micro μPMT®

HAMAMATSU

MICRO PMT ASSEMBLY
MICRO PMT MODULES
MICRO PMT PHOTON COUNTING HEAD

HAMAMATSU

PHOTON IS OUR BUSINESS

World's smallest and lightest photomultiplier tube*

Micro PMT

* By our research (as of December 2015)

Easy to mass produce

Micro PMT can be produced in high volume while still maintaining high reliability and performance. What makes this possible is overall integrated usage of our in-house advanced technologies for MEMS (micro-electro-mechanical systems), semiconductor manufacturing, electron trajectory design, vacuum sealed packaging, and vacuum processing.

Tiny dimensions

Micro PMT has a three-layer structure where a silicon substrate is sandwiched between two glass substrates. Utilizing only three components gives tiny dimensions impossible up until now.

High shock resistance

Micro PMT devices offer strong shock resistance since anodic bonding by MEMS technology is utilized to join the silicon substrate to the glass substrates. This high cushioning or shock resistance makes them ideal for developing high-performance, hand-held testing and analysis devices.

micro μPMT®

HAMAMATSU

Customizing support

Feel free to consult with us on customizing to match customer usage conditions and environments.

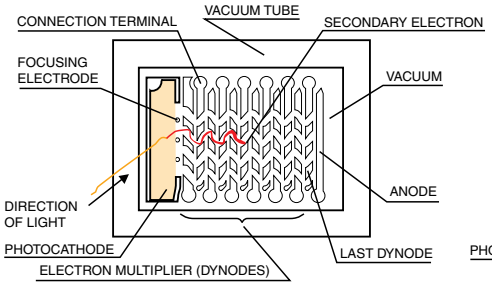
High sensitivity and fast response

Micro PMT utilizes the same high precision structure for electrode arrangement as conventional PMTs and so provides the high sensitivity and fast response needed from a PMT.

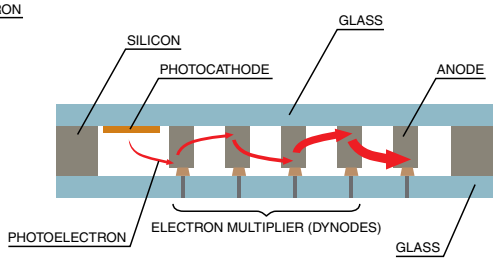
Full-scale Micro PMT image!

Micro PMT works on the same vacuum tube technology and principle as conventional PMTs and so can deliver the same performance as conventional PMT yet in a compact and lightweight unit.

Micro PMT internal structure



[TOP VIEW]



[SECTIONAL VIEW]

What is a PMT (photomultiplier tube)?

The PMT is a photosensor delivering superb high sensitivity and response speed compared with other types of photosensors. The PMT makes use of the secondary emission effect for electron multiplication and so achieves extremely high sensitivity and low noise compared to other photosensors currently in use to measure UV light, visible light, and near-infrared light. These features allow the PMT to be used in a broad range of applications including high-performance medical equipment and environmental monitors, etc.

Medical care

Medical diagnosis in the home or at the bedside

Bringing high-tech closer to the patient via compact and portable medical devices

Tests and inspections normally held in examination rooms or labs can now be made in emergency rooms or small clinics by using the advantages offered by Micro PMT. Performing sophisticated exams in the home could also allow detecting major diseases while still in their early stage. This means the Micro PMT could prove ideal not only for early stage disease diagnosis but also daily health care management.

Measurement

Making environmental pollution measurements on an individual or regional scale

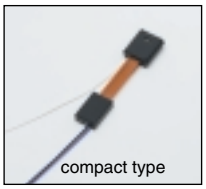
Measurements under various environments and any type of location

Micro PMT also proves ideal as a photosensor for environmental monitoring tasks. Environmental problems including abnormal weather phenomenon and wide-scale natural disasters are recently occurring at places all around the world. If compact measurement devices were readily available, then environmental phenomena could be quickly detected at diverse locations to keep damage and losses to a be minimum.

μPMT® PRODUCT CONFIGURATION

● MICRO PMT ASSEMBLY

MICRO PMT
+
VOLTAGE DIVIDER CIRCUIT



compact type

Type No.	Spectral response
H12400-00-01	300 nm to 650 nm
H12400-01-01	300 nm to 850 nm

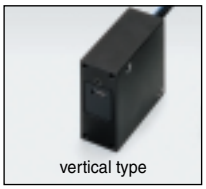
* Suitable high voltage power supply is detailed in last page.

● MICRO PMT MODULES

MICRO PMT
+
VOLTAGE DIVIDER CIRCUIT
+
HIGH-VOLTAGE
POWER SUPPLY CIRCUIT

flat type

Type No.	Spectral response
H12402	300 nm to 650 nm
H12402-01	300 nm to 850 nm



vertical type

Type No.	Spectral response
H12403	300 nm to 650 nm
H12403-01	300 nm to 850 nm

● MICRO PMT PHOTON COUNTING HEAD

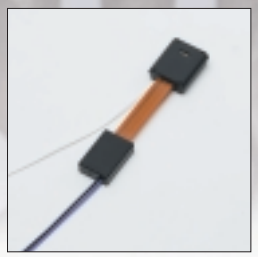
MICRO PMT
+
VOLTAGE DIVIDER CIRCUIT
+
HIGH-VOLTAGE
POWER SUPPLY CIRCUIT
+
PHOTON COUNTING CIRCUIT

flat type

Type No.	Spectral response
H12406	300 nm to 650 nm
H12406-01	300 nm to 850 nm

MICRO PMT ASSEMBLY
H12400 SERIES

The H12400 series is a high sensitivity photosensor that combines a Micro PMT with a voltage divider circuit. The H12400 series can be installed even in narrow spaces due to its small size.



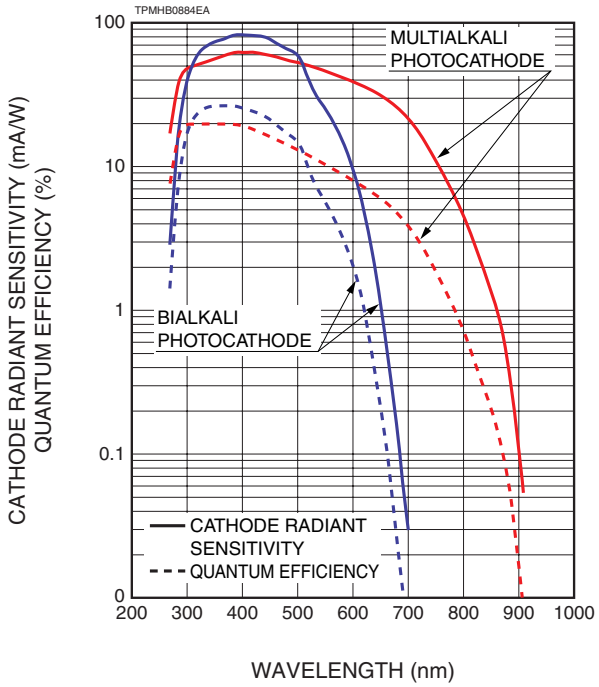
SPECIFICATIONS

(at +25 °C)

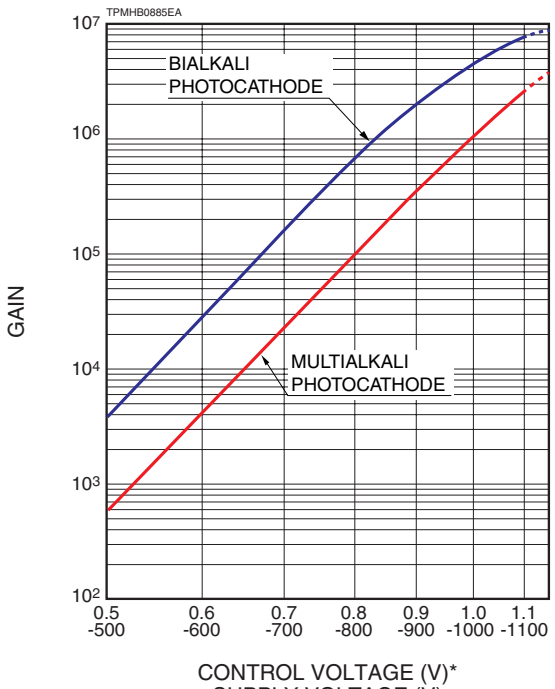
Parameter				H12400-00-01	H12400-01-01	Unit
Spectral response				300 to 650	300 to 850	nm
Peak sensitivity wavelength				420		nm
Photocathode	Material			Bialkali	Multialkali	—
	Effective area			3(X) × 1(Y)		mm
Window material				Borosilicate glass		—
Dynode number of stages				12		—
Maximum ratings	Supply voltage	Between anode and cathode		-1150		V
	Divider current			126		μA
	Average output signal current			5		μA
Cathode	Luminous sensitivity		Min.	50	100	μA/lm
			Typ.	80	200	
	Blue sensitivity index		Typ.	8.0	—	—
	Red / White ratio		Typ.	—	0.2	—
	Radiant sensitivity ①		Typ.	80	62	mA/W
Anode ②	Luminous sensitivity		Min.	30	15	A/lm
			Typ.	160	70	
	Radiant sensitivity ①		Typ.	1.6×10^5	2.1×10^4	A/W
	Dark current ③		Typ.	0.3		nA
			Max.	3		
	Time response	Rise time	Typ.	1.2		ns
		Transit time	Typ.	8.0		
		T.T.S. ④	Typ.	1.3		
Gain ②			Typ.	2×10^6	3.5×10^5	—
Operating ambient temperature				+5 to +50		°C
Storage temperature				-20 to +50		°C
Weight				11		g

①Measured at the peak sensitivity wavelength
②Supply Voltage: -900 V
③After 30 minutes storage in darkness
④T.T.S.=Transit Time Spread (FWHM)

SPECTRAL RESPONSE



GAIN



* Control voltage of a Micro PMT module.

MICRO PMT MODULE
H12402/H12403 SERIES

The H12402/H12403 series are high sensitivity photosensor modules that contain a Micro PMT, a voltage divider circuit, and a high-voltage power supply circuit. These modules can be easily operated with a low voltage supply.

▲Left: H12403 series
Right: H12402 series

PRODUCT VARIATIONS

Type No.	Spectral response	Photocathode material	Features
H12402 / H12403	300 nm to 650 nm	Bialkali	for visible range
H12402-01 / H12403-01	300 nm to 850 nm	Multialkali	for visible to near IR range

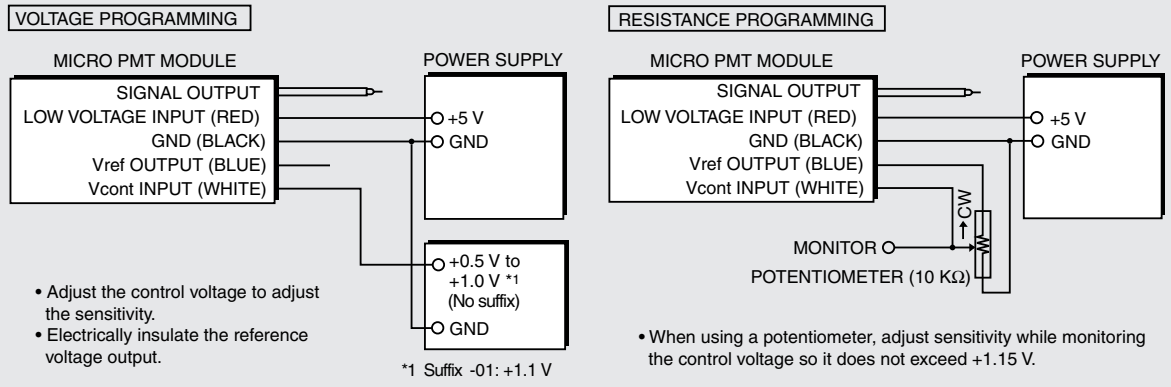
SPECIFICATIONS

(at +25 °C)

Parameter			H12402 / H12403	H12402-01 / H12403-01	Unit
Input voltage			+4.5 to +5.5		V
Maximum input voltage			+5.5		V
Maximum input current ①			20		mA
Maximum average output signal current ②			5		μA
Maximum control voltage			+1.15		V
Recommended control voltage adjustment range			+0.5 to +1.0	+0.5 to +1.1	V
Control voltage input impedance			1		MΩ
Effective area			3(X) × 1(Y)		mm
Peak sensitivity wavelength			420		nm
Cathode	Luminous sensitivity	Min.	50	100	μA/lm
		Typ.	80	200	
	Blue sensitivity index	Typ.	8.0	—	—
	Red / White ratio	Typ.	—	0.2	—
	Radiant sensitivity ③	Typ.	80	62	mA/W
Anode ②	Luminous sensitivity	Min.	30	15	A/lm
		Typ.	160	70	
	Radiant sensitivity ③	Typ.	1.6×10^5	2.1×10^4	A/W
	Dark current ④	Typ.	0.3		nA
		Max.	3		
	Time response Rise time	Typ.	1.2		ns
Gain ②		Typ.	2.0×10^6	3.5×10^5	—
Ripple noise ②⑤ (peak to peak)		Max.	0.3		mV
Settling time ⑥		Max.	10		s
Operating ambient temperature ⑦			+5 to +50		°C
Storage temperature ⑦			-20 to +50		°C
Weight		Typ.	42 (H12402 series), 52 (H12403 series)		g

①At +5 V input voltage, +0.9 V control voltage, and output current equal to dark current
②+0.9 V control voltage
③Measured at the peak sensitivity wavelength
④After 30 minutes storage in darkness.
⑤Cable RG-174/U, Cable length 450 mm, Load resistance=1 MΩ, Load capacitance=22 pF
⑥The time required for the output to reach a stable level following a change in the control voltage from +1.0 V to + 0.5 V.
⑦No condensation

SENSITIVITY ADJUSTMENT METHOD



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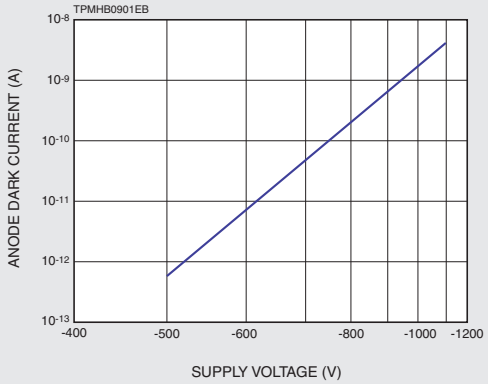
Characteristics

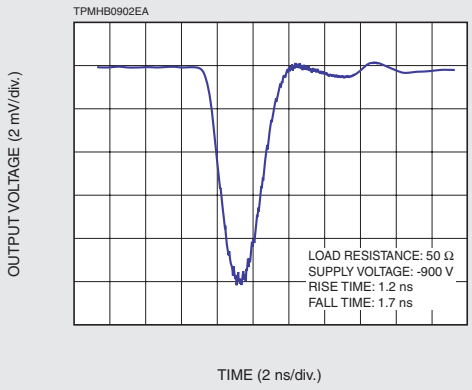
Dark current

A small amount of current is output from a photomultiplier tube even when operated in a completely dark state. This output current is called the anode dark current, and the resulting noise is a critical factor in determining the lower detection limit of photomultiplier tubes. The graph on the right shows typical dark current of a Micro PMT versus the supply voltage.



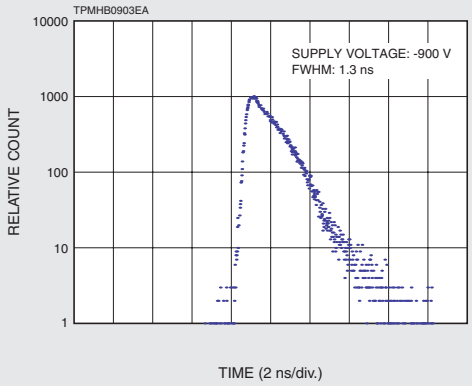
Output waveform

Photomultiplier tubes are photosensors with extremely high speeds. The figure on the right shows an output waveform example of a Micro PMT operating at an anode-to-cathode voltage of -900 V, measured with pulsed light (pulse width: 70 ps) that is sufficiently shorter than the response time of the PMT. This anode output pulse has a rise time of 1.2 ns and a fall time of 1.7 ns.



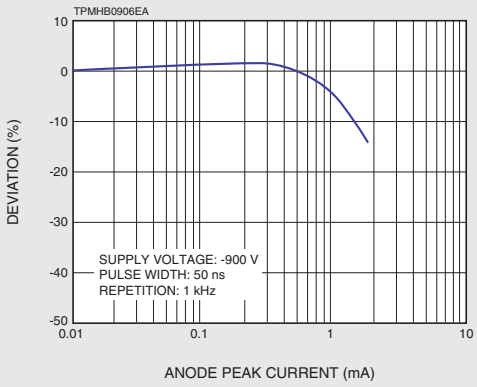
T.T.S. (transit time spread)

The time interval between the arrival of light at the photocathode and the instant when the anode output pulse reaches its peak amplitude is called the electron transit time.
The T.T.S. (transit time spread) indicates the fluctuations of the electron transit time measured when the photocathode is fully illuminated with single photons, and is defined as the FWHM of the histogram of the fluctuations. A typical T.T.S. of Micro PMT is 1.3 ns.



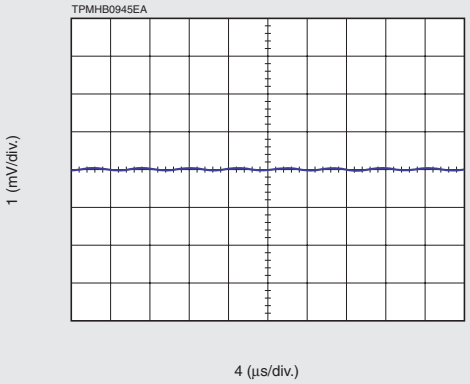
Pulse linearity

When an intense light pulse enters the photocathode of a photomultiplier tube, a large current flows in the latter dynode stages and increases the space charge density, causing current saturation. This causes the anode output to deviate from the ideal linearity. The figure below is a typical linearity of a Micro PMT versus light pulse, showing a deviation of approximately 5 % at an anode peak current of 1 mA.



Ripple noise

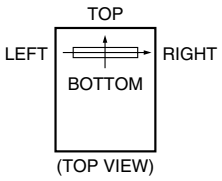
The oscillator circuit used in high-voltage power supplies in photomultiplier tube modules induces noise into the signal input due to oscillation. This induction noise is referred to as ripple. The ripple can be observed on an oscilloscope along the baseline in a low voltage range by feeding the output signal to the oscilloscope input while no light is incident on the modules. For example, under conditions where the load resistance is 1 MΩ and the load capacitance is 22 pF, you will see a signal with an output near 200 μV and a frequency of approximately 220 kHz.

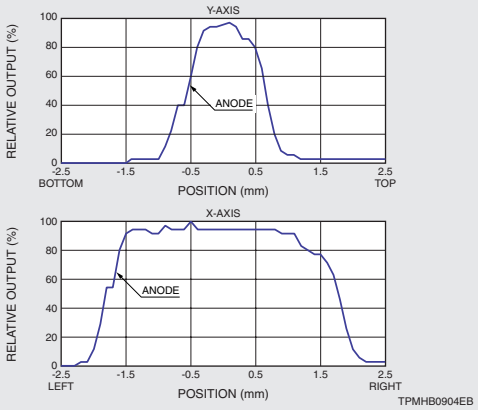


Uniformity

This uniformity is the variation of sensitivity with respect to the incident light position on the photocathode. The figure on the right shows an example of anode output measured by scanning a light spot of 1 mm diameter at 400 nm wavelength over the photocathode surface of a Micro PMT at a pitch of 0.1 mm in the X-axis and Y-axis directions. The output indicates relatively good uniformity.

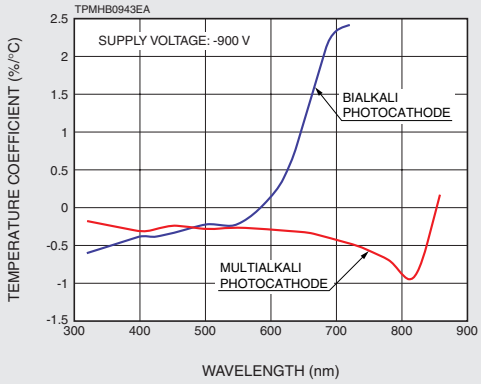
WAVELENGTH: 400 nm
SUPPLY VOLTAGE : -900 V
SPOT DIA. : 1 mm





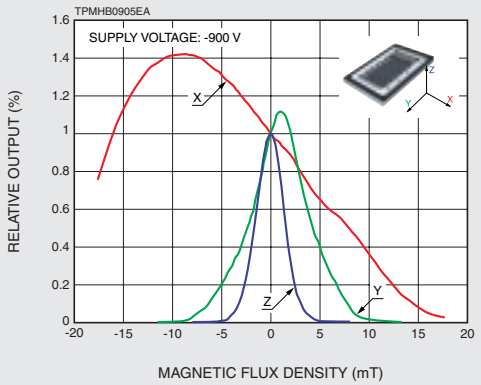
Temperature characteristics

The anode sensitivity of photomultiplier tubes is affected by the ambient temperature. Temperature characteristics for anode sensitivity are wavelength-dependent, and the temperature coefficient generally fluctuates from a negative value to a positive value near the long wavelength limit. The figure on the right shows temperature coefficient data of micro PMT with a bialkali photocathode and multialkali photocathode as a function of wavelength. The temperature coefficient for both photocathodes is approximately -0.3 %/°C at a wavelength around 500 nm.



Magnetic characteristics

An external magnetic field deviates the photoelectrons traveling in a photomultiplier tube from their normal trajectories, causing a loss of gain. The extent of the loss of gain depends on the direction of the magnetic field. The figure on the right shows how magnetic fields affect the output of a Micro PMT. It is seen that the magnetic field in the Z direction most affects the output. Terrestrial magnetism which is less than 0.1 mT will have almost no effect on the output.



MICRO PMT
PHOTO COUNTING HEAD
H12406 SERIES

The H12406 series is a photon counting head that contain a Micro PMT, a high-voltage power supply circuit and a photon counting circuit.
This photon counting head can be easily operated with a low voltage supply.

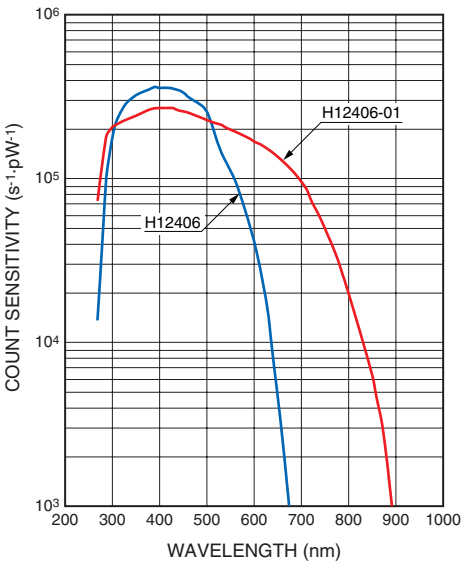
SPECIFICATIONS

(at +25 °C)

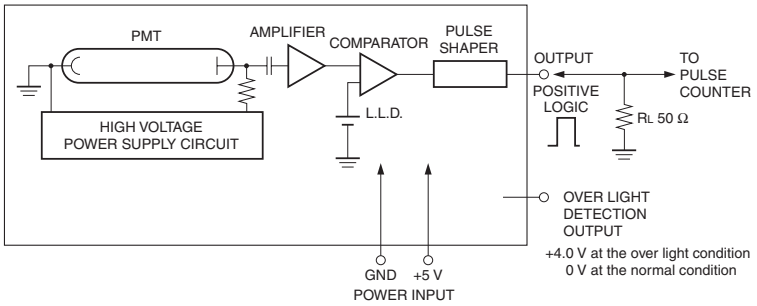
Parameter			H12406	H12406-01	Unit
Input voltage			+4.75 to +5.25		V
Max. Input voltage			+6		V
Max. Input current			40		mA
Effective area			3 × 1		mm
Spectral response			300 to 650	300 to 850	nm
Peak sensitivity wave length			420		nm
Count sensitivity	Typ.	300 nm	1.7×10^5	2.1×10^5	$s^{-1} \cdot pW^{-1}$
		400 nm	3.6×10^5	2.7×10^5	
		500 nm	2.6×10^5	2.3×10^5	
		600 nm	4.3×10^4	1.7×10^5	
		700 nm	1.4×10^2	9.6×10^4	
		800 nm	—	2.1×10^4	
Count linearity ①			5.0×10^6		s^{-1}
Dark count ②		Typ.	10	100	s^{-1}
		Max.	50	500	
Pulse-pair resolution			20		ns
Output pulse width			10		ns
Output pulse height (at load resistance 50 Ω)		Min.	+2.0		V
		Typ.	+2.2		
Recommended load resistance			50		Ω
Signal output logic			Positive logic		—
Excessive light detection output ③	Excessive light incident	Min.	+3.5		V
	Normally	Max.	+0.5		V
Operating ambient temperature ④			+5 to +50		°C
Storage temperature ④			-20 to +50		°C
Weight			46		g

①Random pulse, at 10% count loss
②After 30 minute storage in darkness
③Load resistance 10 kΩ
④No condensation

COUNT SENSITIVITY



BLOCK DIAGRAM

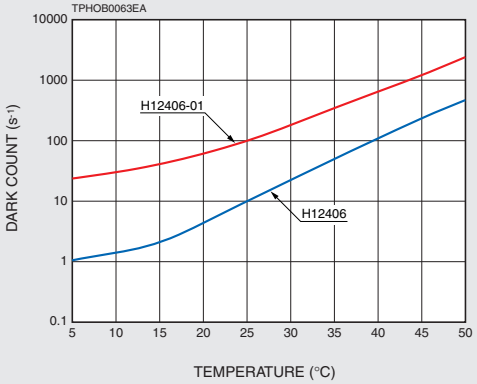


TPMOC0226EB

Characteristics

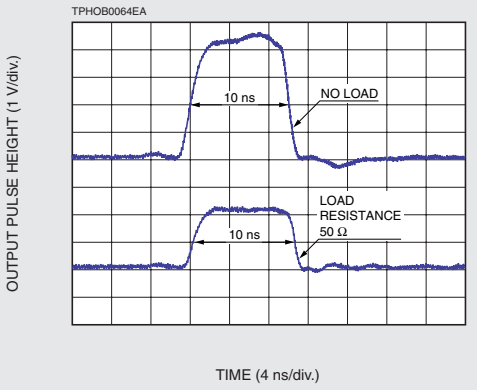
Dark count

Some dark current pulses are generated in a photomultiplier tube during operation even if no light is incident on it. These dark current pulses are amplified by an amplifier and then only those dark pulses with a height exceeding a certain discriminator threshold are output through a pulse shaper. This output, expressed in counts per second (s^{-1}), is the dark count and indicates the lower limit of signal detection.



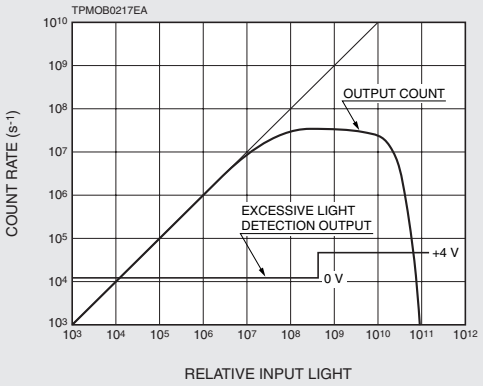
Output waveform

Output waveforms are positive logic signals. The figure on the right shows output waveforms measured with and without a load resistance of 50 Ω. Since photon counting head handles high-speed signals, a 50 Ω impedance cable is usually connected between a photon counting head and external device, and the input impedance of the external device should also preferably be 50 Ω.



Count linearity and excessive light detection characteristics

In a random light input event, when the light level increases and exceeds a certain level, the output pulses begin to overlap each other and the count value is no longer proportional to the light level. As the light level further increases causing more pulses to overlap, the number of output pulses gradually saturates and then begins to decrease and eventually reaches 0. Count linearity is specified as the count value at which a 10 % loss occurs in the counted value compared to the theoretical value.
If the incident light level largely exceeds the count linearity, a signal (4.0 V) is output to indicate an excessive light input.



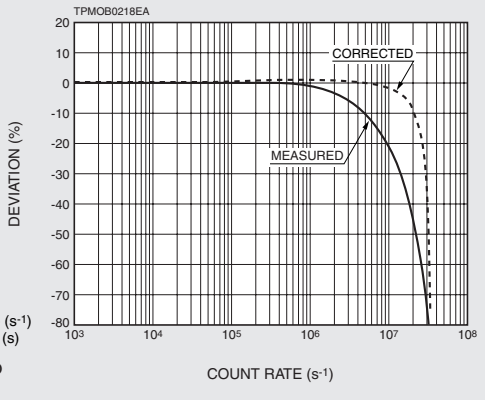
Count rate correction

When the number of pulses measured by photon counting exceeds 10^6 s^{-1}, counting errors begin to occur due to pulse overlap. One method for improving the count linearity utilizes a correction formula to find the approximate values. The graph on the right shows improved count linearity characteristics obtained by using a correction formula to find the approximate values.

Linearity correction formula

$$N = \frac{M}{1-Mt}$$

N: real count rate (s^{-1})
M: measured count rate (s^{-1})
t: pulse pair-resolution (s)

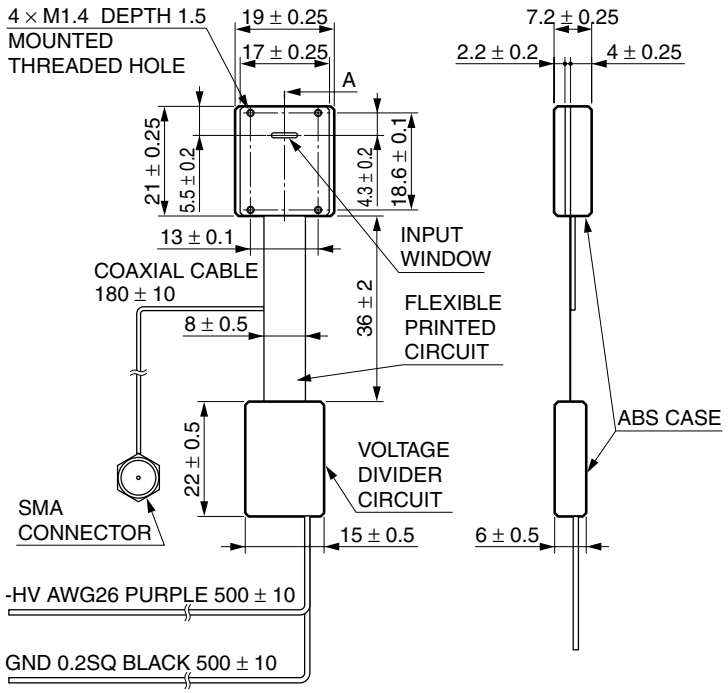


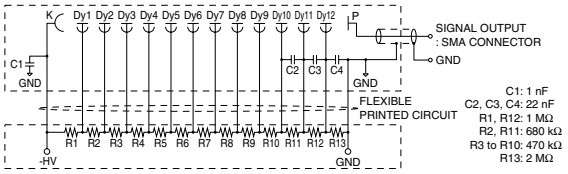
* Micro PMT photon counting head H12406 series do not have the function to automaticlly output a correction value.

■ DIMENSIONAL OUTLINES (Unit: mm)

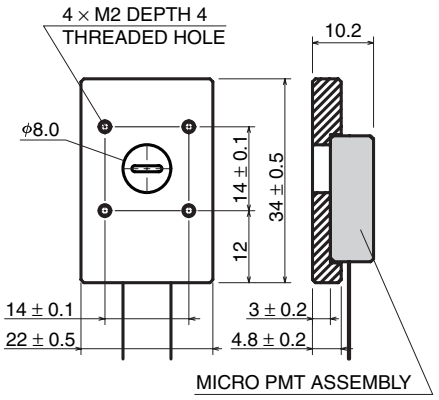
MICRO PMT ASSEMBLY

■ H12400 Series





DEDICATED ADAPTOR FOR OPTICAL BLOCK TO MICRO PMT ASSEMBLY *



* Dedicated Adaptor for optical block is supplied.

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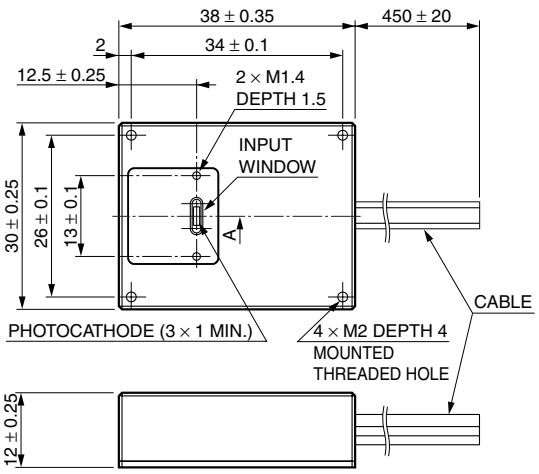
MICRO PMT MODULE

■ H12402 Series



●CABLE

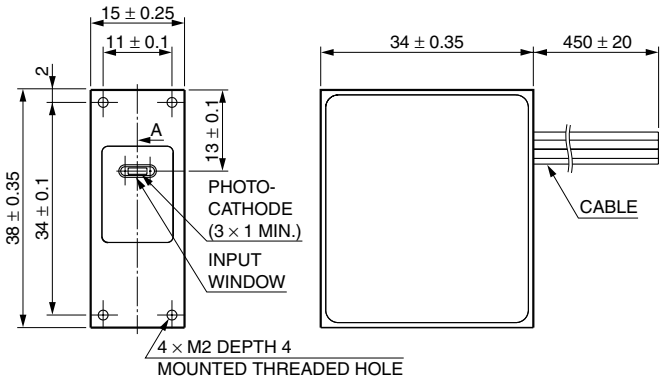
LOW VOLTAGE INPUT (+5 V)	: AWG26 (RED)
GND	: AWG26 (BLACK)
Vref OUTPUT (+1.2 V)	: AWG26 (BLUE)
Vcont INPUT	: AWG26 (WHITE)
SIGNAL OUTPUT	: RG-174/U

Weight: 42 g

TPMOA0083EC

MICRO PMT MODULE

■ H12403 Series



●CABLE

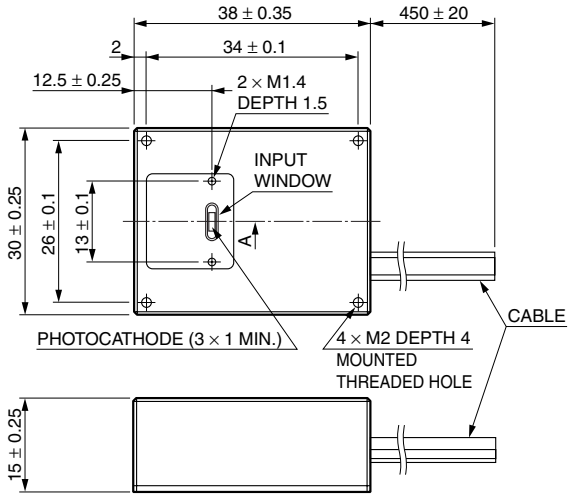
LOW VOLTAGE INPUT (+5 V)	: AWG26 (RED)
GND	: AWG26 (BLACK)
Vref OUTPUT (+1.2 V)	: AWG26 (BLUE)
Vcont INPUT	: AWG26 (WHITE)
SIGNAL OUTPUT	: RG-174/U

Weight: 52 g

TPMOA0084EC

MICRO PMT PHOTON COUNTING HEAD

■ H12406 Series



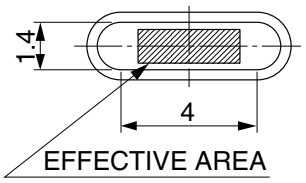
●CABLE

LOW VOLTAGE INPUT (+5 V)	: AWG26 (RED)
GND	: AWG26 (BLACK)
OVER LIGHT DETECTION OUTPUT	: AWG26 (BLUE)
SIGNAL OUTPUT	: RG-174/U

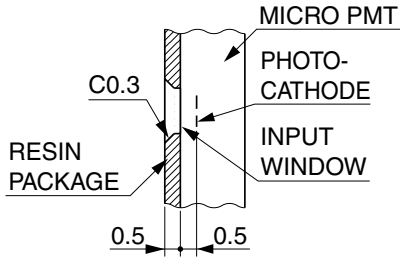
Weight: 46 g

TPMOA0091EB

■ DETAILS OF INPUT WINDOW



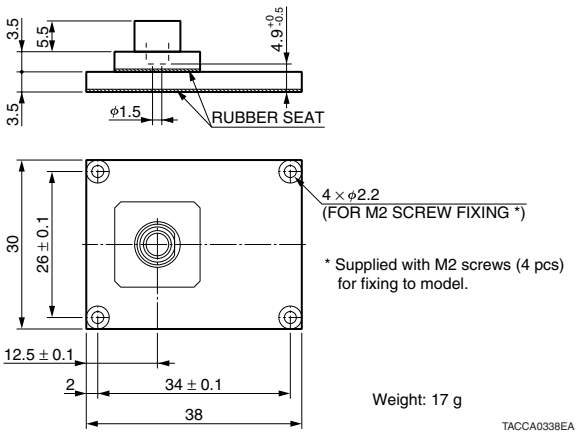
■ A CROSS SECTION



TPMHA0590EB

■ OPTION (sold separately)

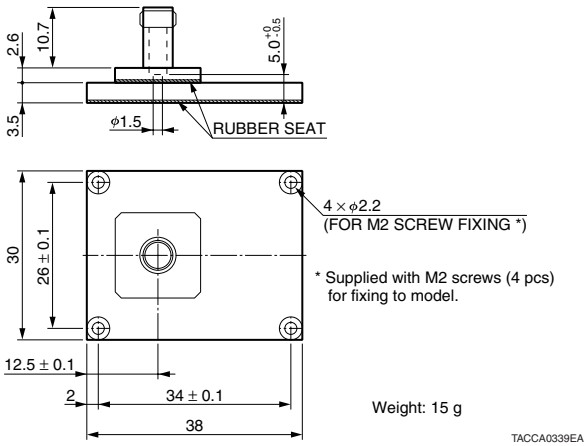
● E13561 (FC type)



Weight: 17 g

TACCA0338EA

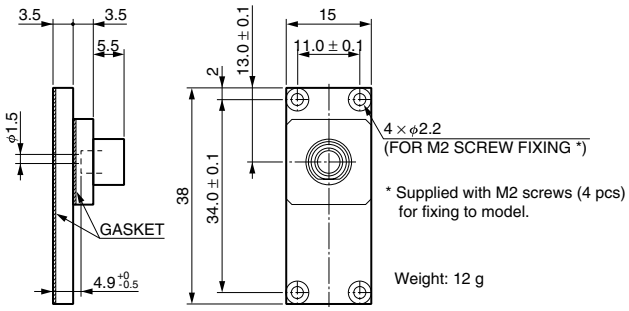
● E13562 (SMA type)



Weight: 15 g

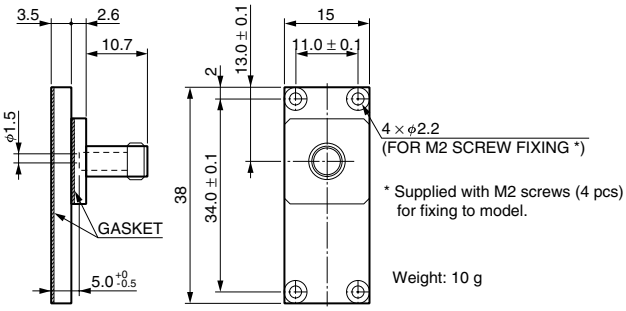
TACCA0339EA

● E13563 (FC type)



Weight: 12 g

● E13564 (SMA type)



Weight: 10 g

* E13561 and E13562 are the exclusive options for H12402/H12406 series. E13563 and E13564 are the exclusive options for H12403 series.

Related Products

HIGH VOLTAGE POWER SUPPLY C10940 SERIES 0.7 W output 1200 V / 0.6 mA

The C10940 series is a high voltage power supply module developed for compact size and high performance. This is designed to mount on a printed circuit making them ideal for use with a H12400 series Micro PMT assembly. Besides high performance and low power consumption, a variety of protective functions are also included.

Protective Functions: Units protected against reversed power input, reversed / excessive controlling voltage input, continuous over loading / short circuit output

Parameter		C10940-03	C10940-03-R2*	C10940-53	C10940-53-R2*	Unit
Input Voltage		+5 ± 0.5				V
Input Current ①	Typ.	60 (no load), 230 (full load)				mA
Output Voltage		-10 to -1200		+10 to +1200		V
Output Current	Max.	0.6				mA
Ripple / Noise (p-p) ①②	Typ.	50				mV
Operating Ambient Temperature ①② / Humidity ③		0 °C to +50 °C / Below 80 %				—
Storage Temperature / Humidity ③		-20 °C to +60 °C / Below 80 %				—
Weight	Typ.	8.5				g
Dimensions (W × H × D)		15 × 18 × 15				mm

①: At maximum output voltage ②: At maximum output current ③: No condensation
* -R2 type: RS-485 control

▲C10709

POWER SUPPLY FOR PMT MODULE C10709

The C10709 is a power supply unit designed to operate a PMT module. This unit supplies both drive voltage and control voltage, making it ideal for operating the H12402 series and H12403 series Micro PMT modules.

▲ (Rear) C7319, C9663, C6438
(Front) C11184, C5594-44

AMPLIFIER UNITS

These amplifier units convert the signal current input from a photomultiplier tube into a voltage output. Please select the desired type with a frequency range and current-to-voltage conversion factor that match your applications.

PHOTON COUNTING CONFIGURATION EXAMPLE

▲Micro PMT assembly
H12400 series

▲Micro PMT modules
H12402, H12403 series

▲Micro PMT photon counting head
H12406 series

▲Photon Counting Unit C9744

▲Counting Unit C8855-01

USB

PC

* μPMT is the registered trademark of Hamamatsu Photonics K.K. in Japan, U.S.A., and EU.

HAMAMATSU PHOTONICS K.K. www.hamamatsu.com

HAMAMATSU PHOTONICS K.K., Electron Tube Division
314-5, Shimokanzo, Iwata City, Shizuoka Pref., 438-0193, Japan, Telephone: (81)539/62-5248, Fax: (81)539/62-2205

U.S.A.: Hamamatsu Corporation: 360 Foothill Road, Bridgewater. N.J. 08807-0910, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: usa@hamamatsu.com
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-2658 E-mail: info@hamamatsu.de
France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: infos@hamamatsu.fr
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, United Kingdom, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: info@hamamatsu.co.uk
North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 SE-164 40 Kista, Sweden, Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01 E-mail: info@hamamatsu.se
Italy: Hamamatsu Photonics Italia S.r.l.: Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy, Telephone: (39)02-93581733, Fax: (39)02-93581741 E-mail: info@hamamatsu.it
China: Hamamatsu Photonics (China) Co., Ltd.: B1201 Jiaming Center, No.27 Dongsanhuan Beilu, Chaoyang District, Beijing 100020, China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: hpc@hamamatsu.com.cn

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