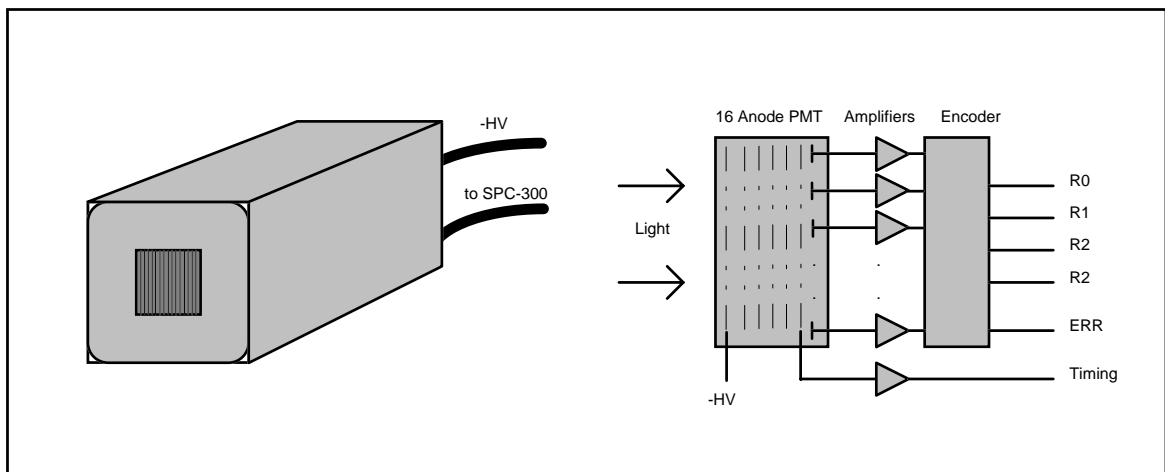




PML-16

16 Channel Detector Head for Time-Correlated Single Photon Counting

- **16 Channel Photomultiplier Head for all bh Time-Correlated Single Photon Counting Modules**
- **1-by-16 Arrangement of Detector Channels**
- **Simultaneous Measurement in all 16 channels**
- **Time Resolution 200 ps**
- **max. Count Rate > 1 MHz**



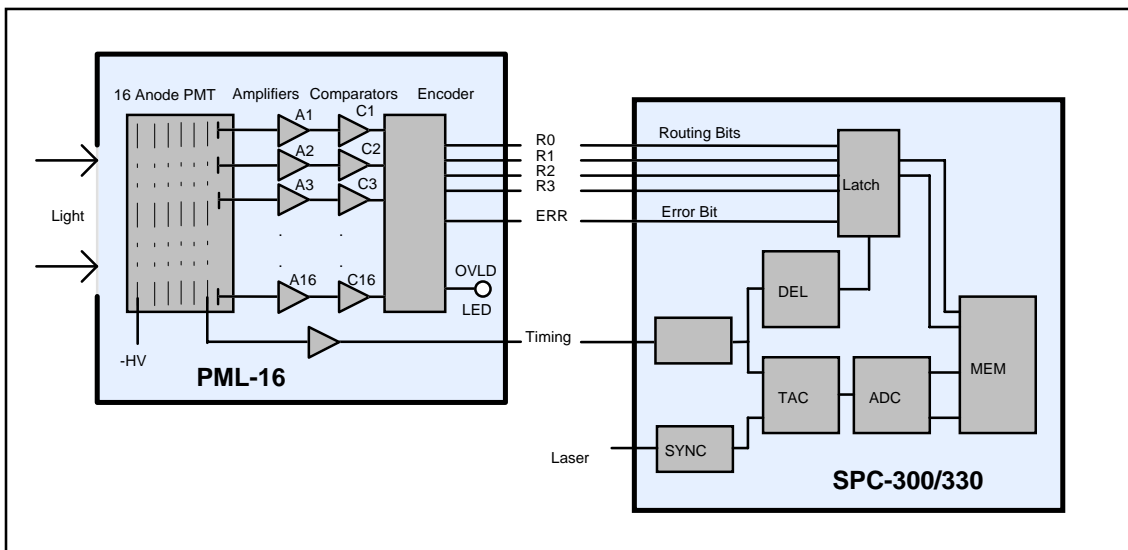
The PML-16 detector head is used in conjunction with the **bh** TCSPC modules to simultaneously record signals in 16 adjacent channels. The channel arrangement is 1-by-16, the time resolution 200 ps FWHM. The photon detection events from the individual detector channels are routed into different curves in the SPC-300 / SPC-330 memory. Thus the measurement yields a separate decay function for each channel without loss of photons. Typical applications are optical tomography or multi wavelength fluorescence measurements.

Specification

Number of Channels	16
Arrangement	linear (1 by 16)
Active Area (each channel)	0.8 × 16 mm
Channel Pitch	1 mm
Spectral response	300 to 650 nm (bi-alkaline) 185 to 650 nm (bi-alkaline UV) 300 to 820 nm (multi-alkaline)
Timing Output Polarity	negative
Average Timing Pulse Amplitude	20 mV
Time Resolution (FWHM)	200 ps (typical value)
Time Skew between Channels	< 40 ps rms
Timing Output Connector	SMA, 50Ω
Routing Efficiency (100 kHz Count Rate)	> 99,9 %
Routing Signal	4 bit + Error Signal, TTL/CMOS
Connector	15 pin Sub-D / HD
Power Supply	± 5V, -800...-900V
HV Supply Current (- 900 V)	0.35 mA
Dimensions	52 mm × 52 mm × 145 mm

Theory of Operation

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



The heart of the PML-16 is a 16 channel photomultiplier tube with 16 separate output (anode) elements and a common cathode and dynode system. The photon pulses from the individual anodes are fed to the amplifiers A1 through A16. The amplifier outputs are connected to the comparators C1 through C16. When a photon is detected in any place of the photocathode the corresponding anode delivers a pulse which is detected by the corresponding amplifier and comparator. The comparator output signals are encoded in the encoder COD to yield 4 routing bits and one error bit. The routing bits contain the information about the detector channel which detected the corresponding photon. The error bit is active when either none or more than one of the comparators respond.

To provide the timing information to the SPC-300/330 the pulses from all detectors are combined by deriving a signal from the last dynode of the PMT. An inverting amplifier is used to deliver a negative output pulse as in normal PMTs.

The inverted dynode pulses are used as photon pulses at the 'CFD-' input of the SPC-300/330. When a pulse is detected in the CFD, the SPC starts the normal processing sequence. It determines the time of the pulse inside the laser pulse sequence at the 'SYNC' input, performs an ADC conversion and addresses a memory location which corresponds to the measured time of the photon.

During the time the photon is processed in the TAC and the ADC, the SPC reads the routing bits and the error signal from the PML into a data latch. The SPC memory is divided into individual parts corresponding to the individual detector channels. The routing information controls the part of the memory into which a particular event is stored thus routing the photons into individual curves for the individual detectors.

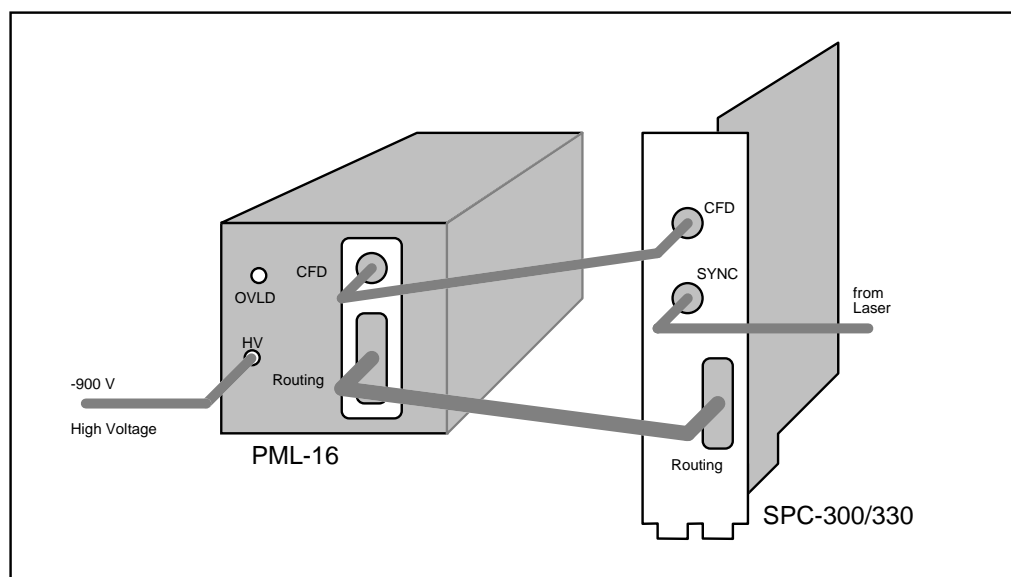
To compensate for the delay in the PML routing circuitry and for cable delays, the routing information is latched with an adjustable delay after each CFD pulse.

Due to the high count rates in the SPC-300/330 there is a certain probability to detect more than one photon within the response time of the amplifier/comparator circuitry in the PML. 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 PML routing circuitry. In such cases the encoder sets the 'Error' bit which suppresses the recording of the misrouted event in the SPC. If the count rate becomes so high, that the routing circuitry cannot reliably distinguish between subsequent photons, an 'Overload' LED is switched on.

Operating Recommendations

Installation

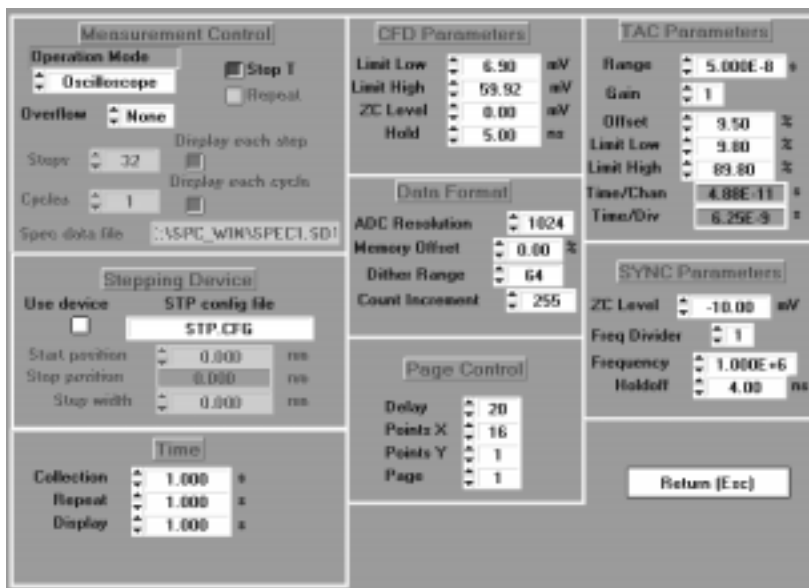
The PML-16 is connected to the SPC-300/330 via the cables delivered with the module as shown in the figure below. The HV cable is connected to a suitable HV power supply.



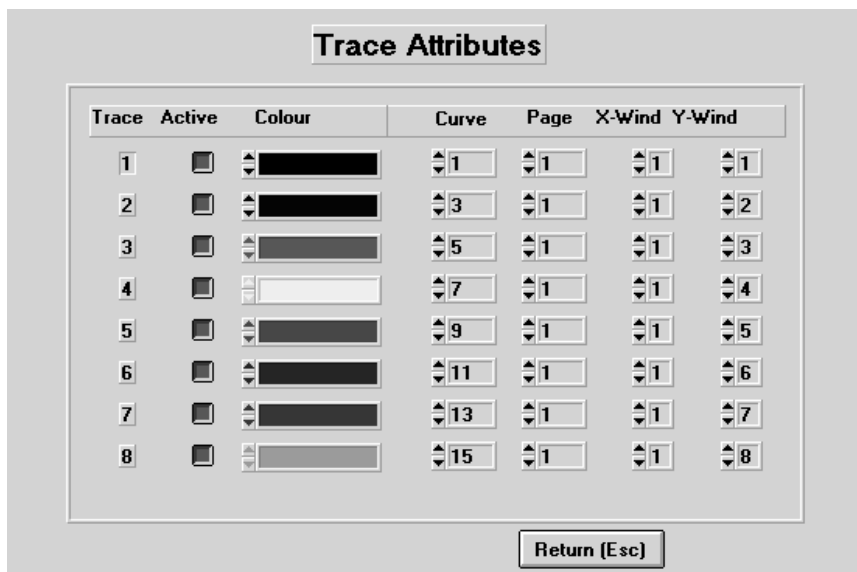
Please pay attention to safety rules when handling the high voltage of the PMT. Make sure that there is a reliable ground connection between the HV supply unit and the PMT. Broken cables, loose connectors and other bad contacts should be repaired immediately. Furthermore, make sure that the HV is switched off before opening the device or taking it down from your optical setup.

As all PMTs, the PML-16 is extremely sensitive. Even light intensities which are not visible by the eye can cause serious overload in the device. Therefore, be careful to keep the room light out of the optical setup before switching on the high voltage.

To configure the SPC-300/330 for measurements with the PML-16, in the system parameters 'Points X' is set to 16 and 'Points Y' to 1. 'Latch Delay' should be approximately 20 ns. For the first test, we recommend to set the other SPC system parameters as shown in the figure below.



For measurements in the 'Oscilloscope Mode' or 'Single Mode' in the 'Trace Parameters' the desired curves within the current memory page must be declared and set to 'active'. The figure below shows the trace parameters for displaying each second detector channel.



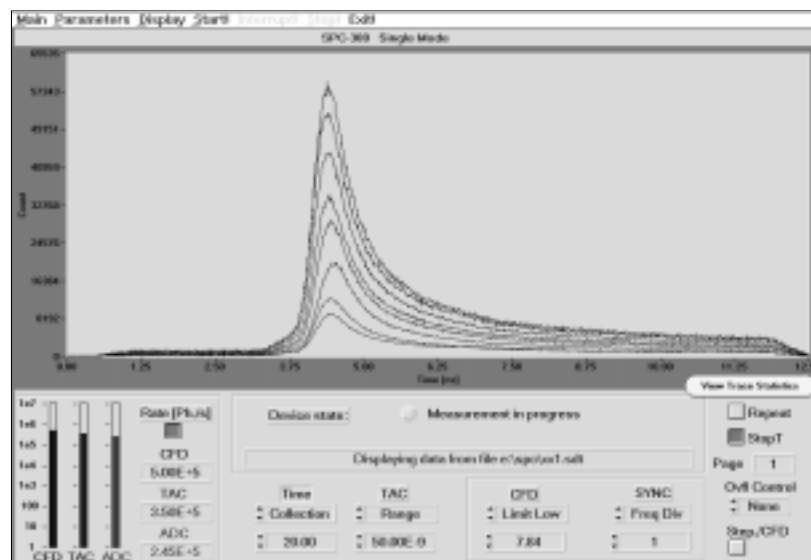
When the cables are connected and the SPC parameters are set the measurement can be started and the high voltage for the detector be switched on. Start with 600 V and slowly increase the voltage. At a voltage of 700 to 800 V the first counts should be indicated by the count rate displays and appear in the displayed curves. Increase the HV to 900 V while reducing the light intensity to hold the count rate below 1 MHz. Now the signals of the individual detector channels should be visible in the corresponding traces (if not, check the Trace Parameters or see section 'Troubleshooting').

If the detector has been exposed to room light shortly before being switched on, it can show a dark count rate which is up to 100 times higher than normal. In this case we recommend to wait for some hours until the dark count rate has returned to the normal value (100 /s for bi-alkaline and 1000 /s for multi-alkaline).

Operation Modes

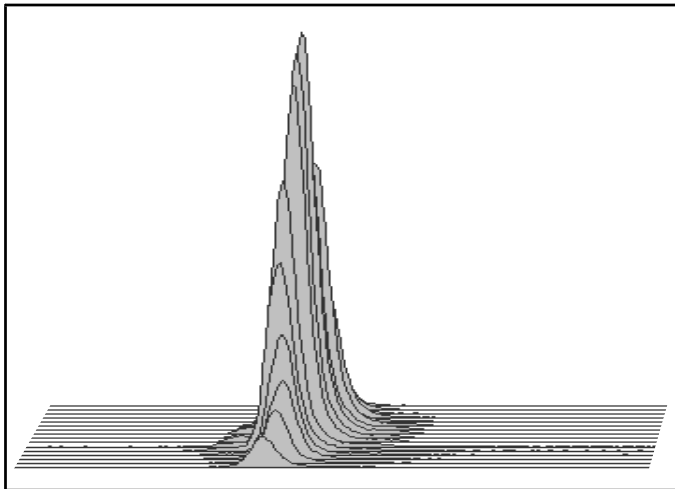
The PML-16 works in the 'Single', 'Oscilloscope' and 'f(xyt)' mode of the SPC-300/330.

In the 'single' mode a single measurement cycle is performed. All 16 curves are measured simultaneously (see figure below). The photon collection is stopped either at the end of the 'Collection Time' (if 'Stop T' is set) or at the first overflow (if 'Stop Ovfl') is set. If both stop conditions are set the measurement stops in both cases. Without any stop condition the measurement will run until it is stopped by the operator. During the measurement intermediate results are shown on the screen in intervals of 'Display Time'. Up to eight curves can be displayed. The numbers of the curves are specified in the 'Trace Parameters'.



In the 'Oscilloscope Mode' the measurement is repeated automatically at the maximum available speed. The result is displayed on the screen at the end of each measurement cycle. Up to eight curves may be displayed simultaneously. The numbers of the displayed curves are specified in the 'Trace Parameters'.

In the f(t,x,y) mode the measurement runs as in the 'single' mode, but all 16 detector channels are displayed as a three-dimensional pattern as shown in the figure below.

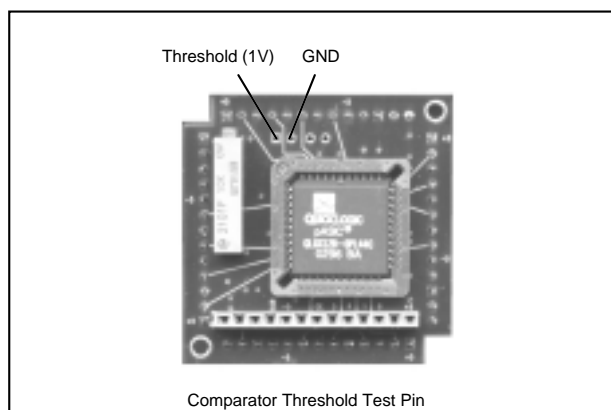


Optimisation

When the signals of all detector channels appear on the screen, the system parameters can be optimised. At first you should adjust the CFD threshold and the CFD Zero Cross level as described in the SPC-300/330 manual. Both parameters affect not only the time resolution, but also the uniformity and the time skew of the detector channels.

After threshold adjustment the latch delay can be optimised. The recommended value for the PML-16 is 20 ns as given in the specification table. The optimum setting can, however, differ from these values by 10 to 20 ns due to variations of cable delays. The most convenient way to adjust the latch delay is to give a signal to some of the detectors only and to adjust for minimum crosstalk.

The threshold for the comparators in the PML-16 module can be adjusted by a trimpot. The threshold is adjusted in the final test of the device and need not normally be changed. However, to achieve maximum performance the threshold can be adjusted for maximum ADC rate (best routing efficiency) and minimum crosstalk. Test pins are provided inside the PML assembly to monitor the actual threshold setting. The test pins (figure below) are accessible after taking down the rear panel. The default setting is 1V at the test pins.



For safety and to avoid overloading the detector by room light, the high voltage should be switched off before the PML is opened.

Overload conditions

Overload conditions are indicated by the 'OVLD' LED at the rear panel of the PML. The overload LED is controlled by the routing circuitry and turns on when the overall count rate in this part of the device exceeds 2 MHz. The number of misrouted events then increases rapidly.

If the overload LED turns on occasionally, there is still no immediate danger of damaging the PMT. Overload conditions for extended periods should, however, be avoided with regard to the life time of the PMT.

Heavy overload (e.g. by accidental exposure to daylight with the HV switched on) can permanently affect the performance of the device. Such a situation is not always indicated by the overload light because the voltages at the PMT break down and the normal output pulses disappear. However, due to the low voltage divider current there is a good chance that the PMT will survive such an accident. If it happens, give the tube a chance to recover for one day more.

If the PMT cathode is exposed to daylight with the high voltage being switched off, this causes a considerable increase of the dark count rate. This increase is, however, reversible and disappears after some hours in the dark. To avoid long recovery times, the photocathode should not be exposed to more light than absolutely necessary. Exposure to direct sunlight is to be avoided.

Troubleshooting

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

All count rates are present, but no curves or not all 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. Is the 'Latch Delay' set correctly (10 to 40 ns)?

No count rates: Are the cables connected correctly? The PML gets its ± 5 V power supply via the sub-D routing cable. Thus it cannot deliver pulses to the SPC if this cable is disconnected. Is the SPC-300 CFD input connected to the correct (-) polarity?

CFD and TAC rates are present, but no ADC Rate: Is the SYNC signal present at the SPC-300/330? Is the SYNC zero cross level correct? For safety, set SYNC ZCL to -10mV. Are the CFD and SYNC signals connected to the correct inputs at the SPC? Is the PML timing pulse output connected to the CFD input of the SPC? Do not connect another detector to the CFD input of the SPC while the PML is connected via the routing cable. This will not work, because the PML delivers an 'Error' signal as long as it does not see a detector pulse.

Incorrect routing or high crosstalk: Check the 'Latch Delay' parameter and the CFD thresholds. Is the comparator threshold of the PML-16 adjusted correctly? Is the CFD connector on the SPC-300 board connected to the negative input of the CFD? Furthermore, check for ground loops and other noise sources in your set-up. Noise at the detector inputs can affect the routing performance.

The overload indicator of the PML-16 turns on: Too much light at the detector or comparator threshold deadjusted (too low).

None of the above errors, but no count rates or no ADC rate: Are the supply voltages present at the sub-D-connector of the SPC? If possible, check with a meter. The SPC has safety resistors (fuses) in the $\pm 5V$ lines to prevent serious damage in case of a short. The fuses may blow if a device is connected to the sub-D connector which is not intended for that purpose. Another possibility is, that the routing input of the SPC has been damaged by such an accident or by electrostatic discharge (everything can happen in the laboratory).

In case of any problems, please make a printout of the system parameters and the trace parameters. Send it by fax to our company (number given below). Add a short description of the problem or call us. We will do our best to help you.

Technical Support

We are pleased to support you in all problems concerning the measurement of fast electrical or optical signals. This includes the installation of the PML and SPC modules, there application to your measurement problem, the technical environment and physical problems related to short time measurement techniques. Simply call us.

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