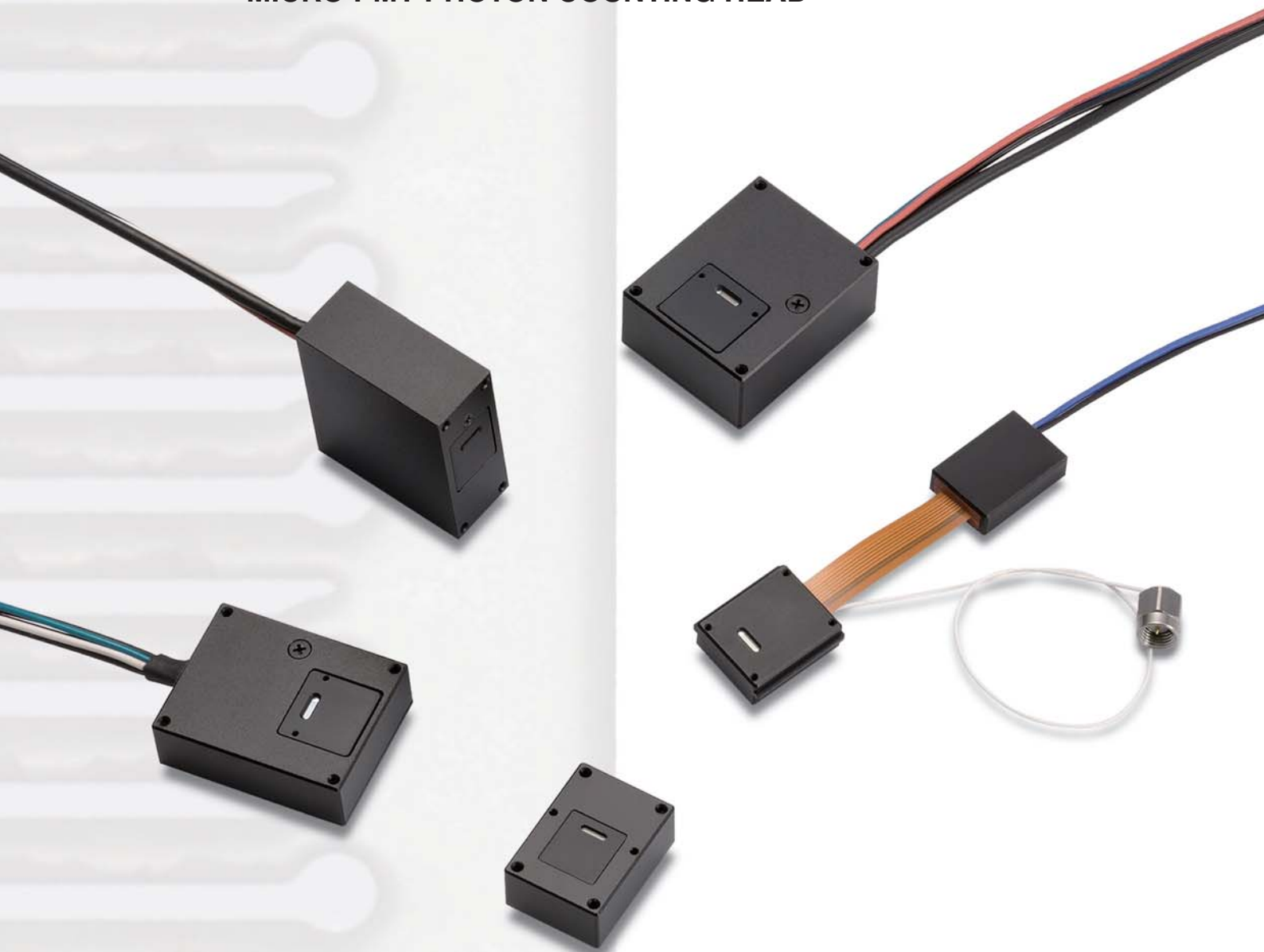


# micro $\mu$ PMT<sup>®</sup> **HAMAMATSU**

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)

### 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.

### 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.

### 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.

### Customizing support

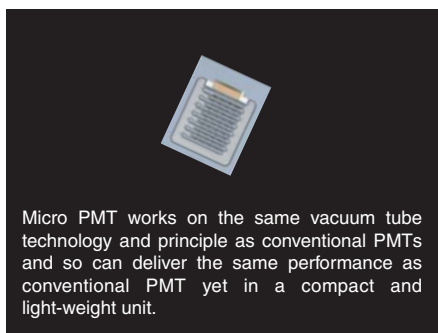
Feel free to consult with us on customizing to match customer usage conditions and environments.

### High sensitivity and fast response

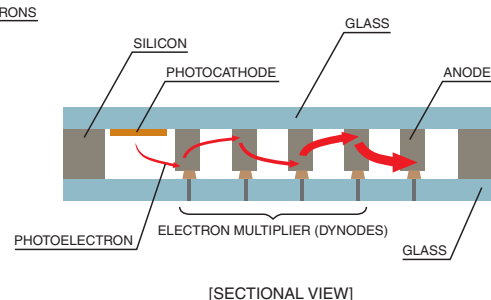
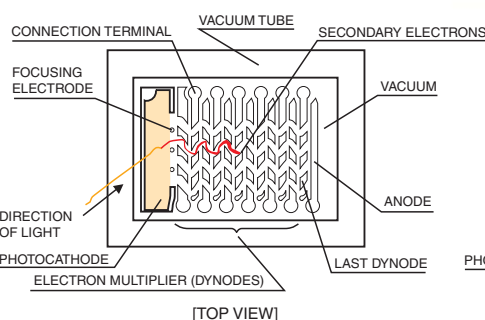
Micro PMT utilizes the same high precision structure for electrode arrangement as conventional PMTs and so provides the high sensitivity and fast response needed from a PMT.

micro  
**μPMT®**  
**HAMAMATSU**

### Full-scale Micro PMT image!



### Micro PMT internal structure



## 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.

micro  
PMT®  
HAMAMATSU

## PRODUCT CONFIGURATION

|                        | Assembly type   | Module type   |   |   |   |
|------------------------|---|---|---|---|---|
| Basic configuration    | Micro PMT + Divider circuit   | Micro PMT + Divider circuit + High voltage power supply circuit                     |   |   |   |
| Additional function    | Current output  |   | Voltage output  | Photon counting   |   |
| Appearance             |  |  |  |  |  |
|                        | H12400 series   | H14066 series   | H12402/H12403 series  | H12404/H12405 series  | H12406 series   |
| Spectral response (nm) | 300 to 650<br>300 to 850<br>300 to 920  | 300 to 650<br>300 to 850  | 300 to 650<br>300 to 850<br>300 to 920  | 300 to 650<br>300 to 850<br>300 to 920  | 300 to 650<br>300 to 850<br>300 to 920  |



# 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.



### PRODUCT VARIATIONS

| Type No.     | Spectral response | Photocathode material    | Features                     |
|--------------|-------------------|--------------------------|------------------------------|
| H12400-00-01 | 300 nm to 650 nm  | Bialkali                 | for visible range            |
| H12400-01-01 | 300 nm to 850 nm  | Multialkali              | for visible to near IR range |
| H12400-20-01 | 300 nm to 920 nm  | Extended red multialkali | for visible to near IR range |

### SPECIFICATIONS

(at +25 °C)

| Parameter                       |                                  |                           |              | H12400-00-01          | H12400-01-01          | H12400-20-01          | Unit  |
|---------------------------------|----------------------------------|---------------------------|--------------|-----------------------|-----------------------|-----------------------|-------|
| Peak sensitivity wavelength     |                                  |                           |              | 420                   |                       | 630                   | nm    |
| Window material                 |                                  |                           |              | 3(X) × 1(Y)           |                       |                       | mm    |
| Effective area                  |                                  |                           |              | 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                   | 300                   | μA/lm |
|                                 |                                  |                           | Typ.         | 80                    | 200                   | 400                   |       |
|                                 | Blue sensitivity index (CS 5-58) |                           | Typ.         | 8.0                   | —                     | —                     |       |
|                                 | Red / White ratio                |                           | Typ.         | —                     | 0.2                   | 0.45                  | —     |
|                                 | Radiant sensitivity ①            |                           | Typ.         | 80                    | 62                    | 60                    | mA/W  |
| Anode ②                         | Luminous sensitivity             |                           | Min.         | 30                    | 15                    | 30                    | A/lm  |
|                                 |                                  |                           | Typ.         | 160                   | 70                    | 100                   |       |
|                                 | Radiant sensitivity ①            |                           | Typ.         | 1.6 × 10 <sup>5</sup> | 2.1 × 10 <sup>4</sup> | 1.5 × 10 <sup>4</sup> | A/W   |
|                                 |                                  |                           | Typ.         | 0.3                   |                       | 0.6                   |       |
|                                 | Dark current ③                   |                           | Max.         | 3                     |                       | 6                     | nA    |
|                                 |                                  |                           | Typ.         | 1.2                   |                       |                       |       |
|                                 | Time response                    |                           | Rise time    | Typ.                  |                       |                       | ns    |
|                                 |                                  |                           | Transit time | Typ.                  |                       |                       |       |
|                                 |                                  | T.T.S. ④                  | Typ.         |                       |                       |                       |       |
| Gain ②                          |                                  |                           | Typ.         | 2.0 × 10 <sup>6</sup> | 3.5 × 10 <sup>5</sup> | 2.5 × 10 <sup>5</sup> | —     |
| Operating ambient temperature ⑤ |                                  |                           |              | +5 to +50             |                       |                       | °C    |
| Storage temperature ⑤           |                                  |                           |              | -20 to +50            |                       |                       | °C    |
| Weight                          |                                  |                           |              | 11                    |                       |                       | g     |

① Measured at the peak sensitivity wavelength

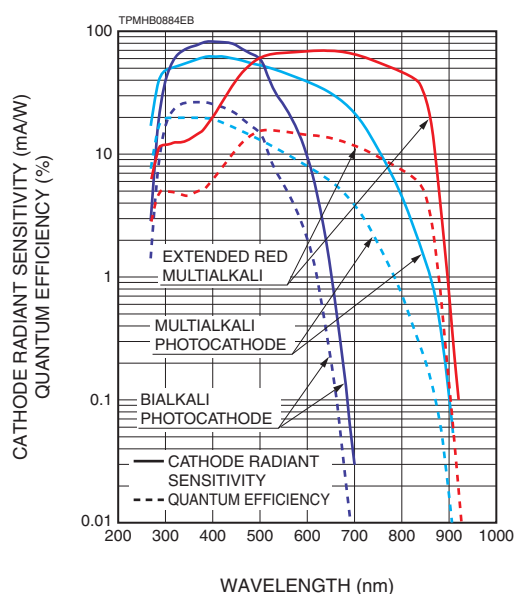
② Supply Voltage: -900 V

③ After 30 minutes storage in darkness

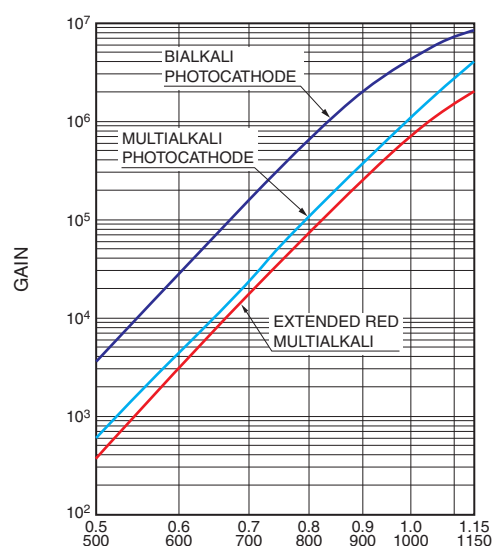
④ T.T.S.=Transit Time Spread (FWHM)

⑤ No condensation

### SPECTRAL RESPONSE



### GAIN



\* Control voltage of a Micro PMT module.

# MICRO PMT MODULE

## H14066 SERIES

The H14066 series is a high sensitivity photosensor module that contain a Micro PMT, a voltage divider circuit, and a high-voltage power supply circuit. This module pin output type can board mounting, which can be easily operated with a low voltage supply.



### PRODUCT VARIATIONS

| Type No.  | Spectral response | Photocathode material | Features                     |
|-----------|-------------------|-----------------------|------------------------------|
| H14066    | 300 nm to 650 nm  | Bialkali              | for visible range            |
| H14066-01 | 300 nm to 850 nm  | Multialkali           | for visible to near IR range |

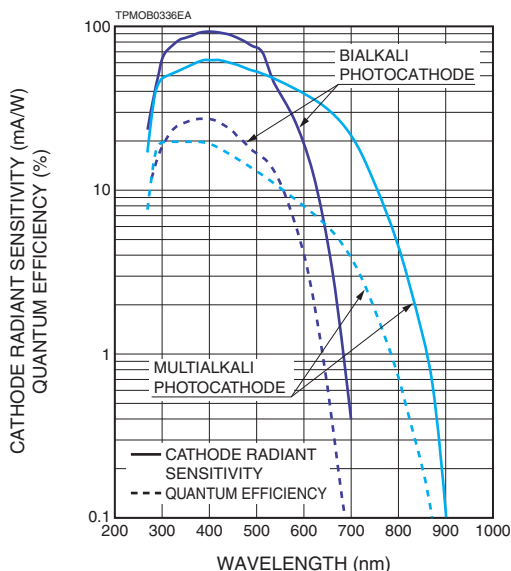
### SPECIFICATIONS

(at +25 °C)

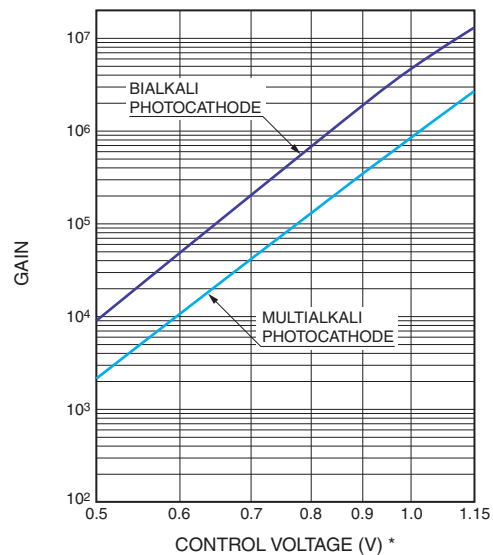
| Parameter                                    |                                   |           | H14066                | H14066-01             | Unit  |
|--|-----------------------------------|-----------|-----------------------|-----------------------|-------|
| Peak sensitivity wavelength                  |                                   |           | 420                   |                       | nm    |
| Effective area                               |                                   |           | 4(X) × 1(Y)           |                       | mm    |
| Window material                              |                                   |           | Borosilicate glass    |                       | —     |
| Dynode number of stages                      |                                   |           | 10                    |                       | —     |
| Input voltage                                |                                   |           | +4.75 to +5.25        |                       | V     |
| Maximum input voltage                        |                                   |           | +5.5                  |                       | V     |
| Maximum input current <sup>①</sup>           |                                   |           | 5                     |                       | mA    |
| Maximum average output signal current        |                                   |           | 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    |
| Cathode                                      | Luminous sensitivity              | Min.      | 70                    | 100                   | μA/lm |
|  |                                   | Typ.      | 100                   | 200                   |       |
|  | Blue sensitivity index (CS 5-58)  | Typ.      | 11.5                  | —                     | —     |
|  | Red / White ratio                 | Typ.      | —                     | 0.2                   | —     |
|  | Radiant sensitivity <sup>②</sup>  | Typ.      | 93                    | 62                    | mA/W  |
| Anode <sup>②</sup>                           | Luminous sensitivity <sup>③</sup> | Min.      | 30                    | 15                    | A/lm  |
|  |                                   | Typ.      | 200                   | 70                    |       |
|  | Radiant sensitivity <sup>②③</sup> | Typ.      | 1.9 × 10 <sup>5</sup> | 2.2 × 10 <sup>4</sup> | A/W   |
|  | Dark current <sup>③④</sup>        | Typ.      | 0.3                   |                       | nA    |
|  |                                   | Max.      | 3                     |                       |       |
|  | Time response                     | Rise time | Typ.                  | 1.2                   |       |
| Gain   |                                   | Typ.      | 2.0 × 10 <sup>6</sup> | 3.5 × 10 <sup>5</sup> | —     |
| Ripple noise <sup>③⑤</sup> (peak to peak)    |                                   | Max.      | 0.3                   |                       | mV    |
| Settling time <sup>⑥</sup>                   |                                   | Max.      | 10                    |                       | s     |
| Operating ambient temperature <sup>⑦</sup>   |                                   |           | +5 to +50             |                       | °C    |
| Storage temperature <sup>⑦</sup>             |                                   |           | -20 to +50            |                       | °C    |
| Weight                                       |                                   |           | 10                    |                       | g     |

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

### SPECTRAL RESPONSE



### GAIN



# 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 |
| H12402-20 / H12403-20 | 300 nm to 920 nm  | Extended red multialkali | for visible to near IR range |

### SPECIFICATIONS

(at +25 °C)

| Parameter  |                                  |                           | H12402 / H12403                        | H12402-01 / H12403-01 | H12402-20 / H12403-20 | Unit                  |     |
|--|----------------------------------|---------------------------|--|-----------------------|-----------------------|-----------------------|-----|
| Peak sensitivity wavelength                        |                                  |                           | 420                                    |                       | 630                   | nm                    |     |
| Effective area                                     |                                  |                           | 3(X) × 1(Y)                            |                       |                       | mm                    |     |
| Window material                                    |                                  |                           | Borosilicate glass                     |                       |                       | —                     |     |
| Dynode number of stages                            |                                  |                           | 12                                     |                       |                       | —                     |     |
| Input voltage                                      |                                  |                           | +4.5 to +5.5                           |                       |                       | V                     |     |
| Maximum input voltage                              |                                  |                           | +5.5                                   |                       |                       | V                     |     |
| Maximum input current <sup>①</sup>                 |                                  |                           | 20                                     |                       |                       | mA                    |     |
| Maximum average output signal current <sup>②</sup> |                                  |                           | 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                    |     |
| Cathode  | Luminous sensitivity             | Min.                      | 50                                     | 100                   | 300                   | μA/lm                 |     |
|  |                                  | Typ.                      | 80                                     | 200                   | 400                   |                       |     |
|  | Blue sensitivity index (CS 5-58) | Typ.                      | 8.0                                    | —                     | —                     | —                     |     |
|  | Red / White ratio                | Typ.                      | —                                      | 0.2                   | 0.45                  | —                     |     |
|  | Radiant sensitivity <sup>③</sup> | Typ.                      | 80                                     | 62                    | 60                    | mA/W                  |     |
| Anode <sup>②</sup>                                 | Luminous sensitivity             | Min.                      | 30                                     | 15                    | 30                    | A/lm                  |     |
|  |                                  | Typ.                      | 160                                    | 70                    | 100                   |                       |     |
|  | Radiant sensitivity <sup>③</sup> | Typ.                      | 1.6 × 10 <sup>5</sup>                  | 2.1 × 10 <sup>4</sup> | 1.5 × 10 <sup>4</sup> | A/W                   |     |
|  |                                  | Dark current <sup>④</sup> | Typ.                                   | 0.3                   |                       |                       | 0.6 |
|  | Max.                             |                           | 3                                      |                       | 6                     |                       |     |
|  | Time response                    | Rise time                 | Typ.                                   | 1.2                   |                       | ns                    |     |
| Gain <sup>②</sup>                                  |                                  |                           | Typ.                                   | 2.0 × 10 <sup>6</sup> | 3.5 × 10 <sup>5</sup> | 2.5 × 10 <sup>5</sup> | —   |
| Ripple noise <sup>②⑤</sup> (peak to peak)          |                                  |                           | Max.                                   | 0.3                   |                       |                       | mV  |
| Settling time <sup>⑥</sup>                         |                                  |                           | Max.                                   | 10                    |                       |                       | s   |
| Operating ambient temperature <sup>⑦</sup>         |                                  |                           | +5 to +50                              |                       |                       | °C                    |     |
| Storage temperature <sup>⑦</sup>                   |                                  |                           | -20 to +50                             |                       |                       | °C                    |     |
| Weight   |                                  | Typ.                      | 42 (H12402 series), 52 (H12403 series) |                       |                       | g                     |     |

① At +5 V input voltage, +0.9 V control voltage, and output current equal to dark current

② +0.9 V control voltage

③ Measured at the peak sensitivity wavelength

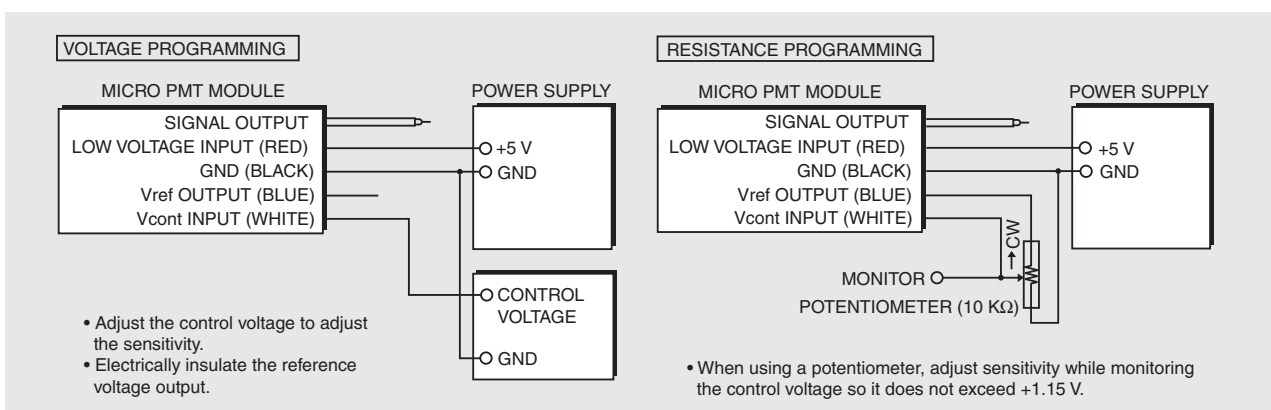
④ After 30 minutes storage in darkness.

⑤ Cable RG-174/U, Cable length 450 mm, Load resistance=1 MΩ, Load capacitance=22 pF

⑥ The 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.

⑦ No condensation

### SENSITIVITY ADJUSTMENT METHOD



# MICRO PMT MODULE

## H12404/H12405 SERIES

The H12404/H12405 series are high sensitivity photosensor modules that contain a Micro PMT, a voltage divider circuit, and a high-voltage power supply circuit and amplifier circuit. These modules can be easily operated with a low voltage supply.



▲Left: H12405 series  
Right: H12404 series

## PRODUCT VARIATIONS

| Type No.              | Spectral response | Photocathode material    | Features                     |
|-----------------------|-------------------|--------------------------|------------------------------|
| H12404 / H12405       | 300 nm to 650 nm  | Bialkali                 | for visible range            |
| H12404-01 / H12405-01 | 300 nm to 850 nm  | Multialkali              | for visible to near IR range |
| H12404-20 / H12405-20 | 300 nm to 920 nm  | Extended red multialkali | for visible to near IR range |

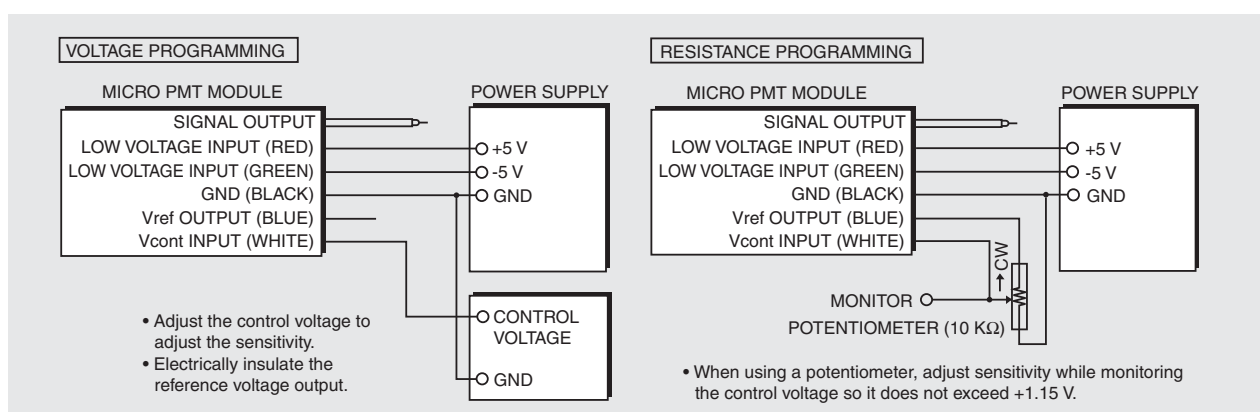
## SPECIFICATIONS

(at +25 °C)

| Parameter                                    |                                  |   | H12404 / H12405                        | H12404-01 / H12405-01 | H12404-20 / H12405-20 | Unit  |
|--|----------------------------------|---|--|-----------------------|-----------------------|-------|
| Peak sensitivity wavelength                  |                                  |   | 420                                    |                       | 630                   | nm    |
| Effective area                               |                                  |   | 3(X) × 1(Y)                            |                       |                       | mm    |
| Window material                              |                                  |   | Borosilicate glass                     |                       |                       | —     |
| Dynode number of stages                      |                                  |   | 12                                     |                       |                       | —     |
| Input voltage                                |                                  |   | ±4.5 to ±5.5                           |                       |                       | V     |
| Maximum input voltage                        |                                  |   | ±5.5                                   |                       |                       | V     |
| Maximum input current ①                      |                                  |   | +23.5 / -3.5                           |                       |                       | mA    |
| Maximum average output signal current        |                                  |   | +4 (Load resistance 10 kΩ)             |                       |                       | V     |
| 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    |
| Cathode                                      | Luminous sensitivity             | Min.  | 50                                     | 100                   | 300                   | μA/lm |
|  |                                  | Typ.  | 80                                     | 200                   | 400                   |       |
|  | Blue sensitivity index (CS 5-58) | Typ.  | 8.0                                    | —                     | —                     | —     |
|  | Red / White ratio                | Typ.  | —                                      | 0.2                   | 0.45                  | —     |
|  | Radiant sensitivity ②            | Typ.  | 80                                     | 62                    | 60                    | mA/W  |
| Anode ②                                      | Luminous sensitivity ③           | Min.  | 3.0 × 10 <sup>7</sup>                  | 1.5 × 10 <sup>7</sup> | 3.0 × 10 <sup>7</sup> | V/lm  |
|  |                                  | Typ.  | 1.6 × 10 <sup>8</sup>                  | 7.0 × 10 <sup>7</sup> | 1.0 × 10 <sup>8</sup> |       |
|  | Radiant sensitivity ②③           | Typ.  | 160                                    | 21                    | 15                    | V/nW  |
|  |                                  | Voltage output depending on PMT dark current ③④ | Typ.                                   | 0.3                   |                       |       |
|  | Max.                             |   | 3                                      |                       | 6                     | mV    |
| PMT gain                                     |                                  | Typ.  | 2.0 × 10 <sup>6</sup>                  | 3.5 × 10 <sup>5</sup> | 2.5 × 10 <sup>5</sup> | —     |
| Frequency bandwidth                          |                                  |   | DC to 20 kHz                           |                       |                       | —     |
| Current-to-voltage conversion factor         |                                  |   | 1                                      |                       |                       | V/μA  |
| Output offset voltage                        |                                  | Typ.  | ±1                                     |                       |                       | mV    |
| Ripple noise ③⑤ (peak to peak)               |                                  | Max.  | 1.5                                    |                       |                       | mV    |
| Settling time ⑥                              |                                  | Max.  | 10                                     |                       |                       | s     |
| Operating ambient temperature ⑦              |                                  |   | +5 to +50                              |                       |                       | °C    |
| Storage temperature ⑦                        |                                  |   | -20 to +50                             |                       |                       | °C    |
| Weight                                       |                                  |   | 44 (H12404 series), 54 (H12405 series) |                       |                       | g     |

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

## SENSITIVITY ADJUSTMENT METHOD

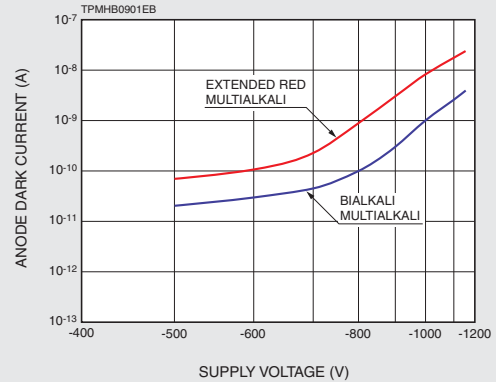


\* See page 4 for spectral response and gain.

# Characteristics

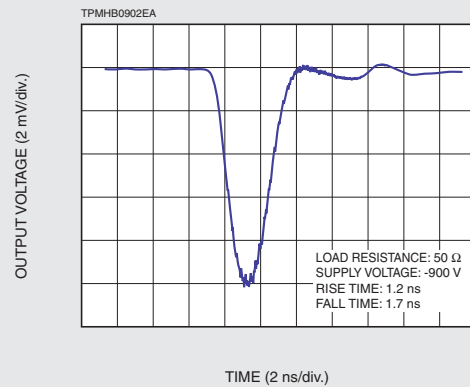
## Dark current

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

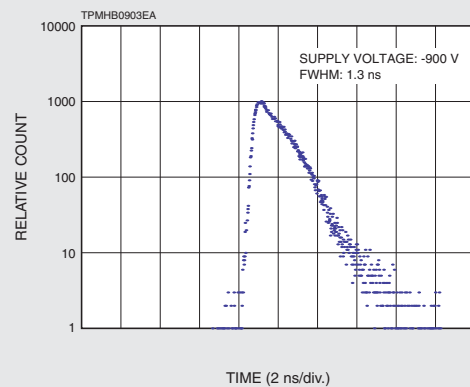
Photomultiplier tubes are photosensors with extremely high speeds. The figure on the right shows an output waveform example of a Micro PMT operating at an anode-to-cathode voltage of -900 V, measured with pulsed light (pulse width: 70 ps) that is sufficiently shorter than the response time of the PMT.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

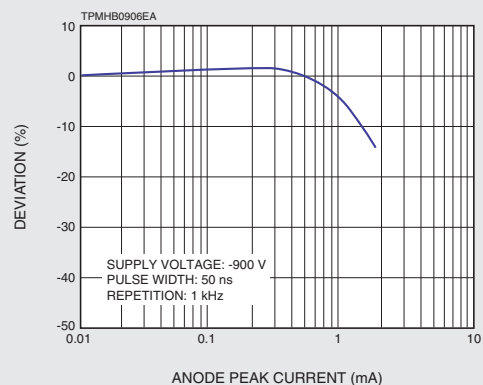
The time interval between the arrival of light at the photocathode and the instant when the anode output pulse reaches its peak amplitude is called the electron transit time.

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

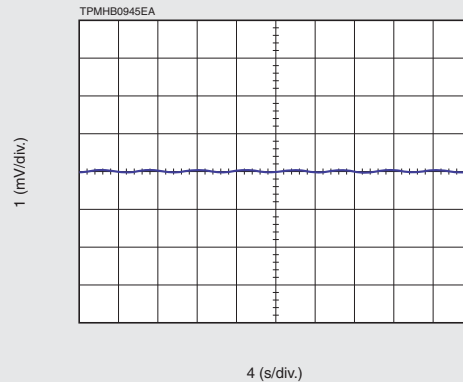
When an intense light pulse enters the photocathode of a photomultiplier tube, a large current flows in the latter dynode stages and increases the space charge density, causing current saturation. This causes the anode output to deviate from the ideal linearity. The figure below is a typical linearity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





## Ripple noise

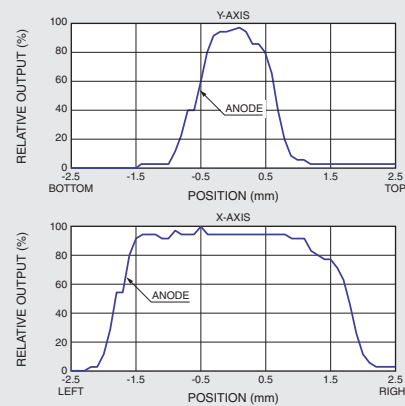
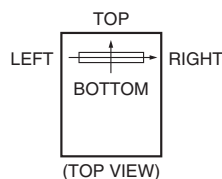
The oscillator circuit used in high-voltage power supplies in photomultiplier tube modules induces noise into the signal input due to oscillation. This induction noise is referred to as ripple. The ripple can be observed on an oscilloscope along the baseline in a low voltage range by feeding the output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



## Uniformity

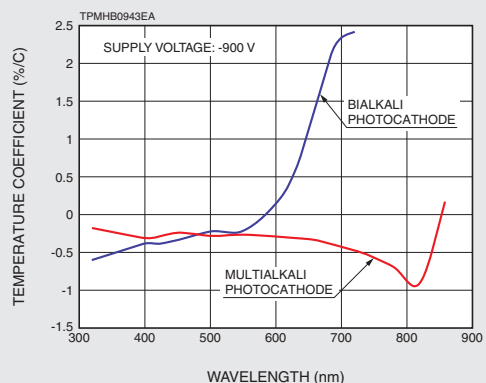
This uniformity is the variation of sensitivity with respect to the incident light position on the photocathode. The figure on the right shows an example of anode output measured by scanning a light spot of  $1\text{ mm}$  diameter at  $400\text{ nm}$  wavelength over the photocathode surface of a Micro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

WAVELENGTH:  $400\text{ nm}$   
SUPPLY :  $-900\text{ V}$   
VOLTAGE  
SPOT DIA. :  $1\text{ mm}$



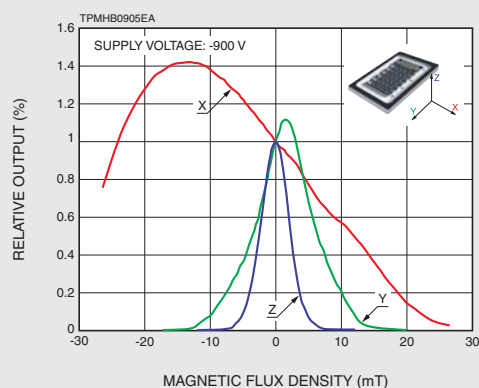
## Temperature characteristics

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  $-0.3\text{ \%}/\text{C}$  at a wavelength around  $500\text{ nm}$ .



## 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  $0.1\text{ mT}$  will have almost no effect on the output.



# MICRO PMT PHOTON 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.



## PRODUCT VARIATIONS

| Type No.  | Spectral response | Photocathode material    | Features                     |
|-----------|-------------------|--------------------------|------------------------------|
| H12406    | 300 nm to 650 nm  | Bialkali                 | for visible range            |
| H12406-01 | 300 nm to 850 nm  | Multialkali              | for visible to near IR range |
| H12406-20 | 300 nm to 920 nm  | Extended red multialkali | for visible to near IR range |

## SPECIFICATIONS

(at +25 °C)

| Parameter  |                          |        | H12406             | H12406-01         | H12406-20         | Unit                   |
|--|--------------------------|--------|--------------------|-------------------|-------------------|------------------------|
| Peak sensitivity wavelength                      |                          |        | 420                |                   | 630               | nm                     |
| Effective area                                   |                          |        | 3(X) × 1(Y)        |                   |                   | mm                     |
| Window material                                  |                          |        | Borosilicate glass |                   |                   | —                      |
| Dynode number of stages                          |                          |        | 12                 |                   |                   | —                      |
| Input voltage                                    |                          |        | +4.75 to +5.25     |                   |                   | V                      |
| Max. Input voltage                               |                          |        | +6                 |                   |                   | V                      |
| Max. Input current                               |                          |        | 40                 |                   |                   | mA                     |
| Count sensitivity                                | Typ.                     | 300 nm | $1.7 \times 10^5$  | $2.1 \times 10^5$ | $5.3 \times 10^4$ | $s^{-1} \cdot pW^{-1}$ |
|  |                          | 400 nm | $3.6 \times 10^5$  | $2.7 \times 10^5$ | $8.8 \times 10^4$ |                        |
|  |                          | 500 nm | $2.6 \times 10^5$  | $2.3 \times 10^5$ | $2.7 \times 10^5$ |                        |
|  |                          | 600 nm | $4.3 \times 10^4$  | $1.7 \times 10^5$ | $3.0 \times 10^5$ |                        |
|  |                          | 700 nm | $1.4 \times 10^2$  | $9.6 \times 10^4$ | $2.9 \times 10^5$ |                        |
|  |                          | 800 nm | —                  | $2.1 \times 10^4$ | $2.1 \times 10^5$ |                        |
|  |                          | 900 nm | —                  | —                 | $3.9 \times 10^3$ |                        |
| Count linearity ①                                |                          |        | $5.0 \times 10^6$  |                   |                   | $s^{-1}$               |
| Dark count ②                                     |                          | Typ.   | 10                 | 100               | 500               | $s^{-1}$               |
|  |                          | Max.   | 50                 | 500               | 2500              |                        |
| Pulse-pair resolution                            |                          |        | 20                 |                   |                   | ns                     |
| Output pulse width                               |                          |        | 10                 |                   |                   | ns                     |
| Output pulse height<br>(at load resistance 50 Ω) |                          | Min.   | +2.0               |                   |                   | V                      |
|  |                          | Typ.   | +2.2               |                   |                   |                        |
| Recommended load resistance                      |                          |        | 50                 |                   |                   | Ω                      |
| Signal output logic                              |                          |        | Positive logic     |                   |                   | —                      |
| Excessive light<br>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                      |

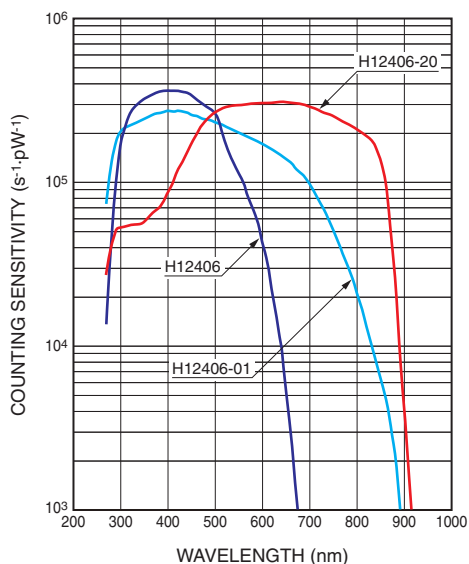
① Random pulse, at 10% count loss

② After 30 minute storage in darkness

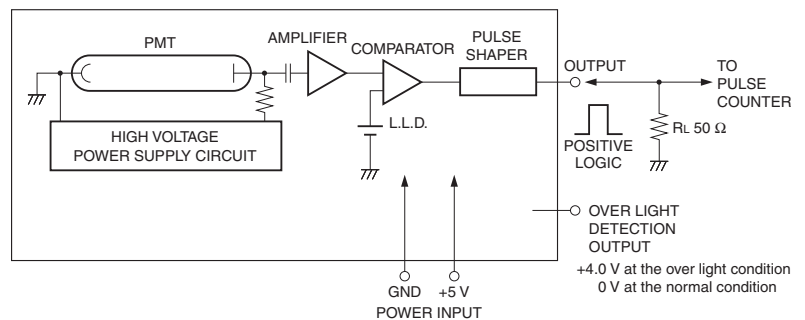
③ Load resistance 10 kΩ

④ No condensation

## COUNT SENSITIVITY



## BLOCK DIAGRAM

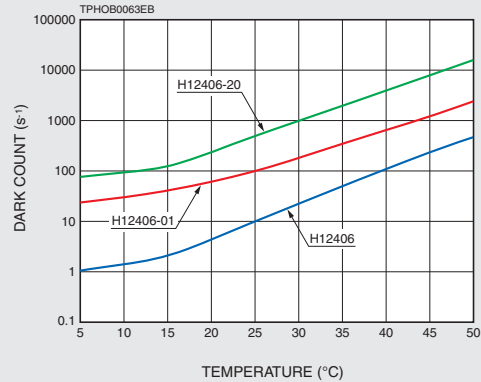


TPMOC0226EC

# Characteristics

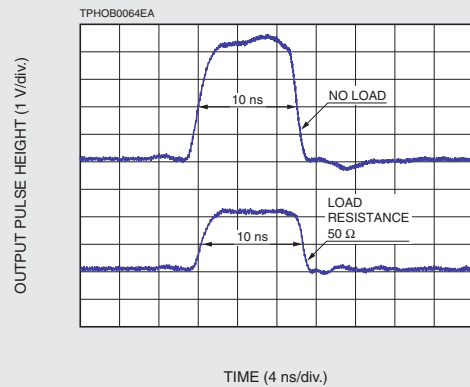
## Dark count

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.



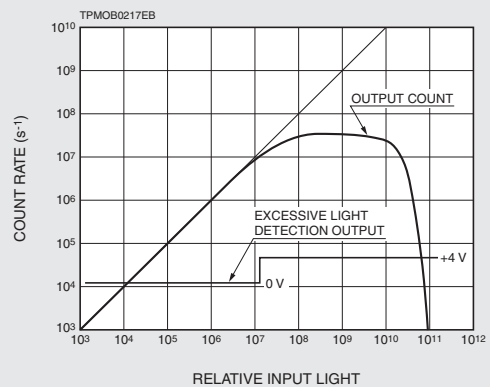
## Output waveform

Output waveforms are positive logic signals. The figure on the right shows output waveforms measured with and without a load resistance of 50  $\Omega$ . Since photon counting head handles high-speed signals, a 50  $\Omega$  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  $\Omega$ .



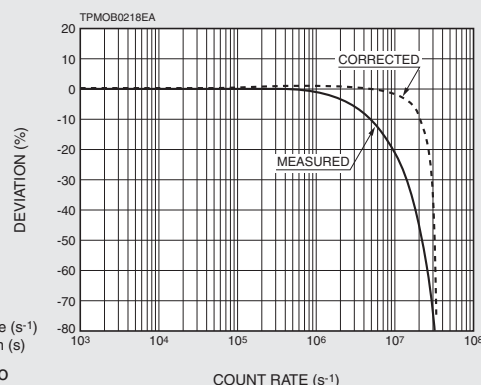
## Count linearity and excessive light detection characteristics

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)

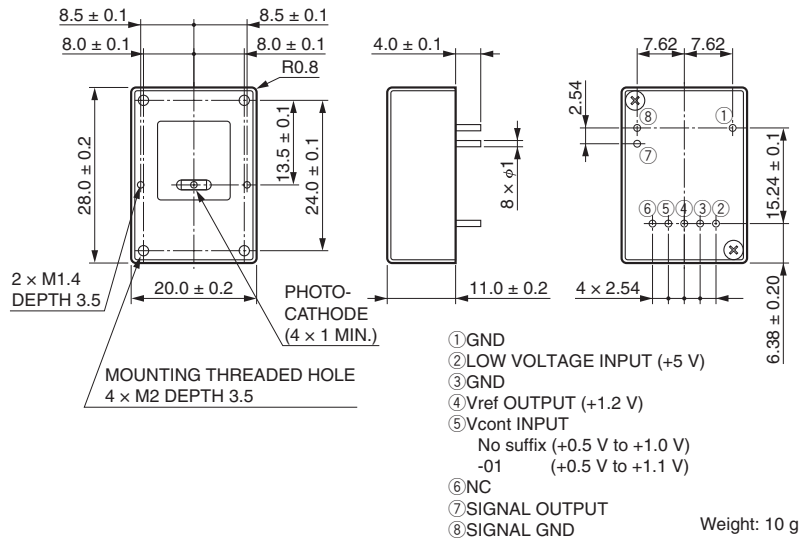
\* Micro PMT photon counting head H12406 series do not have the function to automatically output a correction value.





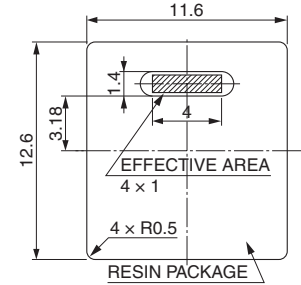
## MICRO PMT MODULE

### ■ H14066 Series

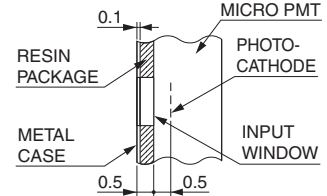


H14066

#### ■ DETAILS OF INPUT WINDOW

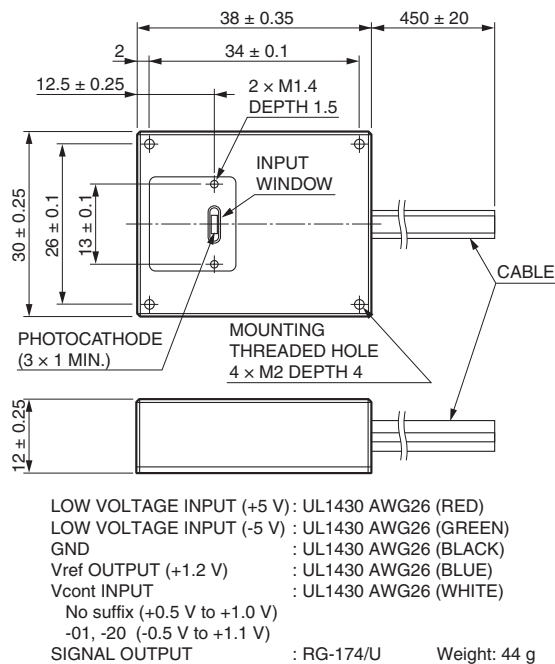


#### ■ CROSS SECTION



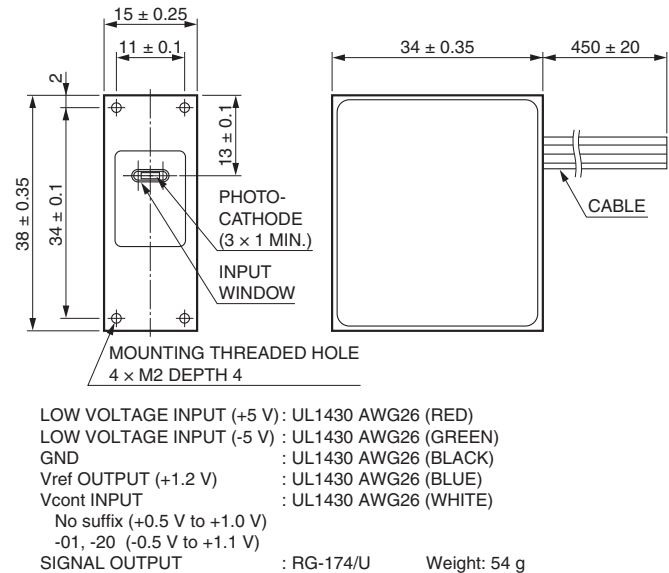
## MICRO PMT MODULE

### ■ H12404 Series



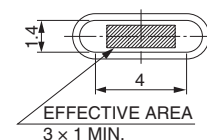
## MICRO PMT MODULE

### ■ H12405 Series

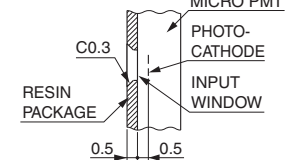


H12402/H12403/H12404/H12405

#### ■ DETAILS OF INPUT WINDOW



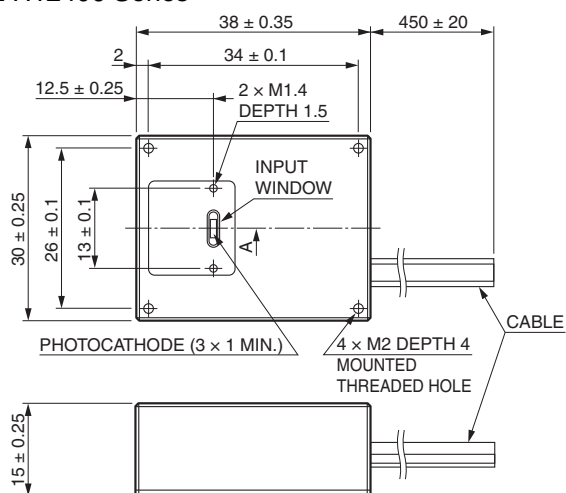
#### ■ A CROSS SECTION



## DIMENSIONAL OUTLINES (Unit: mm)

### MICRO PMT PHOTON COUNTING HEAD

#### H12406 Series

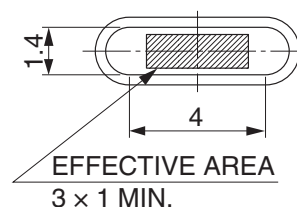


#### CABLE

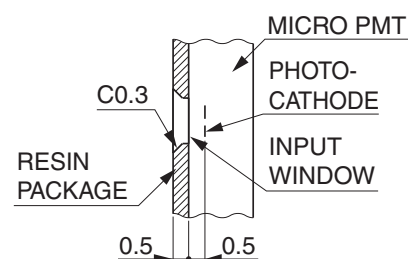
LOW VOLTAGE INPUT (+5 V) : UL1430 AWG26 (RED)  
 GND : UL1430 AWG26 (BLACK)  
 OVER LIGHT DETECTION OUTPUT: UL1430 AWG26 (BLUE)  
 SIGNAL OUTPUT : RG-174/U Weight: 46 g

TPMOA0091EB

#### DETAILS OF INPUT WINDOW



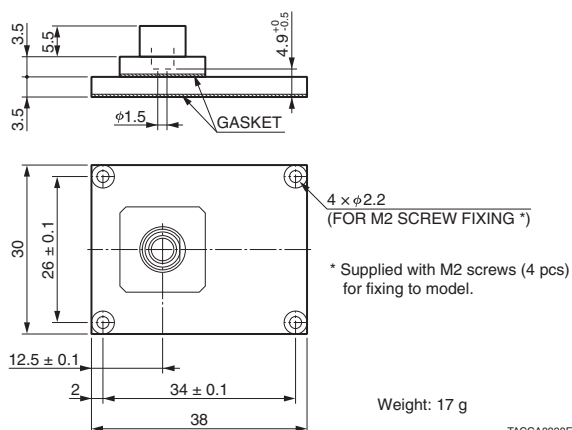
#### A CROSS SECTION



TPMHA0590EB

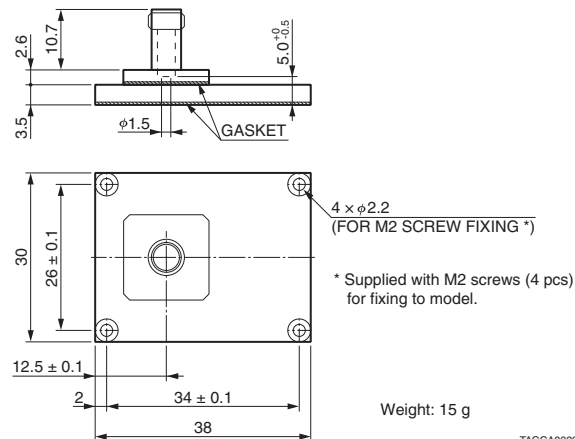
## OPTION: OPTIONAL FIBER ADAPTER (sold separately)

#### E13561 (FC type)



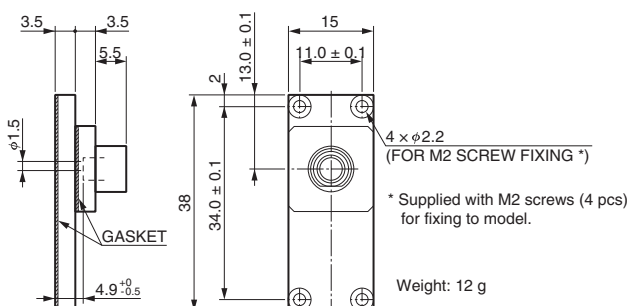
TACCA0338EA

#### E13562 (SMA type)



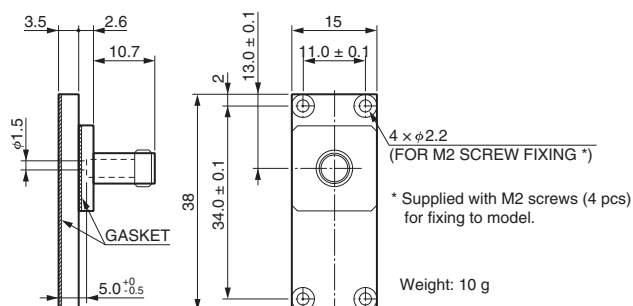
TACCA0339EA

#### E13563 (FC type)



Weight: 12 g

#### E13564 (SMA type)



Weight: 10 g

\* E13561 and E13562 are the exclusive options for H12402/H12404/H12406 series. E13563 and E13564 are the exclusive options for H12403/H12405 series.

# Related Products



## ■ HIGH VOLTAGE POWER SUPPLY C14210-14 0.4 W output 1100 V / 0.4 mA

The C14210-14 is the world's smallest surface-mount high voltage power supply module with a stabilizing circuit for photomultiplier tubes.

That is suitable for operating a H12400 series, which can reflow mounting.

| Parameter                                     | Value  | Unit |
|---|--|------|
| Input voltage range ( $V_{DD}$ )              | +3.0 to +5.0   | V    |
| Input current <sup>①</sup>                    | Max. 270   | mA   |
| Specification guaranteed output voltage range | -200 to -1100  | V    |
| Output current                                | Max. 0.4   | mA   |
| Output voltage rise time <sup>②</sup>         | 150  | ms   |
| Line regulation                               | Typ. $\pm 0.01$  | %    |
| Load regulation                               | Typ. $\pm 0.01$  | %    |
| Temperature coefficient                       | Typ. $\pm 0.01$  | %/°C |
| Ripple / Noise (p-p) <sup>③</sup>             | Typ. 50  | mV   |
| Operating ambient temperature <sup>⑤</sup>    | 0 to +50   | °C   |
| Weight  | 4  | g    |
| Dimensions (W × H × D)                        | 15 × 7 × 15  | mm   |
| Protective functions                          | Short circuit in output / Continuous overloading / Excessive controlling voltage input | —    |

①:  $V_{DD} = +3$  V, at maximum output voltage and current

②: Rise time (0 % → 99 %)

③: 5 kHz or more

④: At ambient humidity below 80 % (no condensation)



## ■ 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 suitable for use with a H12400 series Micro PMT assembly. Besides high performance and low power consumption, a variety of protective functions are also included.

| Parameter  |                |      | C10940-03   | C10940-03-R2* | C10940-53     | C10940-53-R2* | Unit |
|--|----------------|------|---|---------------|---------------|---------------|------|
| Input voltage (V <sub>DD</sub> )                 |                |      | +5.0 ± 0.5  |               |               |               | V    |
| Input current ①                                  | with full load | Typ. | 60  |               |               |               | mA   |
|  | with no load   | Typ. | 230   |               |               |               |      |
| Specification guaranteed output voltage range ②  |                |      | -200 to -1200   |               | +200 to +1200 |               | V    |
| Output current                                   |                | Max. | 0.6   |               |               |               | mA   |
| Line regulation ①③                               |                | Typ. | ±0.02   |               |               |               | %    |
| Load regulation ①                                |                | Typ. | ±0.01   |               |               |               | %    |
| Ripple / Noise (p-p) ①③                          |                | Typ. | 50  |               |               |               | mV   |
| Output voltage rise time (Rise time 0 %→99 %) ①③ |                | Typ. | 120   | 300           | 120           | 300           | ms   |
| Temperature coefficient ①③                       |                |      | ±0.01   |               |               |               | %/°C |
| Operating ambient temperature ①③                 |                |      | 0 to +50  |               |               |               | °C   |
| Weight   |                |      | 7.7   |               |               |               | g    |
| Dimensions (W × H × D)                           |                |      | 15 × 18 × 15  |               |               |               | mm   |
| Protective functions                             |                |      | Units protected against reversed power input, reversed / excessive controlling voltage input, continuous overloading / short circuit output |               |               |               | —    |

①: At maximum output voltage

②: The voltage from 0 V to -200 V/+200 V can be output but all characteristics are not necessarily satisfied.

③: At maximum output current

④: No condensation

\* -R2 type: RS-485 control

# Related Products



▲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, H12403 series, H12404 series, H12405 series and H12406 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.

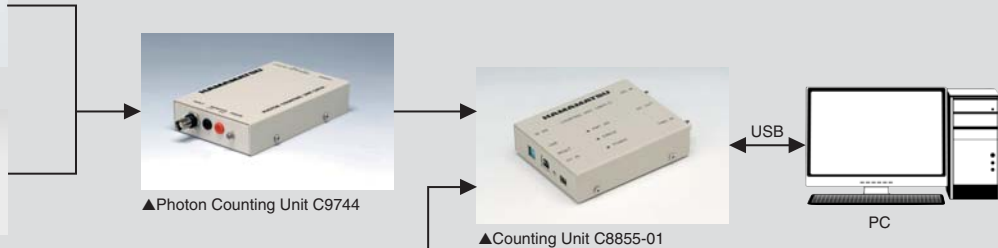


▲Micro PMT assembly  
H12400 series

▲Micro PMT modules  
H12402, H12403, H12406 series

▲Micro PMT photon counting head  
H12406 series

## ■ PHOTON COUNTING CONFIGURATION EXAMPLE



\*  $\mu$ PMT is the registered trademark of Hamamatsu Photonics K.K. in Japan, U.S.A., EU, China and Republic of Korea.

Subject to local technical requirements and regulations, availability of products included in this promotional material may vary. Please consult with our sales office.  
Information furnished by HAMAMATSU is believed to be reliable. However, no responsibility is assumed for possible inaccuracies or omissions. Specifications are subject to change without notice. No patent rights are granted to any of the circuits described herein. ©2019 Hamamatsu Photonics K.K.

**HAMAMATSU PHOTONICS K.K.** [www.hamamatsu.com](http://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, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: [usa@hamamatsu.com](mailto:usa@hamamatsu.com)

Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: [info@hamamatsu.de](mailto: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](mailto:infos@hamamatsu.fr)

United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: [info@hamamatsu.co.uk](mailto:info@hamamatsu.co.uk)

North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01 E-mail: [info@hamamatsu.se](mailto:info@hamamatsu.se)

Italy: Hamamatsu Photonics Italia S.r.l.: Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: [info@hamamatsu.it](mailto:info@hamamatsu.it)

China: Hamamatsu Photonics (China) Co., Ltd.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R.China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: [hpc@hamamatsu.com.cn](mailto:hpc@hamamatsu.com.cn)

Taiwan: Hamamatsu Photonics Taiwan Co., Ltd.: 8F-3, No.158, Section2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: [info@hamamatsu.com.tw](mailto:info@hamamatsu.com.tw)

TPMZ1019E05  
FEB. 2019 IP