PHR 800

Four Channel Detector Router

for use with the PicoHarp300

PicoQuant GmbH

User's Manual

Version 1.0

1. Table of Contents

1. Introduction

The four channel router PHR 800 is an accessory for the PicoHarp 300 Time-Correlated Single Photon Counting (TCSPC) System (from hardware revision 2.0). Using the PHR 800, users can connect up to 4 single photon detectors to perform simultaneous multi-channel time-resolved measurements. These can provide another valuable dimension of information, e.g. colour and/or polarization as well as improved collection efficiency. This permits sophisticated and fast multi-dimensional fluorescence detection methods in the life sciences or in general sensitive analytics. The 4-channel router supports both histogramming and Time-tagged Time-resolved (TTTR) mode. The latter allows the recording of each individual photon with its picosecond timing and the detector channel it came from. This permits ultimate flexibility in data analysis e.g. for burst detection or Fluorescence Correlation Spectroscopy (FCS) combined with fluorescence lifetime information. Using two or more detectors and TTTR mode it is possible to perform cross correlations in FCS. The PHR 800 can be adjusted by software through the control interface of the PicoHarp 300. This allows selection of the input polarity and the trigger threshold, so that almost any detector signal can be used. Standards supported are TTL and NIM from commonly used SPAD detectors.

Dependent on the chosen configuration, the PHR 800 can contain Constant Fraction Discriminators (CFD), separate for all four inputs. These can be adjusted by software through the control interface of the PicoHarp 300. This supports detectors with fluctuating pulse heights such as Photo Multiplier Tubes (PMT) and Multi Channel Plate (MCP)-PMT.

2. Controls and Connectors

Fig. 1 shows the front panel of the PHR 800 router. The left module is the main router unit that is always present. There are four SMA input connectors for the detectors. Unused inputs can be left open. The numbering scheme of the inputs (1..4) reflects the curve numbering in the PicoHarp software as well as the state of the two lower routing channel bits in TTTR mode.

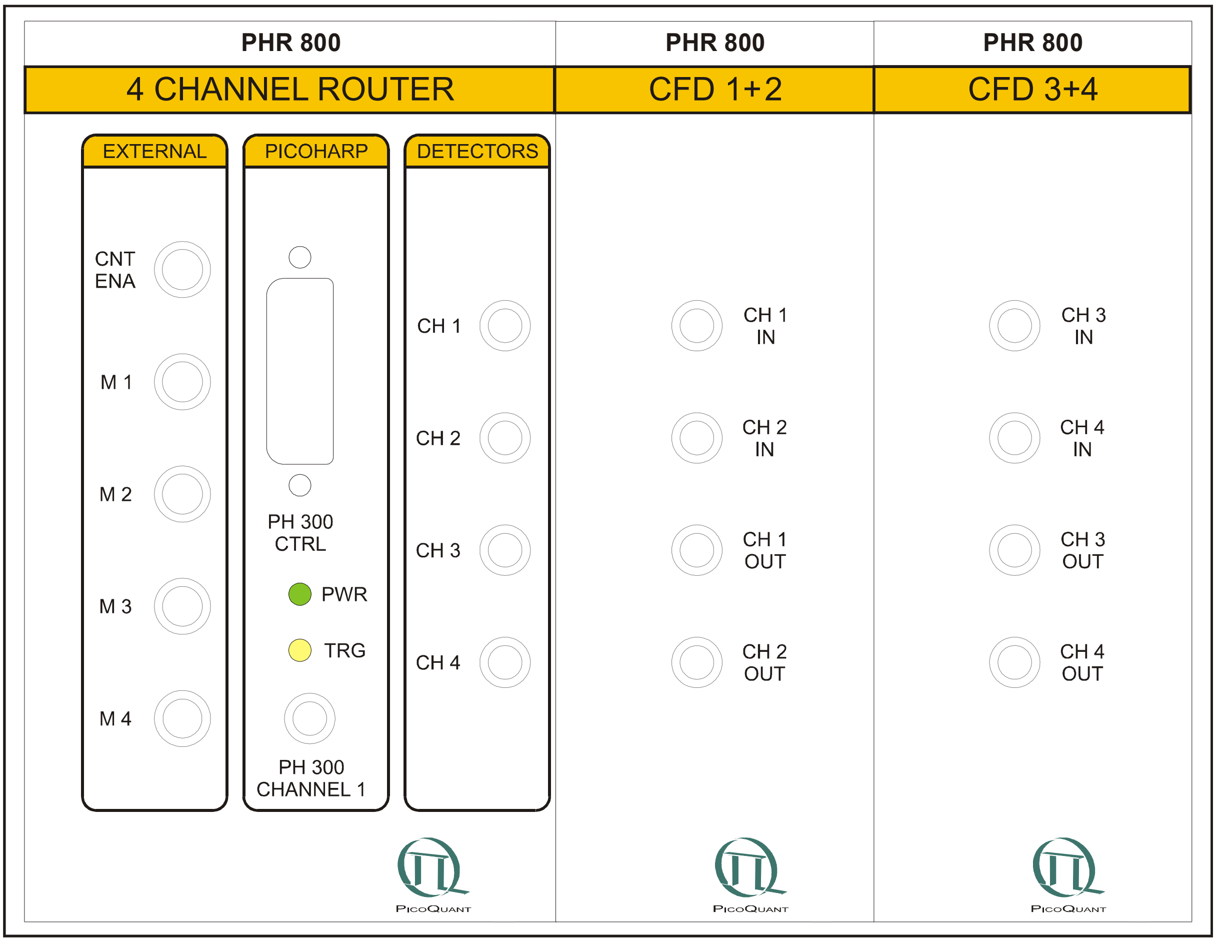

Figure 1

The right hand side modules are CFDs that may or may not be present, dependent on the chosen configuration. They are required for detectors with fluctuating pulse heights, such as PMT and MCP-PMT. They require negative going input signals. Their operation is identical to the built-in CFDs of the PicoHarp 300. The CFDs can be upgraded at a later time. In case only one CFD module is installed, it must be placed in the leftmost slot, next to the main router unit. If CFDs are to be used, their outputs must be connected to the corresponding main router inputs. Dedicated SMA cables for this purpose are shipped with the CFD modules.

AC supply (100-240V) must be provided at the back of the PHR 800. There is also a main power switch that must be switched on prior to use under software control. The SMA connector for the router output (to PicoHarp 300 CHANNEL 1) and the control connector (DVI) are at the front panel. The router is connected to the PicoHarp's general control port through this connector. A PicoHarp 300 from hardware revision 2.0 is required. A dedicated cable for this connection is provided with the PHR 800.

The green power LED at the front indicates the power state of the PHR 800. The yellow LED indicates that one or more inputs are active (being triggered).

Attention: Do not connect/disconnect inputs while PMTs are powered. Their high voltage may damage the input circuits. After PMTs are powered off, allow sufficient time for the dynodes and cables to discharge.

3. Operation

3.1 Internal Principle of Operation

The routing principle of the PHR 800 is 'signal driven multiplexing'. It is also referred to as 'statistical time sharing'*. I.e. the 4 router channels share one timing circuit on a 'first come first serve' principle. This works fine because the probability of receiving a photon in one sync period must be kept on the order of 1..2 % anyway, which is a prerequisite for avoiding pile-up in TCSPC. If two photons arrive during the same sync period, only the first one will be accepted. The router recognizes in which channel it received a photon and delivers that information to the PicoHarp 300 via a dedicated control port. The next photon can be on any other channel, whichever comes first. Because of the inherent count rate limitations in TCSPC this method of multiplexing in fact increases the overall counting efficiency. This is because pile-up effects do not occur across channels, and the overall count rate can be larger than the permitted 1..2 % per channel. Even with mutually inflicted dead time losses the counting efficiency of each channel remains close to 1 and the efficiency over all channels is substantially larger than that of a single channel system. The only limitation multiplexing/routing implies is that the total count rate the Picoharp can handle must be shared by the 4 channels.

Because of the single photon conditions, there are consequently low probabilities of photons impinging on two or more detectors simultaneously. Nevertheless, these probabilities are not zero. The router uses a time window of 60 ns during which a decision is made as to whether a count is valid. This is the case only if there was a signal from a single detector. In the case of multiple simultaneous signals, the events will be discarded. This mechanism ensures a cross talk between channels of typically <0.001% at 200.000 counts/sec. In order to keep the crosstalk low, we recommend not to exceed 500.000 counts/sec per channel.

Because of the multiplexing nature of the routing mechanism it is generally not possible to perform immediate picosecond timing between individual routing channels for the duration of the deadtime. However, cross correlations on the time tags (100 ns resolution) of individual channels can be performed very elegantly from a single data stream.

Using the router does not change the time resolution or the IRF width. In case of the PHR 800, each channel can be equipped with its own CFD which allows to optimally adjust the settings for each detector separately. This is

* Birch, Holmes, Imhof, Nadolski and Cooper, "Multiplexed time-correlated single photon counting", SPIE Vol. 909 Time-Resolved Laser Spectroscopy in BioChemistry (1988)

necessary even with PMTs of the same type because gain, pulse shape and pulse height distributions can vary considerably between individual tubes.

3.2 Hardware Setup

In a routed setup with the basic PHR 800 (no CFDs), the detectors are each directly connected to one router input via 50 Ohms SMA cables (no attenuator). This configuration is suitable for use with detectors that deliver pre-shaped standard signals such as TTL or NIM. Typically these are SPAD detectors from Perkin Elmer or Micro Photon Devices. The router output is directly connected to the PicoHarp 300 input channel 1. The router must also be connected to the PicoHarp 300 via a dedicated DVI cable for control purposes. Both cables must but be of approximately equal length (max. 2 m). The figure below shows the connections required in a routing setup with four SPAD detectors and the basic configuration of the PHR 800.

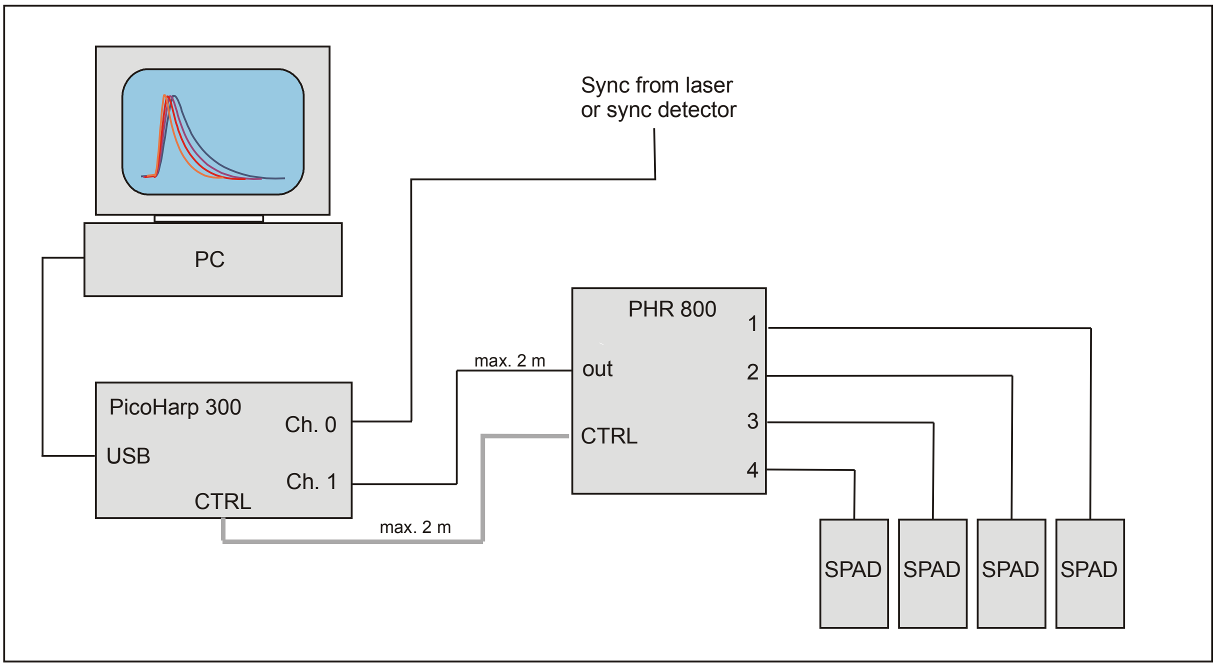

Figure 2a

For detectors with fluctuating pulse heights, such as PMT and MCP-PMT, the PHR 800 can be equipped with CFD modules. They contain 2 CFDs per module. The CFDs require negative going input signals. Their operation is identical to the built-in CFDs of the PicoHarp 300. If CFDs are to be used, their outputs must be connected to the corresponding main router inputs. Dedicated SMA cables for this purpose are shipped with the CFD modules. If CFDs are installed they can but need not be used. SPAD detectors can still be used directly at the main router inputs. The next figure shows a mixed setup where two SPAD detectors are used directly while two PMTs are connected through CFDs. Of course there are different time delays due to the CFDs but these can be compensated by appropriate cable lengths.

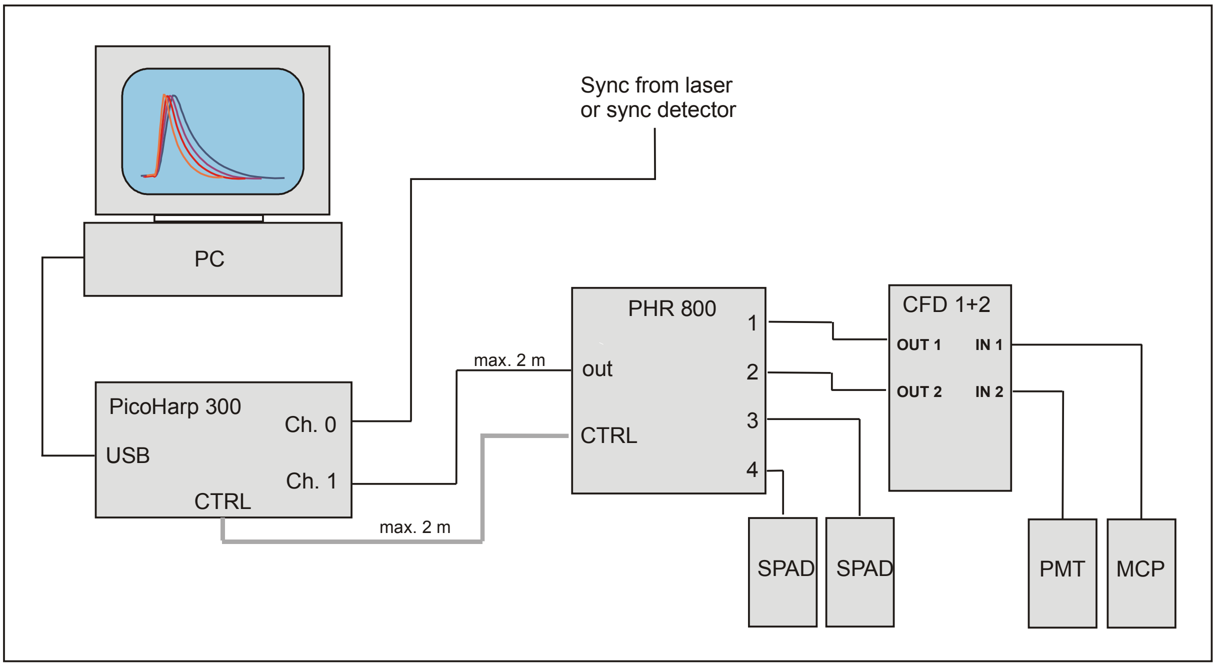

Figure2b

The Router will show its power state via a green LED and its trigger state (signals at any input) through a yellow LED. The latter requires suitable input settings (via software).

3.2 Software Operation

The PHR 800 is exclusively controlled through software. This requires one of the following:

1) the standard PicoHarp data acquisition software version 2.0 or higher (ships with PicoHarp 300),
2) the PicoHarp programmer's library PHLib from Version 2.0 (must be purchased),
3) the SymPhoTime software (must be purchased).

Note that the options 1) and 2) allow a degree of flexibility, that may lead to unexpected results, if the input level and edge settings of the PHR 800 are chosen in inappropriate combinations. This can lead to blocking of the input channels. On this matter, as well as all other aspects of software operation of the PHR 800, please consult the respective software manuals.

4. Technical Data

4.1 Specifications

DETECTORS IN

Input Impedance	50 Ohms
Input trigger Level	+ 2,5V...- 1,5V
Input voltage range	actual trigger Level ±3V
Input trigger edge	falling or rising

EXTERNAL IN

Count enable	TTL, 3..5V, high active
Marker 0..3	TTL, 3..5V, high or low active

CFDs

CFD level range	0 .. -800 mV
CFD zero cross range	0 .. 20 mV
Input Impedance	50 Ohms
Output signal peak	typ. 700 mV
Output signal puls with	typ. 30 ns

Connectors

PicoHarp300 control port	DVI-I female
Input / Output	SMA female
Count enable & Marker Inputs	Lemo ERN.00.250.CTL

Operating Environment

Operating temperature	15 to 35°C

Power Supply

Supply Line 100..240V AC 50/60Hz	max. 25W

Dimensions

table top rack 310 x 235 x 140 mm

Retraction of old Devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling centre for safe treatment. WEEE-Reg.-Nr. DE 96457402

All information given here is reliable to the best of our knowledge. However, no responsibility is assumed for possible inaccuracies or omissions. Specifications and external appearance are subject to change without notice.

5. Support

The PHR 800 has gone through thorough testing at PicoQuant. It is stable and reliable. Nevertheless, we will continually make improvements and incorporate these into upcoming versions and new products. For this purpose your comments and suggestions are highly appreciated.

In any case, we would like to offer you our complete support. Please do not hesitate to contact PicoQuant if you require assistance with your system.

If you observe any errors, e-mail a detailed description of the problem and relevant circumstances to photonics@pq.fta-berlin.de. Your feedback will help us to improve the product and documentation.

Of course we also appreciate good news: If you have obtained exciting results with one of our systems, we would like to know!

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