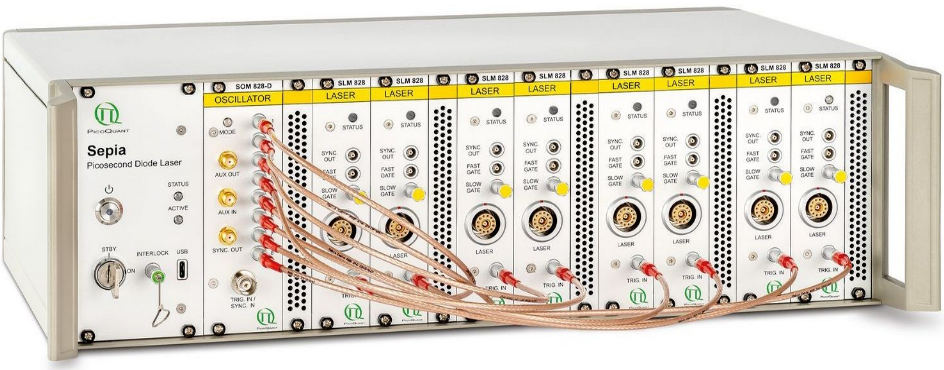
Sepia PDL 828

Computer Controlled
Multichannel Picosecond
Diode Laser Driver

PicoQuant



User Manual

Version 3.0.3

Table of Content

1. General safety information

CAUTION! Before using this device, make sure that you have read and understood the content of this user manual. Store this documentation in a safe and easily accessible place for future reference.

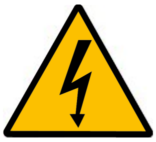
Incorrect handling of this product may result in personal injury or physical damage. The manufacturer assumes no responsibility and cannot be held liable for any injury / damages resulting from operating the device outside of the normal usage defined in this manual.

1.1. Warning Symbols and Conventions

The following symbols and conventions will be used throughout this manual. Please take time to familiarize yourself with their meaning before proceeding.

	The **general safety alert symbol** is used to alert you to hazards that may lead to personal injury or physical damage. Follow all associated safety instructions to avoid possible injury or death.
	A **high voltage warning symbol** is used to indicate the presence of un-insulated, dangerous voltage inside the enclosure. Note that this voltage may be sufficient to constitute a risk of shock.
	The **laser radiation warning symbol** alerts you that the device can generate laser radiation. Follow all applicable laser safety instructions to avoid injury or damages.
	The device's susceptibility to electrostatic discharge (ESD) is indicated by the **ESD warning symbol**. Ensure that you follow proper ESD protection rules to avoid damaging the device.
CAUTION!	Make sure to follow any instructions prefaced with "**CAUTION!**" to avoid personal injury or damaging the device.
WARNING!	The "**WARNING!**" label prefaces any instructions that shall be followed to avoid severe injury or death.
NOTICE	Important tips and information for device operation that do not include a risk of injury or damage are prefaced with the "***NOTICE***" label.
	This symbol indicates that an earth terminal shall be connected to the ground (to avoid risks of electrical shock).

1.2. Electrical Safety Instructions



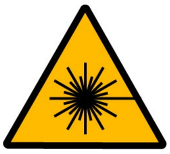
WARNING! To avoid electric shock, the power cord's protective grounding conductor must be connected to the ground.

This devices modules and laser heads contain no user serviceable components. Do not remove covers! Servicing of internal components is restricted to qualified personnel.

CAUTION!	Never connect or disconnect any cable while the system is powered ON. Before plugging or unplugging any interconnection between laser driver and laser head, **switch off** all components using the ON/OFF switch at the rear panel. Charged cables can damage electronic devices!

Disconnect the power cord from the electrical outlet before performing any maintenance.

1.3. Laser Safety Instructions



WARNING! Visible and invisible laser radiation

Diode laser heads from the LDH Series, LDH-FA Series, or laser modules from the VisIR/VisUV family are available at different wavelengths and intensities. Some laser can emit infrared light. Infrared light is not visible to the eye! **Some laser modules can emit laser light of up to class 3B / IIIB.** Please refer to the labels affixed to the laser head for information on classification.

Lasers can be hazardous and have unique safety requirements. Permanent eye injury and blindness is possible if lasers are used incorrectly. Pay close attention to each safety REMARK and WARNING statement in the user manual. Read all instructions carefully BEFORE operating this device.

The Sepia PDL 828 laser driver as well as laser diode heads of the LDH Series and LDH-FA Series or VisIR/VisUV laser modules are manufactured according to the International Laser Safety Standard IEC 60825-1:2014 and comply with the US law 21 CFR §1040.10 and §1040.11.

Required Laser Safety Measures

Please observe the laser safety measures for class 3B / IIIB or 3R / IIIR (depending on laser head) lasers in accordance with applicable national and federal regulations. The owner / operator is responsible for observing the laser safety regulations.

CAUTION!	**VisIR / VisUV laser modules from PicoQuant can be connected to the Sepia PDL 828 via the Sepia Extension Module (SEM 828). These laser modules can emit laser light of class 4 / IV. Please carefully read and observe the laser safety instructions contained in the manuals delivered with these devices.**

What does the owner / operator have to observe?

- The owner / operator of this product is responsible for proper and safe operation and for following all applicable safety regulations.
- The owner / operator is fully liable for all consequences resulting from the use of the laser for any purposes other than those listed in the operating manual. The laser may be operated only by persons who have been instructed in the use of this laser and the potential hazards of laser radiation.
- The owner / operator is responsible for performing and monitoring suitable safety measures (according to IEC/EN 60825-1 and the corresponding national regulations).
- The owner / operator is also responsible for naming a laser safety officer or a laser protection adviser (according to the standard IEC/EN 60825-1: "Safety of laser products, Part 1: Classification of systems, requirements and user guidelines" and the respective national regulations).

The following security instructions must be followed at all times.

CAUTION!	**Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure!**

General Safety Instructions for Operation

- Never look directly into a laser beam or a reflection of the laser beam. Avoid all contact with the laser beam.
- Do not introduce any reflective objects into the laser beam path.
- Every person involved with the installation and operation of this device has to:
  - Be qualified
  - Follow the instructions of this manual

- As it is impossible to anticipate every potential hazard, please be careful and apply common sense when operating the Sepia PDL 828 laser driver and its associated diode laser heads. Observe all safety precautions relevant to class 3B / IIIB or class 3R / IIIR, respectively.
- Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
- For safety reasons, you should periodically check (on a monthly basis) the function of the emission indicators, remote interlock, and key switch on the laser driver, as well as verify that no scattered radiation can escape the collimator (e.g., by missing screws).
- **Do not dismantle the modules or laser heads** under any circumstances! There are no user serviceable parts inside.

1.4. Laser Safety Labels

Laser heads from the LDH and LDH-FA Series use various types of housings depending on the model type. The following sections provide an overview of each housing type and the respective locations wher laser safety and classification labels, as well as aperture warnings (with arrow pointing towards the apreture) are located.

The laser safety label states the laser product classification, certification, power, and wavelength range relevant for the classification. An overview of laser safety labels by model type can be found in the table of Appendix Fehler: Verweis nicht gefunden. Note that this list is not exhaustive and encompasses Sepia PDL 828 compatible laser heads available at the time that this manual was released.

Please refer to the *laser delivery report* provided with each ordered laser head for information on the central emission wavelength, maximum achievable optical output power, and pulse shape of the delivered LDH laser heads.

1.4.1. Short Cylindrical Heads (LDH Series)

Fig. 1: Location of the laser warning, aperture indicator, certification, and laser classification label on laser heads built using short cylindrical housings (LDH-D-C-640 C is used as example here).

1.4.2. Long Cylindrical Heads (LDH Series)

Fig. 2: Location of the laser safety and warning labels as well as aperture indicator on a long cylindrical laser head (here an LDH-D-TA-530).

1.4.3. Flat Cuboid Heads (LDH-FA Series)

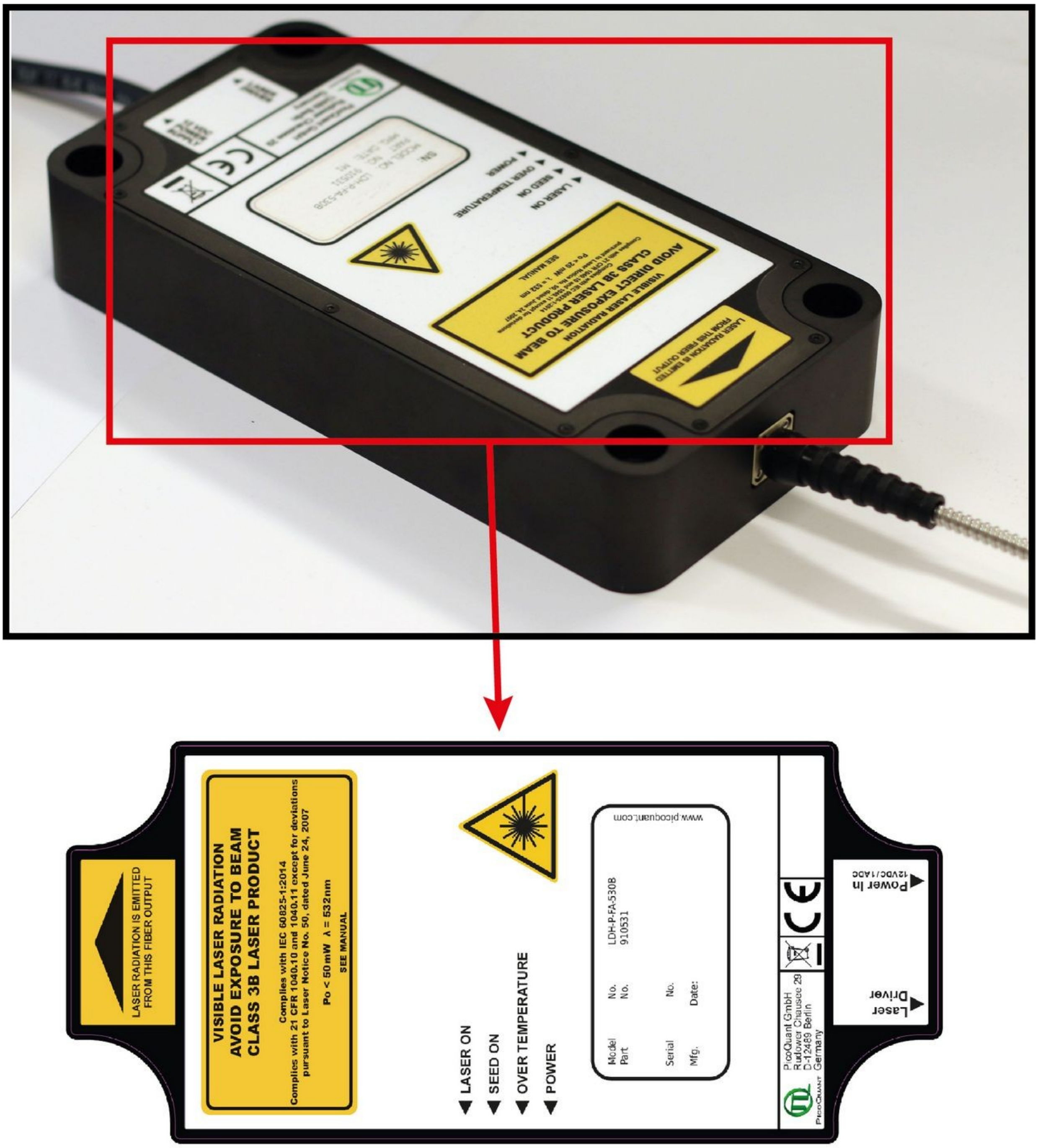


Fig. 3: Location of the laser safety and warning labels as well as aperture indicator on a flat cuboid laser head (here an LDH-P-FA-530B).

1.4.4. Tall Cubioid Heads (LDH-FA Series)

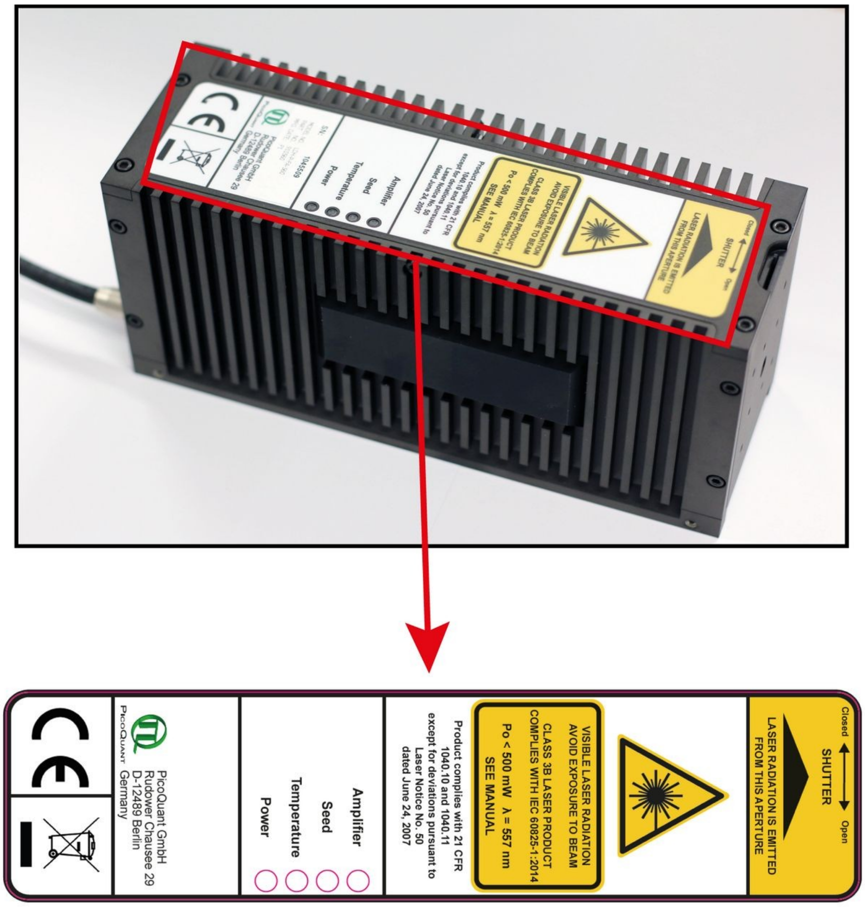


Fig. 4: Location of the laser safety and warning labels as well as aperture indicator on a tall cuboid laser head (here an LDH-P-FA-560).

1.5. Remote Interlock Connector

A hardware lock as well as a remote interlock connector are part of the Sepia PDL 828 laser driver. Removing the green interlock connector (LEMO plug) or breaking the interlock circuit will immediately deactivate the power supply of the laser.

CAUTION!	**The Sepia PDL 828 will resume laser emission as soon as the remote interlock circuit is closed or once power is restored after a power loss. Note that there is no indication of the status of the interlock.**

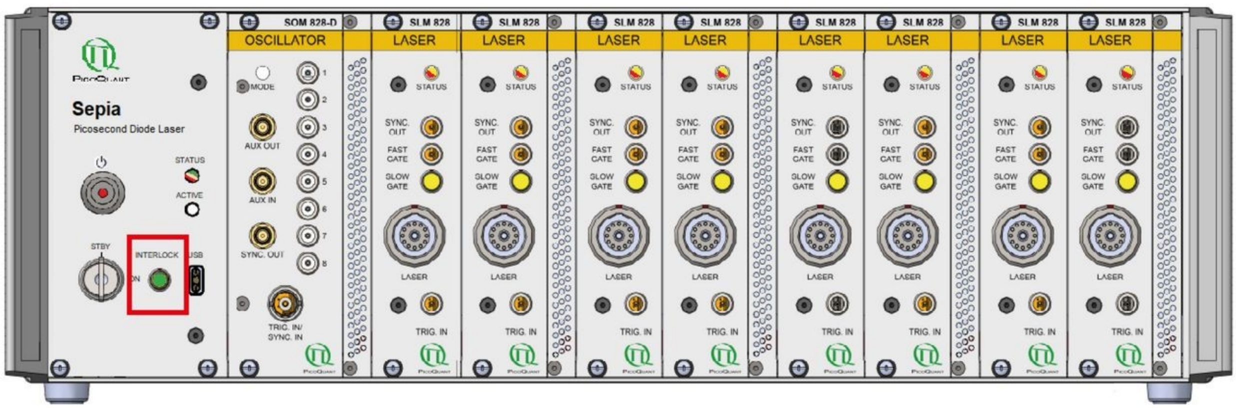


Fig. 5: Location of the remote interlock connectors on the front panel of the Sepia PDL 828 (highlighted by the red box).

The green remote interlock connector (LEMO plug) is located on the front panel as shown in Fig. 5.

CAUTION!	**For safety reasons, any VisIR / VisUv laser module connected to the Sepia PDL 828 will be internally locked if the Sepia PDL 828 loses power. Please refer to the VisIR / VisUV manual for instructions on how to safely unlock the VisIR / VisUV laser module.**

In order to meet laser safety regulations, you may need to install a remote interlock, e.g., a door switch, to deactivate the power to the laser when the door to the laser area is opened.

CAUTION!	**A green LEMO plug is delivered with the laser driver, which bridges pins 2 and 3. Using this plug is NOT intended for everyday use of the laser driver. The plug cannot act as a functional remote interlock circuit, since it has no capability to react to e.g., a door switch.**

Pin assignment for the interlock

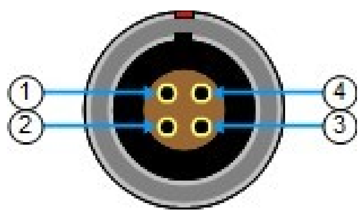


Fig. 6: Interlock LEMO connector

The interlock is a 4 pin LEMO EGG.00.304.CLL female connector as shown in Fig. 6. In order to activate laser emission, **pins 2 and 3** need to be bridged using a suitable adapter. Do **not** apply any voltage.

1.6. Third-party lasers

Only compatible laser heads (LDH or LDH-FA Series), pulsed LEDs (PLS Series) or stand alone laser modules (e.g., VisIR or VisUV) manufactured by PicoQuant can be operated with the Sepia PDL 828 laser driver. Do NOT connect any non-PicoQuant supplied laser heads to the Sepia PDL 828.

PicoQuant declines any responsibility and cannot be held liable for any direct or indirect damages to the users and/or instrumentation resulting from the connection of non-approved third-party laser devices by the end-user.

2. Introduction

The Sepia PDL 828 system is a multiple channel pulsed diode laser driver system that offers a high degree of flexibility in a very compact package. It is a modular system that can be configured by the user in various combinations. Up to 8 laser heads can be driven in parallel: synchronously, delayed or in a user defined sequence. Any output frequency from single shot to 80 MHz is supported. Plus, a wide choice of spectral, temporal and power parameters can be set for each laser. The triggering parameters of the Sepia II system are completely configured from a computer via USB, allowing for a quick set-up and easy storage of predefined set-ups. Standalone operation is possible, if no changes to the parameter set-up is required.

2.1. Light Sources

Starting at the front-end of the signal chain, the user can choose from a wide palette of pulsed light sources with wavelengths ranging from ultra-violet (266 nm) to infrared (1990 nm). With some wavelengths, the laser head can also be optimized for either maximum possible power or shortest pulse width. Currently, more than 30 laser head and pulsed LED (down to 245 nm) models are available - and the choice is continuously growing!

2.2. Driver Modules

Each laser or LED head is driven by a driver module. Since all driver modules are identical, laser or LED heads of different power levels and wavelengths can be connected to any of them. The pulse energy for the emitted light pulses (resulting in an average output power during periodic firing) can be independently adjusted for each driver. Each driver module may trigger the laser autonomously from its built-in crystal oscillator or, if a more complex triggering scheme is needed, can also be triggered by an external signal.

2.3. Oscillator Module

The Sepia PDL 828 system offers the user unparallelled flexibility in driving up to 8 laser heads in a user defined sequence. The concept for a coordinated firing sequence is to synthesize triggering signals for each laser driving module in one central oscillator module. The repetition frequency is derived from 3 user-selectable crystal stabilized oscillators or from an external input signal. Lower repetition frequencies are realized by a prescaler stage that may be configured for any integer dividing ratio ranging from 1 to 255 for the SOM 828 or 65´535 for the SOM 828-D oscillator module. The resulting main clock signal can be distributed to each of the driving channels in several ways. Basically, the channels will fire one after the other in a rotating manner. It is possible to group channels to form complex, synchronized firing patterns or to introduce software controlled delays. Furthermore, any number from one to 16.7 million pulses can be output as a burst before the next channel gets activated. Finally, a “single sweep mode” can be implemented so that the sequencer stops after a full period, waiting for an external signal to be re-triggered (see chapter 4.3.4).

When triggering the drivers or the oscillator module from an external signal source, keep in mind that the quality of that signal is quite important! Low jitter is essential to benefit from the picosecond capability of the laser pulses.

2.4. Cabling

The triggering output signals from an oscillator must be routed to the corresponding input of the driver module through coaxial patch cables. These connections have to be set up manually. Patch cables offer the highest flexibility and allow for insertion of virtually jitter-free delays using cables of different lengths: 20 cm of additional cable length correspond to a delay of about 1 ns. Therefore, cable length must be carefully considered when setting up a synchronized system (especially with gating).

The trigger signal level is the same along the entire path. Any trigger input may be connected to any trigger output with a NIM-CAMAC connector and may also be used to trigger external components. The signal is compatible with the well established NIM standard. The system can therefore be easily integrated into existing NIM-rack based time-resolved set-ups.

3. Installation and Quick Start

This section contains information for the installation of the hardware and software of the device as well as a non-exhaustive quick start guide.

3.1. Hardware Installation

The Sepia PDL 828 is a modular device. The mainframe of the device (PDL 828 mainframe) consists of the external housing (incl. power supply, main power switch, cooling) and of the controller module (SCM 828) with laser key switch, USB port and remote interlock connector.

The mainframe is available in two versions: a compact version which can host 1 or 2 laser driver modules (SLM 828) and a large version which can host up to 8 laser driver modules for laser diode heads from Pico-Quant (LDH series, LDH-FA series, PLS series). Both versions can additionally host an optional oscillator module (SOM 828 or SOM 828-D) used to generate trigger signals for the laser driver modules.

3.1.1. PDL 828 Mainframe

When placing the PDL 828 mainframe, please ensure a sufficient air flow from the fan at the rear panel by keeping a distance of 10 cm to any obstacle. The venting slots at the bottom must not be covered. Leave at least 5 cm of free space under the rack if you mount the rack into a 19"-cabinet.

Environmental conditions: +10 °C - +35 °C, relative humidity 20 % – 80 %.

Power input: 100 – 240 V, 50/60 Hz AC, power consumption < 250 W

The PDL 828 mainframe is controlled from a PC using a USB 2.0 connection (see Fig. 19).

The device can be operated stand alone at fixed parameters. Modifications of the operation parameters requires using the computer interface.

Before making any connections, be sure that all of the following conditions are met:

- Main power switch at the rear panel is in the OFF position.
- Key switch (item 3 in Fig. 19) is set to the “LASER LOCKED“ (horizontal) position.
- Functional ground is connected and the cable must be as short as possible and not longer than 3m

Remote Interlock

In order to meet laser safety regulations, it might be necessary to install a remote interlock, e. g., a door switch, to deactivate power to the laser when the door to the laser area is opened. A Remote interlock connector is provided for this purpose.

See also chapter 1.5 for more details on the interlock connector.

Heat Dissipation

Ensure free air circulation. Do not cover the cooling fan on the rear panel or any of the venting slits of the rack housing.

3.1.2. SOM 828 and SOM 828-D Oscillator Module

The SOM 828 or SOM 828-D oscillator module has to be installed in the leftmost slot of the Sepia II rack.

The connection to SLM 828 laser driver modules is made using coaxial patch cables that come with those modules. The outputs labeled 1..8 on the oscillator module are dedicated to trigger the laser modules. For an oscillator driven set-up, connect the trigger input of each laser driver module (SLM 828) to one of these outputs of the SOM 828 or SOM 828-D.

3.1.3. SLM 828 Laser Driver Module

SLM 828 laser driver modules have to be installed in the slots located at the right side of the oscillator module inside the PDL 828 mainframe.

Each laser driver module provides a synchronization pulse whenever the laser is fired. Use this local synchronization output when you need the most exact correlation of synchronization pulse to the optical output.

3.1.4. SEM 828 Sepia Extension Module (optional component)

These optional modules allow connecting and transparently integrating a laser module from PicoQuant's VisIR / VisUV family to the Sepia PDL 828. The SEM 828 module also needs to be installed in one of the slots located to the right of the oscillator module inside the PDL 828 mainframe.

3.1.5. Laser Diode Heads

Mount the laser heads firmly. Make sure they cannot be directed, even unintentionally, in such a way that laser light emitted from the collimator might cause any eye safety hazard.

CAUTION!	**Before connecting any heads to the driver modules consider that it is mandatory to comply with all applicatple laser safety instructions (see chapter 1.3).**

Use only laser heads of the LDH, LDH-FA or the PLS series supplied by PicoQuant. Connect the head to the SLM 828 via the large connector on the front panel of the SLM 828 driver module.

Heat Dissipation

Temperature controlled laser heads (LDH-P/D–C series, LDH-FA series)

The LDH-...-C and LDH-FA series laser heads contain an active thermoelectric cooling device. This produces, depending on the ambient temperature, a considerable amount of heat. Sufficient air circulation must be ensured to prevent an overheating of the laser head.

3.2. Software Installation

Before installing and using the Sepia PDL 828, please make sure to have

1. a solid base onto which the Sepia PDL 828 can be placed (e. g. an optical table)
2. a computer to install and run the operation software. The computer needs to have a free USB slot as well as a Windows operating system.

Place the Sepia PDL 828 on its dedicated place, insert the power cord and connect the Sepia PDL 828 to the host computer using the delivered USB cable.

NOTICE	**The Sepia PDL 828 should not be turned on before the control software is installed on the host computer!**

The control software "`PQLaserDrv.exe`" for your Sepia PDL 828 and other laser drivers manufactured by PicoQuant needs to be set-up by an installer and is supplied on the CD along with your device. Installing the software is straightforward and performed by a step-by-step installation wizard.

NOTICE	In order to future-proof the software, a switch to a new USB driver architecture is required **starting with software version 1.2.xx.636** (changing from PQUSB to WinUSB). The two driver architectures are **NOT** compatible with each other. This means that once the new drivers have been installed and they have registered the PicoQuant laser driver(s), software packages relying on the older drivers will no longer be able to "see" or connect to these USB devices. The reverse is also true: i.e. a software package relying on the newer drivers will not be able to discover or communicate with laser drivers registered to the older USB driver architecture. An important consequence of this is that both the PQLaserDrv package as well as any software package requiring a connection to a PicoQuant laser driver (i.e. SymPhoTime 64 or EasyTau) should be fully updated together.

To install the software:

1. Insert the installation medium into the host computer
2. Launch the program: `PQLaserDrv_Setup.exe`
3. Follow the instructions on the screen:

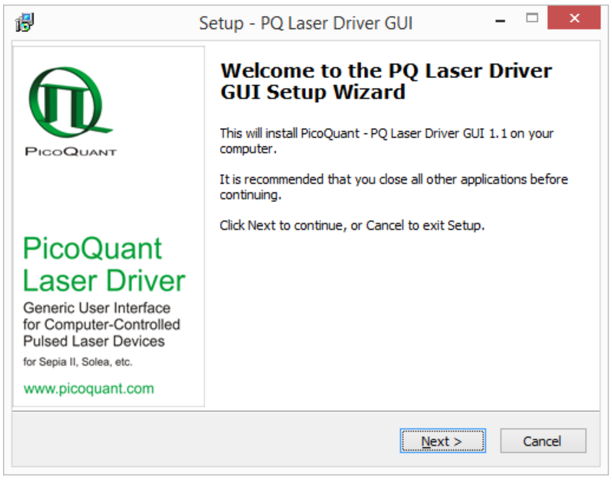


Fig. 7: PQ Laser Driver GUI Setup Wizard - Welcome window

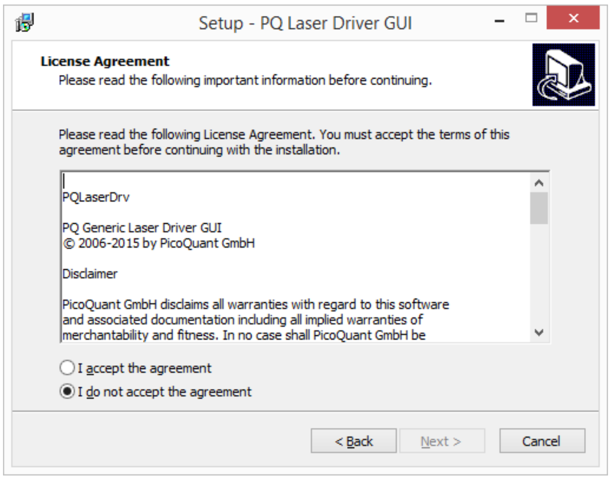


Fig. 8: PQ Laser Driver GUI Setup Wizard - License Agreement

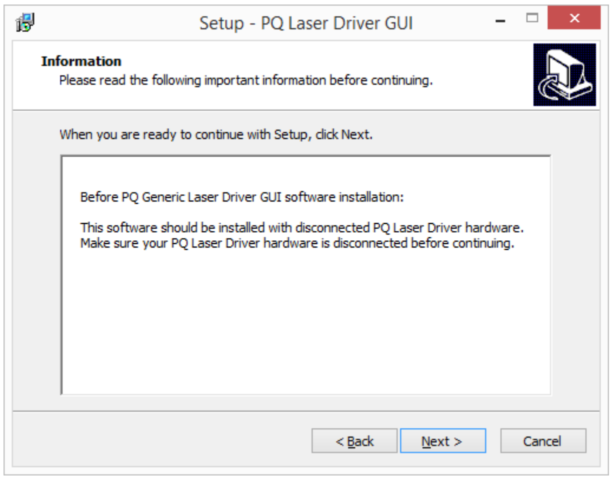


Fig. 9: PQ Laser Driver GUI Setup Wizard - Warning

Accept the License agreement and click *Next* when requested (See Fig. 7, Fig. 8, and Fig. 9).

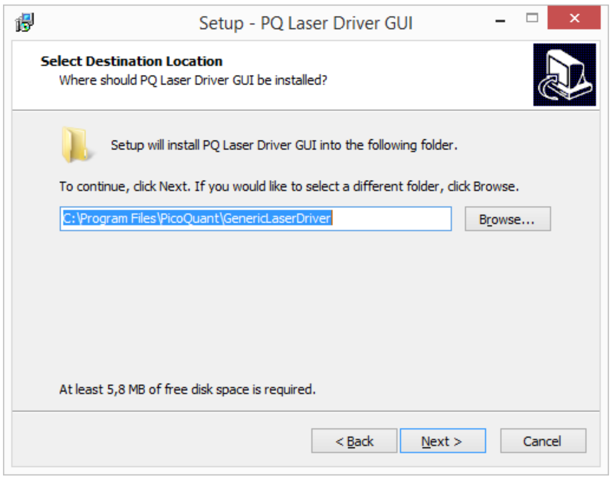


Fig. 10: PQ Laser Driver GUI Setup Wizard – Select destination

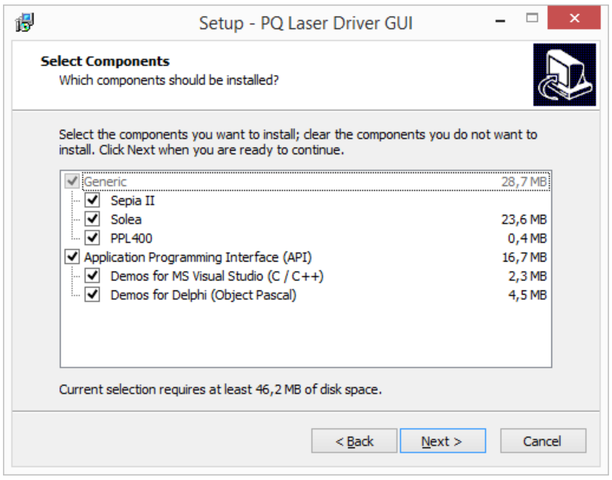


Fig. 11: PQ Laser Driver GUI Setup Wizard - Start installation (available component list may change due to new product releases and / or product discontinuations

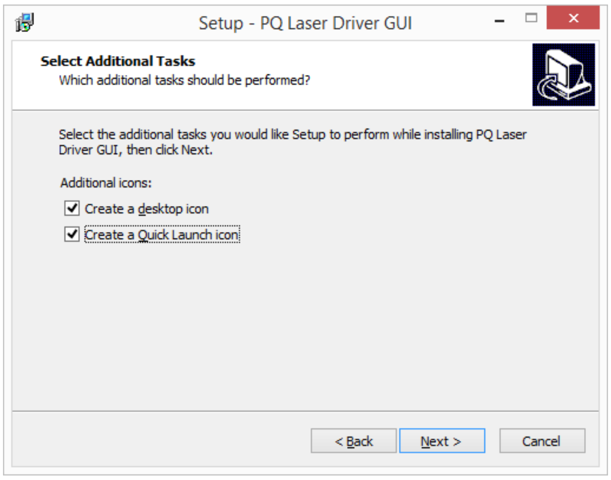


Fig. 12: PQ Laser Driver GUI Setup Wizard - Launch icon

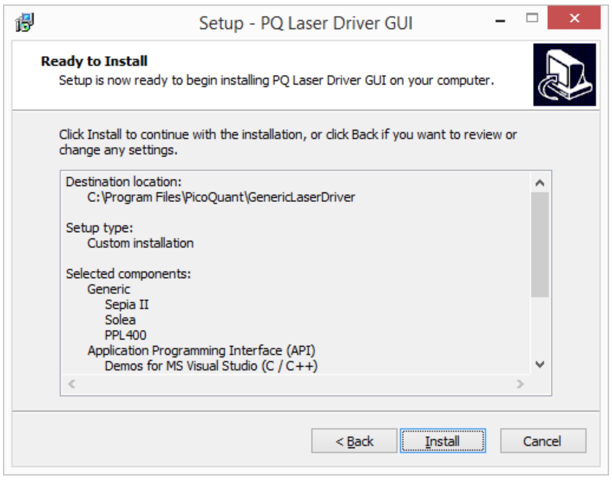


Fig. 13: PQ Laser Driver GUI Setup Wizard - Start installation

Define the destination folder for the installation of the software (Fig. 10), the components to be installed (Sepia II, Solea, and / or PPL 400 Fig. 11), and which launcher icon that should be generated (Fig. 12). Click *Next* to validate your choices and then the *Install* button to start the installation as shown in Fig. 13.

Important Remarks:

The PicoQuant Laser Driver Software can control not only the Sepia PDL 828 but also the VisIR / VisUV laser modules and Prima lasers from PicoQuant. In case you need to control multiple lasers, then it is necessary to install all relevant components (see Fig. 11).

It is recommended to choose at least one of the suggested icon options (see Fig. 12). For each icon option chosen, the installer automatically creates two software launchers corresponding to the “Bright” and “Dark” PicoQuant color themes. For more details about the software color themes please refer to section 5.1.

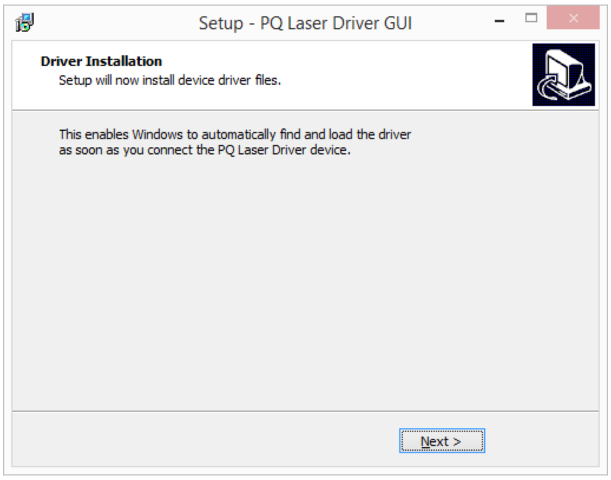


Fig. 14: PQ Laser Driver GUI Setup Wizard - Driver installation

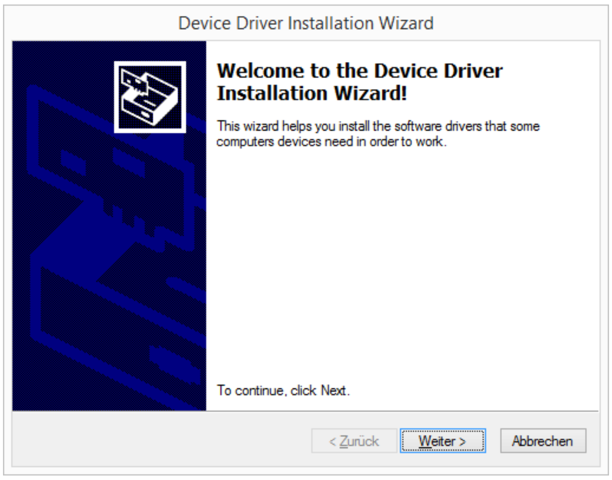


Fig. 15: PQ Laser Driver GUI Setup Wizard - Driver installation

Click *Next* to start the installation of the drivers as shown in Fig. 14 and Fig. 15.

It is possible that a *Windows Safety Warning* windows pops up. In that case confirm the installation when requested in order to continue with the installation.

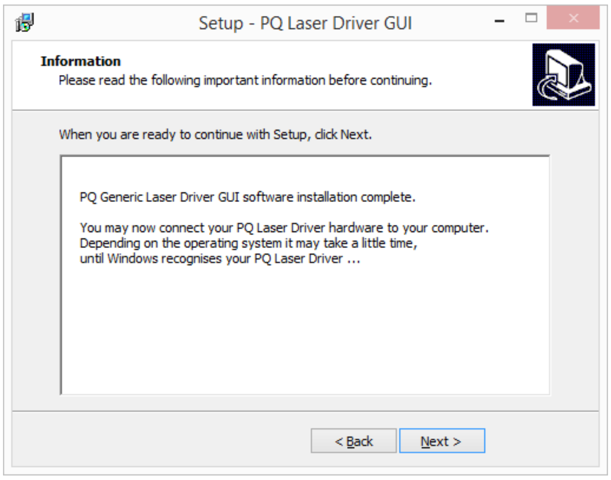


Fig. 16: PQ Laser Driver GUI Setup Wizard - Driver completed

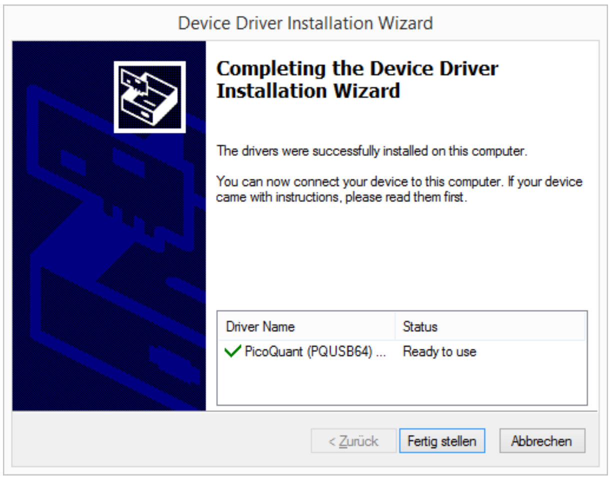


Fig. 17: PQ Laser Driver GUI Setup Wizard - Setup completed

Click *Next* when requested to complete the installation as shown in Fig. 16 and Fig. 17.

Click *Finish* to close the Installation wizard (Fig. 18).

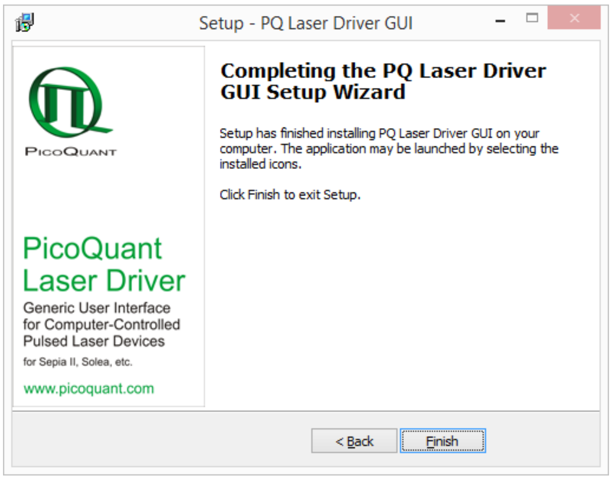


Fig. 18: PQ Laser Driver GUI Setup Wizard - Finish

Once the software is installed, the Sepia PDL 828 can be turned on (see chapter 3.3). When the laser is turned on for the first time, Windows will detect a new device and install the necessary device drivers.

3.3. Quick Start Guide

Before proceeding with the quick start guide, please read chapter 1.3 and follow all required laser safety instructions.

CAUTION! **Before powering the Sepia PDL 828 on, ensure that the key-switch is in the secure “STBY” position (vertical)!**

Switch on the main power using the switch on the rear panel. The controller will then perform some internal checks, initialize the modules and finally enable the laser drivers. This will take no longer than 45 seconds.

Before actually using the laser system, the system has to be configured (see further sections of this manual). After configuration or if the system has been configured before, the lasers can be unlocked with the key switch.

3.3.1. System Indicators and Controls

Fig. 19 shows the indicators and controls available on the front panel of a PDL 828 mainframe:

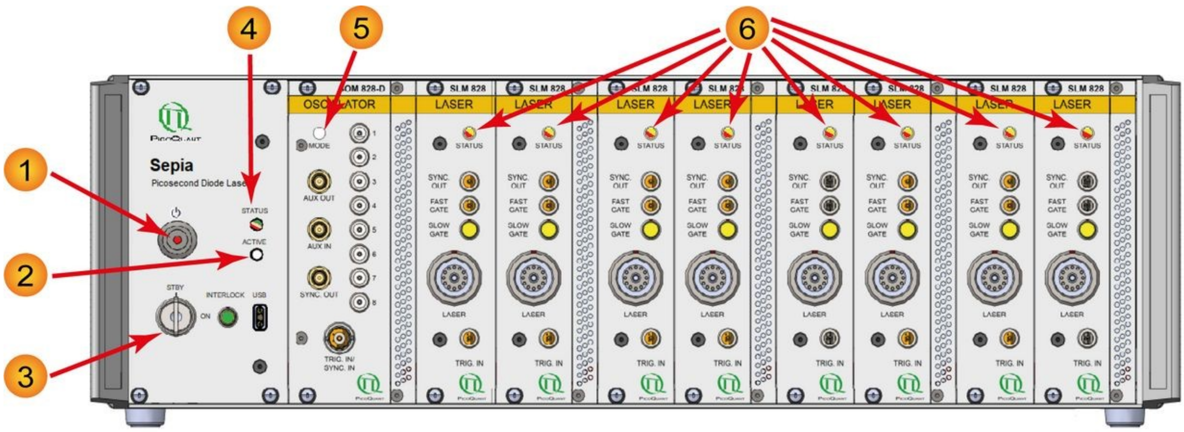


Fig. 19: Sepia PDL 828 Type "L" with SOM 828 module and eight SLM 828 modules

1 Power button and indicator. In general use, it is recommended to turn off the Sepia PDL 828 by using this button (stand by mode). A full power down (via main power switch on the back of the device) is required for some specific tasks, such as installing or changing hardware modules (see section 4.7)

2 Laser active indicator

3 Key switch for laser lock

4 Controller (SCM 828) status indicator

5 Oscillator (SOM 828-D) mode indicator

6 Laser module (SLM 828) status indicator

3.3.2. System Start-Up

1. Make sure the key switch 3 is in the vertical position (*STBY*).
2. Switch on the main power using the switch at the rear panel of the rack (not shown) to put the Sepia PDL 828 in Stand By mode, *POWER* indicator 1 lights up (red)
3. After pushing the Power button 1, the *POWER* indicator 1 goes off and the *LASER ACTIVE* indicator 2 lights up.
4. The *STATUS* indicator of the controller *SCM 828* 4 should light up and flash red, then yellow and finally green. After approx. 15 seconds the *STATUS* indicator should permanently show green. Note that the startup-time depends on number of installed modules. The rack is now ready for use. If the *STATUS* indicator shows red for more than 2 seconds, refer to chapter 11.1 for error diagnosis.
5. The *STATUS* indicator of the SLM 828 laser driver modules 6 should show yellow light.
6. Start the control software by double clicking on the corresponding desktop icon (see chapter 5, page 48). A graphic representation of the SCM 828 controller module is shown on the left hand hand side of the Graphical User Interface (GUI). Control panels for the detected oscillator modules laser drivers, and expansion modules are shown in the right hand part of the GUI.
7. Turn the key switch 3 to the *ON* position (horizontal)
8. Check the *Soft Lock* feature in the GUI. Clicking the button toggles the control that locks (enables / disables) the lasers. This is important should the lasers need to be shut down quickly through the software.
9. Get familiar with the GUI and its global functions (detailed explanations are given in chapter 5, page 48):

- All parameter fields normally display the currently active values.
- It is possible to change one or more parameters by entering new values, but the changes will not be effective until they are transferred to the modules using the *Apply* button. Values that have been changed but not yet submitted to the hardware modules are highlighted with an orange box.
- It is possible to undo changes in the GUI that are not yet transferred to the hardware modules (highlighted with orange boxes) by clicking the *Discard* button.

NOTICE	**Start the GUI only when the SCM status indicator 4 shows continuously green. Close the GUI before switching off the rack.**

3.3.3. Laser Drivers SLM 828 and Laser Heads

CAUTION!	**Do not connect or disconnect any laser head unless the PDL 828 mainframe is completely powered down and the *Laser Active* indicator (item 2 in Fig. 19) is off.**

All laser driver modules of the SLM 828 type are delivered with following default factory settings:

- Trigger from external input
- Trigger at falling edge
- Laser intensity: zero.

The GUI shows the control panels for the installed laser drivers to the right of the oscillator module as shown in Fig. 38 (item 23).

Triggering Modes

The pulse repetition rate of the SLM 828 can be derived either from its internal crystal oscillator or from an externally supplied trigger signal. The triggering source can be selected from the drop down menu labeled *Base Osc./ Trigger.* It is possible to select one of the 6 internal frequencies (2.5 MHz to 80 MHz) or to select external triggering at either rising or falling edge.

Laser diode heads of the LDH-D-C-xxx series can also be operated in continuous wave emission mode. This mode can be enabled by unticking the *Pulsed Mode* check box. Unchecking this box for laser heads from the LDH-P-xxx, LDH-P-C-xxx, LDH-P-FA-xxx or PLS series will disable their laser emission.

If the laser driver is unlocked , the status indicator on the laser driver 6 lights up red as long as the module is actually being triggered.

Examples of Laser Driver Triggering Schemes:

1. **Asynchronous**
   It is possible to operate any laser independently from other connected lasers by using its internal oscillator. Synchronizing the detection system should then be done directly from the local sync output of the respective laser driver module.
2. **Master-Slave**
   One laser driver is used as a master device that controls other lasers (slave device). To realize this scheme, set the master driver to trigger from its internal oscillator and connect its trigger output port to the slaves input port in a daisy-chain. Set the slaves to trigger from an external source. The chain can be extended to more than 2 channels. Use the sync output from the last slave driver in the chain to synchronize with the detection system. The lasers will fire with a delay between trigger in and optical out of more than 30 ns between each channel.
3. **Oscillator driven (requires SOM 828 or SOM 828-D)**
   Set all laser drivers to external triggering at *falling* edge and connect each trigger input port to one output port of the oscillator module. Synchronize the detection system with the sync out port of the oscillator module. Configure the oscillator module to produce the desired pulse pattern.

Intensity

The intensity (optical output power) can be set by the spin edit field "Intensity". Note that the percentage displayed has no linear relationship to the output power, e. g. setting the percentage to 50% does not mean that the laser head will provide 50% of its maximal optical output power (see section 4.4.3).

NOTICE	Always use only as much power as needed for your application to prolong the lifetime of the laser diode / LED.

3.3.4. Sepia Extension Module SEM 828 (optional component for remote control of e.g., VisUV / VisIR modules)

If a fully powered on, stand alone laser module such as a VisIR or VisUV is connected to an SEM 828, the GUI will display the control panels for the connected stand alone laser module to the right of the oscillator module as shown in Fig. 38 (item 23).For example, a connected VisUV or VisIR laser module can then be operated along with laser heads from the LDH or LDH-FA Series as well as with pulsed LEDs from the PLS Series, exploiting the full functionality of the SOM 828-D oscillator module.

3.3.5. Oscillator Module (SOM 828 and SOM 828-D)

There are many ways to configure the oscillator module. Only a few simple configurations are shown in this quick start guide as examples. Please refer to chapters 4.3.3 and 6.1 for a more detailed description of the oscillator module and the possibilities for realizing complex pulse patterns. The oscillator controls available in the GUI are described in chapter 5.

Selecting the Base Oscillator

This is the reference frequency from which all output patterns are derived.

Setting the Main Clock Rate (Divider)

One can generate lower repetition rates by dividing the base frequency of the oscillator through a set divider value. Set the parameter "Divider" to 4 to get a repetition rate of 80 Mhz / 4 = 20 MHz. This will now be the highest possible repetition rate for all output channels.

Burst Lengths

These parameters define how many pulses are generated at one channel before the next output channel becomes active in the sequencer. A value of zero means that that this channel copies the pulse pattern of the preceding channel. There are many more control parameters, allowing for the realization of complex, versatile pulse patterns through the combination of channels and/or introduction of delays. For a basic configuration, set them now as follows:

Burst Out:	all checked, meaning that all channels will be emitting laser pulses
Sync Enable:	all checked, meaning that sync pulses will be emitted for each channel
Pre Sync:	set to zero
Sync Mask Width:	set to zero
Sync Mask Invert:	unchecked

Examples for Oscillator Application

1. **Sequencer Operation**
   Set the burst length for each output channel to one. This defines a pattern where all channels will fire just one pulse one after each other. With a 20 MHz main clock frequency and 8 active channels, the repetition rate at each channel is 20 MHz / 8 = 2.5 MHz.
2. **Splitter Operation**
   Set the burst length for channel 1 to one and for all other channels to zero. Now all output lines will fire synchronously at a repetition rate of 20 MHz.

In order to trigger a laser from the oscillator's output, connect the output jack of the oscillator to the trigger input of the designated laser driver module using the patch cables delivered with the driver module. Set the trigger mode of that module to “falling (ext.)”.

4. Hardware Description

The PDL 828 “Sepia II” is a modular device consisting of a mainframe and a variety of possible modules that can be inserted into dedicated slots. This section describes the mainframe, the most commonly used modules, and possible interactions between them.

4.1. PDL 828 Mainframe

The PDL 828 mainframe consists of the rack housing including a power supply for the system, the back plane electronics to operate the different modules, and a series of empty slots into which different modules can be installed.

The controller module SCM 828 is always delivered along with the mainframe. The controller module includes the necessary USB connection, laser key switch, interlock, and LED indicators. (see chapter 4.2).

The PDL 828 mainframe is available in two sizes:

- Large housing– type PDL 828-L (19 inch rack): The full size rack has one slot for an oscillator module and eight slots for laser driver modules, as shown in Fig. 20.
- Compact housing – type PDL 828-S: The compact mainframe has one slot for an oscillator module and two slots for laser driver modules, as shown in Fig. 21.

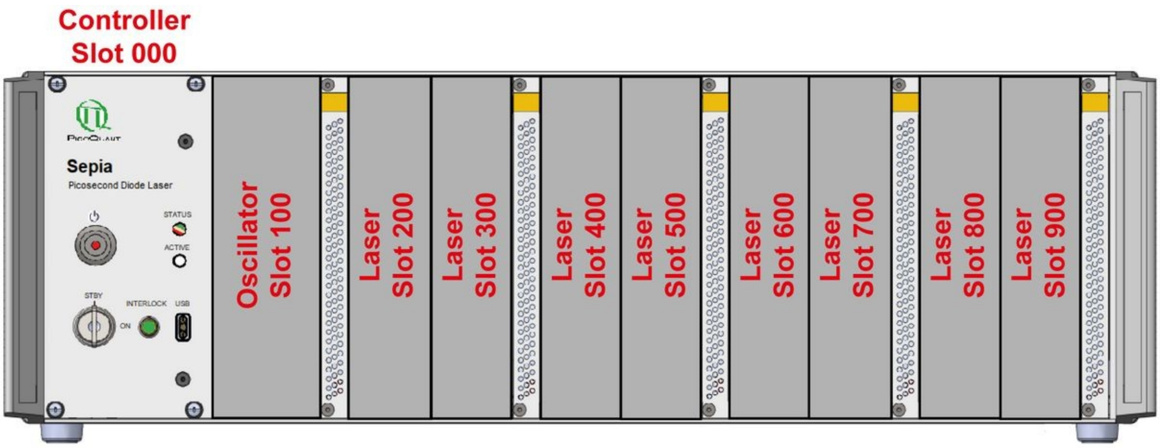


Fig. 20: Large mainframe PDL 828-L with one slot for an oscillator module and eight slots for driver modules

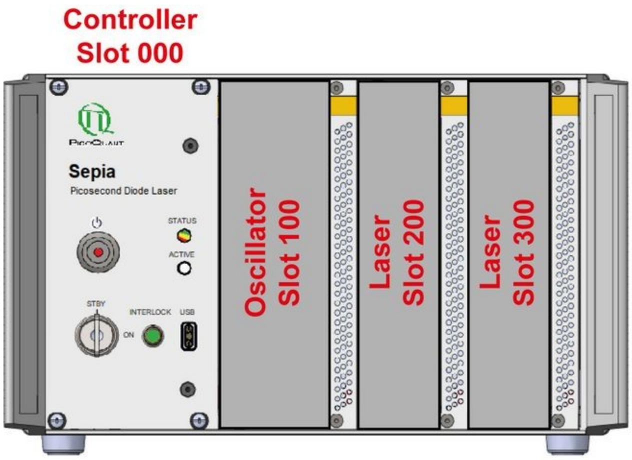


Fig. 21: Compact mainframe PDL 828-S with one slot for an oscillator module and two slots for driver modules

Slot Numbering

The available slots of the PDL 828 mainframe are addressed by the software from the left to right side with the following numbering scheme:

Slot No.	Function
000	Dedicated slot for the controller module SCM 828. The SCM 828 is always delivered along with the mainframe.
100	Dedicated slot for the oscillator module SOM 828 or SOM 828-D.
200…900	Slots available for standard laser driver modules SLM 828 or for the Sepia Extension Modules (SEM 828). 2 slots for PDL 828-S; 8 slots for PDL 828-L.

4.2. Controller Module – SCM 828

The controller module SCM 828 is always delivered along with the PDL 828 mainframe. The SCM 828 contains the micro-controller to operate the other modules installed in the mainframe and to process the communication with the external PC via USB.

4.2.1. Front Panel

The front panel includes not only the USB interface but also the laser key switch, the remote interlock and a series of LED indicators (see Fig. 22).

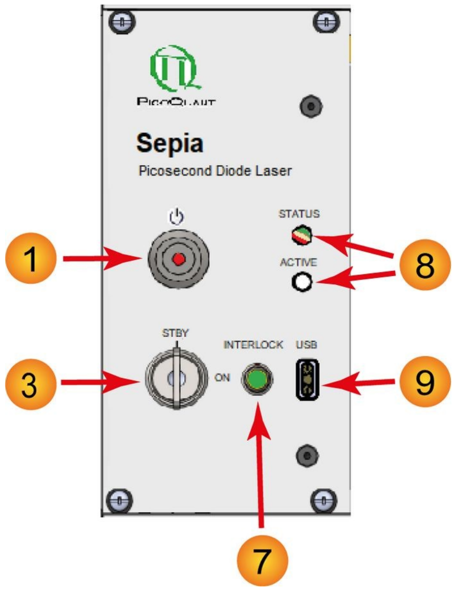


Fig. 22: SCM 828 - front panel

1 **Power button** and indicator. Pressing this button switches the Sepia PDL 828 from stand by mode to on, and vice versa. The LED in the button light up in red when the laser driver is in standy by mode (main power switch is in the *ON* position). The LED turns off when the device is turned on.

3 **LASER LOCK** key switch

7 **REMOTE INTERLOCK** connector

8 LED indicators:

- **STATUS:** green / yellow / red LED. A blinking sequence with various colors displays the device status during check-up and operation of the device. See chapter 11.1 for more information.
- **ACTIVE:** white LED. Lights up as soon as the power supply is on

9 USB-C connector to interface the Sepia PDL 828 with the PC

WARNING!	Laser radiation can be emitted when the white LASER ACTIVE LED is on. Refer to chapter 1.3 for laser safety instructions and chapter 3 for installation information. Turn the key switch to STBY (vertical position) in order to disable laser output from all connected laser heads.

Laser Locked

- The key switch 3 interrupts the laser power supply when it is in the vertical position. The key can be removed only in this position. It's a good practice to keep the key switch locked unless the connected laser heads can be operated according to safety regulations.
- The remote interlock 7 shuts the laser power supply off when the loop current is interrupted.
- To comply to the laser safety regulations, all lasers are locked off for at least the first 10 seconds after the main power has been switched on.
- The controller holds the lasers locked off as long as it checks its hardware while powering up.
- The controller keeps the device locked off, if it detects any abnormal operating conditions.
- The controller can be instructed from the GUI or from any software using the programming library (API DLL) to hold the lasers locked off regardless of the position of the key switch. Refer to chapter 5 (GUI) and the separate API manual for more information on soft locking.

WARNING!	Soft locking the lasers does not ensure eye safety!

4.2.2. Controller Operation

At power up, the micro–controller unit performs some basic checks on the module hardware before the rack is ready for operation. Once these tests are successfully completed, the “STATUS” indicator emits constant green light and all modules operate according to their last settings.

If the check fails, the rack may be become blocked and the “STATUS” indicator will show approx. 15 sec. red light alternating with a yellow blink code to identify the slot number where the error was detected. Refer to chapter 11.1 for details on error diagnosis.

4.3. Oscillator Module – SOM 828 and SOM 828-D

4.3.1. Front Panel

The oscillator front panel (Fig. 23) includes various connectors for the trigger and auxiliary inputs and outputs as well as a synchronization output port. The front panel layout is identical for both the SOM 828 and SOM 828-D oscillator modules.

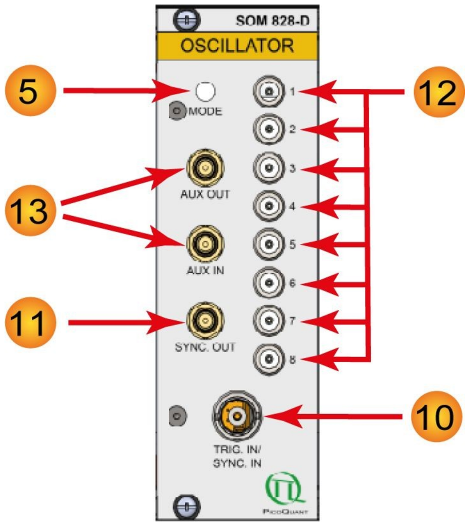


Fig. 23: SOM 828 and SOM 828-D – front panel

5 Operating mode LED indicator

10 External trigger input

11 Synchronization output

12 8 output channels

13 Auxiliary ports:

- AUX IN
- AUX OUT

4.3.2. Function Blocks

The oscillator modules SOM 828 and SOM 828-D are versatile and complex devices. Thus some definitions are needed to clarify the presentation. The sequencer of both oscillator modules features 8 channels are referred to as ***burst channels***. Furthermore, there are 8 channels directly connected to the output port, which are called ***output channels***. These two channel types should not be confused: the burst channels in the sequencer are used to generate a logical burst train, while the output channels are used to generate the NIM signals corresponding to the pattern from the burst channel.

The burst patterns in each channel are known as ***sequencer phases*** (or channel phases) and a full rotation through the burst channels (or sequencer phases) 1 to 8 corresponds to the ***sequencer period***. These definitions will be used throughout the remainder of this manual.

4.3.2.1. Oscillator Module SOM 828

The oscillator module **SOM 828** is composed of several basic function blocks, as schematically depicted in Fig. 24 (A). The scheme shows the logical interconnections of the functional modules and their (GUI / API) parameters, but does not represent the actual electrical realization.

Note: **Black color** is used to show the **modules** and the signal paths that connect them.

Red color indicates **parameters** that may be changed via the software GUI.

1. The base oscillator can be selected from one of three internal crystal oscillators (80 MHz, 64 MHz or 50 MHZ) or the external trigger can be activated to use any external signal source as reference for the base frequency. When using the external trigger input, the trigger level as well as the relevant trigger slope needs to be selected.
2. A prescaler to derive the main frequency from the base frequency provided by the base oscillator. Divider ratio can be set to any integer value between 1 and 255.
3. The sequencer can activate up to eight burst channels that are processed in a rotating manner. Each of these channel can generate bursts ranging from 1 to 16.7 million pulses before the next burst channel becomes active. The pulse patterns from these burst channels are then passed to their corresponding output channels where the NIM signals are generated.
4. A synchronization signal generator acting as a timing reference for the optical output pulses at the SYNC output of the oscillator module. This signal is provided for synchronization with external components, e. g., time-correlated measurement electronics.
   - There is an option to shift the pulses in steps equal to the period of the base frequency. This makes external delays of the synchronization pulse longer than about 20 ns unnecessary.
   - It is possible to mask out synchronization pulses, so that on every change of the output channel a given number *n* of synchronization pulses are suppressed. If the “Invert” option is set only the first *n* pulses of that burst pass to the SYNC output and all the following are suppressed. The maximal value for *n* is 255.
   - It is possible to select whether an output channel generates any synchronization pulses at all.
5. Eight output channels that are controlled by the sequencer. Adjacent output channels may be grouped together to emit simultaneously.
   - It is possible to enable or disable any output channel without affecting the pattern of the whole sequence. Only the electrical output will be disabled.
   - The skew between any two outputs is less than 100 ps.
   - The output lines provide NIM compatible signals (< -0.8 V into 50 Ohms) at NIM-CAMAC connectors, which are well suited for interconnections to other Sepia II modules.

All function blocks are controlled through the computer software. Refer to chapter 5 (GUI) and the separate manual for the API for details on programming your desired pulse configuration.

4.3.2.2. Oscillator Module SOM 828-D

The oscillator module SOM 828-D shares many features and functional blocks with the SOM 828. It contains, however, a few additional blocks in series to the sequencer allowing for advanced functionality such as combining of sequences from any number of the 8 burst channels into an output channel or the introduction of time delays in a specific channel. The logical interconnection of the modules and their GUI / API parameters are shown in Fig. 24 (B). Please note that this scheme does not indicate the actual electrical realization.

Note: **Black color** is used to show the **modules** and the signal paths that connect them.

Red color indicates **parameters** that may be changed via the software GUI.

1. The base oscillator can be selected from one of three internal crystal oscillators (80 MHz, 64 MHz or 50 MHZ) or the external trigger can be activated to use any external signal source as reference for the base frequency. When using the external trigger input, the trigger level as well as the relevant trigger slope needs to be selected. The SOM 828-D features also a phase-locked loop (PLL)

control system on the external trigger input port in order to further improve signal quality by reducing jitter and noise.

2. A prescaler to derive the main frequency from the base frequency provided by the base oscillator. Divider ratio can be set to any integer value between 1 and 65535.
3. The sequencer can activate up to eight burst channels that are processed in a rotating manner. Each of these channel can generate bursts ranging from 1 to 16.7 million pulses before the next burst channel becomes active. The pulse patterns from these burst channels are then passed to their corresponding output channels where the NIM signals are generated.
4. A synchronization signal generator acting as a timing reference for the optical output pulses at the SYNC output of the oscillator module. This signal is provided for synchronization with external components, e. g., time-correlated measurement electronics.
    - There is an option to shift the pulses in steps equal to the period of the base frequency. This makes external delays of the synchronization pulse longer than about 20 ns unnecessary.
    - It is possible to mask out synchronization pulses, so that on every change of the output channel a given number *n* of synchronization pulses are suppressed. If the “Invert” option is set only the first *n* pulses of that burst pass to the SYNC output and all the following are suppressed. The maximal value for *n* is 255.
    - It is possible to select whether an output channel generates any synchronization pulses at all.
5. A burst combiner (shown as small boxes labeled with 'C' for 'combiner unit' in them between the sequencer and NIM output blocks in Fig. 24) allowing to group pulse sequences from any burst channel into a specific output channel. Each burst pattern will be synchronized with their original burst channel (i.e., these pulses will trigger together with the original burst channel). It is also possible to mask all but the first pulse of each pulse pattern originating from combined burst channels in a given output channel.
6. Alternatively, a delay unit (labeled with 'D' in Fig. 24) allows for introducing a software controlled delay into any output channel relative to the other channels by up to ± 1 ms. This delay can be individually set for each channel and adjusted through the software GUI. Please note that a channel can only be used either for burst combiner or delayer, but not both at the same time.
7. Eight output channels controlled by the sequencer. As with the SOM 828, adjacent output channels may also be grouped together to emit simultaneously.
    - It is possible to enable or disable any output channel without affecting the pattern of the whole sequence. Only the electrical output will be disabled.
    - The output lines provide NIM compatible signals (< -0.8 V into 50 Ohms) at NIM-CAMAC connectors, which are well suited for interconnections to other Sepia II modules.

All function blocks are controlled through the computer software. Refer to chapter 5 (GUI) and the separate manual for the API for details on programming your desired pulse configuration.

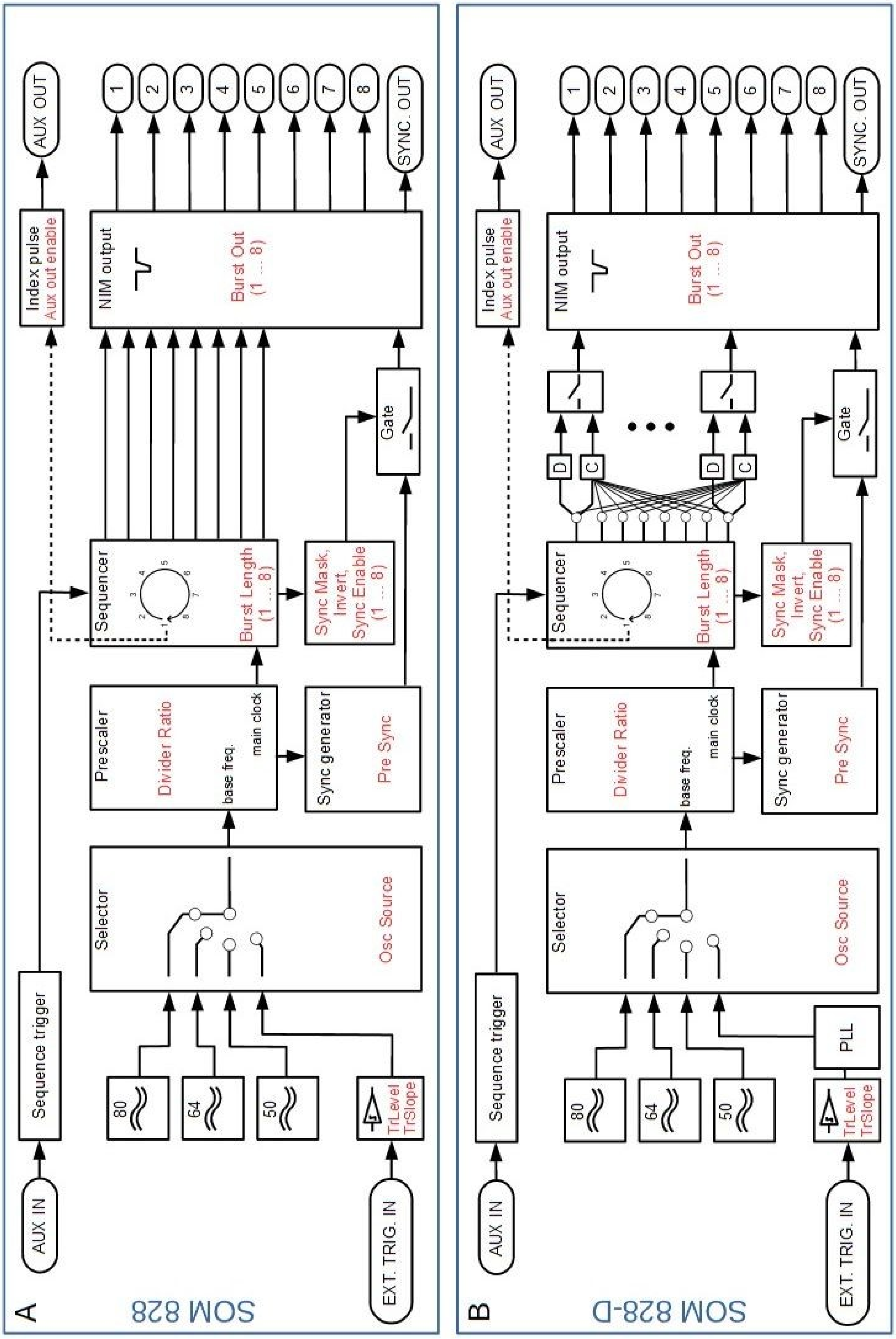


Fig. 24: Logic function block scheme for SOM 828 (A) and SOM 828-D (B)

4.3.3. Oscillator Configuration

4.3.3.1. Main Clock Definition

The main clock is the input signal of the sequencing stage. It is the time graticule to which any output pulses of the SOM 828 and SOM 828-D refer. The main clock period represents the minimal timing distance between any two output pulses. It is defined by two parameters: base clock frequency and divider ratio of the prescaler.

Oscillator Source (OSC source)

The **oscillator source (OSC source)** can be chosen from either the 3 internal crystal oscillators (running at 50 MHZ, 64 MHz or 80 MHz) or from an external trigger source (see Fig. 24). The chosen source is called **base oscillator** and provides the base frequency.

When using an external source, both trigger level and trigger slope must be set according to the used signal (parameters TrLevel and TrSlope in Fig. 25).

Divider Ratio

To generate slower main clock rates, the base frequency can be divided by any integer number between 1 and 255 (**SOM 828**) or 65535 (**SOM 828-D**). This is done by the prescaler (see Fig. 24). This stage works by suppressing *n-1* pulses before the next pulse passes the prescaler, where *n* is the divider ratio. That way the base frequency can be divided by 2, 3, 4, … and so on. Figure 25 illustrates the function of the prescaler when driven from an external triggering signal.

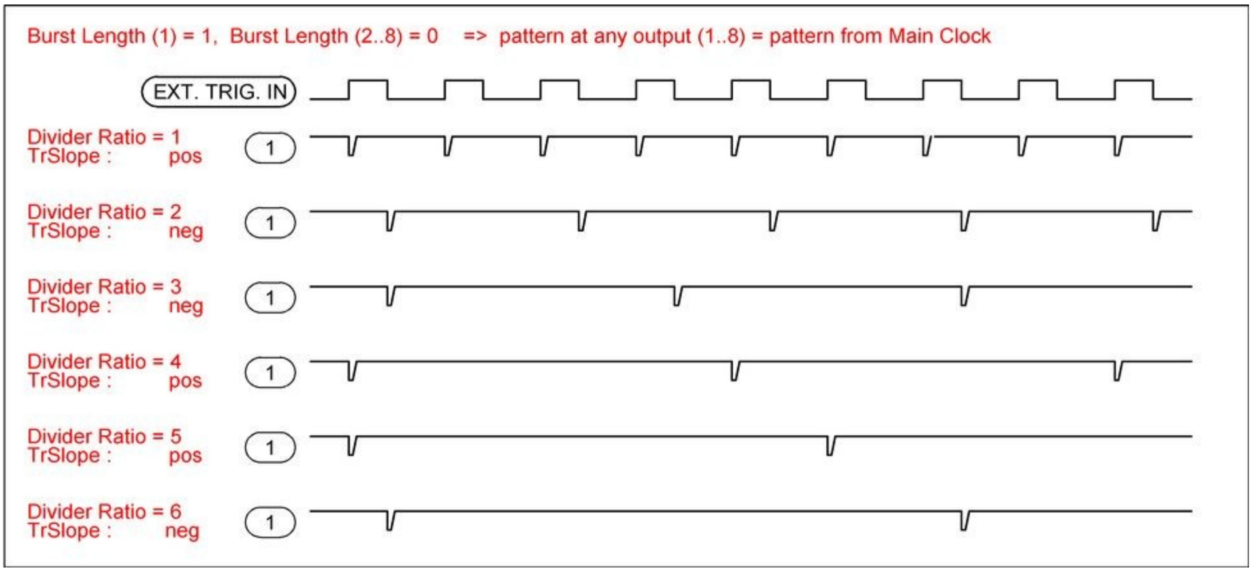


Fig. 25: Pattern from main clock at various divider settings

4.3.3.2. Sequence Composing

The oscillator module has eight individual ***burst channels*** that can be addressed in a cyclic sequence. The full pulse pattern (channel phase) for each output channel is derived from the burst length, channel combiner or delay parameters. A full sequencer period consists of the sum of the individual phases from channels 1 to 8 and has to be completed in order before a new period can start.

Burst Out

It is possible to enable or disable any single output channel without affecting the logical pattern from the sequencer channels or the timing at the other output lines. However, the burst channel corresponding to the disabled output channel is not eliminated from the sequencer period. The programmed number of pulses in the burst is still processed, but no electrical signal is sent to the corresponding output port.

Burst Length

The number of pulses in a burst channel is defined by the burst length parameter and can be varied between 1 and 16.7 millions. Once the number of pulses set has been emitted, the sequencer switches to the next burst channel. This way the 8 **burst length** values actually describe the whole period of the sequencer.

Any burst channel that has a burst length of 0 copies the signal of the preceding channel. This mode reduces the number of phases per sequence and can be used to group adjacent channels. These grouped lasers will allow two or more lasers to be fired simultaneously. Due to the rotatory working principle of the sequencer, the preceding channel for burst channel 1 is burst channel 8.

Time gaps between two laser bursts can be inserted by defining a burst length for an intermediate channel without using the output channel to trigger a laser driver. Of course, the number of actually usable lasers is then reduced.

If all lasers should fire simultaneously (i.e., in “splitter mode”) set burst channel 1 to a burst length 1 and all others to zero. In this case the whole sequence consists of 1 phase with one single pulse emitted by all output channels at the main clock frequency.

For a more complex example, please refer to chapter 6.1.

Combiner (SOM 828-D only)

The combiner of the SOM 828-D offers the possibility to group pulse patterns from different burst channels into a single output channel within the sequencer period. The combiner allows to select between 1 and 8 of the burst channels to be combined into a single phase. Each of the copied pulse patterns will trigger with its parent burst channel.

If, for example, burst channels 1 (with 5 pulses) and 5 (with 3 pulses) are to be combined together with burst channel 3 (with 1 pulse), the resulting pattern at the output channel 3 will consist of a total of 5 + 1 + 3 = 9 pulses. The first 5 pulses will be synchronized to burst channel 1, while the next pulse will coincide with the phase start of burst channel 3 and the last 3 pulses will be synchronized to burst channel 5.

Only burst channels with a burst length greater than 0 can be used in the combiner, as a setting of zero pulses means that the pattern of the preceding channel has to be copied. A burst channel can contain the combined pulse patterns of any number of burst channels, but does not need to include itself. However, a combination needs to contain at least one burst channel.

Disabled and delayed channels can be selected for use in the combiner. A disabled channel will provide its burst to pulse pattern in the target burst channel. The electrical signal will be output from the target output channel in synchronization with the disabled output. Of course, the disabled output will not generate any electrical signals.

Using a delayed channel in a combination will result in the burst pattern being added to the target burst channel. The delay, however, will not be transferred and the burst will be triggered on the original main clock pulse of the corresponding delayed channel.

Please refer to chapter 5 (GUI) for detailed descriptions on how to configure the combiner.

Delay Unit (SOM 828-D only)

The SOM 828-D oscillator module also offers a delay function allowing to shift the output of individual channels by up to ± 1 ms. This feature is extremely useful for the precise tuning of the temporal spacing for different laser heads (e. g., in STED microscopy) or to compensate for different optical path lengths.

The delay adjustment is performed in a two step process: first one sets a coarse value for the delay in steps of 600 ps to 800 ps. This step width depends on both main clock rate and hardware (i.e., on the sequencer burst channel), but is constant and reproducible for a given set-up. This coarse value can then be fine tuned through the “fine” setting in time steps with widths of typically 20 ps. These values depend only on the sequencer burst channel used, but are also constant and reproducible. Long term drifts of these time step widths might occur but have not yet been observed. A detailed description of the delayer software controls is given in chapter 5 (GUI).

4.3.3.3. Synchronization Signal Composing

The “Sync” output is provided to synchronize external detection systems such as TCSPC electronics to the signal generator and subsequently to the optical pulse.

It is possible to control:

1. whether a specific output channel should generate pulses at the sync output at all ("Sync enable")
2. a time shift to position the sync pulse prior to its corresponding output pulse ("Pre sync"),
3. a time window within the signal burst, where sync pulses are suppressed ("Sync mask" width & invert).

A "sync enable" parameter exists for each output channel, whereas the two other are globally effective for all sequencer phases.

Sync Enable

In order to synchronize external devices to a specific output channel, it is possible to select which output channel should be accompanied by synchronization pulses. In that way signal processing can be restricted to certain phases of the sequence.

Pre Sync

A digital timing offset can be inserted between the synchronization pulse and the corresponding output channel with the **Pre Sync** parameter. This offset is selectable in steps of one period of the chosen base clock.

The synchronization pulses will be output earlier than the corresponding output channel by the defined time (i. e., this time-shift corresponds to period of the base clock multiplied with the Pre Sync parameter). This is a global setting and applies for all output channels. See Fig. 7 for examples with different Pre Sync settings.

The Pre Sync feature cannot be used with values greater or equal to the divider setting of the prescaler. If the prescaler runs at unity ratio, the Pre Sync feature is disabled.

Sync Mask

At constant periodic pulse trains, the timing position of the optical pulse with respect to the synchronization pulse will be quite stable. But with signal bursts, depending on burst lengths and periods some settling effects of the optical pulse within a few microseconds may be observed.

By masking out the synchronization pulse during that settling time the detection system can be disabled until the optical pulse is stable.

It is possible to disable ("mask off") the output of synchronization pulses after the start of a burst for up to 255 output pulses by setting the **sync mask width** value. This is a global setting for all output channels. If a burst length setting happens to be shorter than the sync mask value, there will be no synchronization pulses during that burst. Some patterns that result from sync mask settings are shown in Fig. 26.

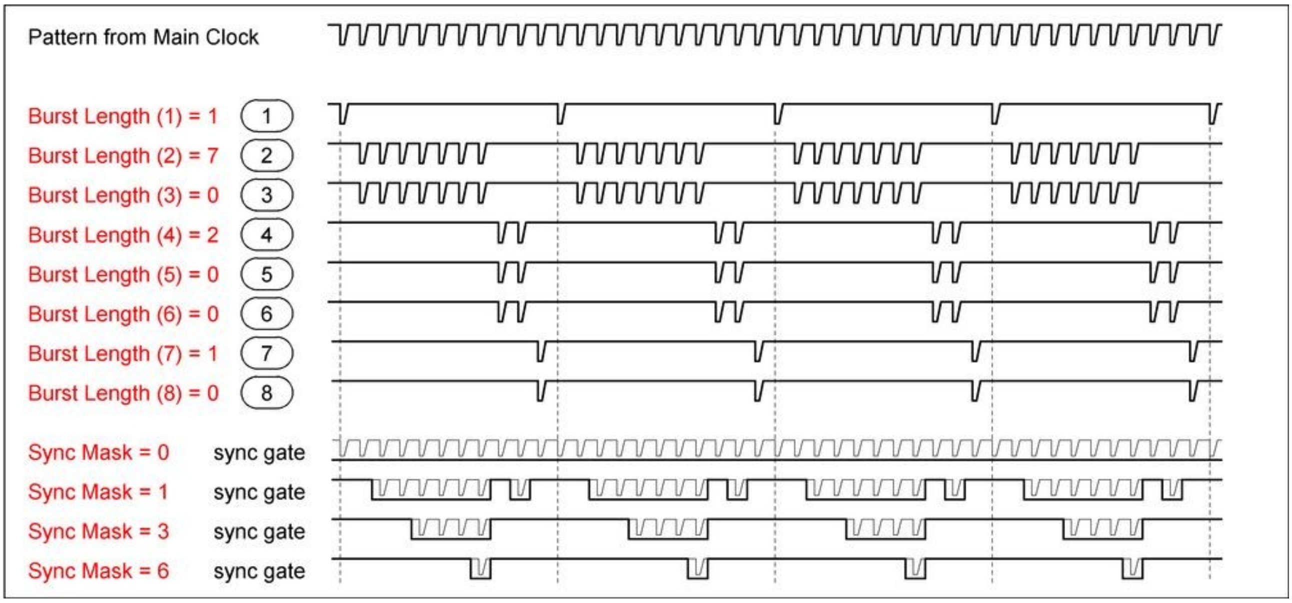


Fig. 26: Gating of synchronization pulses is controlled by the sync mask parameter

Inverse Mask

In the reverse case, i.e., only a certain number of synchronization pulses are required at the beginning of a burst pattern, the **Sync Mask** function can be **inverted**. Fig. 27 illustrates how the pattern changes when the mask is inverted. Inverting a Sync Mask of 0 will lead to no synchronization pluses being generated at the Sync output port.

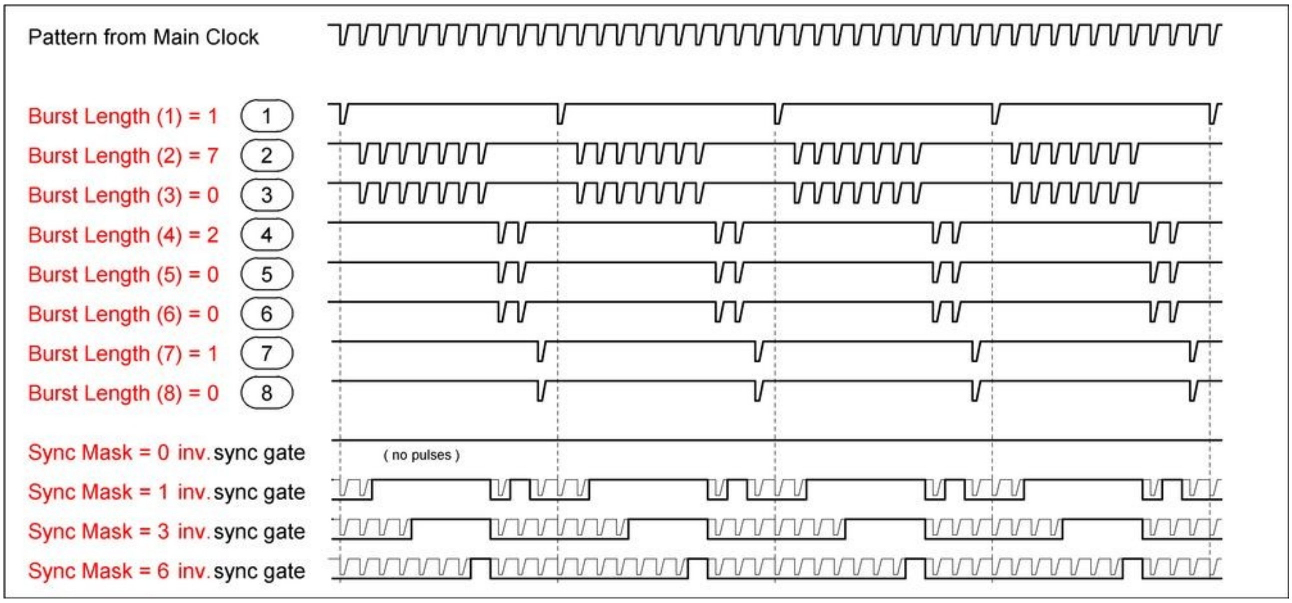


Fig. 27: Synchronization patterns resulting from an inverted sync mask

4.3.4. Auxiliary Input / Output

The auxiliary ports are provided for special functions to control full periods of the sequencer:

Auxiliary Input (AUX IN)

The auxiliary input is used to set the running / restarting condition of the sequencer. The input consumes TTL level signals. Its behavior on a given signal can be controlled by software. Refer to chapter 5.1.4 (GUI) and the separate API manual for details on setting the desired behavior. The sequencer can be run in the following modes:

- running free (AUX IN ignored)
- running on AUX IN set to logical "`High`" signal
- running on AUX IN set to logical "`Low`" signal
- disabled (the sequencer block is fully disabled; SOM 828-D only)

Consider that the state of the auxiliary input is only checked after every last pulse of a sequencer period, just before the next period is about to commence. Once a sequence is started, it will always be completed, regardless of level changes at the auxiliary input. This offers the option for a "**single sweep mode**", if a singular pulse with the currently active level (see above) but shorter than the current sequence length is applied to AUX IN.

The AUX IN input is internally tied to logical high level by a pull-up resistor. Consequently, an open input socket is treated as if a logically high signal is given. This behavior can be utilized as a "work around" for emulating the missing "sequencer disabled" option on the SOM 828. It consists in setting the auxiliary input to "running on false" and not connecting any signal to the AUX IN port. Since in this case the running condition cannot be met, the sequencer will not be running.

Auxiliary Output (AUX OUT)

The auxiliary output may be used to synchronize with the start of a new sequence. If enabled, it produces a TTL level signal. The output goes to logical "`Low`", when the sequencer has finished a period. This is given by the falling (i.e. starting) edge of the last pulse of the sequence. It stays "`Low`" until the falling edge of the first pulse of the next sequence arises. In Fig. 26 to 28 the latter moment is marked by a vertical dashed line. It is defined as the moment, when the sequencer generates the first pulse of the burst that is output from channel 1. Neither must channel 1 be enabled nor has channel 1 to be configured as a part of the sequence.

NOTICE	The auxiliary output AUX OUT delivers TTL levels only to high impedance signal sinks. On 50 Ohms terminated lines, the signal level drops down to approximately 500 mV. The timing of the AUX OUT signals will not meet the same high slew rate / low jitter specifications as the NIM output signals.

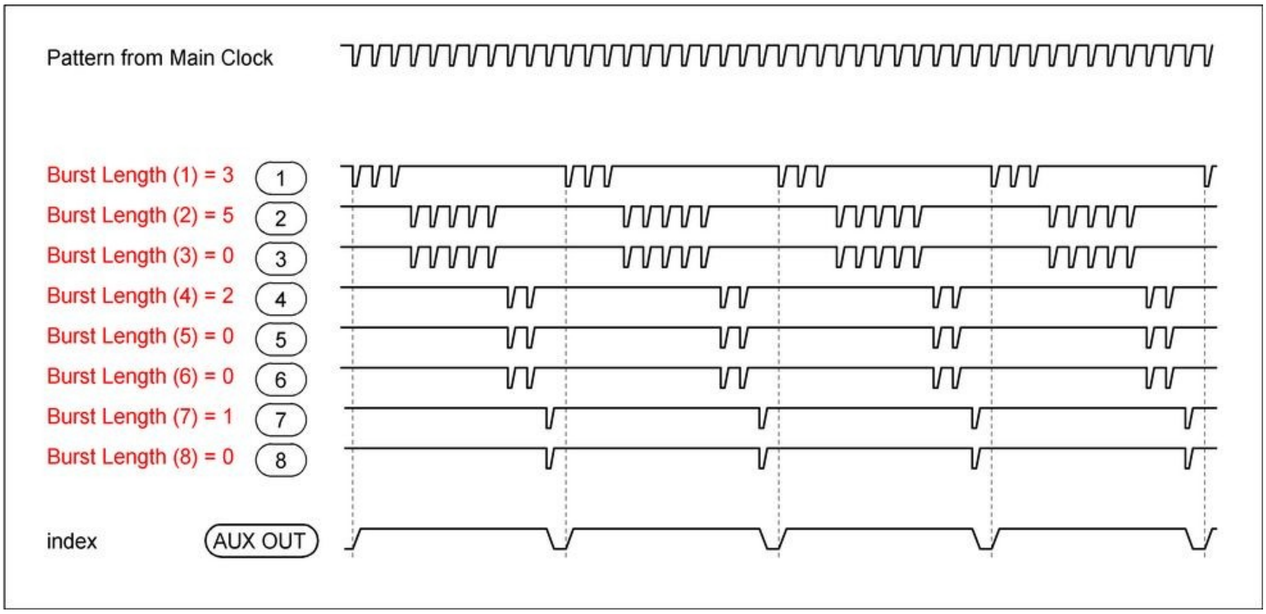


Fig. 28: Index pulse at start of the sequencer period

4.4. Sepia Laser Modules – SLM 828

The laser driver module generates all of the signals and supply voltages for the picosecond laser heads and sub-nanosecond LED heads provided by PicoQuant. Only laser heads supplied by PicoQuant can be used with the laser driver. A direct connecting of other types of laser diodes to the driver is not supported. The laser heads contain a unique circuit that matches the laser diodes to the driving electronics. Please contact us in advance if you have special laser diodes that need to be pulsed in picoseconds.

The SLM828 module also supports LDH-D-C laser heads allowing for CW operation of the laser diode.

4.4.1. Front Panel

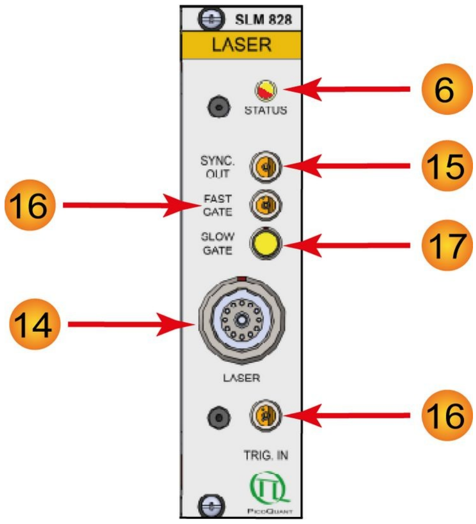


Fig. 29: SLM 828 – front panel

14 **LASER** connector: the laser or LED head has to be connected to this port with its cable. Make sure that the red markings on both cable connector and output port are matched.

CAUTION!	**Do NOT connect or disconnect a laser head unless the PDL 828 mainframe is in stand-by mode (i.e. red LED in power button is lit) !**

6 STATUS LED: indicates the operation mode of the laser head.

- red light indicates that the laser is running in **pulsed mode**.
- yellow light indicates that the laser is operated in CW mode or is held in standby mode.

15 **SYNC OUT**: delivers a NIM-compatible electrical signal synchronized to each laser pulse. This output is active in all triggering modes.

16 **TRIG. IN**: the trigger input is used to trigger laser pulses by an external NIM-compatible signal. This NIM signal can be provided typically by either the oscillator module SOM 828, SOM 828-D or by the SYNC OUT of another laser driver module SLM 828. Any other external source providing a suited NIM signal can also be used.

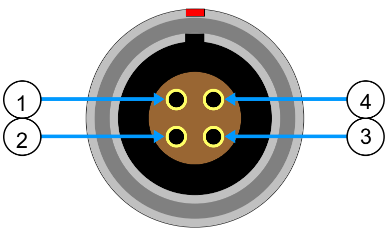


Fig. 30: Pin assignment of the SLOW GATE input port.

Pin #	***Function***
1	Anode
2	Cathode
3	Ground
4	+5 Volts

16 / 17 **FAST GATE / SLOW GATE:** Gating inputs can be used to disable the laser output through a TTL signal. Note that the SLOW GATE input cannot be left open: The yellow tipped 4-pin LEMO (00.304 Series) stub connector (provided with the device) needs to be plugged in if no other source is connected to the SLOW GATE.

The Slow Gate input is isolated by an opto-coupler and a voltage of 5 V between pin 1 and pin 2 of the connector must be fed into the input to unblock the Slow Gate. The pin assignment of the LEMO connector is shown in Fig. 30 Alternatively you can use an external generator delivering 5 V signal into 500 Ohm (ca 10 mA).

NOTICE The front panel of the SLM 828 does not feature any manual controls for the setting of operation parameter such as laser intensity, trigger source, internal repetition rate or operation mode. These parameters must be set via software.
Full details on how to set these parameters with the standard operating software using the graphical user interface (GUI) can be found in chapter 5.1.6 or in the separate manual covering the programming library (API).

4.4.2. Operation Mode and Triggering

Each laser driver module can operate independently, driven either in pulsed mode (triggered by internal oscillator or via external trigger) or in CW mode.

Internal trigger or CW mode:

- Each laser driver module can be **triggered from its internal local oscillator** at six user-selectable frequencies: 80 MHz, 40 MHz, 20 MHz, 10 MHz, 5 MHz or 2.5 MHz.

  The synchronization output of the laser driver module (15 in Fig. 29) delivers a synchronization signal along with each laser pulse. This synchronization output is particularly helpful in independent operation. It can be connected to the detection electronics such as, e. g., a TCSPC module from PicoQuant. A suitable LEMO-SMA or LEMO-BNC adapter cable can be obtained from PicoQuant.

  The shortest possible pulse width can be achieved in this configuration and the drift between synchronization signal and optical pulse will be at its lowest.
- Another independent mode of operation is the **continuous (CW) mode**. It can be used with any CW mode compatible laser heads from PicoQuant, such as the **LDH-D-C series.**

External triggered operation:

- Each SLM 828 can be triggered externally by a suited NIM compatible trigger signal connected to the trigger input **TRIG. IN** (16 in Fig. 29) of the SLM 828.

  The SLM 828 triggers at a fixed trigger level of approx. -0.3 volts from either edge. Triggering on the falling edge of the NIM signal is recommended for best results. The synchronization outputs from another SLM 828 or from an oscillator module (SOM 828 or SOM 828-D) supply such signals. Maximum repetition rate is in all cases 80 MHz.
- In its typical configuration, the PDL 828 mainframe is equipped with more than one laser driver module (SLM 828) and one oscillator module (SOM 828 or SOM 828-D) providing the triggering signal to the respective SLM 828. This type of configuration offers great flexibility in the parallel operation of up to 8 lasers with simultaneous or sequential emission. The sequencer of the oscillator module allows creating complex trigger patterns with channel grouping and even the introduction of software controlled, fine-tunable delays (only in conjunction with a SOM 828-D).

Please note that the maximum user selectable frequency might exceed the maximum pulse repetition frequency (PRF) supported by some laser heads. This could result in overheating of the laser head. Although PicoQuant laser heads are protected against damages caused by excess PRF, it is strongly recommended to avoid such situations. Refer to the test sheet of your laser head for its individual maximum PRF.

4.4.3. Emission Intensity

The intensity of the laser emission is controlled via internal voltage in steps of 1‰ of its full scale value. It is important to note that this voltage does not correlate linearly to its optical output power. Also note that some high-powered laser heads may only operate at very high levels of the intensity control.

The emission pulse shape varies noticeably with increasing output power. Typically, the shortest pulses (without any "tails" or after pulses) can be achieved at output power settings slightly above the lasing threshold. Increasing the power results in higher pulse energy but also broader pulses. It depends on the application and particularly on the detector whether shorter pulses or higher power will be needed.

Please keep in mind that operating the laser at high power decreases the lifetime of the laser diode. To ensure safer working conditions and to prolong the lifetime of the laser, reduce the laser intensity to the lowest possible value supported by your experiment. Full laser power should only be selected when absolutely necessary.

Changing the repetition rate may change the shape of the pulses. In some cases, these changes can be compensated for by adjusting the intensity control.

There are also minimal variations in the output characteristics for each laser driver module (typically < 1%). For laser heads with very steep transfer functions, the maximum power or output at a given intensity setting may, however, differ by up to 10%.

For long-term stability of the output power, allow the laser to warm-up for at least 20 minutes. This is especially important for temperature stabilized laser heads.

4.4.4. Gating Functions

For special applications, such as in scanning devices, the SLM 828 has two gating functions allowing suppression of laser emission by an external signal.

FAST GATE

The fast gate function affects the trigger input line **TRIG. IN**.

It is thus only effective when the module is being triggered from an external source. The fast gate input will have no effect if either the internal oscillator is active or if the laser is operated in CW mode.

The gating function can perform the on/off transition within nanoseconds. It can therefore switch the laser state between two pulses, even at high repetition rates. However, due to thermal effects, the same attention should be paid to burst lengths and periods as for burst generation with the oscillator module.

To use this gating mechanism, connect a low-active TTL signal to the “FAST GATE” connector (16 in Fig. 29). The input has an internal pull-up resistor to “High” level.

SLOW GATE

The slow gate function modulates the laser activity by switching the output power voltage to zero. This method will be effective regardless of the trigger source and will also minimize drift effects. However, this method is a comparably slow modulation with respect to high repetition rates of the laser.

The slow gate input is isolated by an opto-coupler and a current must be fed into the input to activate the laser. When this gating function is not used, the yellow LEMO connector stub (included with the device) must be plugged into Slow Gate connector (17 in Fig. 29) to keep the laser always active.

4.5. Sepia Extension Module – SEM 828 (optional component for remote control of of e.g., VisUV / VisIR modules)

The Sepia Extension Module (SEM 828) allows connecting a stand alone laser module from e.g., the VisIR or VisUV family to the Sepia PDL 828 laser driver and fully controlling it via the Sepia PDL 828's GUI. (see chapter 5.1.7). The control elements of the connected stand alone laser module is displayed in the GUI in the corresponding slot. The connected stand alone module can then be operated along with laser heads from the LDH or LDH-FA Series as well as with plused LEDs from the PLS Series, exploiting the full functionality of the SOM 828-D oscillator module.

Please refer to the corresponding manuals for more details on the characteristics of each stand alone laser module as well as for instructions on how to operate them when connected to a Sepia PDL 828

NOTICE	SEM 828 are used to connect only stand alone laser modules such as e.g., VisUV and VisIR. Common laser diode heads from the LDH or PLS Series must be connected via the SLM 828

The SEM 828 module allows modifying settings (e.g., intensity, repetition rate, trigger source) of the connected device directly from the Sepia PDL 828 software. The connected device then operates according to these settings.

WARNING! Laser Safety

Note that the connected device may be of a higher laser class than the Sepia PDL 828 (e.g., **a Class 4 / IV VisUV or VisIR**). When such a device is connected to the SEM, then all laser safety measures applicable to its laser class also need to be observed. Refer to the manual of the connected device fpr detailed information.

To ensure laser safety, the Sepia PDL 828 will control the interlock state of a connected stand alone laser module (such as a VisUV). This has the following consequences:

- if the interlock is triggered by the Sepia PDL 828, then laser emission is shut down for all laser heads as well as for the connected stand alone device.
- If the Sepia PDL 828 is powered off, the connected laser device will not be able to emit laser light.
- While starting up, the Sepia PDL 828 will also block laser emission from any connected device.
- Using the Soft Lock button in the Sepia PDL 828 GUI will also turn off laser emission from any connected device.
- Activating laser emission from a connected stand alone deivce: turn the laser key switch of the connected device to the appropriate position (LASER) while the Sepia PDL 828 is fully powered on and unlocked.

4.5.1. Front Panel

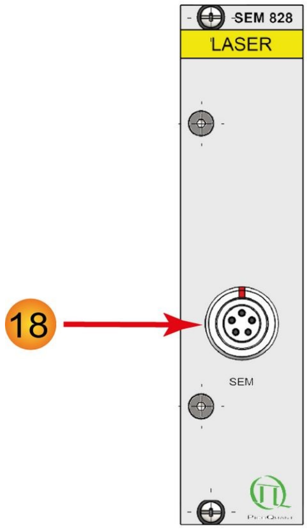


Fig. 31: SEM 828 front panel

18 **SEM** laser connector: the VisIR / VisUV laser module has to be connected to this port with its cable. Make sure that the red markings on both cable connector and output port are matched.

CAUTION!	**Do NOT connect or disconnect a laser head unless the PDL 828 mainframe is in stand by mode!**

4.6. Laser Heads / LED Heads

4.6.1. Temperature Controlled (Model LDH–…–C Laser Heads Only)

The only user adjustable part of the laser head is the set-point for the thermoelectric (TE) cooler. Since the output power at a given potentiometer setting depends slightly on the temperature of the diode element, the set-point should only be changed if absolutely necessary, e.g., if the ambient temperature is too high.

The thermoelectric (TE) cooler maintains the temperature of the diode element and collimating optics at a constant level. The factory pre-set value is approximately 20 °C. The desired temperature can be set via the Temperature Set-Point Adjustment potentiometer located inside the LDH (see Fig. 32). For temperature adjustments a non conductive potentiometer adjustment tool is required.

CAUTION!	**Please note that adjusting the set-point temperature is not meant to be a "daily" process. Constantly changing the temperature set-point will wear out the plastic adjustment potentiometer. Only change the set-point value if the temperature in your laboratory is regularly above (or below) +20 °C.**

The temperature level can be set from +15 to +25 °C. The temperature should be chosen with respect to the ambient temperature and humidity conditions. The outer case acts as a heat sink. To prevent overheating, the temperature should not be set to the lowest value if the ambient temperature is higher than 30°C. Also, if the ambient humidity is high, water may condense on the collimator. Switch the laser OFF and look at the silver colored collimator holder to determine whether condensation is forming.

WARNING! Laser Safety

Do NOT look into the laser optics when the laser is ON!

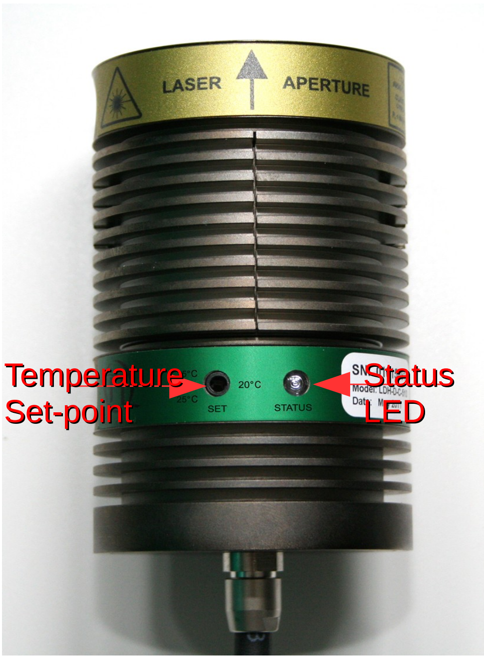


Fig. 32: Top-view of LDH-C series laser head

The temperature of the diode element needs to reach the set-point temperature for stable operation. At start-up the s*tatus LED* may be "red“. The laser head will switch off if the LED is “red“ and the diode element is warmer than approx. 28 °C. Under normal conditions, allow about 2 to 5 minutes after start-up for the TE cooler to reach the set-point temperature. The s*tatus LED* will change to "green" when the set-point temperature has been reached.

Check the t*emperature control status LED* on the laser head. If it is:

- green – the laser diode element is operating at the set-point temperature,
- red – the temperature is not at its set-point, if it is too high, the laser will be shut off.

Check the *status LED* periodically. If it is “red“, the TE cooler is operating but not able to maintain the diode element temperature below 28 °C. In this case, switch the laser OFF and wait until the laser head has cooled down. Then, adjust the temperature set-point to a higher value, reduce the ambient temperature or increase the ventilation near the diode laser housing.

At higher operating temperatures the diode laser can provide approximately 10% more output power, but the diode element lifetime will be much longer if operated at a lower temperature.

4.7. PDL 828 Hardware Upgrade

The PDL 828 is a modular device consisting of a mainframe (PDL 828) with a controller module (SCM 828) along with a variable number (1 or 2 for the compact housing, up to 8 for the large housing) of Sepia Laser Modules (SLM 828) or Sepia Extension Modules (SEM 828), and an optional oscillator module (SOM 828 or SOM 828-D).

Additional modules can be added to a non-fully equipped mainframe at any time. Possible upgrades include the SOM 828 or SOM 828-D (if not purchased originally), additional SLM 828 or SEM 828 modules.

Performing the hardware upgrade is easy and straightforward and is outlined in this section.

CAUTION!	**Fully power down the Sepia PDL 828 and disconnect the power cable from the device prior to performing the procedure outlined below. Ensure that you follow proper ESD (electrostatic discharge) protection rules to avoid damaging the device.**

Please note: The pictures in Fig 29 to 33 show an earlier version of the PDL 828 front panel. The principle is still valid for the new versions of the PDL 828 front panel.

Step 1:

Switch off the PDL 828 **and disconnect the power cable of the device from the wall plug**. Then loosen the two cross head screws that hold the metal plate shielding the empty slot with a suitable screw driver (see the red circled screws in Fig. 33).

Fig. 33: Loosen the screw holding the metal plate.

Step 2:

Carefully remove the metal plate. After removing the plate, the red plastic guide rails into which the new module must be inserted become visible (see Fig. 34 and Fig. 35).

Fig. 34: Carefully remove the metal plate.

Fig. 35: Location of red guide rails

Step 3:

Take the new module (e. g., SLM 828 as shown in Fig. 36) and carefully insert it into the empty slot using the red guide rails. The module should be pushed until it fits perfectly into the housing.

Fig. 36: Inserting the new module into the PDL 828 mainframe

Step 4

Fix the newly inserted module by tightening the cross head screws as shown in Fig. 37.

The hardware upgrade is completed!

The next time you connect the device to the computer and launch the control software, the new module(s) will be automatically detected and the corresponding additional control slot(s) will appear in the graphical user interface.

Fig. 37: Fix the screws of new laser driver module

5. Software Description

5.1. PQLaserDrv – The Graphical User Interface (GUI) for Sepia PDL 828 et al.

NOTICE	The Sepia PDL 828 must be turned on and the initialization process completed, before the software can be started!

The Sepia PDL 828 GUI is available in three different **color schemes:** PicoQuant bright scheme, PicoQuant dark scheme and a standard Windows scheme. The latter can be customized using the standard Window control panel.

The dark scheme is intended for light sensitive set-ups and experiments such as, e.g., photon counting and single molecule sensitive spectroscopy set-ups, where ambient light perturbation should be minimized as far as possible. However, for better readability, all screen shots in this manual correspond to the PicoQuant bright color scheme.

The color scheme is applied by the command line parameter "`/style=<scheme>`" where the placeholder `<scheme>` could be one of the legal values "`dark`", "`bright`" or "`windows`".

During the installation setup of the software, the installer can optionally generate separate desktop as well as quick launch icons for the respective bright and dark schemes (see chapter 3.2).

In the interest of ergonomics, all relevant active controls (button, edit box, etc.) change color when the mouse pointer hovers above them.

An overview of the GUI with all control elements is shown in Fig. 38 below. The GUI displays only the control elements for the modules that are included in the mainframe and detected during the initialization of the hardware. The example shows the GUI for a PDL 828 mainframe equipped with the controller module SCM, the oscillator module SOM 828, a SEM 828 module, which is connected to a VisIR-1950-F module and a laser driver modules SLM 828.

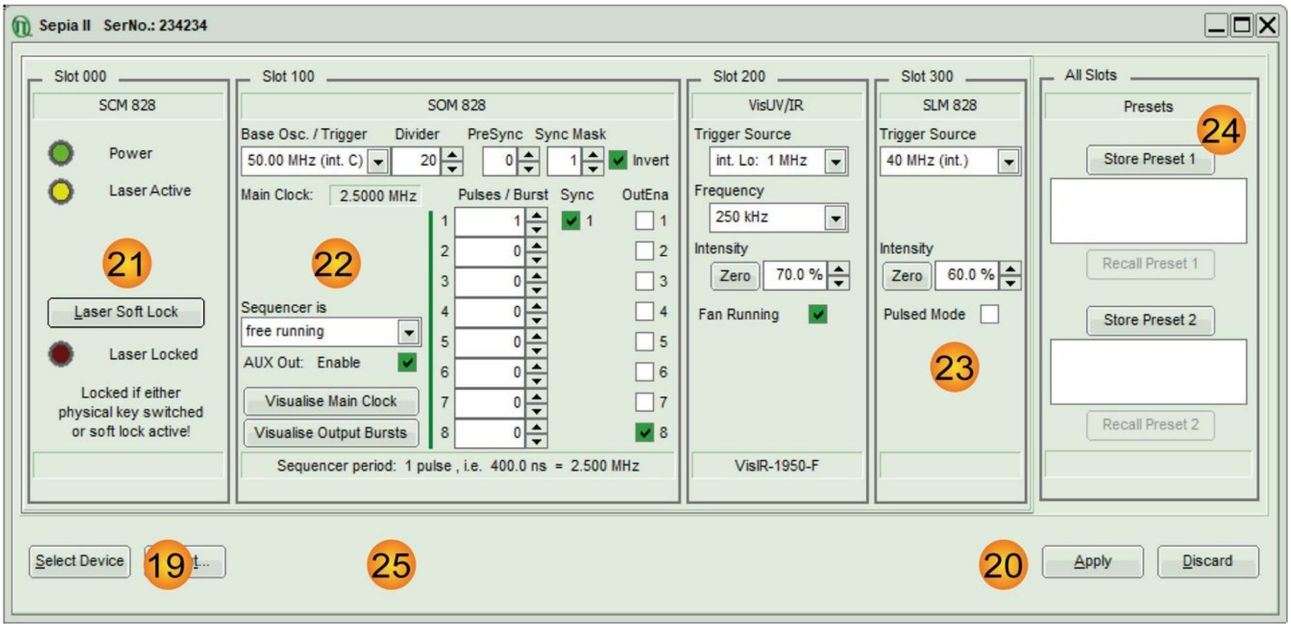


Fig. 38: Sepia PDL 828 GUI - Overview with all control groups with indication of the individual sections

5.1.1. Select Device

The *Select Device* (19) function is useful if more than one Sepia PDL 828 (or any other USB laser device from PicoQuant) are connected to the same host computer. It can also be used to restore the USB connection to the device should it be lost during operation for any reason.

A mouse click on the *Select Device* button will start a scan for supported devices connected to the PC.

A modal dialogue with an *OK* and *Cancel* button presents a list box with the currently connected devices (Fig. 39). When opening the list box, all detected devices are listed by their serial number. The currently selected device is marked with an asterisk “*”.

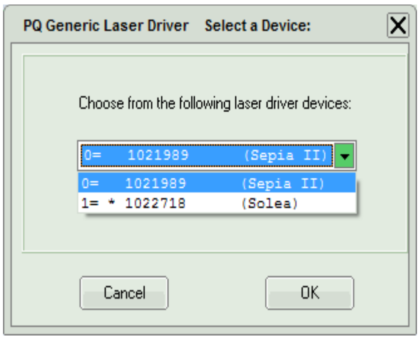


Fig. 39: Select device

Cancel	Back to the main window without any changes.
OK	Change to the newly selected device. Note that this might lead to changes in the GUI, if a device of different type or configuration is selected. The serial number of the currently selected device is always displayed in the title bar of the software.

5.1.2. Apply / Discard

Apply and *Discard* buttons (20) must be used to confirm or discard the configuration changes made in the GUI. In the example shown in Fig. 40, changes have been made to the parameters of the oscillator module. The *SOM 828* label and the *Apply* button are therefore highlighted in orange and remain highlighted until the changes are either applied or discarded.

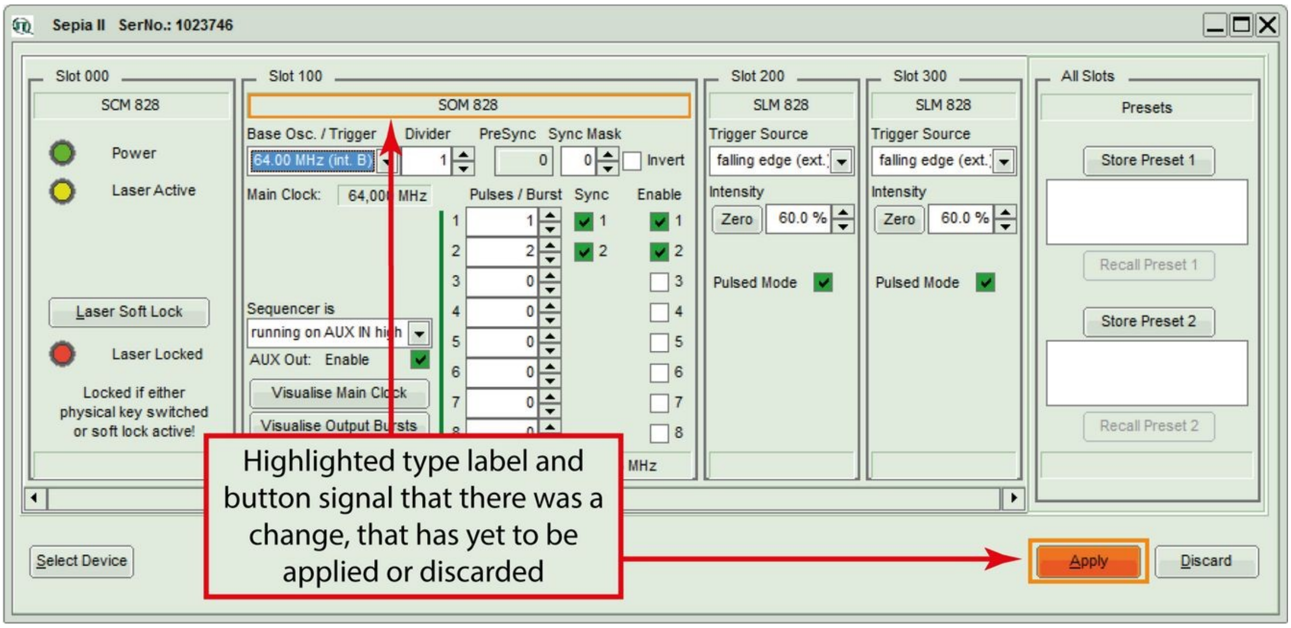


Fig. 40: Elements highlighted in orange indicate a recent change of parameters, which have to be applied or discarded

5.1.3. Soft Lock and Unlock of the Sepia PDL 828

The Sepia PDL 828 can be locked (no laser light emission) and unlocked (laser light is emitted) not only with the hardware key switch on the front panel, but also via the GUI by clicking on the button labeled *Laser Soft Lock / Laser Soft Unlock* 21, which is located in the controller frame on the left side of the software window.

The *Laser Unlocked* state is recognizable in the software by the *Laser Locked* indicator turning dark red (see Fig. 41).

The *Laser Locked* state is recognizable in the software by the *Laser Locked* indicator turning bright red. The button text could be either *Laser Soft Lock* in case the system was hard locked by key or remote interlock circuit (see Fig. 42), or *Laser Soft Unlock* (see Fig. 43) in case the system was soft locked (This even masks a hard lock state).

Please note that the lock state indicated in the GUI may refresh with a slight delay (< 1 s) **Consider:** The soft lock state is not persistently stored in the system; After power down / power up it is lost.

WARNING!	**Before unlocking the laser, please refer to chapter 1.3 for laser safety instructions. Allow about 3 – 5 minutes warm-up time after unlocking the laser to reach a stable output power.**

Fig. 41: Laser unlocked

Fig. 42: Laser hard locked

Fig. 43: Laser soft locked

5.1.4. Oscillator Module SOM 828

The control panel 22 for the SOM 828 is shown in Fig. 44 below:

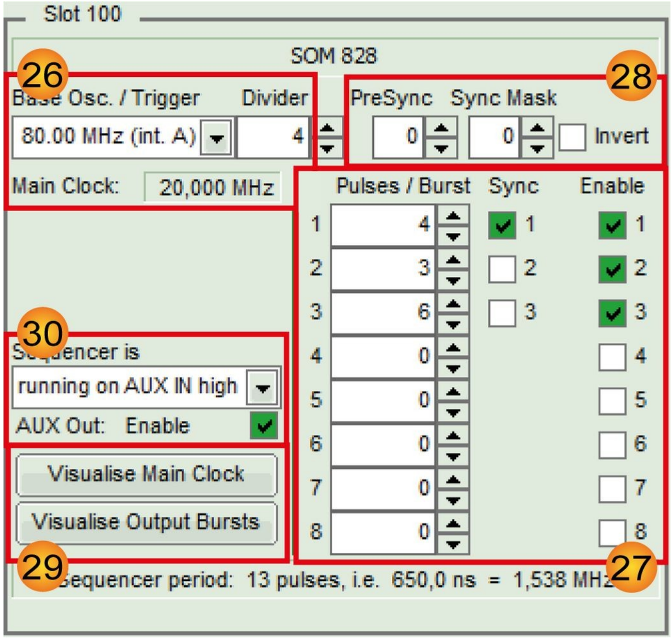


Fig. 44: Control element for the SOM 828

26 **Set Main Clock and Trigger:**

The frequency of the *main clock* is derived from the chosen ***base oscillator*** (*80 MHz, 64 MHz, or 50 MHz*) or external ***Trigger*** source (*rising edge* or *falling edge*) and from the dividing factor ***Divider***. Fig. 44 shows an example of *Main Clock* set at 20 MHz derived from the internal base oscillator of 80 MHz and a dividing factor of 4.

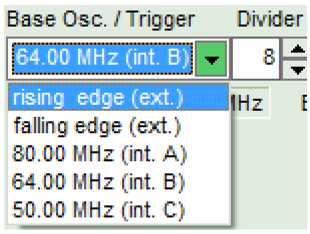


Fig. 45: Setting Main Clock

The *base oscillator* or *trigger* source can be chosen from the drop down menu as shown in Fig. 45. The dividing factor set by the spin edit box labeled *Divider* can be set to any integer value between 1 and 255.

In case an external *trigger* source (*rising edge* or *falling edge*) is chosen, a spin edit box labeled *Trigger Level* appears where the threshold value can be entered (see Fig. 46).

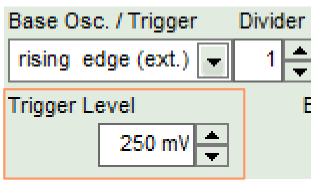


Fig. 46: Setting trigger level

27 **Sequencer configuration panel:**

Pulses / Burst: The exact number of pulses per channel can be set by this spin edit box. A burst can consist of any integer number of pulses between 1 and 16.7 millions (16 777 215 pulses).

The text field labeled *Sequencer period* at the control panel bottom summarizes the content of the whole sequencer period (total amount of pulses, sequence period length, and sequence repetition rate). Note that this timing information cannot be displayed when the SOM 828 is triggered externally.

Sync: The generation of a synchronization pulse at the synchronization output (Fig. 23, items marked (11)) can be *enabled* or *disabled* through the corresponding check box.

Enable*:* The output signals of each channel can be *enabled* or *disabled* at the respective **output channels** (Fig. 23, items marked (12)) through the corresponding check box. Each of the 8 channels can be disabled without influencing the sequencer period or any other channel. A disabled channel will not output any electrical signal, but will still “count” its pulses.

28 **Define sync signal by PreSync, Sync Mask and Invert:**

PreSync: This setting is used for selecting a digital timing offset between the synchronization pulse and corresponding signal output. Pulses at the **Sync Out** port are emitted before the signal at the trigger output. This offset is selectable in steps of one period of the chosen base frequency. The amount of periods can be any integer from zero up to the value of the divider factor-1. Please note that setting a ***PreSync*** value is not possible when the SOM 828-D is triggered externally.

Sync Mask: This setting is used to disable the generation of the **Sync Out** signal (but not the signal at the output channels). The value given defines the number of synchronization pulses that are omitted at the beginning of a burst. The number of pulses that can be masked can be selected between 0 and 255 pulses.

Invert: the invert function can be activated by a check box. It is used to invert the effect of the Sync Masking, i. e. the settings specify the number of synchronization pulses emitted at the beginning of a burst.

29 **Visualise Main Clock and Visualise Output Burst:**

The **Visualise Main Clock** button brings up a visualization window that shows a time based representation of the base oscillator, the main clock, and the synchronization output (unmasked).

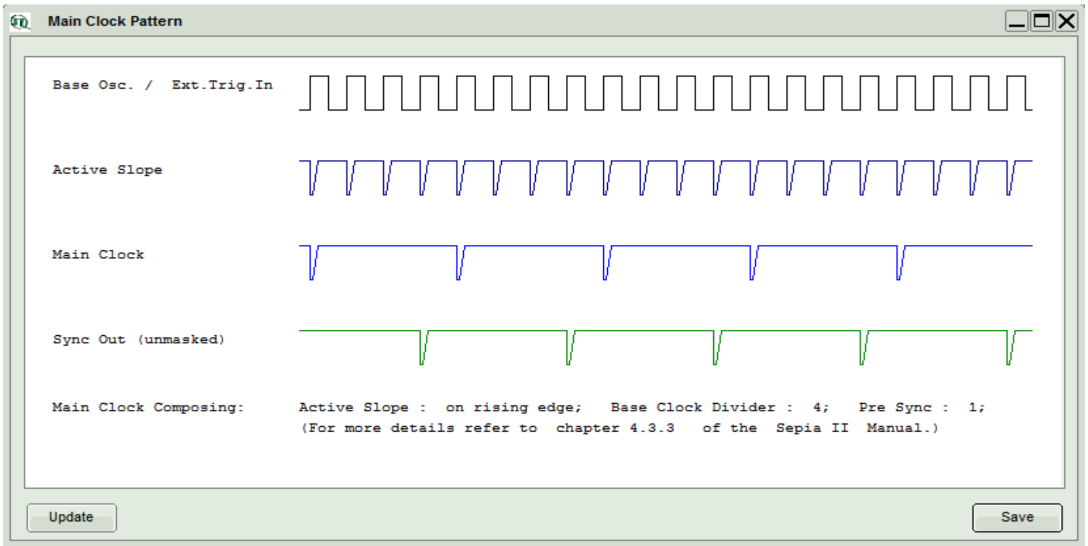


Fig. 47: Visualization of the Main Clock as set in Fig. 44

Visualise Output Bursts brings up a visualization window that shows a time based representation of the main clock, bursts and synchronization output (masked, but Pre Sync shift ignored).

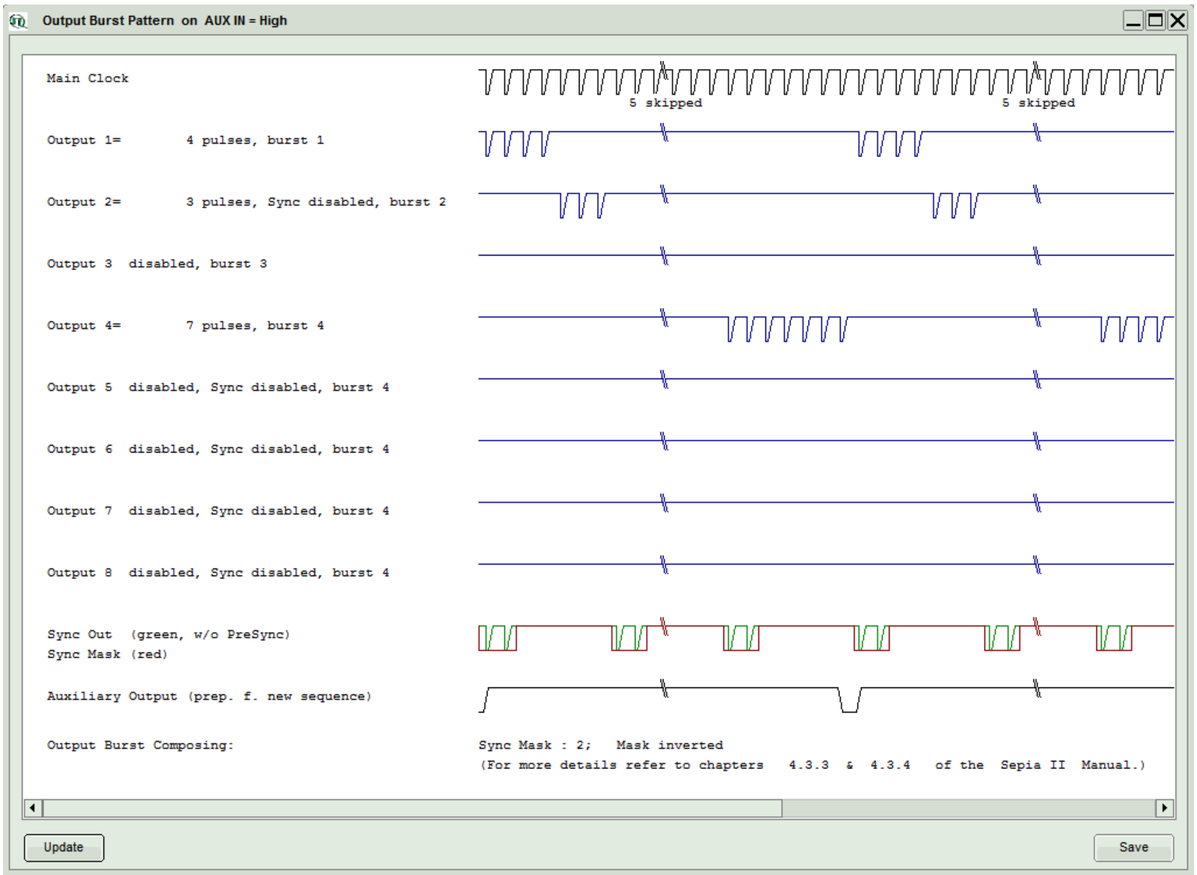


Fig. 48: Visualization of the output bursts as set in Fig. 44.

30 **Set Auxiliary Input / Output:**

The auxiliary input can be used in order to disable or enable the sequencer of the oscillator module. The running / restarting condition of the sequencer can be controlled by the sequencer mode selected here and if chosen the signal level applied to AUX IN, as shown in Fig. 49. It is also possible to fully disable the sequencer by choosing the option “disabled” in the drop down menu. Please note that this last option will only appear if the SOM 828-D is installed. However, this function can be emulated on the SOM 828 by setting the Auxiliary Input to “running on false” and not connecting any signal to the AUX IN port. Since the running condition cannot be met, the sequencer will not be activated.

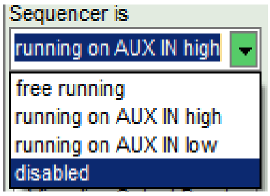


Fig. 49: AUX In: Running states

The auxiliary output can deliver a trigger signal at the end of a SOM 828 sequence. The generation of the *AUX Out* trigger signal can be simply activated/deactivated by a check box as shown in Fig. 50.

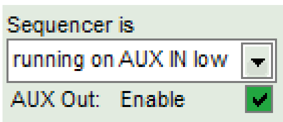


Fig. 50: AUX Out: Enable / Disable per tick box

5.1.5. Oscillator Module SOM 828-D

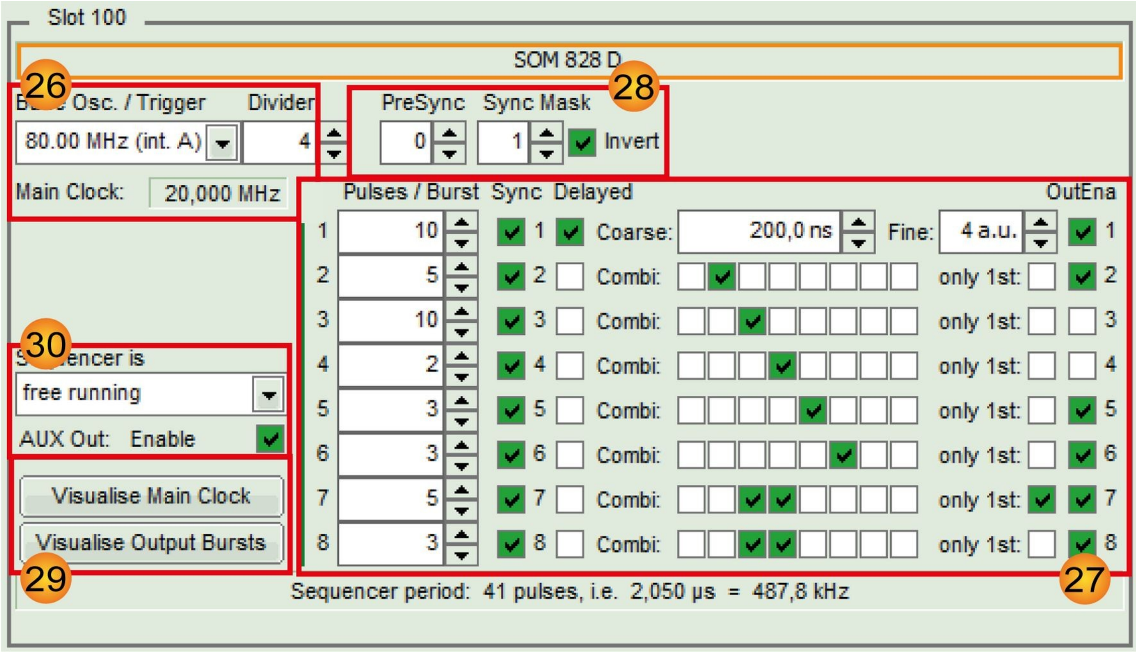


Schaubild 1: Control elements for the SOMD 828

The GUI of the SOM 828-D 22 shares most of the control elements with the SOM 828, as shown in Fig. 53. The main difference reside in the control elements for the external triggering source 26 and the sequencer panel 27. Please refer to the previous section for a description of the control elements 28 to 30.26

Set Main Clock and Triggering

The basic settings (oscillator source and divider) in this panel are similar to those of the SOM 828, with the exception that the divider can be set to any positive integer from 1 to 65535. Another important difference appears when switching the base oscillator to an external trigger source (see Fig. 51): on the SOM 828, one can only set the trigger level through a spin edit box. The SOM 828-D, however, offers additional settings due to the phase-locked loop (PLL) control element connected to the external trigger input port. The primary purpose of the PLL control circuit is to further improve signal quality of the trigger pulses by reducing jitter and noise.

If the ***Synchronize*** check box is enabled, the PLL circuit will be available to synchronize with the frequency of the external trigger signal. Once the box is checked, all controls for the burst channels (burst length, combiner, delayer) will be locked and their GUI elements hidden by an information box highlighted in red. This lock-down will remain until the PLL control circuit has been synchronized with the external trigger signal. This is done by using the *Now* button as described in the procedure below.

The LED-like indicator next to the *Now* button will light up in green if the PLL circuit finds the frequency of a suitably clean trigger signal. The indicator will show up as red if the signal quality is too low (too much jitter or noise). Once the indicator shows continuously green, the *Now* button can be pressed to synchronize the PLL with the external trigger frequency. The locked-in frequency is now indicated in the information box labeled “Trig.-Freq.:” and the derived main clock rate is indicate below in the box labeled “Main Clock:”. As usual, the main clock frequency is derived through dividing the trigger frequency by the divider factor.

Should the quality of the external trigger signal deteriorate significantly (e. g., too much jitter or signal drift), the PLL control circuit will lose the synchronization and immediately lock down the sequencer. Please note that this lock-down will stop the sequencer at the moment the synchronization is lost. The sequencer period might therefore not be completed. Also, the burst channel controls in the GUI will be hidden by an information box highlighted in red. The lock-down can only be removed by re-synchronizing the PLL control element with the external trigger source.

Please be aware that not all frequency generators are able to supply a signal that is suitable for synchronization with the PLL control element. Furthermore, the signal quality of a generator can be frequency dependent. It might happen that a frequency generator can supply suitable signals at some frequencies, while other frequencies will fail to synchronize with the PLL.

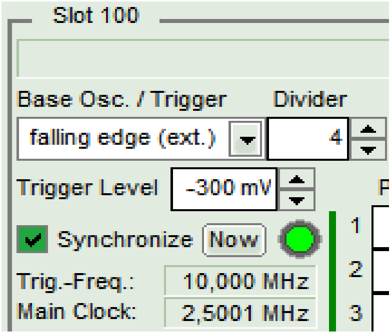


Fig. 51: Extended settings for external triggering - SOM 828-D

27 **Sequencer configuration panel**

Pulses / Burst: The exact number of pulses per channel can be set by this spin edit box. A burst can consist of any integer number of pulses between 1 and 16.7 millions (16 777 215 pulses).

The text field labeled *Sequencer period* at the control panel bottom summarizes the full sequence (i. e. total number of pulses, length of the sequence period, and repetition rate of the period). Please note that contrary to the SOM 828, the SOM 828-D can measure the external trigger frequency and display this information along with the derived main clock rate.

Sync: The generation of synchronization pulses at each output channel (Fig. 23, items marked 11) can be *enabled* or *disabled* through the corresponding check box.

Delayed: Ticking this check box will enable the delayer for the corresponding channel. The GUI elements in this line will change from the combiner check box list a pair of spin edit fields labeled *Coarse* and *Fine*. The delay time for any channel can be set from -1 ms to +1 ms in steps of 600 ps to 800 ps by setting the desired value in the *Coarse* spin edit field. The value entered in the *Coarse* field will be automatically adjusted to the closest valid number. The delay timing can be fine tuned by using the *Fine* spin edit field, where the step width (denominated as arbitrary units, a.u.) is in the range of 15 ps to 30 ps. The time step widths depend on the main clock (Coarse step only) and hardware channel (for both settings).

Combi: By un-ticking the *Delayed* check box, the selected channel is set to combination mode. Both spin edit fields *Coarse* and *Fine* from the delayer mode are replaced by the combiner line. This line consists of 8 check boxes corresponding to channels 1 to 8 (from left to right). Channels with a burst length of 0 will be shown as grayed out boxes and cannot be selected. A combination needs to have at least one channel selected. If only one box in the line is checked, it will not be possible to deselect it until a new one is ticked. It is possible to select up to 8 channels in a combination.

Only 1st: This check box only appears when a channel has been set into combination mode. Ticking this box will mask all pulses in a burst pattern except for the first one for each phase. A phase grouping burst patterns from several channels will in this case emit one pulse synchronized with the start of each combined channel. The effect of this option can be clearly seen in Fig. 52 by comparing the output channels 7 (*Only 1st* checked) and 8 (*Only 1st* not checked). In output channel 7, only the first pulse from each combined channel is active while the others are masked. Channel 8, on the other hand, outputs all pulses from the combined channels.

OutEna*:* The output signal for each of the 8 channels can be *enabled* or *disabled* at the respective **output channels** (Fig. 23, items marked 12) through the corresponding check box. Each individual channel can be deactivated without influencing the sequencer period or any of the other channels. A disabled channel will not output any electrical signal, but will still “count” its pulses.

The **Visualise Output Bursts** button brings up a similar visualization window as for the SOM 828 showing a time based representation of the main clock, bursts, and synchronization output (masked, but Pre Sync shift ignored). In the case of the SOM 828-D, the visualization also shows the bursts resulting from the combiner, the effect of the *Only 1st* check box and indicates the delays that were set for different channels. Please note that the delays are not represented by a shift in the graphical display but by showing the pulse train of the corresponding channel as a green line. The delay value is also indicated in the channel output comments in the left part of the window.

As an example, Fig. 52 shows the visualization of the pulse pattern corresponding the combiner/delayer settings given in Fig. 53. Please note that the output comments in the left hand side of the window also indicate which channel have been combined into a specific channel.

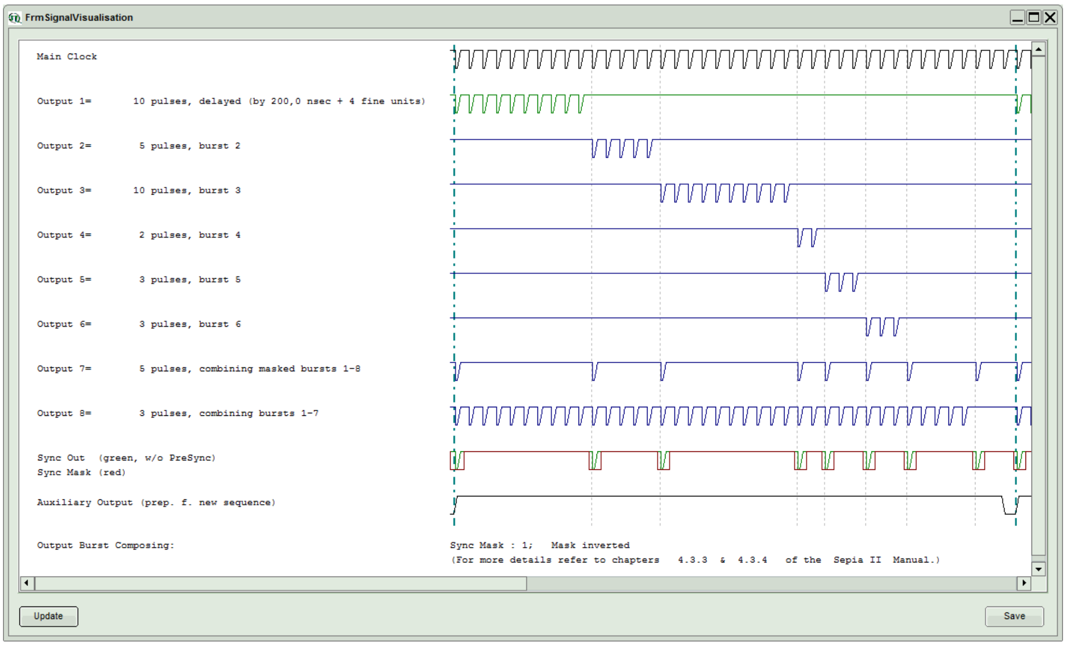


Fig. 52: Visualization of the pulse sequence.

5.1.6. Sepia Laser module SLM 828

The control element for the SLM 828 23 is shown in Fig. 53 below:

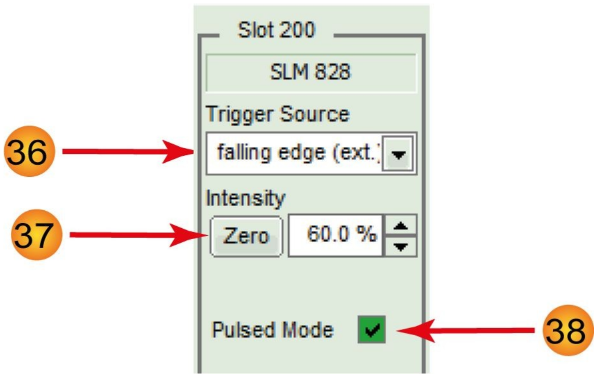


Fig. 53: SLM 828 GUI

36 **Trigger source:**

- 5 user selectable internal repetition rates of 80, 40, 20, 10, 5 or 2.5 MHz.
- 2 external trigger input settings: *rising* or *falling*
  (*falling* is recommended if the laser module is triggered by the SOM 828 or SOM 828-D)

37 **Intensity:**

- The intensity of the laser head can be set on a freely adjustable scale from 0 to 100 %. Please note that the optical output power of a laser head does not correlate linearly with the intensity scale. Each laser head has a particular threshold value for laser emission, a particular slope and a particular maximal power value.
- The *Zero* button provides an easy toggle between any intensity value and zero intensity. This is useful in case a laser needs to be switched off quickly. The button memorizes the intensity previously set. Pressing it again restores this intensity setting (and vice versa).

38 **Pulsed mode:**

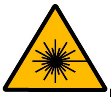
This check box permits to deactivate the pulsed mode. If pulsed mode is deactivated, laser heads of the LDH-D-C series will emit in Continuous Wave mode (CW emission).

CAUTION!	**While most pulsed laser heads (e. g., from the LDH-P, LDH-P-C, and LDH-P-FA series) will shut down if switched to cw operation, some laser heads, especially if manufactured before 2006, might turn into an undefined state. Unchecking *Pulsed Mode* does therefore not guarantee that the laser head will behave safely!**

5.1.7. Sepia Extension Module SEM 828

If an SEM 828 is installed with a stand alone laser module connected to it, then the controls elements of that laser iwill show up in the corresponding slot. As a necessary precondition, the stand alone laser module has to be connected to the SEM 828 and be fully powered-up , before the Sepia II frame initializes. Note that the controls available will depend on the type and state of the connected stand alone laser module. Please refer to the manual of the corresponding laser for details on its software controls.

The SEM 828 module allows modifying settings (e.g., intensity, repetition rate, trigger source) of the connected device directly from the Sepia PDL 828 software. The connected device then operates according to these settings.



WARNING! Laser Safety

Note that the connected device may be of a higher laser class than the Sepia PDL 828 (e.g., **a Class 4 / IV VisUV or VisIR**). When such a device is connected to the SEM, then all laser safety measures applicable to its laser class also need to be observed. Refer to the manual of the connected device fpr detailed information.

To ensure laser safety, the Sepia PDL 828 will control the interlock state of a connected stand alone laser module (such as a VisUV). This has the following consequences:

- if the interlock is triggered by the Sepia PDL 828, then laser emission is shut down for all laser heads as well as for the connected stand alone device.
- If the Sepia PDL 828 is powered off, the connected laser device will not be able to emit laser light.
- While starting up, the Sepia PDL 828 will also block laser emission from any connected device.
- Using the Soft Lock button in the Sepia PDL 828 GUI will also turn off laser emission from any connected device.
- Activating laser emission from a connected stand alone deivce: turn the laser key switch of the connected device to the appropriate position (LASER) while the Sepia PDL 828 is fully powered on and unlocked.

5.1.8. Presets

Two working configurations can be saved and recalled under in the frame labeled *Presets* 24. Each preset stores all working parameters of the device. The currently applied configuration can be saved by clicking on the *Store Preset 1* or *Store Preset 2* button (see Fig. 54). A pop up window gives the possibility to include a short comment with a maximal length of 64 characters for each stored configuration (see Fig. 55). A stored configuration can simply be recalled by clicking on the button labeled *Recall Preset 1* or *Recall Preset 2*.

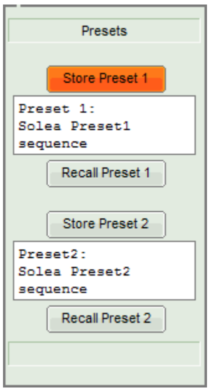


Fig. 54: Save a configuration

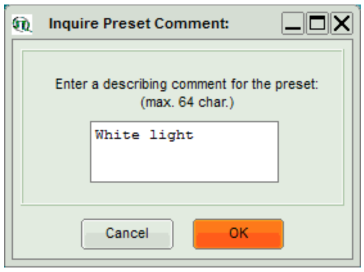


Fig. 55: Edit comment for a preset

Note: The presets are stored in the internal memory of the device and not on the host computer. They can therefore also be recalled if the device is connected to a different host computer.

NOTICE	Clicking on a *Recall Preset* leads to an immediate configuration change without the need to manually apply the changes! The process itself can, however, take some time depending on the difference between current and recalled settings!

5.1.9. “About...” button

Extended information about the device, including hardware version, serial number, operating hours, software and firmware version etc. can be brought up by clicking on the button labeled *About...* 25

For every support request its is recommend to save the entire information by clicking on the button labeled *Copy Support Infos* (see Fig. 56), save the information as a plain text file, and send it per mail to

`support@picoquant.com`

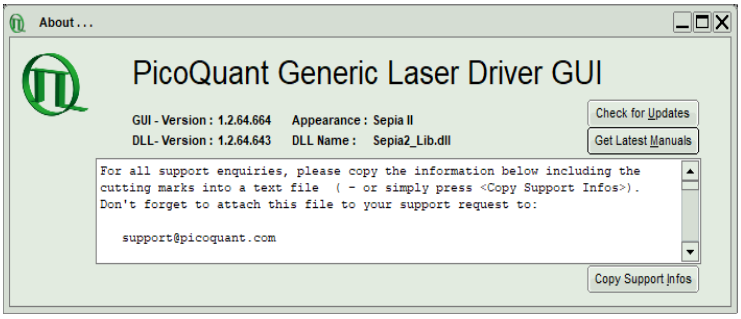


Fig. 56: The “About” window includes extended information about the status of the device

It is also possible to search for possible software updates by clicking on the button labeled *Check for Updates* (Fig. 56). If an update is available, a download link to the latest version will be provided. The button labeled “Get Latest Manuals” will also check online if newer versions of applicable manuals are available. An example of such a search result is shown in Fig. 57.

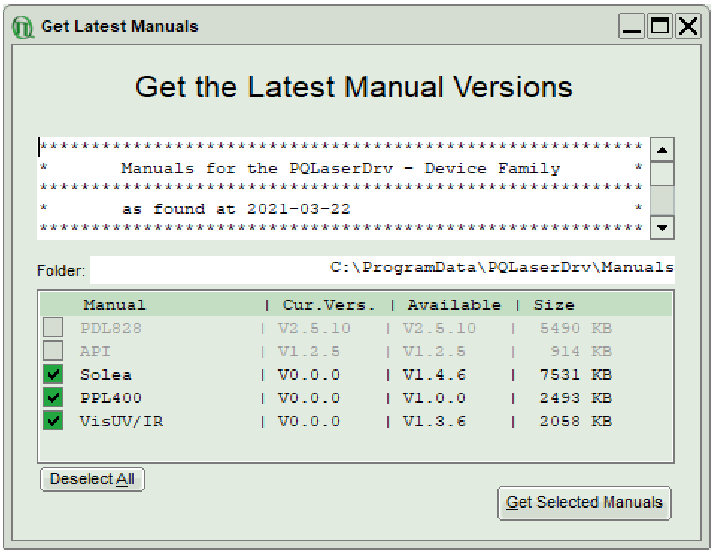


Fig. 57: A potential result screen after searching for latest manual versions

Lines corresponding to manuals that are up-to-date will be greyed out. Manuals that are currently not installed are listed as v0.0.0 in the column *Cur. Vers.*

To download the latest version of one or more manuals, tick the corresponding check-boxes and click on “*Get Selected Manuals*”.

6. Application Hints

This section explains some practical example of configuration for the oscillator module (both SOM 828 and SOM 828-D).

6.1. Step-by-Step Configuration of the Oscillator Module

The following configuration example is intended to demonstrate all usable options of the Sepia II oscillator module SOM 828. Refer to Fig. 24 to understand how the function blocks are connected and how the settings control them:

Suppose two lasers should be fired in the following sequence:

- 3 pulses from laser A with 50 ns pulse period,
- wait for 350 ns,
- 1 pulse from laser B.

Suppose further, this sequence should be repeated at a repetition rate of 1 kHz.

Last but not least there should be two sync pulses within 50 ns from each other, 25 ns after laser B has fired.

Main Clock Selection

As the shortest interval between any pulses in the sequence is 50 ns, the sequencer should run at 20 MHz (20 MHz = 20×10^6 pulses per second; 1 pulse = 1 / 20×10^6 = 50 ns). This can be realized by selecting the internal oscillator with a base clock of 80 MHz, and setting the prescaler to a value of 4.

Define Sequencer Phases

Next, the phases of the sequence need to be defined:

Phase	***Function***	***Pulse count***	***Comments***
1	laser A	3	
2	pause	6	350 ns / 50 ns gives 7 intervals, therefore skip 6 pulses
3	laser B	1	
4	pause	19990	fill up to get 1 kHz repetition rate

At this point, let's map the phases directly to the burst channels for convenience:

phase 1 → channel 1,
phase 2 → channel 2,
phase 3 → channel 3,
phase 4 → channel 4.

Later in this example we will be shown that different mappings must sometimes be made, especially when multiple lasers need to be activated during a single phase.

Set the Burst Lengths

Now the numbers for the “pulse count” from the above table can be set as burst lengths for the sequencer channels (see Fig. 58).

The display at the bottom right of the oscillator frame will indicate how many pulses the whole sequence contains and confirm the 1 kHz repetition rate.

Enable Burst Output

Next, configure the output channels: The *enable* check boxes for channel 1 and channel 3 need to be ticked at least as these will be connected to the laser driver modules.

Enable the Sync Pulses

Next, configure the synchronization output, but for phase 4 only. Check the box to the right of the burst count field, and uncheck all other sync enable fields. Fig. 59 shows the resulting pattern.
(Red stands for laser A, blue for laser B and green for the sync output pattern)

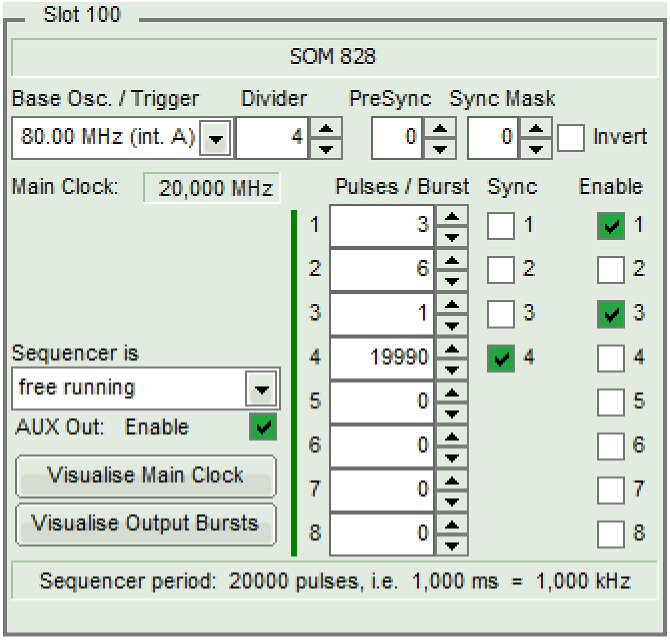


Fig. 58: Setting the SOM 828 to generate the example configuration

Set the Sync Mask

The current setting will generate sync pulses throughout the whole of phase 4. Mask the leading two pulses by setting the *sync mask* value to 2. Now the first two sync pulses during phase 4 will be inhibited (Fig. 60).

Then check the box labeled "Invert" to get just the first two sync pulses whenever the sequencer enters phase 4 (Fig. 61).

Shift the Synchronization Pulses

Still the synchronization pulses come too late, they trail 50 ns after the laser B pulse. Now set the "Pre Sync" value to 2, which shifts all synchronization pulses by 2 periods of the base oscillator before the corresponding output pulse. 2 periods of the base oscillator are in that case: (1/80 MHz) * 2 = 25 ns (Fig. 62).

Now connect the output connectors that are mapped to phase 1 and 3 to the inputs of the respective laser driver modules. Set the trigger mode of those to "external, falling edge".

Any single output line may be enabled or disabled using the check boxes to the right of the burst count fields. This has the same effect as one would get by physically connecting or disconnecting the trigger cables.

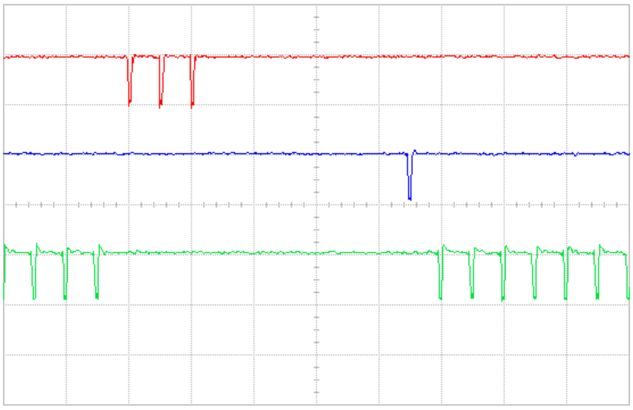


Fig. 59: Sync Mask = 0: pulses throughout phase four

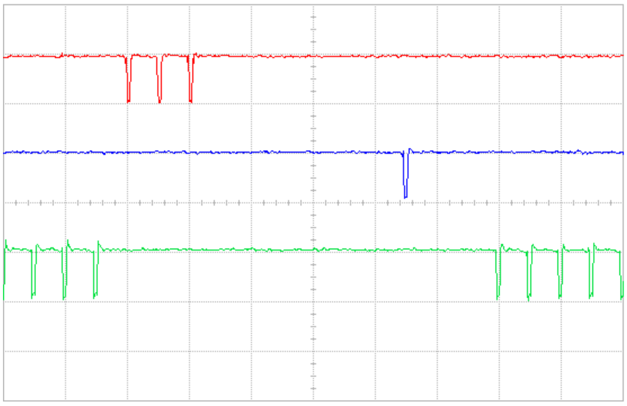


Fig. 60: Sync Mask = 2: leading two sync pulses are suppressed

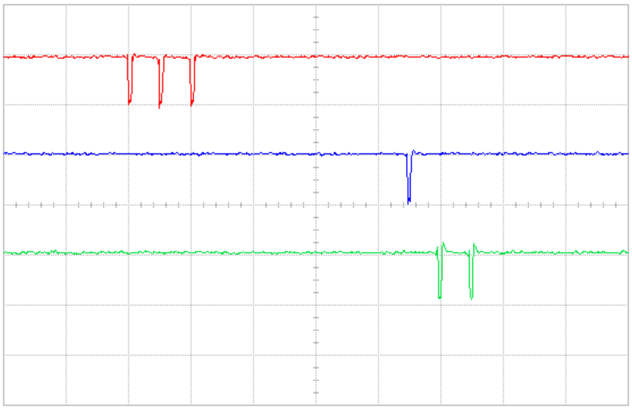


Fig. 61: Sync Mask inverted: leading two sync pulses are enabled

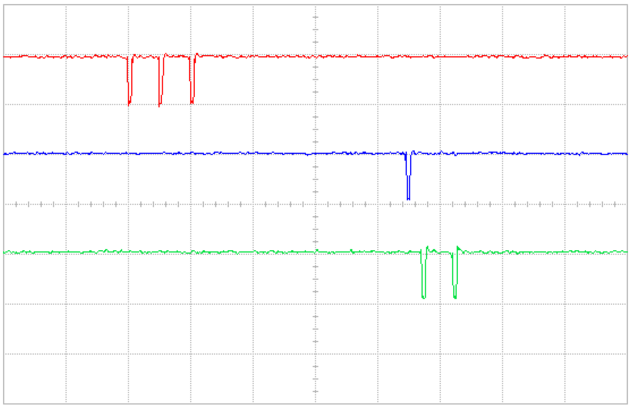


Fig. 62: Pre Sync = 2: Sync pulses are left-shifted against burst pulses

Add Identical Channels

Finally, let's assume that monitoring pulses each time when laser A fires is required. Remember that one can copy the signal of the preceding channel by setting the “Burst length” to zero. The channel preceding channel 1 is channel 8 due to the rotating characteristic of the sequencer. To leave the other phases untouched we move phase 1 to channel 7. Just set the burst length for channel 7 from zero to three, and set the burst length for channel 1 to zero. Channel 1 now runs in splitter mode, copying the pulses from the preceding active channel, namely channel 7 in this example. It is possible to leave the cable from output 1 to the laser driver A as it is and take the monitoring pulse from output 7.

Check the following table for all the output channels. Note that the way how the sequencer phases map to the output channels is not fixed:

Phase	*Function*	*Channel*	*Burst Length*	*Burst Out*	*Sync Out*	*Comments*
1	monitor	7	3	☑	☐	"start" channel
	(not used)	8	0	☐		
	laser A	1	0	☑		synchronous to channel 7
2	pause	2	6	☐	☐	
3	laser B	3	1	☑	☐	
4	pause	4	19990	☐	☑	to get 1 kHz repetition rate
	(not used)	5	0	☐		
	(not used)	6	0	☐		

Note that only self-contained channels offer the option to enable the “SYNC OUT”. The channels with a burst length of zero only copy the preceding channel without effecting the sync signal.

6.2. PIE-STED Pulse Sequence Programming (SOM 828-D only)

This section contains a step-by-step guide to configuring the SOM 828-D oscillator module with a pulse sequence typically used in microscopy for Pulsed Interleaved Excitation (PIE) with confocal and STED resolution. This practical example illustrates the capabilities of the SOM 828-D module and especially the combiner and delayer. Please note that, contrary to the previous example, trying out this example requires a SOM 828-D oscillator module.

The PIE-STED experiment described here involves sample excitation by two lasers with different wavelengths (e. g., a green and a blue one). The required pulse sequence for the three lasers is shown in Fig. 63. The excitation lasers are fired one after another so that the sample will be illuminated by the respective laser separately. A pulse from the STED depletion laser is combined with the excitation laser to obtain superresolution. Additionally, a second excitation laser pulse without STED laser is generated afterward in order to obtain the image with standard confocal resolution. This pulse sequence is used for multi color excitation measurements where both confocal resolution and STED superresolution images are acquired at nearly the same time.

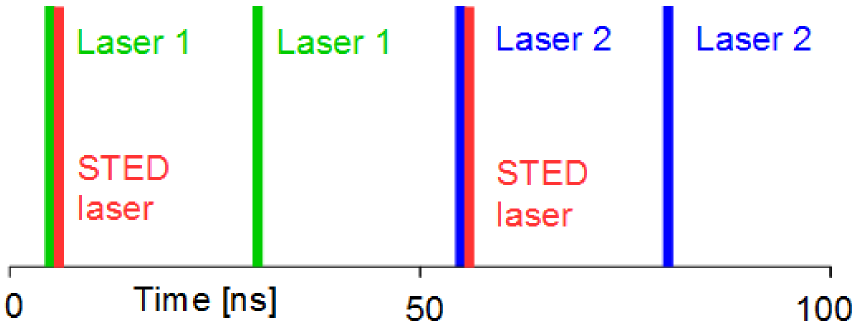


Fig. 63: PIE-STED pulse sequence involving two excitation lasers (blue and green) and a STED depletion laser (red).

Realizing the pulse sequence shown in Fig. 63 requires the combination of two excitation lasers of different wavelengths with a STED depletion laser. In this example, the time spacing between two excitation pulses should be 25 ns. Also a time delay between the excitation and depletion pulse is needed.

Setting the Main Clock

Since the shortest time interval between two pulses is 25 ns, we need a main clock repetition rate of 40 MHz (1 s / 40 x 10^6 = 25 x10^{-9} s = 25 ns). Therefore, select the internal oscillator with the base clock rate of 80 MHz and set the divider to 2.

Defining the Channels

We need to drive three lasers in this experiment. Both excitation lasers need to generate two pulses one after another, thus their burst length should be set to 2. The STED laser has to fire simultaneously on the first pulse of each excitation laser. In order to realize this, we need to use the combiner of the SOM 828-D. The pulse patterns from both excitation laser need to be combined into the STED burst channel. However, the pulses from the STED burst channel are not needed. Therefore, the burst length for the STED laser can be set to 0. The pulse pattern resulting from these setting is shown in the left part of Fig. 64.

In order to realize the desired combination in the STED burst channel, check the first two combiner boxes (corresponding to burst channels 1 and 2) in the row for burst channel 3.

Additionally, there needs to be a short delay between the excitation and STED pulses. Since the burst channel corresponding to the STED laser is using the combiner, that burst channel can no longer have an electronic delay assigned to it. We therefore have to activate the delayer modules on both excitation burst channels and set an appropriate negative time delay (i. e., the excitation laser should fire before the STED laser). Setting a delay of a few hundred picoseconds will be sufficient for this example. The delays will be set later on.

Also make sure that the **OutEna** check box for all three burst channels are ticked, so that all three output channels will generate electrical signals. The burst channels for sequencer period are now defined and the resulting pulse pattern is shown in the right part of Fig. 64.

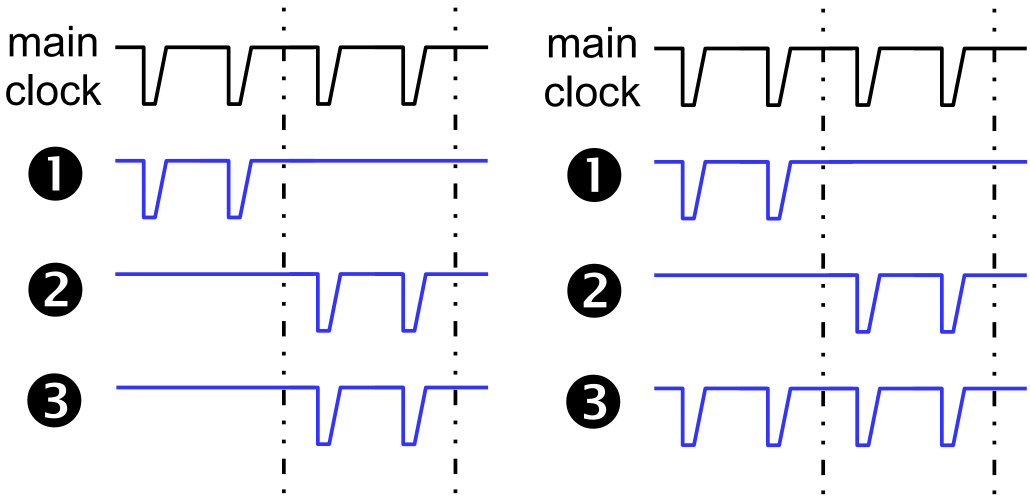


Fig. 64: PIE-STED pulse pattern after definition of burst channels and lengths (left part) and combination (right part).

Generating the Proper STED Burst Patterns

As currently set, the STED laser burst channel is producing two pulses synchronized with each of the burst channels 1 and 2 (see Fig. 7). Since we only need one STED pulse per excitation laser phase, we have to check the box **1st only** for burst channel 3. This option will mask all pulses in burst channel 3 except for the first one corresponding to each burst channel used in the combination. The effect of this option can be seen in Fig. 65. The masked pulses are shown as dotted lines.

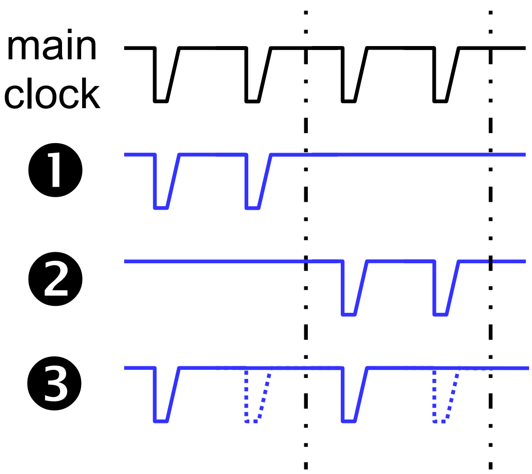


Fig. 65: Effect of activating 1st only for the STED burst channel (masked pulses are shown as dotted lines)

The table below summarizes the configuration of the burst channels made so far:

Burst Channel	Function	Burst Length	Combiner	Delayer
1	Excitation laser 1 (green)	2	Not active	Active
2	Excitation laser 1 (blue)	2	Not active	Active
3	STED laser	0	Burst channels 1+2	Not active

Setting the Delays and Sync Signals

As mentioned above, a short delay of a few hundred picoseconds is needed between the excitation and corresponding STED pulse. Since the STED burst channel already uses the combiner, no electronic delay can be introduced in this burst channel. Furthermore, the two lasers will most probably need different delay times anyway, due to their individual threshold timings. Therefore, the delays have to be implemented in the two excitation burst channels. Tick the **Delayed** check boxes for both excitation burst channels. The delay can now be set by first entering a value into the **coarse** spin edit field. Please note that the entered value might be automatically changed to the nearest valid value since the delayer is working with discreet time steps of 600 ps to 800 ps (depending on the repetition rate and channel used). This coarse value can then be adjusted with the **fine** spin edit box, where the time steps have widths of 15 ps to 30 ps (depending on the channel used). The resulting pattern is illustrated in Fig. 66. The time delays for the two lasers (indicated as Δt_1 and Δt_2 in Fig. 66) can be set independently of each other to any desired value.

The excitation laser pulses are now triggered before the STED pulse, which still triggers on the main clock tick corresponding to the start of the parent excitation burst channel. The delayed pulse traces are indicated in green, as is the case in the **Visualise Output Burst** GUI window. Please note that the delays shown in the scheme are not proportional to the real time settings.

The synchronization pulses should coincide with the excitation pulses and thus the **Sync Out** check boxes on both burst channels 1 and 2 should be ticked, but not on burst channel 3.

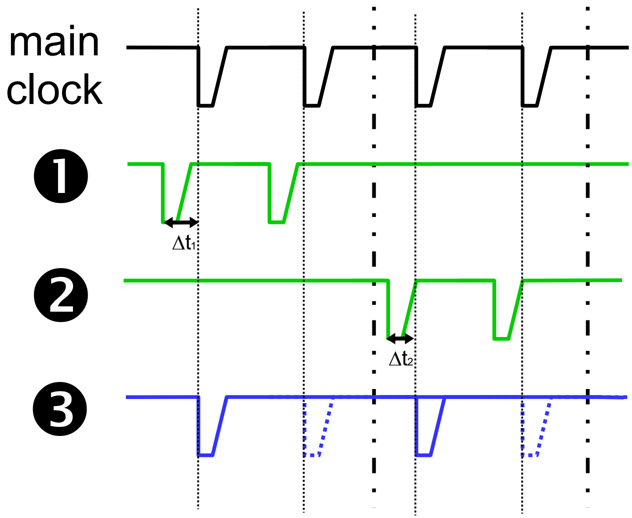


Fig. 66: PIE-STED pulse pattern with delays between excitation and STED laser pulses (Δt_1 and Δt_2).
The thin dotted lines indicate the time points corresponding to the main clock pulses.
The dash-dotted lines group pulses to individual bursts.

A “pause” burst channel could also be introduced if one desires to add a waiting time between two instances of the pulse pattern defined above. In order to do this, just add a burst length corresponding to the desired pause to burst channel 4 and untick the **OutEna** check box. This will let the sequencer “count” these pulses without generating an electrical signal on the output channel 4 before restarting the period.

6.3. Getting Correct Sync Pulses from the Oscillator

If the sync pulses are not generated as expected, please check the following:

- Is the sync pulse for the active burst channel enabled?
  If a channel has an unticked “Output Enable” box but the “Sync” box is checked, then the synchronization pulses will still be generated for pulse pattern of the corresponding burst channel.
- Is the “Sync Mask” setting lower than the burst length setting for the active burst channel?
  A “Sync Mask” higher than the burst length blanks all synchronization pulses during that burst.
- Is the “Sync Mask” function inverted?
  Inverting a “Sync Mask” with a value of zero will lead to blanking out of all sync pulses from any channel.

6.4. Choosing the Correct Laser Intensity

To ensure safer working conditions and to prolong the lifetime of the laser element, select a lower power setting (approx. 35% of full power). Full laser power should not be used unless it is absolutely needed. This applies especially to laser diodes in the ultraviolet to blue region, which still have a shorter lifetime than red or infrared laser diodes. It is recommended to switch these lasers off by disabling the trigger or by the key-switch whenever possible.

6.5. Side Effects of Laser Settings

- The l**aser intensity** setting will influence:

Pulse shape:	Pulses with a higher amplitude but a broader base will be produced. After-pulsing may occur.
Pulse position:	The peak shifts to an earlier time (arrives sooner) in relation to the SYNC signal.
Wavelength shift:	Shift of the emitted light to a shorter or longer wavelength (depending on the laser material).

- The **repetition rate** can slightly change the **pulse energy.** Consequently slight variations caused by laser intensity changes are possible. At repetition rates of 10 MHz or less, the pulse energy remains fairly constant.
- When changing the orientation of the **polarization** plane, different **pulse shapes** and intensities may be detected. Also the amount of **background luminescence** observed by the detector may change.

7. Technical Data / Specifications

Mainframe

Large, L..................................... 1 slot for oscillator module, 8 slots for laser driver modules

Small, S:.................................... 1 slot for oscillator module, 2 slots for laser driver modules

Power supply............................. 115/230 VAC, 50/60 Hz, max. 350 Watts

Grounding................................. cable must be as short as possible and not longer than 3m

Dimensions................................ Large: 464 × 310 × 140 mm (w × d × h)
.... Small: 250 × 310 × 140 mm (w × d × h)

Oscillator Module (SOM 828 or SOM 828-D)

Outputs..................................... 8 trigger (NIM), 1 synchronization (NIM), 1 auxiliary

Inputs.. 1 external trigger, 1 auxiliary (TTL)

Operation mode......................... rotary, programmed sequence of one channel must be completed before
.... next channel is activated, adjacent channels can be grouped multiple
....channels can be combined or delayed (SOM 828-D only)

Oscillator type............................ crystal locked

Master oscillator frequencies..... 80, 64, 50 MHz (selectable)

Repetition frequency.................. user-selectable, derived from the selected master frequency or an external
.... trigger source by division through any integer factor between 1 and 255
.... (SOM 828) or 65536 (SOM 828-D)

Low jitter...................................< 20 ps (FWHM), typ. 3-5 ps (FWHM)

Synchronization Output

Timing....................................... synchronous to repetition frequency, timing position stepwise
.... adjustable within the limits of the repetition frequency,
....step size equals master oscillator period

Masking..................................... synchronization pulses can be inhibited (masked), mask size selectable in
.... integer steps between 0 and 255, step size equals repetition period

Amplitude.................................. < -800 mV into 50 Ohms (NIM)

Auxiliary Output

Timing....................................... at start of complete trigger sequence

Amplitude.................................. +500 mV into 50 Ohms (SOM 828); +1.5 V into 50 Ohms (SOM 828-D)

External Trigger Input

Amplitude................................... -5 to +5 V (maximum limits)

Trigger level............................... -1200 to +1200 mV

Frequency range........................ up to 40 MHz

External synchronization............ 6.25 to 85.00 MHz (SOM 828-D only)

Bursts

Burst length............................... up to 16,7 million pulses

Laser Driver Module

Inputs .... 1 trigger (NIM), 2 gating (TTL)

Outputs..................................... 1 synchronization (NIM)

Operation mode......................... pulsed or continuous-wave

Master oscillator frequency........ 80 MHz

Repetition frequency................. 80, 40, 20, 10, 5, or 2.5 MHz (user-selectable)

Gating Inputs

Slow gate.................................. Transition time < 100 ms (pulsed and cw operation)
.... Internal impedance > 500 Ohms
.... Signal type: TTL (5 V)
.... Connector type: 4-pin LEMO socket – 00.304 Series
.... Example of connector: FGG.00.304.CLA

Fast gate.................................. Transition time typically 10 ns (pulsed only)
.... Internal impedance 50 Ohms
.... Signal type: TTL (5 V)
.... Connector type: 1-pin LEMO socket – 00.250 Series
.... Example of connector: FFA.00.250.NTA

Computer

Operating system....................... Windows™ 10

PC interface............................... USB 2.0

Retraction of Old Devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling center for safe treatment.
WEEE–Reg.–No. DE 96457402

8. Support

8.1. Returning Products for Repair

Should you encounter problems that require sending the device in for inspection / repair, please contact us first at: https://support.picoquant.com or support@picoquant.com and request an RMA number before shipping the device. Please include the serial number of your device. Observe precautions against static discharge under all circumstances during handling, packaging and shipping. Use original or equally protective packaging material. Inappropriate packaging voids any warranty.

9. Legal Terms

9.1. Copyright

9.2. Trademarks

10. Further Reading

10.1. PicoQuant Bibliography

PicoQuant maintains a database of publications mentioning PicoQuant devices. It can be found at our website https://www.picoquant.com/scientific/references. It is a valuable source if you would like to know which laboratories are using PicoQuant products or how broad the field of various applications is.

10.2. Download of Technical Notes / Application Notes

PicoQuant, along with our customers, continuously writes and publishes short documents about techniques, methods and applications that are possible with our hardware or software. The download section can be found at https://www.picoquant.com/scientific/technical-and-application-notes

11. Appendix

This section contains the description of the firmware start-up diagnostic procedure, the list of abbreviations and a table of the figures encountered in this user manual.

11.1. Firmware Start-Up Diagnosis

After power up, several phases during the self test sequence can be distinguished:

Self Test Procedure

phase id.	start up phase	Duration	Status light(s)
	booting the controller	approx. 5.0 sec	off
00	checking controller hardware	approx. 0.5 sec	continuously red
10	initialize device mapping	min. 4.0 sec	blinking yellow (or red *and* green)
20	device mapping		
30	checking frame	depends on configuration of the Sepia PDL 828	blinking green
40	checking modules		
50	checking configuration		
60	modules' calibration		
70	modules' initialization		
80	successfully up and free running, ready to release laser soft lock	until error detection or power down	continuously green
??	on error	repeating sequence …. until power down	long red interval, pause, yellow blink code…, pause, long red interval, pause, …

If a rack remains blocked by a failure, the error may be further diagnosed by software. Start e. g., “ReadAllDataByDelphi.exe” from the demo section of the programming library. This program will help to identify the reasons. Please refer to separate manual for the API for details. If there is no USB host computer available that could run software tools, you may tell from observing the SCM828 “STATUS” indicator in which slot the error was detected. Counting the yellow flashes between the long red intervals gives the leading digit (i. e. the hundreds) of the slot number. If there is no yellow flash, an error was detected either in the back-plane of the frame or quite early before any module was individually activated.

If any failure happens, you may locate the reason coarsely by removing the modules one by one from the rack and redoing the hardware check from power up by cycling the power switch at the rear of the rack. Note that in order to ensure a safe shutdown, the controller of the Sepia PDL 828 has an internal capacitor. This capacitor can supply the controller with electricity for a short period of time. For this reason we recommend to unplug the Sepia PDL 828 from the main power supply and to wait for ca. 3 minutes to ensure a complete reset of the controller.

Common reasons for a failure might be

- Failure of the power supply system
- Failure of the back-plane connecting the modules
- Failure of a module to identify or initialize properly

An error may also occur during the operation of the rack if a module or laser head was removed or added without powering off the device. The best way to avoid this situation is to **power OFF the rack before changing its module configuration or attaching a new laser head.**

11.2. Naming scheme of the LDH Series laser heads

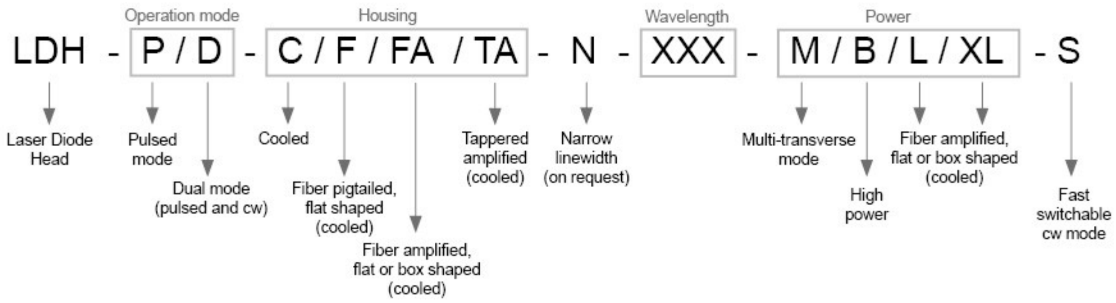


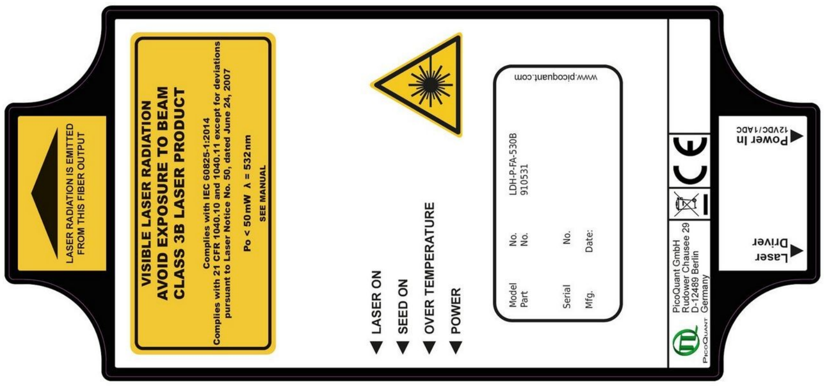
Fig. 67: PicoQuant laser head naming convention

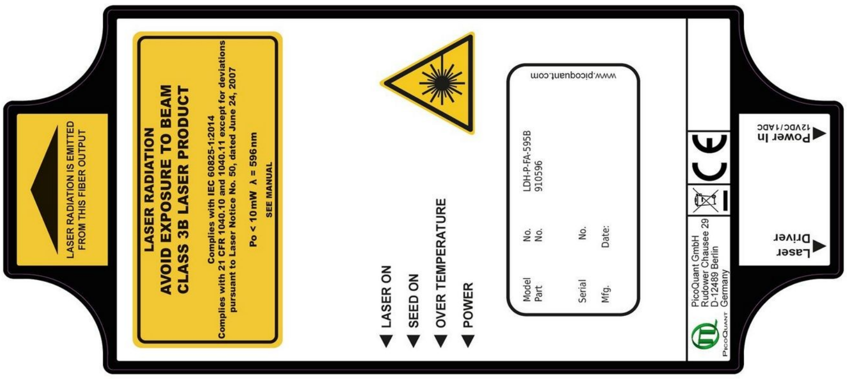
11.3. Overview of Laser Warning Labels by Model Type

The table in this section provides an overview of laser warning labels by model type. Note that this list ist not exhaustive and encompasses Sepia PDL 828 compatible laser heads available at the time this manual was released.

Model type	Warning label on the laser head
LDH Series	
315-400 nm **P_O < 500 mW**	
400-700 nm **P_O < 5 mW**	
400-700 nm **P_O < 500 mW**	
700-1700 nm **P_O < 500 mW**	
blank nm **blank mW**	

Model type	Warning label on the laser head	
LDH-D-TA-532 Part No.: 91		
LDH-D-TA-595 Part No.: 91		
LDH-D-TA-5 Part No.: 91		
LDH-FA Series		

Model type	Warning label on the laser head
LDH-P-FA-266 Part No.: 910266	
LDH-P-FA-355 Part No.: 910355	
LDH-P-FA-515L Part No.: 910517	
LDH-P-FA-530B Part No.: 910531	
LDH-D-FA-530L Part No.: 912534	

Model type	Warning label on the laser head
LDH-P-FA-530L Part No.: 910533	
LDH-P-FA-530XL Part No.: 910534	
LDH-P-FA-560 Part No.: 910560	
LDH-P-FA-595B Part No.: 910596	
LDH-D-FA-765L Part No.: 912766	

Model type	Warning label on the laser head
LDH-P-FA-765XL Part No.: 910765	
LDH-P-FA-775B Part No.: 910765	
LDH-P-FA-1060 Part No.: 911065	
LDH-P-FA-1060XL Part No.: 911066	
LDH-P-FA-1530XL Part No.: 911532	

11.4. Table of Error Codes

The following Table summarizes all error codes that can be output by the Sepia PDL 828 laser driver. Please include any generated errors codes when contacting support.

Symbol	Nr.	Error Text
SEPIA2_ERR_NO_ERROR	0	no error
SEPIA2_ERR_FW_MEMORY_ALLOCATION_ERROR	-1001	FW: memory allocation error
SEPIA2_ERR_FW_CRC_ERROR_WHILE_CHECKING_SCM_828_MODULE	-1002	FW: CRC error while checking SCM 828 module
SEPIA2_ERR_FW_CRC_ERROR_WHILE_CHECKING_BACKPLANE	-1003	FW: CRC error while checking backplane
SEPIA2_ERR_FW_CRC_ERROR_WHILE_CHECKING_MODULE	-1004	FW: CRC error while checking module
SEPIA2_ERR_FW_MAPSIZE_ERROR	-1005	FW: map size error
SEPIA2_ERR_FW_UNKNOWN_ERROR_PHASE	-1006	FW: unknown FW error phase
SEPIA2_ERR_FW_ILLEGAL_MODULE_CHANGE	-1111	FW: illegal module change
SEPIA2_ERR_USB_WRONG_DRIVER_VERSION	-2001	USB: wrong driver version
SEPIA2_ERR_USB_OPEN_DEVICE_ERROR	-2002	USB: open device error
SEPIA2_ERR_USB_DEVICE_BUSY	-2003	USB: device busy
SEPIA2_ERR_USB_CLOSE_DEVICE_ERROR	-2005	USB: close device error
SEPIA2_ERR_USB_DEVICE_CHANGED	-2006	USB: device changed
SEPIA2_ERR_I2C_ADDRESS_ERROR	-2010	I2C: address error
SEPIA2_ERR_DEVICE_INDEX_ERROR	-2011	USB: device index error
SEPIA2_ERR_ILLEGAL_MULTIPLEXER_PATH	-2012	I2C: illegal multiplexer path
SEPIA2_ERR_ILLEGAL_MULTIPLEXER_LEVEL	-2013	I2C: illegal multiplexer level
SEPIA2_ERR_ILLEGAL_SLOT_ID	-2014	I2C: illegal slot id
SEPIA2_ERR_NO_UPTIMECOUNTER	-2015	FRAM: no uptime counter
SEPIA2_ERR_FRAM_BLOCKWRITE_ERROR	-2020	FRAM: blockwrite error
SEPIA2_ERR_FRAM_BLOCKREAD_ERROR	-2021	FRAM: blockread error
SEPIA2_ERR_FRAM_CRC_BLOCKCHECK_ERROR	-2022	FRAM: CRC blockcheck error
SEPIA2_ERR_RAM_BLOCK_ALLOCATION_ERROR	-2023	RAM: block allocation error
SEPIA2_ERR_RAM_SECURE_MEMORY_HANDLING_ERROR	-2024	RAM: secure memory handling error
SEPIA2_ERR_I2C_INITIALISING_COMMAND_EXECUTION_ERROR	-2100	I2C: initialising command execution error
SEPIA2_ERR_I2C_FETCHING_INITIALISING_COMMANDS_ERROR	-2101	I2C: fetching initialising commands error
SEPIA2_ERR_I2C_WRITING_INITIALISING_COMMANDS_ERROR	-2102	I2C: writing initialising commands error
SEPIA2_ERR_I2C_MODULE_CALIBRATING_ERROR	-2200	I2C: module calibrating error
SEPIA2_ERR_I2C_FETCHING_CALIBRATING_COMMANDS_ERROR	-2201	I2C: fetching calibrating commands error
SEPIA2_ERR_I2C_WRITING_CALIBRATING_COMMANDS_ERROR	-2202	I2C: writing calibrating commands error
SEPIA2_ERR_DCL_FILE_OPEN_ERROR	-2301	DCL: file open error
SEPIA2_ERR_DCL_WRONG_FILE_LENGTH	-2302	DCL: wrong file length
SEPIA2_ERR_DCL_FILE_READ_ERROR	-2303	DCL: file read error
SEPIA2_ERR_FRAM_IS_WRITE_PROTECTED	-2304	FRAM: is write protected
SEPIA2_ERR_DCL_FILE_SPECIFIES_DIFFERENT_MODULETYPE	-2305	DCL: file specifies different moduletype
SEPIA2_ERR_DCL_FILE_SPECIFIES_DIFFERENT_SERIAL_NUMBER	-2306	DCL: file specifies different serial number
SEPIA2_ERR_I2C_INVALID_ARGUMENT	-3001	I2C: invalid argument
SEPIA2_ERR_I2C_NO_ACKNOWLEDGE_ON_WRITE_ADRESSBYTE	-3002	I2C: no acknowledge on write adressbyte
SEPIA2_ERR_I2C_NO_ACKNOWLEDGE_ON_READ_ADRESSBYTE	-3003	I2C: no acknowledge on read adressbyte
SEPIA2_ERR_I2C_NO_ACKNOWLEDGE_ON_WRITE_DATABYTE	-3004	I2C: no acknowledge on write databyte
SEPIA2_ERR_I2C_READ_BACK_ERROR	-3005	I2C: read back error
SEPIA2_ERR_I2C_READ_ERROR	-3006	I2C: read error
SEPIA2_ERR_I2C_WRITE_ERROR	-3007	I2C: write error
SEPIA2_ERR_I_O_FILE_ERROR	-3009	I/O: file error
SEPIA2_ERR_I2C_MULTIPLEXER_ERROR	-3014	I2C: multiplexer error
SEPIA2_ERR_I2C_MULTIPLEXER_PATH_ERROR	-3015	I2C: multiplexer path error

Symbol	Nr.	Error Text
SEPIA2_ERR_USB_INIT_FAILED	-3200	USB: init failed
SEPIA2_ERR_USB_INVALID_ARGUMENT	-3201	USB: invalid argument
SEPIA2_ERR_USB_DEVICE_STILL_OPEN	-3202	USB: device still open
SEPIA2_ERR_USB_NO_MEMORY	-3203	USB: no memory
SEPIA2_ERR_USB_OPEN_FAILED	-3204	USB: open failed
SEPIA2_ERR_USB_GET_DESCRIPTOR_FAILED	-3205	USB: get descriptor failed
SEPIA2_ERR_USB_INAPPROPRIATE_DEVICE	-3206	USB: inappropriate device
SEPIA2_ERR_USB_BUSY_DEVICE	-3207	USB: busy device
SEPIA2_ERR_USB_INVALID_HANDLE	-3208	USB: invalid handle
SEPIA2_ERR_USB_INVALID_DESCRIPTOR_BUFFER	-3209	USB: invalid descriptor buffer
SEPIA2_ERR_USB_IOCTRL_FAILED	-3210	USB: IOCTRL failed
SEPIA2_ERR_USB_VCMD_FAILED	-3211	USB: vcmd failed
SEPIA2_ERR_USB_NO_SUCH_PIPE	-3212	USB: no such pipe
SEPIA2_ERR_USB_REGISTER_NOTIFICATION_FAILED	-3213	USB: register notification failed
SEPIA2_ERR_USB_UNKNOWN_DEVICE	-3214	USB: unknown device
SEPIA2_ERR_USB_WRONG_DRIVER	-3215	USB: wrong driver
SEPIA2_ERR_USB_WINDOWS_ERROR	-3216	USB: windows error
SEPIA2_ERR_USB_DEVICE_NOT_OPEN	-3217	USB: device not open
SEPIA2_ERR_I2C_DEVICE_ERROR	-3256	I2C: device error
SEPIA2_ERR_LMP_ADC_TABLES_NOT_FOUND	-3501	LMP: ADC tables not found
SEPIA2_ERR_LMP_ADC_OVERFLOW	-3502	LMP: ADC overflow
SEPIA2_ERR_LMP_ADC_UNDERFLOW	-3503	LMP: ADC underflow
SEPIA2_ERR_SCM_VOLTAGE_LIMITS_TABLE_NOT_FOUND	-4001	SCM: voltage limits table not found
SEPIA2_ERR_SCM_VOLTAGE_SCALING_LIST_NOT_FOUND	-4002	SCM: voltage scaling list not found
SEPIA2_ERR_SCM_REPEATEDLY_MEASURED_VOLTAGE_FAILURE	-4003	SCM: repeatedly measured voltage failure
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_0_VOLTAGE_TOO_LOW	-4010	SCM: power supply line 0: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_1_VOLTAGE_TOO_LOW	-4011	SCM: power supply line 1: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_2_VOLTAGE_TOO_LOW	-4012	SCM: power supply line 2: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_3_VOLTAGE_TOO_LOW	-4013	SCM: power supply line 3: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_4_VOLTAGE_TOO_LOW	-4014	SCM: power supply line 4: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_5_VOLTAGE_TOO_LOW	-4015	SCM: power supply line 5: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_6_VOLTAGE_TOO_LOW	-4016	SCM: power supply line 6: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_7_VOLTAGE_TOO_LOW	-4017	SCM: power supply line 7: voltage too low
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_0_VOLTAGE_TOO_HIGH	-4020	SCM: power supply line 0: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_1_VOLTAGE_TOO_HIGH	-4021	SCM: power supply line 1: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_2_VOLTAGE_TOO_HIGH	-4022	SCM: power supply line 2: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_3_VOLTAGE_TOO_HIGH	-4023	SCM: power supply line 3: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_4_VOLTAGE_TOO_HIGH	-4024	SCM: power supply line 4: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_5_VOLTAGE_TOO_HIGH	-4025	SCM: power supply line 5: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_6_VOLTAGE_TOO_HIGH	-4026	SCM: power supply line 6: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LINE_7_VOLTAGE_TOO_HIGH	-4027	SCM: power supply line 7: voltage too high
SEPIA2_ERR_SCM_POWER_SUPPLY_LASER_TURNING_OFF_VOLTAGE_TOO_HIGH	-4030	SCM: power supply laser turn-off-voltage too high
SEPIA2_ERR_SCM_INVALID_TEMPERATURE_TABLE_COUNT	-4040	SCM: invalid temperature table count
SEPIA2_ERR_SCM_TCONFG_TABLE_READ_FAILED	-4041	SCM: tconfg table read failed
SEPIA2_ERR_SCM_INVALID_NUMBER_OF_TABLE_ENTRIES	-4042	SCM: invalid number of table entries
SEPIA2_ERR_SCM_INVALID_TIMERTICK_VALUE	-4043	SCM: invalid timertick value
SEPIA2_ERR_SCM_INVALID_TEMPERATURE_VALUE_TABLE	-4044	SCM: invalid temperature value table
SEPIA2_ERR_SCM_INVALID_DAC_CONTROL_TABLE_A	-4045	SCM: invalid DAC control table A
SEPIA2_ERR_SCM_INVALID_DAC_CONTROL_TABLE_B	-4046	SCM: invalid DAC control table B
SEPIA2_ERR_SCM_TEMPERATURE_TABLE_READ_FAILED	-4047	SCM: temperature table read failed

Symbol	Nr.	Error Text
SEPIA2_ERR_SOM_INT_OSCILLATOR_S_FREQ_LIST_NOT_FOUND	-5001	SOM: int. oscillator's freq.-list not found
SEPIA2_ERR_SOM_TRIGGER_MODE_LIST_NOT_FOUND	-5002	SOM: trigger mode list not found
SEPIA2_ERR_SOM_TRIGGER_LEVEL_NOT_FOUND	-5003	SOM: trigger level not found
SEPIA2_ERR_SOM_PREDIVIDER_PRETRIGGER_OR_TRIGGERMASK_NOT_FOUND	-5004	SOM: predivider, pretrigger, triggermask not found
SEPIA2_ERR_SOM_BURSTLENGTH_NOT_FOUND	-5005	SOM: burstlength not found
SEPIA2_ERR_SOM_OUTPUT_AND_SYNC_ENABLE_NOT_FOUND	-5006	SOM: output and sync enable not found
SEPIA2_ERR_SOM_TRIGGER_LEVEL_OUT_OF_BOUNDS	-5007	SOM: trigger level out of bounds
SEPIA2_ERR_SOM_ILLEGAL_FREQUENCY_TRIGGERMODE	-5008	SOM: illegal frequency / triggermode
SEPIA2_ERR_SOM_ILLEGAL_FREQUENCY_DIVIDER	-5009	SOM: illegal frequency divider (equal 0)
SEPIA2_ERR_SOM_ILLEGAL_PRESYNC	-5010	SOM: illegal presync (greater than divider)
SEPIA2_ERR_SOM_ILLEGAL_BURST_LENGTH	-5011	SOM: illegal burst length (>/= 2^24 or < 0)
SEPIA2_ERR_SOM_AUX_IO_CTRL_NOT_FOUND	-5012	SOM: AUX I/O control data not found
SEPIA2_ERR_SOM_ILLEGAL_AUX_OUT_CTRL	-5013	SOM: illegal AUX output control data
SEPIA2_ERR_SOM_ILLEGAL_AUX_IN_CTRL	-5014	SOM: illegal AUX input control data
SEPIA2_ERR_SOMD_INT_OSCILLATOR_S_FREQ_LIST_NOT_FOUND	-5051	SOMD: int. oscillator's freq.-list not found
SEPIA2_ERR_SOMD_TRIGGER_MODE_LIST_NOT_FOUND	-5052	SOMD: trigger mode list not found
SEPIA2_ERR_SOMD_TRIGGER_LEVEL_NOT_FOUND	-5053	SOMD: trigger level not found
SEPIA2_ERR_SOMD_PREDIVIDER_PRETRIGGER_OR_TRIGGERMASK_NOT_FOUND	-5054	SOMD: predivider,pretrigger or trig.mask not found
SEPIA2_ERR_SOMD_BURSTLENGTH_NOT_FOUND	-5055	SOMD: burstlength not found
SEPIA2_ERR_SOMD_OUTPUT_AND_SYNC_ENABLE_NOT_FOUND	-5056	SOMD: output and sync enable not found
SEPIA2_ERR_SOMD_TRIGGER_LEVEL_OUT_OF_BOUNDS	-5057	SOMD: trigger level out of bounds
SEPIA2_ERR_SOMD_ILLEGAL_FREQUENCY_TRIGGERMODE	-5058	SOMD: illegal frequency / triggermode
SEPIA2_ERR_SOMD_ILLEGAL_FREQUENCY_DIVIDER	-5059	SOMD: illegal frequency divider (equal 0)
SEPIA2_ERR_SOMD_ILLEGAL_PRESYNC	-5060	SOMD: illegal presync (greater than divider)
SEPIA2_ERR_SOMD_ILLEGAL_BURST_LENGTH	-5061	SOMD: illegal burst length (>/= 2^24 or < 0)
SEPIA2_ERR_SOMD_AUX_IO_CTRL_NOT_FOUND	-5062	SOMD: AUX I/O control data not found
SEPIA2_ERR_SOMD_ILLEGAL_AUX_OUT_CTRL	-5063	SOMD: illegal AUX output control data
SEPIA2_ERR_SOMD_ILLEGAL_AUX_IN_CTRL	-5064	SOMD: illegal AUX input control data
SEPIA2_ERR_SOMD_ILLEGAL_OUT_MUX_CTRL	-5071	SOMD: illegal output multiplexer control data
SEPIA2_ERR_SOMD_OUTPUT_DELAY_DATA_NOT_FOUND	-5072	SOMD: output delay data not found
SEPIA2_ERR_SOMD_ILLEGAL_OUTPUT_DELAY_DATA	-5073	SOMD: illegal output delay data
SEPIA2_ERR_SOMD_DELAY_NOT_ALLOWED_IN_TRIGGER_MODE	-5074	SOMD: delay not allowed in current trigger mode
SEPIA2_ERR_SOMD_DEVICE_INITIALIZING	-5075	SOMD: device initializing
SEPIA2_ERR_SOMD_DEVICE_BUSY	-5076	SOMD: device busy
SEPIA2_ERR_SOMD_PLL_NOT_LOCKED	-5077	SOMD: PLL not locked
SEPIA2_ERR_SOMD_FW_UPDATE_FAILED	-5080	SOMD: firmware update failed
SEPIA2_ERR_SOMD_FW_CRC_CHECK_FAILED	-5081	SOMD: firmware CRC check failed
SEPIA2_ERR_SOMD_HW_TRIGGERSOURCE_ERROR	-5101	SOMD HW: triggersource error
SEPIA2_ERR_SOMD_HW_SYCHRONIZE_NOW_ERROR	-5102	SOMD HW: sychronize now error
SEPIA2_ERR_SOMD_HW_SYNC_RANGE_ERROR	-5103	SOMD HW: SYNC range error
SEPIA2_ERR_SOMD_HW_ILLEGAL_OUT_MUX_CTRL	-5104	SOMD HW: illegal output multiplexer control data
SEPIA2_ERR_SOMD_HW_SET_DELAY_ERROR	-5105	SOMD HW: set delay error
SEPIA2_ERR_SOMD_HW_AUX_IO_COMMAND_ERROR	-5106	SOMD HW: AUX I/O command error
SEPIA2_ERR_SOMD_HW_PLL_NOT_STABLE	-5107	SOMD HW: PLL not stable
SEPIA2_ERR_SOMD_HW_BURST_LENGTH_ERROR	-5108	SOMD HW: burst length error
SEPIA2_ERR_SOMD_HW_OUT_MUX_COMMAND_ERROR	-5109	SOMD HW: output multiplexer command error
SEPIA2_ERR_SOMD_HW_COARSE_DELAY_SET_ERROR	-5110	SOMD HW: coarse delay set error
SEPIA2_ERR_SOMD_HW_FINE_DELAY_SET_ERROR	-5111	SOMD HW: fine delay set error
SEPIA2_ERR_SOMD_HW_FW_EPROM_ERROR	-5112	SOMD HW: firmware EPROM error

Symbol	Nr.	Error Text
SEPIA2_ERR_SOMD_HW_CRC_ERROR_ON_WRITING_FIRMWARE	-5113	SOMD HW: CRC error on writing firmware
SEPIA2_ERR_SOMD_HW_CALIBRATION_DATA_NOT_FOUND	-5114	SOMD HW: calibration data not found
SEPIA2_ERR_SOMD_HW_WRONG_EXTERNAL_FREQUENCY	-5115	SOMD HW: wrong external frequency
SEPIA2_ERR_SOMD_HW_EXTERNAL_FREQUENCY_NOT_STABLE	-5116	SOMD HW: external frequency not stable
SEPIA2_ERR_SLM_ILLEGAL_FREQUENCY_TRIGGERMODE	-6001	SLM: illegal frequency / triggermode
SEPIA2_ERR_SLM_ILLEGAL_INTENSITY	-6002	SLM: illegal intensity (> 100% or < 0%)
SEPIA2_ERR_SLM_ILLEGAL_HEAD_TYPE	-6003	SLM: illegal head type
SEPIA2_ERR_SML_ILLEGAL_INTENSITY	-6501	SML: illegal intensity (> 100% or < 0%)
SEPIA2_ERR_SML_POWER_SCALE_TABLES_NOT_FOUND	-6502	SML: power scale tables not found
SEPIA2_ERR_SML_ILLEGAL_HEAD_TYPE	-6503	SML: illegal head type
SEPIA2_ERR_VUV_VIR_SCALING_TABLES_NOT_FOUND	-6511	VUV/VIR: scaling tables not found
SEPIA2_ERR_VUV_VIR_DEVICE_TYPE_NOT_FOUND	-6512	VUV/VIR: device type not found
SEPIA2_ERR_VUV_VIR_ILLEGAL_TRIGGER_SOURCE_INDEX	-6513	VUV/VIR: illegal trigger source index
SEPIA2_ERR_VUV_VIR_ILLEGAL_FREQUENCY_DIVIDER_INDEX	-6514	VUV/VIR: illegal frequency divider index
SEPIA2_ERR_VUV_VIR_ILLEGAL_TRIGGER_LEVEL_VALUE	-6515	VUV/VIR: illegal trigger level value
SEPIA2_ERR_VUV_VIR_TRIGGER_DATA_NOT_FOUND	-6546	VUV/VIR: trigger data not found
SEPIA2_ERR_VUV_VIR_ILLEGAL_PUMP_REGISTER_READ_INDEX	-6517	VUV/VIR: illegal pump register read index
SEPIA2_ERR_VUV_VIR_ILLEGAL_PUMP_REGISTER_WRITE_INDEX	-6518	VUV/VIR: illegal pump register write index
SEPIA2_ERR_VUV_VIR_INTENSITY_DATA_NOT_FOUND	-6519	VUV/VIR: intensity data not found
SEPIA2_ERR_VUV_VIR_ILLEGAL_INTENSITY_DATA	-6520	VUV/VIR: illegal intensity data
SEPIA2_ERR_VUV_VIR_UNSUPPORTED_OPTION	-6521	VUV/VIR: unsupported option
SEPIA2_ERR_SWM_CALIBRATION_TABLES_NOT_FOUND	-6701	SWM: calibration tables not found
SEPIA2_ERR_SWM_ILLEGAL_CURVE_INDEX	-6702	SWM: illegal curve index
SEPIA2_ERR_SWM_ILLEGAL_TIMBASE_RANGE_INDEX	-6703	SWM: illegal timebase range index
SEPIA2_ERR_SWM_ILLEGAL_PULSE_AMPLITUDE	-6704	SWM: illegal pulse amplitude
SEPIA2_ERR_SWM_ILLEGAL_RAMP_SLEW_RATE	-6705	SWM: illegal ramp slew rate
SEPIA2_ERR_SWM_ILLEGAL_PULSE_START_DELAY	-6706	SWM: illegal pulse start delay
SEPIA2_ERR_SWM_ILLEGAL_RAMP_START_DELAY	-6707	SWM: illegal ramp start delay
SEPIA2_ERR_SWM_ILLEGAL_WAVE_STOP_DELAY	-6708	SWM: illegal wave stop delay
SEPIA2_ERR_SWM_ILLEGAL_TABLENAME	-6709	SWM: illegal tablename
SEPIA2_ERR_SWM_ILLEGAL_TABLE_INDEX	-6710	SWM: illegal table index
SEPIA2_ERR_SWM_ILLEGAL_TABLE_FIELD	-6711	SWM: illegal table field
SEPIA2_ERR_SPM_ILLEGAL_INPUT_VALUE	-7001	Solea SPM: illegal input value
SEPIA2_ERR_SPM_VALUE_OUT_OF_BOUNDS	-7006	Solea SPM: value out of bounds
SEPIA2_ERR_SPM_FW_OUT_OF_MEMORY	-7011	Solea SPM FW: out of memory
SEPIA2_ERR_SPM_FW_UPDATE_FAILED	-7013	Solea SPM FW: update failed
SEPIA2_ERR_SPM_FW_CRC_CHECK_FAILED	-7014	Solea SPM FW: CRC check failed
SEPIA2_ERR_SPM_FW_ERROR_ON_FLASH_DELETION	-7015	Solea SPM FW: error on flash deletion
SEPIA2_ERR_SPM_FW_FILE_OPEN_ERROR	-7021	Solea SPM FW: file open error
SEPIA2_ERR_SPM_FW_FILE_READ_ERROR	-7022	Solea SPM FW: file read error
SEPIA2_ERR_SSM_SCALING_TABLES_NOT_FOUND	-7051	Solea SSM: scaling tables not found
SEPIA2_ERR_SSM_ILLEGAL_TRIGGER_MODE	-7052	Solea SSM: illegal trigger mode
SEPIA2_ERR_SSM_ILLEGAL_TRIGGER_LEVEL_VALUE	-7053	Solea SSM: illegal trigger level value
SEPIA2_ERR_SSM_ILLEGAL_CORRECTION_VALUE	-7054	Solea SSM: illegal correction value
SEPIA2_ERR_SSM_TRIGGER_DATA_NOT_FOUND	-7055	Solea SSM: trigger data not found
SEPIA2_ERR_SSM_CORRECTION_DATA_COMMAND_NOT_FOUND	-7056	Solea SSM: correction data command not found
SEPIA2_ERR_SWS_SCALING_TABLES_NOT_FOUND	-7101	Solea SWS: scaling tables not found
SEPIA2_ERR_SWS_ILLEGAL_HW_MODULETYPE	-7102	Solea SWS: illegal HW moduletype
SEPIA2_ERR_SWS_MODULE_NOT_FUNCTIONAL	-7103	Solea SWS: module not functional
SEPIA2_ERR_SWS_ILLEGAL_CENTER_WAVELENGTH	-7104	Solea SWS: illegal center wavelength
SEPIA2_ERR_SWS_ILLEGAL_BANDWIDTH	-7105	Solea SWS: illegal bandwidth

Symbol	Nr.	Error Text
SEPIA2_ERR_SWS_VALUE_OUT_OF_BOUNDS	-7106	Solea SWS: value out of bounds
SEPIA2_ERR_SWS_MODULE_BUSY	-7107	Solea SWS: module busy
SEPIA2_ERR_SWS_FW_WRONG_COMPONENT_ANSWERING	-7109	Solea SWS FW: wrong component answering
SEPIA2_ERR_SWS_FW_UNKNOWN_HW_MODULETYPE	-7110	Solea SWS FW: unknown HW moduletype
SEPIA2_ERR_SWS_FW_OUT_OF_MEMORY	-7111	Solea SWS FW: out of memory
SEPIA2_ERR_SWS_FW_VERSION_CONFLICT	-7112	Solea SWS FW: version conflict
SEPIA2_ERR_SWS_FW_UPDATE_FAILED	-7113	Solea SWS FW: update failed
SEPIA2_ERR_SWS_FW_CRC_CHECK_FAILED	-7114	Solea SWS FW: CRC check failed
SEPIA2_ERR_SWS_FW_ERROR_ON_FLASH_DELETION	-7115	Solea SWS FW: error on flash deletion
SEPIA2_ERR_SWS_FW_CALIBRATION_MODE_ERROR	-7116	Solea SWS FW: calibration mode error
SEPIA2_ERR_SWS_FW_FUNCTION_NOT_IMPLEMENTED_YET	-7117	Solea SWS FW: function not implemented yet
SEPIA2_ERR_SWS_FW_WRONG_CALIBRATION_TABLE_ENTRY	-7118	Solea SWS FW: wrong calibration table entry
SEPIA2_ERR_SWS_FW_INSUFFICIENT_CALIBRATION_TABLE_SIZE	-7119	Solea SWS FW: insufficient calibration table size
SEPIA2_ERR_SWS_FW_FILE_OPEN_ERROR	-7151	Solea SWS FW: file open error
SEPIA2_ERR_SWS_FW_FILE_READ_ERROR	-7152	Solea SWS FW: file read error
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_INIT_TIMEOUT	-7201	Solea SWS HW: module 0, all motors: init timeout
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_PLAUSI_CHECK	-7202	Solea SWS HW: module 0, all motors: plausi check
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_DAC_SET_CURRENT	-7203	Solea SWS HW: module 0, all motors: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_TIMEOUT	-7204	Solea SWS HW: module 0, all motors: timeout
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_FLASH_WRITE_ERROR	-7205	Solea SWS HW: module 0, all motors: flash write error
SEPIA2_ERR_SWS_HW_MODULE_0_ALL_MOTORS_OUT_OF_BOUNDS	-7206	Solea SWS HW: module 0, all motors: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_0_I2C_FAILURE	-7207	Solea SWS HW: module 0: I2C failure
SEPIA2_ERR_SWS_HW_MODULE_0_INIT_FAILURE	-7208	Solea SWS HW: module 0: init failure
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_DATA_NOT_FOUND	-7210	Solea SWS HW: module 0, motor 1: data not found
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_INIT_TIMEOUT	-7211	Solea SWS HW: module 0, motor 1: init timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_PLAUSI_CHECK	-7212	Solea SWS HW: module 0, motor 1: plausi check
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_DAC_SET_CURRENT	-7213	Solea SWS HW: module 0, motor 1: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_TIMEOUT	-7214	Solea SWS HW: module 0, motor 1: timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_FLASH_WRITE_ERROR	-7215	Solea SWS HW: module 0, motor 1: flash write error
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_1_OUT_OF_BOUNDS	-7216	Solea SWS HW: module 0, motor 1: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_DATA_NOT_FOUND	-7220	Solea SWS HW: module 0, motor 2: data not found
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_INIT_TIMEOUT	-7221	Solea SWS HW: module 0, motor 2: init timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_PLAUSI_CHECK	-7222	Solea SWS HW: module 0, motor 2: plausi check
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_DAC_SET_CURRENT	-7223	Solea SWS HW: module 0, motor 2: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_TIMEOUT	-7224	Solea SWS HW: module 0, motor 2: timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_FLASH_WRITE_ERROR	-7225	Solea SWS HW: module 0, motor 2: flash write error
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_2_OUT_OF_BOUNDS	-7226	Solea SWS HW: module 0, motor 2: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_DATA_NOT_FOUND	-7230	Solea SWS HW: module 0, motor 3: data not found
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_INIT_TIMEOUT	-7231	Solea SWS HW: module 0, motor 3: init timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_PLAUSI_CHECK	-7232	Solea SWS HW: module 0, motor 3: plausi check
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_DAC_SET_CURRENT	-7233	Solea SWS HW: module 0, motor 3: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_TIMEOUT	-7234	Solea SWS HW: module 0, motor 3: timeout
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_FLASH_WRITE_ERROR	-7235	Solea SWS HW: module 0, motor 3: flash write error
SEPIA2_ERR_SWS_HW_MODULE_0_MOTOR_3_OUT_OF_BOUNDS	-7236	Solea SWS HW: module 0, motor 3: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_INIT_TIMEOUT	-7301	Solea SWS HW: module 1, all motors: init timeout
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_PLAUSI_CHECK	-7302	Solea SWS HW: module 1, all motors: plausi check
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_DAC_SET_CURRENT	-7303	Solea SWS HW: module 1, all motors: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_TIMEOUT	-7304	Solea SWS HW: module 1, all motors: timeout

Symbol	Nr.	Error Text
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_FLASH_WRITE_ERROR	-7305	Solea SWS HW: module 1, all motors: flash write error
SEPIA2_ERR_SWS_HW_MODULE_1_ALL_MOTORS_OUT_OF_BOUNDS	-7306	Solea SWS HW: module 1, all motors: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_1_I2C_FAILURE	-7307	Solea SWS HW: module 1: I2C failure
SEPIA2_ERR_SWS_HW_MODULE_1_INIT_FAILURE	-7308	Solea SWS HW: module 1: init failure
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_DATA_NOT_FOUND	-7310	Solea SWS HW: module 1, motor 1: data not found
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_INIT_TIMEOUT	-7311	Solea SWS HW: module 1, motor 1: init timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_PLAUSI_CHECK	-7312	Solea SWS HW: module 1, motor 1: plausi check
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_DAC_SET_CURRENT	-7313	Solea SWS HW: module 1, motor 1: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_TIMEOUT	-7314	Solea SWS HW: module 1, motor 1: timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_FLASH_WRITE_ERROR	-7315	Solea SWS HW: module 1, motor 1: flash write error
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_1_OUT_OF_BOUNDS	-7316	Solea SWS HW: module 1, motor 1: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_DATA_NOT_FOUND	-7320	Solea SWS HW: module 1, motor 2: data not found
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_INIT_TIMEOUT	-7321	Solea SWS HW: module 1, motor 2: init timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_PLAUSI_CHECK	-7322	Solea SWS HW: module 1, motor 2: plausi check
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_DAC_SET_CURRENT	-7323	Solea SWS HW: module 1, motor 2: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_TIMEOUT	-7324	Solea SWS HW: module 1, motor 2: timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_FLASH_WRITE_ERROR	-7325	Solea SWS HW: module 1, motor 2: flash write error
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_2_OUT_OF_BOUNDS	-7326	Solea SWS HW: module 1, motor 2: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_DATA_NOT_FOUND	-7330	Solea SWS HW: module 1, motor 3: data not found
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_INIT_TIMEOUT	-7331	Solea SWS HW: module 1, motor 3: init timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_PLAUSI_CHECK	-7332	Solea SWS HW: module 1, motor 3: plausi check
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_DAC_SET_CURRENT	-7333	Solea SWS HW: module 1, motor 3: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_TIMEOUT	-7334	Solea SWS HW: module 1, motor 3: timeout
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_FLASH_WRITE_ERROR	-7335	Solea SWS HW: module 1, motor 3: flash write error
SEPIA2_ERR_SWS_HW_MODULE_1_MOTOR_3_OUT_OF_BOUNDS	-7336	Solea SWS HW: module 1, motor 3: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_INIT_TIMEOUT	-7401	Solea SWS HW: module 2, all motors: init timeout
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_PLAUSI_CHECK	-7402	Solea SWS HW: module 2, all motors: plausi check
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_DAC_SET_CURRENT	-7403	Solea SWS HW: module 2, all motors: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_TIMEOUT	-7404	Solea SWS HW: module 2, all motors: timeout
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_FLASH_WRITE_ERROR	-7405	Solea SWS HW: module 2, all motors: flash write error
SEPIA2_ERR_SWS_HW_MODULE_2_ALL_MOTORS_OUT_OF_BOUNDS	-7406	Solea SWS HW: module 2, all motors: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_2_I2C_FAILURE	-7407	Solea SWS HW: module 2: I2C failure
SEPIA2_ERR_SWS_HW_MODULE_2_INIT_FAILURE	-7408	Solea SWS HW: module 2: init failure
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_DATA_NOT_FOUND	-7410	Solea SWS HW: module 2, motor 1: data not found
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_INIT_TIMEOUT	-7411	Solea SWS HW: module 2, motor 1: init timeout
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_PLAUSI_CHECK	-7412	Solea SWS HW: module 2, motor 1: plausi check
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_DAC_SET_CURRENT	-7413	Solea SWS HW: module 2, motor 1: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_TIMEOUT	-7414	Solea SWS HW: module 2, motor 1: timeout
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_FLASH_WRITE_ERROR	-7415	Solea SWS HW: module 2, motor 1: flash write error
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_1_OUT_OF_BOUNDS	-7416	Solea SWS HW: module 2, motor 1: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_DATA_NOT_FOUND	-7420	Solea SWS HW: module 2, motor 2: data not found
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_INIT_TIMEOUT	-7421	Solea SWS HW: module 2, motor 2: init timeout
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_PLAUSI_CHECK	-7422	Solea SWS HW: module 2, motor 2: plausi check
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_DAC_SET_CURRENT	-7423	Solea SWS HW: module 2, motor 2: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_TIMEOUT	-7424	Solea SWS HW: module 2, motor 2: timeout
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_FLASH_WRITE_ERROR	-7425	Solea SWS HW: module 2, motor 2: flash write error
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_2_OUT_OF_BOUNDS	-7426	Solea SWS HW: module 2, motor 2: out of bounds
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_DATA_NOT_FOUND	-7430	Solea SWS HW: module 2, motor 3: data not found
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_INIT_TIMEOUT	-7431	Solea SWS HW: module 2, motor 3: init timeout

Symbol	Nr.	Error Text
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_PLAUSI_CHECK	-7432	Solea SWS HW: module 2, motor 3: plausi check
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_DAC_SET_CURRENT	-7433	Solea SWS HW: module 2, motor 3: DAC set current
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_TIMEOUT	-7434	Solea SWS HW: module 2, motor 3: timeout
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_FLASH_WRITE_ERROR	-7435	Solea SWS HW: module 2, motor 3: flash write error
SEPIA2_ERR_SWS_HW_MODULE_2_MOTOR_3_OUT_OF_BOUNDS	-7436	Solea SWS HW: module 2, motor 3: out of bounds
SEPIA2_ERR_LIB_TOO_MANY_USB_HANDLES	-9001	LIB: too many USB handles
SEPIA2_ERR_LIB_ILLEGAL_DEVICE_INDEX	-9002	LIB: illegal device index
SEPIA2_ERR_LIB_USB_DEVICE_OPEN_ERROR	-9003	LIB: USB device open error
SEPIA2_ERR_LIB_USB_DEVICE_BUSY_OR_BLOCKED	-9004	LIB: USB device busy or blocked
SEPIA2_ERR_LIB_USB_DEVICE_ALREADY_OPENED	-9005	LIB: USB device already opened
SEPIA2_ERR_LIB_UNKNOWN_USB_HANDLE	-9006	LIB: unknown USB handle
SEPIA2_ERR_LIB_SCM_828_MODULE_NOT_FOUND	-9007	LIB: SCM 828 module not found
SEPIA2_ERR_LIB_ILLEGAL_SLOT_NUMBER	-9008	LIB: illegal slot number
SEPIA2_ERR_LIB_REFERENCED_SLOT_IS_NOT_IN_USE	-9009	LIB: referenced slot is not in use
SEPIA2_ERR_LIB_THIS_IS_NO_SCM_828_MODULE	-9010	LIB: this is no SCM 828 module
SEPIA2_ERR_LIB_THIS_IS_NO_SOM_828_MODULE	-9011	LIB: this is no SOM 828 module
SEPIA2_ERR_LIB_THIS_IS_NO_SLM_828_MODULE	-9012	LIB: this is no SLM 828 module
SEPIA2_ERR_LIB_THIS_IS_NO_SML_828_MODULE	-9013	LIB: this is no SML 828 module
SEPIA2_ERR_LIB_THIS_IS_NO_SWM_828_MODULE	-9014	LIB: this is no SWM 828 module
SEPIA2_ERR_LIB_THIS_IS_NO_SOLEA_SSM_MODULE	-9015	LIB: this is no Solea SSM module
SEPIA2_ERR_LIB_THIS_IS_NO_SOLEA_SWS_MODULE	-9016	LIB: this is no Solea SWS module
SEPIA2_ERR_LIB_THIS_IS_NO_SOLEA_SPM_MODULE	-9017	LIB: this is no Solea SPM module
SEPIA2_ERR_LIB_THIS_IS_NO_LMP_828_MODULE	-9018	LIB: this is no laser test site module
SEPIA2_ERR_LIB_THIS_IS_NO_SOM_828_D_MODULE	-9019	LIB: this is no SOM 828 D module
SEPIA2_ERR_LIB_NO_MAP_FOUND	-9020	LIB: no map found
SEPIA2_ERR_LIB_DEVICE_CHANGED_RE_INITIALISE_USB_DEVICE_LIST	-9025	LIB: device changed, re-initialise USB device list
SEPIA2_ERR_LIB_INAPPROP_USBDEVICE	-9026	LIB: Inappropriate USB device
SEPIA2_ERR_LIB_WRONG_USBDRIVER_VERSION	-9090	LIB: wrong USB driver version
SEPIA2_ERR_LIB_UNKNOWN_LIBFUNCTION	-9900	LIB: unknown library function
SEPIA2_ERR_LIB_ILLEGAL_PARAMETER	-9910	LIB: illegal parameter on library function call
SEPIA2_ERR_LIB_UNKNOWN_ERROR_CODE	-9999	LIB: unknown error code

11.5. Abbreviations

API	Application Programming Interface
BNC	British Naval Connector or Bayonet Nut Connector or Bayonet Neill Concelman
CAMAC	Corporations and Markets Advisory Committee
CW	Continuous Wave
DLL	Dynamic Link Library
GUI	Graphical User Interface
IEC	International Electrotechnical Commission
LDH	Laser Diode Head
LED	Light Emitting Diode
NIM	Nuclear Instrumentation Methods
PRF	Pulse Repetition Frequency
RMA	Return Merchandize Authorization
SCM	Sepia Controller Module
SLM	Sepia Laser Module
SEM	Sepia Extension Module
SMA	Sub-Miniature version A (connector type)
SOM	Sepia Oscillator Module
TCSPC	Time-Correlated Single Photon Counting
TTL	Transistor-Transistor Logic
USB	Universal Serial Bus
WEEE	Waste Electrical and Electronic Equipment

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