DCC-100 / DCU-400 / DCU-800

Detector Control Card / USB Detector Control Unit

- User Manual -

Designed and manufactured by

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Content

Introduction

The DCC-100PCIe, the DCU-400 and the DCU-800 modules (DCC/DCU) are used to control detectors and bh lasers in conjunction with bh TCSPC systems. The DCC/DCU provides power supply, gain control, and overload shutdown for two/four/eight detectors. It is the standard controller for the bh HPM-100 hybrid detector, the PMC-150, and PML-16 GaAsP, as well as, interface for the bh BDS diode laser series and LHB-104 laser hub. The DCC/DCU also powers the thermoelectric coolers of cooled PMT modules. Furthermore, the DCC/DCU can operate a wide variety of Hamamatsu detectors, including H7422, H5783, H6773 and R3809U. High current digital outputs are available for shutter or filter control. Due to its versatility, the DCU modules or the PCIexpress alternative (DCC-100PCIe) are part of almost any bh TCSPC system. The DCU-400/800 devices are standalone devices which are connected to the TCSPC system computer via USB.

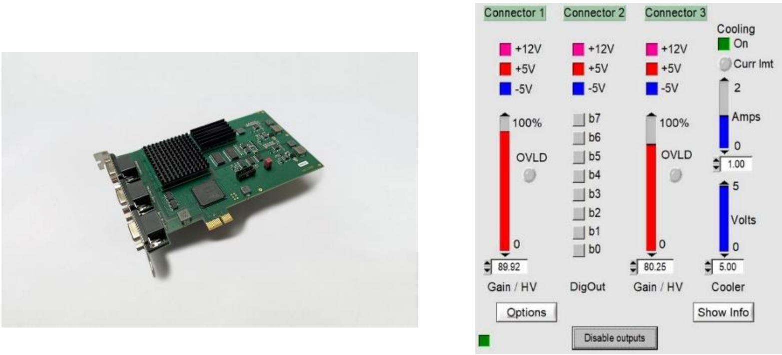


Fig. 1: DCC-100PCIe Detector/Laser Controller. Software panel shown right.

Fig. 2: DCU-400 Detector/Laser Controller with USB interface. Software panel shown right.

Laser and Detector Control – Main Application

The DCC-100PCIe, DCU-400 or DCU-800 devices control lasers and detectors. The DCC/DCU provides gain regulation, ON/OFF control, cooling and overload shutdown for detectors. Detectors are connected to the DCC/DCU as shown in Fig. 3-5. When controlling lasers, the DCU provides variable laser diode drive current and ON/OFF control as shown in Fig. 5. Additionally, the DCU operates the optional optical attenuators of the lasers, providing output power control without changes to the laser pulse form.

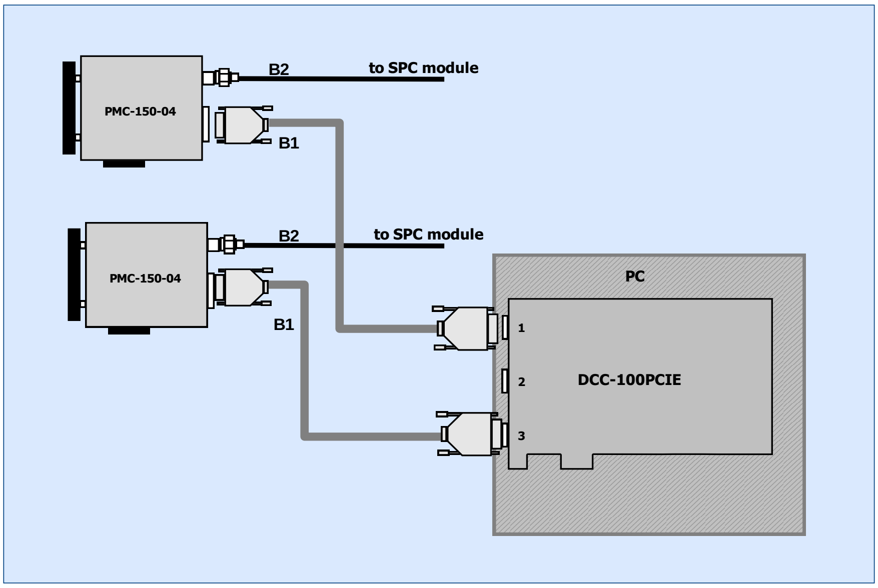


Fig. 3: PMC-150 detectors connected to the detector control outputs of the DCC-100PCIe.

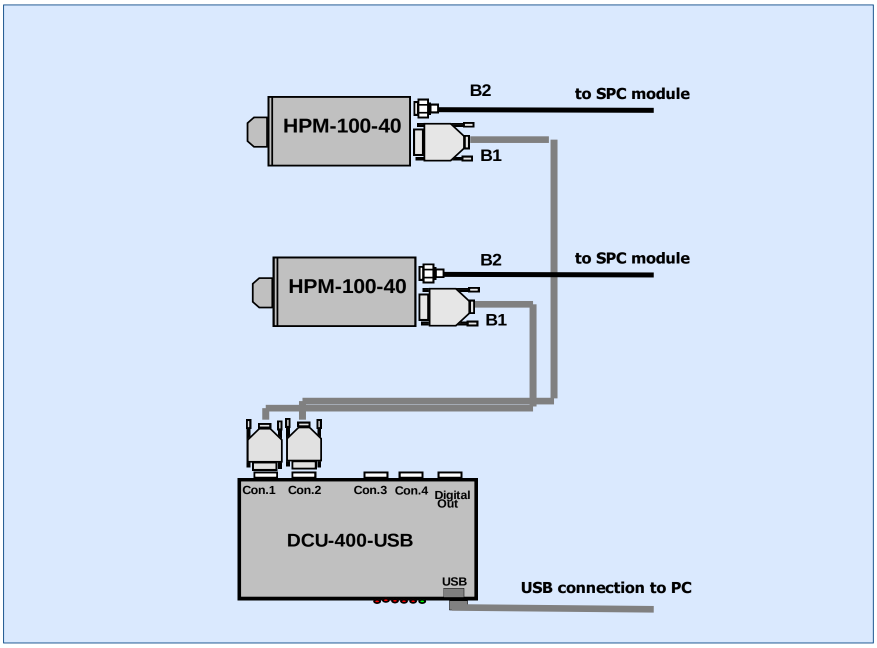


Fig. 4: HPM-100 detectors connected to the detector control outputs of the DCU-400.

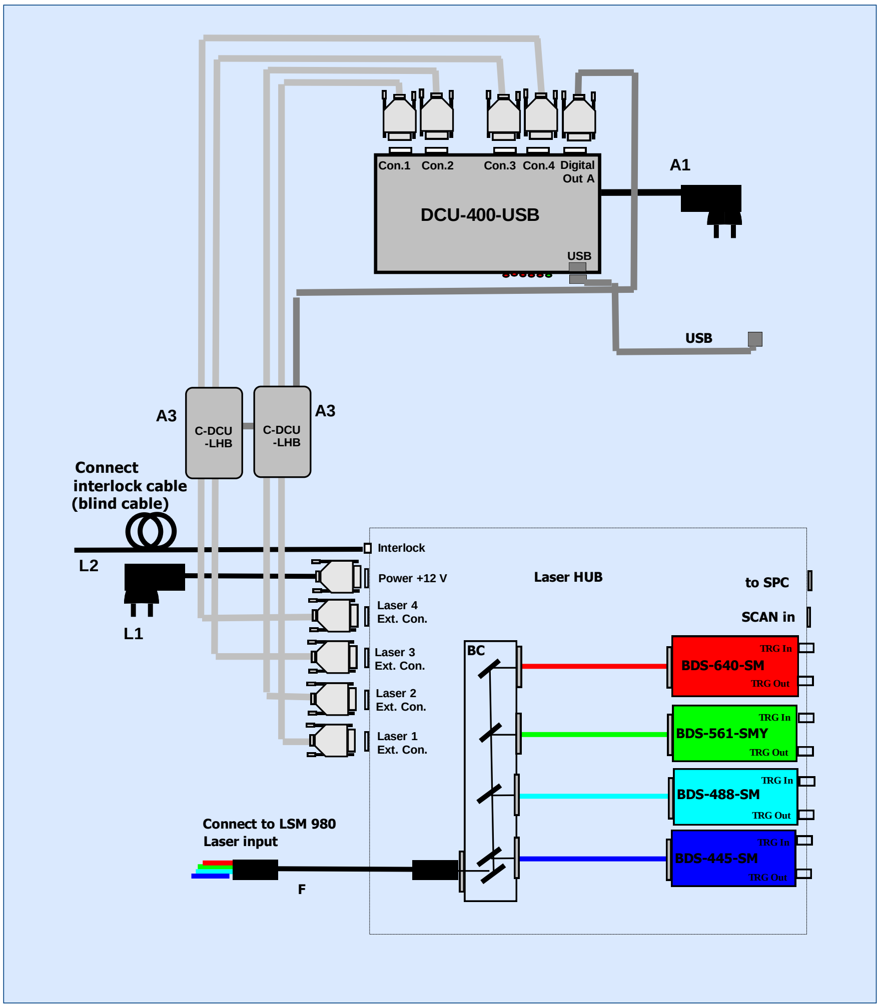


Fig. 5: Laser-HUB controlled by DCU-400. Laser power and laser ON/OFF are controlled via con. 1-4. The connection of the 'Digital Out' is optional to control optical attenuators.

Software

The DCC/DCU is either operated within the SPCM data acquisition software or, alternatively, from a stand-alone application provided within the TCSPC software package. The DCC-100PCIe software panel controlling one laser and one detector is shown in Fig. 6.

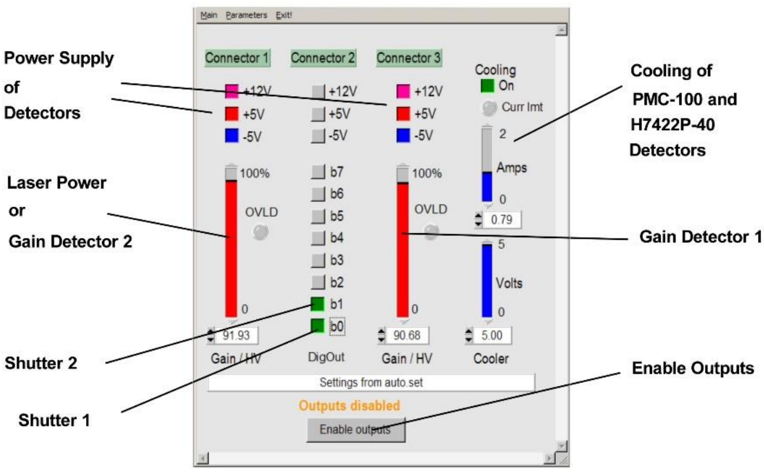


Fig. 6: DCC software panel, control of one laser and one detector.

The main panel is grouped into 'Connector 1', 'Connector 2', 'Connector 3', and 'Cooling'. The supply voltages +12 V, +5 V and -5 V can be toggled individually depending on the use case. The detector Gain control signals are changed by dragging the vertical bars or entering in a value between 0 and 100% manually. Per default, the outputs of the DCC-100PCIe are disabled at the startup. Please note that this is a safety function. It avoids unintentionally switching on the output voltage of a high-voltage power supply or unintentional activation of lasers or detectors. The DCC software can be configured to turn on the outputs automatically (Option 'Enable Outputs on Startup'). This option is *not* intended for operation of PMTs, and should *not* be used in conjunction with lasers.

The power supply of the bh detectors (e.g. HPM-100, PMC-150 and PML-16-C) is provided by the DCC, when the corresponding voltage buttons are activated (-5 V, +5 V and +12 V). Some of the bh detectors have an internal cooler (e.g. PMC-150 and HPM-100C). If you use these detectors, activate the cooling with the 'Cooling On' button and set the cooling current according to the detector test protocol. In general, for PMC-150 the cooling current is 1 A at 5 V and for HPM-100C it is 2 A at 5V. The DCC cooling setting apply to both detection outputs simultaneously.

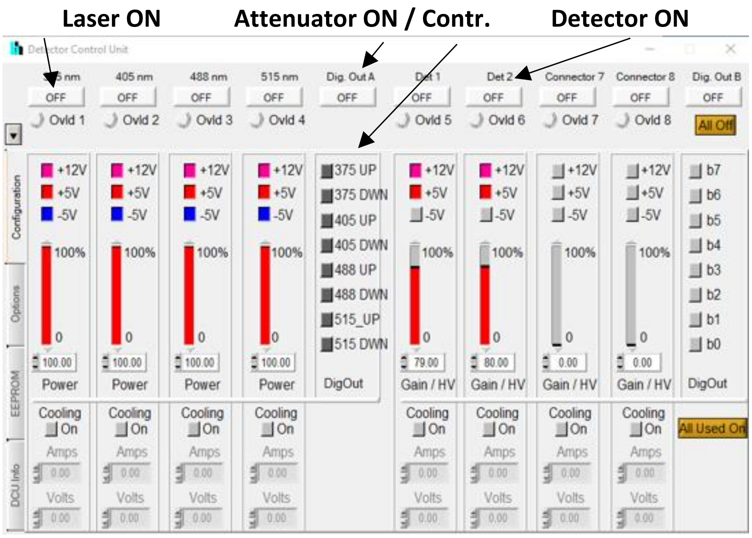


Fig. 7: DCU-800 software panel, control of four lasers and two detectors.

The DCU-800 software panel controlling four lasers and two detectors is shown in Fig. 7. The diode drive current of the four lasers is controlled by the four sliders on the left, providing continuous laser power and pulse shape control. The laser ON/OFF buttons are located above the voltage switches. The +5V switch has to be enabled for bh laser control. The center segment contains buttons to control the optional mechanical laser attenuators, for continuous control of the laser power without changes to the pulse shape. The gain of the detectors is controlled by the two sliders in the middle. Two outputs are left unused. These vacant outputs can be used for additional detectors or other control tasks within the FLIM system. The two detectors require control voltages +5V and +12V, as well as, the gain from connector 5 and 6. An optional current and voltage for peltier cooling can be controlled in the lower part of the panel.

Configuring the Detector and Laser Control Panel

Configuration of 'Digital Out' buttons for Power UP/DWN: Right click on the button opens a control panel showing 'Change Output Name' or 'Change Output Type'. Click on Name to change the name of the button. Click 'Type' to define the button behavior: 'Key' type operation is active as long as the button is pressed, 'Switch' type operation changes state upon activation. The laser attenuator power UP/DWN buttons are 'Key' type.

Other Labels: Right click on buttons for 'Change Label' to assign label.

Detector Gain Setup

The detectors of the bh FLIM systems are operated in the photon counting mode. That means, the detector delivers an electrical pulse for every single photon detected. The average pulse amplitude increases with the detector gain.

The setup procedure for the gain of the HPM-100 detector is shown in Fig. 8. Enable the outputs of the DCC or DCU detector controller. Prevent light from entering the detector (some extremely weak light does not matter). Pull up the 'Gain' bar. Simultaneously, keep an eye on the CFD count rate in the corresponding TCSPC channel. At some point, the TCSPC modules should detect photon pulses, indicated by a rise of the CFD rate at the SPC module. The function of the count rate versus 'gain' is very steep, see Fig. 8. The function has a plateau, as shown in the figure. The optimum gain is in the middle of the plateau. The DCC or DCU gain at this point is in the range of 70 to 90%. When the gain is raised beyond the plateau the count rate will increase steeply, and the detector controller reports detector overload. The correct gain settings for every bh detector are mentioned in the corresponding detector test report. If correct gain settings are not known, it is usually sufficient to find the point where the overload occurs and to take the 'gain' back by a few percent. The click the 'Reset' button in the controller panel to restart the detector, see Fig. 8.

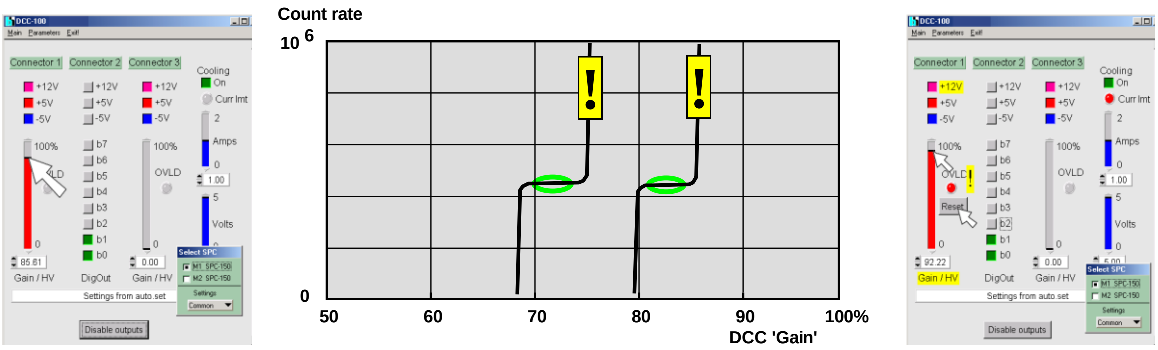


Fig. 8: Adjusting the detector gain for hybrid detector modules. The operating point can be found by determining the gain when the detector shuts down by overload and taking back the gain by a few per cent.

To find a reasonable combination of threshold and gain we recommend to start with the CFD thresholds given in the table below:

Detector	**CFD Threshold**	**DCC Gain (Voltage)**
HPM-100, all versions	-50 mV	70 to 90%, see below
PMC-150	-100 mV	80 to 100%
PML-16C	-100 mV	85 to 100%
PML-16 GaAsP	-100 mV	85 to 100%
PMC-100	-100 mV	80 to 90%
R3809U with FuG-HCN	-80 mV	80 to 86% (-2.9 to -3.0 kV)
R3809U with HVM-100	-80 mV	90 to 100%
PMZ-100	-100 mV	80 to 90%
H7422P-40	-100 mV	70 to 85%

Once the correct detector gain has been determined, we recommend to lock the detector parameters, see Fig. 9. This avoids unintentional changes of the detector gain. Please note: the detector gain is not a tuning parameter for measurement signal strength. Always keep the detector at optimal gain settings and adjust the excitation intensity instead.

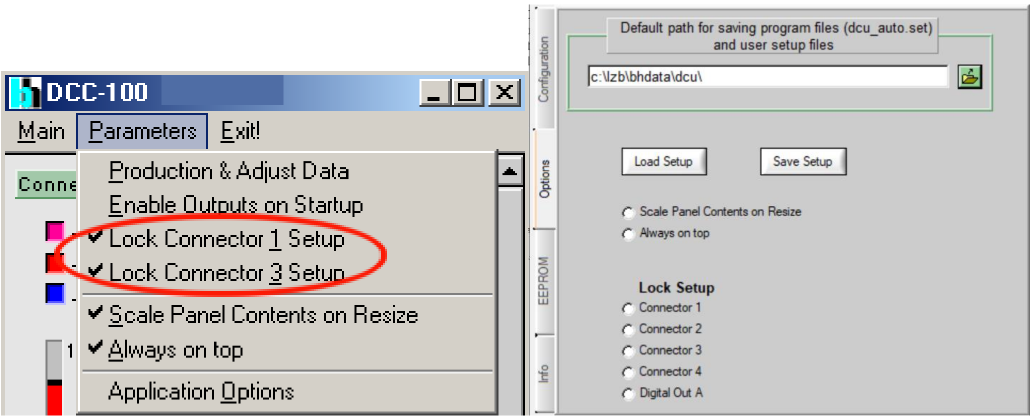


Fig.9: Locking the DCC setup (left) and DCU setup (right).

Detector Overload

If a PMT overload is detected the 'OVLD' light of the corresponding connector turns on and a warning (flashing '!') is issued. At the same time the detector control signal and the +12 V at the corresponding connector are shut down. Current version of the DCC/DCU disable the high current switches on overload, e.g., to close shutters. Jumpers on the DCC/DCU board can disconnect connectors from the overload shutdown. Per default, the overload affects the 'Digital Out' connections.

After an overload occurred, first remove the excessive light from the detectors. Afterwards, hit the 'RESET OVLD' button to resume operation.

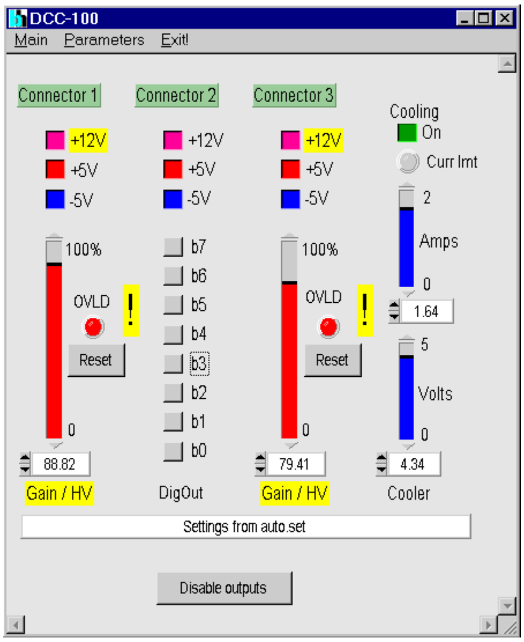


Fig. 10 DCC main panel, after overload. DCU similar.

Safety note: Please make sure that you don't exceed the maximum values for your detector(s). Particularly, if you control a HV power supply, make sure that it is safe to turn on or increase the voltage. Although the DCC/DCU contains some safety features, such as detector shutdown at power-on or overload, it cannot be made safe in terms of operator errors, such as turning on HV power supplies with open or wrong connected output cables, or exceeding the maximum operating voltage for a given detector. bh will not take responsibility for accidents or detector damage resulting from setting or loading values exceeding maximum values for a given experiment setup.

High Current Switches

The high current switches can be switched on and off independently by the control buttons under 'Connector 2' or 'Digital Out'. All switches can be disabled (i.e. switched into the non-conducting state) by the common 'Disable Output' or 'ON/OFF' button.

Current version of the DCU are able to shut down the high current switches on overload (i.e. set into the non-conducting state), for example to close shutters. Appropriate jumpers have to be set on the DCU board. Default setting affect 'Digital Out' when an overload occurs.

If the high current switches have been deactivated by detector overload they must be explicitly switched on after the overload condition is removed.

Cooler Control

The cooling current can be switched on and off by clicking on the 'ON' button. To control the cooling power, you can set an output voltage and an output current. Of course, setting voltage and current in an electrical circuit simultaneously is impossible. The cooling power supply controls the voltage at the output as long as the specified current is not reached. When the specified current is reached current control takes over and the current is controlled. In other words, the cooling is controlled in way that neither the selected voltage nor the selected current is exceeded.

Saving and Loading the Setup

To load or to save the DCC setup, click on 'Main' in the menu bar and select 'Save' or 'Load'. To load or save the DCU setup, click on 'Options' in the side bar and select 'Load Setup' or 'Save Setup'.

When you save a setup you first have to enter or select a file name by clicking into the 'file name' field. You can also change to other directories or drives. An additional field for notes is provided.

Loading a setup file works similarly. Click on the 'file name' field and select the correct setup file. In the 'File Info' field you will see the information typed in when the file was saved. Confirm your choice with 'Load'.

Note: Please make sure that you load the right file for your experiment setup. Although the DCC/DCU contains some safety features, such as detector shutdown at power-on or overload, it cannot be made safe in terms of operator errors, such as turning on HV power supplies with open or wrong connected output cables, or exceeding the maximum operating voltage for a given detector. bh will not take responsibility for accidents or detector damage resulting from setting or loading values exceeding maximum values for a given experiment setup.

Technical Description of DCC-100PCIe and DCU-400/800

Structure of the DCC/DCU

The block diagram of the DCC-100 is shown in Fig. 11. The DCC-100 contains two detector control blocks and one general purpose power switch block.

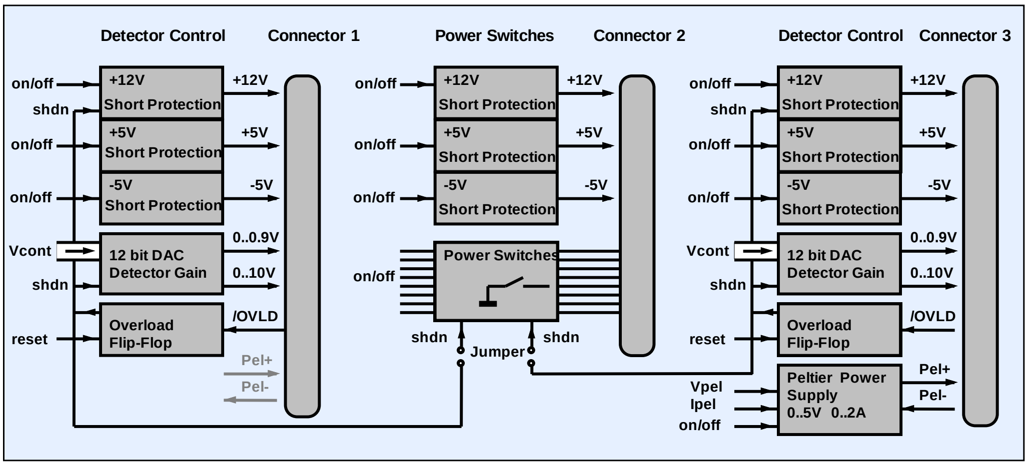


Fig. 11: Block diagram of the DCC-100 detector controller

The DCU-400 contains four laser and detector control blocks (Connector 1-4) and one general purpose power switch block (Digital Out). The DCU-800 provides the functionality of two DCU-400. The block diagram of the DCU-400 is shown in the figure below.

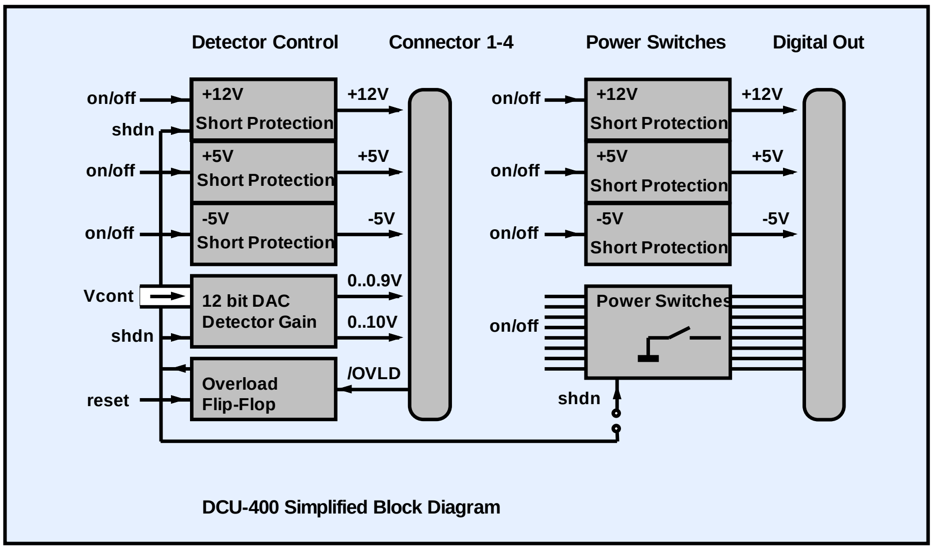


Fig. 12: Simplified block diagram of the DCU detector control unit

Detector and Laser Control Outputs

The detector control connectors contain power supply outputs for detectors, a digital-to-analog converter (DAC) for detector gain and laser control, and an overload shutdown circuit.

The power supply outputs are short-circuit-protected and deliver +12 V, +5 V and -5 V. The outputs can be switched on and off by software.

A 12-bit DAC is used to control the gain of the detector. It delivers the 0 to +1.0 V control voltage required for Hamamatsu photosensor modules (H7422, H5783, H5773 etc.) and a 0 to +10 V control voltage for FuG high voltage power supplies.

Both detector control blocks have a detector overload shutdown function. The shutdown function works in conjunction with bh HFAC-26 preamplifiers. If the preamplifier detects an overload condition it sends an active low overload signal (/ovld) to the DCC/DCU. This signal sets the overload flip-flop which shuts down the detector control voltage and the +12 V detector power supply. Furthermore, it can be used to deactivate the switches in the current switch block (see below).

Each of the DCU detector control blocks contains a power supply for thermoelectric coolers.

High Current Switch Block

The high current switch block contains power supply outputs for detectors and preamplifiers and eight high-current MOSFET switches to operate shutters, motors or magnetic actuators.

The power supply outputs are short-circuit-protected and deliver +12 V, +5 V and -5 V. The outputs can be switched on and off by software. The MOSFET switches are able to switch currents up to 2 A and voltages up to 20 V. One side of each switch is connected to ground, the other side is available at the output connector. The switches are **not** short circuit protected.

The high current switches are shut down (i.e. set into the non-conducting state) by one or both overload signals from the detector control blocks. The configuration is set by the jumpers on the DCC-100PCIe board (see Fig. 11).

Current version of the DCU also shut down (i.e. set into the non-conducting state) the high current switches on overload signals from the detector control blocks e.g. to close shutters. Appropriate jumpers have to be set on the DCU board. Default setting affect 'Digital Out' when an overload occurs (see Fig. 12).

Power Supply for Thermoelectric Coolers

Current supply for thermoelectric coolers (used in bh cooled detectors) is provided at connector 3 or at connector 1-3 for DCC-100. The configuration differs for DCCs manufactured before and after June 2014. In earlier DCCs coolers supplied from connector 1 and 3 are connected in series. The configuration is set by jumpers on the DCC board. Newer DCC units have individual cooling power control circuits for connector 1 and 3 are driven by independent power supply circuits. For DCU-400 cooling is provided at connector 1-4 driven by independent power supply circuits and for DCU-800 at connector 1-4 and 5-8.

The cooler drivers deliver up to 5 V and 2 A. Both voltage and current upper limits can be selected by software. The device automatically controls either the output voltage or the output current. Voltage control is active as long as the current through the load is smaller than the current limit set by the software. When the current through the load reaches the current limit the device automatically switches to current control. A block diagram is shown in Fig. 13: .

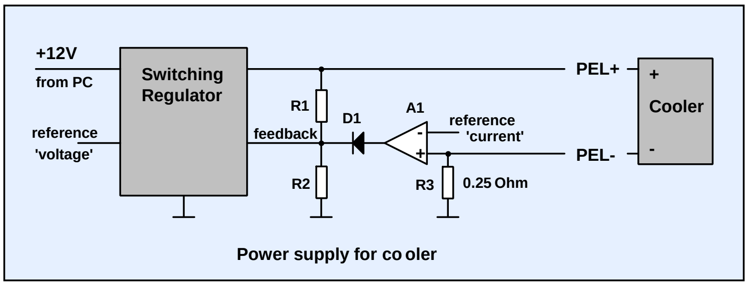


Fig. 13: DCC/DCU, control of the cooling current

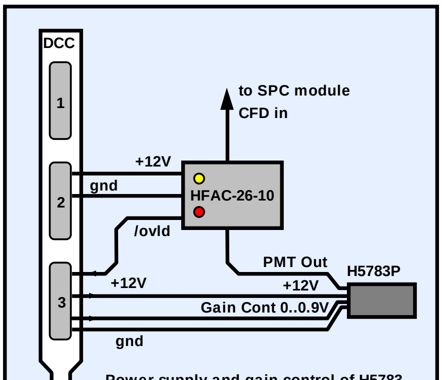
A switching regulator is used to generate the supply current for the cooler. The cooling current flows through the sensing resistor R3. As long as the voltage at R3 is smaller than the reference voltage at A1 ('current' reference) A1 is inactive and the switching regulator works as a normal voltage stabilizer. If the voltage at R3 exceeds the reference voltage at A1, the amplifier becomes active, and, via D1, overwrites the feedback voltage of the switching regulator. This causes the regulator to reduce the output voltage until the voltage at R3 equals the reference of A1.

Applications

The main application of the DCC-100PCIe and DCU-400/800 is to control bh laser from BDS series and the multiwavelength Laser-HUB, as well as, bh detectors such as the HPM-100, PMC-150, 16 Channel PML-Spec, and MW-FLIM detectors as shown in the introduction part. Some further applications of the DCU-400/800 and DCC-100 are described below.

Controlling H5783 and H5773 Photosensor Modules

The H5783 and the H5773 are high speed miniature PMT modules manufactured by Hamamatsu. The modules contain a small photomultiplier along with a high voltage generator. The resolution in the TCSPC (time-correlated single photon counting) mode is typically 150 to 200 ps. The H5783 comes in various cathode versions for the wavelength range up to 820 nm. The H5783 can be controlled in a similar way as the H7422 below. The connections are shown in the figure right. A HFAC-26-10 preamplifier with a 10 µA overload threshold is used to amplify the single photon pulses and to send an overload signal to the DCU/DCC.



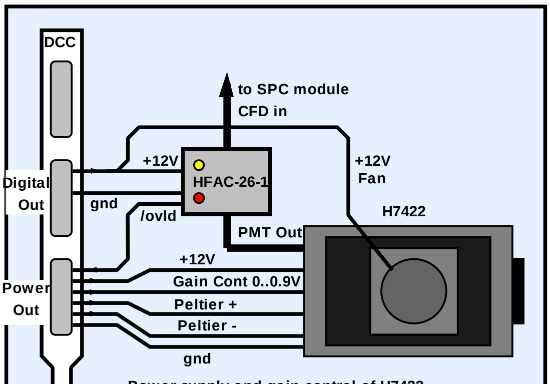
Power supply and gain control of H5783 with overload shutdown

A second H5783 can be controlled separately via one of the other power connectors. In this case the power supply for both HFAC amplifiers should be taken from the ‘Digital Out’ connector.

Don’t connect or disconnect the signal cable from the detector to the preamplifier when the detector is switched on. This can destroy the amplifier. Make sure that the +12 V at ‘Digital Out’ is switched on. Otherwise the HFAC does not work, and the overload protection is inactive. For the DCU the voltages are switched on with the main power switch at the device.

Controlling the H7422 and H8632

The H7422 is a high speed, high sensitivity PMT module of Hamamatsu. It contains a GaAs photomultiplier along with a thermoelectric cooler and a high voltage generator. The resolution in the TCSPC (time-correlated single photon counting) mode is typically 250 ps. The H7422 comes in different cathode versions for the wavelength range up to 900 nm. The H8632 is available for the wavelength range up to 1100 nm.



Power supply and gain control of H7422 with overload shutdown

The recommended connection to the DCC/DCU is shown in the figure on the right. The detector is connected to one of the Power connectors of the DCC/DCU. The DCC/DCU delivers the +12 V operating voltage, the 0 to 1.0 V gain control voltage, and the current for the thermoelectric cooler.

The output signal of the PMT is amplified by the HFAC-26-1 preamplifier. The single photon pulses at the output of the amplifier have a few 100 mV amplitude and are used to trigger the CFD input of a bh TCSPC module (SPC-300 through SPC-730, see manual at www.becker-hickl.de).

The HFAC-26-1 amplifier monitors the output current of the H7422. If an average current of 1 µA is exceeded the /ovld signal of the HFAC-26 goes to 'low'. This sets the overload flip-flop in the DCC/DCU, and the gain control voltage and the +12 V shut down.

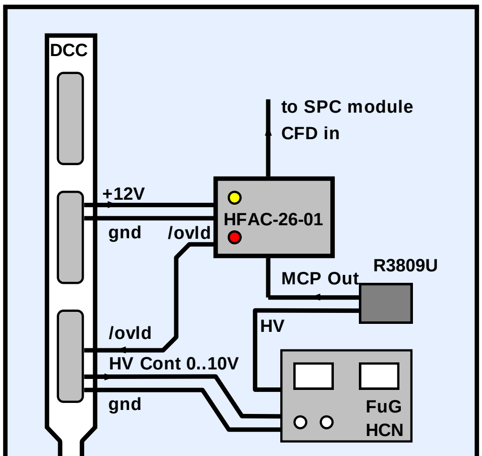
Notice: The H7422 has its own overload shutdown. The H7422 may shut down if the gain control voltage changes at a rate faster than 10 V/s. The changing rate of the gain control voltage in the DCC/DCU is kept below the critical value. If the H7422 shuts down internally for whatever reason, it can only be re-activated by cycling the +12 V operating voltage.

Don't connect or disconnect the signal cable from the detector to the preamplifier when the detector is switched on. This can destroy the amplifier. Make sure that the +12 V at 'Digital Out' is switched on. Otherwise the HFAC does not work, and the overload protection is inactive. For the DCU the voltages are switched on with the main power switch at the device.

Controlling an R3809U MCP PMT

The Hamamatsu R3809U is the fastest photon counting detector currently available. It uses a microchannel plate for electron multiplication. In the TCSPC mode a time resolution of less than 30 ps (FWHM) can be achieved. MCP PMTs are extremely sensitive to overload. Because the microchannels are continuously destroyed by sputtering the lifetime of the detector is limited. The degradation effect is not noticeable under normal operating conditions. However, overloading the detector can rapidly exhaust the residual lifetime. Therefore, MCP PMTs should always be operated with overload protection, or at least with an overload indicator.

The figure right shows how an R3809U MCP can be operated with overload protection. An FuG HCN-14-3500 is used as an high voltage power supply for the R3809U. The HCN-14 is available with a 0 to 10 V control input. The high voltage is proportional to the control voltage. Therefore, the detector operating voltage can be controlled by the DCU/DCC and be shut down on overload.



Overload shutdown for R3809U MCP

For overload detection, the HFAC-26-01 preamplifier - with an overload threshold of 0.1 µA - is used.

Safety notice: Please observe the usual safety rules when working with high voltage. Make sure that there is a reliable ground connection between the detector and the HV power supply. Don't use broken cables, loose connectors or cables with insufficient insulation.

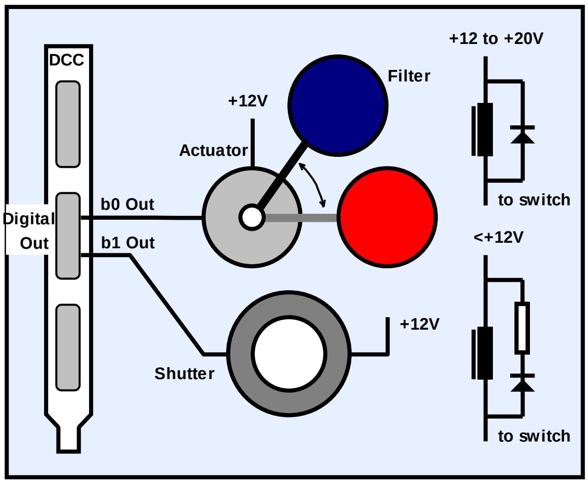
Don't connect or disconnect the signal cable from the detector to the preamplifier when the detector is switched on. This can destroy the amplifier. Make sure that you connected all ground connections. Missing ground connections can result in high voltage instability or unreliable overload shutdown.

Make sure that the +12 V at 'Digital Out' is switched on. Otherwise the HFAC does not work, and the overload protection is inactive. For the DCU the voltages are switched on with the main power switch at the device.

Controlling Shutters

Later versions of the DCU may allow to control shutters or other actuators via the high current switches of 'Digital Out'. Appropriate jumper setting on the board is required. The switches can operate a voltage up to 20 V and up to 2 A. The power supply for the external load can be taken from the 'Digital Out' connector if a current of 100 mA at +12 V or 200 mA at +5 V is not exceeded. For higher currents an external power supply must be used.

Since shutters and other magnetic devices are inductive loads a flyback diode must be connected across the load. For supply voltage up to 12 V a resistor can be connected in series with the flyback diode to achieve a faster turn-off time. The value of the resistor should be about the DC resistance of the actuator or shutter coil.

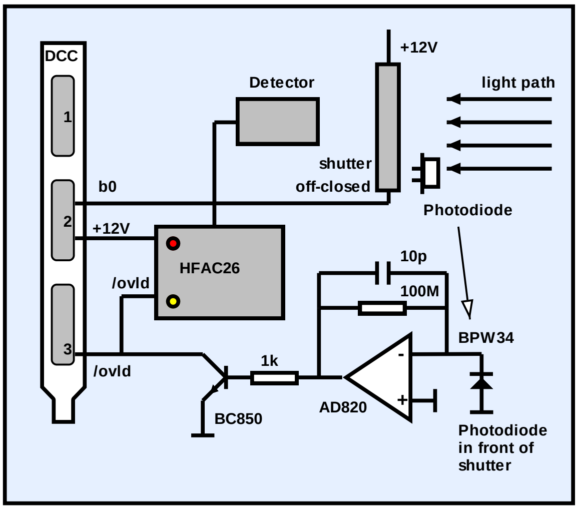


Controlling shutters and filters

The switches can automatically be shut down (i.e. set into the non-conducting state) when an overload condition occurs.

Sometimes it is required to lock a shutter in the 'closed' state as long as a potential overload condition persists. An example is a microscope with a mercury or halogen lamp. When the lamp is on, opening the shutter must be inhibited. A solution is shown in the figure right. The photodiode detects the light from the lamp, and the amplifier sends an '/ovld' to the DCC/DCU. The signal can be connected parallel to the /ovld from the amplifier.

As long as the lamp is on, /ovld remains 'low' and the shutter cannot be opened. This gives additional safety against detector damage.



Locking a shutter in a potential overload situation

It must, however, be pointed out that an absolute safety against detector damage cannot be achieved in this way. If the lamp is switched on when the shutter is open it takes a few milliseconds until the overload is detected and the shutter closes. This can be enough to cause severe detector damage. Therefore, the best option is always a mechanical interlock so that the lamp path is closed when the detection path is opened.

For more details please have a look in the TCSPC Handbook.

Safety Notes

Please use for detector and laser connection to DCC and DCU the delivered cables with the described labels. Using other cables can lead to damage of the equipment.

PIN Assignment

DCC-100PCIe

Connector 1 and 3
15pin HD-SubD

Pin	Signal
1	+5V out switchable
2	Peltier +
3	Peltier +
4	Peltier +
5	GND
6	-5V out switchable
7	Peltier -
8	Peltier -
9	Peltier -
10	+12V out switchable, ovld sdwn
11	-12V out
12	0...+10V HV cont., ovld sdwn
13	0...+1.0V gain cont., ovld sdwn
14	/OVLD1 input, /OVLD3 input
15	GND

Connector 2 (Digital Out)
15pin HD-SubD

Pin	Signal
1	+5V out
2	Bit0 open drain out
3	Bit1 open drain out
4	Bit2 open drain out
5	GND
6	-5V out
7	Bit3 open drain out
8	Bit4 open drain out
9	Bit5 open drain out
10	+12V out
11	-12V out
12	Bit6 open drain out
13	Bit7 open drain out
14	
15	GND

DCU-400/-800

Connector 1-8
15pin HD-SubD

Pin	Signal
1	+5V out switchable
2	
3	
4	
5	GND
6	-5V out switchable
7	
8	
9	
10	+12V out switchable, ovld sdwn
11	-12V out
12	0...+10V HV cont., ovld sdwn
13	0...+1.0V gain cont., ovld sdwn
14	/OVLD1 input
15	GND

2x Digital Out
15pin HD-SubD

Pin	Signal
1	+5V out
2	Bit0 open drain out
3	Bit1 open drain out
4	Bit2 open drain out
5	GND
6	-5V out
7	Bit3 open drain out
8	Bit4 open drain out
9	Bit5 open drain out
10	+12V out
11	-12V out
12	Bit6 open drain out
13	Bit7 open drain out
14	
15	GND

Power Supply Outputs (Connectors 1 to 3)

Max. Current at +12 V	100 mA
Short Circuit Current +12 V	50 mA [1)]
Time from /OVLD to disable +12 V	10 ms [2)]
Output current in disabled state, +12 V	< 0.5 mA
Max. Current at +5 V	200 mA
Short Circuit Current +5 V	60 mA [1)]
Output current in disabled state, +5 V	< 0.5 mA
Max. Current at -5 V	200 mA
Short Circuit Current -5 V	60 mA [1)]
Output current in disabled state, -5 V	< 0.5 mA
Max. Current at -12 V	Sum 120 mA, single output 60 mA
Short Circuit Current -12 V	No short protection. Don't short longer than 1 s

[1)] Foldback Characteristics, don't short several outputs simultaneously for more than 20 s

[2)] Connectors 1 and 3 only. 250 Ω load, time from +12 V to +6 V output voltage.

Detector Gain Control (Connectors 1 and 3)

Resolution	12 bit
Voltage Range Pin 12	0 to +10 V
Load at Pin 12	min. 1 kΩ
Output Resistance at Pin 12	100 Ω
Voltage Range Pin 13	0 to +0.9 V
Load at Pin 13	min. 1 kΩ
Output Resistance at Pin 13	100 Ω
Output Time Constant	100 ms

Overload Shutdown

Overload inputs at connector 1 and 3	TTL, active Low, Pull-up resistor 10 kΩ
Overload Reset	By Software and at Power-ON

High Current Switches (Connector 2)

Typical 'On' Resistance, 25°C	70 mΩ
Max. Switch Current, Single Switch	2 A
Max. Switch Current, Sum of all Switches	5 A [3)]
Max. turn-off Voltage at Switch	20 V
Turn-on and turn-off transition time, Load 10 Ω	100 ns
Disable on /OVLD	configurable by jumper
Disable Transition Time	< 1 us
Time from /OVLD to Disable	< 2 us

[3)] Both GND pins used

Supply for Thermoelectric Coolers (Connector 3)

Output Voltage	0 to 5 V
Output Current	0 to 2 A
Resolution of Output Voltage and Current	12 bit
Output Resistance	0.4 Ω [4)]
Output Capacitance	300 uF
Output Ripple	< 5 mV

[4)] All pins parallel

PC Interface

Dimensions	160 mm x 106 mm x 15 mm
Interface / Connector	PCI Express
Supply Current, +5V, No Load, typ. value	0.6 A
Supply Current, +5V, Maximum Load, typ. value	1.2 A
Supply Current, +12V, No Load, typ. value	0.2 A
Supply Current, +12V, Maximum Load, typ. value	1.6 A

DCU-400 / DCU-800

DCU-400 controls up to 4 detectors with an additional digital output for shutter and filter control.
DCU-800 controls up to 8 detectors with two additional digital outputs for shutter and filter control.

Power Supply Outputs (All Connectors)

Max. Current at +12 V	100 mA
Short Circuit Current +12 V	50 mA [1)]
Time from /OVLD to disable +12V	10 ms [2)]
Output current in disabled state, +12 V	< 0.5 mA
Max. Current at +5 V	200 mA
Short Circuit Current +5 V	60 mA [1)]
Output current in disabled state, +5 V	< 0.5 mA
Max. Current at -5 V	200 mA
Short Circuit Current -5 V	60 mA [1)]
Output current in disabled state, -5 V	< 0.5 mA
Max. Current at -12 V	Sum 120 mA, single output 60 mA
Short Circuit Current -12 V	No short protection. Don't short longer than 1 s

[1)] Foldback Characteristics, don't short several outputs simultaneously for more than 20 s
[2)] Connectors 1 - 4 / 1 – 8 only. 250 Ω load, time from +12 V to +6 V output voltage.

Detector Gain Control (Connectors 1-4 / 1-8)

Resolution	12 bit
Voltage Range Pin 12	0 to +10 V
Load at Pin 12	min. 1 kΩ
Output Resistance at Pin 12	100 Ω
Voltage Range Pin 13	0 to +0.9 V
Load at Pin 13	min. 1 kΩ
Output Resistance at Pin 13	100 Ω
Output Time Constant	100 ms

Overload Shutdown

Overload inputs at connector 1 – 4 / 1 - 8	TTL, active Low, Pull-up resistor 10 kΩ
Overload Reset	By Software and at Power-ON

High Current Switches (Additional Digital Out / Digital Output A + B)

Typical 'On' Resistance, 25°C	70 mΩ
Max. Switch Current, Single Switch	2 A
Max. Switch Current, Sum of all Switches	5 A[3)]
Max. turn-off Voltage at Switch	20 V
Turn-on and turn-off transition time, Load 10 Ω	100 ns
Disable Transition Time	< 1 us
Time from /OVLD to Disable	< 2 us

[3)] Both GND pins used

Supply for Thermoelectric Coolers (Connector 1-4 / 1-8)

Output Voltage	0 to 5 V
Output Current	0 to 2 A
Resolution of Output Voltage and Current	12 bit
Output Resistance	0.4 Ω [4)]
Output Capacitance	300 uF
Output Ripple	< 5 mV

[4)] All pins parallel

General

Dimensions	264 mm x 205 mm x 75 mm
Interface / Connector	USB 2.0 / 2x USB 2.0
Power Supply	+ 19 V DC

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