PMT Detectorhead

PHOTOMULTIPLIER DETECTORHEADS

>> Datasheet <<

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Photomultiplier Detectorheads

1. Design Concept

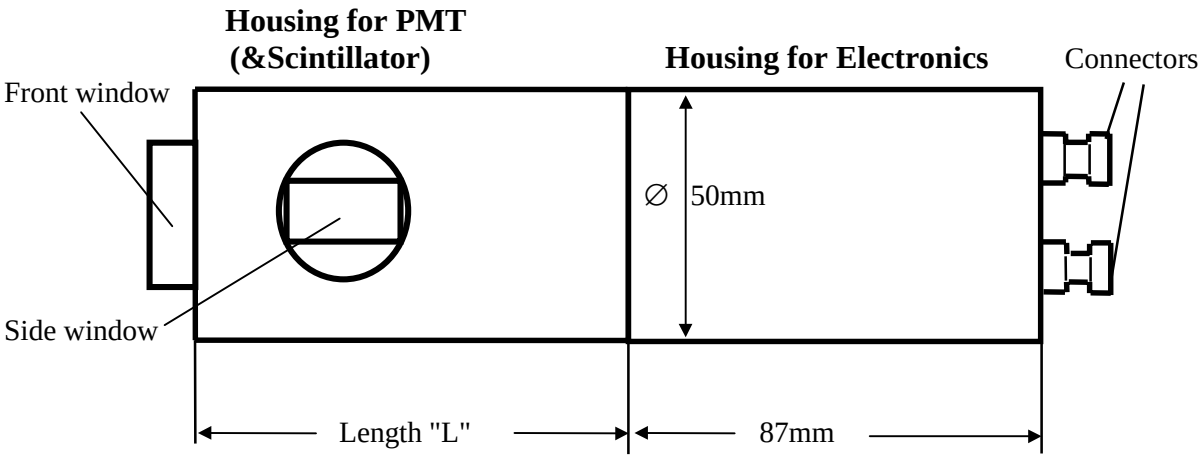
WMT Photomultiplier Detectorheads (PHDs) provide all the necessary peripheral equipment to operate a photomultiplier tube (PMT):

- opaque mechanical assembly
- magnetic shield
- high voltage supply including dynode voltage divider, PMT overcurrent protection, and HV-monitor
- signal processing modules

The modular construction allows easy adaptation to a wide variaty of applications:

- light intensity measurements
- in combination with suitable scintillation detectors measurement of nuclear radiation: α, β, γ, n, x-ray
- depending on the chosen signal processing: single event counting
  pulse height analysis
  integral current measurements

Mechanical construction:



Principal drawing, not to scale.
Front- or side-window of PMT-Housing alternatively.

Diameter:	50 mm.		
Length "L":	Electronic housing:	87 mm	
	PMT housing:	Front window PMT:	116 mm
		Side window PMT:	81 mm

Metal package type PMTs are mounted directly within the electronic housing.

These dimensions are standard, others for particular PMTs or scintillators upon request.

2. Choice of PMTs and Scintillation Detectors

Photomultiplier Detector Heads:

PDH system	PMT type and size	PMT manufacturer
PD 50 FK	metal package PM	Hamamatsu
PD 50 SF	28mm side-on PMT	BURLE, EMI, Hamamatsu
PD 50 FK	19 mm and 28 mm head-on PMT	BURLE, EMI, Hamamatsu, Philips

Photomultiplier Detector Heads with Scintillation Detectors:

PDH system	PMT type and size	PMT manufacturer
PS 50 FK	28 mm head-on PMT	BURLE, EMI, Hamamatsu, Philips

Scintillator materials:

	NaJ(Tl)	CsJ(Tl)	BaF_2(Eu)	YAP(Ce)	BGO	Plastic
Density(g/cm^3)	3.67	4.51	4.89	5.35	7.13	1.03
Max of emiss. (nm)	415	550	315 220	370	480	...420...
Primary relaxation time (ns)	230	1000	630 0.8	25	300	1...3
Sensitivity rel to NaJ(Tl) with bialkali PMT (%)	100	45	16 5	35...40	15...20	25...30
Hygroscopic	yes	no	no	no	no	no
Mainly to be used for	x-ray γ	x-ray γ β	x-ray γ β	x-ray γ β	x-ray γ β	x-ray γ β α n

Scintillation materials and detection windows are to be chosen according to the application.

Note: WMT is an electronic company and is not interested to deliver PMTs and scintillation detectors. We can do so on special request. Usually the customer provides these parts.

3. Electronic Components

3.1. Overview

The minimal configuration of a Photomultiplier Detectorhead is a housing with a PMT and in the electronic part only a voltage divider with mating socket. In this case the high voltage is supplied from an external HV generator, the anode is connected to a BNC jack. All the signal processing is done externally.
This minimal configuration may be suitable for very sophisticated applications not covered by available modules, e.g. picosecond timing with constant fraction discriminators, or in case the customer wants to use his existing equipment to save expense.
Important: If the signal output is connected to a 50Ω-input, e.g. for fast timing, this scheme works perfect. If in contrast the signal is connected to an external transimpedance or charge sensitive amplifier, the cable capacitance adds to the input capacitance and thus noise is increased (see WMT application note PMT-Op-Noise:"Operation of Photomultiplier Tubes: Noise considerations").

By adding approptiate modules, the signal processing in the electronic part can be tailored for a wide variaty of applications:

- Integral anode current measurements with current-to-voltage converters.
- Pulse height analysis with charge-sensitive and pulse-forming amplifiers.
- Pulse counting with threshold or window discriminators.

WMT offers a variety of available modules satisfying almost any reasonable requirement in terms of conversion gain, bandwidth, pulse-pair-resolution, accuracy, stability, or signal-to-noise ratio. For applications not covered so far, WMT is ready to develop further modules in cooperation with the customer to meet his requirements.

Each PDH is 100% tested and shipped with a test protocol containing all relevant data.

3.2. Voltage Dividers

WMT voltage dividers with mating sockets are available for many PMT types.
They exhibit active transistor circuits and decoupling capacitors in the last three or four dynode stages. This design guarantees minimum power consumption and maximum linearity for the transfer function (anode current) / (light intensity).
The customer specifies the PMT, the maximum anode current, and the minimum high voltage for full scale anode current. The voltage divider is then chosen by factory:

> The voltage ratio between stages is set according to the PMT manufacturer`s recommendations, the divider resistance (and thus current) is set suitable for the maximum anode current and the applied high voltage.

In addition, special designs are available on request, e.g. for very high pulse currents or for constant divider currents independent of the applied high voltage.

3.2. High Voltage Modules

The high voltage module HVxxxx exhibits very low ripple and drift, and thus guarantees good gain stability and low noise of the PMT. The mechanical design with shielding assures, that interference of switching spikes with the signal output is kept well below the noise level (see section 8).

The module generates a negative output voltage, proportional to a control voltage "HV-reference" in the range $0 \div +10V_{dc}$, which must be supplied to the reference input. This voltage must therefore be clean and stable. "xxxx" stands for the (maximum) output voltage at HV-reference = 10V.
The customer has to specify "xxxx" when ordering. 800, 1200, 1500 are standard, but any value up to 2500 may be specified.
The output voltage is monitored at the HV-monitor output with scaling factor –1/1000.

The HVxxxx can be shut down for protection purposes by a digital signal generated in the analog signal processing modules. If an overcurrent condition is detected in the signal amplifier, the HV is turned off to prevent a damage of the PMT. The HV is turned on again by a negative pulse at the reset input. The status is monitored by a digital "HV-Control"-signal.

Specifications HVxxxx:

high voltage output:	$0 \div -$ xxxx V, xxxx = 2500 max.
output current:	depending on voltage, 0.8 W max.
HV-reference input:	$0 \div +10$V (±15V no damage), $R_{IN} \geq 100k\Omega$
transfer function:	$HV_{OUT} = -(xxxx)/10 \times$ HV-reference ± 2% ± 3V
output voltage ripple & noise:	$\leq 5 \times 10^{-5}$ at load current ≤ 0.3 mA
temperature drift:	$\leq 10^{-4}$ /°C
HV-monitor:	$V_{mon} = -0.001 \times HV_{OUT}$ ± 2% ± 3mV
HV-control:	status monitor, HCMOS-level, "Lo" = HV Off
HV-reset:	HCMOS input, "Lo" for ≥ 50ms switches HV On
temperature range:	operating: –20°C to +50°C
	storage: – 40°C to +80°C
supply voltage:	$+15V_{dc}$ ($+14 \div +16V_{dc}$)
supply current:	quiescent: 5 mA typ.
	efficiency ≈ 40% (quiescent current not included)

The reference voltage, control functions, and indicators to operate the HVxxxx are provided by the PMT-Detectorhead-Controller, see section 6.

3.3. Current-to-Voltage-Converters (Transimpedance Amplifiers)

A choice of three different I/V-converter designs is available:

- VL for low frequencies up to 3 MHz
- VM for medium frequencies up to 50 MHz
- VH for high frequencies up to 300 MHz

They all have an input for dark current compensation and generate an overcurrent signal to shut down the high voltage supply.
The "VH" models may be used for pulse counting with external discriminators.

Each of these three converter types can be tailored to the customer´s needs within certain bounds:

I/V-Conv. Type	-3dB- Bandwidth [MHz]	Conv. Gain [Ω]	BW×Gain [Hz × Ω]
VL	≤ 3	$\leq 10^9$	$\leq 2 \times 10^{12}$
VM	≤ 50)[1]	$\leq 10^5$	$\leq 10^{12}$
VH	≤ 300	$\leq 2 \times 10^4$)[2]	$\leq 2 \times 10^{12}$

Notes:
1. VM can be configured for 10 V output into ≥ 1 kΩ for bandwidth up to 10 MHz, or for 50 Ω -termination (2 V max. into 50 Ω) for higher bandwidth.
2. VH is designed for 50 Ω-termination. Conversion gain is into 50 Ω load.

Standard units:

VL:
20 MΩ, 100 kHz
10 MΩ, 1 Hz - 200 Hz - 10 kHz - 200 kHz
1 MΩ, 100 kHz
500 kΩ, 500 kHz - 2 MHz
300 kΩ, 1 MHz

VM: None

VH:
20 kΩ - 10 kΩ - 2.5 kΩ, 100 MHz
2 kΩ, 300 MHz

For other requirements, consult factory.

Because of the PMT´s capacitance, the electronic noise heavily depends on the overall bandwidth (see WMT application notes: "Operation of Photomultiplier Tubes: Noise considerations" and "PMT Noise Considerations").
It is essential therefore, to limit the bandwidth to the necessary minimum. This need not necessarily be done within the detector head but may take place outside in a further signal processing arrangement. Note, however, that the signal must not exceed the amplifier´s linear range, even not in the presence of excessive noise e.g. at low cathode currents.

Specifications:

Unless otherwise noted, the specifications are valid under the following conditions:
ambient temperature 25 °C
supply voltages ±15 V ±1 V
output loaded with 10 kΩ to GND for 10 V-models, 50 Ω to GND for 50 Ω-models
input loaded with C_P = 10 pF (= typical parasitic capacitance of PMT + divider + stray)

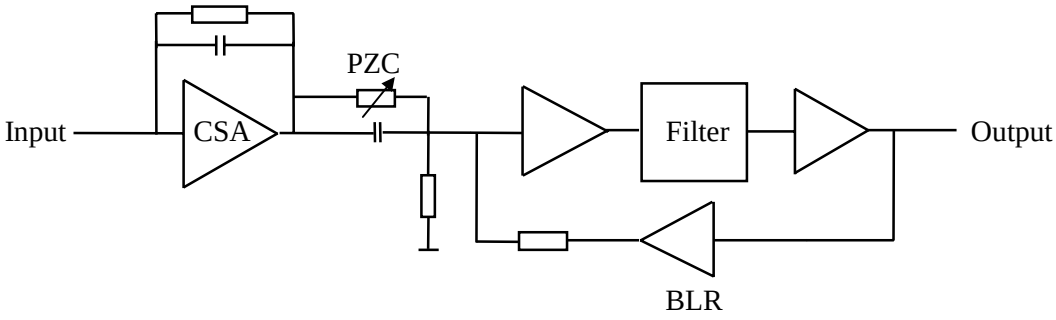
General specifications for all models:

output offset voltage:	±3 mV max, < 1 mV typ. @ 25 °C
output short circuit protection:	@ 25 °C: 1 minute for 10V-models, indefinite for 50Ω-models
bandwidth:	deviation from nominal f_{-3dB} : -0% ÷ +10% max.
gain peaking:	≤ 1dB guaranteed, < 0.5dB typ.
step response:	rise- and falltime: $(0.32 \div 0.38)/f'_{-3dB}$
	overshoot: ≤ 5% guaranteed, < 2% typ.
accuracy of conversion gain:	± 2%
ambient temperature range	
for specified performance:	-20....+50°C
storage:	-40....+80°C

For detailed specifications refer to the individual datasheets.

3.4. Pulseshaping Amplifiers

Pulseshaping amplifiers are used for pulseheight analysis, mainly in combination with scintillation detectors, e.g. for energy spectroscopy.
The WMT pulseshaping amplifier modules are composed of a charge-sensitive preamplifier (CSA), followed by a bandpass filter amplifier with pole-zero-cancellation (PZC) and baseline- restoration (BLR):



The overall filter response is a 5-pole filter with quasi-gaussian pulseshape.
Shaping time constant and overall gain can be configured according to the customer´s needs.
Contact factory for application-specific solutions, there are no standard units available so far.

3.5. Discriminators

Threshold discriminator modules are used for single pulse counting. Two models are offered:

VCT01: Threshold discriminator. Generates an output pulse, whenever the input charge pulse exceeds a fixed threshold.
Standard threshold value is 0.08 pC, others are available upon request.

FD05: Window discriminator. Generates an output pulse, whenever the input charge pulse is between two fixed thresholds. Standard values are 0.3pC for the lower and 1.5pC for the upper threshold, others are available upon request.

In most cases the standard values can be used, because the PMT gain can be adapted to the particular application by adjusting the high voltage.

For detailed specifications see the individual datasheets.

4. Connector Pinout

The PDH is equipped with three connectors:

- BNC-jack: SIGNAL OUT, shield connected to AGND
- BNC-jack: HV-MONITOR (if a HV-modul is installed), shield connected to AGND

  Alternative:
  BNC-HT-jack: HV-INPUT (if no HV-modul is installed), shield connected to AGND

- 8-pole round connector, DIN 45326

  Mating plug: e.g. Amphenol T 3504-001 or Lumberg SV 81

  Pinout:

Pin-No.	Signal Name	Function
1	Dark Current Comp.	units for integral current measurement: pos. dc-voltage to compensate for dark current created offset VCT 01: ratemeter output
2	HV-Reset	logic "lo" ≥ 50ms switches HV-modul On, level is HCMOS
3	Neg. Power Supply	−15V (−14 ÷ −16V)
4	HV-Control	digital status monitor, HCMOS, "lo" indicates HV Off
5	Pos. Power Supply	+15V (+14 ÷ +16V)
6	AGND	Signal GND, connected to case
7	DGND	power return for HV-modul only, must be connected to AGND in the power supply unit
8	HV-Reference	dc-voltage 0 ÷ +10V controls the High Voltage +10V ⇒ HV = max.

  Depending on the actual configuration of the PDH, several of these pins may not be connected.

5. Accessories

PMT-Detectorhead-Controller

This stand-alone instrument provides all the necessary supply and reference voltages and control functions to operate the PMT-detectorheads offered by WMT.
The controller is connected to the detectorhead by a special 10-wire cable, that is terminated by a 9-pole Sub-D-connector on the controller side and an 8-pole round connector plus a BNC-plug on the detectorhead side.

See datasheet for details.

6. Ordering Information

PX50 XX XX XXXX xxxx/yyyy

Bandwidth:	no letter	⇒ Hz
	k	⇒ kHz
	M	⇒ MHz
Conversion Gain:	k	⇒ kΩ
	M	⇒ MΩ
Signal Processing:	VL, VM, VH	= transconductance amplifiers
	VCT01, FD05	= discriminators
	00 = nothing, PMT anode connected directly to output jack	
High Voltage:	First two digits of HV 00 = external HV	
Window:	SF = side-on type FK = head-on type	
Detectorhead:	PD50 ⇒ PMT only PS50 ⇒ PMT with scintillator	

Examples:

PD50 SF 08 VCT01 = detectorhead for side-on PMT, high voltage = 0 to 800 V, with VCT01 preamplifier/discriminator

PD50 FK 12 VL 20M/100k = detectorhead for head-on PMT, high voltage = 0 to 1200 V, lo-speed transconductance amplifier with 20 MΩ conversion gain and 100 kHz bandwidth

PMT type is to be specified with order for correct choice of socket and dimensioning of voltage divider.