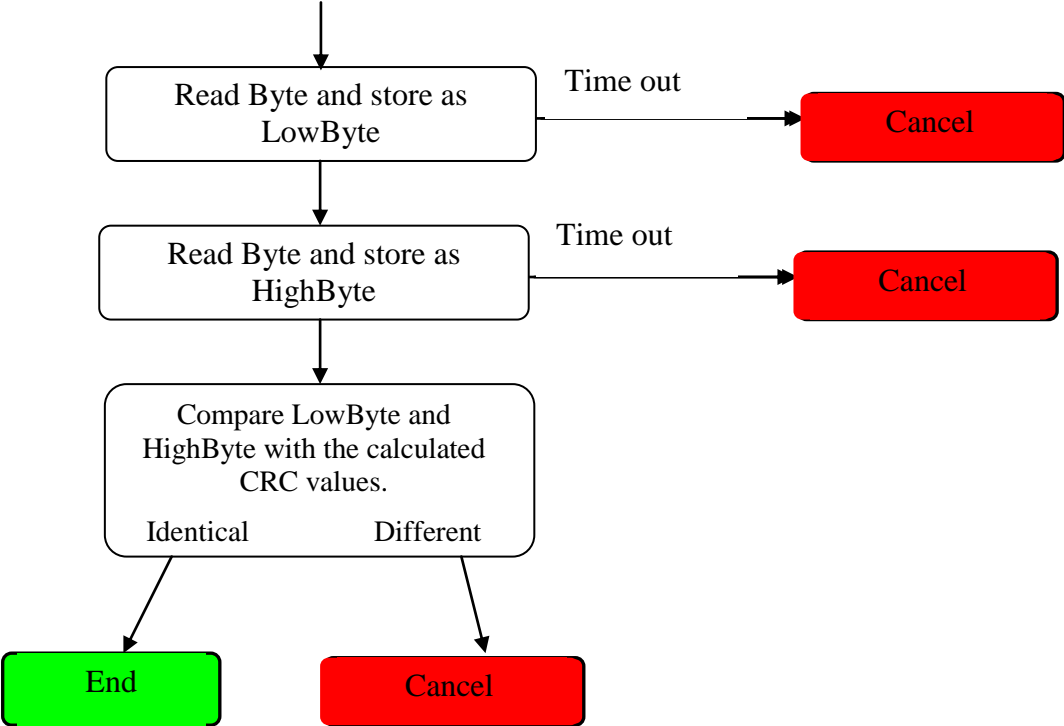
Only the optical channel is measured in the burst and CW modes which simplifies the read procedure.



Further: CRC Check

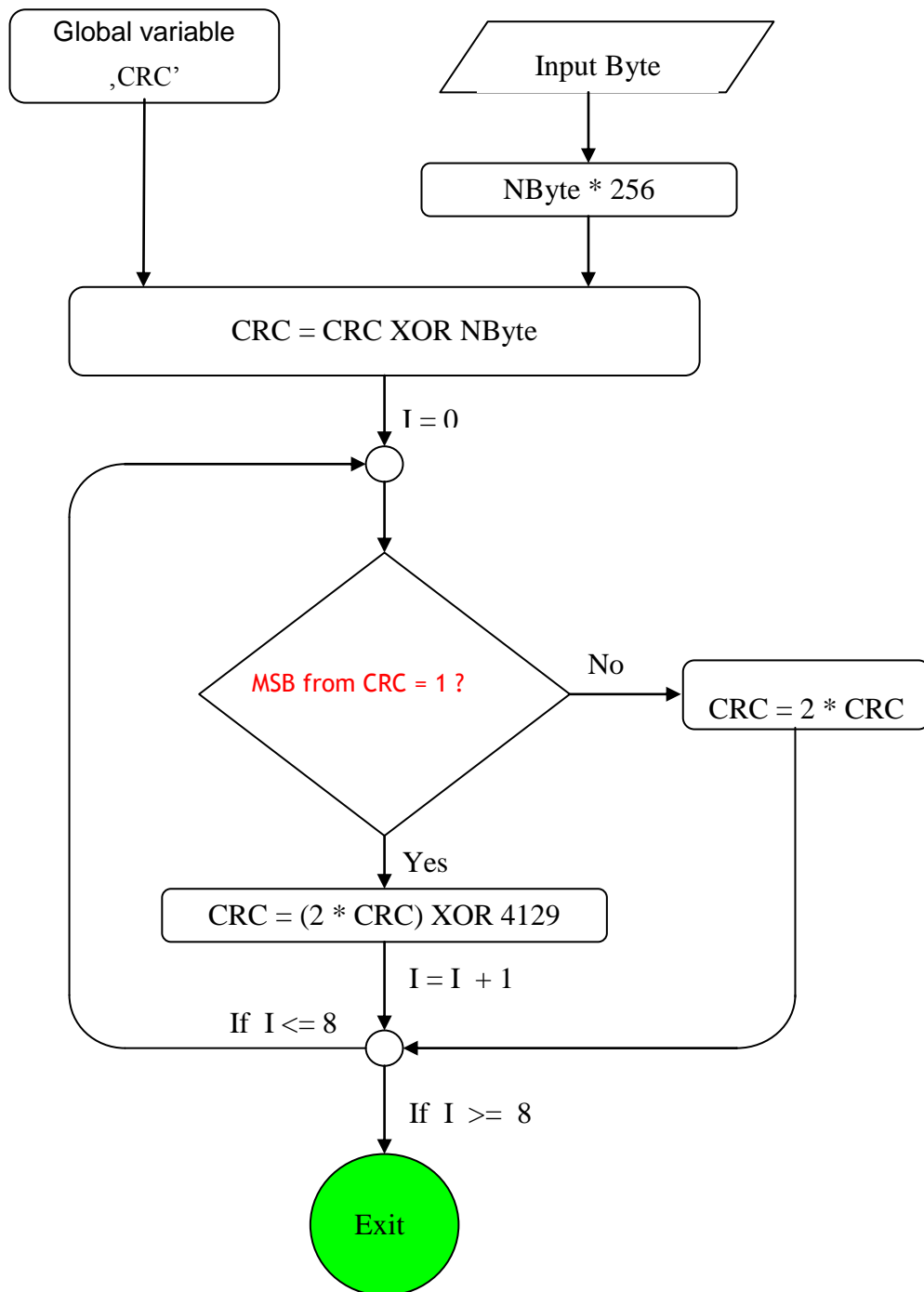


The end of each read procedure involves a data integrity check via the CRC (cyclic redundancy check).



### 10.2.17 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.



### 10.2.18 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 6: Error Codes in Parameter Selection*

Error Code (Byte)	Erroneous Parameter
100	sampling rate
101	pulse width
102	number of burst samples
103	pulse separation
104	minimum set current
105	maximum set current
106	current step size
107	number of averages
108	minimum test contact voltage
109	maximum test contact voltage
110	plateau: tolerance
111	plateau: minimum width
112	memory full
113	thermalization time
114	Test pulse range

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

*Table 7: Error Codes in Measurement*

Error Code (Byte)	Explanation
50	Error in finding plateau
51	Error in contact test (laser not connected?)
52	General: error in parameter set
53	General hardware error
54	Drivers could not be activated
55	Memory error
56	Error during offset calibration
57	The measured voltage across the laser diode is too low
58	The pulse width is too long for the present supply voltage
59	The pulse width is too long for the present pulse separation
60	Interrupted by user

### 10.2.19 Order of Data Values

- a.) Current
- b.) Voltage
- c.) Optical power

### 10.2.20 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 LIV100 to physical values.

#### 10.2.20.1 Current

Current [A/bit]:  $I_{LIVmax} \times 1.05 / 8192$

Example: for LIV100-L010-CW:  $I_{LIVmax} = 10A \Rightarrow 10 \times 1.05 / 8192 = 0.00128 \text{ A/bit}$

#### 10.2.20.2 Voltage

Voltage [V/bit]:  $24/8192 \text{ V/bit} (= 2.93\text{mV/bit})$

#### 10.2.20.3 Optical Power

$P_{opt} = (\text{ADC Value} * 1V / 8192) / (S * R)$

S = Sensitivity of the detection channel in A/W

R = Gain of the transimpedance amplifier:

G0 : 1,000 V/A

G1 : 10,000 V/A

#### 10.2.20.4 Current Upload

The upload of values for setting the driver current requires two calculation parameters:

Resolution:  $I_{max} / 4000 \text{ A/bit}$ .

Example: The upload bit value to generate a 5A pulse with an LIV100-L010-CW instrument:

$5A \times (4000/10) = 2000\text{bit}$ .

## 10.3 The SDK Package

The LIV100 comes with a software development kit (SDK package) in order to ease integration of the instrument into OEM projects. This package includes the source code of the application programme (written in Microsoft VB.net version 2005) as well as a LabVIEW® VI example.

The SDK package is found on the storage media delivered with the instrument.

## 10.4 Source Code of the Application Programme

The project file LIV100.sln is stored on the storage media delivered with the instrument. This file contains all of the necessary window files, modules, graph and icon files as well as the necessary compiling settings. This file may be loaded into the software development environment.

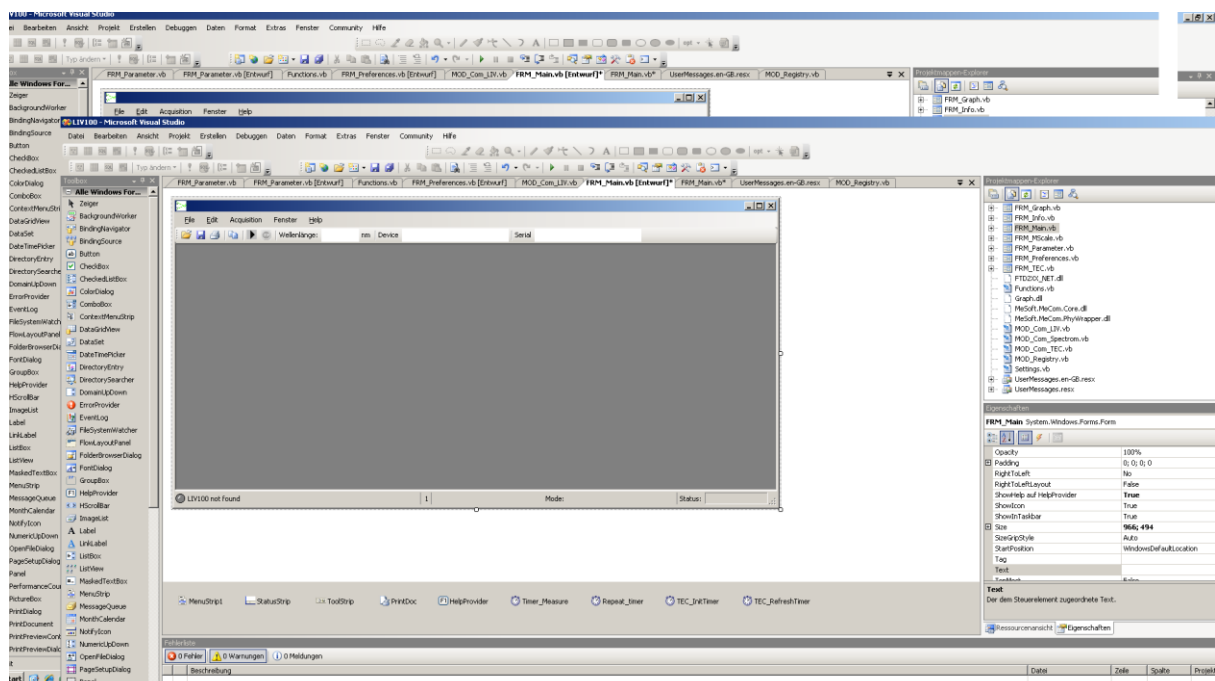


Figure 42: Software Development Kit (SDK) for VB.net

All enclosed files are shown in the project explorer (lower left window). The folder structure is the same as is found on the storage media delivered with the instrument.

The graph in the main window is generated by embedding the file Graph.dll in the output. For more information, see Hinweis.txt.

Further details are contained in the comments in the source code.

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## 10.5 Documentation for LabVIEW® LIV100Com.vi

The LIV100 is delivered with a fully functional demo virtual instrument (VI). In order to implement the LIV100 within a larger LabView programme framework, it is recommended to use the supplied VI as the starting point. The main programme comprises the GUI.vi (graphical user interface) and the library container LIV100.lib. All necessary sub-VIs for the communication and further functions are found in this container.

In order to communicate with the LIV100, a connection with the PC must occur. This is handled by OpenLIV.vi. This gives a reference value for the connection, the so-called handle, which is required for further communication.

In order to perform a measurement, LIV100Com.vi is used. This VI uploads the necessary parameters to the instrument, starts the measurement and downloads the subsequent measurement values to the PC. The sub-VI Puls\_Calculation.vi is implemented during this procedure. It contains an algorithm to determine the required upload parameters for the sampling rate and the number of samples to be taken.

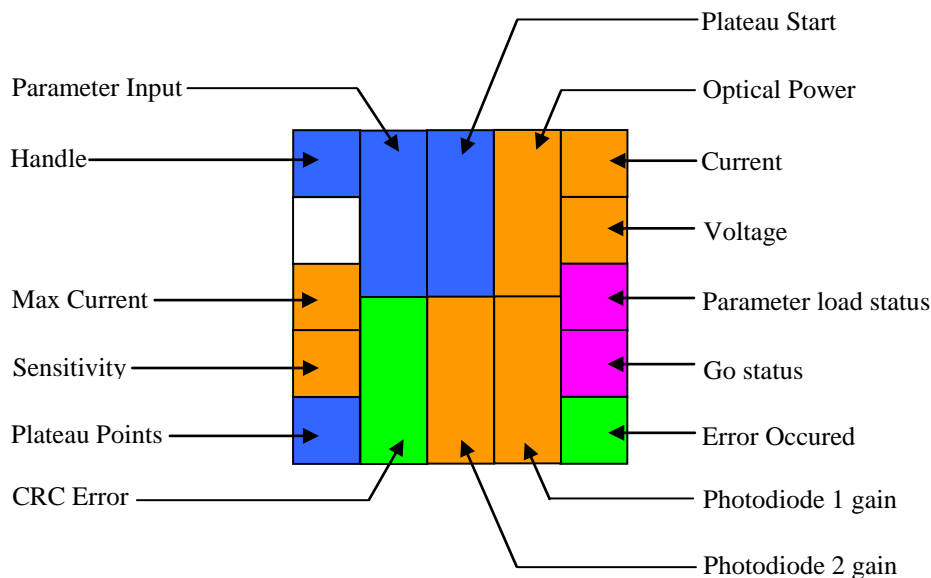


Figure 43: Connection Diagramme for LIV100Com.vi

### Handle (Input, Integer 32bit)

This value is generated by the operating system when the connection to the LIV100 is opened. It is required for all further communication with the instrument.

### Max Current (Input, Double)

The maximum current available for the instrument must be input here in order to scale the measurement values from the AD-converter. For example for an LIV100-L120 the value 120A should be input here.

Sensitivity (Input, Double)

The sensitivity of the optical channel for the wavelength of interest must be input here. This value is obtained from the calibration table delivered with the unit. This scales the digital data to obtain values in units of optical power.

Plateau Points (Output, Unsigned Integer, 16bit)

This returned value indicates how many data points from each pulse will be used for calculating each data point in LIV mode. This value is determined by the plateau algorithm during the test pulses of each measurement sequence.

CRC Error (Output, Boolean)

This control bit indicates whether the data download to the computer was error free: 0 = no errors, 1 = error(s) occurred.

Photodiode 1 gain (Output, Double)

This output indicates the gain value of the transimpedance amplifier in channel 1. The value may be 1 or 10 (kOhm) and has already been taken into account in the calculation of the optical power. This output is for diagnostic purposes only.

Photodiode 2 gain (Output, Double)

This value is only required for units with two optical inputs.

Description: see Photodiode 1.

Go Status (Output, String)

This output indicates the validity of the measurement. If the measurement was error free, the output is:

OK

If an error occurs during the measurement, an error code in the following format (for example) will be returned:

Error: 54

Parameter load status (Output, String)

This output indicates the validity of the parameter upload. If the upload was error free, the output is:

OK

If an error occurs during the upload, an error code in the following format (for example) will be returned:

Error: 107;102;

For a complete list of error codes, see 10.2.18 Error Codes, pg. 99.

Voltage (Output, Array type Double)

This one-dimensional array contains the voltage measurement data in volts (V).

Current (Output, Array type Double)

This one-dimensional array contains the current measurement data in amps (A).

Optical Power (Output, Array type Double)

This one-dimensional array contains the optical power measurement data in watts (W).

Plateau start (Output, Unsigned Integer 16bit)

This value indicates the position of the first data point within the pulse which has been selected by the plateau algorithm. This may be useful for diagnostic purposes.

Parameter (Input, Array type Byte with 25 fields)

This array is used to upload the parameters for the measurement. Each field is of data type Byte. All parameters must have valid entries, even if the corresponding parameter will not be used for the measurement! The following bytes must be uploaded:

For a complete list of upload parameters, see 10.2 Parameter Upload, pg. 82.



## 11 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.

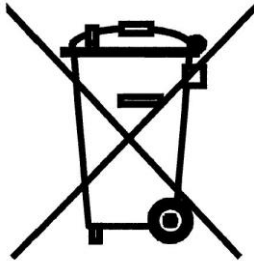


### NOTICE!

#### **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.



## 12 Type plate

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

- Manufacturer
- Partnumber
- Serial number
- Manufacturing date



LIV100

Model No.: LIV100

Ser. No.: 0011

[www.artifex-engineering.com](http://www.artifex-engineering.com)



## 13 Notice

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**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!**

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