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Intelligent Measurement
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Routing Modules for Time-Correlated Single Photon Counting

HRT-41 Four Channel Router for PMTs
HRT-81 Eight Channel Router for PMTs
HRT-82 Eight Channel Router for APD Modules

- The HRT modules connect up to eight separate detectors to one bh Time-Correlated Single Photon Counting Module

- Simultaneous measurement in all detector channels

- HRT-41, -81: For conventional PMTs and MCPs

- HRT-82 : For SPCM-AQR avalanche photodiode modules

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Introduction

The HRT modules are used to connect several detectors to one bh Time-Correlated Single Photon Counting Module.

Simultaneous operation of the detectors is accomplished by combining the photon pulses from all detectors into one common timing pulse line and providing a routing signal which directs the photons from the individual detectors into different memory blocks. Thus, for each detector an individual decay curve is recorded.

For high repetition rate measurements (e.g. with a Ti:Sa laser) the overall count rate for all detectors can be in the in the Mcps range. Since a simultaneous detection of several photons in different detectors within one laser period is unlikey, no loss of photons is associated with the routing.

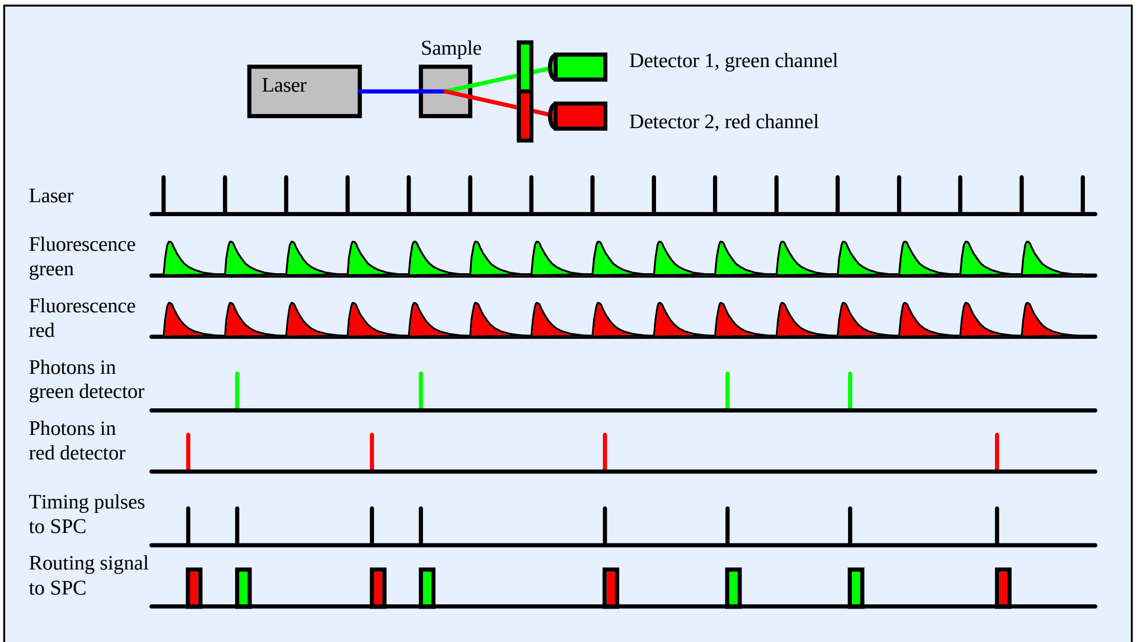
Routing devices are available for up to 4 and up to 8 PMTs or MCPs (HRT-41 and HRT-81) and for up to eight SPCM-AQR APD modules (HRT-82).

For complete detector heads with multichannel PMT and routing electronics please see description of PML-16 Multichannel Detector Head, www.becker-hickl.de.

Principle of Operation

General Principle

The principle of TCSPC multi-detector operation is shown in the figure below.



Principle of Multi Detector Operation

The sample is excited with a high repetition rate laser. The fluorescence is detected by two detectors. One detector detects the green light, the other the red light. For each detector the probability to detect a photon in one signal period is less than one. Therefore, it is unlikely that both detectors detect a photon in the same signal period.

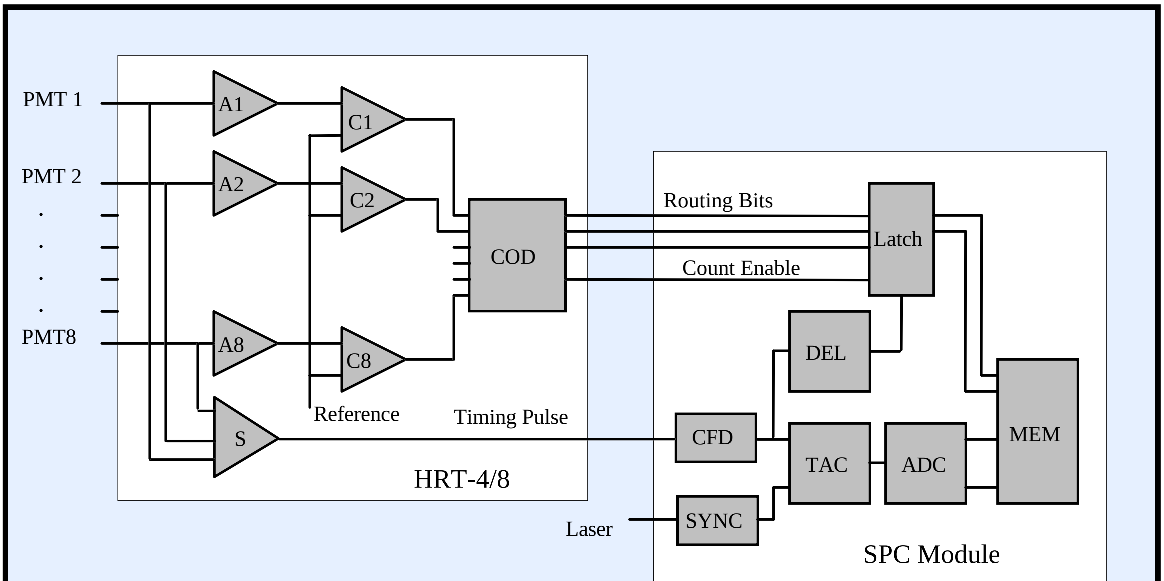
The single photon pulses from the red detector and from the green detector are combined and sent as timing pulses to the CFD input of the SPC module. At the same time the routing module delivers a ‘Routing Signal’ which indicates in which detector an individual photon was detected.

For each CFD pulse, the SPC modules starts the usual time measurement and histogramming sequence. However, in the memory of SPC module space is provided for the histograms of both detector channels. When the SPC modules writes a detected photon into the memory, it uses the routing signal to select the histogram for the detector that detected the particular photon.

The results are separate histograms (i.e. decay curves) for the individual detectors. The restriction that the detection probability per laser period must be less than one is not crucial. PMTs and APD modules deliver a few 10^6 counts per second at maximum. This is considerably less than the 80 MHz repetition rate of a Ti:Sa laser or the 50 MHz of a diode laser. Furthermore, the count rate restriction is a general feature of the TCSPC method. It is valid independently of whether a router is used or not.

Architecture of the HRT / SPC System

The block diagram of the HRT / SPC combination is shown in the figure below.



Block Diagram of HRT / SPC System

The photon pulses from the individual detectors PMT1 through PMT8 are fed to the amplifiers A1 trough A8. The amplifier outputs are connected to the comparators C1 through C8. When a photon is detected in one of the PMTs so that the amplifier output voltage exceeds the reference voltage at the comparators, the corresponding comparator responds. The comparator output pulses have a duration of some 10 ns.

The comparator output signals are encoded in the encoder COD to yield 3 (2 for HRT-41) routing bits and one ‘count enable’ bit. The routing bits contain the information about the detector channel which detected the corresponding photon. The ‘count enable’ bit is ‘true’ as long as a valid routing information is present, i.e. if one (and only one) of the comparators responds. If either none or more than one of the comparators respond the ‘count enable’ is ‘false’.

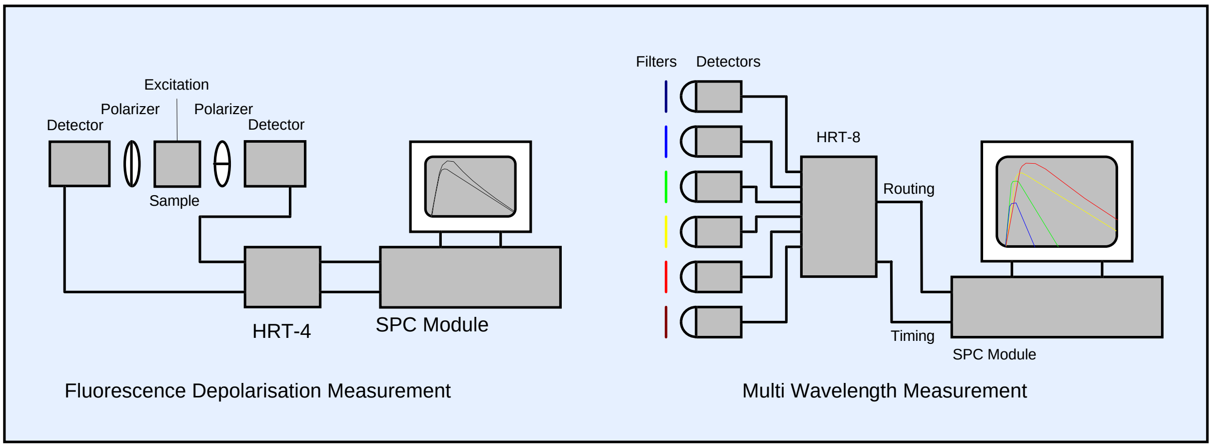
To provide the timing information to the SPC module the input pulses from all detectors are combined in the summing amplifier S. The output pulses from S are used as photon pulses at the 'CFD' input of the SPC module. When a pulse at the CFD is detected, the SPC starts the normal processing sequence. It determines the time of the pulse referred to the laser pulse sequence, performs an ADC conversion and addresses a memory location which corresponds to the measured time of the photon.

During the photon is processed in the TAC and the ADC, the SPC reads the routing bits and the ‘count enable’ from the encoder COD into a data latch. The SPC memory is divided into individual parts which are assigned to the individual detectors. The routing information controls the part of the memory into which the event is stored, thus routing the photons into individual curves for the individual detectors. To compensate the delay in the HRT and cable delays, the routing information is latched with an adjustable delay after each CFD pulse.

Due to the high count rates in the SPC modules there is some probability to detect more than one photon within the response time of the amplifier/comparator circuitry in the HRT. Furthermore, it can happen that the CFD of the SPC detects a photon pulse which was too small to be seen by a comparator in the HRT. In such cases the encoder sends ‘count enable’ = ‘false’ which suppresses the recording of the invalid event in the SPC module.

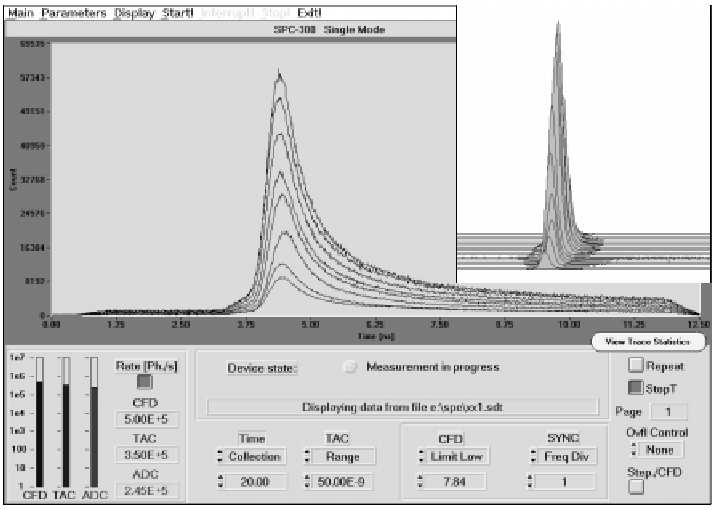
Applications

In the figures below two applications of the SPC's multichannel capability are shown. The first example shows an arrangement for fluorescence depolarisation measurements with two polariser / detector channels. In the second example the fluorescence of the sample is measured in different wavelength channels simultaneously.



Multichannel measurements are possible with the SPC-3, -4, -5, -6 and -7 modules. The SPC-134 is not recommended for routing application. Please contact bh if you want to use an SPC-134 in conjunction with a router.

The results can be displayed as individual curves (up to 8 curves simultaneously), as 3-dimensional intensity-time-distance/wavelength or colour-intensity pattern. Some examples are shown in the figure below. For 2-dimensional detector arrays different sections through the internal (t,x,y) data set can be selected.

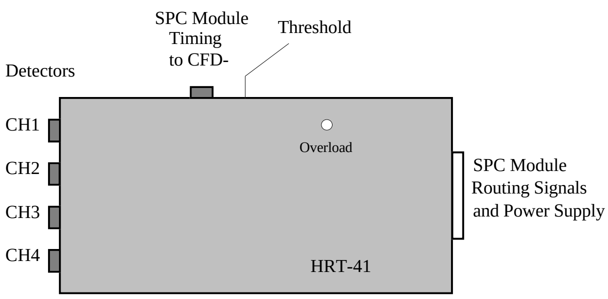


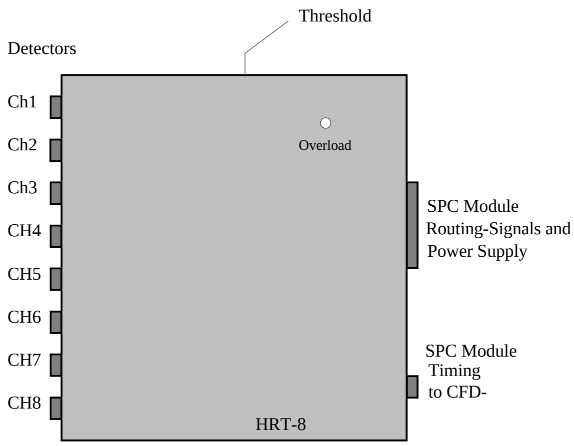
Installation of the Routing Modules

System Connections

The HRT modules are connected to the SPC module via the routing cable (SUD-D-15 connector) and the timing cable (50 Ω SMA connector). If you have an SPC-x00 module, please make sure that the CFD input is configured for 'negative pulses'. (Also for the HRT-82 and SPCM modules)

The detectors are connected to the inputs of the HRT by 50 Ω SMA connectors. The location of the connectors is shown in the figure below.





When you connect PMTs to the HRT inputs, please observe the usual safety rules and precautions against damage:

Don’t connect a photomultiplier tube to the HRT input when the high voltage is switched on! Don’t connect a photomultiplier to the HRT if the high voltage was switched on before with the PMT output left open! Don’t use switchable attenuators between the PMT and the HRT! Don’t use cables and connectors with bad contacts.

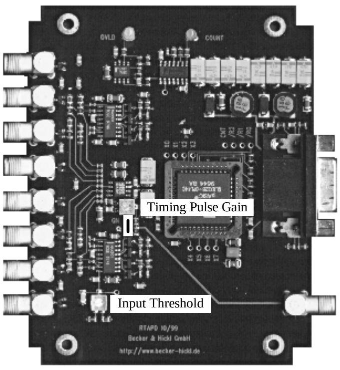
The reason is as follows: If the PMT runs without output termination, the output cable is charged by the PMT dark current. The voltage can easily reach several 100V. When connected to the HRT, the cable is discharged into the HRT input. The energy stored in the cable is more than sufficient to destroy the input circuitry. The HRT modules have safety diodes which limit the input voltage to a safe value, but these diodes can withstand only a limited amount of charge. So be careful and don't tempt fate.

To provide maximum safety against damage we recommend to connect a resistor of some 10 kΩ from the PMT anode to ground inside the PMT case as close to the PMT anode as possible. This will prevent cable charging and provide protection against damage due to bad contacts in connectors and cables.

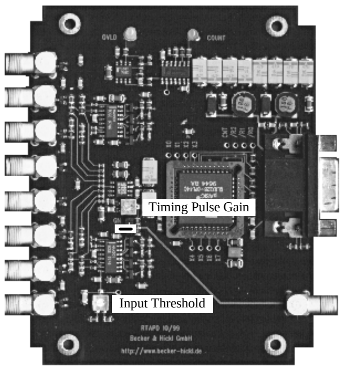
Furthermore, please pay attention to safety rules when handling the high voltage of the PMT. Make sure that there is a reliable ground connection between the HV supply unit and the PMT. Broken cables, lose connectors and other bad contacts should be repaired immediately.

Adapting the HRT-82 to the SPC Type and the SPCM

The SPCM-AQR detectors deliver pulses with an amplitude of +3 V to +5 V and a width of 20 ns to 50 ns. The HRT-82 converts these pulses into negative signals with SPC compatible amplitudes. The output amplitude range can be configured by a jumper in the HRT-82 module for optimum operation with SPC-x00 or SPC-x30 modules. The location of the jumper is shown in the figure below.



Vout = 120 ... 150 mV mV (SPC-x30)



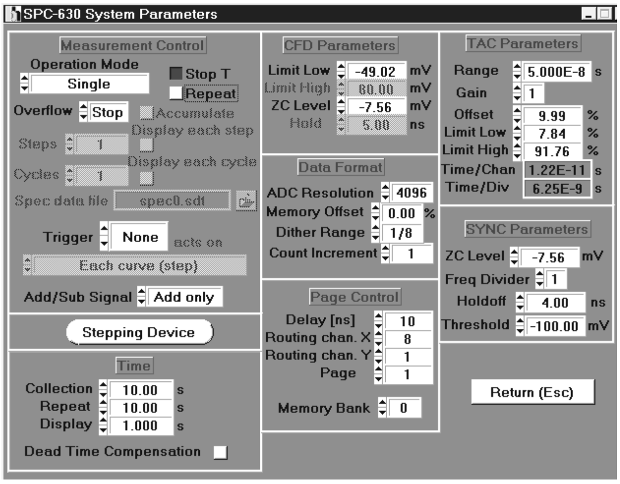
Vout = 50 ... 60 mV (SPC-x00)

The output amplitude can be fine-adjusted by a trimpot near the jumper. However, the trimpot changes also the pulse shape. If the trimpot setting is changed for whatever reason, we recommend to check the output pulse shape by an oscilloscope.

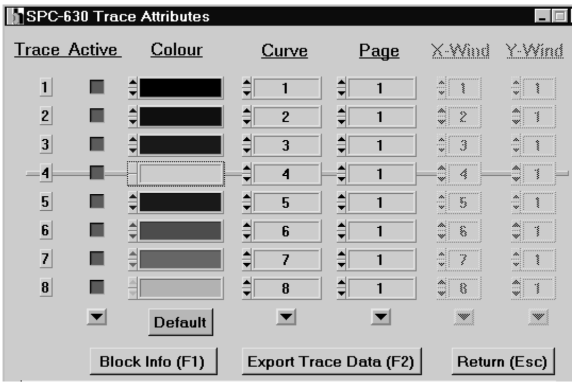
Different versions of the SPCM avalanche diode modules deliver output pulses witch different amplitude and pulse width. Normally the HRT-82 should work with all EG&G / Perkin Elmer APD modules. Nevertheless, the discriminator threshold of the routing circuitry can be adjusted. If this is necessary, run the SPCM with a moderate light signal and change the threshold until the 'Count' led indicates that the pulses are recognised by the router. The normal threshold is +0.5 V to +0.8 V, it can be checked at the test point near the trimpot.

SPC System and Trace Parameters

To configure the SPC module for measurements with the HRT devices, the system parameter 'Points X' must be set to the number of detector channels used. 'Points Y' must be 1. 'Latch Delay' should be 30 ns for the HRT-41 and 10 ns for the HRT-81 and HRT-82. The trace parameters should be set to display the curves for the used detector channels in the current memory page. The recommended parameter settings for the HRT-8 routers are shown below.



SPC System Parameters for Routing Operation



SPC Trace Parameters for Routing Operation

Optimisation

SPC Parameters

The HRT can be used in the 'Single', 'Oscilloscope', 'f(x,yt)', 'f(t,T)', f(t,ext), 'fi', 'Continuous Flow' and 'FIFO' mode of the **bh** SPC modules.

For the first adjustments we recommend the oscilloscope mode with a 'Count Increment' parameter of 100. Don't forget to set 'Stop T'.

When the cables are connected and the parameters are set correctly the detectors can be switched on. When the measurement is started, the count rate display should show rates corresponding to the overall counts of all detectors. After the 'Collection Time' the signals recorded by the individual detectors should be displayed in the corresponding traces.

When the signals of all detector channels appear on the screen, the system parameters can be optimised.

The most important parameter for multichannel operation is 'Latch Delay'. This parameter controls the delay from the moment when the CFD triggers to the moment when the SPC module reads the routing signals. For clean routing function it is substantial that the routing signals are read in a moment when they are valid for the current photon. The recommended 'Latch Delay' is

Router	Latch delay
HRT-41	20 to 50 ns
HRT-81	10 to 40 ns
HRT-82	0 to 40 ns

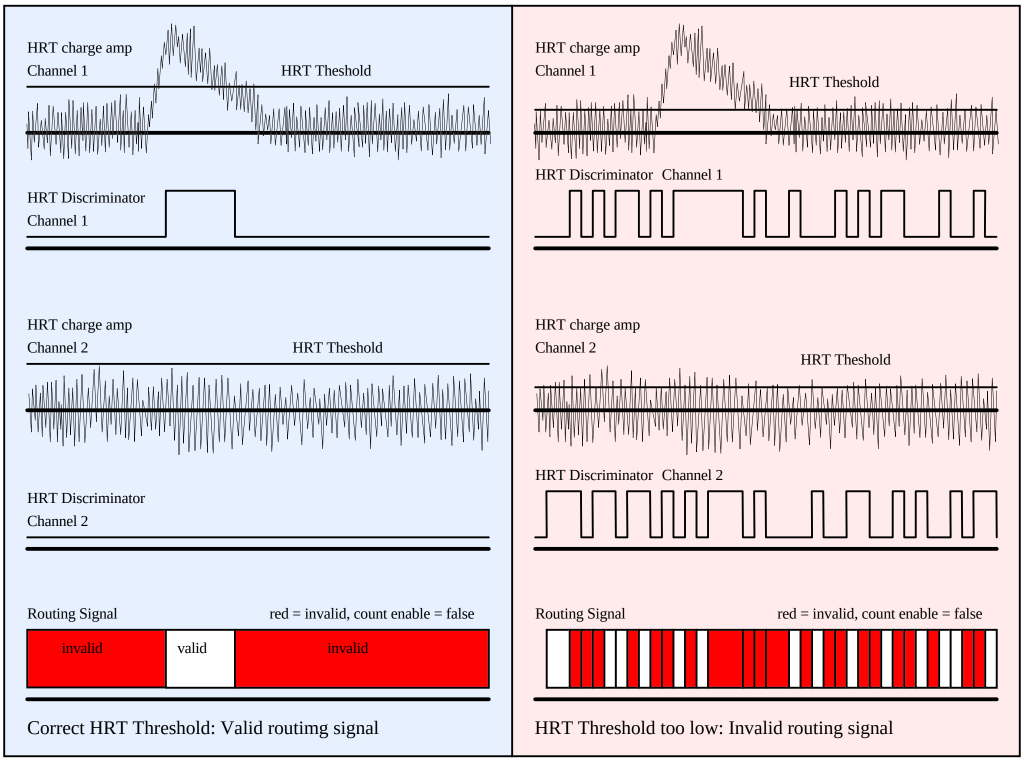
To find the best value, switch off or disconnect some of the detectors and optimise the latch delay for minimum crosstalk into the unused channels. (Set the display to ‘logarithmic’ for this test.) The best value depends on the length of the cables from the router to the SPC.

When the routing works, you can adjust the CFD zero cross and the CFD threshold in the usual way (see SPC manual, ‘Optimising the CFD and SYNC Parameters’. We recommend to start with the values shown below.

	HRT-41 with PMT or MCP	HRT-81 with PMT or MCP	HRT-82 with SPCM
SPC-x30			
CFD Limit Low	-40 mV	-40 mV	-80 mV
CFD Zero Cross	-10 mV	-10 mV	-80 mV
SPC-x00 (CFD negative input)			
CFD Limit Low	10 mV	10 mV	20 mV
CFD Limit High	80 mV	80 mV	80 mV
CFD Zero Cross	-5 mV	-5mV	-10 mV

Threshold Adjustment in the HRT-41 and HRT-81

The threshold for the comparators in the HRT-41 and HRT-81 module can be adjusted by a trimpot. The effect of the threshold is shown in the figure below.



If the threshold is adjusted correctly the HRT discriminators are triggered when the corresponding detector delivers a photon pulse. Since the amplitude of PMT pulses changes from pulse to pulse the threshold should be as low as possible in order to provide a routing information for all photons.

However, if the threshold is too low, the HRT discriminators are triggered by the noise. These false events appear not only in the channel where the photon pulses is detected, but also in the other channels. The encoder is therefore unable to provide a valid routing information. The ‘count enable’ bit is ‘false’ for most of the time, and the photons are not stored in the SPC memory.

On the delivery of the HRT the threshold is adjusted well above the noise level of the charge amplifiers. Normally there is no reason to change it. However, changes can be required if

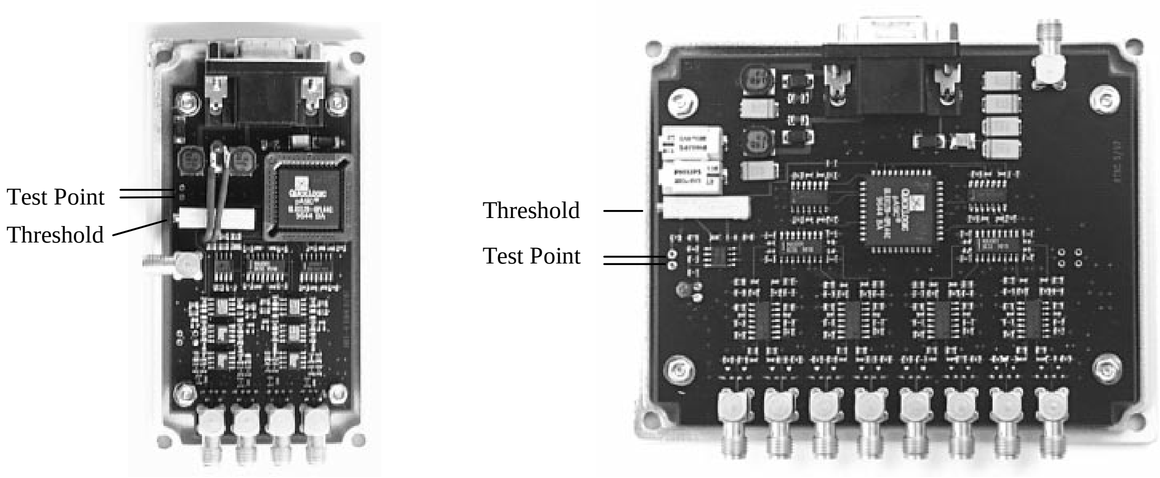
- the detector pulses are very small so that the sensitivity of the HRT is insufficient
- there is additional noise from a preamplifiers or the detectors picks up noise from the environment

If you adjust the HRT threshold please proceed as follows:

Disconnect or switch off one or some of the detectors. Adjust the light intensity at the used detectors to a CFD count rate between 10^4 to 10^5 photons per second. Set the mode to ‘Oscilloscope’ and switch on the ‘Trace Statistics’ button. Change the HRT threshold until the ‘Total number of photons’ in the Trace Statistics panel is at maximum and the recorded curves have maximum size. Don’t use the ADC rate as a measure for routing efficiency, it doesn’t react to the ‘count enable’.

Check the unused channels for misrouted events. Normally the number of misrouted events should not appreciably depend on the threshold, but for detectors with an extremely wide pulse height spectrum it can happen that you have to find a compromise between the effective count rate and the routing accuracy.

The threshold voltage can be measured at a test point on the HRT-41 and HRT-81 boards. The location of the test point is shown in the figure below. The default voltage at the test point is +3 V for the HRT-41 and +2 V for the HRT-81.



Test points for threshold adjust. HRT-41 (left) and HRT-81 (right)

Threshold Adjustment in the HRT-82

Because the HRT-82 works with the stable output pulses of the SPCM modules the threshold adjustment is less critical than for the HRT-41 and the HRT-81.

If you want to adjust the threshold of the HRT-82 proceed as follows:

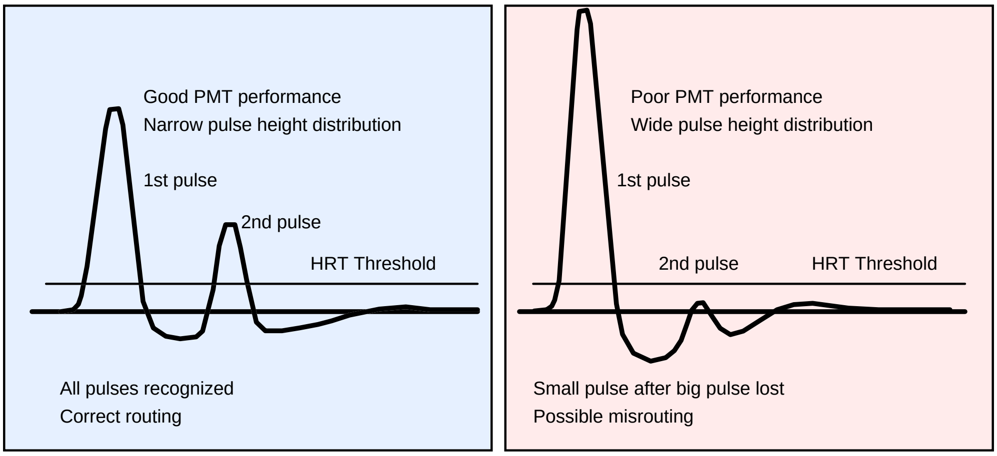
Disconnect or switch off one or some of the detectors. Adjust the light intensity at the used detectors to a CFD count rate between 10^4 to 10^5 photons per second. Set the mode to 'Oscilloscope' and switch on the 'Trace Statistics' button. Change the HRT threshold until the 'Total number of photons' in the Trace Statistics panel is at maximum and the recorded curves have maximum size. Don't use the ADC rate as a measure for routing efficiency, it doesn't react to the 'count enable'. Check the unused channels for misrouted events.

The routing performance of the HRT-82 does not appreciably depend on the threshold. It just works if the threshold is within the amplitude range of the SPCM pulse.

The threshold voltage can be measured at a test point on the HRT-82 board. For the location of the test point please see 'Adapting the HRT-82 to the SPC Type and the SPCM'. The default voltage at the test point is +0.5 V to +0.8 V.

The PMT

As for any TCSPC application, the pulse height distribution of the PMT is essential to get maximum performance from multichannel systems. To achieve a low crosstalk between different detector channels, use - if possible - photomultipliers which are specified for photon counting. Other PMTs often have an extremely wide pulse height distribution which may cause increased crosstalk between the detector channels and reduce the effective count rate. The influence of the pulse height distribution on the crosstalk is explained in the figure below.



The amplifiers in the router are AC coupled. This is required to reject low frequency noise which otherwise would swamp the PMT signal in the charge amplifier. Due to the AC coupling some undershoot after each photon pulse appears. If the detector pulse amplitude does not change too much this does not cause any problems. However, if the pulse height distribution is very wide, a small pulse appearing after a very big one may not reach the comparator threshold. It is therefore not seen by the encoder circuitry but can trigger the CFD in the SPC module. If another pulse arrives in another channel some ns later, the encoder delivers a routing signal for the second pulse - and the first pulse is routed into the channel of the second one.

Furthermore, a PMT with a bad pulse height spectrum delivers a lot of very small pulses. These pulses cause a lot of unnecessary trigger events in the HRT discriminators. The result is an increased number of simultaneous events in different channels which reduce the effective count rate.

The Noise Problem

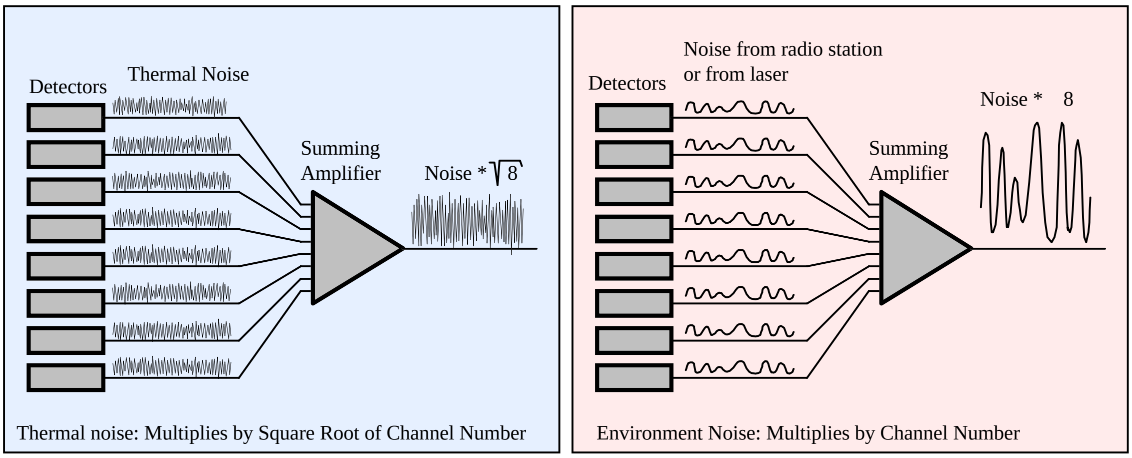
Noise is the performance killer in any TCSPC system. There are several possible noise sources:

- Noise of the input termination resistor of the HRT
- Noise from the Detector, e.g. from a PMT with an extremely bad pulse height distribution
- Noise from preamplifiers used in front of the HRT
- Noise from the environment, especially from radio and television stations
- Noise from the laser

The first four noise sources are not correlated with the photon detection. Noise from these sources impairs the time resolution in the CFD and the routing efficiency. If a photon is detected and another HRT channel is triggered by the noise in the same moment, the photon cannot be routed and is suppressed by 'count enable' = 'false'.

Noise from the laser is correlated with the photon detection. The ripple on the signal baseline of the CFD signal causes periodical changes in the detection probability and in the trigger point of the CFD. As a result, the differential nonlinearity is impaired, i.e. a ripple appears in the measured curves.

Compared to single detector TCSPC devices, noise problems in multi-detector systems are literally multiplied by the number of detectors. The reason is that the detector pulses of all detectors must be added into one common timing signal. This adds also the noise from all detector channels. The situation is shown in the figure below.



As long as there is only the unavoidable thermal noise of detectors, matching resistors, and preamplifiers, the noise at the output of the summing amplifier increases proportionally to the square root of the number of detector channels. The resulting noise level is still acceptable even for a high number of detectors.

However, if there is any noise pickup from the environment, the noise in the individual detector channels is more or less the same. The resulting noise level increases directly with the number of detectors and can easily reach disastrous values. Therefore, noise pickup in multi-detector TCSPC systems must strictly be avoided.

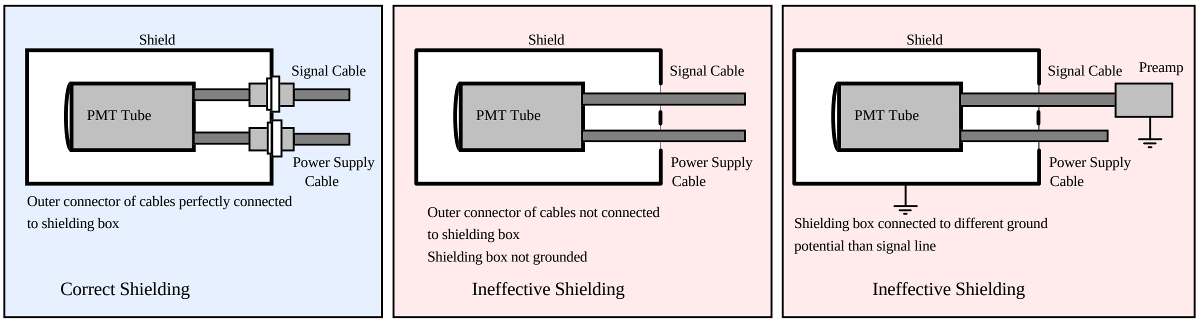
The following recommendations can be given to avoid noise pickup:

- Use proper shielding of the detector (see section below)

- Avoid HF ground loops. Put the detector, router and SPC close together
- Disconnect network cables from the computer
- Get the power for all system components from only one socket via a distribution board
- Avoid noise sources in the vicinity of the TCSPC system. The most common sources of trouble are diode lasers and pulse pickers.

Shielding and Grounding

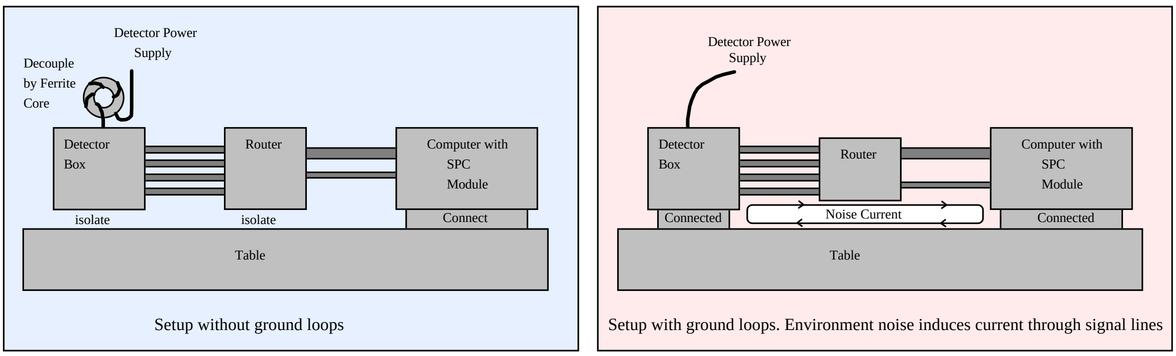
As shown in the section above, noise pickup from the environment is the most serious source of problems in multichannel TCSPC systems. Proper setup and shielding of the detector electronics is therefore essential. The figure below shows a correct detector shielding setup and two examples of inefficient shielding.



High speed electronics uses impedance-matched signal connections. These connections are relatively immune against capacitive noise pickup. Therefore, inductive coupling is the dominating effect that introduces noise into the system.

The most important way of inductive noise coupling are 'ground loops'. Ground loops are formed if there are several ground connections between different parts of the system. If HF radiation from external noise sources penetrates the setup, currents are generated in the loop and transformed into the signal lines. Furthermore, power supply currents can flow in the ground system. These currents contain HF components which can be transformed into the signal lines.

If ground loops are the reason for noise pickup simple screening of the system often has little effect. The ground loops must be found and disrupted or at least minimised. An example is shown in the figure below.



The setup shown left has no ground loops. The detector and the router are isolated, and the detector power supply is decoupled by a ferrite core. HF radiation from the environment has little chance to induce noise currents in the system.

The setup shown right has the detector and the computer grounded. If the setup is penetrated by HF radiation the magnetic field induces a noise current through the signal lines. This current is partially transformed into the detector signals.

Typical Multi-Detector Setups

Hamamatsu Photosensor Modules

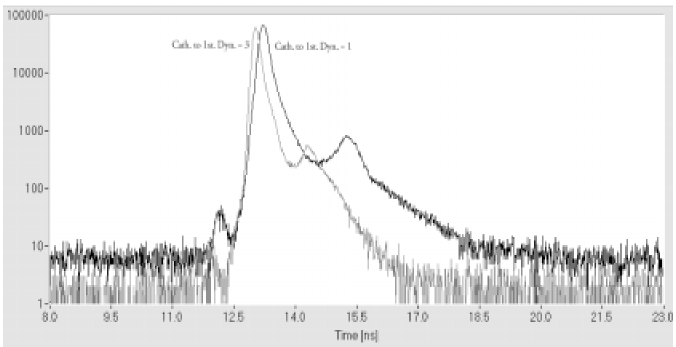
Due to their reasonable cost, small size and high speed the Hamamatsu H5783P and H5773P Photosensor modules are a good choice for multi-detector setups. The modules incorporate a small size R5600 PMT and the HV power supply. They require a +12 V power supply and some gain setting resistors only. The TCSPC time resolution is 150 to 240 ps FWHM. For optimum results, use the '-P' type, which is specified for photon counting.

The H5783P and H5773P can be connected directly to the HRT-41 and the HRT-81 routers. For best results, the modules should be operated near their maximum gain.

The HV generator of the H5783P and H5773P generates some noise which can trigger the routing discriminators of the HRT. The noise consists of short spikes with a frequency of some 100 kHz. Although triggering of the HRT by these spikes does not cause an appreciable loss of routing efficiency an extremely low HRT threshold should be avoided.

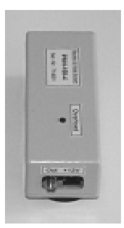
Hamamatsu R5600 and R7400

The R5600 and R7400 are a miniature PMTs with high speed and reasonable cost. They works well if connected directly to the HRT-41 or HRT-81. The TCSPC time resolution is 150 to 240 ps FWHM. For optimum results, use the '-P' type, which is specified for photon counting.



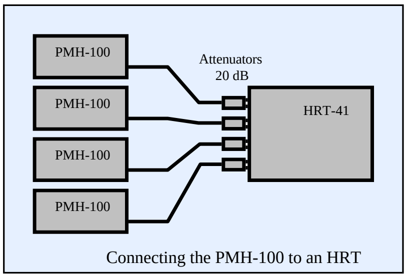
The TCSPC time resolution of the R5600 and the R7400 can be improved by increasing the voltage between the cathode and the first dynode. Up to three times the nominal voltage has been used without damaging the tube. The TCSPC instrument response width decreases with the square root of the voltage between the cathode and the first dynode (figure right).

PMH-100



The PMH-100 module contains an H5773-P, a fast 20 dB preamplifier and an overload indicator LED. The PMH-100 has a ‘C Mount’ adapter for simple attaching it to an optical setup. Its simple +12 V power supply and the internal preamplifier allow direct interfacing to all bh photon counting devices. The resolution of the PMH-100 is, as for the

H5773, 150 to 240 ps FWHM. The PMH delivers single photon pulses in the range of -100 to -600 mV. If connected directly to the HRT, these pulses would drive the HRT amplifiers into saturation. Furthermore, the noise from the H5773 HV generator would trigger the HRT discriminators. Therefore, the PMH must be used with a 20 dB attenuator as shown in the figure right. With the attenuators directly in front of the HRT, the system benefits from the high noise immunity of the PMH-100 module.



Connecting the PMH-100 to an HRT

R3809U MCP

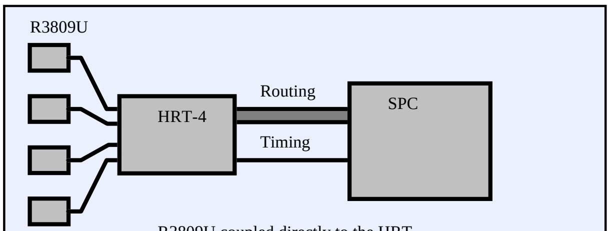
The figure below shows some possible routing setups with the Hamamatsu R3809U MCP.

The R3809 can be connected directly to the HRT-41 and to the HRT-81. The single photon pulses delivered by the R3809U have an amplitude of 10 to 20 mV and a width of less than 500ps. To achieve a sufficient single photon pulse amplitude for the HRT the R3809U must be operated at a supply voltage of -3100 V to -3300 V. Noise pickup by the detector or by the connection cables must be absolutely avoided. The HRT threshold should be adjusted just above the noise level.

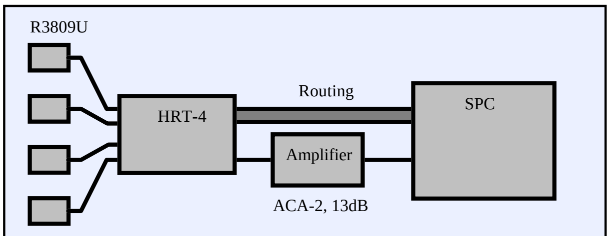
For best timing performance some additional gain in the timing path can be recommended. This can be achieved by a ACA-2 13dB amplifier between the HRT and the SPC. Together with the 15 dB gain of the router the overall gain of 27 dB is close to the optimum value for using an R3809U with a -x30 SPC. However, if the amplifier is inserted between the HRT and the SPC, the HRT does not benefit from the additional gain.

It is therefore better to insert amplifiers in front of the HRT. Several suitable amplifiers are available from bh.

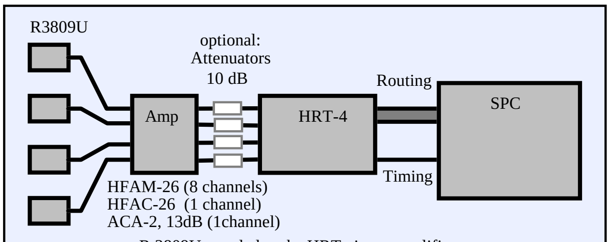
The HFAM-26 has 26 dB gain, 8 parallel channels and an overload warning LED which indicates exceeding of the maximum safe output current of the MCP. The HFAC-26 has 20 dB to 26 dB gain, an overload warning LED and an overload output which can be used to shut down an MCP when it is overloaded. With the gain of the HFAM or HFAC amplifiers the overall gain is 35 dB to 41 dB or 56 to 112. This gain requires an extremely clean setup, or the amplifiers will oscillate or be saturated by noise picked up from the environment. To avoid this, it can be useful to insert attenuators between the preamplifier and the HRT. Nevertheless, the HFAM or HFAC amplifiers are a good solution offering high counting efficiency and maximum safety against damaging the MCPs.



R3809U coupled directly to the HRT



R3809U coupled directly to the HRT, amplifier in timing output



R 3809U coupled to the HRT via preamplifiers

To avoid excessive gain you can also use the ACA-2 13dB preamplifier in front of the HRT. The overall gain is then 27 dB, which is close to the optimum value for MCPs. However, the ACA amplifiers have no overload detection circuit and you must be very careful to avoid overload.

Trouble Shooting

If the HRT / SPC system does not work as expected please check the following items:

All count rates are present, but no curves are displayed

Is 'Points X' set to the required number of channels? Are the trace parameters set correctly? The active traces must be set to curve numbers corresponding to the numbers of the detector channels and the 'page' must be set to the active page.

The photons from all detectors are recorded in curve 1

Set 'Points X' to the required number of detector channels.

No count rates

Are the cables connected correctly? The HRT gets its power supply via the sub-D routing cable. Thus, it cannot deliver pulses to the SPC module if this cable is disconnected.

If you have a -x00 SPC, is the CFD input configured for negative polarity?

Check the detector pulses at the HRT output by an oscilloscope.

CFD Rate present, but no TAC rate

SPC-x00 with HRT-82: Set CFD Limit H to 80 mV. Check the output amplitude at the HRT output. If the amplitude is > 80mV, check the gain setting jumper in the HRT.

All SPCs: Change the CFD zero cross level

CFD and TAC rate present, but no ADC Rate

Is the SYNC signal present at the SPC module? Is the SYNC zero cross level correct? For -x00 modules, set SYNC ZCL to -10mV. Are the CFD and SYNC signals connected to the correct inputs at the SPC?

No curves displayed when a detector is connected directly to the SPC

Do not connect a detector directly to the CFD input of the SPC while the HRT is connected via the routing cable. This will not work, because the HRT delivers ‘count enable’ = ‘false’ as long as it does not see a detector pulse.

The SPC suddenly does not work without the HRT

Is the HRT disconnected from the SPC? If the HRT is still connected via the routing cable but does not receive the PMT pulses, it steadily delivers ‘count enable = ‘false’ to the SPC which, in turn, rejects the recording.

Number of recorded photons much less than indicated by ADC rate

Check ‘Latch Delay’ in the SPC system parameters.

Check the system for noise sources. Check the HRT output by an oscilloscope. Check the HRT threshold. If the HRT is triggered by noise it cannot deliver a valid routing information for the photons.

Incorrect routing or high crosstalk

Check the 'Latch Delay' parameter and the CFD thresholds.

Check for ground loops and other noise sources in your set-up. Excessive noise at the HRT inputs can cause false routing. Check the HRT pulse output by an oscilloscope.

Check the HRT threshold.

SPC x00: Is the CFD cable on the board connected to the negative input of the CFD?

Is your PMT specified for single photon counting? Do not use other PMTs, the pulse height distribution may be disastrous.

Overload LED of HRT is on

Check the HRT threshold.

Check for ground loops and other noise sources in your set-up. Excessive noise at the HRT inputs can cause false routing. Check the noise level at the HRT pulse output by an oscilloscope.

None of the above errors, but still no count rates

Are the supply voltages present at the sub-D-connector of the SPC? If possible, check with a meter. Oldere SPC-300 boards have safety resistors (fuses) in the ±5V lines to avoid serious damage in case of a short. The fuses may have blown when a device is was connected to the sub-D connector which is not intended for that purpose. Another unpleasant possibility is, that the routing input of the SPC has been damaged by such an accident or by electrostatic discharge. For SPC-4 through SPC-7 modules: Check whether the fan on the SPC board is still working. If not, the +12V output of the SPC board is probably damaged.

Specification

HRT-41

Input Polarity	negative
Input Impedance	50 Ohm
Input Connectors	SMA
Input Pulse Charge for best Routing	0.2 ... 2 pAs
Timing Output Polarity	negative
Delay Difference between Channels	60 ps per Channel
Timing Output Connector	SMA
Timing Output Impedance	50 Ohm
Gain of Timing Pulse Output	6
Routing-Signal	TTL 2 bit + Count Enable Signal
Recommended SPC 'Latch Delay'	20 ns to 50 ns
Routing Signal Connector	15 pin Sub-D/HD
Power Supply	+5V, -5V, +12V via Sub-D Connector from SPC Module
Dimensions	110mm × 60mm × 31mm

HRT-81

Input Polarity	negative
Input Impedance	50 Ohm
Input Connectors	SMA
Input Pulse Charge for best Routing	0.2 ... 2 pAs
Timing Output Polarity	negative
Delay Difference between Channels	60 ps per Channel
Timing Output Connector	SMA
Timing Output Impedance	50 Ohm
Gain of Timing Pulse Output	6
Routing-Signal	TTL 3 bit + Count Enable Signal
Recommended SPC 'Latch Delay'	10 ns to 40 ns
Routing Signal Connector	15 pin Sub-D/HD
Power Supply	+5V, -5V, +12V via Sub-D Connector from SPC Module
Dimensions	120mm × 95mm × 34mm

HRT-82

Input Polarity	positive
Input Voltage	TTL, 1.2 V to 5 V
Input Threshold	adjustable from 0.1 V to 2 V
Input Impedance	50 Ω
Input Pulse Duration	8 ns to 60 ns
Input Connectors	SMA
Timing Output Polarity	negative
Timing Output Voltage (2.5 V Input)	120 mV or 60 mV into 50 Ω (Jumper)
Timing Output Impedance	50 Ω
Timing Output Connector	50 Ohm, SMA
Delay Difference between Channels	max. 60 ps per Channel
Routing-Signal	TTL 3 bit + Count Enable Signal
Recommended SPC 'Latch Delay'	0 to 40 ns
Routing Signal Connector	15 pin Sub-D/HD
Power Supply	+5V, -5V, via Sub-D Connector from SPC Module
Dimensions	120mm × 95mm × 34mm

Maximum Values

	HRT-41	**HRT-81**	**HRT-82**
Continuous input voltage	+2V to -2V	+2V to -2V	-0.3V to 5V
Pulse current into input (1us)	100 mA	100 mA	100 mA
Voltage into HRT timing pulse output	+2V to -2V	+2V to -2V	+2V to -2V

Assistance through bh

Software updates, new manual versions and application notes about new applications are available from our web site www.becker-hickl.de. Furthermore, we are pleased to support you in all problems concerning the measurement of fast electrical or optical signals. This includes discussions of new applications, the installation of the SPC modules, their application to your measurement problem, the technical environment and physical problems related to short time measurement techniques. Simply call us or send us an email.

Should there be a problem with your HRT / SPC system, please contact us. To fix the problem please send us a data file (.sdt) of the questionable measurement or (if a measurement is not possible) a setup file (.set) with your system settings. Furthermore, please add the following information:

Description of the Problem
SPC Module Type and Serial Number
Software Version
Detector type, Operating voltage of the detector, PMT Cathode type
Preamplifier type, Gain, Bandwidth etc.
Laser System: Type, Repetition Rate, Wavelength, Power
SYNC Signal Generation: Photodiode, Amplitude, Rise Time
Optical System: Basic Setup, Sample, Monochromator
System Connections: Cable Lengths, Ground Connections. Add a drawing if possible.
Environment: Possible Noise Sources
Your personal data: E-mail, Telephone Number, Postal Address

The fastest way is to send us an email with the data file(s) attached. We will check your system settings and – if necessary – reproduce your problem in our lab. We will send you an answer within one or two days.

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