Becker & Hickl GmbH

BDS-SM and BDS-MM Series

Picosecond Diode Lasers

with

LSB-C and LSB-C2

Laser Switch Boxes

2022

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BDS-SM and BDS-MM Series
Picosecond Diode Lasers

Small-size modules, 40 x 40 x 120 mm³, 40 x 70 x 120 mm with heat sink
Wavelengths 375, 405, 445, 473, 488, 515, 640, 685, 785, 1064 nm
Pulse width down to < 40 ps
Internal clock frequencies 20, 40, 80 MHz
Synchronisation input to external clock signal
Precision timing output to TCSPC devices
Fast ON/OFF and multiplexing capability
Excellent power stability by internal regulation loop
Excellent timing stability
All electronics integrated, no external driver unit
Simple +12 V power supply
Compatible with all bh TCSPC devices

BDS-SM: Transversal single mode
Elliptical free beam, circular free beam, or single-mode fibre output
Pulse repetition rate 20, 50, 80 MHz, and CW mode
Power in pulsed mode up to 5 mW @ 80 MHz
Power in CW mode up to 50 mW

BDS-MM: Transversal multi mode
Free-beam or multimode fibre output
High power, up to 40 mW @ 50 MHz
Pulse repetition rate 20, 50 MHz

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Overview

BDS-SM Lasers

The bh BDS-SM picosecond diode lasers deliver picosecond light pulses at high repetition rate and short pulse width. The lasers radiate a single transversal mode, i.e. the beam can be focused in a diffraction-limited spot. With repetition rates from 20 to 80 MHz and pulse widths down to 30 ps the lasers are perfectly compatible with the bh TCSPC technique [1, 2]. The lasers are part of the bh FLIM systems, such as the DCS-120 confocal FLIM system, the DCS-120 MACRO system [3], the FLIM system for the Zeiss LSM laser scanning microscopes [4, 5], and the Nikon A1 microscopes [6]. The BDS-SM series lasers are also part of the bh 'Laser Hub', a device containing four lasers the beams of which are combined into one single-mode output fibre [7].

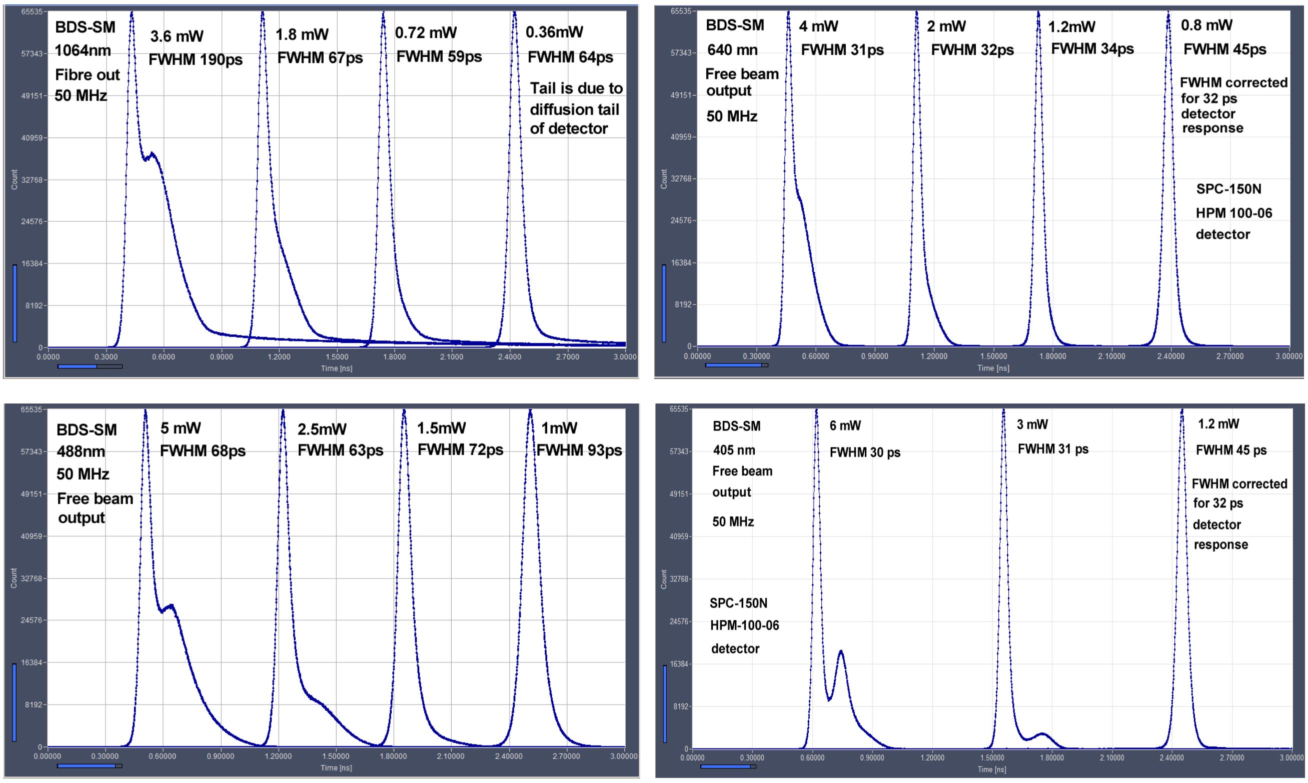


Fig. 1: Examples of pulse shapes for BDS-SM lasers of different wavelength at different optical power

The lasers can be operated both in the picosecond pulsed mode and in the CW mode. In the picosecond mode, the pulse shape is almost Gaussian up to an average power of 1 to 2 mW, with a pulse width on the order of 30 to 80 ps. The pulse width typically remains below 200 ps up to an average power of 4 to 8 mW at 80 MHz repetition rate. Both in the ps mode and in the CW mode, the output power is stabilised by an internal power regulation loop. The lasers thus feature low intensity noise and high power stability.

The BDS-SM lasers are available with and without integrated beam-profile correction optics. Lasers with correction optics deliver beams of about 0.8 mm in diameter, approximately circular cross section, and low astigmatism. The beams can be coupled into a single-mode fibre by standard fibre couplers. Moreover, a version with a permanently attached single-mode fibre is available.

BDS-MM Lasers

The BDS-MM are designed for high power. Average power can be up to 40 mW at 50 MHz. To reach a power this high the BDS-MM versions use multi-mode laser diodes. That means the light cannot be focused into a diffraction-limited spot or into a single-mode fibre. Applications are diffuse tissue imaging and spectroscopy in the near-infrared (NIRS and fNIRs), and cuvette-based fluorescence lifetime spectrometers. Multi-mode diodes require high driving power. In order to keep heat dissipation at a manageable level, the MM lasers cannot run at 80 MHz, and there is no CW mode. Examples of optical pulse shapes are shown in Fig. 2.

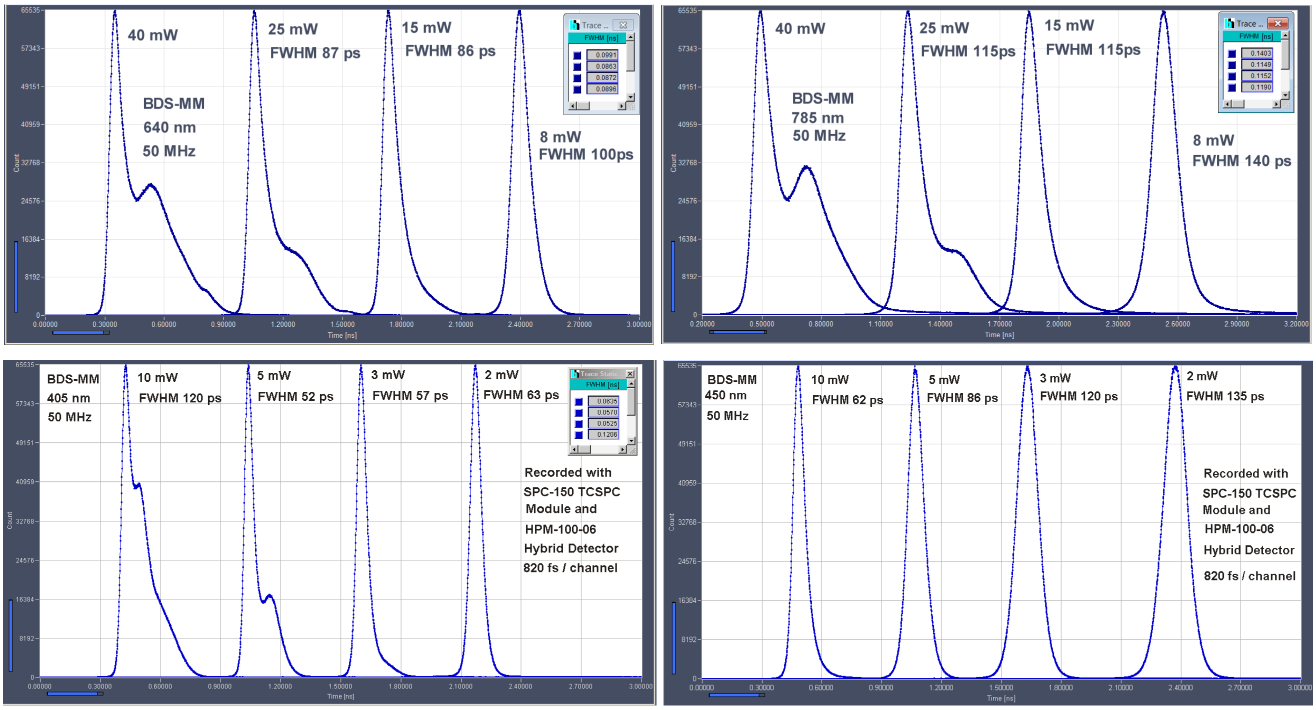


Fig. 2: Examples of pulse shapes for BDS-MM lasers of different wavelength at different optical power

Control Features

The output power of the BDS-SM and -MM lasers is controlled by an external signal. Moreover, the emission can be switched on and off by a digital control signal. Reaction time to the ON/OFF signal is only a few microseconds. Therefore, the lasers are perfectly suitable to multiplex several beams of different wavelength or polarisation on the microsecond or millisecond time scale, and to turn off the laser emission during the beam flyback in scanning applications. The ON/OFF input is also used for combined fluorescence and phosphorescence decay applications in combination with the bh TCSPC devices [8, 9].

External Triggering

The BDS lasers can be synchronised to an external clock source via a trigger input. With an external trigger source the BDS-SM and -MM lasers deliver pulses from single shot to 80 MHz and 50 MHz, respectively.

All Electronics Integrated

The BDS lasers have the complete driver electronics integrated in the laser head. Operation of the lasers does not require anything but a +12 V power supply, in the simplest case a wall-mounted AC-DC converter. However, to meet the requirements of laser safety in laboratory applications, the lasers come with a connection box that contains the mandatory key switch, a safety-interlock connector and an emission indicator.

General Description

System Components

The BDS-SM and -MM lasers come with a small wall-mounted +12V power supply and a 'laser switch box' that contains the key switch mandatory for class 3B lasers. The power supply, the laser switch box, and the laser module are shown in Fig. 3, left to right.

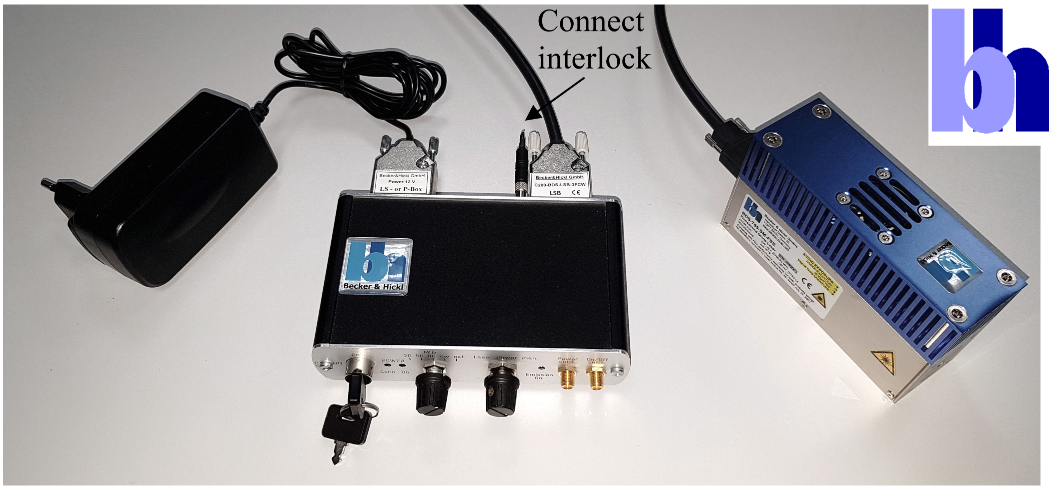


Fig. 3: BDS-SM laser. Left: Wall mounted power supply. Middle: Switch box with safety key, frequency switch for CW and pulsed operation, power control and SMA connectors for external control. Right: Laser module containing the complete driving and control electronics.

Laser Switch Box

Starting from May 2018, the 3-Frequency BDS lasers are operated via the new LSB-C switch box. The laser switch box is shown in Fig. 4.

Fig. 4: LSB-C Laser Switch Box

At the front panel, the LSB-C box has the mandatory key switch, a switch for the pulse frequency, a potentiometer for the laser power, and SMA connectors for an external power control signal and the laser ON/OFF signal. At the rear panel the box has a 9-pin connector for a +12V power supply, a 15-pin connector directly to the laser, and a 15-pin connector for external control signals. The 'Interlock' connector of the LSB-C box is used to build up a laser-safety loop when the BDS laser is integrated in larger systems. To enable laser operation the safety cable delivered with the LSB-C box must be connected to the interlock connector, and the blue wire connected to the black wire or to ground either directly or via the laser safety loop.

Laser action is indicated by three LEDs of different colour. The red 'POWER' LED indicates +12 V power connection, the green LED indicates that key switch in the ON position, and the blue LED indicates laser emission. The laser switch box also contains a switch to select between three pulse frequencies and CW operation, and input connectors for the control signals of the laser.

The fron-panel connectors for the control signals are shown in Fig. 4, left. There are two SMA connectors, one for the ON/OFF signal and one for the power control signal. The same signals can be connected via a 15 pin sub-D connector at the rear panel, see Fig. 4, right. This connector has also inputs for remote switching between 20, 50, and 80 MHz, and CW operation. Please note that the frequency switch must be in the 'ext.' position when external frequency control is used.

A similar switch box is available for operation of two BDS type lasers. In addition to the controls of the LSB-C box, the LSB-D box has numerical displays which indicate the selected laser power.

Fig. 5: LSB-D laser switch box for control of two lasers

From the technical point of view, the laser switch box is not absolutely required to operate the BDS-SM lasers. It is, however, part of the laser safety concept. Thus, if the BDS-SM laser is operated without the box, e.g. in OEM applications, the system integrator is responsible to comply to the usual laser safety regulations by suitable design of the instrument into which the BDS-SM laser is integrated.

DCS-120 Switch Box

In the DCS-120 confocal scanning FLIM system the laser switch box is replaced with the DCS connection box, shown in Fig. 3. This box contains the key switch, the repetition rate selectors for two lasers, and the signal distribution logics to control the lasers from the GVD-120 scan controller of the DCS system.

Fig. 6: Signal distribution and control box of the DCS-120 confocal scanning FLIM system

Application Information

Frequency Selection

The 3-Frequency-Version BDS laser can be operated at three internal clock frequencies, 20 MHz, 50 MHz and 80 MHz, and in the CW mode. The frequency and the mode are selected by three TTL input lines, F1, F2, F3 and CW. The pin assignment is shown in Table 1.

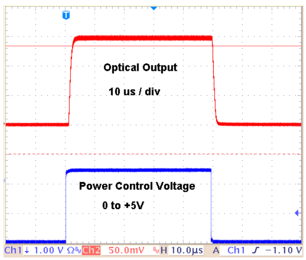
Signal	Pin at 15-pin laser connector	Frequency	Logic Level
F1	7	50 MHz	active H, internal pull-up resistor
F2	3	20 MHz	active H, internal pull-down resistor
F3	10	80 MHz	active H, internal pull-down resistor (-SM version only)
CW	9	CW mode	active H, internal pull-down resistor (-SM version only)

Signal	Pin at 15-pin LSB-C	Frequency	Logic Level
F1	3	50 MHz	active H, internal pull-up resistor
F2	2	20 MHz	active H, internal pull-down resistor
F3	4	80 MHz	active H, internal pull-down resistor (-SM version only)
CW	8	CW mode	active H, internal pull-down resistor (-SM version only)

F1	F2	F3	CW	Function
H	L	L	L	50 MHz
L	H	L	L	20 MHz
L	L	H	L	80 MHz (not active for -MM version)
L	L	L	H	CW mode (not active for -MM version
L	L	L	L	No laser operation. Not for normal use.
H	H	H	L	Don't use.
open	open	open	open	50 MHz

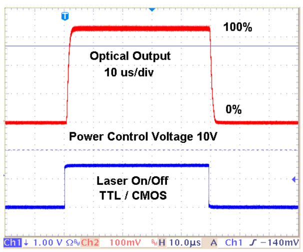
Table 1: Pin assignment and function of the control signals at the laser head connector

Power Control



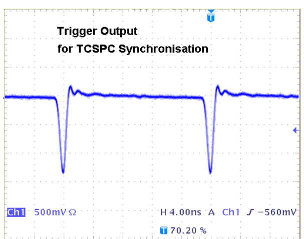
The optical power is controlled via a 0 to 10 V analog signal. The signal is connected to pin 8 of the 15-pin connector of the laser or pin 12 at the LSB-C control box. The source of the signal should have less to 100 Ω source impedance. If the input is left open the laser runs at approximately 20 % of its maximum power. The reaction to a change in the power control voltage occurs within a time of about 2 µs, see diagram on the right.

ON / OFF / Multiplexing Control



The optical output of the laser can be switched on and off by a 'Laser ON/OFF' signal at pin 7 of the 15-pin connector of the laser. The logic level is TTL /CMOS, H means 'Laser ON', L means 'Laser OFF'. The laser is ‘ON’ if the input is left open. The reaction time to the Laser ON/OFF signal is in the range of 1 to 5 µs, see figure on the right. The SYNC output of the laser becomes inactive when the Laser is in the ‘OFF’ state. When several lasers are multiplexed their SYNC signals can be combined into a single SYNC line to a TCSPC module by a simple resistive power combiner.

Synchronisation Output

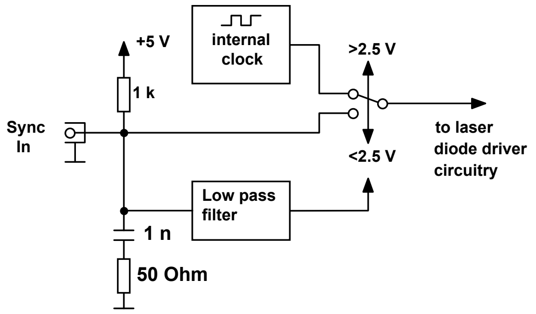


The laser delivers a synchronisation (SYNC) output for TCSPC modules. The pulse polarity is negative, the amplitude is about -1.2 V. The pulse duration is about 1ns. The SYNC output is inactive when the laser is in the ‘OFF’ state (Laser ON/OFF = L). When lasers are multiplexed their SYNC Out signals can be combined by a simple resistive power combiner.

Synchronisation Input

The synchronisation input is used to synchronise a BDS laser to an external clock source. The input signal must be TTL/CMOS compatible, and DC coupled into the synchronisation input from a 50 Ω source. The pulses must be positive, with a duty cycle of no more than 30 %. With a signal like that, the laser automatically recognises that a synchronisation signal is connected, and switches its clock path from the internal clock generator to the synchronisation input.

The principle of clock source switching is shown in Fig. 7. The average voltage at the Sync input connector is sensed via a low-pass filter. The output voltage from the filter sets a switch. If the average voltage is > 3 V the clock comes from the internal clock generator, if the voltage is < 3 V it comes from the Sync input connector. The active edge of the input signal is the rising edge.



Sync Input:	open	TTL High	TTL Low		
Average voltage:	>3 V	>3 V	<3 V	<3 V	>3 V
Clock source:	internal	internal	external, but no clock. Don't use	external	internal Don't use

Fig. 7: Principle of switching between the internal clock generator and an external clock source

Power Regulation Loop

Light generation in a laser diode is a highly nonlinear process. The slightest changes in the driving conditions or junction temperature, or mode fluctuations and back-reflection of light into the laser diode can result in large changes in the optical power. Therefore, the BDS-SM lasers have an internal power regulation loop, see Fig. 8. The laser power is monitored by a photodiode, and the photodiode current, Ipd, compared with a reference current, Iref. The difference of both is amplified, and used to control the electrical driving power to the laser diode. Thus, the difference between the photodiode current and the power control signal is regulated down to zero. That means the optical power is linearly related to the power control signal. Changes in the optical power due to temperature variation, variation in the supply voltages, or mode fluctuations in the laser diode are largely suppressed.

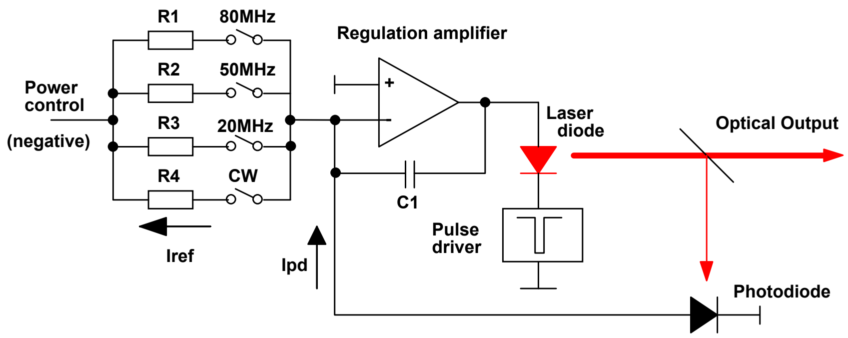


Fig. 8: Principle of power regulation loop

The regulation loop reacts to the average intensity of the optical output, not to the peak intensity of the laser pulses. For constant average power the peak power therefore changes with the pulse repetition rate. When the lasers are running with the internal clock oscillators the variation with the repetition rate is taken into account by switching the resistors, R1, R2 and R3, in proportion to repetition rate selected. For operation with external clock frequencies the peak power changes with the pulse period. To obtain a reasonable power regulation range with an external clock we recommend to choose the F1, F2 and F3 signals for an internal clock frequency as close as possible to the external clock frequency.

Dependence of the Pulse Shape on the Laser Power

When a laser diode is sharply driven from the off state into the on state is emits a short pulse of light before it settles into its steady-state intensity. In a picosecond diode laser, driving conditions are chosen which result in a short pulse with virtually no steady-state emission. The pulse shape depends on the amplitude of the current pulse that drives the diode. At low pulse current light pulses of near Gaussian shape are emitted. The pulses get narrower with increasing pulse current. If the pulse current through the diode is increased further, emission by the normal light generation mechanism occurs. It more or less follows the current flowing through the diode junction, and forms a bump following the initial peak. At very high power, the amplitude of the bump can reach or exceed the amplitude of the initial peak, and, eventually, become the dominating part of the pulse profile. Please see Fig. 1 and Fig. 2, page 4 and page 5 of this manual. The change of the pulse profile versus laser power makes it recommendable to keep the laser power at a constant level within one series of experiments.

Timing Stability

The bh BDS-SM and -MM series lasers feature a timing stability in the sub-2ps range between the sync-out pulses and the optical pulses. The figure below shows a series of TCSPC recordings of the laser pulses over a period of 640 seconds after power-on of the laser. The left panel shows the data displayed in colour-intensity mode, the right panel in multi-curve mode. The measurement was performed by a bh SPC-150NX TCSPC module and a bh HPM-100-06 hybrid detector. The figure shows that a timing drift of the light pulses versus the synchronisation-output pulses, if present at all, must be far smaller than the laser pulse width of 49 ps fwhm. That means TRS, FLIM, or NIRS experiments can be started from the first second after turning on the laser, and do not require repeated reference measurements.

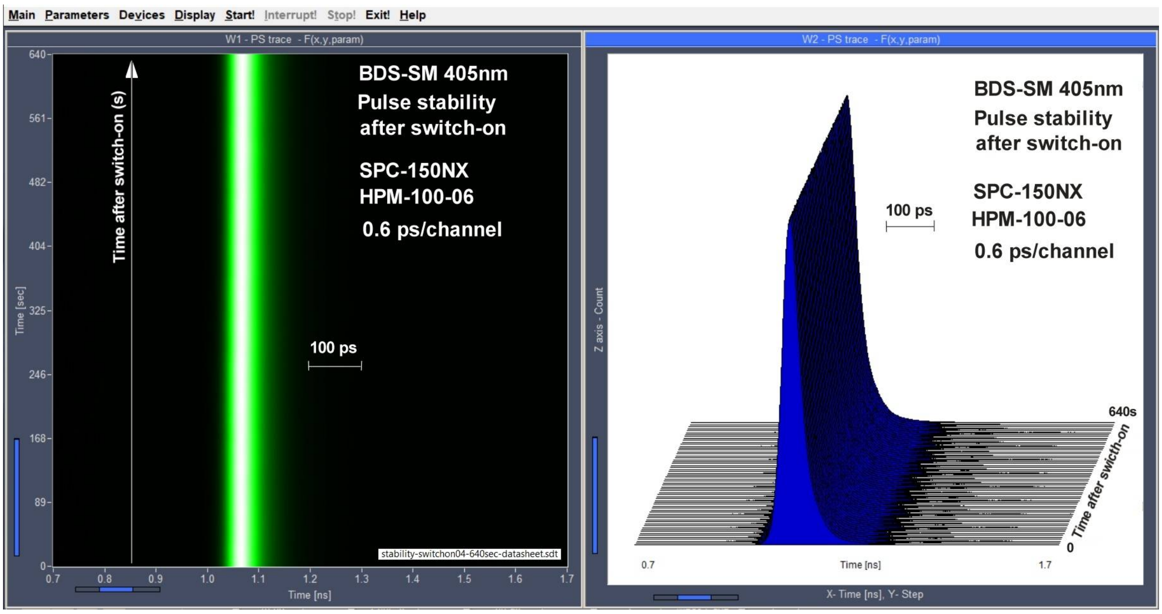


Fig. 9: Timing stability of a BDS-SM laser. Series of IRF measurements over 10 minutes after turn-on. Left: colour-intensity mode, Right: multi-curve mode. Timing drift is less than ±2 picoseconds.

External Laser Control with LSB-C Laser Switch Box

At the front panel, the LSB-C box has SMA connectors for an external power control signal and the laser ON/OFF signal. At the rear panel of the box a 15-pin connector for external control signals is located. The pin assignment for the control signals is shown in Table 2.

Pin number 15 pin control connector of LSB-C	Function of Signal
1	do not connect
2	F2: 20 MHz [1,2)]
3	F1: 50 MHz [1,2)]
4	F3: 80 MHz [1,2)]
5	GND
6	reserved, do not connect
7	Laser ON/OFF, TTL/CMOS, parallel to SMA connector
8	CW Operation [1,2)]
9	not connected
10	not connected
11	reserved, do not connect
12	Power control signal, 0 to +10 V, parallel to SMA connector
13	not connected
14	not connected
15	GND

1) Put frequency switch in 'EXT' position
2) Only one of the inputs must be in H state, the other two inputs must be pulled to Low (GND).

Table 2: Control signals at 15-pin external-control connector of LSB-C laser switch box

Safety Interlock Connector

The LSB-C and LSB-C2 laser switch boxes have two laser-safety interlock inputs. Either the Interlock Negative (ILN) input must be connected to Ground or the Interlock Positive (ILP) input must be connected to +5 V or +12 V to enable laser function, see Fig. 10. The interlock acts on the power supply of the laser(s). Input current is -0.1 mA for the ILN pin and +0.1 mA for the ILP pin. The interlock signal connector is located at the back panel of the LSB. A laser interlock cable is delivered with the LSB devices, see Fig. 11.

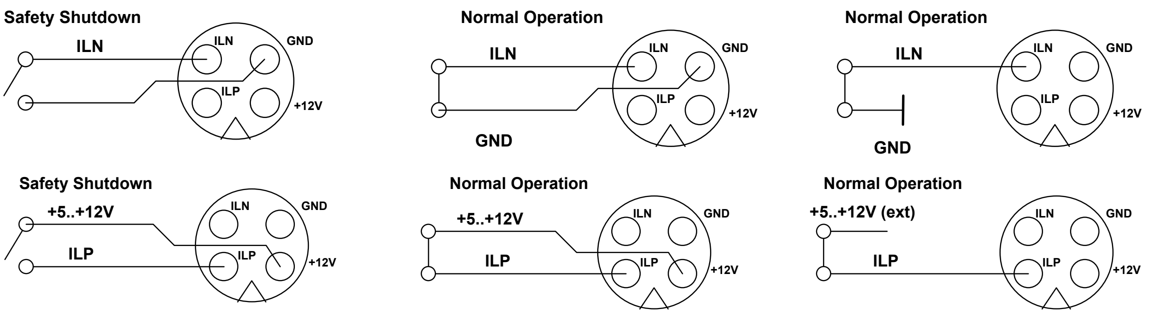


Fig. 10: Interlock Signal connections

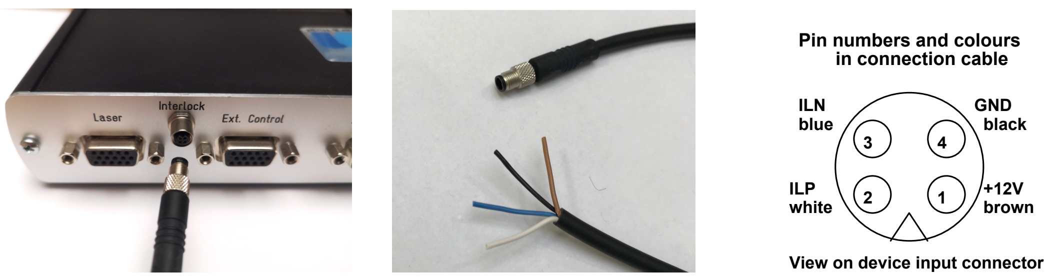


Fig. 11: Laser-safety interlock. Left: Interlock connector at LHB-104 rear panel. Middle: Safety interlock cable. Right: Pin assignment of safety-interlock connector.

Application Examples

Controlling the BDS Lasers from a DCC-100 Card

The BDS series lasers can be controlled via the bh DCC-100 detector / laser controller card (Fig. 12). One of the outputs, Con1, is connected to the control input connector of the laser switch box. The laser power can then be controlled via the ‘Gain’ slider, and the laser output be turned on and off via the +5V button. The other output, Con3, can be used to control a detector or a second laser. Con2 is reserved for controlling shutters and optical attenuators.

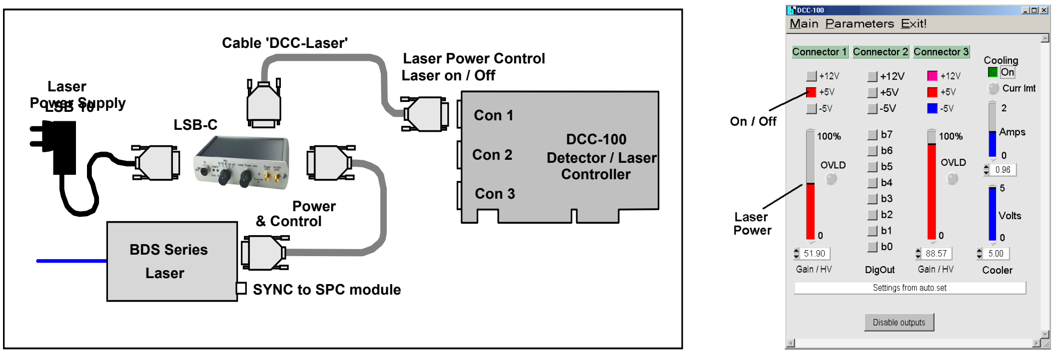


Fig. 12: Controlling the BDS-SM from a DCC Detector / Laser Controller card

Simple Fluorescence-Decay Experiment

The setup shown in Fig. 13 uses a BDS-MM or BDS-SM laser for a simple fluorescence lifetime experiment. The sample is excited by the picosecond pulses from the laser. The fluorescence photons are detected by a bh HPM-100 or PMC-100 detector, and recorded by an SPC-150N, or SPC-130EMN TCSPC module (any bh TCSPC module will work). The timing synchronisation signal for the TCSPC module comes from the Sync output of the laser. Both the laser and the detector are controlled by a DCC-100 detector / laser controller card. The entire setup is operated via the bh SPCM TCSPC operating software, see Fig. 7, right.

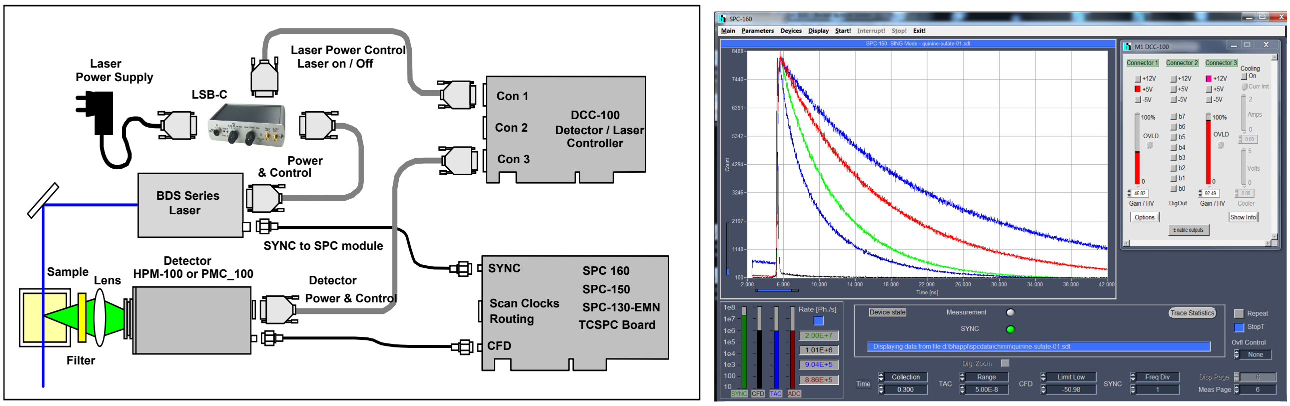


Fig. 13: Simple fluorescence-lifetime experiment. Left: System setup. Right: SPCM panel.

Laser Multiplexing

Two or more lasers are switched ON/OFF alternatingly at a period in the microsecond or millisecond range. Simultaneously with the switching of the lasers, the memory block address in the SPC module is switched. Thus, photons excited by different lasers are stored in different memory blocks in the SPC module [1, 2].

A connection diagram is shown in Fig. 14. The laser ON/OFF signals are generated in a DDG-210 pulse generator card. Switching of the lasers is achieved via the ‘Laser ON/OFF’ inputs of the lasers. The DDG-210 card also generates the routing signal for the SPC module. It is applied to the lowest routing bit, R0, via the 15-pin control connector of the SPC module. Please see [2] for details.

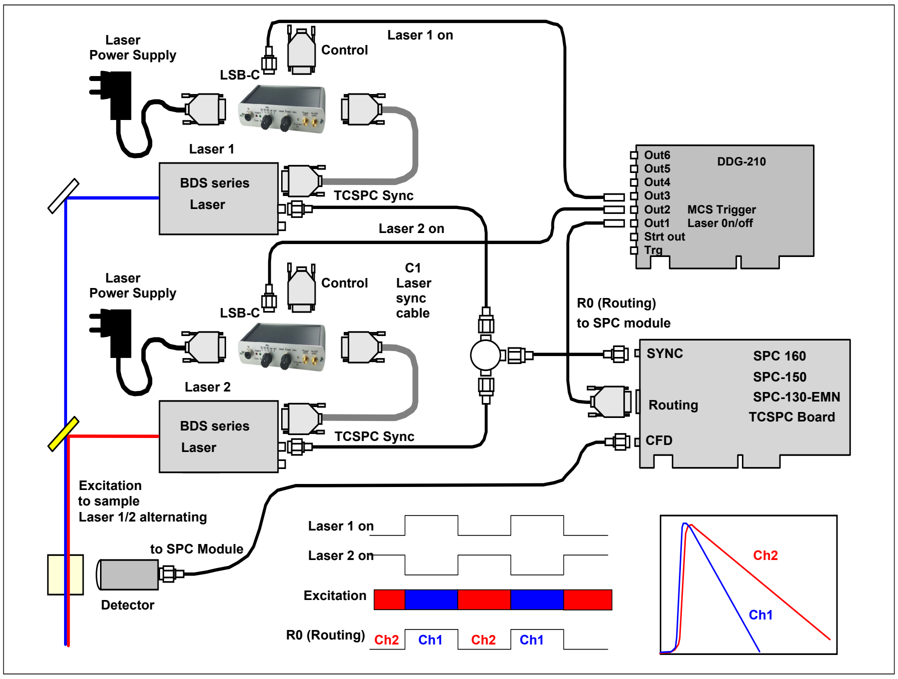
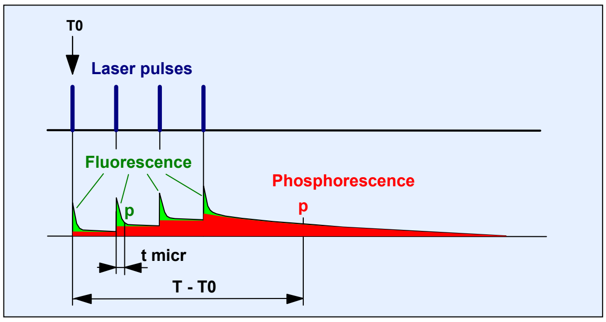


Fig. 14: Laser multiplexing. The lasers are switched ON/OFF alternatingly, the photons excited by different lasers are stored in separate TCSPC memory channels

Combined Fluorescence / Phosphorescence Lifetime Detection System

The system shown in Fig. 14 can be used to simultaneously record fluorescence and phosphorescence decay curves. Only one laser is used, the other one is blocked optically or replaced with a LSG-02i sync generator [2]. The laser is ON/OFF modulated at a period in the microsecond or millisecond range. In the ‘ON’ phase fluorescence is excited and phosphorescence is build up. In the ‘OFF’ phase pure phosphorescence is observed, see Fig. 9, left. Fluorescence decay curves are built up from the photon times in the laser pulse period, t_{micr}, phosphorescence decay curve from the times in the modulation period, $T\text{-}T_0$. A result is shown in Fig. 15, right. The method can be combined with confocal or two-photon laser scanning. Details are described in [2, 8, 9].



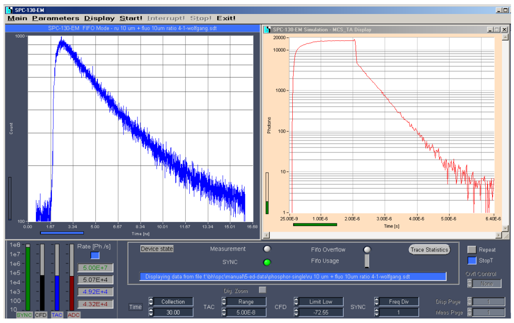
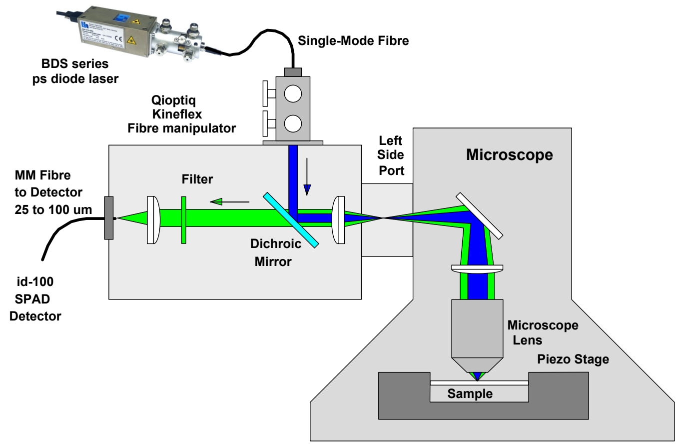


Fig. 15: Simultaneous recording of fluorescence and phosphorescence decay curves. Left: Principle. Right: Display of fluorescence (left) and phosphorescence decay (right) in SPCM software

Stage-Scanning FLIM System with the BDS-SM Laser

The optical principle of a simple FLIM system with a BDS-SM laser and a piezo scan stage is shown in Fig. 16, left. A BDS-series ps-diode laser is coupled into the system via a single-mode fibre. A Qioptics fibre collimator is used to obtain a collimated beam out of the fibre. The beam is reflected down into the microscope beam path by a dichroic mirror. A lens focuses the laser into the upper image plane of the microscope. The laser thus forms a focused spot in the sample. The fluorescence light from the sample is collected back through the microscope lens, collimated by the lens, and separated from the laser beam by the dichroic mirror. A bandpass or longpass filter in the collimated beam selects the detection wavelength range. The light passing the filter is focused into a multi-mode fibre by a second lens, and transferred to an id-100-50 SPAD detector. The electrical connections are shown in Fig. 16, right. The scanner is controlled via a bh GVD-120 scanner control card, the FLIM data are recorded by an SPC-150N, SPC-150NX, SPC-180N or SPC-180NX TCSPC / FLIM module. Please see [2, 10, and 11] for details.



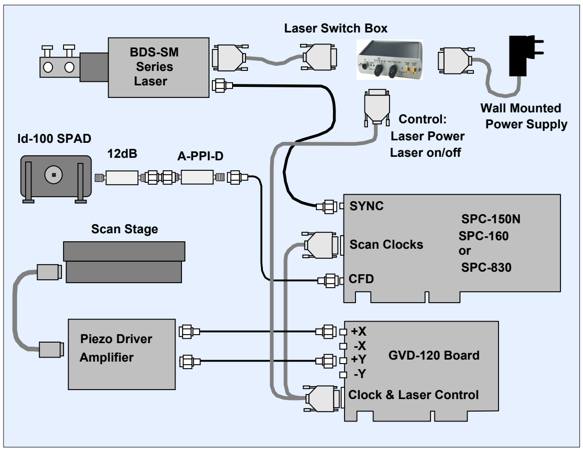


Fig. 16: Stage-scanning FLIM System with BDS-MM laser. Left: Optical principle. Right: System connections

Fig. 17 shows a FLIM image recorded by this setup. Decay curves in selected pixels are shown on the right.

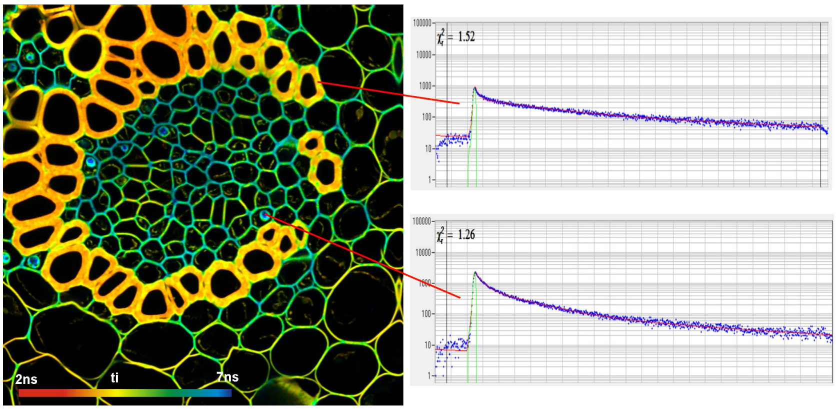


Fig. 17: FLIM of a Convallaria sample. 512x512 pixels, 1024 time channels per pixel. Decay curves in selected pixels shown right.

Confocal FLIM System with Fast Galvanometer Scanner

A piezo scanning system as the one shown above is relatively easy to implement. However, it is not really compatible with the most frequent TCSPC FLIM application, which is the measurement of molecular parameters in biological samples [2, 3, 4, 6]. For these types of experiments fast scanning by galvanometer mirrors is necessary.

The design of the optical system for fast confocal scanning is anything but simple. We therefore recommend to use a bh DCS-120 or DCS-120 MACRO system [3] or, if you can't resist the temptation to build your own instrument, to use system components of the DCS-120 system. The principal architecture of a system with DCS-120 components is shown in Fig. 18.

The system consists of a microscope with the DCS-120 confocal scan head attached to it. The scanhead contains the confocal optics and the galvanometer mirrors. Two BDS-SM ps diode lasers are coupled into the scan head by single-mode fibres. A DCS-120 switch box is used to provide power supply and control signals to the lasers. The scanner is controlled by a GVD-120 scan controller card. The card also controls the lasers, i.e. turns them off in the beam flyback or when the system is not scanning. It provides also for laser on/off modulation for simultaneous FLIM/PLIM, and for multiplexing of the lasers of different wavelength or polarisation. The photons coming out of the confocal beam path are detected by two HPM-100-40 or -06 hybrid detectors. It is also possible to connect multi-wavelength detectors to the scanner. The single-photon pulses from the detectors are recorded by two parallel TCSPC / FLIM modules. Controlled by SPCM data acquisition software, the TCSPC modules build up the FLIM data. In the simplest case, these are arrays of pixels, each containing a large number (usually 256 or 1024) time channels with photon numbers for consecutive times after the excitation pulses. For advanced applications, the data can be more complex, and also contain the wavelength of the photons, the time from a stimulation of the sample, or an identifier of two or more multiplexed lasers. Please see bh TCSPC Handbook and Handbook of the DCS-120 systems [2, 3] for details.

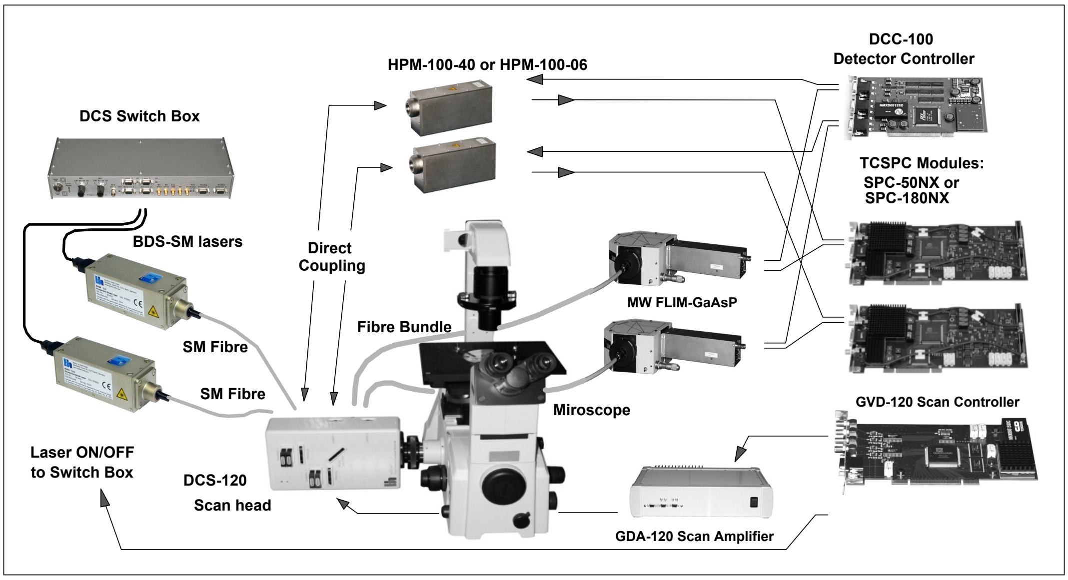


Fig. 18: Architecture of DCS-120 Confocal Scanning System

An example of a FLIM result is shown in Fig. 19. Two lasers of different wavelength were multiplexed, two FLIM data sets built up for two different combinations of excitation and detection wavelength, and colour-coded lifetime images and decay functions displayed by the SPCM online display functions. The lasers and the scanner are controlled via the 'Galvano Scanner Control' panel at the bottom.

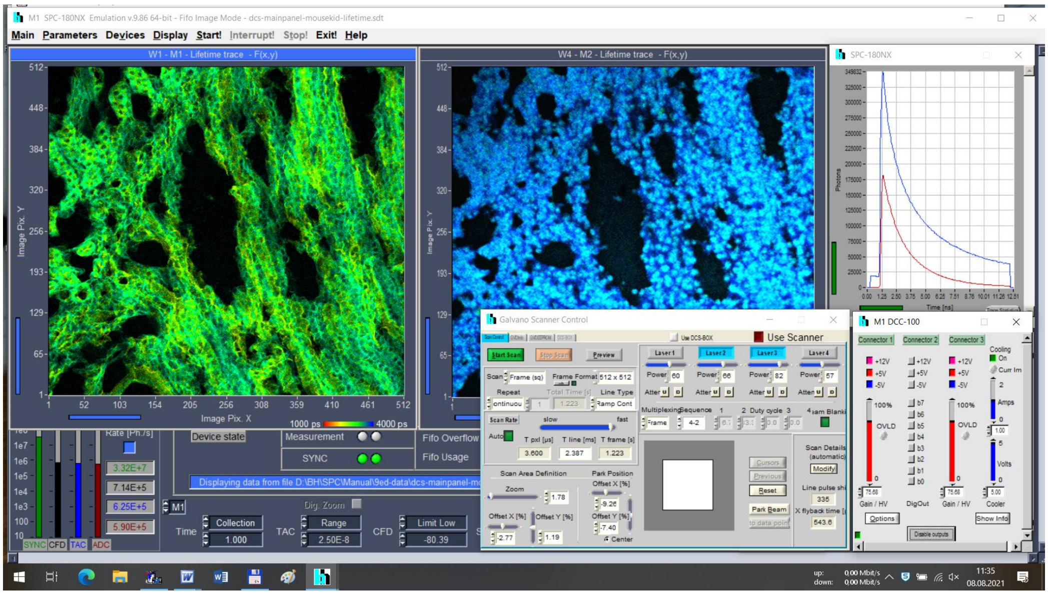


Fig. 19: Data-acquisition and Control panel of a DCS-120 confocal scanning system with BDS-SM lasers

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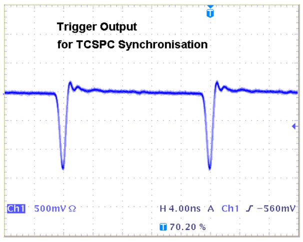
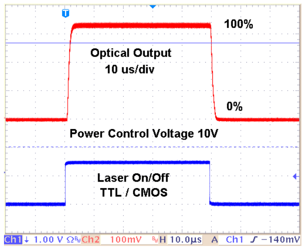
Specifications BDS-SM

Optical
Repetition Rate, switchabel by TTL signal 20 MHz, 50 MHz, 80 MHz and CW, other repetition rates on request
Wavelengths 375, 405, 445, 470, 485, 515, 640, 685, 785, 1064 nm, other on request
Pulse width (FWHM, at medium power) 30 to 90 ps
Pulse width (FWHM, at maximum power) 60 to 300 ps
Power control range (power in free beam) 0 to 1 mW ..... 0 to 5 mW (depends on wavelength version)
Power control range (CW mode, power in free beam) 0 to 20 mW ..... 0 to 50 mW (depends on wavelength version)
Beam diameter, free beam 0.8 mm (circular) or 1 x 3 mm (elliptical, depends on version)
Polarisation horizontal
Coupling efficiency into single-mode fibre, typically up to 60 % (circular version)

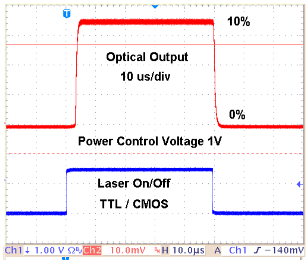


Trigger Output, to TCSPC Modules
Pulse Amplitude -1.2 V (peak) into 50 Ω
Pulse Width 1 ns, see figure right
Output Impedance 50 Ω
Connector SMA
Jitter between Trigger and Optical Pulse < 10 ps

Synchronisation Input
Input amplitude +3.3 to +5 V into 50 Ω
Duty cycle 10 to 30 %. DC equivalent must be < 2.5 V
Input frequency single shot to 80 MHz
Active power stabilization / power control 10 to 80 MHz
Connector SMA
Switch between internal clock and sync input automatic, by average voltage at trigger connector

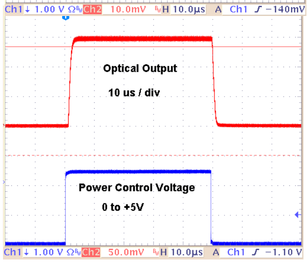


Control Inputs
Laser ON/OFF TTL / CMOS, 'low' means 'OFF', internal pull-up
Response of optical output to ON/OFF signal < 4 us for power 10 to 100 %, see figures right
External Power Control analog input, 0 to +10 V
Response time of optical output to power control < 4 us for power 10 to 100 %, see figure right
F1: 50 MHz active H, internal pull-up resistor
F2: 20 MHz active H, internal pull-down resistor
F3: 80 MHz active H, internal pull-down resistor
CW active H, internal pull-down resistor
Laser runs at 50 MHz when Frequency/CW inputs unconnected

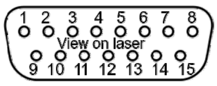


Power Supply
Power Supply Voltage + 9 V to +15 V
Power Supply Current at 12V 200 mA to 500 mA [1)]

Mechanical Data
Dimensions (OEM) 40 mm x 40 mm x 120 mm
Dimensions (w/ cooling) 40 mm x 70 mm x 120 mm
Mounting holes four holes for M3 screws
Heat sink requirements < 2 °C / W [2)]



Connector Pin Assignment
Connector version Micro Sub-D 15 pin
Power supply +12V 1, 2
GND 4, 5, and case
Power control voltage 8
Laser ON/OFF (TTL/CMOS, active H) 6
F2: 20 MHz (active H, int. pull-down resistor) 3
F1: 50 MHz (active H, int. pull-up resistor) 7
F3: 80 MHz (active H, int. pull-down resistor) 10
CW (active H, int. pull-down resistor) 9
Do not connect: 11, 12, 13, 14, 15



Maximum Values
Power Supply Voltage 0 V to +15 V
Voltage at 'Laser ON/OFF' and 'Frequency' inputs -2 V to +7 V
Voltage at 'Laser Power' input -12 V to +12 V
Ambient Temperature 0 °C to +40 °C [2)]

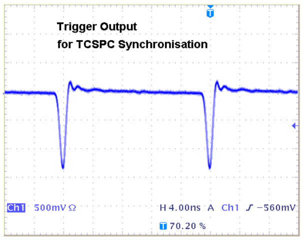
1) Depends on case temperature due to laser diode cooling. Cooling current changes with case temperature.
2) OEM version without active cooling must be mounted on heat sink. Case temperature must remain below 40 °C.

Caution: Class 3B laser product. Avoid direct eye exposure. Light emitted by the device may be harmful to the human eye. Please obey laser safety rules when operating the devices.
Complies with US federal laser product performance standards.

Specifications BDS-MM

Optical

Repetition Rate, switchable by TTL signal	20 MHz and 50 MHz, other combinations on request
Wavelengths	405, 450, 525, 640, 685, 785, 915 nm, others on request
Max. optical power	10 to 60 mW at 50 MHz, depends on wavelength version
Coupling efficiency into fibres (multi-mode, typical values)	100 µm: 60% 200 µm: 80 % 500 µm: 90 %
Pulse width (FWHM, at medium power)	65 to 120 ps
Pulse width (FWHM, at maximum power)	120 to 300 ps
Warm-up time for power and pulse shape stabilisation after power on	1 min [1]

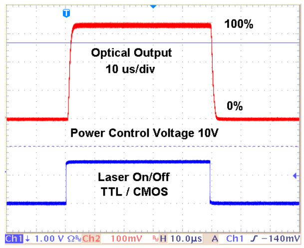


Trigger Output, to TCSPC Modules

Pulse Amplitude	-1 V (peak) into 50 Ω
Pulse Width	1 ns, see figure right
Output Impedance	50 Ω
Connector	SMA
Jitter between Trigger and Optical Pulse	< 10 ps

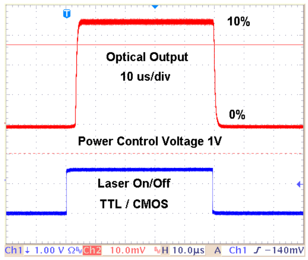
Synchronisation Input

Input amplitude	+3.3 to +5 V into 50 Ω
Duty cycle	10 to 30 %. DC equivalent must be < 2.5V
Input frequency	20 to 50 MHz, others on request
Connector	SMA
Switch between internal clock and sync input	automatic, by average voltage at trigger connector



Control Inputs

Laser ON/OFF	TTL / CMOS, 'low' means 'OFF', internal pull-up
Response of optical output to ON/OFF signal	< 4 us for power 10 to 100 %, see figures right
External Power Control	analog input, 0 to + 10 V
Response time of optical output to power control	< 4 us for power 10 to 100 %, see figure right
F1: 50 MHz	active H, internal pull-up resistor
F2: 20 MHz	active H, internal pull-down resistor
	Laser runs at 50 MHz with Frequency inputs unconnected



Power Supply

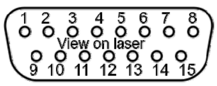
Power Supply Voltage	+ 9 V to +15 V
Power Supply Current at 12V	200 mA to 500 mA [2]

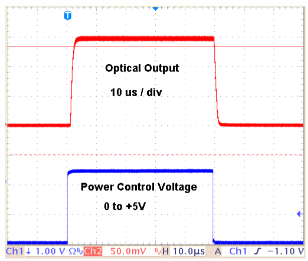
Mechanical Data

Dimensions (OEM)	40 mm x 40 mm x 120 mm
Dimensions (w/ cooling)	40 mm x 70 mm x 120 mm
Mounting holes	four holes for M3 screws
Heat sink requirements	< 2°C / W [3]

Connector Pin Assignment

Connector version	Micro Sub-D
Power supply +12V	1, 2
GND	4, 5, 9, and case
Power control voltage	8
Laser ON/OFF (active H)	6
F1: 50 MHz (active H, internal pull-up resistor)	7
F2: 20 MHz (active H, internal pull-down resistor)	3
Do not connect:	9 to 15





Maximum Values

Power Supply Voltage	0 V to +15 V
Voltage at 'Laser ON/OFF' and 'Frequency' inputs	-2 V to +7 V
Voltage at 'Laser Power' input	-12 V to + 12 V
Ambient Temperature	15 °C to +35 °C [3]

1) Operation below 15 °C ambient temperature may result in extended warm-up time.
2) Depends on case temperature due to laser diode cooling. Cooling current changes with case temperature.
3) OEM version without active cooling must be mounted on heat sink. Case temperature must remain below 40 °C.

Caution: Class 3B laser product. Avoid direct eye exposure. Light emitted by the device may be harmful to the human eye. Please obey laser safety rules when operating the devices.
Complies with US federal laser product performance standards.

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