PMA Hybrid Series

Cooled Hybrid-Photomultiplier Assembly

PicoQuant

User Manual

Document version 2.2

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1. Brief Description

The PMA Hybrid is a compact single photon sensitive detector based on a fast Hybrid Photomultiplier Tube with peltier cooler to reduce dark count rate and stabilize power management. The detector includes a high voltage power supply and a pre-amplifier with overload protection and emergency shut down procedure if the detector count rate reaches a critical limit. Overload protection, high voltage setup and temperature regulation are calibrated at PicoQuant and do not require any adjustment. The detector is prepared for PicoQuant system integration via CAN interface.

The PMA Hybrid is built in a nickel coated aluminum housing to achieve a high level of RF shielding and protection against the interference with other devices. The built-in pre-amplifier is specially targeted at timing sensitive applications such as Time-Correlated Single Photon Counting (TCSPC).

The PMA Hybrid has a very good timing resolution. In contrast to other detector types, the afterpulsing is negligible. With these special characteristics, the PMA Hybrid is especially suited for e.g. Fluorescence Correlation Spectroscopy (FCS), where an afterpulsing peak at early lag times would complicate the analysis of the autocorrelation function.

The PMA Hybrid interfaces directly with all PicoQuant TCSPC products such as the TimeHarp 260, PicoHarp 300 or HydraHarp 400. Due to its large active area of 3-6 mm (depending on model), the detector can be connected to spectrometers such as the FluoTime 200 or FluoTime 300. It can also be attached to Laser Scanning Microscopes in Non-Descanned Detection (NDD) setups via a C mount adapter. Integration in descanned detection mode or other systems, such as the confocal time-resolved microscope MicroTime 200 is of course also possible.

The PMA Hybrid models feature two signal outputs on standard 50 Ohms SMA connectors: a negative voltage pulse for timing applications and an analog positive output voltage that can be connected to e.g. A/D converters. The module only needs a 12 V DC power supply line, which is supplied with the PMA Hybrid.

2. Operation

2.1. Handling Photomultiplier Tubes

The PMA Hybrid is an extremely sensitive device. It can be permanently damaged by over-exposure to intense light, despite of the built-in overload protection (see also section 5.1).

Never open or disassemble the PMA Hybrid housing when the power supply unit is connected. The light leaking into the housing will reach the photo-cathode and will destroy the hybrid PMT despite of the automatically closed shutter.

While room light can reach the entrance window of the PMA Hybrid:

- Do not attach the delivered LEMO plug to the shutter interlock connector
- Do not close the shutter interlock circuitry

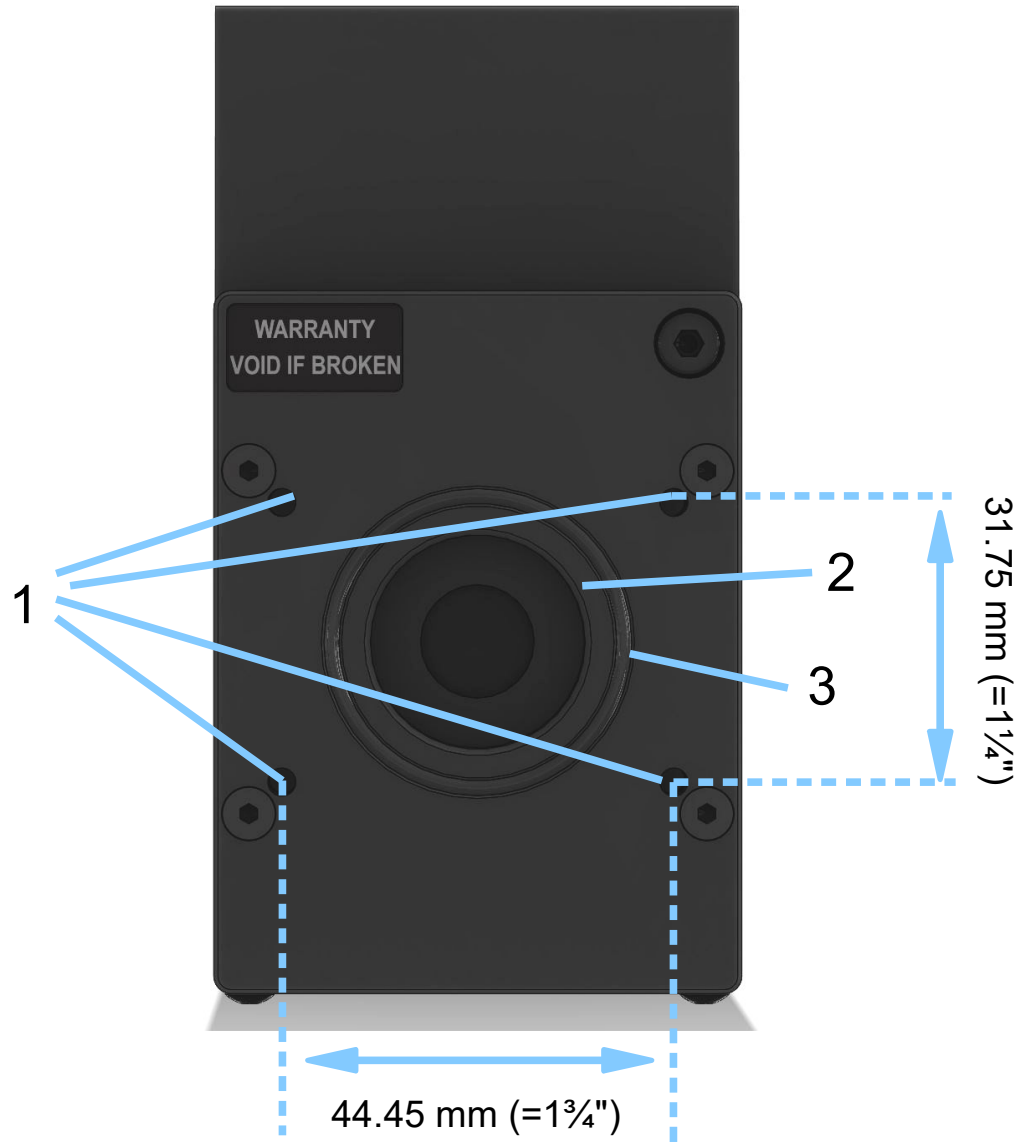
Handle the PMA Hybrid detector with care. Do not drop it or expose it to excessive mechanical shocks or vibrations.

Do not attempt to modify the electronic control circuits inside the housing.

When the PMA Hybrid detector is mounted on another instrument, take care that the connection is light-tight, especially if the detector is used for single photon counting. Caution: High Voltage!

2.2. Mounting the PMA Hybrid Unit

(a) Front mounting options



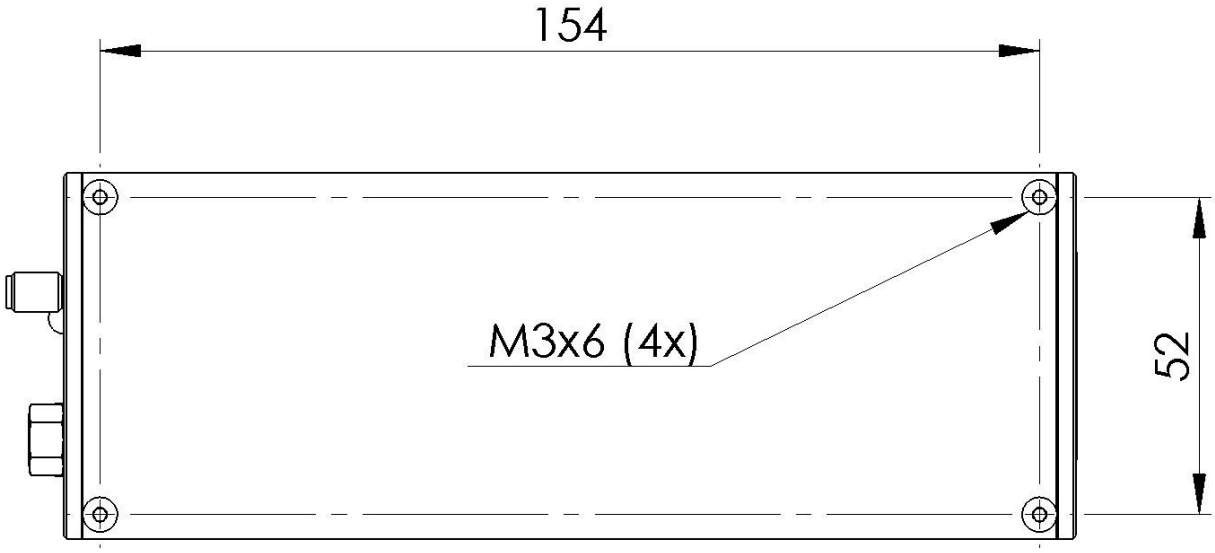
1 – Four mounting holes (3.2 mm diameter suited for M3 screws). Use these holes to attach, for example, an adapter plate. Access the holes rom the side of the detector.

2 – C-mount thread, 1-32 UN. Note that you still have to support the weight of the detector when this mounting style is used.

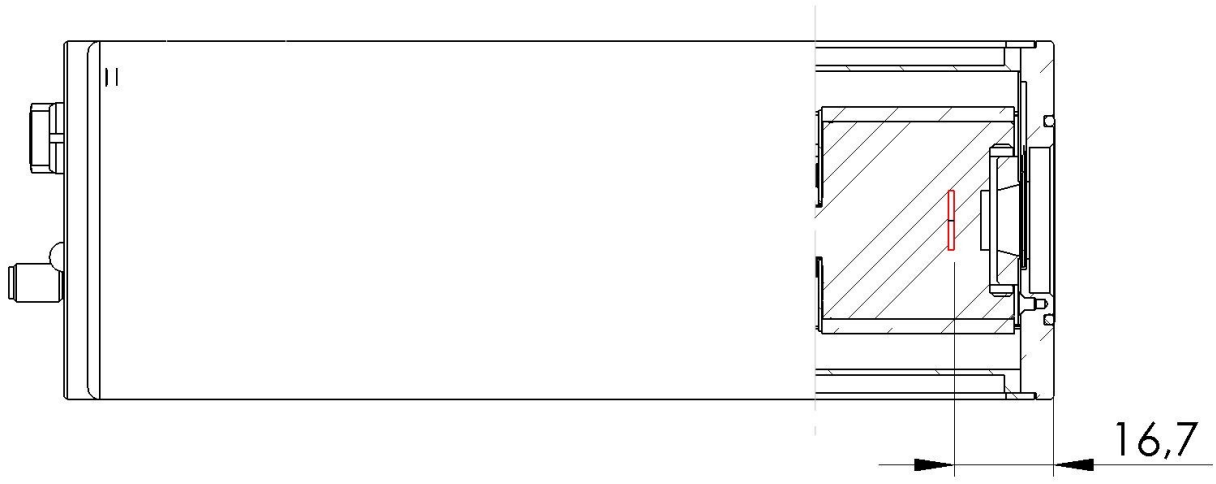
3 – O-ring (inner diameter = Ø 31.47 mm). Ensures light-tight connection to a flat surface, for example to an adapter plate or monochromator side wall.

(b) Bottom mounting options:

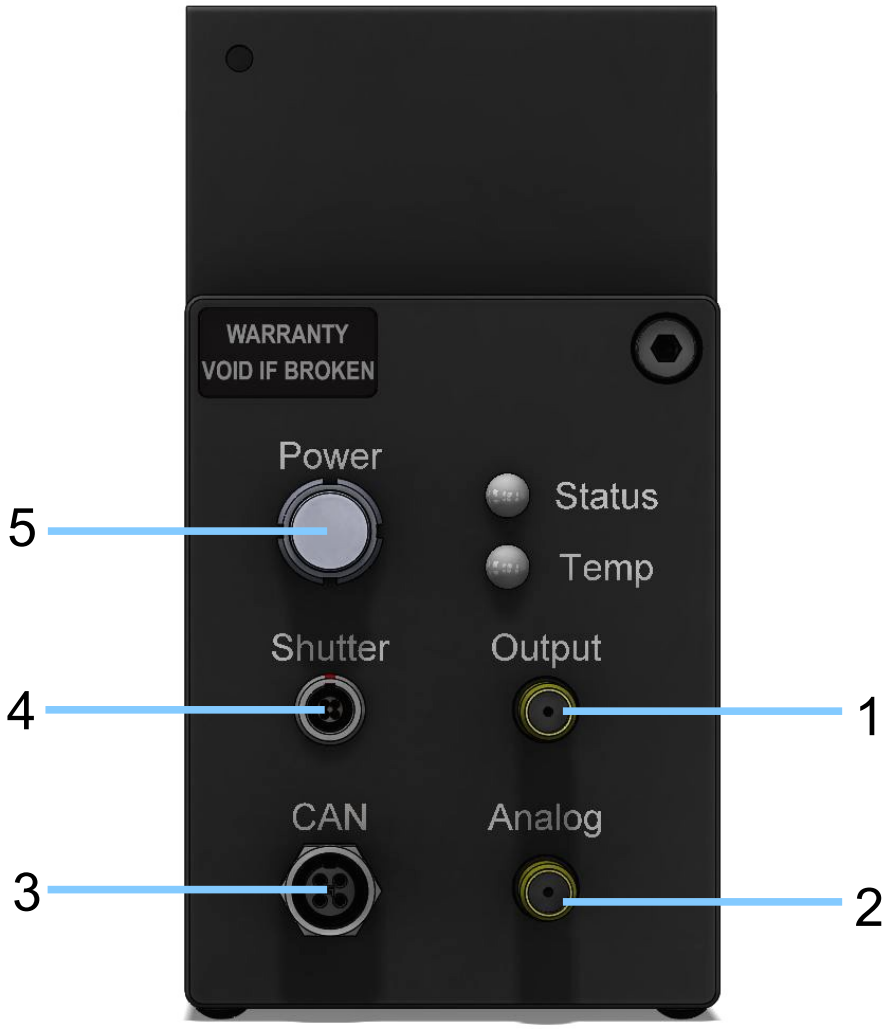
Four threads (M3x6) at the bottom of the detector fix the detector housing to the detector base plate. These screws can be replaced in order to mount the detector on a custom designed base plate. Remove the existing screws and replace by screws long enough to hold base plate and housing.



(c) Location of the sensor:



The distance between entrance window and active area of PMA Hybrid is 16.7 mm.



2.3. Electrical Connections (Rear Side)

1 – Timing output signal (standard 50 Ohms SMA female). Use a double shielded RG233/U coaxial cable to connect this signal to the appropriate input of e.g. TimeHarp 260, PicoHarp 300 or HydraHarp 400.

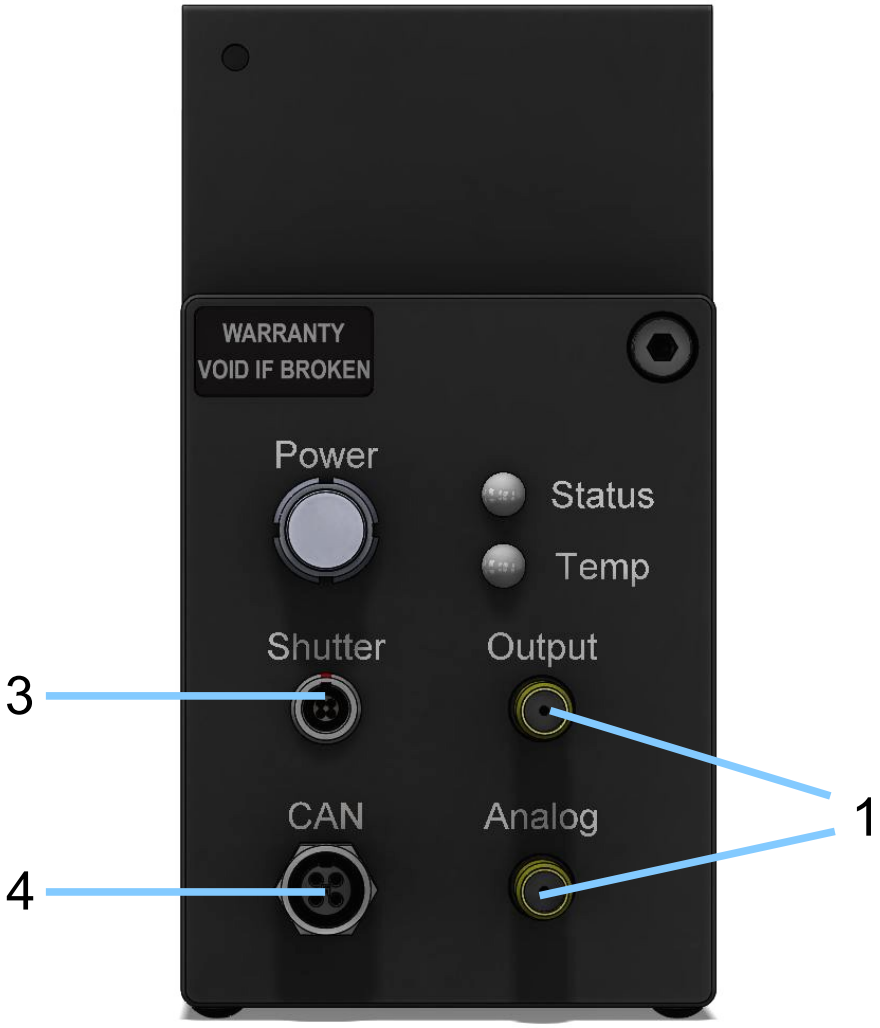
2 – Analog output signal (SMA female, designed for > 1k Ohm impedance).

3 – CAN interface for communication with PicoQuant equipment only.

4 – Shutter interlock (4-pin LEMO EGG.00.304.CLL, female connector). To close the shutter shunt pins 2 and 3 using a suited adapter. Alternatively, attach the LEMO plug delivered with the PMA Hybrid unit to open and close the shutter. Please do not apply any voltage.

5 – Power supply (2-pin LEMO connector, type EXG.0B.302, pin at key position +12V, other pin GND). This is for +12 V DC power adapter which is delivered with the PMA Hybrid.

2.4. Connecting the detector



1 – Connect a suited SMA signal cable (ideally double shielded RG233/U coaxial cable) to the Output connector or the Analog connector of the detector.

2 – Connect the other end of the SMA signal cable to your data acquisition electronics (such as the TCSPC modules TimeHarp 260, PicoHarp 300 or HydraHarp 400 for timing measurements via the Output connector).

3 – Connect the power supply cable to the detector power connector.

4 – Open the detector shutter by inserting the interlock plug into the shutter connector - or - alternatively short circuit the connection using the supplied interlock cable. **ATTENTION**: Before opening the shutter, make sure that the detector entrance window is connected light-tight to your experimental setup to avoid detector overload.

2.5. Cooling

When the PMA Hybrid is switched on, the thermoelectric cooling is activated and both the Power status LED and the Temp status LED are **green**. If no problems are detected during the start-up procedure both LED switch off after two seconds to avoid stray light during measurements. If this is not the case please check in section 2.7 for the cause and action.

It takes approximately 5 minutes to reach a stable operation temperature. You may want to use this time for preliminary measurements. Cooling reduces only the dark count rate without any effect on temporal resolution or photon detection efficiency.

2.6. Overload Protection

In order to avoid permanent damage to the PMA Hybrid, a fully automatic circuitry closes the shutter in front of the detector when the detector count rate reaches a critical level. This happens at a photon flux of 80 million photons per second (see also section 2.7 and 5.1).

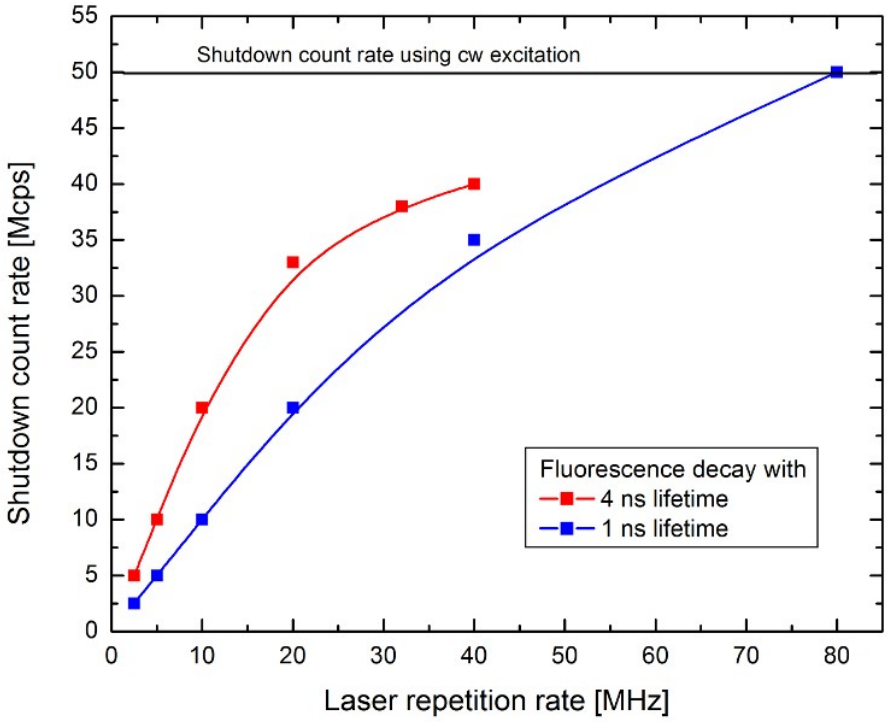
Overload is indicated by a **red** Power status LED at the rear panel and a beep sound. The PMA Hybrid continues to work normally with closed shutter and the typical dark count rate (dependent on the cooling status, which is not affected by the overload) should be detectable at the signal output. The shutter opens again after three seconds. In case the count rate is still too high it closes again. This procedure is repeated until the count rate has again dropped below the critical level.

This overload protection has a few millisecond latency and is meant as a last protection only. Please protect the PMA Hybrid against over-illumination as much as possible.

2.7. Overload Shutdown Count Rate

The overload shutdown rate is determined by measuring the current flow through the detector. In case the current has reached a critical limit, a fully automatic circuitry closes the shutter in front of the detector. This happens at a photon flux of approx. 80 million photons per second (see also section 5.1).

NOTE: A photon flux of 80 million photons per second does not necessarily mean that it is possible to measure up to count rates of 80 Mcps (Mcps: million counts per second). This is due to the fact that typical counting electronics can not discriminate between single photon events and multi-photon events, i.e. situations in which several photons hit the detector at the same time. Consequently, the relation between current and measured count rate becomes non-linear at conditions that favor multi-photon events. Typical conditions are operation at pulsed excitation with a high photon flux in a short time interval. At these conditions the measured shut down count rate decreases with decreasing excitation rate as illustrated in the plot below.



The plot shows the measured shutdown rate using pulsed excitation and samples with different fluorescence lifetimes. The PMA Hybrid used had a preset shutdown count rate of 50 Mcps under cw excitation. As can be seen, the measured shutdown count rate depends on the characteristics of the sample signal. In addition, a low duty cycle of the light source (e.g. due to a low laser repetition rate) can decrease the shutdown count rate, as the multi-photon probability will be increased.

2.8. Analog output

The analog output signal is related to the photo current from the detector. It is obtained by amplifying the detector current (internal time constant of the amplifier is 20 µs). The slope of the amplifier is factory set using cw light and corresponds to a maximum output voltage of +10V at 50 Mcps (output voltages of +5V or +3V on customer request).

2.9. LED color code

The following tables describe the color code of Status and Temp LEDs

Status LED:

Color	Cause	Action
red	**overload**	**reduce light intensity on the detector, see section 2.6 and 2.7**
green	**normal operation condition - LED turns off after two seconds**	
orange	**No connection at shutter interlock**	**connect shutter interlock plug or cable, see section 2.4**
off	**normal operation condition**	

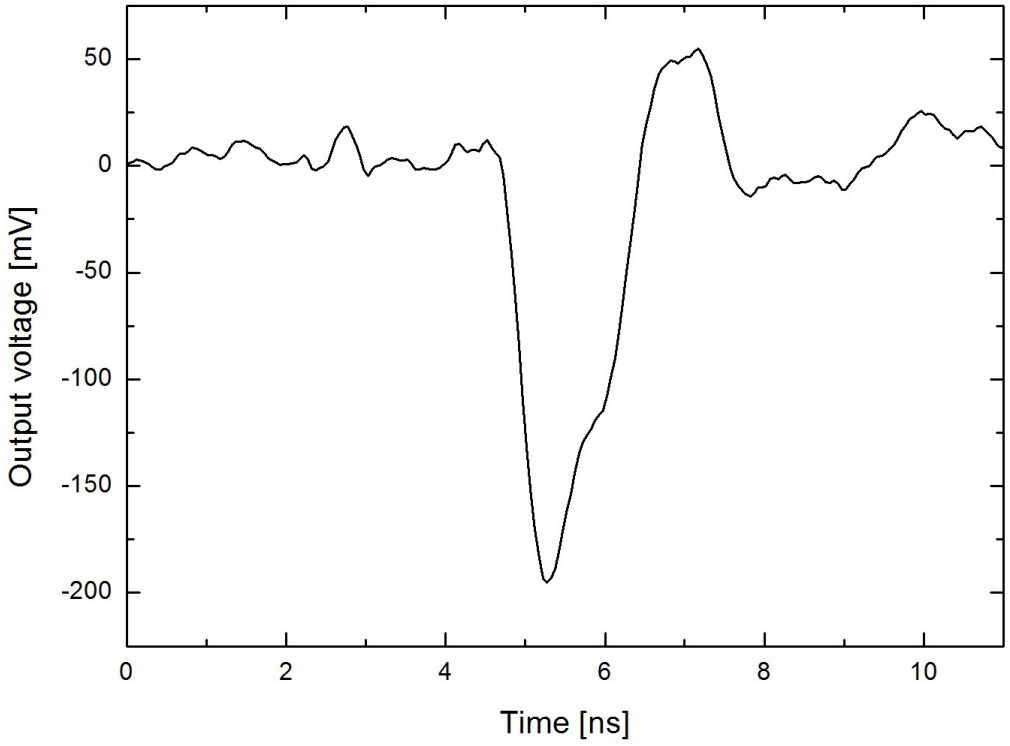
Temp LED:

Color	Cause	Action
red	**Housing temperature limit out of bounds (>40° C)**	**optimize heat transfer by e.g. mounting the detector on a suited heat sink**
green	**normal operation condition - LED turns off after two seconds**	
orange	**Target temperature (17±1° C) at peltier element out of bounds**	**wait until target temp is reached (The environment temperature of the detector need to be higher than 17° C)**
off	**normal operation condition**	

3. Typical performance

3.1. Temporal Response

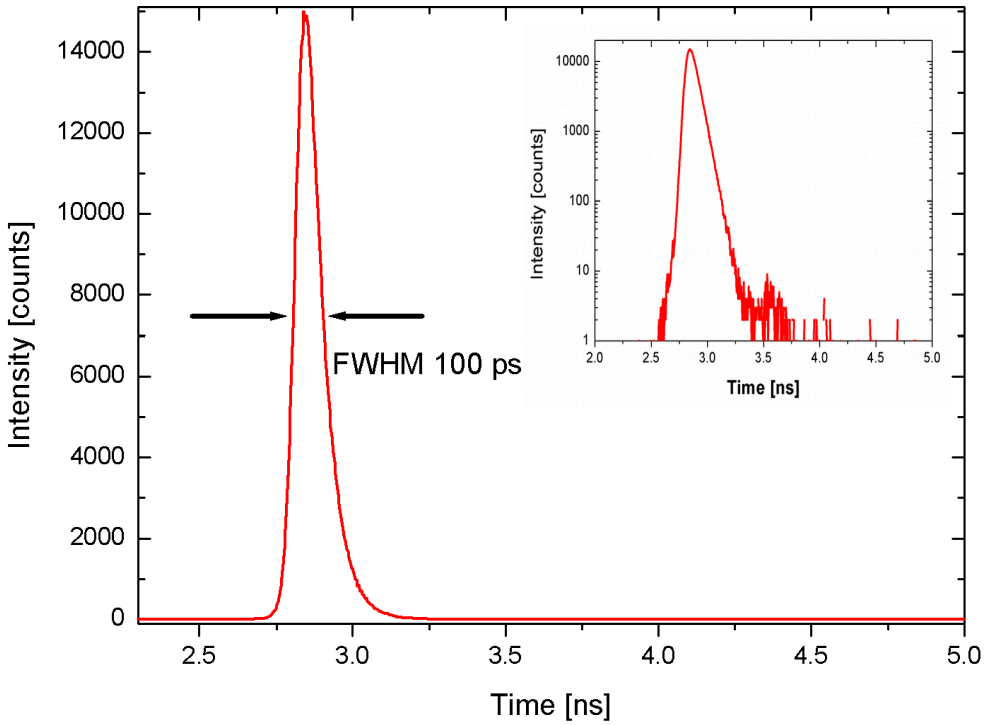
The PMA Hybrid series units are suited for time-resolved applications such as time-correlated single-photon counting (TCSPC) measurements. A typical electrical response of a PMA Hybrid unit to a single photon impact is shown on the graph below:



The output signal is a short, negative going voltage pulse with an amplitude of approximately -200 mV into 50 Ohms. Note that the voltage output of the PMA Hybrid scales linearly with the number of impinging photons, i.e. two photons generate twice the amplitude.

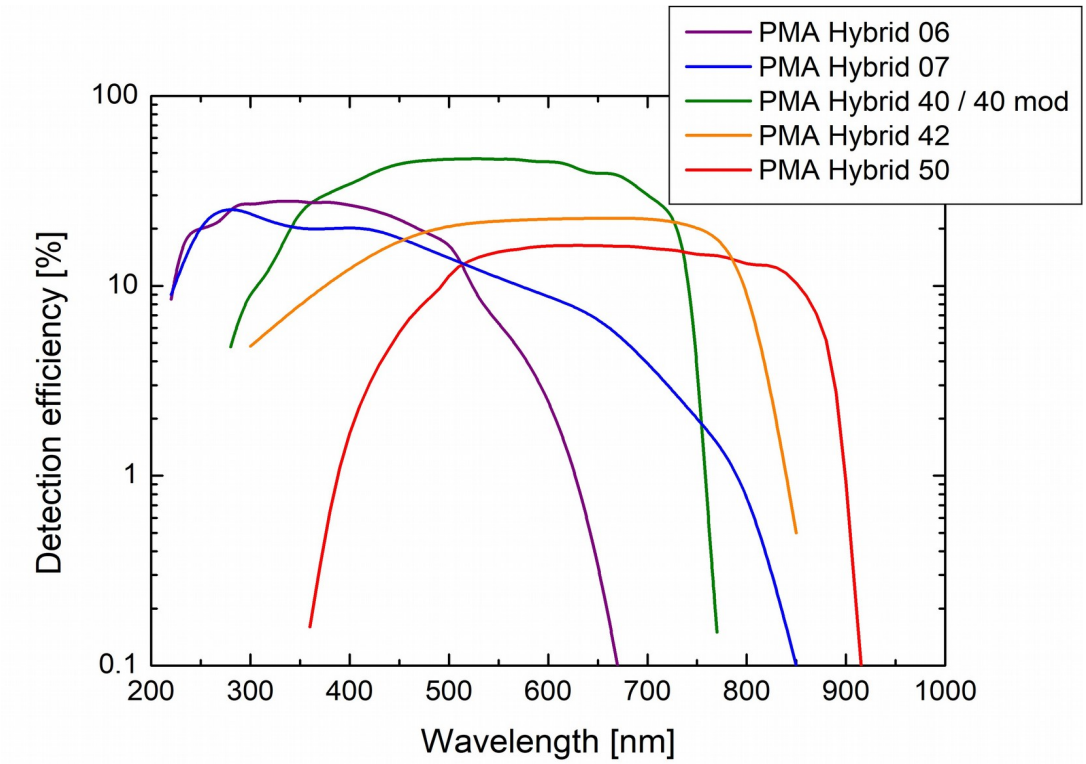
The pulse duration is approximately 1.2 ns (full width at half of the maximum, FWHM). However, the ultimate time resolution achievable with a PMA Hybrid is determined by the steepness of the leading edge and the photo-electron transit time spread (TTS). The leading edge of a typical output pulse has less than 300 ps rise time. The TTS varies between <50 ps and <160 ps as specified in section 4.1.

Example: IRF measurement using a PMA Hybrid 40



This IRF has been recorded on a FluoTime 300 spectrometer equipped with PMA Hybrid 40 detector and PicoHarp 300 TCSPC module. The sample was a strongly diluted Ludox scattering solution irradiated with 375 nm light pulses of approximately 70 ps optical duration from an LDH-P-C-375 picosecond pulsed laser diode.

3.2. Spectral Response



The spectral sensitivity of a detector based on PMA Hybrid is mainly determined by the photo-cathode material.

4. Technical Data / Specifications

Electrical Parameters

Model	-06	-07	-40	-40mod	-42	-50
Wavelength range	220 nm - 650 nm	220 nm - 850 nm	300 nm - 720 nm	300 nm - 720 nm	300 nm - 870 nm	380 nm - 890 nm
Dark counts (cooled, typ. value)	<100 cps	<200 cps	<700 cps	<4000 cps	<500 cps	<1000 cps
Transit time spread (FWHM, typ. value)	<50 ps	<50 ps	<120 ps	<120 ps	<130 ps	<160 ps

Max. count rate..... 80 MHz (with cw excitation, lower values at different conditions,
..... see section 2.7)

Signal Output (Timing)

Connector..... SMA female
Impedance..... 50 Ohms
Polarity..... negative

Signal Output (Analog)

connector..... SMA female
Impedance..... > 1k Ohms
Polarity..... positive
Max. output voltage..... + 10 V (corresponds to 50 Mcps)
Time constant of the amplifier..... 20 µs

Power Supply

Input..... 12 V DC

Dimensions

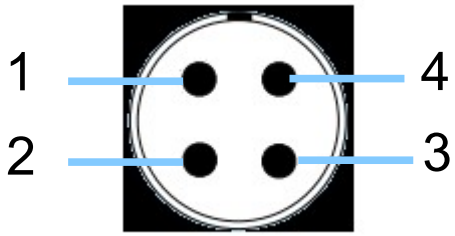
Model	-06	-07	-40	-40mod	-42	-50
Detector area diameter	6 mm	6 mm	3 mm	5 mm	3 mm	3 mm

Housing (w × d × h)..... 114.5 × 175.3 × 60 mm
Optical adapters..... C-mount, 4 mounting holes

The ambient temperature has to be kept between +15°C and 25°C. Please ensure a sufficient air flow around the detector for an effective heat dissipation.

Shutter Connection

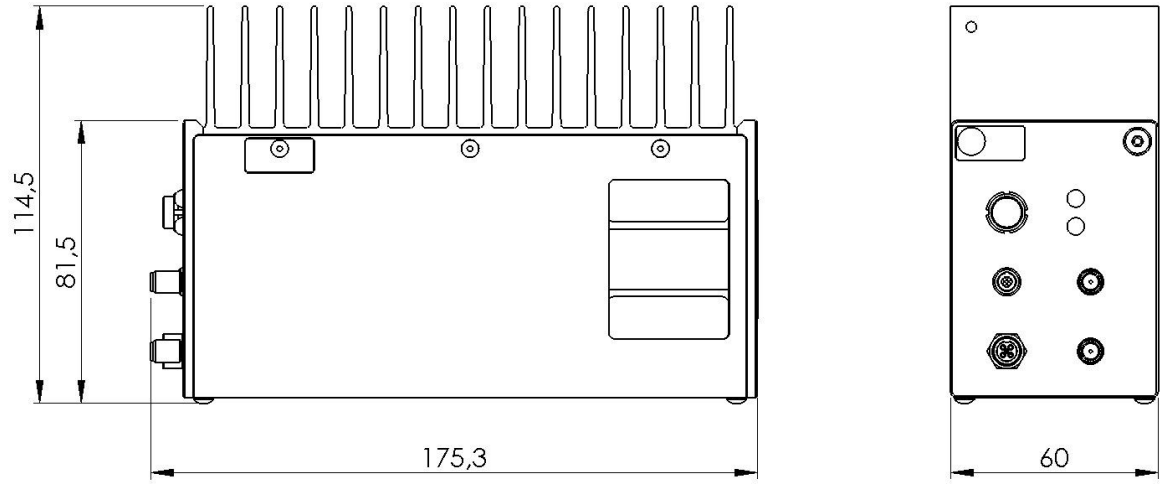
4-pin LEMO EGG.00.304.HLN, female connector, possible matching plug: LEMO FGG.00.304.CLAD35Z
In order to close the shutter shunt pins 2 and 3.



Power Pin Connection

2-pin LEMO EXG.0B.302.CLL, female connector, possible matching plug: LEMO FGG.0B.302.CLAD52

Mechanical Layout



Retraction of Old Devices

Waste electrical products must not be disposed of with household waste. This equipment should be taken to your local recycling center for safe treatment.
WEEE–Reg.–No. DE 96457402

5. Support

The PMA Hybrid Series detectors have gone through testing at PicoQuant. It is stable and reliable. Nevertheless, we continually make improvements that will be incorporated into future versions.

5.1. Returning Products for Repair

If you have serious problems that require the device to be sent in for inspection / repair, please contact us at: support@picoquant.com and request an RMA number before shipping the device. Observe precautions against static discharge under all circumstances in handling, packaging and shipping. Use original or equally protective packaging material. Inappropriate packaging voids any warranty.

5.2. PicoQuant Community Forum

This forum is intended as a platform for users of PicoQuant's systems, components and software packages. It is not strictly limited to software related questions. As PicoQuant products cover a wide range of applications from single molecule experiments to life sciences and material science, discussions of the scientific background are of course welcome. The forum can be found at http://forum.picoquant.com

5.3. Sensor degradation / warranty

Please note that the sensitivity of the detector may degrade with usage, especially if operated continuously under high counting rates. A reduction of the detection efficiency is therefore normal and is not covered by warranty.

6. Legal Terms

6.1. Copyright

6.2. Trademarks

7. Further Reading

7.1. PicoQuant Bibliography

PicoQuant maintains a database of publications mentioning PicoQuant devices. It can be found at our website http://www.picoquant.com/scientific/references. It is a valuable source if you would like to know which laboratories are using PicoQuant products or how broad the field of various applications is.

7.2. Download of Technical Notes / Application Notes

PicoQuant, along with our customers, continuously writes and publishes short documents about techniques, methods and applications that are possible with our hardware or software. The download section can be found at http://www.picoquant.com/scientific/technical-and-application-notes

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